FINAL

Remediation by Natural Attenuation Treatability Study for Operable Unit 1

Hill Air Force Base
Ogden, Utah

Prepared For

Air Force Center for Environmental Excellence
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and

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Hill Air Force Base
Ogden, Utah

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ACRONYMS AND ABBREVIATIONS

°C	degrees Centigrade
°F	degrees Fahrenheit
ΔG°r	Gibbs free energy of the reaction
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
2-D	two-dimensional
3-D	three-dimensional
AFB	Air Force Base
AFCEE	United States Air Force Center for Environmental Excellence
ASCII	American Standard Code for Information Interchange
AVGAS	aviation gasoline
bgs	below ground surface
BNAE	base neutral/acid extractable compounds
BTEX	benzene, toluene, ethylbenzene, and xylenes
CA	chloroethane
$CaCO_3$	calcium carbonate
CAH	chlorinated aliphatic hydrocarbons
CB	chlorobenzene
CDP	chemical disposal pit
cf	cubic feet
cm/sec	centimeters per second
CPT	cone penetrometer test
CSR	CalScience Research, Inc.
DCA	dichloroethane
DCB	dichlorobenzene
DCE	dichloroethene
DCM	dichloromethane
DO	dissolved oxygen
ES	Engineering-Science, Inc.
ESE	Environmental Science and Engineering, Inc.

ACRONYMS AND ABBREVIATIONS (Continued)

FS	feasibility study
ft/day	feet per day
ft/ft	foot per foot
ft/yr	feet per year
FTA	Fire Training Area
gpm	gallons per minute
H_2	hydrogen
HDPE	high-density polyethylene
HSA	hollow-stem auger
ID	inside diameter
IRP	Installation Restoration Program
IWTP	industrial wastewater treatment plan
JMM	James M. Montgomery Consulting Engineers Inc.
JP-4	jet fuel
kg/L	kilograms per liter
K_{oc}	soil sorption coefficient
LF	landfill
LLNL	Lawrence Livermore National Laboratories
LNAPL	light nonaqueous-phase liquid
LTM	long-term monitoring
MCL	maximum contaminant level
MEK	methyl ethyl ketone
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MOC	method of characteristics
msl	mean sea level
mV	millivolts
N	nitrogen
NAPL	nonaqueous-phase liquid
nM/L	nanomoles per liter

ACRONYMS AND ABBREVIATIONS(Continued)

NPL	National Priorities List
NRMRL	National Risk Management Research Laboratory
OH^-	hydroxyl group
ORD	Office of Research and Development
ORP	oxidation reduction potential
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PA/SI	preliminary assessment/site inspection
Parsons ES	Parsons Engineering Science, Inc.
PCA	tetrachloroethane
PCB	polychlorinated biphenyls
PCE	tetrachloroethene
PID	photoionization detector
POC	point of compliance
PVC	polyvinyl chloride
QC	quality control
R	coefficient of retardation
Radian	Radian Corporation
RAO	remedial action objective
redox	reduction/oxidation
RI	remedial investigation
RMS	root mean squared
RNA	remediation by natural attenuation
SAC	Strategic Air Command
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SDWA	Safe Drinking Water Act
SS	stainless steel
SVE	soil vapor extraction
TCA	trichloroethane

ACRONYMS AND ABBREVIATIONS(Continued)

TCB	trichlorobenzene
TCE	trichloroethene
TEAP	terminal electron-accepting process
TeCB	tetrachlorobenzene
TEMB	tetramethylbenzene
TMB	trimethylbenzene
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRPH	total recoverable petroleum hydrocarbons
TS	treatability study
TVH	total volatile hydrocarbons
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VC	vinyl chloride
VFAs	volatile fatty acids
VOC	volatile organic compound
WOST	waste oil storage tank area
WPOP	waste phenol/oil pit
YSI	Yellow Springs Instruments

EXECUTIVE SUMMARY

This report presents the results of a remediation by natural attenuation treatability study (RNA TS) performed by Parsons Engineering Science, Inc. (Parsons ES) at Operable Unit 1 (OU 1), Hill Air Force Base, Utah. The TS evaluates the use of natural attenuation with long-term monitoring (LTM) as a remedial option for dissolved chlorinated aliphatic hydrocarbon (CAH) contamination in the surficial water-bearing zone. The presence of groundwater and soil contamination at the site has been documented during previous investigations. This TS focuses on the impact of dissolved CAHs, primarily *cis*-1,2-dichloroethene (*cis*-1,2-DCE), on the shallow groundwater system at and downgradient from the site. Site history and the results of soil, soil gas, groundwater, and surface water investigations conducted previously are summarized in this report.

Several lines of chemical and geochemical evidence indicate that dissolved CAHs are undergoing biologically facilitated reductive dehalogenation within and immediately downgradient from the contaminant source area. Microbial consumption of both native and anthropogenic organic carbon compounds have created reducing conditions that are favorable for reductive dehalogenation. The presence of these favorable conditions is supported by the following evidence:

- Concentrations of reductive dehalogenation daughter products are elevated beneath the upland terrace within and immediately downgradient from the source area, and parent solvent concentrations are relatively low;
- Historical concentration data for total 1,2-DCE suggest that concentrations of this compound in many portions of the site are gradually decreasing over time due to the combined effects of RNA and engineered remedial activities;
- Plots of electron donors, electron acceptors, and metabolic byproducts of microbially mediated reduction/oxidation (redox) reactions provide strong qualitative evidence of microbial consumption of organic carbon compounds, creating conditions favorable for reductive dehalogenation; and
- Additional indicators, such as oxidation/reduction potential (ORP), alkalinity, ammonia, and volatile fatty acids further confirm that biodegradation reactions are ongoing and have created reducing conditions that foster reductive dehalogenation.

Conditions that are conducive to the occurrence of reductive dehalogenation appear to be limited to the on-Base portion of the OU. Reductive dehalogenation appears to be relatively insignificant in the Weber River Valley alluvial aquifer; therefore, further reductive dehalogenation of CAHs that migrate off-Base appears to be minimal to non-existent. However, aerobic degradation of the less-chlorinated CAHs (DCE and vinyl chloride [VC]) is probably more prevalent. The abrupt truncation of the VC plume near the Base boundary is a direct indication that VC is being degraded in aerobic, microbially mediated redox reactions.

An important component of this study was an assessment of the potential for contamination in groundwater to impact potential receptor exposure points at concentrations above regulatory levels intended to be protective of human health and the environment. To accomplish this objective, the numerical model codes MODFLOW and MT3D were used to estimate the impacts of potential future engineered remedial actions on the future migration and persistence of dissolved *cis*-1,2-DCE within the surficial water-bearing zone under the influence of advection, dispersion, sorption, and biodegradation. In addition, the fate and transport of the *cis*-1,2-DCE plume under the influence of RNA combined with existing remedial actions was simulated to provide a baseline against which the effectiveness of potential future remedial actions can be compared. Input parameters for the numerical model were obtained from existing site characterization data, supplemented with data collected during the RNA TS. Model parameters that were not measured at the site were estimated using reasonable literature values.

The results of this study suggest that the dissolved *cis*-1,2-DCE plume will not migrate further north than is currently observed, and will gradually decrease in magnitude and extent due to the effects of natural attenuation processes operating in the groundwater, the effects of the currently operating remedial systems, and weathering of the contamination source. If additional engineered remedial actions are not implemented, then model results suggest that dissolved DCE concentrations throughout the area north of the Bambrough Canal will decrease below the Utah groundwater standard of 70 µg/L by year 2040 to 2045. In addition, dissolved DCE concentrations throughout nearly all of the off-Base area are predicted to decrease below 70 µg/L by 2097. However, the model indicates that dissolved DCE concentrations will substantially exceed 70 µg/L in the source area for more than 100 years unless natural source attenuation rates are significantly more rapid than simulated by the model.

If the preferred remedial alternative is implemented, then the model predicts that dissolved DCE concentrations north of the Bambrough Canal will decrease below 70 µg/L by approximately year 2017. Although simulated DCE concentrations in the source area decrease more rapidly than if the preferred alternative is not implemented, maximum DCE concentrations are predicted to remain above 70 µg/L for more than 100 years due to persistence of the contamination source.

Model results suggest that implementation of Source Area Alternative 3 and Non-Source Area Alternative 6 would not hasten the diminishment of the dissolved DCE plume substantially relative to the preferred alternative. Therefore, if the off-Base plume does not represent a significant threat to potential receptors, then implementation of Non-Source Area Alternative 6 may not be advisable. The effectiveness of Non-Source Area Alternative 6 could potentially be increased by increasing the pumping rates of the Non-Source Area extraction wells; however, this was not assessed using the numerical model.

The groundwater flow and contaminant transport system that is modeled is very complex, and the relevant properties and parameters are not well defined in some portions of the modeled area. As a result, the numerical model necessarily is a very simplified representation of the groundwater and contaminant transport system. However, the sensitivity analysis indicates that the selected model input parameters are reasonable, and the model predictions are believed to be useful approximations that can facilitate selection of an appropriate remedial approach.

To further calibrate the numerical model for use as a management tool at OU 1, regular sampling of LTM wells in the non-source area is recommended to monitor the degradation of the dissolved CAH plumes. Regular sampling and analysis of groundwater from selected wells will allow the effectiveness of RNA and engineered remedial actions to be monitored, and should allow assessment of whether additional engineering controls should be implemented. Likewise, the model can be adjusted to reflect future conditions measured in the aquifer.

Contaminant fate and transport model results indicate that sampling in the non-source area should continue on a biennial (every other year) basis until *cis*-1,2-DCE concentrations decrease below 70 µg/L. Assuming that the preferred remedial alternative is implemented, LTM may be required for approximately 20 years in the area north of the Bambrough Canal, and for less than 10 years in the on-Base portion of the non-source area west of the source area. Monitoring of the source area may be required for more than 100 years unless the contaminant source diminishes significantly more rapidly than simulated in the numerical model. If Source Area Remedial Alternative 3 is implemented, then annual monitoring of selected source area wells may be desirable for approximately 5 years, followed by progressively less frequent monitoring in subsequent years. The LTM plan should be reevaluated periodically and modified as necessary on the basis of newly obtained data and further calibration of the numerical model. Along with other analyses used to assess the effectiveness of RNA, the groundwater samples should be analyzed for volatile organic compounds by US Environmental Protection Agency Method SW8260A.

SECTION 1

INTRODUCTION

This report was prepared by Parsons Engineering Science, Inc. (Parsons ES) to present the results of a treatability study (TS) conducted to evaluate the use of remediation by natural attenuation (RNA) for groundwater contaminated with chlorinated aliphatic hydrocarbons (CAHs) and fuel hydrocarbons at Operable Unit (OU) 1, located at Hill Air Force Base (AFB), Utah. As used in this report, RNA refers to a management strategy that relies on natural attenuation mechanisms to remediate contaminants dissolved in groundwater and to control receptor exposure risks associated with contaminants in the subsurface. The United States Environmental Protection Agency (USEPA) Offices of Research and Development (ORD) and Solid Waste and Emergency Response (OSWER) define natural attenuation as (Wilson, 1996):

> *The biodegradation, dispersion, sorption, volatilization, and/or chemical and biochemical stabilization of contaminants to effectively reduce contaminant toxicity, mobility, or volume to levels that are protective of human health and the ecosystem.*

As suggested by this definition, mechanisms for natural attenuation of CAHs include advection, dispersion, dilution from recharge, sorption, volatilization, abiotic chemical transformation, and biodegradation. Of these processes, biodegradation is the most common mechanism working to transform contaminants into innocuous byproducts. During biodegradation, indigenous microorganisms bring about a reduction in the total mass of contamination in the subsurface without the engineered addition of nutrients. Patterns and rates of natural attenuation can vary markedly from site to site depending on governing physical and chemical processes.

RNA is advantageous for the following reasons:

- Contaminants can be transformed to innocuous byproducts (e.g., carbon dioxide, ethene, or water), not just transferred to another phase or location within the environment;
- Current pump-and-treat technologies are energy-intensive and generally not as effective in reducing residual contamination;
- The process is nonintrusive and allows continuing use of infrastructure during remediation;
- Engineered remedial technologies may pose a greater risk to potential receptors than RNA (e.g., contaminants may be transferred into another medium during remediation activities); and

- RNA is less costly than conventional, engineered remedial technologies.

A potential disadvantage of RNA is that, in some cases, natural attenuation rates are too slow to make RNA a practical remedial alternative. In addition, biodegradation of highly chlorinated compounds, such as trichloroethene (TCE), can produce vinyl chloride, which is relatively toxic. Under certain geochemical conditions, vinyl chloride may accumulate in the environment rather than be transformed to innocuous byproducts.

The main emphasis of the work described herein was to evaluate the potential for naturally occurring degradation mechanisms to reduce dissolved CAH concentrations in groundwater to levels that are protective of human health and the environment. This study is not intended to be a contamination assessment report or a remedial action plan; rather, it is provided for the use of the Base and its prime environmental contractor(s) as information to be used for future decision making regarding this site.

1.1 SCOPE AND OBJECTIVES

Parsons ES, in conjunction with researchers of the USEPA National Risk Management Research Laboratory (NRMRL), was retained by the United States Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division to conduct site characterization and groundwater modeling to evaluate the scientific defensibility of RNA with long-term monitoring (LTM) as a remedial option for contaminated groundwater at OU 1.

The following tasks were performed to fulfill the project objectives:

- Reviewing existing site-specific hydrogeologic information and laboratory analytical data for soil, soil gas, groundwater, and surface water;
- Conducting supplemental site characterization activities to more thoroughly characterize the nature and extent of surface water and groundwater contamination;
- Collecting geochemical data in support of RNA;
- Developing a conceptual hydrogeologic model of the shallow saturated zone, including the current distribution of contaminants;
- Evaluating site-specific data to determine whether naturally occurring processes of contaminant attenuation and destruction are occurring in groundwater at the site;
- Designing and executing a groundwater flow and contaminant fate and transport model for site hydrogeologic conditions;
- Simulating the fate and transport of *cis*-1,2-DCE in groundwater under the influence of advection, dispersion, adsorption, and biodegradation using the calibrated model;
- Evaluating a range of model input parameters to determine the sensitivity of the model to those parameters and to consider several contaminant fate and transport scenarios;

- Determining if natural processes are minimizing dissolved CAH and hydrocarbon plume expansion so that groundwater and surface water quality standards can be met at a downgradient point of compliance (POC);

- Conducting an exposure pathways analysis for potential current and future receptors;

- Using the results of modeling to assess the effect of current or planned future remedial actions on the dissolved 1,2-DCE plume; and

- Providing a LTM plan that includes LTM and POC wells and a sampling and analysis plan (SAP).

Field work conducted under this program was oriented toward the collection of supplementary hydrogeologic and chemical data necessary to document and model the effectiveness of RNA with LTM for restoration of CAH-contaminated groundwater.

Site characterization activities in support of RNA included the collection of soil samples and installation of groundwater monitoring points with a hollow-stem auger (HSA) and Geoprobe®; static groundwater level measurement; surface water sample collection and analysis; and groundwater sample collection and analysis from preexisting site monitoring wells and piezometers and newly installed monitoring points.

Site-specific data were used to develop a solute fate and transport model for the site and to conduct a preliminary receptor exposure pathways analysis. The modeling effort was used to predict the future extent and concentration of the dissolved CAH plume by modeling the combined effects of advection, dispersion, sorption, and biodegradation on *cis*-1,2-DCE. Results of the model were used to predict future discharge to surface water, to assess the potential for completion of other exposure pathways involving groundwater, and to identify whether RNA with LTM is an appropriate and defensible remedial option for contaminated groundwater, in conjunction with ongoing and planned engineered remedial actions. The results will be used to provide technical support for the RNA-with-LTM remedial option during regulatory negotiations, as appropriate.

This TS is organized into eight sections, including this introduction, and six appendices. Section 2 summarizes site characterization activities, and Section 3 summarizes the physical characteristics of the study area. Section 4 describes the nature and extent of soil, groundwater, and surface water contamination, and the evidence of contaminant biodegradation in groundwater at the site. Section 5 describes the fate and transport model and design of the conceptual hydrogeologic model for the site; lists model assumptions and input parameters; and describes sensitivity analysis results. Section 6 describes the predicted effects of planned or potential future remedial actions on the *cis*-1,2-DCE plume and presents conclusions regarding the effectiveness of the simulated remedial alternatives. Section 7 presents the LTM plan for the site. Section 8 lists the references used to develop this document. Appendix A contains selected information from previous reports. Appendix B contains Geoprobe® borehole logs, monitoring point construction diagrams, monitoring well/point development and sampling forms, and survey data. Appendix C presents soil, surface water, and groundwater analytical results that were used in the preparation of this report and generated as a part of this TS. Appendix D contains model input parameters, calculations

related to model calibration, and biodegradation rate calculations. Appendix E contains concentration-versus-time graphs for *cis*-1,2 DCE. Appendix F contains model input and output in American Standard Code for Information Interchange (ASCII) format on a diskette.

1.2 BASE AND OU 1 BACKGROUND

Hill AFB is located 25 miles north of Salt Lake City, Utah, just east of Interstate 15 in Davis County (Figure 1.1). Hill AFB was added to the National Priorities List (NPL) in July 1987. OU 1 is located in the northeastern corner of Hill AFB (Figure 1.1). This TS focuses on the cis-1,2-DCE plume in the OU 1 area. Eight potential contaminant source areas are present, including Chemical Disposal Pits (CDPs) 1 and 2, Landfills (LFs) 3 and 4, Fire Training Areas (FTAs) 1 and 2, a Waste Phenol/Oil Pit (WPOP), and a former Waste Oil Storage Tank (WOST) area. Potential sources of the *cis*-1,2-DCE plume include CDPs 1 and 2 and LF3. Locations of these areas are depicted on Figure 1.2, and the locations of existing groundwater monitoring wells, piezometers, extraction wells, and seeps/springs are shown on Figure 1.3. The following historical review of the eight sites included in OU 1 was compiled during the performance of the remedial investigation (RI) (Montgomery Watson, 1995b).

Construction of CDPs 1 and 2 began in 1939 and 1940, as gravel was excavated from these areas for use in roadway and runway construction. The borrow pits were used for disposal of liquid industrial waste from the early 1950s (possibly as early as 1952) through 1973. Typically, the waste dumped into the unlined pits was periodically burned. The wastes most frequently reported to be disposed of at CDPs 1 and 2 include waste oil, fuels (most likely aviation gasoline [AVGAS], diesel, and jet fuel [JP-4]), and spent solvents including Stoddard™ solvent and paint thinner. Waste from the Base industrial wastewater treatment plant (IWTP) flocculation tank also was periodically deposited in the CDPs. In 1986, the CDPs were capped using silty sand with some bentonite. Aerial photographs reveal that the CDP locations shifted over time, and that there probably is no distinct delineation between the two pits. For example, a 1965 photograph shows that the pits were merged and covered a larger area at that time than in previous photographs.

An aerial photograph taken in 1952 showed the first indications of landfilling at OU1. Liquid and solid wastes were disposed of at LF 3 through 1967. Wastes disposed of at LF 3 (and the approximate dates of disposal, where known) included: solid refuse (construction debris); IWTP sludge (1956-1967), drying bed, and flocculation tank wastes; spent solvents and residues from solvent cleaning operations (until 1967); sanitary and industrial refuse; paint sludges, paint booth scrubber sludge, plastic and other maskings; spent sandblast media; and residues and filters from plating and cleaning operations. Waste was burned in LF 3 on a daily basis until most disposal activities were moved to LF 4 in 1967. A 1985 aerial photograph indicates that activities had ceased at LF 3 by that time.

LF 4 was used as a sanitary landfill from 1967 to 1973, receiving mostly solid waste (scrap metal, construction debris, domestic and industrial refuse, and sludge from the IWTP drying beds) and small amounts of sulfuric acid, chromic acid, phenol, and methyl ethyl ketone (MEK). In the 1970s, the Hill AFB Civil Engineering Department was directed to stop disposing of liquid wastes at LF 4. However, subsequent inspections indicated that dumping of chemicals near or in LF 4 continued periodically during the

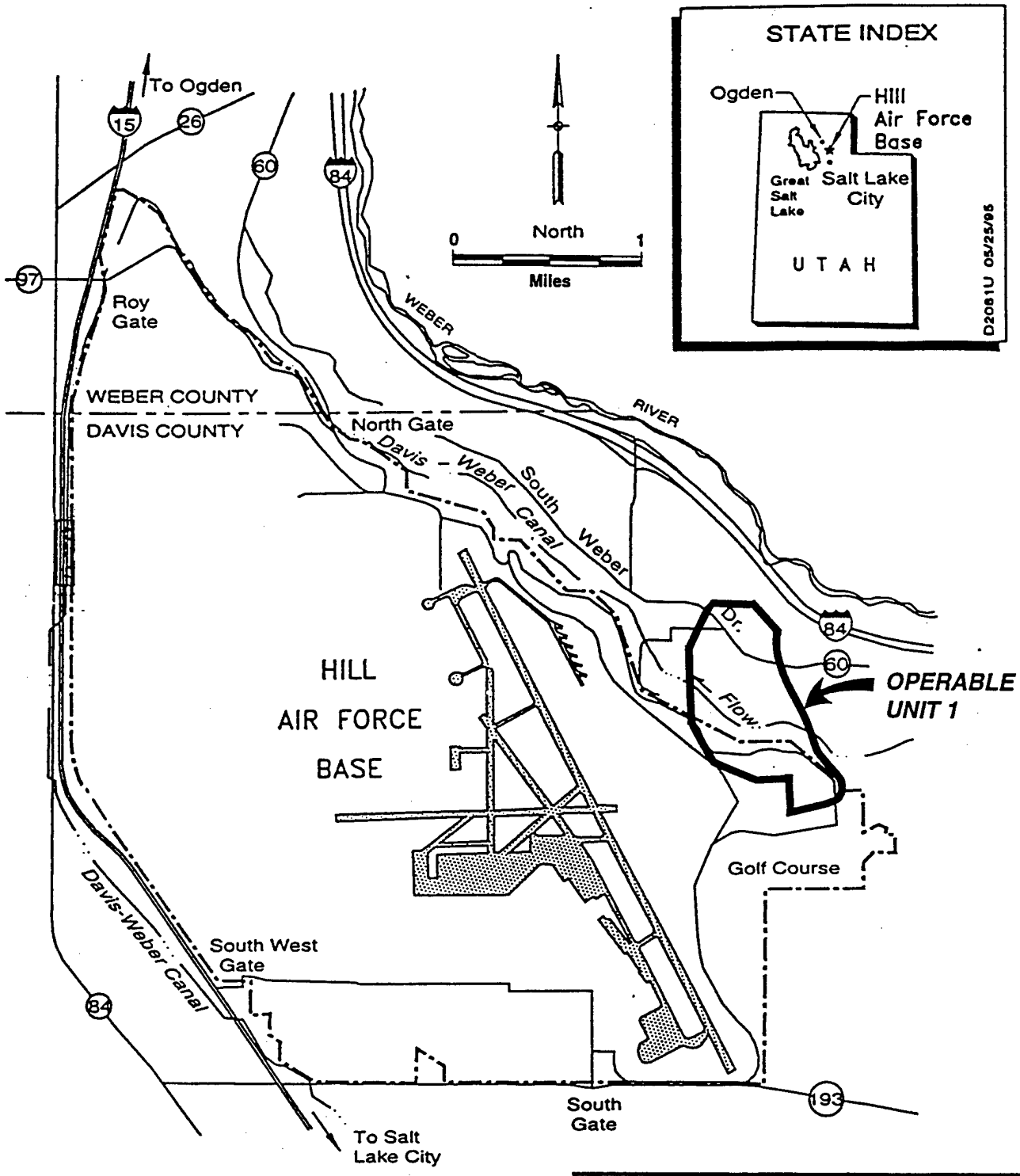
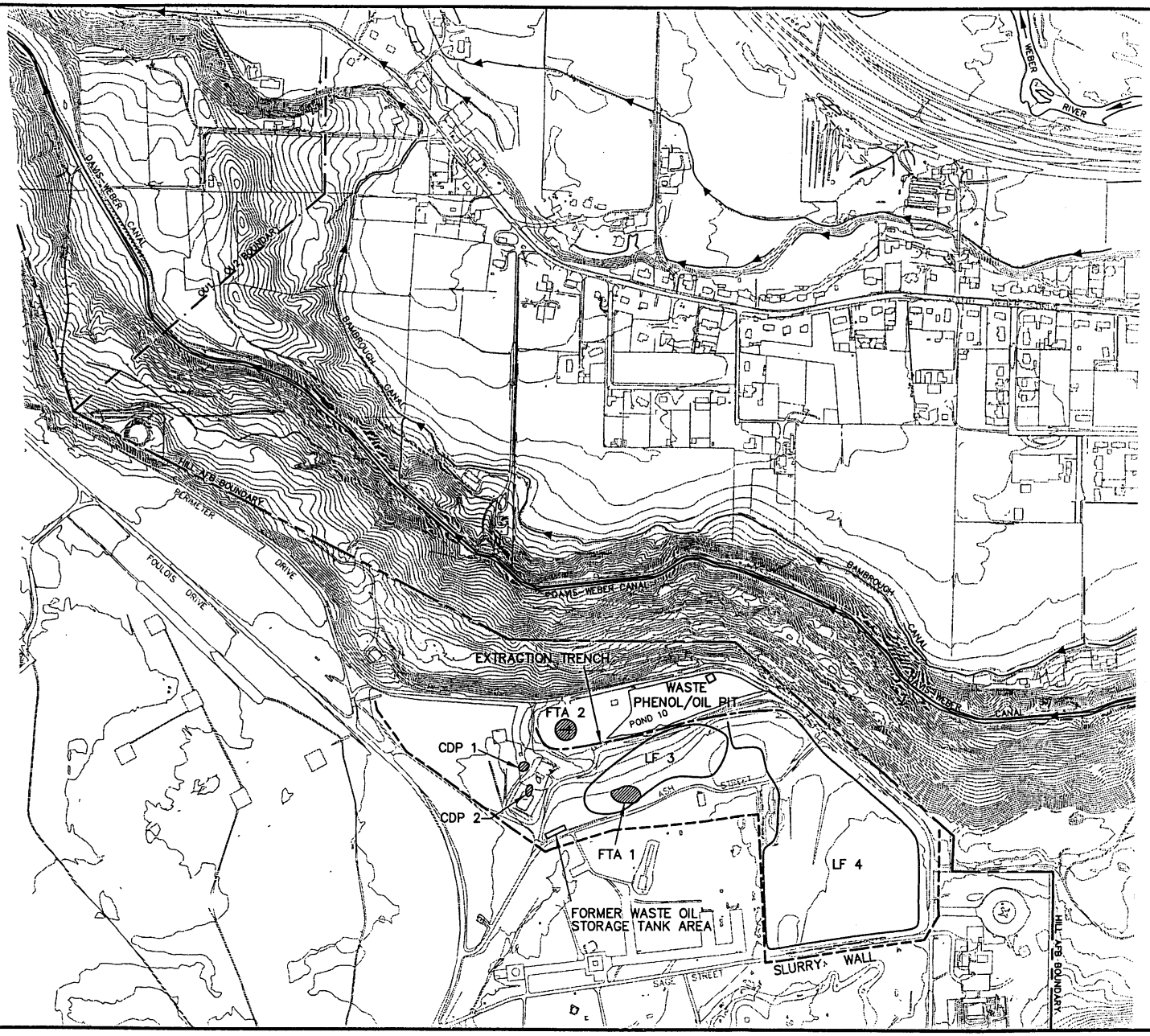


FIGURE 1.1

LOCATION OF HILL AFB AND OPERABLE UNIT 1

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado



LEGEND

- LINE OF EQUAL GROUND SURFACE ELEVATION, CONTOUR INTERVAL = 5 FEET
- SURFACE DRAINAGE WITH FLOW DIRECTION
- LF LANDFILL
- FTA FIRE TRAINING AREA
- CDP CHEMICAL DISPOSAL PIT

N

0 300 600 1200
FEET

FIGURE 1.2

SITE LAYOUT

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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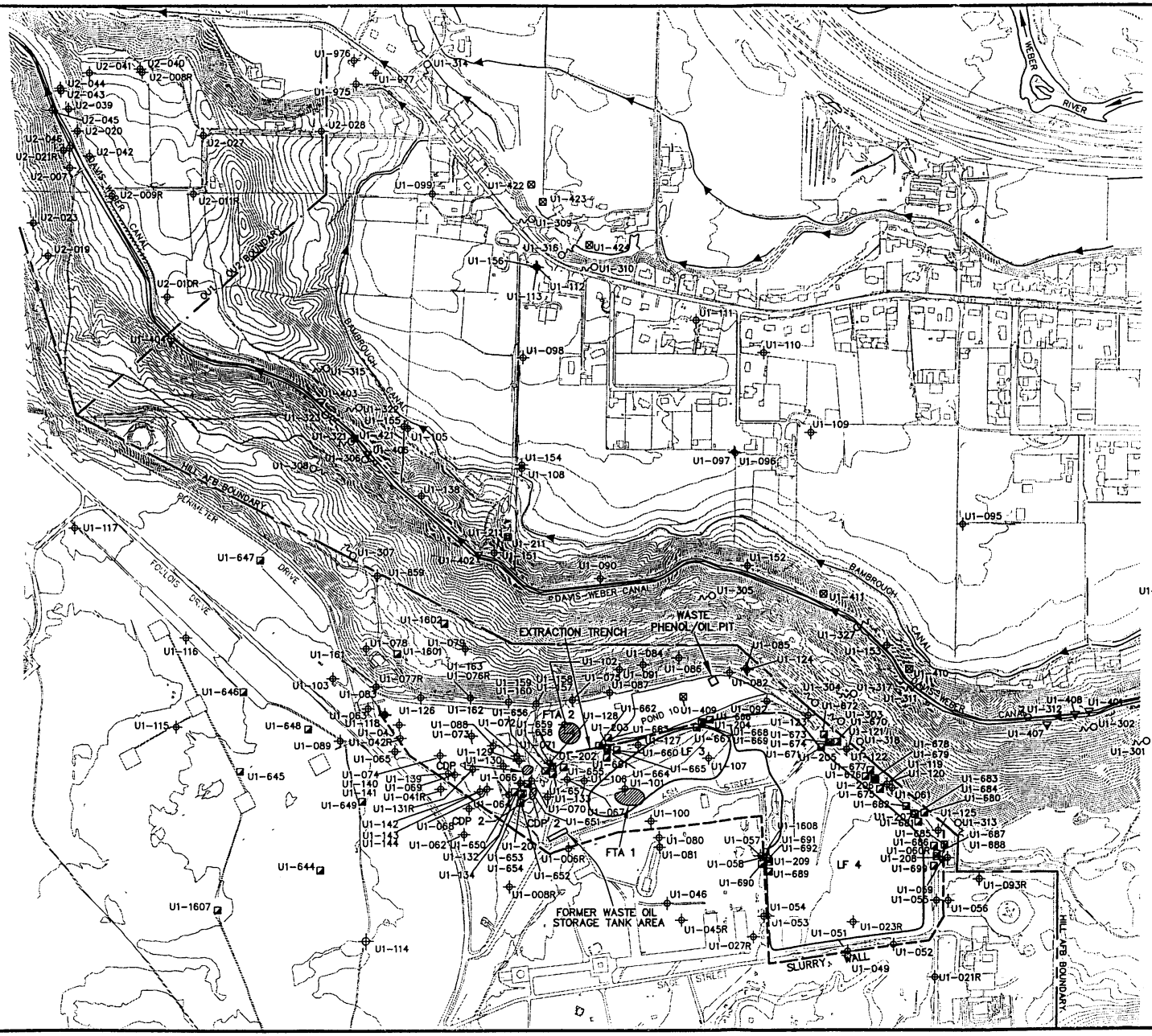

FIGURE 1.3

LOCATIONS OF EXISTING MONITORING AND EXTRACTION WELLS, PIEZOMETERS, SEEPS/SPRINGS, AND CANAL/ POND SAMPLES

OU1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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mid-1970s. In 1985, LFs 3 and 4 were capped with a bentonite soil layer. Currently, a compass repair facility, a generator repair building, and a cannon test facility are located between LFs 3 and 4.

FTAs 1 and 2 were used as practice areas to extinguish simulated aircraft fires. FTA 1 was used from the mid-1950s through 1973, when the training activities were moved to FTA 2 and continued until January 1995. No evidence of controls for the containment of fuels or chemical retardants were found at FTA 1; exercises at FTA 2 were staged on an earthen pad surrounded by a berm. During fire training exercises, liquids were observed overflowing the bermed area, but it is not known how large an area was affected. The FTA 2 pad was lined with asphalt in 1986; however, effluent migrated into the underlying soil through cracks in the asphalt. Between 1986 and 1990, the asphalt lining in the pit area was replaced with 4-inch-thick concrete. The primary type of waste associated with the FTAs is liquid hydrocarbon fuels that were burned during fire training exercises, but the waste fuels may have contained other products such as hydraulic fluids or solvents. Beginning in 1986, only on-specification JP-4 was used as the training fuel at FTA 2. In 1994, the fuel used in the training exercises for aircraft fires was changed from JP-4 to propane, which burns relatively cleanly. Fire training activities utilizing the earthen pad at FTA 2 were discontinued in January 1995. As of 1995, a smokehouse at FTA 2 was being used as the training area until a new training area is completed.

The WPOP was a brick-lined burn pit, used periodically to dispose of waste oil and phenol from approximately 1954 through 1965. During its first use, the brick pit broke apart due to high combustion temperatures; however, the burning continued on a weekly basis, apparently without repairs to the WPOP. In 1986, the WPOP was removed, along with associated soils, and disposed of at LF 3.

The WOST area consisted of four aboveground storage tanks located southeast of the CDPs and southwest of LF 3 (Figure 1.2). One tank was installed in 1965 to store fuel and crankcase oil. Analyses of the contents of this tank in the early 1970s indicated the presence of engine oil, JP-4, and hydraulic fluid. The date of removal of this tank and the condition of the site at the time of removal (e.g., evidence of spills) are not known. Three additional 20,000- to 25,000-gallon tanks were installed in 1981. It is believed these tanks contained wastes similar to those stored in the original tank. In 1981, two of the three tanks contained JP-4, and the third tank contained hydraulic oil. These tanks were removed in 1985. There is no documentation available regarding the condition of the WOST site at this time.

Based on the historical information gathered by Montgomery Watson (1995), it is highly unlikely that explosives or unconventional munitions (chemical warfare agents or defoliants) were used or disposed of at CDPs 1 and 2, LFs 3 and 4, FTAs 1 and 2, the WPOP, or the WOST area.

As early as 1976, Hill AFB recognized that there were potential problems associated with waste disposal practices at OU 1 (Montgomery Watson, 1995). Early investigations were conducted by Goodwin (1976) and CalScience Research, Inc. (CSR, 1981). The purpose of the investigation by Goodwin (1976) was to evaluate contamination associated with LFs 3 and 4. The study ultimately included CDPs 1 and 2 and 40 acres of private property bordering the Davis-Weber Canal along the northeastern Base boundary. During that investigation, soil borings were drilled, monitoring wells (U1-001 through

U1-011) were installed, and soil, groundwater, drainline effluent, and surface water samples were collected and analyzed. A clay layer was identified approximately 30 feet below ground surface (bgs). Organic and inorganic contaminants were found in the areas of the LFs and in seeps downgradient of LF 4. Mobile light, nonaqueous-phase liquid (LNAPL) was detected on the groundwater west of the CDPs and west of FTA 2.

The object of the CSR (1981) investigation was to examine the migration of LF 4 leachate to groundwater and springs on the escarpment north of LF 4 (Figure 1.3). Aspects of this study included evaluating groundwater elevation and flow direction, characterizing the soils underlying the southern portion of LF 4, determining the mass balance of groundwater moving through LF 4, and detailing possible mechanisms for the generation and migration of leachate. The investigation included drilling two soil borings, collecting surface soil and groundwater samples, installing two monitoring wells, and measuring water levels at the site monitoring wells.

Beginning in 1982, field work at the OU 1 sites was conducted as part of the Installation Restoration Program (IRP). A Phase I Records Search was conducted to identify past and present waste disposal practices that led to contamination at Hill AFB, and to assess the potential off-Base migration of contaminants (Engineering-Science, Inc. (ES), 1982). The search included interviews with personnel aware of past and present disposal practices, and record searches on the associated facilities. Results of this study consist of a history of waste disposal practices at Hill AFB, including the areas of CDPs 1 and 2, LFs 3 and 4, FTAs 1 and 2, WPOP, and WOST area. The United States Air Force (USAF) Hazard Assessment Rating Methodology (HARM) was used to evaluate the potential for environmental contamination based on site characteristics, waste material characteristics, and waste management practices.

Additional site assessments further examined the contamination at OU 1. After installing additional monitoring wells (U1-041A - U1-048), obtaining groundwater samples, and performing geophysical surveys at CDPs 1 and 2, LF 3, and the 160-acre site golf course south of OU 1 (Figure 1.1), volatile organic compounds (VOCs) were identified in the groundwater in the vicinity of CDPs 1 and 2 and LF 3 (Radian Corporation [Radian] *et al.*, 1984). The clay layer identified at 30 to 35 feet bgs during previous investigations was determined to be present as a continuous layer beneath the CDPs at depths of 30 to 50 feet bgs, and as clay lenses beneath LF 3. Radian *et al.* (1984) concluded that groundwater flowed from the CDPs toward the northwest with a secondary northern component.

A subsequent investigation (Radian and Science Applications International Corporation [SAIC], 1988) included geophysical surveys (Weston Geophysical, 1986); soil borings; installation of monitoring wells (U1-037 - U1-040, U1-049 - O1-061, and U1-064 - U1-087); collecting soil, surface water, and groundwater samples; slug tests; and groundwater modeling. The areas studied were CDPs 1 and 2, LFs 3 and 4, FTA 1, and the golf course. VOCs were identified in groundwater and surface water near and downgradient from LFs 3 and 4 and CDPs 1 and 2. Metals (arsenic, barium, iron, chromium, and manganese) at concentrations exceeding the Safe Drinking Water Act (SDWA) maximum concentration levels (MCLs) were detected in groundwater samples from CDPs 1 and 2 and LFs 3 and 4. The study also concluded that by increasing the amount of aquifer recharge, irrigation water from the golf course had the potential of increasing the migration rate of contaminants originating at OU 1.

A Phase I RI was conducted by James M. Montgomery, Consulting Engineers, Inc. (JMM, 1991) in 1990 and 1991. The purpose of the Phase I RI was to assess the risk to human health and the environment resulting from disposal practices at LFs 3 and 4, CDPs 1 and 2, and FTAs 1 and 2. Locations of these areas are indicated on Figure 1.2. During Phase I of the RI the following activities were conducted:

- A water rights survey located nine sources of potable water, including the City of South Weber Municipal Well 6-210, six springs, and two seeps.

- A passive soil gas survey of 200 locations in the Weber River Valley and adjacent hillside was conducted to identify possible source areas of contaminants, and to aid in the selection of monitoring well locations.

- Sixteen on-Base soil borings (U1-727 through U1-742) were drilled and sampled to evaluate soil contamination in the vicinities of CDPs 1 and 2 and LFs 3 and 4. Four 2-foot intervals of soil were collected from each boring and submitted for analysis of soil-pore fluid. Eight of the soil borings were completed as monitoring wells.

- Three deep soil borings were drilled to provide continuous logs of underlying sediments. Two of these borings were completed as monitoring wells (U1-088 and U1-090).

- Eight off-Base shallow monitoring wells (U1-091 and U1-093A through U1-099) were installed to evaluate the presence of contaminants in groundwater.

- Groundwater from the monitoring wells was collected and analyzed for various compounds, including anions, cations, metals, and VOCs.

Phase II RI work was initiated by JMM in 1992. During this RI, JMM collected additional information to better characterize the contamination associated with the CDPs, LFs, and FTAs, WOST, and WPOP, as well as to determine the lateral extent and thickness of mobile LNAPL associated with these areas. Cone penetrometer tests (CPTs) were conducted, soil borings were advanced, and monitoring wells were installed. Mobile LNAPL sampling was conducted to determine the product constituents. Results of this work are summarized in a comprehensive RI report (Montgomery Watson, 1995b).

Additional field investigations were conducted by Montgomery Watson (1996) under Delivery Order 5075 during the summer and fall of 1995. The primary objective of this work was to provide data needed to design a slurry wall and a groundwater extraction system that have been proposed to contain on-Base contamination. Five soil borings were drilled, and soil samples were collected for geotechnical, slurry mix compatibility, and vertical permeability analyses. Level II (screening quality) groundwater samples also were collected during soil borehole drilling and analyzed for VOCs and arsenic. Seven monitoring wells were installed to assess the depth to groundwater and the hydraulic gradient in the silty clay unit along the northwestern boundary of OU 1; groundwater samples from these wells were analyzed for VOCs and dissolved arsenic. Mobile LNAPL samples also were collected for compatibility tests with the proposed slurry wall material.

1.3 SITE REMEDIATION ACTIVITY

In 1984, a Cease and Desist Order was issued by the Utah Water Pollution Control Board (currently the Division of Water Quality) for leachate discharge below LF 4. Hill AFB implemented several interim remedial actions to mitigate the migration of contaminants originating from OU 1. The following remedial options were executed:

- LFs 3 and 4 and CDPs 1 and 2 were capped with bentonite soil layers to reduce precipitation infiltration and potential contaminant migration. Phase I of the capping project (37 acres in the area of LF 4) was started in 1983 and completed in 1984. Phase II (capping of an additional 30 acres, including CDPs 1 and 2 and LF 3) was completed in 1986.

- A retention pond (Pond 10, Figure 1.2) was constructed in 1986 to collect surface runoff from the LF caps.

- In 1984, a slurry wall was installed around the southern (upgradient) perimeter of OU 1 to divert groundwater recharge from upgradient sources around the sites (Figure 1.2).

- In 1984-1985, a groundwater extraction and treatment system with infiltration gallery was installed downgradient from LFs 3 and 4 to intercept contaminated groundwater before it migrates off-Base. The system became operational in August 1985.

The design specifications for the caps for LFs 3 and 4 called for 2 feet of compacted bentonite overlaid with approximately 3 feet of silty soil. However, during a subsequent investigation it was determined that the bentonite cap was 2 to 2.5 inches thick and was covered by 15.5 to 20 inches of soil. Laboratory results also indicated that the cap of LF 4 did not meet its specified permeability requirement of 10^{-7} centimeters per second (cm/sec) or less (Dames & Moore, 1986).

In 1984, the slurry wall was constructed to prevent groundwater flow from the south and southeast from recharging the OU 1 source areas. The 5,200-foot long slurry wall was designed to extend 47 to 52 feet bgs and to be keyed into the underlying clay layer. According to Dames & Moore (1985a and 1985b), the slurry wall extended only 35.5 to 40.5 feet bgs and did not completely tie into the clay layer, allowing potential horizontal seepage of groundwater into the OU 1 source area, and failed to meet permeability specifications. In an additional study, Dames & Moore (1985c) indicated that redirection of the groundwater by the slurry wall could adversely affect slope stability on the escarpment north of the terrace area. The comprehensive RI report (Montgomery Watson, 1995) observed that there is no difference in the head measured in groundwater monitoring wells on opposite sides of the slurry wall, and concluded that groundwater was migrating beneath the wall.

The groundwater extraction and treatment system consists of seven groundwater extraction wells, an extraction trench, and pumps to collect spring waters. The wells include two near the CDPs, four on the eastern boundary of OU 1, and one west of LF 4. Two of the extraction wells (U1-208 on the eastern boundary) and well U1-209, west of LF 4, are inactive; the other five wells are active. A 1,500-foot-long groundwater

extraction trench with two sumps extends east from FTA 2 to the perimeter road (Figure 1.2). The system also includes three pumping stations that collect water from hillside springs north of the sites. The collected groundwater is transported to a 250,000-gallon holding tank at the on-Base IWTP via a 3-mile-long, high-density polyethylene (HDPE) underground pipeline. According to Montgomery Watson (1995b), groundwater extraction wells are spaced too far apart to prevent off-Base migration of contaminated groundwater, and the extraction system was not being operated at its maximum efficiency. In 1996, a total of 14,792,770 gallons of groundwater were reportedly pumped (excluding the hillside springs), which equates to an average total pumping rate of approximately 28 gallons per minute (gpm).

Hill AFB has had an LTM program (i.e., chemical analysis of groundwater samples and collecting groundwater elevation measurements) in place since 1976. Off-Base seeps have been monitored since 1976, while monthly groundwater elevation measurements have been collected since 1985. Analysis of contaminants began in 1981, and since 1988, the extraction wells and seeps have been sampled and analyzed for contaminants. The effectiveness of interim remedial measures was evaluated by Dalpias *et al.* (1989). Based on the analytical results of samples collected from Spring U1-304 before and after the initiation of the interim remedial measures, the Dalphias *et al.* study concluded that they were effective and had reduced off-Base migration of contaminants. Concentrations of iron, phenols, 1,1,1-trichloroethane (1,1,1-TCA), toluene, and MEK were reduced to 5 to 20 percent of their pre-remediation concentrations at off-Base seeps.

Various additional remedial actions are being planned for sites in the OU 1 area. Presently the chemical disposal trenches in the CDP area are undergoing eight separate TSs. In June 1994, a pilot-scale bioventing system was installed at FTA 2 to remediate petroleum hydrocarbons present in the shallow subsurface soil. A soil vapor extraction system is under consideration for CDP 1. Remedial alternatives for groundwater, subsurface soil, springs, and seeps at OU 1 are described in the Proposed Plan, published in June 1997 (USAF, 1997). Under the preferred alternative described in the Proposed Plan, contaminated groundwater in the immediate vicinity of multiple contaminant source areas would be pumped using new and existing (but upgraded) extraction/collection trenches and an additional groundwater extraction well. Existing landfill covers would be improved and maintained over time. Additionally, a new surface water seep collection system and associated water treatment facility would be installed off-site. The implementation of on- and off-site institutional controls would prevent receptor exposures to subsurface soils and sediments around seeps/springs, and continued groundwater and surface water monitoring would be performed.

Numerical groundwater flow modeling for the vicinity of the on-Base contaminant source areas was performed by Montgomery Watson (1995a) to evaluate the performance of the existing containment system and to evaluate the potential effectiveness of six proposed groundwater containment alternatives for the area west of the existing system. The simulation of the groundwater flow system was performed using the MODFLOW (McDonald and Harbough, 1988) and MODPATH (Pollock, 1989) codes. On the basis of the modeling results, three containment alternatives were retained for further study.

SECTION 2

SITE CHARACTERIZATION ACTIVITIES

To meet the requirements of the RNA TS, additional data were required to evaluate near-surface hydrogeology and geochemistry, and the extent of surface water and groundwater contamination. Site characterization activities involved borehole advancement, soil sampling, and groundwater monitoring point installation using HSAs and a Geoprobe®; collection of groundwater samples from existing monitoring wells and piezometers and newly installed monitoring points; and collection of surface water samples from a drainage located north of South Weber Drive. The work performed is described in the work plan for this RNA TS (Parsons ES, 1996). However, more groundwater monitoring points than were originally scoped in the work plan were installed to provide additional lateral and vertical plume definition and to facilitate calculation of contaminant biodegradation rates. Field work was performed from March 14 through March 24, 1997.

The physical and chemical data listed below were collected during the field work phase of the TS:

- Depth from measurement datum to the water table or potentiometric surface in monitoring wells, piezometers, and monitoring points;
- Stratigraphy of subsurface media;
- Groundwater geochemical data, including pH, temperature, electrical conductivity, total alkalinity, oxidation/reduction potential (ORP), dissolved oxygen (DO), carbon dioxide, chloride, nitrate+nitrite [as nitrogen (N)], ammonia, ferrous iron, sulfate, hydrogen sulfide, total organic carbon (TOC), dissolved hydrogen, phenols, aliphatic and aromatic acids, methane, ethane, and ethene;
- Compound identification for mobile LNAPL samples;
- Groundwater concentrations of chlorinated and aromatic VOCs and metals;
- Concentrations of TOC in soil; and
- Concentrations of CAHs in surface water.

In addition, soil microcosm samples were collected for long-term testing at the USEPA NRMRL. The following sections describe the procedures that were followed when collecting site-specific data. Additional details regarding investigative activities are presented in the work plan (Parsons ES, 1996).

2.1 HSA AND GEOPROBE® FIELD ACTIVITIES

At OU 1, an HSA and a Geoprobe® were used to collect soil samples for visual description and TOC analysis, and to install groundwater monitoring points. A Giddings® rig equipped with a rear-mounted, 2.75-inch, inside-diameter (ID) HSA and a side-mounted Geoprobe® was used to advance boreholes for monitoring points. The HSA was used for all on-Base drilling due to the relatively deep groundwater depths. The Geoprobe® was used at all other borehole locations, and was supplemented with the HSA where the Geoprobe® rods could not be advanced due to the presence of gravels and/or cobbles in the subsurface. The Geoprobe® system is an hydraulically powered percussion/probing machine used to advance sampling tools through unconsolidated soils. This system provides for the rapid collection of soil, soil gas, and groundwater samples at shallow depths while minimizing the generation of investigation-derived waste materials. Figure 2.1 is a diagram of the Geoprobe® system.

2.1.1 Groundwater Monitoring Point Locations and Completion Intervals

HSA- and Geoprobe®-related field work included borehole advancement and monitoring point installation at one on-Base and eight off-Base locations (Figure 2.2). An attempt was made to install a groundwater monitoring point at a second on-Base location (SB-1); however, the augers could not penetrate the abundant cobbles present above the water table, and the borehole was abandoned. The term "monitoring point" is used in this report to distinguish these groundwater monitoring stations from conventionally constructed monitoring wells. During borehole advancement with the HSA, the subsurface stratigraphy was described using soil cuttings returned from the augers. With the Geoprobe®, a minimum of one soil core sample was collected from each borehole for logging. The core barrel was 4 feet long; however, in many cases less than 4 feet of core was recovered due to the abundance of gravel and cobbles in the subsurface. Monitoring point pairs, consisting of points screened at different elevations in the surficial aquifer, were installed at two off-Base locations (U1-1638/1639 and U1-1631/1640), resulting in the installation of a total of 11 monitoring points at 1 on-Base and 8 off-Base locations. Completion details for new monitoring points and previously installed monitoring wells are provided in Table 2.1.

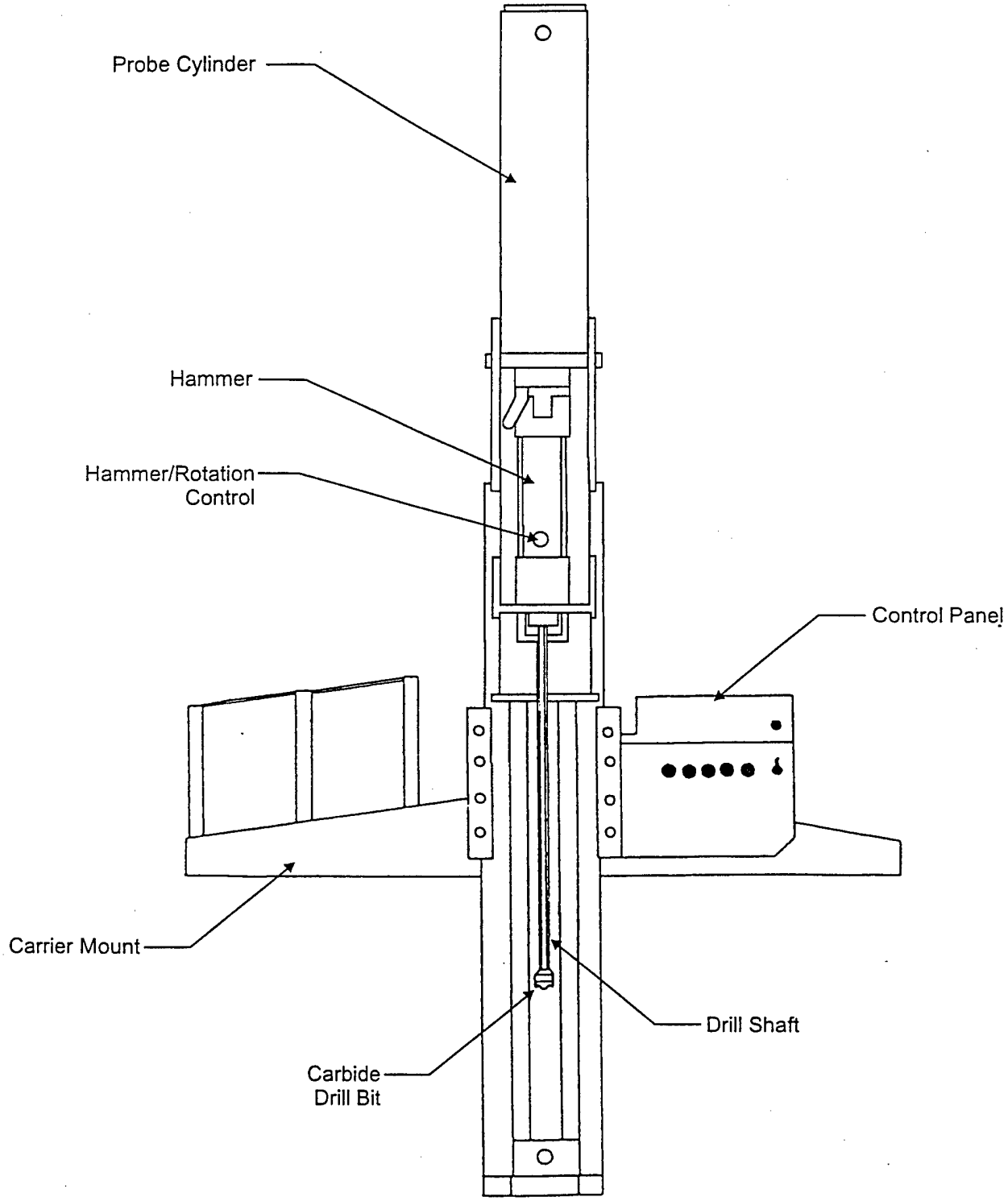
2.1.2 Groundwater Monitoring Point Installation and Soil Sampling Procedures

2.1.2.1 Pre-Installation Activities

All subsurface utility lines and other man-made subsurface features were located, and proposed monitoring point locations were cleared and approved by the Base or the off-Base utility location group ("Blue Stakes") prior to any drilling activities. Monitoring point locations were moved as necessary to avoid damage to subsurface utilities.

2.1.2.2 Equipment Decontamination Procedures

Prior to arriving at the site and between each monitoring point location, all downhole HSA and Geoprobe® equipment (e.g., auger flights, bits, rods, tips, sleeves, samplers, and tools) were decontaminated using a steam cleaner. Decontamination was performed at a designated wash area at FTA 2; wash water drained to a sewer line that discharges to the IWTP.



NOT TO SCALE

FIGURE 2.1

CROSS-SECTION OF GEOPROBE®

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

COREL/DRAW/GEOPROBE.CDR NAP 4/4/97 -TIF

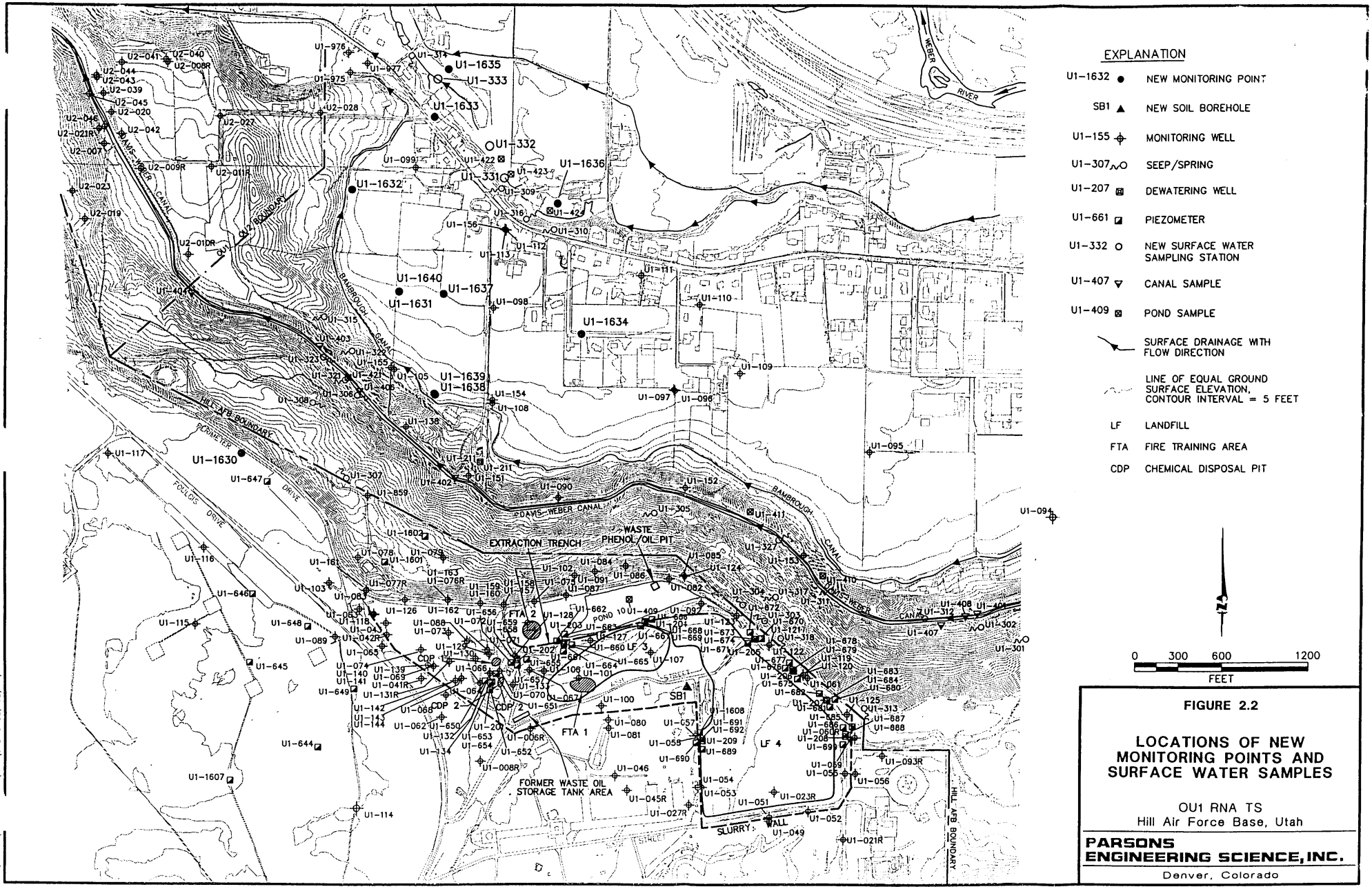


FIGURE 2.2

LOCATIONS OF NEW MONITORING POINTS AND SURFACE WATER SAMPLES

OU1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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TABLE 2.1
MONITORING POINT COMPLETION DATA
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Initial Monitoring Point Identification	Final Monitoring Point Identification	Installation Date	Monitoring Point Diameter (Inches)	Screened Interval (Feet bgs)[a/]	Survey Northing (State Plane)[b/]	Survey Easting (State Plane)	Top of Casing Elevation (Feet msl)[c/]	Ground Surface Elevation (Feet msl)
MP3	U1-1630	3/17/97	2.0	45.5-50.5	290893.00	1872065.59	4787.42	4787.83
MP4s	U1-1631	3/20/97	0.5	5.1-8.3	292022.26	1873158.07	4479.78	4479.75
MP5	U1-1632	3/20/97	0.5	13.8-17.0	292702.85	1872826.90	4478.46	4478.49
MP6	U1-1633	3/19/97	0.25	21.5-22.0	293189.73	1873393.82	not surveyed	4460.57
MP7	U1-1634	3/18/97	0.5	13.4-16.6	291721.67	1874424.63	4486.88	4486.99
MP8	U1-1635	3/19/97	0.5	11.7-14.9	293511.86	1873493.04	4447.52	4447.53
MP9	U1-1636	3/18/97	0.5	7.6-10.8	292603.12	1874254.42	4450.05	4450.11
MP10	U1-1637	3/20/97	0.5	9.8-13.0	291992.24	1873464.77	4479.21	4479.42
MP11s	U1-1638	3/21/97	0.25	29.0-29.5	291307.91	1873408.84	not surveyed	4498.41
MP11d	U1-1639	3/21/97	0.25	40.0-40.5	291314.62	1873404.02	not surveyed	not surveyed
MP4d	U1-1640	3/20/97	0.25	14.5-15.0	not surveyed	not surveyed	not surveyed	not surveyed

[a/] Feet bgs = Feet below ground surface.

[b/] State Plane = State of Utah Plane Coordinate System.

[c/] Feet msl = feet above mean sea level.

Fuel, lubricants, and other similar substances were handled in a manner consistent with accepted safety procedures and standard operating practices. All monitoring point completion materials were factory sealed and were not stored near or in areas that could be affected by these substances.

2.1.2.3 Borehole Advancement and Soil Sampling

During borehole advancement, soil samples were obtained for visual description, TOC analysis, and/or microcosm studies. During borehole advancement using the HSA, soil samples were obtained from drill cuttings. Geoprobe®-collected soil samples were obtained using a probe-drive sampler. The probe-driven sampler serves as both the driving point and the sample collection device and is attached to the leading end of the probe rods. To collect a soil sample, the sampler was pushed or driven to the desired sampling depth, and the stop pin was removed, allowing the piston and drive point to retract as the sample barrel was pushed into undisturbed soil. The soil cores were retained within a clear acetate liner inside the sampling barrel. The probe rods were then retracted, bringing the sampling device to the surface. The samples were visually described, and, in some cases, a sample for laboratory TOC analysis was retained in a clean glass jar or sealable plastic bag. A summary of chemical analyses performed for soil samples is presented in Table 2.2.

USEPA personnel operated the HSA and Geoprobe®, and the Parsons ES field scientist observed soil sampling and monitoring point installation activities and maintained a descriptive log of subsurface materials recovered. Soil sample descriptions are provided in Appendix B.

2.1.3 Monitoring Point Installation

Groundwater monitoring points were installed in 11 boreholes under this program. Monitoring point installation procedures are described in the following paragraphs. Monitoring point completion diagrams are included in Appendix B.

2.1.3.1 Monitoring Point Materials Decontamination

Monitoring point completion materials were inspected by the field scientist and determined to be clean and acceptable prior to use. All monitoring point completion materials were factory sealed in plastic wrap. Pre-packaged casing, sand, bentonite, possible external contamination before use. Materials that could not be cleaned to the satisfaction of the field scientist were not used.

2.1.3.2 Monitoring Point Casing and Screen

Three monitoring point designs were used to construct shallow monitoring points. Monitoring point U1-1630, drilled using HSAs, was constructed of 2-inch-ID, Schedule 40, polyvinyl chloride (PVC) riser pipe connected to a 5-foot-long, factory-slotted, PVC screen of the same diameter. The screen slot size is 0.010-inch.

The majority of the other shallow monitoring points, advanced using a Geoprobe®, were constructed of 0.5-inch-ID, Schedule 40 PVC riser pipe connected to 3.3-feet-long, factory-slotted PVC screens of the same diameter. The screen slot size is 0.010 inch.

TABLE 2.2
ANALYTICAL METHODS FOR GROUNDWATER, SURFACE WATER, AND SOIL SAMPLES
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

MATRIX/PARAMETER	METHOD	ANALYTICAL LABORATORY
GROUNDWATER		
Phenols, Aliphatic/Aromatic Acids	RSKSOP-177	NRMRL[a/]
Dissolved Hydrogen	Reduction Gas Analyzer	Field
Ferrous Iron (Fe+2)	Colorimetric, Hach Method 8146	Field
Sulfate	N-601 [b/]	NRMRL
Nitrate + Nitrite (as Nitrogen)	E353.1	NRMRL
Oxidation-Reduction Potential	Direct-reading meter	Field
Dissolved Oxygen	Direct-reading meter	Field
pH	Direct-reading meter	Field
Conductivity	Direct-reading meter	Field
Temperature	Direct-reading meter	Field
Alkalinity (Carbonate [CO3-2] and Bicarbonate [HCO3-1])	Titrimetric, Hach Method 8221	Field
Hydrogen Sulfide	Colorimetric, Hach Method 8131	Field
Carbon Dioxide	CHEMetrics Method 4500	Field
Chloride	N-601 [b/]	NRMRL
Ammonia--Diss. Gas in Water	E350.1	NRMRL
Methane	RSKSOP-175/RSKSOP-147	NRMRL
Ethene/Ethane	RSKSOP-175/RSKSOP-147	NRMRL
Total Organic Carbon	RSKSOP-102	NRMRL
Aromatic Hydrocarbons + Fuel Carbon	RSKSOP-133	NRMRL
Total Metals	ICP, GFAA (lead only) [c/]	NRMRL
Chlorinated Volatile Organics	RSKSOP-146	NRMRL
SOIL		
Total Organic Carbon	RSKSOP-102, RSKSOP-120	NRMRL
SURFACE WATER		
Volatile Organics	RSKSOP-146	NRMRL
COMBINED SOIL/GROUNDWATER		
Soil Microcosm Studies		NRMRL

[a/] USEPA National Risk Management Research Laboratory in Ada, Oklahoma.

[b/] Waters capillary electrophoresis Method N-601.

[c/] ICP = inductively coupled plasma spectrometry; GFAA = graphite furnace atomic absorption.

The 0.5-inch-ID PVC points were placed wherever formation soils did not collapse into the borehole after the Geoprobe® rods were extracted. All PVC casing and screen sections on the monitoring points were flush threaded; glued joints were not used. The riser pipe at each PVC monitoring point was fitted with a PVC top cap, and an aluminum drive point was inserted into the bottoms of the 0.5-inch ID PVC screens.

Where collapsing soils prevented the placement of the PVC screen after the extraction of the soil probe (monitoring points U1-1633 and U1-1639), the monitoring points were constructed with 0.25-inch-ID stainless steel (SS) mesh implants acting as monitoring point screens and 0.25-inch-ID, Teflon®-lined, HDPE tubing acting as risers connecting the SS mesh to the surface (HDPE tubing was threaded through the center of the Geoprobe® drive rods). Monitoring point screens constructed of SS were 0.5 foot in length with pore openings of 0.0057 inch. The riser tubing for these monitoring points extended to the surface, and the bottom of the SS mesh screen was threaded to the dedicated stainless steel drive point/implant anchor that remained in place after the drive rods were removed.

Monitoring point construction details are summarized in Table 2.1. The field scientist verified and recorded the borehole depth and the lengths of all casing sections and tubing. All lengths and depths were measured to the nearest 0.1 foot.

2.1.4 Monitoring Point Development

Before being sampled, newly installed monitoring points were developed. Typically, well development removes sediment from inside the well casing and flushes fines, cuttings, and drilling fluids from the sand pack and the portion of the formation adjacent to the well screen. Use of the Geoprobe® system to place monitoring points eliminates cuttings and drilling fluids. Therefore, development of monitoring points installed in Geoprobe® boreholes was primarily intended to minimize the amount of fine sediment that might accumulate in the casing.

Development was accomplished using a peristaltic pump with dedicated silicone and HDPE tubing. Typically, development was continued until a minimum of seven casing volumes of water were removed, and the pH, temperature, and conductivity of the groundwater had stabilized. Monitoring point U1-1633 had a very low recharge rate, and was pumped dry only once during the development process; approximately 0.25 liter of water was removed during development. Development waters were containerized and disposed of at the Base IWTP. Development records are contained in Appendix B.

2.2 GROUNDWATER SAMPLING

This section describes the procedures used for collecting groundwater quality samples. In order to maintain a high degree of quality control (QC) during this sampling event, the procedures described in the site work plan (Parsons ES, 1996) and summarized in the following sections were followed. Targeted analytes are summarized in Table 2.2.

2.2.1 Groundwater Sampling Locations

Groundwater samples were collected from 47 previously installed monitoring wells and piezometers, and 9 of the 11 newly installed monitoring points (U1-1632 through

U1-1640). Newly-installed monitoring point U1-1630 was dry, and U1-1631 did not recover after being evacuated. A partial sample was obtained from U1-1633 due to an extremely low recharge rate. After completion of installation and development activities, the monitoring points were purged and sampled using a peristaltic pump with dedicated HDPE and silicone tubing.

2.2.2 Preparation and Equipment Cleaning

All equipment used for sampling was assembled and properly cleaned and calibrated (if required) prior to use in the field. Calibrations were performed in accordance with the manufacturer's specifications. An electrical water level meter was used to measure the static water level in the monitoring well/point prior to initiation of purging. Prior to each use, the water level probe was cleaned with a potable water and phosphate-free, laboratory-grade detergent solution, followed by a distilled-water rinse. In addition, a clean pair of new, disposable latex or nitrile gloves was worn each time a different well or monitoring point was sampled. Dedicated HDPE and silicone tubing were used at each sampling location, eliminating the need for decontaminating these items between wells.

2.2.3 Groundwater Sampling Procedures

2.2.3.1 Preparation of Location

Prior to starting the sampling procedure, the area around the well or monitoring point was cleared of foreign materials, such as brush, rocks, and debris. These procedures prevented sampling equipment from inadvertently contacting debris around the monitoring well/point. The integrity of the monitoring well/point also was inspected, and any irregularities in the visible portions of the well/point, protective cover, or concrete pad were noted.

2.2.3.2 Water Level and Total Depth Measurements

Prior to removing any water from the well or shallow monitoring points, an electrical water level probe was used to measure the depth to groundwater below the well datum to the nearest 0.01 foot. Water levels in the newly installed points constructed of Teflon®-lined HDPE tubing were not obtained because the water level probe diameter was larger than the tubing diameter. If the monitoring well/point depth was not known, the water level probe was then lowered to the bottom of the well/point for measurement of total depth (recorded to the nearest 0.1 foot). Based on these measurements, or using total depths recorded in the comprehensive RI report (Montgomery Watson, 1995b), the volume of water to be purged from the well/point was calculated.

2.2.3.3 Monitoring Well/Point Purging

Where possible, a minimum of three times the calculated saturated casing volume was removed from each monitoring well/point prior to sampling. Purging continued until the pH, DO concentration, ORP, conductivity, and temperature stabilized between successive readings. Physical and chemical parameters were measured at the well head using field meters and a flow-through cell consisting of an Erlenmeyer flask. Where present, dedicated bladder pumps usually were used for purging and sampling. In some instances however, wells containing dedicated bladder pumps were sampled using a peristaltic

pump due to mechanical failure of the bladder pump controller. Wells sampled with a peristaltic pump are indicated on sampling records in Appendix B. A peristaltic pump with dedicated silicone and HDPE tubing was used for well evacuation at all other sampling locations where the depth to groundwater was sufficiently shallow (less than approximately 20 feet bgs). At these wells, the HDPE tubing was lowered to within 2 feet of the bottom of the well. Purging from monitoring points constructed of tubing was accomplished by attaching the silicone peristaltic pump tubing directly to the top of the monitoring point tubing. A decontaminated Bennett pump connected to Teflon® discharge tubing was used to purge wells having deeper static water levels and no dedicated bladder pump. The Bennett pump is a submersible piston pump powered by compressed air. All purge water was containerized and disposed of at the Base IWTP. Purging and sampling field forms are contained in Appendix B.

2.2.3.4 Sample Collection

As described above for purging, the dedicated bladder pumps were used for sampling to the extent possible; however, mechanical failure of the bladder pump controller necessitated use of a peristaltic pump at some wells that contained bladder pumps. A peristaltic pump with dedicated silicone and HDPE tubing was used to extract groundwater samples from all other sampling locations where the depth to groundwater was less than approximately 20 feet bgs. A Bennett pump connected to Teflon® tubing was used to sample wells having deeper static water levels and no dedicated bladder pump. In almost all cases, the sampling was performed immediately following well purging (i.e., the pump was not turned off between purging and sampling activities). In a few instances, the monitoring well/point was purged dry, and the samples were collected after sufficient recharge had occurred. All samples were collected within 24 hours of purging.

The samples were transferred directly into the appropriate sample containers. The water was carefully poured down the inner walls of each sample bottle to minimize aeration of the sample. Sample bottles for aromatic and chlorinated VOCs and dissolved gases (methane and ethene) were filled so that no headspace or air bubbles remained within the container.

2.2.4 Onsite Chemical Parameter Measurement

DO measurements were taken using an Orion® model 840 or Yellow Springs Instruments (YSI) model 55 DO meter in a flow-through cell at the outlet of the peristaltic pump. DO concentrations were recorded after the readings stabilized, and in all cases represent the lowest DO concentration observed.

Because the electrical conductivity, pH, ORP, and temperature of the groundwater change significantly within a short time following sample acquisition, these parameters were measured in the field, in the same flow-through cell used for DO measurements. Measured values were recorded on the groundwater sampling records (Appendix B).

2.2.5 Sample Handling

The fixed-base analytical laboratory (NRMRL) provided pre-preserved sample containers where appropriate. The sample containers were filled as described in Section

2.2.3.4, and the container lids were tightly closed. The samples were labeled as described in the work plan (Parsons ES, 1996).

After the samples were sealed and labeled, they were transported to the onsite USEPA mobile laboratory. USEPA personnel packaged the samples to prevent breakage and leakage or vaporization from the containers. Sample shipment to NRMRL and the associated chain-of-custody documentation was the responsibility of the USEPA/NRMRL field personnel.

2.3 SURFACE WATER SAMPLING

Three surface water samples were collected from a shallow, northwesterly-flowing drainage located immediately north of South Weber Drive (Figure 2.2). These samples were collected in order to assess the degree to which CAH-contaminated groundwater is discharging to the drainage. The surface water samples, which were analyzed for CAHs only, were collected directly into the sample bottle by placing the bottle in the drainage with the opening facing up and allowing the water to slowly fill the bottle. Sample handling proceeded as described for groundwater samples in Section 2.2.5.

2.4 AQUIFER TESTING

Results from analysis of 36 slug tests and at least one pump test are reported in the comprehensive RI report (Montgomery Watson, 1995b). The RI report also contains vertical permeability data derived from laboratory testing of core samples. Therefore, additional aquifer testing was not performed during the TS field program.

2.5 SURVEYING

After completion of field work, the locations and elevations of all new monitoring points were surveyed by Mountain West Land Surveyors, Inc. a licensed land surveyor from Roy, Utah. The elevations of the water surface in the drainages south of monitoring points U1-1635 and U1-1636 also were surveyed. The survey tied into preexisting monitoring wells installed during the RI and cultural features such as road intersections. For monitoring points constructed of PVC, the horizontal locations and elevations of the measurement datum (top of PVC well casing) and the ground surface adjacent to the well casing were measured relative to the Utah state plane coordinate system. Only the ground surface elevations were measured for monitoring points constructed of Teflon®-lined tubing. Survey data are presented in Table 2.1 and Appendix B.

SECTION 3

PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section describes the physical characteristics of OU 1. Existing site-specific data were reviewed and supplemented with data collected by Parsons ES in March 1997 to develop a synopsis of OU 1 physical characteristics. The following sections include data from the following sources:

- Montgomery Watson (1995b); and
- JMM (1991).

3.1 CLIMATE

The climate of Hill AFB is semi-arid. Mean annual precipitation is just over 18 inches, and annual evaporation is approximately 45 inches (Feth *et al.*, 1966). Most of the precipitation occurs from October through May. Based on data collected from 1980 through 1994, the months with the highest average precipitation are March (2.2 inches), May (2.7 inches), and October (2.0 inches). June through August was the driest period (Montgomery Watson, 1995b). At Ogden, just north of Hill AFB, the average temperature is 50.5 degrees Fahrenheit (°F); mean monthly temperatures range from 25°F in January to 75°F in July. Winds average about 5 knots and are generally out of the south and east-southeast, although winds from the north and northwest are common.

3.2 SURFACE FEATURES

3.2.1 Geography and Physiography

Hill AFB is located in northern Utah, approximately 25 miles north of Salt Lake City and 5 miles south of Ogden (Figure 1.1). The Base covers 6,666 acres in Davis and Weber Counties. The western boundary of the Base is near Interstate 15, and the southern boundary is near State Route 193. The western, northern, and northeastern perimeters of the Base are bounded by the Davis-Weber Canal, a privately-owned irrigation canal. The Wasatch Mountain Range is about 4 miles to the east, and the Great Salt Lake is about 6 miles to the west. The Base is located within the Bonneville Basin subsection of the Great Basin section of the Basin and Range physiographic province.

3.2.2 Ground Surface Topography

Hill AFB is located on a plateau that rises approximately 300 feet above the Weber River Valley on the east and approximately 50 to 100 feet above Sunset and Clinton on the west. Except for areas dissected by erosion, most of Hill AFB is relatively level,

ranging in elevation between approximately 4,550 and 4,800 feet above mean sea level (msl). The immediate vicinity around the CDPs, LFs, FTAs, WPOP, and WOST is a relatively flat terrace that slopes gradually toward the north and east. The elevation of the terrace surface in the immediate vicinity of the source areas ranges from approximately 4,780 to 4,810 feet msl. The ground surface to the north and east of this area slopes steeply downward to the Weber River Valley (Figure 1.2). There is approximately 300 feet of relief between the top of the escarpment at OU 1 and the edge of the valley floor to the north. The portion of OU 1 located in the Weber River Valley slopes gradually to the north, and ranges in elevation from 4500 feet msl at the south edge of the valley to 4,445 feet msl at the north edge of the investigated area.

3.2.3 Surface Hydrology

Precipitation at Hill AFB generally infiltrates through coarse-grained, near-surface sediments to shallow, perched water tables. At OU 1, groundwater locally discharges to a series of 19 seeps and springs. Fifteen of these springs are located on or immediately adjacent to the escarpment, and the remaining four are located in the Weber River Valley on private land along South Weber Drive. Of the 15 springs located on the escarpment, one is located on the Base, and the remaining 14 are located on private land lower on the slope (Montgomery Watson, 1995b).

Surface water runoff may flow locally in small erosional gullies during storm events; the gullies are often diverted into a series of retention ponds throughout the Base. Pond 10 was built in 1986 to intercept runoff within the OU 1 area. It is about 12 feet deep, and covers approximately 5 acres (Figure 1.2). The pond is located at the edge of the escarpment at OU 1, and collects surface runoff from a 40- to 60-acre area south and west of the pond (Montgomery Watson, 1995b). The interaction between surface water in the pond and groundwater has not been quantified. Discharge of groundwater to the pond, if it occurs, may be seasonal. According to Oliver (1997), the pond is excavated to the top of the silty clay layer that underlies the sand and gravel aquifer. The pond generally fills during the spring and early summer months, then the water level slowly recedes throughout the remainder of the year until the following spring.

The northerly-flowing Davis-Weber Canal traverses the escarpment immediately north of OU 1 and carries irrigation water from April to October each year. The Canal is lined throughout the OU1 area. However, the lining is cracked and mostly non-existent on the uphill side. A new section of lining was recently constructed further to the east (east of Well U1-153 [Figure 1.3]). A previous investigation of the canal indicates a loss of flow in sections to the east and west of OU 1, but no loss of flow in the immediate vicinity of OU 1 (Herbert *et al.*, 1987). However, groundwater levels in the portion of the Weber River Valley occupied by the CAH plume can be substantially affected by the presence of irrigation water in the Davis-Weber Canal, reportedly rising by as much as 5 feet during irrigation season (Carter-Drain, 1997). This observation indicates that there is a significant loss of water in the immediate vicinity of OU 1. Located downslope (north) of the Davis-Weber Canal is the smaller Bambrough canal, which also carried irrigation water from April to October through 1995. Use of this canal has since been discontinued.

3.3 REGIONAL GEOLOGY AND HYDROGEOLOGY

3.3.1 Regional Geology

The geologic formations exposed at the surface in the vicinity of Hill AFB vary from Precambrian-age crystalline bedrock at the western margin of the Wasatch Mountain Range to Pleistocene unconsolidated deposits forming benches, plateaus, and lowlands west of the Wasatch Front (Figure 3.1). The plateau upon which Hill AFB is located is an erosional remnant of a fan-delta complex that formed as sediments were transported from the Wasatch front into Pleistocene Lake Bonneville. Cross-section A-A', traced on Figure 3.2 and displayed on Figure 3.3, illustrates the aquifers and confining units comprising the plateau and underlying formations. Coarse-grained fan-delta deposits of the (most recent) Provo stage of Lake Bonneville are exposed at the surface within the boundaries of the Base. The fan-delta has been dissected along the northeastern perimeter of the Base by the Weber River, creating a steep terrace. Silts, sands, and clays of the Alpine stage of Lake Bonneville underlie the Provo deposits across much of the Base and are exposed on the steep hillsides northeast of the Base and on the hilltops in the eastern portion of the Base. Although older than the Provo stage sediments, some of the upper Alpine stage units were deposited at higher altitudes than Provo stage sediments because the lake level was higher during Alpine stage.

In addition to the formations exposed at the surface, 2,000 to 3,000 feet of pre-Lake Bonneville sediments are present in a north/south-trending graben underlying the area of Hill AFB (Feth *et al.*, 1966). This basin fill consists of thick sequences of interbedded coarse alluvium and lacustrine clays. The coarse alluvial units are successively older (and deeper) lobes and layers of the fan-delta complex, and they function as artesian aquifers.

3.3.2 Regional Hydrogeology

Shallow (surficial) aquifers are present in unconsolidated deposits. In addition, localized perched aquifers occur in shallower deposits at various locations on and around Hill AFB. In the upper part of the delta, the interaction of Lake Bonneville and the delta resulted in a complex system of interfingering lenticular strata where the more coarse-grained units likely act as preferential pathways for groundwater flow. Shallow groundwater zones are constrained vertically with depth by the fine-grained units within the Lake Bonneville Group deposits. The base of the shallow groundwater system (shallow unconfined aquifer) is defined by an irregular contact with low-permeability clay (Figure 3.3).

