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Supplemental Remedial Investigation Report

for

Frontier Fertilizer

Davis, California

Volume 1

Submitted to:

U.S. Environmental Protection Agency
Region IX

EPA Contract Number 68-W9-0060
EPA Work Assignment Number 60-28-9L4R

Prepared by
Bechtel Environmental, Inc.

June 1999

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Acronyms and Abbreviations

AT&ASI	American Testing and Analytical Services, Inc.
BEI	Bechtel Environmental, Inc.
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAS	Chemical Abstract Service
CCAL	continuing calibration
CCl_4	carbon tetrachloride
CLP	(EPA) Contract Laboratory Program Analytical Services
cm^3	cubic centimeter
cm/sec	centimeters per second
COC	chemical of concern
CRDL	contract-required detection limit
CRQL	contract-required quantitation limit
C_v	leachate concentration
C_{ws}	diluted leachate concentration in the aquifer
CZ	capture zone
d	distance
D	aquifer thickness
%D	percent difference
DBCP	1,2-dibromo-3-chloropropane
1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
DCP	1,2-dichloropropane
DHS	California Department of Health Services
DMLS	Dialysis Multi-Level Sampler
DNAPL	dense nonaqueous-phase liquid
DQO	data quality objective
DTSC	Department of Toxic Substances Control
E&E	Ecology & Environment
EDB	1,2-dibromoethane

EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
FASP	Field Analytical Support Program
FS	Feasibility Study
FSP	Field Sampling Plan
ft/day	feet per day
ft^2/day	square feet per day
ft/yr	feet per year
f_{oc}	fraction of organic carbon
GAC	granular activated carbon
g/cm^3	grams per cubic centimeter
GC/MS	gas chromatography/mass spectrometry
gpd	gallons per day
gpd/ft	gallons per day per foot
gpm	gallons per minute
GTI	Groundwater Technology, Inc.
Hg	mercury
i	average horizontal groundwater gradient
ICAL	internal calibration
J	estimated concentration
k	hydraulic conductivity
K_d	soil/water distribution coefficient
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol/water partition coefficient
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LMF	leachate mixing factor
LSCE	Luhdorff and Scalmanini, Consulting Engineers

L_v	length of groundwater plume (parallel to direction of flow)
m	mass (of contaminant)
MCL	maximum contaminant level
M&E	Metcalf & Eddy
µg/L	micrograms per liter
µg/min-m^2	micrograms per minute per square meter
mg/L	milligrams per liter
mL	milliliter
mm	millimeter
MSL	mean sea level
n	effective porosity
NAPL	nonaqueous-phase liquid
ND	nondetect or not detected
Nm	nanometer
NPL	National Priorities List
PAR	Preliminary Assessment Report
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCE	tetrachloroethene (perchloroethene)
ppb	parts per billion
ppbv	parts per billion by volume
ppm	parts per million
PRG	preliminary remediation goal
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
q_v	infiltration rate
RAS	Routine Analytical Services
RCRA	Resource Conservation and Recovery Act
ρ_b (rho)	soil bulk density
RI	Remedial Investigation
RPD	relative percent difference

RWQCB	Regional Water Quality Control Board
SAS	Special Analytical Services
SIM	selected ion monitoring
SQL	sample quantitation limit
STLC	soluble threshold limit concentration
t	time
T	aquifer transmissivity
TCE	trichloroethene
TCL	Target Compound List
TCLP	toxicity characteristic leaching procedure
θ (theta)	volumetric water (or moisture) content
TPH	total petroleum hydrocarbons
1,1,2-TCA	1,1,1-trichloroethane
U	undetected concentration
USCS	Unified Soil Classification System
v_c	solute velocity (in groundwater)
VOC	volatile organic compound
v_x	average linear groundwater velocity
YCDPH	Yolo County Department of Public Health

Executive Summary

This Supplemental Remedial Investigation Report presents the results of remedial investigation activities conducted at the Frontier Fertilizer site near Davis, California during 1997, 1998, and 1999 for the U.S Environmental Protection Agency (EPA), Region IX.

BACKGROUND

The Frontier Fertilizer site is located at 4303 and 4309 Second Street in Davis, Yolo County, California. It was first developed in the 1950s as an area to store agricultural equipment. In the 1970s, the site was used to store, mix, and distribute pesticides and fertilizer for local agriculture. Pesticide handling was discontinued in 1983 when it was discovered that the levels of pesticides in the wastewater, which had been placed in an unlined disposal basin, were toxic.

Several investigations of site soils and groundwater were conducted in 1984 through 1996 by various private and government entities. Subsurface soils on the site were found to be contaminated with pesticides including 1,2-dibromomethane (EDB), 1,2-dichloropropane (DCP), and 1,2-dibromo-3-chloropropane (DBCP) at concentrations above their respective EPA Region IX preliminary remediation goals. The contaminated soil was found to extend to a minimum depth of 23 feet below ground surface and comprise approximately 30,000 cubic yards. In 1985, most of the contaminated soils were removed. The nature and extent of residual soil contamination was discussed in the *Final Interim Remedial Investigation Report* for Frontier Fertilizer issued in April 1997.

Groundwater was found to occur in three shallow water-bearing zones: from shallowest to deepest, the S-1 zone, the S-2 zone, and the A-1 aquifer. The S-1 and S-2 zones were found to consist of silty sand lenses surrounded by a clay and silt matrix. The A-1 aquifer was found to be a more regionally extensive gravel and sand aquifer with greater transmissivity than that of the shallower sand zones. Groundwater flow was found to be generally from south to north. The nearest downgradient public water supply well, City of Davis Well No. 29, occurs approximately 2,600 feet northwest of the site, but is screened in a deeper water-bearing zone, the A-2 aquifer.

The groundwater beneath and downgradient of the site was also found to be contaminated with pesticides. In the disposal basin area, a plume of EDB, DBCP, and DCP was discovered. To the east, an apparently separate plume of carbon tetrachloride (CCl_4) was discovered. The highest contaminant concentrations in groundwater were found to occur in the S-1 and S-2 zones in the disposal basin area.

An interim groundwater remediation system was installed by EPA and began operating in June 1995. This system consisted of 17 extraction wells screened in either the S-1 or S-2 zones and 7 injection wells screened in both zones. Extracted water was treated with activated carbon and then injected into the subsurface or discharged to the sanitary sewer. (The injection wells have since been deactivated.)

SUPPLEMENTAL RI INVESTIGATION ACTIVITIES

The Supplemental Remedial Investigation activities described in this report include:

- Phase II groundwater investigation: installation, development, and sampling of new monitoring wells OW-5A, -5B, and -5C; OW-6A, -6B, and -6C; OW-7A, -7B, and -7C; OW-8A, -8B, and -8C; and OW-11A, -11B, and -11C in October - November 1997;
- Phase III groundwater contaminant plume investigation using SimulProbe™ sampling and installation, development, and sampling of new monitoring wells OW–9A and OW–9B, OW-10A and -10B, OW-12A and -12B, and OW-13B in July 1998;
- Decommissioning wells MW-4A, MW-4B, and MW-7C to reduce the potential for cross-contamination of aquifers;
- Decommissioning wells OW-2A, OW-2B, and OW-2C to relocate these wells from a residential lot to the street and because at this location the hydrographs indicated an interconnection between water-bearing zones;
- Continued quarterly groundwater sampling;
- A study to determine the presence of dense nonaqueous-phase liquids (DNAPLs) in the aquifer zones;
- A soil-gas flux chamber investigation in the area downgradient (north) of the site where residential construction has recently been completed; and
- Modeling of vadose zone contaminant transport to groundwater using the VLEACH code.

Well and sample locations are shown in Figure ES-1. Appendix F presents the investigation work plans.

This Supplemental RI Report describes and presents the results of these investigations and provides an updated site conceptual model. The information presented here will be used to support a feasibility study, remedy selection, and final remedial design.

HYDROSTRATIGRAPHY

The presence of the S-1, S-2, and A-1 aquifer zones, and their intervening aquitards, were confirmed, onsite and in the downgradient area. Groundwater is first encountered in the S-1 zone at a depth of approximately 20 feet below ground surface. The average hydraulic conductivity values for the S-1, S-2, and A-1 aquifer zones are 30 ft/day, 10 ft/day, and 500 ft/day, respectively.

GROUNDWATER FLOW

Groundwater flow patterns in the S-1 and S-2 zones were found to be consistent with those observed since 1995, when the interim remediation system was started. Groundwater flow in these zones is dominated by the depressions caused by the extraction wells. Groundwater flow is radially inward toward the extraction wells in the area immediately north of the disposal area. Beyond the influence of pumping, groundwater flow in the S-1 and S-2 zones is toward the north/northeast.

Groundwater flow in the A-1 aquifer is thought to be generally toward the north/northeast, but there is still some uncertainty. There is a steep trough or depression in the vicinity of wells X-1C, MW-7D, and MW-9C.

Vertical groundwater gradients are generally downward in the summer and fall months and upward during the winter and spring months, when recharge increases and local pumping decreases.

EXTENT OF GROUNDWATER CONTAMINATION

The highest concentrations of EDB, DBCP, and DCP (indicator chemicals of concern [COCs]), on the order of several hundred to several thousand micrograms per liter (µg/L), have consistently been detected in samples from the S-1 and S-2 zone extraction wells located immediately downgradient (north) of the former disposal basin: MW-7B, MW-7C (abandoned), X-1A, and X-1B. The EDB plume occupies an irregular region extending from the disposal basin area north to the vicinity of Vistosa Street. While the DBCP and DCP plume also extends north from the disposal basin area, it is less extensive than that of EDB.

The distribution of the other indicator COC, CCl_4, in groundwater is different from that of the pesticides EDB, DBCP, and DCP. Consistently, the highest concentrations of CCl_4 have been detected in samples from well clusters OW-3 and OW-4, which are located to the east of the EDB plume. The CCl_4 plume either mingles with the EDB plume in the vicinity of the MW-9 and MW-11 well clusters, or there is a separate CCl_4 plume in the vicinity of those wells. CCl_4 has also been detected in the OW-6 cluster wells, which are considerably farther downgradient than the leading edge of the pesticide plume.

OCCURRENCE OF DNAPL

The high concentrations of EDB and DCP in the S-2 zone cannot be explained solely by advective transport of a dissolved phase. If only dissolved-phase contaminants are introduced into the S-2 zone, there should be some dilution, but this is not the case. In addition, steep lateral concentration gradients are observed and pesticide disposal activities at this site support a DNAPL release scenario. In 1995, the combined percent of saturation of EDB and DCP in well X-1B exceeded 1 percent. The data obtained during this investigation indicate that the combined percent saturation of EDB and DCP still approaches 0.4 percent in well X-1B, but the combined

percent of saturation has generally declined in the other most highly contaminated wells. The initial presence of a DNAPL in the vadose zone and in the saturated zone is supported by several lines of evidence, but despite considerable testing, a separate-phase DNAPL has not been directly observed at Frontier Fertilizer. The initial DNAPL release may have been depleted by the removal of the source of contamination in the vadose zone and extraction of contaminated groundwater.

EFFECTIVENESS OF INTERIM GROUNDWATER REMEDIATION SYSTEM

The most highly concentrated regions of the EDB/DBCP/DCP plumes in the S-1 and S-2 zones appear to be contained within the capture zone. A portion of these plumes may have migrated downgradient before the extraction system was started in 1995, as evidenced by low concentrations of these contaminants in downgradient monitoring wells. The main CCl_4 plume also appears to be captured in these zones. However, because there is some uncertainty in both the exact extent of the plume and the configuration of the potentiometric surface in the area to the northeast of well OW-4A, the exact extent of capture is difficult to assess.

TRENDS IN GROUNDWATER CONTAMINATION OVER TIME

Overall, EDB, DBCP, and DCP concentrations in the core of the EDB plume have decreased significantly since 1995. This is thought to be the result of groundwater extraction and removal of the DNAPL source from the vadose zone. Concentrations in the far downgradient portion of the plume have generally increased, however, since 1995. This is probably because this portion of the plume was at the limit of the capture zone when the extraction system was started, so it escaped capture and will continue to migrate downgradient. CCl_4 concentrations in the S-1 and S-2 zones have remained relatively unchanged.

COC concentrations in the A-1 aquifer have remained relatively unchanged over time, which suggests that there has been no significant mass transfer of contaminants downward from the S-2 zone. As in the upper zones, it appears that there is a portion of the plume in this zone that has migrated downgradient. As this portion of the plume arrives at progressively downgradient monitoring wells, COC concentrations may continue to increase in those wells for some time.

GROUNDWATER CONTAMINATION FATE AND TRANSPORT

It appears there was a release of dissolved pesticides and a quantity of DNAPL from the former disposal basin that migrated through the vadose zone into S-1 zone, through the S-1/S-2 aquitard and then into the S-2 zone. Dissolved COCs then migrated by advection downward to the A-1 aquifer and laterally to the north through the thin sand layers that comprise the S-1, S-2, and A-1 zones. It may be that little residual, nonmobile DNAPL remains in the S-1 and S-2 zones. Any residual DNAPL will continue to slowly dissolve into the groundwater.

In the S-1 zone, the pesticides are diluted, adsorbed, biodegraded, volatilized to soil gas and then to the atmosphere, or migrate downward to the S-2 zone. In the S-2 zone, the pesticides are adsorbed, biodegraded, diluted, or migrate vertically into the A-1 aquifer. During summer when irrigation pumping occurs in the A-1 aquifer, there is a strong downward gradient, and dissolved pesticides migrate vertically. These compounds are diluted because of the relatively high flux of groundwater in this aquifer.

In the A-1 aquifer, very low concentrations of EDB are conservatively estimated to arrive at the location of City Well No. 29 within approximately 185 days. However, because: 1) the contamination must then migrate downward to the A-2 aquifer; 2) City Well No. 29 draws from multiple water-bearing zones, causing dilution; 3) City Well No. 29 is sealed to a depth below the A-2 aquifer; and 4) continuous decay and dispersion are not accounted for in this estimate, it is also possible that measurable concentrations of COCs will never be detected in City Well No. 29, especially if migration of the relatively high COC concentrations near the OW-5 well cluster is halted.

LEACHING OF SOIL CONTAMINANTS TO GROUNDWATER

The vadose zone leaching evaluation indicates that concentrations of EDB, DCP, and DBCP detected at the disposal basin in 1995 could have affected groundwater in the S-1 zone. Since the other four COCs were not detected in the soil, they could have no impact on the aquifer, according to the leaching model.

Vadose zone leaching could have contributed up to 233 µg/kg of DCP to the S-1 zone groundwater immediately beneath the former disposal basin. For comparison, the concentration of DCP in extraction well X-1A in August 1998 was 4,100 µg/L. Hence leaching alone of EDB, DCP, and perhaps DBCP from vadose zone soils can have contributed only a minor amount of contamination to groundwater in the S-1 zone compared to concentrations of these COCs found in the core of the pesticide plume.

CONTAMINANTS IN SOIL-GAS

The highest concentrations of COCs in soil-gas were detected in the disposal basin area (19,000 parts per billion by volume DCP at SG-4). Soil-gas concentrations are considerably lower in the samples from the area north of the disposal basin area. The highest contaminant flux was also measured at this location (0.0023 grams per square meter per minute EDB at FLX-4). COCs were generally not detectable in the flux-chamber samples in the area north of the disposal basin.

RECOMMENDATIONS

The following recommendations are made for improving the understanding of the site, improving capture of contaminants in groundwater, and for improving the groundwater monitoring program:

1. Install one or more additional monitoring wells as needed to further define the extent of the CCl_4 plume.

2. Closely monitor concentration trends at wells OW-5, OW-7, and OW-8 cluster wells to determine if further investigation in these areas is warranted.

3. Install and pump-test an additional extraction well in the vicinity of well cluster OW-11.

4. Add additional A-1 aquifer wells to the groundwater monitoring program and improve water level gauging procedures.

Section 1

Introduction

This Supplemental Remedial Investigation Report (hereinafter referred to as the Supplemental RI) was prepared for the U.S. Environmental Protection Agency (EPA) Region IX by Bechtel Environmental, Inc. (BEI), under Contract No. 68-W9-0060, as specifically authorized by Work Assignment No. 60-28-9L4R.

This Supplemental RI presents the results of remedial investigation activities conducted at the Frontier Fertilizer site near Davis, California. In 1994 the site was placed on the National Priorities List (NPL) because of pesticide contamination in the soil and groundwater. An RI was conducted in 1995 - 1996 to identify the sources and nature of the contamination, to delineate the extent of the contamination, and to describe the fate and transport of the contaminants in the environment. The results of the RI were presented in the *Final Interim Remedial Investigation Report for Frontier Fertilizer, April 1997* (Bechtel, 1997a). Since completion of that study, additional investigation activities have been conducted at the site, including:

- Phase II groundwater investigation: installation, development, and sampling of new monitoring wells OW-5A, -5B, and -5C; OW-6A, -6B, and -6C; OW-7A, -7B, and -7C; OW-8A, -8B, and -8C; and OW-11A, -11B, and -11C in October – November 1997;
- Phase III groundwater contaminant plume investigation using SimulProbe™ sampling and installation, development, and sampling of new monitoring wells OW–9A and OW–9B, OW-10A and -10B, OW-12A and -12B, and OW-13B in July 1998;
- Decommissioning wells MW-4A, MW-4B, and MW-7C to reduce the potential for cross-contamination of aquifers;
- Decommissioning wells OW-2A, OW-2B, and OW-2C to relocate these wells from a residential lot to the street and because at this location the hydrographs indicated an interconnection between water-bearing zones;
- Continued quarterly groundwater sampling;
- A study to determine the presence of dense nonaqueous-phase liquids (DNAPLs) in the aquifer zones;
- A soil-gas flux chamber investigation in the area downgradient (north) of the site where residential construction has recently been completed; and
- Modeling of vadose zone contaminant transport to groundwater using the VLEACH code.

This Supplemental RI describes and presents the results of these investigations and provides an updated site conceptual model. The information presented here will be used to support a Feasibility Study (FS), remedy selection, and remedial design.

The remainder of this section provides a discussion of the site background, history, and physical setting. Section 2 of this report describes the Supplemental RI activities. Section 3 presents the results of the groundwater investigation and discusses the nature and extent of groundwater contamination. Sections 4 and 5 present the results of the VLEACH modeling and soil-gas investigation, respectively. Section 6 provides conclusions and recommendations, and Section 7 provides a list of references cited.

1.1 SITE BACKGROUND AND SETTING

The Frontier Fertilizer site is located at 4303 and 4309 Second Street in Davis, Yolo County, California. The geographic coordinates of the site are 38° 33' 9.5" N latitude and 121° 42' 7.0" W longitude (Township 8 North, Range 2 East, Section 12, Mt. Diablo Baseline and Meridian, Davis, California, 7.5-minute quadrangle). The location of the site is shown in Figure 1-1.

The Frontier Fertilizer site was first developed in the 1950s as an area to store agricultural equipment. In the 1970s, the site was used to store, mix, and distribute pesticides and fertilizer for local agriculture. Pesticide handling was discontinued during the 1980s when it was discovered that the levels of pesticides in the wastewater, which had been placed in an unlined disposal basin, were toxic. This discovery occurred when an employee's pet dog died after drinking some water ponded in the basin.

1.1.1 Site Description

The Frontier Fertilizer site is in a developing area at the eastern edge of the city of Davis, California. The site consists of several warehouses, shops, a pole barn, a labor camp complex, a tomato grading station, several sumps and culverts, and a disposal basin area. The 18-acre site is bounded on the south by Second Street and Interstate I-80, and on the north, west, and east by agricultural fields. Construction of the Mace Ranch Park industrial and residential development is underway for most of the agricultural land surrounding the site. The nearest residence is approximately 0.2 mile north of the site. The site layout is shown in Figure 1-2.

1.1.1.1 Topography and Surface Drainage

The site is situated in the Central Valley, which has a very minor topographic relief. Surface elevations vary on the order of 5 feet over a distance of several thousand feet. Creeks and drainage channels are downcut into the land surface by several feet, with relatively steep banks and levees. Surface drainage flows from west to east in this part of the Central Valley, but most local overland flow occurs in creek beds and irrigation drainage ditches. There is a drainage ditch north of the site. This features provides local control over surface runoff, but the very low relief at the site permits intermittent ponding.

1.1.1.2 Meteorology and Climate

Meteorological data were obtained for the weather station at the Sacramento airport, located approximately 15 miles north of Frontier Fertilizer, and for the University of California at Davis Experimental Farm (Climatedata, 1992). Average annual rainfall in Davis is 16.77 inches. Monthly average temperatures range from 45 degrees Fahrenheit (°F) in January to 76 °F in July. Rainfall monthly averages range from trace amounts in July to 3.6 inches in January. The prevailing wind direction ranges from southeast through south-southwest to southwest for all months except October and November, when the prevailing wind direction is from the north-northwest.

1.1.1.3 Demography and Land Use

The Frontier Fertilizer property will be incorporated into a light-industrial business park. Single-family residences have recently been constructed to the north of Arroyo Avenue.

1.1.2 Regional Geologic and Hydrogeologic Setting

The site is located in the Central Valley geomorphic province. The valley is asymmetrical and was formed as a crustal block rotated downward to the west. The same block rotated upward in the east to form the Sierra Nevada Mountains. As the block subsided, erosion from the Sierra Nevada and Coastal ranges filled the valley with sediments to thicknesses greater than 50,000 feet.

The area is underlain, from oldest to youngest, by pre-Cenozoic basement rocks, Mesozoic marine sedimentary rocks of the Great Valley Sequence, Tertiary marine and nonmarine sedimentary rocks, and Quaternary sediments. The Great Valley Sequence contains economic oil and gas resources. The Mesozoic and Tertiary deposits are several thousand feet thick along the western edge of the Central Valley. Pliocene Tehama Formation rocks are the youngest Tertiary unit in the area. This formation underlies the Pleistocene Modesto-Riverbank and Red Bluff Formations. The surficial Quaternary deposits are alluvial, as shown in Figure 1-3.

Only the Quaternary alluvial deposits are of interest to the RI because soil and groundwater contamination is limited to these deposits. The Quaternary alluvial deposits are further divided into the upper alluvium (approximately 140 feet thick), the lower alluvium (approximately 200 feet thick), and the blue clay (at least 300 feet thick).

The upper alluvium consists of coarser channel deposits serving as aquifers within a matrix of finer overbank and floodplain deposits acting as aquitards. The strata from approximately 20 feet below ground surface (bgs) are saturated, and water occurs in discontinuous silty sand lenses. These sand lenses vary in extent and thickness, but in general are not considered water-producing zones for agricultural or municipal uses. The uppermost water-bearing zone is called the S-1 zone, and the lower zone is called the S-2 zone. Underlying the S-2 zone is a regionally

extensive aquifer zone called the A-1 aquifer, as shown in Figure 1-4. Silt and clay beds occur between these sand zones and the A-1 aquifer. The A-1 aquifer is pumped by agricultural and water supply wells, but most local wells tap the more prolific and deeper A-2 aquifer

1.1.3 Operational History

The site was first used as a farming headquarters by the C. Bruce Mace Ranch Company in 1950. Grain warehouses and barns for machinery storage were the first buildings erected. A labor camp for Mexican nationals was constructed between 1952 and 1954. Site development continued from east to west, eventually occupying 14 acres in 1970. In 1970, the 14-acre site was sold to Anderson Farms, Inc. The next major improvement of the site and its operations occurred in 1972, when a tomato grading station and a wash rack to rinse off tomato trucks were installed in the south-central area. In addition, Barber-Rowland Company (Barber-Rowland) moved onto 4 acres to the west of the original 14 acres.

The arrival of Barber-Rowland in 1972 marked the beginning of fertilizer and pesticide operations on the site. In 1982, Frontier Fertilizer took over the fertilizer and pesticide operations from Barber-Rowland. Frontier's operations were terminated in 1987.

During site operations by Barber-Rowland and Frontier Fertilizer, fertilizers and pesticides were stored in containers or sold in bulk or mixed and placed in 500- to 1,000-gallon trailer tanks that were attached to a purchaser's truck for transport to the farm. If a pesticide container or trailer was returned with residual material inside, the excess pesticide and container rinsate was discharged onto the ground or into at least one unlined disposal basin located near the northwest corner of the site (Figure 1-2). In addition, used pesticide, insecticide, and herbicide containers were stored, crushed, and disposed of on site and at other locations off site. Frontier Fertilizer operations were confined to the western end of the property.

According to California Department of Health Services (DHS) records, on July 27, 1983, an employee's dog came in contact with liquid in the disposal basin. The dog died of pesticide poisoning while being examined by a veterinarian. Yolo County Department of Public Health (YCDPH) personnel visited the site on August 2, 1983, and observed the 20-foot by 15-foot by 4-foot-deep basin, with approximately 1,500 gallons of fluid ("dark, oily liquids") in it. YCDPH personnel returned 2 days later to collect fluid samples but the pit had been pumped out. Soil samples collected from the base of the pit contained 1,676 parts per million (ppm) disyston and 1,056 ppm 1,2-dibromethane (EDB). In September 1983, YCDPH, under the guidance of the DHS, specified that corrective action be taken at the site.

Soil samples taken by YCDPH on March 2, 1984 indicated that soil contamination by EDB, 1,2-dichloropropane (DCP), 1,2-dibromo-3-chloropropane (DBCP), and other pesticide- and herbicide-related compounds existed at the site. EDB was used as a soil fumigant to kill nematodes. Its use in California was discontinued in 1982. EDB was typically purchased from

manufacturers as a powder, or in a 5 percent solution in water. DBCP was employed as a nematicide until its use was discontinued in California in 1977. DBCP was typically purchased from manufacturers in powder form or in 7.5 percent solutions in water. DCP is still employed in California as a nematicide and for weed control.

In May 1984, the Frontier case was referred to the Yolo County District Attorney's office for action. A temporary restraining order was issued on January 6, 1984 by the Honorable James Rouch, Judge of the Superior Court, requiring Frontier to cooperate with interested agencies in hazardous waste cleanup. On January 11, 1985, the Federal Bureau of Investigation and EPA investigated the site under a search warrant to determine whether site waste storage and the disposal practices violated federal laws. On March 30, 1985, the DHS notified Mr. John Anderson, owner of Frontier Fertilizer, that the facility had been evaluated for inclusion on the Priority Ranking List of hazardous waste sites within the State of California.

The first remedial measures began on the site on April 12, 1985. Frontier contracted Laugenour and Meikle, Civil Engineers, of Woodland, California, to excavate soil from the pesticide disposal basin area, and to land-farm the excavated soil over a 15-acre site nearby. This action was under the supervision of the California Regional Water Quality Control Board (RWQCB) and the DHS. The dimensions of the excavation were 25 feet by 45 feet by 20 feet deep, and approximately 1,100 cubic yards (yd^3) of soil were transported to the treatment area. The excavation did not remove all of the contaminated soils from the disposal basin area but it did help to mitigate the immediate threat of exposure to soil contamination. Based on analyses of soil samples collected during excavation, a total of approximately 59 pounds of EDB was removed by excavation.

In response to a Cleanup and Abatement Order issued by the RWQCB, Frontier Fertilizer contracted Luhdorff and Scalmanini, Consulting Engineers (LSCE), of Woodland, California, to conduct a soil and groundwater investigation of the site. Twenty-four monitoring wells were installed on or near the site between June 1985 and March 1986. A Preliminary Assessment Report (PAR) was submitted to the DHS in November 1987 (Luhdorff and Scalmanini, 1987).

The LSCE report did not completely define the extent of soil and groundwater contamination on the site, particularly to the north. The most contaminated groundwater detected in the LSCE investigation was 24,000 parts per billion (ppb) EDB in samples collected from well MW-7B, to the north of the site. The DHS issued a Remedial Action Order to Frontier on September 11, 1987. In a February 29, 1988 letter, the DHS issued a notice of final determination of non-compliance to the responsible parties named in the Remedial Action Order.

1.1.4 Summary of Previous Investigations

Five previous investigations have been conducted at Frontier Fertilizer (see Table 1-1). The first was carried out by LSCE for Frontier Fertilizer. The second was conducted by Groundwater

Technology, Inc. (GTI) for RAMCO Enterprises, Inc. The third, performed by Metcalf and Eddy (M&E), was an investigation for the State of California Environmental Protection Agency's Department of Toxic Substances Control (DTSC). The fourth, conducted by Ecology and Environment (E&E), was a preliminary assessment for EPA. The fifth and most recent investigation conducted at the site was the Interim RI conducted by BEI in 1995-1996. These investigations are discussed below.

Figure 1-2 shows well locations and Table 1-1 presents a list of wells installed by various entities.

1.1.4.1 Investigation Conducted by LSCE for Frontier Fertilizer

The Frontier Fertilizer Company and its consultant, LSCE, in response to Cleanup and Abatement Orders issued by the RWQCB, conducted activities to investigate air, soil, and groundwater contamination on and adjacent to the site from 1984 to 1988. These activities included an initial characterization of the site, excavation and land farming of contaminated soil from a former disposal basin on the site, development of health and safety plans for investigative activities, development of quality assurance and quality control (QA/QC) plans for sampling and analytical activities associated with the investigation, onsite air monitoring, onsite and offsite soil sampling, and construction and sampling of 24 onsite and offsite monitoring wells.

In 1987, Frontier Fertilizer's environmental consultant, LSCE, submitted a PAR to the DHS. The report presented the results of soil sampling and of the installation and sampling of 24 groundwater monitoring wells. Most, but not all, of the contaminated soil around the disposal basin had been excavated in 1985. Three water-bearing zones, separated by semiconfining layers or clay and silty clay, were identified by LSCE. The shallowest, S-1, was found to extend from approximately 30 to 50 feet bgs and to consist of medium- to fine-grained sands (see Figure 1-4). The intermediate zone, S-2, was found to extend from approximately 60 to 90 feet bgs and to consist of fine sands to silty sands. The deepest zone, A-1, was found to extend from 110 to 130 feet bgs and to consist of gravels to coarse sands. The most contaminated well (24,000 ppb of EDB) was found to be MW-7B (screened in the S-1 zone). Since MW-7B was the northernmost S-1 well at that time, the extent of the groundwater plume was not defined by LSCE (Luhdorff and Scalmanini, 1987).

1.1.4.2 Investigation Conducted by GTI for RAMCO Enterprises, Inc.

GTI was contracted by RAMCO Enterprises, Inc., to complete a remedial investigation of the Frontier Fertilizer site in Davis, California. RAMCO is the former owner of the property north of the Frontier Fertilizer site. The work performed by GTI included soil sampling and analysis, installation of 12 additional monitoring wells screened in discrete water-bearing zones, and water level gauging and sampling of all monitoring wells that contained water.

A feasibility study of remediation alternatives is included in the GTI report. The alternatives were screened for engineering feasibility, ability to meet cleanup goals, and the safety of the public health. Excavation of soil and treatment by a combination of enhanced biological degradation and ventilation were recommended for the unsaturated zone contamination. Four to eight pumping wells were recommended for control and treatment of groundwater contamination, half screened in the S-1 zone and half screened in the S-2 zone (Groundwater Technology, 1990).

1.1.4.3 Investigation Conducted by M&E for the State of California

M&E was retained by the California EPA to conduct a focused RI in support of an interim remedial measure at the Frontier Fertilizer site. The scope of the focused RI was:

- Further delineation of contaminant migration at the site by installing a cluster of three groundwater monitoring wells (MW-13) approximately 200 feet west of the previously defined hot spot (MW-7 well cluster);
- Determination of the aquifer hydraulic properties beneath the site by conducting a series of step drawdown and long-term pumping tests in the S-1 and S-2 zones;
- Monthly water level measurements from August 1991 through April 1992; and
- Groundwater sampling and analyses at the MW-7 and MW-13 well clusters.

The state's field activities confirmed the presence of the three water-bearing zones, S-1, S-2, and A-1, as defined by previous investigations. The water level measurements showed that groundwater flow at the site is influenced by seasonal variations as well as pumping of the nearby domestic, municipal, and agricultural water supply wells. High concentrations of EDB, DBCP, and DCP were detected in samples from the MW-7 well cluster, and samples from the MW-13 well cluster indicated the migration of contaminants from the MW-7 site to the MW-13 site. Carbon tetrachloride (CCl_4) was also detected at relatively high concentrations in samples from well MW-12A or MW-12B, to the east of the apparent EDB/DBCP/DCP plume. The results of the aquifer hydraulic tests indicated relatively high groundwater velocity in the S-1 and S-2 zones ranging from approximately 1 foot per day (ft/day) to 5 ft/day. The mean transmissivity and mean storage coefficients for the S-1 and S-2 zones were determined at 970 gallons per day per foot (gpd/ft) and 1,360 gpd/ft and 0.004 and 0.002, respectively (Metcalf and Eddy, 1992).

1.1.4.4 Preliminary Assessment Conducted by E&E for the EPA

In 1994, the site was listed on the NPL and EPA took over supervision of the site investigation. In 1993, the EPA Emergency Response Section retained E&E to collect soil samples to determine levels of pesticide contamination remaining in the soil and to attempt to locate a source for the CCl_4 contamination. The analytical data were used to determine if a removal action was warranted for any source area on site. Removal options considered included soil

vapor extraction and soil excavation. EPA determined that soil containing levels of EDB, DBCP, and DCP above 1,000 ppb would be considered for removal action (Ecology and Environment, 1994).

Soil Investigation. E&E (for EPA) collected soil samples during two phases of site work. Phase I took place from March 3 through March 18, 1993. Phase I sampling focused on the former pesticide disposal basin area. Samples were collected from four depths on a 20-foot-square grid. Background samples were taken at a location near the southwest corner of the site. Phase II samples were collected from the disposal basin area, from the labor camp area next to the concrete sump suspected of being a source of CCl_4 contamination, and from other locations near pesticide-handling areas. Background samples were collected at a location west of the site at the edge of a cultivated field. Samples were collected from four depth intervals at each soil sample location. Depth intervals were generally 1-2 feet bgs, 8-9 feet bgs, 18-19 feet bgs, and 26-27 feet bgs.

During Phase I, a total of 105 soil samples and two soil vapor samples from the pesticide disposal basin area were collected. The samples were analyzed on site in the EPA Field Analytical Support Program (FASP) mobile laboratory for the following volatile organic compounds (VOCs):

- CCl_4;
- DCP;
- 1,3-dichloropropane;
- EDB; and
- DBCP.

During Phase II, 141 soil samples were collected. Two water samples were collected from underground concrete tanks. All of the samples were analyzed on site in the FASP laboratory for VOCs, including the pesticides EDB, DBCP, and DCP.

A total of 71 Phase II soil samples (the 1-foot and 8-foot samples at each sampling location) and two water samples were analyzed on site in the FASP laboratory for organochlorine pesticides by FASP-modified Method 8080. Selected Phase II samples were also sent to the EPA Region IX laboratory in Las Vegas, Nevada, for confirmation analysis.

Another 76 Phase II soil samples were analyzed by American Technical & Analytical Services, Inc. (AT&ASI) for organophosphorus pesticides by EPA Method 8141. A total of 65 Phase II soil samples were also analyzed by AT&ASI for carbamate/urea pesticides by EPA Method 632.

Based on the results of this study, EPA determined that pesticide contamination was present at concentrations above 1,000 ppb in soil around the site of the former disposal basin, but that the

contamination was not extensive. Near the surface, EDB, DBCP, and DCP contamination was isolated to a few small areas. At depths greater than 20 feet, EDB and DCP contamination became more widespread. Soil contamination sources were not found at the other locations investigated in this study.

Groundwater Investigation. Groundwater sampling was conducted between August 24 and September 1, 1993. A total of 25 of the 39 wells associated with the site were sampled. Wells were selected from all areas of the contaminated groundwater and all three water-bearing zones. The objective of the sampling event was to determine whether contamination concentrations had changed or spread since the previous sampling. Of particular concern was whether contamination was entering the A-1 aquifer.

The following wells were sampled:

S-1 Zone	S-2 Zone	A-1 Aquifer
MW-3A	MW-3B	MW-2B
MW-8A	MW-5C	MW-3C
MW-9A	MW-6C	MW-4C
MW-10A	MW-7C	MW-7D
MW-11A	MW-8B	MW-9C
MW-12A	MW-10B	MW-13C
MW-13A	MW-11B	
MW-5B	MW-12B	
MW-6B	MW-13B	
MW-7B		

The results of this sampling and analysis indicated groundwater north of the disposal basin area was highly contaminated. Concentrations of EDB, DCP, and DBCP far exceeded federal maximum contaminant levels (MCLs). These results were later used by EPA to justify the emergency response installation of a groundwater extraction and treatment system (see Section 1.1.5.3).

1.1.4.5 Interim Remedial Investigation Conducted by BEI for the EPA

From 1995 through 1996, an Interim Remedial Investigation (Bechtel, 1997a) was conducted for the EPA Region IX by BEI under Contract No. 68-W9-0060, Work Assignment No. 60-28-9L4R. The Interim RI included investigation of site soils and groundwater, as described below. Figure 1-2 shows well locations and Table 1-1 presents a list of wells installed by BEI.