In the OU 1 area, flow in the surficial aquifer is generally to the north and northeast. Elsewhere on the Base, local groundwater flow in the surficial aquifers may be locally controlled by topography or other features. Two aquifers in deeper unconsolidated deposits supply water to area communities. The Sunset aquifer is found primarily beneath the City of Sunset and the western portion of the Base (Figure 3.3). This aquifer is approximately 250 to 400 feet bgs. The aquifer most commonly used for water supply is the Delta Aquifer, which is approximately 500 to 700 feet bgs. The regional hydraulic gradient in the deeper aquifers is to the west-northwest. The potentiometric surfaces in the deep aquifers beneath the Base are relatively flat. However, because of high

Symbol	System	Series	Formation and Lithology	Thickness in Feet
Qa	Quaternary	Recent	Alluvium: Permeable river sand and gravel; includes mudflow deposits near mountains which are impermeable locally.	200
Qg			Gravel: Permeable floodplain sand and gravel.	
Qs			Sand: Permeable fine sands underlying low-lands.	10-20
Qc			Clay: Impermeable plastic to non-plastic clay overlaying artesian aquifer.	35+
		UNCONFORMITY		
	Quaternary	Pleistocene	(Lake Bonneville Group): Provo Formation:	
Qpg			gravel, permeable;	5-20
Qpgs			gravel and sand, permeable;	10-50
Qps			sand, permeable	10-20
Qba			Bonneville and Alpine Formation: sand and gravel over bedrock, very permeable	5-50
			Alpine Formation:	
Qag			gravel, permeable;	<25
Qas			sand, permeable;	100
Qac			clay silt, fine sand, usually impermeable;	200
Q			Unconsolidated basin-fill deposits	>1000
		UNCONFORMITY		
Cl	Cambrian	Middle to Late (?)	Limestone: Silty with interbedded shale and dolomite. Permeable.	1375(±)
Ct		Lower to Middle (?)	Tintic Quartzite: massive, cross-bedded, pebbly. Permeable where fractured.	500-700
		ANGULAR UNCONFORMITY		
Pcf		Precambrian	Farmington Canyon Complex: metasedimentary and metavolcanic rocks. Permeable where jointed or fractured.	10,000

SOURCE: Modified from Feth et al. (1966)

FIGURE 3.1

GENERALIZED STRATIGRAPHY OF THE HILL AFB AREA

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

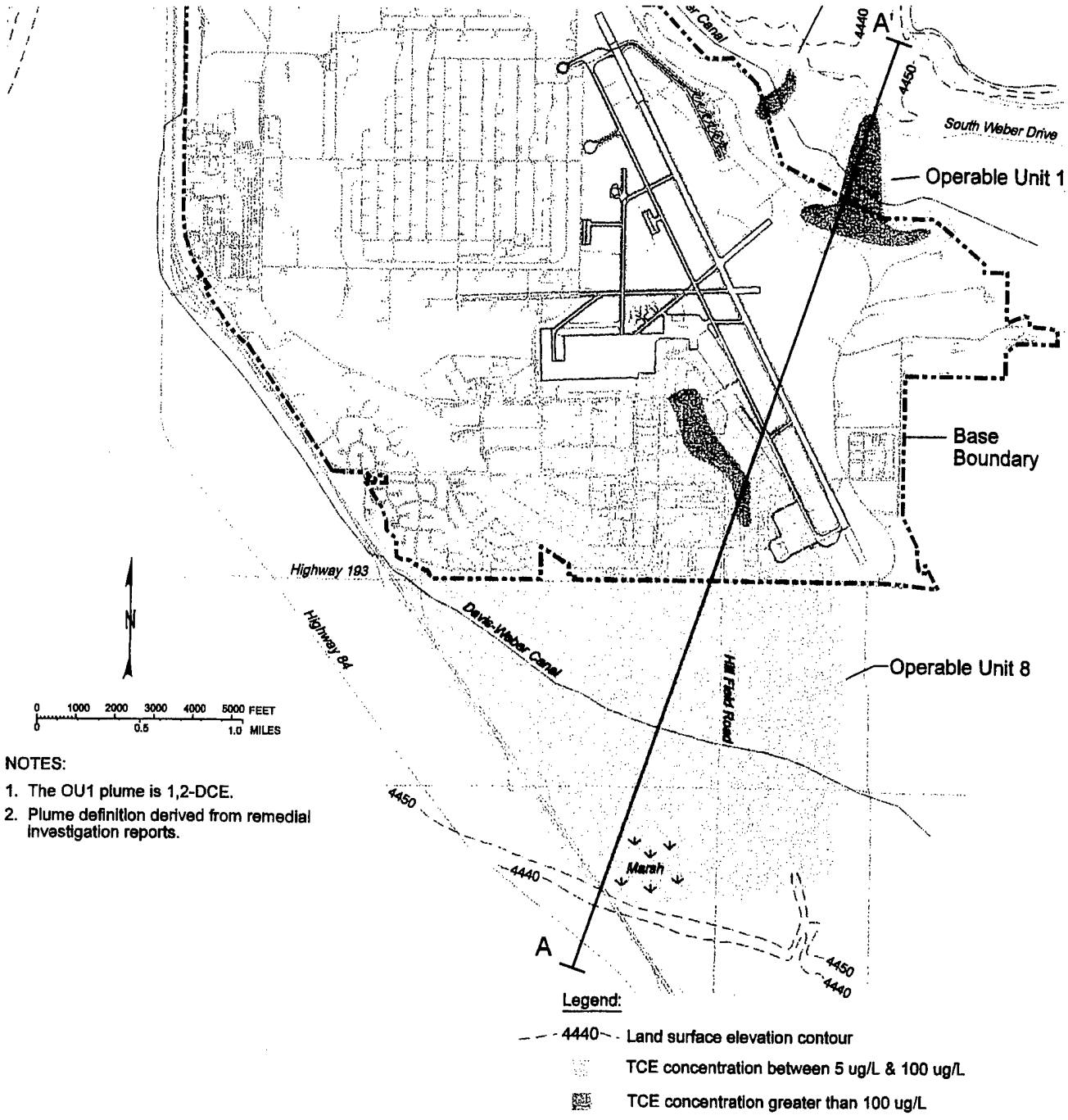
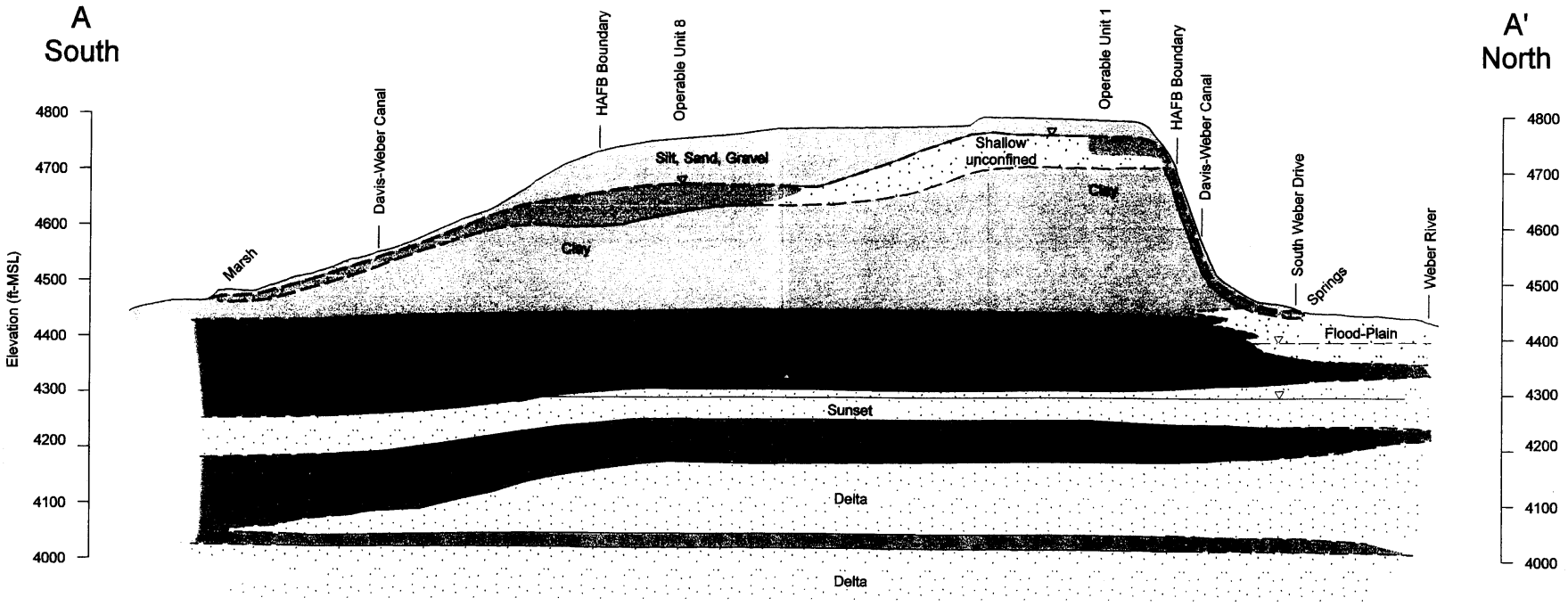


FIGURE 3.2

LOCATION OF REGIONAL HYDROSTRATIGRAPHIC CROSS-SECTION A-A'

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado



Legend:

- Aquifers (Shallow Unconfined, Flood-plain, Sunset, Delta)
- Groundwater Contaminant Plumes
- Lake Bonneville Group (Provo and Alpine Stage)
- Confining Units (primarily clay)
- Shallow Unconfined Aquifer static water level
- Sunset Aquifer potentiometric surface (JMM, 1989)
- Delta Aquifer potentiometric surface - 1985 (Clark and others, 1990)
- Contact (dashed where inferred)

0 2000
Horizontal Scale in Feet
Vertical Exaggeration = 10x

FIGURE 3.3

REGIONAL HYDROSTRATIGRAPHIC CROSS-SECTION

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

pumpage, local perturbations of the potentiometric surfaces are evident, and the potentiometric surfaces have been lowered substantially.

With respect to regional groundwater flow patterns, vertical flow is downward in recharge areas near the mountain front and upward in discharge areas to the west of the Base, near the Great Salt Lake. This general pattern of recharge and discharge may be locally affected by groundwater pumping, but should be relatively unaffected at the regional scale. On the basis of the potentiometric surfaces of the aquifers beneath the Base, downward components of flow from the shallow unconfined aquifer to the deeper Sunset and Delta aquifers are inferred. However, the downward movement of groundwater through the confining units between the aquifers depends on the degree of hydraulic connection among the aquifers, which in turn depends on the thickness and hydraulic properties of the clay layers separating the aquifers. Drillers' logs indicate that the confining units in the area of the Base are primarily tight, blue-gray clay. The extensive clays separating the aquifers appear to limit the hydraulic connection among the aquifers, and thus, the amount of recharge and vertical leakage. The deep aquifer system becomes unconfined and less differentiated near the mountain front and the mouth of Weber Canyon. The unconfined extension of the deep aquifer system is the main source of recharge to the deep aquifers. Recharge to the deeper aquifers primarily occurs by direct infiltration into the more permeable Lake Bonneville deposits and by seepage losses from the Weber River.

High-yield production wells at Hill AFB are screened in one or both coarse-grained water-bearing units of the Delta Aquifer starting at about the 4,200-foot-msl elevation (Figure 3.3). Logs for city wells to the west and south of Hill AFB indicate that the upper water-bearing unit or lobe of the Delta Aquifer fan complex thins and eventually terminates in these directions. Therefore, this upper lobe is unique to the Hill AFB area. The lower water-bearing unit of the Delta Aquifer is tapped elsewhere outside of the Base. The shallower, lower-yield Sunset Aquifer is more differentiated from the Delta Aquifer in the areas west and southwest of the Base, and is used for water supply in these areas, though less frequently than the Delta Aquifer.

3.4 OU 1 GEOLOGY AND HYDROGEOLOGY

The geologic and hydrogeologic features of OU 1 and nearby, hydraulically downgradient areas described in the RI report (Montgomery Watson, 1995b) were defined by a combination of drilling and logging at a total of 49 locations on-Base and 15 off-Base locations, and CPT at 40 locations off-Base. Additional field activities were conducted in 1995 to provide data needed to design the proposed slurry wall and groundwater extraction system (see Sections 1.2 and 1.3). Eleven monitoring points were installed for this TS in March 1997 using a combination of Geoprobe® and HSA borehole advancement methods. These points are primarily located in the shallow alluvial deposits north of the escarpment. Depth to groundwater, groundwater flow, and hydraulic parameters have been defined from the collection of water-level measurements at most site wells and slug tests at 37 monitoring wells.

3.4.1 Site Geology

The subsurface features in the vicinity of OU 1 and downgradient areas are consistent with the regional setting of the Provo and Alpine Formations, consisting of fluvial-deltaic

deposits of clay, silt, sand, and gravel. In general, deposits in the OU 1 area show a downward fining trend. A surficial cap, 2- to 5-feet thick, of silty sand with occasional bentonite intervals covers Landfills 3 and 4 and the LNAPL plume area. The unconsolidated deposits underlying the surficial cap in the on-Base portion of OU 1 are described below (Montgomery Watson, 1995b):

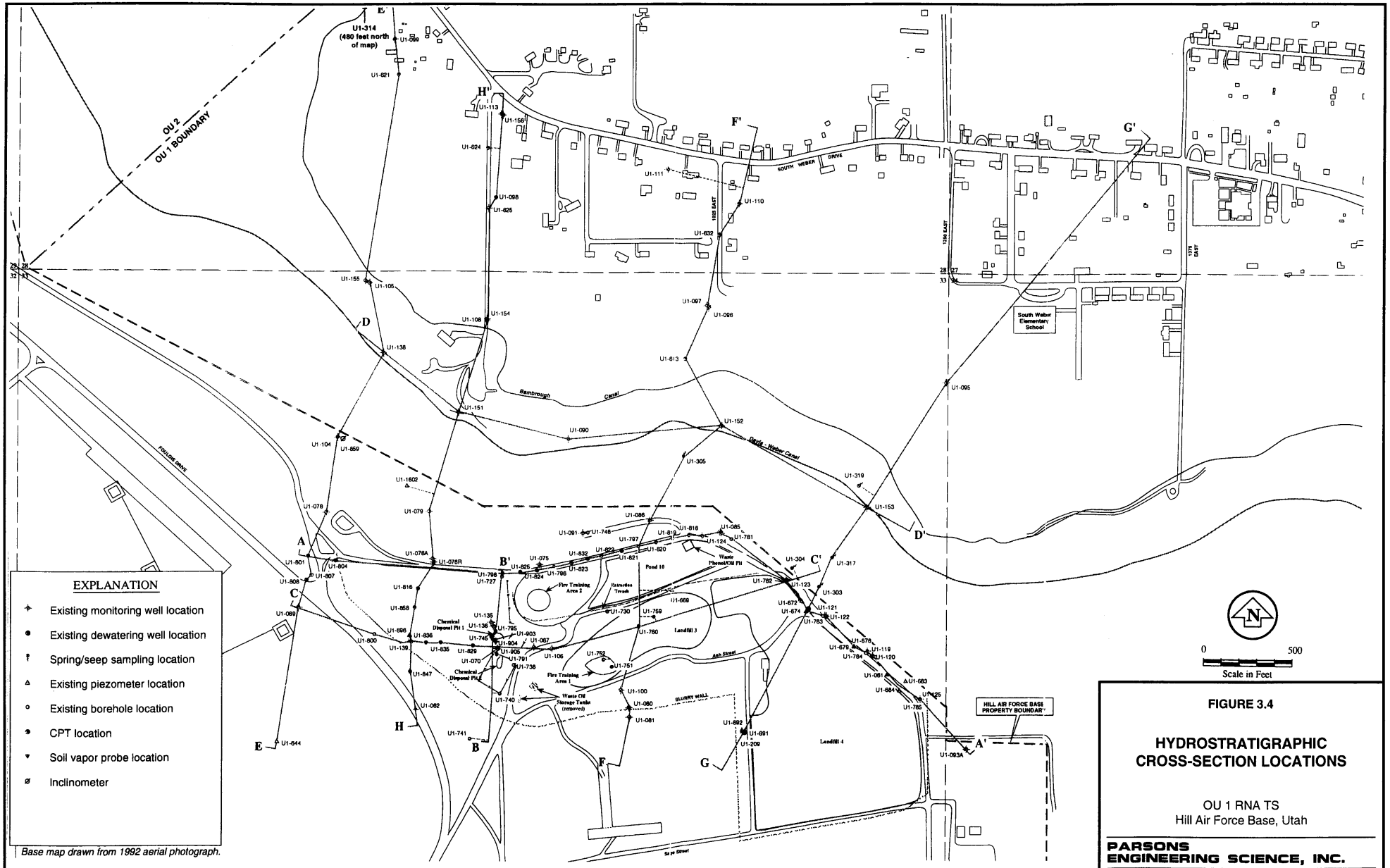
Upper Sand and Gravel Unit - consists of fine to coarse, clean to silty sands interbedded with gravel and some clay stringers. The unit ranges in thickness from 0 to 62 feet and has an average thickness of approximately 30 feet. This unit (the Provo Formation) comprises the shallow aquifer underlying the on-Base terrace.

Silty Clay Unit - consists primarily of silty clay interbedded with fat clays and silts containing thin stringers of very fine sand (0 to 10 inches thick). This unit (the Alpine Formation) is potentially 200 feet thick and appears to be saturated over most of its depth. The silty clay has intermittently saturated sand stringers from its top to the depth it has been penetrated by drilling (approximately 150 to 200 feet). Based on historical drilling records from OU 1, the abundance and thickness of sand stringers decrease with depth. Drilling data indicate the presence of paleochannels eroded in the surface of the silty clay unit. The thickness of the upper sand and gravel unit is greatest in these paleochannels. The depth to the silty clay unit is variable, ranging from less than 5 feet to 40 feet bgs, and the thickness of this unit is estimated to be at least 200 feet.

A possible third stratigraphic unit, described as the lower sand unit, has been penetrated only by deep monitoring wells on the hillside near and below the Davis-Weber Canal and in the Weber River Valley. This unit consists of clean sand with occasional stringers and interbeds of silty to fat clay. Because it has been penetrated by few boreholes, there is little information about the lateral and vertical extent of this unit, and its thickness is unknown. At locations where this unit has been encountered, the water table is below the top the unit, suggesting that the overlying silty clay layer acts as an aquitard between the shallow on-Base aquifer and this deeper unit.

The shallow stratigraphy in the Weber River Valley generally consists of interlayered silt, sand and gravel, cemented gravel, and silty sand. A silty to clayey unit ranging from 10 to 20 feet in thickness appears to underlie the shallow sandy deposits throughout much of the contaminant plume area in the valley; however, the lateral continuity of this layer has not been established. Available data indicate that the silt/clay unit is underlain by the lower sand unit described above.

The locations of site hydrostratigraphic cross-sections constructed during the RI (Montgomery Watson, 1995b) are shown on Figure 3.4. Three representative sections (C-C', E-E', and H-H') that depict subsurface conditions in the vicinity of the primary groundwater contaminant plume that has migrated off-Base into the Weber River Valley are presented on Figures 3.5 through 3.7. These cross-sections depict the surface topography, hydrostratigraphic units, and the estimated groundwater surface along the section lines. Section C-C' trends west to east on top of the escarpment, perpendicular to the general groundwater flow direction. This section depicts a 2- to 5-foot-thick surficial silty sand layer with occasional bentonite intervals overlying 14 to 30 feet of gravelly sand and gravelly, silty sand. Below this unit is a silt, clay and silty clay unit of unknown thickness, with some sand stringers. The surface of the clay/silt unit is uneven, and



Base map drawn from 1992 aerial photograph.

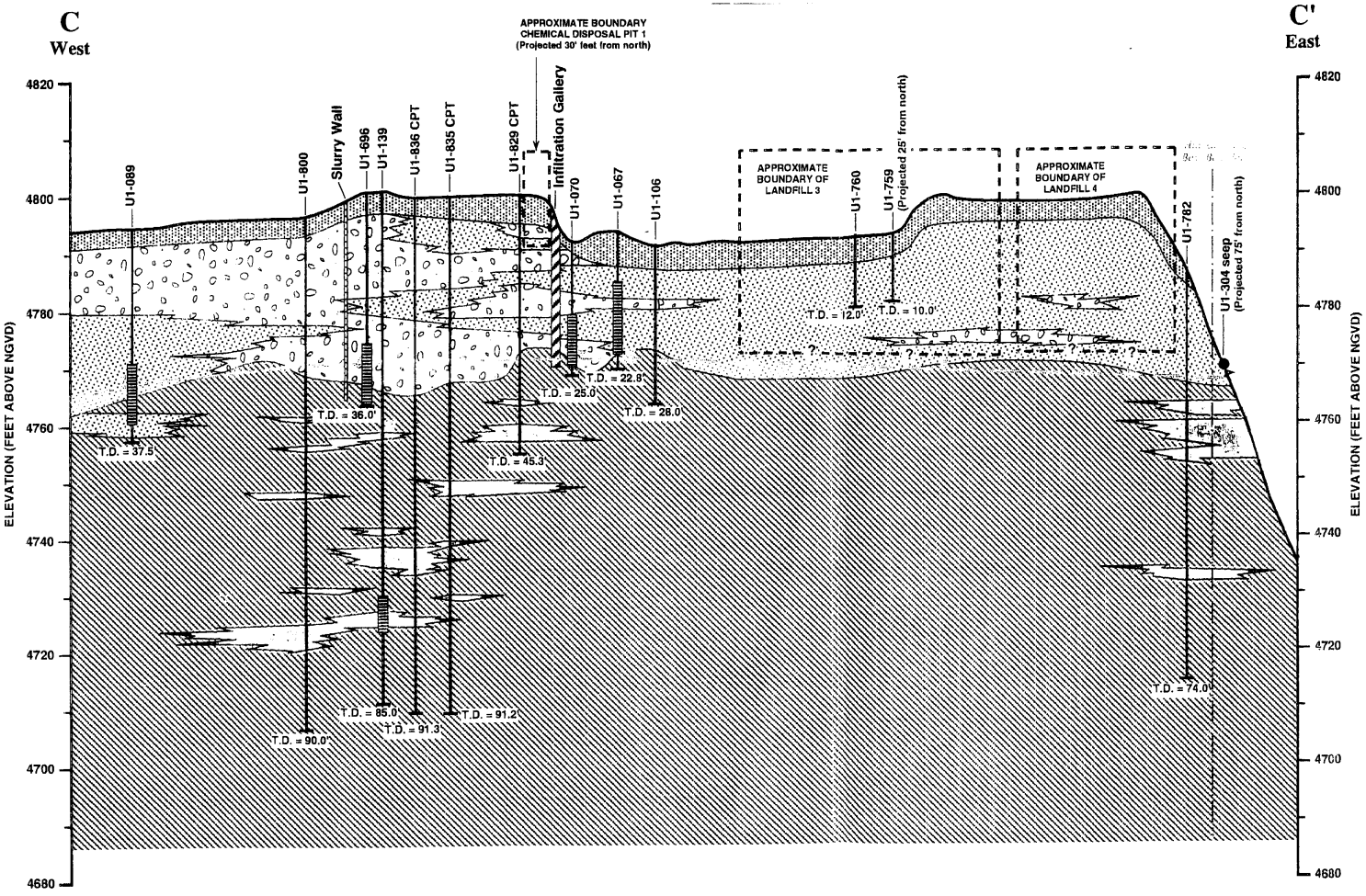
Source: Montgomery Watson, 1995b.

FIGURE 3.4

HYDROSTRATIGRAPHIC CROSS-SECTION LOCATIONS

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado



EXPLANATION

- Cap—silty sand with occasional bentonite
- UPPER UNIT (PROVO FORMATION):
  - Sand
  - Water-saturated sand
  - Gravelly sand and gravelly silty sand
  - Water-saturated sand and gravel
- INTERMEDIATE UNIT (ALPINE FORMATION):
  - Fat clay, silty clay, and silt with interbedded sand stringers
  - Silt and very fine sand
- Ground-water elevation
- U1-767 — Monitoring well or CPT identification number
- Monitoring well or CPT
- T.D. = 26.5' — Well screened interval
- Total depth of bore hole
- Seep

Based on water levels measured in November, 1994

0 300

Horizontal Scale in Feet
Vertical: 1" = 20 feet
(15x vertical exaggeration)

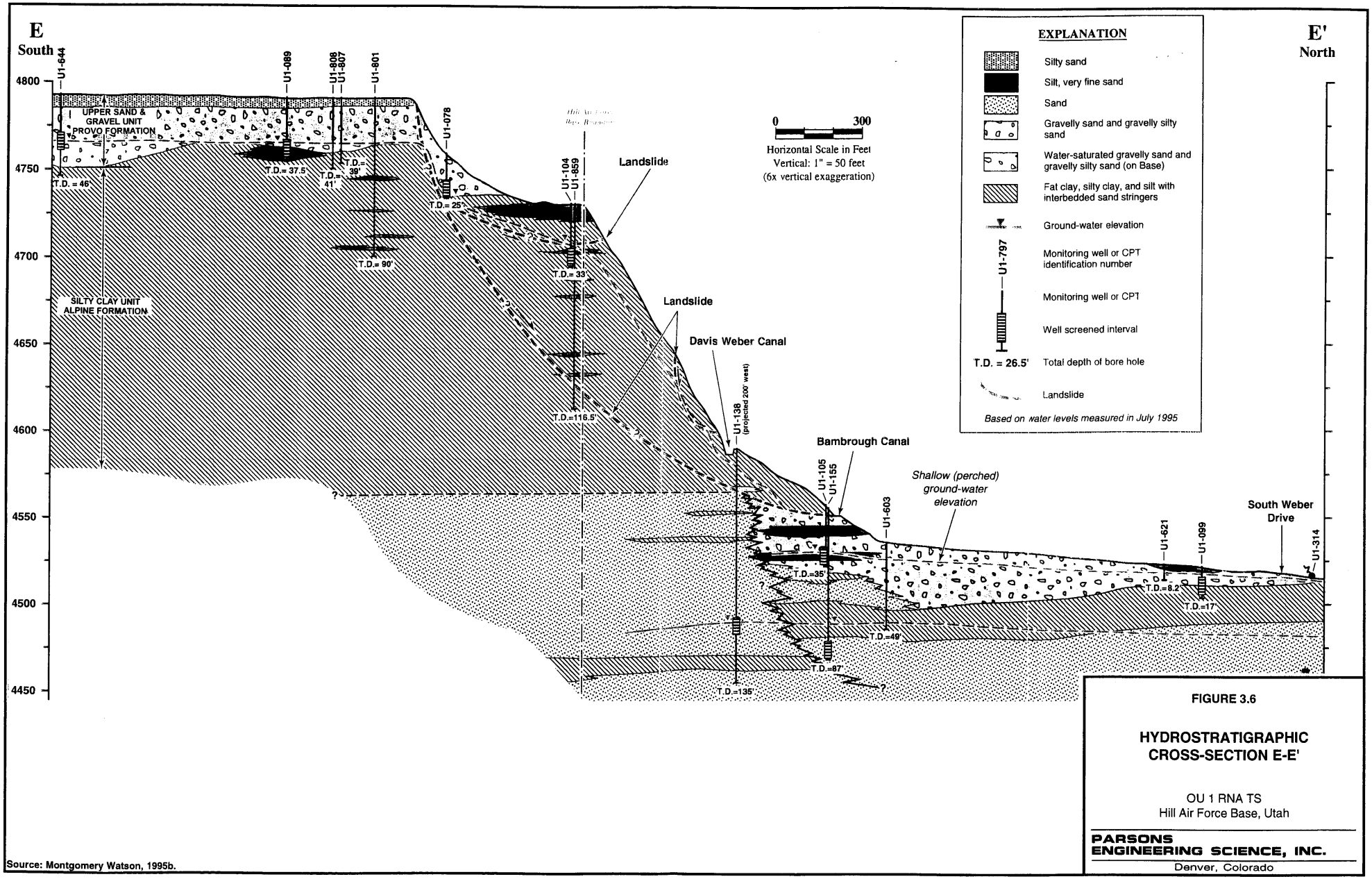
Source: Montgomery Watson, 1995b.

FIGURE 3.5

HYDROSTRATIGRAPHIC CROSS-SECTION C-C'

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado



Source: Montgomery Watson, 1995b.

FIGURE 3.6

HYDROSTRATIGRAPHIC CROSS-SECTION E-E'

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
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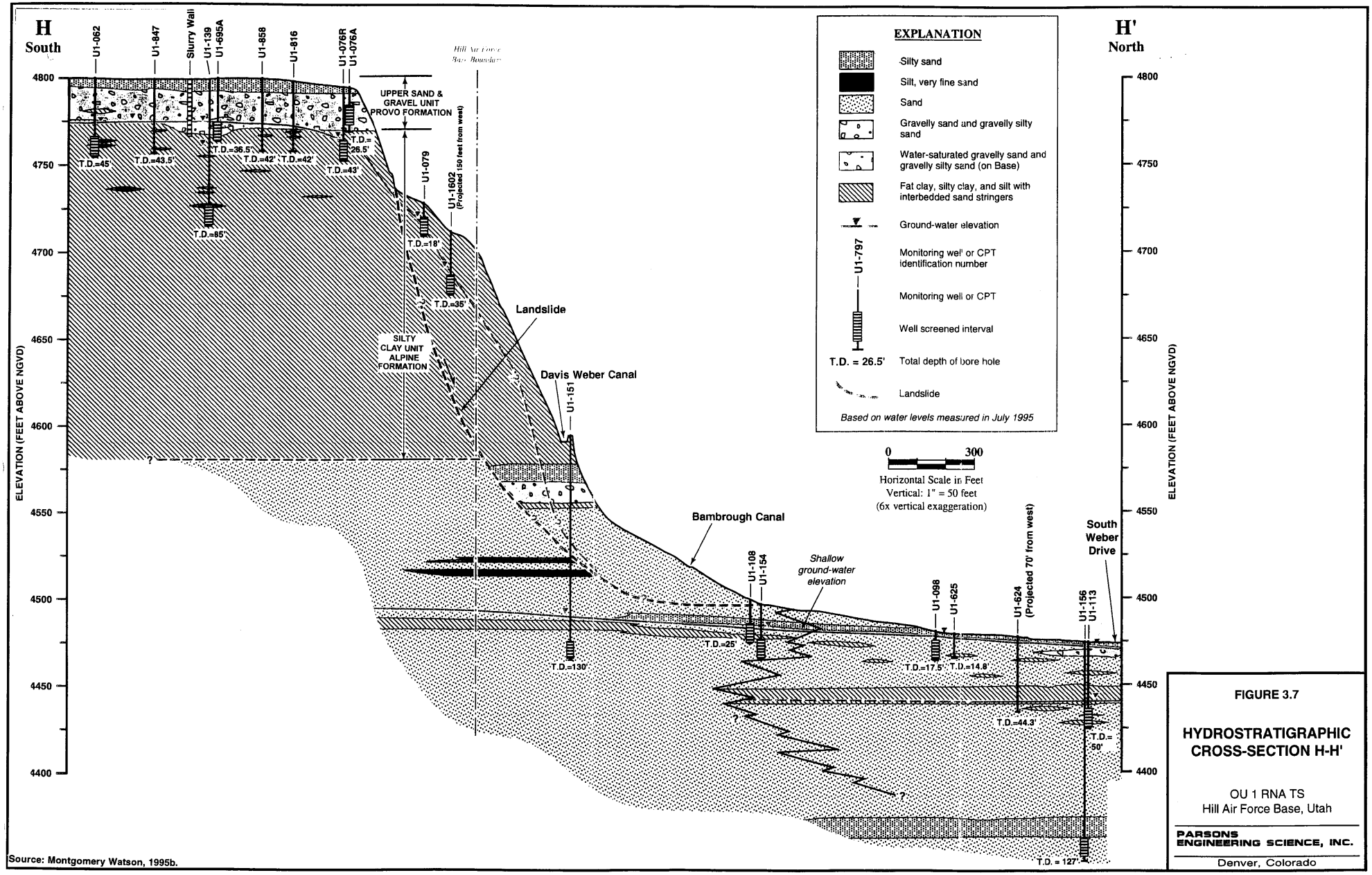


Source: Montgomery Watson, 1995b.

FIGURE 3.7

HYDROSTRATIGRAPHIC CROSS-SECTION H-H'

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

contains mounds and channels; the resulting paleochannels potentially represent preferential groundwater and contaminant migration pathways.

Sections E-E' and H-H' trend south-to-north across the on- and off-Base portions of OU 1, roughly parallel to groundwater flow. The terrace surface is underlain by 5 to 8 feet of silty sand overlying 18 to 34 feet of gravelly sand and gravelly silty sand, which in turn overlies the clay and silty clay unit. The hillside is underlain by the clay/silty clay unit. Within the Weber River Valley, Section E-E' shows a northward-thinning, 2- to 35-foot-thick deposit of gravelly sand and gravelly silty sand with lenses of silt and very fine sand. These deposits overly 16 to 25 feet of silty to clayey sediments, which overlie the lower sand unit of unknown thickness. Section H-H' shows a 25- to 45-foot-thick sand unit interbedded with clay, silty clay, and silty sand overlying an approximately 10-foot-thick silty to clayey zone within the Weber River Valley. Limited data indicate the presence of the lower sand unit beneath the silty to clayey unit; however, the lateral continuity and thickness of both the silty/clayey zone and the lower sand unit along this section line have not been well defined.

3.4.2 Site Hydrogeology

3.4.2.1 Groundwater Depths and Aquifer Saturated Thicknesses

Groundwater depths and potentiometric surface elevations were measured for this TS in March 1997 (Table 3.1). The depth to groundwater is approximately 15 to 30 feet bgs in the on-Base OU 1 area, and groundwater emerges at the surface in the form of seeps and springs along the escarpment north of the on-Base terrace. The presence of springs or seeps at downgradient locations may result from several factors such as structural contacts with clay units, topographic lows, and upward hydraulic gradients in the lowland areas. The groundwater depths measured in escarpment wells U1-104, U1-079, and U1-084 ranged from 13 to 21 feet bgs. In the Weber River Valley, the water table within the surficial, sandy deposits occurs at depths of less than 5 to nearly 20 feet bgs. The water level elevations measured in wells penetrating into the lower sand unit beneath the Weber River Valley (U1-113 and U1-155) were lower than the elevations measured in the paired shallow wells (U1-112 and U1-105) by 28 to 37 feet, indicating that the lower sand is, to some degree, hydraulically separate from the surficial sandy aquifer.

The saturated thickness of the upper sand and gravel unit beneath the on-Base terrace ranges from 0 to 10 feet with an average of 3 feet (Montgomery Watson, 1995b). The saturated thickness of the surficial sandy water-bearing zone in the Weber River Valley ranges from less than 10 feet to nearly 30 feet at locations where the full thickness of this zone was penetrated (see Figures 3.5 and 3.6). The saturated thickness of the lower sand unit is unknown.

3.4.2.2 Groundwater Flow Directions, Hydraulic Gradients, and Preferential Migration Pathways

The configuration of the water table in the surficial water-bearing zones in March 1997 is illustrated on Figure 3.8. The orientation of the equipotential lines indicates an overall northerly groundwater flow direction. However, as described in Sections 4.1.1 and 4.3.2, the distributions of dissolved contaminants and mobile LNAPL in the on-Base terrace deposits indicate the presence of preferential migration pathways within

TABLE 3.1
GROUNDWATER ELEVATION SUMMARY
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Location	Measuring Point Elevation (ft msl[a])	Depth to Water (ft toc[b])	Groundwater Elevation (ft msl)	Mobile LNAPL Thickness (feet)	Corrected Groundwater Elevation (ft msl)
U1-006R	4804.18	23.88	4780.30	--[c]	NA[d]
U1-008R	4803.38	22.45	4780.93	--	NA
U1-021R	4812.39	18.87	4793.52	--	NA
U1-027R	4805.59	18.83	4786.76	--	NA
U1-041R	4800.17	25.26	4774.91	0.01	4774.92
U1-042R	4801.21	30.37	4770.84	--	NA
U1-043	4800.10	36.18	4763.92	--	NA
U1-045R	4805.01	19.55	4785.46	--	NA
U1-046	4804.80	18.12	4786.68	--	NA
U1-049	4810.64	18.52	4792.12	--	NA
U1-051	4810.99	20.49	4790.50	--	NA
U1-052	4810.67	18.32	4792.35	--	NA
U1-053	4806.38	19.91	4786.47	--	NA
U1-055	4811.96	21.58	4790.38	--	NA
U1-056	4812.50	23.02	4789.48	--	NA
U1-057	4807.32	26.16	4781.16	--	NA
U1-058	4809.42	26.27	4783.15	--	NA
U1-060R	4809.99	26.51	4783.48	--	NA
U1-061	4805.90	26.85	4779.05	--	NA
U1-062	4799.68	25.27	4774.41	--	NA
U1-064	4800.20	24.00	4776.20	0.01	4776.21
U1-065	4798.14	27.95	4770.19	0.01	4770.20
U1-066	4801.76	26.58	4775.18	0.08	4775.24
U1-067	4794.86	22.01	4772.85	0.01	4772.86
U1-068	4801.08	25.85	4775.23	--	NA
U1-069	4800.94	26.57	4774.37	0.22	4774.55
U1-071	4794.44	21.96	4772.48	0.01	4772.49
U1-073	4800.43	29.52	4770.91	--	NA
U1-074	4800.05	25.77	4774.28	0.03	4774.30
U1-076R	4796.98	35.15	4761.83	--	NA
U1-077R	4795.88	29.79	4766.09	--	NA
U1-078	4761.06	25.21	4735.85	--	NA
U1-079	4728.05	13.11	4714.94	--	NA
U1-080	4802.90	19.95	4782.95	--	NA
U1-082	4780.73	34.05	4746.68	--	NA
U1-083	4798.79	48.15	4750.64	--	NA
U1-084	4744.19	15.46	4728.73	--	NA
U1-085	4778.81	13.84	4764.97	--	NA
U1-086	4760.06	24.98	4735.08	--	NA
U1-087	4781.66	35.37	4746.29	--	NA
U1-088	4800.93	37.90	4763.03	--	NA
U1-089	4794.38	24.51	4769.87	--	NA
U1-090	4591.79	107.61	4484.18	--	NA
U1-091	4737.74	55.66	4682.08	--	NA
U1-092	4783.26	12.82	4770.44	--	NA
U1-093R	4812.74	27.64	4785.10	--	NA
U1-094	4513.62	60.29	4453.33	--	NA
U1-095	4500.83	42.08	4458.75	--	NA

TABLE 3.1 (Continued)
GROUNDWATER ELEVATION SUMMARY
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

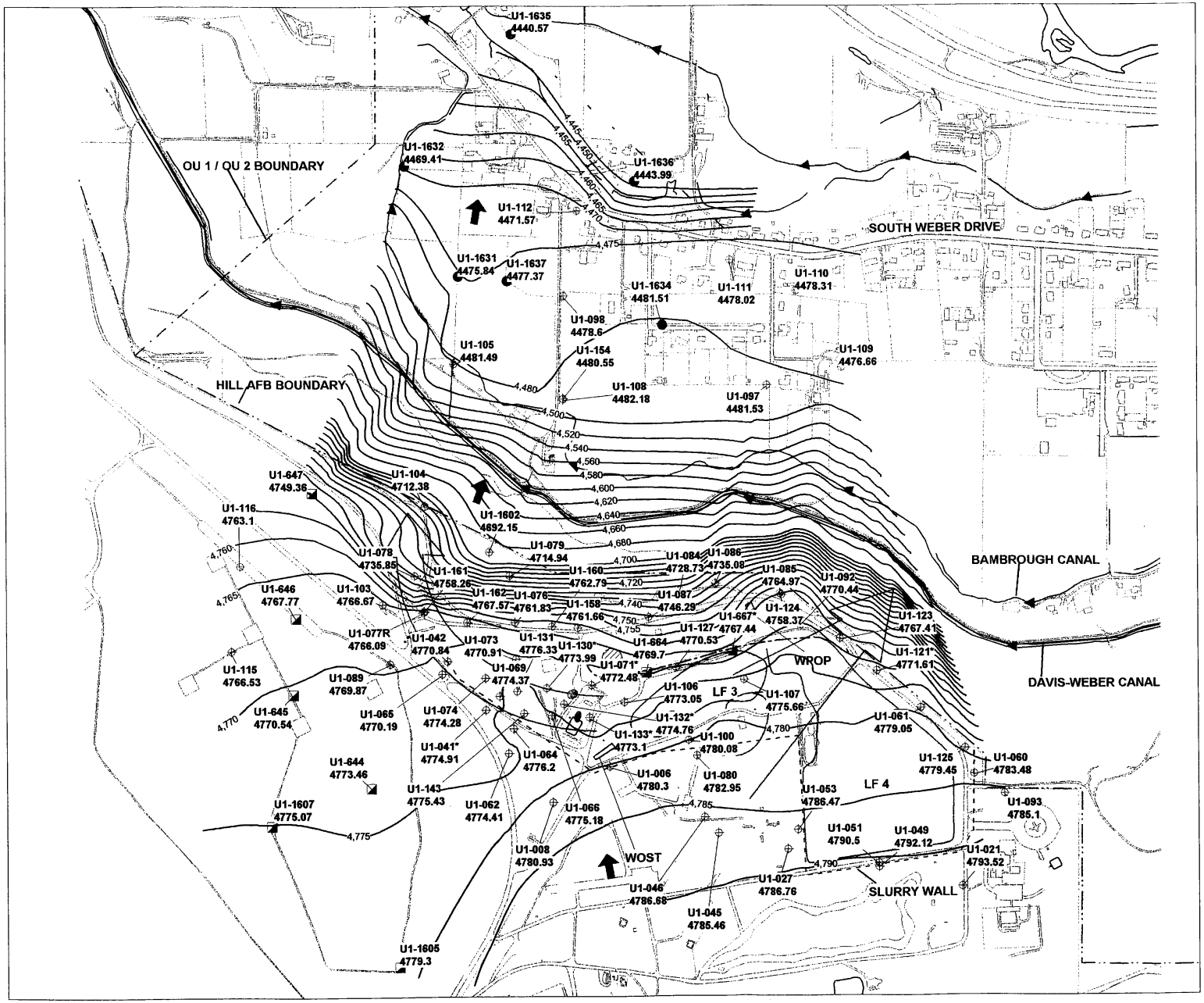
Location	Measuring Point Elevation (ft msl[a/])	Depth to Water (ft toc[b/])	Groundwater Elevation (ft msl)	Mobile LNAPL Thickness (feet)	Corrected Groundwater Elevation (ft msl)
U1-096	4495.16	41.74	4453.42	--	NA
U1-097	4495.31	13.78	4481.53	--	NA
U1-098	4484.01	5.41	4478.60	--	NA
U1-100	4804.86	24.78	4780.08	--	NA
U1-101	4800.71	28.18	4772.53	0.29	4772.76
U1-103	4795.78	29.11	4766.67	--	NA
U1-104	4733.76	21.38	4712.38	--	NA
U1-105	4511.26	29.77	4481.49	--	NA
U1-106	4792.85	19.80	4773.05	--	NA
U1-107	4805.79	30.13	4775.66	--	NA
U1-108	4500.94	18.76	4482.18	--	NA
U1-109	4495.76	19.10	4476.66	--	NA
U1-110	4493.52	15.21	4478.31	--	NA
U1-111	4488.18	10.16	4478.02	--	NA
U1-112	4479.28	7.71	4471.57	--	NA
U1-113	4479.19	35.23	4443.96	--	NA
U1-115	4790.82	24.29	4766.53	--	NA
U1-116	4786.81	23.71	4763.10	--	NA
U1-118	4799.16	29.30	4769.86	--	NA
U1-119	4806.56	35.24	4771.32	--	NA
U1-120	4807.10	48.97	4758.13	--	NA
U1-121	4804.88	33.27	4771.61	--	NA
U1-122	4804.72	56.07	4748.65	--	NA
U1-123	4790.44	23.03	4767.41	--	NA
U1-124	4779.45	21.08	4758.37	--	NA
U1-125	4806.41	26.96	4779.45	--	NA
U1-126	4799.02	35.91	4763.11	--	NA
U1-127	4783.61	13.08	4770.53	--	NA
U1-130	4801.82	27.83	4773.99	0.36	4774.28
U1-131R	4804.48	28.15	4776.33	0.18	4776.47
U1-132	4799.34	24.58	4774.76	0.01	4774.77
U1-133	4797.23	24.13	4773.10	0.19	4773.25
U1-134	4798.87	24.05	4774.82	0.06	4774.87
U1-138	4590.12	91.87	4498.25	--	NA
U1-139	4801.91	40.22	4761.69	--	NA
U1-141	4800.68	39.01	4761.67	--	NA
U1-142	4803.25	35.91	4767.34	--	NA
U1-143	4802.63	27.20	4775.43	--	NA
U1-144	4802.50	31.82	4770.68	--	NA
U1-151	4592.16	108.94	4483.22	--	NA
U1-152	4589.30	107.94	4481.36	--	NA
U1-154	4498.06	17.51	4480.55	--	NA
U1-155	4511.70	67.70	4444.00	--	NA
U1-156	4479.15	35.67	4443.48	--	NA
U1-157	4790.77	30.05	4760.72	--	NA
U1-158	4790.85	29.19	4761.66	--	NA
U1-159	4792.84	30.35	4762.49	--	NA
U1-160	4792.76	29.97	4762.79	--	NA

TABLE 3.1 (Concluded)
GROUNDWATER ELEVATION SUMMARY
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Location	Measuring Point Elevation (ft msl[a/])	Depth to Water (ft toc[b/])	Groundwater Elevation (ft msl)	Mobile LNAPL Thickness (feet)	Corrected Groundwater Elevation (ft msl)
U1-161	4793.35	35.09	4758.26	--	NA
U1-162	4794.24	26.67	4767.57	--	NA
U1-163	4793.91	37.42	4756.49	--	NA
U1-644	4796.57	23.11	4773.46	--	NA
U1-645	4792.29	21.75	4770.54	--	NA
U1-646	4792.45	24.68	4767.77	--	NA
U1-647	4787.32	37.96	4749.36	--	NA
U1-664	4782.25	12.55	4769.70	--	NA
U1-667	4786.29	18.85	4767.44	--	NA
U1-1602	4711.47	19.32	4692.15	--	NA
U1-1605	4797.37	18.07	4779.30	--	NA
U1-1607	4791.27	16.20	4775.07	--	NA
U1-1631	4479.78	3.94	4475.84	--	NA
U1-1632	4478.46	9.05	4469.41	--	NA
U1-1634	4486.88	5.37	4481.51	--	NA
U1-1635	4447.52	6.95	4440.57	--	NA
U1-1636	4450.05	6.06	4443.99	--	NA
U1-1637	4479.21	1.84	4477.37	--	NA

[a/] ft msl = feet above mean sea level.
[b/] ft toc = feet below top of casing.
[c/] "--" = measurable mobile LNAPL not present.
[d/] NA = not applicable.

Figure 3.8 Groundwater Elevations for March 1997



LEGEND

- U1-1637 ● MONITORING POINT
- U1-154 ⊕ MONITORING WELL
- U1-661 ◪ PIEZOMETER
- –4475– INFERRED LINE OF EQUAL GROUNDWATER SURFACE ELEVATION (FEET MSL) CONTOUR INTERVAL = VARIABLE
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- * DATUM COLLECTED BY MONTGOMERY WATSON DURING 13TH SAMPLING ROUND
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- – · – EXTRACTION TRENCH
- WPOP WASTE PHENOL/OIL PIT
- WOST FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

0 300 600
Feet

Note: Only groundwater elevation data from wells screened in the shallow portion of the surficial aquifer were used to draw isopleths. The continuity of the contours on the hillside above the Weber River Valley result from the use of an electronic contouring package; in reality, the shallow aquifer beneath the hillside is not laterally continuous.

N

FIGURE 3.8

GROUNDWATER ELEVATIONS FOR MARCH 1997

OU1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

FILE NAME: S:\ES\REMED\BIOPLUME\HILL\OU1\FIGURES\HILLGW1.WOR DATE: 09/20/99 TIME: 0255

paleochannels incised into the silty clay surface. The locations of the primary paleochannels, derived from stratigraphic data collected during the RI (Montgomery Watson, 1995b), are shown on Figure 3.8. Contaminant distribution data (Section 4.3) indicate a significant westerly to northwesterly component to the groundwater flow direction within the westernmost paleochannel.

According to the conceptual hydrogeologic model developed by Montgomery Watson (1995b), the majority of the groundwater in the sand and gravel unit migrates off the terrace in areas where the paleochannels intersect the hillside, and continues downslope along preferential flowpaths in the veneer of eroded sediments on the surface of the hillside. Preferential flowpaths on the escarpment may include the contact between the colluvial veneer and the unweathered clay unit, landslump deposits and failure planes, and rubble on the hillside. In addition, field drains installed in the 1950s to stabilize the hillside may provide preferential groundwater flow paths.

Most seeps and springs on the escarpment have geochemical characteristics similar to those of groundwater from wells screened in the upper sand and gravel unit beneath the on-Base terrace, and different from those of groundwater from the silty clay unit. Therefore, only a minor portion of the shallow on-Base groundwater may move through the silty clay before discharging as seeps on the hillside. The majority of the groundwater appears to flow horizontally through the upper sand and gravel unit to the edge of the escarpment, and then downslope through the thin soil veneer, landslump failure planes, or other pathways near the surface of the hillside (Montgomery Watson, 1995b).

The horizontal hydraulic gradient beneath the on-Base terrace, measured in March 1997, ranges from 0.007 foot per foot (ft/ft) to 0.04 ft/ft, and averages approximately 0.015 ft/ft. In the Weber River Valley, the horizontal hydraulic gradient ranges from 0.007 to 0.11 ft/ft and averages approximately 0.01 ft/ft in the off-Base portion of the site that is south of South Weber Drive and occupied by the CAH plume. Along the escarpment, the lateral hydraulic gradient averages approximately 0.20 ft/ft. The directions and magnitudes of these gradients are similar to those measured in June 1994 and January 1995 (Montgomery Watson, 1995b).

Vertical hydraulic gradients measured in well clusters in March 1997 are listed in Table 3.2 along with data from a November/December 1994 measurement round performed by Montgomery Watson (1995b). The gradients were computed by dividing the difference in potentiometric surface elevations by the distance between the midpoints of the saturated portions of the well screens. In 1994, vertical hydraulic gradients measured in 14 on-Base monitoring well clusters ranged from 0.81 ft/ft downward to 0.076 ft/ft upward. Vertical gradients measured at five on-Base well clusters in March 1997 were similar in magnitude and direction to the 1994 values, ranging from 0.002 ft/ft downward to 0.81 ft/ft downward. The minimum gradient (0.002 ft/ft downward) was measured in well cluster U1-141/139, which exhibited an upward gradient in 1994.

Vertical gradients measured in off-Base well clusters U1-097/096, U1-112/113, and U1-105/155 in November/December 1994 and March 1997 ranged from 0.75 ft/ft downward to 1.12 ft/ft downward. Montgomery Watson (1995b) states that the horizontal component of flow is expected to be much greater than the vertical component, despite the presence of significant vertical gradients, due to the interbedded nature of the shallow on- and off-Base aquifers.

TABLE 3.2
VERTICAL HYDRAULIC GRADIENTS
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Well Number	Screened Interval (ft msl)[a]	Potentiometric Surface Elevation (ft msl)		Vertical Hydraulic Gradient (ft/ft)[b]	
		Nov/Dec 1994	March 1997	Nov/Dec 1994	March 1997
ON-BASE SHALLOW AQUIFER					
U1-061	4769-4779	4778.22	4779.05	0.52	0.55
U1-119	4757-4762	4770.93	4771.32	0.54	0.54
U1-120	4730-4740	4757.68	4758.13		
U1-121	4756-4761	4770.1	4771.61	0.81	0.81
U1-122	4725-4735	4746.99	4748.65		
U1-653	4768-4778	4773.7	NA[c]	0.09	NA
U1-654	4747-4752	4771.86	NA		
U1-658	4768-4778	4772.53	NA	0.10	NA
U1-659	4756-4761	4771.35	NA		
U1-664	4763-4773	4768.84	4769.70	0.19	NA
U1-665	4740-4745	4764.38	NA		
U1-668	4763-4768	4768.34	NA	0.07	NA
U1-669	4743-4748	4766.85	NA		
U1-673	4767-4777	4773.06	NA	0.33	NA
U1-674	4757-4763	4769.70	NA		
U1-678	4771-4781	4777.98	NA	0.51	NA
U1-679	4756-4761	4769.76	NA		
U1-683	4771-4781	4779.89	NA	0.10	NA
U1-684	4759-4764	4778.48	NA		
U1-687	4772-4782	4781.44	NA	-0.05	NA
U1-688	4761-4766	4782.09	NA		
U1-691	4773-4783	4783.73	NA	0.08	NA
U1-692	4753-4758	4781.95	NA		
U1-118	4762-4772	4766.22	4769.86	0.59	0.54
U1-126	4749-4754	4758.76	4763.11	0.43	0.48
U1-083	4723-4728	4747.47	4750.64		
U1-140	4763-4773	4772.67	NA	0.399	NA
U1-141	4735-4740	4760.58	4761.67	-0.076	0.002
U1-139	4722-4728	4761.53	4761.69		
U1-143	4765-4775	4773.29	4775.43	0.25	0.22
U1-144	4745-4750	4767.86	4770.68	0.19	0.15
U1-142	4722-4727	4763.42	4767.34		
OFF-BASE SHALLOW AQUIFER					
U1-097	4474-4484	4480.99	4481.53	1.08	1.12
U1-096	4451-4461	4453.94	4453.42		
U1-112	4461-4471	4471.83	4471.57	0.78	0.79
U1-113	4426-4436	4444.37	4443.96		
U1-105	4474-4484	NA	4481.49	NA	0.75
U1-155	4423-4433	NA	4444.00		

[a] ft msl = feet above mean sea level.

[b] ft/ft = foot per foot.

[c] NA = data not available.

Note: Downward vertical gradients are positive, upward are negative.

3.4.2.3 Hydraulic Conductivity

Results of pump and slug tests performed during the RI (Montgomery Watson, 1995b) were used to calculate the horizontal hydraulic conductivity of the on- and off-Base portions of OU 1. A table summarizing these results is included in Appendix A. Horizontal hydraulic conductivity values derived from pump tests within the on-Base upper sand and gravel unit ranged from 28.4 feet per day (ft/day) to 425.3 ft/day; seven of the eight values ranged from 28.4 ft/day to 198.5 ft/day (Montgomery Watson, 1995b). The arithmetic mean conductivity value (145 ft/day) may be biased high because the maximum hydraulic conductivity value is somewhat anomalous relative to the other data. Therefore, the geometric mean or median value (103 ft/day and 113 ft/day, respectively) may be more representative of the average hydraulic conductivity of this unit. Results of slug tests performed in 13 wells screened in the on-Base upper sand and gravel unit during the RI (Montgomery Watson, 1995b) were substantially lower than the pump test results. The hydraulic conductivities derived from slug tests ranged from 0.2 to 56.7 ft/day, with arithmetic mean, geometric mean, and median values of 1.9 ft/day, 1.7 ft/day, and 0.6 ft/day, respectively. The pump test data are used to compute groundwater velocities because pump test results are generally considered to be more representative of the aquifer as a whole than slug test results.

Horizontal hydraulic conductivity values derived from slug tests performed within the on-Base silty clay deposits ranged from 0.03 ft/day to 0.6 ft/day, with arithmetic mean, geometric mean, and median values 0.15 ft/day, 0.11 ft/day, and 0.11 ft/day, respectively. Horizontal hydraulic conductivity values derived from slug tests within the shallow alluvium in the Weber River Valley ranged from 0.02 ft/day to 11.3 ft/day, with arithmetic mean, geometric mean, and median values of 1.9 ft/day, 0.6 ft/day, and 1.7 ft/day, respectively.

Vertical hydraulic conductivities also were calculated for the silty clay unit based on constant-head permeability testing of core samples in a laboratory (Montgomery Watson, 1995b). These values ranged from 2.4E-05 ft/day to 7.3E-02 ft/day, and average 5.9E-03 ft/day. It should be noted that hydraulic conductivity values derived from laboratory tests are often substantially lower than values measured in field tests due to the presence preferential migration pathways (e.g., fractures) that may not be present in the core samples.

3.4.2.4 Groundwater Velocity

The advective velocity of groundwater in the direction parallel to groundwater flow is given by:

$$\bar{v} = \frac{K}{n_e}\frac{dH}{dL}$$

Where: $\bar{v}$ = Average advective groundwater velocity (seepage velocity) [L/T]

K = Hydraulic Conductivity [L/T]

dH/dL = Hydraulic Gradient [L/L]

n_e = Effective porosity

Based on a hydraulic conductivity range for the upper sand and gravel unit beneath the on-Base terrace of 28 to 425 ft/day, an average horizontal hydraulic gradient of 0.015 ft/ft, and an estimated effective porosity for a sandy/gravelly material of 0.25, the advective groundwater flow velocity ranges from 1.7 ft/day to 25 ft/day (620 to 9,120 feet per year [ft/yr]). These values are similar to velocities of 310 to 4,660 ft/yr computed by Montgomery Watson (1995b). Assuming an average hydraulic conductivity of 103 ft/day, the average advective groundwater flow velocity in the upper sand and gravel unit is 6.2 ft/day (2,260 ft/yr). It should be noted that the hydraulic gradient used in the velocity calculations is the northerly gradient derived from the water table map (Figure 3.8). The magnitudes of the horizontal hydraulic gradients associated with preferential groundwater migration toward the northwest within paleochannels incised in the silty clay surface are not accurately known, and may be less than the measured values, resulting in lower velocities.

The distribution of mobile LNAPL at OU 1 (and site history) suggests that the CDPs and LF3 are primary LNAPL sources. LNAPL has migrated at least 1,400 feet since the mid-1950s when this fire training area was first used (42 years ago, assuming that LNAPL was first introduced in 1955). This translates to an LNAPL migration velocity of at least 33 ft/yr. The LNAPL migration rate would be expected to be substantially lower than the groundwater migration rate due to the greater viscosity of the LNAPL.

Based on a hydraulic conductivity range for the surficial aquifer in the Weber River Valley of 0.02 to 11.3 ft/day, a horizontal hydraulic gradient in the plume area of 0.01 ft/ft, and an estimated effective porosity for the alluvial sediments of 0.20, the advective groundwater flow velocity ranges from 0.001 ft/day to 0.6 ft/day (0.4 to 219 ft/yr). These values are very similar to velocities computed by Montgomery Watson (1995b) of 0.3 to 184 ft/yr. Assuming an average hydraulic conductivity of 1.9 ft/day, the average advective groundwater flow velocity in the shallow alluvial unit is 0.09 ft/day (33 ft/yr).

Based on historical data (Section 1.2), the earliest waste disposal activities that could have introduced CAHs into the subsurface began in 1952 at LF 3. Assuming that the CAH plume has migrated at least 5,000 feet from LF 3 in the 45 years since 1952 (Section 4.3.2), the average CAH migration rate over the entire plume flowpath during this time period was 0.30 ft/day (111 ft/yr). This CAH migration rate includes both the average advective migration rate (which is most likely lower than 0.30 ft/day) and the dispersive effects of the aquifer, which causes the plume to be elongated as it migrates from the source area. Assuming an average CAH retardation coefficient of 1.2 (the value for *cis*-1,2-DCE, see Section 5.3.3.3), the average groundwater migration velocity over the entire plume flowpath (resulting from both advection and dispersion) during the previous 45 years was 0.36 ft/day (131 ft/yr). It should be noted that if the contaminants were first introduced to the groundwater after 1952, or if the *cis*-1,2-DCE plume reached its current size prior to 1997 and is currently at steady state or is receding, then the average migration velocities presented above may be low.

3.5 WATER USE

A water rights search was conducted by Montgomery Watson (1995b) to evaluate the use of groundwater from the shallow aquifer by residents in the South Weber area. The data collected indicates that all residences, schools, and businesses in South Weber area receive potable water from the municipal water system, and that no residents of the South

Weber area are obtaining shallow aquifer groundwater for potable use. In addition, Hill AFB is aware of all springs and wells that have associated water rights, and has notified the residents of the South Weber area regarding the risks associated with the use of groundwater from the shallow aquifer. The Town of South Weber has a deep production well located at 1600 East South Weber Drive. In addition, a domestic groundwater well operated by the Weber Basin Water Conservancy District, is located at the southern end of 850 East in the City of South Weber. This well is called South Weber No. 2.

SECTION 4

CONTAMINANT DISTRIBUTION AND EVIDENCE OF BIODEGRADATION

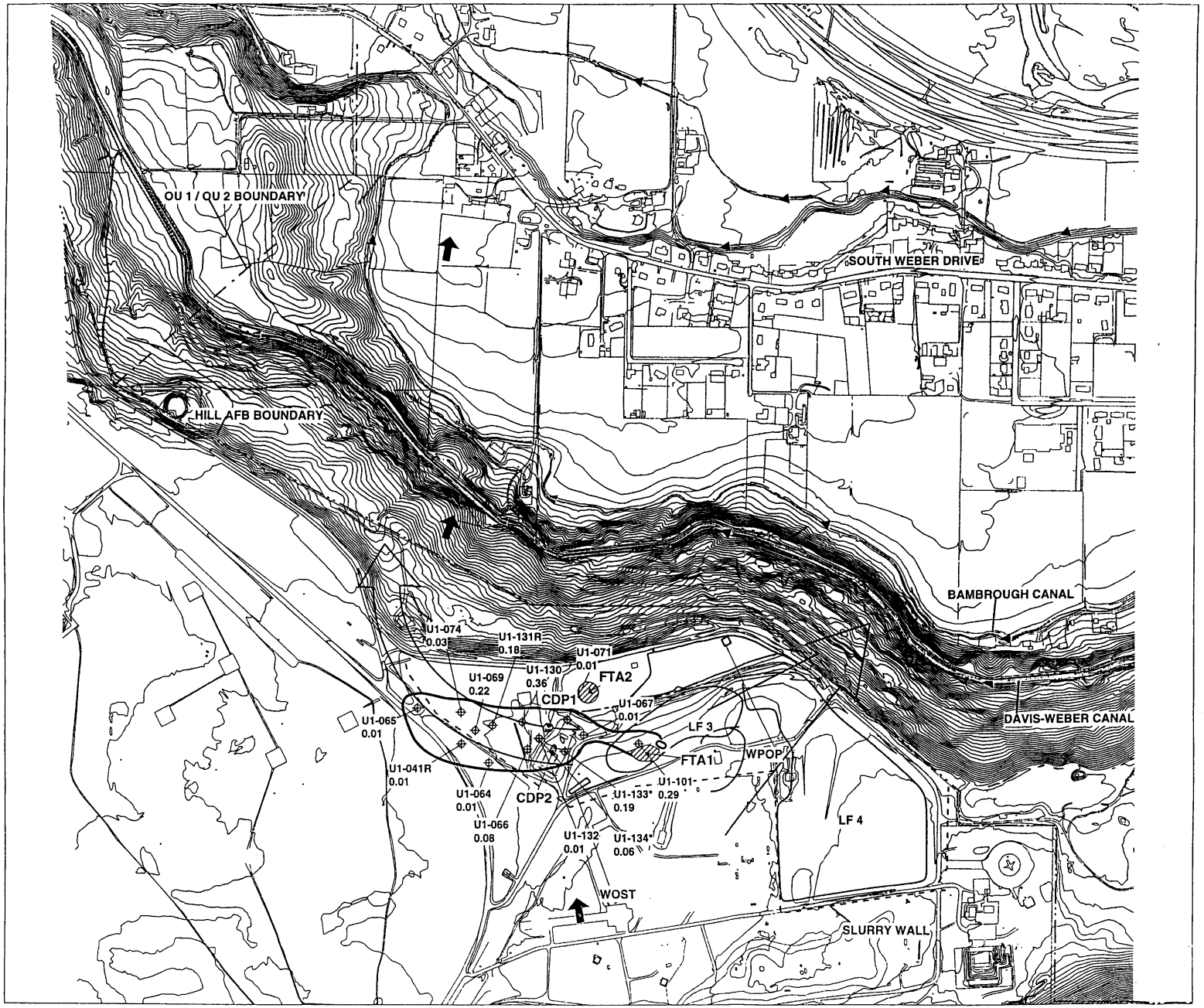
As noted in Section 1, contaminants at OU 1 emanate from eight potential sources, including CDPs 1 and 2, LFs 3 and 4, FTAs 1 and 2, a WPOP, and a WOST area. Work performed during the RI and related sampling events focused on defining the nature and extent of contamination at the site. Results of those studies that are useful for the objectives of this TS are summarized in the following subsections, along with data collected during the field phase of this work. In particular, this section focuses on data useful for evaluating and modeling natural attenuation of CAHs.

4.1 CONTAMINANT SOURCES AND SOIL CHEMISTRY

4.1.1 Mobile LNAPL

As described in Montgomery Watson (1995b), liquid waste was disposed of and periodically burned at the CDPs, the WPOP, and LF 3. Liquid fuels also were used in training exercises at FTAs 1 and 2. LNAPL present on the groundwater at OU 1 is derived from these activities. Mobile LNAPL is defined as the LNAPL that is free to flow in the aquifer and that will flow from the aquifer matrix into a well under the influence of gravity. Mobile LNAPL thicknesses measured in March 1997 are summarized in Table 3.1 and shown on Figure 4.1. The thickness of the LNAPL layer in monitoring wells ranged from 0.01 to 0.36 foot, and the distribution of LNAPL suggests that LF 3 and the CDPs are primary LNAPL source areas. FTA 1 also is a source of LNAPL, but its relative contribution in comparison to the CDPs is unknown. Based on site history, the contribution of FTA 1 is expected to be less than either the CDPs or LF 3. The areal extent of LNAPL inferred from the March 1997 measurements is similar to that depicted in the RI report (Montgomery Watson, 1995b), indicating that the extent has not increased or decreased substantially since 1994. LNAPL thicknesses generally are similar to those measured in the same wells during 1993 and 1994. The northwest-trending paleochannel incised in the surface of the silty clay layer underlying the on-Base portion of OU 1 appears to be a preferential migration pathway for the LNAPL, resulting in a westerly migration direction rather than a northerly migration as suggested by the water table map (Figure 3.8).

The relationship between the measured LNAPL thickness in a monitoring well and the total amount of mobile LNAPL in the subsurface at a site is difficult to quantify. It is well documented that LNAPL thicknesses measured in groundwater monitoring wells are not indicative of actual mobile LNAPL thicknesses in the formation (de Pastrovich *et al.*, 1979; Blake and Hall, 1984; Hall *et al.*, 1984; Hughes *et al.*, 1988; Abdul *et al.*, 1989; Testa and Paczkowski, 1989; Kemblowski and Chiang, 1990; Lehnard and Parker, 1990;



LEGEND

- U1-071 / 0.01 — MONITORING WELL WITH MOBILE LNAPL THICKNESS (FEET)
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- * — THICKNESS MEASURED BY MONTGOMERY WATSON DURING 13TH SAMPLING ROUND
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- EXTRACTION TRENCH
- WPOP — WASTE PHENOL/OIL PIT
- WOST — FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

0 300 600
Feet

N

FIGURE 4.1

EXTENT OF MOBILE LNAPL MARCH 1997

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS
ENGINEERING SCIENCE, INC.
Denver, Colorado

Mercer and Cohen, 1990; Ballestero *et al.*, 1994). It has been noted by these authors that the thickness of LNAPL measured in a monitoring well is greater than the actual mobile LNAPL thickness present in the aquifer, and according to Mercer and Cohen (1990), measured LNAPL thickness in wells is typically 2 to 10 times greater than the actual mobile LNAPL thickness in the formation. Furthermore, only a fraction of the mobile LNAPL may be recoverable. The results of bail-down/recovery tests performed in six wells during the RI indicated that true LNAPL thicknesses in the formation adjacent to the wells ranged from 5 to 54 percent of the apparent thickness measured in the wells (Montgomery Watson, 1995b).

The volume of the LNAPL plume during the Phase I RI (1990-1991) was estimated at 3,400 cubic feet (cf) (Montgomery Watson, 1995b). This estimate was made assuming that the actual thickness of the LNAPL plume was equal to the average thickness of the LNAPL layer in monitoring wells divided by four, and assuming a formation effective porosity of 0.25. The volume calculations were repeated for the LNAPL plume as it appeared in 1993 and 1994, with volume estimates ranging from 2,000 to 8,500 cf. Using March 1997 LNAPL data, the estimated volume of the LNAPL plume is 2,500 cf, which is within the range of previous estimates. It should be noted that only a small fraction of the mobile LNAPL may be recoverable using current remediation technologies.

The RI report (Montgomery Watson, 1995b) states that the LNAPL most likely consists of jet fuels or naphtha and light lubricating oils mixed with various solvents and other chemicals. Analytical results for LNAPL samples from three wells indicated that the LNAPL is highly weathered. Samples from wells U1-004 and U1-065 were used to characterize LNAPL downgradient from the CDPs where the primary constituent of the LNAPL was tentatively identified as JP-4. Chlorinated solvents detected in one or both LNAPL samples (and the maximum detected concentration) included total 1,2-DCE (87,000 micrograms per kilogram [µg/kg]), 1,1,1-TCA (92,000 µg/kg), and PCE (38,000 µg/kg). Aromatic VOCs detected included toluene (770,000 µg/kg), ethylbenzene (210,000 µg/kg), total xylenes (1,400,000 µg/kg), and chlorobenzene (2,300,000 µg/kg). During the RI, an LNAPL sample also was collected from well U1-101 to characterize LNAPL downgradient from FTA 1. JP-4 was identified as the primary constituent, and chlorinated VOCs were not detected. The aromatic VOCs ethylbenzene and total xylenes were detected at maximum concentrations of 201,000 µg/kg and 540,000 µg/kg, respectively. Xylenes were not detected in the blind duplicate sample. On the basis of these data, Montgomery Watson (1995b) concluded that the LNAPL downgradient from the CDPs and FTA 1 constituted a principal source of contaminants for the shallow groundwater at OU 1.

Mobile LNAPL samples were collected in March 1997 from wells U1-101, U1-130, and U1-161. The samples were analyzed for compound identification at the USEPA NRMRL; analysis results are contained in Appendix C. The relative paucity of VOCs in the LNAPL samples supports the observation that the mobile LNAPL at OU 1 is highly weathered and consists largely of heavier, long-chained hydrocarbons.

4.1.2 Soil Gas and Soil Contamination

During the performance of the Phase 1 RI at OU 1 (1990-1991), a soil gas survey was conducted to identify potential source areas for VOC contamination originating from the OU 1 sites, to evaluate the extent of contaminant migration in the shallow aquifer, and to

help determine the locations of future off-Base monitoring wells. The soil gas samples, taken from a 150-acre area north of the source areas at OU 1 including the Davis-Weber Canal escarpment area and the Weber River Valley, were analyzed by photoionization detector (PID) for benzene, toluene, *trans*-1,2-DCE, TCA, and 1,1-dichloroethane (DCA). Subsequent to these analyses, *cis*-1,2-DCE concentrations were estimated using the *trans*-1,2-DCE calibration standard because the sensitivity of the PID to both DCE isomers is similar. The presence of *cis*-1,2-DCE, a major byproduct of reductive dehalogenation of TCE (Section 4.2.3.1), at concentrations significantly greater than the *trans*- isomer is evidence of biodegradation of TCE. The distribution of elevated *cis*-1,2-DCE soil gas concentrations (northwest of the source areas) indicates that this compound is primarily in groundwater migrating along the paleochannel that is inferred to extend west and north from the source areas beneath the on-Base portion of OU 1.

Subsurface soil contamination at OU 1 was evaluated during drilling activities associated with the Phase II Stage 2 IRP Investigation (Radian and SAIC, 1988) and the RI (Montgomery Watson, 1995b). Soil samples from several depths, ranging from 0 to 36 feet bgs, at 49 locations were analyzed for various compounds, including halogenated volatiles, aromatic volatiles, metals, pesticides/polychlorinated biphenyls (PCBs), base neutral/acid extractable compounds (BNAEs), dioxins/furans, and TOC. Soil sample locations, depth intervals, and analyses performed are summarized by Montgomery Watson (1995b). Results of the soil analyses are discussed in the following paragraphs, grouped by potential source areas. The discussions focus on the magnitudes and distributions of VOCs and total petroleum hydrocarbons (TPH) because these analytes are most relevant to the RNA TS.

In the CDP 1 and 2 area, VOCs most frequently detected were CAHs and petroleum hydrocarbons. During Phase I drilling, a black-stained or oily layer with a strong hydrocarbon odor was observed during advancement of most boreholes associated with the CDPs. The layer was generally found near the water table, and ranged from 1 to 10 feet thick. Some contamination also was observed in more shallow portions of the vadose zone substantially above the water table.

The highest concentrations of chlorinated hydrocarbons at the CDPs were detected in soils obtained from the LNAPL smear zone created by fluctuations in groundwater levels, in the capillary fringe, and the upper portion of the shallow aquifer. The most commonly detected chlorinated hydrocarbons were chlorobenzenes, 1,1,1-TCA, PCE, and TCE. The highest detected concentrations of these compounds were: 1,2,4-trichlorobenzene at 19,000 µg/kg; 1,2-dichlorobenzene (DCB) at 170,000 µg/kg; 1,4-DCB at 21,000 µg/kg; 1,1,1-TCA at 8,100 µg/kg; PCE at 9,100 µg/kg; and TCE at 40,000 µg/kg. The most frequently detected fuel hydrocarbons (ethylbenzene, naphthalene, toluene, and xylenes) were detected in the highest concentrations in the capillary fringe and upper portion of the shallow aquifer. Concentrations for the commonly detected fuel hydrocarbons ranged up to 2,100 µg/kg for ethylbenzene, 6,900 µg/kg for naphthalene, 5,500 µg/kg for toluene, and 4,700 µg/kg for xylenes. Jet fuel (JP-4 or JP-8) was detected as TPH in the vadose zone, capillary fringe, and saturated zone matrices at concentrations ranging from 500 milligrams per kilogram (mg/kg) to 42,100 mg/kg.

Chlorinated benzenes were detected at the highest concentrations at LF 3. Other VOCs detected included naphthalene, 1,2-DCE (no isomers reported), and xylenes. At LF 4 the VOCs 1,1-DCA, PCE, 1,2-DCE, and TCE were detected in soil samples at

levels above respective practical quantitation limits. The highest concentrations of PCE (55 µg/kg), TCE (190 µg/kg), and 1,2-DCE (1,600 µg/kg) were detected at a depth of 6 to 8 feet bgs from the hydrocarbon-stained zone mentioned above.

Soil samples were collected as monitoring wells were drilled upgradient and downgradient from FTA 1, and four soil borings were drilled within FTA 1. Visible evidence of LNAPL was noted in the vadose zone, capillary fringe, and/or beneath the water table in two soil boreholes drilled at FTA 1. Chlorinated and petroleum VOCs were detected in a portion of the samples; however, petroleum VOCs were detected more often and at higher concentrations than CAHs. Of the petroleum hydrocarbons, ethylbenzene, xylenes, 1,2,4-trichlorobenzene, and 1,2-DCB were detected at levels ranging up to 3,500 µg/kg, 37,000 µg/kg, 41,000 µg/kg, and 15,000 µg/kg, respectively. PCE and TCE were detected in one sample at 11 µg/kg and 1.9 µg/kg, respectively. TPH in the soil ranged from 270 mg/kg to 3,200 mg/kg.

During drilling activities near FTA 2, soil samples were taken from 2 depth intervals at 12 locations. Hydrocarbon staining and/or odors were observed in the vadose zone and/or near or just below the water table in multiple boreholes. Soil samples were analyzed for various parameters, including VOCs and TPH. Several samples were analyzed only for TPH. Xylenes, naphthalene, and ethylbenzene were the most frequently detected VOCs. TCE and 1,2-DCE were found at concentrations ranging up to 43 µg/kg and 32 µg/kg, respectively. The RI report (Montgomery Watson, 1995b) states that the CAH concentrations at FTA 2 may be the result of leachate migration from LF 3.

Two soil borings were drilled near the WPOP during the RI. Hydrocarbon staining was observed in one borehole from approximately 4 feet bgs to the water table at a depth of approximately 8 feet bgs. A total of three soil samples were collected for VOC, BNAE, pesticide, PCB, TPH, and metals analysis, and two of the samples also were analyzed for dioxins, furans, and TOC. TCE, 1,2-DCE, and chlorinated benzenes were the only VOCs detected in the three soil samples. Maximum TCE and 1,2-DCE concentrations were 1,400 µg/kg and 92 µg/kg, respectively.

During the drilling of two soil borings at the WOST area, hydrocarbon staining was apparent at depths of 5 and 15 feet bgs during advancement of one boring, and mobile LNAPL was observed on the water table. Soil samples were collected for VOC, BNAE, pesticide, PCB, TPH, and metals analysis. VOCs detected included acetone, 2-butanone (MEK), TCE, 1,2-DCE, benzene, chlorobenzene, xylenes, and naphthalene were detected. Maximum TCE and 1,2-DCE concentrations both were 13 µg/kg. The RI report (Montgomery Watson, 1995b) states that contaminants present near the water table at the WOST area may have originated at the CDPs or at nearby FTA 1 and LF 3.

In summary, concentrations of chlorinated and petroleum hydrocarbons were detected in soil samples collected throughout the site. The more ubiquitous chlorinated hydrocarbons included TCE, 1,2-DCE, and chlorinated benzenes. BTEX and naphthalene were frequently detected in soil samples collected at OU 1. Chlorinated and fuel hydrocarbons were generally detected at depths near LNAPL, in the capillary fringe, and in the upper portion of the shallow aquifer.

4.1.3 Total Organic Carbon in Soil

TOC concentrations are used to estimate the amount of organic matter sorbed to soil particles or trapped in the interstitial passages of a soil matrix. The TOC concentration in the saturated zone is an important parameter used to estimate the amount of contaminant that could potentially be sorbed to the aquifer matrix. Sorption results in retardation of contaminant plume migration relative to the average advective groundwater velocity. In addition, TOC can be used as a gross indicator of organic compounds that are available as a source of carbon and electron donors (or substrate) for microbial activity.

During the RI, soil TOC concentrations were measured in 19 soil samples collected at CDPs 1 and 2, LF 3, FTAs 1 and 2, the WPOP, and the WOST. In addition, 10 soil samples collected during the March 1997 TS field program were analyzed for TOC. TOC analysis results are summarized in Table 4.1 (RI data) and Table 4.2 (TS data).

The range of TOC concentrations resulting from analysis of the TS samples (Table 4.2) was 0.018 to 0.115 percent, with mean and median values of 0.065 percent and 0.072 percent, respectively. These values are generally one to two orders of magnitude lower than the RI results. This apparent discrepancy is due to the fact that the RI samples were collected within or very near contaminant source areas, and contained petroleum hydrocarbons and/or CAHs, whereas the TS samples were collected from locations distant from source areas and mobile LNAPL. For example, the RI TOC sample collected from boring U1-744 at a depth of 24 to 25 feet bgs had a TOC concentration of 2.4 percent. A soil sample collected from 19.5 to 23 feet bgs in the same borehole had a JP4 concentration of 5,000 mg/kg (Montgomery Watson, 1995b). In addition, the TS samples were mostly collected from sandy deposits, which may represent preferential groundwater and contaminant migration pathways. Sandy deposits often have low native TOC concentrations relative to clayey deposits. Some of the RI TOC samples may have been collected from more clayey deposits.

4.2 OVERVIEW OF BTEX AND CAH BIODEGRADATION

Mechanisms for natural attenuation of CAHs and BTEX include biodegradation, dispersion, dilution from recharge, sorption, and volatilization. Of these processes, biodegradation is the only mechanism working to transform contaminants into innocuous byproducts. Intrinsic bioremediation occurs when indigenous microorganisms work to bring about a reduction in the total mass of contamination in the subsurface without the addition of nutrients. In order to provide a foundation for interpreting site data, the following subsections review the major bioremediation processes that act upon CAHs and benzene, toluene, ethylbenzene, and xylenes (BTEX).

As discussed previously, the focus of this evaluation is on RNA of CAHs dissolved in groundwater. However, because BTEX compounds are present at OU 1, and because such compounds may play a role in the biodegradation of CAHs, the following sections discuss the biodegradation of both BTEX and CAHs. Because the terminology describing biodegradation of both types of compounds is similar, a generalized review of the processes is presented first.

TABLE 4.1
SUMMARY OF RI SOIL TOC DATA
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Location	No. of Samples	Range (percent)	Mean TOC [a/] (percent)	Median TOC (percent)
CDPs 1 and 2	5	0.6-3.3	1.9	2.0
Landfill 3	2	0.14-0.3	0.22	NA[b/]
FTA 1	6	<0.05-0.69	0.28	0.08
FTA 2	4	0.13-0.45	0.53	0.34
WPOP	1	0.32	NA	NA
WOST	1	1.4	NA	NA

[a/] Non-detects (<0.05 percent) assumed to be 0.025 percent in calculation of means.

[b/] NA = not applicable.

Note: CDP = chemical disposal pit, FTA = fire training area, WPOP = waste phenol/oil pit, WOST = waste oil storage tank area.

TABLE 4.2
SOIL TOTAL ORGANIC CARBON CONCENTRATIONS
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Sampling Location	Depth (feet bgs)	Soil Type	Total Organic Carbon[a/] (%)	Mean TOC (%)
U1-1630	45.0	fine to coarse sand	0.048 0.046	0.047
U1-1631	7-7.5	fine to medium silty sand	0.018 0.023	0.021
U1-1632	12-13.5	fine to coarse sand	0.043 0.047	0.045
U1-1635	4-6	medium to coarse sand w/ gravel	0.121 0.083	0.102
U1-1636	4-5.5	fine to very coarse sand w/ gravel	0.114 0.116	0.115
U1-1637	4-6	silt to clayey silt	0.075 0.092	0.084
U1-1637	6-7	fine to medium sand	0.017 0.019	0.018
U1-1639	20-20.5	clayey silt, trace of fine sand	0.087 0.075	0.081
-1639	25-28	very fine to fine sand with silt	0.080 0.064	0.072

a/ Moisture-adjusted result for two subsamples from each depth.
Note: Analysis method was SW9060, modified.

4.2.1 Review of Biodegradation Processes

Microorganisms obtain energy for cell production and maintenance by facilitating thermodynamically advantageous reduction/oxidation (redox) reactions involving the transfer of electrons from electron donors to available electron acceptors. This results in the oxidation of the electron donor and the reduction of the electron acceptor. Electron donors may be natural organic carbon, fuel hydrocarbon compounds, and less-chlorinated solvents (e.g., vinyl chloride [VC], DCE, or DCA). Fuel hydrocarbons or solvents are completely degraded or detoxified if they are utilized as the primary electron donor (i.e., as a primary substrate or carbon source) for microbial metabolism (Bouwer, 1992). Electron acceptors are elements or compounds that occur in relatively oxidized states, and may include oxygen, nitrate, ferric iron, sulfate, manganese, carbon dioxide, and highly chlorinated solvents [e.g., PCE, TCE, TCA, and polychlorinated benzenes].