Soil Investigation

The soil investigation consisted of the following activities:

- **Subsurface Soil Hot-Spot Sampling:** Subsurface soil samples were collected from approximately 250 locations selected using a statistically based sampling scheme. The samples were collected from three areas of the site: the northwestern portion (using a 30-foot grid), the southern portion (using a 40-foot grid), and the eastern portion (using a 50-foot grid). Samples were collected at a depth of 3 feet and were analyzed for VOCs by the EPA FASP onsite laboratory. If VOCs were detected, samples were collected at additional 5-foot intervals. Selected surface soil samples were also analyzed for organochlorine pesticides by the FASP, and organophosphorus pesticides and carbamate/urea pesticides by a CLP laboratory.
- **Surface Soil Confirmation Sampling:** Surface soil samples were collected from approximately 25 percent of the 30-foot grid and 40-foot grid locations mentioned above and were analyzed for organochlorine pesticides, organophosphorus pesticides, and/or carbamate/urea pesticides.
- **Sump Sampling:** Soil/sediment samples (designated SMP-1 through SMP-5) were collected from five onsite sumps and were analyzed for VOCs, organochlorine pesticides, organophosphorus pesticides, carbamate/urea pesticides (if VOCs were detected), and total petroleum hydrocarbons (TPH).
- **Disposal Basin Investigation:** In one boring (designated DB) within the disposal basin, samples were collected at the surface and at 3-foot depth intervals and were analyzed by the EPA FASP onsite laboratory for VOCs and by the EPA Region IX laboratory for CLPAS TCLP metals, and CLPAS TCLP semivolatile organic compounds. Undisturbed soil samples were also collected and tested for dry bulk density, specific gravity, volumetric water content, and organic carbon fraction to provide input for the vadose zone leaching modeling study.
- **Samples at Locations with Visible Signs of Contamination:** Six locations that showed visible signs of contamination (e.g., oil stains, distressed vegetation) in surface soil were sampled (samples BS-1 through BS-6) and were analyzed for organochlorine pesticides, organophosphorus pesticides, and carbamate/urea pesticides.
- **Offsite Samples:** Six offsite surface soil samples (OF-1 through OF-6) were collected from areas likely to receive windblown site soil and/or site soil deposited by surface water runoff and were analyzed for organochlorine pesticides, organophosphorus pesticides, carbamate/urea pesticides, and TPH.
- **Background Samples:** Background soil samples were collected at three locations (BG-1 through BG-3) in the site vicinity that are unlikely to have received site-related contaminants. The samples were collected at the soil surface and at 5-foot-deep

intervals and were analyzed for VOCs (subsurface samples only), organochlorine pesticides, organophosphorus pesticides, and carbamate/urea pesticides.

Summary of Soil Investigation Findings

Key findings of the soil investigation are summarized below:

- Site surface soils were found to contain pesticides at concentrations generally below EPA Region IX preliminary remediation goals (PRGs);
- Soils beneath and adjacent to the former disposal basin were found to be contaminated with the pesticides EDB, DCP, and DBCP at concentrations above their respective PRGs. The contaminated soil was found to extend to a minimum depth of 23 feet bgs and comprise approximately 30,000 yd^3. Concentrations of these contaminants were not above toxicity characteristic levels as specified by the Resource Conservation and Recovery Act (RCRA);
- Other possible sources of contaminants were investigated but none was found;
- Contaminated soil has not been transported off site by wind or surface water runoff;
- Background soils contained detectable concentrations of several pesticides; and
- Contaminant concentrations in the disposal basin soils are indicative of a dense nonaqueous-phase liquid (DNAPL) release, and the DNAPL probably extends into the S-2 water-bearing zone.

Groundwater Investigation

The groundwater investigation consisted of the following activities:

- **HydroPunch™ Survey:** The HydroPunch survey included 10 exploratory borings (B-1 through B-10) to gather stratigraphic information and to define the boundaries of the pesticide plume. At each HydroPunch location, samples were extracted from the S-1 and S-2 groundwater, and in some cases, from the A-1 aquifer. Each sample was analyzed by the FASP laboratory for VOCs and via Method 504 for EDB and DBCP.
- **Installation of Monitoring Wells:** Based on the information collected during the HydroPunch survey, permanent monitoring wells were drilled and installed in each of the water-bearing zones where the EDB and DBCP concentrations were at or below federal MCLs: OW-1A, OW-1B, and OW-1C; OW-2A, OW-2B, and OW-2C; OW-3A, OW-3B, and OW-3C; and OW-4A, OW-4B, and OW-4C. The three deep borings (those with a "C" designation) were continuously sampled and logged during drilling to define the lithology between the ground surface and the A-1 aquifer.

- **Quarterly Groundwater Monitoring Program:** Six rounds of groundwater sampling were conducted from 1993 to December 1995. Groundwater samples collected from monitoring wells were analyzed for VOCs, including EDB and DBCP. Background groundwater samples were collected from monitoring wells MW-2A, MW-2B, MW-3A, MW-3B, MW-3C, MW-6A, MW-6B, and MW-6C.

Summary of Groundwater Investigation Findings

Key findings of the groundwater investigation are summarized below:

- As reported in previous investigation reports, groundwater was found to occur in three water-bearing zones: from shallowest to deepest, the S-1 zone, the S-2 zone, and the A-1 aquifer. The S-1 and S-2 zones were found to consist of silty sand lenses surrounded by a clay and silt matrix. The A-1 aquifer was found to be a more regionally extensive gravel and sand aquifer with one to two orders of magnitude greater transmissivity than that of the shallower sand zones.
- There is an areally extensive clay aquitard between the S-1 and S-2 zones, but there is evidence of localized regions of interconnection between these zones. The S-2 zone and A-1 aquifer were thought to be hydraulically interconnected to the north where the aquitard separating them pinches out.
- The highest concentrations of EDB, DBCP, and DCP were detected in the S-1 and S-2 zone wells located immediately downgradient from the former disposal basin. The concentrations in the A-1 aquifer were found to be much lower.
- Contaminant concentrations in the S-1 and S-2 zones indicated a localized presence of DNAPL, which appears to have migrated into the S-2 zone around wells MW-7C.
- Dissolved-phase contaminants were thought to enter the A-1 aquifer where the intervening aquitard thins or pinches out, and the downward gradients between the A-1 aquifer and S-2 zone induce migration of groundwater from the S-2 into the A-1 aquifer.
- CCl_4 was detected at concentrations above the federal and state MCL in the S-1, S-2, and A-1 zones. The source of the CCl_4 plume was not found, but it was determined that it is not the former disposal basin.
- Organic compounds were detected in samples from upgradient background wells.

Recommendations of the RI included:

- Conducting a focused FS for soils and a focused FS for groundwater;
- Establishing a database for the interim remediation system;
- Continuing groundwater monitoring;

- Abandoning and replacing intermediate zone wells that may provide a migration pathway for dissolved contaminants to the A-1 aquifer;
- Evaluating the soil vapor inhalation pathway;
- Delineating the northern extent of contaminated groundwater; and
- Verifying the presence of DNAPL.

Interim Remediation System

An interim remediation system was installed by EPA and began operating in June 1995. This system, consisted of 17 pumping wells screened in either the S-1 or S-2 zones and 7 injection wells screened in both zones, replaced a smaller pumping system installed by the DTSC in 1993. Extracted water was treated with activated carbon and then injected into the subsurface or discharged to the sanitary sewer. Preliminary analyses of operating data by EPA indicated the system could achieve hydraulic containment of the dissolved plumes within the S-1 and S-2 zones, and may cut off or reduce the amount of dissolved pesticides migrating into the A-1 aquifer.

1.1.5 Previous Remedial Activities

This section describes the remedial activities that have been conducted at the site to date.

1.1.5.1 Soil Removal Conducted by Frontier Fertilizer

Frontier Fertilizer implemented preliminary remedial action at the site during April 1985 as a result of soil sampling activities which had been completed between August 1983 and November 1984. The remedial action consisted of the removal of soil from the pesticide disposal basin northeast of the pole barn, and land farming of the excavated soil.

Following a pilot treatment study, the RWQCB and the DHS approved plans to proceed with preliminary remedial action at the site. On April 11 to April 15, 1985, the pesticide disposal basin was excavated to a depth of 20 feet, and approximately 1,100 yd^3 of soil was excavated and transported to the treatment site. The excavated soil was hauled to the treatment site, where it was unloaded in windrows approximately 75 feet apart, graded until smooth, and laser-leveled to an applied soil thickness of 1.5 inches. After the soil had been spread, the field was disked. The soil was disked again the following week, and disked a third time after about a month (Luhdorff and Scalmanini, 1987).

1.1.5.2 Groundwater Extraction and Treatment Conducted by the State

The DTSC began a removal action in early 1993 by installing a groundwater pumping system in MW-7B and MW-7C and a treatment system on site. This system was designed to draw down the water levels in the two extraction wells by several feet at a flow rate of 0.25 gallons per minute (gpm) in each well. Wells MW-7B and MW-7C were selected for use as extraction wells because they had the highest concentrations of pesticides and they are approximately 100 feet downgradient from the former pesticide disposal basin. This system operated until May 1995, when it was replaced by a larger system, as shown in Figure 1-5, installed by EPA (URS Consultants, 1993).

1.1.5.3 Groundwater Extraction and Treatment Conducted by EPA

In July 1995 as an emergency response, EPA installed a groundwater extraction and treatment system at Frontier Fertilizer. Pumps were installed in 17 wells, and seven wells were plumbed as injection wells. These wells are shown in Figure 1-2.

Ecology and Environment monitored the treatment system from July 1995 to April 1997, when BEI took over the task. Initially, the 17 wells were pumping approximately 28 gpm. Flows were increased gradually since July 1995 to about 50 gpm as of April 1996. The current (August 1998) extraction rate is approximately 32 gpm.

Extracted groundwater is treated using three activated carbon vessels in series. These vessels hold 2,000 pounds of carbon, and reportedly one vessel was exhausted for every million gallons of water treated (CET Environmental Services, 1996).

Influent concentrations are currently between 17 micrograms per liter (µg/L) and 310 µg/L for EDB, between 110 µg/L and 2,700 µg/L for DCP, and between 3.0 µg/L and 30.4 µg/L for DBCP. Effluent concentrations are nondetectable at the contract-required detection limits (CRDLs) of 0.05 µg/L for EDB, less than 1 µg/L for DCP, and less than 0.05 µg/L for DBCP.

1.1.5.4 Site Security Measures

In June 1996, EPA implemented new site access procedures to secure the site. These measures included agreements with Anderson Farms (the property owner), new locks on gates, and replacement of the existing main site gate with a keypad-activated security gate. These measures are expected to reduce the likelihood of future illegal disposal of hazardous materials at the Frontier Fertilizer site.

1.2 SUPPLEMENTAL REMEDIAL INVESTIGATION ORGANIZATION

Figure 1-6 shows the supplemental RI project organization. Two EPA sections were involved in the supplemental investigation effort. The Remedial Response Section planned and executed the RI. The Quality Assurance Management Section reviewed and approved work plans, procured and oversaw data validation services, and procured and oversaw analytical laboratory services.

Section 2

Investigation Methodology

The investigation methodology described in this section is consistent with the requirements specified in the following U.S. EPA Region IX-approved project plans:

- Quality Assurance Project Plan, Remedial Investigation, Revision 1; August 27, 1997 (Bechtel, 1997b).
- Field Sampling Plan, Groundwater Monitoring Program, Revision 0; February 28, 1994 (Bechtel, 1994).
- Field Sampling Plan, Soil-Gas and Flux-Chamber Sampling, Revision 0; August 27, 1997 (Bechtel, 1997c).
- Field Sampling Plan, DNAPL Confirmation and Plume Characterization, Revision 0; August 27, 1997 (Bechtel, 1997d).
- Field Sampling Plan, Groundwater Investigation, Revision 1; June 4, 1998 (Bechtel, 1998a).

These plans are presented in Appendix F; their requirements are summarized in this section.

2.1 DATA QUALITY OBJECTIVES

The following sections describe the measurement parameters, sample matrices, and applicable action levels for each environmental measurement. A discussion is provided of the summary statistics, which were used when comparing measured data to action levels. A discussion is also provided that addresses the precision, accuracy, representativeness, completeness, and comparability (PARCC) goals for each measurement.

Table 2-1 presents the list of analytes that were determined during quarterly groundwater monitoring and the plume characterization. Table 2-2 presents the analytes determined in soil-gas and flux-chamber samples. These tables include VOCs plus EDB and DBCP for water and VOCs for soil-gas and soil-flux samples. Each table lists the target analyte and the contract-required quantitation limit (CRQL) associated with the analytes available for the analytical method selected. The tables also list maximum contaminant levels (MCLs) for water and PRGs, and indicate if each analyte is a carcinogen or a noncarcinogen.

The analytical methods and required quantitation limits that were selected provided data consistent with and comparable to data collected by the EPA in September/October 1993 and summer 1995. The analytical methods and required quantitation limits enabled evaluation of whether the contamination levels at the site were below or above published PRGs and federal MCLs.

2.1.1 Decision Criteria and Acceptable Level of Confidence

Decision criteria and confidence differ for each of the sampling activities conducted. Since the objective of the quarterly groundwater monitoring program was to evaluate trends in contaminant concentrations and groundwater levels, a statistical approach to data analysis was not required. Sampling and analysis for plume characterization and the north-south transect associated with the soil-gas investigation were undertaken based on professional judgment and therefore are not amenable to statistical analysis. The soil-gas sampling conducted in the disposal basin area was, however, undertaken in accordance with a statistically valid sample plan and the data thus generated are suitable for developing confidence limit calculations.

2.1.2 PARCC Parameters

Table 2-3 presents the quantitative analytical precision, accuracy, and completeness goals for each measurement parameter determined during quarterly groundwater monitoring, the groundwater investigation, and the soil-gas investigation. The goals for each analytical group of measurements are based on the requirements of analytical methods; as such, they represent only analytical uncertainty.

Total analytical precision, accuracy, and completeness goals (analytical plus sampling) are also presented. These goals were used to evaluate results based on field QC samples (duplicates and spikes). While goals are established for total measurement precision, accuracy, and completeness, professional judgment has also been used to determine if data should be qualified based solely on field QC sample results.

2.1.2.1 Precision

Sampling precision (total precision) was evaluated by analysis of field duplicate samples. Analytical precision was evaluated by analysis of matrix spike duplicates. The precision of pH, temperature, conductivity, and water level depth measurements was not independently assessed. The precision of these measurements was assured by following the manufacturers' instructions on the use of each instrument, including all calibration requirements and a review of the field data for consistency.

2.1.2.2 Accuracy

Sampling accuracy (total accuracy) was not evaluated for groundwater. Analytical accuracy was evaluated by analysis of matrix spike samples. The accuracy of pH, temperature, conductivity, and water depth measurement was not independently assessed. The accuracy of these measurements was ensured by following the manufacturers' instructions on the use of each instrument, including all calibration requirements and a review of the field data for consistency.

2.1.2.3 Representativeness

For quarterly groundwater monitoring, the monitoring wells have been located and screened at depths to provide access to groundwater that represents each saturated zone beneath the site. For the groundwater investigation, samples were taken from each saturated zone. Soil-gas sample locations were selected to be representative of site conditions by selecting sample locations in the area of known soil contamination. To ensure the representativeness of all samples collected, the procedures provided in the FSPs were strictly followed.

2.1.2.4 Completeness

For quarterly groundwater monitoring, the required level of completeness was 100 percent, or one analytical result for each parameter for each of the monitoring wells. Achieving 100 percent completeness was assured by collecting duplicate samples at a rate of 1 per 10 routine samples. The required level of completeness for all other sampling activities was 95 percent.

2.1.2.5 Comparability

The comparability of data was assured by reporting data in consistent units as specified in Tables 2-1 and 2-2. In addition, the sampling and analytical methods used in this study were consistent with those used in previous rounds of groundwater sampling and previous groundwater investigations.

2.1.3 Objectives of RI and Required Measurements

The following sections describe the specific data quality objectives and identify the measurements required to satisfy these objectives. Each section presents general conclusions of previous studies as needed to explain the requirements for the new data collection activities.

A target analyte list was developed based on hazardous substances found at the Frontier Fertilizer site during previous investigations, specifically the EPA preliminary site assessment conducted in spring 1993 and the Phase I RI conducted in 1995.

2.1.3.1 Quarterly Groundwater Monitoring

The objectives of the quarterly groundwater monitoring activities are to:

- Measure the concentrations of VOCs, including EDB and DBCP, in groundwater in the wells at the Frontier Fertilizer site within the detection limits achievable by currently identified analytical methods;
- Monitor trends in the areal distribution of VOCs in groundwater in each of three water-bearing zones at the Frontier Fertilizer site;

- Monitor trends in the vertical distribution of VOCs in groundwater between the shallow water-bearing zones and the A-1 aquifer;
- Monitor water level changes in the monitoring wells on a quarterly basis;
- Prepare potentiometric surface maps to evaluate groundwater flow patterns;
- Define seasonal variation in groundwater flow directions;
- Monitor seasonal changes in VOC concentrations in groundwater and compare these changes with seasonal water level variations;
- Monitor groundwater quality downgradient of the site to detect movement of contaminated groundwater; and
- Assess the performance of the groundwater extraction and treatment system.

The environmental measurements required to meet these objectives include:

- Measurement of VOCs in groundwater samples from the monitoring and extraction wells;
- Measurement of the pH, conductivity, and temperature of groundwater from the monitoring wells; and
- Measurement of water levels in the monitoring and extraction wells.

2.1.3.2 Phase II Groundwater Investigation

The objectives of the groundwater investigation were to:

- Define the leading edge of VOC/pesticide-contaminated groundwater plume and the CCl_4/pesticide-contaminated groundwater plume in the S-1 and S-2 zones;
- Determine the locations for additional monitoring wells; and
- Define the stratigraphy between the ground surface and the A-1 aquifer.

The activities required to meet these objectives include:

- Conducting a groundwater survey to determine the extent of the VOCs and to select permanent monitoring well locations;
- Collecting stratigraphic information from exploratory drilling; and
- Installation, development, sampling, and analysis of new monitoring wells.

2.1.3.3 Phase III Groundwater Investigation: DNAPL Confirmation and Plume Characterization

The objectives of DNAPL confirmation and plume characterization sampling were to:

- Confirm, if possible, the presence and nature of DNAPL (dense nonaqueous-phase liquid) in the subsurface. This information is needed for assessing the technical practicability of site cleanup.
- Delineate the extent of the pesticide plume to the north and northwest of the OW-2 well cluster in the S-1 and S-2 zones and the A-1 aquifer, and the extent of the carbon tetrachloride plume to the east and north of the OW-4 well cluster.
- Reduce the potential for cross-contamination of aquifer zones through existing wells.
- Provide early warning of migration of contaminants toward municipal wells; and
- Determine the current groundwater flow direction in the A-1 aquifer and assess its seasonal variability.

To address the objective of confirming the presence of DNAPLs in the subsurface, well-sump sediment samples were collected from several wells and qualitative (UV fluorescence and Sudan IV dye) DNAPL testing was performed in the field. When no DNAPL was detected by these methods, groundwater sampling with the dialysis multiple-level sampler (DMLS) was conducted in several wells.

To address the objective of defining the boundaries of the plumes, a groundwater sampling survey, using a SimulProbe™ sampler and quick-turnaround analysis, were used to determine the presence and concentration of the VOCs in groundwater. This information was also used to help select the new monitoring well locations. Next, the well installation and sampling program was conducted as described in Section 2.2.2.2.

To address the objective of reducing the potential for cross-contamination of aquifer zones through existing wells, a program of well decommissioning was conducted. Wells MW-4A, MW-4B, MW-7C, OW-2A, OW-2B, and OW-2C were decommissioned because hydrographs at these cluster locations indicate an interconnection between the water-bearing zones.

To address the objective of determining the flow characteristics of the A-1 Aquifer, water level measurements in the existing and new monitoring wells were made and evaluated.

2.1.3.4 Soil-Gas and Flux-Chamber Sampling

The release of volatile organic chemicals to the air from contaminated soil and groundwater at the Frontier Fertilizer site may be of concern to prospective home-owners north of the site. Therefore, the objective of the soil-gas and flux-chamber sampling was to obtain sufficient data to support evaluation of the human health risk associated with inhalation of the VOCs. While standard EPA risk assessment procedures consider the risk associated with the release of VOCs from soil into the air, the risk is estimated based on measurements of the total concentration of contaminants in soil.

The soil flux-chamber samples provided a direct measure of the flux of contaminants from the soil surface and thus provide better-quality data for use in a human health risk assessment.

To meet this objective, both soil-gas samples and soil-gas flux-chamber samples were collected from the disposal basin area, and from locations along a north-trending transect extending from the disposal basin area to the proposed Mace Ranch Park development. The soil gas sampling program is described in Section 2.2.3.

2.1.3.5 Leaching Modeling

There were two purposes of the leaching modeling effort: 1) to determine the impact of leaching chemicals from the vadose zone to the groundwater relative to the known level of existing groundwater contamination, and 2) to determine the maximum level of contamination in the vadose zone that would cause no impact to the groundwater (an impact to the groundwater being defined as an MCL exceedance).

2.2 SAMPLING AND ANALYSIS PROGRAM AND RATIONALE

The following sections describe the experimental design and rationale for conducting each environmental measurement, as well as the methodology. Figure 2-1 illustrates the locations of all samples collected. Figure 2-2 presents an integrated schedule of activities associated with this investigation. Table 2-4 presents a comprehensive list of sample locations, dates, and analyses performed.

2.2.1 Quarterly Groundwater Monitoring Program

Groundwater sampling is conducted quarterly at wells on or adjacent to the Frontier Fertilizer site (see Figure 2-1). Generally, routine monitoring focuses on perimeter and downgradient monitoring wells to assure that closed concentration isopleths can be interpreted. A minimal number of plume-core-area wells, including extraction wells, are sampled since these wells have a long history of high contaminant concentrations. Table 2-5 presents a summary of the wells sampled since May 1996.

2.2.1.1 Groundwater Level Measurements

If well heads were accessible, wells were measured for depth to water from the top of casing and for total well depth prior to purging. An electronic water level sounder, accurate to the nearest +/-0.01 foot, was used to measure depth to water in each well. The electronic sounder probe was lowered down the casing to the top of the water column, and the graduated markings on the cable were used to measure the depth to water from the surveyed reference point on the rim of the well casing. Total well depth was sounded from the surveyed top of casing by lowering the probe to the bottom of the well. Because the probe is weighted and tends to sink into any silt at the bottom of wells, total well depths were measured and recorded only to the nearest 0.1 foot. Water level gauging equipment was

decontaminated before and after use in each well. Measurements were made first in wells that have the lowest contaminant concentrations, to reduce the risk of cross-contamination. Water levels in extraction wells were determined by electronically accessing the dedicated pressure transducer in each well.

2.2.1.2 Well Purging

All monitoring wells were purged prior to sampling. Three to five casing volumes of water were purged using an electric submersible pump, a hand-bailer, or a hand-pump, depending on the diameter and capacity of the well. In cases where hand-bailers were used to purge the well, clean disposable bailers were used. When pumps were used for purging, clean flexible plastic or Teflon™ tubes or well-dedicated tubes were used for groundwater extraction. All non-dedicated downhole equipment was decontaminated before and after use in each well. Pumps were placed 2 to 3 feet from the bottom of the well to permit reasonable drawdown but to prevent cascading conditions.

Prior to the start of purging, casing volumes were calculated by measuring total well depth, standing water level, and casing diameter. (Monitoring well construction details are specified in Table 2-6.)

One casing volume was calculated as:

$V = \pi d^2 h / 77.01$, where:

V is the volume of one well casing of water (in gallons, 7.48 gallons = 1 ft^3);

d is the inner diameter of the well casing (in inches); and

h is the total depth of water in the well (in feet).

Prior to the start of sampling and after each well casing volume was purged, water temperature, pH, and specific conductance were measured using field testing instruments. The measurements were recorded in the field notebook. Samples were collected after a minimum of three well casing volumes had been removed and the parameters had stabilized. If a monitoring well was found to dewater during purging, and three casing volumes had not been purged, the well was allowed to recharge up to 80 percent of the static water column and dewatered once more. After water levels recharged to 80 percent of the static water column, groundwater samples were collected.

Extraction wells were purged directly into the groundwater treatment system. Water temperature, pH, and specific conductance were not measured since these wells are continuously pumped. Therefore, groundwater in these wells is representative of formation water.

All field instruments were calibrated according to manufacturers' guidelines and specifications prior to beginning field work each day. Field instrument probes were decontaminated before and after use at each well.

2.2.1.3 Groundwater Sample Collection

All wells were sampled within 24 hours after purging. Clean nitrile gloves were worn while collecting samples. Groundwater samples were collected from monitoring wells using a Teflon bailer or tap. Groundwater was transferred from the Teflon bailer to the appropriate sample container using a bottom-emptying device to reduce agitation of the water samples during transfer.

Extraction wells were sampled directly from the sampling tap closest to the well head. All aerators, strainers, or hoses were removed from the tap prior to sample collection. The flow was adjusted so that a gentle stream was obtained. Groundwater samples were transferred from the tap directly into the appropriate sample containers.

When transferring samples, care was taken not to touch the bailer discharge device or tap to the sample container. The sample containers (40 ml glass vials) were inverted and checked for air bubbles to ensure zero headspace. If bubbles were present, the vial was opened and topped off. If air bubbles persisted, the vial was discarded and a new sample was collected. When collecting duplicate groundwater samples, bottles with the two different sample designations were alternated in the filling sequence. The samples were then preserved as appropriate, chilled, and processed for shipment to the laboratory. All groundwater sampling equipment was decontaminated before and after each sample was collected.

2.2.1.4 Groundwater Sample Analysis

Groundwater samples were shipped via Federal Express or hand-delivered to the EPA Region IX laboratory in Richmond, California, for analysis. The analytical method for each groundwater sample was selected based upon the historical concentrations of EDB and DBCP found in the well. Previous groundwater sample analytical results from monitoring wells MW-7B, X-1A, and X-1B indicated that EDB and DBCP were present at concentrations above 10 micrograms per liter (µg/L). The Contract Laboratory Program (CLP) special analytical services (SAS) for Target Compound List (TCL) VOCs, plus EDB and DBCP, were used to analyze these samples, achieving a contract-required quantitation limit (CRQL) of 10 µg/L.

Groundwater samples collected from all other wells were analyzed for the TCL VOCs plus EDB and DBCP using a 25-milliliter (mL) purge method to lower the CRQL to 1 µg/L. If EDB and DBCP were not found in the sample at a concentration greater than 1 µg/L, then the sample was analyzed for EDB and DBCP using EPA Method 504 to further lower the CRQLs to 0.05 µg/L.

2.2.1.5 Background Groundwater Sampling

Monitoring wells MW-3A, MW-3B, MW-3C, MW-6A, MW-6B, and MW-6C were chosen as background/upgradient locations. Monitoring wells MW-3A, MW-6A, and MW-6B are designated as the background sample locations for groundwater zone S-1. Monitoring wells MW-3B and

MW-6C are designated as the background sample locations for groundwater zone S-2. Monitoring well MW-3C is designated as the background sample location for the A-1 aquifer.

2.2.2 Groundwater Investigation

This section describes the groundwater investigation activities.

2.2.2.1 Phase II Groundwater Investigation: Monitoring Well Installation, Sampling, and Decommissioning

In October through November 1997, 12 additional groundwater monitoring wells were installed at four locations. The four well clusters are designated OW-5, OW-6, OW-7, and OW-8. At each location, three wells were installed: one well in each of the S-1 and S-2 zones and one in the A-1 aquifer. Each monitoring well was given a unique well identification number, using the cluster number appended with either the letter A, B, or C for the S-1, S-2, and A-1 zones, respectively. The OW-5 and OW-6 wells were installed, developed, and sampled first so that their analytical results would be available for use in selecting additional well locations later during the field program.

Well cluster OW-5 was installed approximately 550 feet northwest of the now abandoned OW-2 well cluster that was located along the south side of Arroyo Avenue near the intersection of Caricia Drive. The OW-5 location was selected to address the uncertainty in groundwater flow directions in the three water-bearing zones in the region beyond OW-2.

The OW-6 well cluster was installed approximately 725 feet north of the former OW-2 well cluster. The location was selected because the plume's northern extent, at the time of sampling plan development, was likely near previous boring B5, based on the very low pesticide concentrations detected in the S-1 and S-2 zones and the A-1 aquifer. It was anticipated that the groundwater at OW-6 would not be affected by the site-related pesticides in any of the upper water-bearing zones.

The OW-7 well cluster was installed approximately 900 feet northeast of the OW-3 well cluster. This well cluster was intended to delineate the northern extent of the carbon tetrachloride plume in the S-1, S-2, and A-1 zones.

The OW-8 well cluster was installed approximately 550 feet east of the OW-4 well cluster. The OW-8 wells were intended to help delineate and monitor the eastern extent of the carbon tetrachloride plume.

The wells were drilled using a 10-inch-diameter hollow-stem auger rig. Each well was then developed and sampled. The groundwater samples were analyzed, as described in Section 3.2, for TCL VOCs plus EDB and DBCP using the 25 ml purge volume method and for EDB and DBCP using EPA Method 504 to achieve a detection limit of 0.05 µg/L .

2.2.2.2 Phase III Groundwater Investigation

This section describes the Phase III groundwater investigation, which included exploratory drilling, a SimulProbe survey, and the installation and sampling of additional monitoring wells based on the information collected during the SimulProbe survey.

SimulProbe Survey Sampling and Analysis. The exploratory program included drilling eight borings to depths up to 80 feet bgs (B-11 through B-15) and collecting groundwater samples from the borings with a SimulProbe sampler. The SimulProbe sampler is similar to a HydroPunch™ but has the advantage of forming a more effective seal with the surrounding formation, therefore preventing drilling fluid or groundwater from leaking through joints into the sample canister, and a sample canister that can be back-pressurized with nitrogen to assure that a more representative sample is recovered.

In the three deeper borings (extending to the A-1 aquifer), soil samples were collected every 5 feet to determine the depth of the water-bearing zones at each well cluster location. Groundwater samples were collected from each of the two uppermost water-bearing zones, S-1 and S-2, at each SimulProbe boring location. Table 2-7 lists the sampling intervals. Each groundwater sample collected during the SimulProbe survey was given a unique sample number. The sample number was the boring location number (B-11 through B-15) appended with an A for a sample collected from the S-1 groundwater zone and a B for a sample collected from the S-2 zone. The SimulProbe groundwater samples were submitted for 36-hour-turnaround-time analysis by the 25 ml purge method for low-concentration VOCs, including DCP and CCl_4 and Method 504 for EDB and DBCP.

The stratigraphic and chemical data from each preceding boring was used to determine the depth and location of the next boring. If no contaminants of concern were detected in samples collected from both the S-1 and S-2 water-bearing zones at concentrations greater than their respective maximum contaminant levels (MCLs), then the next boring was located half way between the nearest existing well and the previous location. If a contaminant of concern was detected in either sample collected from the S-1 or S-2 water-bearing zones at concentrations greater than their respective MCLs, then the next boring was located 150 feet beyond the previous location. Any borings where contaminants were detected in at concentrations above the MCLs were properly abandoned. At locations where the four indicator COCs had concentrations below the MCLs, a permanent monitoring well was installed as described below.

Installation and Sampling of Phase III Monitoring Wells. Based on the information collected during the SimulProbe survey, seven monitoring wells were installed: three clusters of S-1 zone and S-2 zone wells, and one individual S-2 zone well. Each monitoring well in the clusters was given a unique well identification number indicating the zone it was completed in, as described in Section 2.2.2.2. The wells were numbered as follows: the two wells drilled at the northern leading edge of the plume were designated OW-9A and OW-9B. The two wells drilled at the northeastern leading edge of the plume were designated OW-10A and OW-10B. The two wells drilled along the northern

edge of the carbon tetrachloride plume were designated OW-12A and OW-12B. The well installed at the corner of Alegre Way and Arroyo Avenue was designated OW-13B.

The borings were logged and well completion as-builts were prepared (see Appendix A). Each well was surveyed for elevation and horizontal position and was developed as described in Section 5 of the Field Sampling Plan (Bechtel, 1998a). Field measurements of pH, temperature, and conductivity were made during development of each monitoring well. Groundwater samples were collected from each monitoring well after development. The samples were analyzed by the EPA Region IX laboratory for VOCs using the 25 ml purge method and EPA Method 504. Analytical results were compared to the results of the SimulProbe samples for a quality and consistency check.

2.2.2.3 DNAPL Sampling and Analysis

The purpose of the DNAPL sampling and analysis was to confirm, if possible, the presence of DNAPL in the saturated zone, which was implied by the high VOC concentrations measured in groundwater samples from wells in the disposal basin area. Therefore, the DNAPL analyses were conducted using samples from wells that historically had high VOC concentrations. The sampling program consisted of first collecting well sump sediment samples and testing them by ultraviolet (UV) fluorescence and Sudan IV dye-shaker tests. Second, if the results of these tests were negative (which they were, as discussed in Section 3.4), discrete groundwater samples were collected from the wells using the DMLS sampler. This sampling program is described below.

UV Fluorescence and Sudan IV Dye Testing. A stainless-steel sand bailer was lowered to the bottom of wells X-1A, X-1B, MW-7B, and MW-7C to collect sump sediments and liquids for testing. The well sump sediment samples were transferred from the bailer to the inner of two sealable polyethylene bags. First, the contents were examined for evidence of two liquid phases, as may be indicated by two different colors or refractive index differences that highlight the boundary between the two immiscible liquids. The samples were then examined in a dark room under UV light for indications of fluorescence. The UV light source was capable of emitting both 254 nanometer and 300 to 400 nanometer light. The bag was scanned with the UV light while being manipulated to squeeze the fluid around in and against the bag.

Next, approximately 30 cubic centimeter (cm^3) sample aliquots were transferred with a pipette into 50 ml polypropylene centrifuge tubes and were visually examined for the presence of immiscible liquid phases. The samples were then centrifuged at about 1,300 revolutions per minute for 10 minutes and again examined for the presence of immiscible liquid phases. Next, approximately 2 milligrams of Sudan IV were placed in the centrifuge tubes. (Sudan IV is a reddish brown powder that dyes organic liquids red upon contact but is practically insoluble in water at ambient temperatures. Since it is insoluble in water, the Sudan IV will remain suspended and undissolved in the aqueous phase of the sample.) The contents of the tubes were then mixed by shaking manually for approximately 10 to 30 seconds and then visually examined.

Groundwater Dialysis Multiple-Level Sampling (DMLS) and Analysis. DMLS sampling was conducted in order to determine if high-concentration, potential DNAPL, zones were present in the groundwater. The DMLS is a sampler designed to passively collect samples of groundwater as it flows horizontally across a well screen. DMLS permits sampling at discrete, thin-depth intervals to assess the vertical distribution of potential DNAPLs in monitoring wells, and to measure the true maximum groundwater concentrations.

Wells X-1A, MW-7C, and OW-4B were sampled with the DMLS. Well X-1A is an S-1 zone well located within the EDB plume. Well MW-7C is an S-2 zone well in the plume, and has historically contained some of the highest concentrations of dissolved pesticides. Well OW-4B, located in the CCl_4 plume, contains the highest concentrations of dissolved CCl_4 (300 µg/L). Each well was sampled at 1-foot intervals along 10 feet of the well screen.

2.2.2.4 Geologic and Hydrogeologic Samples

In the deeper borings (to the A-1 aquifer), which were drilled first at each cluster location, soil samples were collected every 5-feet to determine the depth of the water-bearing zones and select the screen interval for each well in the cluster. Soil samples were collected using a split-spoon sampler, examined by the field geologist, and classified in accordance with the Unified Soil Classification System. A geologic log was prepared for each boring and a well completion as-built was prepared for each permanent monitoring well. These are provided in Appendix A.

2.2.3 Soil–Gas Investigation

To evaluate the average soil-gas concentration and the average contaminant soil-gas flux in the former disposal basin area, 10 soil-gas borings were drilled and 10 soil-gas samples were collected. These samples were collected on a regular square grid designed, with randomly selected origin coordinates, to cover the full half-acre area (see Figure 2-1). Samples were collected from 5 feet bgs. The soil-gas flux measurements were made at the soil surface.

In addition to the samples in the disposal basin area, samples were collected along a north-south transect originating in the disposal basin area. Soil-gas samples were collected along this transect at 50-foot intervals, then a soil-gas flux-chamber sample was collected at each location. Soil-gas and flux-chamber samples were analyzed for contaminants of concern via Method TO-14. The samples were analyzed by a BEI subcontract laboratory, Environmental Analytical Services, Inc.

2.2.4 Leaching Modeling

A leachate computer model was developed for the primary source area, the former disposal basin, at the Frontier Fertilizer site. The details of the modeling study are provided in the following subsections.

2.2.4.1 Chemicals of Concern

Seven chemicals of concern (COCs) were identified by EPA for the leaching analysis: DCP, EDB, DBCP, CCL_4, benzene, trichloroethene (TCE), and tetrachloroethene (PCE).

2.2.4.2 Leaching Transport Analysis Methodology

The VLEACH model (EPA, 1995) estimates adsorption, dissolution, and volatilization in the vadose zone and calculates time-varying migration rates to the water table. The model includes time-dependent modeling of desorption by infiltration and volatilization within the vadose zone. This vadose zone model was selected because it allows use of a site-specific depth to the water table and allows site-specific vertical distribution of initial soil concentrations. Leaching from soil during a time period of up to 100 years was analyzed with the VLEACH model.

From the VLEACH-determined leaching rate to the first water-bearing zone (S-1 zone), an analytical model for mixing of leachate and groundwater is then used to evaluate whether the soil COCs have the potential to affect groundwater at levels exceeding their MCLs. The approach used is similar to the Summers analytical model for mixing of leachate and aquifer flow (EPA, 1989). The COC concentration in groundwater (C_{ws}) resulting from the leachate loading at the water table (calculated using the VLEACH model) was estimated with the following equation:

C_{ws} = C_v /LMF, where:

- C_{ws} = calculated concentration in groundwater,
- C_v = highest concentration in vadose zone leachate water (VLEACH result),

LMF = $(q_vA_v + q_aA_a)/q_vA_v$, where:

- LMF = leachate mixing factor,
- q_v = vadose zone infiltration rate,
- A_v = source length parallel to groundwater flow direction,
- q_a = Ki where K = hydraulic conductivity and i = hydraulic gradient, and
- A_a = cross-sectional area of mixing zone in the aquifer.