The driving force of biodegradation is electron transfer, which is quantified by the Gibbs free energy of the reaction ($\Delta G°_r$) (Stumm and Morgan, 1981; Bouwer, 1994; Godsey, 1994). The value of $\Delta G°_r$ represents the quantity of free energy consumed ($\Delta G°_r>0$) or yielded ($\Delta G°_r<0$) to the system during the reaction. Although thermodynamically favorable, most of the reactions involved in biodegradation of fuel hydrocarbons or CAHs cannot proceed abiotically because of the lack of activation energy. Microorganisms are capable of providing the necessary activation energy; however, they will facilitate only those redox reactions that have a net yield of energy (i.e., $\Delta G°_r < 0$). Microorganisms preferentially utilize electron acceptors while metabolizing hydrocarbons (Bouwer, 1992). DO is utilized first as the prime electron acceptor. After the DO is consumed, anaerobic microorganisms typically use native electron acceptors in the following order of preference: nitrate, manganese, ferric iron hydroxide, sulfate, and finally carbon dioxide. Chlorinated solvents are generally used as electron acceptors when aquifer conditions are such that sulfate or carbon dioxide is the preferred electron acceptor.

In addition to being controlled by the energy yield of the reaction, the expected sequence of redox processes also is a function of the oxidizing potential of the groundwater. This potential is a measure of the relative tendency of a solution or chemical reaction to accept or transfer electrons. As each subsequent electron acceptor is utilized, the groundwater becomes more reducing, and the ORP of the water decreases. The main force driving this change in redox potential is microbially mediated redox reactions. ORP can be used as an indicator of which redox reactions may be operating at a site. Environmental conditions and microbial competition ultimately determine which processes will dominate.

Depending on the types and concentrations of electron acceptors present (e.g., nitrate, sulfate, carbon dioxide), pH conditions, and ORP, anaerobic biodegradation can occur by denitrification, manganese reduction, ferric iron reduction, sulfate reduction, or methanogenesis. Other, less common anaerobic degradation mechanisms such as manganese or nitrate reduction or reductive dechlorination may dominate if the physical and chemical conditions in the subsurface favor use of these electron acceptors. Vroblesky and Chapelle (1994) show that the dominant terminal electron accepting process can vary both temporally and spatially in an aquifer with fuel hydrocarbon contamination.

4.2.2 Biodegradation of BTEX

Numerous laboratory and field studies have shown that hydrocarbon-degrading bacteria can participate in the degradation of many of the chemical components of fuel hydrocarbons, including the BTEX compounds (e.g., Jamison *et al.*, 1975; Atlas, 1981, 1984, 1988; Gibson and Subramanian, 1984; Reinhard *et al.*, 1984; Young, 1984; Bartha, 1986; Wilson *et al.*, 1986, 1987, and 1990; Barker *et al.*, 1987; Baedecker *et al.*, 1988; Lee, 1988; Chiang *et al.*, 1989; Grbic-Galic, 1989 and 1990; Cozzarelli *et al.*, 1990; Leahy and Colewell, 1990; Altenschmidt and Fuchs, 1991; Alvarez and Vogel, 1991; Baedecker and Cozzarelli, 1991; Ball *et al.*, 1991; Bauman, 1991; Borden, 1991; Brown *et al.*, 1991; Edwards *et al.*, 1991 and 1992; Evans *et al.*, 1991a and 1991b; Haag *et al.*, 1991; Hutchins and Wilson, 1991; Hutchins *et al.*, 1991a and 1991b; Beller *et al.*, 1992; Bouwer, 1992; Edwards and Grbic-Galic, 1992; Thierrin *et al.*, 1992; Malone *et al.*, 1993; Davis *et al.*, 1994). Fuel hydrocarbons biodegrade naturally when an indigenous population of hydrocarbon-degrading microorganisms is present in the aquifer and sufficient concentrations of electron acceptors and nutrients are available to these organisms.

During biodegradation of fuel hydrocarbons, the fuel compounds are used as electron donors. They are the primary substrate ("food") for the microbes, while the electron acceptors provide the oxidant used to reduce (metabolize) the substrate and produce energy. In most subsurface environments, both aerobic and anaerobic degradation of fuel hydrocarbons can occur, often simultaneously in different parts of the plume. The nearly ubiquitous nature of these processes is well documented (e.g., Rice *et al.*, 1995; Wiedemeier *et al.*, 1995; Kuehne and Buscheck, 1996; and Mace *et al.*, 1997). Aerobic destruction of BTEX compounds dissolved in groundwater results in the consumption (reduction) of DO and the formation of carbon dioxide. Anaerobic destruction of the BTEX compounds is associated with the accumulation of fatty acids, production of methane, solubilization of iron, and reduction of nitrate and sulfate (Cozzarelli *et al.*, 1990; Wilson *et al.*, 1990).

4.2.3 Biodegradation of Chlorinated Solvents

Chlorinated solvents can be transformed, directly or indirectly, by biological processes (e.g., Bouwer *et al.*, 1981; Miller and Guengerich, 1982; Wilson and Wilson, 1985; Nelson *et al.*, 1986; Bouwer and Wright, 1988; Little *et al.*, 1988; Mayer *et al.*, 1988; Arciero *et al.*, 1989; Cline and Delfino, 1989; Freedman and Gossett, 1989; Folsom *et al.*, 1990; Harker and Kim, 1990; Alvarez-Cohen and McCarty, 1991a, 1991b; DeStefano *et al.*, 1991; Henry, 1991; McCarty *et al.*, 1992; Hartmans and de Bont, 1992; McCarty and Semprini, 1994; Vogel, 1994; Bradley and Chapelle, 1996; Klier *et al.*, 1996). Biodegradation of CAHs results from the same general processes that bring about biodegradation of fuel hydrocarbons. However, a more complex series of processes often is involved, and CAHs may act as both a substrate (electron donor) and are electron acceptors.

Whereas BTEX are biodegraded in essentially one step by acting as an electron donor/carbon source, CAHs and chlorinated benzenes may undergo several types of biodegradation involving several steps. CAHs may undergo biodegradation through three different pathways: use as an electron acceptor, use as an electron donor, or cometabolism, which is degradation resulting from exposure to a catalytic enzyme

fortuitously produced during an unrelated process. For example, Wilson and Wilson (1985) showed that TCE could be cometabolically oxidized under aerobic conditions in soils that were fed methane. During this reaction methanotrophs utilize oxygen as the electron acceptor and methane as the electron donor. TCE is degraded using the same enzyme required for methane oxidation. At a given site, one or all of these processes may be operating, although at many sites the use of CAHs as electron acceptors appears to be the most likely.

In a pristine aquifer, native organic carbon is utilized as an electron donor, and DO is utilized first as the prime electron acceptor. Where anthropogenic carbon (e.g., fuel hydrocarbons, less-chlorinated CAHs, or chlorinated benzenes with four or fewer chlorines) is present, it also may be utilized as an electron donor. Most chlorinated solvents that can act as electron donors have thus far only been demonstrated to do so under aerobic conditions, with the notable exception of vinyl chloride (Bradley and Chapelle, 1996). After the DO is consumed, anaerobic microorganisms typically use native electron acceptors (as available) in the following order of preference: nitrate, ferric iron oxyhydroxide, sulfate, and finally carbon dioxide. Evaluation of the distribution of these electron acceptors can provide evidence of where and how biodegradation of chlorinated solvents is occurring. In addition, because solvents may be used as electron acceptors or electron donors (in competition with other acceptors or donors), isopleth maps showing the distribution of these compounds also will provide evidence of the types of biodegradation processes acting at a site. A more complete description of the main types of biodegradation reactions affecting chlorinated solvents dissolved in groundwater is presented in the following subsections.

4.2.3.1 Electron Acceptor Reactions (Reductive Dehalogenation)

Under anaerobic conditions, biodegradation of chlorinated solvents usually proceeds through a process called reductive dehalogenation. During this process, the halogenated hydrocarbon is used as an electron acceptor, not as a source of carbon, and a halogen atom is removed and replaced with a hydrogen atom. As an example, Figure 4.2 illustrates the transformation of chlorinated ethenes via reductive dehalogenation. In general, reductive dehalogenation of chlorinated ethenes occurs by sequential dehalogenation from PCE to TCE to DCE to VC to ethene. An analogous pattern for chlorinated ethanes might be tetrachloroethane (PCA) to TCA to DCA to chloroethane (CA), and for chlorinated benzenes the pattern might be tetrachlorobenzene (TeCB) to trichlorobenzene (TCB) to DCB to chlorobenzene (CB). Depending upon environmental conditions, these sequences may be interrupted, with other processes (e.g., aerobic or abiotic degradation) then acting upon the products. Reductive dehalogenation of chlorinated solvent compounds is associated with the accumulation of daughter products and an increase in chloride.

Reductive dehalogenation affects chlorinated compounds differently. Of the ethenes, PCE is the most susceptible to reductive dehalogenation because it is the most oxidized. Conversely, VC is the least susceptible to reductive dehalogenation because it is the least oxidized of these compounds. Likewise, hexachlorobenzene is more susceptible to reductive dehalogenation than less-chlorinated benzenes. In general, the rate of reductive dehalogenation of chlorinated solvents has been observed to decrease as the degree of chlorination decreases (Vogel and McCarty, 1985; Bouwer, 1994). Murray and

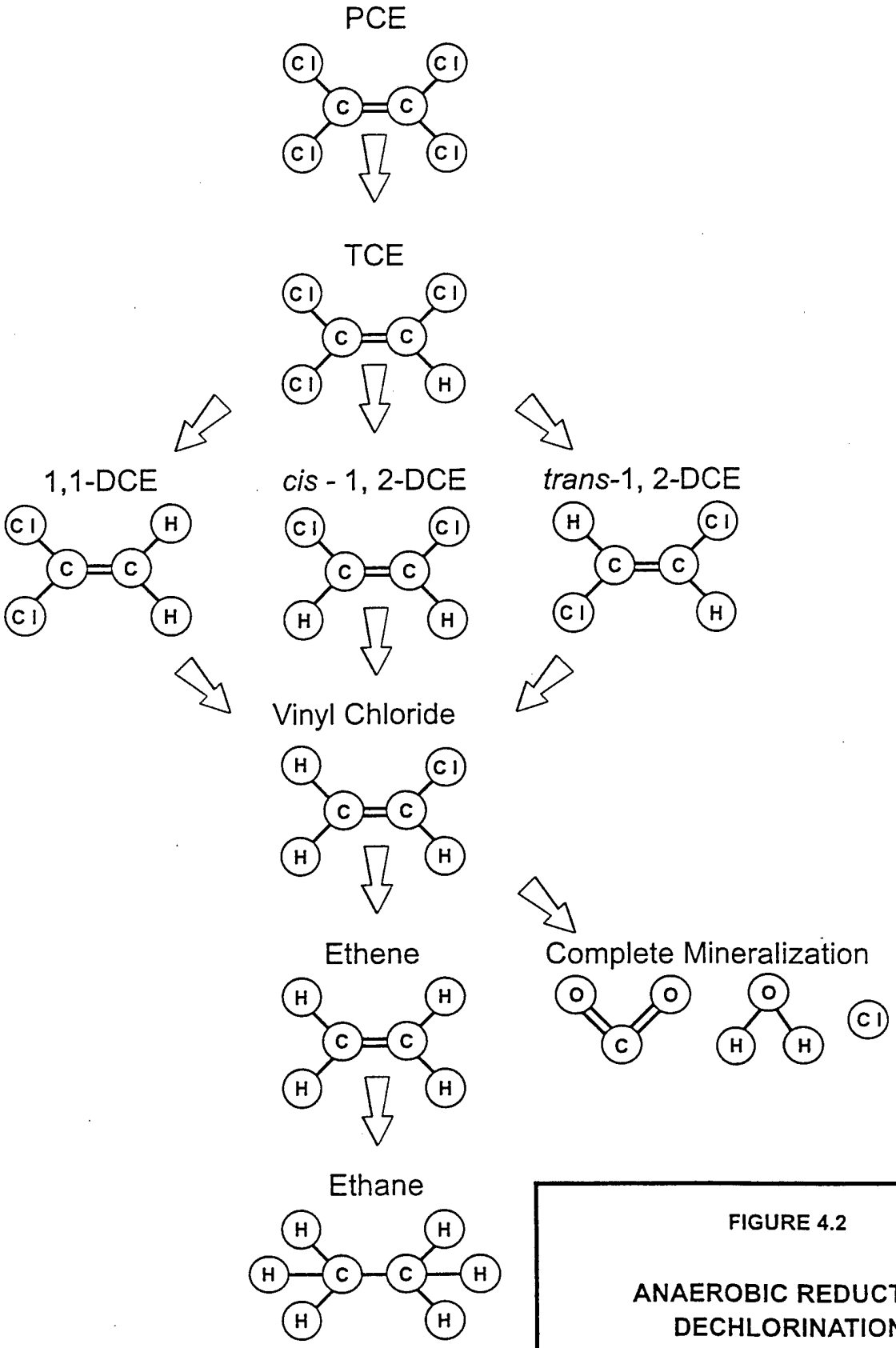


FIGURE 4.2

ANAEROBIC REDUCTIVE DECHLORINATION

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Richardson (1993) have postulated that this rate decrease may explain the accumulation of VC in PCE and TCE plumes that are undergoing reductive dehalogenation.

In addition to being affected by the degree of chlorination of the compound, reductive dehalogenation also can be controlled by the redox conditions of the site groundwater system. In general, reductive dehalogenation has been demonstrated under anaerobic nitrate- and sulfate-reducing conditions, but the most rapid biodegradation rates, affecting the widest range of compounds, occur under methanogenic conditions (Bouwer, 1994). Dehalogenation of PCE and TCE to DCE can proceed under mildly reducing conditions such as nitrate reduction or ferric iron reduction (Vogel *et al.*, 1987), while the transformation of DCE to VC, or the transformation from VC to ethene requires more strongly reducing conditions (Freedman and Gossett, 1989; DeStefano *et al.*, 1991; De Bruin *et al.*, 1992).

Reductive dehalogenation of some compounds also has been shown to preferentially produce specific daughter compounds. For example, during reductive dehalogenation of TCE or PCE, all three isomers of DCE can theoretically be produced; however, Bouwer (1994) reports that under the influence of biodegradation, *cis*-1,2-DCE is a more common intermediate than *trans*-1,2-DCE, and that 1,1-DCE is the least prevalent intermediate of the three DCE isomers.

When chlorinated compounds are used as electron acceptors, there must be an appropriate source of carbon for microbial growth in order for reductive dehalogenation to occur (Bouwer, 1994). Potential carbon sources/electron donors can include low-molecular-weight compounds (e.g., lactate, acetate, methanol, or glucose) present in natural organic matter, fuel hydrocarbons, or less-chlorinated solvents (as discussed below).

4.2.3.2 Electron Donor Reactions

Under aerobic conditions some chlorinated solvents can be utilized as the primary substrate (i.e., electron donor) in biologically mediated redox reactions (McCarty and Semprini, 1994). In this type of reaction, the facilitating microorganism obtains energy and organic carbon from the degraded compound. In contrast to reactions in which the chlorinated compound is used as an electron acceptor, only the least oxidized chlorinated solvents (e.g., VC, DCE, or CB) may be utilized as electron donors in biologically mediated redox reactions. Also, chlorinated benzenes with up to four chlorines (i.e., CB, DCB isomers, TCB isomers, and TeCB isomers) have been shown to act as electron donors under aerobic conditions.

For example, while Murray and Richardson (1993) write that microorganisms are generally believed to be incapable of growth using TCE and PCE, other less chlorinated CAHs have been shown to be used as substrates. Davis and Carpenter (1990) describe the aerobic oxidation of VC in groundwater. McCarty and Semprini (1994) describe investigations in which VC and 1,2-DCA were shown to serve as primary substrates. These authors also document that dichloromethane has the potential to function as a primary substrate under either aerobic or anaerobic environments. Klier *et al.* (1996) describe aerobic mineralization of all three isomers of DCE. In addition, Bradley and Chapelle (1996) show evidence of oxidation of VC under iron-reducing conditions so long as there is sufficient bioavailable iron (III). Chlorinated solvent oxidation may be

characterized by a loss of solvent mass, a decreasing molar ratio of daughter solvents to other parent solvent compounds, and rarely, the presence of chloromethane.

CB and polychlorinated benzenes (up to and including TeCB) have been shown to be biodegradable under aerobic conditions. Several studies have shown that bacteria are able to utilize CB (Reineke and Knackmuss, 1984), 1,4-DCB (Reineke and Knackmuss, 1984; Schraa *et al.*, 1986; Spain and Nishino, 1987), 1,3-DCB (de Bont *et al.*, 1986), 1,2-DCB (Haigler *et al.*, 1988), 1,2,4-TCB (van der Meer *et al.*, 1987; Sander *et al.*, 1991), and 1,2,4,5-TeCB (Sander *et al.*, 1991) as primary growth substrates in aerobic systems. Nishino *et al.* (1994) note that aerobic bacteria able to grow on chlorobenzene have been detected at a variety of CB-contaminated sites, but not at uncontaminated sites. Spain (1996) notes that this provides strong evidence that the bacteria are selected for their ability to derive carbon and energy from CB degradation *in situ*. The pathways for all of these reactions are similar, and are also similar to that of benzene (Chapelle, 1993; Spain, 1996). The only significant difference between aerobic oxidation of chlorobenzenes and benzene is the required elimination of chlorine. Anaerobic oxidation of chlorobenzenes has not been conclusively documented, although little research has been conducted on the subject (Spain, 1997).

4.2.3.3 Cometabolism

When a CAH is biodegraded through cometabolism, it serves as neither an electron acceptor nor a primary substrate in a biologically mediated redox reaction. Instead, the degradation of the CAH is catalyzed by an enzyme or cofactor that is fortuitously produced by organisms for other purposes. The organism receives no known benefit from the degradation of the CAH; rather the cometabolic degradation of the CAH may in fact be harmful to the microorganism responsible for the production of the enzyme or cofactor (McCarty and Semprini, 1994).

Cometabolism is best documented in aerobic environments, although it potentially could occur under anaerobic conditions. Aerobic degradation pathways for chlorinated ethenes are illustrated in Figure 4.3. It has been reported that under aerobic conditions chlorinated ethenes, with the exception of PCE, are susceptible to cometabolic degradation (Murray and Richardson, 1993; Vogel, 1994; McCarty and Semprini, 1994). Vogel (1994) further elaborates that the cometabolism rate increases as the degree of halogenation decreases.

In the cometabolic process, TCE is indirectly transformed by bacteria as they use BTEX or another substrate to meet their energy requirements. Therefore, TCE does not enhance the degradation of BTEX or other carbon sources, nor will its cometabolism interfere with the use of electron acceptors involved in the oxidation of those carbon sources. Given this relationship, it would follow that depletion of suitable substrates (BTEX or other organic carbon sources) likely limits cometabolism of CAHs.

4.2.3.4 Behavior of Chlorinated Solvent Plumes

Chlorinated solvent plumes can exhibit three types of behavior depending on the amount of solvent, the amount of native and/or anthropogenic organic carbon in the aquifer, the distribution and concentration of natural electron acceptors, and the types of electron acceptors being utilized. Individual plumes may exhibit all three types of

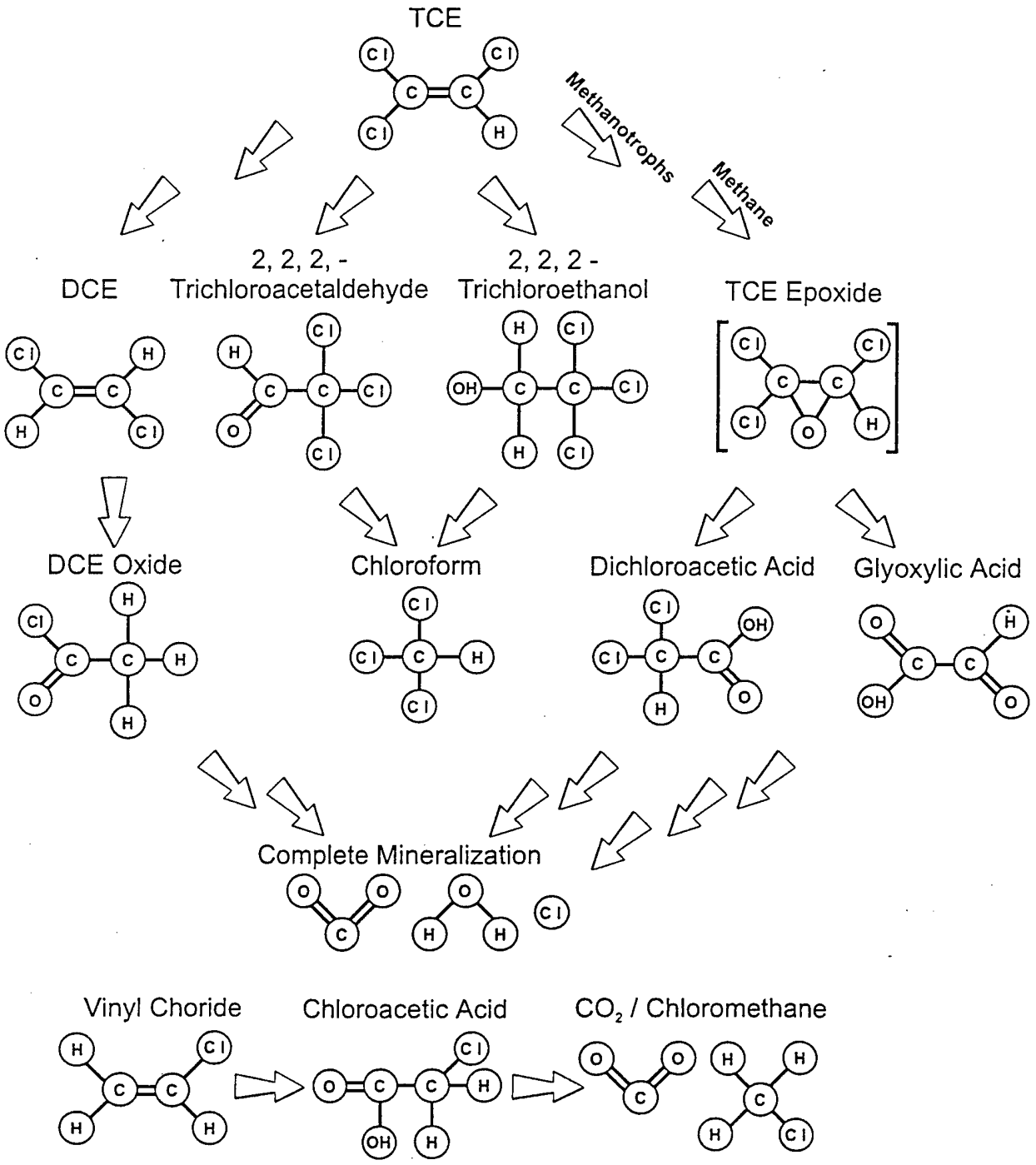

FIGURE 4.3

AEROBIC DEGRADATION

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behavior in different portions of the plume. The different types of plume behavior are summarized below.

4.2.3.4.1 Type 1 Behavior

Type 1 behavior occurs where the primary substrate is anthropogenic carbon (e.g., BTEX or landfill leachate), and this anthropogenic carbon drives reductive dechlorination. When evaluating natural attenuation of a plume exhibiting type 1 behavior the following questions must be answered:

1) Is the electron donor supply adequate to allow microbial reduction of the chlorinated organic compounds? In other words, will the microorganisms "strangle" before they "starve" (i.e., will they run out of CAHs [electron acceptors] before they run out of primary substrate [anthropogenic carbon])?

2) What is the role of competing electron acceptors (e.g., dissolved oxygen, nitrate, ferric iron and sulfate)?

3) Is VC being oxidized, or is it being reduced?

Type 1 behavior results in the rapid and extensive degradation of the highly chlorinated solvents such as PCE, TCE, or DCE.

4.2.3.4.2 Type 2 Behavior

Type 2 behavior dominates in areas that are characterized by relatively high concentrations of biologically available native organic carbon. This natural carbon source drives reductive dehalogenation (i.e., the primary substrate for microorganism growth is native organic carbon). When evaluating natural attenuation of a type 2 chlorinated solvent plume, the same questions as those posed in the description of type 1 behavior must be answered. Type 2 behavior generally results in slower biodegradation of the highly chlorinated solvents than type 1 behavior, but under the right conditions (e.g., areas with high natural organic carbon contents), this type of behavior also can result in rapid degradation of these compounds.

4.2.3.4.3 Type 3 Behavior

Type 3 behavior dominates in areas that are characterized by low concentrations of native and/or anthropogenic carbon, and concentrations of DO that are greater than 1.0 milligram per liter (mg/L). Under these aerobic conditions reductive dehalogenation will not occur. Thus there is little or no removal of PCE, TCE, and DCE. Biodegradation may proceed via the much slower process of cometabolism, but will be limited by the low concentrations of native or anthropogenic carbon. The most significant natural attenuation mechanisms for CAHs will be advection, dispersion, and sorption. However, VC can be rapidly oxidized under these conditions, DCE may be oxidized, and cometabolism may also occur.

4.2.3.4.4 Mixed Behavior

As mentioned above, a single chlorinated solvent plume can exhibit all three types of behavior in different portions of the plume. This can be beneficial for natural biodegradation of CAH plumes. For example, Wiedemeier *et al.* (1996a) describe a plume at Plattsburgh AFB, New York that exhibits type 1 behavior in the source area and type 3 behavior downgradient from the source. The best scenario involves a plume in which PCE, TCE, and DCE are reductively dehalogenated (type 1 or type 2 behavior), then VC is oxidized (type 3 behavior), either aerobically or via iron reduction. VC is oxidized to carbon dioxide in this type of plume and does not accumulate. The following sequence of reactions occurs in a plume that exhibits this type of mixed behavior:

$$\text{PCE} \rightarrow \text{TCE} \rightarrow \text{DCE} \rightarrow \text{VC} \rightarrow \text{Carbon Dioxide}$$

In general, the TCE, DCE, and VC may attenuate at approximately the same rate, and thus these reactions may be confused with simple dilution. Note that no ethene is produced during this reaction. VC is removed from the system much faster under these conditions than it is under VC-reducing conditions.

A less desirable scenario, but one in which all contaminants may be entirely biodegraded, involves a plume in which all CAHs are reductively dehalogenated via type 1 or type 2 behavior. VC is reduced to ethene, which may be further reduced to ethane or methane. The following sequence of reactions occur in this type of plume:

$$\text{PCE} \rightarrow \text{TCE} \rightarrow \text{DCE} \rightarrow \text{VC} \rightarrow \text{Ethene or Ethane}$$

This sequence has been investigated by Freedman and Gossett (1989). In this type of plume, VC degrades more slowly than TCE, and thus tends to accumulate.

4.2.4 Abiotic Degradation of Chlorinated Solvents

Chlorinated solvents dissolved in groundwater may also be degraded by abiotic mechanisms, although the reactions may not be complete and often result in the formation of a toxic intermediate. The most common abiotic reactions affecting chlorinated solvents are hydrolysis and dehydrohalogenation. Hydrolysis is a substitution reaction in which a halogen substituent is replaced with a hydroxyl (OH^-) group from a water molecule. Dehydrohalogenation is an elimination reaction in which a halogen is removed from a carbon atom, followed by removal of a hydrogen atom from an adjacent carbon atom, with a double bond between the carbon atoms being produced. Other possible reactions include oxidation and reduction, although Butler and Barker (1996) note that no abiotic oxidation reactions involving common halogenated solvents have been reported in the literature. They also note that reduction reactions are most commonly microbially mediated.

Hydrolysis of chlorinated methanes and ethanes has been well demonstrated in the literature (e.g., Vogel *et al.*, 1987; Jeffers *et al.*, 1989; Vogel, 1994; Butler and Barker, 1996). The likelihood that a solvent will hydrolyze is partly dependent upon the number of halogen substituents, typically with fewer halogens resulting in more rapid hydrolysis. Dehydrohalogenation, on the other hand, is more likely to take place as the number of halogen substituents increases. One common solvent for which abiotic degradation

reactions are well documented is 1,1,1-TCA. 1,1,1-TCA may be transformed through a series of abiotic processes (including hydrolysis) to acetic acid. Vogel and McCarty (1987) demonstrated that 1,1,1-TCA can also dehydrohalogenate to 1,1-DCE, and Jeffers *et al.* (1989) demonstrated that 1,1,2-TCA reacts in the same manner to form 1,1-DCE. Also, once TCA is reductively dehalogenated to CA, it can then hydrolyze to ethanol (Vogel and McCarty, 1987) or dehydrohalogenate to VC (Jeffers *et al.*, 1989).

Butler and Barker (1996) note that attributing changes in the presence, absence, or concentration of halogenated solvents to abiotic processes is usually difficult, particularly at the field scale. Solvents may undergo both biotic and abiotic degradation, and discerning the effects of each mechanism (at the field scale), if possible, would be very difficult. Also, as Butler and Barker (1996) note, the breakdown products of some reactions such as hydrolysis (e.g., acids and alcohols) may be more easily degraded (biotically or abiotically); these products also require additional analyses that may not be feasible for a field investigation. This makes collection of field evidence to demonstrate hydrolysis very difficult to collect and interpret, and Butler and Barker (1996) note that such evidence has not been successfully collected and presented. Evidence of dehydrohalogenation is also difficult to collect, although the presence of 1,1-DCE in conjunction with 1,1,1-TCA can provide a tentative indication that the process is ongoing, and strong evidence where it is known that no DCE has been released.

4.3 DISTRIBUTION OF CAHS AND DAUGHTER PRODUCTS

One of the most straightforward methods for evaluating the occurrence and method of biodegradation of CAHs is to look at the distribution of target CAHs and the products of biodegradation of those compounds. At the same time, it is also useful to look at the distribution of other contaminants that may be acting as sources of electron donors (e.g., BTEX).

Because reductive dehalogenation is the most common biodegradation reaction, a typical pattern (e.g., as presented by Vogel, 1994) would have TCE (and/or PCE) concentrations highest in the source area, with elevated DCE concentrations (consisting mostly of *cis*-1,2-DCE) in and just downgradient from the source area. VC concentrations could be present along the entire plume length, with the highest VC concentrations likely to be found near the downgradient end of the CAH plume. If VC also is being reductively dehalogenated, dissolved ethene also will be present downgradient of the source area, in the vicinity of the highest concentrations of VC. The degree to which this pattern is observed at OU 1 is assessed in this section.

Two separate groundwater sampling events were performed at OU 1 in March 1997, including sampling in support of this TS and sampling performed by Montgomery Watson as part of the thirteenth (13th) sampling round in ongoing LTM of groundwater. In some cases, the sampling rounds overlapped and some wells were sampled twice. In these cases, both sets of analytical results are included in the data summary tables, and the maximum detected contaminant concentrations (e.g., TCE, DCE) are plotted on the contaminant distribution figures. For non-contaminant (geochemical) data (e.g., ORP, DO, ferrous iron), all available TS data are plotted on figures, and 13th-round data are used for wells not sampled for the TS. During the 13th sampling round performed by Montgomery Watson (1997), four samples were collected from each well to assess the variability introduced during the sampling and analysis processes. The 13th-round data

presented in tables and figures in this section are the average values computed from each set of four discrete samples.

4.3.1 Trichloroethene and Tetrachloroethene

As shown in Table 4.3, PCE was not detected at concentrations exceeding the 5-µg/L MCL for this compound in March 1997, and therefore is not a contaminant of concern in OU 1 groundwater. As measured in March 1997, dissolved concentrations of TCE in excess of the 5-µg/L MCL were infrequently detected. Figure 4.4 shows the configuration of the TCE plumes as determined from March 1997 data. An elevated dissolved TCE concentration (490 µg/L) was detected at well U1-085, located at the edge of the slope near the WPOP. According to Montgomery Watson (1995b), this well is located near the mouth of an east-to-northeastward-trending paleochannel in the surface of the clay layer beneath LF 3 and the northern portion of LF 4 that may constitute a preferential contaminant migration pathway from these areas. Other on-Base wells that contained TCE concentrations in excess of 5 µg/L included U1-106 (27.3 µg/L), U1-107 (12.5 µg/L), and U1-092 (6.2 µg/L). Low concentrations of TCE, ranging from less than 1.0 µg/L to 29.8 µg/L, also were detected near the southern edge of the Weber River Valley, indicating that some migration from the on-Base portion of OU 1 has occurred. However, TCE concentrations greater than the 5-µg/L MCL were not detected north of the toe of the escarpment that bounds the alluvial valley.

4.3.2 Dichloroethene

Historically, 1,2-DCE has been the CAH with the greatest areal extent and the highest dissolved concentrations in OU 1 groundwater. According to the summary of historical chemical usage at Hill AFB presented in the RI report (Montgomery Watson, 1995b), both PCE and TCE have been used at the Base as a solvent, but DCE has not been used. Therefore, the prevalence of 1,2-DCE in OU 1 groundwater (and the relative scarcity of PCE and TCE) indicates that this CAH is a daughter product resulting from the reductive dehalogenation of TCE. Historical groundwater quality data indicate that concentrations of the *cis*-1,2-DCE isomer in groundwater are substantially greater than concentrations of *trans*-1,2-DCE and 1,1-DCE. The low magnitude of detected *trans*-1,2-DCE and 1,1-DCE concentrations relative to those of *cis*-1,2-DCE is common in environments where reductive dehalogenation of TCE occurs. As discussed in Section 4.2.3.1, *cis*-1,2-DCE is the main metabolic intermediate of this process (Bouwer, 1994).

March 1997 analytical data for DCE are summarized in Table 4.3, and the distribution of *cis*-1,2-DCE concentrations detected in groundwater in March 1997 is shown on Figure 4.5. The areal extent and magnitude of the March 1997 *cis*-1,2-DCE plume is similar to the May-June 1994 total DCE plume presented in the RI report (Montgomery Watson, 1995b). The highest DCE concentrations (>1,000 µg/L) were detected within and immediately downgradient from the on-Base source areas, especially beneath the mobile LNAPL body described in Section 4.1.1. More dilute concentrations extend to the west toward well U1-117 and to the north beneath the Weber River valley. The detection of low concentrations of *cis*-1,2-DCE in the surface drainage north of South Weber Drive (sampling locations U1-332 and U1-333, Figure 4.5), suggest that some discharge to surface water is occurring near the leading edge of the DCE plume.

TABLE 4.3
CHLORINATED ALIPHATIC HYDROCARBONS IN SURFACE WATER AND GROUNDWATER
MARCH 1997
OU 1 RNA TS
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Sampling Location	VC[a] (µg/L)[b]	1,1-DCE[a] (µg/L)	trans-1,2-DCE (µg/L)	cis-1,2-DCE (µg/L)	1,1-DCA[a] (µg/L)	Chloroform (µg/L)	1,1,1-TCA[a] (µg/L)	1,2-DCA (µg/L)
SURFACE WATER								
U1-331	ND[c]	ND	ND	ND	ND	< 1.0	ND	ND
U1-332	ND	ND	ND	3.7	ND	< 1.0	ND	ND
U1-333	ND	ND	ND	1.4	ND	ND	ND	ND
GROUNDWATER								
U1-008	ND	ND	ND	ND	ND	ND	ND	ND
U1-041*[d]	24.5	< 20	< 20	48	< 20	< 20	< 20	< 20
U1-053	ND	ND	ND	ND	ND	ND	ND	ND
U1-061	11.6	ND	ND	ND	< 1.0	ND	ND	ND
U1-062	ND	ND	ND	ND	ND	ND	ND	ND
U1-065	73.9	ND	< 1.0	18.6	3.1	ND	ND	ND
U1-065*	70	< 50	< 50	< 50	< 50	< 50	< 50	< 50
U1-067	205	12.7	8.3	4000	52.2	2.0	52.2	3.5
U1-070*	< 50	< 50	< 50	3948	< 50 / 60	< 50	< 50	< 50
U1-071*	< 200	< 200	< 200	7083	< 200	< 200	< 200	< 200
U1-072	43.7	2.1	1.0	524	95.7	< 1.0	179	4.8
U1-073	236	3.9	6.8	1250	187	1.4	257	18.0
U1-074	9.0	4.7	1.5	1550	101	< 1.0	32.4	8.5
U1-077R	ND	ND	< 1.0	61.6	5.3	ND	ND	< 1.0
U1-077*	< 5	< 5	< 5	92	6.7	< 5	< 5	< 5
U1-078	ND	ND	ND	20.5	1.9	ND	ND	ND
U1-081	ND	ND	ND	ND	ND	ND	ND	ND
U1-084	ND	ND	ND	ND	ND	ND	ND	ND
U1-085	118	2.8	63.4	118	18.3	ND	ND	3.3
U1-085*	150	< 10	77	153	20.7	< 10	< 10	< 10
U1-088*	< 1	< 1	< 1	0.5 T	< 1	< 1	< 1	< 1
U1-089	213	ND	1.2	5.8	10.0	ND	ND	4.0
U1-089*	293	< 50	< 50	< 50	< 50	< 50	< 50	< 50
U1-090	ND	ND	ND	4.9	ND	ND	ND	ND
U1-092	16	ND	< 1.0	1.7	7.8	ND	ND	1.0
U1-092*	11	< 1	< 1	2	7	< 1	< 1	< 1
U1-097	ND	ND	ND	ND	ND	5.3	ND	ND
U1-098	ND	ND	ND	12.1	< 1.0	1.5	ND	ND

TABLE 4.3 (Continued)
CHLORINATED ALIPHATIC HYDROCARBONS IN SURFACE WATER AND GROUNDWATER
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Sample Location	Carbon Tetrachloride (µg/L)	TCE[a/] (µg/L)	PCE[a/] (µg/L)	Chlorobenzene (µg/L)	1,3-DCB[a/] (µg/L)	1,4-DCB (µg/L)	1,2-DCB (µg/L)	Ethene (µg/L)
SURFACE WATER								
U1-331	ND	ND	ND	ND	ND	ND	ND	ND
U1-332	ND	ND	ND	ND	ND	ND	ND	ND
U1-333	ND	ND	ND	ND	ND	ND	1.5	ND
GROUNDWATER								
U1-008	ND	ND	ND	ND	ND	ND	ND	ND
U1-041*[d/]	< 20	< 20	< 20	401	16 T[f/]	94	11 T	NA[e/]
U1-053	ND	ND	ND	ND	ND	ND	1.7	NA
U1-061	ND	ND	ND	2.0	< 1.0	3.0	1.9	NA
U1-062	ND	ND	ND	ND	ND	ND	ND	ND
U1-065	ND	ND	ND	3293	77.4	347	59.2	ND
U1-065*	< 50	< 50	< 50	3465	70	343	65	NA
U1-067	ND	1.3	2.0	156	34.1	177	1830	9
U1-070*	< 50	< 50	< 50	44 T	< 50 / 90	80	735	NA
U1-071*	< 200	< 200	< 200	83 T	< 200	195 T	2125	NA
U1-072	18.9	1.5	3.0	26.3	17.7	141	1180	NA
U1-073	27.7	< 1.0	1.1	37.5	30.2	196	1280	NA
U1-074	ND	< 1.0	2.0	48.7	33.0	215	1700	3
U1-077R	ND	ND	ND	ND	< 1.0	< 1.0	1.5	NA
U1-077*	< 5	< 5	< 5	< 5	< 5	< 5	< 5	NA
U1-078	ND	ND	ND	ND	ND	ND	< 1.0	ND
U1-081	ND	ND	ND	ND	ND	ND	< 1.0	ND
U1-084	ND	ND	ND	ND	ND	ND	< 1.0	ND
U1-085	ND	446	ND	ND	ND	ND	3.8	16
U1-085*	< 10	490	< 10	5 T	< 10	< 10	< 10	NA
U1-088*	< 1	< 1	< 1	< 1	< 1	< 1	< 1	NA
U1-089	ND	ND	ND	1590	28.4	153	68.9	NA
U1-089*	< 50	< 50	< 50	1960	29 T	168	70	NA
U1-090	ND	1.8	ND	ND	ND	ND	< 1.0	ND
U1-092	ND	6.2	ND	ND	< 1.0	1.0	7.2	22
U1-092*	< 1	6	< 1	< 1	0.4 T	1 T	5.7	NA
U1-097	ND	ND	ND	ND	< 1.0	ND	ND	NA
U1-098	ND	< 1.0	ND	ND	ND	ND	ND	ND

TABLE 4.3 (Continued)
CHLORINATED ALIPHATIC HYDROCARBONS IN SURFACE WATER AND GROUNDWATER
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Sampling Location	VC[a] (µg/L)[b]	1,1-DCE[a] (µg/L)	trans-1,2-DCE (µg/L)	cis-1,2-DCE (µg/L)	1,1-DCA[a] (µg/L)	Chloroform (µg/L)	1,1,1-TCA[a] (µg/L)	1,2-DCA (µg/L)
U1-099	ND	ND	ND	27.9	< 1.0	ND	ND	ND
U1-100	ND	ND	ND	ND	< 1.0	ND	< 1.0	ND
U1-101	10.4	ND	ND	2.4	2.1	ND	ND	ND
U1-101*	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
U1-103	ND	ND	1.8	335	2.9	< 1.0	ND	< 1.0
U1-104	ND	ND	< 1.0	59.0	23.6	1.0	< 1.0	1.4
U1-105	< 1.0	< 1.0	< 1.0	648	7.2	< 1.0	< 1.0	1.0
U1-105*	< 20	< 20	< 20	551	< 20	< 20	< 20	< 20
U1-106	469	4.7	1.5	1007	24.0	< 1.0	6.6	166
U1-106*	394	< 20	< 20	1285	< 20	< 20	< 20	180
U1-107	26.3	ND	< 1.0	5.4	13.5	ND	ND	1.2
U1-108	ND	< 1.0	< 1.0	379	7.8	1.4	4.0	< 1.0
U1-108*	< 20	< 20	< 20	350	7 T	< 20	< 20	< 20
U1-111	ND	ND	ND	ND	ND	3.0	ND	ND
U1-112	ND	ND	ND	5.9	ND	ND	ND	ND
U1-113	ND	ND	ND	5.5	< 1.0	ND	ND	ND
U1-115	ND	ND	ND	7.1	ND	ND	ND	< 1.0
U1-116	ND	ND	ND	133	< 1.0	ND	ND	ND
U1-117	ND	ND	ND	ND	ND	ND	ND	ND
U1-118	62.9	ND	< 1.0	2.7	29.3	ND	ND	2.8
U1-119*	15	< 1	< 1	3	< 1	< 1	< 1	< 1
U1-121*	33	< 1	< 1	11	2	< 1	< 1	< 1
U1-123	59.6	< 1.0	< 1.0	94.9	7.8	ND	ND	1.2
U1-123*	69	< 2	< 2	125	10	< 2	< 2	< 2
U1-126	ND	ND	ND	ND	ND	ND	ND	ND
U1-129*	< 50	< 50	< 50	480	< 50 / 90	< 50	< 50	< 50
U1-130	16.4	ND	ND	124	23.2	ND	20.2	ND
U1-132*	< 50 / 60	< 50	< 50	593	< 50	< 50	170	< 50
U1-133*	< 50	< 50	< 50	1125	< 50	< 50	< 50 / 90	< 50
U1-138	1.4	< 1.0	< 1.0	547	4.0	< 1.0	< 1.0	1.0
U1-143	3.8	ND	ND	7.8	2.0	ND	ND	ND
U1-151	1.7	1.2	< 1.0	747	11.8	1.1	3.5	1.3
U1-154	ND	< 1.0	< 1.0	198	3.2	1.4	1.6	< 1.0
U1-155	ND	ND	ND	16.7	ND	ND	ND	ND
U1-155*	< 1	< 1	< 1	22	< 1	< 1	< 1	< 1
U1-156*	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

TABLE 4.3 (Continued)
CHLORINATED ALIPHATIC HYDROCARBONS IN SURFACE WATER AND GROUNDWATER
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Sample Location	Carbon Tetrachloride (µg/L)	TCE[a/] (µg/L)	PCE[a/] (µg/L)	Chlorobenzene (µg/L)	1,3-DCB[a/] (µg/L)	1,4-DCB (µg/L)	1,2-DCB (µg/L)	Ethene (µg/L)
U1-099	ND	ND	ND	ND	ND	ND	ND	ND
U1-100	ND	< 1.0	ND	ND	ND	ND	ND	ND
U1-101	ND	< 1.0	ND	ND	ND	ND	ND	ND
U1-101*	< 50	< 50	< 50	< 50	< 50	< 50	< 50	NA
U1-103	ND	< 1.0	ND	ND	ND	ND	ND	NA
U1-104	ND	< 1.0	ND	ND	ND	ND	ND	NA
U1-105	ND	3.4	ND	ND	ND	ND	ND	ND
U1-105*	< 20	< 20	< 20	< 20	< 20	< 20	< 20	NA
U1-106	ND	27.3	ND	14.6	6.1	14.8	91.4	3
U1-106*	< 20	17.7	< 20	39	< 20	16.3	128	NA
U1-107	ND	12.5	ND	16.0	< 1.0	5.0	4.8	NA
U1-108	ND	9.8	ND	ND	ND	ND	ND	ND
U1-108*	< 20	10.5	< 20	< 20	< 20	< 20	< 20	NA
U1-111	ND	ND	ND	ND	ND	ND	ND	ND
U1-112	ND	< 1.0	ND	ND	ND	ND	ND	ND
U1-113	ND	< 1.0	ND	ND	ND	ND	ND	ND
U1-115	ND	< 1.0	ND	ND	ND	ND	ND	NA
U1-116	ND	ND	ND	ND	ND	ND	ND	NA
U1-117	ND	ND	ND	ND	ND	ND	ND	ND
U1-118	ND	< 1.0	ND	681	14.5	85.2	46.0	NA
U1-119*	< 1	< 1	< 1	0.7 T / 9	< 1	0.8 T	0.5 T / 2	NA
U1-121*	< 1	4	< 1	5	0.8 T	< 1 / 4	0.9 T	NA
U1-123	ND	ND	ND	ND	ND	ND	< 1.0	50
U1-123*	< 2	< 2	< 2	5 T	< 2	< 2	< 2	NA
U1-126	ND	< 1.0	ND	< 1.0	ND	< 1.0	ND	NA
U1-129*	< 50	< 50	< 50	32 T	< 50	90	878	NA
U1-130	ND	< 1.0	0.9	16.5	ND	118	938	NA
U1-132*	< 50	< 50	< 50	< 50	< 50	135	1083	NA
U1-133*	< 50	< 50	< 50	< 50	< 50	< 50	95	NA
U1-138	ND	4.9	ND	ND	ND	ND	ND	ND
U1-143	ND	< 1.0	ND	26.4	ND	18.7	109	NA
U1-151	ND	29.8	ND	ND	ND	ND	ND	ND
U1-154	ND	6.9	ND	ND	ND	ND	ND	ND
U1-155	ND	10.7	ND	ND	ND	ND	ND	<3
U1-155*	< 1	< 1	0.4 T	< 1	< 1	< 1	< 1	NA
U1-156*	< 1	< 1	< 1	< 1	< 1	< 1	< 1	NA

TABLE 4.3 (Continued)
CHLORINATED ALIPHATIC HYDROCARBONS IN SURFACE WATER AND GROUNDWATER
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Sampling Location	VC[a] (µg/L)[b]	1,1-DCE[a] (µg/L)	trans-1,2-DCE (µg/L)	cis-1,2-DCE (µg/L)	1,1-DCA[a] (µg/L)	Chloroform (µg/L)	1,1,1-TCA[a] (µg/L)	1,2-DCA (µg/L)
U1-159*	< 1	< 1	< 1	6	< 1	< 1	< 1	< 1
U1-160	ND	ND	ND	4.6	ND	ND	ND	< 1.0
U1-162	< 50 / 100	ND	< 1.0	3.9	< 50 / 60	ND	ND	5.4
U1-162*	96.7	< 50	< 50	< 50	60	< 50	< 50	< 50
U1-201*	< 50	< 50	< 50	1470	< 50	< 50	< 50	< 50
U1-202*	250	< 50	< 50	3930	80	< 50	< 50	< 50
U1-203*	305	< 10	< 10	240	29	< 10	28	< 10
U1-204*	87	< 10	< 10	46	10	< 10	3 T	< 10
U1-205*	26	< 1	< 1	2	2	< 1	< 1	< 1
U1-206*	15	< 1	< 1	< 1	< 1	< 1	< 1	< 1
U1-207*	2	< 1	< 1	2	< 1	< 1	< 1	< 1
U1-303*	7	< 1	< 1	< 1	2	< 1	< 1	< 1
U1-304*	14	< 1	< 1	4	4	< 1	< 1	< 1
U1-307*	< 10	< 10	< 10	526	< 10	< 10	< 10	< 10
U1-647	ND	ND	ND	ND	ND	ND	ND	ND
U1-661*	128	< 5	< 5	< 5	47	< 5	< 5	37
U1-667*	< 500	< 500	< 500	4050	< 500	< 500	< 500	< 500
U1-1607	ND	ND	ND	ND	ND	< 1.0	ND	ND
U1-1632	ND	ND	ND	ND	ND	ND	ND	ND
U1-1633	ND	ND	ND	ND	ND	ND	ND	ND
U1-1634	ND	ND	ND	ND	ND	3.7	ND	ND
U1-1635	ND	ND	ND	< 1.0	ND	ND	ND	ND
U1-1636	ND	ND	ND	ND	ND	ND	ND	ND
U1-1637	ND	< 1.0	< 1.0	233	4.4	< 1.0	1.6	< 1.0
U1-1638	< 1.0	ND	< 1.0	244	2.6	ND	ND	ND
U1-1639	ND	ND	ND	10.2	ND	ND	ND	ND
U1-1640	ND	ND	ND	124	1.4	ND	ND	ND

TABLE 4.3 (Continued)
CHLORINATED ALIPHATIC HYDROCARBONS IN SURFACE WATER AND GROUNDWATER
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Sample Location	Carbon Tetrachloride (µg/L)	TCE[a/] (µg/L)	PCE[a/] (µg/L)	Chlorobenzene (µg/L)	1,3-DCB[a/] (µg/L)	1,4-DCB (µg/L)	1,2-DCB (µg/L)	Ethene (µg/L)
U1-159*	< 1	< 1	< 1	< 1 / 2	< 1	0.5 T	< 1	NA
U1-160	ND	3.1	1.3	ND	ND	ND	ND	ND
U1-162	ND	ND	ND	1410	25.4	157	62.5	247
U1-162*	< 50	< 50	< 50	1530	24.7 T	155	85	NA
U1-201*	< 50	< 50	< 50	41 T	< 50	33 T	340	NA
U1-202*	< 50	< 50	< 50	100	36 T	290	4550	NA
U1-203*	< 10	< 10	< 10	34	5 T	31	240	NA
U1-204*	< 10	20	< 10	77	21	81	160	NA
U1-205*	< 1	< 1	< 1	1	8	8	5	NA
U1-206*	< 1	< 1	< 1	2	< 1	4	2	NA
U1-207*	< 1	< 1	< 1	1	< 1	1	1	NA
U1-303*	< 1	< 1	< 1	< 1	< 1	0.8 T	0.4 T	NA
U1-304*	< 1	< 1	< 1	1	< 1	0.7 T	0.4 T	NA
U1-307*	< 10	< 10	< 10	< 10	< 10	< 10	< 10	NA
U1-647	ND	ND	ND	ND	ND	ND	ND	NA
U1-661*	< 5	< 5	< 5	< 5 / 80	< 5	12	39	NA
U1-667*	< 500	< 500	< 500	583	275 T	1925	28500	NA
U1-1607	ND	< 1.0	ND	ND	ND	ND	ND	ND
U1-1632	ND	ND	ND	ND	ND	ND	ND	ND
U1-1633	ND	ND	ND	ND	ND	ND	ND	ND
U1-1634	ND	ND	ND	ND	ND	ND	ND	ND
U1-1635	ND	ND	ND	ND	ND	ND	ND	ND
U1-1636	ND	ND	ND	ND	ND	ND	ND	ND
U1-1637	ND	3.1	ND	ND	ND	ND	ND	ND
U1-1638	ND	< 1.0	ND	ND	ND	ND	ND	ND
U1-1639	ND	ND	ND	ND	ND	ND	ND	ND
U1-1640	ND	< 1.0	ND	ND	ND	ND	ND	ND

[a/] VC = vinyl chloride, DCE = dichloroethene, DCA = dichloroethane, TCA = trichloroethane, TCE = trichloroethene, PCE = tetrachloroethene, DCB=dichlorobenzene.

[b/] µg/L = micrograms per liter.

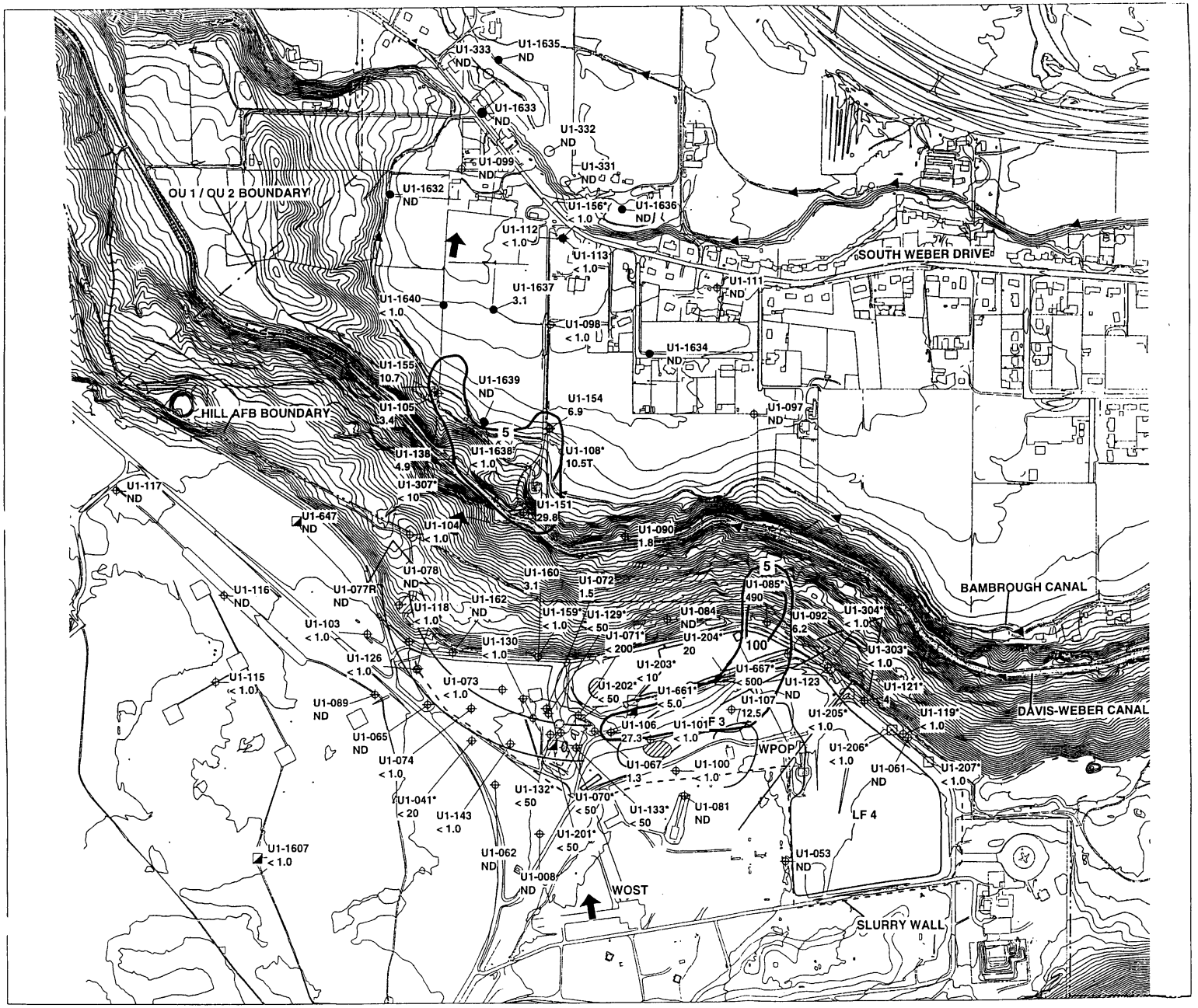
[c/] ND = not detected.

[d/] * Data from Montgomery Watson (1997), 13th sampling round.

[e/] NA = not available.

[f/] T qualifier equals detected concentratrion is below practical quantitation limit.

Notes: -Montgomery Watson data are average concentrations in cases where multiple results were reported for a single sample.
-Where two results are reported for a sample (eg. < 100 / 110) they represent the minimum/maximum concentrations reported by Mongomery Watson.



LEGEND

- U1-1637 ● MONITORING POINT
- U1-154 ⊕ MONITORING WELL
- U1-307 ~○ SEEP/SPRING
- U1-203 ⊡ DEWATERING WELL
- U1-661 ◪ PIEZOMETER
- U1-332 ○ SURFACE WATER SAMPLE LOCATION
- — 5 — INFERRED LINE OF EQUAL TCE CONCENTRATION (µg/L) CONTOUR INTERVAL = VARIABLE
- ND NOT DETECTED
- T DETECTED BELOW STANDARD REPORTING LIMIT
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- * DATUM COLLECTED BY MONTGOMERY WATSON DURING 13TH SAMPLING ROUND
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- EXTRACTION TRENCH
- WPOP WASTE PHENOL/OIL PIT
- WOST FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

0 300 600
Feet

N

FIGURE 4.4

TCE CONCENTRATIONS IN GROUNDWATER MARCH 1997

OU 1 RNA TS
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As shown on Figure 4.5, a northwest-trending, sand- and gravel-filled paleochannel incised in the silty clay layer underlying the on-Base portion of OU 1 appears to be a preferential migration pathway for the DCE plume. In addition, high-permeability landslide rubble/failure planes on the hillside downgradient from the CDPs and/or clay-tile field drains installed in the 1950s to aid in dewatering and stabilizing the hillside may have constituted preferential contaminant migration pathways between the terrace and the Weber River valley (Montgomery Watson, 1995b).

The configuration of the mobile LNAPL body and the distribution of the multiple source areas also are likely to have influenced the formation and migration of the 1,2-DCE plume, in that the locations of the sources control which preferential pathways are used during plume migration. The location of the LNAPL toward the western part of OU 1 may have allowed contaminants to more easily reach existing pathways in that area.

4.3.3 Vinyl Chloride

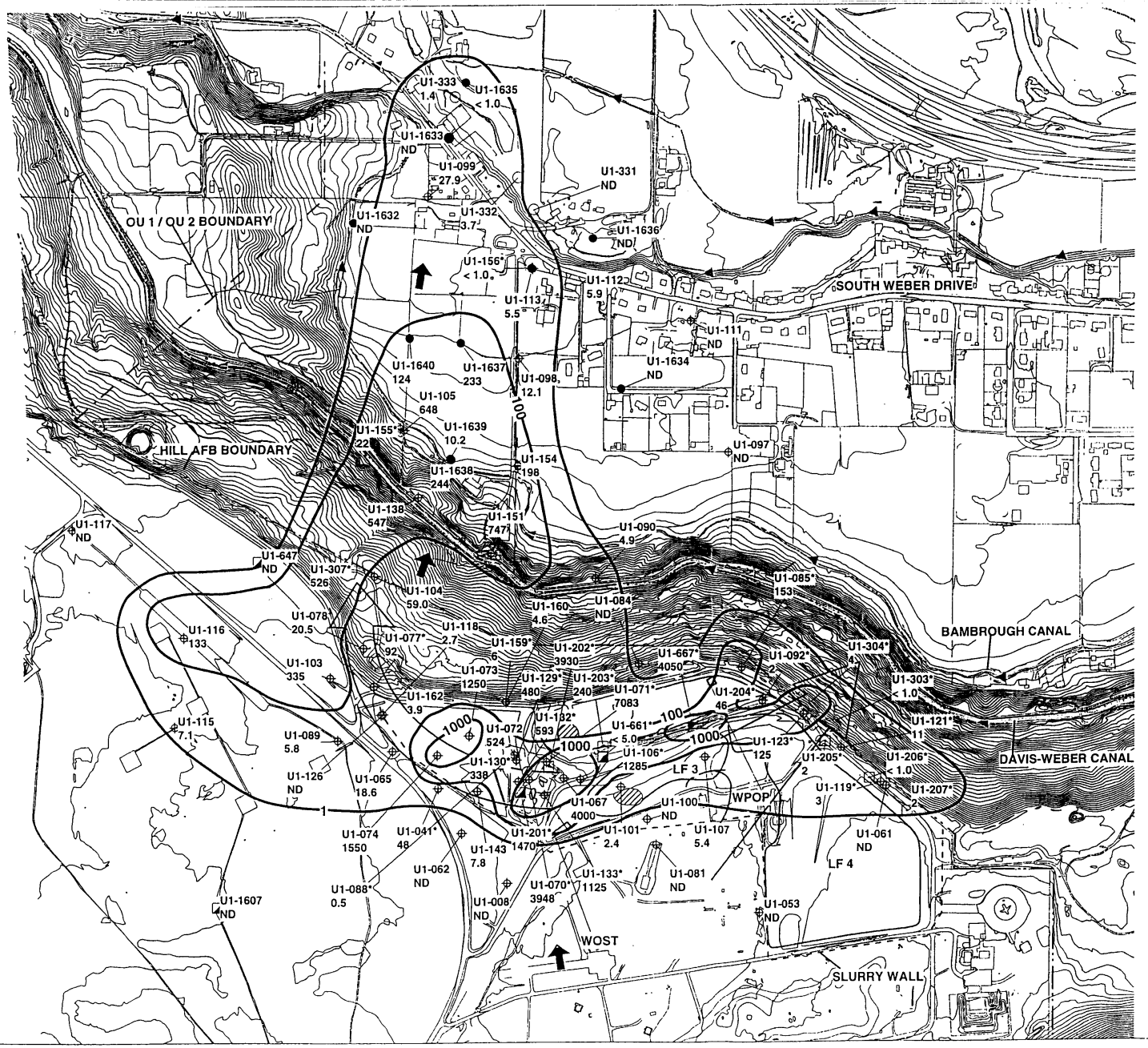
The distribution of VC in OU 1 groundwater is shown on Figure 4.6. VC concentrations detected at the site range from <1 to 469 µg/L (Table 4.3). The VC plume is present primarily beneath the on-Base portion of the study area, within, near, and immediately downgradient from the source areas. Trace concentrations appear to extend northward to the edge of the Weber River valley, but VC was not detected north of well U1-105 and monitoring point U1-1638. VC has not be detected in off-Base groundwater during other sampling events. As described above for DCE, available historical information indicates that VC has not been used at Hill AFB; therefore, its presence in groundwater indicates that it is a daughter product created during the reductive dehalogenation of DCE.

4.3.4 Ethene

Ethene is the final product in the series of reductive dehalogenation reactions involving chlorinated ethenes. Ethene was detected in site groundwater at concentrations ranging from <3 µg/L to 274 µg/L (Table 4.3). As shown on Figure 4.7, the area of ethene detections approximately coincides with the VC plume, and its presence implies that some of the VC dissolved in groundwater is undergoing reductive dehalogenation. As previously described, the rate of dehalogenation decreases as the number of chlorine atoms in the molecules decreases. Therefore, the reaction that produces ethene from VC is the slowest of the series of reductive dehalogenation reactions involving chlorinated ethenes, accounting for the low concentrations of ethene relative to VC and DCE.

4.3.5 Other CAHs

Other CAHs detected during the March 1997 sampling events (and the range of detected concentrations) include 1,1-DCA (43 wells <1.0 to 187 µg/L), 1,2-DCA (24 wells <1.0 to 166 µg/L), 1,1,1-TCA (18 wells <1.0 to 257 µg/L), chloroform (18 wells <1.0 to 5.3 µg/L), and carbon tetrachloride (2 wells <1.0 to 27.7 µg/L). Significant concentrations of these analytes (exceeding USEPA MCLs and/or Utah groundwater quality standards) were detected in at least one on-Base well; however, detected concentrations in the off-Base area did not exceed USEPA MCLs or Utah groundwater quality standards.



LEGEND

- U1-1637 ● MONITORING POINT
- U1-154 ⊕ MONITORING WELL
- U1-307 ~○ SEEP/SPRING
- U1-203 ⊡ DEWATERING WELL
- U1-661 ◪ PIEZOMETER
- U1-332 ○ SURFACE WATER SAMPLE LOCATION
- —100— INFERRED LINE OF EQUAL cis-1,2-DCE CONCENTRATION (µg/L) CONTOUR INTERVAL = VARIABLE
- ND NOT DETECTED
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- * DATUM COLLECTED BY MONTGOMERY WATSON DURING 13TH SAMPLING ROUND
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- EXTRACTION TRENCH
- WPOP WASTE PHENOL/OIL PIT
- WOST FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

0 300 600
Feet

N

FIGURE 4.5

cis-1,2-DCE CONCENTRATIONS IN GROUNDWATER MARCH 1997

OU 1 RNA TS
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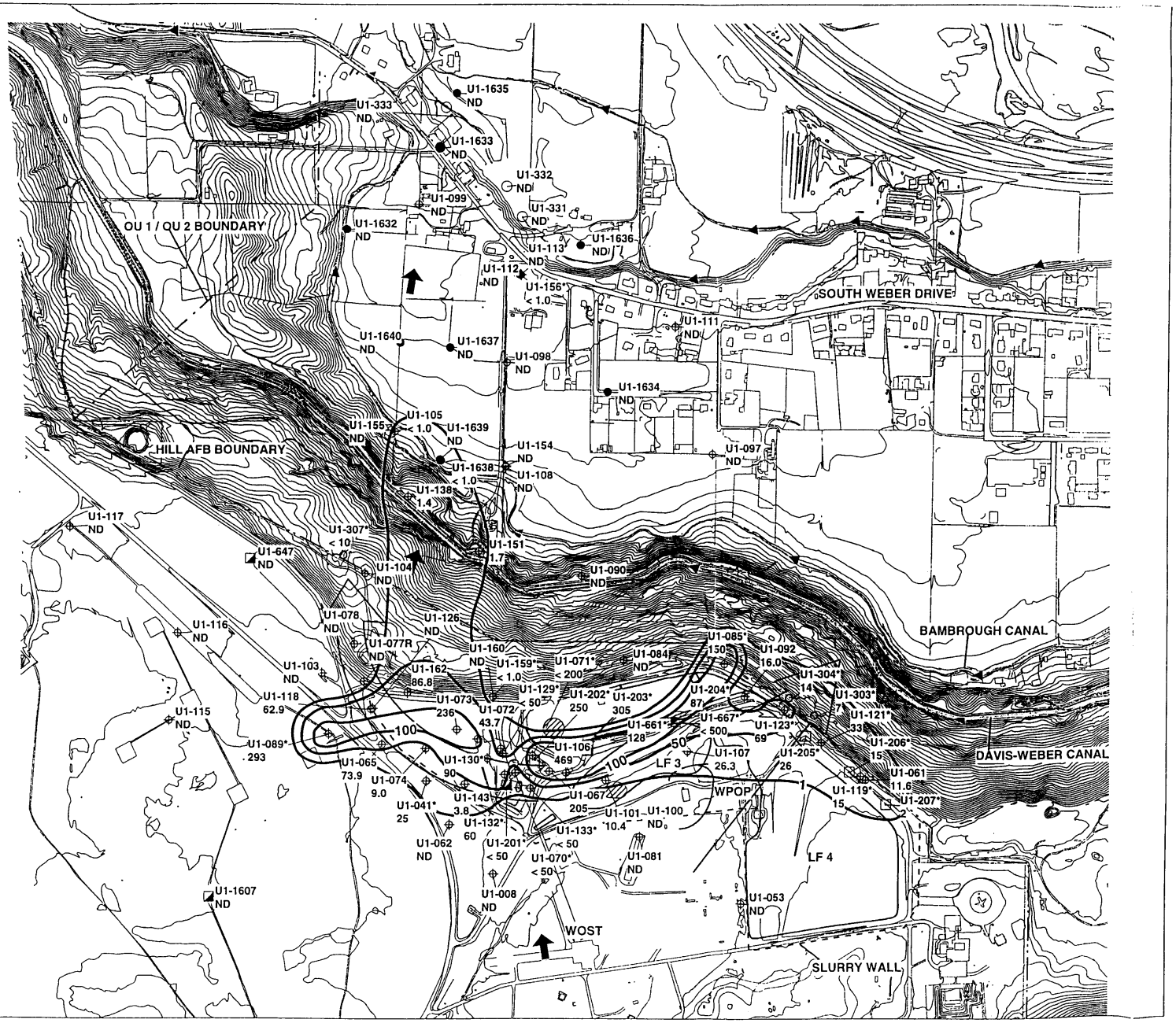
FILE NAME: I:\HILL\OU1\FIGURES\HILLCDCE.WOR DATE: 01/19/98 TIME: 1015



LEGEND

- U1-1637 ● MONITORING POINT
- U1-154 ⊕ MONITORING WELL
- U1-307 SEEP/SPRING
- U1-203 DEWATERING WELL
- U1-661 PIEZOMETER
- U1-332 ○ SURFACE WATER SAMPLE LOCATION
- — 1 — INFERRED LINE OF EQUAL VINYL CHLORIDE CONCENTRATION (µg/L) CONTOUR INTERVAL = VARIABLE
- ND NOT DETECTED
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- * DATUM COLLECTED BY MONTGOMERY WATSON DURING 13TH SAMPLING ROUND
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- EXTRACTION TRENCH
- WPOP WASTE PHENOL/OIL PIT
- WOST FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

FIGURE 4.6

VINYL CHLORIDE CONCENTRATIONS IN GROUNDWATER MARCH 1997

OU 1 RNA TS
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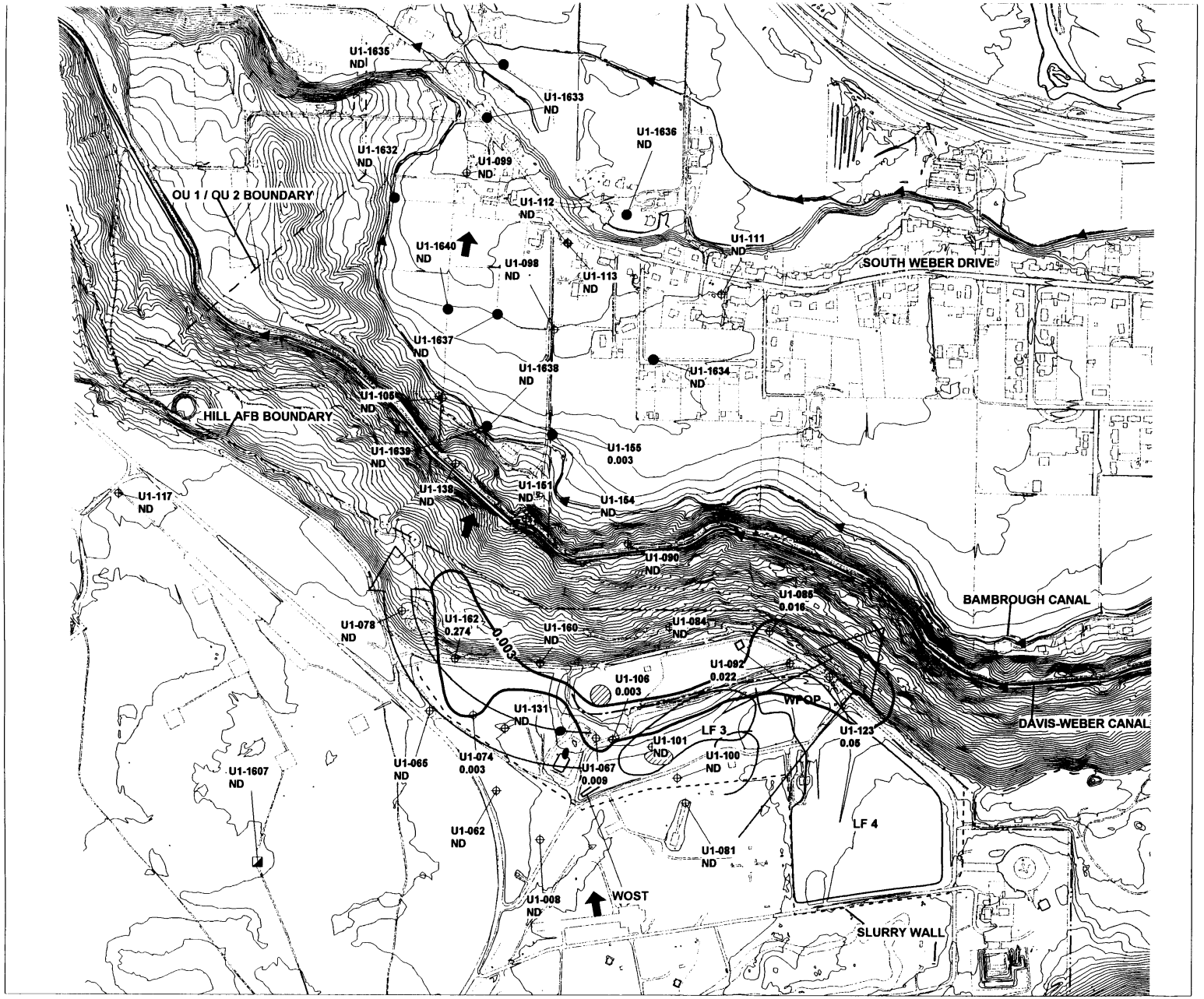
Denver, Colorado

FILE NAME: I:\HILL\OU1\FIGURES\HILLVC.WOR DATE: 01/21/98 TIME: 1055



LEGEND

- U1-1637 ● MONITORING POINT
- U1-154 ⊕ MONITORING WELL
- U1-1607 ◪ PIEZOMETER
- —0.003— INFERRED LINE OF EQUAL ETHENE CONCENTRATION (mg/L) CONTOUR INTERVAL = 0.003
- INFERRED GROUNDWATER FLOW DIRECTION
- ND NOT DETECTED
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- SURFACE DRAINAGE WITH FLOW DIRECTION
- EXTRACTION TRENCH
- WPOP WASTE PHENOL/OIL PIT
- WOST FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

Note: Concentrations reported in mg/L

0 300 600
Feet

N

FIGURE 4.7

ETHENE CONCENTRATIONS IN GROUNDWATER MARCH 1997

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

FILE NAME: L:\HILL\OU1\FIGURES\HILLETHE.WOR DATE: 01/30/98 TIME: 1140

Almost all of the samples that contained elevated concentrations of 1,1,1-TCA also contained 1,1-DCE. McCarty (1996) states that the presence of 1,1-DCE is common when TCA is present as a contaminant, and that abiotic (chemical) transformation (dehydrohalogenation, see Section 4.2.4) of TCA is probably the main source of 1,1-DCE contamination found in groundwater. Almost all of the samples that contained TCA also contained DCA, and the three highest 1,1-DCA concentrations coincided with similarly-elevated 1,1,1-TCA concentrations. These patterns suggest that TCA (which may either have been an impurity in the source TCE or was disposed of directly at OU 1) has undergone reductive dehalogenation to DCA. DCA is an intermediate product of the reductive dehalogenation of TCA, with CA and/or ethane the ultimate end products of this series of reactions (Bouwer, 1994).

Carbon tetrachloride was reportedly used at Hill AFB prior to the mid-1950s, and its presence in OU 1 groundwater probably results from disposal of this CAH at the site. Chloroform was detected in a sample of the distilled water used for sampling equipment decontamination; therefore, its detection in environmental samples at low concentrations may result, at least in part, from use of the distilled water. Alternatively, chloroform can be produced as an intermediate product during the aerobic biodegradation of TCE, and also is a daughter product resulting from the reductive dechlorination of carbon tetrachloride.

4.3.6 CAHs in Deep Wells

Monitoring wells sampled for the TS and the 13th-round event in March 1997 were primarily screened within the shallow portion of the surficial aquifer; historical data has indicated that deeper zones are either uncontaminated or contain only low levels of contamination due to the presence of silty clay underlying the shallow sand and gravel unit. Deeper on-Base wells screened in the silty clay unit that were sampled in March 1997 (and the screened interval in feet bgs) included U1-088 (63-73), U1-126 (42-47), U1-119 (43-48), U1-121 (42-47), and U1-159 (40-50). Deeper off-Base wells sampled (and the screened interval in feet bgs) included U1-156 (114-124), U1-113 (40-50), U1-155 (77-87), U1-1639 (40-40.5), and U1-138 (97-107). Detections of CAHs in these deep wells at concentrations in excess of MCLs and Utah groundwater quality standards were limited to VC in U1-121 (33 µg/L), TCE in U1-155 (10.7 µg/L), and *cis*-1,2-DCE in U1-138 (547 µg/L). These detections are consistent with historical sampling data. Wells U1-151 and U1-090, located on the hillside above the Weber River valley, are deep (screened intervals of 114-124 feet bgs and 109-119 feet bgs, respectively), but are screened at approximately the same elevation as shallow wells in the valley. Therefore, these wells are not discussed in this subsection.

4.3.7 CAHs in Surface Water

Periodic sampling of springs by Montgomery Watson during and following the RI has documented the discharge of CAH-contaminated groundwater to the surface on the hillside above the Weber River valley and adjacent to South Weber Drive. In general, CAHs are discharging to the surface in the area immediately north and northeast of LF 3, Pond 10, and the WPOP, and within the area of the dissolved 1,2-DCE plume extending north of the Base and into the Weber River valley. According to Montgomery Watson (1995b), the only VOC detected at concentrations greater than its MCL in three seeps/springs on the hillside downgradient from the CDPs was DCE. *cis*-1,2-DCE in U1-

306 (450-490 µg/L) and total 1,2-DCE in U1-307 (19-220 µg/L) exceeded the MCL of 70 µg/L for the *cis-* isomer. The only detection of CAHs in three surface water samples collected from the Davis-Weber Canal downgradient from the on-Base portion of OU 1 (U1-401, U1-402, and U1-403) was TCE at a concentration of 3.6J µg/L at U1-403. The locations of these seeps/springs and canal samples are shown on Figure 1.3.

In March 1997, three surface water samples were collected in the northwesterly-flowing surface drainage located immediately north of South Weber Drive to assess whether the CAH plume was discharging to surface water and the degree to which contaminants were being transported from the study area in surface water. The samples were designated U1-331, U1-332, and U1-333, and were collected along an 800-foot reach of the drainage within and adjacent to the toe of the 1,2-DCE plume (Figure 4.5). The surface water samples were analyzed for VOCs; analytical results are summarized in Table 4.3. As shown on Figure 4.5, *cis*-1,2-DCE was detected at a concentration of 3.7 µg/L in sample U1-332, and at 1.4 µg/L in sample U1-333, suggesting that some discharge of contaminated groundwater to the surface drainage was occurring. Other VOCs detected in one or more of the surface water samples included chloroform (<1.0 µg/L) and 1,2-DCB (1.4 µg/L).

4.4 RNA ANALYSIS

Available information indicates that the on-Base portion of the CAH plumes exhibit Type 1 behavior (see Section 4.3.4). The abundance of fuel hydrocarbons remaining in this area indicates that the electron donor supply is adequate to allow continued microbial reduction of CAHs. The role of competing electron acceptors (e.g., DO, nitrate, ferric iron, and sulfate) is described later in this subsection. The type 1 conditions are resulting in extensive degradation of the highly chlorinated solvents PCE and TCE; degradation of DCE and VC also is occurring, as evidenced by the presence of VC and ethene dissolved in groundwater in this area. As stated in Section 4.2.3, the rate of reductive dehalogenation decreases as the degree of chlorination decreases. Therefore, the dehalogenation of DCE to VC and of VC to ethene occurs at progressively slower rates, explaining the abundance of DCE and the relative scarcity of VC and ethene in site groundwater. DCE (particularly *cis*-1,2-DCE) is being produced from TCE and PCE faster than it can be dehalogenated to VC.

The off-Base portion of the CAH plume appears to exhibit primarily Type 3 behavior. There is little or no anaerobic reductive dehalogenation of TCE and DCE occurring; however, DCE is probably being aerobically degraded (oxidized). That VC is being rapidly oxidized as it migrates into the more aerobic off-Base environment is evidenced by the general lack of VC detections in the Weber River valley north of the Base.

4.4.1 Field-Scale Contaminant Mass Losses

One line of evidence that should be assessed to evaluate the occurrence of RNA of contaminants in groundwater at OU 1 is changes in dissolved concentrations of contaminants over time. As part of the RI, Montgomery Watson (1995b) used available historical VOC concentration data to evaluate long-term trends in groundwater contaminant concentrations through June 1994. The RI concluded that trends in VOC concentrations were inconclusive.

Available concentration-versus-time data for total 1,2-DCE in samples from 12 wells, obtained between May 1990 and March 1997, were examined to reassess whether or not long-term trends in total 1,2-DCE concentrations are apparent. Time-versus-concentration graphs were constructed and are presented in Appendix E. Table 4.4 summarizes the analysis results. As indicated by the concentration-versus-time analyses, the data suggest that concentrations at many wells are gradually decreasing over time. This is most likely due to RNA combined with the effects of source area remediation activities (Section 1.3). However, in many cases the data are insufficient to document decreasing 1,2-DCE concentrations with confidence. Concentrations of 1,2-DCE near the toe of the DCE plume are decreasing at well U1-112 and appear to be increasing at well U1-099. Therefore, an accurate assessment regarding the degree to which the plume is at equilibrium (neither expanding nor receding) cannot be made on the basis of the available data. However, given the indications of decreasing concentrations at several wells, it is possible that the plume is at or near equilibrium.

4.4.2 Presence of Daughter Products and CAH Ratios

As described in Section 4.3, the presence of daughter products that were not used in Base operations, particularly *cis*-1,2-DCE, VC, and ethene, is strong evidence that the parent solvents (TCE and/or PCE) are being reductively dehalogenated. However, the anaerobic dehalogenation process occurring in OU 1 groundwater is not sufficient to transform the bulk of the contaminant mass to non-chlorinated, non-toxic end products. If reductive dechlorination of DCE were occurring in the Weber River Valley, then the mass fraction of DCE would be expected to decrease relative to that of VC and ethene. As shown on Figure 4.8, the molar fraction of DCE does not decrease with distance from the on-Base source areas, and remains substantially elevated above the molar fractions of PCE, TCE, VC, and ethene. The rapid decrease in the molar fraction of VC with distance from the source area indicates that, beyond the source area, VC is used as an electron donor and is aerobically degraded. The geochemical conditions that are conducive to aerobic degradation of VC do not at the same time support anaerobic reductive dechlorination of DCE. DCE is most likely also aerobically degraded, but at a slower rate than VC.