The concentration in vadose zone leachate water, C_v, is determined by the VLEACH simulation. The groundwater concentration estimate, C_{ws}, indicates the effect on groundwater from vadose zone leaching of the COC.

The following sections discuss the VLEACH modeling input parameters, and include tabulations of parameter values for the site and for each COC analyzed. The results of the leaching analyses are presented in Section 4.

2.2.4.3 Soil Properties

Vadose zone soil property values were determined from soil data collected in July 1995 from boring DB at the former disposal basin. These data are reported in Table 2-8. Soil properties utilized in the VLEACH model include total organic carbon (f_{oc}), moisture content (θ), porosity (n), and bulk density (ρ_b).

The average total organic carbon (f_{oc}) from the disposal basin borehole is 0.37% (Table 2-8). The highest measured f_{oc} value was 0.78%. The average dry bulk density is 1.61 grams per cubic centimeter (g/cm^3), the average porosity is 40%, and the average moisture content is 39%. Most soil samples were at or near saturation. For the vadose zone leaching analyses, an effective porosity of 85% of the total porosity, or 34%, was assumed. The difference between the total porosity and the effective porosity represents the irreducible water content (6%). The irreducible water content was subtracted from the volumetric water content to arrive at the effective water content used in the VLEACH analysis (39% - 6% = 33%). This value indicates a relatively high saturation, which is typical of fine-grained soils above a shallow water table. The air space remaining in the soil is therefore: 34%-33%=1%.

2.2.4.4 Chemical Properties

For organic COCs, the applicable properties include organic carbon partition coefficient (K_{oc}), Henry's Law constant (K_H, for liquid-gas partitioning), water solubility, and free air diffusion coefficient (D_{air}, for transfer of analyte due to Brownian motion in the air phase). The soil-groundwater distribution coefficient (K_d) for organic compounds may be estimated as the product of the organic carbon partition coefficient (K_{oc}) and the soil organic content (f_{oc}). (The VLEACH model computes K_d internally from the K_{oc} and the f_{oc} values.) Decay rates for organic COCs were not included in the leaching analyses, partly because of the difficulty in determining appropriate values in the vadose zone, and partly to maintain a conservative estimate of concentrations reaching groundwater.

Most chemical property values were obtained from Appendix A of the VLEACH user manual "Properties of Volatile and Semi-Volatile Compounds" (EPA, 1995). Literature values for chemical properties of the COCs are summarized in Table 2-9. Published values of the free air diffusion coefficient were only available for TCE. However, within the range of published values for common VOCs (0.4 – 1.4 square meters per day [m^2/d]), the groundwater contaminant loading computed by VLEACH is highly insensitive to this parameter, as indicated by the sensitivity analysis provided with the VLEACH manual. The value of 0.7 m^2/d for TCE was therefore assumed to be applicable for all COCs.

2.2.4.5 Net Infiltration Rate

The net infiltration rate was estimated based upon the "no action alternative," with no irrigation water applied and no injection wells operating. The infiltration parameters that affect the leaching rate of COCs include evapotranspiration and precipitation. To estimate the net infiltration, the long-term (1917-1992) monthly average precipitation and evaporation measured at the Davis Experimental Farm was obtained, as shown in Table 2-10 (Climatedata, 1992). The excess rainfall was computed as the monthly precipitation minus the monthly evaporation, with negative values discarded. While the annual total rainfall is 16.77 inches, the excess rainfall is only 4.19 inches. Net infiltration should be somewhat less than the excess rainfall since some of the rainfall would run off as overland flow. However, the site is quite level and without performing a detailed runoff analysis, the excess rainfall can be estimated as the upper limit of infiltration. Since overestimating infiltration will yield a higher and more conservative estimate of leachate, 4.19 inches (0.35 feet) of net infiltration was used for the VLEACH analysis.

2.2.4.6 Hydraulic Parameters

Several hydraulic parameters of the S-1 zone are used in the analysis of potential leaching of soil COCs. The depth to water of 26 feet is used in the VLEACH model to designate the thickness of the vadose zone. Other parameters are used to estimate the mixing of leachate and groundwater, including the hydraulic gradient, the hydraulic conductivity of the S-1 zone, and an assumed thickness for the mixing zone.

An average hydraulic conductivity of 9.53×10^{-3} centimeters per second (cm/sec) was based on seven pumping and slug tests (see Table 3-1).

The hydraulic gradient at each site was determined from isopleths of the February 1998 groundwater levels (Bechtel, 1998b). The gradient was estimated by determining the elevation change across the site vicinity and dividing by the distance over which the change occurs. Since this analysis is based on no action, the local effect of the existing extraction system was ignored. The hydraulic gradient was estimated as 0.0036, by taking the gradient from well MW-6A, south of the site, to well OW-6A, north of the site (see Figure 1-2).

A mixing zone thickness of 10 feet (representative thickness of the S-1 zone) was used for estimating the effect from mixing of leachate concentrations with groundwater flow. The contribution of groundwater flow to the mixing effect is determined by estimating the aquifer flow, which is given by the product of the hydraulic conductivity, the hydraulic gradient, and the mixing zone thickness:

$Q_a = q_a A_a = kiA_a$, where:

Q_a = total aquifer flow within mixing zone per foot width of aquifer,

q_a = unit aquifer flow per ft^2,

k = average hydraulic conductivity for materials within the first water-bearing zone (S-1 zone),

i = hydraulic gradient within the first water-bearing zone, and

A_a = mixing zone thickness or mixing zone area per foot width of aquifer.

2.2.4.7 Loading Area

For the VLEACH model analyses, the loading area, or potential vadose zone source area, is estimated as the area of vadose zone soil COC concentrations that could produce leachate with a potential to affect groundwater at concentrations above the MCLs. The loading area for an organic COC is determined by the area in which the organic COC has reported concentrations in vadose zone soil. The critical dimension of the loading area is the distance parallel to groundwater flow.

The natural direction of groundwater flow in the vicinity is from south to north. The length of vadose zone contamination in the direction of groundwater flow varies from about 85 feet to 105 feet. One-hundred feet was used for this analysis.

The loading area dimension parallel to groundwater flow is used to estimate the leachate flow to groundwater per foot width of the aquifer mixing zone:

$Q_v = q_v A_v$, where:

Q_v = leachate flow per foot width of mixing zone,

q_v = vadose zone infiltration rate, and

A_v = loading area dimension parallel to groundwater flow.

2.2.4.8 Measured Concentrations in Soil

The vadose zone chemical concentration profile was obtained from discrete samples taken from a second disposal basin borehole, adjacent to the borehole sampled for the soil parameter analysis. Samples were taken with a 3-foot spacing from 3 feet to 24 feet bgs. All concentrations for CCl_4, benzene, TCE, and PCE were below detection limits. Measured concentrations for EDB, DCP, and DBCP are presented in Table 2-11.

2.2.4.9 Uncertainty Evaluation

The leaching migration analysis included assumptions for certain parameters for which site-specific measurements are not available. The VLEACH user manual provides a detailed sensitivity analysis of all the model input parameters. The sensitivity of groundwater impact to variations in each of the input parameters is highest for K_{oc}, f_{oc}, and the infiltration rate, q. Since K_{oc} is a well-defined

published value, the sensitivity of groundwater impact at the Frontier Fertilizer site was tested for variations in q and f_{oc} only. The sensitivity analysis was performed using the measured DCP soil concentrations because they were the highest. To test the sensitivity to infiltration rate, the rate was reduced by a factor of 2, to 0.175 ft/year. The average value of f_{oc} (0.37%) over the soil column was used for the base analysis. The value of f_{oc} actually varied from 0.78% near the surface to 0.08% at 26 feet bgs. The sensitivity to f_{oc} was tested by using the maximum and minimum measured f_{oc}. The results of the sensitivity analysis are included in the table of results (see Table 4-1).

Section 3

Results of Groundwater Investigation

This section presents the results of the Phase I and supplemental (Phases II and III) groundwater investigations. The data considered herein include that in the Interim Remedial Investigation Report; and the results of exploratory drilling, SimulProbe™ sampling, and monitoring and extraction well sampling and analysis conducted through March 1999, the most recent regularly scheduled sampling round available. The results of the DNAPL investigation (DMLS sampling) conducted in September through November 1998 are also included.

The site hydrogeology is discussed in Section 3.1, the nature of contamination is discussed in Section 3.2, and the extent of contamination is discussed in Section 3.3. Section 3.4 discusses the presence of DNAPL, and Section 3.5 discusses the effects of the interim remediation system on the extent of site groundwater contamination. Section 3.6 discusses contaminant fate and transport in groundwater. Section 3.7 summarizes the results of the groundwater investigation.

3.1 SITE HYDROGEOLOGY

The regional hydrogeologic setting of the site was discussed in Section 1.1.2, and the relationship of the site hydrogeology to the regional setting is shown in Figure 1-4.

The Frontier Fertilizer site is underlain by Quaternary alluvium to depths exceeding 300 feet bgs. This alluvium is made up of lenses of sand and gravel within a clay and silt matrix. Groundwater is transmitted primarily through the sand and gravel, and the rate of groundwater movement depends on the thickness, composition (percentage of silt and clay), length, width, and degree of interconnection between the lenses. Three shallow water-bearing zones have been designated. These are, from shallowest to deepest, the S-1 zone, S-2 zone, and A-1 aquifer. The depth of exploration at the site has been limited to approximately 130 feet, in the A-1 aquifer. Another deeper aquifer, designated the A-2 aquifer, underlies the A-1 aquifer but has not been explored.

3.1.1 Site Hydrostratigraphy

This section discusses the depth, thickness, lithology, and hydraulic conductivity/transmissivity of each of the designated water-bearing zones and aquitards at the site. These zones are illustrated in the cross sections in Figures 3-1, 3-2, and 3-3 (cross-section locations are shown in Figure 2-1). The hydraulic characteristics of each zone are summarized in Table 3-1.

3.1.1.1 S-1 Zone

Groundwater is first encountered, in the S-1 zone, at a depth of approximately 20 feet bgs. The S-1 zone is an approximately 20-foot-thick series of discontinuous sand lenses. The sand lenses are typically 1 to 4 feet thick, and of variable width and length. These lenses are generally silty and have variable clay content. In a few boreholes, no S-1 sand zones were observed.

Hydraulic conductivity and transmissivity were measured in seven wells screened in the S-1 zone using slug tests and pumping tests. Hydraulic conductivity values in this zone range from 5.3 to 54 ft/day and average approximately 30 ft/day. The average transmissivity for this zone is approximately 300 ft^2/day, and the average storativity is 0.004 (Metcalf and Eddy, 1992).

3.1.1.2 S-1/S-2 Aquitard

A clay layer, designated the S-1/S-2 aquitard, occurs at a depth of approximately 40 feet bgs. The aquitard is approximately 20 feet thick and appears continuous throughout most of the site. Water level measurements, however, indicate hydraulic interconnection exists between the S-1 and S-2 zones separated by this aquitard (please see the discussion in Section 3.1.2.1).

3.1.1.3 S-2 Zone

The S-2 zone occurs at a depth of approximately 60 feet bgs. The S-2 zone is an approximately 30-foot-thick series of discontinuous sand lenses of variable thickness and permeability. This zone was formerly thought to pinch out to the northeast and north of the disposal basin, but the stratigraphy observed in recently drilled wells and SimulProbe boreholes (OW-5, OW-6, OW-7, OW-9, OW-12, OW-13, B-11, B-13, and B-15) suggests S-2 zone sand lenses are present in the downgradient area (see Figure 3-1).

The results of slug tests and pumping tests conducted in five wells indicate that the S-2 zone has a lower hydraulic conductivity than the S-1 zone, with values ranging from 2.4 to 24 ft/day and averaging 10 ft/day. The highest hydraulic conductivity values were measured in wells MW-7C and MW-8B, located immediately north of the former disposal basin. The average transmissivity for this zone is approximately 100 ft^2/day, and the average storativity is 0.002 (Metcalf and Eddy, 1992).

3.1.1.4 S-2/A-1 Aquitard

A clay and silt layer, designated the S-2/A-1 aquitard, occurs at a depth of approximately 90 feet bgs and is approximately 25 feet thick. It is generally continuous in the site area, but is thin or absent at some well locations north of the former disposal basin, where the S-2 zone may be vertically continuous with the underlying A-1 aquifer (see Figure 3-1).

3.1.1.5 A-1 Aquifer

The A-1 aquifer occurs at a depth of approximately 115 feet bgs and is approximately 20 to 40 feet thick. The A-1 aquifer is laterally continuous throughout the site and, reportedly, throughout most of the region (see Figures 1-1 and 1-4). This aquifer is a coarse gravel unit with high hydraulic conductivity (490 to 630 ft/day) and transmissivity (4,900 to 6,300 ft^2/day). These values are approximately 1 order of magnitude greater than those of the S-1 zone and nearly 2

orders of magnitude greater than those of the S-2 zone. The A-1 aquifer is reportedly pumped locally during the growing season for irrigation supply.

3.1.1.6 A-1/A-2 Aquitard

A 25- to 30-foot-thick clay layer, designated the A-1/A-2 aquitard, reportedly underlies the A-1 aquifer and separates it from the A-2 aquifer (see Figure 1-4). This aquitard has not been explored at the site.

3.1.1.7 A-2 Aquifer

The A-2 aquifer is a sequence of discontinuous gravel layers extending from 180 to 350 ft below ground surface (see Figure 1-4). The A-2 aquifer is the primary water supply aquifer in the Davis area. The nearest known wells drawing from the A-2 aquifer are City of Davis Wells No. 10, No. 15, No.16, No. 21, No. 22, No. 26, and No. 29, which are shown in Figure 1-1. City of Davis Well No. 29 is the closest well downgradient of the site, at a distance of approximately 2,600 feet to the northwest.

3.1.2 Groundwater Levels, Gradients, and Flow Patterns

This section describes groundwater levels, horizontal and vertical gradients, and flow patterns for the S-1 zone, S-2 zone, and A-1 aquifer. This section evaluates groundwater level data from the period 1991-1998, as well as that from two recent sampling rounds, May and August 1998.

3.1.2.1 Groundwater Levels

In the S-1 and S-2 zones, there is a wide range of elevations because of the comparatively low levels maintained in the extraction wells. The approximate water level elevation ranges in August 1998, in feet above mean sea level (ft msl), are shown below:

Zone	Maximum Elevation	Minimum
S-1	18 ft msl (well MW-6A)	-20 ft msl (well MW-12A)
S-2	12 ft msl (well MW-3B)	-40 ft msl (well MW-12B)
A-1	-5 ft msl (well OW-5C)	-10 ft msl (well MW-3C)

Groundwater levels measured in 20 site well clusters are plotted in the hydrographs in Appendix B. (All of the wells in the hydrographs are monitoring wells except for MW-7B, MW-8A, MW-8B, MW-11A, and MW-11B, which are extraction wells.) The hydrographs, particularly those for wells beyond the influence of the extraction wells, may be used to evaluate seasonal water level trends. The water levels for the extraction wells, however, reflect changes in pumping status and variable extraction rates, as well as seasonal variations.

In all three zones, the highest water levels are observed in the late winter and spring and the lowest water levels are observed in the fall. The seasonal water level fluctuations are on the order of 4 to 10 feet in the S-1 zone and 4 to 25 feet in the S-2 zone. The A-1 aquifer water levels vary on the order of 20 to 30 feet seasonally because of the additional influence of the seasonal pumping of local irrigation wells. In the winter months, irrigation pumping stops and the water levels rebound to levels similar to those measured in the S-1 and S-2 zones.

At many well clusters, water level changes in the S-2 zone well parallel those in the S-1 zone well. This is also observed in water levels in S-2 zone wells and A-1 aquifer wells at some well clusters. This indicates that, at these locations, hydraulic connection exists between the S-1/S-2 zones and the S-2 zone/A-1 aquifer.

3.1.2.2 Horizontal Groundwater Gradients and Flow

Groundwater elevations and interpreted potentiometric isopleths for the three zones are shown in Figures 3-4, 3-5, and 3-6 (December 1998), and 3-7, 3-8, and 3-9 (March 1999).

S-1 and S-2 Zones

The groundwater flow patterns in the S-1 and S-2 zones are similar in both the December and March isopleth plots. Groundwater flow in these zones is dominated by the depressions caused by the extraction wells. Groundwater flow is radially inward toward the extraction wells in the area immediately north of the disposal area. Beyond the influence of pumping, groundwater flow in the S-1 and S-2 zones is toward the north/northeast, which is consistent with previous observations.

In the S-1 zone, the horizontal gradients in the vicinity of the extraction wells are very steep, on the order of 0.13. The gradients around the extraction wells in the S-2 zone are even steeper, on the order of 0.25. The S-2 zone has a transmissivity approximately one-third of that of the S-1 zone. Beyond the influence of pumping, the horizontal gradient in the S-1 zone is quite flat, from generally less than 0.001 to a maximum of approximately 0.005. The horizontal gradient in the S-2 zone, beyond the influence of pumping, averages approximately 0.005.

A-1 Aquifer

It has historically been difficult to evaluate the flow direction in the A-1 aquifer because the gradient is quite flat (less than 0.001 to a maximum of approximately 0.003) and therefore slight variations in water levels can significantly change the flow pattern. During December and March, there is no discernable trend suggested by the water level measurements; therefore, no contours have been constructed.

3.1.2.3 Vertical Gradients

Vertical hydraulic gradients were evaluated by comparing water level elevations in the three zones. Table 3-2 provides a summary of vertical gradients measured in the monitoring well clusters.

S-1/S-2 Vertical Gradients

In the area of the pumping depressions, the vertical gradients are downward from the S-1 zone to the S-2 zone. These gradients are very steep, on the order of -0.25 to -1, for the monitoring period July through August 1998, likely representing a period of maximum vertical gradients.

In the monitoring wells, generally downward, but occasionally upward, gradients were observed between the S-1/S-2 zones. The vertical gradients at the monitoring well clusters average -0.115 (downward). However, gradients at monitoring wells near the extraction wells, such as the MW-13 and OW-1 clusters, show much steeper downward gradients between the S-1 and S-2 zones. In the winter and spring, gradients between these zones are generally upward except in the immediate vicinity of the extraction wells.

S-2/A-1 Vertical Gradients

In August 1998, the vertical gradients between the S-2 and A-1 zones in the vicinity of the extraction wells ranged from -0.09 to -0.4 (downward). Downward vertical gradients were also observed at every monitoring well cluster except OW-1. The vertical gradients at the monitoring well clusters averaged -0.272 (downward), which is approximately twice as steep as between the S-1 and S-2 zones. However, the gradients are not consistently steeper at monitoring wells near the extraction wells.

These steep downward gradients from the S-2 zone to the A-1 aquifer are typical during the summer months. During the winter months, when there is no irrigation pumping from the A-1 aquifer zone, the vertical gradient between the S-2 zone and A-1 aquifer is generally slightly upward, even in the vicinity of the extraction wells.

3.2 NATURE OF GROUNDWATER CONTAMINATION

This evaluation of the nature of groundwater contamination is based on data collected from groundwater sampling and analysis conducted since 1995, the SimulProbe survey conducted in August 1998, and the DNAPL investigation (DMLS sampling and analysis) conducted in September through November 1998. Table 3-3 provides a summary of all contaminants detected in samples from wells during the most recent sampling round, March 1999. Table 3-4 provides a summary of the contaminants detected in the SimulProbe samples. An evaluation of data quality is provided in Appendix C.

3.2.1 Occurrence of Contaminants

The following table shows the maximum concentrations of VOCs detected above the federal and/or State of California MCLs in groundwater monitoring samples since 1995:

VOC	Percent of Detections[1]	MCL (µg/L)	Maximum Concentration (µg/L)
Benzene	6.2	5	180
Carbon tetrachloride (CCl_4)	1.7	0.5†	3,500
1,2-Dibromoethane (EDB)	36.9	0.05	28,000
1,2-Dibromo-3-chloropropane (DBCP)	14.6	0.2	780
1,1-Dichloroethane (1,1-DCA)	0.6	5	7
1,2-Dichloroethane (1,2-DCA)	7.0	5	60
1,2-Dichloropropane (DCP)	18.3	5	34,000
Tetrachloroethene (PCE)	14.0	5	370
1,1,2-Trichloroethane (1,1,2-TCA)	0.5	5	7
Vinyl chloride	0.1	2	3

1 Normalized with respect to number of detections of VOCs above MCLs.

† California MCL.

The data in the table show that EDB, DBCP, and DCP were detected at the greatest frequency, and that EDB and DCP occur at higher concentrations, than any other VOCs. DBCP, while occurring at lower concentrations than EDB and DCP, also has a lower MCL than any of the other VOCs. Carbon tetrachloride was detected at a much lower frequency than EDB, DBCP, and DCP, but apparently represents a source of contamination distinct from these three pesticides (please see discussion in Section 3.3.2). For these reasons, EDB, DBCP, DCP, and CCl_4 were selected as indicator chemicals of concern (COCs) for the purpose of illustrating the extent of contamination discussed in Section 3.3 and the temporal contaminant concentration trends discussed in Section 3.5. The other VOCs have distributions similar to those of the indicator COCs and are not as widespread and/or as concentrated in the groundwater. They are breakdown products of other compounds and may or may not be site-related.

3.2.2 Contaminant Characteristics

This section summarizes the chemical and physical properties of the indicator contaminants of concern at Frontier Fertilizer: EDB, DBCP, DCP, and CCl_4. The chemical properties of each of these COCs are summarized in the table below:

COC	Solubility (mg/L)	Specific Gravity	Vapor Pressure (mm Hg)	K_{ow}
EDB	2,700	2.172 @ 25° C	11.7	1.76
DBCP	1,000	2.093 @ 14° C	0.8	2.29
DCP	2,700	1.159 @ 25° C	42	2.00
CCl_4	800	1.589 @ 25° C	90	2.64

The indicator COCs, because they have low solubility values, are considered immiscible in water and exist as nonaqueous-phase liquids (NAPLs) in some aqueous systems. The solubility values are moderately high, however, compared to many other common organic contaminants such as PCE (150 mg/L) or pentachlorophenol (15 mg/L). EDB, DBCP, DCP, and CCL_4 all have specific gravity greater than 1.0, making them denser than water, or dense NAPLs (DNAPLs). The K_{ow} value (the log of the octanol/water partition coefficient) indicates the degree to which the COCs will partition between a nonpolar organic compound (octanol) and water (a polar substance). The indicator COCs have relatively high K_{ow} values. This means they are nonpolar and are adsorbed onto the naturally occurring (nonpolar) organic compounds in soil.

DBCP and EDB have relatively low vapor pressures, which means they volatilize slowly. DCP and CCl_4 have higher vapor pressures of 42 and 90 mm Hg, respectively, and thus higher rates of volatilization than the other indicator COCs.

3.3 EXTENT OF GROUNDWATER CONTAMINATION

This section describes the extent of each of the indicator COCs. As noted previously, Table 3-3 provides a summary of all contaminants detected in samples from wells in the most recent sampling round. Table 3-4 provides a summary of the contaminants detected in the SimulProbe samples.

3.3.1 Background Levels of Contaminants in Groundwater

Wells MW-2A, MW-2B, MW-3A, MW-3B, MW-3C, MW-6A, MW-6B, and MW-6C (see Figure 1-2) are the designated site background wells because: 1) they are consistently hydraulically upgradient from the Frontier Fertilizer site; and 2) they are not likely to be affected by site activities since there is no direct transport pathway for contaminants to enter them.

Samples from these wells have historically contained several VOCs, including benzene and PCE. Most compounds were detected sporadically in these wells at low concentrations. PCE was detected at concentrations exceeding its MCL in samples from S-2 zone wells MW-2B and MW-6C in August 1994. Subsequent samples showed lower concentrations of PCE. The presence of 1,2-DCA, however, a breakdown product of PCE, suggests that these wells are affected by a chlorinated solvent source upgradient from the site. Samples collected from the

upgradient wells have not contained significant concentrations of the indicator COCs EDB, DCP, DBCP, or CCl_4.

3.3.2 Indicator COCs in Groundwater

This section describes the extent of the four indicator COCs, EDB, DCP, DBCP, and CCl_4, in site groundwater.

EDB, DBCP, and DCP

The highest concentrations of EDB, DBCP, and DCP have consistently been detected in samples from the S-1 and S-2 zone extraction wells located immediately downgradient (north) of the former disposal basin: MW-7B, MW-7C (abandoned), X-1A, and X-1B. The EDB plume, defined as the area in which concentrations exceed the MCL of 0.05 µg/L, is an irregular region extending from the disposal basin area north to the vicinity of Vistosa Street. While the DBCP and DCP plume also extends north from the disposal basin area, it is less extensive than that of EDB.

CCl_4

The distribution of CCl_4 in groundwater is different from that of EDB, DBCP, and DCP. Consistently, the highest concentrations of CCl_4 have been detected in samples from well clusters OW-3 and OW-4, which are located to the east of the EDB plume. The CCl_4 plume, defined as the region in which concentrations exceed the California MCL of 0.5 µg/L, either mingles with the EDB plume in the vicinity of the MW-9 and MW-11 well clusters, or there is a separate CCl_4 plume in the vicinity of those wells. CCl_4 has also been detected in the OW-6 cluster wells, which are considerably farther downgradient than the leading edge of the EDB plume.

The following sections describe the extent of each indicator COC in more detail, by aquifer zone.

3.3.2.1 S-1 Zone

Figures 3-10 and 3-11 illustrate the apparent distribution of EDB in the S-1 zone. The plume, as defined by the 0.05 µg/L (MCL) isopleth, is irregular and extends from the disposal basin area to around Vistosa Street. The maximum concentrations of EDB detected were 490 and 150 µg/L, respectively, in samples from extraction wells X-1A and MW-7B. EDB concentrations decrease to approximately 50 µg/L in the sample from extraction well MW-8A, located approximately 250 feet north of MW-7B, and to several tenths of an mg/L in samples from downgradient wells OW-5A, OW-6A, and OW-12A. In March, EDB was also detected at a concentration (0.18 µg/L), above the MCL in the sample from well OW-8A, located approximately 600 feet east of the EDB plume area. This may be a small separate plume because EDB has not been detected in samples from intervening wells, such as MW-9A and OW-4A.

Figures 3-10 and 3-11 also illustrate the apparent distribution of CCl_4 in the S-1 zone, as defined by the 0.5 µg/L (California MCL) isopleth. The highest CCl_4 concentrations were detected in samples from wells MW-12A and OW-4A (35 and 28 µg/L, respectively). The extent of the main CCl_4 plume, in the vicinity of OW-3A, OW-4A, and OW-12A, is bracketed by nondetectable concentrations in samples from wells OW-12A, OW-7A, and OW-8A, to the north, northeast, and east, respectively. Based on the observed concentration gradient, the plume is thought to extend downgradient only to the vicinity of the drainage ditch shown in these figures. CCl_4 was also detected at concentrations above the California MCL in the sample from wells MW-11A and MW-8A, in the EDB plume area.

Figures 3-12 and 3-13 illustrate the apparent distribution of DBCP in the S-1 zone. The DBCP plume is defined by the 0.2 µg/L (MCL) isopleth. The lateral extent of DBCP above the MCL is more limited than that of EDB in the S-1 zone (see Figures 3-10 and 3-11), as it does not extend beyond the fenced area. The concentrations of DBCP are also much lower than those of EDB. The maximum concentration of DBCP is approximately 1 µg/L in the samples from well MW-8A, located downgradient from the former disposal basin.

Figures 3-12 and 3-13 also illustrate the apparent distribution of DCP in the S-1 zone, as defined by the 5 µg/L (MCL) isopleth. The maximum concentrations were detected in the samples from extraction wells X-1A and MW-7B (3,500 and 1,500 µg/L, respectively). Concentrations apparently decrease to the north; to approximately 300 µg/L in the sample from well MW-8A and 12 µg/L in the December sample from well OW-11A. DCP was not detected in samples from downgradient wells OW-5A and OW-12A. However, in March, DCP was detected in well OW-6A. This suggests that the DCP plume extent may be similar to that of EDB, with the leading edge near Vistosa Street.

3.3.2.2 S-2 Zone

Figures 3-14 and 3-15 illustrate the apparent distribution of EDB in the S-2 zone. The maximum concentrations detected in this zone are higher than in the S-1 zone. The EDB plume in the S-2 zone also appears to be more extensive than that in the S-1 zone, based on the relatively high concentration (270 µg/L) detected in the sample from well OW-11B, which is at the downgradient extent of the S-1 zone plume.

Figures 3-14 and 3-15 also illustrate the apparent distribution of CCl_4 in the S-2 zone. CCl_4 was detected in wells OW-4B, OW-3B, MW-8B, MW-11B, and MW-12B, and at concentrations ranging from 180 to 1 µg/L. The S-2 zone plume is as extensive as the S-1 zone plume but the concentrations are several times higher. The CCl_4 plume may commingle with the EDB plume in the S-2 zone.

Figures 3-16 and 3-17 illustrate the apparent distribution of DBCP in the S-2 zone. DBCP in this zone is more extensive than in the S-1 zone. The DBCP plume extends beyond Arroyo Avenue, based on the concentration (19 µg/L) in the sample from well OW-11B in March. DBCP concentrations are also higher in this zone, with a maximum of 19 µg/L in the sample from extraction well OW-11B, compared to a maximum concentration of 0.11 µg/L in the S-1 zone.

Figures 3-16 and 3-17 also illustrate the apparent distribution of DCP in the S-2 zone. DCP is about as extensive in the S-2 zone as in the S-1 zone. The highest concentrations of DCP in the S-2 zone were detected in the samples from wells X-1B (3,800 µg/L) and OW-11B (2.900 µg/L). Concentrations in samples from intervening wells MW-8B (80 µg/L) and MW-11B (up to 210 µg/L) are an order of magnitude lower. This suggests that a high-concentration portion of the DCP plume had already migrated downgradient before beginning groundwater extraction in 1995.

3.3.2.3 A-1 Aquifer

Figures 3-18 and 3-19 illustrate the apparent distribution of EDB in the A-1 aquifer. The highest EDB concentration (20 µg/L) was detected in the sample from well OW-11C, located approximately 450 feet north of the former disposal basin. The EDB concentration in this well is much lower than the concentrations detected in samples from adjacent S-2 zone well OW-11B (1,100 µg/L in December). In March, EDB was also detected at a concentration (0.26 µg/L) above the MCL in the sample from well MW-7D, located in the disposal basin area. Because of the relatively low concentrations in other disposal basin area wells, the two occurrences of EDB may represent distinct plumes. In March, a low concentration of EDB (0.45 µg/L) was also detected in the sample from OW-8C. Because this well is approximately 700 feet east of the main EDB plume, and EDB was not detected in samples from the intervening wells, this also appears to be a separate plume.

Figures 3-18 and 3-19 also illustrate the apparent distribution of CCl_4 in the A-1 aquifer. CCl_4 has been detected in samples from A-1 aquifer wells OW-3C and OW-4C at concentrations of 0.2 and 0.8 µg/L, respectively, but it was not detected in these wells during December and March.

Figures 3-20 and 3-21 illustrate the distribution of DBCP and DCP in the A-1 aquifer. Detectable DBCP concentrations were inconsistently observed, with concentrations above the MCL detected in wells OW-5C, OW-11C, and MW-9C during December, but only in well OW-11C in March. DCP was detected at concentrations above the MCL only in the samples from wells MW-7D, OW-5C, and OW-11C. The extent of DCP in this zone is somewhat similar to that of EDB, with the highest concentration occurring in the sample from the well near Arroyo Avenue (OW-11C). The DCP concentration in the disposal basin area (5 µg/L in the sample from well MW-7D), however, is much lower.

3.3.3 Other COCs in Groundwater

This section describes the occurrence of the other COCs that have been detected at concentrations above the MCLs: benzene, 1,1-DCA, 1,2-DCA, PCE, 1,1,2-TCA, and vinyl chloride.

Benzene

Benzene has been detected in S-1 and S-2 zone wells at concentrations above the MCL of 5 µg/L. Samples from disposal basin area wells MW-7C, MW-7B, X-1A, and X-1B, have the highest, and most frequently detected, concentrations. The maximum concentration of 180 µg/L was detected in extraction well MW-7B in 1993. Concentrations in recent samples from this well have been below the MCL. Lower concentrations (<5.0 µg/L) have been consistently detected in wells throughout the site, including the upgradient well MW-6C. Benzene appears to be both: 1) associated with site-related VOC contamination; and 2) a low-concentration background contaminant.

1,1-DCA

1,1-DCA has been detected in S-1 and S-2 zone wells at concentrations above its MCL of 5 µg/L (in wells MW-7B and MW-7C). The maximum concentrations detected have been on the order of 6 to 7 µg/L. No concentrations of 1,1-DCA above the MCL have been detected since 1995.

1,2-DCA

1,2-DCA has been detected at concentrations above its MCL of 5 µg/L in samples from wells in the disposal basin area. The maximum concentration detected was 160 µg/L in a 1993 sample from well X-1A. Concentrations in more recent samples from this well have been on the order of 25 µg/L. It is not clear whether 1,2-DCA is a site-related contaminant. Its distribution appears to be similar to the other VOCs on site, but it is also present at low concentrations in samples from upgradient wells. 1,2-DCA is also a breakdown product of PCE, which is found in samples from the upgradient wells.

PCE

PCE has been detected at concentrations above its MCL of 5 µg/L. The maximum reported concentration of 3,500 µg/L was in a 1993 sample from well MW-7B. Subsequent samples from this well, however, contained PCE concentrations less than the MCL, indicating that the compound was misidentified in the 1993 sample. The highest PCE concentrations, on the order of 20 µg/L, were detected in August 1994 samples from upgradient S-2 zone wells MW-5C, MW-6C, and MW-2B. PCE has not been detected in samples from any wells at concentrations above the MCL since 1997.

1,1,2-TCA

1,1,2-TCA has been detected at concentrations above its MCL of 5 µg/L in samples from only four wells: MW-14B, MW-7B, MW-7C, and X-1A. These detections were in 1994 and 1995. None of the samples collected since October 1995 have contained 1,1,2-TCA at concentrations above the MCL.

Vinyl Chloride

Vinyl chloride has been detected at a concentration above the federal MCL of 2 µg/L only once, in the May 1998 sample from extraction well X-1B. Vinyl chloride is a breakdown product of PCE, TCE, and dichloroethenes.

3.4 DNAPL ASSESSMENT

The Final Interim RI Report concluded that contaminant levels in the S-1 and S-2 zones indicated a localized presence of DNAPL, and suggested that the DNAPL may no longer be mobile but appears to have migrated into the S-2 zone. This report also recommended that a direct observation of a DNAPL might be made if well sump sediment samples were collected and evaluated using a water-insoluble organic soluble dye. The report also suggested that inferential data could be collected by obtaining a high-resolution vertical profile of contaminant concentrations in highly contaminated wells. As described in Section 2, both recommendations were implemented and the results of these DNAPL studies are reported below.

The results of the tests described in Section 2.2.2.3 on the four well samples taken are given in Table 3-5. It is apparent from this table that no separate phase organic liquid (DNAPL) was observed in samples collected from the indicated well sumps.

Since the result of tests to directly observe a DNAPL in well sump sediment samples was negative, the dialysis multilevel sampler (DMLS) described in Section 2 was employed to further test the presence of DNAPL. The general theory behind the DMLS is that DNAPL-impacted groundwater may be entering a monitoring well via one or more thin stratigraphic layers. If this is true, then groundwater present in the monitoring well at the elevation of the thin, highly contaminated layer should contain concentrations of the DNAPL chemical much higher than the concentrations observed in a routine groundwater monitoring sample. The key difference between a DMLS-collected sample and a routine groundwater monitoring sample is that the DMLS sample is collected from a discrete water-bearing zone while the routine groundwater monitoring sample is collected after purging three or more well volumes from the well. This purging prior to sampling mixes the water in the well so the concentration measured in a routine groundwater monitoring sample represents an average concentration of the contaminant in the water-bearing zone(s) that intersect the well screen. In contrast, the DMLS samples are more representative of the contaminant concentration in each of the stratigraphic layers intersecting the

well screen. The results of the DMLS sampling and analysis for chemicals of concern are presented in Table 3-6. Only compounds detected at concentrations above the quantitation limit for these samples are reported.

As described in Section 2, the DMLS was used in the following monitoring wells: OW-4B, X-1B, and MW-7B. Monitoring well OW-4B is an S-2 zone well and is located in the CCl_4 plume area. It is apparent from Table 3-6 that several common laboratory contaminants (e.g., chloroform and methyl ethyl ketone) were detected in DMLS samples from OW-4B. CCl_4 was detected at concentrations around 200 µg/L and as illustrated by Figure 3-22, there was no discernable trend in the vertical concentration profile. With a water solubility of approximately 800,000 µg/L, even the highest reported CCl_4 concentration in a DMLS sample, 290 µg/L, represents only 0.04 percent of the solubility limit.

Monitoring wells X-1B and MW-7B are in the S-2 and S-1 zones, respectively, and are located in the center of the pesticide plume area. Analyses of samples collected from these two wells indicate that DCP is the most concentrated chemical in groundwater at these locations. Due to the high concentration levels in these samples, method quantitation limits were so elevated that DCP, 1,2,3-trichloropropane, and EDB were the only chemicals detected. Table 3-6 and Figures 3-23, 3-24, and 3-25 illustrate that while vertical trends in concentration were observed, even the highest measured concentrations are extremely small percentages of these chemicals' solubility limits. As noted in Section 3.2.2, the solubility limit of DCP is 2,700,000 µg/L. The solubility limit of 1,2,3-trichloropropane is 1,800,000 µg/L. Therefore, the highest measured concentrations of these chemicals in groundwater from these two wells represent less than one tenth of one percent of their solubility limits.