Data from wells located along the approximate CAH plume axis from well U1-106, located between FTA 1 and the CDPs, to U1-1637 in the Weber River valley were used to assess the magnitude of the *cis*-1,2-DCE:*trans*-1,2-DCE ratio throughout the CAH plume. Because the *cis*- isomer is preferentially produced by microbial reductive dehalogenation, the ratio of *cis*-1,2-DCE to *trans*-1,2-DCE should be relatively high, especially in areas where the parent solvent(s) is being transformed. The reported concentrations of *trans*-1,2-DCE at off-Base wells U1-138, U1-105, and U1-1637 were reported as <1 µg/L; these concentrations were assumed to be 0.5 µg/L for calculation purposes. As shown on Figure 4.9, the magnitude of this ratio varies from 184 at well U1-073 to more than 1,000 at several wells, indicating that the *cis*- isomer predominates throughout the plume. This is a strong indication that TCE is being reductively dehalogenated, because much more *cis*-1,2-DCE is present relative to *trans*-1,2-DCE.

4.4.3 Chloride as an Indicator of Dehalogenation

Chlorine is removed from CAHs during reductive dehalogenation and enters solution. Therefore, chloride concentrations in groundwater should increase above background

TABLE 4.4
SUMMARY OF TRENDS IN 1,2-DCE CONCENTRATIONS OVER TIME
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Well	Location	Concentration Versus Time Trend Analysis
U1-085	Top edge of hillside, north of LFs 3 and 4	Erratic variation, no trend apparent
U1-092	Top edge of hillside, north of LFs 3 and 4	Erratic variation, but decreasing concentrations suggested
U1-072	Northern edge of mobile LNAPL plume, northwest of CDP-1	Decreasing concentrations suggested
U1-073	Northwest of CDP-1, north of mobile LNAPL plume	Decreasing concentrations possible, but insufficient data to assess with confidence
U1-065	West of CDPs at toe of mobile LNAPL plume	Decreasing concentrations possible, but insufficient data to assess with confidence
U1-103	West of CDPs and mobile LNAPL plume	Decreasing concentrations possible, but insufficient data to assess with confidence
U1-116	West of CDPs and mobile LNAPL plume, near western limit of 1,2-DCE plume	Decreasing concentrations possible, but insufficient data to assess with confidence
U1-104	On hillside at Base boundary	Decreasing concentrations indicated
U1-105	Base of hillside at south edge of Weber River valley	Erratic variation, no trend apparent
U1-108	Base of hillside at south edge of Weber River valley	Erratic variation, no trend apparent
U1-099	Near toe of plume	Increasing concentrations possible, but data are insufficient to assess with confidence
U1-112	Near toe of plume	Decreasing concentrations evidenced over time

FIGURE 4.8
MOLAR FRACTIONS OF CAHS ALONG PLUME FLOWPATH
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

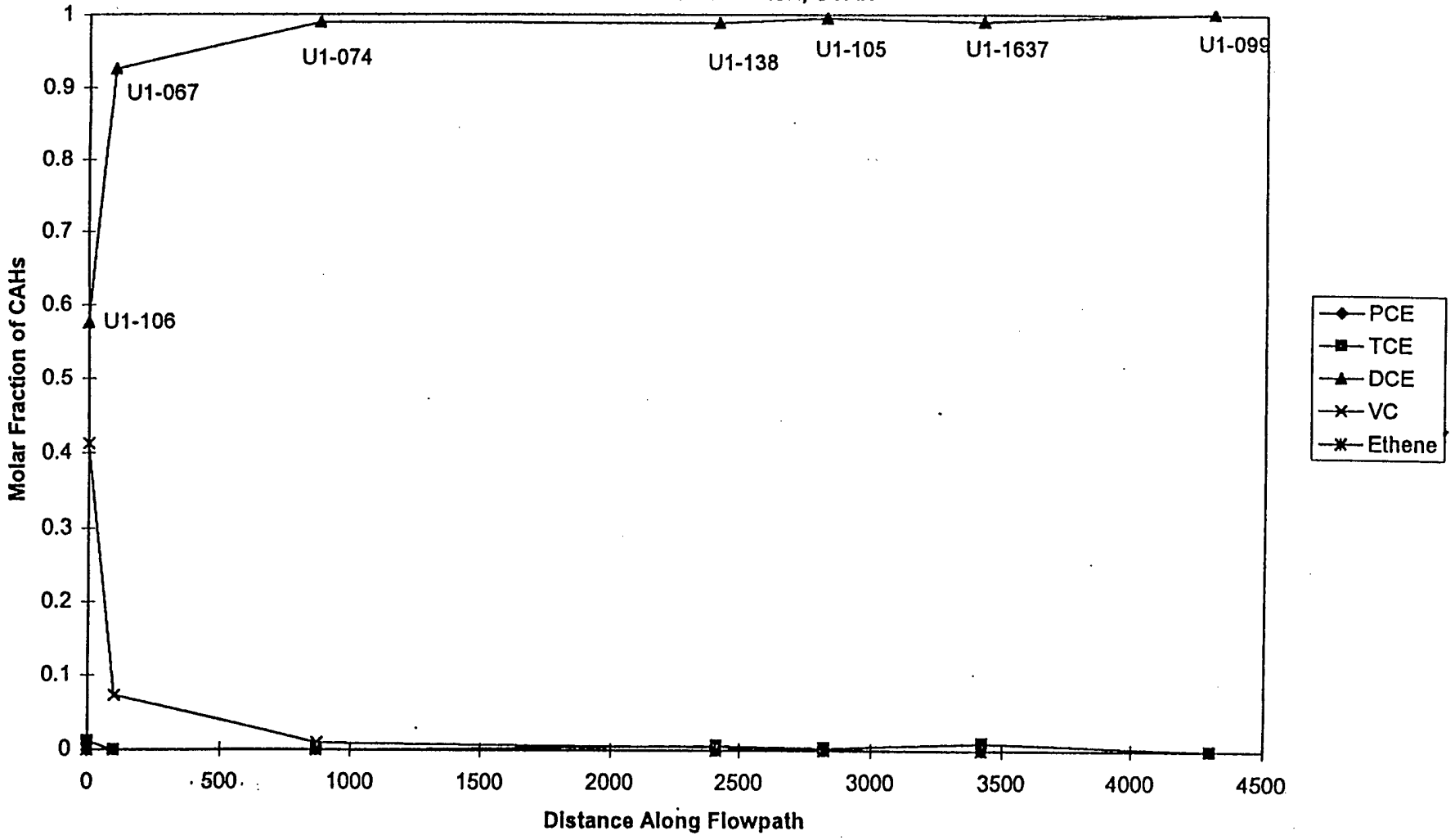
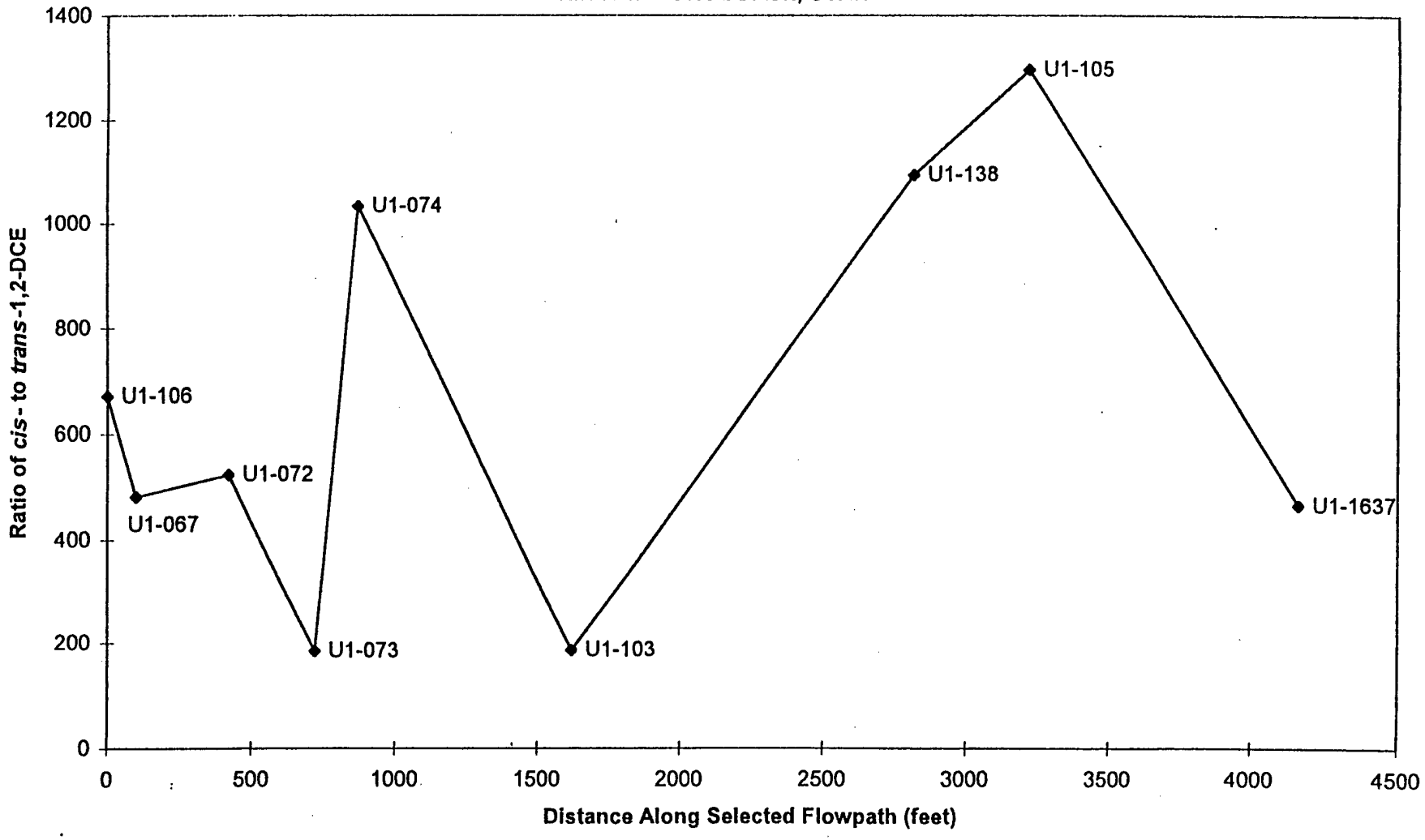


FIGURE 4.9
RATIO OF *cis* - TO *trans* -1,2-DCE ALONG CAH PLUME AXIS
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH



levels in areas where reductive dehalogenation is taking place. March 1997 chloride concentrations are presented in Table 4.5. Chloride concentrations were plotted on a site map; however, a definitive correlation between the presence of elevated dehalogenation daughter product concentrations and chloride concentrations in on-Base groundwater was not apparent. For example, chloride concentrations in three on-Base wells (U1-106, U1-072, and U1-073) that had elevated concentrations of dehalogenation daughter products (*cis*-1,2-DCE and/or vinyl chloride) ranged from 50.5 mg/L to 75.2 mg/L and averaged 59 mg/L. Background chloride concentrations in this area, as determined from upgradient wells U1-062, U1-008, U1-081, U1-100, and U1-1607, ranges from 47 mg/L to 86 mg/L and averages 57 mg/L.

Chloride concentrations in off-Base wells U1-138, U1-105, U1-1639, U1-1637, U1-1640, and U1-154, which had *cis*-1,2-DCE concentrations ranging from 124 µg/L to 648 µg/L, had chloride concentrations ranging from 40.5 mg/L to 51.6 mg/L and averaging 46.0. The background chloride concentrations in the Weber River valley, as determined from cross-gradient wells U1-1634, U1-097, U1-111, ranges from 27.7 mg/L to 43.2 mg/L and averages 34 mg/L. These data suggest that chloride concentrations in the off-Base plume area may be slightly elevated above background concentrations due to the occurrence of reductive dehalogenation upgradient from the Weber River valley.

4.4.4 ORP and Dissolved Hydrogen as Indicators of Redox Processes

As described in Section 4.2.1, microorganisms will facilitate only those redox reactions that will yield energy. For example, by coupling the oxidation of fuel hydrocarbon compounds (or native organic carbon), which requires energy, to the reduction of other compounds (e.g., oxygen, nitrate, manganese, ferric iron, sulfate, carbon dioxide, and possibly *cis*-1,2-DCE), which yields energy, the overall reaction will yield energy.

Figure 4.10 illustrates the sequence of microbially mediated redox processes and identifies the approximate ranges of ORPs that are favorable for each process. In general, reactions yielding more energy tend to take precedence over processes that yield less energy (Stumm and Morgan, 1981; Godsey, 1994; Reinhard, 1994). As Figure 4.10 shows, oxygen reduction would be expected to occur in an aerobic environment with microorganisms capable of aerobic respiration because oxygen reduction yields significant energy (Bouwer, 1992; Chapelle, 1993). However, once the available DO is depleted and anaerobic conditions dominate the interior regions of a contaminant plume, anaerobic microorganisms can utilize other electron acceptors in the following order of preference: nitrate (denitrification), manganese (manganese reduction), ferric iron (iron reduction), sulfate (sulfate reduction), and finally carbon dioxide (methanogenesis). Each successive redox reaction provides less energy to the system, and each step down in redox energy yield would have to be paralleled by an ecological succession of microorganisms capable of facilitating the pertinent redox reactions.

ORPs were measured at groundwater monitoring wells and points in March 1997. The ORP values measured during the 13th sampling round are significantly higher than the values measured during the TS sampling. For example, the ORP of groundwater from well U1-089, measured for this TS in March 1997, was -209 millivolts (mV); the value measured by Montgomery Watson in March 1997 was 70 mV. Because the two data sets are not consistent, only the TS ORP data were used.

BLE 4.5
GROUNDWATER GEOCHEMICAL DATA
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Sampling Location	Sampling Date	Temp (°C)[a]	pH (Std. units)	Conductivity (µs/cm)[b]	Dissolved Oxygen (mg/L)[c]	Redox Potential (mV)[d]	Total Alkalinity (mg/L)	Chloride (mg/L)	Ammonia (mg/L)	Ferrous Iron (mg/L)	Nitrate + Nitrite (as N) (mg/L)	Sulfate (mg/L)	Hydrogen Sulfide (mg/L)	Carbon Dioxide (mg/L)	TOC (mg/L)	Methane (mg/L)
U1-008	03/17/97	10.5	7.33	500	8.15	240	302	47.0	0.11	< 0.05	4.51	30.8	NA[e]	84	61.5	0.001
U1-041R*[e]	03/06/97	12.3	6.78	758[e]	1.18	183	NA	NA	NA	7.40	0.3	6.8	< 0.2	NA	38	NA
U1-053	03/24/97	11.4	7.81	NA	7.59	0	NA	NA	< 0.05	< 0.05	3.59	NA	NA	NA	NA	NA
U1-061	03/19/97	12.9	NA	1122	0.0	-200	500	52.1	1.10	10.5	< 0.05	109	< 0.1	580	8.13	NA
U1-062	03/17/97	12.4	8.50	440	1.17	-134	265	53.1	1.05	< 0.05	< 0.05	0.64	NA	58	3.63	0.329
U1-065	03/20/97	12.9	NA	1226	0.1	-190	570	69.4	0.78	8.7	< 0.05	< 0.1	< 0.1	NA	16.1	10.361
U1-065*	03/10/97	13.0	6.73	1164	0.19	98	NA	NA	NA	14.5	< 0.1	4.7	0.2	NA	31	NA
U1-067	03/24/97	NA	NA	NA	NA	NA	505	NA	1.78	11.0	< 0.05	NA	NA	NA	106	1.246
U1-070*	03/20/97	11.4	6.76	802[b]	0.48	93	NA	NA	NA	19.1	< 0.1	1.6	< 0.2	NA	34	NA
U1-071*	03/20/97	13.1	6.72	1028[b]	0.47	118	NA	NA	NA	19.7	0.1	2.8	0.20	NA	91	NA
U1-072	03/19/97	13.4	6.90	950	3.5	-148	525	51.4	2.61	34.8	< 0.05	< 0.1	< 0.1	NA	136	NA
U1-073	03/19/97	14.7	6.74	1200	3.95	-136	625	75.2	3.28	26.4	< 0.05	< 0.1	< 0.1	NA	122	NA
U1-074	03/20/97	11.7	7.09	950	4.87	-162	600	67.5	3.68	8.7	< 0.05	< 0.1	< 0.1	NA	122	0.689
U1-077R	03/18/97	13.5	NA	901	6.6	142	371	51.0	< 0.05	< 0.05	5.29	26.2	NA	140	6.95	NA
U1-077R*	03/06/97	12.2	7.38	765	7.4	308	NA	NA	NA	0.019	6.2	26.6	< 0.2	NA	8	NA
U1-078	03/17/97	12.6	NA	790	2.5	5	311	51.1	< 0.05	< 0.05	2.32	13.1	NA	150	10.2	ND
U1-081	03/14/97	11.1	7.30	1025	3.3	262	273	51.9	< 0.05	< 0.05	19.4	127	NA	172	5.15	ND
U1-084	03/17/97	9.6	7.40	1012	0.2	5	444	72.9	4.35	< 0.05	0.66	17.8	NA	252	3.49	0.212
U1-085	03/14/97	9.4	7.20	1442	1.8	75	564	94.9	< 0.05	0.6	< 0.05	78.7	NA	180	6.82	0.336
U1-085*	03/17/97	11.0	7.22	1071	2.16	214	NA	NA	NA	0.1	< 0.1	77.9	< 0.2	NA	10	NA
U1-088*	03/06/97	12.8	7.84	527	0.2	57	NA	NA	NA	1	< 0.1	<0.2/0.6	< 0.2	NA	7	NA
U1-089	03/18/97	13.4	NA	1114	0.1	-209	371	67.2	1.21	14.0	< 0.05	< 0.1	< 0.1	460	24.8	NA
U1-089*	03/17/97	12.5	6.87	914	0.17	70	NA	NA	NA	17.5	< 0.1	0.3	< 0.2	NA	21	NA
U1-090	03/20/97	12.0	NA	792	5.3	89	290	52.2	< 0.05	< 0.05	0.51	47.3	NA	96	3.46	ND
U1-092	03/22/97	9.2	NA	1203	2.5	25	560	51.7	< 0.05	0.1	0.79	38.5	NA	280	8.37	1.513
U1-092*	03/12/97	9.2	7.25	899	1.81	228	NA	NA	NA	0.46	0.9	38	< 0.2	NA	12	NA
U1-097	03/15/97	7.9	NA	577	5.0	318	224	27.7	< 0.05	< 0.05	1.40	28.9	NA	110	NA	NA
U1-098	03/17/97	5.8	7.10	825	1.6	263	340	41.1	< 0.05	< 0.05	2.89	34.5	NA	90	2.98	0.001
U1-099	03/15/97	6.1	7.46	640	0.5	18	345	43.7	0.66	< 0.05	5.47	49.4	NA	210	5.68	< 0.001
U1-100	03/14/97	12.4	NA	1003	2.5	260	327	46.9	< 0.05	< 0.05	12.5	82.7	NA	120	6.91	ND[b]
U1-101	03/22/97	NA	NA	NA	NA	NA	825	59.2	9.86	10.5	< 0.05	6.58	NA	NA	75.5	6.173
U1-101*	03/20/97	15.0	6.91	1404	1.66	119	NA	NA	NA	8.6	0.2	10.6	0.6	NA	87	NA
U1-103	03/18/97	13.7	7.01	950	6.6	200	397	129	< 0.05	< 0.05	7.65	31.1	NA	140	2.62	NA
U1-104	03/19/97	12.5	7.36	700	4.27	17	405	58.8	< 0.05	0.4	1.65	37.5	< 0.1	150	4.58	NA
U1-105	03/20/97	11.6	NA	904	NA	NA	NA	48.8	< 0.05	NA	0.45	43.1	NA	NA	2.89	0.001

TABLE 4.5 (Continued)
GROUNDWATER GEOCHEMICAL DATA
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

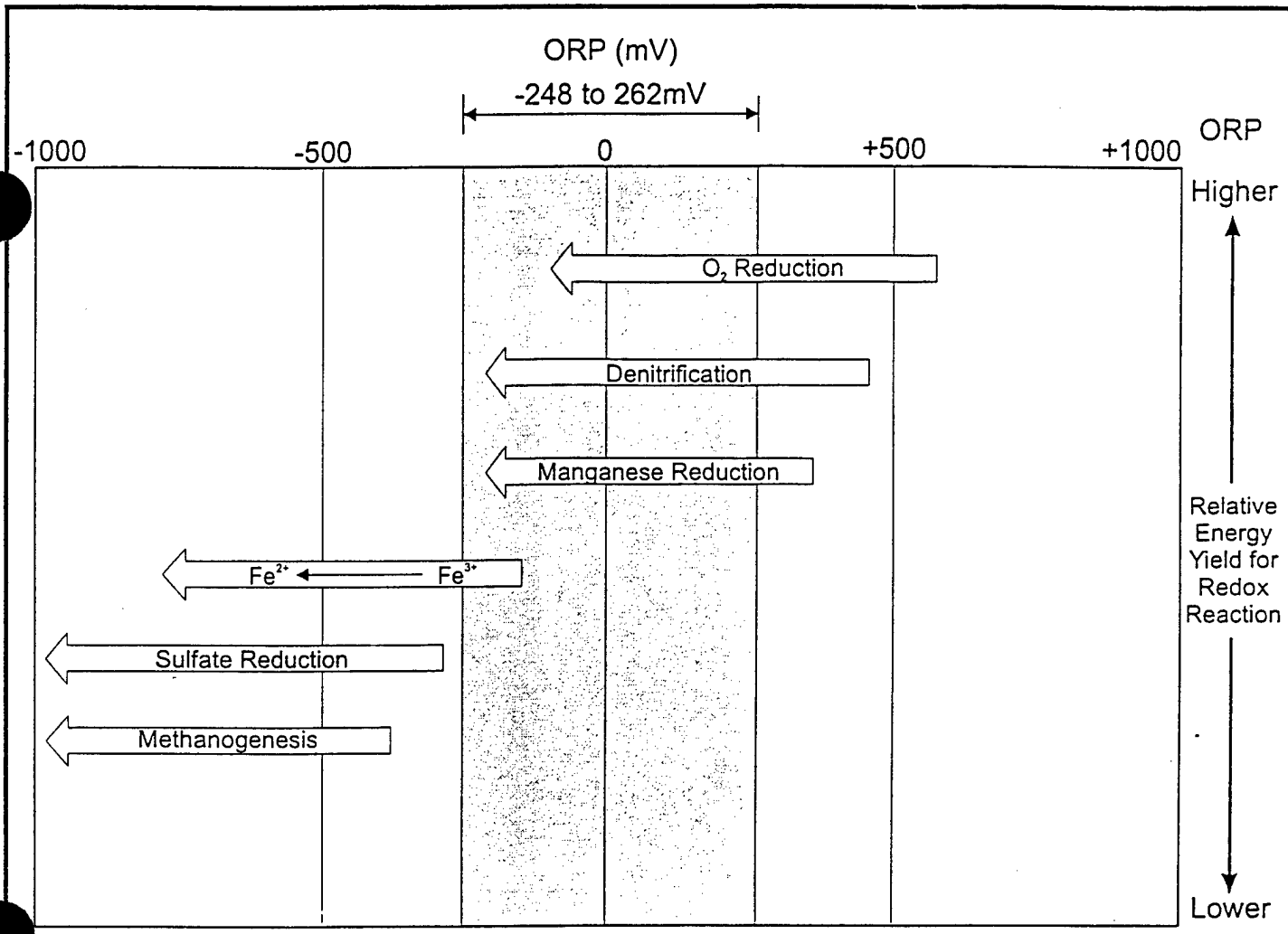
Sampling Location	Sampling Date	Temp (°C)[a]	pH (Std. units)	Conductivity (µs/cm)[b]	Dissolved Oxygen (mg/L)[c]	Redox Potential (mV)[d]	Total Alkalinity (mg/L)	Chloride (mg/L)	Ammonia (mg/L)	Ferrous Iron (mg/L)	Nitrate + Nitrite (as N) (mg/L)	Sulfate (mg/L)	Hydrogen Sulfide (mg/L)	Carbon Dioxide (mg/L)	TOC (mg/L)	Methane (mg/L)
U1-105*	03/05/97	10.7	7.33	696	5.76	283	NA	NA	NA	0.03	0.6	38.6	< 0.2	NA	5	NA
U1-106	03/22/97	11.4	NA	1085	0.0	35	406	50.5	0.59	< 0.05	0.48	51.2	NA	120	7.26	0.193
U1-106*	03/12/97	12.0	7.26	803	0.54	299	NA	NA	NA	< 0.05	0.2	23.4	< 0.2	NA	9	NA
U1-107	03/19/97	13.9	NA	1803	0.1	83	675	107	3.36	1.8	1.89	176	< 0.1	400	9.18	NA
U1-108	03/17/97	9.5	7.20	837	5.1	293	349	46.2	< 0.05	< 0.05	0.95	38.8	NA	124	3.1	< 0.001
U1-108*	03/05/97	9.8	7.33	629	6.9	303	NA	NA	NA	< 0.05	1.3	34.1	< 0.2	NA	4	NA
U1-111	03/15/97	8.8	6.87	490	1.33	184	226	43.2	< 0.05	< 0.05	4.35	42.9	NA	92	1.73	ND
U1-112	03/17/97	6.1	7.20	912	0.2	207	353	44.4	0.12	< 0.05	2.95	42.9	NA	132	6.32	0.003
U1-113	03/20/97	12.4	NA	869	0.7	109	345	55.6	0.30	< 0.05	0.75	40.8	NA	204	2.74	0.016
U1-115	03/18/97	11.7	7.12	650	10.66	28	304	66.3	< 0.05	< 0.05	5.13	37.5	NA	94	6.7	NA
U1-116	03/19/97	13.5	NA	1474	5.3	-74	460	135	< 0.05	0.3	20.8	41.1	NA	150	3.34	NA
U1-117	03/17/97	12.2	7.22	3000	0.80	59	610	931	< 0.05	< 0.05	2.87	266	NA	350	5.59	ND
U1-118	03/19/97	13.5	7.31	750	8.19	-34	445	75.2	1.42	2.3	1.55	23.0	< 0.1	210	27.8	NA
U1-119*	03/12/97	12.5	7.05	1014[h]	0.7	135	NA	NA	NA	8.7	ND	31.5	< 0.2	NA	8	NA
U1-121*	03/10/97	12.9	6.89	1064[h]	0.23	181	NA	NA	NA	0.35	ND	34.4	< 0.2	NA	9	NA
U1-123	03/21/97	11.5	6.75	1581	0.29	35	626	152	0.31	3.0	< 0.05	21.4	0.1	280	6.84	3.595
U1-123*	03/12/97	12.0	7.19	1276	0.12	117	NA	NA	NA	3.35	< 0.1	20.8	< 0.2	NA	7.7	NA
U1-126	03/18/97	13.1	7.55	450	2.16	-120	232	35.5	1.50	0.7	0.10	18.3	< 0.1	120	3.16	NA
U1-129*	03/19/97	12.8	6.87	948[h]	1.03	111	NA	NA	NA	43.98	0.1	7.6	0.40	NA	96	NA
U1-130*	03/19/97	12.4	7.10	824[h]	0.94	153	NA	NA	NA	27.9	ND	0.7	0.20	NA	79	NA
U1-132*	03/24/97	11.8	7.14	783[h]	0.94	141	NA	NA	NA	16.5	ND	0.4	< 0.2	NA	55	NA
U1-133*	03/24/97	11.4	7.04	766[h]	0.67	116	NA	NA	NA	14.98	ND	2.3	< 0.2	NA	71	NA
U1-138	03/21/97	11.4	NA	918	0.5	93	392	51.6	< 0.05	< 0.05	0.15	57.0	NA	110	1.94	0.01
U1-143	03/18/97	13.5	7.15	700	3.32	-240	470	38.5	0.49	6.0	0.06	3.64	NA	380	15.7	NA
U1-151	03/20/97	17.6	7.55	650	2.26	-170	310	48.8	0.06	1.4	0.16	46.5	< 0.1	144	3	0.007
U1-154	03/15/97	10.9	NA	835	5.0	169	355	40.5	< 0.05	< 0.05	1.32	38.5	NA	150	4.06	ND
U1-155	03/15/97	18.5	7.67	790	3.19	-2	450	58.6	2.68	< 0.05	0.10	11.4	NA	122	3.17	0.171
U1-155*	03/05/97	9.9	7.78	750	2.42	103	NA	NA	NA	0.749	< 0.1	13.5	< 0.2	NA	7	NA
U1-156*	03/04/97	10.2	8.35	364[h]	0.7	42	NA	NA	NA	0.14	< 0.1	0.2	< 0.2	NA	6	NA
U1-159*	03/17/97	11.7	7.71	819[h]	4.12	247	NA	NA	NA	< 0.05	0.4	44.2	< 0.2	NA	< 1 / 3	NA
U1-160	03/22/97	16.7	7.78	800	1.5	-20	190	159	0.19	0.5	0.57	44.1	NA	180	2.09	0.002
U1-162	03/20/97	12.8	NA	1150	0.0	-147	472	NA	2.01	8.8	0.07	NA	< 0.1	NA	24.4	3.325
U1-162*	03/18/97	12.3	7.06	932	0.21	105	NA	NA	NA	18.78	< 0.1	14.3	< 0.2	NA	30	NA
U1-201*	03/19/97	14.2	7.40	938[h]	0.73	95	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
U1-202*	03/18/97	12.9	6.90	940[h]	0.79	111	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
U1-203*	03/13/97	8.2	7.22	865[h]	1.61	140	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 4.5 (Concluded)
GROUNDWATER GEOCHEMICAL DATA
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Sampling Location	Sampling Date	Temp (°C)[a]	pH (Std. units)	Conductivity (µs/cm)[b]	Dissolved Oxygen (mg/L)[c]	Redox Potential (mV)[d]	Total Alkalinity (mg/L)	Chloride (mg/L)	Ammonia (mg/L)	Ferrous Iron (mg/L)	Nitrate + Nitrite (as N) (mg/L)	Sulfate (mg/L)	Hydrogen Sulfide (mg/L)	Carbon Dioxide (mg/L)	TOC (mg/L)	Methane (mg/L)
U1-204*	03/05/97	8.6	7.01	1175[h]	1.93	168	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
U1-205*	03/13/97	11.0	6.71	1092[h]	1.04	162	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
U1-206*	03/13/97	11.6	6.79	980[h]	1.67	189	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
U1-207*	03/13/97	12.2	7.09	828[h]	0.97	163	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
U1-303*	03/12/97	6.6	7.68	1035[h]	2.16	173	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
U1-304*	03/13/97	7.4	4.47	1008[h]	3.09	387	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
U1-307*	03/10/97	8.4	7.42	808[h]	4.48	361	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
U1-647	03/19/97	11.3	7.63	700	6.35	139	371	53.9	< 0.05	< 0.05	3.38	74.8	NA	92	2.61	NA
U1-661*	03/18/97	11.4	7.13	1006[h]	0.92	102	NA	NA	NA	15.05	ND	19.6	< 0.2	NA	10	NA
U1-667*	03/18/97	13.2	7.32	1810[h]	1.14	164	NA	NA	NA	3.16	ND	70.7	0.4	NA	206	NA
U1-1607	03/17/97	11.8	7.73	700	8.34	117	360	86.0	< 0.05	< 0.05	2.53	43.3	NA	220	1.77	0.066
U1-1632	03/22/97	10.0	7.59	600	1.9	-19	317	42.4	< 0.05	< 0.05	0.71	36.4	NA	204	1.04	ND
U1-1633	03/21/97	NA	NA	NA	NA	NA	NA	108	1.37	NA	0.10	15.8	NA	NA	6.46	0.005
U1-1634	03/21/97	7.4	7.72	350	9.62	58	197	31.0	< 0.05	< 0.05	1.15	31.6	NA	56	0.753	ND
U1-1635	03/21/97	8.2	7.43	800	0.1	14	400	80.1	< 0.05	1.8	< 0.05	83.3	< 0.1	100	5.82	0.011
U1-1636	03/21/97	7.0	7.25	370	6.41	-19	525	88.3	0.85	8.9	< 0.05	4.38	< 0.1	500	8.22	1.194
U1-1637	03/21/97	7.7	7.69	600	6.0	12	301	46.9	< 0.05	< 0.05	13.2	45.6	NA	140	3.56	0.002
U1-1638	03/22/97	10.7	7.76	500	4.8	-19	312	39.4	< 0.05	< 0.05	0.37	36.0	NA	158	1.22	0.001
U1-1639	03/22/97	9.8	7.91	500	0.1	-19	325	45.1	1.52	2.5	0.09	43.5	NA	162	1.41	0.003
U1-1640	03/21/97	9.8	7.79	550	4.5	-19	302	43.0	< 0.05	< 0.05	0.66	38.7	NA	184	1.31	ND

[a] °C = degrees Centigrade.
[b] µs/cm = microsiemens per centimeter.
[c] mg/L = milligrams per liter.
[d] mV = millivolts.
[e] NA = not available.
[f] * Data from Montgomery Watson (13th sampling round).
[g] value reported in microohms per centimeter
[h] ND = not detected.

Notes: -Montgomery Watson data are average concentrations in cases where multiple results were reported for a single sample.
-Where 2 results are reported for a sample (eg. < 100 / 110) they represent the minimum / maximum concentrations reported by Mongomery Watson.



Notes

ORP = Oxidation Reduction Potential

Range of ORP measured at OU1

1. These reactions would be expected to occur in sequence if the system is moving toward equilibrium.

2. These redox processes occur in order of their energy-yielding potential (provided microorganisms are available to mediate a specific reaction). Reduction of a highly oxidized species decreases the ORP of the system.

3. The ORP of the system determines which electron acceptors are available for organic carbon oxidation.

4. Redox reaction sequence is paralleled by an ecological succession of biological mediators.

Adapted from Stumm and Morgan, 1981.

FIGURE 4.10

SEQUENCE OF MICROBIALLY MEDIATED REDOX PROCESSES

OU1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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The range of ORPs measured in OU 1 groundwater (-248 mV to 262 mV) suggests that sulfate reduction and methanogenesis are not operative terminal electron-accepting processes (TEAPs) in the OU. This observation is contradicted, however, by the apparent depletion of sulfate in a portion of the study area (Section 4.4.6.4) and the presence of methane (Section 4.4.6.5). Many authors have noted that field ORP data alone cannot be used to reliably predict the electron acceptors that may be operating at a site, because the platinum electrode probes are not sensitive to some redox couples (e.g., sulfate/sulfide) (Stumm and Morgan, 1981; Godsey, 1994; Lovley *et al.*, 1994).

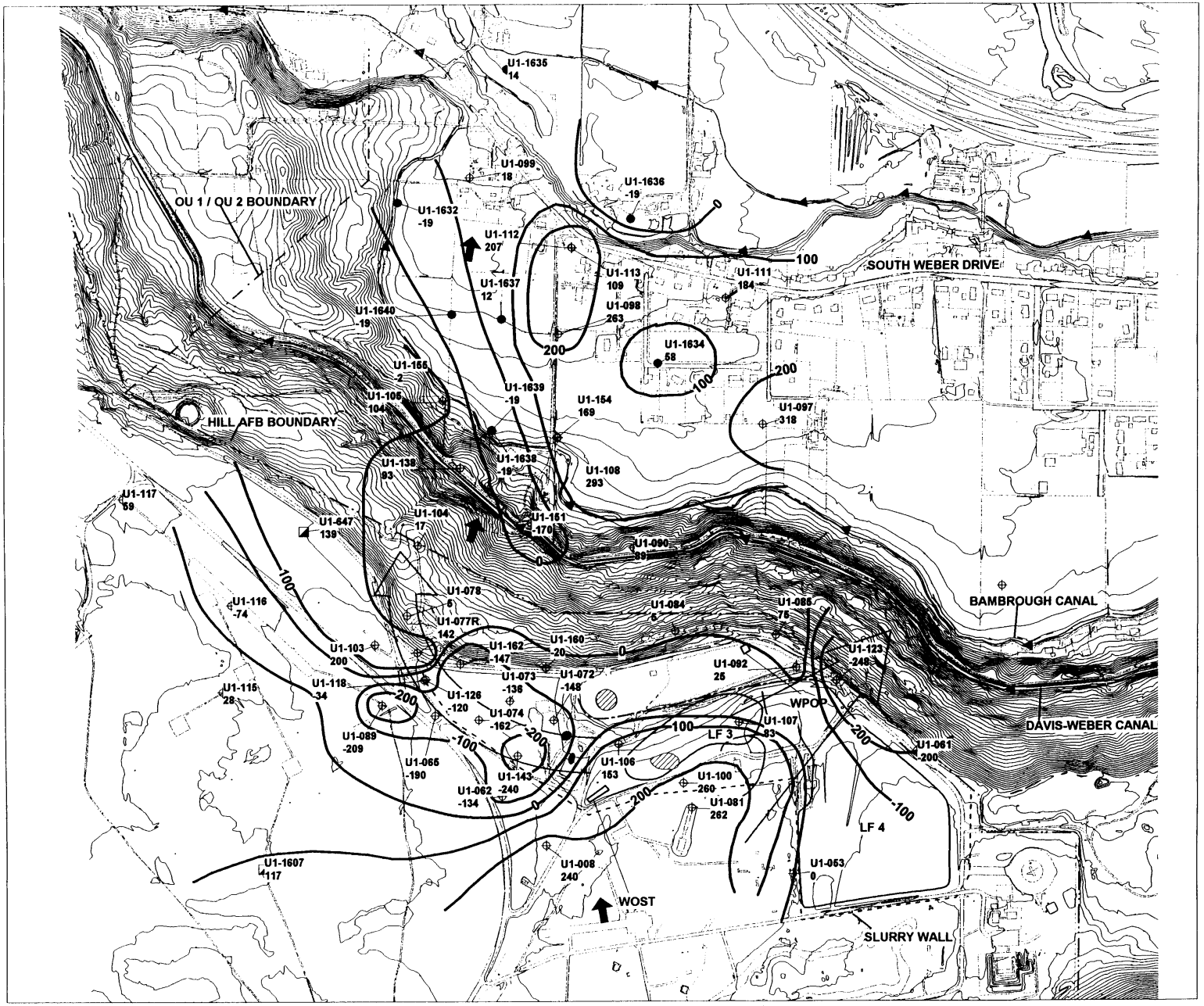
Table 4.5 summarizes available ORP data collected for the TS, and the areal distribution of ORPs is illustrated on Figure 4.11. As expected, areas at the site with low ORPs appear to coincide with areas of elevated BTEX and total fuel carbon contamination; decreased DO, nitrate, and sulfate; and elevated ferrous iron and methane concentrations. Also as expected, these areas coincide with areas where there is evidence of significant, ongoing reductive dehalogenation. Relatively low ORPs (<200 mV) also were measured in groundwater from wells U1-061 and U1-123, located immediately east and north of LF 4, respectively. Relatively high ORPs (>200 mV) were measured upgradient (south) from the on-Base source areas. Most ORPs measured in the Weber River valley were greater than zero, with the exception of negative ORPs measured in wells U1-1632, U1-1640, U1-1636, and U1-1639.

Dissolved hydrogen (H_2) concentrations also can be used to determine the dominant terminal electron-accepting process (TEAP) in an aquifer. This method has been shown to provide a direct, independent measurement that identifies which redox reactions are taking place in anaerobic groundwater (Lovley and Goodwin, 1988; Lovley *et al.*, 1994; Vroblesky and Chapelle, 1994; Chapelle *et al.*, 1995). The efficiency of reductive dehalogenation increases as a system becomes more reducing (i.e., proceeds from denitifying conditions to ferric-iron-reducing, sulfate-reducing, and methanogenic conditions). Therefore, it is helpful to be able to define redox conditions more accurately than can be determined using field redox meters when evaluating the potential for natural attenuation of CAHs in groundwater. When dissolved H_2 concentrations are measured using the methods presented by the aforementioned authors, the concentrations directly indicate which TEAP is dominant in a given location at a given time, as outlined in Table 4.6.

Groundwater samples for analysis of dissolved H_2 were collected from four wells at OU 1 in March 1997. These results are summarized in Table 4.7. Measured H_2 concentrations range from 0.47 nanomoles per liter (nM/L) to 1.40 nM/L. Wells U1-108, U1-111, and U1-154 are located in the Weber River Valley; the magnitudes of the detected H_2 concentrations indicate that iron reduction or sulfate reduction were the dominant TEAPs at the time of sample collection. Well U1-085 is located at the edge of the escarpment north of LF 4. The H_2 concentration detected in groundwater from this well also suggests the predominance of iron reduction. Vroblesky and Chapelle (1994) state that TEAPs can vary both spatially and temporally, with shifts taking place in as little as 10 days.

4.4.5 Electron Donors

When investigating the biodegradation of CAHs, it is also necessary to look at the distribution of other compounds that are used in the microbially mediated reactions that



LEGEND

- U1-1637 ● MONITORING POINT
- U1-154 ⊕ MONITORING WELL
- —100— INFERRED LINE OF EQUAL ORP (mV) CONTOUR INTERVAL = 100mV
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- EXTRACTION TRENCH
- WPOP WASTE PHENOL/OIL PIT
- WOST FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

0 300 600
Feet

N

FIGURE 4.11

OXIDATION-REDUCTION POTENTIAL OF GROUNDWATER MARCH 1997

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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TABLE 4.6
RANGE OF HYDROGEN CONCENTRATIONS FOR GIVEN TERMINAL ELECTRON-ACCEPTING PROCESSES
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Terminal Electron-Accepting Process	Hydrogen Concentration (nM)
Denitrification	<0.1
Iron (III) Reduction	0.2 to 0.8
Sulfate Reduction	1 to 4
Methanogenesis	>5

Source: Chapelle *et al.*, 1995.

TABLE 4.7
DISSOLVED HYDROGEN CONCENTRATIONS IN GROUNDWATER MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Well	Hydrogen Concentration (nM/L)
U1-085	0.68
U1-108	0.47
U1-111	1.40
U1-154	0.78

facilitate CAH degradation. The distributions of potential electron donors, including BTEX compounds, dissolved native organic carbon, and CAHs themselves, are useful for evaluating the feasibility of reductive dehalogenation, aerobic biodegradation, or cometabolism (i.e., CAH degradation reactions involving another substrate).

4.4.5.1 BTEX and Total Fuel Carbon in Groundwater

BTEX compounds and petroleum hydrocarbons in general are typically considered solely as contaminants. However, for the purposes of this discussion, these analytes are viewed differently because the focus of this work is on natural attenuation of the CAHs. The presence of BTEX and fuel carbon in the same area as the CAH plume creates favorable conditions for reductive dehalogenation, because the petroleum compounds

provide a source of electron donors and facilitate microbial reactions that drive down the local groundwater ORP. It is likely that the introduction of petroleum hydrocarbons due to fire training and other waste disposal activities stimulated additional microbial activity and made the groundwater system reducing enough to allow reductive dehalogenation of CAHs. Given these conditions, the presence of BTEX and fuel carbon in site groundwater is considered to be a favorable factor in the biodegradation of CAHs. In addition, BTEX and fuel carbon concentrations are much lower than CAH concentrations, and the extent and concentrations of the BTEX/fuel carbon plumes are such that detectable concentrations of these compounds do not appear to have migrated off-Base (except for detections of 1 µg/L BTEX and 30 µg/L fuel carbon at well U1-155).

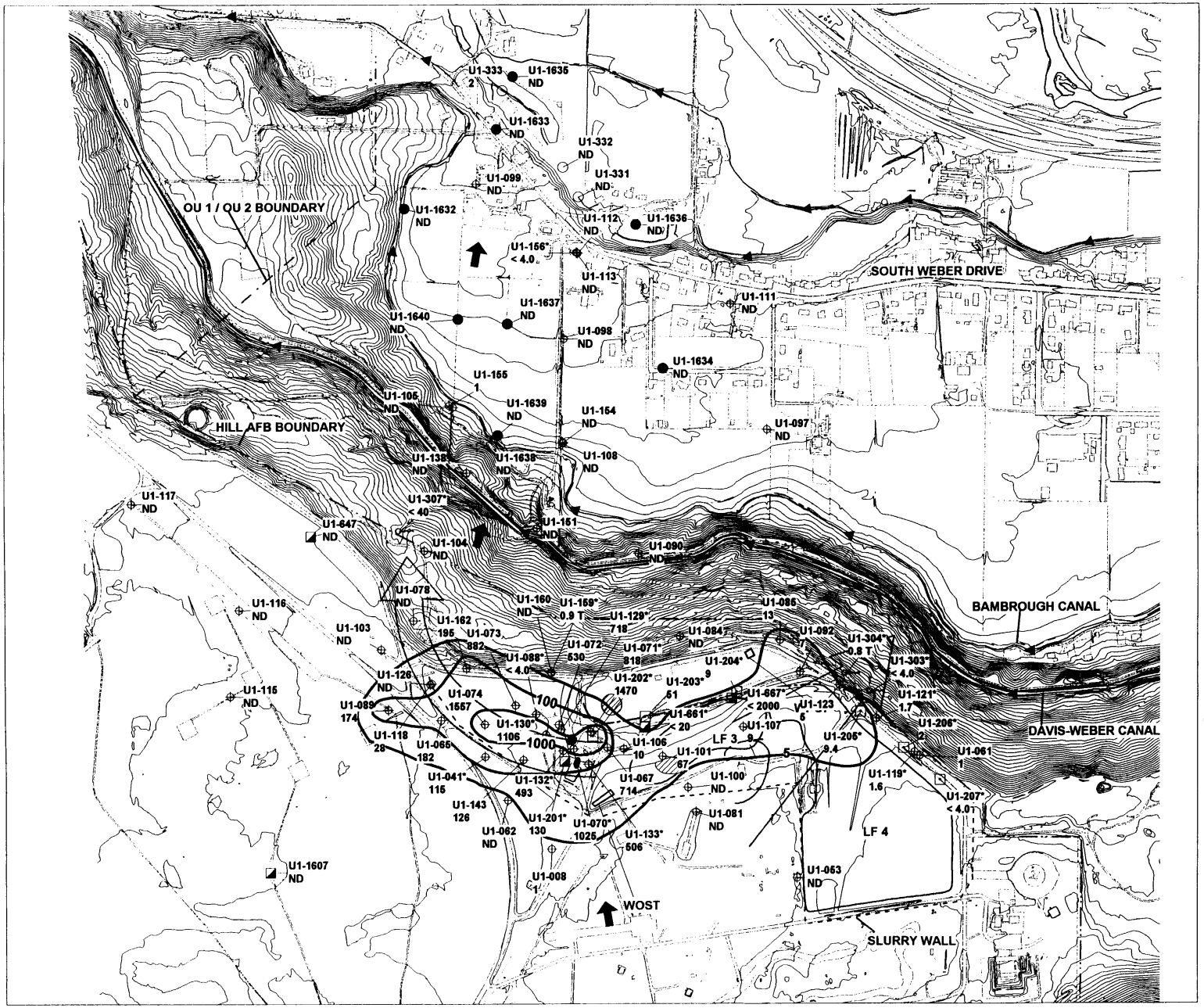
Experience implementing the AFCEE *Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater* (Wiedemeier *et al.*, 1995) at nearly 40 locations at Air Force Bases nationwide suggests that biodegradation of fuel hydrocarbons is essentially ubiquitous for a wide range of hydrogeologic settings. Also, data presented by Lawrence Livermore National Laboratories (LLNL) indicates that at over 1,000 sites with fuel hydrocarbon releases, 33 percent of the plumes were shrinking, 59 percent were stable, and 8 percent were expanding, with most plumes less than 250 feet long (Rice *et al.*, 1995). Unpublished data provided by Kuehne and Buscheck (1996) indicate similar trends, with 52 percent of plumes contracting, 35 percent stable, and 92 percent of the plumes being less than 200 feet long. Mace *et al.* (1997) present similar evidence for more than 600 fuel-release sites in Texas. The results of these studies, combined with the fact that the petroleum hydrocarbon contamination is largely confined to the Base, support the observation that a thorough demonstration of BTEX biodegradation and attenuation is less important relative to the need to demonstrate the efficiency of RNA to address CAHs dissolved in groundwater at OU 1.

The distribution of BTEX measured in groundwater at OU 1 in March 1997 is shown on Figure 4.12, and Table 4.8 summarizes detected petroleum hydrocarbon data from that sampling event. Where detected, total BTEX concentrations range from <1 µg/L to 1,557 µg/L. The highest concentrations were detected in monitoring well U1-074 (1,557 µg/L) and extraction well U1-202 (1,470 µg/L). U1-074 and U1-202 are both located within the mobile LNAPL body west and east of the CDPs, respectively.

The relatively low magnitude and limited areal extent of dissolved BTEX concentrations present at the site, in conjunction with electron acceptor and biodegradation byproduct data (discussed in following subsections), indicate that biodegradation has contributed to removal of petroleum hydrocarbon mass. Although this discussion focuses on BTEX, other petroleum hydrocarbons also will dissolve into groundwater and undergo biodegradation. For example, CB and DCBs can be used as electron donors in aerobic environments during microbially mediated redox reactions.

The distribution of total fuel carbon dissolved in groundwater is nearly identical to that of dissolved BTEX (Table 4.8). Total fuel carbon concentrations detected in TS groundwater samples ranged up to 3,694 µg/L at well U1-065 near the leading edge of the LNAPL plume.

The CAH and daughter product data presented in Sections 4.3 and 4.4.1 imply the occurrence of anaerobic reductive dehalogenation. The presence of petroleum



LEGEND

- U1-1637 ● MONITORING POINT
- U1-154 ⊕ MONITORING WELL
- U1-307 ~○ SEEP/SPRING
- U1-203 ⊡ DEWATERING WELL
- U1-661 ◪ PIEZOMETER
- S2 ○ SURFACE WATER SAMPLE LOCATION
- —100— INFERRED LINE OF EQUAL TOTAL BTEX CONCENTRATION (µg/L) CONTOUR INTERVAL = VARIABLE
- ND NOT DETECTED
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- ★ DATUM COLLECTED BY MONTGOMERY WATSON DURING 13TH SAMPLING ROUND
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- — · — EXTRACTION TRENCH
- WPOP WASTE PHENOL/OIL PIT
- WOST FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

0 300 600
Feet

N

FIGURE 4.12

TOTAL BTEX CONCENTRATIONS IN GROUNDWATER MARCH 1997

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

FILE NAME: L:\HILL\OU1\FIGURES\HILLBTEX.WOR DATE: 01/30/98 TIME: 1100

TABLE 4.8
PETROLEUM HYDROCARBONS IN GROUNDWATER AND SURFACE WATER
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Sampling Location	Benzene (µg/L)[a]	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	Total BTEX[b] (µg/L)	1,3,5-TMB[c] (µg/L)	1,2,4-TMB (µg/L)	Fuel Carbon (µg/L)
SURFACE WATER								
U1-331	ND[d]	ND	ND	ND	ND	ND	ND	NA[e]
U1-332	ND	ND	ND	ND	ND	ND	ND	NA
U1-333	ND	1	ND	< 1.0	2	ND	ND	8
GROUNDWATER								
U1-008	ND	1	ND	ND	1	ND	ND	4
U1-041R*[f]	< 20	< 20	28	87	115	82	173	NA
U1-053	ND	ND	ND	ND	ND	ND	ND	NA
U1-061	1	ND	ND	ND	1	ND	ND	7
U1-062	ND	ND	ND	ND	ND	ND	ND	NA
U1-065	2	24	27	129	182	118	200	3694
U1-065*	< 50	37.7 T	22 T	120	180	95	168	NA
U1-067	6	314	57	337	714	117	296	3442
U1-070*	< 50	465	80	< 200 / 500	< 745 / 1045	41 T[g]	< 100 / 110	NA
U1-071*	< 200	518	< 200	300	818	< 200	< 200	NA
U1-072	4	346	12	168	530	58	90	1620
U1-073	10	620	21	231	882	43	36	1827
U1-074	16	933	88	520	1557	82	164	2930
U1-077R*	< 5	< 5	< 5	< 5	< 5	< 5	< 5	NA
U1-078	ND	ND	ND	ND	ND	ND	ND	NA
U1-081	ND	ND	ND	ND	ND	ND	ND	NA
U1-084	ND	ND	ND	ND	ND	ND	ND	NA
U1-085	13	ND	ND	ND	13	ND	ND	115
U1-085*	10	5 T	< 10	< 20	15	< 10	< 10	NA
U1-088*	< 1	1.1 T	< 1	< 2	1.1 T	< 1	< 1	NA
U1-089	4	28	37	105	174	13	42	1585
U1-089*	< 50	47 T	44 T	130	221	30 T	53	NA
U1-090	ND	ND	ND	ND	ND	ND	ND	NA
U1-092	2	1	1	3	7	0	1	20
U1-092*	1	1.7	0.9 T	1.4 T	5	< 1	0.4 T	NA
U1-097	ND	ND	ND	ND	ND	ND	ND	NA
U1-098	ND	ND	ND	ND	ND	ND	ND	NA
U1-099	ND	ND	ND	ND	ND	ND	ND	NA
U1-100	ND	ND	ND	ND	ND	ND	ND	NA
U1-101	5	2	27	33	67	66	403	1538
U1-101*	< 50	< 50	< 50	< 100	< 250	< 50	325	NA

TABLE 4.8 (Continued)
PETROLEUM HYDROCARBONS IN GROUNDWATER AND SURFACE WATER
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Sampling Location	Benzene (µg/L)[a/]	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	Total BTEX[b/] (µg/L)	1,3,5-TMB[c/] (µg/L)	1,2,4-TMB (µg/L)	Fuel Carbon (µg/L)
U1-103	ND	ND	ND	ND	ND	ND	ND	NA
U1-104	ND	ND	ND	ND	ND	ND	ND	NA
U1-105	ND	ND	ND	ND	ND	ND	ND	NA
U1-105*	< 20	< 20	< 20	< 40	< 100	< 20	< 20	NA
U1-106	7	4	ND	1	12	ND	1	38
U1-106*	< 20	10 T	< 20	< 40	10 T	< 20	< 20	NA
U1-107	5	1	1	2	9	1	ND	48
U1-108	ND	ND	ND	ND	ND	ND	ND	NA
U1-108*	< 20	< 20	< 20	< 40	< 100	< 20	< 20	NA
U1-111	ND	ND	ND	ND	ND	ND	ND	NA
U1-112	ND	ND	ND	ND	ND	ND	ND	NA
U1-113	ND	ND	ND	ND	ND	ND	ND	NA
U1-115	ND	ND	ND	ND	ND	ND	ND	NA
U1-116	ND	ND	ND	ND	ND	ND	ND	NA
U1-117	ND	ND	ND	ND	ND	ND	ND	NA
U1-118	5	4	6	13	28	5	14	643
U1-119*	0.5 T	1.1	< 1	< 2	1.6	< 1	0.4 T	NA
U1-121*	1	0.7 T	< 1	< 1	1.7	0.6 T	< 1 / 1	NA
U1-123	4	ND	ND	1	5	ND	ND	18
U1-123*	4	< 2	< 2	< 4	4	< 2	< 2	NA
U1-126	ND	ND	ND	ND	ND	ND	ND	NA
U1-129*	< 50	428	25 T	265	718	33.3 T	42.3 T	NA
U1-130	ND	79	39	268	386	106	277	2682
U1-130*	< 50	448	120	538	1106	< 50	283	NA
U1-132*	< 50	160	65	268	493	23 T	73	NA
U1-133*	< 50	290	37 T	179	506	< 50	120	NA
U1-138	ND	ND	ND	ND	ND	ND	ND	NA
U1-143	ND	1	35	90	126	50	148	868
U1-151	ND	ND	ND	ND	ND	ND	ND	NA
U1-154	ND	ND	ND	ND	ND	ND	ND	NA
U1-155	ND	1	ND	ND	1	ND	ND	30
U1-155*	< 1	0.4 T	< 1	< 2	0.4 T	< 1	< 1	NA
U1-156*	< 1	< 1	< 1	< 1	< 1	< 1	< 1	NA
U1-159*	< 1	0.9 T	< 1	< 1	0.9 T	< 1	< 1	NA
U1-160	ND	ND	ND	ND	ND	ND	ND	NA
U1-162	8	100	17	70	195	17	38	1500

TABLE 4.8 (Concluded)
PETROLEUM HYDROCARBONS IN GROUNDWATER AND SURFACE WATER
MARCH 1997
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Sampling Location	Benzene (µg/L)[a/]	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	Total BTEX[b/] (µg/L)	1,3,5-TMB[c/] (µg/L)	1,2,4-TMB (µg/L)	Fuel Carbon (µg/L)
U1-162*	< 50	115	17 T	73 T	205	< 50	29 T	NA
U1-201*	< 50	130	< 50	< 50	130	< 50	< 50	NA
U1-202*	< 50	870	70	530	1470	170	380	NA
U1-203*	< 10	34	< 10	17 T	51	4 T	10	NA
U1-204*	< 10	5 T	4 T	< 10	9	< 10	< 10	NA
U1-205*	4	0.5 T	4	0.9 T	9.4	< 1	< 1	NA
U1-206*	1	1	< 1	< 1	2	< 1	< 1	NA
U1-207*	< 1	< 1	< 1	< 1	< 4	< 1	< 1	NA
U1-303*	< 1	< 1	< 1	< 1	< 4	< 1	< 1	NA
U1-304*	0.8 T	< 1	< 1	< 1	0.8 T	< 1	< 1	NA
U1-307*	< 10	< 10	< 10	< 10	< 40	< 10	< 10	NA
U1-647	ND	ND	ND	ND	ND	ND	ND	NA
U1-661*	< 5	< 5	< 5	< 5	< 20	< 5	5 T	NA
U1-667*	< 500	< 500	< 500	< 500	< 2000	< 500	< 500	NA
U1-1607	ND	ND	ND	ND	ND	ND	ND	NA
U1-1632	ND	ND	ND	ND	ND	ND	ND	NA
U1-1633	ND	ND	ND	ND	ND	ND	ND	NA
U1-1634	ND	ND	ND	ND	ND	ND	ND	NA
U1-1635	ND	ND	ND	ND	ND	ND	ND	NA
U1-1636	ND	ND	ND	ND	ND	ND	ND	NA
U1-1637	ND	ND	ND	ND	ND	ND	ND	NA
U1-1638	ND	ND	ND	ND	ND	ND	ND	NA
U1-1639	ND	ND	ND	ND	ND	ND	ND	NA
U1-1640	ND	ND	ND	ND	ND	ND	ND	NA

[a/] µg/L = micrograms per liter.

[b/] BTEX = benzene, toluene, ethyl benzene, and xylenes.

[c/] TMB = trimethylbenzene.

[d/] ND = not detected.

[e/] NA = not analyzed.

[f/] * Data from Montgomery Watson (13th sampling round).

[g/] T qualifier = detected concentratrion is below practical quantitation limit.

Notes: -Montgomery Watson data are average concentrations in cases where multiple results were reported for a single sample.

-Where two results are reported for a sample (eg. < 100 / 110) they represent the minimum / maximum concentrations reported by Mongomery Watson.

hydrocarbons dissolved in groundwater is important because the biodegradation of those compounds helps create reducing conditions that favor CAH dehalogenation. In addition, the petroleum compounds provide a source of electron donors and carbon (i.e., a substrate) for the microbial population, supplementing native organic carbon already present in the shallow aquifer. The coincidence of the dissolved BTEX and fuel carbon plumes with the highest concentrations of the reductive dehalogenation daughter products VC and ethene further establishes the importance of petroleum hydrocarbons in the effective reductive dehalogenation of chlorinated compounds at the site.

4.4.5.2 Native Organic Carbon in Groundwater

Dissolved native organic carbon also can act as a source of electron donors during the reductive dehalogenation of CAHs. Dissolved TOC concentrations can be used as an indicator of the presence of such native carbon compounds in wells outside of the area containing dissolved contamination (anthropogenic organic compounds, such as CAHs or petroleum hydrocarbons, also are measured by the TOC analytical method).

TOC dissolved in groundwater was measured in samples collected in March 1997. These concentrations are presented in Table 4.5. Dissolved TOC concentrations in shallow groundwater at OU 1 range from <1 mg/L to 290 mg/L. In general, dissolved TOC concentrations were elevated in wells in which BTEX, total fuel carbon, and/or CAH concentrations also were elevated. Dissolved TOC concentrations measured in groundwater from 10 wells that also contained more than 100 µg/L of total fuel carbon ranged from 16.1 to 136 mg/L, with mean and median values of 67 mg/L and 52 mg/L, respectively. In comparison, dissolved TOC concentrations measured upgradient from the contaminated area (wells U1-062, 008, 081, 100, and 1607) ranged from 1.8 to 61.5 mg/L, with mean and median values of 15.8 and 5.2 mg/L, respectively.

The significantly elevated dissolved TOC concentrations likely represent the presence of organic contaminants, as well as the native TOC. The background concentrations of dissolved TOC are noteworthy because they represent additional organic matter that is available for use as a substrate in biodegradation reactions. The background concentrations likely represent compounds dissolved from dispersed organic matter throughout the aquifer. In addition to the soil TOC (Table 4.3), this native carbon source should provide a continuing source of electron donors to be used in microbial redox reactions.

4.4.5.3 Use of CAHs as Electron Donors

As described in Section 4.2.3.2, less-chlorinated CAHs (e.g., DCE and VC) can be used as electron donors in aerobic environments, resulting in biodegradation of the CAHs. Shallow groundwater throughout much of the off-Base portion of OU 1 is relatively aerobic (DO >1 mg/L), and the silty to sandy alluvial sediments do not have a high native organic carbon content (Table 4.2). In these areas, DCE and VC are probably being degraded through use as electron donors in microbially mediated redox reactions.

4.4.6 Alternate Electron Acceptors and Metabolic Byproducts

Biodegradation of organic compounds, whether natural or anthropogenic, brings about measurable changes in the chemistry of groundwater in the affected area. Concentrations

of compounds used as electron acceptors (e.g., DO, nitrate, and sulfate) are depleted, and byproducts of electron acceptor reduction (e.g., ferrous iron, methane, and sulfide) are enhanced. By measuring these changes, it is possible to evaluate the importance of natural attenuation at a site.

Results of alternate electron acceptor and metabolic byproduct analyses are presented in Table 4.5. The table contains data collected for this TS and all available data from the 13th sampling round performed in March 1997 by Montgomery Watson (1997). Figures that show the distributions of geochemical parameters in groundwater, presented in the following subsections, use all available TS data, supplemented with 13th-round data for wells not sampled for the TS. The following paragraphs discuss those parameters that are most useful in the evaluation of site biodegradation processes.

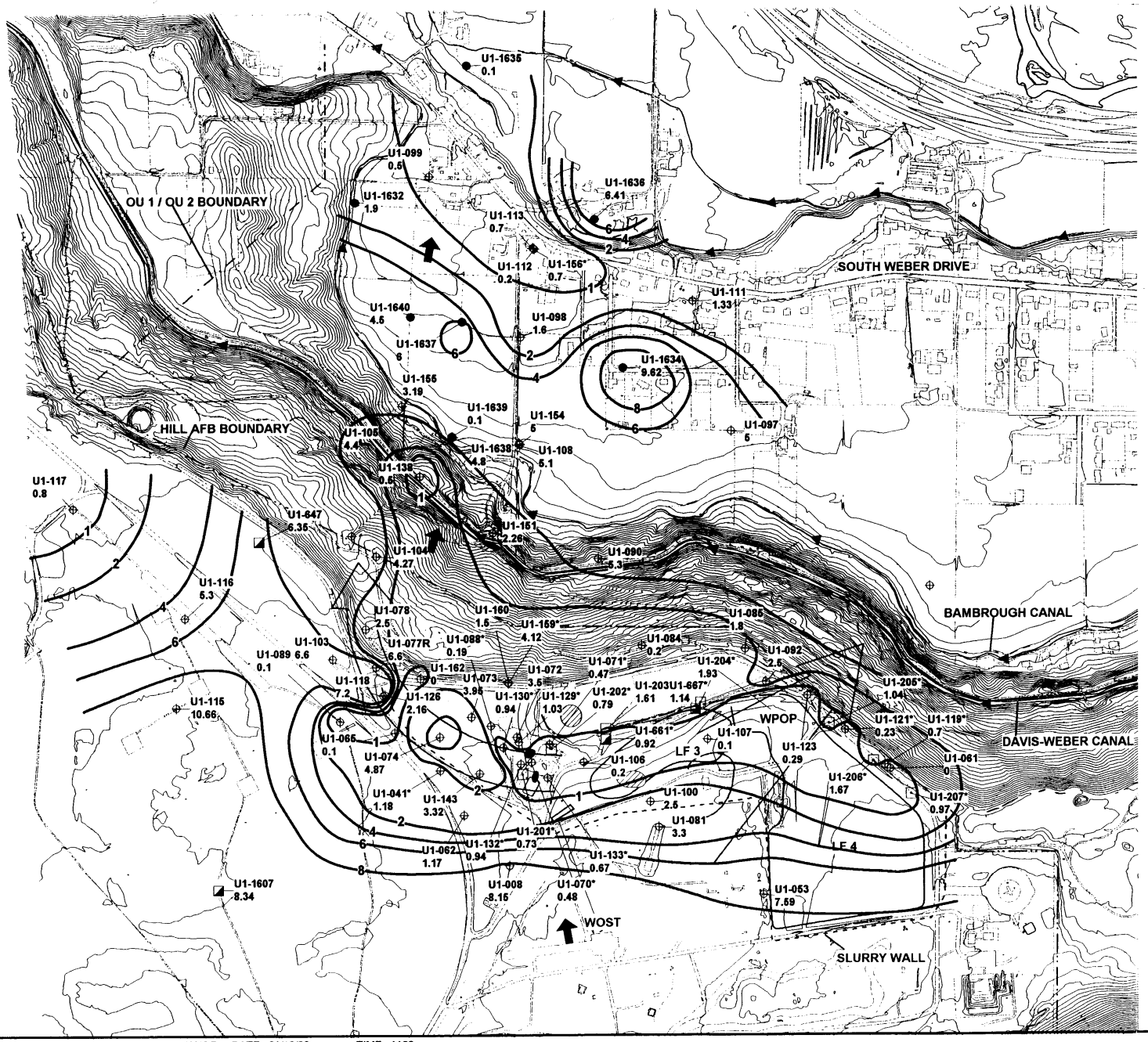
4.4.6.1 Dissolved Oxygen

Reductive dechlorination is an anaerobic process, therefore the presence of DO may suppress the reductive dechlorination pathway. Highly chlorinated compounds, such as PCE, TCE, and TCA, are biologically recalcitrant under aerobic conditions. However, all three isomers of DCE can be biodegraded in aerobic systems, and *cis*-1,2-DCE is degraded more rapidly than the other isomers (Klier *et al.*, 1996). In addition, aerobic biodegradation of VC is rapid relative to other mechanisms of VC degradation, especially reductive dechlorination.

DO concentrations were measured during the TS and 13th-round sampling events performed in March 1997. Table 4.5 summarizes measured DO concentrations, and Figure 4.13 illustrates the distribution of DO concentrations in site groundwater. Concentrations ranged from not detected (<0.1 mg/L) to 10.7 mg/L. The area of depleted oxygen concentrations in and near the contaminant source areas coincides with the dissolved BTEX and fuel carbon plumes (Figure 4.12), and is a strong indication of biological activity stimulated by the presence of petroleum hydrocarbons in this area. DO concentrations in the deeper monitoring wells U1-126, U1-159, and U1-119 were higher than in the paired shallow wells because deeper zones are relatively uncontaminated.

Because DO is recharged in the shallow groundwater through rainwater infiltration, it might be expected that DO concentrations in shallow groundwater upgradient from the CAH plume would contain DO concentrations near equilibrium with atmospheric oxygen. At groundwater temperatures between 6 degrees Celsius (°C) and 18°C (as observed at the site), DO concentrations would be expected to be in the range of about 6 mg/L to about 12 mg/L, depending on the salinity of the water (Colt, 1984). Figure 4.13 indicates that background DO concentrations in the on-Base portion of OU 1 are approximately equal to or greater than 8 mg/L.

Background DO concentrations in the shallow Weber River valley alluvium north of Hill AFB, as estimated using data from cross-gradient wells U1-1634, U1-097, and U1-111, range from 1.33 mg/L to 9.62 mg/L; mean and median DO concentrations were 5.3 and 5 mg/L, respectively. The detection of lower DO concentrations in some uncontaminated areas suggests that DO is naturally being consumed in these areas, most likely as microbes use native organic carbon as a substrate. DO concentrations measured in groundwater samples from five off-Base wells that contained more than 100 µg/L of *cis*-1,2-DCE (wells U1-105, U1-1638, U1-108, U1-1640, and U1-1637) ranged from 3.2



LEGEND

- U1-1637 ● MONITORING POINT
- U1-154 ⊕ MONITORING WELL
- U1-203 ⊡ DEWATERING WELL
- U1-661 ◪ PIEZOMETER
- — 2 — INFERRED LINE OF EQUAL DISSOLVED OXYGEN CONCENTRATION (mg/L) CONTOUR INTERVAL = VARIABLE
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- * DATUM COLLECTED BY MONTGOMERY WATSON DURING 13TH SAMPLING ROUND
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- EXTRACTION TRENCH
- WPOP WASTE PHENOL/OIL PIT
- WOST FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

FIGURE 4.13

DISSOLVED OXYGEN CONCENTRATIONS IN GROUNDWATER MARCH 1997

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Denver, Colorado

FILE NAME: L:\HILL\OU1\FIGURES\HILLDOXY.WOR DATE: 01/19/98 TIME: 1120

to 6.0 mg/L, with mean and median values of 4.7 mg/L and 4.8 mg/L, respectively. The similarity of these values to average background values measured in cross-gradient wells does not provide specific geochemical evidence of the aerobic biodegradation of less-chlorinated ethenes such as DCE. However, the relatively low magnitude of DCE concentrations detected in the off-Base area suggests that any changes in electron acceptor concentrations resulting from aerobic biodegradation would be subtle. The lack of true anaerobic conditions throughout most of the Weber River valley probably limits the occurrence of reductive dechlorination in this area.

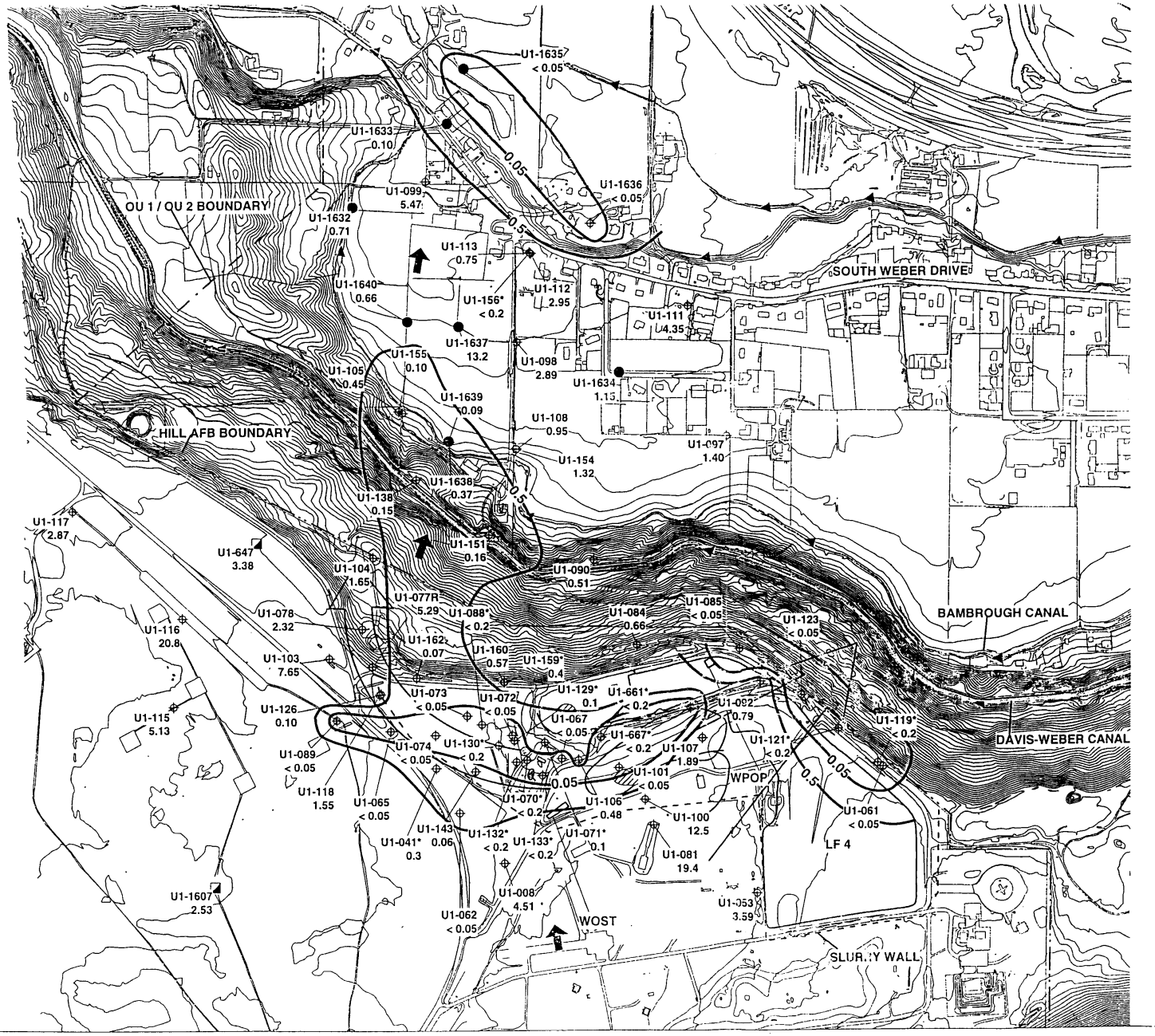
4.4.6.2 Nitrate/Nitrite

After DO has been depleted in the microbiological treatment zone, nitrate may be used as an electron acceptor for anaerobic biodegradation of organic carbon via denitrification. Nitrate concentrations below background levels in areas with high organic carbon concentrations and low DO are indicative of denitrification. The oxidation of organic carbon via the process of denitrification (using nitrate as an electron acceptor) yields a relatively large amount of free energy to microorganisms, and therefore is energetically preferable to the use of CAHs as electron acceptors. Therefore, if nitrate concentrations exceed 1 mg/L, then microorganisms may use nitrate instead of CAHs to produce energy (Wiedemeier *et al.*, 1996b).

Concentrations of nitrate + nitrite [as nitrogen (N)] were measured in TS groundwater samples collected in March 1997. In addition, groundwater samples collected by Montgomery Watson during the 13th sampling round were analyzed separately for nitrate (as N) and nitrite (as N). Table 4.5 summarizes measured nitrate +nitrite (as N) concentrations from both sampling events, and the measured values are plotted and contoured on Figure 4.14.

An area of depleted nitrate + nitrite (as N) concentrations (<0.5 mg/L) was identified from near FTA 1 to the southern edge of the Weber River valley. The lowest nitrate/nitrate (as N) concentrations were detected in the vicinity of the mobile LNAPL plume, where dissolved BTEX and fuel carbon were elevated and DO concentrations were depleted. These patterns indicate that nitrate has been/is being used in this area as an electron acceptor for anaerobic biodegradation of organic carbon via denitrification. Conversely, nitrate/nitrite (as N) concentrations in other portions of the study area are higher, and, in some cases, are sufficiently elevated such that reductive transformation of CAHs may be inhibited. Wiedemeier *et al.* (1996b) state that nitrate concentrations greater than 1 mg/L may compete with the reductive pathway.

Background nitrate+nitrite (as N) concentrations in the Weber River valley, estimated using data from cross-gradient wells U1-111, U1-1634, and U1-097, ranged from 1.15 to 4.35 mg/L; mean and median values were 2.3 mg/L and 1.4 mg/L, respectively. Nitrate + nitrite concentrations measured in groundwater samples from five off-Base wells that contained more than 100 µg/L of *cis*-1,2-DCE (U1-105, U1-1638, U1-108, U1-1640, and U1-1637) ranged from 0.37 mg/L to 13.2 mg/L, with mean and median values of 3.5 mg/L and 0.66 mg/L, respectively. The detection of 13.2 mg/L nitrate + nitrate (as N) in groundwater from well U1-1637 is anomalous, and may reflect introduction of nitrate from anthropogenic sources (e.g., fertilizer). As with DO, the nitrate + nitrite (as N) concentrations within the plume are similar to estimated background concentrations, and do not provide strong evidence of the anaerobic biodegradation of less-chlorinated



LEGEND

- U1-1637 ● MONITORING POINT
- U1-154 ⊕ MONITORING WELL
- U1-661 ◪ PIEZOMETER
- —0.5— INFERRED LINE OF EQUAL NITRATE+NITRITE (AS N) CONCENTRATION (mg/L) CONTOUR INTERVAL = VARIABLE
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- * DATUM COLLECTED BY MONTGOMERY WATSON DURING 13TH SAMPLING ROUND
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- — · — EXTRACTION TRENCH
- WPOP WASTE PHENOL/OIL PIT
- WOST FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

FIGURE 4.14

NITRATE+NITRITE (AS N) CONCENTRATIONS IN GROUNDWATER MARCH 1997

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS
ENGINEERING SCIENCE, INC.
Denver, Colorado

FILE NAME: L:\HILL\OU1\FIGURES\HILLNITR.WOR DATE: 01/21/98 TIME: 1105

ethenes. The relatively low nitrogen concentrations detected off-Base at the base of the escarpment (wells U1-105 and U1-1638) may result from the migration of nitrogen-depleted groundwater from the on-Base area.

4.4.6.3 Ferrous Iron

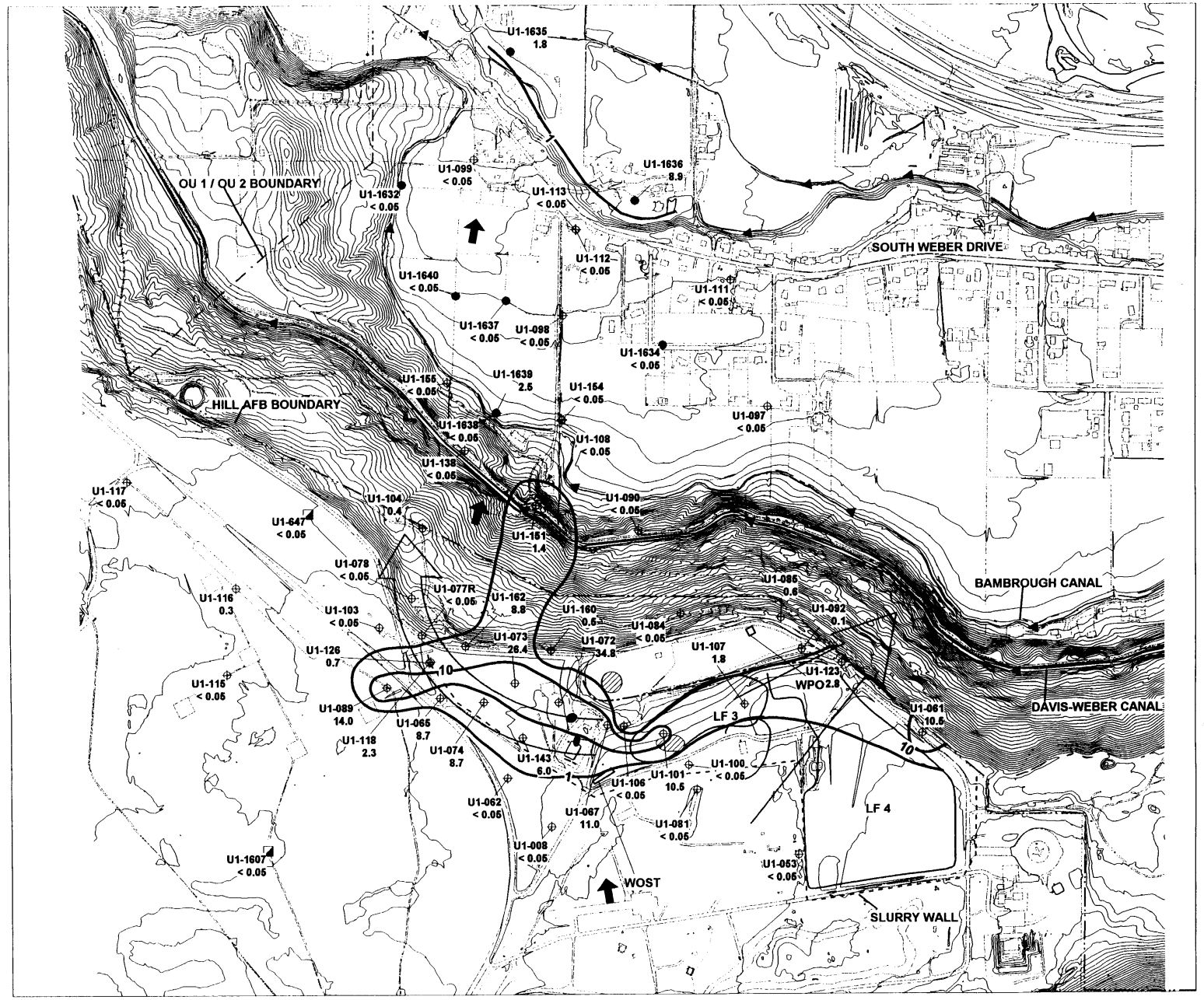
Although relatively little is known about the anaerobic metabolic pathways involving the reduction of ferric iron (Fe^{3+}), this process has been shown to be a major metabolic pathway for some microorganisms (Lovley and Phillips, 1988; Chapelle, 1993). The reduction of ferric iron results in the formation of ferrous iron (Fe^{2+}). Elevated concentrations of ferrous iron are often found in anaerobic groundwater systems. These concentrations once were attributed to the spontaneous and reversible reduction of ferric oxyhydroxides, which are thermodynamically unstable in the presence of organic compounds such as BTEX, trimethylbenzenes (TMB), and naphthalene. However, recent evidence suggests that the reduction of ferric iron cannot proceed at all without microbial mediation (Lovley and Phillips, 1988 and 1991; Chapelle, 1993). None of the common organic compounds found in low-temperature (i.e., non-hydrothermal), neutral, reducing groundwater could reduce ferric oxyhydroxides to ferrous iron under sterile laboratory conditions (Lovley *et al.,* 1991). This means that the reduction of ferric iron requires mediation by microorganisms with the appropriate enzymatic capabilities.

To determine if ferric iron is being used as an electron acceptor for CAH biodegradation at OU 1, ferrous iron concentrations were measured in groundwater samples collected for this TS in March 1997. These measurements are summarized in Table 4.5. Measured ferrous iron concentrations range from <0.05 mg/L to 34.8 mg/L. Figure 4.15 shows the areal extent of ferrous iron in groundwater. Elevated ferrous iron concentrations coincide with the area characterized by elevated dissolved BTEX and fuel carbon concentrations, and depleted nitrate and DO concentrations. The elevated concentrations of ferrous iron are strong indicators of microbial activity, and suggest that ferric iron hydroxide is being reduced to ferrous iron during biodegradation of native organic carbon and BTEX/fuel carbon compounds.

Background levels of ferrous iron both on- and off-Base appear to be generally less than 0.05 mg/L, except north of South Weber Drive, where ferrous iron concentrations ranged from 1.8 mg/L at well U1-1635 to 8.9 mg/L at well U1-1636. The presence of ferrous iron in these locations, together with the depleted nitrate + nitrite (as N) concentrations, suggests that native organic material is available for biodegradation through iron reduction. Bradley and Chapelle (1996) show evidence of direct biological oxidation of VC (i.e., use of VC as a substrate) under iron-reducing conditions so long as there is sufficient bioavailable iron. This may be occurring in very localized areas on-Base and beneath the escarpment face (e.g., at well U1-151).

4.4.6.4 Sulfate

Sulfate also may be used as an electron acceptor during microbial degradation of organic carbon under anaerobic conditions (Grbic-Galic, 1990). This redox reaction is commonly called sulfate reduction. Sulfate is reduced to sulfide during the oxidation of natural or anthropogenic carbon. Wiedemeier *et al.* (1996b) report that sulfate may compete with CAHs as an electron acceptor (i.e., sulfate may be preferentially used by microorganisms instead of CAHs) if sulfate concentrations exceed 20 mg/L. To



LEGEND

- U1-1637 — MONITORING POINT
- U1-154 — MONITORING WELL
- U1-647 — PIEZOMETER
- –10– — INFERRED LINE OF EQUAL FERROUS IRON CONCENTRATION (mg/L) CONTOUR INTERVAL = VARIABLE
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- EXTRACTION TRENCH
- WPOP — WASTE PHENOL/OIL PIT
- WOST — FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

0 300 600
Feet

N

FIGURE 4.15

FERROUS IRON CONCENTRATIONS IN GROUNDWATER MARCH 1997

OU 1 RNA TS
Hill Air Force Base, Utah

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FILE NAME: L:\HILL\OU1\FIGURES\HILLIRON.WOR DATE: 01/19/98 TIME: 1130

investigate the potential for sulfate reduction at OU 1, sulfate concentrations were measured in groundwater samples collected in March 1997. Sulfate concentrations in shallow groundwater at the site ranged from <0.1 mg/L to 266 mg/L (Table 4.5). As shown on Figure 4.16, the dissolved sulfate concentrations are depleted in and immediately adjacent to the area containing the mobile LNAPL plume (shown on Figure 4.1), indicating that sulfate reduction is or has recently been an ongoing anaerobic biodegradation process in this area. The widespread detection of sulfate concentrations greater than 20 mg/L throughout the remaining portions of OU 1 indicate that use of CAHs as electron acceptors in those areas could be inhibited due to preferential use of sulfate if groundwater conditions become sufficiently reducing in the future to support a higher reductive dechlorination rate.

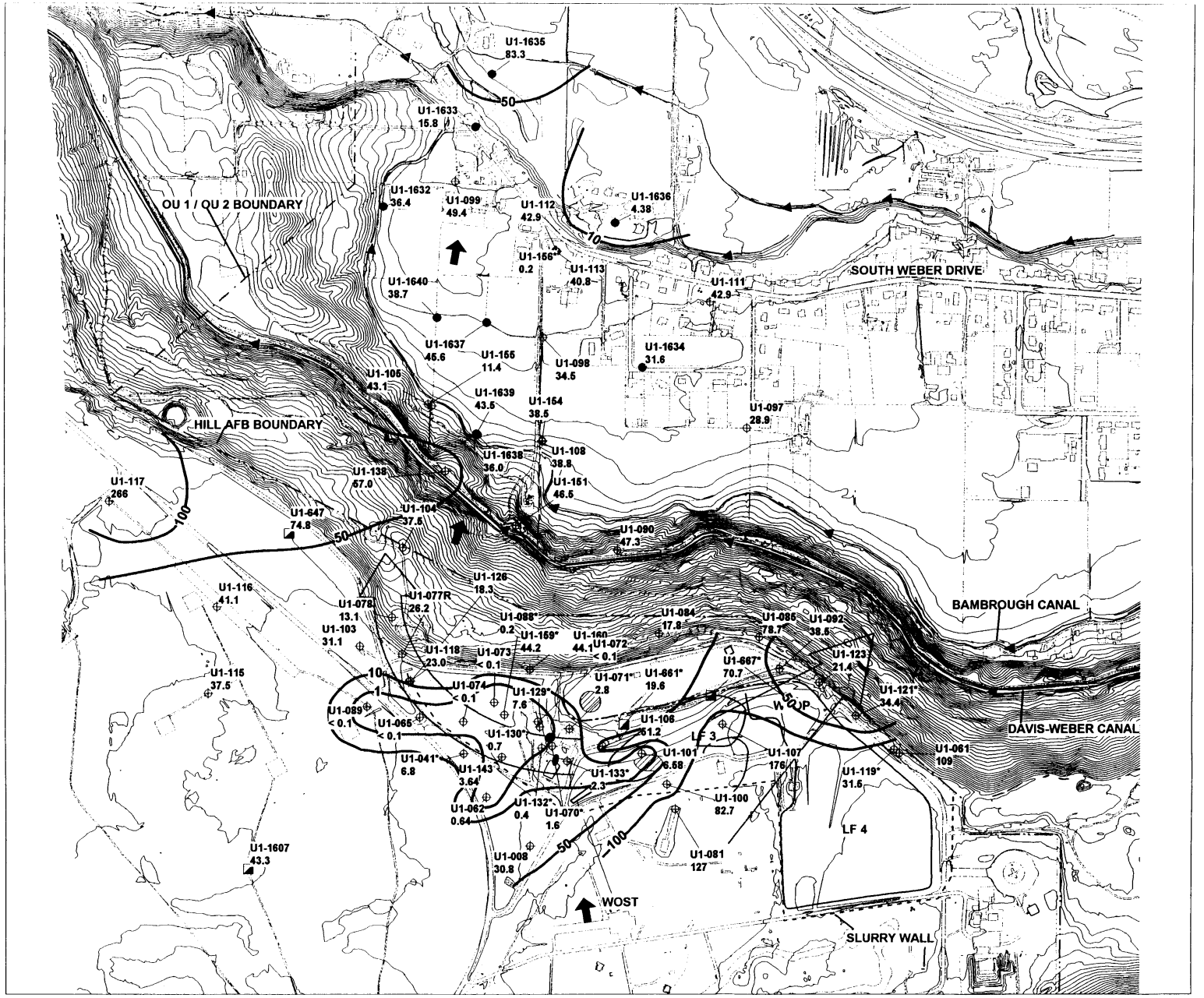
4.4.6.5 Methane and Carbon Dioxide

Although reductive dehalogenation may occur under nitrate- and sulfate-reducing conditions (Vogel *et al.*, 1987; Chapelle, 1996), the most rapid dehalogenation rates, affecting the widest ranges of CAHs, occurs under methanogenic conditions (Bouwer, 1994). Methane and carbon dioxide concentrations were measured in selected groundwater samples collected for the TS in March 1997. Table 4.5 lists analytical results for these compounds, and Figure 4.17 shows the distribution of methane in shallow site groundwater. Detected methane concentrations ranged from <0.001 mg/L to 10.36 mg/L. Methane concentrations are greatest near the inferred toe of the mobile LNAPL plume (well U1-065) and adjacent to FTA 1 (well U1-101). Elevated (above-background) methane concentrations also were detected along the edge of the hillside at wells U1-123, U1-092, U1-085, U1-084, and U1-162, as well as at other wells located near contaminant source areas. The presence of methane in the vicinity of the on-Base contaminant source areas indicates that conditions are sufficiently reducing that petroleum hydrocarbons, native organic matter, and possibly also sanitary water in the landfills are being used to support methanogenesis. Further, the fact that methanogenesis is ongoing indicates that conditions in this on-Base area are highly reducing and therefore favorable for reductive dehalogenation of CAHs.

Background carbon dioxide concentrations (March 1997) for the on-Base portion of OU 1, determined using data from upgradient wells U1-1607, U1-062, U1-008, U1-081, and U1-100 ranged from 58 mg/L to 220 mg/L, with mean and median values of 131 and 130 mg/L, respectively. Carbon dioxide concentrations measured in five wells located within, near, or immediately downgradient from contaminant source areas (U1-118, U1-089, U1-143, U1-092, and U1-123) ranged from 210 mg/L to 460 mg/L, with mean and median values of 322 and 280 mg/L, respectively. Methanogenesis produces more carbon dioxide than it uses; therefore, an unlimited supply of carbon dioxide is theoretically available once the process of methanogenesis has been initiated, and this process is limited by the rate of reaction rather than the source of electron acceptors. The presence of significantly elevated carbon dioxide concentrations in the plume area indicates biologic activity.

4.4.6.6 Volatile Fatty Acids and Phenols

Fatty acids are synthesized by microorganisms to be used in the production of lipids necessary for incorporation into various cell membranes. A portion of these fatty acids are volatile. Volatile fatty acids (VFAs) are produced when the bacterial cell has



LEGEND

- U1-1637 ● MONITORING POINT
- U1-154 ⊕ MONITORING WELL
- U1-661 ◪ PIEZOMETER
- −10− INFERRED LINE OF EQUAL SULFATE CONCENTRATION (mg/L) CONTOUR INTERVAL = VARIABLE
- * DATUM COLLECTED BY MONTGOMERY WATSON DURING 13TH SAMPLING ROUND
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- EXTRACTION TRENCH
- WPOP WASTE PHENOL/OIL PIT
- WOST FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

0 300 600
Feet

N

FIGURE 4.16

SULFATE CONCENTRATIONS IN GROUNDWATER MARCH 1997

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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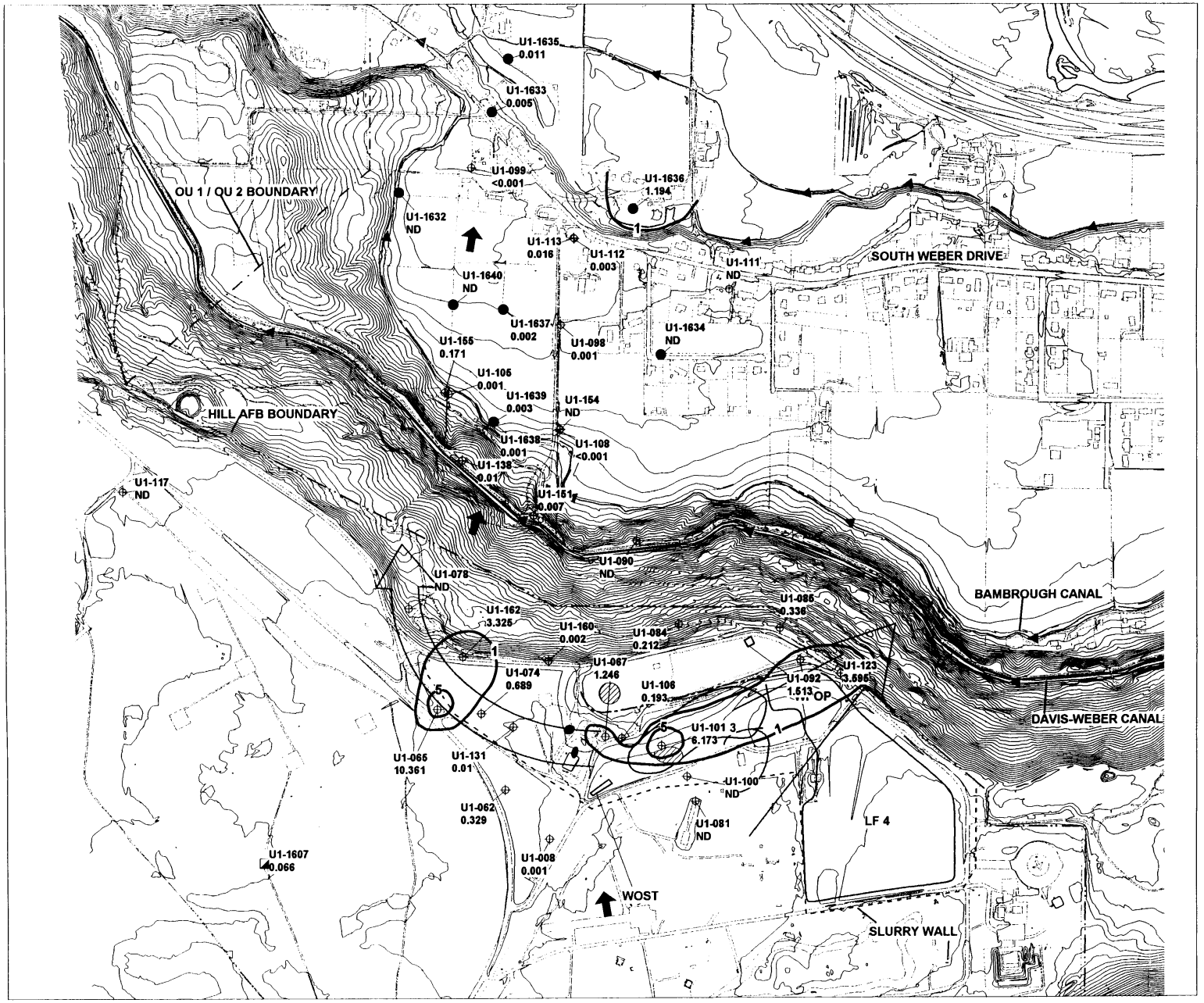

LEGEND

- U1-1637 ● MONITORING POINT
- U1-154 ⊕ MONITORING WELL
- U1-1607 ◪ PIEZOMETER
- — 5 — INFERRED LINE OF EQUAL METHANE CONCENTRATION (mg/L) CONTOUR INTERVAL = 4 mg/L
- ND NOT DETECTED
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- EXTRACTION TRENCH
- WPOP WASTE PHENOL/OIL PIT
- WOST FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

0 300 600
Feet

N

FIGURE 4.17

METHANE CONCENTRATIONS IN GROUNDWATER MARCH 1997

OU 1 RNA TS
Hill Air Force Base, Utah

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Denver, Colorado

FILE NAME: L:\HILL\OU1\FIGURES\HILLMETH.WOR DATE: 01/19/98 TIME: 1150

obtained the required energy from metabolism of a carbon source (i.e., BTEX, CAHs, or naturally occurring organic carbon). After VFAs are secreted from the bacterial cell, they volatilize fairly rapidly; therefore, detection of VFAs in groundwater is a strong indication of recent metabolic activity and possibly biodegradation of BTEX or CAHs. The standard method of VFA analysis performed by USEPA researchers is a gas chromatography/mass spectrometry method in which groundwater samples are compared to a standard mixture containing 58 phenols, aromatic acids, and aliphatic acids.

Samples for VFA analysis were collected from four wells at OU 1, including U1-072, U1-073, U1-106, and U1-154. The first three wells listed are located on-Base near contaminant source areas; well U1-154 is located in the Weber River valley near the base of the escarpment. Analysis results are presented in Appendix C, and are summarized in the following paragraph.

Collectively, 57 of the 58 compounds in the standard were detected in these samples at concentrations ranging from <3 µg/L to 801 µg/L. By far, the greatest number of detections and the highest concentrations of VFAs occurred in the three on-Base samples, further supporting the conclusion that significant microbial activity is occurring in the vicinity of the LNAPL plume. The relative lack of VFAs in the sample from well U1-154 is consistent with data presented previously in this section that indicates that microbial activity in the Weber River valley is more limited.

4.4.6.7 Ammonia

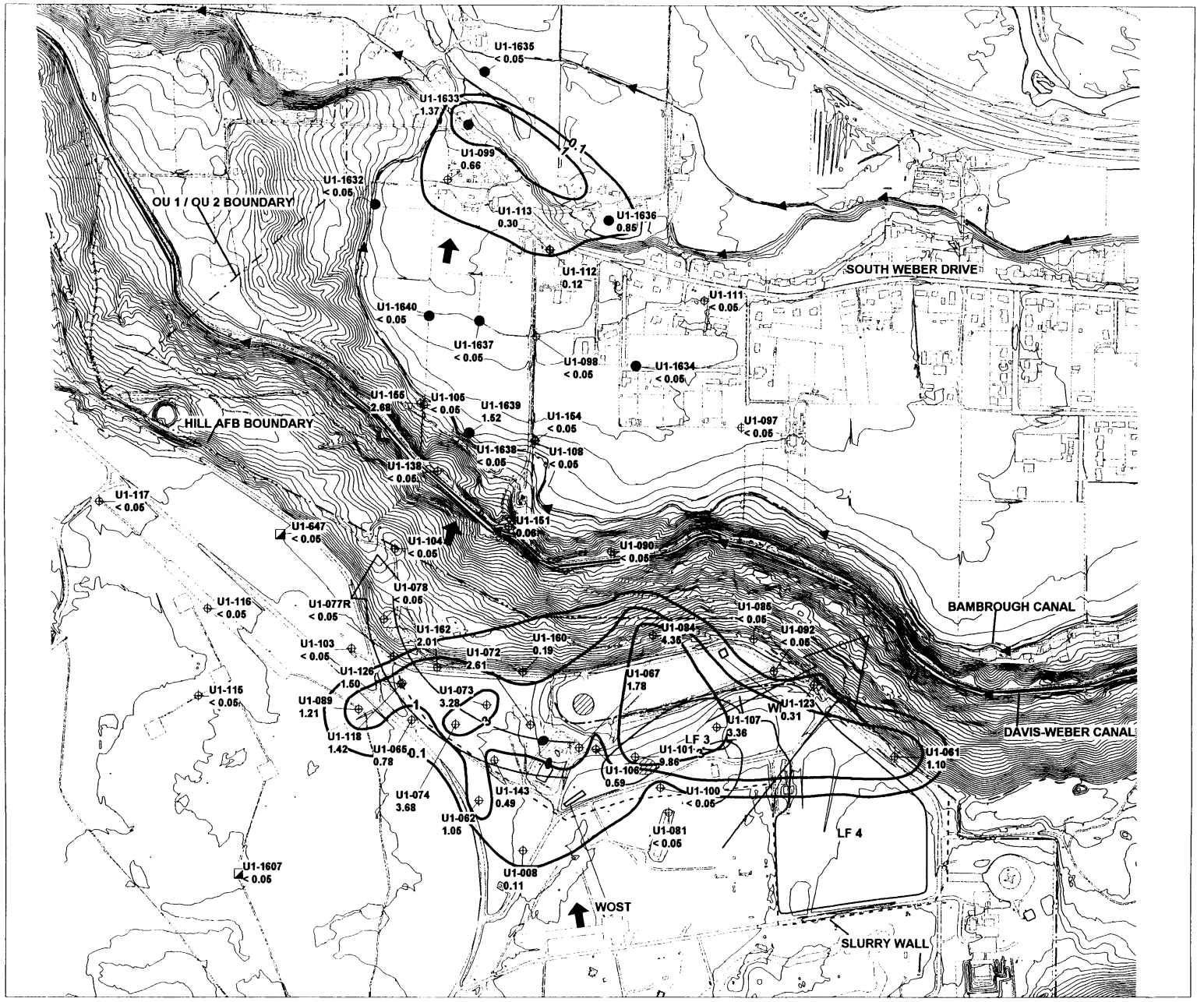
The presence of ammonia in groundwater can result from either nitrate reduction (facilitated by microbes), fixing of atmospheric nitrogen (also a microbial process), or anthropogenic sources such as land application of fertilizer. If the presence of ammonia in groundwater results from nitrate reduction or fixing of atmospheric nitrogen, it is a strong indication of microbial activity. Figure 4.18 shows the distribution of ammonia (as N) concentrations measured in groundwater samples collected from OU 1. Ammonia concentrations ranged from less than 0.05 mg/L to 9.86 mg/L (Table 4.5), with the area of highest ammonia concentrations occurring within and near the contaminant source areas. The presence of ammonia in these areas further supports the observation that significant microbial activity is occurring, resulting in biodegradation of petroleum hydrocarbons and CAHs.

4.4.7 Additional Geochemical Indicators

Other geochemical data collected for this evaluation can be used to further interpret and support the contaminant, electron donor, electron acceptor, and byproduct data previously discussed. These parameters provide additional qualitative indications of what processes may be operating at the site.

4.4.7.1 Alkalinity

Carbon dioxide is produced during the biodegradation of petroleum hydrocarbons and native organic carbon compounds. The presence of elevated carbon dioxide concentrations within and near contaminant source areas was noted in Section 4.4.6.5. In aquifers that have carbonate minerals as part of the matrix, carbon dioxide forms carbonic acid, which dissolves these minerals, increasing the alkalinity of the groundwater. An



LEGEND

- U1-1637 ● MONITORING POINT
- U1-154 ⊕ MONITORING WELL
- U1-647 ◪ PIEZOMETER
- — 1 — INFERRED LINE OF EQUAL AMMONIA CONCENTRATION (mg/L) CONTOUR INTERVAL = VARIABLE
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- EXTRACTION TRENCH
- WPOP WASTE PHENOL/OIL PIT
- WOST FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

0 300 600
Feet

N

FIGURE 4.18

AMMONIA CONCENTRATIONS IN GROUNDWATER MARCH 1997

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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increase in alkalinity [measured as calcium carbonate ($CaCO_3$)] in an area with BTEX concentrations elevated above background conditions can be used to infer that petroleum hydrocarbons (or native organic carbon) have been destroyed through aerobic and anaerobic microbial respiration.

Total alkalinity (as $CaCO_3$) was measured in groundwater samples collected in January 1996. These measurements are summarized in Table 4.5 and illustrated on Figure 4.19. Alkalinity is a measure of the ability of groundwater to buffer changes in pH caused by the addition of biologically generated acids. Total alkalinity at the site varied from 190 mg/L to 825 mg/L. This range of alkalinity is sufficient to buffer potential changes in pH caused by biologically mediated reactions and suggests that aerobic and/or anaerobic biodegradation processes should not cause detrimental shifts in groundwater pH (see Section 4.4.7.2). In addition, the areas with increased alkalinity generally coincide with the locations of contaminant source areas and the presence of dissolved petroleum hydrocarbon contamination. This is further evidence that biodegradation utilizing BTEX and other fuel-based carbon compounds as substrates is ongoing at the site.

4.4.7.2 pH

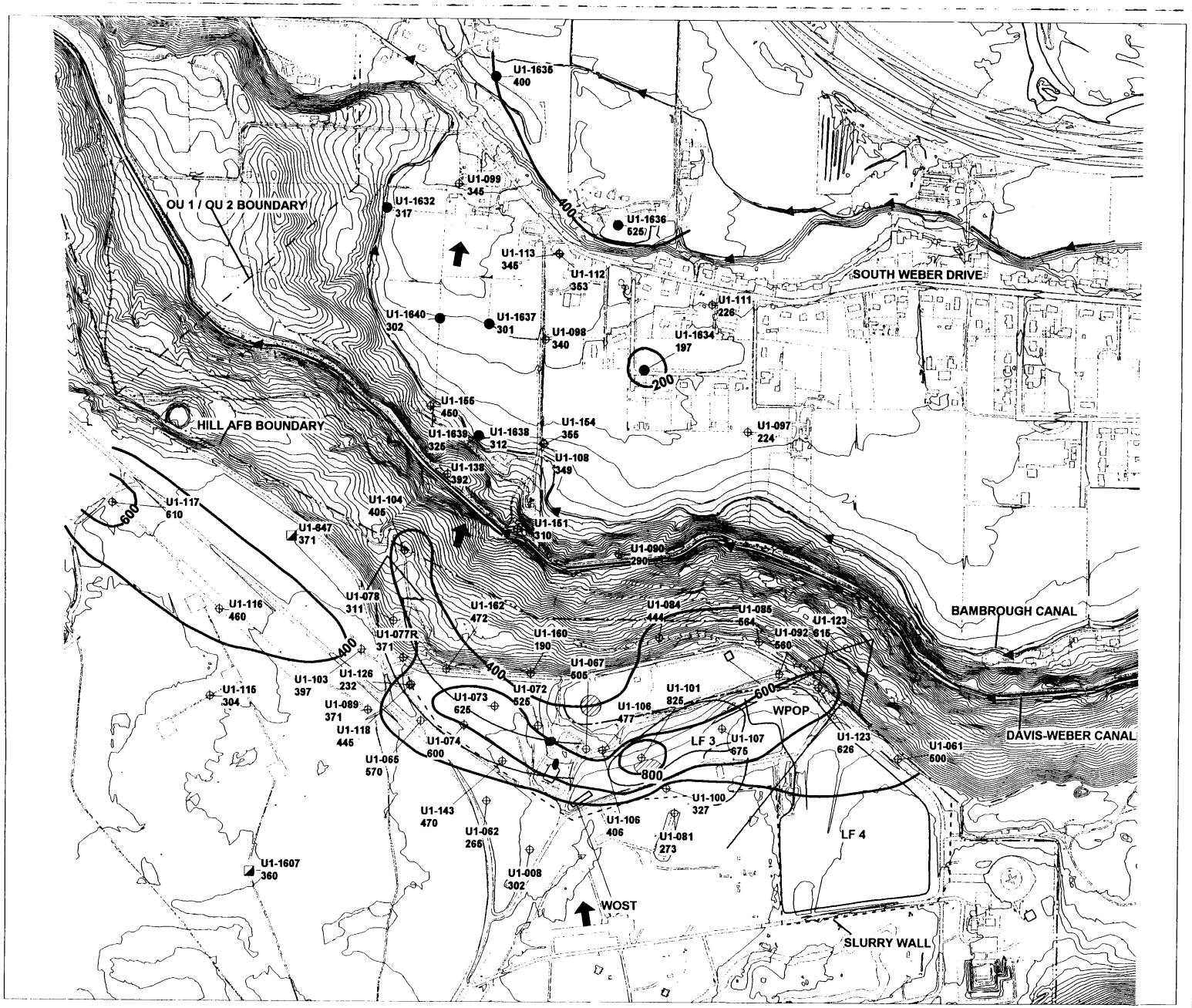
pH was measured for groundwater samples collected from groundwater monitoring points and monitoring wells in March 1997. These measurements are summarized in Table 4.5. The pH of a solution is the negative logarithm of the hydrogen ion concentration [H^+]. Groundwater pH measured at the site in March 1997 ranged from 6.71 to 8.50 standard units. This range of pH is within the optimal range of 5 to 9 for BTEX-degrading microbes. The limited and relatively neutral range of pHs also indicates that microbial reactions have a minimal effect on groundwater pH, likely due to the moderately high alkalinity of site groundwater (Section 4.4.3.2).

4.4.7.3 Temperature

Groundwater temperature was measured at groundwater monitoring points and monitoring wells in March 1997. Table 4.5 summarizes groundwater temperature readings. Temperature affects the types and growth rates of bacteria that can be supported in the groundwater environment, with higher temperatures generally resulting in higher growth rates. In March 1997, groundwater temperatures varied from 5.8°C to 18.5°C. Wiedemeier *et al.* (1996b) report that biochemical processes are accelerated when groundwater temperatures exceed 20°C. The temperature data summarized above indicate that this is not the case at OU 1; however, the temperatures should not inhibit microbial activity.

4.5 APPROXIMATION OF BIODEGRADATION RATES

Biodegradation rate constants are necessary to accurately simulate the fate and transport of contaminants dissolved in groundwater. In many cases, biodegradation of contaminants can be approximated using first-order kinetics. First-order biodegradation rate constants may be calculated on the basis of field-scale data, or by using a small sample of the aquifer material and groundwater for microcosm studies. For reductive dehalogenation of chlorinated compounds, first-order rates are not necessarily an accurate representation because the degradation of CAHs depends on both concentration of



LEGEND

- U1-1637 ● MONITORING POINT
- U1-154 ⊕ MONITORING WELL
- U1-661 ◪ PIEZOMETER
- —400— INFERRED LINE OF EQUAL TOTAL ALKALINITY CONCENTRATION (mg/L CaC03) CONTOUR INTERVAL = 200 mg/L CaCO3
- PALEOCHANNEL IN SURFACE OF SILTY CLAY LAYER
- INFERRED GROUNDWATER FLOW DIRECTION
- SURFACE DRAINAGE WITH FLOW DIRECTION
- EXTRACTION TRENCH
- WPOP WASTE PHENOL/OIL PIT
- WOST FORMER WASTE OIL STORAGE TANK AREA
- FIRE TRAINING AREAS 1 AND 2
- CHEMICAL DISPOSAL PITS 1 AND 2

0 300 600
Feet

N

FIGURE 4.19

TOTAL ALKALINITY CONCENTRATIONS IN GROUNDWATER MARCH 1997

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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electron donors (e.g., fuel hydrocarbons or native organic material) and the concentrations of electron acceptors (including inorganic acceptors and CAHs) (Moutoux *et al.*, 1996). Second-order rates would therefore allow more accurate modeling, but at this time there are no readily available groundwater contaminant transport models that can utilize such rates. Therefore, first-order rates must be estimated for such an application.

Microcosm studies are used to show that the microorganisms necessary for biodegradation are present and to help quantify rates of biodegradation. Because microcosm studies are time consuming and expensive, they should be undertaken only at sites where there is considerable uncertainty concerning the biodegradation of contaminants. The results of a microcosm study are strongly influenced by the nature of the geological material submitted for study, the physical properties of the microcosm, the sampling strategy, and the duration of the study. Biodegradation rate constants determined by microcosm studies often are much higher than those observed in the field. Microcosms are most appropriate as indicators of the potential for natural bioremediation, and to prove that losses are biological, but it may be inappropriate to use them to generate rate constants. The preferable method of contaminant biodegradation rate-constant determination is by use of field data.

In order to calculate first-order biodegradation rate constants on the field scale, the apparent degradation rate must be normalized for the effects of dilution, dispersion, and sorption. Two methods for determining first-order rate constants for BTEX compounds are described by Wiedemeier *et al.* (1996b). One method involves the use of a biologically recalcitrant compound found in the dissolved contaminant plume that can be used as a conservative tracer. One organic compound that can be used at some sites is TMB. For many chlorinated solvent plumes, chloride that is released to the groundwater during dehalogenation reactions also can serve as a tracer. Chloride was not used as a tracer for OU 1 due to the similarity between background chloride concentrations and those in the CAH plume (Section 4.4.3). The other method, proposed by Buscheck and Alcantar (1995), involves interpretation of a steady-state contaminant plume and is based on the one-dimensional, steady-state analytical solution to the advection-dispersion equation presented by Bear (1979). Decay rates computed using this method account for chemical (abiotic) decay and biological (aerobic and anaerobic) decay. For an expanding plume, this first-order approximation can be viewed as an upper bound on the biodegradation rate. Use of this method results in an overestimation of the rate of biodegradation because a typical expanding plume exhibits decreasing source area concentrations, increasing downgradient concentrations, or both. Over time, these changes result in a decreasing slope on a log-linear plot, and consequently a decreasing biodegradation rate. Both methods can be adapted to estimate rate constants for CAHs.

Another method for estimating reductive dehalogenation rates of CAHs is described by Moutoux *et al.* (1996). This method provides a total dechlorination rate for all dechlorination steps. All rates (including the rapid TCE to DCE rate and the slow VC to ethene) are averaged together using the Moutoux *et al.* (1996) method. Because abiotic reactions and aerobic reactions that involve CAH compounds in the role of an electron donor are not included in this rate (and may in fact decrease the rate estimated by this method), the rate should be considered a lower bound on the destructive attenuation rate.

It should be noted that the magnitudes of the decay rates calculated using these methods are sensitive to the estimated migration velocity of the contaminant along the selected flowpath; therefore, inaccuracies in the estimated velocity will cause the decay rates to be less accurate. Overestimation of the groundwater velocity will result in overestimation of the decay rate, and vice versa.

The conservative tracer method, and the methods of Buscheck and Alcantar (1995) and Moutoux *et al.* (1996) were used to estimate first-order biodegradation rate constants for *cis*-1,2-DCE at OU 1. This is the principal contaminant of concern in OU 1 groundwater because the extent and magnitude of the *cis*-1,2-DCE plume in the off-Base area is substantially greater than any other dissolved contaminant. The decay rate calculations are summarized in Table 4.9 and Appendix D. Rate constants were not calculated for BTEX compounds because of the relatively low remaining concentrations (Table 4.8) and because this study focuses on the CAHs.

The first-order, steady-state, *cis*-1,2-DCE decay rate computed using data from the flowpath U1-074>U1-105>U1-1637>U1-099 and the method of Buscheck and Alcantar (1995) is 0.00026 day^{-1}, which corresponds to a half-life of 7.3 years. This flowpath extends from near the leading edge of the on-Base mobile LNAPL body to near the leading edge of the dissolved *cis*-1,2-DCE plume in the Weber River valley, and therefore is not representative of decay rates in groundwater beneath or east of the LNAPL body. As described above, the decay rates computed using this method can be viewed as an upper bound on the biodegradation rate if the plume is expanding. However, data presented in Section 4.4.1 suggest that the plume may not be expanding to a significant degree due to the effects of RNA and engineered remedial actions. Therefore, the computed decay rate may be a reasonable representation of the combined effects of both reductive dehalogenation occurring on-Base and aerobic decay occurring off-Base.

An attempt was made to compute a lower bound dechlorination rate along this same flowpath using the method of Moutoux *et al.* (1996); however, the corrected CAH concentrations increased with distance along the flowpath, invalidating use of this method for this flowpath. This increase is due to the occurrence of aerobic biodegradation of DCE and/or VC, because the method assumes that both parent and daughter CAHs are conserved along the selected flowpath. The failure of this method indicates that other biodegradation processes besides reductive dechlorination (e.g., aerobic processes) are occurring along this flowpath. Because the anaerobically recalcitrant TMB compounds were not detected in groundwater from off-Base wells, the tracer method (Wiedemeier *et al.*, 1996b) was not used for the flowpath U1-074>U1-105>U1-1637>U1-099.

The method of Buscheck and Alcantar (1995) also was used to estimate decay rates for more localized flowpaths within the on-Base and off-Base portions of OU 1 (Table 4.9 and Appendix D). The first-order, steady-state, *cis*-1,2-DCE decay rates computed for the flowpaths U1-667>U1-123 and U1-067>U1-070>U1-074 are 0.00016 day^{-1} (half-life = 11.9 years) and 0.00029 day^{-1} (half-life = 6.5 years), respectively. Use of the latter pathway for calculation of decay rates is not entirely legitimate because it is entirely within the area occupied by the mobile LNAPL plume, which is a potential source of dissolved DCE to the groundwater. However, if DCE was dissolving into the groundwater from the LNAPL along this pathway, then the computed decay rate should

TABLE 4.9
SUMMARY OF cis-1,2-DCE DECAY RATES
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Analysis Method	Selected Flow Path	General Location of Flow Path	Decay Rate (day-1)
B&A[a/]	U1-074 > U1-155 > U1-1637 > U1-099	On-Base Terrace to Weber River Valley	0.00026
Moutoux[b/]	U1-074 > U1-155 > U1-1637 > U1-099	On-Base Terrace to Weber River Valley	NA[c/]
Conserv. Tracer[d/]	U1-074 > U1-155 > U1-1637 > U1-099	On-Base Terrace to Weber River Valley	NA[e/]
B&A	U1-667 > U1-123	On-Base Terrace	0.00016
Moutoux	U1-667 > U1-123	On-Base Terrace	NA[f/]
Conserv. Tracer	U1-667 > U1-123	On-Base Terrace	NA[e/]
B&A	U1-067 > U1-070 > U1-074	On-Base Terrace	0.00029
Moutoux	U1-067 > U1-070 > U1-074	On-Base Terrace	NA[c/]
Conserv. Tracer	U1-067 > U1-070 > U1-074	On-Base Terrace	0.0003
B&A	U1-105 > U1-1637 > U1-099	Weber River Valley	0.00028
Moutoux	U1-105 > U1-1637 > U1-099	Weber River Valley	4×10^{-8}
Conserv. Tracer	U1-105 > U1-1637 > U1-099	Weber River Valley	NA[e/]

[a/] B&A = Method of Buscheck and Alcantar (1995) for steady-state plumes.

[b/] Method of Moutoux et al. (1996) for total reductive dechlorination rate.

[c/] NA = not applicable due to increasing corrected CAH concentrations with distance along flow path.

[d/] Conserv. Tracer = conservative tracer method described by Wiedemeier et al. (1996b).

[e/] NA = not applicable due to tracer compounds not being detected in all wells.

[f/] NA = not applicable due to uncertainty regarding presence and concentrations of CAHs and ethene.

be conservatively low. The first-order, steady-state, *cis*-1,2-DCE decay rate computed for the South Weber river valley flowpath U1-105>U1-1637>U1-099 is 0.00028 day^{-1} (half-life = 6.8 years).

The total reductive dechlorination rate for the flowpaths U1-067>U1-070>U1-074 could not be computed using the Moutoux *et al.* (1996) method for the reason described above for flowpath U1-074>U1-105>U1-1637>U1-099. In addition, the CAH detection limits for well U1-070, sampled by Montgomery Watson (1997) during the 13th sampling round, were relatively high (50 to 100 µg/L); therefore, the presence and actual concentrations of non-detected analytes is uncertain. In addition, the 13th-round samples were not analyzed for ethene. Quantification of the concentrations of all chlorinated ethenes (PCE, TCE, DCE, and VC) and ethene are required for the Moutoux, *et al.* (1996) method. The total reductive dechlorination rate for the flowpath U1-667>U1-123 also was not computed due to high detection limits and the lack of ethene data for the sample from well U1-667. The total reductive dechlorination rate computed for the flowpath U1-105>U1-1637>U1-099 in the Weber River valley is 4×10^{-8} day^{-1} (half-life = 47,466 years). This low rate is compatible with the general lack of evidence that reductive dechlorination is occurring along this flowpath; however, the probable aerobic degradation of less-chlorinated ethenes along this flowpath will result in inaccuracies in the computed decay rate.

The tracer method also was not used for the flowpaths U1-667>U1-123 and U1-105>U1-1637>U1-099 because groundwater from these wells did not contain detectable concentrations of TMBs. The tracer method was used to estimate a decay rate of 0.0003 day^{-1} (half-life = 6.3 years) for the flowpath U1-067>U1-070>U1-074. This rate is nearly identical to the rate computed for this flowpath using the Buscheck and Alcantar (1995) method (0.00029 day^{-1}). As described above, the rates computed for this flowpath may be conservatively low due to the presence of mobile LNAPL which acts as a source of both CAHs and fuel-related compounds.

4.6 DISCUSSION

Several lines of chemical and geochemical evidence indicate that dissolved CAHs at OU 1 are undergoing biologically facilitated reductive dehalogenation. The presence of *cis*-1,2-DCE, VC, and ethene in site groundwater, accompanied by a decrease in parent solvent (TCE and/or PCE) concentrations, are the primary lines of chemical evidence. In addition, the ratios of *cis*-1,2-DCE to *trans*-1,2-DCE within the CAH plume (Figure 4.5) are indicative of biologically mediated reductive dehalogenation. The prevalence of DCE relative to VC and ethene indicates that the reductive dehalogenation process is not sufficient to transform the majority of the DCE to less chlorinated daughter products. The contaminant migration velocity in the sand and gravel aquifer underlying the on-Base terrace may be sufficiently high that the DCE migrates out of the anaerobic, reducing zone before it can be degraded to VC. Diminishing dissolved BTEX concentrations, which provide a ready food source for microbial populations, also may be resulting in diminishing reductive dehalogenation rates. As described in Section 4.4.1, available concentration versus time data for total 1,2-DCE in samples from 12 wells suggest that 1,2-DCE concentrations in many portions of the site are gradually decreasing over time due to the combined effects of RNA and engineered remedial activities. However, additional data are needed to confirm this observation.

Microbial consumption of both native and anthropogenic organic carbon compounds creates conditions favorable for reductive dehalogenation. Anthropogenic carbon compounds are present as petroleum hydrocarbons (including, but not limited to, BTEX) that are dissolved in groundwater, while native carbon compounds include solid organic matter in the aquifer matrix and whatever portion of that matter that has dissolved into site groundwater. These compounds are electron donors in redox reactions that are also consuming electron acceptors such as DO, ferric iron, carbon dioxide, and CAHs. Plots of these electron donors, electron acceptors, and byproducts of these reactions (Figures 4.12 through 4.17) provide strong qualitative evidence of the occurrence of these processes. Additional indicators, such as ORP, alkalinity, ammonia concentrations, and VFAs, further confirm that biodegradation reactions are ongoing and have created reducing conditions that foster reductive dehalogenation.

Despite the strong indications that reductive dehalogenation of CAHs is occurring in OU 1 groundwater, it should be noted that the conditions that are conducive to the occurrence of this process appear to be limited to the on-Base portion of the OU. Reductive dehalogenation appears to be relatively insignificant in the Weber River valley alluvial aquifer; therefore, further reductive dehalogenation of CAHs that migrate off-Base appears to be minimal to nonexistent. However, aerobic degradation of the less-chlorinated CAHs (DCE and VC) is probably more prevalent. The abrupt truncation of the VC plume near the Base boundary, where groundwater becomes relatively aerobic, is a direct indication that VC is being used as an electron donor in aerobic, microbially-mediated redox reactions.

As discussed in Section 4.5, rates of CAH degradation estimated from data collected for this investigation range from 4×10^{-8} day^{-1} to 4×10^{-4} day^{-1}, with most rates ranging from 1.4×10^{-4} day^{-1} to 4.3×10^{-4} day^{-1} (equivalent to half-lives of 13.6 years to 4.4 years). These rates are similar to field-scale biodegradation rates for total DCE or *cis*-1,2-DCE, derived from seven other studies and reported by Wiedemeier *et al.* (1996b), which range from 0.00016 day^{-1} to 0.009 day^{-1} (half-lives = 11.9 years to 0.2 year).

As petroleum hydrocarbons continue to be consumed, reductive dehalogenation will continue; however, once BTEX compounds are completely degraded, the rate at which CAHs are dehalogenated in the on-Base area may slow slightly as the microbes utilize less easily degradable fuel hydrocarbons and possibly also chlorinated benzenes. However, these other fuel hydrocarbons and the native carbon compounds should be sufficient to sustain continuing biodegradation and maintain reducing conditions within the on-Base portion of the plume area unless the fuel constituents are removed via engineered remediation. It also is conceivable that the plume may eventually come to display only type 3 behavior, but this will depend on the concentrations and degradability of the remaining (non-BTEX) fuel hydrocarbon compounds relative to the native organic matter.

As the type of organic matter used during biodegradation changes, the redox conditions may change and alter which reactions are favored. This also could affect the rates at which CAHs are reductively dehalogenated and cause dehalogenation of some compounds to cease. If and how this will happen is difficult to predict; the relative "degradability" of the native organic matter (or non-BTEX fuel hydrocarbons) and the effect of a changing electron donor source is not yet well-understood. It can be stated that if conditions become more oxidizing (but not aerobic), dehalogenation of VC may cease

outright, and that the dehalogenation of DCE may also cease or slow. However, aerobic and/or anaerobic mineralization of VC and DCE may become more important.

Wiedemeier *et al.* (1996b) present a worksheet to allow an initial assessment of the prominence of natural attenuation at a site. The worksheet, including the point values determined for OU 1 near the source areas and within the northern portion of the contaminant plume in the Weber River valley, are included in Table 4.10. The interpretation of points awarded during the screening process outlined in Table 4.10 is shown in Table 4.11. The score for the on-Base portion of the contaminant plume near the source areas is 33, indicating that strong evidence for reductive dechlorination of chlorinated organics is present. The score for the downgradient portion of the DCE plume in the Weber River Valley is 2.5, indicating inadequate evidence for reductive transformation of chlorinated organics is present. The low score for the downgradient portion of OU 1 does not necessarily mean that biodegradation of CAHs is not occurring. The screening process presented in Table 4.10 is oriented toward reductive dehalogenation, which is an anaerobic process. DCE and vinyl chloride can be degraded aerobically, and aerobic degradation of these CAHs is most likely occurring in the Weber River Valley.

TABLE 4.10
ANALYTICAL PARAMETERS AND WEIGHTING FOR PRELIMINARY RNA SCREENING
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Analysis	Concentration in Most Contaminated Zone	Interpretation	Value	On-Base near Source Areas	Weber River Valley
Oxygen	<0.5 mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	3	3	1
	>1 mg/L	VC may be oxidized aerobically	-3	-1	-2
Nitrate	<1 mg/L	At higher concentrations may compete with reductive pathway	2	2	1
Ferrous Iron	>1 mg/L	Reductive pathway possible	3	3	1
Sulfate	<20 mg/L	At higher concentrations may compete with reductive pathway	2	2	0
Sulfide	>1 mg/L	Reductive pathway possible	3	0	0
Methane	<0.5 mg/L	VC oxidizes	0	0	0
	>0.5 mg/L	Ultimate reductive daughter product, VC accumulates	3	1.5	0
ORP	<50 mV	Reductive pathway possible	1	--	1
	<-100mV	Reductive pathway likely	2	2	0
pH	5 < pH < 9	Optimal range for reductive pathway	0	0	0
	5 > pH >9	Outside optimal range for reductive pathway	-2	0	0
TOC	> 20 mg/L	Carbon and energy source; drives dechlorination; can be natural or anthropogenic	2	2	0
Temperature	> 20°C	At T >20°C biochemical processes are accelerated	1	0	0
Carbon Dioxide	>2x background	Ultimate oxidative daughter product	1	1	0
Alkalinity	>2x background	Results from interaction of carbon dioxide with aquifer minerals	1	.5	0
Chloride	>2x background	Daughter product of organic chlorine	2	0	0
Hydrogen	>1 nM/L	Reductive pathway possible, VC may accumulate	3	3	0
Hydrogen	<1 nM/L	VC oxidized	0	0	0

TABLE 4.10 (Continued)
ANALYTICAL PARAMETERS AND WEIGHTING FOR PRELIMINARY RNA SCREENING
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Analysis	Concentration in Most Contaminated Zone	Interpretation	Value	On-Base Near Source Areas	Weber River Valley
Volatile Fatty Acids	> 0.1 mg/L	Intermediates resulting from biodegradation of aromatic compounds; carbon and energy source	2	2	0
BTEX	> 0.1 mg/L	Carbon and energy source; drives dechlorination	2	2	0
PCE		Material released	0	0	0
TCE		Material released	0	0	0
		Daughter product of PCE	2[a/]	0	0
DCE		Material released	0	0	0
		Daughter product of TCE.	2[a/]	2	0
		If *cis* is greater than 80% of total DCE it is likely a daughter product of TCE			
VC		Material released	0	0	0
		Daughter product of DCE	2[a/]	2	0
Ethene/Ethane	>0.01mg/L	Daughter product of VC/ethene	2	0	0
	>0.1 mg/L		3	3	0
Chloroethane		Daughter product of VC under reducing conditions	2	--	--
1,1,1-Trichloroethane		Material released	0	0	0
1,2-dichlorobenzene		Material released	0	--	--
1,3- dichlorobenzene		Material released	0	--	--
1,4- dichlorobenzene		Material released	0	--	--
chlorobenzene		Material released or daughter product of dichlorobenzene	2[a/]	0	0
1,1-DCE		Daughter product of TCE or chemical reaction of 1,1,1-TCA	2[a/]	2	.5
		TOTAL		**33**	**2.5**

Note: Partial points are awarded in cases where the stated condition is partially fulfilled (e.g., when the condition is fulfilled within a portion of the area of interest, but not within the entire area).

a/ Points awarded only if it can be shown that the compound is a daughter product (i.e., not a constituent of the source NAPL).

TABLE 4.11
INTERPRETATION OF POINTS AWARDED DURING NATURAL ATTENUATION SCREENING
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Score	Interpretation
0 to 5	Inadequate evidence for reductive transformation of chlorinated organics
6 to 14	Limited evidence for reductive transformation of chlorinated organics
15 to 20	Adequate evidence for reductive transformation of chlorinated organics
>20	Strong evidence for reductive transformation of chlorinated organics

SECTION 5

GROUNDWATER FLOW AND CONTAMINANT TRANSPORT MODEL

5.1 GENERAL OVERVIEW AND MODEL DESCRIPTION

In order to help predict the future migration and fate of *cis*-1,2-DCE (hereafter referred to as DCE) dissolved in groundwater in the vicinity of OU 1 at Hill AFB, Parsons ES modeled shallow groundwater flow and the fate and transport of the dissolved DCE plume. The modeling effort had three primary objectives: 1) predict the future extent and concentrations of the dissolved contaminant plume by modeling the combined effects of advection, dispersion, sorption, and biodegradation; 2) assess the potential for downgradient receptors to be exposed to contaminants at concentrations above regulatory levels of concern; and 3) if applicable, provide technical support for the natural attenuation remedial option at post-modeling regulatory negotiations. The model was developed using site-specific data and conservative assumptions about governing physical and chemical processes. The model input data are believed to be reasonably conservative so that the actual reduction in contaminant mass caused by natural attenuation should meet or exceed model predictions.

The model codes MODFLOW (McDonald and Harbaugh, 1988) and MT3D (Zheng, 1990) were used to estimate the potential for dissolved DCE migration and attenuation by natural processes operating at the site. MODFLOW was used to generate a groundwater flow model for the site. The MODFLOW flow field was incorporated into the transport solution computed by MT3D (version 1.1). The pre- and post-processors contained in Visual MODFLOW, version 2.50 (Waterloo Hydrogeologic Software, 1997), were used to facilitate model development and analysis and presentation of the model results. The MT3D code incorporates advection, dispersion, sorption, and biodegradation to simulate contaminant plume migration and degradation. MT3D uses solution routines based on the Method of Characteristics (MOC) solute transport model [e.g., as developed by Konikow and Bredehoeft (1978) for the US Geological Survey (USGS) two-dimensional (2-D) MOC model code]. The MOC model was modified by Zheng (1990) to allow three-dimensional (3-D) solutions, and to allow use of a modified MOC that reduces numerical dispersion; the modified model is called MT3D.

5.2 CONCEPTUAL MODEL DESIGN AND ASSUMPTIONS

The area of concern for this model includes the on-Base and off-Base portions of OU 1, especially where DCE has been detected. The hydrogeology of the model area is described in detail in Section 3. As described in that section, the groundwater system of concern for this model area is quite complex, including the shallow saturated zones beneath the on-Base terrace, the escarpment, and the Weber River valley. This system

includes more than 300 feet of head drop from south to north, through multiple heterogeneous units. The DCE plume is migrating primarily through the shallowest hydrogeologic units on the terrace and in the Weber River valley. On-Base, DCE migration is almost entirely within the shallow sand and gravel unit (Provo Formation) overlying the clays of the Alpine Formation, while off-Base the DCE migrates down the escarpment and through the shallow upper sand units in the Weber River valley. The hydrogeology of the on-Base unit is relatively well understood, and the valley hydrogeology is less well understood. The hydrogeology and migration pathways within the escarpment are poorly understood.

Modeling of the complex hydrogeologic system at OU 1 required that simplifying assumptions be made to allow completion of the modeling task within the scope and budget of this effort. The nature of the site required a 3-dimensional model, but the paucity of data regarding flow and transport through the escarpment and some of the valley area limited the detail that could be represented. It therefore was assumed that the system could be adequately represented by a 6-layer model, with the upper layer used for the on-Base terrace, the next three layers used to account for the escarpment, and the lower two layers used to represent the valley aquifer system.

March 1997 water level data and hydraulic gradients within the OU 1 flow system are presented in Section 3. Review of these data and the water table maps presented by Montgomery Watson (1995b), indicate that the groundwater flow patterns interpreted from March 1997 water levels are reasonably representative of steady-state conditions. The water table across the study area is assumed to be influenced by continuous recharge from areas south of OU 1, recharge from precipitation and the Davis-Weber Canal, and discharge to areas north of the OU.

Solvents, fuels, and other liquid wastes were disposed of in the landfills, CDPs, and FTA 1 through the mid-1970s. For modeling purposes, it was assumed that contaminants first entered the groundwater when wastes were first introduced into Landfill 3 in 1940, and that residual and mobile NAPL contamination associated with the buried waste has acted as a continuous source. It was also assumed that after waste disposal in the source areas ceased in the 1970s, the contaminant flux into the aquifer remained constant until 1980. After 1980, it is assumed that the source began to significantly weather (lose mass) due to processes such as volatilization, dissolution, and biodegradation, and that the mass of contaminants entering groundwater began to decline. Past experience with the AFCEE Natural Attenuation Initiative has suggested that residual and mobile LNAPL sources can weather at rates as rapid as 7 percent per year. However, to be conservative, and because the contaminant sources are poorly characterized, it was assumed that the source at OU 1 would weather at about 2 percent per year. Thus, the model assumes that after 1980, the source loading rates decreased geometrically by 2 percent per year (each year's source strength was decreased by 2 percent from the previous year's strength).

The most important assumption made when using the MT3D code is that dispersion, sorption, and biodegradation are major factors controlling contaminant fate and transport at the site. According to data presented in Sections 3 and 4, concentrations of organic carbon within the site soils may support significant sorption. Data also suggest that both anaerobic and aerobic biodegradation of DCE is occurring within the contaminant plume. Dispersivity, which is a characteristic of the porous medium, is a measure of the longitudinal and lateral spreading of the contaminant plume caused by local

heterogeneities that cause deviations from the average linear solute migration velocity. The magnitude of dispersion is generally believed to be scale-dependent: the longer the plume flowpath, the greater the dispersion. Given the considerable length of the plume flowpath (4,000 feet) and the documented presence of subsurface heterogeneities (Section 3), it is reasonable to assume that dispersion is an important parameter influencing solute transport in the study area. Dispersion is estimated using literature values and accepted rules-of-thumb; sorption (assumed to be a linear process) is simulated using a coefficient of retardation; and biodegradation is simulated using a first-order decay constant. Selection of values for these model input parameters is discussed in Section 5.3.3.

5.3 INITIAL MODEL SETUP

Where possible, the initial setup for this model was based on site-specific data. Where site-specific data were not available (e.g., for effective porosity), reasonable assumptions were made on the basis of widely accepted literature values for materials similar to those found in the shallow units at OU 1. The following sections describe the basic model setup. Those model parameters that were varied during model calibration are discussed in Section 5.4.

5.3.1 Grid Design

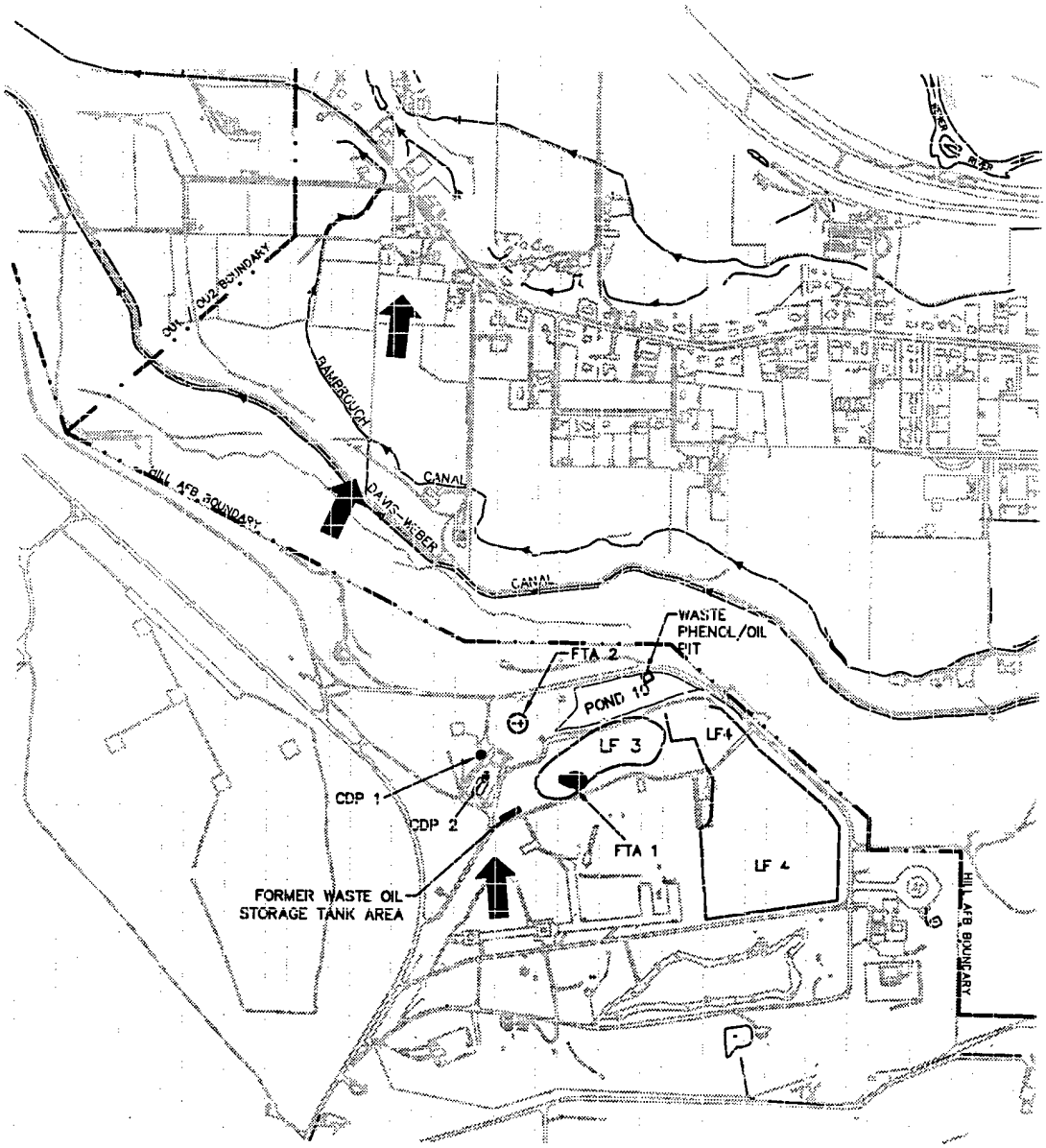
As noted above, the model domain for OU 1 is represented using 6 layers, with a 50-cell by 50-cell horizontal grid. The long axis of the model grid is oriented north-south, parallel to the primary direction of shallow groundwater flow in the area. The model cells are of uniform size, with dimensions of 136 feet (west-to-east) by 180 feet (north-to-south). The model grid is shown on Figure 5.1. A finer grid was considered, especially to aid in representing features in the on-Base area; however, this required more computing time and data storage than was feasible.

5.3.2 Groundwater Flow Model

5.3.2.1 Boundary Conditions

In defining the model domain, the area of interest must be separated from the surrounding system. Boundary conditions describe the interaction between the system being modeled and its surroundings or, for transport models, the loading of contaminant mass into the system. Boundary conditions are used to include the effects of the system outside the area being modeled with the system being modeled, while at the same time allowing the isolation of the desired model domain from the larger system. In effect, the boundaries of the model tell the area immediately inside the boundaries what to expect from the outside world. The solution of any differential equation requires specification of the conditions at the periphery of the system. Model boundaries are thus mathematical statements that specify the dependent variable (head or contaminant concentration) or the flux (derivative of the head or contaminant concentration with respect to time) at the model grid boundaries.

Three types of boundary conditions generally are used to describe groundwater flow and solute transport. Boundary conditions are referred to as specified-head type (Dirichlet), specified-flux type (Neumann), and head-dependent or mixed type (Cauchy). Table 5.1 summarizes boundary conditions for groundwater flow and solute transport.



LEGEND

INFERRED GROUNDWATER FLOW DIRECTION

0 600 1200

FEET

FIGURE 5.1

MODEL GRID

OU 1 RNA TS
Hill Air Force Base, Utah

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Denver, Colorado

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TABLE 5.1
COMMON DESIGNATIONS FOR SEVERAL IMPORTANT BOUNDARY CONDITIONS
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Boundary Condition	Formal Name	General Mathematical Description	
		Groundwater Flow	Contaminant Transport
Specified-Head or Specified-Concentration	Dirichlet	$H = f(x,y,z,t)$	$C = f(x,y,z,t)$
Specified-Flux	Neumann	$\frac{\partial H}{\partial n} = f(x,y,z,t)$	$\frac{\partial C}{\partial n} = f(x,y,z,t)$
Head-Dependent or Concentration-Dependent Flux (mixed-boundary condition)	Cauchy	$\frac{\partial H}{\partial n} + cH = f(x,y,z,$	$\frac{\partial C}{\partial n} + cC = f(x,y,z,t)$

(Modified from Franke *et al.*, 1987)

In flow models, boundary conditions are ideally used to specify actual hydrogeologic boundaries to the system, such as a geologic feature that may bound a system or areas where properties (e.g., flux) are known and can be defined. When using a numerical flow model, hydrologic boundaries such as constant-head features (e.g., lakes, streams, etc.) or constant-flux features (e.g., groundwater divides, confining units, etc.,) should, when possible, coincide with the perimeter of the model. In areas that lack obvious hydrologic boundaries, constant-head or constant-flux boundaries can be specified at the numerical model perimeter as long as the perimeter is far enough removed from the contaminant plume that transport calculations will not be affected by inaccuracies in the simulated boundary conditions.

The actual model area is a sub-area of the grid shown in Figure 5.1, and is defined using no-flow (specified-flux) cells. The configuration of each of the six model layers is shown in Appendix D. Some of the cells above some of the model layers (i.e. layers 2 - 6) are defined as no-flow cells. This does not mean those layers actually represent confined units, because MODFLOW treats a layer as confined only if the simulated head is higher than the top of the model cell. In addition, MODFLOW applies precipitation recharge to the uppermost active cells.

Because of the long horizontal distance involved, the shallow aquifer in the Weber River valley was split into two layers to allow for sufficient head drop (the observed head drop from the base of the escarpment to well U1-1636 is more than 50 feet, and the shallow aquifer is not nearly as thick as this head-drop valve). One thicker layer could have been used, but this would have allowed for excessive dilution of the simulated contaminant plume.

The base of layer 1 was defined using borehole data presented by Montgomery Watson (1995b) to contour the top of the silty clay (Alpine) unit. As a result, the channels and other features of that surface are represented in the model. Specified-head cells were defined at the northern and/or southern ends of model layers 1, 5, and 6

(Appendix D). The specified heads at the northern end of layer 6 and the southern end of layer 1 were estimated by projecting heads from the March 1997 groundwater flow maps. In addition, the constant-head boundary at the southern end of layer 5 was set so that this unit was unconfined. North of the escarpment, flow from the upper layers merges with the flow from this layer. While all the groundwater in the lower sand unit may not necessarily merge with the flow from the escarpment, data from hydrostratigraphic cross-sections (Section 3) suggest that there is some combining of flow in that area.

Constant-head cells also were placed at the southern end of layer 6, in part because groundwater elevation contour patterns in the area appear to be partially controlled by discharge to springs and surface water in the area of South Weber Drive. This was also done because little is known about the hydraulic conditions in that area, and some form of control on the water table was necessary.

The base or lower boundary of the model was assumed to be no-flow and was set at 4,400 feet msl. The upper model boundary is defined by the simulated water table surface, although an arbitrary top of the model domain was set at 5,000 ft msl because cell-top elevations are required for initial grid configuration.

5.3.2.2 Recharge and Evapotranspiration

The recharge package of MODFLOW was used to simulate recharge from precipitation, in addition to leakage from the Davis-Weber Canal. Recharge over most of the model area was set at 2.5 inches per year, or about 14 percent of annual precipitation. This is consistent with recharge values used by Montgomery Watson (1995a) in their model of the OU 1 terrace area. In the area of the Davis-Weber Canal, recharge was increased by about 0.06 inch per year to reflect leakage. This fraction is relatively small because the leakage is spread out over an entire year rather than for part of the year, as actually occurs.

5.3.2.3 Aquifer Properties

Hydraulic conductivity values were obtained from the results of slug and pumping tests performed by Montgomery Watson (1995b). The calculated values are summarized in Appendix A and discussed in Section 3.4.2.3. Average hydraulic conductivities similar to those discussed in Section 3.4.2.3 were initially defined for each portion of the model domain (e.g., for the on-Base sand and gravel unit and for the valley alluvium).

As discussed in Section 3.3.2.3, the effective porosity is the percentage of a rock or sediment through which fluids can travel. Effective porosity values of 20 to 25 percent were defined for the units within the model domain on the basis of the grain-size distribution observed in the shallow surficial aquifer (Spitz and Moreno, 1996). Generally, the lower effective porosity was assigned to off-Base units, as they tended to be finer-grained than the on-Base units.

5.3.2.4 Aquifer Stresses

Because pumping has been ongoing in the on-Base area of OU 1, the model also included pumping wells. These wells were used to simulate pumping from wells U1-201, U1-202, U1-205, U1-206, and U1-207, as well as from the trench just north of LF 3

(Figure 1.3). Pumping rates were calculated as an average of rates reported for 1994 through 1996 (Bourne, 1997). For the trench, it was assumed that half the length of the trench contributed to the pumping from each of the sumps (U1-203 and U1-204), and the pumping rates were thus divided among the cells representing the trench. Initial calibration runs suggested that the wells had little influence on the head distribution; this also is suggested by the lack of observable cones of depression on water table maps presented in Section 3 and by Montgomery Watson (1995b). Therefore, to simplify the model, the wells were set to be pumping for the entire length of the simulation. This likely required that contaminant source concentrations for the transport model were slightly higher than they would have otherwise been, but most of the plume area is not influenced by this pumping.

5.3.2.5 Aquifer Storage

Because MT3D version 1.1 requires that hydraulic data from the MODFLOW model is from a transient simulation, aquifer storage properties had to be assigned. In general, the model area is largely unconfined, and a specific yield of 0.20 was assigned. Specific yield can be assumed to be similar to the effective porosity of the aquifer because it represents the water that can drain from the pores of the aquifer material.

5.3.3 Contaminant Transport Model

As noted at the beginning of this section, the model was set up to simulate fate and transport of DCE. Biodegradation rates calculated in Section 4 represent both reductive dechlorination (on-Base) and aerobic oxidation (off-Base). However, because VC generally has not been observed in off-Base wells, the fate and transport of VC was not simulated in conjunction with that of DCE. The *cis*-1,2-DCE concentrations obtained from March 1997 laboratory analytical results for 58 monitoring wells/points and piezometers were used as targets for model calibration. Table 4.3 presents dissolved DCE concentration data for March 1997, and Figure 4.5 shows the spatial distribution of dissolved DCE in March 1997.

5.3.3.1 Source

Transport models use boundary conditions to express the influence of contaminant sources such as mobile and residual nonaqueous-phase liquid (NAPL), biodegradation of parent compounds, and dissolved mass entering through recharge, injection wells, surface water bodies, or leaking structures. Sources such as NAPL bodies may be represented as specified-concentration boundaries (limited by solubility constraints or observed maximum concentrations) or as specified-flux boundaries (for which the chemical loading rate must be known or estimated). However, in most cases, only the effects of the source are measured; the detailed source characteristics and history are typically unknown (Spitz and Moreno, 1996). The source must therefore be represented as a "black box" that produces appropriate contaminant concentrations or fluxes at selected points in the model. The source may be misrepresented under such a scenario, but there is often little choice in the matter. Estimating contaminant flux into groundwater from NAPL is difficult and is dependent upon several parameters, most of which cannot be measured (Abriola, 1996; Feenstra and Guiguer, 1996).

Rather than using various calculations to attempt to estimate DCE partitioning from mobile and residual NAPL into groundwater, the "black-box" source approach was used. Experience modeling contaminated sites as part of the AFCEE Natural Attenuation Initiative has suggested that this is the best currently available method for reproducing observed plumes. At OU 1, the DCE is assumed to enter groundwater in the study area through contact between groundwater and mobile or residual NAPL at or below the water table. The NAPL at this site actually contains TCE, but site data and experience at other Air Force sites indicate that dechlorination of TCE to DCE is very rapid in the vicinity of the source when fuel hydrocarbons are present, as at OU 1. Partitioning of DCE from this source into groundwater was simulated by defining source area recharge concentrations in 43 model cells in the vicinity of the LNAPL body (Appendix D). As noted in Section 5.2, it was assumed that contaminants first entered groundwater in 1940. The model assumes that source concentrations were constant until 1980, and then decreased geometrically at a rate of 2 percent per year to reflect the effects of source weathering.

5.3.3.2 Dispersivity

Published data summarized by Spitz and Moreno (1996) suggest that, as a rule of thumb, longitudinal dispersivity is approximately one-tenth the travel distance of the plume (from the source to the downgradient toe), which is equivalent to approximately 490 feet at OU 1 (plume length of 4,900 feet) (Figure 4.3). Transverse dispersivity values are estimated as one-tenth of the longitudinal dispersivity values, and vertical dispersivity typically is assumed to be one-hundredth of the longitudinal dispersivity (Domenico and Schwartz, 1990).

5.3.3.3 Retardation

Retardation of contaminants relative to the advective velocity of the groundwater occurs when contaminant molecules are sorbed to organic carbon, silt, or clay in the aquifer matrix. Using measured TOC concentrations near the water table at 11 locations across the site (see Table 4.1), an assumed bulk density of 1.4 kilograms per liter (kg/L), and a published value of the soil sorption coefficient (K_{oc}) for DCE (as listed in Wiedemeier *et al.*, 1996b), the coefficient of retardation for *cis*-1,2-DCE was calculated. The results of these calculations are summarized in Table 5.2. The lower the assumed coefficient of retardation, the faster the DCE plume will migrate downgradient. Initially, the average calculated retardation coefficient of 1.15 was assigned to the model.

5.3.3.4 Biodegradation

As discussed in Section 4.5, first-order decay rates of about 2×10^{-4} day^{-1} to 3×10^{-4} day^{-1} were calculated for DCE using site-specific data. These rates were used to define initial values for model input. An initial estimate of 2×10^{-4} day^{-1} was defined for the model domain.

5.4 MODEL CALIBRATION

Model calibration is an important component in the development of any numerical groundwater model. Calibration of the flow model demonstrates that the model is capable of matching hydraulic conditions observed at the site; calibration of a contaminant transport model superimposed upon the calibrated flow model helps

TABLE 5.2
CALCULATION OF RETARDATION COEFFICIENTS
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Location	Compound	K_{oc} (L/kg [a])	Maximum Fraction Organic Carbon [b]	Minimum Fraction Organic Carbon [b]	Average Fraction Organic Carbon [b]	Distribution Coefficient K_d (L/kg) Maximum [c1]	Minimum [c2]	Average [c3]	Bulk Density (kg/L) [d]	Effective Porosity [d]	Coefficient of Retardation Maximum	Minimum	Average
On-Base Sand/Gravel	cis-1,2-DCE	49	0.00047	0.00047	0.00047	0.023	0.023	0.023	1.65	0.25	1.15	1.15	1.15
Hillside Colluvium	cis-1,2-DCE	49	NM [e]	NM	NM	--	--	--	NA	NA	--	--	--
Shallow Valley Alluvium	cis-1,2-DCE	49	0.00115	0.00018	0.00067	0.056	0.009	0.033	1.60	0.20	1.45	1.07	1.26

[a] From technical protocol (Wiedemeier *et al.*, 1996b).
[b] From laboratory analyses of site soil samples.
[c1] K_d = Maximum Fraction Organic Carbon x K_{oc}.
[c2] K_d = Minimum Fraction Organic Carbon x K_{oc}.
[c3] K_d = Average Fraction Organic Carbon x K_{oc}.
[d] Estimated Value.
[e] NM = Not measured.

demonstrate that contaminant loading and transport conditions are being appropriately simulated. Model input and output summaries are included in Appendix F.

5.4.1 Groundwater Flow Model

Groundwater elevation data collected in March 1997 and presented on Figure 3.9 were used to calibrate the flow model. Water level elevation data from 84 monitoring wells/points were used to compare measured and simulated heads for calibration. The selected locations are listed in Appendix D.

The numerical flow model was calibrated by altering hydraulic conductivity, constant-head elevations at the model boundaries, and the recharge parameters in a trial-and-error fashion until simulated heads approximated observed field values within a prescribed accuracy. In general, hydraulic conductivities were varied within the limits of the observed data, although some values were increased slightly beyond the measured range. The flow model was initially calibrated as a steady-state model; later, it was run as a transient model to facilitate the transport solution. The steady-state heads were used as initial heads for the transient model, and the heads did not change significantly because the transient system quickly matched the steady-state system.

Figure 5.2 shows the calibrated water table. Calibrated model hydraulic conductivities ranged between 0.07 and 250 ft/day. In general, the highest conductivity values (40 to 250 ft/day) were used for the terrace, while lower values (0.07 to 100 ft/day) were used for the escarpment. In the valley, hydraulic conductivities were in the range of 10 to 25 ft/day. A continuous aquifer is not present beneath the hillside; however, the aquifer was assumed to be continuous for modeling purposes. Hydraulic conductivities of the hillside aquifer are spatially variable in the calibrated model to simulate the presence of preferential migration pathways such as field drains and failure planes. Hydraulic conductivity distributions for each layer are presented in Appendix D. Vertical hydraulic conductivities that produced the best fit were generally in the range of 0.02 to 0.15 ft/day. Higher values, particularly for the escarpment, resulted in models that failed to converge or that produced division by zero errors.

The root mean squared (RMS) error is commonly used to express the average difference between simulated and measured heads. RMS error is the average of the squared differences between measured and simulated heads, and can be expressed as:

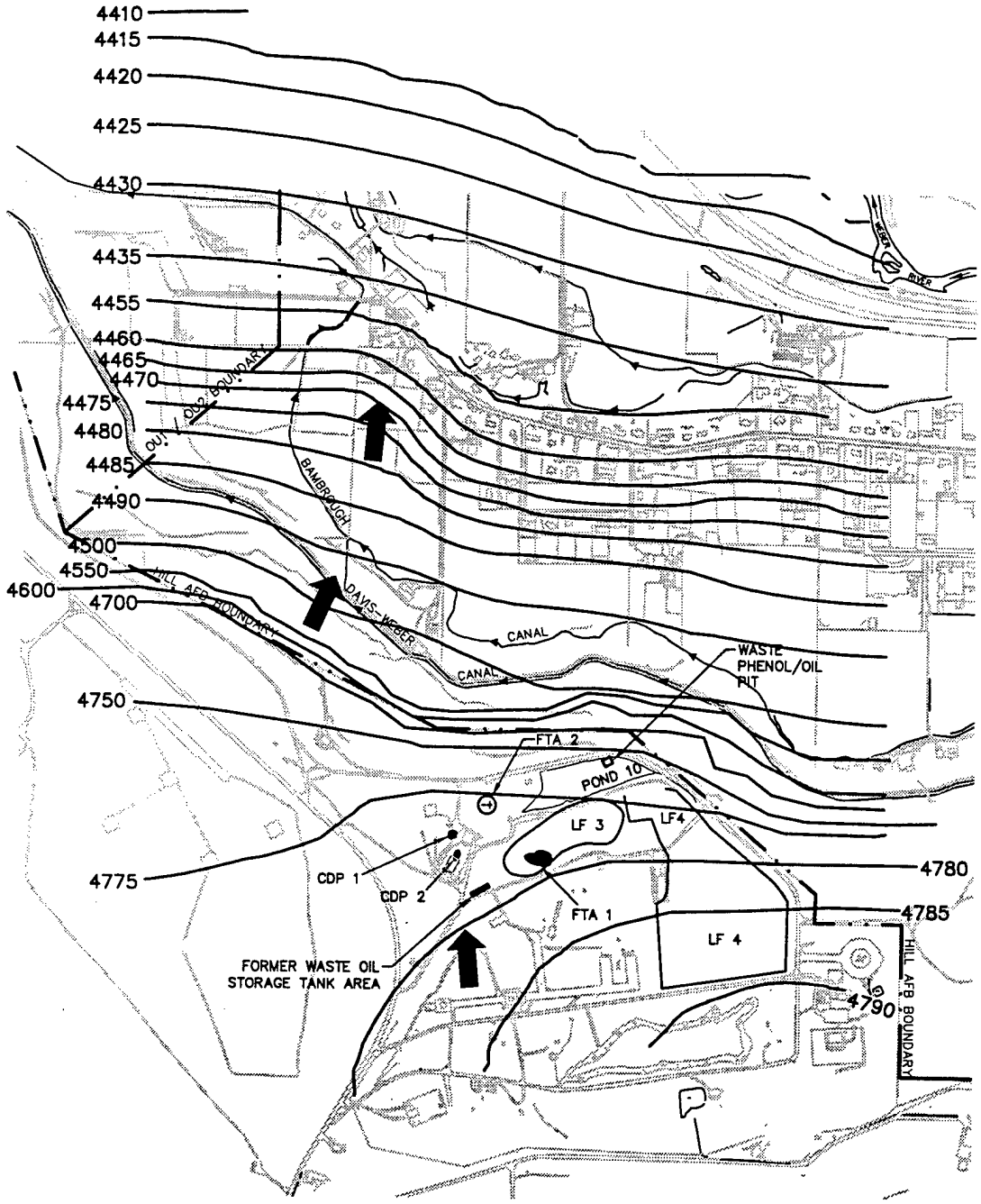
$$\mathrm{RMS} = \left[\frac{1}{n} \sum_{i=1}^{n} \left(h_m - h_s \right)_i^2 \right]^{0.5}$$

where: n = the number of points where heads are being compared,

h_m = measured head value, and

h_s = simulated head value.

The RMS error between observed and calibrated values at the 84 comparison points was 13.5 feet, which corresponds to a calibration error of 3.8 percent (water levels



LEGEND

4780 — LINE OF EQUAL SIMULATED GROUNDWATER ELEVATION (feet msl), CONTOUR INTERNAL = VARIABLE

INFERRED GROUNDWATER FLOW DIRECTION

0 600 1200
FEET

FIGURE 5.2

CALIBRATED GROUNDWATER SURFACE

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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dropped approximately 353 feet over the model domain). The relation between measured heads and simulated heads and the resulting RMS is shown in Appendix D. This plot provides a qualitative method of checking the calibrated head distribution; the points should scatter randomly about the straight line (Anderson and Woessner, 1992). In general, this is the case for the OU 1 model; however, several points at the edge of the escarpment had similar calculated head values, resulting in a horizontal line of points. This is not a true random scattering, but heads at these locations did not change significantly during calibration, and attempts to alter them produced less desirable changes elsewhere. It is likely that these heads are somewhat controlled by the elevation of the edge of the escarpment. As a result, this non-random pattern was not considered to be a significant problem.

In solving the groundwater flow equation, Visual MODFLOW establishes the water table surface and calculates an overall hydraulic balance that accounts for the numerical difference between flux into and out of the system. The hydraulic mass balance for the steady-state calibrated flow model was adequate to accomplish the objectives of this modeling effort, with a 0.6-percent discrepancy. According to Anderson and Woessner (1992), a mass balance error of around 1 percent is acceptable, while Konikow (1978) indicates an error of less than 0.1 percent is ideal.

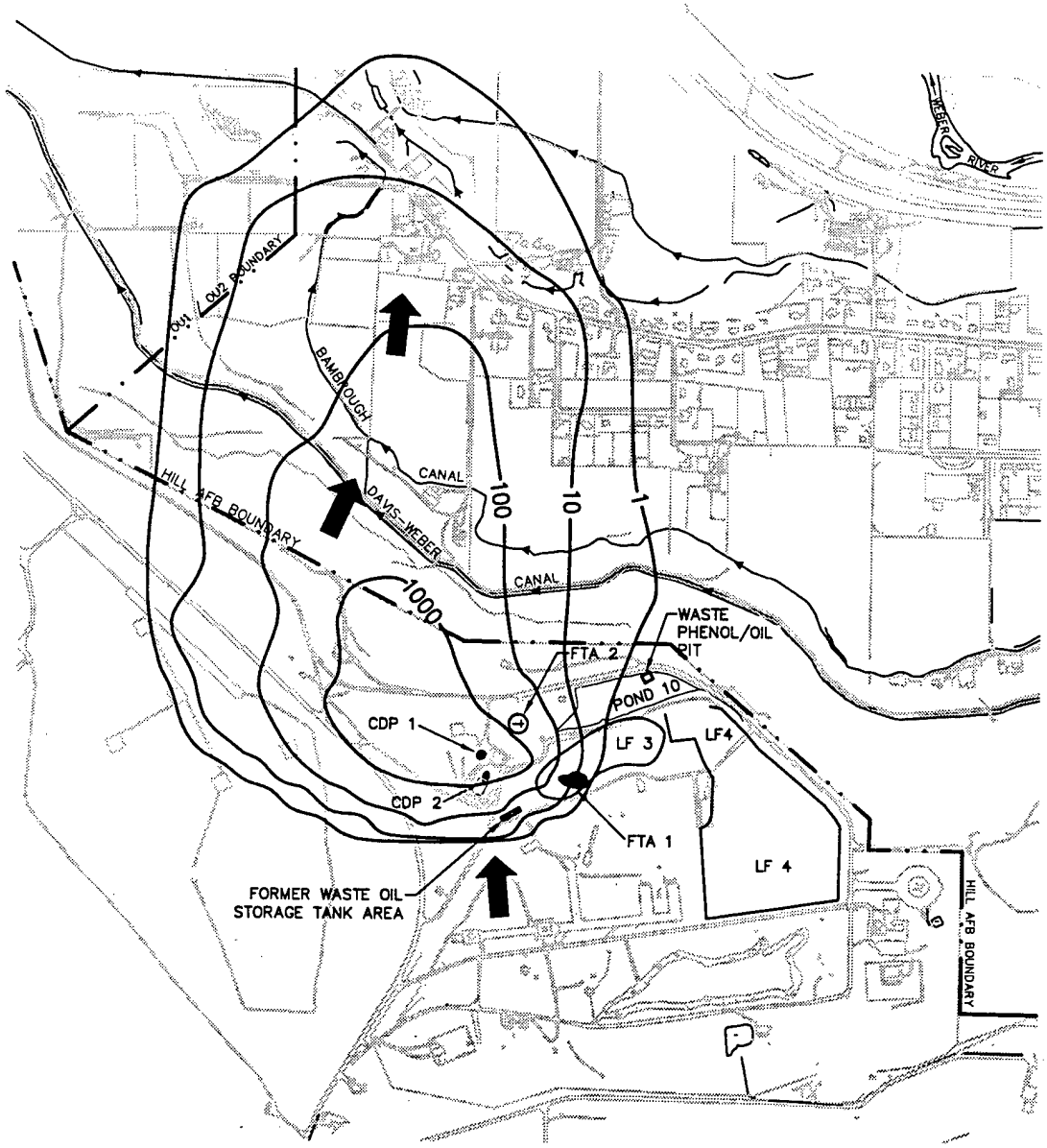
5.4.2 Plume Calibration

After calibration of the flow model, the numerical solute transport model was calibrated by altering the contaminant specified-flux rate in the source cells and contaminant transport parameters in a trial-and-error fashion until the simulated plume approximated observed field values. For plume calibration, the model was run for a 57-year period (1940 to 1997). The transport parameters varied during plume calibration were the source-cell loading concentrations, the plume dispersivity, the DCE decay rate constant, and the distribution coefficient for contaminant sorption. In addition, the hydraulic conductivity of the alluvium in the Weber River valley was reduced slightly (this did not affect model heads noticeably).