As reported previously in the Interim RI Report, if a chemical is detected at greater than 1.0 percent of its solubility limit, there is a high probability of a DNAPL zone upgradient from the monitoring point. However, as previously noted, the presence of a chemical in monitoring wells at concentrations less than 1.0 percent of saturation does not rule out the possible presence of a DNAPL. In fact, the results reported here and in the Interim RI Report do not rule out nor do they provide direct evidence for the presence of a DNAPL. There is, however, a preponderance of indirect evidence for the presence of a DNAPL at Frontier Fertilizer, as summarized below.

The high concentrations of EDB and DCP in the S-2 zone cannot be explained by advective transport of a dissolved phase. If only dissolved-phase contaminants are introduced into the S-2 zone, there should be some dilution, but this is not the case. In addition, steep lateral concentration gradients are observed and pesticide disposal activities at this site support a DNAPL release scenario. In 1995, the combined percent saturation of EDB and DCP in well X-1B exceeded 1 percent. Recent data indicate that the combined percent saturation of EDB and DCP still approaches 0.4 percent in well X-1B, but the combined percent saturation has generally declined in the other most highly contaminated wells (see Table 3-7). The potential presence of a DNAPL in the vadose zone and in the saturated zone is supported by several lines of evidence,

but despite extensive testing, a separate-phase DNAPL has not been directly observed at Frontier Fertilizer.

3.5 EFFECTIVENESS OF THE INTERIM REMEDIATION SYSTEM

An interim groundwater pump-and-treat system was installed at Frontier Fertilizer to prevent further migration of dissolved contaminants. The system consists of 17 pumping wells and a granular-activated carbon (GAC) water treatment system. The pumping wells are all screened in either the S-1 or S-2 zones. There are also 7 injection wells, which were shut down in March 1998. As of August 1998, the system was extracting a total flow of 31.7 gallons per minute (gpm). The treated water is discharged to the sanitary sewer. Daily groundwater levels in each extraction well are presented in Appendix H-2. These charts indicate the operational status of extraction wells during the first quarter of 1999.

3.5.1 Capture Zones

The capture zones are the regions where all groundwater flow is toward the extraction wells. The capture zones achieved by the extraction system in December 1998 and March 1999 may be estimated by examination of the groundwater level isopleths. In the S-1 zone, there are two irregular pumping depressions, one centered around the extraction wells just north of the disposal basin and the other centered around wells MW-11A and MW-12A (see Figures 3-4 and 3-7). These areas are indicated by the hatched 10-foot-elevation isopleth. It is clear that all groundwater flow inside this area is toward the extraction wells. At some distance outside of this area, flow is away from the extraction wells, to the northeast. For the S-1 zone, the capture zone limit is indicated by the heavy dashed line. The northern limit of the capture zone is in the vicinity of Arroyo Avenue.

In the S-2 zone, the pumping depression varies, depending on which extraction wells are operating, and usually encompasses wells AW-2B, MW-8B, X-4B, MW-11B, and MW-12B (see Figures 3-5 and 3-8). The limit of the S-2 capture zone is indicated by the heavy dashed line. The downgradient limit of capture is around Arroyo Avenue.

Although there are no extraction or injection wells in the A-1 aquifer, flow in that zone may be influenced by the remediation system because there is some interconnection between it and the upper zones.

The most highly concentrated area of the EDB/DBCP/DCP plume in the S-1 zone appears to be contained within the capture zone. The diffuse, lower concentration region of the plume north of Arroyo Avenue and centered around the OW-7 and OW-8 well clusters is not in this region of capture. The main CCl_4 plume also appears to be captured in this zone, but because there is some uncertainty in both the exact extent of the plume and the configuration of the potentiometric surface in the area to the northeast of well OW-4A, the exact extent of capture is difficult to assess. In addition, the small CCl_4 plume in the vicinity of OW-6A is not being captured.

The most concentrated region of the EDB/DBCP/DCP plume also appears to be captured by the extraction system in the S-2 zone. EDB-, DBCP-, and DCP-contaminated groundwater is not being captured, however, in the vicinity of the peripheral wells north of Arroyo Avenue and east to the OW-8, OW-7, and OW-10 well clusters. As previously mentioned, a portion of the plume may have migrated downgradient before the extraction system was started. The CCl_4 plume appears to be captured in the S-2 zone; however, the same uncertainty as to CCl_4 capture in the S-1 zone applies to CCl_4 capture in this zone.

3.5.2 Contaminant Recovery

From July through August 1998, the total extraction rate averaged 31.7 gpm. The minimum and maximum concentrations of the four indicator COCs at the inlet to the treatment system over this period were:

Chemical of Concern	Minimum µg/L)	Maximum (µg/L)
EDB	17	310
DBCP	30.4	3.0
DCP	110	2,700
CCl_4	0.5	10.0

Given the historical flow rates and influent concentrations of EDB, DBCP, DCP, and CCl_4, a cumulative recovery of approximately 377 kilograms was calculated for the period from July 1995 through August 1998:

Chemical of Concern	Cumulative Recovery (kg)
EDB	71.6
DBCP	2.2
DCP	302.5
CCl_4	0.72
Total	377.02

The cumulative recoveries of each of these VOCs are illustrated in Figures 3-26, 3-27, 3-28, and 3-29.

Injection of treated water was discontinued in March 1998 in order to reduce extraction of clean water, thereby increasing residence time in the aquifer and improving contaminant recovery. The contaminant recovery increased noticeably, particularly for CCl_4 and DBCP, in April 1998.

3.5.3 Contaminant Concentration Trends

This section describes the temporal concentration trends of the four indicator COCs: EDB, DCP, DBCP, and CCl_4. A comparison of the concentration isopleth plots (Figures 3-10 through 3-21) with those in previous monitoring reports and an examination of the concentration-versus-time plots in Appendix D were conducted to evaluate temporal COC concentration trends. The Appendix D graphs illustrate trends in concentrations as a result of extracting, treating, and injecting groundwater over the last several years. However, interpretation of these trends is complicated by variations in concentrations caused by the following factors:

- Variations in seasonal recharge (e.g., drought or wet years);
- Complex hydrogeologic interaction between the three water-bearing zones, S-1, S-2, and A-1; and
- Changes in the treatment system (e.g., pumping rates, set points, distribution of treated water to the currently inactive injection wells).

Overall, COC concentrations in the water-bearing zones have diminished by orders of magnitude since the system was installed, as discussed below.

Analysis of Trend - Mann-Kendall Test

Where sufficient data existed, a well-by-well analysis of trends in concentration for the four COCs was performed. The Mann-Kendall nonparametric test for trends was performed as described in Gilbert (1987). A complete description of this analysis, along with a listing of the data used and results, is provided in Appendix E.

To assure sufficient reliability in the test results, the groundwater monitoring database was screened for monitoring locations that had 8 or more samples with detected concentrations of EDB, DCP, DBCP, or CCl_4. One well that did not have 8 samples with detects, OW-5C, was also included due to special concerns at this location. Based on this criteria, a total of 21 separate analyzes were performed for 14 different wells with 4 COCs.

Of the 21 separate computations, 11 show a clear downward trend in concentration (confidence level > 95%). The wells X-1A, X-1B, MW-7B, and MW-11A all show a clear downward trend for both EDB and DCP. The data show a weaker indication of a downward trend (confidence level > 80%) for DBCP at wells MW-7B and MW-7C. For CCl_4, there is a strong indication of a downward trend at well OW-4B, and a weak indication of a downward trend at MW-12B.

Only wells MW-8A and OW-5C showed any indication of an upward trend. Both show an upward trend in concentration for DCP. The trend is most apparent for OW-5C. Reviewing the time history plots of EDB concentrations in Appendix D on Figure D-2, the observed

concentrations at MW-8A peaked in 1995 and has gradually declined since then. The concentration in OW-5C, however, shows a gradual increase.

S-1 Zone

Figures D-1 and D-2 show the trends in EDB concentrations over time in selected S-1 zone monitoring and extraction wells, respectively. EDB concentrations have decreased by two orders of magnitude in the center of the S-1 zone plume over time. For example, the concentrations in wells MW-7B, MW-8A, and X-1A, those with historically high EDB concentrations in the center of the plume, have decreased as follows:

	EDB Concentrations, S-1 Zone	
Well	**1995**	**1999**
MW-7B	9,400 µg/L	<10 µg/L
MW-8A	1,400 µg/L	50 µg/L
MW-11A	8 µg/L	1 µg/L
X-1A	10,000 µg/L	400 µg/L

The EDB concentrations in wells further downgradient from the center of the plume may be unchanged or even slightly increasing.

Figures D-3 and D-4 show the changes in CCl_4 concentrations over time in selected S-1 zone monitoring and extraction wells, respectively. In extraction well MW-12A and monitoring well OW-4A, CCl_4 concentrations have not changed significantly since 1995. Concentrations of CCl_4 in samples from monitoring well OW-3A have decreased since 1995.

	CCl_4 Concentrations, S-1 Zone	
Well	**1995**	**1999**
OW-3A	60 µg/L	<0.5 µg/L
OW-4A	28 µg/L	14 µg/L
MW-12A	58 µg/L	35 µg/L

A decreasing concentration trend is also apparent for DBCP in the S-1 zone, as shown by the following extraction well data:

	DBCP Concentrations, S-1 Zone	
Well	**1995**	**1999**
MW-7B	160 µg/L	<10 µg/L
MW-8A	2 µg/L	1.1 µg/L
MW-11A	3.2 µg/L	0.04 µg/L

The trend in DCP concentrations in the S-1 zone is similar to that of EDB. Since 1995, concentrations of DCP in the S-1 zone decreased significantly in samples from the extraction wells in the core of the plume (MW-8A and X-1A):

	DCP Concentrations, S-1 Zone	
Well	**1995**	**1999**
MW-8A	7,100 µg/L	340 µg/L
MW-11A	10 µg/L	2 µg/L
X-1A	22,000 µg/L	2,900 µg/L

Overall, EDB, DBCP, and DCP concentrations in the core of the EDB plume have decreased significantly since 1995. This is thought to be the result of extraction from this zone, removal of the DNAPL source from the vadose zone, and downward migration to the S-2 zone. Concentrations in the downgradient portion of the plume have increased, however, since 1995. This is probably because a portion of the plume migrated before extraction began. Because this portion of the plume was at the limit of the capture zone when the extraction system was started, it escaped capture and will continue to migrate downgradient.

CCl_4 concentrations may continue to decrease in this zone because of continued capture by extraction well MW-12A, and downward migration to the S-2 zone. However, the fact that concentrations are not decreasing as much as the other indicator COCs may indicate that a remaining CCl_4 source is present in the vadose zone or upper saturated zone.

S-2 Zone

Figures D-5 and D-6 show the trends in EDB concentrations in selected S-2 zone monitoring and extraction wells. The EDB concentrations decreased considerably in the sample from well X-1B, the well with the highest concentrations historically. As with the trends observed in the S-1 zone, EDB concentrations increased in samples from some of the wells (e.g., MW-8B) that are further downgradient in this zone:

	EDB Concentrations, S-2 Zone	
Well	**1995**	**1999**
MW-8B	0.7 µg/L	16 µg/L
MW-11B	20 µg/L	0.96 µg/L
X-1B	8,200 µg/L	800 µg/L

Figures D-7 and D-8 show CCl_4 concentrations in selected S-2 zone monitoring and extraction wells. The concentrations appear to be relatively unchanged:

	CCl_4 Concentrations, S-2 Zone	
Well	**1995**	**1999**
OW-3B	100 µg/L	98 µg/L
OW-4B	300 µg/L	180 µg/L

The DBCP concentrations in samples from extraction well X-1B, in the core of the plume, have varied by several orders of magnitude since 1995. The DBCP concentrations in samples from extraction well MW-11B, which is farther downgradient, have decreased:

	DBCP Concentrations, S-2 Zone	
Well	**1995**	**1999**
MW-11B	1 µg/L	0.04 µg/L
X-1B	0.2 µg/L	<10 µg/L

Like the trend observed for EDB in this zone, DCP concentrations in the S-2 zone have decreased in the extraction well X-1B in the plume core. DCP concentrations in samples from well MW-11B, which is farther downgradient, may also have decreased:

	DCP Concentrations, S-2 Zone	
Well	**1995**	**1999**
MW-11B	130 µg/L	14 µg/L
X-1B	14,000 µg/L	2,700 µg/L

Overall indicator COC trends for this zone are similar to those of the S-1 zone; concentrations in the core of the plume are decreasing, and concentrations farther downgradient are increasing or are relatively unchanged. CCl_4 concentrations in this zone are decreasing somewhat or are relatively unchanged.

A-1 Aquifer

Figure D-9 shows the trends in EDB concentrations over time in the A-1 aquifer monitoring wells. For most wells, EDB concentrations have not changed significantly in groundwater samples from this zone since 1995. However, beginning in 1998, EDB was first detected in wells OW-5C and OW-6C:

	EDB Concentrations, A-1 Aquifer	
Well	**1995**	**1999**
MW-7D	0.28 µg/L	0.26 µg/L
MW-9C	0.096 µg/L	<0.05 µg/L
OW-5C	Not Measured	2 µg/L
OW-6C	Not Measured	0.45 µg/L

Figure D-10 shows trends in CCl_4 concentrations over time in the A-1 aquifer. CCl_4 concentrations have decreased in this zone since 1995:

	CCl_4 Concentrations, A-1 Aquifer	
Well	**1995**	**1999**
OW-3C	0.8 µg/L	<0.5 µg/L
OW-4C	38 µg/L	<0.5 µg/L

Wells OW-11C and OW-5C, north of the drainage ditch, have shown an increase in DCP concentrations since 1997.

	DCP Concentrations, A-1 Aquifer			
Well	**1995**	**1997**	**1998**	**1999**
OW-2C	0.43 µg/L	0.036 µg/L	Not Measured	Not Measured
OW-11C	Not Measured	0.11 µg/L	0.89 µg/L	170 µg/L
OW-5C	Not Measured	< 0.05 µg/L	30 µg/L	21 µg/L

As in the upper zones, it appears that there is a portion of the plume in this zone that has migrated downgradient (see Figures 3-20 and 3-21). As this portion of the plume arrives at progressively downgradient monitoring wells, COC concentrations may continue to increase in those wells for some time.

3.6 CONTAMINANT FATE AND TRANSPORT

The potential transport pathways of site contaminants include dissolved-phase flow zone in saturated zones, free-phase (DNAPL) flow in the vadose and saturated zones, and vapor-phase

flow in the vadose zone. These pathways are illustrated conceptually in Figure 3-30. The groundwater pathways, DNAPL and dissolved phase flow, are discussed in the sections below.

Of the three mechanisms listed above, the most efficient, in terms of transfer of contaminant mass to the groundwater, is DNAPL migration. Mass transfer of dissolved contaminants typically requires large volumes of infiltrating water because of the relatively low solubility values of the organic compounds. Transfer of contaminant mass from soil gas is also an inefficient mechanism (Rivett et al., 1991).

Movement of low-volume DNAPL releases follows thin, tortuous migration pathways through the vadose zone. Depending on the source, there may be multiple pathways or one pathway. A pathway may be as thin as a fracture or root hole in a clay bed, or it may be several 10s of feet long horizontally and only several feet downward.

DNAPL in the subsurface will remain mobile only if there is a source of DNAPL at the surface or a sufficient driving head to overcome entry pressure (the pressure needed for the DNAPL, as it migrates, to displace air or water from the pores of the soil). However, DNAPL in the saturated zone has the potential to remain mobile or to remobilize under certain conditions such as large changes in hydraulic gradients or drilling through a DNAPL pool. In order for DNAPL to dissolve into the groundwater, the water and the DNAPL must be in contact for a "residence time" sufficient for the solution to come to equilibrium. If the residence time is insufficient, the DNAPL will not dissolve to its fullest capacity (solubility). This is one reason why injection of treated groundwater is not always desirable. By eliminating the additional source of water flux through the aquifer and minimizing gradients, a longer residence time, and hence improved contaminant removal, may be achieved.

The fate of contaminants in the environment depends on the complex physiochemical and biochemical interactions within the saturated zones. The DNAPL's fate is primarily dissolution and diffusion into groundwater. Once dissolved into groundwater, the contaminants are degraded biologically, adsorbed onto organic particles in the geologic material, where they may eventually be broken down or desorbed, volatilized into the soil gas (in the vadose zone), diluted, or discharged from the aquifer system at pumping wells. The most likely ultimate fates of these compounds is biodegradation and discharge to the surface via pumping wells.

Another factor that affects a chemical's persistence is the geologic matrix into which it is released. Open, permeable geologic materials are more conducive to volatilization, whereas clays and silts in the vadose zone can trap the liquid pesticide residues and reduce volatilization rates. The proportion of natural organic material in the vadose zone can also influence the persistence of certain organic compounds, for various reasons. Adsorption occurs when an organic compound is removed from solution and adheres to organic carbon in the soil matrix. This process, however, can be reversed. Because the infiltrating fluids carry lower concentrations of organic compounds, the previously adsorbed molecules will be desorbed back into solution.

Volatile organic compounds can decay by various mechanisms in the environment. Most VOCs in soil will slowly decay into benign substances by biodegradation, oxidation, and light-enhanced oxidation. Organic compounds can volatilize into soil gas, eventually diffusing into the atmosphere where they are oxidized. In some cases, the pesticide, when it is adsorbed to soil organic carbon, may be consumed by bacteria as a food source.

3.6.1 Fate and Transport of DNAPL

The evidence indicates that the release at the Frontier Fertilizer site was a low-volume persistent release caused by disposal of pesticide residue and wastewater in the former disposal basin. The release probably consisted of a quantity of DNAPL from the pesticide residues along with dissolved pesticides in the wastewater. This is indicated by the fact that the groundwater concentrations (in the S-1 and S-2 zones) were initially (prior to extraction) about 1 percent of the respective saturated concentrations (solubility limits) of EDB and DCP. The results of the DNAPL testing discussed in Section 3.4, however, were negative. The DNAPL source in the saturated zone may have become depleted, as indicated by the orders-of-magnitude concentration changes observed since the vadose zone source was removed and groundwater extraction began. This is likely the result of the relatively (with respect to other VOCs) higher solubility and mobility of the site COCs.

It appears that DNAPL migrated to the deeper vadose zone beyond the practical limits of the excavation, the S-1 zone, and the S-2 zone, but did not enter the A-1 aquifer. DNAPL migration may have halted within the S-2 zone due to closure of the former disposal basin and removal of the DNAPL source in the vadose zone.

3.6.2 Fate and Transport of Dissolved-Phase VOCs in Groundwater

Transport of dissolved-phase pesticides from the surface has affected the S-1 zone, S-2 zone, and the A-1 aquifer. Migration of dissolved phase COCs to the A-1 aquifer may have occurred along more than one pathway. For example, relatively high COC concentrations were detected in well MW-11C, located on Arroyo Avenue. These concentrations may be due to: 1) direct downward transport of dissolved EDB between the S-2 zone and the A-1 aquifer in the disposal basin area, and subsequent lateral migration; or 2) migration directly from the S-2 zone at a location farther downgradient. Downward flow induced by seasonal pumping from the A-1 aquifer probably enhances transport of dissolved pesticides into the A-1 aquifer.

Once the dissolved contaminants have entered the A-1 aquifer, there appears to be significant dilution due to the very high groundwater flux through the A-1 aquifer. This results in concentrations that are much lower in the A-1 aquifer than in the S-2 zone.

3.6.3 Estimate of Arrival Time of EDB at City Well No. 29

This section provides an estimate of the time it will take for the EDB plume in the A-1 aquifer to reach the nearest public water supply well. The farthest downgradient detection of EDB was a concentration of 2 μg/L in the March 1999 sample from well OW-5C. The nearest public supply well, City of Davis Well No. 29, is located 1,200 feet downgradient of OW-5C. The first screened zones in City Well No. 29 are reportedly in the A-2 aquifer.

First, v_x, the average linear velocity, was calculated for the A-1 aquifer:

$v_x = ki/n$, where:

k = hydraulic conductivity = 560 ft/day
i = average horizontal gradient = 0.003
n = effective porosity (assume = 0.25)

$v_x = 6.72$ ft/day.

Then, the solute velocity, v_c (where the concentration, C, equals one-half the initial concentration, C_0) was calculated:

$v_c = v_x/[1+(\rho_b/\theta)(K_d)]$, where:

ρ_b = bulk density (assume = 1.75 g/cm^3)
θ = volumetric water content ~ n ~ 0.25
K_d = distribution coefficient = $K_{oc}\ f_{oc}$
K_{oc} = organic carbon partition coefficient = 28.2 mL/g
f_{oc} = organic carbon fraction (0.0008)

$v_c = 5.8$ ft/day.

Finally, the arrival time, t, was calculated:

$t = d/v_c$ = 1,200 ft/5.8 ft/day = 207 days or approximately 7 months.

3.6.4 Estimate of Arrival Time of EDB at City Well No. 22

This section provides an estimate of the time it will take for the EDB plume in the A-1 aquifer to reach City Well No. 22. The farthest downgradient detection of EDB was a concentration of 2 μg/L in the March 1999 sample from well OW-5C. City of Davis Well No. 22 is located 5,500 feet downgradient of OW-5C. The first screened zones in City Well No. 22 are reportedly in the A-2 aquifer.

First, v_x, the average linear velocity, was calculated for the A-1 aquifer:

$v_x = ki/n$, where:

k = hydraulic conductivity = 560 ft/day
i = average horizontal gradient = 0.003
n = effective porosity (assume = 0.25)

$v_x = 6.72$ ft/day.

Then, the solute velocity, v_c (where the concentration, C, equals one-half the initial concentration, C_0) was calculated:

$v_c = v_x/[1+(\rho_b/\theta)(K_d)]$, where:

ρ_b = bulk density (assume = 1.75 g/cm^3)
θ = volumetric water content ~ n ~ 0.25
K_d = distribution coefficient = $K_{oc}\ f_{oc}$
K_{oc} = organic carbon partition coefficient = 28.2 mL/g
f_{oc} = organic carbon fraction (0.0008)

$v_c = 5.8$ ft/day.

Finally, the arrival time, t, was calculated:

$t = d/v_c$ = 5,500 ft/5.8 ft/day = 948 days or approximately 2½ years.

These estimates mean an EDB concentration of 2 µg/L may arrive at the location of City Wells No. 29 and No. 22 in approximately 7 months and 2½ years, respectively. The contamination would then have to migrate downward to the A-2 aquifer to be detected in the city wells. If the only vertical migration pathway is through the A-1/A-2 aquitard, this migration will require a long time. If, however, there are other pathways, such as inadequate well seals as at City Well No. 22, the downward migration could occur quickly. If the contamination does enter the city wells, they are open to other water-bearing zones so the measurable concentration in the wells will be lower, perhaps even below detection, because of dilution. The effects of decay and dispersion, not quantified herein, would be expected to further reduce the EDB concentration in groundwater prior to arrival at these wells. Appendix H-1 contains the Water Well Driller's Reports for City of Davis Well Nos. 22 and 29.

Section 4

Results of VLEACH Modeling

This section presents the results of VLEACH modeling, which was used to estimate the leaching of contaminants from the vadose zone to the groundwater. The vadose zone modeling methodology is described in Section 2.2.4.

4.1 SUMMARY OF RESULTS

All impacts discussed here refer only to the impact of leaching from the vadose zone to the S-1 zone. Potential DNAPL impacts to the S-1 zone are disregarded for this vadose zone analysis so as to isolate the impacts from water leaching through the soil column to the groundwater. In fact, the contribution from the leachate is quite minor when compared to the level of contamination in the S-1 and S-2 aquifer zones.

All results from the VLEACH modeling are summarized in Table 4-1. The first column of Table 4-1 lists the seven chemicals of concern evaluated, and the second column identifies the VLEACH model run scenario. The "1995 Soil" scenarios represent an initial soil concentration profile based on the samples collected from disposal basin area boring DB in July 1995. Since only DCP, EDB, and DBCP were detected in these samples, only three scenarios were conducted for this case.

To determine the level of soil contamination at which no significant impact to groundwater would occur, the "No Impact" scenarios were run. The "No Impact" scenario for each chemical actually represents the final run of a series of trial-and-error runs conducted to find the final "No Impact" soil concentration. The criteria for "No Impact" is that the diluted concentration in the S-1 zone, C_{ws}, is equal to or less than the groundwater MCL listed in the last column of Table 4-1. The initial soil concentration corresponding to the "No Impact" scenario is listed in Table 4-2, along with the vertically averaged soil concentration detected in 1995, for comparison. The DCP soil concentration at which no significant additional degradation of the S-1 aquifer would occur is 20.0 µg/kg. The concentration for EDB is only 0.18 µg/kg, due to the very low MCL for EDB. The allowable soil concentration for CCl_4 is 90 µg/kg, for benzene it is 22 µg/kg, for TCE it is 35 µg/kg, and for PCE it is 125 µg/kg. The differences in the allowable soil concentrations among the seven COCs is primarily due to the different MCLs and organic carbon distribution coefficients (K_{oc}).

The diluted concentration C_{ws} was computed in an Excel spreadsheet from the leachate concentration (C_v) and the leachate mixing factor (LMF). The LMF was computed in the spreadsheet from the hydraulic conductivity (k), the hydraulic gradient (i), the S-1 zone thickness (D), the infiltration rate (q_v) and the length of the plume parallel to the groundwater flow, L_v, all of which are also shown in Table 4-1. The leachate concentration was computed as the mass of contaminant (m), which is the result from the VLEACH model, divided by the infiltration rate (q_v). (Please see Section 2.2.4 for more details about these calculations.)

The VLEACH model output provides the mass of chemical leaching from the soil column in the vadose zone to the groundwater table. Figure 4-1 demonstrates how the leaching process proceeds over time for DCP. The plume of elevated soil concentration gradually moves downward and dissipates over a 60-year period. While the VLEACH model assumes a constant rate of natural infiltration, in the environment the rate of infiltration varies greatly depending on the amount of annual precipitation.

The year of maximum impact, column 4 of Table 4-1, is largely a function of the rate of infiltration and the initial soil concentration profile. Figure 4-1 shows the initial concentration profile for DCP as the "Year 0" line. For the "1995 Soil" scenario, the maximum impact occurs after 5 to 10 years of simulated operation. For the "No Impact" scenario, the maximum increase in groundwater concentration would occur within the first year of simulated operation since a homogeneous soil concentration profile is assumed.

The evaluation indicates that concentrations of EDB, DCP, and DBCP detected at the disposal basin in 1995 would affect groundwater in the S-1 zone if the groundwater were not already contaminated. Since the other four COCs were not detected in the soil, they have no impact on the aquifer. Column 12 of Table 4-1 (C_{ws}) essentially represents the increase in groundwater concentration due to leaching from the vadose zone. For example, vadose zone leaching contributes 233 µg/kg of DCP to the S-1 zone groundwater immediately beneath the former disposal basin. For comparison, the concentration of DCP in extraction well X-1A in August 1998 was 4,100 µg/L. Hence leaching alone of EDB, DCP, and perhaps DBCP from vadose zone soils can have contributed a minor amount of contamination to groundwater in the S-1 zone compared to concentrations of these COCs found in the core of the pesticide plume.

4.2 UNCERTAINTY EVALUATION

The leaching migration analysis includes assumptions for certain parameters for which site-specific measurements are not available. The VLEACH user manual provides a detailed sensitivity analysis of all the model input parameters. The sensitivity of groundwater impact to variations in each of the input parameters is highest for K_{oc}, f_{oc}, and the infiltration rate, q. Since K_{oc} is a well-defined published value, the sensitivity of groundwater impact at the Frontier Fertilizer site was tested for variations in q and f_{oc} only. The sensitivity analysis was performed using the measured DCP soil concentrations only since DCP had the highest soil concentrations. To test the sensitivity to infiltration rate, the rate was reduced by a factor of 2, to 0.175 ft/year. In Table 4-1, this scenario is identified as the "Low Infiltration" scenario. The result of a reduced infiltration rate would be that the S-1 zone groundwater concentration of DCP would be reduced from 233 µg/L to 128 µg/L from the baseline 1995 soil scenario.

The average value of f_{oc} (0.37%) over the soil column was used for the baseline analysis. The value of f_{oc} actually varied from 0.78% near the surface to 0.08% at 26 feet bgs. The sensitivity to f_{oc} was tested by using the maximum and minimum measured f_{oc}. The results of these two scenarios are listed in Table 4-1 as the Maximum f_{oc} and the Minimum f_{oc} scenarios.

Section 5

Results of Soil-Gas and Flux-Chamber Investigation

A soil-gas and flux-chamber investigation was conducted to support evaluation of the human health risk associated with potential exposure to chemicals present at the Frontier Fertilizer site. During development of the conceptual exposure model for the baseline risk assessment, it was determined that one of the ways an individual could become exposed to site-related chemicals is through inhalation of potentially contaminated air within buildings that may be constructed on site or in the residential area north of the site (Bechtel, 1999).

Since the objective of the soil-gas and flux-chamber sampling and analysis was to provide information to estimate the potential concentration of chemicals in hypothetical buildings, this section highlights the data used to make those estimates in the risk assessment report (Bechtel, 1999). The soil-gas and flux-chamber sampling and analysis program was not designed to provide information on the extent of soil-gas, soil, or groundwater contamination. Separate soil and groundwater investigations have been conducted to delineate the extent of contamination in these two media.

In order to estimate the concentrations of chemicals that may be present in hypothetical onsite and offsite buildings, samples of the gases present in soil were collected at 5 feet bgs and analyzed for site-related chemicals. In addition, the rate of flux of chemicals from the ground surface into the atmosphere was measured. Both the concentration of chemicals in gases present in soil and the rate of flux of chemicals from the ground surface into the atmosphere were measured at the same locations as described in Section 2. These locations, shown on Figure 5-1, included ten measurements in the disposal basin area. The highest measured soil-gas concentration and flux were used to calculate the risk associated with potential exposure to indoor air in a hypothetical building in the disposal basin area.

Along a transect extending north from the disposal basin into the residential area, soil-gas samples and flux- chamber measurements were made at intervals of 50 feet. Only the measurements performed on samples collected in the residential area (SG-23, SG-24, FLX-23, and FLX-24) were used to estimate the potential risk associated with exposure to air in a hypothetical residential building. The remaining measurements along this transect illustrate that the concentrations of contaminants in soil gas decrease rapidly with distance from the disposal basin area (see Figure 5-2).

Tables 5-1 and 5-2 present the flux-chamber data and soil-gas data, respectively. It is evident from Figure 5-2 and Table 5-2 that the concentrations of the COCs in soil gas generally decrease with distance north from the disposal basin area. The highest measured concentration of DCP was 19,000 parts per billion by volume (ppbv) and occurred in soil-gas sample SG-4. The highest concentrations of EDB and TCP, 320 and 3,800 ppbv, respectively, also occurred in this sample. The highest concentration of CCl_4, however, was observed in soil gas sample SG-24 (4.6 ppbv).

Table 5-1 presents the flux-chamber data. In contrast to the soil-gas data, EDB, DCP, and TCP were generally not detected in flux chambers along the transect extending north from the disposal basin. These compounds were, however, detected in flux-chamber samples from the disposal basin area. Consistent with findings from the soil-gas study, flux measurements were greatest at FLX-4. At this location, the flux of EDB was 0.0023 micrograms per minute per square meter ($\mu g/min\text{-}m^2$). The fluxes of DCP and TCP were 2.798 $\mu g/min\text{-}m^2$ and 0.2129 $\mu g/min\text{-}m^2$, respectively. The greatest flux of CCl_4 was detected in sample FLX-7 (0.0283 $\mu g/min\text{-}m^2$).

The flux is calculated from the concentration of contaminants measured in sample of air withdrawn from the flux chamber. The calculation is performed in accordance with the following formula:

$$\text{Flux } (\mu g/min\text{-}m^2) = QC/A$$

Where Q is the flux chamber sweep air flow rate in m^3/min;
C is the measured concentration in $\mu g/m^3$; and
A is the area of soil covered by the flux chamber in m^2.

The flux of compounds not detected above method detection limits can be calculated by inserting method detection limits or one-half method detection limits into the equation provided above.

Section 6

Conclusions and Recommendations

This section presents a summary of the findings from the supplemental remedial investigation and recommendations for data-gathering activities to improve the understanding of this site, the capture of contaminants, and the groundwater monitoring program.

6.1 CONCLUSIONS

In summary, it appears there was a release of dissolved pesticides and a quantity of DNAPL from the former disposal basin that migrated through the vadose zone into the S-1 water-bearing zone, through the S-1/S-2 aquitard and then into the S-2 water-bearing zone. Dissolved COCs then migrated by advection downward to the A-1 aquifer and laterally to the north through the thin sand layers that comprise the S-1 and S-2 zones and the A-1 aquifer. It may be that little residual, nonmobile DNAPL remains in the S-1 and S-2 zones. Any residual DNAPL will continue to slowly dissolve into the groundwater.

In both the S-1 and S-2 zones, the release resulted in plumes of EDB/DBCP/DCP extending from the disposal basin area north to around Vistosa Street. Concentrations of COCs are generally an order of magnitude higher in the S-2 zone than in the S-1 zone. Lower concentrations of COCs are present in the A-1 aquifer. There is a CCl_4 plume to the east of the EDB/DBCP/DCP plume. The source of this plume is not known. In both the S-1 and S-2 zones, there are occurrences of some COCs beyond the main plumes. In the downgradient area beyond Arroyo Avenue, these COCs may represent portions of the plumes which migrated downgradient before groundwater extraction began in 1995. The COCs beyond the capture zone of the interim treatment system will continue to migrate downgradient.

In the S-1 zone, the COCs are diluted, adsorbed, biodegraded, volatilized to soil gas and then to the atmosphere, or migrate downward to the S-2 zone. In the S-2 zone, the pesticides are adsorbed, biodegraded, diluted, or migrate vertically into the A-1 aquifer. During summer when irrigation pumping occurs in the A-1 aquifer, there is a strong downward gradient, and dissolved pesticides migrate vertically. These compounds are diluted because of the relatively high flux of groundwater in this aquifer.

The groundwater extraction system is currently capturing the most concentrated region of the EDB/DBCP/DCP plumes in both the S-1 and S-2 zones. The system also appears to be capturing the CCl_4 plumes in both zones, although there is some uncertainty as to their horizontal extents. Concentrations of COCs in groundwater samples from the plume cores have decreased by orders of magnitude since extraction began, indicating that substantial contaminant removal, as well as hydraulic containment, has been effected by the interim remediation system. Contaminant mass removal is expected to continue at a slower rate, however, as any residual DNAPL slowly dissolves in the groundwater and becomes available for extraction.

In the A-1 aquifer, low concentrations of EDB are conservatively estimated to arrive at the location of City Well No. 29 within approximately 7 months. However, because: 1) the

contamination must then migrate downward to the A-2 aquifer; 2) City Well No. 29 draws from multiple water-bearing zones, causing dilution; and 3) continuous decay and dispersion are not accounted for in this estimate, it is also possible that measurable concentrations of COCs will never be detected in City Well No. 29, especially if migration of the relatively high COC concentrations near the OW-11 well cluster is halted.

The results of the VLEACH modeling effort indicate that concentrations of EDB, DCP, and DBCP detected at the disposal basin in 1995 could have affected groundwater in the S-1 zone. The other four COCs were not detected in the soil, and hence could have no impact on the aquifer, according to the model results. Vadose zone leaching could have contributed up to 233 µg/kg of DCP to the S-1 zone groundwater immediately beneath the former disposal basin. For comparison, the concentration of DCP in extraction well X-1A in March 1999 was 2,900 µg/L. Hence leaching alone of EDB, DCP, and perhaps DBCP from vadose zone soils has contributed a relatively minor amount of contamination to groundwater in the S-1 zone compared to concentrations of these COCs found in the core of the pesticide plume.

The results of soil-gas sampling and analysis show that the concentrations of the COCs in soil gas generally decrease with distance north from the disposal basin area. The highest measured COC concentration was DCP at 19,000 ppbv in soil-gas sample SG-4 from the disposal basin area. The highest concentrations of EDB and TCP were 320 and 3,800 ppbv, respectively, and also occurred in sample SG-4. The highest concentration of CCl_4, however, was observed in soil gas sample SG-24 (4.6 ppbv) near the residential area north of the site.

In contrast to the soil-gas data, EDB, DCP, and TCP were generally not detected in flux-chamber samples along the transect extending north from the disposal basin. These compounds were, however, detected in the disposal basin area samples. Consistent with findings from the soil-gas study, flux measurements were greatest at FLX-4. At this location, the flux of EDB was 0.0023 micrograms per minute per square meter (µg/min-m^2). The fluxes of DCP and TCP were 2.798 µg/min-m^2 and 0.2129 µg/min–m^2, respectively. The greatest flux of CCl_4 was detected in sample FLX-7 (0.0283 µg/min-m^2). The potential human health consequences of these measurements are discussed in the baseline risk assessment report.

6.2 RECOMMENDATIONS

This section gives recommendations for data-gathering activities to improve the understanding of the site, to improve the capture of contaminants in groundwater, and to improve the groundwater monitoring program.

6.2.1 Recommendations for Additional Site Characterization

Although the Supplemental RI met most of the information-gathering objectives, there remain a few deficiencies in the understanding of the site.