The dissolved DCE concentrations obtained from March 1997 laboratory analytical data from 58 monitoring wells/points and surface water or seep locations were used to calibrate the contaminant transport model. Calibration sample locations and names are presented in Appendix D.

The longitudinal dispersivity of 490 feet produced a simulated plume far longer and wider than that observed in 1997. This value was gradually decreased to 25 feet. This is the value used to produce the calibrated plume depicted on Figure 5.3.

The decay rate was varied during plume calibration, and was important in controlling plume length and concentration distributions. The calibrated model used values ranging from 3×10^{-4} day^{-1} for the layers representing the escarpment to 1.3×10^{-3} day^{-1} in layer 6 (the northern portion of the Weber River Valley). On the terrace (layer 1), the rate was 8×10^{-4} day^{-1}, and in layer 5 (the southern portion of the Weber River valley) the rate was 5×10^{-4} day^{-1}. Such variation was needed to produce a DCE isopleth distribution similar to that shown on Figure 4.5.



LEGEND

—100— LINE OF EQUAL SIMULATED DCE CONCENTRATION (µg/L) CONTOUR INTERVAL = VARIABLE

INFERRED GROUNDWATER FLOW DIRECTION

0 600 1200

FEET

FIGURE 5.3

CALIBRATED cis-1,2-DCE PLUME

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

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During plume calibration, the K_d and consequently the retardation coefficient (R) was varied, and the calibrated model used a value of 2 for the terrace (layer 1) and a value of 2.5 for all other portions of the model. This value is greater than the range estimated on the basis of observed TOC concentrations. However, Domenico and Schwartz (1992) and Pankow and Cherry (1996) note that sorption of organic compounds estimated on the basis of TOC alone is often underestimated because the role of sorption onto clays and other mineral surfaces is ignored. In addition, Ball and Roberts (1991) note that partitioning coefficients (used to calculate retardation coefficients in conjunction with TOC data) can be underestimated because the laboratory studies used to derive the partitioning coefficients are performed on a short time scale (days to months). In reality, most field-scale situations (such as OU 1) involve time scales of tens of years. Regardless, the higher retardation coefficients used in the model were needed to help reproduce observed concentrations without eliminating dispersivity and without raising decay rates well above the calculated range.

The calibrated plume calculated by the model (Figure 5.3) is similar, but not identical, to the observed March 1997 plume (Figure 4.5). Simulated DCE concentrations in the heart of the source area are slightly lower than observed March 1997 concentrations, but the extent of the 1,000-µg/L isopleth is greater than observed in 1997. Simulated DCE concentrations upgradient from the source area are higher than observed concentrations. Simulated on-Base DCE concentrations downgradient from the source area are generally higher than observed March 1997 concentrations.

Although the maximum simulated source area concentrations were no greater than 3,500 µg/L, it is likely that adequate DCE mass was introduced into the system. The extent of the simulated 1,000-µg/L isopleth is greater than observed, and at many locations the model concentrations are higher than observed. This is important to note because the introduction of sufficient contaminant mass facilitates prediction of downgradient receptor impacts and of plume persistence by accurately reproducing DCE concentrations in the downgradient (off-Base) portions of the plume.

Simulated off-Base DCE concentrations are higher than observed in some locations and lower than observed in other locations. However, the distribution of the isopleths is similar, and this was relied upon more than the actual location-specific concentrations. In part this was done because little is known about the hydrogeology of the off-Base area, and the corresponding model layers are thus relatively homogeneous. At the toe of the plume, concentrations are slightly higher, and the simulated 1-µg/L isopleth extends slightly farther than on Figure 4.5.

5.5 SENSITIVITY ANALYSIS

The purpose of a sensitivity analysis is to determine the effect of varying model input parameters on model output. The sensitivity analysis was conducted by varying the K_d (and consequently the coefficient of retardation), the first-order decay rate, dispersivity, hydraulic conductivity, and effective porosity.

To perform the sensitivity analyses, the calibrated model was adjusted by systematically changing the aforementioned parameters individually, and then comparing the new simulations to the results of the calibrated model. The models were run for a 57-year period, just as the calibrated model was, so that the independent effect of each

variable could be assessed. Thirteen sensitivity runs of the calibrated model were made, with the following variations:

1. K_d reduced until retardation coefficient equaled 1 (no retardation);
2. K_d increased until retardation coefficient equaled calculated average values (1.15 for the terrace and 1.26 for the rest of the domain);
3. K_d increased until retardation coefficient equaled 2.5 for the terrace and 3.0 for the remaining model layers;
4. Decay rate for all layers set to 1.6×10^{-4};
5. Decay rate for all layers set to 1.6×10^{-3};
6. Longitudinal dispersivity set to 490 feet;
7. Longitudinal dispersivity set to 10 feet;
8. All hydraulic conductivities doubled;
9. All hydraulic conductivities halved;
10. All vertical hydraulic conductivities increased by a factor of 10;
11. All vertical hydraulic conductivities decreased by a factor of 10;
12. Effective porosity set to 0.1; and
13. Effective porosity set to 0.35.

The results of the sensitivity analyses are discussed in the following subsections and summarized in Table 5.3. As described in the following paragraphs, the parameter modifications listed above generally resulted in substantial changes in the resulting plumes, with the effective porosity modifications having the smallest effect.

5.5.1 Sensitivity to Variations in the Distribution Coefficient/Coefficient of Retardation

The effects of varying the coefficient of retardation (R) are summarized in columns 1 through 3 of Table 5.3. Uniformly decreasing R to 1.0 greatly increased the length and width of the DCE plume and increased DCE concentrations outside of the source area. Setting R to the calculated average values produced similar results, although the changes were not as great. Increasing R to values of 2.5 and 3 produced shorter and slightly narrower plumes, with concentrations outside of the source area below those in the calibrated model.

5.5.2 Sensitivity to Variations in the Decay Rate Constant

The effects of varying the first-order DCE decay rate are summarized in columns 4 and 5 of Table 5.3. Uniformly setting this parameter to 1.6×10^{-4} day^{-1} (the minimum

TABLE 5.3
SUMMARY OF SENSITIVITY ANALYSIS RESULTS
OU-1 RNA TS
HILL AIR FORCE BASE, UTAH

Well	Measured *cis*-1,2-DCE Concentration March 1997 (μg/L)	Calibrated Plume (μg/L)	Sensitivity Analysis Run with Simulated *cis*-1,2-DCE Concentration (μg/L)[a/]												
			1	2	3	4	5	6	7	8	9	10	11	12	13
S3	1.4	5.0	14	12	2.3	91	0.1	3.5	5.1	34	0.1	**	0.0	5.1	5.1
U1-099	27.9	70.7	138	122	41.9	224	1.54	52.7	71.1	141	10.2		0.09	70.7	70.7
U1-1640	124	116	199	180	75.2	311	4.03	92.5	117	178	26.4		0.22	116	116
U1-307	526	545	715	680	445	1009	271	465	545	533	363		15.0	544	544
U1-103	335	365	419	409	338	495	259	947	320	361	151		254	368	368
U1-074	1550	2500	2609	2591	2490	2718	2290	2091	2541	1396	4052		4362	2514	2514
U1-201	1470	990	987	985	983	999	948	709	1000	505	1846		1948	976	976
Distance from U1-333 downgradient to 1-μg/L contour (ft) [b/]	250	610	1226	1011	260	> 1670 [c/]	-754 [d/]	437	613	> 1670	-413		NA	596	615
Distance from U1-1640 downgradient to 1-μg/L contour (ft) [e/]	1640	1348	1345	1354	1331	521	979	1332	1332	1343	1170		NA	1348	1340
Distance from U1-1640 downgradient to 100-μg/L contour (ft) [e/]	100	129	1009	938	-494	253	NA	-212	212	1029	-1026		NA	133	145
Width of 1-μg/L contour (ft) at U1-1640 [e/]	1,230	3065	3296	3223	2905	2460	1306	4363	2983	> 3182	2373		NA	3049	3050
Width of 100-μg/L contour at U1-1640 [e/]	670	824	1486	1345	NA	1097	NA	NA	849	1496	NA		NA	823	833

** Model crashed.

[a/] Run 1: retardation = 1.0.
Run 2: retardation = 1.15 to 1.26.
Run 3: retardation = 2.5 to 3.0.
Run 4: decay = 1.6×10^{-4}.
Run 5: decay = 1.6×10^{-3}.
Run 6: longitudinal dispersivity = 490 feet.
Run 7: longitudinal dispersivity = 10 feet.
Run 8: all hydraulic conductivities doubled.
Run 9: all hydraulic conductivities halved.
Run 10: vertical hydraulic conductivities increased by factor of 10.
Run 11: vertical hydraulic conductivities decreased by factor of 10.
Run 12: effective porosity = 0.1.
Run 13: effective porosity = 0.35.

[b/] Measured in Model Layer 6.

[c/] Contour was outside of active model area.

[d/] A negative value indicates the distance from U1-1640 upgradient to contour.

[e/] Measured in Model Layer 5.

calculated value) resulted in less rapid degradation of dissolved contaminants, producing a much longer plume that is generally wider. In addition, DCE concentrations outside of the source area were much higher than in the calibrated simulation. Uniformly increasing the degradation rate to 1.6×10^{-3} day^{-1} resulted in a much shorter and narrower plume. Concentrations outside the source area were much lower than in the calibrated model.

5.5.3 Sensitivity to Variations in Dispersivity

The effects of varying dispersivity are summarized in columns 6 and 7 of Table 5.3. Longitudinal, transverse, and vertical dispersivity were all varied for this analysis, as the ratio of the longitudinal to transverse dispersivity was kept constant at 0.1 and the ratio of longitudinal to vertical dispersivity was kept constant at 0.01. Increasing the longitudinal dispersivity to 490 feet resulted in concentrations lower than the calibrated model everywhere, including the source area. In addition, the plume was much wider and somewhat shorter. When longitudinal dispersivity was decreased to 10 feet, the plume was slightly longer, with slightly higher concentrations throughout the plume.

5.5.4 Sensitivity to Variations in Hydraulic Conductivity

Hydraulic conductivity is an important aquifer characteristic that represents the ability of the water-bearing strata to transmit groundwater. An accurate estimate of hydraulic conductivity is important to help quantify advective groundwater flow velocities and to define the flushing potential of the aquifer. As a result, models used to estimate contaminant transport are particularly sensitive to variations in hydraulic conductivity. Lower values of hydraulic conductivity result in a slower-moving plume. Higher values of hydraulic conductivity result in a faster-moving plume. The effects of varying hydraulic conductivity are summarized in columns 8 through 11 of Table 5.3.

Uniformly increasing the hydraulic conductivity by a factor of two greatly increased the extent of the plume so that the 1-µg/L isopleth reached the downgradient model boundary, and the simulated concentrations downgradient of the source area were much higher than the calibrated model. At the same time, source area concentrations decreased to well below those in the calibrated model. In contrast, decreasing the hydraulic conductivity by a factor of two slowed overall plume migration, and caused the contaminant mass to be concentrated within a smaller area because the plume was much shorter.

Increasing vertical conductivities by a factor of 10 caused the model to diverge and produce a run-time error. Decreasing vertical conductivities by a factor of 10 resulted in no contamination being present in the Weber River valley at the end of the simulation. Therefore, the model is quite sensitive to this parameter. This is probably because vertical flow predominates in the area of the escarpment.

5.5.5 Sensitivity to Variations in Effective Porosity

The results of increasing and decreasing effective porosity are summarized in columns 12 and 13 of Table 5.3. Decreasing and increasing this parameter to 0.1 and 0.35, respectively, did not significantly affect the plume configuration and concentrations.

5.5.6 Summary of Sensitivity Analysis Results

The results of the sensitivity analysis suggest that the calibrated model depicted in Figure 5.3 and discussed in Section 5.4 is a reasonable and useful approximation of site conditions. Varying the model parameters within the prescribed ranges generally caused the extent and magnitude of the dissolved plume to differ substantially from observed site conditions.

5.6 DISCUSSION OF THE MODEL

Before discussing model predictions in Section 6, some points about the model should be emphasized. Most notably, the system that is modeled is very complex, yet in many areas the relevant properties and parameters are not well defined. Therefore, creating a more complex and detailed model than described above was not warranted. In addition, model computation time increases greatly as additional complexity or detail is added. During calibration, the decision to not incorporate additional complexity and detail in the model was validated because attempts to use a finer grid or to add other details resulted in simulations that would not converge on a solution or that "crashed" the computer. Also, the pathways of groundwater flow from the terrace down the escarpment to the valley are poorly understood, and this specific portion of the domain necessarily includes a large vertical flow component. Finite-difference models such as MODFLOW and MT3D are not optimal for such systems; however, use of more-optimal, finite-element codes would require more computing power and time than the project scope allowed. As a result, this model necessarily is a very simplified representation of the OU1 groundwater and contaminant transport system.

The 3-D nature of the system requires the use of a numerical model, but the lack of data about factors such as the flow pathways down the escarpment and the hydraulic properties of the escarpment materials required simplifying assumptions. Calibration of the flow model therefore focused on producing a flow field that reasonably matched observed conditions in the plume area, and less so to the east of the source area (where little contaminant mass appears to migrate off-Base). This was done because the transport model also incorporated significant uncertainty with respect to the source and parameters such as dispersion and retardation. Moreover, the vertical flow in the escarpment likely has introduced some numerical errors into the solution due to the methods the model codes use to arrive at solutions. Thus, the benefits resulting from using a highly detailed model grid and expending a large amount of time on calibration would be negated by such numerical errors. Completion of this portion of the work required assumptions that simplify the system considerably.

Results of modeling should therefore be interpreted in this light. Important transport properties such as the contaminant decay rates, retardation, and dispersion are within reasonable ranges, and the flow model generally conforms well to the observed data and to the measured hydraulic properties of the system. The sensitivity analysis indicates that the selected parameters and properties are appropriate. In some locations, the model will simulate heads or concentrations that are quite different from the observed values. However, in light of the sensitivity analysis and the uncertainties discussed above, the modeling predictions are meaningful on a broad scale, especially as the primary goal is to compare the long-range effects of differing remedial scenarios imposed upon the same basic model.

SECTION 6

ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents the predicted impacts of planned and probable engineered remedial actions on dissolved *cis*-1,2-DCE in the surficial water-bearing zone at OU 1. The intent of this evaluation is to assist the Base in developing final remedial strategies for the site.

6.1 SUMMARY OF REMEDIAL ALTERNATIVES

Typically, multiple remedial alternatives would be developed and compared in this section in terms of effectiveness, technical and administrative implementability, and cost. This discussion would address factors influencing alternatives development, including the objectives of the RNA demonstration program, contaminant properties, site geology and hydrogeology, potential exposure pathways, and remediation goals. However, a feasibility study (FS) that evaluates multiple remedial technologies has already been performed for OU 1 (CH2M Hill, 1998). Remedial alternatives have been reviewed, and a preferred alternative has been selected with USEPA and Utah Department of Environmental Quality (DEQ) oversight and agreement. The various remedial alternatives evaluated, together with a description of the preferred alternative, are described in the Final Proposed Plan (US Air Force, 1998).

In addition to the remedial actions already implemented in the OU 1 source area (see Section 1.3), the following source area remedial alternatives were evaluated (CH2M Hill, 1998):

1. No further action (including continued operation of the existing groundwater collection systems, maintenance of the existing landfill cap and passive gas vent system, environmental monitoring, and institutional controls);

2. Alternative 1 plus landfill cap repair, installation of one groundwater extraction well near existing monitoring well U1-085, and installation of three groundwater collection trenches across paleochannels that constitute preferential contaminant migration pathways in the surface of the silty clay layer;

3. Alternative 1 plus landfill cap repair, installation of one groundwater extraction well near existing monitoring well U1-085, and LNAPL recovery/dewatering of the source area by installing an extensive network of extraction trenches;

4. Alternative 3 plus installation of a slurry wall along the edge of the terrace west of the existing extraction trench to provide a physical barrier to off-Base migration of dissolved contaminants;

5. All aspects of Alternative 4, upgrade of the existing landfill cap with clay or a geosynthetic liner, and installation of a new passive landfill gas vent system;

6. Alternative 5 plus soil vapor extraction (SVE) in the CDPs, FTA-1, and the residual LNAPL area to remove volatile contaminants; and

7. Institutional controls; modifications to Pond 10; groundwater monitoring; dewatering of source area groundwater using extraction trenches; excavation and incineration of CDPs 1 and 2, FTA-1, and LNAPL areas; and excavation and disposal of LF 3 and 4 contents.

To date, remedial actions implemented in non-source areas have included the collection of surface water via an existing spring/seep collection system, and the installation of institutional controls (fencing) at the springs and seeps where remediation goals were exceeded. In addition to these remedial actions, the following non-source area supplemental remedial actions were evaluated:

1. No further action (includes continued operation of existing seep/spring collection systems, environmental monitoring, and institutional controls, and assumes that the source area is not remediated and that continued off-Base migration of dissolved contaminants will occur);

2. Alternative 1 plus the monitoring of the natural attenuation of OU1 contaminants;

3. Alternative 2 plus collection of discharge from additional seeps/springs that are contaminated above remediation goals, and excavation of arsenic-contaminated sediments at four seeps/springs;

4. Alternative 3 plus installation of a plume cutoff system at the base of the escarpment to capture any contaminated groundwater that reaches the Weber River Valley;

5. Alternative 3 plus installation of groundwater extraction wells on-Base at the western edge of the DCE plume and off-Base at the northern edge of the plume to prevent migration of contamination into uncontaminated areas; and

6. Alternative 3 plus groundwater collection (via an extensive network of extraction wells) throughout the non-source area plume (on-Base west of the source area and off-Base in the Weber River Valley), treatment, and discharge to central Weber-Sewer Improvement District (CWSID).

The preferred remedial alternative proposed by Hill AFB for OU 1 combines Source Area Alternative 3 and Non-Source Area Alternative 3, and incorporates the following elements:

- Dewatering of the terrace sand and gravel aquifer overlying the silt/clay layer by operating the existing extraction wells and trenches and constructing one groundwater extraction well in an isolated contamination "hotspot" and six dewatering trenches through the areas of greatest saturated thickness;

- Recovery of mobile LNAPL from the dewatering trenches;

- Maintaining the existing cap and gas vent system over the source areas to minimize infiltration and migration of contaminants;

- Improving the existing cap over LF 4 to prevent ponding of water;

- Upgrading the existing spring/seep collection systems to prevent further discharges of groundwater exceeding remediation goals to the surface;

- Excavation of arsenic-contaminated seep sediments;

- Maintenance of institutional controls to prevent receptor exposures to site soils, landfill contents, and contaminated surface water and groundwater; and

- Environmental and natural attenuation monitoring.

The proposed locations of specific remedial elements of the preferred alternative are illustrated on a site map provided in Appendix A.

Because a remedial action plan for OU 1 groundwater has already been developed, and a risk assessment has been performed to identify which exposure scenarios pose an unacceptable current or future risk to human health or the environment, the primary focus of the remainder of this section is assessing how selected remedial alternatives will affect the identified *cis*-1,2-DCE contamination in groundwater. The remedial alternatives that are evaluated in terms of their effectiveness at achieving remediation goals include the following:

1. Remediation by natural attenuation alone;

2. The preferred alternative described above (Source Area Alternative 3 and Non-Source Area Alternative 3); and

3. A combination of Source Area Alternative 3 and Non-Source Area Alternative 6 (see map in Appendix A).

The remedial objective for OU 1 consists of reducing dissolved CAH concentrations to or below the Utah groundwater standards for these compounds (Utah DEQ, 1995). Because *cis*-1,2-DCE is the CAH that exceeds its groundwater quality standard of 70 µg/L by the greatest margin over the widest area, the predictive numerical model simulations simulated the fate and transport of this compound. It is assumed that remedial actions that successfully reduce *cis*-1,2-DCE concentrations below 70 µg/L also will be successful in reducing other contaminants of concern below their respective state standards.

6.2 EVALUATION OF REMEDIAL ALTERNATIVES

The predicted effectiveness of three remedial alternatives is described in this section using output from numerical model simulations. The implementability and cost of the remedial alternatives have already been considered during the FS performed by CH2M Hill (1997). Therefore, these comparison criteria are not discussed in this report.

6.2.1 Source Area and Non-Source Area Alternative 1 – RNA, LTM, Institutional Controls, and Continued Operation of the Existing Remedial Systems

This alternative incorporates continued operation of the existing groundwater collection systems, treatment of extracted groundwater at the OU 2 air stripper, maintenance of the existing landfill cap and passive gas vent system, environmental monitoring, and institutional controls. Evaluation of this alternative provides a baseline against which the numerical model simulations incorporating more active, engineered remediation can be compared.

The effectiveness of this remedial alternative was evaluated using the calibrated numerical model described in Section 5. Specifically, the calibrated model was run for 100 years beyond 1997 to assess the long-term effects of RNA combined with the existing remedial systems. The resulting model was termed Model NA_ONLY. The geometric source weathering rate of 2 percent per year, simulated to begin in 1980 in the calibrated model (Section 5.2), was continued throughout the 100-year predictive simulation period. As a result, the magnitude of the source term was reduced by about 92 percent by the year 2097.

Figure 6.1 presents the projected impact of the above-described remedial actions over time. DCE concentrations throughout most of the Weber River Valley are below 70 µg/L (the USEPA MCL and Utah groundwater quality standard for *cis*-1,2-DCE) by year 2027. By 2057, the model predicts that DCE concentrations in the entire valley area north of the Bambrough Canal will be below 70 µg/L. By year 2097, only a small portion of the off-Base escarpment has simulated DCE concentrations exceeding 70 µg/L.

Simulated DCE concentrations at two existing source area monitoring wells and three existing non-source area monitoring wells during the 100-year predictive period are shown on Figures 6.2 and 6.3, respectively. As shown on Figure 6.1, wells U1-201 and U1-074 are located in the portion of the upland terrace defined in the Final Proposed Plan as the source area (US Air Force, 1998). Well U1-103 is located in the portion of the upland terrace designated in the Proposed Plan as the non-source area. Wells U1-154 and U1-1640 are located in the Weber River Valley.

Simulated DCE concentrations at each of the five wells decrease throughout the 100-year predictive period due to the simulated weathering of the contaminant source. The effects of the weathering, simulated to begin in 1980, are evidenced first in wells closest to the source area. For example, simulated DCE concentrations at well U1-074 begin to decrease in 1980, whereas simulated concentrations at well U1-1640, which is relatively distant from the source area, do not begin to decrease until approximately 1990. At the end of the 100-year predictive period (year 2097), simulated DCE concentrations in source area wells U1-074 and U1-201 are still substantially greater than 70 µg/L. In

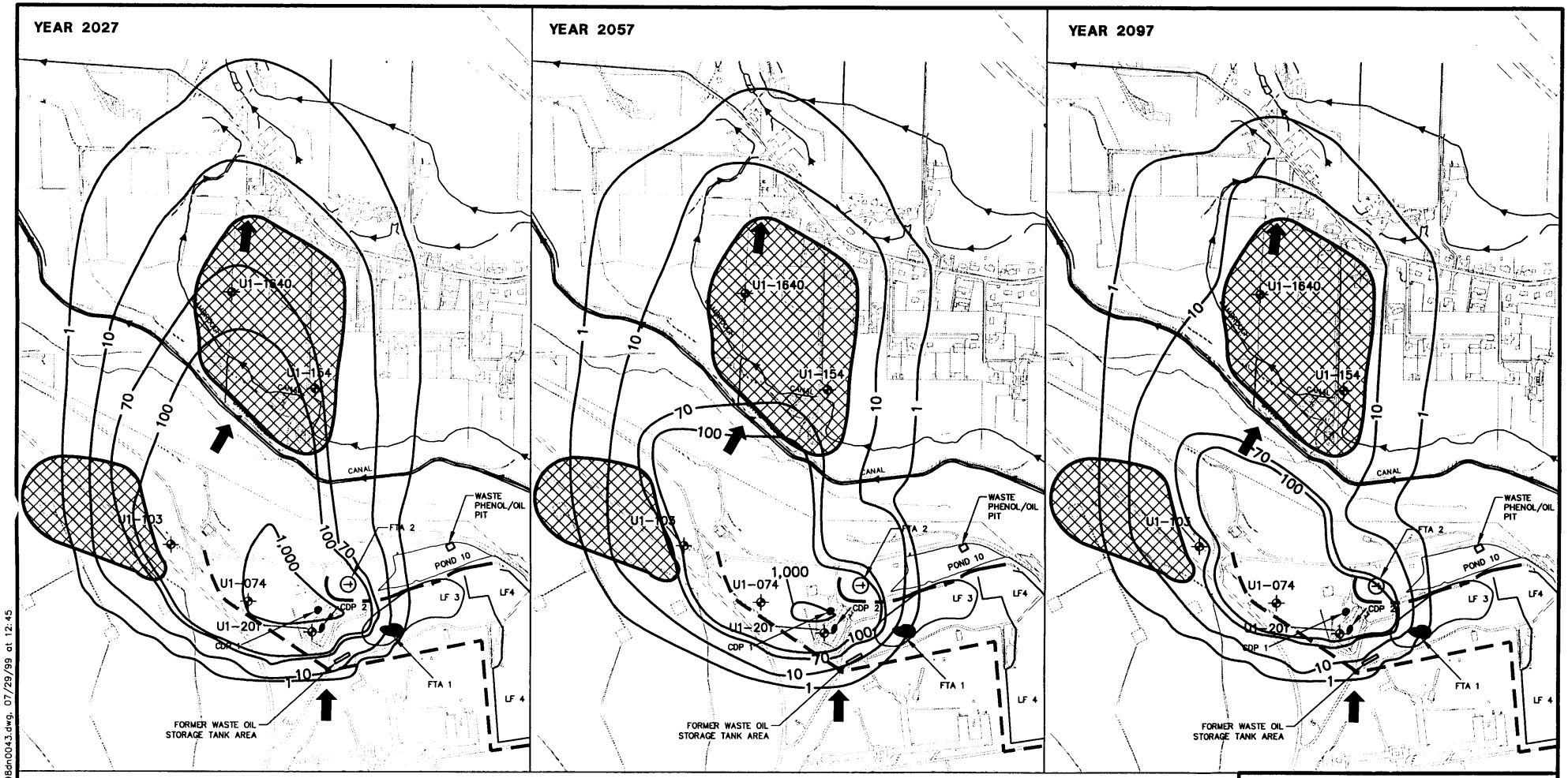

FIGURE 6.1

SIMULATED DCE PLUMES MODEL NA_ONLY

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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FIGURE 6.2
SIMULATED DCE CONCENTRATIONS AT SOURCE AREA WELLS
MODEL NA_ONLY
OU1 RNA TS
HILL AIR FORCE BASE, UTAH

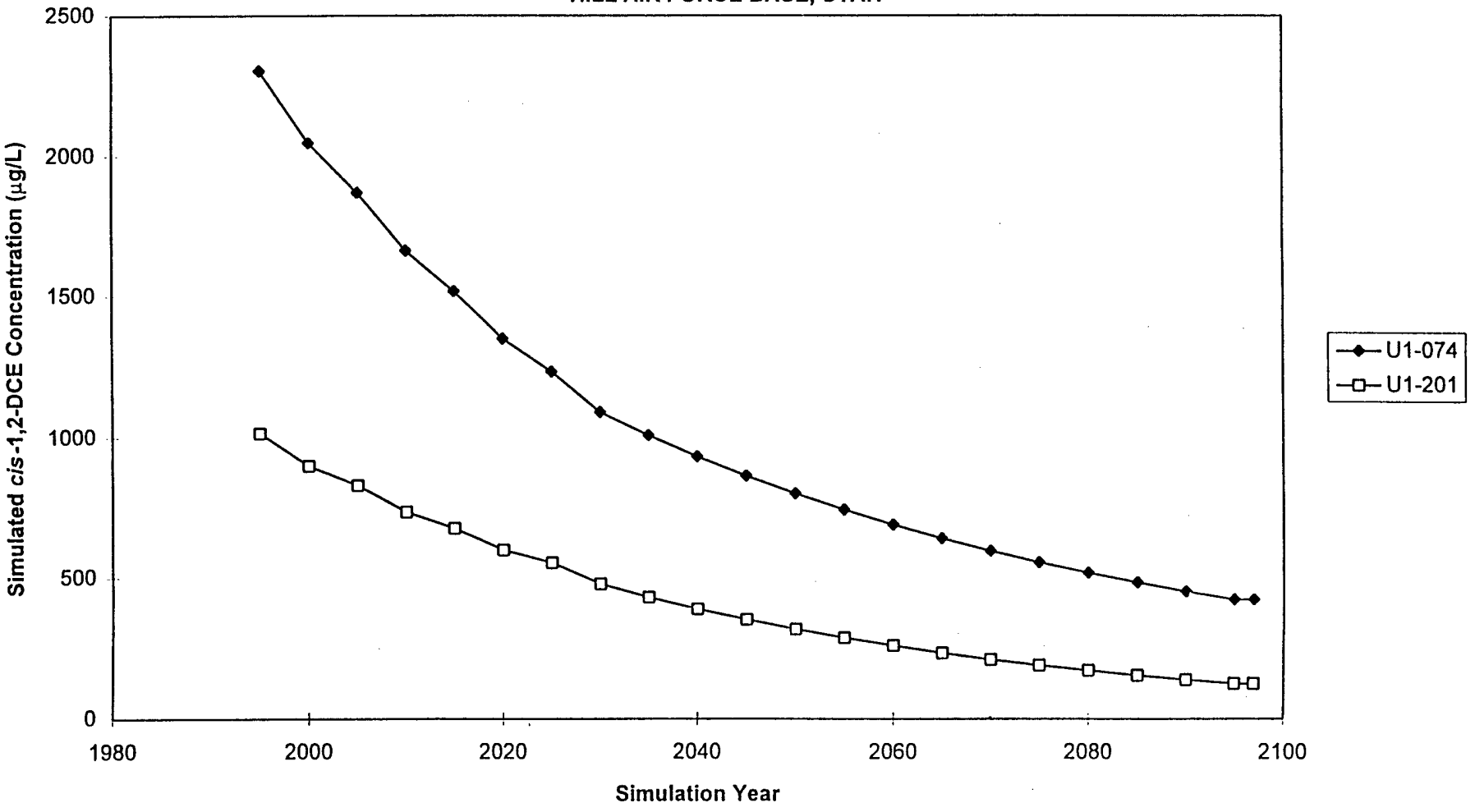
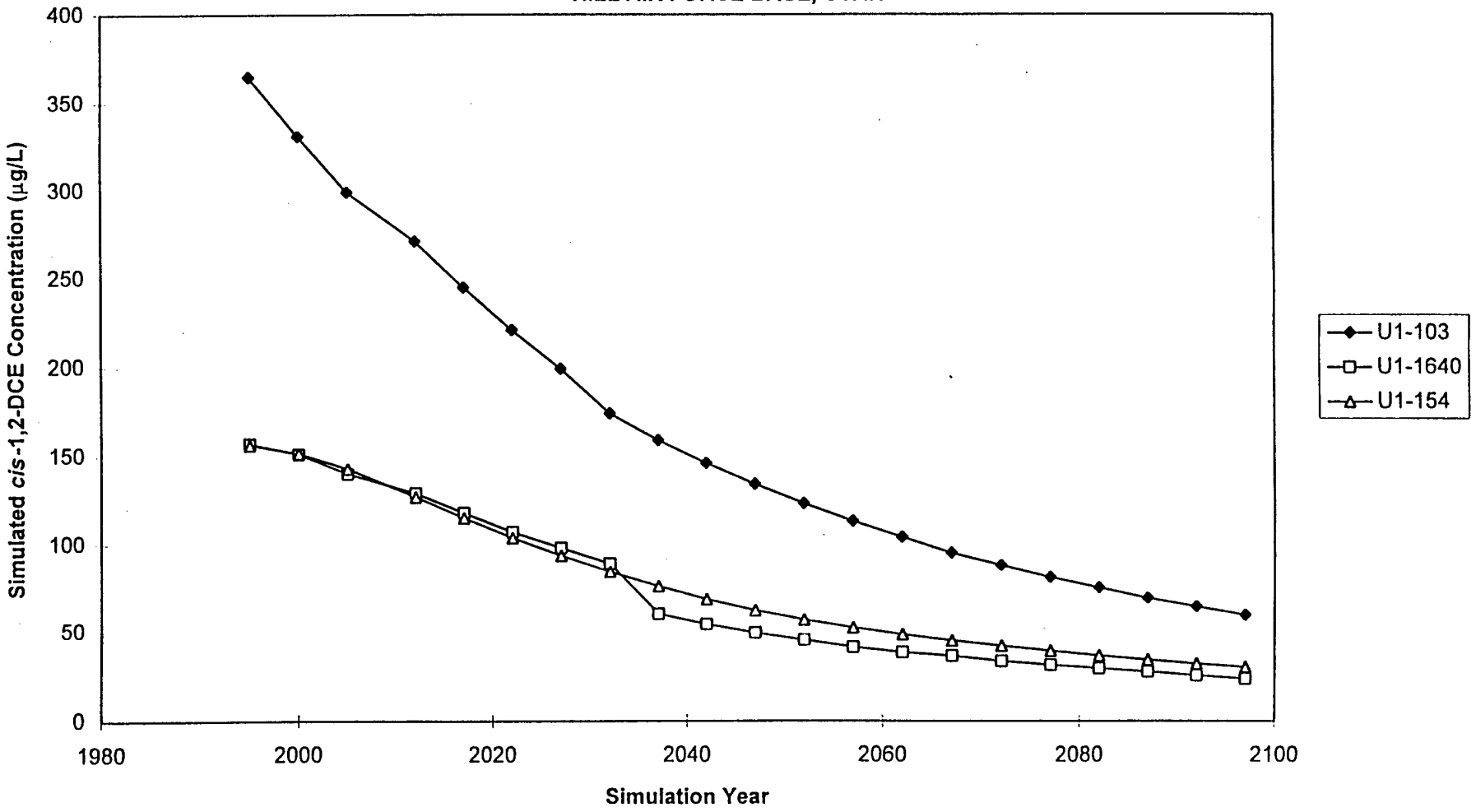


FIGURE 6.3
SIMULATED DCE CONCENTRATIONS AT NON-SOURCE AREA WELLS
MODEL NA_ONLY
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH



contrast, simulated DCE concentrations in non-source area wells U1-103, U1-1640, and U1-154 are below 70 µg/L.

6.2.2 Source Area and Non-Source Area Alternative 3 -- RNA, LTM, Institutional Controls, Continued Operation of the Existing Remedial Systems, Dewatering of Source Area Groundwater, Landfill Cap Repair, and LNAPL Recovery.

This alternative incorporates all aspects of the alternative described in Section 6.2.1, as well as the installation of six groundwater extraction trenches within and immediately downgradient from the contaminant source area. In addition, installation of a single groundwater extraction well adjacent to well U1-085 is proposed. A map depicting the proposed locations of the extractions trenches and well is presented in Appendix A. The objectives of the extraction trenches and well are to extract recoverable LNAPL and to effectively dewater the Provo Formation (the uppermost water-bearing zone beneath the on-Base terrace, consisting primarily of sand and gravel), thereby preventing further off-Base migration of dissolved contaminants.

Model NA_ONLY, used to simulate the remedial alternative described in Section 6.2.1, was revised to incorporate simulation of the proposed extraction well and trenches. This model is called ALTS3_3. MODFLOW's Drain Package was used to simulate extraction trenches. This package is designed to simulate the effects of drains that remove water from the aquifer at a rate proportional to the difference between the head in the aquifer and some fixed head or elevation. The Drain Package assumes that the drain has no effect if the head in the aquifer falls below the fixed head of the drain. In order to simulate dewatering of the Provo formation sands and gravels, the hydraulic head assigned to each drain was between 0.5 and 1.5 feet above the base of the Provo Formation, and a conductance of 10 square feet per day was used. The proposed groundwater extraction well adjacent to well U1-085 (see Figure 7, Appendix A) was not simulated because the model is not calibrated to adequately simulate groundwater flow and contaminant transport in the eastern portion of the upland terrace, where the off-Base migration of dissolved contaminants appears to be relatively minor (Section 5.6). Operation of the trenches for the entire 100-year predictive simulation period (1998-2097) was assumed. Locations of cells used for the trenches are shown in Appendix D.

In addition to the extraction of water from the source area, it was assumed that additional source mass would be lost due to recovery of LNAPL and increased source weathering. Therefore, for the 10 years from 1999 to 2009, the source terms in the model were decreased by a total of 40 percent of the 1997 strength by subtracting 8 percent of the 1997 strength for each of the five 2-year stress periods representing those time periods. Following this decrease, the source was assumed to weather at the previous geometric rate (2 percent per year) for the remainder of the simulation.

Figure 6.4 presents the projected impact of the above-described remedial actions over time. DCE plumes are depicted for years 2007, 2013, and 2017 because the effects of the engineered remedial actions cause simulated DCE concentrations in the Weber River Valley to diminish rapidly relative to the natural-attenuation-only alternative described in Section 6.3.1. As shown on Figure 6.4, the simulated groundwater extraction causes much of the source area to become dewatered in the model. DCE concentrations in the Weber River Valley north of the Bambrough Canal are predicted to decrease below

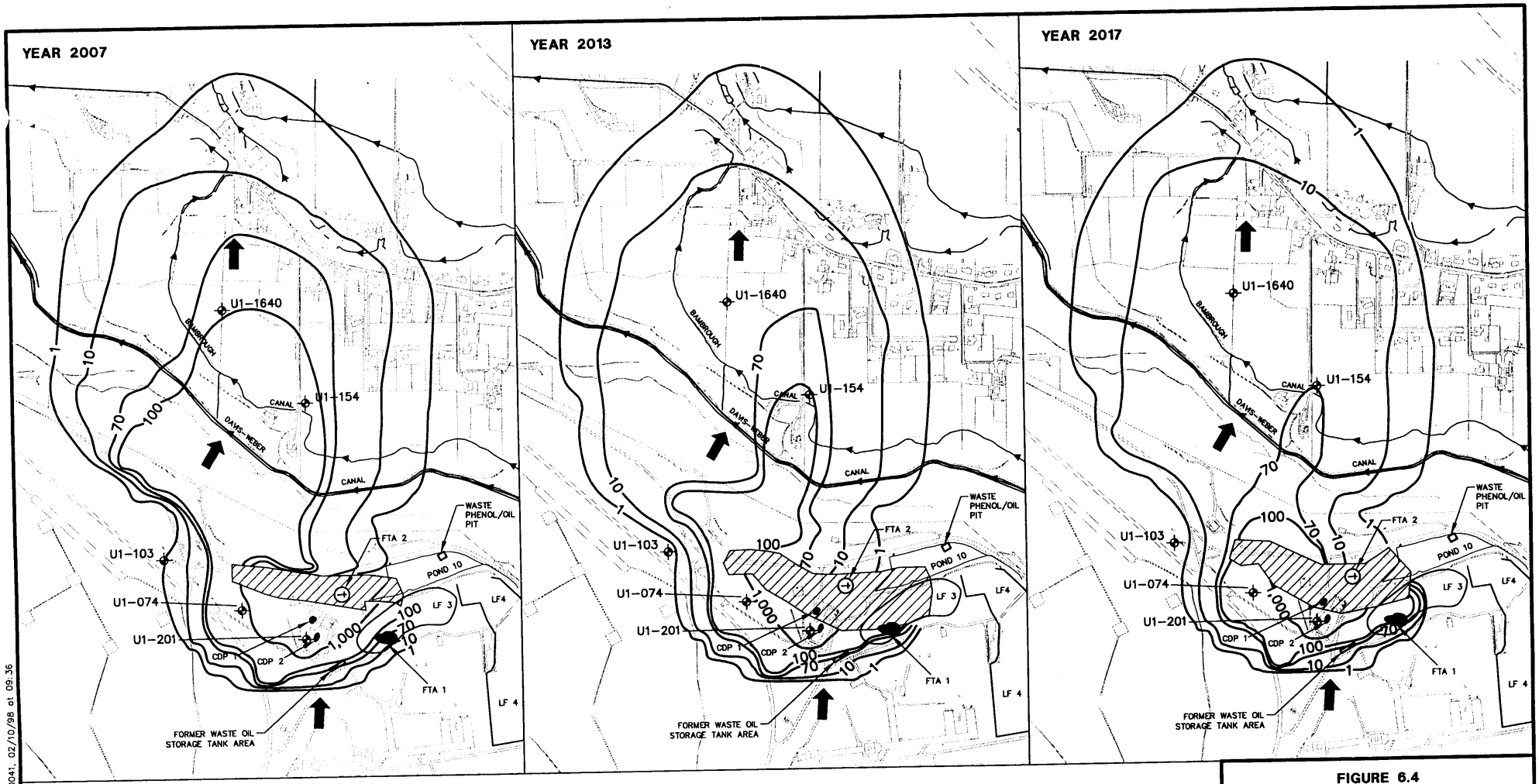


FIGURE 6.4

SIMULATED DCE PLUMES
MODEL ALTS3_3

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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70 µg/L by year 2017. By year 2023 (not shown on Figure 6.4), the 70-µg/L DCE isopleth extends only a very short distance north of the Base boundary.

Simulated DCE concentrations during the 100-year predictive period at the same two source-area and three non source-area monitoring wells described in Section 6.2.1 are depicted on Figures 6.5 and 6.6, respectively. The model predicts that DCE concentrations at wells U1-074, U1-201, and U1-103, located on the upland terrace, will decrease relatively rapidly between 1999 and 2009. This decrease results from the simulated implementation of groundwater extraction in 1999, and the simulated 40-percent decrease in the source strength during this 10-year period to account for the removal of mobile LNAPL from the source area. Between 2009 and 2097, the rate of decrease in simulated DCE concentrations is more gradual, reflecting the geometric 2-percent-per-year source weathering rate incorporated in the model. At the end of the 100-year predictive period (year 2097), simulated DCE concentrations at wells U1-074 and U1-201 are still greater than 70 µg/L. However, the model predicts that DCE concentrations at non-source area wells U1-103, U1-1640, and U1-154 will decrease below 70 µg/L in years 2003, 2012, and 2017, respectively.

6.2.3 Source Area Alternative 3 and Non-Source Area Alternative 6 - RNA, LTM, Institutional Controls, Continued Operation of the Existing Remedial Systems, Dewatering of Source Area Groundwater, Landfill Cap Repair, LNAPL Recovery. and Groundwater Collection Throughout the Non-Source Area Plume

Model ALTS3_3, used to simulate Source Area and Non-Source Area Alternative 3, was revised to simulate the effects of 25 groundwater extraction wells in the Weber River Valley and 10 groundwater extraction wells in the upland terrace area west of the source area. A figure showing the proposed locations of these wells is contained in Appendix A. The resulting model is referred to as Model ALTS3_6. The pumping rate assigned to each well in the Weber River valley was 1 gpm, and each terrace well was assigned a pumping rate of 6 gpm. These are the rates estimated for these wells in the Final Proposed Plan (US Air Force, 1998). Operation of the source area and non-source area extraction wells and trenches for the entire 100-year predictive simulation period (1998-2097) was assumed.

Figure 6.7 presents the predicted impact of the above-described remedial actions over time. The extent and magnitude of the plume over time are very similar to those depicted for the preferred remedial alternative depicted on Figure 6.4, indicating that the effectiveness of the simulated groundwater extraction in the non-source area at reducing the plume magnitude and extent is low. In general, remediation of the non-source area DCE plume appears to be accelerated over that predicted by model ALTS3_3 by approximately 3-5 years.

The simulated decrease in dissolved DCE concentrations over time (beginning in 1997) at non-source area wells U1-103, U1-154, and U1-1640 is shown on Figure 6.8. The time-versus-concentration curves for model ALTS3_6 are very similar to those depicted for model ALTS3_3 on Figure 6.6, supporting the observation that the addition of the extraction wells does not substantially accelerate cleanup of non-source area groundwater. However, the rates of concentration decrease at wells U1-154 and U1-1640 are slightly more rapid on Figure 6.8.

FIGURE 6.5
SIMULATED DCE CONCENTRATIONS AT SOURCE AREA WELLS
MODEL ALTS3_3
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

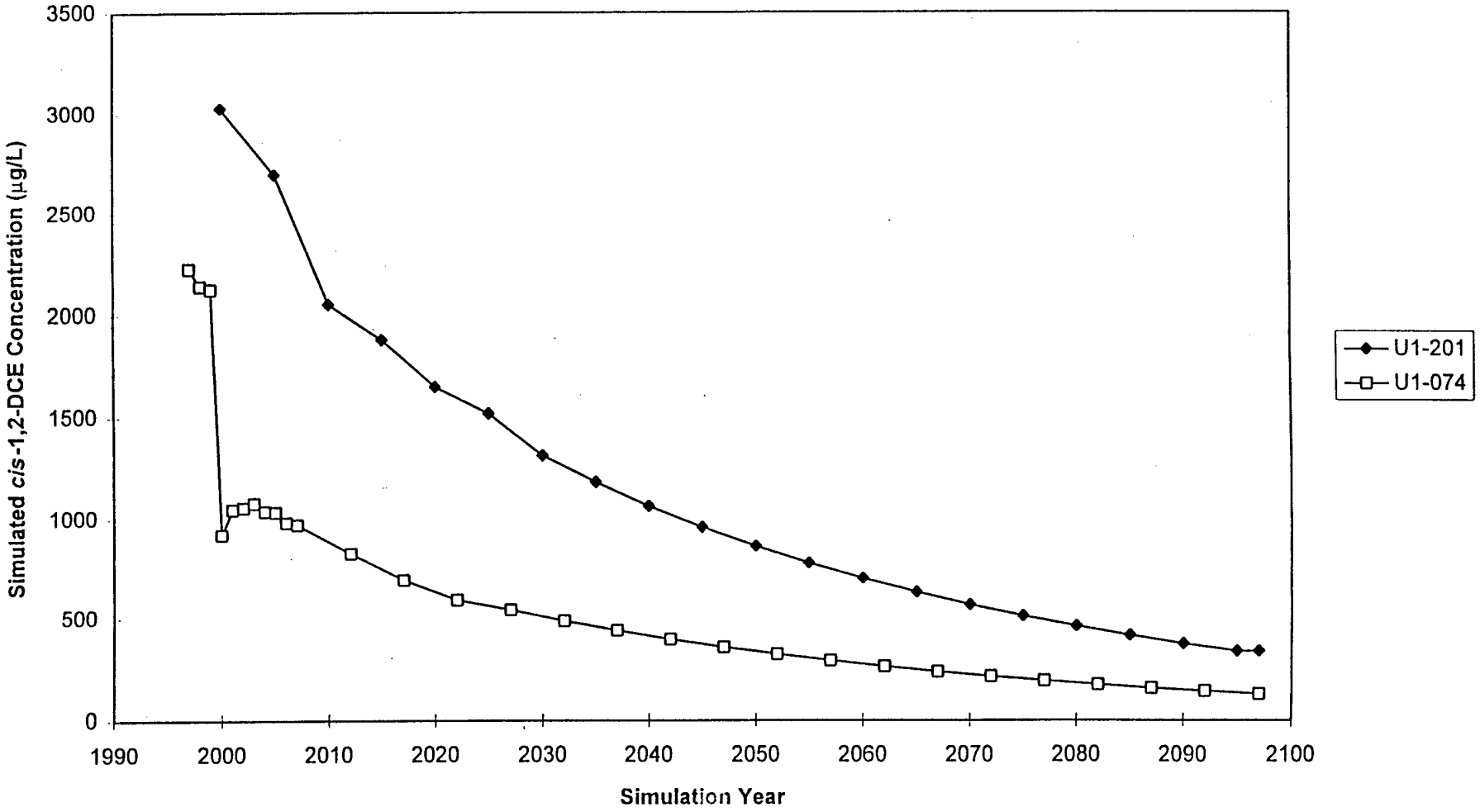
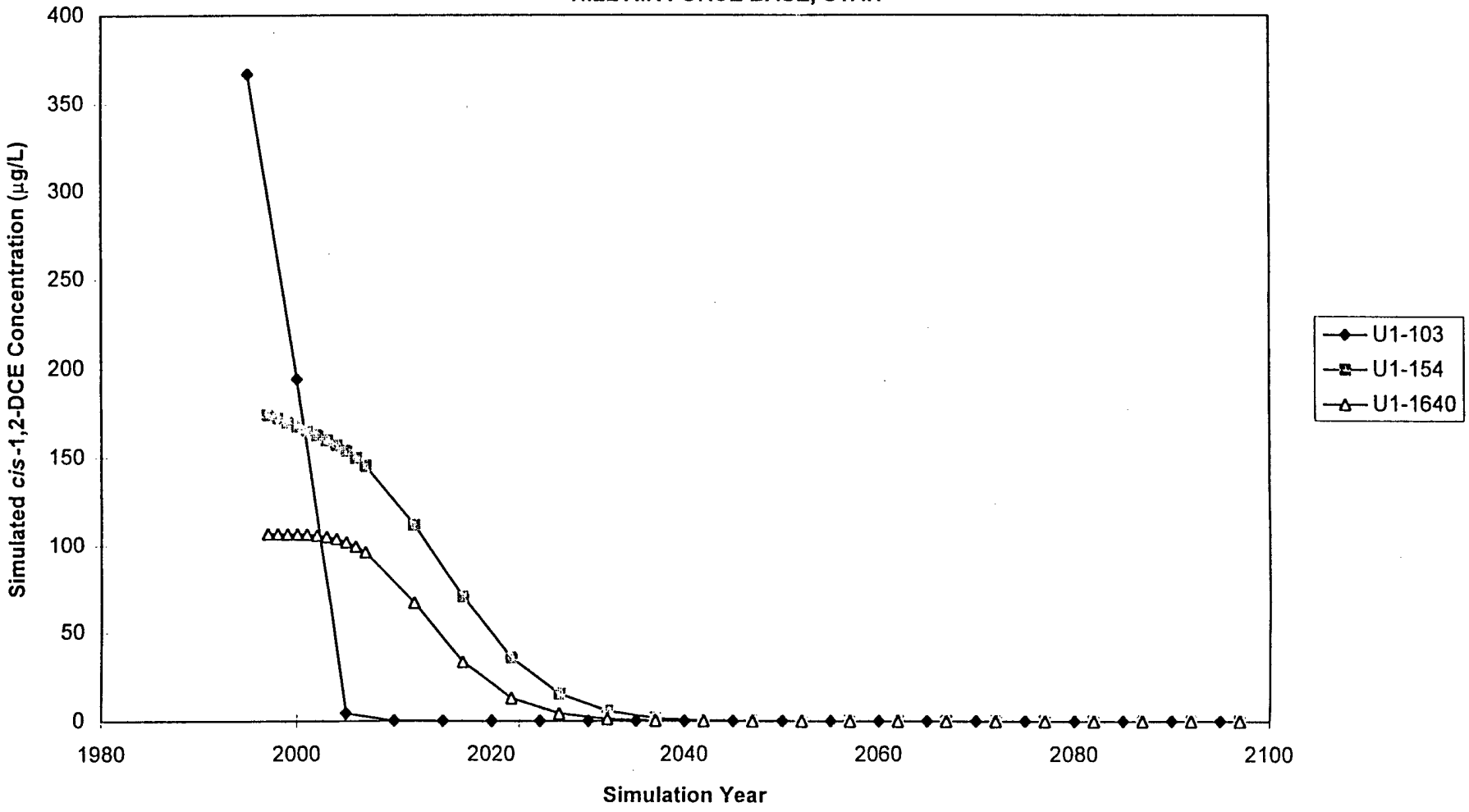


FIGURE 6.6
SIMULATED DCE CONCENTRATIONS AT NON-SOURCE AREA WELLS
MODEL ALTS3_3
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH



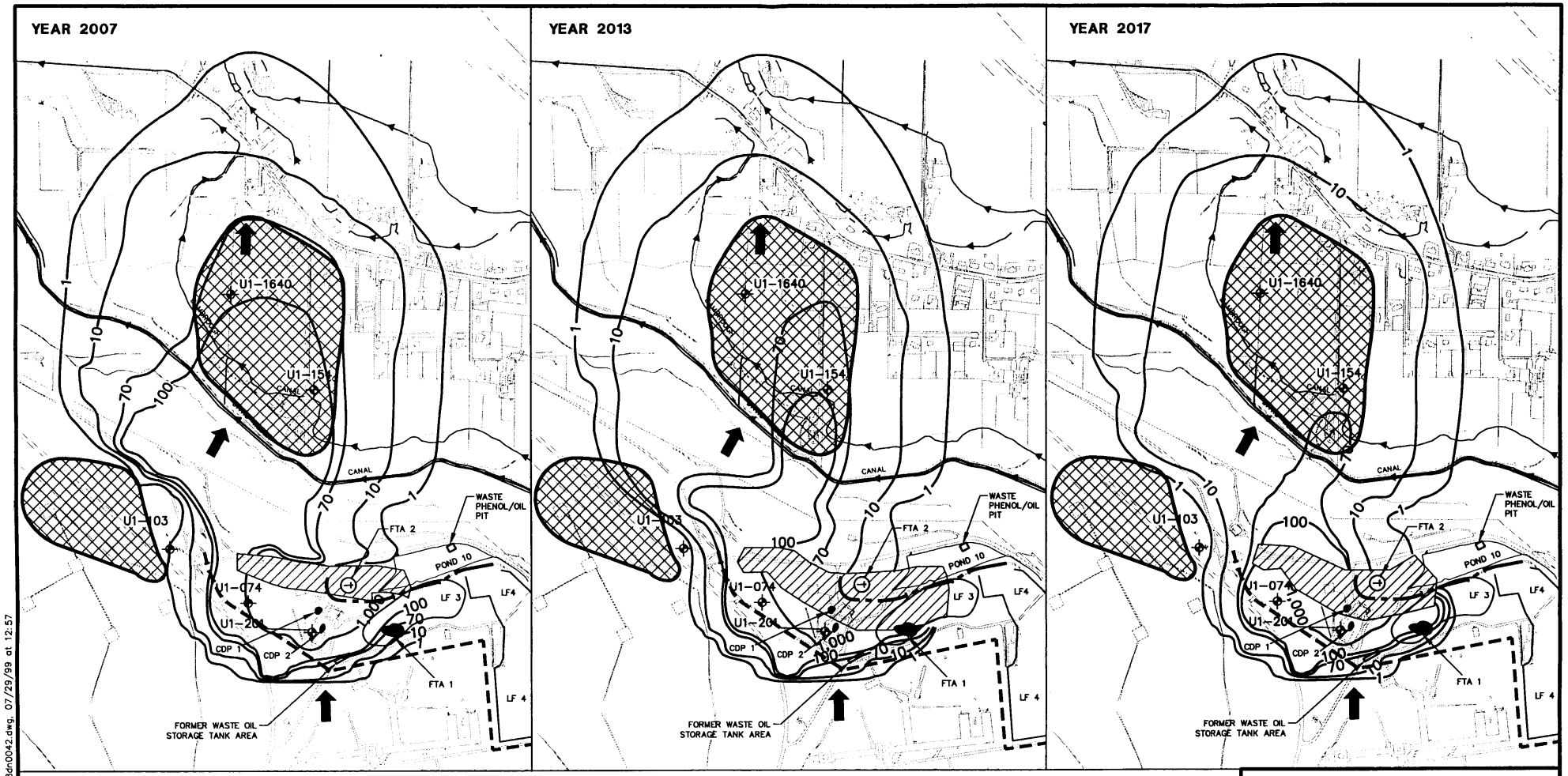


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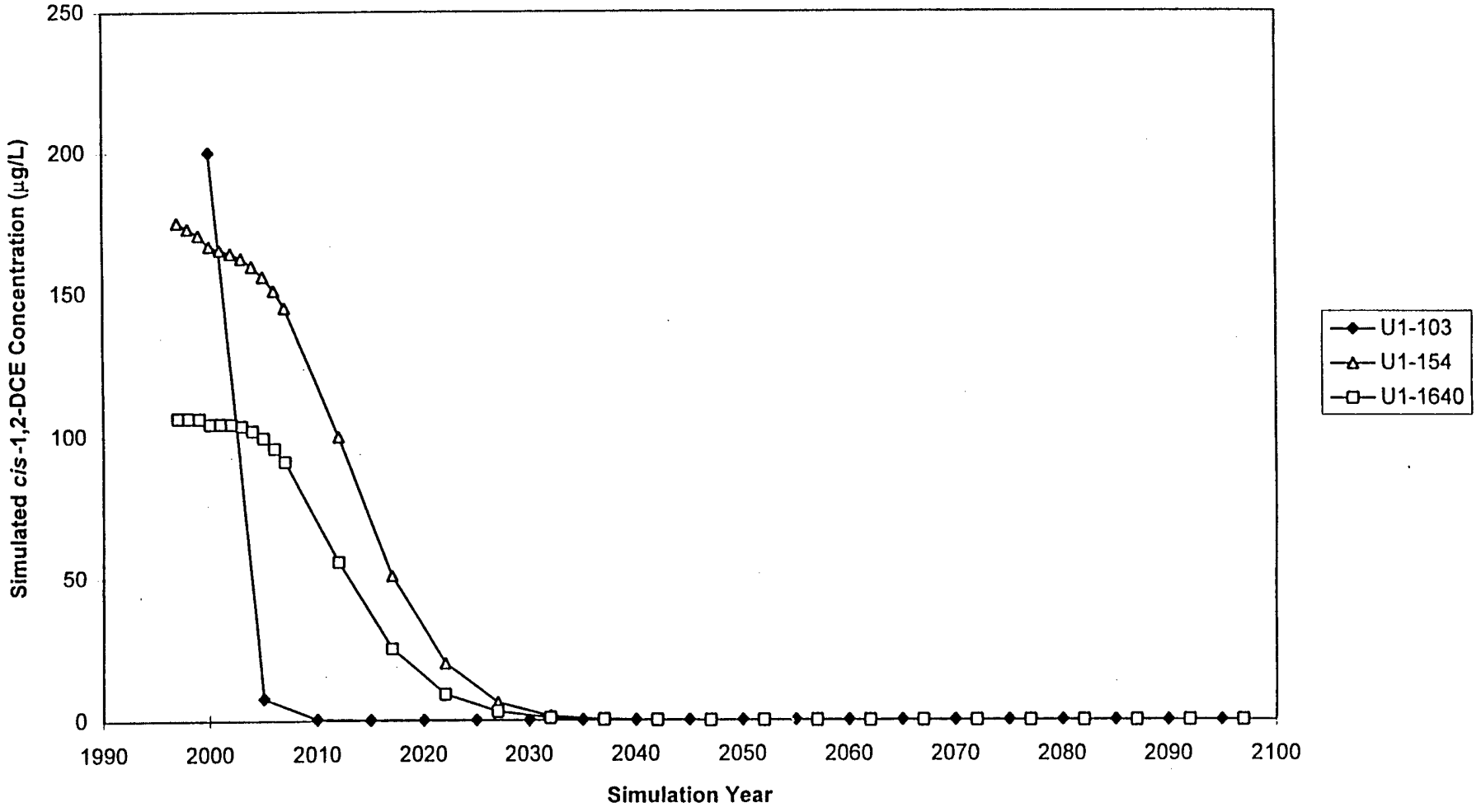
FIGURE 6.7

SIMULATED DCE PLUMES MODEL ALTS3_6

OU 1 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

FIGURE 6.8
SIMULATED DCE CONCENTRATIONS AT NON-SOURCE AREA WELLS
MODEL ALTS3_6
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH



6.4 SUMMARY AND CONCLUSIONS

The effectiveness of three remedial alternatives at reducing the extent and magnitude of *cis*-1,2-DCE in shallow groundwater at OU 1 has been evaluated using numerical models. Remedial components of the alternatives evaluated include RNA, groundwater and mobile LNAPL extraction in the source area via extraction trenches and wells, and groundwater extraction in the non-source area via pumping wells.

The numerical model results suggest that the dissolved DCE plume will not migrate further to the north than is currently observed, but will gradually decrease in magnitude and extent due to the effects of natural attenuation processes operating in the groundwater and weathering of the contamination source. If the beneficial results of RNA are supplemented only by continuation of the currently operating remedial systems (model NA_ONLY), then model results suggest that dissolved DCE concentrations throughout the area north of the Bambrough Canal will decrease below 70 µg/L by year 2040 to 2045. The model predicts that dissolved DCE concentrations throughout nearly all of the off-Base area will decrease below 70 µg/L by 2097. However, the model indicates that dissolved DCE concentrations will substantially exceed 70 µg/L in the source area for more than 100 years unless source weathering rates are significantly more rapid than simulated by the model.

If the preferred remedial alternative is implemented, then the model predicts that dissolved DCE concentrations in the Weber River Valley will decrease much more rapidly; concentrations north of the Bambrough Canal are predicted to decrease below 70 µg/L by approximately year 2017. Source area DCE concentrations will also decrease more rapidly with implementation of the preferred alternative. However, maximum DCE concentrations are predicted to remain above 70 µg/L for more than 100 years due to persistence of the contamination source.

The model predicts that implementation of Source Area Alternative 3 and Non-Source Area Alternative 6 would not hasten the diminishment of the dissolved DCE plume substantially relative to the preferred alternative. The model suggests that remedial objectives in the Weber River Valley may be achieved approximately 3 to 5 years faster if the remedial systems simulated by model ALTS3_6 are implemented. Therefore, if the off-Base plume does not represent a significant threat to potential receptors, then implementation of Non-Source Area Alternative 6 may not be advisable. The effectiveness of Non-Source Area Alternative 6 could potentially be increased by increasing the pumping rates of the non-source area extraction wells; however, this was not assessed using the numerical model.

As described in Section 5.6, the groundwater flow and contaminant transport system that is modeled is very complex, and the relevant properties and parameters are not well defined in some portions of the modeled area (particularly the escarpment). The magnitude and persistence of the DCE plume predicted by the model is highly sensitive to the strength of the contaminant source, yet the source weathering rate over time cannot be accurately defined on the basis of currently available data. As a result, this model necessarily is a very simplified representation of the groundwater and contaminant transport systems. However, the sensitivity analysis (described in Section 5.5) indicates that the selected model input parameters are reasonable, and the model predictions are

believed to be useful approximations that can be used to help select an appropriate remedial approach.

SECTION 7

LONG-TERM MONITORING PLAN

7.1 OVERVIEW

A preliminary groundwater monitoring plan for the non-source area of OU 1 was developed for the Proposed Plan (USAF, 1997); preliminary locations of proposed LTM wells and surface water sampling stations are shown in Figure 7 of the Proposed Plan (Appendix A). If the preferred remedial alternative is implemented and has the desired effect, the shallow water-bearing zone in the source area beneath the upland terrace would be effectively dewatered; therefore, LTM in this area may consist primarily of monitoring dissolved contaminant concentrations in the dewatering system effluent and measuring static water levels and mobile LNAPL thicknesses in source area monitoring wells and piezometers to assess the degree to which the dewatering system is capturing dissolved contaminants and mobile LNAPL. Once the hydraulic effects of the dewatering system are assessed, then selected source area wells that still have a sufficient volume of water could be incorporated into the LTM plan as appropriate to monitor temporal changes in dissolved contaminant concentrations.

The costs for implementing the preferred remedial alternative, summarized in the Proposed Plan (USAF, 1997), include costs for natural attenuation monitoring in the non-source area for a period of 12 years after the preferred remedial alternative for the source area is activated. This is the estimated restoration timeframe for the non-source area included in the Proposed Plan. The model simulations described in Section 6.2.2 suggest that the restoration time frame for the off-Base area may be longer than 12 years.

Because a preliminary LTM plan has already been developed and costed, a new LTM plan is not fully developed in this TS. However, recommended sampling frequencies are described based on numerical modeling results, and recommended analytical parameters are presented.

7.2 SAMPLING FREQUENCY

The recommended sampling frequency will vary depending on which remedial alternative is implemented. Assuming that the preferred alternative is implemented, then biennial (every other year) monitoring of groundwater quality in the non-source area is recommended to allow assessment of the effects of source area remediation on the off-Base DCE plume. Historical groundwater quality data indicate that the plume is not migrating substantially, nor are dissolved DCE concentrations in the Weber River Valley increasing. Therefore, more frequent monitoring should not be necessary, and biennial monitoring should be adequate to assess the effects of source area remediation on non-source area groundwater over time. The model results suggest that monitoring of the area

north of the Bambrough Canal may be required for approximately 20 years, assuming that the preferred alternative is implemented in 1999. The model results further suggest that groundwater cleanup goals in the on-Base portion of the non-source area that is located west of the source area may be achieved relatively rapidly (i.e., less than 10 years after implementation of the preferred alternative).

Monitoring of the source area may be required for more than 100 years unless the contaminant source diminishes significantly more rapidly than simulated in the numerical model. Once the hydraulic effects of the groundwater extraction system are observed, then selected source area wells should be sampled annually for a defined period (e.g., 5 years) to assess the effectiveness of the remedial system and monitor temporal changes in dissolved contaminant concentrations. Once several years of data are obtained, the LTM frequency in the source area could conceivably be reduced (e.g., to every other year).

7.3 ANALYTICAL PROTOCOL

All LTM wells should be sampled and analyzed to determine compliance with chemical-specific remediation goals and to verify the effectiveness of remediation at the site. Groundwater level measurements should be made during each sampling event. Groundwater samples from LTM wells should be analyzed for the parameters listed in Table 7.1. Surface water samples should be analyzed for VOCs using USEPA Method SW8260A. Of particular interest is whether the anaerobic, reducing groundwater environment that currently exists in the source area (and that is conducive to reductive dechlorination of PCE and TCE) is affected by the removal of petroleum hydrocarbons. If shallow groundwater in this area becomes more aerobic and less reducing as a result of the operation of the remedial system, then highly-chlorinated CAHs that will not easily degrade in the aerobic, off-Base environment, may migrate off-Base if the system does not capture all source area groundwater or when the operation of the remedial system is terminated.

7.4 PERIODIC LTM PLAN REVIEW

The LTM plan should be periodically reviewed and revised as appropriate on the basis of available groundwater quality data. For example, if the data collected during this time period indicate that the plume has stabilized or is receding, and that CAH concentrations are diminishing, then the sampling frequency can be reduced. If sampling results indicate that geochemical conditions in the plume area are stable over time (e.g., nitrate, sulfate, and ferrous iron concentrations), then the sampling frequency for these parameters could be reduced. If the data collected at any time during the monitoring period indicate the need for additional remedial activities at the site, sampling frequency should be adjusted accordingly.

TABLE 7.1
LONG-TERM GROUNDWATER MONITORING ANALYTICAL PROTOCOL
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Analyte	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Ferrous Iron (Fe^{2+})	Colorimetric A3500-Fe D	Filter if turbid	May indicate an anaerobic degradation process due to the depletion of oxygen, nitrate, and manganese	Each sampling event	Collect 100 mL of water in a glass container; acidify with hydrochloric acid per method	Field
Ferrous Iron (Fe^{2+})	Colorimetric Hach 25140-25	Alternate method	Same as above.	Same as above	Collect 100 mL of water in a glass container	Field
Temperature	E170.1, direct-reading meter	Measure at well-head	Purging adequacy; metabolism rates for microorganisms depend on temperature	Each sampling event	Measure at well-head using a flow-through cell	Field
Dissolved Oxygen	Dissolved oxygen meter	Measure at well-head; refer to Method A4500 for a comparable laboratory procedure	Purging adequacy; concentrations less than 1 mg/L generally indicate an anaerobic pathway	Each sampling event	Measure at well-head using a flow-through cell	Field
pH	E150.1/SW9040, direct-reading meter	Measure at well-head	Purging adequacy; aerobic and anaerobic processes are pH-sensitive	Each sampling event	Measure at well-head using a flow-through cell	Field
Conductivity	E120.1/SW9050, direct-reading meter	Measure at well-head	General water quality parameter used as a marker to verify that site samples are obtained from the same groundwater system	Each sampling event	Collect 100–250 mL of water in a glass or plastic container	Field
Nitrate (NO_3^{-1})	IC method E300 or method SW9056; colorimetric, method E353.2	Method E300 is a Handbook[a/] method; method SW9056 is an equivalent procedure	Substrate for microbial respiration if oxygen is depleted	Each sampling event	Collect up to 40 mL of water in a glass or plastic container; cool to 4°C; analyze within 48 hours	Fixed-base

TABLE 7.1 (Concluded)
LONG-TERM GROUNDWATER MONITORING ANALYTICAL PROTOCOL
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH

Analyte	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Sulfate (SO_4^{2-})	IC method E300 or method SW9056 or Hach SulfaVer 4 method	Method E300 is a Handbook method; method SW9056 is an equivalent procedure. Hach method is Photometric	Substrate for anaerobic microbial respiration	Each sampling event	Collect up to 40 mL of water in a glass or plastic container; cool to 4°C	Fixed-base or field (for Hach method)
Oxidation-Reduction Potential (ORP)	A2580 B, direct-reading meter	Measurements are made with electrodes; results are displayed on a meter; samples should be protected from exposure to atmospheric oxygen	The redox potential of groundwater influences and is influenced by biologically mediated reactions; the redox potential of groundwater may range from more than 200 mV to less than -400 mV	Each sampling event	Measure at well-head using a flow-through cell	Field
Methane, Ethane, and Ethene	RSKSOP-114 modified to analyze water samples for methane by headspace sampling with dual thermal conductivity and flame ionization detection.	Method published and used by the USEPA Robert S. Kerr Laboratory	The presence of methane indicates the presence of sufficiently reducing conditons for reductive dehalogenation to occur	Each sampling event	Collect water samples in 40 mL volatile organic analysis (VOA) vials with butyl gray/Teflon-lined caps (zero headspace); cool to 4°C	Fixed-base
Volatile Organics	GC/MS method SW8260A	Analytes could be limited to chemicals of concern.	Measured for regulatory compliance	Each sampling event	Collect water samples in a 40 mL VOA vial; cool to 4°C; add hydrochloric acid to pH < 2	Fixed-base

a/ Handbook refers to "AFCEE Handbook to Support the Installation Restoration Program (IRP) Remedial Investigation / Feasibility Study (RI/FS)."

SECTION 8

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APPENDIX A

SELECTED FIGURES AND TABLES FROM THE COMPREHENSIVE RI REPORT (MONTGOMERY WATERSON, 1995B)

TABLE 4-2

OPERABLE UNIT I MASTER MONITORING WELL AND PIEZOMETER LIST

(1 of 6)

Current Location ID	Old Site ID	Date Installed	Date Abandoned	Easting	Northing	Ground-Surface Elevation	Measuring Point Elevation	Stick-Up (feet)	Reported Boring Depth (ft bgs)	Well Depth [a] (ft bgs)	Screened Interval (ft bgs)	Screen Length (feet)	Borehole Diameter (inches)	Well Screen Formation Type	General Location in OU1	Construction Details/Comments
Monitoring Wells																
U1-001A	W-1	Jun-76		1876209.00	289129.00	4802.50	4803.45	0.95	--	24.00	unknown	unknown	unknown	unknown	N-PER	Abandoned
U1-002A	W-2	Jun-76		unknown	unknown	4807.11	4809.61	2.50	--	25.00	unknown	unknown	unknown	unknown	S-PER	Abandoned
U1-003A	W-3	Jun-76		unknown	unknown	4808.45	unknown	unknown	--	23.00	unknown	unknown	unknown	unknown	S-PER	Abandoned
U1-004A	W-4	Jun-76	Aug-94	1873507.00	289512.00	4800.67	4803.77	3.10	37.00	39.72	unknown	unknown	unknown	unknown	W-OU-1	Abandoned
U1-005A	W-7	Jun-76	Mar-90	unknown	unknown	unknown	unknown	2.00	--	26.50	unknown	unknown	unknown	unknown	S-PER	4-inch PVC, no inner casing, natural sand pack
U1-006A	W-8	Jun-76	Aug-94	1874082.00	289013.00	4802.26	4804.76	2.50	35.00	27.08	unknown	unknown	unknown	sa-gv/si-cl	S-PER	4-inch PVC, no inner casing
U1-006R	--	Aug-94		1874084.68	289000.91	4801.65	4804.18	2.53	35.00	32.50	22.5-32.5	10.00	7.75	sa-gv/si-cl	S-PER	2-inch PVC riser, SS Screen (0.10), prot. casing
U1-007A	W-9	Jun-76	Mar-90	unknown	unknown	unknown	unknown	2.50	--	14.50	unknown	unknown	unknown	unknown	N-PER	4-inch PVC, no inner casing, casing broken off 2.5' bgs, natural sand pack
U1-008A	W-10	Jun-76	Aug-94	1873749.00	288771.00	4801.45	4803.25	1.80	35.00	30.20	unknown	unknown	unknown	sa-gv	S-PER	Abandoned
U1-008R	--	Aug-94		1873733.12	288780.27	4800.74	4803.38	2.64	26.00	24.80	14.6-24.6	10.00	7.75	sa-gv	S--PER	2-inch PVC riser, SS Screen (0.10), prot. casing
U1-009A	W-11	1976	Mar-90	unknown	unknown	4802.16	4804.16	2.00	--	41.00	0.0-41.0	41.00	unknown	unknown	S-PER	4-inch PVC, 1/2-3/4" handmade slots throughout casing
U1-010A	W-12	1976		unknown	unknown	4809.28	4811.78	2.50	--	31.00	unknown	unknown	unknown	unknown	LF-4	Abandoned
U1-011A	W-14	1976	Mar-90	unknown	unknown	4777.61	unknown	1.00	--	21.00	21.0-23.0	2.00	unknown	unknown	N-PER	6-inch PVC 21' outer casing, 4-inch PVC 23' inner casing, grouted borehole
U1-012A	80-1	Jan-80		unknown	unknown	4780.12	unknown	unknown	--	33.00	0.0-33.0	33.00	unknown	unknown	N-PER	Abandoned
U1-013A	80-2	Jan-80		unknown	unknown	4781.06	4783.56	2.50	--	31.00	0.0-23.0	23.00	unknown	unknown	N-PER	Abandoned
U1-014A	80-3	Jan-80		unknown	unknown	4802.56	4804.16	1.60	--	34.00	0.0-34.0	34.00	unknown	unknown	LF-4	Abandoned
U1-015A	80-4	Jan-80	Apr-95	1875957.70	289361.11	4805.22	4805.99	0.77	--	33.00	0.0-33.0	33.00	unknown	unknown	LF-4	Abandoned
U1-016A	80-5	Jan-80	Apr-95	1876127.78	289213.52	4805.58	4806.99	1.41	--	31.00	0.0-31.0	31.00	unknown	unknown	LF-4	Abandoned
U1-017A	80-6	Jan-80	Apr-95	1876216.63	288859.08	4811.55	4813.61	2.06	--	38.00	2.4-40.4	38.00	unknown	unknown	LF-4	Abandoned
U1-018A	80-7	Jan-80	Apr-95	1875997.11	288854.27	4812.23	4814.78	2.55	--	36.00	2.5-38.5	36.00	unknown	unknown	LF-4	Abandoned
U1-019A	80-8	Jan-80	Mar-90	unknown	unknown	4810.68	4813.18	0.75	--	37.00	1.6-38.6	37.00	unknown	unknown	LF-4	4-inch PVC, No outer casing, 1/2" holes screen holes throughout casing
U1-020A	80-9	Jan-80		unknown	unknown	4807.58	4810.08	2.50	--	33.00	1.2-34.2	33.00	unknown	unknown	LF-4	Abandoned
U1-021A	80-10	Jan-80	May-94	1876270.00	288264.00	4810.89	4812.19	1.30	40.00	33.00	0.0-33.0	33.00	unknown	sa-gv/si-cl	S-PER	4-inch PVC, Abandoned
U1-021R	--	May-94		1876270.96	288253.25	4810.91	4812.39	1.48	25.00	23.61	14.0-24.0	10.00	7.75	sa-gv	S-PER	4-inch PVC, No outer casing
U1-022A	80-11	Jan-80	Mar-90	unknown	unknown	4812.45	4814.95	1.50	--	33.00	0.0-33.0	33.00	unknown	unknown	LF-4	4-inch PVC, No outer casing, holes throughout casing
U1-023A	80-12	Jan-80	Aug-94	1875803.00	288579.00	4812.46	4815.11	2.65	40.00	31.95	3.0-35.0	35.00	unknown	sa-gv/si-cl	LF-4	4-inch PVC, No outer casing
U1-023R	--	Aug-94		1875786.19	288573.62	4812.30	4815.37	3.07	41.50	33.00	23.0-33	10.00	7.75	sa-gv	LF-4	2-inch PVC riser, SS Screen (0.10), prot. casing
U1-024	80-13	Jan-80		unknown	unknown	4807.69	4809.99	2.20	--	35.00	3.3-38.3	35.00	unknown	unknown	LF-4	4-inch PVC
U1-025A	80-14	Jan-80		1874374.00	288711.00	4802.24	4804.74	2.50	41.00	24.22	0.0-30.0	30.00	unknown	sa-gv/si-cl	S-PER	4-inch PVC
U1-026A	80-15	Jan-80		unknown	unknown	4802.00	DNS	unknown	--	36.00	0.0-36.0	36.00	unknown	unknown	S-PER	Abandoned
U1-027A	80-16	Jan-80	Aug-94	1875198.00	288480.00	4803.16	4806.21	3.05	40.00	23.45	0.0-36.0	36.00	unknown	sa-gv/si-cl	SPER	4-inch PVC, No outer casing
U1-027R	--	Aug-94		1875191.73	288487.17	4802.95	4805.59	2.64	29.00	25.00	15-25.0	10.00	7.75	si-sa	S-PER	2-inch PVC riser, SS Screen (0.10), prot. casing
U1-028A	80-17	Jan-80		unknown	unknown	4809.07	unknown	unknown	--	32.00	0.0-32.0	32.00	unknown	unknown	S-PER	Abandoned
U1-029A	80-18	Jan-80		unknown	unknown	4815.60	unknown	unknown	--	35.00	0.0-35.0	35.00	unknown	unknown	S-PER	Abandoned
U1-030A	80-19	Jan-80	May-94	1875108.00	287869.00	4806.67	4808.41	1.74	40.00	36.00	0.0-33.0	33.00	unknown	sa-gv	S-PER	Abandoned
U1-030R	--	May-94		1875096.91	287871.48	4807.14	4808.41	1.27	22.00	26.78	12.0-22.0	10.00	7.75	sa-gv	S-PER	No outer casing
U1-031A	80-20	Jan-80		unknown	unknown	4798.83	4801.33	2.50	--	35.00	1.0-36.0	35.00	unknown	unknown	CDP-1,2	Abandoned
U1-032	80-21	Jan-80	Mar-90	unknown	unknown	4776.16	unknown	3.00	--	33.00	0.0-33.0	33.00	unknown	unknown	N-PER	No outer casing, Offsetting handcut slots, Natural sand pack
U1-033A	80-22	Jan-80	Aug-94	1874864.00	289529.00	4802.63	4802.88	0.25	40.00	34.73	2.0-36.0	34.00	unknown	unknown	LF-3	Abandoned
U1-034A	80-23	Jan-80	Mar-90	unknown	unknown	4794.89	4797.37	3.58	--	37.00	unknown	unknown	unknown	unknown	LF-4	4-inch PVC, No outer casing, Natural sand pack
U1-035A	80-24	Jan-80	Apr-95	1875920.87	289105.96	4810.32	4812.49	2.17	--	34.00	1.7-35.7	34.00	unknown	unknown	LF-4	Abandoned
U1-036A	80-25	Jan-80		unknown	unknown	4801.80	unknown	unknown	--	38.00	0.0-38.0	38.00	unknown	unknown	LF-4	Abandoned
U1-037	GC-1	Dec-82		1874358.00	286140.00	4863.30	unknown	unknown	62.00	39.70	none	unknown	6.50	sa-gv	Golf Course	6-inch steel casing with an open hole screen type
U1-038	GC-2	Jul-86		1872662.00	286373.00	4786.57	4789.62	3.05	56.50	55.43	38.04-54.4	16.36	7.75	si-cl	Golf Course	2-inch PVC, No outer casing, Colorado Silica sand pack
U1-039	GC-3	Jul-86		1872664.00	286682.00	4792.21	4795.30	3.09	24.50	24.80	11.64-22.67	11.03	7.75	si-sa	Golf Course	2-inch PVC, No outer casing, Colorado Silica sand pack
U1-040	GC-4	Jul-86		1874399.00	287262.00	4877.11	4879.32	2.21	97.00	96.20	73.0-94.0	21.00	7.75	sa-gv/si-cl	Golf Course	2-inch PVC, No outer casing, Colorado Silica sand pack
U1-041A	M-1	Nov-82	Aug-94	1873312.00	289356.00	4797.18	4799.28	2.10	33.00	31.00	26.0-31.0	5.00	6.50	sa-gv	S-PER	Abandoned
U1-041R	--	Aug-94		1873322.57	289347.33	4797.63	4800.17	2.54	33.00	32.00	22.0-32.0	10.00	7.75	sa-gv/si-cl	S-PER	2-inch PVC riser, SS Screen (0.10), prot. casing
U1-042A	M-2	Nov-82	Aug-94	1873076.00	289639.00	4798.61	4801.11	2.50	33.00	32.30	27.3-32.3	5.00	6.50	sa-gv	N-PER	6.75-inch Protective casing, 6" SS Screen
U1-042R	--	Aug-94		1873083.28	289647.67	4798.57	4801.21	2.64	38.00	39.50	27.0-37.0	10.00	7.25	sa-gv/si-cl	S-PER	2-inch PVC riser, SS Screen (0.010), prot. casing
U1-043	M-3	Nov-82		1873078.00	289728.00	4797.51	4800.10	2.59	92.00	58.00	43.0-58.0	15.00	8.00	si-cl	N-PER	8" Protective casing, 4" PVC Screen

TABLE 4-2

OPERABLE UNIT I MASTER MONITORING WELL AND PIEZOMETER LIST

(2 of 6)

Current Location ID	Old Site ID	Date Installed	Date Abandoned	Easting	Northing	Ground-Surface Elevation	Measuring Point Elevation	Stick-Up (feet)	Reported Boring Depth (ft bgs)	Well Depth [a] (ft bgs)	Screened Interval (ft bgs)	Screen Length (feet)	Borehole Diameter (inches)	Well Screen Formation Type	General Location in OU1	Construction Details/Comments
U1-044	M-4	Nov-82		unknown	unknown	4798.41	4800.94	2.53	--	27.50	20.9-25.9	5.00	unknown	unknown	N-PER	Abandoned
U1-045A	M-6	Nov-82	Aug-94	1874776.00	288589.00	4802.80	4804.65	1.85	77.00	40.70	35.7-40.7	5.00	8.00	sa-gv/si-cl	S-PER	6.75" Protective casing, 6" SS Screen
U1-045R	--	Aug-94		1874757.56	288586.28	4802.20	4805.01	2.81	43.00	43.80	31.0-41.0	10.00	7.25	si-cl	S-PER	2-inch PVC riser, SS Screen (.010), prot. casing
U1-046	M-7	Nov-82		1874673.00	288685.00	4802.80	4804.80	2.00	25.00	18.80	13.5-18.8	5.20	8.00	si-cl	S-PER	6" Protective casing, 4" PVC Screen
U1-047	M-9	Nov-82	Mar-90	unknown	unknown	4778.00	unknown	1.33	--	15.00	9.0-14.4	5.40	8.00	unknown	N-PER	4" PVC casing, 6" steel casing, 8" outer casing, grouted
U1-048	M-10	Nov-82	Mar-90	unknown	unknown	4779.40	unknown	7.00	--	29.50	unknown	unknown	unknown	unknown	N-PER	8" Protective casing, 6" inner casing
U1-049	M-11	Apr-86		1875756.00	288377.00	4808.92	4810.64	1.72	57.00	27.50	11.3-27.5	16.20	8.00	si-sa	S-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-050	M-12	May-86	Mar-90	unknown	unknown	4809.10	4811.47	2.37	--	65.58	unknown	unknown	16.00	unknown	S-PER	2-inch PVC riser, 8" steel outer casing, s.s. screen
U1-051	M-13	May-86		1875754.00	288403.00	4809.39	4810.99	1.60	35.00	30.30	15.3--30.3	15.00	8.00	si-sa	S-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-052	M-14	Jul-86		1876025.00	288442.00	4809.63	4810.67	1.04	65.00	65.00	55.0-65.0	10.00	12.00	si-cl	S-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-053	M-15	May-86		1875255.00	288607.00	4805.23	4806.38	1.15	49.50	34.00	19.0-34.0	15.00	8.00	si-sa	S-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-054	M-16	May-86		1875281.00	288608.00	4805.19	4806.82	1.63	41.50	30.00	15.0-30.0	15.00	8.00	si-sa	S-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-055	M-17	Jul-86		1876280.00	288701.00	4810.36	4811.96	1.60	63.00	63.00	53.0-63.0	10.00	12.00	si-sa	LF-4	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-056	M-18	Jul-86		1876350.00	288699.00	4810.78	4812.50	1.72	63.00	63.00	53.0-63.0	10.00	12.00	si-sa	S-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-057	M-19	Jun-86		1875236.00	288958.00	4805.80	4807.32	1.52	80.00	62.00	52.0-62.0	10.00	12.00	si-sa	S-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-058	M-20	Jul-86		1875258.00	288951.00	4807.87	4809.42	1.55	67.00	67.00	57.0-67.0	10.00	12.00	si-sa	S-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-059	M-21	May-86		1876315.00	288936.00	4807.24	4808.64	1.40	35.00	34.00	19.0-34.0	15.00	8.00	si-sa	F-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-060A	M-22	Apr-86	Aug-94	1876324.19	288947.13	4807.20	4808.85	1.65	54.50	54.00	39.0-54.0	15.00	8.00	si-sa	F-PER	Sched. 40 FVC riser, SS Screen, Protective Casing
U1-060R	--	Oct-94		1876345.72	288945.90	4807.19	4809.99	2.80	41.00	33.50	23.3-33.3	10.00	7.25	si-sa	E-PER	2-inch PVC riser, SS Screen (.020), Protective Casing
U1-061	M-23	Jun-86		1876016.00	289353.00	4804.25	4805.90	1.65	45.00	34.90	24.9-34.9	10.00	8.00	sa-gv	E-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-062	M-24	Jun-86		1873463.00	289081.00	4797.78	4799.68	1.90	45.00	46.15	33.0-43.0	10.00	12.00	si-sa	S-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-063	M-25	Jun-86		1872893.00	289824.00	4794.20	4797.10	2.90	45.00	45.00	35.0-45.0	10.00	12.00	si-sa	S-PER	Sched. 40 PVC riser
U1-064	M-26	May-86		1873493.00	289233.00	4798.40	4800.20	1.80	44.00	31.80	16.0-31.8	15.80	8.00	sa-gv	S-PER	Sched. 40 PVC riser
U1-065	M-27	May-86		1873051.00	289570.00	4795.94	4798.14	2.20	38.00	34.00	19.0-34.0	15.00	8.00	sa-gv	S-PER	Sched. 40 PVC riser
U1-066	M-28	May-86		1873730.38	289314.39	4801.72	4801.76	0.04	30.50	30.50	14.7-30.9	16.20	8.00	si-sa	CDP-1,2	Sched. 40 PVC riser
U1-067	M-29	May-86		1874077.00	289404.00	4794.16	4794.86	0.70	22.80	20.00	11.1-22.1	11.00	8.00	sa-gv	CDP-1,2	Sched. 40 PVC riser
U1-068	M-30	May-86		1873601.00	289347.00	4800.58	4801.08	0.50	31.50	28.50	12.1-28.5	16.40	8.00	sa-gv	S-PER	Sched. 40 PVC riser
U1-069	M-31	May-86		1873407.00	289432.00	4799.84	4800.94	1.10	33.10	31.00	14.5-31.0	16.50	8.00	sa-gv	S-PER	Sched. 40 PVC riser
U1-070	M-32	May-86		1873868.00	289395.00	4793.97	4794.37	0.40	25.80	26.13	11.64-23.0	11.40	8.00	sa-gv	CDP-1,2	Sched. 40 PVC riser
U1-071	M-33	Jun-86		1873975.00	289500.13	4791.94	4794.44	2.50	23.50	22.60	11.6-22.6	11.00	8.00	sa-gv	CDP- 1,2	Sched. 40 PVC riser
U1-072	M-34	May-86		1873780.00	289543.00	4795.80	4796.90	1.10	23.80	23.00	11.8-23.0	11.80	8.00	sa-gv	CDP-1,2	Sched. 40 PVC riser
U1-073	M-35	May-86		1873510.00	289661.00	4799.23	4800.43	1.20	31.50	29.60	13.1-29.6	16.50	8.00	sa-gv	N-PER	Sched. 40 PVC riser
U1-074	M-36	Nov-86		1873320.00	289545.00	4799.55	4800.05	0.50	31.00	30.00	15.0-30.0	15.00	8.00	sa-gv	N-PER	Sched. 40 PVC riser
U1-075	M-37	Jun-86		1874108.00	289874.00	4778.70	4780.20	1.50	45.00	44.82	35.0-45.0	11.00	8.00	si-cl	N-PER	Sched. 40 PVC riser
U1-076A	M-38	Jun-86	Apr-95	1873495.61	289904.71	4794.70	4797.50	2.80	26.50	23.00	12.0-23.0	11.00	8.00	sa-gv	N-PER	Sched. 40 PVC riser
U1-076R	--	Apr-95		1873504.59	289886.22	4794.06	4796.98	2.92	43.00	42.00	32.0-42.0	10.00	10.00	si-cl	N-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-077A	M-39	Jun-86	Apr-95	1872991.68	289959.73	4795.33	4798.38	3.05	26.50	21.00	10.0-21.0	11.00	8.00	sa-gv	N-PER	Sched. 40 FVC riser.
U1-077R	--	Apr-95		1872941.57	289954.20	4793.48	4795.88	2.40	38.00	38.00	27.0-37.0	10.00	10.00	si-sa	N-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-078	M.40	Jun-86		1872881.00	290179.00	4759.06	4761.06	2.00	25.00	25.00	13.7-25.0	11.30	8.00	sa-gv	N-PER	Sched. 40 PVC riser
U1-079	M-41	Jun-86		1873471.15	290176.43	4726.05	4728.05	2.00	18.00	18.00	8.0-18.0	10.00	8.00	si-cl	N-PER	Sched. 40 PVC riser
U1-080	M.42	May-86		1874625.27	289063.78	4801.10	4802.90	1.80	24.30	20.00	10.0-20.0	10.00	8.00	sa-gv	S-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-081	M-43	Jul-86		1874628.04	289008.40	4801.73	4803.93	2.20	30.00	26.00	16.0-26.0	10.00	8.00	sa-gv/si-cl	S-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-082	M-44	Jun-86		1875046.00	290034.00	4779.33	4780.73	1.40	57.00	56.10	45.5-56.1	10.60	8.00	si-cl	N-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-083	--	Nov-94		1872989.14	289789.62	4796.54	4798.79	2.25	90.00	73.00	68.0-73.0	10.00	10.00	si-cl	N-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-084	M-46	Jun-86		1874528.00	290083.00	4742.09	4744.19	2.10	25.00	27.50	11.0-27.5	15.00	8.00	si-sa	N-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-085	M-47	Jun-86		1875149.00	290060.00	4776.71	4778.81	2.10	20.00	20.00	10.0-20.0	10.00	7.75	si-sa	N-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-086	M-48	Jun-86		1874743.00	290123.00	4757.76	4760.06	2.30	55.00	37.00	27.0-37.0	10.00	7.75	si-sa	N-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-087	M-49	Jun-86		1874329.00	289918.00	4780.28	4781.66	1.38	45.00	46.60	36.3-46.6	10.00	8.00	si-sa	N-PER	Sched. 40 PVC riser, SS Screen, Protective Casing
U1-088	M-50	Jul-90		1873638.81	289603.37	4799.94	4800.93	0.99	80.00	73.40	63.4-73.4	10.00	8.00	si-cl	CDP-1,2	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-089	M-51	Dec-92		1872725.28	289634.39	4794.74	4794.38	-0.36	37.50	34.00	24.0-34.0	10.00	8.00	si-sa	S-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing, Flush Mount
U1-090	M-52	Aug-90		1874272.40	290590.10	4589.89	4591.79	1.90	122.00	119.10	109.1-119.1	10.00	8.00	si-sa	N-OB	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Deep
U1-091	M-53	Aug-90		1874387.50	290055.40	4735.94	4737.74	1.80	75.00	72.30	62.3-72.3	10.00	8.00	si-cl	N-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-092	M-54	Dec-92		1875273.79	289865.35	4781.91	4783.26	1.35	20.50	20.50	10.5-20.5	10.00	8.00	sa-gv	N-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing

TABLE 4-2

OPERABLE UNIT I MASTER MONITORING WELL AND PIEZOMETER LIST

(3 of 6)

Current Location ID	Old Site ID	Date Installed	Date Abandoned	Easting	Northing	Ground-Surface Elevation	Measuring Point Elevation	Stick-Up (feet)	Reported Boring Depth (ft bgs)	Well Depth [a] (ft bgs)	Screened Interval (ft bgs)	Screen Length (feet)	Borehole Diameter (inches)	Well Screen Formation Type	General Location in OU1	Construction Details/Comments
U1-093A	M-55	Sep-90	Dec-93	1876552.30	288823.60	4810.75	4812.74	1.99	40.00	33.80	23.8-33.8	10.00	10.00	sa-gv	E-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-093R	--	Dec-93		1876536.11	288823.36	4810.78	4812.74	1.96	36.00	35.00	25.0-35.0	10.30	10.00	sa-gv	E-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-094	M-56	Sep-90		1877706.20	290458.80	4511.70	4513.62	1.92	65.00	64.00	54.0-64.0	10.00	8.00	si-sa	N-OB	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Deep
U1-095	M-57	Sep-90		1876435.30	290908.00	4499.13	4500.83	1.70	45.00	42.80	33.2-42.8	9.60	8.00	si-sa	N-OB	Sched. 40 PVC riser, SS Screen, 6" Prolective Casing. Off Base, Deep
U1-096	M-58	Sep-90		1875079.20	291338.80	4493.49	4495.16	1.67	47.00	42.20	32.2-42.2	10.00	8.00	si-sa	N-OB	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Deep
U1-097	M-59	Sep-90		1875072.00	291345.50	4493.37	4495.31	1.94	20.00	19.00	9.0-19.0	10.00	8.00	si-sa	N-OB	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Shallow
U1-098	M-60	Sep-90		1873813.00	291898.20	4482.29	4484.01	1.72	17.50	14.40	4.4-14.4	10.00	8.00	sa-gv	N-OB	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Shallow
U1-099	M-61	Sep-90		1873267.80	292852.70	4467.84	4469.62	1.78	21.00	14.60	4.6-14.6	10.00	8.00	sa-gv/si-cl	N-OB	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Shallow
U1-100	M-62	Aug-92		1874576.69	289160.18	4803.45	4804.86	1.41	33.00	31.00	21.0-31.0	10.00	8.00	sa-gv/si-cl	S-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Shallow
U1-101	M-63	Aug-92		1874419.85	289349.88	4799.46	4800.71	1.25	33.50	31.00	21.0-31.0	10.00	8.00	sa-gv	FTA-1	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-102	M-64	Aug-92		1874062.85	289729.73	4779.04	4778.69	-0.35	13.50	13.20	3.2-13.2	10.00	8.00	sa-gv/si-cl	FTA-2	Sched. 40 PVC riser, SS Screen, 6" Protective Casing, Flush Mount
U1-103	M-65	Dec-92		1872681.55	290002.60	4793.53	4795.78	2.25	40.00	40.00	23.0-33.0	10.00	8.00	sa-gv/si-cl	N-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-104	M-66	Dec-92		1872948.10	290606.19	4731.71	4733.76	2.05	33.00	33.00	23.0-33.0	10.00	8.00	si-cl	N-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-105	M-67	Dec-92		1873127.65	291482.00	4509.28	4511.26	1.98	35.00	35.00	25.0-35.0	10.00	8.00	si-sa	N-OB	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Shallow
U1-106	M-68	Aug-92		1874178.36	289396.02	4791.66	4792.85	1.19	28.00	27.30	17.3-27.3	10.00	8.00	sa-gv/si-cl	LF-3	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-107	M-69	Aug-92		1874921.03	289528.49	4804.46	4805.79	1.33	38.00	39.40	26.4-36.4	10.00	8.00	sa-gv	LF-3	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-108	M-70	Dec-92		1873807.44	291262.87	4498.97	4500.94	1.97	25.00	25.00	15.0-25.0	10.00	8.00	sa-gv	N-OB	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Shallow
U1-109	M-71	Dec-92		1875533.93	291457.00	4494.10	4495.76	1.66	25.00	25.00	15.0-25.0	10.00	8.00	sa-gv	N-OB	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Shallow
U1-110	M-72	Dec-92		1875251.24	291924.55	4491.17	4493.52	2.35	23.00	23.00	13.0-23.0	10.00	8.00	sa-gv	N-OB	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Shallow
U1-111	M-73	Jan-93		1874839.89	292115.01	4486.85	4488.18	1.33	17.00	17.00	7.0-17.0	10.00	8.00	sa-gv	N-OB	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Shallow
U1-112	M-74	Dec-92		1873896.61	292422.03	4476.99	4479.28	2.29	15.00	15.00	5.0-15.0	10.00	8.00	sa-gv	N-OB	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Shallow
U1-113	M-75	Dec-92		1873891.23	292424.73	4476.94	4479.19	2.25	50.00	50.00	40.0-50.0	10.00	8.00	si-sa	N-OB	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Off Base, Deep
U1-114	--	unknown		1872874.47	288463.68	4794.99	4796.08	1.09	--	--	--	--	--	unknown	S-PER	Abandoned-Well never established.
U1-115	--	Dec-93		1871746.17	289715.93	4789.46	4790.82	1.36	35.10	35.10	25.0-5.0	10.00	10.00	si-sa	SW-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-116	--	Dec-93		1871802.62	290242.74	4786.81	4786.81	0.00	32.50	32.50	22.2-32.2	10.00	10.00	sa-gv/si-cl	NW-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-117	--	Dec-93		1871139.08	290890.83	4784.47	4786.56	2.09	57.20	57.20	47.2-57.2	10.00	10.00	sa-gv/si-cl	NW-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-118	--	Nov-94		1872983.65	289787.08	4796.70	4799.16	2.46	35.00	35.00	24.0-34.0	10.00	6.00	sa-gv/si-cl	NW-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-119	--	Dec-93		1875984.67	289375.63	4804.90	4806.56	1.66	48.00	48.00	43.0-48.0	10.00	10.00	si-cl	N-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Nested pair (U1-119/U1-120)
U1-120	--	Dec-93		1875989.75	289372.09	4804.71	4807.10	2.39	75.00	75.00	65.0-75.0	10.00	10.00	si-cl	N-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Nested pair (U1-119/U1-120)
U1-121	--	Dec-93		1875747.04	289582.25	4803.01	4804.88	1.87	47.00	47.00	42.0-47.0	5.00	10.00	si-cl	N-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Nested pair (U1-121/U1-122)
U1-122	--	Dec-93		1875752.89	289577.62	4803.03	4804.72	1.69	78.00	78.00	68.0-78.0	10.00	10.00	si-cl	N-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing. Nested pair (U1-121/U1-122)
U1-123	--	Dec-93		1875520.10	289782.72	4788.65	4790.44	1.79	35.00	35.00	30.0-35.0	5.00	10.00	si-sa	N-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-124	--	Dec-93		1875155.17	290050.71	4777.90	4779.45	2.06	30.00	30.00	25.0-30.0	5.00	10.00	si-cl	N-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-125	--	Nov-93		1876290.40	289103.89	4804.31	4806.41	2.10	47.00	47.00	42.0-47.0	5.00	10.00	si-sa	NW-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-126	--	Nov-94		1872993.43	289790.91	4796.19	4799.02	2.83	48.00	47.00	42.0-47.0	5.00	6.00	si-cl	NW-PER	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-127	SB-4, SB-730	Mar-90		1874499.10	289608.23	4781.71	4783.61	1.90	13.50	13.50	3.5-13.5	10.00	8.00	sa-gv	LF-3	Sched. 40 PVC riser, SS Screen, 6" Protective Casing
U1-128	SB-7, SB-733	Mar-90		1873964.29	289502.89	4793.01	4795.01	2.00	25.00	25.00	15.0-25.0	10.00	8.00	sa-gv	CDP-1,2	Sched. 40 PVC riser, SS Screen, No protective Casing
U1-129	SB-8, SB-734	Mar-90		1873792.23	289512.78	4796.66	4799.55	2.89	28.00	28.00	18.0-28.0	10.00	8.00	sa-gv	CDP-1,2	Sched. 40 PVC riser, SS Screen, No protective Casing
U1-130	SB-9, SB-735	Mar-90		1873698.62	289483.11	4799.69	4801.82	2.13	30.00	30.00	15.0-30.0	10.00	8.00	sa-gv	CDP-1,2	Sched. 40 PVC riser, SS Screen, No protective Casing
U1-131A	SB-10, SB-736	Mar-90	Aug-94	1873521.68	289456.22	4799.98	4801.93	1.95	31.00	31.00	2.01-31.0	10.00	8.00	sa-gv	CDP-1,2	Sched. 40 PVC riser, SS Screen, No protective Casing
U1-131R	--	Aug-94		1873515.20	289463.10	4800.07	4804.48	4.41	35.00	34.20	24.0-34.2	10.00	7.25	si-cl	CDP-1,2	Sched. 40 PVC riser, SS Screen, No protective Casing
U1-132	SB-11, SB-737	Feb-90		1873804.31	289384.09	4797.50	4799.34	1.84	28.50	28.70	18.7-28.7	10.00	8.00	sa-gv	CDP-1,2	Sched. 40 PVC riser, SS Screen, No protective Casing
U1-133	SB-12, SB-738	Feb-90		1873961.41	289301.97	4795.19	4797.23	2.04	27.00	27.00	17.0-27.0	10.00	8.00	sa-gv	CDP-1,2	Sched. 40 PVC riser, SS Screen, No protective Casing
U1-134	SB-16, SB-742	Mar-90		1873802.10	289380.10	4797.50	4798.87	1.37	29.00	29.00	19.0-29.0	10.00	8.00	sa-gv	CDP-1,2	Sched. 40 PVC riser, SS Screen, No protective Casing
U1-135	--	Jun-94		1873835.04	289537.51	4792.26	4791.56	-0.70	30.50	26.00	16.0-26.0	10.00	8.25	si-sa	CDP-1,2	Sched. 40 PVC riser, SS Screen, No protective Casing
U1-136	--	Jun-94		1873835.39	289513.99	4793.23	4792.65	-0.58	29.50	11.60	11.6-21.6	10.00	8.25	unknown	CDP-1,2	Sched. 40 PVC riser, SS Screen, No protective Casing
U1-137	--	Jun-94		1873848.77	289531.93	4792.30	4791.87	-0.43	30.50	21.50	11.5-21.5	10.00	8.25	unknown	CDP-1,2	Sched. 40 PVC riser, SS Screen, No protective Casing
U1-138	--	Jul-95		1873210.84	291080.18	4590.12	4590.12	0.00	135	107.00	97.0-107.0	10.00		si-sa		
U1-139	--	Nov-94		1873367.89	289439.26	4799.77	4801.91	2.14	85.00	77.00	72.0-77.0	5.00	10.00	si-cl	S-PER	2-inch PVC casing
U1-140	--	Nov-94		1873370.96	289442.88	4799.56	4802.56	3.00	41.00	36.00	26.0-36.0	10.00	6.00	sa-gv/si-cl	S-PER	2-inch PVC casing
U1-141	--	Nov-94		1873364.52	289436.10	4799.60	4800.68	1.08	64.00	64.00	59.0-64.0	5.00	6.00	si-cl	S-PER	2-inch PVC casing
U1-142	--	Nov-94		1873558.79	289332.30	4800.02	4803.25	3.23	90.00	78.00	73.0-78.0	5.00	10.00	si-cl	S-PER	2-inch PVC casing
U1-143	--	Nov-94		1873558.76	289327.31	4799.99	4802.63	2.64	35.00	35.00	25.0-35.0	10.00	6.00	sa-gv/si-cl	S-PER	2-inch PVC casing

TABLE 4-2

OPERABLE UNIT I MASTER MONITORING WELL AND PIEZOMETER LIST

(4 of 6)

Current Location ID	Old Site ID	Date Installed	Date Abandoned	Easting	Northing	Ground-Surface Elevation	Measuring Point Elevation	Stick-Up (feet)	Reported Boring Depth (ft bgs)	Well Depth [a] (ft bgs)	Screened Interval (ft bgs)	Screen Length (feet)	Borehole Diameter (inches)	Well Screen Formation Type	General Location in OU1	Construction Details/Comments
U1-144	--	Nov-94		1873559.02	289337.10	4799.97	4802.50	2.53	56.00	55.00	50.0-55.0	5.00	6.00	si-cl	CDP-1,2	2-inch PVC casing
U1-145	--	Aug-94		1873834.77	289533.37	4792.36	4792.22	-0.14	21.00	20.50	15.5-20.5	5.00	8.00	sa-gv	CDP-1,2	2-inch PVC casing
U1-146	--	Aug-94		1873830.24	289529.81	4792.65	4792.58	-0.07	30.00	30.00	26.0-30.0	4.00	8.00	sa-gv/si-cl	CDP-1,2	2-inch PVC casing
U1-147	--	Aug-94		1873832.97	289518.42	4792.88	4792.89	0.01	31.50	30.50	27.5-30.5	3.00	8.00	si-cl	CDP-1,2	2-inch PVC casing
U1-148	--	Aug-94		1873846.26	289519.97	4792.15	4791.99	-0.16	26.00	24.00	19.0-24.0	5.00	8.00	sa-gv	CDP-1,2	2-inch PVC casing
U1-149	--	Aug-94		1873847.55	289524.61	4792.12	4791.97	-0.15	32.00	32.00	29.0-32.0	3.00	8.00	si-cl	CDP-1,2	2-inch PVC casing
U1-150	--	Aug-94		1873842.37	289534.40	4792.06	4791.87	-0.19	22.50	22.50	15.5-20.5	5.00	8.00	sa-gv/si-cl	CDP-1,2	2-inch PVC casing
U1-151	--	Jul-95		1873645.36	290741.21	4592.16	4592.16	0.00	124.00	124.00	114.0-124.0	10.00		sa-gv		
U1-152	--	Jul-95		1875156.87	290663.81	4589.06	4589.30	0.24	115.00	115.00	105.0-115.0	10.00		si-sa		
U1-153	--	Jul-95		1875983.48	290194.95	4590.02	4590.17	0.15	128.00	128.00	118.0-128.0	10.00		si-cl		
U1-154	--	Jul-95		1873807.85	291268.64	4498.06	4498.06	0.00	33.00	33.00	23.0-33.0	10.00		sa-gv		
U1-155	--	Jul-95		1873105.62	291492.10	4509.62	4511.70	2.08	87.00	87.00	77.0-87.0	10.00		si-sa		
U1-156	--	May-95		1873886.61	292426.76	4476.99	4479.15	2.16	124.00	124.00	114.0-124.0	10.00		si-cl		
Dewatering Wells																
U1-201	--	Oct-84		1873815.03	289323.66	4797.55	4794.70	-2.85	--	31.00	20.0-30.0	10.00	12.00	unknown	CDP-1,2	10-inch SS casing and screen
U1-202	--	Oct-84		1873988.05	289475.14	4793.73	4793.70	-0.03	--	29.00	16.5-26.5	10.00	12.00	unknown	CDP-1,2	10-inch SS casing and screen
U1-203	--	Jun-85		1874312.83	289593.25	4872.50	4780.70	-91.80	--	18.00	4.0-17.0	13.00	24.00	unknown	LF-3	20-inch slotted steel casing
U1-204	--	Jun-85		1874881.57	289743.43	4782.36	4781.10	-1.26	--	18.50	4.0-17.0	13.00	24.00	unknown	LF-4	20-inch slotted steel casing
U1-205	--	Jun-85		1875651.91	289622.36	4804.76	4804.76	0.00	--	44.00	34.0-40.0	6.00	12.00	unknown	LF-4	10-inch SS casing and screen
U1-206	--	Jun-85		1875917.15	289401.05	4806.84	4806.84	0.00	--	40.00	28.0-38.0	10.00	12.00	unknown	LF-4	10-inch SS casing and screen
U1-207	--	Jun-85		1876141.66	289204.80	4808.47	4808.47	0.00	--	38.50	28.5-37.0	8.50	12.00	unknown	LF-4	10-inch SS casing and screen
U1-208	--	Jun-85		1876279.19	288955.36	4810.24	4810.24	0.00	--	41.00	28.5-38.5	10.00	12.00	unknown	LF-4	10-inch SS casing and screen
U1-209	--	Jun-85		1875286.81	288925.47	4807.76	4807.80	0.04	--	49.50	38.0-48.0	10.00	12.00	unknown	LF-4	10-inch SS casing and screen
U1-210	So Weber #1	Jan-62		unknown	unknown	unknown	unknown	unknown	--	unknown	unknown	unknown	unknown	unknown	N-OB	Municipal production well
U1-211	So Weber #2	1961		1873725.00	290835.00	4530.00	unknown	unknown	--	1208	unknown	unknown	unknown	unknown	N-OB	Municipal production well
Pumping Wells																
U1-213	--	Nov-94	1994	1872986.05	289799.72	4796.41	4799.04	2.63	--	38.50	27.5-37.5	10.00	10.30	unknown	CDP-1,2	
U1-214	--	Nov-94	1994	1873358.32	289446.85	4799.49	4802.04	2.55	--	38.00	26.0-36.0	10.00	10.30	unknown	CDP-1,2	
U1-215	--	Nov-94	1994	1873553.21	289332.05	4800.22	4802.60	2.38	--	38.00	26.0-36.0	10.00	6.00	unknown	CDP-1,2	
Seeps/Springs																
U1-301	S-1	NA		1877527.99	289619.37	4679.67	--	--	--	--	--	--	--	not applicable	N-PER	
U1-302	S-2	NA		1877218.15	289704.00	4599.36	--	--	--	--	--	--	--	not applicable	N-PER	
U1-303	S-3	NA		1875715.24	289747.26	4753.01	--	--	--	--	--	--	--	not applicable	N-PER	
U1-304	S-4	NA		1875561.50	289855.45	4759.64	--	--	--	--	--	--	--	not applicable	N-PER	
U1-305	S-6	NA		1874940.66	290486.68	4642.14	--	--	--	--	--	--	--	not applicable	N-PER	
U1-306	S-7	NA		1872873.44	291301.53	4599.27	--	--	--	--	--	--	--	not applicable	N-PER	
U1-307	S-8	NA		1872801.03	290725.17	4708.49	--	--	--	--	--	--	--	not applicable	N-PER	
U1-308	S-9	NA		1872563.50	291248.88	4673.26	--	--	--	--	--	--	--	not applicable	N-PER	
U1-309	OB-2-EP	NA		1873862.52	292705.48	4463.28	--	--	--	--	--	--	--	not applicable	N-PER	
U1-310	OB-3-EP	NA		1874230.29	292426.31	4467.86	--	--	--	--	--	--	--	not applicable	N-PER	
U1-311	--	NA		1876175.80	289948.40	4590.44	--	--	--	--	--	--	--	not applicable	N-PER	
U1-312	--	NA		1876826.10	289766.00	4590.51	--	--	--	--	--	--	--	not applicable	N-PER	
U1-313	--	NA		1876409.32	289147.60	4799.31	--	--	--	--	--	--	--	not applicable	N-PER	
U1-314	D. Byrum	NA		1873235.37	293604.92	4443.37	--	--	--	--	--	--	--	not applicable	N-PER	
U1-315	Z. Cook	NA		1872640.73	291837.73	4537.05	--	--	--	--	--	--	--	not applicable	N-PER	
U1-316	Wilson	NA		1874037.00	292495.81	4466.40	--	--	--	--	--	--	--	not applicable	N-PER	
U1-317	--	NA		1875789.31	289909.23	4690.49	--	--	--	--	--	--	--	not applicable	N-PER	

TABLE 4-2

OPERABLE UNIT I MASTER MONITORING WELL AND PIEZOMETER LIST

(5 of 6)

Current Location ID	Old Site ID	Date Installed	Date Abandoned	Easting	Northing	Ground-Surface Elevation	Measuring Point Elevation	Stick-Up (feet)	Reported Boring Depth (ft bgs)	Well Depth [a] (ft bgs)	Screened Interval (ft bgs)	Screen Length (feet)	Borehole Diameter (inches)	Well Screen Formation Type	General Location in OU1	Construction Details/Comments
U1-318	--	NA		1875827.68	289626.49	4762.01	--	--	--	--	--	--	--	not applicable	N-PER	
U1-319	--	NA		1875938.66	290319.12	4548.67	--	--	--	--	--	--	--	not applicable	N-PER	
U1-320	--	NA		1875952.42	290166.58	4588.64	--	--	--	--	--	--	--	not applicable	N-PER	
U1-321	--	NA		No survey data available			--	--	--	--	--	--	--	not applicable	N-PER	
U1-322	--	NA		No survey data available			--	--	--	--	--	--	--	not applicable	N-PER	
U1-323	--	NA		1872635.37	291561.58	4588.05	--	--	--	--	--	--	--	not applicable	N-PER	
U1-327	--	NA		1875808.76	290300.97	4590.14	--	--	--	--	--	--	--	not applicable	N-PER	
Canal and Surface Water Sampling Locations																
U1-401	--	NA		1877190.00	289800.00	4594.00	--	--	--	--	--	--	--	not applicable	N-PER	
U1-402	--	NA		1873550.00	290730.00	4580.00	--	--	--	--	--	--	--	not applicable	N-PER	
U1-403	--	NA		1872610.00	291640.00	4580.00	--	--	--	--	--	--	--	not applicable	N-PER	
U1-404	--	NA		1871710.97	291994.92	4589.54	--	--	--	--	--	--	--	not applicable	N-PER	
U1-405	--	NA		1878984.32	290086.28	4594.94	--	--	--	--	--	--	--	not applicable	N-PER	
U1-406	--	NA		1872887.23	291333.57	4585.72	--	--	--	--	--	--	--	not applicable	N-PER	
U1-407	--	NA		1876941.14	289720.94	4590.54	--	--	--	--	--	--	--	not applicable	N-PER	
U1-408	--	NA		1876990.13	289938.06	4590.70	--	--	--	--	--	--	--	not applicable	N-PER	
U1-409	--	NA		No survey data available			--	--	--	--	--	--	--	not applicable	N-PER	
U1-421	--	NA		1872809.71	291423.95	4586.06	--	--	--	--	--	--	--	not applicable	N-PER	Surface water associated with Spring U1-321
Piezometers																
U1-644	--	Nov-93		1872605.73	288875.43	4794.40	4796.57	2.17	--	46.50	22.0-32.0	10.00	10.00	si-sa	W-OU-1	Sched. 40 PVC riser, Sched. 40 PVC Screen, 6" Protective Casing
U1-645	--	Nov-93		1872128.21	289453.84	4790.36	4792.29	1.93	--	46.50	20.0-30.0	10.00	10.00	si-sa	W-OU-1	Sched. 40 PVC riser, Sched. 40 PVC Screen, 6" Protective Casing
U1-646	--	Nov-93		1872146.75	289924.11	4789.31	4792.45	3.14	--	45.00	21.0-31.0	10.00	10.00	sa-gv/si-cl	W-OU-1	Sched. 40 PVC riser, Sched. 40 PVC Screen, 6" Protective Casing
U1-647	--	Nov-93		1872248.34	290697.59	4785.24	4787.32	2.08	--	71.50	47.0-57.0	10.00	10.00	sa-gv/si-cl	W-OU-1	Sched. 40 PVC riser, Sched. 40 PVC Screen, 6" Protective Casing
U1-648	--	Nov-93		1872537.97	289703.04	4793.80	4795.82	2.02	--	50.00	22.7-32.7	10.00	10.00	sa-gv/si-cl	W-OU-1	Sched. 40 PVC riser, Sched. 40 PVC Screen, 6" Protective Casing
U1-649	--	Nov-93		1872856.84	289275.31	4794.44	4796.32	1.88	--	51.00	22.0-32.0	10.00	10.00	sa-gv/si-cl	W-OU-1	Sched. 40 PVC riser, Sched. 40 PVC Screen, 6" Protective Casing
U1-650	--	Oct-94		1873767.02	289328.66	4799.79	4801.67	1.88	--	32.00	22.0-32.0	10.00	8.00	sa-gv/si-cl	S-PER	Sched. 40 PVC riser, Sched. 40 PVC Screen, 6" Protective Casing
U1-651	--	Oct-94		1873842.71	289377.02	4794.93	4796.83	1.90	--	27.00	15.0-25.0	10.00	8.00	sa-gv/si-cl	CDP-1,2	2 inch Sched. 40 PVC riser, Sched. 40 PVC Screen
U1-652	--	Oct-94		1873800.69	289265.93	4797.71	4799.98	2.27	--	37.00	24.0-34.0	10.00	8.00	sa-gv/si-cl	CDP- 1,2	2 inch Sched. 40 PVC riser, Sched. 40 PVC Screen
U1-653	--	Oct-94		1873804.19	289314.58	4797.12	4799.10	1.98	--	30.00	19.0-29.0	10.00	8.00	sa-gv	CDP-1,2	2 inch Sched. 40 PVC riser, Sched. 40 PVC Screen
U1-654	--	Oct-94		1873805.16	289317.47	4797.16	4799.11	1.95	--	50.00	45.0-50.0	10.00	8.00	sa-gv	CDP-1,2	2 inch Sched. 40 PVC riser, Sched. 40 PVC Screen
U1-655	--	Oct-94		1874057.98	289476.21	4792.79	4794.94	2.15	--	24.00	13.0-23.0	10.00	8.00	si-cl	CDP-1,2	2 inch Sched. 40 PVC riser, Sched. 40 PVC Screen
U1-656	--	Oct-94		1873993.13	289435.20	4792.02	4794.16	2.14	--	24.00	13.0-23.0	10.00	8.00	sa-gv	CDP-1,2	2 inch Sched. 40 PVC riser, Sched. 40 PVC Screen
U1-657	--	Oct-94		1873947.81	289454.03	4791.79	4794.10	2.31	--	24.00	13.0-23.0	10.00	8.00	sa-gv	CDP-1,2	2 inch Sched. 40 PVC riser, Sched. 40 PVC Screen
U1-658	--	Oct-94		1873979.04	289470.4;3	4791.76	4794.25	2.49	--	23.00	13.0-23.0	10.00	8.00	sa-gv	CDP-1,2	2 inch Sched. 40 PVC riser, Sched. 40 PVC Screen
U1-659	--	Oct-94		1873976.57	289472.50	4791.55	4794.24	2.69	--	42.00	30.0-35.0	5.00	8.00	sa-gv/si-cl	CDP-1,2	Sched. 40 PVC riser, Sched. 40 PVC Screen, 6" Protective Casing
U1-660	--	Oct-94		1874371.96	289578.11	4781.50	4784.17	2.67	--	19.00	8.0-18.0	10.00	8.00	si-cl	CDP-1,2	2 inch Sched. 40 PVC riser, Sched. 40 PVC Screen
U1-661	--	Oct-94		1874311.60	289532.68	4781.19	4783.67	2.48	--	24.00	12.5-22.5	10.00	8.00	sa-gv/si-cl	LF-3, FTA-2	LF-3, FTA-2 2 inch Sched. 40 PVC riser.
U1-662	--	Oct-94		1874265.75	289604.32	4777.74	4777.53	-0.21	--	15.50	7.0-12.0	5.00	8.00	sa-gv	LF-3, FTA-2	LF-3, FTA-2 2 inch Sched. 40 PVC riser.
U1-663	--	Oct-94		1874319.67	289649.85	4777.27	4777.09	-0.18	--	14.00	7.0-12.0	5.00	8.00	sa-gv/si-cl	LF-3, FTA-2	LF-3, FTA-2 2 inch Sched. 40 PVC riser.
U1-664	--	Oct-94		1874315.45	289582.64	4780.02	4782.25	2.23	--	18.00	7.0-17.0	10.00	8.00	si-cl	LF-3, FTA-2	LF-3, FTA-2 2 inch Sched. 40 PVC riser.
U1-665	--	Oct-94		1874311.15	289582.67	4780.00	4782.33	2.33	--	41.00	35.0-40.0	5.00	8.00	sa-gv/si-cl	LF-3, FTA-2	LF-3, FTA-2 2 inch Sched. 40 PVC riser.
U1-666	--	Oct-94		1874928.98	289755.66	4781.70	4783.62	1.92	--	23.00	13.0-23.0	10.00	8.00	si-cl	LF-3	2 inch Sched. 40 PVC riser
U1-667	--	Oct-94		1874850.18	289709.73	4784.45	4786.29	1.84	--	25.00	13.0-23.0	10.00	8.00	si-cl	LF-3	2 inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-668	--	Oct-94		1874878.40	289735.74	4782.35	4784.10	1.75	--	19.00	14.0-19.0	5.00	8.00	si-cl	LF-3	2 inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-669	--	Oct-94		1874876.24	289734.53	4782.32	4784.14	1.82	--	40.00	34.0-39.0	5.00	8.00	si-cl	LF-3	2 inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-670	--	Oct-94		1875693.47	289625.26	4802.39	4804.53	2.14	--	34.00	22.0-32.0	10.00	8.00	sa-gv/si-cl	NE-PER	2 inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-671	--	Oct-94		1875599.02	289593.12	4799.79	4801.56	1.77	--	32.00	22.0-32.0	10.00	8.00	sa-gv/si-cl	NE-PER	2 inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-672	--	Oct-94		1875614.59	289667.62	4799.88	4801.73	1.85	--	33.00	23.0-33.0	10.00	8.00	sa-gv/si-cl	NE-PER	2 inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-673	--	Oct-94		1875643.30	289622.20	4802.45	4804.33	1.88	--	35.00	25.0-35.0	10.00	8.00	sa-gv/si-cl	NE-PER	2 inch Sched. 40 PVC riser Sched. 40 PVC Screen

TABLE 4-2

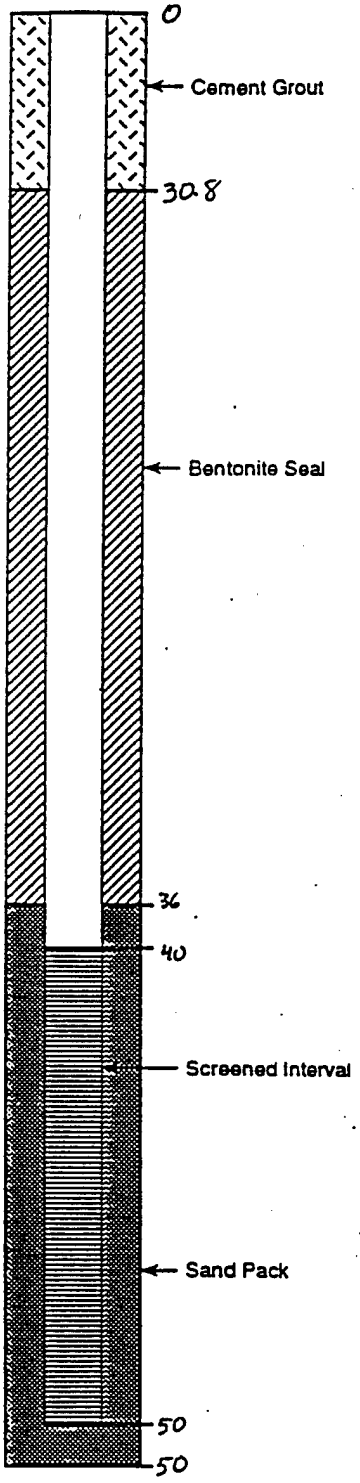
OPERABLE UNIT I MASTER MONITORING WELL AND PIEZOMETER LIST

(6 of 6)

Current Location ID	Old Site ID	Date Installed	Date Abandoned	Easting	Northing	Ground-Surface Elevation	Measuring Point Elevation	Stick-Up (feet)	Reported Boring Depth (ft bgs)	Well Depth [a] (ft bgs)	Screened Interval (ft bgs)	Screen Length (feet)	Borehole Diameter (inches)	Well Screen Formation Type	General Location in OU1	Construction Details/Comments
U1-674	--	Oct-94		1875641.79	289619.10	4802.36	4804.19	1.83	--	50.00	40.0-45.0	10.00	8.00	si-cl	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-675	--	Oct-94		1875944.98	289345.98	4806.45	4808.35	1.90	--	37.00	24.0-34.0	10.00	8.00	sa-gv	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-676	--	Oct-94		1875859.97	289420.86	4805.25	4807.04	1.79	--	39.00	26.0-36.0	10.00	8.00	sa-gv/si-cl	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-677	--	Oct-94		1875888.50	289458.42	4804.70	4806.60	1.90	--	34.00	24.0-34.0	10.00	8.00	sa-gv/si-cl	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-678	--	Oct-94		1875909.73	289411.03	4805.06	4806.99	1.93	--	34.00	24.0-34.0	10.00	8.00	sa-gv/si-cl	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-679	--	Oct-94		1875911.46	289409.89	4805.08	4807.05	1.97	--	56.00	44.0-49.0	5.00	8.00	si-cl	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-680	--	Oct-94		1876207.40	289207.40	4801.92	4804.51	2.59	--	35.00	24.0-34.0	10.00	8.00	sa-gv/si-cl	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-681	--	Oct-94		1876171.35	289153.61	4806.85	4809.16	2.31	--	37.00	25.0-35.0	10.00	8.00	sa-gv/si-cl	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-682	--	Oct-94		1876100.00	289245.91	4805.19	4808.00	2.81	--	37.00	24.0-34.0	10.00	8.00	sa-gv/si-cl	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-683	--	Oct-94		1876153.03	289199.00	4805.95	4808.29	2.34	--	37.00	24.0-34.0	10.00	8.00	sa-gv/si-cl	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-684	--	Oct-94		1876149.99	289200.51	4805.96	4808.27	2.31	--	50.00	41.0-46.0	5.00	8.00	si-cl	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-685	--	Nov-94		1876327.18	289021.28	4805.56	4807.82	2.26	--	36.00	26.0-36.0	10.00	8.00	sa-gv/si-cl	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-686	--	Nov-94		1876265.14	288899.02	4808.95	4811.28	2.33	--	36.00	26.0-36.0	10.00	8.00	sa-gv	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-687	--	Oct-94		1876282.53	288969.26	4808.02	4810.12	2.10	--	37.00	26.0-36.0	10.00	8.00	sa-gv	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-688	--	Oct-94		1876282.56	288966.95	4808.06	4809.96	1.90	--	50.00	42.0-47.0	5.00	8.00	si-cl	NE-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-689	--	Nov-94		1875286.49	288867.06	4805.52	4807.90	2.38	--	35.00	25.0-35.0	10.00	8.00	si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-690	--	Nov-94		1875242.27	288910.90	4804.86	4807.43	2.57	--	35.00	25.0-35.0	10.00	8.00	sa-gv/si-cl	S-PER	Sched. 40 PVC riser, Sched. 40 PVC Screen, 6" Protective Casing
U1-691	--	Nov-94		1875284.60	288936.11	4805.87	4808.34	2.47	--	33.00	22.0-32.0	10.00	8.00	sa-gv/si-cl	S-PER	Sched. 40 PVC riser, Sched. 40 PVC Screen, 6" Protective Casing
U1-692	--	Nov-94		1875284.28	288939.64	4805.84	4808.21	2.37	--	52.00	47.0-52.0	5.00	8.00	si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-693	--	Nov-94		1873022.56	289787.19	4797.07	4799.29	2.22	--	34.50	24.0-34.0	10.00	8.00	sa-gv/si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-694	--	Nov-94		1872964.98	289822.13	4796.12	4798.60	2.48	--	34.00	24.0-34.0	10.00	8.00	sa-gv/si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-695	--	Nov-94		1873361.11	289480.54	4799.61	4802.35	2.74	--	36.50	26.0-36.0	10.00	6.00	sa-gv/si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-696	--	Nov-94		1873321.28	289432.63	4799.20	4801.71	2.51	--	36.00	26.0-36.0	10.00	6.00	sa-gv/si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-697	--	Nov-94		1873539.43	289311.69	4800.17	4802.89	2.72	--	36.00	25.0-35.0	10.00	6.00	sa-gv/si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-698	--	Nov-94		1873554.53	289367.53	4800.01	4802.54	2.53	--	36.00	25.0-35.0	10.00	6.00	sa-gv/si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-699	--	Nov-94		1876264.73	288898.88	4808.95	4811.26	2.31	--	39.00	29.0-39.0	10.00	8.00	sa-gv/si-cl	LF-4	Sched. 40 PVC riser, Sched. 40 PVC Screen, 6" Protective Casing
U1-1600	--	Nov-94		1872959.14	289767.51	4796.87	4799.24	2.37	--	35.00	25.0-35.0	10.00	8.00	sa-gv/si-cl	W-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-1601	--	Dec-94		1873067.34	290146.84	4750.15	4752.58	2.43	--	35.00	25.0-35.0	10.00	8.00	sa-gv/si-cl	N-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-1602	--	Feb-95		1873346.83	290322.33	4708.85	4711.47	2.62	--	35.00	25.0-35.0	10.00	8.00	si-cl	N-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-1603	--	Nov-94		1875791.23	287813.28	4810.53	4812.65	2.12	--	26.00	14.0-24.0	10.00	8.00	sa-gv/si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-1604	--	Nov-94		1873817.86	287653.26	4800.86	4803.56	2.70	--	26.00	16.0-26.0	10.00	8.00	sa-gv/si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-1605	--	Dec-94		1872780.40	287781.20	4794.63	4797.37	2.74	--	27.00	17.0-27.0	10.00	8.00	sa-gv/si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-1606	--	Dec-94		1872311.30	287793.72	4789.27	4791.54	2.27	--	25.00	15.0-25.0	10.00	8.00	sa-gv/si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-1607	--	Dec-94		1871992.81	288646.13	4788.93	4791.27	2.34	--	26.00	15.0-25.0	10.00	8.00	sa-gv/si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen
U1-1608	--	Nov-94		1875267.89	288980.02	4805.22	4807.66	2.44	--	37.00	21.0-31.0	10.00	8.00	si-cl	S-PER	2-inch Sched. 40 PVC riser Sched. 40 PVC Screen

OU 1 Northern Perimeter	N-PER
OU 1 Southern Perimeter	S-PER
Western OU 1	W-OU-1
Chemical Disposal Pit Area	CDP- 1,2
Landfill 3	LF-3
Landfill 4	LF-4

(a) Current Depth Measured prior to 1992 Monitoring Well Installations



SOIL BORING/WELL NUMBER VI-157

LOCATION: NORTHING _____ EASTING _____

GROUND SURFACE ELEV. _____ MEASURING POINT ELEV. _____

GEOLOGIST E. HICKEY

DATE CONSTRUCTION STARTED 10/18/95

DATE CONSTRUCTION COMPLETED 10/18/95

WATER LEVEL 30.91 MEASURED 10/18/95

RELEVANT INFORMATION (Problems, corrective actions)

5.5 sx 16-40, 1sx 100 mesh, 3.5 sx bentonite.

CASING SCHEDULE:

RISER TYPE PVC

RISER DIAMETER 4"

RISER LENGTH 40'

SCREEN TYPE TYPE 304 stainless steel

SCREEN LENGTH 10'

SCREEN DIAMETER 4"

PROTECTIVE CASING NONE FLUSH MOUNT

0' - 30.8' CEMENT GROUT INTERVAL

30.8 - 36 BENTONITE SEAL INTERVAL

BENTONITE TYPE chips

36-50' SAND PACK INTERVAL

SAND SIZE 16-40, 100 mesh

40'-50' SCREENED INTERVAL
(Beginning and ending depth below ground surface)

SLOT SIZE 0.010

ML & CL USCS CLASSIFICATION OF FORMATION MATERIAL IN SCREENED INTERVAL

50' DEPTH OF CASING
(Below ground surface)

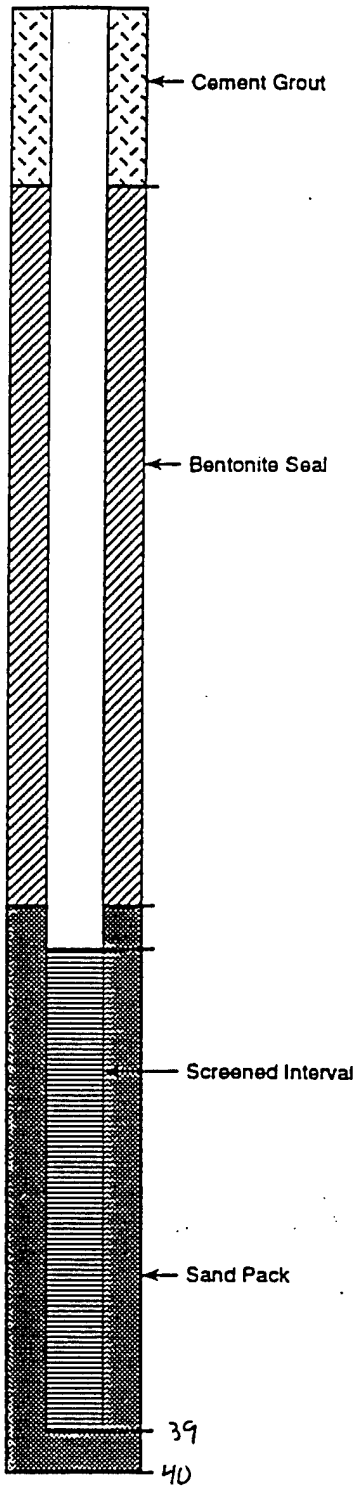
50' BOREHOLE DEPTH

10" BOREHOLE DIAMETER

(NOT TO SCALE)

HILL AIR FORCE BASE
OPERABLE UNIT 1
MONITORING WELL COMPLETION

PROJECT NO. 2208.1353



SOIL BORING/WELL NUMBER U1-158

LOCATION: NORTHING _____ EASTING _____

GROUND SURFACE ELEV. _____ MEASURING POINT ELEV. _____

GEOLOGIST E. HICKEY

DATE CONSTRUCTION STARTED 10/19/95

DATE CONSTRUCTION COMPLETED 10/19/95

WATER LEVEL 30.91 MEASURED 10/19/95

RELEVANT INFORMATION (Problems, corrective actions)

See U1-157 for log of boring

5sx 16-40 sand, 1sx 100 mesh, 3sx bentonite

CASING SCHEDULE:

RISER TYPE PVC

RISER DIAMETER 4"

RISER LENGTH 39'

SCREEN TYPE TYPE 304 Stainless steel

SCREEN LENGTH 10'

SCREEN DIAMETER 4"

PROTECTIVE CASING none, flush mount

0-20' CEMENT GROUT INTERVAL

20-25' BENTONITE SEAL INTERVAL

BENTONITE TYPE chips

25-40' SAND PACK INTERVAL

SAND SIZE 16-40

29-39 SCREENED INTERVAL
(Beginning and ending depth below ground surface)

SLOT SIZE 0.010

ML & CL USCS CLASSIFICATION OF FORMATION MATERIAL IN SCREENED INTERVAL

39' DEPTH OF CASING
(Below ground surface)

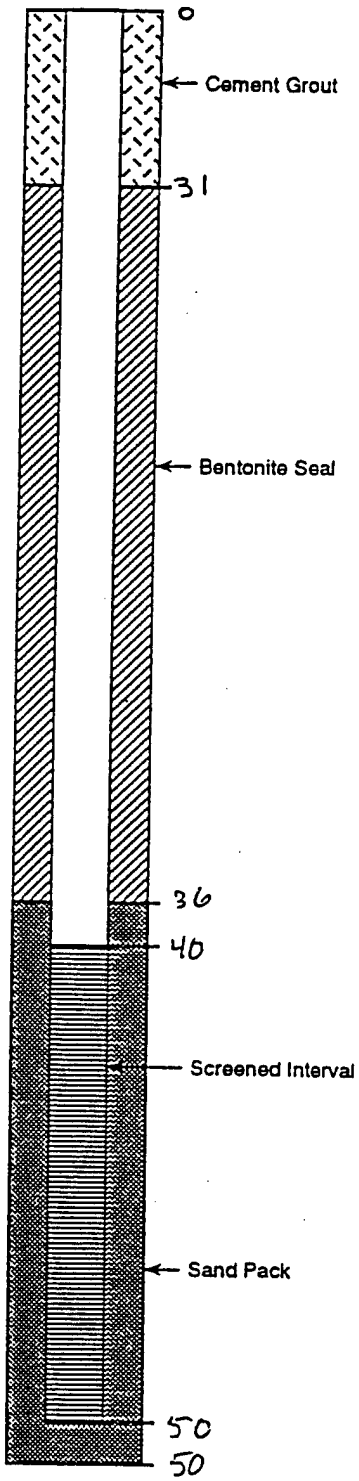
40' BOREHOLE DEPTH

10" BOREHOLE DIAMETER

(NOT TO SCALE)

PROJECT NO. _____

HILL AIR FORCE BASE
OPERABLE UNIT 1
MONITORING WELL COMPLETION



SOIL BORING/WELL NUMBER U1-159
LOCATION: NORTHING _____ EASTING _____
GROUND SURFACE ELEV. _____ MEASURING POINT ELEV. _____
GEOLOGIST E. HICKEY
DATE CONSTRUCTION STARTED 10/18/95
DATE CONSTRUCTION COMPLETED 10/18/95
WATER LEVEL 33.40 MEASURED 10/18/95

RELEVANT INFORMATION (Problems, corrective actions)
5 sx 10-20 1 sx 100 mesh
3 sx bentonite 5 sx grout

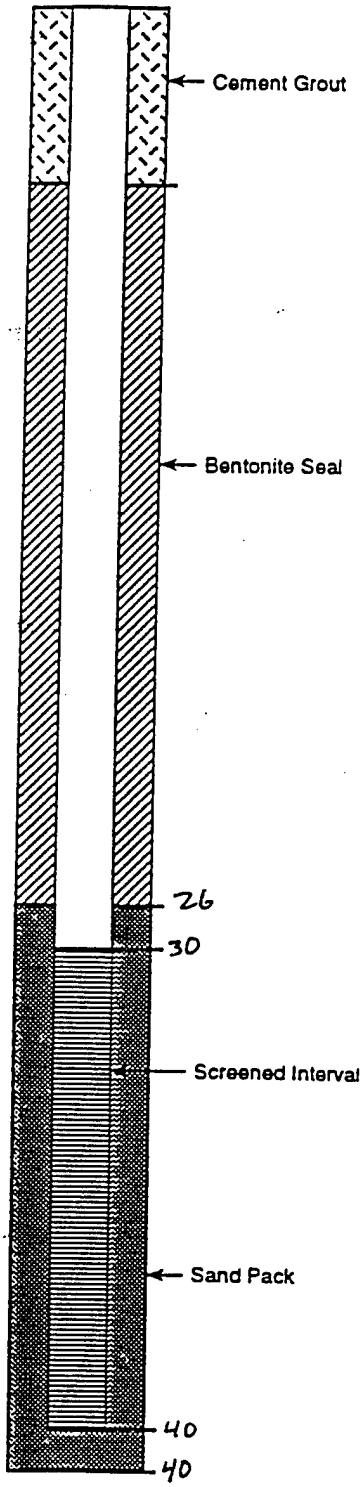
CASING SCHEDULE:
RISER TYPE 4" PVC
RISER DIAMETER 4"
RISER LENGTH 40'
SCREEN TYPE TYPE 304 stainless steel
SCREEN LENGTH 10'
SCREEN DIAMETER 4"
PROTECTIVE CASING none, flush mount surface

0 - 31 CEMENT GROUT INTERVAL
31 - 36 BENTONITE SEAL INTERVAL
BENTONITE TYPE chips
36'- 50' SAND PACK INTERVAL
SAND SIZE 10-20 ; 100 mesh
40'-50' SCREENED INTERVAL
(Beginning and ending depth below ground surface)
SLOT SIZE 0.010
ML/CL USCS CLASSIFICATION OF FORMATION MATERIAL IN SCREENED INTERVAL
50' DEPTH OF CASING
(Below ground surface)
50' BOREHOLE DEPTH
10" BOREHOLE DIAMETER

(NOT TO SCALE)

PROJ. NO. _____

HILL AIR FORCE BASE
OPERABLE UNIT 1
MONITORING WELL COMPLETION



(NOT TO SCALE)

SOIL BORING/WELL NUMBER U1-160
LOCATION: NORTHING _____ EASTING _____
GROUND SURFACE ELEV. _____ MEASURING POINT ELEV. _____
GEOLOGIST E. HICKEY
DATE CONSTRUCTION STARTED 10/18/95
DATE CONSTRUCTION COMPLETED 10/18/95
WATER LEVEL 33.43' MEASURED 10/18/95

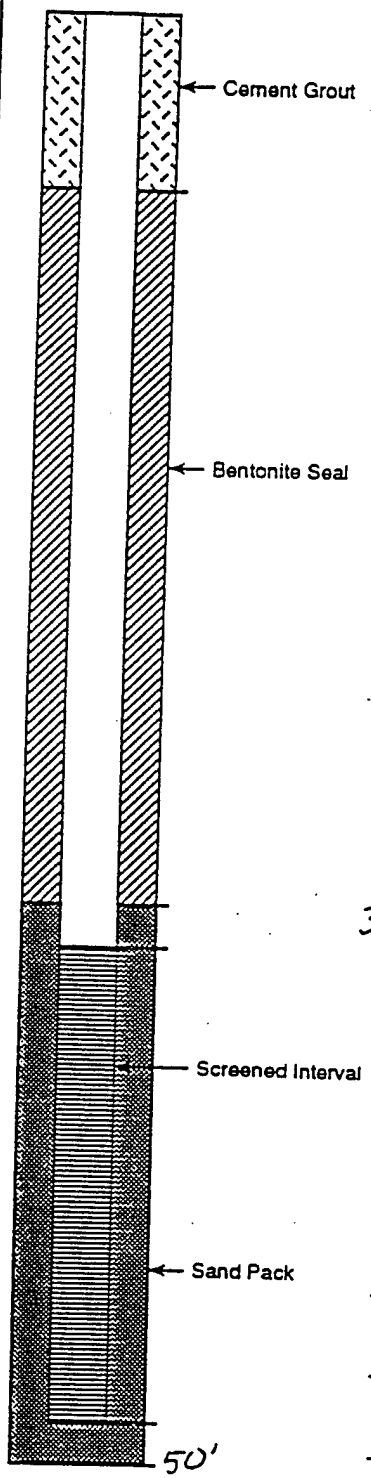
RELEVANT INFORMATION (Problems, corrective actions)
SEE U1-159 for log of soil boring.
GEOTECHNICAL SAMPLE U1-160-21' (GW)(SW)
GEOTECHNICAL SAMPLE U1-160-41' (CL)
5 SX 16-40 sand; 3 SX bentonite 6 SX grout
1 SX 100 mesh

CASING SCHEDULE:
RISER TYPE PVC
RISER DIAMETER 4"
RISER LENGTH 30'
SCREEN TYPE TYPE 304 Stainless Steel
SCREEN LENGTH 10'
SCREEN DIAMETER 4"
PROTECTIVE CASING NONE FLUSH MOUNT SURFACE COMPLETION

0' - 2' CEMENT GROUT INTERVAL
2' - 26' BENTONITE SEAL INTERVAL
BENTONITE TYPE CHIPS
26 - 40' SAND PACK INTERVAL
SAND SIZE 16-40, 100 MESH
30' - 40' SCREENED INTERVAL
(Beginning and ending depth below ground surface)
SLOT SIZE 0.010
CL/ML USCS CLASSIFICATION OF FORMATION MATERIAL IN SCREENED INTERVAL
40' DEPTH OF CASING
(Below ground surface)
40' BOREHOLE DEPTH
10" BOREHOLE DIAMETER

PROJECT NO. _____

HILL AIR FORCE BASE
OPERABLE UNIT 1
MONITORING WELL COMPLETION



SOIL BORING/WELL NUMBER U1-161
LOCATION: NORTHING _____ EASTING _____
GROUND SURFACE ELEV. _____ MEASURING POINT ELEV. _____
GEOLOGIST E. HICKEY
DATE CONSTRUCTION STARTED 10/31/95
DATE CONSTRUCTION COMPLETED 10/31/95
WATER LEVEL _____ MEASURED _____

RELEVANT INFORMATION (Problems, corrective actions)
6 SX sand, 3 sx bentonite chips
hole caved in 20 to 30'
4 bags grout

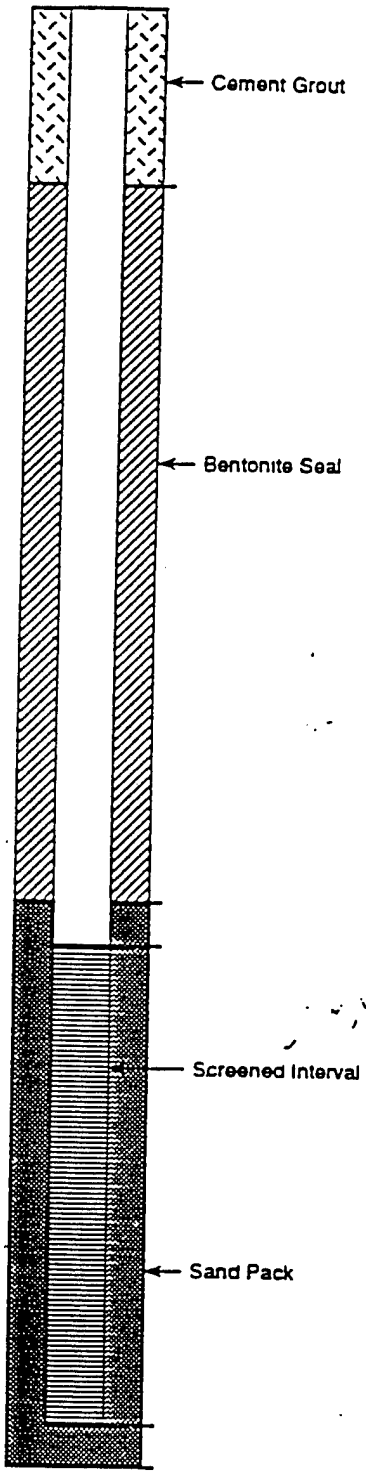
CASING SCHEDULE:
RISER TYPE PVC
RISER DIAMETER 4"
RISER LENGTH 40'
SCREEN TYPE TYPE 304 stainless
SCREEN LENGTH 10'
SCREEN DIAMETER 4"
PROTECTIVE CASING none, flush mount

_____ CEMENT GROUT INTERVAL
31-36' BENTONITE SEAL INTERVAL
BENTONITE TYPE chips
36'-50' SAND PACK INTERVAL
SAND SIZE 16-40 & 20-40, & 100 mesh
40'-50' SCREENED INTERVAL
(Beginning and ending depth below ground surface)
SLOT SIZE 0.010
CL & ML USCS CLASSIFICATION OF FORMATION MATERIAL IN SCREENED INTERVAL
_____ DEPTH OF CASING
(Below ground surface)
50' BOREHOLE DEPTH
10" BOREHOLE DIAMETER

(NOT TO SCALE)

PROJECT NO. _____

HILL AIR FORCE BASE
OPERABLE UNIT 1
MONITORING WELL COMPLETION



SOIL BORING/WELL NUMBER U1-162
LOCATION: NORTHING _____ EASTING _____
GROUND SURFACE ELEV. _____ MEASURING POINT ELEV. _____
GEOLOGIST Tim McHale
DATE CONSTRUCTION STARTED 11/2/95
DATE CONSTRUCTION COMPLETED 11/2/95
WATER LEVEL _____ MEASURED _____

RELEVANT INFORMATION (Problems, corrective actions)
6 bags sand, 3 bags bentonite, 7 bags portland cement (~2-55 gallon drums of cement-grout).

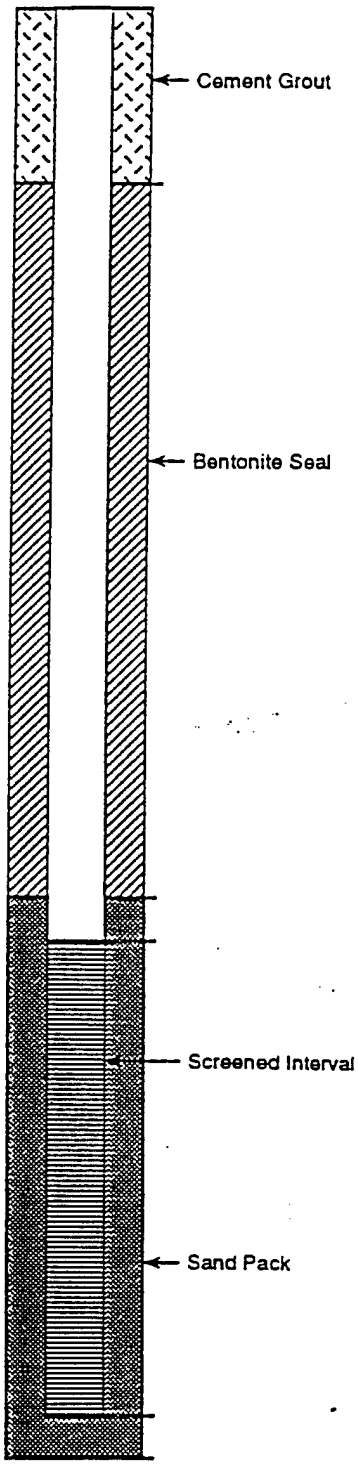
CASING SCHEDULE:
RISER TYPE PVC
RISER DIAMETER 4"
RISER LENGTH 30'
SCREEN TYPE Stainless steel
SCREEN LENGTH 10'
SCREEN DIAMETER 4"
PROTECTIVE CASING none - flush mount

0-21 CEMENT GROUT INTERVAL
21-26 BENTONITE SEAL INTERVAL
BENTONITE TYPE chips
26-40.3' SAND PACK INTERVAL
SAND SIZE 16-40 & 20-40; 100 mesh (2-28')
30'-40' SCREENED INTERVAL
(Beginning and ending depth below ground surface)
SLOT SIZE 0.010
CL USCS CLASSIFICATION OF FORMATION MATERIAL IN SCREENED INTERVAL
30 DEPTH OF CASING
(Below ground surface)
40.3' BOREHOLE DEPTH
10" BOREHOLE DIAMETER

(NOT TO SCALE)

HILL AIR FORCE BASE
OPERABLE UNIT 1
MONITORING WELL COMPLETION

PROJECT NO 2208 1024



SOIL BORING/WELL NUMBER U1-163

LOCATION: NORTHING _____ EASTING _____

GROUND SURFACE ELEV. _____ MEASURING POINT ELEV. _____

GEOLOGIST Tim McHale

DATE CONSTRUCTION STARTED 11/1/95

DATE CONSTRUCTION COMPLETED _____

WATER LEVEL _____ MEASURED _____

RELEVANT INFORMATION (Problems, corrective actions)

- Bottom of screen has ¾" solid steel - unlike the 4" cap usually used.
- 6 bags medium sand, 1 bag 100 mesh, 3 bags bentonite
- 8 bags grout

CASING SCHEDULE:

RISER TYPE PVC

RISER DIAMETER 4"

RISER LENGTH _____

SCREEN TYPE stainless steel

SCREEN LENGTH 10'

SCREEN DIAMETER 4"

PROTECTIVE CASING none - flush mount

0-34.0 CEMENT GROUT INTERVAL

34.0-39.0 BENTONITE SEAL INTERVAL

BENTONITE TYPE chips

53.6-39.0 SAND PACK INTERVAL

SAND SIZE 16-40, 20-40, + 100 (top 2 feet)

~~53.6~~ 43-53' SCREENED INTERVAL
(Beginning and ending depth below ground surface)

SLOT SIZE 0.010

CL USCS CLASSIFICATION OF FORMATION MATERIAL IN SCREENED INTERVAL

43 DEPTH OF CASING
(Below ground surface)

53.5 BOREHOLE DEPTH

10" BOREHOLE DIAMETER

(NOT TO SCALE)

PROJECT NO. _____

HILL AIR FORCE BASE
OPERABLE UNIT 1
MONITORING WELL COMPLETION

TABLE 5-5

SUMMARY OF HYDRAULIC CHARACTERISTICS ON AND OFF BASE

Well No.	Estimated Horizontal Hydraulic Conductivity (cm/sec)	Estimated Horizontal Hydraulic Conductivity (ft/day)	Estimated Horizontal Hydraulic Gradient (ft/ft)	Calculated Average Linear Horizontal Velocity (ft/yr)	Aquifer Material Adjacent to Screened Interval	Depth of Screened Interval (ft bgs)	Type Test
ON-BASE UPPER SAND AND GRAVEL UNIT							
U1-050[b]	8×10^{-5}	0.2	0.09	25	Sand with clay and silt	Unknown	Slug
U1-093[b]	3×10^{-3}	8.5	0.09	1,000	Sand with gravel	24-34	Slug
U1-116	4×10^{-4}	1.1	0.02	30	Sand/clay	22-32	Slug
U1-117	4×10^{-4}	1.1	0.06	80	Sand with gravel/clay	37-47	Slug
U1-119	2×10^{-3}	5.7	0.08	600	Silty sand to sand	43-48	Slug
U1-121	6×10^{-4}	1.7	0.12	300	Silty sand	42-47	Slug
U1-123	5×10^{-4}	1.4	0.1	200	Silt/silty sand	30-35	Slug
U1-125	2×10^{-4}	0.6	0.09	100	Silty sand, some gravel	42-47	Slug
U1-132	3×10^{-4}	0.9	0.09	93	Sand	18-28	Slug
U1-645	5×10^{-4}	1.4	0.01	20	Silty sand, some gravel	20-30	Slug
U1-646	4×10^{-4}	1.1	0.01	10	Silty sand, some gravel	21-31	Slug
U1-648	1×10^{-3}	2.8	0.01	40	Silty sand, some gravel	23-33	Slug
U1-649	2×10^{-2}	56.7	0.01	700	Sand	22-32	Slug
U1-118	3×10^{-2}	85.1	0.009	931	Sand/clay	24-34	Pump
U1-140	1.5×10^{-1}	425.3	0.009	4,656	Sand with gravel	26-36	Pump
U1-143	1×10^{-2}	28.4	0.009	310	Sand/clay	25-35	Pump
U1-655	4×10^{-2}	113.4	0.01	1,380	Sand with gravel	13-23	Pump
U1-658	1×10^{-2}	28.4	0.01	345	Sand with gravel	13-23	Pump
U1-696	7×10^{-2}	198.5	0.009	2,173	Sand with gravel	26-36	Pump
U1-670	4×10^{-2}	113.4	0.017	2,345	Sand with gravel	22-32	Pump
U1-671	6×10^{-2}	170.1	0.017	3,518	Sand with gravel	22-32	Pump
ON-BASE SILTY CLAY UNIT							
U1-043A[b]	2×10^{-5}	0.1	0.16	7	Clay	43-58	Slug
U1-062[b]	2×10^{-5}	0.1	0.009	0.4	Clay with fine sand lenses	33-43	Slug
U1-063[b]	2×10^{-5}	0.1	0.1	4	Clay with fine sand lenses	35-45	Slug
U1-088A[a]	4×10^{-5}	0.1	0.009	1	Clay with fine sand lenses	64-74	Slug
U1-120	1×10^{-5}	0.0	0.08	2	Clay with fine sand lenses	65-75	Slug
U1-122	2×10^{-4}	0.6	0.12	50	Clay with fine sand lenses	68-78	Slug
U1-124	2×10^{-5}	0.1	0.16	7	Clay with fine sand lenses	25-30	Slug
U1-040	3×10^{-5}	0.1	0.16	10	Clay with fine sand lenses	73-94	Slug
OFF-BASE SHALLOW SOIL							
U1-090[a]	6×10^{-4}	1.7	0.01	28	Sand	109-119	Slug
U1-091[a]	1×10^{-5}	0.0	0.01	0.5	Clay	62-72	Slug
U1-094[a]	1×10^{-3}	2.8	0.01	46	Sand with silt	54-64	Slug
U1-095[a]	8×10^{-4}	2.3	0.01	37	Sand	33-43	Slug
U1-096[a]	4×10^{-5}	0.1	0.01	2	Sand with silt	32-42	Slug
U1-097[a]	1×10^{-3}	2.8	0.01	46	Sand with silt	09-19	Slug
U1-098[a]	4×10^{-3}	11.3	0.01	184	Sand	04-14	Slug
U1-099[a]	4×10^{-5}	0.1	0.01	2	Clay with silt	4.6-14.6	Slug
U1-138	6×10^{-4}	1.7	0.01	28	Silty sand	97-107	Slug
U1-151	8×10^{-5}	0.2	0.01	3	Sand	114-124	Slug
U1-152	9×10^{-5}	0.2	0.01	3	Silty sand	105-115	Slug
U1-153	6×10^{-6}	0.02	0.01	0.3	Silty sand	118-128	Slug
U1-154	1×10^{-3}	2.8	0.01	41	Sand	23-33	Slug
U1-155	6×10^{-4}	1.7	0.01	28	Sandy silt	77-87	Slug
U1-156	5×10^{-4}	1.4	0.01	23	Sand with silt	114-124	Slug

(a) Measured by JMM. Values calculated using method of Bouwer.
(b) From Radian (1988); values calculated using method of Hvorslev.

ft bgs Feet below ground surface

evised Draft

roposed Plan

Operable Unit 1
Hill Air Force Base, Utah
Davis and Weber Counties

OGDEN ALC

June 1997

Introduction

Hill Air Force Base (Hill AFB), the lead agency responsible for cleaning up contaminated sites at the base, is requesting public comments on this *Proposed Plan*. The Proposed Plan proposes cleanup of groundwater, subsurface soil, springs and seeps at Operable Unit 1 (OU 1), which is located in the northeastern portion of Hill AFB. Cleanup/remedial alternatives have been reviewed, and a *preferred alternative* has been selected with U.S. Environmental Protection Agency (EPA) and Utah Department of Environmental Quality (UDEQ) oversight and agreement. This Proposed Plan has been prepared in fulfillment of the U.S. Air Force's public participation responsibilities under Section 113(k) and 117(a) of the *Comprehensive Environmental Response, Compensation, nd Liability Act* (CERCLA).

r the preferred alternative, contaminated groundwater immediate vicinity of multiple On-Site contaminant source areas at OU 1 will be pumped from the subsurface, using *new* and existing *upgraded extraction/collection trenches* and an additional groundwater *dewatering well*. The collected groundwater will be treated at the OU 2 air-stripper and discharged to the CWSD POTW. Existing landfill *covers/caps*, which cover the ground surface atop contaminant source areas, will be *improved* and then maintained as they are today. Additionally, a new surface water *seep collection system* and associated *water treatment facility* will be installed Off-Site. The implementation of On-and Off-Site *institutional controls* will prevent exposure to subsurface soils and sediments around seeps/springs. Groundwater *monitoring* activities will continue to ensure that there are no threats to human health or the environment, either on Hill AFB property or on properties not owned by Hill AFB but located in close proximity to OU 1.

Public Involvement Process

You are encouraged to read and provide comments on this Proposed Plan, as well as the *Comprehensive Remedial Investigation Report* (RI) - *Baseline Risk Assessment, Feasibility Study* (FS) reports, and any other documents in the *inistrative Record* for OU 1.

All of this information is available for public review and copying at the following information repositories:

Davis County Library	**Environmental Management**
Central Branch	**Directorate**
155 North Wasatch Drive	00-ALC/EMR - Bldg. 5 - NE 2nd
Layton, Utah 84041	7274 Wardleigh Road
Ph: (801) 547-0729	Hill AFB, UT 84056-5137
Mon.-Th, 10:00 a.m.- 9:00 p.m.	Mon.-Fri.,7:30a.m.-4:30p.m.
Fri.-Sat., 10:00 a.m. - 6:00 p.m.	Contact: Mr. Kevin Bourne

Mark Your Calendar

Public Comment Period
Thursday, January 15, 1998
through
Saturday, February 14, 1998

Open House
Wednesday
February 11, 1998
4:00 - 8:00 pm

Location
South Weber Elem. School
1285 East Lester Street
South Weber, Utah 84405

JANUARY 1998

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

FEBRUARY 1998

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

Public comments may be submitted during the public comment period, which extends from **January 15, 1998, to February 14, 1998**. You may send written comments (postmarked no later than February 14, 1998) to Mr. Kevin Bourne at the above address. The public comment period may be extended by up to 30 days, if a written request (postmarked no later than February 14, 1998) is submitted to Mr. Kevin Bourne at Hill AFB.

SOURCE AREA ALTERNATIVE 1
No Further Action

Capital Costs:	$114,800
Annual O&M Costs:	$158,107
Present Worth Costs:	$2,545,300
Time to Implement:	Not applicable

This No Further Action alternative incorporates continued operation of the existing groundwater collection systems, treatment of extracted groundwater at the HAFB OU 2 air-stripper, maintenance of the existing landfill cap and passive gas vent system, environmental monitoring and institutional controls. This alternative provides a baseline for alternatives evaluation, but may not achieve ARARs. No figure is provided.

SOURCE AREA ALTERNATIVE 2
Existing System Upgrade

Capital Costs:	$1,151,100
Annual O&M Costs:	$215,768
Present Worth Costs:	$4,468,000
Time to Implement:	Construction

Alternative 2 includes:

- All aspects of Alternative 1;
- Landfill cap repair; and
- Upgrade the existing groundwater collection system along primary flow paths.

Alternative 2 would increase the reliability of preventing migration by installing trenches across the troughs of the Provo Formation. However, it would not prevent migration through the upper Alpine Formation. This alternative is less certain in its effectiveness at preventing offsite migration, but with routine groundwater monitoring, it is expected to be protective of public health and the environment. The Alternative 2 features are shown in Figure 5.

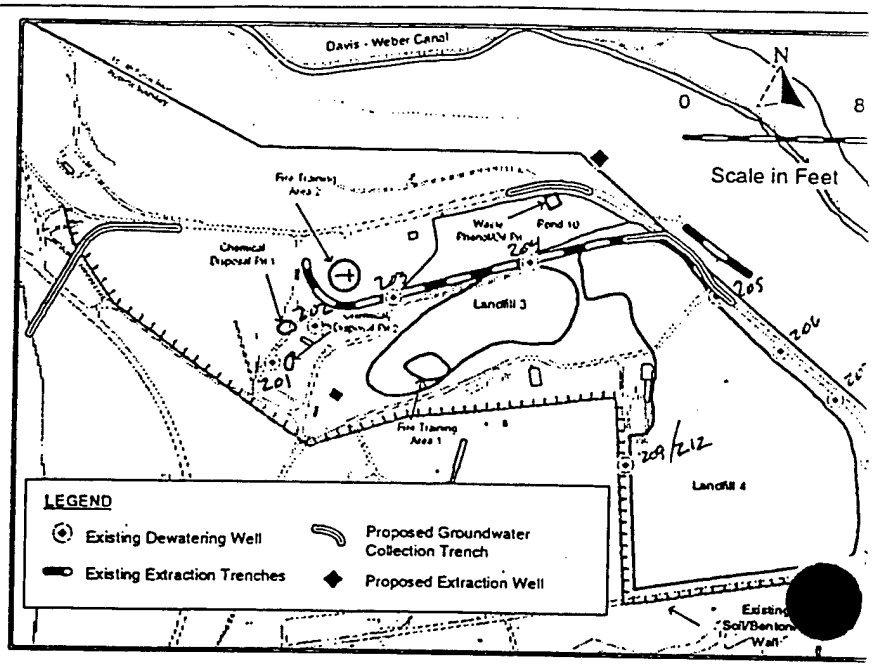


Figure 5. Source Area Alternative 2

SOURCE AREA ALTERNATIVE 3
Groundwater Dewatering

Capital Costs:	$2,241,600
Annual O&M Costs:	$240,254
Present Worth Costs:	$5,934,900
Time to Implement:	Construction

Alternative 3 includes:

- All aspects of Alternative 1;
- Landfill cap repair;
- Dewatering of source area groundwater using extraction trenches; and
- LNAPL recovery from extraction trench.

Alternative 3 would increase the reliability of preventing offsite migration by removing groundwater before it can migrate through the Provo Formation. However, since it cannot capture all the water in the upper Alpine Formation, there may still be a small amount of migration through the upper Alpine. All components involving treatment of groundwater and soils would be designed to meet ARARs. This includes meeting discharge pretreatment limits, air emission requirements, and RCRA land disposal restrictions for characteristic or listed waste. The Alternative 3 features are shown in Figure 6.