First, the extent of the CCl_4 plume has not been fully delineated, although it is known that it extends no farther than to well cluster OW-7, located approximately 930 feet to the northeast of well cluster OW-4. Specifically, it is not known how far the plume extends northeast from well clusters OW-3 and OW-4. A monitoring well cluster, screened in all three water-bearing zones, could be placed about 200 feet northeast of well cluster OW-4. If there are detectable concentrations of CCl_4 in samples from those wells, installation of additional monitoring wells farther to the northeast should be considered.

Second, the downgradient extent of the EDB/DBCP/DCP plume has not been fully delineated, based on recent detections of COCs in samples from monitoring wells OW-5B, OW-5C, OW-9A, OW-9B, and OW-10B. Locations of additional downgradient monitoring wells are currently being evaluated.

Third, concentrations of COCs have recently been detected in the samples from S-1 and S-2 zone wells in clusters OW-7 and OW-8, and in A-1 aquifer well OW-8C. In some cases the COC concentrations are above the MCLs. Concentrations in samples from these wells should be closely monitored to rule out false positive detections. If the presence of COCs in samples from these wells is confirmed, additional site characterization work to locate the contaminant sources, and delineate the extent of the plumes, may be warranted.

Fourth, there is still uncertainly as to the groundwater flow pattern in the A-1 aquifer in the vicinity of and to the north of the site. This uncertainty could be partially addressed by changes to the monitoring program as described in the next section. The installation and monitoring of the additional wells, as described above, would also provide additional measurement locations to help define flow in the A-1 aquifer. A more vigorous well canvas effort around the Mace Ranch Park development would provide information on pumping activity in the A-1 aquifer.

Finally, precautions should be taken, in the installation of any new wells or drilling of exploratory borings, to prevent downward migration of contaminants to the A-1 aquifer. Such precautions could involve casing the hole and changing drilling fluid before advancing any hole through the S-2/A-1 aquitard.

6.2.2 Recommendations for Groundwater Extraction

In order to hydraulically contain and treat that portion of the EDB/DBCP/DCP plume that is beyond the present extent of the capture zone, such as in the vicinity of OW-5, installation of an additional extraction well should be considered. The extraction well could be located in the vicinity of the OW-11 well cluster, where it could help both: 1) extend the capture zone to the north; and 2) remove the relatively high-concentration contaminants in that vicinity. Additional extraction wells may be installed at the leading edge of the plume if this is determined to be necessary to contain contaminant migration. Care should be taken in the design of this well such that it does not exacerbate downgradient migration of contaminants from the disposal basin area.

Numerical modeling will be used as a tool to help optimize the location and extraction rate for the additional extraction well, considering the complexity of the existing well field.

After installation and development, it is recommended the pumping tests be conducted in the new well to determine: 1) aquifer transmissivity and storativity; 2) well efficiency; and 3) radius of influence. The pumping tests should include step-drawdown and distance-drawdown analyses and should be preceded by several weeks of monitoring the extraction well and nearby monitoring wells prior to pumping. This information would be useful in designing the final groundwater remedy.

Finally, the need for an additional extraction well to fully capture the CCl_4 plume should be considered if the plume is found to be beyond capture of the present system after the additional characterization work.

6.2.3 Recommendations for Groundwater Monitoring

The following are recommendations for improving the groundwater monitoring program to optimize the usefulness of the information collected.

First, there is general uncertainty in interpreting water level data because: 1) the water levels are collected over a period of a week or more (each monitoring well is gauged the day of its sampling); and 2) the pumping status of each extraction well is not noted at the time of the gauging, making it difficult to determine if a measurement is anomalous because of equipment problems, or if the pump is inactive. It is recommended that all of the wells be gauged for water level on the same day, and that the pumping status of each well at the time of gauging be determined and recorded. It is also recommended that the measurements from the dedicated transducers in the extraction wells be verified by measuring with an electric sounder. This may require the installation of access ports on some of the extraction wells.

Second, in order to address the uncertainty of the flow pattern in the A-1 aquifer, it is recommended that the monitoring program be reviewed and additional (existing) wells be added for water level gauging.

Third, it is recommended that COC concentrations in samples from downgradient well clusters be closely monitored, as described in the previous section.

Section 7

References

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Tables

Table 1-1
Entities That Have Installed Wells at Frontier Fertilizer

Entity	Wells
Luhdorff and Scalmanini for Frontier Fertilizer	AW-1, AW-2, AW-3, AW-4, AW-5, AW-6, MW-1, MW-2A, MW-2B, MW-3A, MW-3B, MW-3C, MW-4A, MW-4B, MW-4C, MW-5A, MW-5B, MW-5C, MW-6A, MW-6B, MW-6C, MW-7A, MW-7B, MW-7C
Groundwater Technology, Inc. for RAMCO Enterprises, Inc.	MW-7D, MW-8A, MW-8B, MW-9A, MW-9B, MW-9C, MW-10A, MW-10B, MW-11A, MW-11B, MW-12A, MW-12B
Metcalf and Eddy for California EPA, DTSC	MW-13A, MW-13B, MW-13C
Ecology and Environment, Inc. for U.S. EPA	IW-1, IW-2, IW-3, IW-4, IW-5, IW-6, X-1A, X-1B, X-1C, X-2A, X-2B, X-3A, X-3B, X-4A, X-4B
Bechtel Environmental, Inc. for U.S. EPA	OW-1A, OW-1B, OW-1C, OW-2A, OW-2B, OW-2C, OW-3A, OW-3B, OW-3C, OW-4A, OW-4B, OW-4C, OW-5A, OW-5B, OW-5C, OW-6A, OW-6B, OW-6C, OW-7A, OW-7B, OW-7C, OW-8A, OW-8B, OW-8C, OW-9A, OW-9B, OW-1-A, OW-10B, OW-11A, OW-11B, OW-11C, OW-12A, OW-12B, OW-13B

Table 2-1
Analytical Methods, Detection Limits, MCLs, and PRGs

		CRQL (µg/L)				
Volatile Organic Compound	CAS Number	TCL VOCs plus EDB and DBCP (5 mL purge)(1)	TCL VOCs plus EDB and DBCP (25 mL purge)(2)	Method 504(3)	Federal Maximum Contaminant Levels(4) (µg/L)	PRG (µg/L)(6)
Methylene Chloride	75-09-2	10	1	NA	none	4.3
1,1-Dichloroethene	75-35-4	10	1	NA	none	0.046
1,1-Dichloroethane	75-34-3	10	1	NA	none	810
Chloroform	67-66-3	10	1	NA	none	0.16
1,2-Dichloroethane	107-06-2	10	1	NA	5.0	0.12
1,1,1-Trichloroethane	71-55-6	10	1	NA	200	1,300
Carbon Tetrachloride	56-23-5	10	1	NA	0.5(5)	0.17
Bromodichloromethane	75-27-4	10	1	NA	none	0.18
1,2-Dichloropropane	78-87-5	10	1	NA	5.0	0.16
1,3-Dichloropropane	none	10	1	NA	none	none
cis-1,3-Dichloropropene	10061-01-5	10	1	NA	none	0.081
Trichloroethene	79-01-6	10	1	NA	none	1.6
Dibromochloromethane	124-48-1	10	1	NA	none	1
1,1,2-Trichloroethane	79-00-5	10	1	NA	5.0	0.2
Benzene	71-43-2	10	1	NA	5.0	0.39
trans-1,3-Dichloropropene	10061-02-6	10	1	NA	none	0.081
Bromoform	75-25-2	10	1	NA	none	8.5
Tetrachloroethene	127-18-4	10	1	NA	none	1.1
Toluene	108-88-3	10	1	NA	1,000	720
1,1,2,2-Tetrachloroethane	79-34-5	10	1	NA	1.0(5)	0.055
Chlorobenzene	108-90-7	10	1	NA	100	39
Ethylbenzene	100-41-4	10	1	NA	700	1,300
Styrene	100-42-5	10	1	NA	100	1,600
Xylenes (total)	1330-20-7	10	1	NA	10,000	1,400
1,2-Dibromoethane	106-93-4	10	1	NA	0.05	0.00076
1,2-Dibromoethane	106-93-4	10	1	0.05	0.05	0.00076
1,2-Dibromo-3-chloropropane	96-12-8	10	1	NA	0.2	0.048
1,2-Dibromo-3-chloropropane	96-12-8	10	1	0.05	0.2	0.048

Notes:

(1) Method used for samples of high known concentration.
(2) Method used for all other samples.
(3) Method used for low-concentration analysis of EDB and DCP in samples that had nondetectable results for EDB and DBCP using Method (2).
(4) 40 Code of Federal Regulations Part 141.61.
(5) Title 22 California Code of Regulations Part 6444.5.
(6) EPA Region IX Tap Water preliminary remediation goals (PRGs).
NA Not applicable.
TCL Target Compound List.

Table 2-2
Determination of Volatile Organic Compounds in Soil-Gas and Flux-Chamber Samples by Method TO-14

Volatile Organic Compound	Carcinogen (c) or Noncarcinogen (nc)	CAS Number	Lowest Available CRQL µg/m³	Ambient Air PRG* (µg/m³)
Benzene	c	71-43-2	0.08	0.23
Bromodichloromethane	c	75-27-4	0.017†	0.11
Bromoform	c	75-25-2	0.08	1.7
Bromomethane	nc	74-83-9	0.28	5.2
Carbon tetrachloride	c	56-23-5	0.013†	0.13
Chlorobenzene	nc	108-90-7	0.19	21
Chloroform	c	67-66-3	0.01†	0.084
1,2-Dibromo-3-chloropropane	c	96-12-8	0.08	0.21
1,2-Dibromoethane	c	106-93-4	0.008†	0.0087
1,2-Dichlorobenzene	nc	95-50-1	0.4	210
1,4-Dichlorobenzene	c	106-46-7	0.04†	0.28
1,2-Dichloroethane	c	107-06-2	0.008†	0.074
1,1-Dichloroethane	nc	75-34-3	0.08	520
1,1-Dichloroethene	c	75-35-4	0.03†	0.038
1,2-Dichloropropane	c	78-87-5	0.01†	0.099
cis-1,3-Dichloropropene	c	10061-01-5	0.025†	0.052
trans-1,3-Dichloropropene	c	10061-02-6	0.025†	0.052
Methylene chloride	c	75-09-2	0.18	4.1
Tetrachloroethene	c	127-18-4	0.14	3.3
Toluene	nc	108-88-3	0.40	400
1,1,1-Trichloroethane	nc	71-55-6	0.06	1,000
1,1,2-Trichloroethane	c	79-00-5	0.06	0.12

Table 2-2 (Cont'd)
Determination of Volatile Organic Compounds in Soil-Gas and Flux-Chamber Samples by Method TO-14

Volatile Organic Compound	Carcinogen (c) or Noncarcinogen* (nc)	CAS Number	Lowest Available CRQL µg/m³	Ambient Air PRG* (µg/m³)
Trichloroethene	c	79-01-6	0.06	1.1
1,2,3-Trichloropropane	c	96-18-4	0.008†	0.00096
Vinyl chloride	ca	75-01-4	0.016†	0.022
Xylene (total)	nc	1330-20-7	0.31	730

*EPA Region 9 Ambient Air Preliminary Remediation Goals (PRGs).
†Indicates that lowest available CRQL is associated with gas chromatography/mass spectroscopy (GS/MS) operated in the selected ion mode; otherwise CRQLs are for GC/MS operated in the standard mode.

Table 2-3
Precision, Accuracy, and Completeness Goals

Measurement	Precision (Total[1]/ Analytical[2])	Accuracy (Total[1]/ Analytical[2])	Completeness
VOCs plus EDB and DBCP in Water	40/30%[3]	na/60-140%[4]	90% (Quarterly GW) 95% (GW Investigation)
VOCs Soil Gas and Flux Chamber Samples	60%/50%[3]	60-135%/65-130%[4]	95%
pH in Water	±0.2 S.U.	na	100%
Temperature in Water	±1°C	na	100%
Conductivity in Water	±10 µohms	na	100%
Depth to Water	±0.1 foot	na	100%

[1] Measured using field QC samples
[2] Measured using laboratory QC samples
[3] Measured as relative percent difference between duplicate samples
[4] Measured as percent recovery of the compound from a spiked solution
µohms – micro-ohms
na – not applicable
S.U. – Standard Units

Table 2-4a
Flux-Chamber Sample Summary

Sample Location	Sampling Date	Analysis	Sample Designation
FLX-1	10/8/97	Method TO-14	Investigative
FLX-2	10/8/97	Method TO-14	Investigative
FLX-3	10/8/97	Method TO-14	Investigative
FLX-4	10/8/97	Method TO-14	Investigative
FLX-5	10/8/97	Method TO-14	Investigative
FLX-6	10/8/97	Method TO-14	Investigative
FLX-6R	10/8/97	Method TO-14	Duplicate
FLX-7	10/8/97	Method TO-14	Investigative
FLX-8	10/8/97	Method TO-14	Investigative
FLX-9	10/8/97	Method TO-14	Investigative
FLX-10	10/8/97	Method TO-14	Investigative
FLX-11	10/8/97	Method TO-14	Investigative
FLX-12	10/8/97	Method TO-14	Investigative
FLX-13	10/8/97	Method TO-14	Investigative
FLX-14	10/8/97	Method TO-14	Investigative
FLX-14R	10/8/97	Method TO-14	Duplicate
FLX-15	10/8/97	Method TO-14	Investigative
FLX-16	10/8/97	Method TO-14	Investigative
FLX-17	10/8/97	Method TO-14	Investigative
FLX-18	10/8/97	Method TO-14	Investigative
FLX-19	10/8/97	Method TO-14	Investigative
FLX-20	10/8/97	Method TO-14	Investigative
FLX-21	10/8/97	Method TO-14	Investigative
FLX-23	10/8/97	Method TO-14	Investigative
FLX-24	10/8/97	Method TO-14	Investigative
FLX-B1	10/9/97	Method TO-14	Field Blank
FLX-B2	10/9/97	Method TO-14	Field Blank
CAL-GAS 6177	11/10/97	Method TO-14	Performance Eval.
CAL-GAS 6286	11/10/97	Method TO-14	Performance Eval.

Table 2-4b
Soil-Gas Sample Summary

Sample Location	Sampling Date	Analysis	Sample Designation
SG-1	10/8/97	Method TO-14	Investigative
SG-1D	10/8/97	Method TO-14	Duplicate
SG-2	10/8/97	Method TO-14	Investigative
SG-3	10/8/97	Method TO-14	Investigative
SG-4	10/8/97	Method TO-14	Investigative
SG-5	10/8/97	Method TO-14	Investigative
SG-6	10/8/97	Method TO-14	Investigative
SG-7	10/8/97	Method TO-14	Investigative
SG-8	10/8/97	Method TO-14	Investigative
SG-9	10/8/97	Method TO-14	Investigative
SG-10	10/8/97	Method TO-14	Investigative
SG-11	10/8/97	Method TO-14	Investigative
SG-12	10/8/97	Method TO-14	Investigative
SG-13	10/8/97	Method TO-14	Investigative
SG-14	10/8/97	Method TO-14	Investigative
SG-15	10/8/97	Method TO-14	Investigative
SG-16	10/8/97	Method TO-14	Investigative
SG-17	10/8/97	Method TO-14	Investigative
SG-18	10/8/97	Method TO-14	Investigative
SG-19	10/8/97	Method TO-14	Investigative
SG-19D	10/8/97	Method TO-14	Duplicate
SG-20	10/8/97	Method TO-14	Investigative
SG-21	10/8/97	Method TO-14	Investigative
SG-22	10/8/97	Method TO-14	Investigative
SG-23	10/8/97	Method TO-14	Investigative
SG-24	10/8/97	Method TO-14	Investigative
SG-B1	10/8/97	Method TO-14	Blank

Table 2-4c
March 1999 Quarterly Groundwater Sample Summary

Sample Location	Sampling Date	Analysis
AW-2A	3/17/99	Method 504, VOC 25 mL purge
AW-2B	3/17/99	Method 504, VOC 25 mL purge
AW-4	3/15/99	Method 504, VOC 25 mL purge
AW-5	3/15/99	Method 504, VOC 25 mL purge
MW-3A	3/15/99	Method 504, VOC 25 mL purge
MW-3B	3/15/99	Method 504, VOC 25 mL purge
MW-3C	3/15/99	Method 504, VOC 25 mL purge
MW-4C	3/16/99	Method 504, VOC 25 mL purge
MW-5A	3/15/99	Method 504, VOC 25 mL purge
MW-5B	3/15/99	Method 504, VOC 25 mL purge
MW-5C	3/15/99	Method 504, VOC 25 mL purge
MW-6A	3/15/99	Method 504, VOC 25 mL purge
MW-6B	3/15/99	Method 504, VOC 25 mL purge
MW-6C	3/15/99	Method 504, VOC 25 mL purge
MW-7B	3/17/99	VOC 5 mL purge
MW-7D	3/17/99	Method 504, VOC 25 mL purge
MW-8A	3/17/99	Method 504, VOC 25 mL purge
MW-8B	3/17/99	Method 504, VOC 25 mL purge
MW-9A	3/17/99	Method 504, VOC 25 mL purge
MW-9B	3/17/99	Method 504, VOC 25 mL purge
MW-9C	3/17/99	Method 504, VOC 25 mL purge
MW-10A	3/17/99	Method 504, VOC 25 mL purge
MW-11A	3/17/99	Method 504, VOC 25 mL purge
MW-11B	3/17/99	Method 504, VOC 25 mL purge
MW-12A	3/17/99	Method 504, VOC 25 mL purge
MW-13A	3/16/99	Method 504, VOC 25 mL purge
MW-13B	3/16/99	Method 504, VOC 25 mL purge
MW-13C	3/16/99	Method 504, VOC 25 mL purge
OW-1A	3/16/99	Method 504, VOC 25 mL purge
OW-1B	3/16/99	Method 504, VOC 25 mL purge
OW-1C	3/16/99	Method 504, VOC 25 mL purge

Table 2-4c (Cont'd)
March 1999 Quarterly Groundwater Sample Summary

Sample Location	Sampling Date	Analysis
OW-3A	3/16/99	Method 504, VOC 25 mL purge
OW-3B	3/16/99	Method 504, VOC 25 mL purge
OW-3C	3/16/99	Method 504, VOC 25 mL purge
OW-4A	3/17/99	Method 504, VOC 25 mL purge
OW-4B	3/17/99	Method 504, VOC 25 mL purge
OW-4C	3/17/99	Method 504, VOC 25 mL purge
OW-5A	3/18/99	Method 504, VOC 25 mL purge
OW-5B	3/18/99	Method 504, VOC 25 mL purge
OW-5C	3/18/99	Method 504, VOC 25 mL purge
OW-6A	3/18/99	Method 504, VOC 25 mL purge
OW-6B	3/18/99	Method 504, VOC 25 mL purge
OW-6C	3/18/99	Method 504, VOC 25 mL purge
OW-7A	3/18/99	Method 504, VOC 25 mL purge
OW-7B	3/19/99	Method 504, VOC 25 mL purge
OW-7C	3/18/99	Method 504, VOC 25 mL purge
OW-8A	3/18/99	Method 504, VOC 25 mL purge
OW-8B	3/18/99	Method 504, VOC 25 mL purge
OW-8C	3/18/99	Method 504, VOC 25 mL purge
OW-9A	3/19/99	Method 504, VOC 25 mL purge
OW-9B	3/19/99	Method 504, VOC 25 mL purge
OW-10A	3/18/99	Method 504, VOC 25 mL purge
OW-10B	3/19/99	Method 504, VOC 25 mL purge
OW-11A	3/18/99	Method 504, VOC 25 mL purge
OW-11B	3/19/99	Method 504, VOC 25 mL purge
OW-11C	3/19/99	Method 504, VOC 25 mL purge
OW-12A	3/19/99	Method 504, VOC 25 mL purge
OW-12B	3/19/99	Method 504, VOC 25 mL purge
OW-13B	3/19/99	Method 504, VOC 25 mL purge
X-1A	3/17/99	VOC 5 mL purge
X-1B	3/18/99	VOC 5 mL purge
X-2A	3/17/99	Method 504, VOC 25 mL purge

Table 2-5
Historical Summary of Wells Sampled

Well	Date Sampled									
	5/96	10/96	3/97	6/97	10/97	2/98	5/98	8/98	12/98	3/99
AW-1	O	O	X	X	O	O	O	O	O	O
AW-2	O	O	O	O	O	O	O	O	O	O
AW-2A	X	O	O	O	X	X	X	X	X	X
AW-2B	X	O	O	O	X	X	X	X	X	X
AW-3	X	O	O	O	O	O	O	O	O	O
AW-4	X	O	O	O	O	X	X	X	X	X
AW-5	O	O	O	O	O	X	X	X	X	X
AW-6	X	O	O	O	O	O	O	O	O	O
MW-1	O	O	O	O	O	O	O	O	O	O
MW-2A	O	O	O	O	O	O	O	O	O	O
MW-2B	O	O	O	O	O	O	O	O	O	O
MW-3A	X	X	X	X	X	X	X	X	X	X
MW-3B	X	X	X	X	X	X	X	X	X	X
MW-3C	X	X	X	X	X	X	X	X	X	X
MW-4A	X	O	O	O	O	O	O	O	O	O
MW-4B	X	O	O	O	O	O	O	O	O	O
MW-4C	X	X	X	X	X	X	X	X	X	X
MW-5A	X	X	X	X	X	X	X	X	X	X
MW-5B	X	X	X	X	X	X	X	X	X	X
MW-5C	X	X	X	X	X	X	X	X	X	X
MW-6A	X	X	X	X	X	X	X	X	X	X
MW-6B	X	X	X	X	X	X	X	X	X	X
MW-6C	X	X	X	X	X	X	X	X	X	X
MW-7A	X	O	O	O	X	O	O	O	O	O
MW-7B	X	X	X	X	X	X	X	X	X	X
MW-7C	X	X	X	X	O	O	O	O	O	O
MW-7D	X	X	X	X	X	X	X	X	X	X
MW-8A	X	O	O	O	X	X	X	X	X	X
MW-8B	X	O	O	O	O	X	X	X	X	X
MW-9A	X	X	X	X	X	O	X	X	X	X
MW-9B	X	X	X	X	X	O	X	X	X	X
MW-9C	X	X	X	X	X	O	X	X	X	X

Table 2-5 (Cont'd)
Historical Summary of Wells Sampled

Well	Date Sampled									
	5/96	10/96	3/97	6/97	10/97	2/98	5/98	8/98	12/98	3/99
MW-10A	X	O	O	O	X	X	X	X	X	X
MW-10B	X	O	O	O	O	O	O	O	O	O
MW-11A	X	O	O	O	X	X	X	X	X	X
MW-11B	X	O	O	O	X	X	X	X	X	X
MW-12A	X	O	O	O	X	X	X	O	X	X
MW-12B	X	O	O	O	O	O	O	X	X	O
MW-13A	X	X	X	X	X	O	X	X	X	X
MW-13B	X	X	X	X	X	O	X	X	X	X
MW-13C	X	X	X	X	X	O	X	X	X	X
OW-1A	X	X	X	X	X	X	X	X	X	X
OW-1B	X	X	X	X	X	X	X	X	X	X
OW-1C	X	X	X	X	X	O	X	X	X	X
OW-2A	X	X	X	X	O	O	O	O	O	O
OW-2B	X	X	X	X	O	O	O	O	O	O
OW-2C	X	X	X	X	O	O	O	O	O	O
OW-3A	X	X	X	X	X	O	X	X	X	X
OW-3B	X	X	X	X	X	O	X	X	X	X
OW-3C	X	X	X	X	X	O	X	X	X	X
OW-4A	X	X	X	X	X	O	X	X	X	X
OW-4B	X	X	X	X	X	O	X	X	X	X
OW-4C	X	X	X	X	X	O	X	X	X	X
OW-5A	O	O	O	O	X	X	X	X	X	X
OW-5B	O	O	O	O	X	X	X	X	X	X
OW-5C	O	O	O	O	X	X	X	X	X	X
OW-6A	O	O	O	O	X	X	X	X	X	X
OW-6B	O	O	O	O	X	X	X	X	X	X
OW-6C	O	O	O	O	X	X	X	X	X	X
OW-7A	O	O	O	O	X	X	X	X	X	X
OW-7B	O	O	O	O	X	X	X	X	X	X
OW-7C	O	O	O	O	X	X	X	X	X	X
OW-8A	O	O	O	O	X	X	X	X	X	X
OW-8B	O	O	O	O	X	X	X	X	X	X
OW-8C	O	O	O	O	X	X	X	X	X	X

Table 2-5 (Cont'd)
Historical Summary of Wells Sampled

Well	Date Sampled									
	5/96	10/96	3/97	6/97	10/97	2/98	5/98	8/98	12/98	3/99
OW-9A	X	O	O	O	O	O	O	X	X	X
OW-9B	X	O	O	O	O	O	O	X	X	X
OW-10A	X	O	O	O	O	O	O	X	X	X
OW-10B	X	O	O	O	O	O	O	X	X	X
OW-11A	X	O	O	O	X	X	X	X	X	X
OW-11B	X	O	O	O	X	X	X	O	X	X
OW-11C	X	O	O	O	X	X	X	X	X	X
OW-12A	X	O	O	O	O	O	O	X	X	X
OW-12B	X	O	O	O	O	O	O	X	X	X
OW-13B	X	O	O	O	O	O	O	X	X	O
X-1A	X	X	X	X	X	X	X	X	X	X
X-1B	X	X	X	X	X	X	X	X	X	X
X-1C	X	O	O	O	O	O	X	O	O	O
X-2A	X	O	O	O	X	X	X	X	X	X
X-2B	X	O	O	O	O	O	O	O	O	O
X-3A	X	O	O	O	O	O	O	O	O	O
X-3B	X	O	O	O	O	O	O	O	O	O
X-4A	X	O	O	O	O	O	O	O	O	O
X-4B	X	O	O	O	O	O	O	O	O	O

Legend:

X = Well sampled
O = Well not sampled
Bold/Italic = Well abandoned

Table 2-6
Well Construction Summary

Well ID	Northing	Easting	Installation Date	Installer	Ground Elevation (ft)	Top of Casing Elevation (ft)	Depth of Screen (ft)	Depth of Filter pack (ft)	Total Depth of Well (ft)	Total Depth Explored (ft)	Well Type	Zone
AW-2A	NA	NA	NA	NA	NA	NA	NA	NA	NA	BA	Extraction	S-1
AW-2B	322997.00	2085330.00	6/1/85	LS	32.00	32.57	73 to 93	71 to 98	96	98	Extraction	S-2
AW-3	322869.95	2085487.12	6/1/85	LS	31.46	32.92	13 to 53	9 to 55	53	55	Monitoring	S-1
AW-4	322782.99	2085900.24	6/1/85	LS	31.47	32.88	15 to 32.5	12.5 to 99	32.5	39	Monitoring	S-1
AW-5	322970.79	2085685.24	6/1/85	LS	31.26	32.18	14 to 24	9 to 33	24	33	Monitoring	S-1
AW-6	322606.79	2085293.16	6/1/85	LS	31.96	31.70	13 to 23, 33 to 53	9 to 55	53	55	Monitoring	S-1
IW-1	322934.14	2085059.43	5/18/95	EE	32.39	32.64	25 to 90	23 to 93	93	93	Injection	S-1/2
IW-2	322898.74	2085148.83	5/19/95	EE	31.95	32.07	25 to 90	23 to 93	93	93	Injection	S-1/2
IW-3	322874.85	2085215.10	5/21/95	EE	31.91	32.19	25 to 90	23 to 93	93	93	Injection	S-1/2
IW-4	322922.29	2085314.81	5/22/95	EE	31.34	31.37	25 to 90	23 to 93	93	93	Injection	S-1/2
IW-5	322948.45	2085358.02	5/23/95	EE	31.52	31.75	25 to 90	23 to 93	93	93	Injection	S-1/2
IW-6	322969.07	2085397.89	5/24/95	EE	31.27	31.65	25 to 90	23 to 93	93	93	Injection	S-1/2
MW-3A	322705.96	2085692.00	3/7/86	LS	27.7	27.52	34 to 44	30 to 46	44	46	Monitoring	S-1
MW-3B	322701.49	2085694.44	3/7/86	LS	27.72	27.32	66 to 76	61 to 78	76	78	Monitoring	S-2
MW-3C	322705.84	2085697.05	3/7/86	LS	27.7	27.32	116 to 126	112 to 135	126	140	Monitoring	A-1
MW-4C	322897.67	2085281.65	3/7/86	LS	31.45	31.29	114 to 124	110 to 140	124	145	Monitoring	A-1
MW-5A	322842.18	2085060.19	7/1/87	LS	31.91	33.05	10 to 30	7 to 32	40	42	Monitoring	S-1
MW-5B	322818.94	2085061.50	7/1/87	LS	31.76	33.15	34 to 44	32 to 48	54	56	Monitoring	S-1
MW-5C	322830.48	2085060.56	7/1/87	LS	31.81	33.15	70 to 80	65 to 80	90	94	Monitoring	S-2
MW-6A	322382.75	2085335.91	10/7/87	LS	32.17	34.11	12.5 to 30	10 to 34	40	42	Monitoring	S-1
MW-6B	322385.00	2085345.97	10/7/87	LS	32.18	34.06	40 to 50	36 to 54	60	62	Monitoring	S-1

Table 2-6 (Cont'd)
Well Construction Summary

Well ID	Northing	Easting	Installation Date	Installer	Ground Elevation (ft)	Top of Casing Elevation (ft)	Depth of Screen (ft)	Depth of Filter pack (ft)	Total Depth of Well (ft)	Total Depth Explored (ft)	Well Type	Zone
MW-6C	322388.52	2085354.78	10/7/87	LS	32.26	34.08	70 to 80	70 to 80	90	93.5	Monitoring	S-2
MW-7A	323047.76	2085261.99	7/27/87	LS	31.37	33.94	12.5 to 30	9 to 33	40	42	Monitoring	S-1
MW-7B	323059.65	2085256.80	7/27/87	LS	31.27	29.81	36 to 46	34 to 49	56	58	Extraction	S-1
MW-7D	323048.18	2085269.04	12/11/89	GTI	31	33.88	114 to 124	111 to 130	129	130	Monitoring	A-1
MW-8A	323259.17	2085268.08	12/12/89	GTI	31.6	34.52	25 to 45	24 to 46	50	50	Extraction	S-1
MW-8B	323257.05	2085285.66	12/21/89	GTI	31.36	34.57	80 to 90	78 to 90	90	90	Extraction	S-2
MW-9A	323230.82	2085492.48	12/13/89	GTI	30.79	33.92	25 to 45	23 to 46	45	46	Monitoring	S-1
MW-9B	323247.90	2085479.24	12/21/89	GTI	30.69	33.76	71 to 81	69 to 82	87	88	Monitoring	S-2
MW-9C	323232.23	2085460.27	12/12/89	GTI	30.84	33.45	115 to 125	110 to 128	125	128	Monitoring	A-1
MW-10A	323363.89	2085108.47	12/15/89	GTI	32.05	35.05	25 to 45	23 to 46	50	50	Monitoring	S-1
MW-10B	323361.00	2085079.22	12/14/89	GTI	32.05	35.12	67 to 77	64 to 90	77	90	Monitoring	S-2
MW-11A	323410.05	2085266.93	12/14/89	GTI	31.53	34.23	25 to 45	23 to 46	45	45	Extraction	S-1
MW-11B	323407.70	2085274.82	12/28/89	GTI	31.51	34.65	67 to 77	63 to 79	77	90	Extraction	S-2
MW-12A	323379.77	2085538.9	12/14/89	GTI	30.79	34.05	25 to 45	24 to 46	45	46	Extraction	S-1
MW-12B	323379.03	2085553.92	12/27/89	GTI	30.74	33.87	67 to 77	67 to 90	77	90	Extraction	S-2
MW-13A	323078.01	2085100.26	12/9/91	GTI	31.98	31.55	37 to 51	35 to 53	52	53	Monitoring	S-1
MW-13B	323078.06	2085080.60	12/4/91	GTI	31.98	31.54	75 to 85	72 to 86	85.5	86	Monitoring	S-2
MW-13C	323078.94	2085060.37	11/18/91	GTI	31.98	33.92	115 to 125	113 to 127	125	126	Monitoring	A-1
OW-1A	323298.84	2084941.15	7/19/95	B	32.62	34.82	42 to 57	39 to 59	59	59	Monitoring	S-1
OW-1B	323310.53	2084941.29	7/17/95	B	32.41	34.62	68 to 88	66 to 89	88	90	Monitoring	S-2
OW-1C	323309.40	2084948.07	7/73/95	B	32.29	34.58	112 to 137	110 to 138	138	138	Monitoring	A-1
OW-3A	323527.40	2085536.45	7/31/95	B	30.95	33.20	39 to 49	38 to 50	51	51	Monitoring	S-1

Table 2-6 (Cont'd)
Well Construction Summary

Well ID	Northing	Easting	Installation Date	Installer	Ground Elevation (ft)	Top of Casing Elevation (ft)	Depth of Screen (ft)	Depth of Filter pack (ft)	Total Depth of Well (ft)	Total Depth Explored (ft)	Well Type	Zone
OW-3B	323523.87	2085555.89	7/28/95	B	31.04	33.10	64 to 84	62 to 86	86	86	Monitoring	S-2
OW-3C	323517.63	2085547.71	7/26/95	B	31.09	33.44	103 to 133	100 to 139	139	139	Monitoring	A-1
OW-4A	323381.97	2085640.82	8/4/95	B	30.71	32.99	37 to 47	35 to 49	49	49	Monitoring	S-1
OW-4B	323366.94	2085634.32	8/3/95	B	30.76	33.02	65 to 85	62 to 87	87	87	Monitoring	S-2
OW-4C	323379.66	2085629.75	8/2/95	B	30.7	32.94	113 to 145	110 to 147	147	147	Monitoring	A-1
OW-5A	324066.75	2084968.74	11/3/97	B	32.06	31.69	39 to 49	38 to 49	50	50	Monitoring	S-1
OW-5B	324069.97	2084974.72	11/4/97	B	32.08	31.85	69 to 79	69 to 79	80	80	Monitoring	S-2
OW-5C	324063.01	2084962.28	11/4/97	B	32.13	31.75	93 to 103	94 to 104	104	104	Monitoring	A-1
OW-6A	324336.77	2085287.63	11/4/97	B	30.87	30.51	37.5 to 42.5	38 to 44	43.5	43.5	Monitoring	S-1
OW-6B	324337.43	2085272.15	11/4/97	B	30.78	30.30	92 to 97	90 to 110	98	98	Monitoring	S-2
OW-6C	324337.22	2085279.36	11/4/97	B	30.83	30.31	124 to 134	115.5 to 135	135	135	Monitoring	A-1
OW-7A	324000.26	2086329.02	11/4/97	B	29.81	29.41	40 to 45	35.5 to 44	46	46	Monitoring	S-1
OW-7B	324008.55	2086335.19	11/5/97	B	29.76	29.29	68 to 73	67 to 72.5	74	74	Monitoring	S-2
OW-7C	324017.09	2086340.98	11/4/97	B	29.71	29.19	112.5 to 122.5	110 to 123.5	123.5	123.5	Monitoring	A-1
OW-8A	323449.71	2086237.99	11/5/97	B	30.21	31.35	40 to 45	36 to 48	46	46	Monitoring	S-1
OW-8B	323466.53	2086239.53	11/5/97	B	30.17	30.69	65.5 to 70.5	64.5 to 71.5	71.5	71.5	Monitoring	S-2
OW-8C	323458.05	2086223.36	11/5/97	B	30.22	31.86	109 to 119	108 to 120	120	120	Monitoring	A-1
OW-9A	324588.92	2085311.78	7/2/98	B	31.10	31.03	40 to 45	37 to 48.5	48.5	48.5	Monitoring	S-1
OW-9B	324588.67	2085306.65	7/1/98	B	31.1	31.02	65 to 75	62 to 77.5	78.5	78.5	Monitoring	S-2
OW-10A	324271.63	2086668.43	7/9/98	B	27.5	29.99	32-42	29-44	46	46	Monitoring	S-1
OW-10B	324271.02	2086672.90	7/9/98	B	27.6	29.99	63-68	60-77.5	78.5	78.5	Monitoring	S-2
OW-11A	323671.15	2085210.54	11/7/97	B	31.73	31.19	40 to 45	40 to 53	46	46	Monitoring	S-1

Table 2-6 (Cont'd)
Well Construction Summary

Well ID	Northing	Easting	Installation Date	Installer	Ground Elevation (ft)	Top of Casing Elevation (ft)	Depth of Screen (ft)	Depth of Filter pack (ft)	Total Depth of Well (ft)	Total Depth Explored (ft)	Well Type	Zone
OW-11B	323672.63	2085217.34	11/7/97	B	31.68	31.51	68 to 73	66 to 73.5	74	74	Monitoring	S-2
OW-11C	323669.19	2085204.52	11/7/97	B	31.86	31.64	116 to 126	114.5 to 127	127	127	Monitoring	A-1
OW-12A	323847.27	2085759.45	7/10/98	B	30.4	30.21	43-53	41-56	56	56	Monitoring	S-1
OW-12B	323845.86	2085755.00	7/7/98	B	30.3	30.09	69-79	67-80	80	80	Monitoring	S-2
OW-13B	324326.67	2086332.57	7/8/98	B	30.2	29.95	70-75	67-82.5	83.5	83.5	Monitoring	S-2
X-1A	232052.76	2085194.26	4/22/95	EE	31.11	31.1	31 to 51	30 to 52	53	53.5	Extraction	S-1
X-1B	323061.14	2085176.87	4/25/95	EE	31.13	34.2	66 to 85	64 to 86	88	90	Extraction	S-2
X-1C	323066.87	2085192.22	5/3/95	EE	31.4	30.8	111 to 131	109 to 134	133	134	Extraction (Inactive)	A-1
X-2A	323253.40	2085153.84	4/26/95	EE	31.41	31.23	30 to 50	29 to 54	54	54	Extraction	S-1
X-2B	323239.28	2085160.04	4/28/95	EE	31.46	31.61	71 to 91	70 to 94	94	94	Extraction	S-2
X-3A	323243.00	2085057.24	5/6/95	EE	32.17	32.02	30 to 50	28 to 53	53	53	Extraction	S-1
X-3B	323235.94	2085057.13	5/11/95	EE	32.36	31.79	65 to 90	62 to 93	93	93	Extraction	S-2
X-4A	323397.19	2085184.59	4/29/95	EE	31.65	31.37	28 to 48	26 to 48	53	53	Extraction	S-1
X-4B	323387.25	2085171.22	5/5/95	EE	31.38	31.28	68 to 88	67 to 91	91	91	Extraction	S-2

Acronyms/Abbreviations:
- B – Bechtel
- EE – Ecology and Environment
- GTI – Groundwater Technology, Inc.
- ID – identifier
- LS – Luhdorff and Scalmanini
- NA – not available

Table 2-7
Depths At Which SimulProbe Samples Were Collected

Boring Number	Sample I.D.	Interval Sampled (feet bgs)
B-11	B11-A	42-43
	B11-B	70-71
B-12	B12-A	Temporary well at 46
B-13	B13-A	25-26.5
	B13-B	Temporary well at 60-70
B-14	B14-A	38.5-40
	B14-B	Temporary well at 66-71
B-15	B15-A	45-46.5
	B15-A	Temporary well at 46
	B-15-B	Temporary well at 69-79 (converted to well OW-12B)

Table 2-8
Vadose Zone Soil Profile Data

Depth from (ft)	Depth to (ft)	Moisture Content (fraction)	Wet Density lb/cf	Dry Bulk Density lb/cf (ρ_b)	Specific Gravity	Percent Organic Content	Porosity n	Effective Porosity 0.85 * n	Volumetric % H_2O
4	6.5	0.32	116	87	2.70	0.75%	48%	41%	46%
6.5	9	0.29	118	91	2.70	0.78%	46%	39%	43%
9	11.5	0.28	122	95	2.70	0.59%	44%	37%	43%
11.5	14	0.24	125	101	2.68	0.40%	40%	34%	38%
14	16.5	0.2	128	106	2.70	0.11%	37%	32%	35%
16.5	19	0.22	128	105	2.67	0.25%	37%	31%	37%
19	21.5	0.22	129	106	2.72	0.21%	38%	32%	37%
21.5	23.4	0.22	128	106	2.71	0.12%	37%	32%	35%
23.4	26	0.19	129	108	2.74	0.08%	37%	31%	34%
Average			124.8	100.6	2.70	0.37%	40%	34%	39%

Table 2-9
Chemical Properties Used in the VLEACH Model

	Organic Carbon Partition Coefficient Koc	Henry's Law Constant	Solubility (mg/l)	Free Air Diffusion Coefficient (m^2/d)
DCP	51.3	0.146	2700	0.7
EDB	28.2	0.0129	3400	0.7
DBCP	98.0	0.0126	1000	0.7
CCl_4	436.5	0.813	800	0.7
Benzene	64.6	0.22	1780	0.7
TCE	125.9	0.36	1000	0.7
PCE	660.7	0.92	150	0.7

Table 2-10
Precipitation and Evaporation Rates for Davis, California

	Average Precipitation, inches	Average Evaporation, inches	Excess Rainfall, inches
January	3.28	1.44	1.84
February	3.17	2.37	0.80
March	2.37	4.41	0.00
April	1.22	7.02	0.00
May	0.38	10.17	0.00
June	0.13	12.06	0.00
July	0.01	12.63	0.00
August	0.03	11.01	0.00
September	0.26	8.91	0.00
October	0.88	6.09	0.00
November	2.05	2.78	0.00
December	2.99	1.44	1.55
Total	16.77	80.33	4.19

Table 2-11
Disposal Basin Soil Concentrations (µg/kg)

Depth, ft	DCP	EDB	DBCP
3	150	4.3	6.8
6	240	10.0	8.0
9	640	11.0	5.8
12	390	21.0	6.1
15	610	81.0	6.1
18	1100	410.0	5.3
21	1100	340.0	30.0
24	930	390.0	25.0
Avg Conc	645.0	158.4	11.6

Table 3-1
Hydrogeologic Parameters

Well	Zone	Transmissivity (ft^2/day)	Aquifer Thickness (ft)	Hydraulic Conductivity (ft/day)	Test Type Slug or Pumping	Source
MW-13A	S-1	70	8	8.7	Pumping	M&E
AW-2	S-1	106	20	5.3	Pumping	M&E
MW-4A	S-1	150	10	15	Pumping	M&E
MW-8A	S-1	194	6.5	30	Pumping	M&E
MW-9A	S-1	354	13	27	Slug-out	GTI
MW-12A	S-1	636	13	49	Slug-out	GTI
MW-11A	S-1	707	13	54	Slug-out	GTI
Average		**317**		**27**		
MW-9B	S-2	24	10	2.4	Slug-out	GTI
	S-2	24	10	2.4	Slug-in	GTI
MW-11B	S-2	38	10	3.8	Slug-out	GTI
	S-2	38	10	3.8	Slug-in	GTI
MW-4B	S-2	91	10	9.1	Pumping	M&E
MW-8B	S-2	167	7	24	Pumping	M&E
MW-7C	S-2	287	13	22	Pumping	M&E
Average		**96**		**10**		
MW-9C	A-1	4,889	10	489	Slug-out	GTI
	A-1	6,298	10	630	Slug-in	GTI

M&E – Metcalf and Eddy, Final Focused RI/FS (1992)
GTI – Groundwater Technology, Inc., RI/FS (1990)

Table 3-2
Vertical Gradient Summary
(August 1998)

Aquifer Zone	Monitoring Well Number	Water Level Elevation (ft MSL)	Bottom Screen Depth (ft)	Differential (ft)				Gradient (ft/ft)	
				Depth		Head			
				S-1/S-2	S-2/A-1	S-1/S-2	S-2/A-1	S-1/S-2	S-2/A-1
S1	MW-3A	13.06	44	32	50	-0.56	-22.79	-0.018	-0.456
S2	MW-3B	12.50	76						
A1	MW-3C	-10.29	126						
S1	MW-5A	15.75	30	50	36	0.24	-8.36	0.005	-0.232
S1	MW-5B	15.99	44						
S2	MW-5C	7.63	80						
S1	MW-6A	17.78	30	20	30	-0.16	-5.23	-0.008	-0.174
S1	MW-6B	17.62	50						
S2	MW-6C	12.39	80						
S1	MW-9A	11.82	45	36	44	-0.98	-17.86	-0.027	-0.406
S2	MW-9B	10.84	81						
A1	MW-9C	-7.02	125						
S1	MW-13A	9.01	51	34	40	-11.99	-3.74	-0.353	-0.094
S2	MW-13B	-2.98	85						
A1	MW-13C	-6.72	125						
S1	OW-1A	12.79	57	31	49	-20.63	1.22	-0.665	0.025
S2	OW-1B	-7.84	88						
A1	OW-1C	-6.62	137						
S1	OW-3A	10.84	49	35	49	-0.10	-17.59	-0.003	-0.359
S2	OW-3B	10.74	84						
A1	OW-3C	-6.85	133						
S1	OW-4A	12.07	47	38	60	-11.56	-7.46	-0.304	-0.124
S2	OW-4B	0.51	85						
A1	OW-4C	-6.95	145						
S1	OW-5A	10.92	49	30	24	-0.37	-16.07	-0.012	-0.670
S2	OW-5B	10.55	79						
A1	OW-5C	-5.52	103						
S1	OW-6A	10.02	42.5	54.5	37	-15.51	-1.55	-0.285	-0.042
S2	OW-6B	-5.49	97						
A1	OW-6C	-7.04	134						
S1	OW-7A	9.66	45	28	49.5	-1.48	-15.64	-0.053	-0.316
S2	OW-7B	8.18	73						
A1	OW-7C	-7.46	122.5						
S1	OW-8A	12.73	45	25.5	48.5	-2.57	-17.57	-0.101	-0.362
S2	OW-8B	10.16	70.5						
A1	OW-8C	-7.41	119						
S1	OW-9A	8.54	45	30		0.24		0.008	
S2	OW-9B	8.78	75						
S1	OW-10A	7.59	42	26		0.16		0.006	
S2	OW-10B	7.75	68						
S1	OW-11A	10.85	45	28	53	-0.35	-17.43	-0.013	-0.329
S2	OW-11B	10.50	73						
A1	OW-11C	-6.93	126						
S1	OW-12A	10.89	53	26		-0.37		-0.014	
S2	OW-12B	10.52	79						
							Average	-0.115	-0.272

Table 3-3
Summary of Compounds Detected in Monitoring and Extraction Wells
(March 1999)

Station Id	Sample Date	Chemical Name	Result (µg/L)	Analysis Method
AW-2A	3/17/1999	1,2-Dibromo-3-Chloropropane	1.2	Method 504
AW-2A	3/17/1999	1,2-Dibromoethane	0.8	Method 504
AW-2A	3/17/1999	1,2-Dichloroethane	0.4	VOC 25 ML Purge
AW-2A	3/17/1999	1,2-Dichloropropane	120	VOC 25 ML Purge
AW-2B	3/17/1999	1,2-Dichloropropane	90	VOC 25 ML Purge
AW-5	3/15/1999	1,2-Dichloroethane	0.3	VOC 25 ML Purge
MW-3B	3/15/1999	1,2-Dichloropropane	0.6	VOC 25 ML Purge
MW-7B	3/17/1999	1,2-Dichloropropane	160	VOC 25 ML Purge
MW-7D	3/17/1999	1,2-Dibromoethane	0.26	Method 504
MW-7D	3/17/1999	1,2-Dichloroethane	0.4	VOC 25 ML Purge
MW-7D	3/17/1999	1,2-Dichloropropane	5	VOC 25 ML Purge
MW-8A	3/17/1999	1,2-Dibromo-3-Chloropropane	1.1	Method 504
MW-8A	3/17/1999	1,2-Dibromoethane	50	VOC 25 ML Purge
MW-8A	3/17/1999	1,2-Dichloroethane	1	VOC 25 ML Purge
MW-8A	3/17/1999	1,2-Dichloropropane	340	VOC 25 ML Purge
MW-8A	3/17/1999	Carbon Tetrachloride	0.3	VOC 25 ML Purge
MW-8B	3/17/1999	1,2-Dibromo-3-Chloropropane	0.28	Method 504
MW-8B	3/17/1999	1,2-Dibromoethane	16	VOC 25 ML Purge
MW-8B	3/17/1999	1,2-Dichloroethane	0.5	VOC 25 ML Purge
MW-8B	3/17/1999	1,2-Dichloropropane	80	VOC 25 ML Purge
MW-8B	3/17/1999	Carbon Tetrachloride	3	VOC 25 ML Purge
MW-8B	3/17/1999	Chloroform	0.6	VOC 25 ML Purge
MW-9B	3/17/1999	1,2-Dichloroethane	2	VOC 25 ML Purge
MW-9B	3/17/1999	1,2-Dichloropropane	1	VOC 25 ML Purge
MW-9B	3/17/1999	Carbon Tetrachloride	1	VOC 25 ML Purge
MW-10A	3/17/1999	1,2-Dichloroethane	0.4	VOC 25 ML Purge
MW-11A	3/17/1999	1,2-Dibromo-3-Chloropropane	0.04	Method 504
MW-11A	3/17/1999	1,2-Dibromoethane	1	Method 504
MW-11A	3/17/1999	1,2-Dichloropropane	2	VOC 25 ML Purge
MW-11A	3/17/1999	Carbon Tetrachloride	7	VOC 25 ML Purge
MW-11A	3/17/1999	Chloroform	1	VOC 25 ML Purge
MW-11B	3/17/1999	1,2-Dibromo-3-Chloropropane	0.04	Method 504
MW-11B	3/17/1999	1,2-Dibromoethane	0.96	Method 504
MW-11B	3/17/1999	1,2-Dichloroethane	0.4	VOC 25 ML Purge
MW-11B	3/17/1999	1,2-Dichloropropane	14	VOC 25 ML Purge
MW-11B	3/17/1999	Carbon Tetrachloride	4	VOC 25 ML Purge
MW-11B	3/17/1999	Chloroform	0.8	VOC 25 ML Purge

Table 3-3 (Cont'd)
Summary of Compounds Detected in Monitoring and Extraction Wells
(March 1999)

Station Id	Sample Date	Chemical Name	Result (µg/L)	Analysis Method
MW-12A	3/17/1999	1,2-Dibromoethane	0.06	Method 504
MW-12A	3/17/1999	1,2-Dichloropropane	0.6	VOC 25 ML Purge
MW-12A	3/17/1999	Carbon Tetrachloride	35	VOC 25 ML Purge
MW-12A	3/17/1999	Chloroform	8	VOC 25 ML Purge
OW-1B	3/16/1999	1,2-Dichloroethane	0.4	VOC 25 ML Purge
OW-1C	3/16/1999	1,2-Dichloroethane	0.6	VOC 25 ML Purge
OW-3A	3/16/1999	Chloroform	4	VOC 25 ML Purge
OW-3B	3/16/1999	1,2-Dichloropropane	2	VOC 25 ML Purge
OW-3B	3/16/1999	Carbon Tetrachloride	98	VOC 25 ML Purge
OW-3B	3/16/1999	Chloroform	8	VOC 25 ML Purge
OW-4A	3/17/1999	Carbon Tetrachloride	14	VOC 25 ML Purge
OW-4A	3/17/1999	Chloroform	6	VOC 25 ML Purge
OW-4B	3/17/1999	1,2-Dichloroethane	2	VOC 25 ML Purge
OW-4B	3/17/1999	1,2-Dichloropropane	4	VOC 25 ML Purge
OW-4B	3/17/1999	Carbon Tetrachloride	180	VOC 25 ML Purge
OW-4B	3/17/1999	Chloroform	13	VOC 25 ML Purge
OW-4C	3/17/1999	Chloroform	10	VOC 25 ML Purge
OW-4C	3/17/1999	Methylene Chloride	2	VOC 25 ML Purge
OW-5B	3/18/1999	1,2-Dibromoethane	0.03	Method 504
OW-5C	3/18/1999	1,2-Dibromoethane	2	VOC 25 ML Purge
OW-5C	3/18/1999	1,2-Dichloropropane	21	VOC 25 ML Purge
OW-5C	3/18/1999	Benzene	0.6	VOC 25 ML Purge
OW-6A	3/18/1999	1,2-Dibromoethane	0.92	Method 504
OW-6A	3/18/1999	1,2-Dichloropropane	6	VOC 25 ML Purge
OW-6A	3/18/1999	Carbon Tetrachloride	5	VOC 25 ML Purge
OW-6A	3/18/1999	Chloroform	0.8	VOC 25 ML Purge
OW-6B	3/18/1999	1,2-Dibromoethane	0.27	Method 504
OW-6B	3/18/1999	1,2-Dichloropropane	1	VOC 25 ML Purge
OW-6C	3/18/1999	1,2-Dibromoethane	0.45	Method 504
OW-6C	3/18/1999	1,2-Dichloropropane	3	VOC 25 ML Purge
OW-6C	3/18/1999	Benzene	0.8	VOC 25 ML Purge
OW-7A	3/18/1999	1,2-Dibromoethane	0.14	Method 504
OW-7A	3/18/1999	1,2-Dichloropropane	0.8	VOC 25 ML Purge
OW-7B	3/19/1999	1,2-Dibromoethane	0.41	Method 504
OW-7B	3/19/1999	1,2-Dichloropropane	3	VOC 25 ML Purge
OW-7C	3/18/1999	1,2-Dibromoethane	0.41	Method 504
OW-7C	3/18/1999	1,2-Dichloropropane	2	VOC 25 ML Purge

Table 3-3 (Cont'd)
Summary of Compounds Detected in Monitoring and Extraction Wells
(March 1999)

Station Id	Sample Date	Chemical Name	Result (µg/L)	Analysis Method
OW-8A	3/18/1999	1,2-Dibromoethane	0.18	Method 504
OW-8A	3/18/1999	1,2-Dichloropropane	0.7	VOC 25 ML Purge
OW-8B	3/18/1999	1,2-Dibromoethane	2.4	Method 504
OW-8B	3/18/1999	1,2-Dibromoethane	2	VOC 25 ML Purge
OW-8B	3/18/1999	1,2-Dichloropropane	10	VOC 25 ML Purge
OW-8C	3/18/1999	1,2-Dibromoethane	0.45	Method 504
OW-8C	3/18/1999	1,2-Dichloropropane	2	VOC 25 ML Purge
OW-9A	3/19/1999	1,2-Dibromoethane	0.32	Method 504
OW-9A	3/19/1999	1,2-Dichloropropane	1	VOC 25 ML Purge
OW-9B	3/19/1999	1,2-Dibromoethane	0.43	Method 504
OW-9B	3/19/1999	1,2-Dichloropropane	2	VOC 25 ML Purge
OW-10B	3/19/1999	1,2-Dibromoethane	0.06	Method 504
OW-11A	3/18/1999	1,2-Dibromoethane	0.2	Method 504
OW-11A	3/18/1999	1,2-Dichloropropane	0.9	VOC 25 ML Purge
OW-11B	3/19/1999	1,1,2-Trichloroethane	1	VOC 25 ML Purge
OW-11B	3/19/1999	1,1-Dichloroethane	1	VOC 25 ML Purge
OW-11B	3/19/1999	1,2-Dibromo-3-Chloropropane	19	VOC 25 ML Purge
OW-11B	3/19/1999	1,2-Dibromoethane	400	VOC 25 ML Purge
OW-11B	3/19/1999	1,2-Dichloroethane	5	VOC 25 ML Purge
OW-11B	3/19/1999	1,2-Dichloropropane	2,500	VOC 25 ML Purge
OW-11B	3/19/1999	Benzene	1	VOC 25 ML Purge
OW-11B	3/19/1999	Chloroform	0.8	VOC 25 ML Purge
OW-11C	3/18/1999	1,2-Dibromo-3-Chloropropane	0.9	Method 504
OW-11C	3/18/1999	1,2-Dibromoethane	22	VOC 25 ML Purge
OW-11C	3/18/1999	1,2-Dichloroethane	0.3	VOC 25 ML Purge
OW-11C	3/18/1999	1,2-Dichloropropane	170	VOC 25 ML Purge
OW-12A	3/19/1999	1,2-Dibromoethane	0.09	Method 504
OW-12A	3/19/1999	1,2-Dichloropropane	0.5	VOC 25 ML Purge
OW-12A	3/19/1999	Benzene	1	VOC 25 ML Purge
OW-12B	3/19/1999	1,2-Dibromoethane	0.66	Method 504
OW-12B	3/19/1999	1,2-Dichloropropane	1	VOC 25 ML Purge
OW-13B	3/19/1999	1,2-Dibromoethane	0.62	Method 504
OW-13B	3/19/1999	1,2-Dichloropropane	4	VOC 25 ML Purge
X-1A	3/17/1999	1,2-Dibromoethane	400	VOC 5 ML Purge
X-1A	3/17/1999	1,2-Dichloroethane	20	VOC 5 ML Purge
X-1A	3/17/1999	1,2-Dichloropropane	2,900	VOC 5 ML Purge
X-1A	3/17/1999	Chlorobenzene	6	VOC 5 ML Purge

Table 3-3 (Cont'd)
Summary of Compounds Detected in Monitoring and Extraction Wells
(March 1999)

Station Id	Sample Date	Chemical Name	Result (µg/L)	Analysis Method
X-1B	3/18/1999	1,2-Dibromoethane	800	VOC 5 ML Purge
X-1B	3/18/1999	1,2-Dichloroethane	8	VOC 5 ML Purge
X-1B	3/18/1999	1,2-Dichloropropane	2,700	VOC 5 ML Purge
X-2A	3/17/1999	1,2-Dibromoethane	1	Method 504
X-2A	3/17/1999	1,2-Dichloropropane	20	VOC 25 ML Purge

Table 3-4
Summary of SimulProbe Sample Analytical Results

Station ID	Sample Date	Chemical Name	Result (µg/L)	Lab Qualifier	Validation Qualifier	MCL (µg/L)	Analysis Method
B-11-A	6/24/1998	1,1,1-Trichloroethane	1	U		200	VOC 25 ML Purge
B-11-A	6/24/1998	1,1,2,2-Tetrachloroethane	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	1,1,2-Trichloroethane	1	U		5	VOC 25 ML Purge
B-11-A	6/24/1998	1,1-Dichloroethane	1	U		5	VOC 25 ML Purge
B-11-A	6/24/1998	1,1-Dichloroethene	1	U		7	VOC 25 ML Purge
B-11-A	6/24/1998	1,2,3-Trichloropropane	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	1,2-Dibromo-3-Chloropropane	0.05	U		0.2	Method 504
B-11-A	6/24/1998	1,2-Dibromo-3-Chloropropane	1	U		0.2	VOC 25 ML Purge
B-11-A	6/24/1998	1,2-Dibromoethane	0.05	U		0.05	Method 504
B-11-A	6/24/1998	1,2-Dibromoethane	1	U		0.05	VOC 25 ML Purge
B-11-A	6/24/1998	1,2-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-11-A	6/24/1998	1,2-Dichloroethane	0.5	U		5	VOC 25 ML Purge
B-11-A	6/24/1998	1,2-Dichloropropane	1	U		5	VOC 25 ML Purge
B-11-A	6/24/1998	1,3-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-11-A	6/24/1998	1,3-Dichloropropane	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	1,4-Dichlorobenzene	1	U		75	VOC 25 ML Purge
B-11-A	6/24/1998	2-Hexanone	10	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Acetone	10	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Benzene	1	U		5	VOC 25 ML Purge
B-11-A	6/24/1998	Bromodichloromethane	1	U		100	VOC 25 ML Purge
B-11-A	6/24/1998	Bromoform	1	U		100	VOC 25 ML Purge
B-11-A	6/24/1998	Bromomethane	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Carbon Disulfide	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Carbon Tetrachloride	0.5	U		0.5	VOC 25 ML Purge
B-11-A	6/24/1998	Chlorobenzene	1	U		100	VOC 25 ML Purge
B-11-A	6/24/1998	Chloroethane	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Chloroform	1	U		100	VOC 25 ML Purge
B-11-A	6/24/1998	Chloromethane	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Cis-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Cis-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Dibromochloromethane	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Dichlorodifluoromethane	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Ethylbenzene	1	U		700	VOC 25 ML Purge
B-11-A	6/24/1998	Methyl Ethyl Ketone	10	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Methyl Isobutyl Ketone	10	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Methyl-T-Butyl Ether	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Methylene Chloride	1	U		5	VOC 25 ML Purge
B-11-A	6/24/1998	Styrene	1	U		100	VOC 25 ML Purge
B-11-A	6/24/1998	Tetrachloroethene	1	U		5	VOC 25 ML Purge
B-11-A	6/24/1998	Toluene	1	U		1,000	VOC 25 ML Purge
B-11-A	6/24/1998	Trans-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Trans-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Trichloroethene	1	U		5	VOC 25 ML Purge
B-11-A	6/24/1998	Trichlorofluoromethane	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Vinyl Chloride	0.5	U		2	VOC 25 ML Purge
B-11-A	6/24/1998	Xylene (Meta & Para)	1	U		NA	VOC 25 ML Purge
B-11-A	6/24/1998	Xylene (Ortho)	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	1,1,1-Trichloroethane	1	U		200	VOC 25 ML Purge
B-11-B	6/24/1998	1,1,2,2-Tetrachloroethane	1	U		NA	VOC 25 ML Purge

Table 3-4 (Cont'd)
Summary of SimulProbe Sample Analytical Results

Station ID	Sample Date	Chemical Name	Result (µg/L)	Lab Qualifier	Validation Qualifier	MCL (µg/L)	Analysis Method
B-11-B	6/24/1998	1,1,2-Trichloroethane	1	U		5	VOC 25 ML Purge
B-11-B	6/24/1998	1,1-Dichloroethane	1	U		5	VOC 25 ML Purge
B-11-B	6/24/1998	1,1-Dichloroethene	1	U		7	VOC 25 ML Purge
B-11-B	6/24/1998	1,2,3-Trichloropropane	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	1,2-Dibromo-3-Chloropropane	0.05	U		0.2	Method 504
B-11-B	6/24/1998	1,2-Dibromo-3-Chloropropane	1	U		0.2	VOC 25 ML Purge
B-11-B	6/24/1998	1,2-Dibromoethane	0.05	U		0.05	Method 504
B-11-B	6/24/1998	1,2-Dibromoethane	1	U		0.05	VOC 25 ML Purge
B-11-B	6/24/1998	1,2-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-11-B	6/24/1998	1,2-Dichloroethane	0.5	U		5	VOC 25 ML Purge
B-11-B	6/24/1998	1,2-Dichloropropane	1	U		5	VOC 25 ML Purge
B-11-B	6/24/1998	1,3-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-11-B	6/24/1998	1,3-Dichloropropane	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	1,4-Dichlorobenzene	1	U		75	VOC 25 ML Purge
B-11-B	6/24/1998	2-Hexanone	10	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Acetone	11	B		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Benzene	1	U		5	VOC 25 ML Purge
B-11-B	6/24/1998	Bromodichloromethane	1	U		100	VOC 25 ML Purge
B-11-B	6/24/1998	Bromoform	1	U		100	VOC 25 ML Purge
B-11-B	6/24/1998	Bromomethane	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Carbon Disulfide	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Carbon Tetrachloride	0.5	U		0.5	VOC 25 ML Purge
B-11-B	6/24/1998	Chlorobenzene	1	U		100	VOC 25 ML Purge
B-11-B	6/24/1998	Chloroethane	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Chloroform	1	U		100	VOC 25 ML Purge
B-11-B	6/24/1998	Chloromethane	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Cis-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Cis-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Dibromochloromethane	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Dichlorodifluoromethane	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Ethylbenzene	1	U		700	VOC 25 ML Purge
B-11-B	6/24/1998	Methyl Ethyl Ketone	10	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Methyl Isobutyl Ketone	10	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Methyl-T-Butyl Ether	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Methylene Chloride	1	U		5	VOC 25 ML Purge
B-11-B	6/24/1998	Styrene	1	U		100	VOC 25 ML Purge
B-11-B	6/24/1998	Tetrachloroethene	1	U		5	VOC 25 ML Purge
B-11-B	6/24/1998	Toluene	0.2	J		1,000	VOC 25 ML Purge
B-11-B	6/24/1998	Trans-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Trans-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Trichloroethene	1	U		5	VOC 25 ML Purge
B-11-B	6/24/1998	Trichlorofluoromethane	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Vinyl Chloride	0.5	U		2	VOC 25 ML Purge
B-11-B	6/24/1998	Xylene (Meta & Para)	1	U		NA	VOC 25 ML Purge
B-11-B	6/24/1998	Xylene (Ortho)	1	U		NA	VOC 25 ML Purge
B-12-A	6/25/1998	1,2-Dibromo-3-Chloropropane	0.05	U		0.2	Method 504
B-12-A	6/25/1998	1,2-Dibromoethane	0.05	U		0.05	Method 504
B-12-A	6/26/1998	1,1,1-Trichloroethane	1	U		200	VOC 25 ML Purge
B-12-A	6/26/1998	1,1,2,2-Tetrachloroethane	1	U		NA	VOC 25 ML Purge

Table 3-4 (Cont'd)
Summary of SimulProbe Sample Analytical Results

Station ID	Sample Date	Chemical Name	Result (µg/L)	Lab Qualifier	Validation Qualifier	MCL (µg/L)	Analysis Method
B-12-A	6/26/1998	1,1,2-Trichloroethane	1	U		5	VOC 25 ML Purge
B-12-A	6/26/1998	1,1-Dichloroethane	1	U		5	VOC 25 ML Purge
B-12-A	6/26/1998	1,1-Dichloroethene	1	U		7	VOC 25 ML Purge
B-12-A	6/26/1998	1,2,3-Trichloropropane	1	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	1,2-Dibromo-3-Chloropropane	1	U		0.2	VOC 25 ML Purge
B-12-A	6/26/1998	1,2-Dibromoethane	1	U		0.05	VOC 25 ML Purge
B-12-A	6/26/1998	1,2-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-12-A	6/26/1998	1,2-Dichloroethane	0.5	U		5	VOC 25 ML Purge
B-12-A	6/26/1998	1,2-Dichloropropane	1	U		5	VOC 25 ML Purge
B-12-A	6/26/1998	1,3-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-12-A	6/26/1998	1,3-Dichloropropane	1	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	1,4-Dichlorobenzene	1	U		75	VOC 25 ML Purge
B-12-A	6/26/1998	2-Hexanone	10	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Acetone	10	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Benzene	1	U		5	VOC 25 ML Purge
B-12-A	6/26/1998	Bromodichloromethane	1	U		100	VOC 25 ML Purge
B-12-A	6/26/1998	Bromoform	1	U		100	VOC 25 ML Purge
B-12-A	6/26/1998	Bromomethane	1	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Carbon Disulfide	1	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Carbon Tetrachloride	0.5	U		0.5	VOC 25 ML Purge
B-12-A	6/26/1998	Chlorobenzene	1	U		100	VOC 25 ML Purge
B-12-A	6/26/1998	Chloroethane	1	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Chloroform	1	U		100	VOC 25 ML Purge
B-12-A	6/26/1998	Chloromethane	1	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Cis-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Cis-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Dibromochloromethane	1	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Dichlorodifluoromethane	1	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Ethylbenzene	1	U		700	VOC 25 ML Purge
B-12-A	6/26/1998	Methyl Ethyl Ketone	10	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Methyl Isobutyl Ketone	10	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Methyl-T-Butyl Ether	1	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Methylene Chloride	1	U		5	VOC 25 ML Purge
B-12-A	6/26/1998	Styrene	1	U		100	VOC 25 ML Purge
B-12-A	6/26/1998	Tetrachloroethene	1	U		5	VOC 25 ML Purge
B-12-A	6/26/1998	Toluene	1	U		1,000	VOC 25 ML Purge
B-12-A	6/26/1998	Trans-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Trans-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Trichloroethene	1	U		5	VOC 25 ML Purge
B-12-A	6/26/1998	Trichlorofluoromethane	1	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Vinyl Chloride	0.5	U		2	VOC 25 ML Purge
B-12-A	6/26/1998	Xylene (Meta & Para)	1	U		NA	VOC 25 ML Purge
B-12-A	6/26/1998	Xylene (Ortho)	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	1,1,1-Trichloroethane	1	U		200	VOC 25 ML Purge
B-13-A	6/29/1998	1,1,2,2-Tetrachloroethane	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	1,1,2-Trichloroethane	1	U		5	VOC 25 ML Purge
B-13-A	6/29/1998	1,1-Dichloroethane	1	U		5	VOC 25 ML Purge
B-13-A	6/29/1998	1,1-Dichloroethene	1	U		7	VOC 25 ML Purge
B-13-A	6/29/1998	1,2,3-Trichloropropane	1	U		NA	VOC 25 ML Purge

Table 3-4 (Cont'd)
Summary of SimulProbe Sample Analytical Results

Station ID	Sample Date	Chemical Name	Result (µg/L)	Lab Qualifier	Validation Qualifier	MCL (µg/L)	Analysis Method
B-13-A	6/29/1998	1,2-Dibromo-3-Chloropropane	0.05	U		0.2	Method 504
B-13-A	6/29/1998	1,2-Dibromo-3-Chloropropane	1	U		0.2	VOC 25 ML Purge
B-13-A	6/29/1998	1,2-Dibromoethane	0.05	U		0.05	Method 504
B-13-A	6/29/1998	1,2-Dibromoethane	1	U		0.05	VOC 25 ML Purge
B-13-A	6/29/1998	1,2-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-13-A	6/29/1998	1,2-Dichloroethane	0.5	U		5	VOC 25 ML Purge
B-13-A	6/29/1998	1,2-Dichloropropane	1	U		5	VOC 25 ML Purge
B-13-A	6/29/1998	1,3-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-13-A	6/29/1998	1,3-Dichloropropane	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	1,4-Dichlorobenzene	1	U		75	VOC 25 ML Purge
B-13-A	6/29/1998	2-Hexanone	10	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Acetone	10	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Benzene	1	U		5	VOC 25 ML Purge
B-13-A	6/29/1998	Bromodichloromethane	1	U		100	VOC 25 ML Purge
B-13-A	6/29/1998	Bromoform	1	U		100	VOC 25 ML Purge
B-13-A	6/29/1998	Bromomethane	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Carbon Disulfide	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Carbon Tetrachloride	0.5	U		0.5	VOC 25 ML Purge
B-13-A	6/29/1998	Chlorobenzene	1	U		100	VOC 25 ML Purge
B-13-A	6/29/1998	Chloroethane	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Chloroform	1	U		100	VOC 25 ML Purge
B-13-A	6/29/1998	Chloromethane	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Cis-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Cis-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Dibromochloromethane	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Dichlorodifluoromethane	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Ethylbenzene	1	U		700	VOC 25 ML Purge
B-13-A	6/29/1998	Methyl Ethyl Ketone	10	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Methyl Isobutyl Ketone	10	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Methyl-T-Butyl Ether	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Methylene Chloride	1	U		5	VOC 25 ML Purge
B-13-A	6/29/1998	Styrene	1	U		100	VOC 25 ML Purge
B-13-A	6/29/1998	Tetrachloroethene	1	U		5	VOC 25 ML Purge
B-13-A	6/29/1998	Toluene	1	U		1,000	VOC 25 ML Purge
B-13-A	6/29/1998	Trans-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Trans-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Trichloroethene	1	U		5	VOC 25 ML Purge
B-13-A	6/29/1998	Trichlorofluoromethane	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Vinyl Chloride	0.5	U		2	VOC 25 ML Purge
B-13-A	6/29/1998	Xylene (Meta & Para)	1	U		NA	VOC 25 ML Purge
B-13-A	6/29/1998	Xylene (Ortho)	1	U		NA	VOC 25 ML Purge
B-13-B	6/29/1998	1,2-Dibromo-3-Chloropropane	0.05	U		0.2	Method 504
B-13-B	6/29/1998	1,2-Dibromoethane	0.05	U		0.05	Method 504
B-13-B	6/30/1998	1,1,1-Trichloroethane	1	U		200	VOC 25 ML Purge
B-13-B	6/30/1998	1,1,2,2-Tetrachloroethane	1	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	1,1,2-Trichloroethane	1	U		5	VOC 25 ML Purge
B-13-B	6/30/1998	1,1-Dichloroethane	1	U		5	VOC 25 ML Purge
B-13-B	6/30/1998	1,1-Dichloroethene	1	U		7	VOC 25 ML Purge
B-13-B	6/30/1998	1,2,3-Trichloropropane	1	U		NA	VOC 25 ML Purge

Table 3-4 (Cont'd)
Summary of SimulProbe Sample Analytical Results

Station ID	Sample Date	Chemical Name	Result (µg/L)	Lab Qualifier	Validation Qualifier	MCL (µg/L)	Analysis Method
B-13-B	6/30/1998	1,2-Dibromo-3-Chloropropane	1	U		0.2	VOC 25 ML Purge
B-13-B	6/30/1998	1,2-Dibromoethane	1	U		0.05	VOC 25 ML Purge
B-13-B	6/30/1998	1,2-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-13-B	6/30/1998	1,2-Dichloroethane	0.5	U		5	VOC 25 ML Purge
B-13-B	6/30/1998	1,2-Dichloropropane	1	U		5	VOC 25 ML Purge
B-13-B	6/30/1998	1,3-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-13-B	6/30/1998	1,3-Dichloropropane	1	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	1,4-Dichlorobenzene	1	U		75	VOC 25 ML Purge
B-13-B	6/30/1998	2-Hexanone	10	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Acetone	10	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Benzene	1	U		5	VOC 25 ML Purge
B-13-B	6/30/1998	Bromodichloromethane	1	U		100	VOC 25 ML Purge
B-13-B	6/30/1998	Bromoform	1	U		100	VOC 25 ML Purge
B-13-B	6/30/1998	Bromomethane	1	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Carbon Disulfide	1	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Carbon Tetrachloride	0.5	U		0.5	VOC 25 ML Purge
B-13-B	6/30/1998	Chlorobenzene	1	U		100	VOC 25 ML Purge
B-13-B	6/30/1998	Chloroethane	1	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Chloroform	1	U		100	VOC 25 ML Purge
B-13-B	6/30/1998	Chloromethane	1	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Cis-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Cis-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Dibromochloromethane	1	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Dichlorodifluoromethane	1	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Ethylbenzene	1	U		700	VOC 25 ML Purge
B-13-B	6/30/1998	Methyl Ethyl Ketone	10	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Methyl Isobutyl Ketone	10	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Methyl-T-Butyl Ether	1	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Methylene Chloride	1	U		5	VOC 25 ML Purge
B-13-B	6/30/1998	Styrene	1	U		100	VOC 25 ML Purge
B-13-B	6/30/1998	Tetrachloroethene	1	U		5	VOC 25 ML Purge
B-13-B	6/30/1998	Toluene	1	U		1,000	VOC 25 ML Purge
B-13-B	6/30/1998	Trans-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Trans-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Trichloroethene	1	U		5	VOC 25 ML Purge
B-13-B	6/30/1998	Trichlorofluoromethane	1	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Vinyl Chloride	0.5	U		2	VOC 25 ML Purge
B-13-B	6/30/1998	Xylene (Meta & Para)	1	U		NA	VOC 25 ML Purge
B-13-B	6/30/1998	Xylene (Ortho)	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	1,1,1-Trichloroethane	1	U		200	VOC 25 ML Purge
B-14-A	6/30/1998	1,1,2,2-Tetrachloroethane	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	1,1,2-Trichloroethane	1	U		5	VOC 25 ML Purge
B-14-A	6/30/1998	1,1-Dichloroethane	1	U		5	VOC 25 ML Purge
B-14-A	6/30/1998	1,1-Dichloroethene	1	U		7	VOC 25 ML Purge
B-14-A	6/30/1998	1,2,3-Trichloropropane	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	1,2-Dibromo-3-Chloropropane	0.05	U		0.2	Method 504
B-14-A	6/30/1998	1,2-Dibromo-3-Chloropropane	1	U		0.2	VOC 25 ML Purge
B-14-A	6/30/1998	1,2-Dibromoethane	0.05	U		0.05	Method 504
B-14-A	6/30/1998	1,2-Dibromoethane	1	U		0.05	VOC 25 ML Purge

Table 3-4 (Cont'd)
Summary of SimulProbe Sample Analytical Results

Station ID	Sample Date	Chemical Name	Result (µg/L)	Lab Qualifier	Validation Qualifier	MCL (µg/L)	Analysis Method
B-14-A	6/30/1998	1,2-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-14-A	6/30/1998	1,2-Dichloroethane	0.5	U		5	VOC 25 ML Purge
B-14-A	6/30/1998	1,2-Dichloropropane	1	U		5	VOC 25 ML Purge
B-14-A	6/30/1998	1,3-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-14-A	6/30/1998	1,3-Dichloropropane	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	1,4-Dichlorobenzene	1	U		75	VOC 25 ML Purge
B-14-A	6/30/1998	2-Hexanone	10	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Acetone	10	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Benzene	1	U		5	VOC 25 ML Purge
B-14-A	6/30/1998	Bromodichloromethane	1	U		100	VOC 25 ML Purge
B-14-A	6/30/1998	Bromoform	1	U		100	VOC 25 ML Purge
B-14-A	6/30/1998	Bromomethane	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Carbon Disulfide	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Carbon Tetrachloride	0.5	U		0.5	VOC 25 ML Purge
B-14-A	6/30/1998	Chlorobenzene	1	U		100	VOC 25 ML Purge
B-14-A	6/30/1998	Chloroethane	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Chloroform	1	U		100	VOC 25 ML Purge
B-14-A	6/30/1998	Chloromethane	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Cis-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Cis-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Dibromochloromethane	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Dichlorodifluoromethane	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Ethylbenzene	1	U		700	VOC 25 ML Purge
B-14-A	6/30/1998	Methyl Ethyl Ketone	10	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Methyl Isobutyl Ketone	10	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Methyl-T-Butyl Ether	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Methylene Chloride	0.3	J		5	VOC 25 ML Purge
B-14-A	6/30/1998	Styrene	1	U		100	VOC 25 ML Purge
B-14-A	6/30/1998	Tetrachloroethene	1	U		5	VOC 25 ML Purge
B-14-A	6/30/1998	Toluene	1	U		1,000	VOC 25 ML Purge
B-14-A	6/30/1998	Trans-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Trans-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Trichloroethene	1	U		5	VOC 25 ML Purge
B-14-A	6/30/1998	Trichlorofluoromethane	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Vinyl Chloride	0.5	U		2	VOC 25 ML Purge
B-14-A	6/30/1998	Xylene (Meta & Para)	1	U		NA	VOC 25 ML Purge
B-14-A	6/30/1998	Xylene (Ortho)	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	1,1,1-Trichloroethane	1	U		200	VOC 25 ML Purge
B-14-B	7/1/1998	1,1,2,2-Tetrachloroethane	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	1,1,2-Trichloroethane	1	U		5	VOC 25 ML Purge
B-14-B	7/1/1998	1,1-Dichloroethane	1	U		5	VOC 25 ML Purge
B-14-B	7/1/1998	1,1-Dichloroethene	1	U		7	VOC 25 ML Purge
B-14-B	7/1/1998	1,2,3-Trichloropropane	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	1,2-Dibromo-3-Chloropropane	0.05	U		0.2	Method 504
B-14-B	7/1/1998	1,2-Dibromo-3-Chloropropane	1	U		0.2	VOC 25 ML Purge
B-14-B	7/1/1998	1,2-Dibromoethane	0.05	U		0.05	Method 504
B-14-B	7/1/1998	1,2-Dibromoethane	1	U		0.05	VOC 25 ML Purge
B-14-B	7/1/1998	1,2-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-14-B	7/1/1998	1,2-Dichloroethane	0.5	U		5	VOC 25 ML Purge

Table 3-4 (Cont'd)
Summary of SimulProbe Sample Analytical Results

Station ID	Sample Date	Chemical Name	Result (µg/L)	Lab Qualifier	Validation Qualifier	MCL (µg/L)	Analysis Method
B-14-B	7/1/1998	1,2-Dichloropropane	1	U		5	VOC 25 ML Purge
B-14-B	7/1/1998	1,3-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-14-B	7/1/1998	1,3-Dichloropropane	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	1,4-Dichlorobenzene	1	U		75	VOC 25 ML Purge
B-14-B	7/1/1998	2-Hexanone	10	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Acetone	10	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Benzene	1	U		5	VOC 25 ML Purge
B-14-B	7/1/1998	Bromodichloromethane	1	U		100	VOC 25 ML Purge
B-14-B	7/1/1998	Bromoform	1	U		100	VOC 25 ML Purge
B-14-B	7/1/1998	Bromomethane	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Carbon Disulfide	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Carbon Tetrachloride	0.5	U		0.5	VOC 25 ML Purge
B-14-B	7/1/1998	Chlorobenzene	1	U		100	VOC 25 ML Purge
B-14-B	7/1/1998	Chloroethane	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Chloroform	1	U		100	VOC 25 ML Purge
B-14-B	7/1/1998	Chloromethane	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Cis-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Cis-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Dibromochloromethane	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Dichlorodifluoromethane	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Ethylbenzene	1	U		700	VOC 25 ML Purge
B-14-B	7/1/1998	Methyl Ethyl Ketone	10	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Methyl Isobutyl Ketone	10	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Methyl-T-Butyl Ether	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Methylene Chloride	1	U		5	VOC 25 ML Purge
B-14-B	7/1/1998	Styrene	1	U		100	VOC 25 ML Purge
B-14-B	7/1/1998	Tetrachloroethene	1	U		5	VOC 25 ML Purge
B-14-B	7/1/1998	Toluene	1	U		1,000	VOC 25 ML Purge
B-14-B	7/1/1998	Trans-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Trans-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Trichloroethene	1	U		5	VOC 25 ML Purge
B-14-B	7/1/1998	Trichlorofluoromethane	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Vinyl Chloride	0.5	U		2	VOC 25 ML Purge
B-14-B	7/1/1998	Xylene (Meta & Para)	1	U		NA	VOC 25 ML Purge
B-14-B	7/1/1998	Xylene (Ortho)	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	1,1,1-Trichloroethane	1	U		200	VOC 25 ML Purge
B-15-B	7/8/1998	1,1,2,2-Tetrachloroethane	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	1,1,2-Trichloroethane	1	U		5	VOC 25 ML Purge
B-15-B	7/8/1998	1,1-Dichloroethane	1	U		5	VOC 25 ML Purge
B-15-B	7/8/1998	1,1-Dichloroethene	1	U		7	VOC 25 ML Purge
B-15-B	7/8/1998	1,2,3-Trichloropropane	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	1,2-Dibromo-3-Chloropropane	0.05	U		0.2	Method 504
B-15-B	7/8/1998	1,2-Dibromo-3-Chloropropane	1	U		0.2	VOC 25 ML Purge
B-15-B	7/8/1998	1,2-Dibromoethane	0.05	U		0.05	Method 504
B-15-B	7/8/1998	1,2-Dibromoethane	1	U		0.05	VOC 25 ML Purge
B-15-B	7/8/1998	1,2-Dichlorobenzene	1	U		600	VOC 25 ML Purge
B-15-B	7/8/1998	1,2-Dichloroethane	0.5	U		5	VOC 25 ML Purge
B-15-B	7/8/1998	1,2-Dichloropropane	1	U		5	VOC 25 ML Purge
B-15-B	7/8/1998	1,3-Dichlorobenzene	1	U		600	VOC 25 ML Purge

Table 3-4 (Cont'd)
Summary of SimulProbe Sample Analytical Results

Station ID	Sample Date	Chemical Name	Result (µg/L)	Lab Qualifier	Validation Qualifier	MCL (µg/L)	Analysis Method
B-15-B	7/8/1998	1,3-Dichloropropane	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	1,4-Dichlorobenzene	1	U		75	VOC 25 ML Purge
B-15-B	7/8/1998	2-Hexanone	10	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Acetone	10	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Benzene	1	U		5	VOC 25 ML Purge
B-15-B	7/8/1998	Bromodichloromethane	1	U		100	VOC 25 ML Purge
B-15-B	7/8/1998	Bromoform	1	U		100	VOC 25 ML Purge
B-15-B	7/8/1998	Bromomethane	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Carbon Disulfide	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Carbon Tetrachloride	0.5	U		0.5	VOC 25 ML Purge
B-15-B	7/8/1998	Chlorobenzene	1	U		100	VOC 25 ML Purge
B-15-B	7/8/1998	Chloroethane	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Chloroform	1	U		100	VOC 25 ML Purge
B-15-B	7/8/1998	Chloromethane	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Cis-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Cis-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Dibromochloromethane	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Dichlorodifluoromethane	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Ethylbenzene	1	U		700	VOC 25 ML Purge
B-15-B	7/8/1998	Methyl Ethyl Ketone	10	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Methyl Isobutyl Ketone	10	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Methyl-T-Butyl Ether	0.7	J		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Methylene Chloride	1	U		5	VOC 25 ML Purge
B-15-B	7/8/1998	Styrene	1	U		100	VOC 25 ML Purge
B-15-B	7/8/1998	Tetrachloroethene	1	U		5	VOC 25 ML Purge
B-15-B	7/8/1998	Toluene	0.5	J		1,000	VOC 25 ML Purge
B-15-B	7/8/1998	Trans-1,2-Dichloroethene	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Trans-1,3-Dichloropropene	0.5	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Trichloroethene	1	U		5	VOC 25 ML Purge
B-15-B	7/8/1998	Trichlorofluoromethane	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Vinyl Chloride	0.5	U		2	VOC 25 ML Purge
B-15-B	7/8/1998	Xylene (Meta & Para)	1	U		NA	VOC 25 ML Purge
B-15-B	7/8/1998	Xylene (Ortho)	1	U		NA	VOC 25 ML Purge

Table 3-5
Summary of Field Results for Presence of DNAPLs

Test \ Sample	Blank (Pure H_2O)	Well X-1B	Well X-1A	Well MW-12A	Well MW-7C
Visual Inspection	None	None	None	None	None
UV Inspection	No Fluorescence @ 254 or 360 nm	No Fluorescence @ 254 or 360 nm	No Fluorescence @ 254 or 360 nm	No Fluorescence @ 254 or 360 nm	No Fluorescence @ 254 or 360 nm
Dye Testing	No color, No fluorescence	No color, No Fluorescence @ 254 or 360 nm	No color, No Fluorescence @ 254 or 360 nm	No color, No Fluorescence @ 254 or 360 nm	No color, No Fluorescence @ 254 or 360 nm
Centrifuge UV	No fluorescence @ 254 or 360 nm	No fluorescence @ 254 or 360 nm	No fluorescence @ 254 or 360 nm	No fluorescence @ 254 or 360 nm	No fluorescence @ 254 or 360 nm
Centrifuge Dye	No color No Fluorescence @ 254 or 360 nm	No color No Fluorescence @ 254 or 360 nm	No color No Fluorescence @ 254 or 360 nm	No color No Fluorescence @ 254 or 360 nm	No color No Fluorescence @ 254 or 360 nm

Table 3-6
Results of DMLS Sampling and Analysis

Well OW-4B, S-2 Zone in Carbon Tetrachloride Plume

Sample Depth (ft bgs)	Sample Number	Date	Compound	Result (µg/L)	Lab Qualifier
75.0	DMLS-OW-4B1	9/23/1998	Carbon Tetrachloride	170	
75.5	DMLS-OW-4B2	9/23/1998	Carbon Tetrachloride	230	
76.0	DMLS-OW-4B3	9/23/1998	Carbon Tetrachloride	170	
76.5	DMLS-OW-4B4	9/23/1998	Carbon Tetrachloride	170	
77.0	DMLS-OW-4B5	9/23/1998	Carbon Tetrachloride	290	
77.5	DMLS-OW-4B6	9/23/1998	Carbon Tetrachloride	150	
78.0	DMLS-OW-4B7	9/23/1998	Carbon Tetrachloride	180	
78.5	DMLS-OW-4B8	9/23/1998	Carbon Tetrachloride	210	
79.0	DMLS-OW-4B9	9/23/1998	Carbon Tetrachloride	210	
79.5	DMLS-OW-4B10	9/23/1998	Carbon Tetrachloride	210	
80.0	DMLS-OW-4B11	9/23/1998	Carbon Tetrachloride	210	
80.5	DMLS-OW-4B12	9/23/1998	Carbon Tetrachloride	210	
81.0	DMLS-OW-4B13	9/23/1998	Carbon Tetrachloride	160	
81.5	DMLS-OW-4B14	9/23/1998	Carbon Tetrachloride	220	
82.0	DMLS-OW-4B15	9/23/1998	Carbon Tetrachloride	170	
82.5	DMLS-OW-4B16	9/23/1998	Carbon Tetrachloride	190	
83.0	DMLS-OW-4B17	9/23/1998	Carbon Tetrachloride	180	
83.5	DMLS-OW-4B18	9/23/1998	Carbon Tetrachloride	190	
84.0	DMLS-OW-4B19	9/23/1998	Carbon Tetrachloride	220	
84.5	DMLS-OW-4B20	9/23/1998	Carbon Tetrachloride	180	
85.0	DMLS-0W-4B21	9/23/1998	Carbon Tetrachloride	210	
85.5	DMLS-0W-4B22	9/23/1998	Carbon Tetrachloride	230	
86.0	DMLS-0W-4B23	9/23/1998	Carbon Tetrachloride	180	
86.5	DMLS-0W-4B24	9/23/1998	Carbon Tetrachloride	190	

Table 3-6 (Cont'd)
Results of DMLS Sampling and Analysis

Well X-1B, S-2 Zone in Pesticide Plume

Sample Depth (ft bgs)	Sample Number	Date	Compound	Result (µg/L)	Lab Qualifier
66.0	DMSLX-1B1	11/30/1998	1,2-Dichloropropane	4,200	
66.5	DMSLX-1B2	11/30/1998	1,2-Dichloropropane	3,700	
67.0	DMSLX-1B3	11/30/1998	1,2-Dichloropropane	3,200	
67.5	DMSLX-1B4	11/30/1998	1,2-Dichloropropane	3,200	
68.0	DMSLX-1B5	11/30/1998	1,2-Dichloropropane	3,900	
68.5	DMSLX-1B6	11/30/1998	1,2-Dichloropropane	2,900	J
69.0	DMSLX-1B7	11/30/1998	1,2-Dichloropropane	3,000	
69.5	DMSLX-1B8	11/30/1998	1,2-Dichloropropane	3,100	
70.0	DMSLX-1B9	11/30/1998	1,2-Dichloropropane	3,100	
70.5	DMSLX-1B10	11/30/1998	1,2-Dichloropropane	3,200	
71.0	DMSLX-1B11	11/30/1998	1,2-Dichloropropane	3,100	
71.5	DMSLX-1B12	11/30/1998	1,2-Dichloropropane	4,600	
72.0	DMSLX-1B13	11/30/1998	1,2-Dichloropropane	4,900	
72.5	DMSLX-1B14	11/30/1998	1,2-Dichloropropane	4,900	
73.0	DMSLX-1B15	11/30/1998	1,2-Dichloropropane	4,800	J
73.5	DMSLX-1B16	11/30/1998	1,2-Dichloropropane	5,000	
74.0	DMSLX-1B17	11/30/1998	1,2-Dichloropropane	5,400	
74.5	DMSLX-1B18	11/30/1998	1,2-Dichloropropane	4,300	
75.0	DMSLX-1B19	11/30/1998	1,2-Dichloropropane	4,600	
75.5	DMSLX-1B20	11/30/1998	1,2-Dichloropropane	4,600	
76.0	DMSLX-1B21	11/30/1998	1,2-Dichloropropane	4,800	
76.5	DMSLX-1B22	11/30/1998	1,2-Dichloropropane	5,200	
77.0	DMSLX-1B23	11/30/1998	1,2-Dichloropropane	2,200	
77.5	DMSLX-1B24	11/30/1998	1,2-Dichloropropane	4,000	

Table 3-6 (Cont'd)
Results of DMLS Sampling and Analysis
Well MW-7B, S-1 Zone in Pesticide Plume

Sample Depth (ft bgs)	Sample Number	Date	Compound	Result (µg/L)	Lab Qualifier
36.0	MW-7B1	10/14/1998	1,2,3-Trichloropropane	110	J
36.5	MW-7B2	10/14/1998	1,2,3-Trichloropropane	100	J
37.0	MW-7B3	10/14/1998	1,2,3-Trichloropropane	100	J
37.5	MW-7B4	10/14/1998	1,2,3-Trichloropropane	110	J
38.0	MW-7B5	10/14/1998	1,2,3-Trichloropropane	110	J
38.5	MW-7B6	10/14/1998	1,2,3-Trichloropropane	120	J
39.0	MW-7B7	10/14/1998	1,2,3-Trichloropropane	110	J
39.5	MW-7B8	10/14/1998	1,2,3-Trichloropropane	120	J
40.0	MW-7B9	10/14/1998	1,2,3-Trichloropropane	120	J
40.5	MW-7B10	10/14/1998	1,2,3-Trichloropropane	130	J
41.0	MW-7B11	10/14/1998	1,2,3-Trichloropropane	130	J
41.5	MW-7B12	10/14/1998	1,2,3-Trichloropropane	110	J
42.0	MW-7B13	10/14/1998	1,2,3-Trichloropropane	160	J
42.5	MW-7B14	10/14/1998	1,2,3-Trichloropropane	140	J
43.0	MW-7B15	10/14/1998	1,2,3-Trichloropropane	130	J
43.5	MW-7B16	10/14/1998	1,2,3-Trichloropropane	71	J
44.0	MW-7B17	10/14/1998	1,2,3-Trichloropropane	48	J
46.0	MW-7B21	10/14/1998	1,2,3-Trichloropropane	54	J
47.0	MW-7B23	10/14/1998	1,2,3-Trichloropropane	100	J
47.5	MW-7B24	10/14/1998	1,2,3-Trichloropropane	120	J
42.0	MW-7B13	10/14/1998	1,2-Dibromoethane	55	J
42.5	MW-7B14	10/14/1998	1,2-Dibromoethane	180	J
43.0	MW-7B15	10/14/1998	1,2-Dibromoethane	110	J
36.0	MW-7B1	10/14/1998	1,2-Dichloropropane	2,000	
36.5	MW-7B2	10/14/1998	1,2-Dichloropropane	1,900	
37.0	MW-7B3	10/14/1998	1,2-Dichloropropane	2,100	
37.5	MW-7B4	10/14/1998	1,2-Dichloropropane	2,100	
38.0	MW-7B5	10/14/1998	1,2-Dichloropropane	2,200	
38.5	MW-7B6	10/14/1998	1,2-Dichloropropane	2,300	
39.0	MW-7B7	10/14/1998	1,2-Dichloropropane	2,200	
39.5	MW-7B8	10/14/1998	1,2-Dichloropropane	2,400	
40.0	MW-7B9	10/14/1998	1,2-Dichloropropane	2,600	
40.5	MW-7B10	10/14/1998	1,2-Dichloropropane	2,500	
41.0	MW-7B11	10/14/1998	1,2-Dichloropropane	3,100	
41.5	MW-7B12	10/14/1998	1,2-Dichloropropane	2,500	
42.0	MW-7B13	10/14/1998	1,2-Dichloropropane	3,200	
42.5	MW-7B14	10/14/1998	1,2-Dichloropropane	2,900	
43.0	MW-7B15	10/14/1998	1,2-Dichloropropane	2,800	
43.5	MW-7B16	10/14/1998	1,2-Dichloropropane	2,600	
44.0	MW-7B17	10/14/1998	1,2-Dichloropropane	2,800	
44.5	MW-7B18	10/14/1998	1,2-Dichloropropane	2,900	
45.0	MW-7B19	10/14/1998	1,2-Dichloropropane	3,200	
45.5	MW-7B20	10/14/1998	1,2-Dichloropropane	2,400	
46.0	MW-7B21	10/14/1998	1,2-Dichloropropane	3,400	
46.5	MW-7B22	10/14/1998	1,2-Dichloropropane	1,000	
47.0	MW-7B23	10/14/1998	1,2-Dichloropropane	3,800	
47.5	MW-7B24	10/14/1998	1,2-Dichloropropane	3,900	

Table 3-7
DNAPL Assessment and Indicators

Well	Compound	Date	Maximum Detected Since May 1996 (µg/L)	Concentrations (moles/liter)	Solubility Limit (moles/liter)	Saturation (molar)	Combined EDB and DCP Saturation
MW-7A	1,2-Dibromoethane	10/23/97	300	1.6E-06	1.81E-02	0.009%	
MW-7A	1,2-Dichloropropane	5/20/96	760	6.7E-06	2.39E-02	0.028%	0.037%
MW-7B	1,2-Dibromoethane	10/8/96	7,600	4.0E-05	1.81E-02	0.223%	
MW-7B	1,2-Dichloropropane	5/29/96	14,000	1.2E-04	2.39E-02	0.518%	0.742%
MW-7C	1,2-Dibromoethane	5/29/96	4,900	2.6E-05	1.81E-02	0.144%	
MW-7C	1,2-Dichloropropane	5/29/96	8,000	7.1E-05	2.39E-02	0.296%	0.440%
MW-8A	1,2-Dibromoethane	5/29/96	810	4.3E-06	1.81E-02	0.024%	
MW-8A	1,2-Dichloropropane	5/29/96	7,000	6.2E-05	2.39E-02	0.259%	0.283%
MW-11A	1,2-Dibromoethane	5/24/96	55	2.9E-07	1.81E-02	0.002%	
MW-11A	1,2-Dichloropropane	5/24/96	300	2.7E-06	2.39E-02	0.011%	0.013%
MW-11B	1,2-Dibromoethane	5/28/96	560	3.0E-06	1.81E-02	0.016%	
MW-11B	1,2-Dichloropropane	5/28/96	2,200	1.9E-05	2.39E-02	0.081%	0.098%
X-1A	1,2-Dibromoethane	5/29/96	3,900	2.1E-05	1.81E-02	0.115%	
X-1A	1,2-Dichloropropane	5/29/96	9,600	8.5E-05	2.39E-02	0.355%	0.470%
X-1B	1,2-Dibromoethane	10/9/96	19,000	1.0E-04	1.81E-02	0.559%	
X-1B	1,2-Dichloropropane	10/9/96	21,000	1.9E-04	2.39E-02	0.778%	1.336%

Table 4-1
Results of VLEACH Modeling

VLEACH™ Results				Calculation to Estimate Groundwater Concentration from Leachate Impact in S1 Zone								
Soil COC	Scenario	Estimated Maximum Groundwater Impact, m ($g/yr/ft^2$)	Year of Maximum Impact	Hydraulic Conductivity, K (cm/sec)	Hydraulic Gradient, I (ft/ft)	S-1 Zone Thickness D (ft)	Infiltration Rate, q_v (ft/yr)	Length of Plume Parallel to Groundwater Flow, L_v (ft)	Leachate Concentration C_v $=m/q_v$ (µg/l)	Aquifer-Leachate Mixing Factor LMF = $(KID + q_vL_v)/(q_vL_v)$	Diluted Concentration in S-1 Zone C_{ws} (µg/L)	Groundwater MCL Criteria (µg/L)
DCP	1995 Soil	0.0269	10	0.0095	0.0036	10	0.35	100	2595	11.14	233	5.00
	Low Infiltration	0.0135	20	0.0095	0.0036	10	0.175	100	2718	21.27	128	5.00
	Maximum f_{oc}	0.0175	15	0.0095	0.0036	10	0.35	100	1771	11.14	159	5.00
	Minimum f_{oc}	0.0431	5	0.0095	0.0036	10	0.35	100	4353	11.14	391	5.00
	No Impact	0.0005	1	0.0095	0.0036	10	0.35	100	50	11.14	4.5	5.00
EDB	1995 Soil	0.0115	5	0.0095	0.0036	10	0.35	100	1163	11.14	104	0.05
	No Impact	0.000006	1	0.0095	0.0036	10	0.35	100	1	11.14	0.05	0.05
DBCP	1995 Soil	0.0005	5	0.0095	0.0036	10	0.35	100	46	11.14	4	0.20
	No Impact	0.00002	1	0.0095	0.0036	10	0.35	100	2	11.14	0.2	0.20
CCL_4	No Impact	0.0005	1	0.0095	0.0036	10	0.35	100	50	11.14	4.5	5.00
Benzene	No Impact	0.0005	1	0.0095	0.0036	10	0.35	100	50	11.14	4.5	5.00
TCE	No Impact	0.0005	1	0.0095	0.0036	10	0.35	100	50	11.14	4.5	5.00
PCE	No Impact	0.0005	1	0.0095	0.0036	10	0.35	100	50	11.14	4.5	5.00

Table 4-2
No-Groundwater-Impact Scenarios

Chemical of Concern	Estimated Maximum Allowable Soil Concentration (µg/kg)	Vertically Averaged Sample Soil Concentration (1995 sampling event) (µg/kg)
DCP	20.0	645
EDB	0.18	158
DBCP	1.20	11.6
CCL_4	90	ND
Benzene	22	ND
TCE	35	ND
PCE	125	ND

ND – Not detected

Table 5-1
Results of Flux-Chamber Investigation

Case No.: MR958-00 Memo #01
Site: Frontier Fertilizer
Lab.: Environmental Analytical Services (EAS)
Reviewer: Frank Arceneaux, ESAT/Lockheed
Date: April 2, 1998

Analysis Type: Ambient Air Samples for Volatile Organics by EPA Method TO-14

Lab Sample I.D.	70454-24					70454-23					70454-20					70454-21					70454-22					70454-18				
Field Sample I.D.	FLX-1					FLX-2					FLX-3					FLX-4					FLX-5					FLX-6				
Date of Collection	10/8/97					10/8/97					10/8/97					10/8/97					10/8/97					10/8/97				
Parameter	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration in ppbv	Concentration in µg/m³	Flux in µg/(min*m²)	Val	Com
1,1,2-Trichloroethane	0.030 U					0.030 U					0.030 U					0.030 U					0.030 U					0.030 U				
Vinyl chloride	0.012 U			J	C	0.012 U			J	C	0.012 U			J	C	0.012 U			J	C	0.012 U			J	C	0.014 L	0.037	0.0014	J	AC
Bromomethane	0.20 U					0.21 U					0.20 U					0.20 U					0.21 U					0.22 U				
1,1-Dichloroethene	0.007 U			J	C	0.007 U			J	C	0.045 L	0.123	0.0047	J	AC	0.007 U			J	C	0.007 U			J	C	0.73 L	2.00	0.077	J	A
Methylene chloride	0.26 U	0.94	0.036	J	B	0.49 U	1.76	0.068	J	B	0.33 U	1.20	0.046	J	B	0.31 U	1.12	0.043	J	B	0.23 U	0.82	0.031	J	B	0.40 U	1.42	0.055	J	B
1,1-Dichloroethane	0.06 U					0.06 U					0.06 U					0.06 U					0.06 U					0.06 U				
Chloroform	0.19 L	0.97	0.037	J	A	0.076 L	0.380	0.0149	J	AC	0.089 L	0.448	0.0172	J	AC	0.016 L	0.080	0.0031	J	AC	0.017 L	0.084	0.0032	J	AC	0.070 L	0.350	0.0135	J	AC
1,1,1-Trichloroethane	0.03 U					0.03 U					0.03 U					0.03 U					0.03 U					0.03 U				
1,2-Dichloroethane	0.011 L	0.047	0.0018	J	AC	0.007 U			J	C	0.007 U			J	C	0.007 U			J	C	0.007 U			J	C	0.007 U			J	C
Benzene	0.17 U	0.55	0.021	J	B	0.19 U	0.64	0.024	J	B	0.16 U	0.53	0.021	J	B	0.38 L	1.24	0.048	J	A	0.14 U	0.46	0.018	J	B	0.22 U	0.72	0.028	J	B
Carbon tetrachloride	0.092 L	0.599	0.0231	J	AC	0.019 L	0.126	0.0048	J	AC	0.019 L	0.123	0.0047	J	AC	0.042 L	0.275	0.0106	J	AC	0.021 L	0.139	0.0053	J	AC	0.030 L	0.192	0.0074	J	AC
1,2-Dichloropropane	0.46 L	2.22	0.085	J	A	0.90	4.31	0.166			0.042 L	0.198	0.0076	J	AC	15.23	72.68	2.798			2.02	9.66	0.372			0.121 L	0.576	0.0222	J	AC
Trichloroethene	0.03 U					0.03 U					0.70 L	3.90	0.150	J	A	0.03 U					0.03 U					3.74	20.67	0.796		
Bromodichloromethane	0.005 U			J	C	0.005 L	0.033	0.0013	J	AC	0.005 U			J	C	0.007 L	0.050	0.0019	J	AC	0.015 L	0.107	0.0041	J	AC	0.014 L	0.096	0.0037	J	AC
trans-1,3-Dichloropropene	0.014 L	0.067	0.0026	J	AC	0.002 U			J	C	0.002 U			J	C	0.002 U			J	C	0.002 U			J	C	0.002 U			J	C
cis-1,3-Dichloropropene	0.019 L	0.087	0.0034	J	AC	0.007 U			J	CF	0.007 U			J	C	0.014 L	0.065	0.0025	J	ACF	0.007 U			J	CF	0.007 U			J	C
Toluene	0.23 L	0.90	0.035	J	A	2.57 L	9.99	0.385	J	A	2.04 L	7.95	0.306	J	A	0.93 L	3.62	0.139	J	A	0.49 L	1.89	0.073	J	A	19.66	76.46	2.944		
1,2-Dibromoethane	0.007 U			J	C	0.007 U			J	C	0.007 U			J	C	0.008 L	0.061	0.0023	J	AC	0.007 U			J	C	0.007 U			J	C
Tetrachloroethene	0.06 U					0.97 L	6.83	0.263	J	A	0.08 L	0.54	0.021	J	A	0.06 U					0.06 U					0.78 L	5.49	0.211	J	A
Chlorobenzene	0.12 U					0.12 U					0.12 U					0.12 U					0.12 U					0.12 U				
Xylene (meta- & para-)	0.20 U					0.39 L	1.73	0.066	J	A	1.16 L	5.21	0.201	J	A	0.25 L	1.12	0.043	J	A	0.21 U					12.57	56.28	2.167		
Bromoform	1.46 U			J	DG	1.48 U			J	DG	1.45 U			J	DG	1.46 U			J	DG	1.49 U			J	DG	1.55 U			J	DG
Xylene (ortho)	0.09 U					0.09 U					0.44 L	1.98	0.076	J	A	0.09 U					0.09 U					4.87 L	21.79	0.839	J	A
1,2,3-Trichloropropane	0.082 U			J	C	0.083 U			J	C	0.081 U			J	C	0.554	5.530	0.2129	J	C	0.083 U			J	C	0.087 U			J	C
1,4-Dichlorobenzene	0.056 U			J	CEF	0.057 U			J	CE	0.056 U			J	C	0.056 U			J	CE	0.057 U			J	CE	0.060 U			J	C
1,2-Dichlorobenzene	0.20 U			J	D	0.21 U			J	D	0.20 U			J	D	0.20 U			J	D	0.21 U			J	D	0.22 U			J	D
1,2-Dibromo-3-chloropropane	38.83	241.68	9.305			19.18 U				G	18.85 U				G	19.01 U				G	19.34 U				G	20.15 U				G
Xylenes (total)	0.29 U					0.39 L	1.73	0.066	J	A	1.61 L	7.19	0.277	J	A	0.29 U					0.30 U					17.44	78.06	3.005		

Lab Sample I.D.	70454-19					70454-8					70454-9					70454-10					70454-25					70454-12				
Field Sample I.D.	FLX-6R					FLX-7					FLX-8					FLX-9					FLX-10					FLX-11				
Date of Collection	10/8/97					10/8/97					10/8/97					10/8/97					10/8/97					10/8/97				
Parameter	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration in ppbv	Concentration in µg/m³	Flux in µg/(min*m²)	Val	Com
1,1,2-Trichloroethane	0.030 U					0.030 U					0.030 U					0.030 U					0.030 U					0.030 U				
Vinyl chloride	0.012 U			J	C	0.012 U			J	C	0.012 U			J	C	0.012 U			J	C	0.012 U			J	C	0.020 L	0.054	0.0021	J	AC
Bromomethane	0.22 U					0.21 U					0.22 U					0.22 U					0.21 U					0.21 U				
1,1-Dichloroethene	0.007 U			J	C	0.29 L	0.78	0.030	J	A	0.007 U			J	C	0.026 L	0.071	0.0027	J	AC	0.007 U			J	C	0.020 L	0.054	0.0021	J	AC
Methylene chloride	0.33 U	1.18	0.045	J	B	0.52 U	1.88	0.072	J	B	0.37 U	1.32	0.051	J	B	0.44 U	1.56	0.060	J	B	0.32 U	1.14	0.044	J	B	0.54 U	1.94	0.075	J	B
1,1-Dichloroethane	0.06 U					0.06 U					0.06 U					0.06 U					0.06 U					0.06 U				
Chloroform	0.071 L	0.358	0.0138	J	AC	0.065 L	0.324	0.0125	J	AC	0.024 L	0.118	0.0045	J	AC	0.219 L	1.099	0.0423	J	AC	0.026 L	0.129	0.0049	J	AC	0.58 L	2.89	0.111	J	A
1,1,1-Trichloroethane	0.03 U					0.13 L	0.72	0.028	J	A	0.03 U					0.03 U					0.03 U					0.03 U				
1,2-Dichloroethane	0.007 U			J	C	0.350 L	1.465	0.0564	J	AC	0.008 L	0.032	0.0012	J	AC	0.007 U			J	C	0.007 U			J	C	0.010 L	0.042	0.0016	J	AC
Benzene	0.07 U	0.24	0.009	J	B	0.40 L	1.32	0.051	J	A	0.23 U	0.77	0.030	J	B	0.36 L	1.18	0.045	J	A	0.27 U	0.90	0.035	J	B	0.32 U	1.06	0.041	J	B
Carbon tetrachloride	0.034 L	0.220	0.0085	J	AC	0.113 L	0.735	0.0283	J	AC	0.053 L	0.347	0.0133	J	AC	0.088 L	0.569	0.0219	J	AC	0.063 L	0.412	0.0159	J	AC	0.156 L	1.014	0.0390	J	AC
1,2-Dichloropropane	0.130 L	0.618	0.0238	J	AC	0.030 L	0.143	0.0055	J	AC	0.018 L	0.086	0.0033	J	AC	0.011 L	0.054	0.0021	J	AC	0.011 L	0.054	0.0021	J	AC	0.010 U			J	C
Trichloroethene	0.03 U					1.84 L	10.16	0.391	J	A	0.03 U					0.03 U					0.03 U					0.03 U				
Bromodichloromethane	0.005 U			J	C	0.005 U			J	C	0.006 L	0.038	0.0015	J	AC	0.005 L	0.037	0.0014	J	AC	0.005 U			J	C	0.007 L	0.051	0.0020	J	AC
trans-1,3-Dichloropropene	0.002 U			J	C	0.002 U			J	C	0.002 U			J	C	0.002 U			J	C	0.002 U			J	C	0.002 U			J	C
cis-1,3-Dichloropropene	0.007 U			J	C	0.007 U			J	C	0.007 U			J	C	0.007 U			J	C	0.007 U			J	C	0.007 U			J	C
Toluene	0.28 L	1.07	0.041	J	A	7.38	28.69	1.104			0.45 L	1.74	0.067	J	A	1.08 L	4.20	0.162	J	A	3.34 L	12.97	0.500	J	A	0.50 L	1.95	0.075	J	A
1,2-Dibromoethane	0.007 U			J	C	0.007 U			J	C	0.007 U			J	C	0.007 U			J	C	0.007 U			J	C	0.007 U			J	C
Tetrachloroethene	0.06 U					1.70 L	11.91	0.459	J	A	0.06 U					0.06 U					0.06 U					0.06 U				
Chlorobenzene	0.12 U					0.14 L	0.68	0.026	J	A	0.12 U					0.12 U					0.12 U					0.12 U				
Xylene (meta- & para-)	0.22 U					2.73 L	12.21	0.470	J	A	0.25 L	1.14	0.044	J	A	0.64 L	2.86	0.110	J	A	0.33 L	1.49	0.057	J	A	0.27 L	1.19	0.046	J	A
Bromoform	1.55 U			J	DG	1.50 U			J	DG	1.54 U			J	DG	1.55 U			J	DG	1.49 U			J	DG	1.53 U			J	DG
Xylene (ortho)	0.09 U					1.52 L	6.82	0.262	J	A	0.09 U					0.15 L	0.69	0.026	J	A	0.09 U					0.09 U				
1,2,3-Trichloropropane	0.087 U			J	C	0.084 U			J	C	0.086 U			J	C	0.087 U			J	C	0.083 U			J	C	0.085 U			J	C
1,4-Dichlorobenzene	0.060 U			J	CE	0.058 U			J	CE	0.059 U			J	CE	0.060 U			J	C	0.057 U			J	C	0.059 U			J	C
1,2-Dichlorobenzene	0.22 U			J	D	0.21 U			J	D	0.22 U			J	D	0.22 U			J	D	0.21 U			J	D	0.21 U				
1,2-Dibromo-3-chloropropane	20.15 U				G	19.50 U				G	19.99 U				G	20.15 U				G	19.34 U				G	19.83 U				G
Xylenes (total)	0.31 U					4.25 L	19.03	0.733	J	A	0.31 U					0.79 L	3.55	0.137	J	A	0.33 L	1.49	0.057	J	A	0.31 U				

Table 5-1
Results of Flux-Chamber Investigation

Lab Sample I.D.	70454-11					70454-15					70454-13					70454-14					70454-17					70454-16				
Field Sample I.D.	FLX-12					FLX-13					FLX-14					FLX-14R					FLX-15					FLX-16				
Date of Collection	10/8/97					10/8/97					10/8/97					10/8/97					10/8/97					10/8/97				
Parameter	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com
1,1,2-Trichloroethane	0.030	U				0.030	U				0.030	U				0.030	U				0.030	U				0.030	U			
Vinyl chloride	0.012	U		J	C	0.017	L	0.045	0.0017	J	AC	0.013	U		J	C	0.012	U		J	C	0.012	U		J	C	0.012	U		J	C
Bromomethane	0.21	U				0.67	L	2.68	0.103	J	A	0.22	U				0.21	U				0.80	L	3.21	0.124	J	A	0.21	U			
1,1-Dichloroethene	0.020	L	0.055	0.0021	J	AC	0.019	L	0.053	0.0020	J	AC	0.008	U		J	C	0.028	L	0.077	0.0029	J	AC	0.027	L	0.074	0.0028	J	AC	0.024	L	0.064	0.0025	J	AC
Methylene chloride	0.33	U	1.18	0.046	J	B	0.86	U	3.09	0.119	J	B	0.89	U	3.19	0.123	J	B	0.38	U	1.35	0.052	J	B	0.83	U	2.96	0.114	J	B	0.42	U	1.51	0.058	J	B
1,1-Dichloroethane	0.06	U				0.06	U				0.06	U				0.06	U				0.06	U				0.06	U			
Chloroform	0.016	L	0.079	0.0031	J	AC	0.109	L	0.549	0.021	J	AC	0.020	L	0.102	0.0039	J	AC	0.014	L	0.071	0.0027	J	AC	0.037	L	0.186	0.0071	J	AC	0.013	L	0.066	0.0025	J	AC
1,1,1-Trichloroethane	0.03	U				0.03	U				0.03	U				0.03	U				0.03	U				0.03	U			
1,2-Dichloroethane	0.007	U		J	C	0.007	U			J	C	0.009	L	0.036	0.0014	J	AC	0.007	U		J	C	0.007	U		J	C	0.007	U		J	C
Benzene	0.38	L	1.27	0.049	J	A	0.27	U	0.90	0.035	J	B	0.30	U	1.00	0.038	J	B	0.32	U	1.05	0.040	J	B	0.61	L	2.00	0.077	J	A	0.26	U	0.86	0.033	J	B
Carbon tetrachloride	0.055	L	0.358	0.0138	J	AC	0.092	L	0.601	0.0231	J	AC	0.085	L	0.552	0.0213	J	AC	0.065	L	0.424	0.0163	J	AC	0.100	L	0.649	0.0250	J	AC	0.074	L	0.480	0.0185	J	AC
1,2-Dichloropropane	0.010	U		J	C	0.010	U			J	C	0.010	U			J	C	0.010	U			J	C	0.010	U			J	C	0.010	U			J	C
Trichloroethene	0.03	U				0.03	U				0.03	U				0.03	U				0.03	U				0.03	U			
Bromodichloromethane	0.005	U		J	C	0.005	L	0.034	0.0013	J	AC	0.005	U			J	C	0.005	U			J	C	0.005	U			J	C	0.005	U			J	C
trans-1,3-Dichloropropene	0.002	U		J	C	0.002	U			J	C	0.003	U			J	C	0.002	U			J	C	0.002	U			J	C	0.002	U			J	C
cis-1,3-Dichloropropene	0.007	U		J	C	0.007	U			J	C	0.008	U			J	C	0.007	U			J	C	0.007	U			J	C	0.007	U			J	C
Toluene	0.95	L	3.69	0.142	J	A	0.70	L	2.72	0.105	J	A	2.27	L	8.83	0.340	J	A	0.83	L	3.24	0.125	J	A	1.26	L	4.88	0.188	J	A	0.61	L	2.39	0.092	J	A
1,2-Dibromoethane	0.007	U		J	C	0.007	U			J	C	0.008	U			J	C	0.007	U			J	C	0.007	U			J	C	0.007	U			J	C
Tetrachloroethene	0.06	U				0.06	U				0.06	U				0.06	U				0.06	U				0.06	U			
Chlorobenzene	0.12	U				0.12	U				0.13	U				0.12	U				0.12	U				0.12	U			
Xylene (meta- & para-)	0.98	L	4.39	0.169	J	A	0.57	L	2.55	0.098	J	A	2.86	L	12.80	0.493	J	A	0.94	L	4.22	0.162	J	A	0.43	L	1.93	0.074	J	A	0.21	U				
Bromoform	1.51	U		J	DG	1.50	U			J	DG	1.56	U			J	DG	1.50	U			J	DG	1.55	U			J	DG	1.53	U			J	DG
Xylene (ortho)	0.22	L	0.99	0.038	J	A	0.17	L	0.74	0.029	J	A	1.06	L	4.74	0.183	J	A	0.29	L	1.29	0.050	J	A	0.90	U					0.09	U				
1,2,3-Trichloropropane	0.085	U		J	C	0.084	U			J	C	0.088	U			J	C	0.084	U			J	C	0.087	U			J	C	0.085	U			J	C
1,4-Dichlorobenzene	0.058	U		J	CE	0.058	U			J	CE	0.060	U			J	C	0.058	U			J	C	0.060	U			J	CE	0.059	U			J	CE
1,2-Dichlorobenzene	0.21	U				0.21	U					0.22	U					0.21	U					0.22	U					0.21	U				
1,2-Dibromo-3-chloropropane	19.66	U			G	19.50	U				G	20.31	U				G	19.50	U				G	20.15	U				G	19.83	U				G
Xylenes (total)	1.20	L	5.37	0.207	J	A	0.74	L	3.30	0.127	J	A	3.92	L	17.54	0.675	J	A	1.23	L	5.51	0.212	J	A	0.43	L	1.93	0.074	J	A	0.31	U				

Lab Sample I.D.	70454-2					70454-1					70454-4					70454-3					70454-7					70454-6				
Field Sample I.D.	FLX-17					FLX-18					FLX-19					FLX-20					FLX-22					FLX-23				
Date of Collection	10/8/97					10/8/97					10/8/97					10/8/97					10/8/97					10/8/97				
Parameter	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com	Concentration ppbv	Concentration µg/m³	Flux µg/(min*m²)	Val	Com
1,1,2-Trichloroethane	0.030	U				0.030	U				0.030	U				0.030	U				0.030	U				0.030	U			
Vinyl chloride	0.011	U		J	C	0.011	U			J	C	0.012	U		J	C	0.012	U		J	C	0.011	U		J	C	0.012	U		J	C
Bromomethane	0.20	U				0.20	U					0.20	U				0.20	U				0.20	U				0.20	U			
1,1-Dichloroethene	0.007	U		J	C	0.007	U			J	C	0.007	U			J	C	0.007	U			J	C	0.007	U		J	C	0.007	U			J	C
Methylene chloride	0.41	U	1.46	0.056	J	B	0.47	U	1.69	0.065	J	B	0.39	U	1.41	0.054	J	B	0.42	U	1.50	0.058	J	B	0.23	U	0.84	0.032	J	B	0.48	U	1.74	0.067	J	B
1,1-Dichloroethane	0.06	U				0.06	U				0.06	U				0.06	U				0.06	U				0.06	U			
Chloroform	0.015	L	0.074	0.0028	J	AC	0.013	L	0.065	0.0025	J	AC	0.015	L	0.075	0.0029	J	AC	0.011	L	0.056	0.0022	J	AC	0.131	L	0.661	0.0254	J	AC	0.020	L	0.100	0.0038	J	AC
1,1,1-Trichloroethane	0.03	U				0.03	U				0.03	U				0.03	U				0.03	U				0.03	U			
1,2-Dichloroethane	0.007	U		J	C	0.007	U			J	C	0.007	U			J	C	0.007	U			J	C	0.007	U		J	C	0.007	U			J	C
Benzene	0.33	U	1.09	0.042	J	B	0.64	L	2.12	0.082	J	A	0.20	U	0.67	0.026	J	B	0.25	U	0.83	0.032	J	B	0.13	U	0.45	0.017	J	B	0.22	U	0.71	0.027	J	B
Carbon tetrachloride	0.086	L	0.559	0.0215	J	AC	0.089	L	0.580	0.0223	J	AC	0.100	L	0.649	0.0250	J	AC	0.076	L	0.494	0.0190	J	AC	0.028	L	0.185	0.0071	J	AC	0.092	L	0.599	0.0231	J	AC
1,2-Dichloropropane	0.009	U		J	C	0.009	U			J	C	0.009	U			J	C	0.009	U			J	C	0.009	U			J	C	0.009	U			J	C
Trichloroethene	0.03	U				0.03	U					0.03	U					0.03	U					0.03	U					0.03	U				
Bromodichloromethane	0.005	U		J	C	0.005	U			J	C	0.005	U			J	C	0.005	U			J	C	0.005	U			J	C	0.005	U			J	C
trans-1,3-Dichloropropene	0.002	U		J	C	0.002	U			J	C	0.002	U			J	C	0.002	U			J	C	0.002	U			J	C	0.002	U			J	C
cis-1,3-Dichloropropene	0.007	U		J	C	0.007	U			J	C	0.007	U			J	C	0.007	U			J	C	0.007	U			J	C	0.007	U			J	C
Toluene	0.59	L	2.30	0.088	J	A	1.21	L	4.72	0.182	J	A	0.34	L	1.32	0.051	J	A	0.43	L	1.65	0.064	J	A	0.19	L	0.74	0.029	J	A	0.75	L	2.90	0.112	J	A
1,2-Dibromoethane	0.007	U		J	C	0.007	U			J	C	0.007	U			J	C	0.007	U			J	C	0.007	U			J	C	0.007	U			J	C
Tetrachloroethene	0.06	U				0.42	L	2.96	0.114	J	A	0.06	U					0.06	U					0.06	U					0.06	U				
Chlorobenzene	0.11	U				0.11	U					0.12	U					0.12	U					0.11	U					0.12	U				
Xylene (meta- & para-)	0.22	L	0.97	0.038	J	A	0.37	L	1.64	0.063	J	A	0.20	U					0.20	U					0.20	U					0.20	U				
Bromoform	1.43	U		J	DG	1.43	U			J	DG	1.45	U			J	DG	1.44	U			J	DG	1.43	U			J	DG	1.46	U			J	DG
Xylene (ortho)	0.09	U				0.09	L	0.41	0.016	J	A	0.09	U					0.09	U					0.09	U					0.09	U				
1,2,3-Trichloropropane	0.080	U		J	C	0.080	U			J	C	0.081	U			J	C	0.081	U			J	C	0.080	U			J	C	0.082	U			J	C
1,4-Dichlorobenzene	0.055	U		J	CE	0.055	U			J	CE	0.056	U			J	CE	0.055	U			J	CE	0.055	U			J	C	0.056	U			J	CE
1,2-Dichlorobenzene	0.20	U				0.20	U					0.20	U					0.20	U					0.20	U					0.20	U				
1,2-Dibromo-3-chloropropane	18.53	U			G	18.53	U				G	18.85	U				G	18.69	U				G	18.53	U				G	19.01	U				G
Xylenes (total)	0.29	U				0.46	L	2.04	0.079	J	A	0.29	U					0.29	U					0.29	U					0.29	U				

Table 5-1
Results of Flux-Chamber Investigation

Lab Sample I.D.	70454-5					
Field Sample I.D.	FLX-24					
Date of Collection	10/8/97					
Parameter	Concentration ppbv		Concentration µg/m³	Flux µg/(min*m²)	Val	Com
1,1,2-Trichloroethane	0.030	U				
Vinyl chloride	0.012	U			J	C
Bromomethane	0.20	U				
1,1-Dichloroethene	0.007	U			J	C
Methylene chloride	0.34	U	1.24	0.048	J	B
1,1-Dichloroethane	0.06	U				
Chloroform	0.013	L	0.063	0.0024	J	AC
1,1,1-Trichloroethane	0.03	U				
1,2-Dichloroethane	0.007	U			J	C
Benzene	0.19	U	0.62	0.024	J	B
Carbon tetrachloride	0.046	L	0.297	0.0114	J	AC
1,2-Dichloropropane	0.009	U			J	C
Trichloroethene	0.03	U				
Bromodichloromethane	0.005	U			J	C
trans-1,3-Dichloropropene	0.002	U			J	C
cis-1,3-Dichloropropene	0.007	U			J	C
Toluene	0.27	L	1.05	0.040	J	A
1,2-Dibromoethane	0.007	U			J	C
Tetrachloroethene	0.06	U				
Chlorobenzene	0.12	U				
Xylene (meta- & para-)	0.20	U				
Bromoform	1.46	U			J	DG
Xylene (ortho)	0.09	U				
1,2,3-Trichloropropane	0.082	U			J	C
1,4-Dichlorobenzene	0.056	U			J	CE
1,2-Dichlorobenzene	0.20	U			J	D
1,2-Dibromo-3-chloropropane	19.01	U				G
Xylenes (total)	0.29	U				

MDL-Method Detection Limit. CRQL-Contract Required Quantitation Limit.
D1, D2, etc. -Field Duplicate Pai FB-Field Blank, EB-Equipment Blank,
TB-Trip Blank, BG-Background Sample,NA-Not Available
*See following pages

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
L Indicates results which fall below the Contract Required Quantitation Limit. Results are estimated and are considered qualitatively acceptable but quantitatively unreliable due to uncertainties in the analytical precision near the limit of detection.
J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
N The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification."
NJ The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Explanation for Table 5-1

A. The following results, denoted with an "L" qualifier, are estimated and flagged "J" in Table 5-1.

- All results below the contract required quantitation limits.

  Results below the contract required quantitation limits (CRQLs) are considered to be qualitatively acceptable, but quantitatively unreliable, due to the uncertainty in analytical precision near the limit of detection.

B. The following detected results from the full scan analyses are qualified as nondetected and estimated due to laboratory blank contamination. The results are flagged "U, J" in Table 5-1.

- Methylene chloride in all of the samples.
- Benzene in samples FLX-1 FLX-2, FLX-3, FLX-5, FLX-6, FLX-6R, FLX-8, FLX-10, FLX-11, FLX-13, FLX-14, FLX-14R, FLX-16, FLX-17, FLX-19 FLX-20, FLX-22, FLX-23, and FLX-24.

  Methylene chloride and benzene were found in several of the full scan laboratory method blanks (see Table 5-1 for concentrations). The results for the samples listed above are considered nondetected and estimated (U, J) and the quantitation limits have been increased according to the blank qualification rules presented below.

  No positive results are reported unless the concentration of the compound in the sample exceeds 10 times the amount in any associated blank for the common laboratory contaminants or S times the amount for other compounds. If the sample result is greater than the CRQL, the quantitation limit is raised to the sample result (U, J). If the sample result is less than the CRQL, the result is reported as nondetected (U, J) at the CRQL.

  Although 1,2-dichloropropane, trichloroethene, and toluene were found in laboratory method blanks at concentrations above the method detection limits, no qualification of data was required by the above rules for qualification of data due to blank contamination.

  A laboratory method blank is zero-grade air, analyzed with all reagents, surrogates, and internal standards and carried through the same sample preparation and analytical procedures as the field samples. The laboratory method blank is used to determine the level of contamination introduced by the laboratory during analysis.

C. The detected results and quantitation limits for the following analyses are estimated due to missed technical holding time in the selected ion monitoring (SIM) mode analyses. The results are flagged "J" in Table 5-1.

- Vinyl chloride, 1,2-dichloroethane, carbon tetrachloride, bromodichloromethane, trans-1,3-dichloropropene, cis-1,3-dichloropropene, 1,2-dibromoethane, 1,2,3-trichloropropane, and 1,4-dichlorobenzene in all of the samples.

- 1,1-Dichloroethene in samples FLX-1 through FLX-5, FLX-6R, FLX-8 through FLX-14, FLX-14R, FLX-15 through FLX-20, FLX-22, FLX-23, FLX-24, FLX-B1, and FLX-B2.
- Chloroform in samples FLX-2 through FLX-6, FLX-6R, FLX-7 through FLX-10, FLX-12, FLX-13, FLX-14, FLX-14R, FLX-15 through FLX-20, FLX-22, FLX-23, FLX-24, FLX-B1, and FLX-B2.
- 1,2-Dichloropropane in samples FLX-3, FLX-6, FLX-6R, FLX-7 through FLX-14, FLX-14R, FLX-15 through FLX-20, FLX-22, FLX-23, FLX-24, FLX-B1, and FLX-B2.

The SIM analyses exceeded the 14-day technical holding times as shown below.

Sample	Date Collected	Date Analyzed	No. of Days Exceeded
FLX-1	10-8-97	11-22-97	31
FLX-2	10-8-97	11-20-97	29
FLX-3	10-8-97	11-11-97	20
FLX-4	10-8-97	11-20-97	29
FLX-5	10-8-97	11-20-97	29
FLX-6	10-8-97	11-11-97	20
FLX-6R	10-8-97	11-10-97	19
FLX-7	10-8-97	11-22-97	31
FLX-8	10-8-97	11-10-97	19
FLX-9	10-8-97	11-11-97	20
FLX-10	10-8-97	11-11-97	20
FLX-11	10-8-97	11-11-97	20
FLX-12	10-8-97	11-10-97	19
FLX-13	10-8-97	11-10-97	19
FLX-14	10-8-97	11-11-97	20
FLX-14R	10-8-97	11-11-97	20
FLX-15	10-8-97	11-10-97	19
FLX-16	10-8-97	11-10-97	19
FLX-17	10-8-97	11-10-97	19
FLX-18	10-8-97	11-10-97	19
FLX-19	10-8-97	11-10-97	19
FLX-20	10-8-97	11-10-97	19
FLX-22	10-8-97	11-11-97	20
FLX-23	10-8-97	11-10-97	19
FLX-24	10-8-97	11-10-97	19
FLX-B1	10-9-97	11-07-97	15
FLX-B2	10-9-97	11-10-97	18

The detected results for the samples listed above may be biased low and are the minimum values at which these analyses may be present in the samples. Where the results are nondetected, false negatives may exist.

D. The detected results and quantitation limits for the following analyses are estimated due to large percent differences (%Ds) in the continuing calibrations (CCAL) for the full scan gas chromatography/mass spectrometry (GC/MS) analyses. The results are flagged "J" in Table 5-1.

- Bromoform in all of the samples and the full scan method blanks.
- 1,2-Dichlorobenzene in samples FLX-1 through FLX-6, FLX-6R, FLX-7 through FLX-10, FLX-24, FLX-B1, FLX-B2, and method blanks B10187 and B10207.

Percent differences exceeding the ±30.0% QC advisory validation criterion were observed for the analyses listed above in the continuing calibrations performed October 18, 20, 21, and 22, 1997.

It should be noted that the %Ds for 1,2-dibromo-3-chloropropane were not calculated since the compound was not detected in any of the CCAL standards.

The continuing calibration checks the instrument performance daily.

E. The detected results and quantitation limits for the following analyses are estimated due to large percent differences (%Ds) in the continuing calibrations for the SIM analyses. The results are flagged "J" in Table 5-1.

- 1,4-Dichlorobenzene in samples FLX-1, FLX-2, FLX-4, FLX-5, FLX-6R, FLX-7, FLX-8, FLX-12, FLX-13, FLX-15 through FLX-20, FLX-23, FLX-24, FLX-B1, FLX-B2, and method blanks B11077, B11107, B11207, B11227A, and B11227B.

Percent differences exceeding the ±30.0% QC advisory validation criterion were observed for the analyte listed above in the continuing calibrations performed November 7, 10, 20, and 22, 1997.

The continuing calibration checks the instrument performance daily.

F. The results for several SIM laboratory control samples (LCSs) and laboratory control sample duplicates (LCSDs) did not meet the criteria for accuracy specified in the laboratory's case narrative. The percent recoveries for cis-1,3-dichloropropene and 1,4-dichlorobenzene are presented below.

Analyte	QC11207 %Recovery	QC11207DUP %Recovery	QC limits %Recovery
Cis-1,3-Dichloropropene	108	131	70-130
Analyte	**QC11227C %Recovery**	**QC11227CDUP %Recovery**	**QC limits %Recovery**
1,4-Dichlorobenzene	67	53	70-130

Since the recovery for cis-1,3-dichloropropene in QC sample QC11207DUP is only slightly outside the QC limits, no adverse effect on the quality of the data is expected. The effect of the low recoveries for 1,4-dichlorobenzene on the quality of the data is not known.

Results which fall outside acceptance criteria may indicate poor laboratory technique or matrix effects which may interfere with accurate analysis.

The purpose of the LCS and LCSD is to serve as a monitor of the overall performance of all steps in the analysis, including sample preparation.

G. The CRQLs for the following analyses have been raised to the concentration of the lowest initial calibration standard in which each analyte was detected.

- Bromoform in all of the samples and full scan method blanks.
- 1,2-Dibromo-3-chloropropane in samples FLX-2, FLX-3, FLX-4, FLX-5, FLX-6, FLX-6R, FLX-7, FLX-8, FLX-9, FLX-10, FLX-11, FLX-12, FLX-13, FLX-14, FLX-14R, FLX-15, FLX-16, FLX-17, FLX-18, FLX-19, FLX-20, FLX-22, FLX-23, FLX-24, FLX-B1, and FLX-B2 and full scan method blanks.

Bromoform was recovered only in the four highest (of six) internal calibration (ICAL) standards and 1,2-dibromo-3-chloropropane was recovered only in the two highest ICAL standards.

Table 5-2
Summary of Compounds Detected in Soil Gas

Station	Sample Date	Chemical Name	Concentration (ppbv)	Lab Qualifier	LRL (ppbv)	Analysis Method
SG-1	10/8/1997	1,1-Dichloroethene	8.10		0.73	TO14
SG-1	10/8/1997	1,2,3-Trichloropropane	190.00		8.47	TO14
SG-1	10/8/1997	1,2-Dichloroethane	9.20	Q	6.05	TO14
SG-1	10/8/1997	1,2-Dichloropropane	4,600.00		6.05	TO14
SG-1	10/8/1997	Bromodichloromethane	53.00	Q	0.48	TO14
SG-1	10/8/1997	Carbon Tetrachloride	1.20		0.73	TO14
SG-1	10/8/1997	Chloroform	4,300.00		6.05	TO14
SG-1	10/8/1997	Methylene Chloride	91.00	B	15.13	TO14
SG-1	10/8/1997	Tetrachloroethene	38.00	Q	6.05	TO14
SG-1	10/8/1997	Trans-1,3-Dichloropropene	1.60		0.24	TO14
SG-1	10/8/1997	Vinyl Chloride	8.30	Q	1.21	TO14
SG-2	10/8/1997	1,1-Dichloroethene	2.50		0.37	TO14
SG-2	10/8/1997	1,2,3-Trichloropropane	220.00		153.75	TO14
SG-2	10/8/1997	1,2,3-Trichloropropane	170.00		4.31	TO14
SG-2	10/8/1997	1,2-Dibromoethane	8.20		0.37	TO14
SG-2	10/8/1997	1,2-Dichloropropane	5,200.00		6.15	TO14
SG-2	10/8/1997	Bromodichloromethane	22.00	Q	0.25	TO14
SG-2	10/8/1997	Chlorobenzene	22.00	Q	12.3	TO14
SG-2	10/8/1997	Chloroform	940.00		6.15	TO14
SG-2	10/8/1997	Cis-1,3-Dichloropropene	2.30		0.37	TO14
SG-2	10/8/1997	Methylene Chloride	39.00	B	15.38	TO14
SG-2	10/8/1997	Tetrachloroethene	18.00	Q	6.15	TO14
SG-2	10/8/1997	Trans-1,3-Dichloropropene	0.45		0.12	TO14
SG-3	10/8/1997	1,2-Dichloropropane	1,500.00		11.8	TO14
SG-3	10/8/1997	Bromodichloromethane	4.40	Q	1.18	TO14
SG-3	10/8/1997	Carbon Tetrachloride	2.40		1.77	TO14
SG-3	10/8/1997	Chloroform	1,500.00		11.8	TO14
SG-3	10/8/1997	Methylene Chloride	79.00	B	29.5	TO14
SG-3	10/8/1997	Tetrachloroethene	36.00	Q	11.8	TO14
SG-3	10/8/1997	Toluene	8.10	Q	5.9	TO14
SG-4	10/8/1997	1,2,3-Trichloropropane	3,800.00			TO14
SG-4	10/8/1997	1,2-Dibromoethane	320.00		96	TO14
SG-4	10/8/1997	1,2-Dichloroethane	34.00		3.6	TO14
SG-4	10/8/1997	1,2-Dichloropropane	19,000.00		48	TO14
SG-4	10/8/1997	Benzene	150.00	B	24	TO14
SG-4	10/8/1997	Chloroform	19.00		2.4	TO14
SG-4	10/8/1997	Cis-1,3-Dichloropropene	13.00	Q	3.6	TO14
SG-4	10/8/1997	Methylene Chloride	240.00	B,Q		TO14
SG-4	10/8/1997	Vinyl Chloride	12.00		6	TO14
SG-5	10/8/1997	1,2,3-Trichloropropane	61.00		4.2	TO14
SG-5	10/8/1997	1,2-Dibromoethane	27.00		0.36	TO14
SG-5	10/8/1997	1,2-Dichloroethane	6.00		0.36	TO14
SG-5	10/8/1997	1,2-Dichloropropane	1,000.00		6	TO14
SG-5	10/8/1997	Benzene	6.70	B	3	TO14

Table 5-2 (Cont'd)
Summary of Compounds Detected in Soil Gas

Station	Sample Date	Chemical Name	Concentration (ppbv)	Lab Qualifier	LRL (ppbv)	Analysis Method
SG-5	10/8/1997	Carbon Tetrachloride	0.48		0.36	TO14
SG-5	10/8/1997	Chloroform	5.00		0.24	TO14
SG-5	10/8/1997	Toluene	7.20	Q	3	TO14
SG-6	10/8/1997	1,2,3-Trichloropropane	53.00		8.68	TO14
SG-6	10/8/1997	1,2-Dibromoethane	5.50		0.74	TO14
SG-6	10/8/1997	1,2-Dichloropropane	80.00	B	0.62	TO14
SG-6	10/8/1997	Benzene	1.20	B	0.31	TO14
SG-6	10/8/1997	Bromodichloromethane	2.30	Q	0.5	TO14
SG-6	10/8/1997	Carbon Tetrachloride	1.10		0.74	TO14
SG-6	10/8/1997	Chloroform	10.00		0.62	TO14
SG-6	10/8/1997	Methylene Chloride	12.00	B	1.55	TO14
SG-6	10/8/1997	Toluene	36.00	B	0.31	TO14
SG-7	10/8/1997	1,2-Dibromoethane	0.41		0.36	TO14
SG-7	10/8/1997	1,2-Dichloropropane	12.00		0.48	TO14
SG-7	10/8/1997	Benzene	0.93	B	0.3	TO14
SG-7	10/8/1997	Chloroform	1.20		0.24	TO14
SG-7	10/8/1997	Methylene Chloride	2.90	B	1.51	TO14
SG-7	10/8/1997	Toluene	3.70		0.3	TO14
SG-7	10/8/1997	Trichloroethene	2.60	B	0.3	TO14
SG-8	10/8/1997	1,2,3-Trichloropropane	10.00		4.34	TO14
SG-8	10/8/1997	1,2-Dibromoethane	3.40		0.37	TO14
SG-8	10/8/1997	1,2-Dichloropropane	25.00	Q	0.62	TO14
SG-8	10/8/1997	Benzene	0.80	B	0.31	TO14
SG-8	10/8/1997	Chloroform	0.64		0.25	TO14
SG-8	10/8/1997	Methylene Chloride	4.90	B	1.55	TO14
SG-8	10/8/1997	Tetrachloroethene	3.90		0.62	TO14
SG-8	10/8/1997	Toluene	0.65	Q	0.31	TO14
SG-9	10/8/1997	1,2,3-Trichloropropane	6.80		4.17	TO14
SG-9	10/8/1997	1,2-Dibromoethane	2.20		0.36	TO14
SG-9	10/8/1997	1,2-Dichloropropane	17.00	Q	0.6	TO14
SG-9	10/8/1997	Benzene	0.39	B	0.3	TO14
SG-9	10/8/1997	Chloroform	1.00		0.24	TO14
SG-9	10/8/1997	Methylene Chloride	5.60	B	1.49	TO14
SG-9	10/8/1997	Toluene	0.37	Q	0.3	TO14
SG-10	10/8/1997	1,2,3-Trichloropropane	10.00		4.27	TO14
SG-10	10/8/1997	1,2-Dibromoethane	2.50		0.37	TO14
SG-10	10/8/1997	1,2-Dichloropropane	20.00	Q	0.61	TO14
SG-10	10/8/1997	Chloroform	2.60		0.24	TO14
SG-10	10/8/1997	Methylene Chloride	3.50	B	1.53	TO14
SG-11	10/8/1997	1,2,3-Trichloropropane	4.70		4.17	TO14
SG-11	10/8/1997	1,2-Dibromoethane	0.94		0.36	TO14
SG-11	10/8/1997	1,2-Dichlorobenzene	2.80		2.08	TO14
SG-11	10/8/1997	1,2-Dichloropropane	19.00	Q	0.6	TO14
SG-11	10/8/1997	1,4-Dichlorobenzene	3.30		2.38	TO14

Table 5-2 (Cont'd)
Summary of Compounds Detected in Soil Gas

Station	Sample Date	Chemical Name	Concentration (ppbv)	Lab Qualifier	LRL (ppbv)	Analysis Method
SG-11	10/8/1997	Benzene	1.40	B	0.3	TO14
SG-11	10/8/1997	Chloroform	0.38		0.24	TO14
SG-11	10/8/1997	Methylene Chloride	3.70	B	1.49	TO14
SG-11	10/8/1997	Toluene	18.00	B	0.3	TO14
SG-11	10/8/1997	Xylene (Meta & Para)	5.40		2.08	TO14
SG-11	10/8/1997	Xylene (Ortho)	2.00		0.89	TO14
SG-12	10/8/1997	1,2,3-Trichloropropane	6.80		4.2	TO14
SG-12	10/8/1997	1,2-Dibromoethane	1.10		0.36	TO14
SG-12	10/8/1997	1,2-Dichloropropane	24.00	Q	0.6	TO14
SG-12	10/8/1997	Benzene	1.20	B	0.3	TO14
SG-12	10/8/1997	Chloroform	0.70		0.24	TO14
SG-12	10/8/1997	Methylene Chloride	4.50	B	1.5	TO14
SG-12	10/8/1997	Toluene	2.10	B,Q	0.3	TO14
SG-13	10/8/1997	1,2-Dichloropropane	0.67	Q	0.59	TO14
SG-13	10/8/1997	Benzene	0.47	B	0.29	TO14
SG-13	10/8/1997	Methylene Chloride	5.10	B	1.46	TO14
SG-13	10/8/1997	Toluene	2.20	B	0.29	TO14
SG-14	10/8/1997	1,2-Dichloropropane	6.90	Q	0.58	TO14
SG-14	10/8/1997	Benzene	0.94	B	0.29	TO14
SG-14	10/8/1997	Methylene Chloride	3.20	B	1.45	TO14
SG-14	10/8/1997	Toluene	2.10	B	0.29	TO14
SG-15	10/8/1997	1,2-Dichloropropane	1.90	Q	0.58	TO14
SG-15	10/8/1997	Benzene	0.72	B	0.29	TO14
SG-15	10/8/1997	Bromodichloromethane	0.79		0.23	TO14
SG-15	10/8/1997	Methylene Chloride	3.70	B	1.45	TO14
SG-15	10/8/1997	Toluene	2.10	B	0.29	TO14
SG-16	10/8/1997	1,2-Dichloropropane	7.30	Q	0.59	TO14
SG-16	10/8/1997	Benzene	1.30	B	0.3	TO14
SG-16	10/8/1997	Chloroform	0.27		0.24	TO14
SG-16	10/8/1997	Methylene Chloride	3.60	B	1.48	TO14
SG-16	10/8/1997	Toluene	2.50	B	0.3	TO14
SG-17	10/8/1997	1,2-Dichloropropane	3.30	Q	0.59	TO14
SG-17	10/8/1997	Benzene	0.80	B	0.3	TO14
SG-17	10/8/1997	Carbon Tetrachloride	0.38	Q	0.35	TO14
SG-17	10/8/1997	Chloroform	0.27		0.24	TO14
SG-17	10/8/1997	Methylene Chloride	3.10	B	1.48	TO14
SG-17	10/8/1997	Toluene	1.40	B	0.3	TO14
SG-18	10/8/1997	1,2-Dichloropropane	4.00	Q	0.59	TO14
SG-18	10/8/1997	1,4-Dichlorobenzene	2.40		2.34	TO14
SG-18	10/8/1997	Benzene	0.69	B	0.29	TO14
SG-18	10/8/1997	Bromodichloromethane	3.00	Q	2.93	TO14
SG-18	10/8/1997	Methylene Chloride	3.60	B	1.46	TO14
SG-18	10/8/1997	Tetrachloroethene	1.80		0.59	TO14
SG-18	10/8/1997	Toluene	1.70	B	0.29	TO14

Table 5-2 (Cont'd)
Summary of Compounds Detected in Soil Gas

Station	Sample Date	Chemical Name	Concentration (ppbv)	Lab Qualifier	LRL (ppbv)	Analysis Method
SG-19	10/8/1997	1,2,3-Trichloropropane	27.00		14.63	TO14
SG-19	10/8/1997	1,2-Dichlorobenzene	3.00		2.05	TO14
SG-19	10/8/1997	1,2-Dichloropropane	4.70	Q	0.59	TO14
SG-19	10/8/1997	1,4-Dichlorobenzene	4.50		2.34	TO14
SG-19	10/8/1997	Benzene	0.76	B	0.29	TO14
SG-19	10/8/1997	Bromoform	30.00		14.63	TO14
SG-19	10/8/1997	Chlorobenzene	1.60		1.17	TO14
SG-19	10/8/1997	Methylene Chloride	2.80	B	1.46	TO14
SG-19	10/8/1997	Tetrachloroethene	2.90		0.59	TO14
SG-19	10/8/1997	Toluene	2.30	B	0.29	TO14
SG-19	10/8/1997	Trichloroethene	1.10	Q	0.29	TO14
SG-19	10/8/1997	Xylene (Meta & Para)	4.10		2.05	TO14
SG-19	10/8/1997	Xylene (Ortho)	1.30	Q	0.88	TO14
SG-20	10/8/1997	1,2-Dibromoethane	0.38		0.35	TO14
SG-20	10/8/1997	1,2-Dichloropropane	6.20	Q	0.59	TO14
SG-20	10/8/1997	Benzene	0.76	B	0.3	TO14
SG-20	10/8/1997	Chloroform	0.28		0.24	TO14
SG-20	10/8/1997	Methylene Chloride	4.60	B	1.48	TO14
SG-20	10/8/1997	Toluene	1.20	B,Q	0.3	TO14
SG-21	10/8/1997	1,2-Dibromoethane	0.41		0.35	TO14
SG-21	10/8/1997	1,2-Dichloropropane	11.00	Q	0.59	TO14
SG-21	10/8/1997	Benzene	0.43	B	0.3	TO14
SG-21	10/8/1997	Chloroform	0.25		0.24	TO14
SG-21	10/8/1997	Methylene Chloride	2.60	B	1.48	TO14
SG-21	10/8/1997	Toluene	0.68	B,Q	0.3	TO14
SG-22	10/8/1997	1,2-Dibromoethane	0.45		0.35	TO14
SG-22	10/8/1997	1,2-Dichloropropane	5.30	Q	0.59	TO14
SG-22	10/8/1997	Benzene	0.88	B	0.29	TO14
SG-22	10/8/1997	Chloroform	1.50		0.23	TO14
SG-22	10/8/1997	Methylene Chloride	4.10	B	1.46	TO14
SG-22	10/8/1997	Toluene	1.70	B	0.29	TO14
SG-23	10/8/1997	1,2-Dibromoethane	0.55		0.35	TO14
SG-23	10/8/1997	1,2-Dichloropropane	7.50	Q	0.59	TO14
SG-23	10/8/1997	Benzene	0.74	B	0.3	TO14
SG-23	10/8/1997	Bromodichloromethane	1.10	Q	0.24	TO14
SG-23	10/8/1997	Chloroform	0.37		0.24	TO14
SG-23	10/8/1997	Methylene Chloride	7.60	B	1.48	TO14
SG-23	10/8/1997	Toluene	0.95	B,Q	0.3	TO14
SG-24	10/8/1997	1,2-Dichloropropane	4.40	Q	0.59	TO14
SG-24	10/8/1997	Carbon Tetrachloride	4.60		0.35	TO14
SG-24	10/8/1997	Chloroform	0.67		0.24	TO14

LRL – laboratory reporting limit