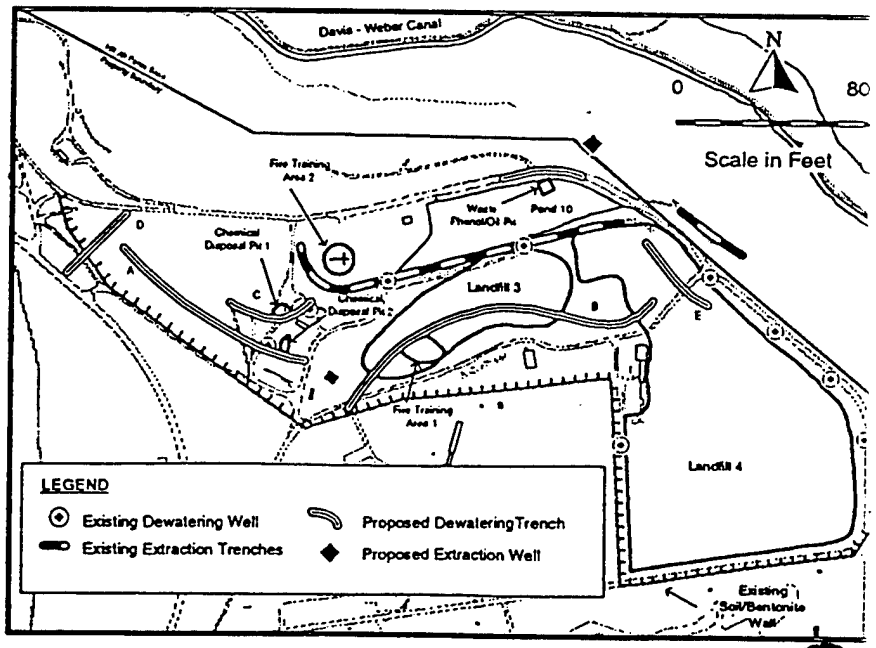


Figure 6. Source Area Alternative 3

NON-SOURCE AREA ALTERNATIVE 2

Natural Attenuation

Capital Costs:	$455,200
Annual O&M Costs:	$122,212
Present Worth Costs:	$1,538,400
Time to Implement, or Achieve Remedial Goals:	12 years

Alternative 2 includes:

- All aspects of Alternative 1;
- Natural Attenuation monitoring; and,
- Environmental monitoring.

Alternative 2, coupled with the Source Area alternatives that prevent offsite migration, would increase the reliability of meeting ARARs than Alternative 1. This alternative also provides additional monitoring to better understand the mechanisms occurring naturally, and it will provide better warnings if natural attenuation processes are not being effective. The Alternative 2 features are shown in Figure 10.

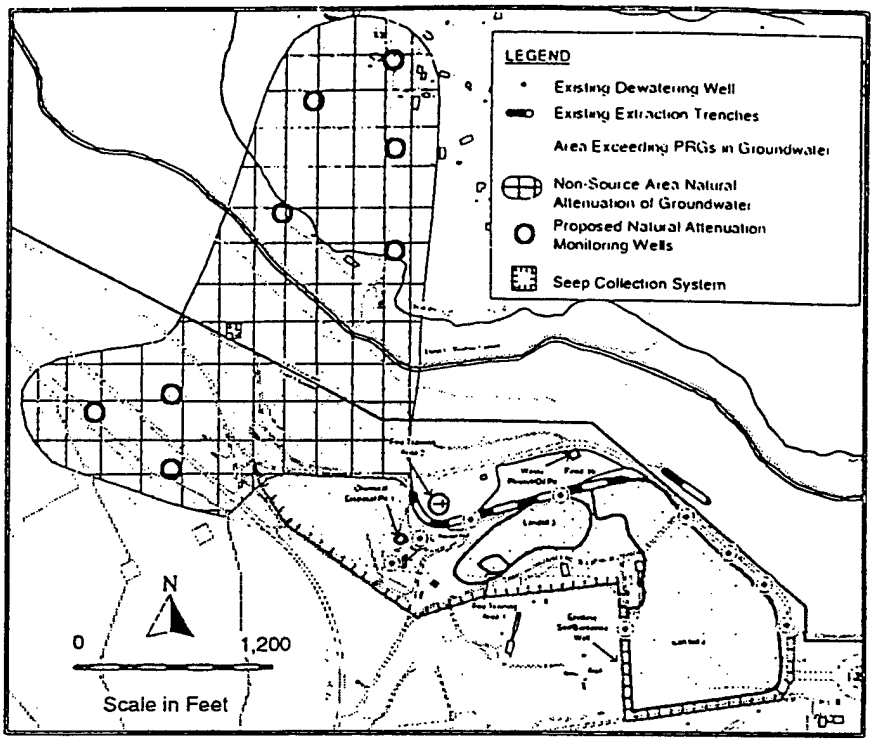


Figure 10. Non-Source Area Alternative 2

NON-SOURCE AREA ALTERNATIVE 3

Existing Seep Collection Upgrade

Capital Costs:	$717,500
Annual O&M Costs:	$176,266
Present Worth Costs:	$2,279,800
Time to Implement, or Achieve Remedial Goals:	12 years

Alternative 3 includes:

- All aspects of Alternative 2;
- Upgraded seep collection and treatment; and
- Excavation of arsenic-contaminated sediment at seeps U1-301, U1-303 and U1-305.

Alternative 3 provides an additional protection by collecting additional seeps/springs that are contaminated above remedial goals, and by removing sediments contaminated by arsenic. The added reliability of this protectiveness is probably small because chances for use as a drinking water supply are low. All components involving treatment of groundwater and soils would be designed to meet ARARs. This includes meeting discharge pretreatment limits, and air emission requirements. The Alternative 3 features are shown in Figure 11.

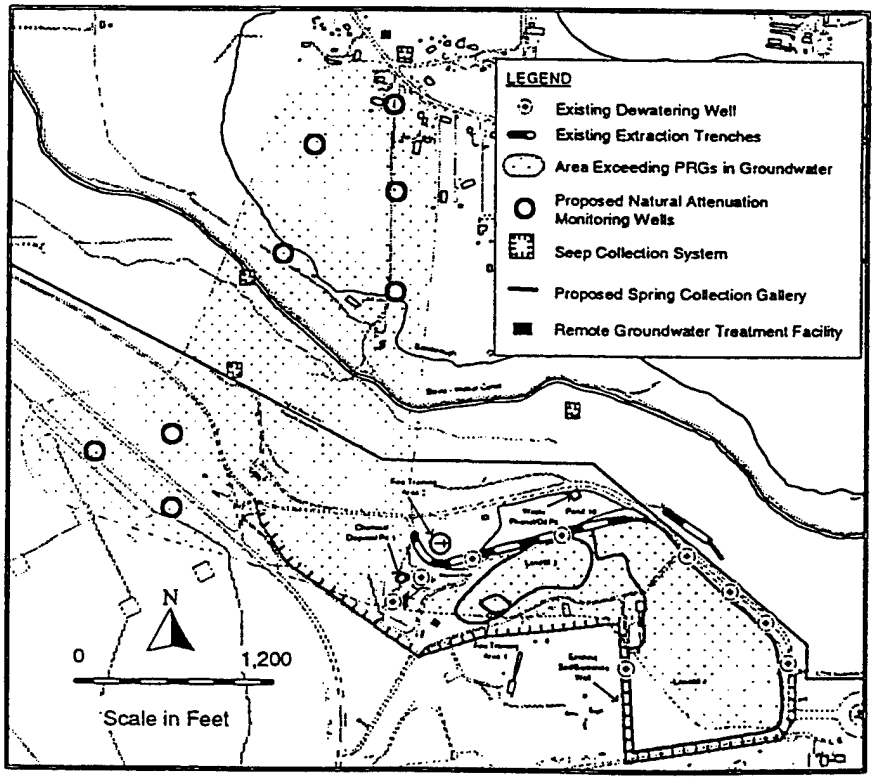


Figure 11. Non-Source Area Alternative 3

NON-SOURCE AREA
ALTERNATIVE 6

Groundwater Collection Throughout Plume

Capital Costs:	$2,258,300
Annual O&M Costs:	$235,963
Present Worth Costs:	$3,279,900
Time to Implement, or Achieve Remedial Goals:	5 years

Alternative 6 includes:

- All aspects of Alternative 3; and
- Groundwater collection throughout the non-source area plume, treatment and discharge to POTW.

Alternative 6 is the only non-source area alternative that substantially decreases the time to achieve ARARs. However, given the low potential for exposure currently caused by the offsite contamination and the use of institutional controls to prevent changes in land use or use of the groundwater, the overall increase in protectiveness is small. All components involving treatment of groundwater and soils would be designed to meet discharge pretreatment limits, and air emission requirements. Alternative 6 features are shown in Figure 14.

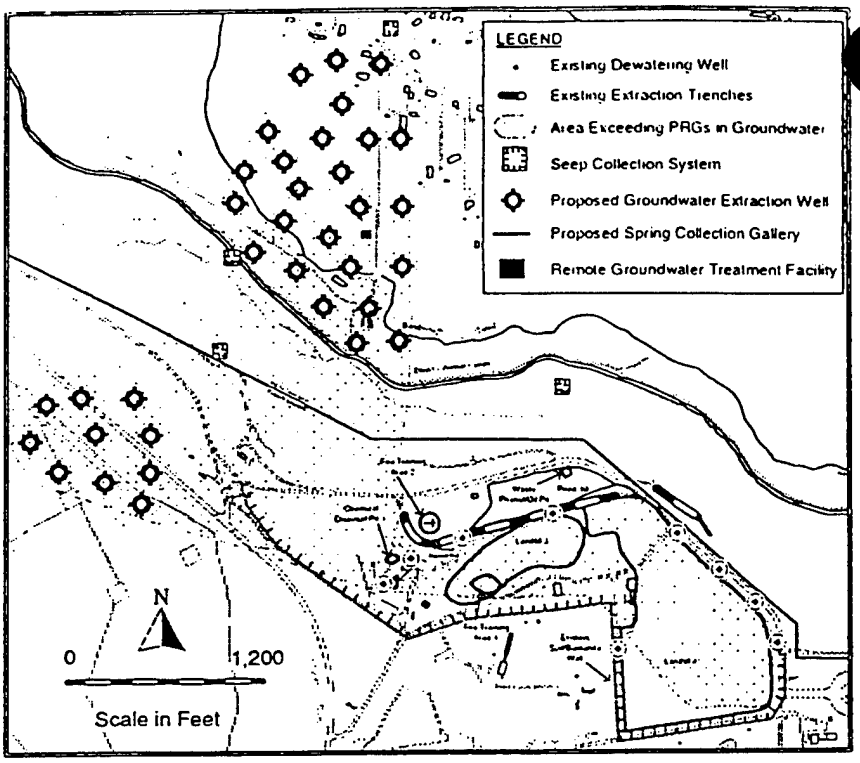
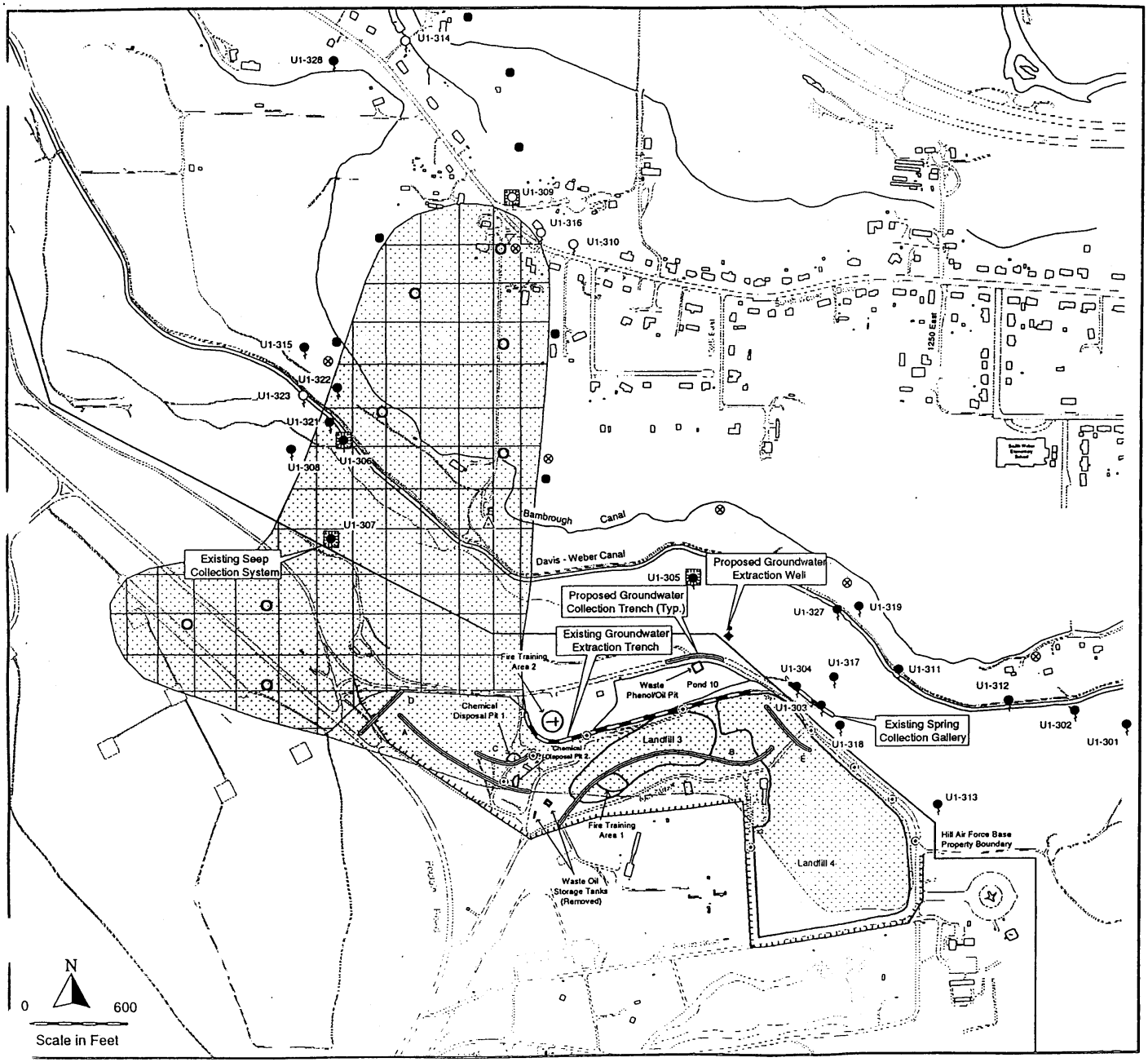


Figure 14. Non-Source Area Alternative 6

From the above discussion of the Non-Source alternatives, it is clear that their evaluation depends significantly on the ability of the Source Area alternatives to effectively prevent offsite contaminant migration. Consequently, it may be prudent to stage the implementation of the preferred Non-Source Area alternative until information is available on the performance of the Source Area alternative. Likewise, further investigations of natural attenuation are currently underway at OU 1 that may provide more information on the effectiveness of Alternative 2.



LEGEND

- Existing Dewatering Well
- Spring/seep
- Existing Groundwater Extraction Trench and Spring Collection Gallery
- Proposd Dewatering Trench Included In Souce Area Alternative 3
- Proposed Groundwater Extraction Well Included In Source Area Alternative 3
- Area Exceeding Preliminary Remediation Goals (PRGs) in Groundwater
- Non-Source Area Natural Attenuation of Groundwater
- Springs/Seeps included in Non-Source Area Alternative 2 Monitoring Plan
- Shallow Groundwater monitoring wells included in Non-Source Area Alternative 2 Monitoring Plan
- Deep Groundwater monitoring wells included in Non-Source Area Alternative 2 Monitoring Plan
- South Weber No. 2 Potable Well (Included in Non-Source Area Alternative 2 Monitoring Plan)
- Shallow Groundwater Monitoring Wells Situated Inside The Contaminant Plume Area Included In The Non-Source Area Alternative 3 Monitoring Plan For Monitoring of Natural Attenuation
- Seep Collection System

Note: Original Figure Was Created In Color

Hill Air Force Base
Operable Unit 1

PREFERRED ALTERNATIVE

SOURCE AREA ALTERNATIVE 3
GROUNDWATER DEWATERING
AND
NON-SOURCE AREA ALTERNATIVE 3
EXISTING SEEP COLLECTION UPGRADE

FIGURE 7

APPENDIX B

MONITORING WELL/POINT DEVELOPMENT AND SAMPLING RECORDS, SURVEY DATA, GEOLOGIC LOGS, AND WELL CONSTRUCTION DIAGRAMS

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

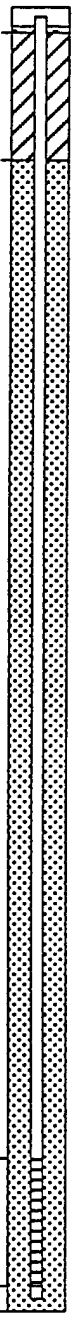
LOG OF BORING U1-1630

Operable Unit 1
Hill Air Force Base, Utah

Date Completed	: 3/17/97	Northing	: 290892.9955
Drilling Method	: Hollow Stem Auger	Easting	: 1872065.5900
Drilling Contractor	: USEPA-Frank Beck	Ground Elevation	: 4787.83 (feet msl)
Boring Logged By	: John Hicks	TOC Elevation	: 4787.42 (feet msl)

Depth in Feet	Surf. Elev. 4787.83	GRAPHIC	USCS	DESCRIPTION
0				
	4785		ML	SILT with some sand
5				
	4780			
10				
	4775		SW	Brown, very fine to fine SAND with some silt, trace gravel to 2" diameter, moist
15				
	4770		GW	Sandy GRAVEL to 2" diameter, rounded, moist
20				
	4765		SP	Well sorted, medium SAND with gravel
25				
	4760			
30			SP	Well sorted SAND
	4755		GW	GRAVEL, 0.5" - 2" diameter
35				
	4750			No cuttings returned.
40				
	4745		SW	
45				TOC sample MP3-1 collected from auger (corresponding to approximately 45' bgs). Material from auger is brown, fine to coarse (mostly medium) SAND with trace to some gravel to 0.5" diameter
	4740			Refusal at 51.5' due to cobbles binding augers
50				
	4735			
55				

U1-1630
ELEV: 4787.42



Well Construction Information

WELL CASING

Casing Material	: PVC
Casing Diameter	: 2" ID
Joint Type	: threaded

WELL SCREEN

Screen Material	: PVC
Screen Diameter	: 2" ID
Screen Slot Size	: 0.010 "
Screen Joint Type	: threaded

ANNULUS

Natural Pack	: 0 - 1'
Bentonite Pellets	: 1' - 6'
Natural Pack	: 6' - 18'
Bentonite Pellets	: 18' - 22'
Natural Pack	: 22' - 51.5'
Borehole	: 6" diameter
Protective Casing	: Flush Mount

NOTES

Groundwater not encountered during drilling or well installation.

Logged from cuttings, therefore lithologic contacts are approximate.

Borehole/monitoring point previously labeled MP3.

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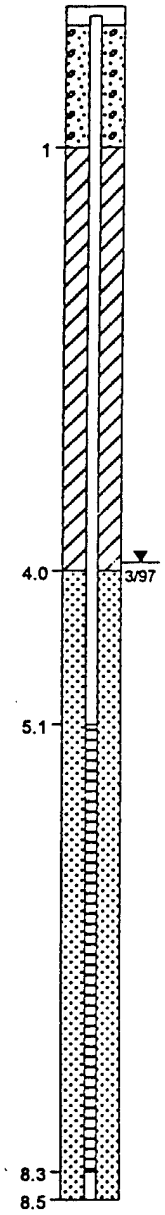
PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

LOG OF BORING U1-1631

Operable Unit 1
Hill Air Force Base, Utah

Date Completed	: 3/20/97	Northing	: 292022.2623
Drilling Method	: Geoprobe	Easting	: 1873158.0700
Drilling Contractor	: USEPA-Frank Beck	Ground Elevation	: 4479.75 (feet msl)
Boring Logged By	: John Hicks	TOC Elevation	: 4479.78 (feet msl)

Depth in Feet	Surf. Elev. 4479.75	Samples	Recovery (feet)	GRAPHIC	USCS	DESCRIPTION
0						
	4479				CL	Dark brown silty CLAY, moist
1						
	4478					
2		1	2.7		SM	Medium brown silty SAND, moist
					SW	Medium brown, medium to very coarse SAND with gravel to 1.5" diameter, wet
	4477					
3						No recovery.
	4476					
4					SW	Medium brown, medium to very coarse SAND with gravel to 1.5" diameter, wet
	4475					
5						Medium brown clayey SILT, moist
	4474					
6		2	3.5		ML	
	4473					
7					SM	Medium brown, fine to medium silty SAND, wet TOC sample MP4-1 (7 - 7.5' bgs).
	4472					
8						No recovery. Refusal at 8.5'.
	4471					
9						
	4470					
10						



WELL CASING

Casing Material	: PVC
Casing Diameter	: 0.5" ID
Joint Type	: threaded

WELL SCREEN

Screen Material	: PVC
Screen Diameter	: 0.5" ID
Screen Slot Size	: 0.010 "
Screen Joint Type	: threaded

ANNULUS

Natural Pack	: 0 - 1
Bentonite Pellets	: 1' - 4'
Sand Pack	: 4' - 8.5'
Borehole	: 2" diameter
Protective Casing	: Flush Mount

NOTES

Borehole/monitoring point previously labeled MP4s.

6-26-1997 c:\mtech3\hillou1\geou1_1631.ge3

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

LOG OF BORING U1-1640

Operable Unit 1
Hill Air Force Base, Utah

Date Completed	: 3/20/97	Northing	: 292025
Drilling Method	: Geoprobe	Easting	: 1873158
Drilling Contractor	: USEPA-Frank Beck	Ground Elevation	: 4479.75 (feet msl)
Boring Logged By	: John Hicks	TOC Elevation	: NA/tubing well

Depth in Feet	Surf. Elev. 4479.75	GRAPHIC	USCS	DESCRIPTION	U1-1640 ELEV: 4479.75	Well Construction Information
0				See log of boring U1-1631 for stratigraphy.		
5	4475					
10	4470					
15	4465				14.5 / 15.0	
20	4460					

WELL CASING
Casing Material : Teflon tubing
Casing Diameter : 0.25" ID
Joint Type : NA

WELL SCREEN
Screen Material : Stainless steel
Screen Diameter : 0.25" ID
Screen Slot Size : 0.0057"
Screen Joint Type : barbed

ANNULUS
Bentonite Pellets : NA
Natural Pack : 0 - 15.0'
Borehole : 1" diameter
Protective Casing : Flush Mount

NOTES
Borehole/monitoring point previously labeled MP4d.

c:\mtech3\hillou1\geo\u1_1640.ge3

6-26

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

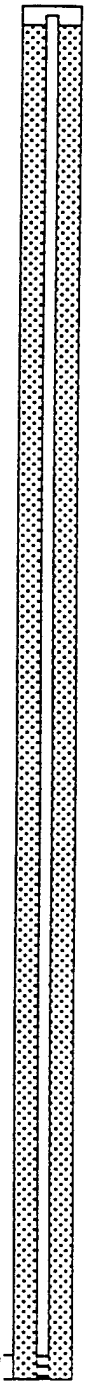
LOG OF BORING U1-1638

Operable Unit 1
Hill Air Force Base, Utah

Date Completed	: 3/21/97	Northing	: 291307.9058
Drilling Method	: Geoprobe	Easting	: 1873408.8380
Drilling Contractor	: USEPA-Frank Beck	Ground Elevation	: 4498.41 (feet msl)
Boring Logged By	: John Hicks	TOC Elevation	: NA/tubing well

Depth in Feet	Surf. Elev. 4498.41	Samples	Recovery (feet)	GRAPHIC	USCS	DESCRIPTION
0						See log of boring U1-1639 for stratigraphy.
	4495					
5						
	4490					
10						
	4485					
15						
	4480					Refusal of 2" rods at 19.5'
20						Continued with 1" rods to 29.5'
	4475					
25						
	4470					
30						

U1-1638
ELEV: 4498.41



Well Construction Information

WELL CASING

Casing Material	: Teflon tubing
Casing Diameter	: 0.25" ID
Joint Type	: NA

WELL SCREEN

Screen Material	: Stainless steel
Screen Diameter	: 0.25" ID
Screen Slot Size	: 0.0057"
Screen Joint Type	: barbed

ANNULUS

Bentonite Pellets	: NA
Natural Pack	: 0 - 29.5'
Borehole	: 1" diameter
Protective Casing	: Flush Mount

NOTES

Well U1-1638 is located east of well U1-1639.

Borehole/monitoring point previously labeled MP11S.

c:\mtech3\hillou1\geo\u1_1638.ge3

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

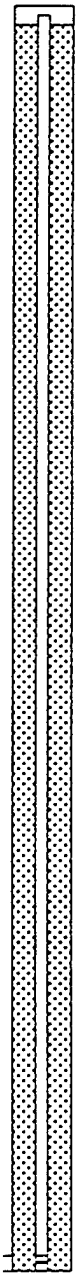
LOG OF BORING U1-1639

Operable Unit 1
Hill Air Force Base, Utah

Date Completed	: 3/21/97	Northing	: 291314.6237
Drilling Method	: HSA/Geoprobe	Easting	: 1873404.0160
Drilling Contractor	: USEPA-Frank Beck	Ground Elevation	: 4498.41 (feet msl)
Boring Logged By	: John Hicks	TOC Elevation	: NA/tubing well

Depth in Feet	Surf. Elev. 4498.41	GRAPHIC	USCS	DESCRIPTION
0				No log.
	4495			
5				
	4490			
10				
	4485			
15				
	4480			
20			ML	Medium brown clayey SILT, trace fine sand, wet TOC sample MP11-1 (20-20.5' bgs).
				No log.
	4475			
25			SP	Medium brown, very fine to fine, well sorted SAND with silt TOC sample MP11-2 (25-28' bgs).
	4470			
30				No log.
	4465			
35				
	4460			
40				
	4455			
45				

U1-1639
ELEV: 4498.41



Well Construction Information

WELL CASING

Casing Material	: Teflon tubing
Casing Diameter	: 0.25" ID
Joint Type	: NA

WELL SCREEN

Screen Material	: Stainless steel
Screen Diameter	: 0.25" ID
Screen Slot Size	: 0.0057"
Screen Joint Type	: barbed

ANNULUS

Bentonite Pellets	: NA
Natural Pack	: 0 - 40.5
Borehole	: 1" diameter
Protective Casing	: Flush Mount

NOTES

Well U1-1639 is located west of well U1-1638.

Logged from cuttings, therefore lithologic contacts are approximate.

Borehole/monitoring point previously labeled MP11d.

6-26-1997 c:\mtech3\hillou1\geolu1_1639.ge3

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

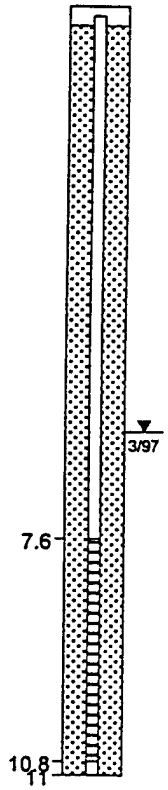
LOG OF BORING U1-1636

Operable Unit 1
Hill Air Force Base, Utah

Date Completed	: 3/18/97	Northing	: 292603.1213
Drilling Method	: Geoprobe	Easting	: 1874254.4200
Drilling Contractor	: USEPA-Frank Beck	Ground Elevation	: 4450.11 (feet msl)
Boring Logged By	: John Hicks	TOC Elevation	: 4450.05 (feet msl)

Depth in Feet	Surf. Elev. 4450.11	Samples	Recovery (feet)	GRAPHIC	USCS	DESCRIPTION
0	4450	1	2.5		SW	Medium to dark brown, fine to coarse (mostly fine to medium) SAND with trace gravel to 1" diameter Interbedded with moist, dark brown sandy SILT with clay.
						No recovery.
5	4445	2	1.5		SW	Fine to very coarse sand with gravel to 1.5" diameter. TOC sample MP9-1 (4-5.5' bgs)
						No recovery.
						Refusal at 7.2'. Remaining boring advanced with solid 2" diameter rods. No log.
10	4440					
15	4435					
20						

U1-1636
ELEV: 4450.05



Well Construction Information

WELL CASING

Casing Material	: PVC
Casing Diameter	: 0.5" ID
Joint Type	: threaded

WELL SCREEN

Screen Material	: PVC
Screen Diameter	: 0.5" ID
Screen Slot Size	: 0.010 "
Screen Joint Type	: threaded

ANNULUS

Bentonite Pellets	: NA
Natural Pack	: 1' - 11'
Borehole	: 2" diameter
Protective Casing	: Flush Mount

NOTES

Borehole/monitoring point previously labeled MP9.

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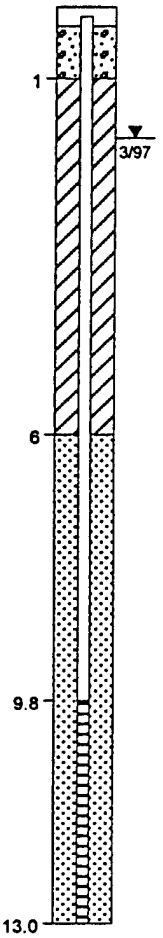
LOG OF BORING U1-1637

Operable Unit 1
Hill Air Force Base, Utah

Date Completed	: 3/20/97	Northing	: 291992.2357
Drilling Method	: Geoprobe	Easting	: 1873464.7690
Drilling Contractor	: USEPA-Frank Beck	Ground Elevation	: 4479.42 (feet msl)
Boring Logged By	: John Hicks	TOC Elevation	: 4479.21 (feet msl)

Depth in Feet	Surf. Elev. 4479.42	Samples	Recovery (feet)	GRAPHIC	USCS	DESCRIPTION
0		1	2.5		ML	Dark brown SILT with some clay, moist
					SW	Same as above, grading to medium brown, fine to medium SAND with trace gravel, wet
						No recovery.
	4475	2	3		ML	Medium brown SILT to silty CLAY, moist TOC sample MP10-2 (4-6' bgs)
5					SP	Medium brown, fine to medium, well-sorted SAND, wet TOC sample MP10-1 (6-7' bgs)
						No recovery.
	4470					Remaining boring advanced with 1" rods. No log.
10						
	4465					
15						
	4460					
20						

U1-1637
ELEV: 4479.21



WELL CASING

Casing Material	: PVC
Casing Diameter	: 0.5" ID
Joint Type	: threaded

WELL SCREEN

Screen Material	: PVC
Screen Diameter	: 0.5" ID
Screen Slot Size	: 0.010 "
Screen Joint Type	: threaded

ANNULUS

Natural Pack	: 0 - 1'
Bentonite Pellets	: 1' - 6'
Natural Pack	: 6' - 13'
Borehole	: 2" diameter
Protective Casing	: Flush Mount

NOTES

Borehole/monitoring point previously labeled MP10.

6-26-1997 c:\mlech3\hillou1\geolu1_1637.ge3

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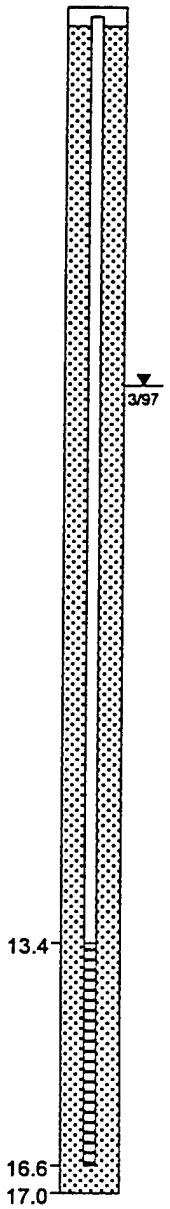
LOG OF BORING U1-1634

Operable Unit 1
Hill Air Force Base, Utah

Date Completed	: 3/18/97	Northing	: 291721.6715
Drilling Method	: Geoprobe	Easting	: 1874424.6310
Drilling Contractor	: USEPA-Frank Beck	Ground Elevation	: 4486.99 (feet msl)
Boring Logged By	: John Hicks	TOC Elevation	: 4486.88 (feet msl)

Depth in Feet	Surf. Elev. 4486.99	Samples	Recovery (feet)	GRAPHIC	USCS	DESCRIPTION
0						No Log.
	4485					
5						
	4480					
10						
	4475					
15						
	4470					
20						



WELL CASING

Casing Material	: PVC
Casing Diameter	: 0.5" ID
Joint Type	: threaded

WELL SCREEN

Screen Material	: PVC
Screen Diameter	: 0.5" ID
Screen Slot Size	: 0.010 "
Screen Joint Type	: threaded

ANNULUS

Bentonite Pellets	: NA
Natural Pack	: 1' - 17'
Borehole	: 2" diameter
Protective Casing	: Flush Mount

NOTES

Borehole/monitoring point previously labeled MP7.

c:\mtech3\hillou1\geou1_u_1634.ge3

6-2

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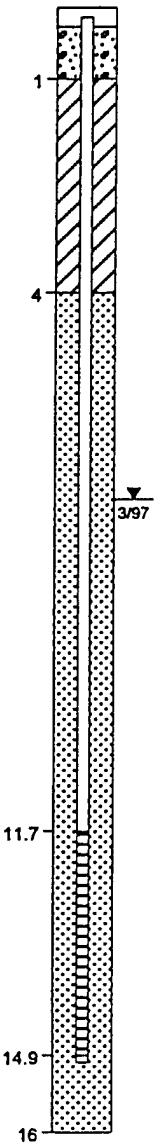
LOG OF BORING U1-1635

Operable Unit 1
Hill Air Force Base, Utah

Date Completed	: 3/19/97	Northing	: 293511.8646
Drilling Method	: Geoprobe	Easting	: 1873493.0450
Drilling Contractor	: USEPA-Frank Beck	Ground Elevation	: 4447.53 (feet msl)
Boring Logged By	: John Hicks	TOC Elevation	: 4447.52 (feet msl)

Depth in Feet	Surf. Elev. 4447.53	Samples	Recovery (feet)	GRAPHIC	USCS	DESCRIPTION
0		1	2.5		SM	Dark brown, very fine to medium silty SAND to sandy SILT, moist
	4445				SW	Gravelly SAND
						No recovery.
5		2	2		SW	Medium brown, medium to coarse gravelly SAND TOC sample MP8-1 (4' - 6' bgs)
	4440					No recovery.
10						No recovery.
	4435					
15						
	4430					
20						

U1-1635
ELEV: 4447.52



Well Construction Information

WELL CASING

Casing Material	: PVC
Casing Diameter	: 0.5" ID
Joint Type	: threaded

WELL SCREEN

Screen Material	: PVC
Screen Diameter	: 0.5" ID
Screen Slot Size	: 0.010 "
Screen Joint Type	: threaded

ANNULUS

Natural Pack	: 0 - 1'
Bentonite Pellets	: 1' - 4'
Sand Pack	: 4' - 5'
Natural Pack	: 5' - 16'
Borehole	: 2" diameter
Protective Casing	: Flush Mount

NOTES

Borehole/ monitoring point previously labeled MP8.

6-26-1997 c:\mtech3\hillou1\geolu1_1635.ge3

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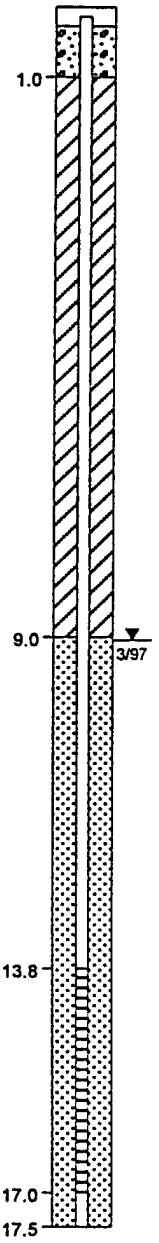
LOG OF BORING U1-1632

Operable Unit 1
Hill Air Force Base, Utah

Date Completed	: 3/20/97	Northing	: 292702.8521
Drilling Method	: Geoprobe	Easting	: 1872826.9000
Drilling Contractor	: USEPA-Frank Beck	Ground Elevation	: 4478.49 (feet msl)
Boring Logged By	: John Hicks	TOC Elevation	: 4478.46 (feet msl)

Depth in Feet	Surf. Elev. 4478.49	Samples	Recovery (feet)	GRAPHIC	USCS	DESCRIPTION
0	4478				CL	Dark brown silty CLAY, moist, plastic
1	4477	1	4		ML	Medium brown clayey SILT with very fine to fine sand, moist
2	4476					
3	4475					
4	4474	2	3.6		SM	Same as above, grading to silty SAND with trace clay, moist
5	4473					
6	4472					
7	4471					
8	4470					No recovery.
9	4469	3	2		SM	Very fine to medium silty SAND, wet
10	4468					No recovery.
11	4467					
12	4466	4	1.5		SW	Fine to very coarse SAND with gravel to 2" diameter, wet TOC sample MP5-1 (12 -13.5' bgs)
13	4465					No recovery.
14	4464					
15	4463					
16	4462					
17	4461					
18	4460					
19	4459					
20						

U1-1632
ELEV: 4478.46



Well Construction Information

WELL CASING

Casing Material	: PVC
Casing Diameter	: 0.5" ID
Joint Type	: threaded

WELL SCREEN

Screen Material	: PVC
Screen Diameter	: 0.5" ID
Screen Slot Size	: 0.010 "
Screen Joint Type	: threaded

ANNULUS

Natural Pack	: 0 - 1'
Bentonite Pellets	: 1' - 9'
Sand Pack	: 9' - 17.5'
Borehole	: 2" diameter
Protective Casing	: Flush Mount

NOTES

Borehole/monitoring point previously labeled MP5.

c:\mtech3\hillou1\geolu1_1632.ge3

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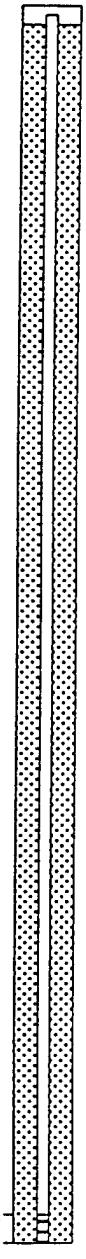
LOG OF BORING U1-1633

Operable Unit 1
Hill Air Force Base, Utah

Date Completed	: 3/19/97	Northing	: 293189.7253
Drilling Method	: HSA/Geoprobe	Easting	: 1873393.8210
Drilling Contractor	: USEPA-Frank Beck	Ground Elevation	: 4460.57 (feet msl)
Boring Logged By	: John Hicks	TOC Elevation	: NA/tubing well

Depth in Feet	Surf. Elev. 4460.57	Samples	Recovery (feet)	GRAPHIC	USCS	DESCRIPTION
0	4460	1	3		SW	Very fine to very coarse SAND with gravel to 2" diameter, trace silt, moist
					ML	Dark brown sandy SILT, trace clay, moist
					ML	Medium brown SILT, trace fine sand, moist No recovery.
5	4455	2	1.3		SP	Medium brown, medium to coarse SAND with gravel to 1.5" diameter, moist
						No recovery.
10	4450					Auger refusal at 8 ft. Rocks up to 5" diameter coming to surface. Finished boring with 1" diameter Geoprobe rods and installed tubing well. No log. On 3/23/97, pushed 1" slotted rods to 30' bgs to locate water-bearing zones. Increment every 3' from 11-30'. Did not find zone that yielded water.
15	4445					
20	4440					
25						

U1-1633
ELEV: 4460.57



Well Construction Information

WELL CASING

Casing Material	: Teflon tubing
Casing Diameter	: 0.25" ID
Joint Type	: NA

WELL SCREEN

Screen Material	: Stainless steel
Screen Diameter	: 0.25" ID
Screen Slot Size	: 0.0057"
Screen Joint Type	: barbed

ANNULUS

Bentonite Pellets	: NA
Natural Pack	: 0 - 22'
Borehole	: 1" diameter
Protective Casing	: Flush Mount

NOTES

Groundwater not encountered during drilling or well installation.

Borehole/monitoring point previously labeled MP6.

6-26-1997 c:\mlech3\hillou1\geo\u1_1633.ge3

Northing	Easting	Elevation	Note
1,291514.328000,	1873762.947000,	4486.430000,	S1/4 COR 28 5N1W
2,291545.230800,	1871159.146000,	4736.014000,	SW 28 5N1W
10,290018.425000,	1872538.379000,	4792.540000,	73-97
11,291039.634000,	1871239.843000,	4783.480000,	MON 92-
12,290697.239500,	1872249.005000,	4787.326000,	U1-647 TOP PVC
13,290893.183000,	1872065.626000,	4787.416000,	TOP PVC
14,290894.539500,	1872066.105000,	4787.832000,	GRND
15,290892.995500,	1872065.590000,	4787.985000,	MP3 CNTR LID
20,291314.623700,	1873404.016000,	4498.147000,	MP11D CNTR LID
21,291307.905800,	1873408.838000,	4498.443000,	MP11S CNTR LID
22,291307.293000,	1873409.855000,	4498.411000,	GRND
23,292022.193100,	1873158.027000,	4479.777000,	TOP PVC
24,292023.574800,	1873158.164000,	4479.749000,	GRND
25,292022.262300,	1873158.070000,	4480.049000,	MP4S CNTR LID
26,291992.232300,	1873464.714000,	4479.209000,	TOP PVC
27,291993.107700,	1873465.008000,	4479.424000,	GRND
28,291992.235700,	1873464.769000,	4479.532000,	MP10 CNTR LID
29,291259.883800,	1873807.292000,	4500.859000,	U1-108 TOP PVC
30,291265.694000,	1873807.648000,	4499.487000,	U1-154 TOP PVC
32,292849.299200,	1873267.606000,	4469.299000,	U1-099 TOP PVC
33,292702.800900,	1872826.894000,	4478.461000,	TOP PVC
34,292704.517200,	1872826.981000,	4478.490000,	GRND
35,292702.852100,	1872826.900000,	4478.760000,	MP5 CNTR LID
36,291721.604500,	1874424.642000,	4486.879000,	TOP PVC
37,291721.671500,	1874424.631000,	4487.117000,	MP7 CNTR LID
38,291723.332300,	1874424.475000,	4486.987000,	GRND
39,291895.619500,	1873813.276000,	4483.534000,	U1-098 TOP PVC
41,292603.121300,	1874254.420000,	4450.293000,	MP9 CNTR LID
42,292603.044600,	1874254.401000,	4450.053000,	TOP PVC
43,292604.329600,	1874253.907000,	4450.108000,	GRND
44,292419.008000,	1873896.478000,	4478.869000,	U1-113 TOP PVC
45,292421.676900,	1873890.862000,	4478.794000,	U1-112 TOP PVC
46,292423.503800,	1873886.289000,	4478.584000,	U1-156 TOP PVC
47,292641.607500,	1873795.703000,	4474.719000,	STREET INTR
48,293189.725300,	1873393.821000,	4460.748000,	MP6 CNTR LID
49,293190.734200,	1873394.950000,	4460.571000,	GRND
50,293511.864600,	1873493.045000,	4447.695000,	MP8 CNTR LID
51,293511.923100,	1873493.058000,	4447.524000,	TOP PVC
52,293513.106900,	1873494.067000,	4447.526000,	GRND
53,293417.355700,	1873457.997000,	4442.815000,	WTR SURFACE MP8
54,293179.538900,	1873364.351000,	4460.943000,	STREET INTR
55,292504.916600,	1874253.645000,	4447.993000,	WTR SURFACE MP9

MP3 = U1-1630
MP4S = U1-1631
MP5 = U1-1632
MP6 = U1-1633
MP7 = U1-1634
MP8 = U1-1635
MP9 = U1-1636
MP10 = U1-1637
MP11S = U1-1638
MP11D = U1-1639

SURVEY DATA

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220 Job Name: AFCEE-RNA
Location Hill AFB - OU 1 by RN/JH/CM Date: 3/21/97
Well Identification MP4 (S) (UL-1631) Measurement Datum TOC

Pre-Development Information Time (Start): 1 40 pm

Water Level: 3.89 Total Depth of Well: 8.1

Water Characteristics

Color Slightly cloudy-brown Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material
pH Temperature (°C) 14.7
Specific Conductance (µS/cm) 839
Dissolved Oxygen (mg/L) 2.2
Redox (mV) -45

not producing will use MP4D (UL-1640)

Interim Water Characteristics

Gallons Removed

pH

Temperature (°C)

Specific Conductance(µS/cm)

Dissolved Oxygen (mg/L)

Redox (mV)

Post-Development Information Time (Finish):

Water Level: Total Depth of Well:

Approximate Volume Removed:

Water Characteristics

Color Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material
pH Temperature (°C)
Specific Conductance (µS/cm)
Dissolved Oxygen (mg/L)
Redox (mV)

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220
Location Hill AFB - OU 1
Well Identification MP5 (414637)

Job Name: AFCEE-RNA
by RN/JH/CM Date: 3/21/97
Measurement Datum TOC

Pre-Development Information Time (Start): 259

Water Level: 9.00 Total Depth of Well: 16.98

Water Characteristics

Color Brown Clear (Cloudy)
Odor: (None) Weak Moderate Strong
Any Films or Immiscible Material —
pH Temperature (°C) 11.5
Specific Conductance (µS/cm) 825
Dissolved Oxygen (mg/L) 1.2
Redox (mV) −160

Interim Water Characteristics

Gallons Removed 1 gallon 3:00

pH

Temperature (°C) ~~11.5~~ 10.9

Specific Conductance(µS/cm) 819

Dissolved Oxygen (mg/L) ~~1.2~~ 1.6

Redox (mV) ~~−160~~ −50

Post-Development Information Time (Finish): 315

Water Level: 9.00 Total Depth of Well: ~~16~~.0

Approximate Volume Removed: 1.5 gallons

Water Characteristics

Color (Clear) Cloudy
Odor: (None) Weak Moderate Strong
Any Films or Immiscible Material —
pH Temperature (°C) 10.7
Specific Conductance (µS/cm) 820
Dissolved Oxygen (mg/L) 1.3
Redox (mV) −115

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220
Location Hill AFB - OU 1
Well Identification MP-6 (WL-1633)
Job Name: AFCEE-RNA
by RN/JH/CM Date: 3/21/97
Measurement Datum

Pre-Development Information

Time (Start):

Water Level: NA (tubing)

Total Depth of Well: ~22'

Water Characteristics

Color brown Clear (Cloudy)
Odor: (None) Weak Moderate Strong
Any Films or Immiscible Material —
pH - Temperature (°C) 13.5
Specific Conductance (µS/cm) 1200
Dissolved Oxygen (mg/L) 0.0
Redox (mV) -40

Pumped for 4 minutes 920-924 20 mL

Interim Water Characteristics

Gallons Removed

pH

Temperature (°C)

Specific Conductance(µS/cm)

Dissolved Oxygen (mg/L)

Redox (mV)

Post-Development Information

Time (Finish):

Water Level:

Total Depth of Well:

Approximate Volume Removed:

Water Characteristics

Color Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material
pH Temperature (°C)
Specific Conductance (µS/cm)
Dissolved Oxygen (mg/L)
Redox (mV)

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220
Location Hill AFB - OU 1
Well Identification MP8 (41-1635)

Job Name: AFCEE-RNA
by RN/JH/CM Date: 3/21
Measurement Datum TOC

Pre-Development Information Time (Start): 10:22

Water Level: 6.92 Total Depth of Well: 11.66' must have been stuck

Water Characteristics

Color brown Clear (Cloudy)
Odor: (None) Weak Moderate Strong
Any Films or Immiscible Material
pH Temperature (°C) 10.2
Specific Conductance (µS/cm) 1110
Dissolved Oxygen (mg/L) 0.0
Redox (mV) -202

Interim Water Characteristics Time 1036

Gallons Removed 1 gallon slightly cloudy

pH

Temperature (°C) 8.2

Specific Conductance(µS/cm) 1090

Dissolved Oxygen (mg/L) 0.0

Redox (mV) -110

Post-Development Information Time (Finish): 10:44 am

Water Level: 6.99 Total Depth of Well: 14.20

Approximate Volume Removed: 2 gallons

Water Characteristics

Color v slightly cloudy lt. brown Clear Cloudy
Odor: (None) Weak Moderate Strong
Any Films or Immiscible Material —
pH Temperature (°C) 8.0
Specific Conductance (µS/cm) 1102
Dissolved Oxygen (mg/L) 0.0
Redox (mV) -118

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220
Location Hill AFB - OU 1
Well Identification MPTO (41-1637)

Job Name: AFCEE-RNA
by (RN/JH/CM Date: 3/21/97
Measurement Datum TOC

Pre-Development Information

Time (Start): 11:25

Water Level: 1.78

Total Depth of Well: 10.32
must have had obstruction

Water Characteristics

Color brown Clear (Cloudy)
Odor: (None) Weak Moderate Strong
Any Films or Immiscible Material —
pH Temperature (°C) 9.6
Specific Conductance (µS/cm) 889
Dissolved Oxygen (mg/L) 1.4
Redox (mV) −130

Interim Water Characteristics

Gallons Removed 1

pH

Temperature (°C) 8.3

Specific Conductance(µS/cm) 870

Dissolved Oxygen (mg/L) 4.6

Redox (mV) −53

Post-Development Information

Time (Finish): 1148

Water Level: 1.83

Total Depth of Well: 12.35

Approximate Volume Removed: 2 gallons

Water Characteristics

Color (Clear) Cloudy
Odor: (None) Weak Moderate Strong
Any Films or Immiscible Material —
pH Temperature (°C) 8.2
Specific Conductance (µS/cm) 869
Dissolved Oxygen (mg/L) 4.8
Redox (mV) −61

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220
Location Hill AFB - OU 1
Well Identification MP11 (5) (41-1631)

Job Name: AFCEE-RNA
by RN/JH/CM Date: 3/21/97
Measurement Datum —

Pre-Development Information

Time (Start): 1207

Water Level: — estimate 17' Total Depth of Well: 28'

Water Characteristics

Color dk brown Clear (Cloudy)
Odor: (None) Weak Moderate Strong
Any Films or Immiscible Material —
pH Temperature (°C) 13.9
Specific Conductance (µS/cm) 717
Dissolved Oxygen (mg/L) 0.0
Redox (mV) −20

Interim Water Characteristics

Gallons Removed 0.75 1247

pH

Temperature (°C) 13.6

Specific Conductance(µS/cm) 704

Dissolved Oxygen (mg/L) 4.3

Redox (mV) 33.1

Post-Development Information

Time (Finish): 1:00 pm

Water Level: Total Depth of Well:

Approximate Volume Removed: 1 gallon

Water Characteristics

Color (Clear) Cloudy
Odor: (None) Weak Moderate Strong
Any Films or Immiscible Material —
pH Temperature (°C) 13.4
Specific Conductance (µS/cm) 701
Dissolved Oxygen (mg/L) 4.0
Redox (mV) 23

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220
Location Hill AFB - OU 1
Well Identification MP11D (414639)

Job Name: AFCEE-RNA
by (RN)/JH/CM Date: 3/21/97
Measurement Datum —

Pre-Development Information

Time (Start): 345

Water Level: NA (tubing) est 17 Total Depth of Well: 240'

Water Characteristics

Color Brown Clear (Cloudy)
Odor: (None) Weak Moderate Strong
Any Films or Immiscible Material —
pH ____ Temperature (°C) 13.1
Specific Conductance (µS/cm) 775
Dissolved Oxygen (mg/L) 0.0
Redox (mV) -125

Interim Water Characteristics

Gallons Removed 0.5

pH ____

Temperature (°C) 13.1

Specific Conductance(µS/cm) 780

Dissolved Oxygen (mg/L) 0.0

Redox (mV) -195

Post-Development Information

Time (Finish): 416

Water Level: —

Total Depth of Well: —

Approximate Volume Removed: 1 gallon

Water Characteristics

Color Slightly cloudy - brown Clear Cloudy
Odor: (None) Weak Moderate Strong
Any Films or Immiscible Material —
pH ____ Temperature (°C) 12.2
Specific Conductance (µS/cm) 775
Dissolved Oxygen (mg/L) 0.0
Redox (mV) -227

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220
Job Name: AFCEE-RNA
Location Hill AFB - OU 1
by RN/JH/CM Date: 3/21
Well Identification MP4(d) (41-16)
Measurement Datum —

Pre-Development Information
Time (Start): 203
Water Level: ~4' (Depth at MP45)
Total Depth of Well: ~15'

Water Characteristics

Color tan
Clear (Cloudy)
Odor: (None) Weak Moderate Strong
Any Films or Immiscible Material —
pH
Temperature (°C) 19.3
Specific Conductance (µS/cm) 770
Dissolved Oxygen (mg/L) 2.0
Redox (mV) −254

Interim Water Characteristics

208

Gallons Removed 0.25
pH —
Temperature (°C) 11.6
Specific Conductance(µS/cm) 769
Dissolved Oxygen (mg/L) 3.4
Redox (mV) −209

Post-Development Information
Time (Finish): 217

Water Level: —
Total Depth of Well: —

Approximate Volume Removed: 0.75

Water Characteristics

Color
(Clear) Cloudy
Odor: (None) Weak Moderate Strong
Any Films or Immiscible Material —
pH
Temperature (°C) 11.6
Specific Conductance (µS/cm) −97
Dissolved Oxygen (mg/L) 3.7
Redox (mV) 160

Comments: no air in lines

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MW - 068
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/17/97 at 9:15 (a.m./p.m.)
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: Cloudy, light rain, breezy, ~40°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe):

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH ~~Alk~~ Isopropyl Alcohol, DI H2O
Items Cleaned (List): W.L. indicator

2 [ ] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 22.48' FT. BELOW DATUM
Measured with:

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance:
Odor:
Other Comments:

4 [ ] WELL EVACUATION:
Method:
Volume Removed:
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors:
Other comments:

Groundwater Sampling Record

Monitoring Well No. _____ (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[ ] Pump, type:_
[ ] Other, describe:_____
_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	8:54	9:07	9:15			Measured with
Temp (°C)	10.2	10.3	10.5			
pH	7.06	7.23	7.33			
Cond ~~(µS/cm)~~ mmhos/cm	500	500	500			
DO (mg/L)	8.42	8.16	8.15			
Redox (mV)	253.9	245	240.3			
Vol. purged	10.5 gal	2.5 gal				

7 [ ] SAMPLE CONTAINERS (material, number, size):_____
_____
_____
_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____
_____
_____
_____
_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL UI-053
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING 3/25 at 1153 a.m./p.m. sampled
SAMPLE COLLECTED BY: JH/EN/CM of Parsons ES
WEATHER: 60 Windy, 3x mph
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED; [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH Distilled water
Items Cleaned (List): probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 19.91 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: slightly cloudy - gray
Odor: none
Other Comments: —

4 [ ] WELL EVACUATION:
Method: Bladder
Volume Removed: 7 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

34
- 20
14/2 = 7

Groundwater Sampling Record

Monitoring Well No. UI-053 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of: _____

[X] Pump, type: Bladder

[ ] Other, describe: _____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	1219	1227	1238	1022	1220	Measured with
Temp (°C)	11.1	11.3	11.4	11.5	11.4	YSI 55
pH	7.93	7.94	7.89	7.82	7.81	Orion 250A
Cond (µS/cm)	—	—	—	—	—	YSI 33 not functioning
DO (mg/L)	7.88	7.87	7.83	7.53	7.59	YSI 55
Redox (mV)	-0.4	-0.4	-0.3	-0.4	-0.4	Orion 250A
Gallons	3	4	5	6	7	

7 [ ] SAMPLE CONTAINERS (material, number, size): _____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____

[ ] Preservatives added:

Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA Lawked samples
DO meter probably not calibrated/functioning properly

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL UI-061
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/19 at 1205 a.m./p.m. 1220 Sampled
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 60's Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): Pro pos

2 [ ] PRODUCT DEPTH ____ FT. BELOW DATUM
Measured with: ____

WATER DEPTH 26.78 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bladder Pump
Volume Removed: 8 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

Groundwater Sampling Record

Monitoring Well No. MW-061 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of: _____
[X] Pump, type: Bladder
[ ] Other, describe: _____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	1210	1212	1217			Measured with
Temp (°C)	13.0	12.9	12.9			Orion 846
pH						Orion 1
Cond (µS/cm)	1123	1125	1122			Orion 140
DO (mg/L)	0.2	0.1	0.0			Orion 840
Redox (mV)	-175	-193	-200			Orion 240 A
Gallons	5	6	8			

7 [ ] SAMPLE CONTAINERS (material, number, size): _____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____

[ ] Preservatives added:

Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA Low flow samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL OU1 - 062
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/17/97 at 1:15 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: partly cloudy 50°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH Isopropyl, Distilled Water
Items Cleaned (List): Water level meter

2 [ ] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 25.2 FT. BELOW DATUM
Measured with: Water level meter

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: silty
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bennett pump
Volume Removed: 11 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

Groundwater Sampling Record

Monitoring Well No MW-062 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Bennett
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	11:49	12:15	12:49	1:02	1:15	Measured with
Temp (°C)	12.4	12.7	12.2	12.3	12.4	
pH	7.78	8.06	8.17	8.42	8.5	
Cond ~~(µS/cm)~~	~~[illegible]~~	450	435	440	440	
DO (mg/L)	0.80	0.47	1.99	0.70	1.17	
Redox (mV)	-146.9	-141.3	-145	-171.7	-133.5	
Vol purged (gal)	1.0	4.0	6.0	8.0	11.0	

450 (mS) µmoh/cm

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

12:3 / 12:4 / 1:0

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-0165
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/20 at 840 a.m./p.m. Sampled 900
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 50° windy
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Toc

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH detected FT. BELOW DATUM
Measured with: wpe of Solinst

WATER DEPTH 28.10 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: slightly cloudy
Odor: strong
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bladder
Volume Removed: 6 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: yes - strong
Other comments:

34
-28
+ 6
8/2 = 4 gallons

L:\forms\gwsample.doc

Groundwater Sampling Record

Monitoring Well No. U1-065 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Bladder
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	847	851	854	856	858	Measured with
Temp (°C)	12.7	12.9	12.9	12.9	12.9	Orion 840
pH						Orion
Cond (µS/cm)	1293	1260	1240	1235	1226	Orion 140
DO (mg/L)	0.3	0.0	0.0	0.0	0.1	Orion 840
Redox (mV)	-179	-183	-188	-180	-190	Orion 290A
Gallons	2	3	4	4.5	5	

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA handled sampling

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL GW11-074067
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/27/97 at 0930 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: partly sunny, windy, cool (40's °F)
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH DI H2O, isopropyl alcohol, Alconox
Items Cleaned (List): Interface probe

2 [ ] PRODUCT DEPTH 22.00 FT. BELOW DATUM
Measured with: Interface probe

WATER DEPTH 22.01 FT. BELOW DATUM
Measured with: Interface probe

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: cloudy
Odor: petroleum
Other Comments:

4 [ ] WELL EVACUATION:
Method: bailer (polyethylene disposable)
Volume Removed: 2 gal
Observations: Water (slightly) - very) cloudy
Water level (rose - fell) - no change)
Water odors: petroleum
Other comments:

Groundwater Sampling Record

Monitoring Well No. U1-067 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[✓] Bailer made of: Teflon, disposable

[ ] Pump, type:

[✓] Other, describe: Teflon bottom emptying device for VOC

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS: No readings obtained

Time						Measured with
Temp (°C)						
pH						
Cond (µS/cm)						
DO (mg/L)						
Redox (mV)						

7 [ ] SAMPLE CONTAINERS (material, number, size):

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method Containers:
Method Containers:
Method Containers:

[ ] Preservatives added:

Method Containers:
Method Containers:
Method Containers:
Method Containers:

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-072
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/19/97 at 4:00 a.m./(p.m.)
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: sunny ~70°F.
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC stickup

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH alcohol, distilled water
Items Cleaned (List): Water level probe

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: water level meter

WATER DEPTH 23.20 FT. BELOW DATUM
Measured with: water level meter

3 [✓] TD = 26.20 Approx Purge Vol. 1.5 gallons
WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: cloudy
Odor: rotten eggs
Other Comments: —

4 [✓] WELL EVACUATION:
Method: Pump
Volume Removed:
Observations: Water (slightly - ~~very~~) cloudy
Water level (rose - fell - no change)
Water odors: rotten eggs
Other comments: —

Groundwater Sampling Record

Monitoring Well No. W-072 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Bennett Sample Pump
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	3:44	3:55	4:00			Measured with
Temp (°C)	14.1	14.7	13.4			YSI 55
pH	9.0	6.93	6.90			ORION 250A
Cond (µS/cm)	950	950	950			YSI 33
DO (mg/L)	5.0	3.13	3.5			~~DO~~ YSI 55
Redox (mV)	~~DO~~	-145	-148			ORION
DO (mg/L)	0.6	1.0	0.8			ORION

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-073
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/19/97 at 2:40 a.m./p.m.
SAMPLE COLLECTED BY: JH/RM/CM of Parsons ES
WEATHER: sunny, 70°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC stick up

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH alcohol, distilled water
Items Cleaned (List): Water level probe

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: —

WATER DEPTH 29.62 FT. BELOW DATUM
Measured with: water level meter

3 [✓] TD=32.3 Purge Vol 1.31
WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: light odor - rotten eggs
Other Comments: —

4 [✓] WELL EVACUATION:
Method: Pump
Volume Removed: 2 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: rotten eggs
Other comments:

Groundwater Sampling Record

Monitoring Well No. U1-073 (Continued)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: Bennett

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	2:29	2:34	2:39			Measured with
Temp (°C)	16.1	14.8	14.7			YSI 55
pH	7.00	6.77	6.74			ORION 250A
Cond (µS/cm)	1250	1200	1200			YSI 33
DO (mg/L)	5.42	4.44	3.96			YSI 55
Redox (mV)	-108.3	-128.0	-138.5			OAKTON
DO (mg/L)	1.1	1.3	1.2			ORION 840

0.5g 0.75g 1g

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-074
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/20/97 at 8:15 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: clear, 45°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC stickup

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [Y] EQUIPMENT CLEANED BEFORE USE WITH alcohol, distilled water
Items Cleaned (List): Water level probe

2 [Y] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: —

WATER DEPTH 25.82 FT. BELOW DATUM
Measured with: water level meter
TD - not known

3 [Y] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: —

4 [ ] WELL EVACUATION:
Method: Pump
Volume Removed: 5 gallons
Observations: Water (slightly) - very) cloudy
Water level (rose - fell) - no change)
Water odors: rotten eggs
Other comments:

Groundwater Sampling Record

Monitoring Well No. MW-074 (Continued)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: Bennett

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	7:58	8:07	8:12			Measured with
Temp (°C)	11.1	11.7	11.7			
pH	8.1	7.09	7.09			
Cond (µS/cm)	960	950	950			
DO (mg/L)	6.09	4.98	4.87			
Redox (mV)	NM	-159	-162			
DO (mg/L)	0.7	0.6	0.6			
Vol Purged	1 gal	4 gal	5 gal			

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL 111-077R
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/18 at 1205 a.m. (p.m.) sample 300
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 55 Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:

[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): Probe

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 29.78 FT. BELOW DATUM
Measured with: Sollnst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bladder pump
Volume Removed: 20 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

38
- 30
8 gallons
+ 2
10 gal
+ 20

L:\forms\gwsample.doc

Groundwater Sampling Record

Monitoring Well No. MI-07R (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Bladder
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	1235	1240	~~1245~~ 1300	~~1250~~ 1227	1245	Measured with
Temp (°C)	13.6	13.4	13.3	13.5	13.5	Orion 840
pH						Orion
Cond (µS/cm)	916	932	909	909	901	Orion 140
DO (mg/L)	6.9	5.8	6.5	6.5	6.6	Orion 840
Redox (mV)	113	100	139	152	142	Orion 290A
Gallons	8	9	16	18	20	

7 [ ] SAMPLE CONTAINERS (material, number, size):

~~2 pint~~ poly, 250 mL
3 poly, 125 mL
4 VOAs, 2 serum glass

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method Acid Containers: VOAs, 1 poly 125, 2 se
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA sampled

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-078
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling:
DATE AND TIME OF SAMPLING: 3/17 at 2:50 a.m. (p.m.) 4:00 sample
SAMPLE COLLECTED BY: (JH)/RN/CM of Parsons ES
WEATHER:
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 25.20 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Cloudy - brown
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Peristaltic
Volume Removed: 2 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

27
25
20 = 1 gallon
+2
2 gal

Groundwater Sampling Record

Monitoring Well No. U1-078 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of: _____
[X] Pump, type: Peristaltic
[ ] Other, describe: _____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	315	330	340	350		Measured with
Temp (°C)	13.0	12.9	12.6	12.6		Orion 840
pH						Orion
Cond (µS/cm)	783	792	788	790		Orion
DO (mg/L)	2.3	2.8	2.7	2.5		Orion 840
Redox (mV)	113	5.6	9.8	4.5		Orion 290A
gallons	1.0	1.5	1.75	2.0		

7 [ ] SAMPLE CONTAINERS (material, number, size): _____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____

[ ] Preservatives added:

Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA handled samples
Some air in line

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-081
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/14 at 145 a.m./p.m. 305 sampled
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: cloudy cold 40°
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 24.00 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Slightly cloudy - Clear
Odor: none
Other Comments: began 1353 pm

4 [ ] WELL EVACUATION:
Method: peristaltic
Volume Removed: 4 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: ~~began~~ 1353

29.0
+2.5
1.5 = 3.75 ⇒ 4.0 gal

Groundwater Sampling Record

Monitoring Well No. U1-091 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type:_ Peristaltic
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	230	242	253	302		Measured with
Temp (°C)	11.5	11.4	11.2	11.1		Orion 810
pH	7.29	7.29	7.29	7.30		Orion 230
Cond (µS/cm)	979	1006	1014	1025		Orion 140
DO (mg/L)	4.0	3.2	3.2	3.3		Orion 840
Redox (mV)	207.5	244.0	260	262		Orion 290A
gallons	2.5	3.0	3.5	4.0		~~Cole-Parmer~~

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EFA handled samples

Air bubbles in line

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL GI-084
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/17 at 1206 a.m./p.m. Sample 1240
SAMPLE COLLECTED BY: JH/RM/CM of Parsons ES
WEATHER: 55 Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 15.82 FT. BELOW DATUM
Measured with: T

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Cloudy brown
Odor: none
Other Comments: —

4 [ ] WELL EVACUATION:
Method: Peristaltic
Volume Removed:
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors:
Other comments:

23.4
15.8
7.6/2 3.8
4.0

Groundwater Sampling Record

Monitoring Well No. U1-084 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Peristaltic
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	1225	1230	1233	1240		Measured with
Temp (°C)	9.8	9.6	10.0	9.6		Orion 840
pH				7.4		Orion
Cond (µS/cm)	1010	1012	1011	1012		Orion 140
DO (mg/L)	0.2	0.7	0.8	0.2		Orion 840
Redox (mV)	44	0.1	0.1	4.5		Orion 290A
gallons	2.5	3.0	4.0	4.5		

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: sampled by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-085
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/17/97 at 11 a.m./p.m.
SAMPLE COLLECTED BY: JH/KN/CM of Parsons ES
WEATHER: cold calm 40°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top of casing

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 13.72 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: cloudy red-brown
Odor: none
Other Comments: —

4 [ ] WELL EVACUATION:
Method: Peristaltic
Volume Removed: 5 Gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

Groundwater Sampling Record

Monitoring Well No. U-085 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: Peristaltic

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	1110	1115	1132	1138		Measured with
Temp (°C)	9.4	9.4	9.4	9.4		~~YSI~~ Orion 840
pH	7.2	7.1	7.1	7.2		Orion 290A
Cond (µS/cm)	1442	1441	1441	1442		Orion 140
DO (mg/L)	0.9	1.1	1.4	1.8		Orion 840
Redox (mV)	89.8	81.8	79.6	75.0		Orion 290A
gallon	3.5	4.0	4.5	5.0		

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

EPA

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA handled samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-089 (Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling:
DATE AND TIME OF SAMPLING: 3/18 at 340 a.m./(p.m.) Sampled 4:30
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 60 sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): toc

MONITORING WELL CONDITION:
LOCKED: [X] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 24.64 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bladder
Volume Removed: 6 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

34
24
10 = 5

Groundwater Sampling Record

Monitoring Well No. MW-089 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type:_ Bladder
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	4:11	4:15	4:18	4:22		Measured with
Temp (°C)	13.4	13.4	13.4	13.4		Orion 840
pH						Orion
Cond (µS/cm)	1117	1116	1117	1114		Orion 140
DO (mg/L)	0.0	0.1	0.1	0.1		Orion 840
Redox (mV)	-219	-215	-212	-209		Orion 290A
Gallons	4	4.5	5	5.3		

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA sampled

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-090
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling:
DATE AND TIME OF SAMPLING: 3/20 at 150 a.m./(p.m.) Sampled 215
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 70 Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS) - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS) - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH Distilled Water
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —
WATER DEPTH ~9 feet of water (tape wet) "no beep" FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Slightly cloudy
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bladder
Volume Removed: 6 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

$\frac{9}{+1}$
$\frac{10}{2} = 5$

Groundwater Sampling Record

Monitoring Well No. U1-090 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of: _____
[X] Pump, type: Bladder
[ ] Other, describe: _____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	157	159	202	206	210	Measured with
Temp (°C)	12.2	12.0	12.0	12.0	12.0	Orion 840
pH						Orion
Cond (µS/cm)	788	790	791	792	792	Orion 140
DO (mg/L)	5.4	5.3	5.5	5.7	5.3	Orion 840
Redox (mV)	67	82	84	88	89	Orion 290A
Gallons	2	3	4	5	6	

7 [ ] SAMPLE CONTAINERS (material, number, size): _____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____

[ ] Preservatives added:

Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA handled samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-092
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/27 at 1150 a.m./p.m.
SAMPLE COLLECTED BY: JH/KN/CM of Parsons ES
WEATHER: 60 Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

sample 1245

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS) IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH Distilled water
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 12.81 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Cloudy (red-brown)
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bladder Pump
Volume Removed: 15 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

$$\begin{array}{r} 20.5 \\ -\ 12.8 \\ \hline 7.7 \end{array} \quad \frac{7.7}{2} = 3.9 \text{ gal}$$

Groundwater Sampling Record

Monitoring Well No. MW-092 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of: _____

[X] Pump, type: Peristaltic

[ ] Other, describe: _____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	1153	1155	1157	1200	1203	Measured with	1205	1210	1214
Temp (°C)	10.7	10.3	9.9	9.5	9.5	Orion 840	9.5	9.4	9.3
pH						Orion			
Cond (µS/cm)	1433	1369	1318	1260	1251	Orion 140	1228	1216	1217
DO (mg/L)	0.0	0.4	1.3	2.5	2.6	Orion 840	2.7	2.7	2.7
Redox (mV)	160	130	90	66	62	Orion 290	52	45	38
Gallons	1	2	3	4	5		6	8	10

7 [ ] SAMPLE CONTAINERS (material, number, size): _____

1221
9.2
1207
27
32
12

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method _____ Containers: _____

Method _____ Containers: _____

Method _____ Containers: _____

[ ] Preservatives added:

Method _____ Containers: _____

Method _____ Containers: _____

Method _____ Containers: _____

Method _____ Containers: _____

1227	12
9.2	9.0
1205	12
2.7	2.5
27	25
14	16

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled

[ ] Container Lids Taped

[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: GPA handled samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-097
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: ~~3/15~~ 3/15 at 1000 (a.m.)/p.m. Sampled 1045
SAMPLE COLLECTED BY: (JH)/RN/CM of Parsons ES
WEATHER: 50° Cloudy
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:

[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS (NOT) APPARENT
[X] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 13.63 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: —

4 [ ] WELL EVACUATION:
Method: bladder Pump (dedicated)
Volume Removed:
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

Groundwater Sampling Record

Monitoring Well No. U1-097 (Continued)

SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type:_ Bladder
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	1025	1032	1037			Measured with
Temp (°C)	8.0	7.9	7.9			Orion 840
pH						Orion
Cond (µS/cm)	577	580	577			Orion 140
DO (mg/L)	~~330~~ 1.7	5.0	5.0			Orion 840
Redox (mV)	330	328	318			Orion 290A
Gallons	4	~~4~~ 5	6			

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: GPA handled sampling did not sample for dissolved gases as pump control inoperable.

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-098
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/17 at 932 a.m./p.m. 1000 sampled
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 50 Rain
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH Alconox / Distilled H2O
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 6.6.0 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Peristaltic
Volume Removed: 5 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

14.4
3.9
11
4

Groundwater Sampling Record

Monitoring Well No. U1-098 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: Peristaltic

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	940	947	953			Measured with
Temp (°C)	5.8	5.7	5.8			Orion 840
pH			7.1			Orion
Cond (µS/cm)	830	825	825			Orion 140
DO (mg/L)	1.7	1.7	1.6			Orion 840
Redox (mV)	260	245	263			Orion 290
Gallons	2	4	5			

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA blanked sam

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL 141-098(B)
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/27 at 903 a.m./p.m. Sample 915
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 50 windy
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH Distilled water
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 5.35 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance:
Odor:
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bladder
Volume Removed:
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors:
Other comments:

14.4
5.4
9/2 = 4.5 gallons

Groundwater Sampling Record

Monitoring Well No. MW-098 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Bladder
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	905	906	907	908	911	Measured with
Temp (°C)	6.3	6.2	6.2	6.2	6.2	Orion 840
pH						Orion
Cond (µS/cm)	830	823	823	822	824	Orion 140
DO (mg/L)	1.2	1.6	1.7	1.9	1.8	Orion 840
Redox (mV)	157	159	161	166	166	Orion 290A
Gallons	1	2	3	4	5	

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

VOAs only

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA handled samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-099
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/15/97 at 1500 a.m./(p.m.)
SAMPLE COLLECTED BY: (JH/RN/CM) of Parsons ES
WEATHER: Cloudy, cool (~40°F), Calm
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top of pump cap

MONITORING WELL CONDITION:
[✓] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS / IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS / IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH DI H2O, Trigrapl Alcohol
Items Cleaned (List): W.L. Indicator

2 [ ] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 7.20' FT. BELOW DATUM
Measured with: W.L. Indicator

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: brown, turbid
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Peristaltic pump - pushed HDPE tubing to bottom of well next to dedicated pump
Volume Removed: 4.5 gal
Observations: Water (slightly - very) cloudy slightly to moderately
Water level (rose / fell / no change)
Water odors: None
Other comments: Dedicated Bladder pump present - our Controller not operational

Groundwater Sampling Record

Monitoring Well No. MW-099 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[✓] Pump, type: Peristaltic w/ HDPE + Silicon tubing
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	1507	1517	1528			Measured with
Temp (°C)	6.1	6.0	6.1			Sunearth-155
pH	7.57	7.55	7.46			↓
Cond ~~(µS/cm)~~ mmhos/cm	650	650	640			↓
DO (mg/L)	2.6	0.7	0.5			↓
Redox (mV)	39	26	18			↓
Vol. removed	1 gal	2.5 gal	4.5 gal			↓

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-100
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling: 440 - sampled
DATE AND TIME OF SAMPLING: 3/14 at 345 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 40's cold cloudy
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 24.82 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: peristaltic
Volume Removed: 5 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: air in line

33
23
10/2 = 5

Groundwater Sampling Record

Monitoring Well No. U 1-100 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Peristaltic
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	405	414	425	430	440	Measured with
Temp (°C)	12.2	12.3	12.4	12.1	12.4	Orion 840
pH						Orion 730
Cond (µS/cm)	963	975	995	1000	1003	Orion 140
DO (mg/L)	2.2	2.0	2.2	2.5	2.5	Orion 840
Redox (mV)	235	270	260	263	260	Orion 290A
Gallons	2.5	3.0	4.0	4.5	5.0	—

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA sampled – air in line

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-101 (Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/22 at 1545 a.m./(p.m.)
SAMPLE COLLECTED BY: (JHRN/CM) of Parsons ES
WEATHER: Clear, mild (60°F)
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH DI H2O, isopropyl alcohol
Items Cleaned (List): Oil/water interface probe

2 [ ] PRODUCT DEPTH 27.49' FT. BELOW DATUM
Measured with: Oil/water interface probe

WATER DEPTH 28.18 FT. BELOW DATUM
Measured with: interface probe

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Sl. cloudy
Odor: petroleum
Other Comments:

4 [ ] WELL EVACUATION:
Method: PE bailer (disposable)
Volume Removed: 4 gal
Observations: Water (slightly - very) cloudy
Water level (rose - (fell) - no change)
Water odors: petroleum
Other comments:

Groundwater Sampling Record

Monitoring Well No. MW-101 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[✓] Bailer made of: Teflon (disposable)
[ ] Pump, type:
[✓] Other, describe: Teflon bottom ~~emptier~~ 3/4" emptying device for VOCs

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS: No readings obtained

Time						Measured with
Temp (°C)						
pH						
Cond (µS/cm)						
DO (mg/L)						
Redox (mV)						

7 [ ] SAMPLE CONTAINERS (material, number, size):

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method Containers:
Method Containers:
Method Containers:

[ ] Preservatives added:

Method Containers:
Method Containers:
Method Containers:
Method Containers:

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL LL-103
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/18/97 at 2:20 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER:
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH alcohol, distilled water
Items Cleaned (List): water level meter

2 [ ] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: —

WATER DEPTH 29.80 FT. BELOW DATUM
Measured with: water level meter
TD 36.4 Purge Vol 3.2 gallons

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: silty brown
Odor: none
Other Comments: —

4 [ ] WELL EVACUATION:
Method: pump
Volume Removed: 4.5 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: —

Groundwater Sampling Record

Monitoring Well No. MW-103 (Continued)

5 [X] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: Bennett

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Time	2:03	2:06	2:10	2:14	2:17	~~Measured with~~ 2:20	
Temp (°C)	13.7	13.3	13.5	13.7	13.7	13.7	YSI 55
pH	6.39	6.71	6.86	6.94	6.99	7.01	ORION 250A
Cond (µS/cm)	950	950	950	950	950	950	YSI 33
DO (mg/L)	11.30	8.51	7.37	7.08	6.6	6.42	YSI 55
Redox (mV)	207	195.6	195.6	197.5	200.2	201.1	OAKTON
Vol Purged	0.5gal	2 gal	3 gal	3.5 gal	4 gallons	4.5 gallons	

7 [ ] SAMPLE CONTAINERS (material, number, size): EPH Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL UI-104
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/19/97 at 10:40 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: Sunny - Windy 40°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [X] EQUIPMENT CLEANED BEFORE USE WITH alcenol, distilled water
Items Cleaned (List): Water level probe

2 [X] PRODUCT DEPTH N/A FT. BELOW DATUM
Measured with: —

WATER DEPTH 21.36 FT. BELOW DATUM
Measured with: Water level meter

3 [X] TD 35.10 Purge Vol. 6.72 gallons
WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: —

4 [X] WELL EVACUATION:
Method: pump
Volume Removed: 700
Observations: Water (slightly - very) cloudy to clear
Water level (rose - fell - no change)
Water odors: none
Other comments:

Groundwater Sampling Record

Monitoring Well No. MW-104 (Continued)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: Bennett

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Time	10:12	10:17	10:21	10:26	10:30	Measured with	10:35	10:40
Temp (°C)	12.3	12.3	12.4	12.5	12.5	YSI 55	12.5	12.5
pH	7.09	7.17	7.21	7.25	7.26	ORION 250A	7.33	7.36
Cond (µS/cm)	500	650	650	650	650	YSI 33	700	700
DO (mg/L)	6.11	5.14	5.00	4.98	4.89	YSI 55	4.30	4.27
Redox (mV)	23.3	-18.2	-9.2	19.8	19.9	ORION	16.6	17.4
ORION DO	NM	2.4	2.3	2.3	2.1	ORION	1.5	1.5

Vol Purged 1 gal 2 gal 3 gal 4 gal 5 gal 6 gal 7 gal

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

EPA sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-105
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/20/97 at 245 a.m./p.m. 315 sampled
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: sunny 70°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC stickup

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH alcohol, distilled water
Items Cleaned (List): Solinst water level probe

2 [ ] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: ~~water level meter~~ (air)

WATER DEPTH 29.72 FT. BELOW DATUM
Measured with: water level meter (Solinst)

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: slightly cloudy
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bladder Pump
Volume Removed: 8 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

35
-30
5
+3
8/2 = 4

Groundwater Sampling Record

Monitoring Well No. UT-105 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Bladder
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	255	258	300	303	306	Measured with
Temp (°C)	11.8	11.9	11.8	11.7	11.6	Orion 840
pH						Orion
Cond (µS/cm)	903	904	904	903	904	Orion 140
DO (mg/L)	2.3	3.9	4.3	4.3	4.4	Orion 840
Redox (mV)	106	100	102	101	104	Orion 290A
	2	3.5	5	6	7	

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA handled samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL LL1-106
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: (3) 3/17 at 420 a.m./p.m. 510 Sampled
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 60 Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with:

WATER DEPTH 19.89 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Peristaltic
Volume Removed:
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

27.3
20.0
7.4 + 1.5 =
9/2 = 4.5
5 gal

Groundwater Sampling Record

Monitoring Well No. U1-106 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Peristaltic
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	432	445	453	458	505	Measured with
Temp (°C)	11.9	12.0	11.9	11.9	11.8	Orion 840
pH						Orion
Cond (µS/cm)	1106	1115	1110	1107	1104	Orion 140
DO (mg/L)	0.0	0.0	0.0	0.0	0.0	Orion 840
Redox (mV)	64	-2.2	39	19	34.7	Orion 2 DA
gallons	2	3	4	4.5	5	

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA sampled

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-106 (Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/27 at 740 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 45 windy
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

sampled BD

MONITORING WELL CONDITION:

[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS) IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH Distilled water
Items Cleaned (List): Probe

2 [ ] PRODUCT DEPTH ____ FT. BELOW DATUM
Measured with: ____

WATER DEPTH 19.85 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: @ cloudy red-brown
Odor: none
Other Comments: ____

4 [ ] WELL EVACUATION:
Method: Bladder
Volume Removed: 5 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: ____

27.3
19.8
7.5 / 2 = 3.25

Groundwater Sampling Record

Monitoring Well No. U1-106 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Bladder
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	749		754	759	801	Measured with
Temp (°C)	11.0		11.2	11.4	11.4	Orion 840
pH						Orion
Cond (µS/cm)	1115		1100	1088	1085	Orion 140
DO (mg/L)	0.4		0.2	0.2	0.2	Orion 840
Redox (mV)			153	153	153	Orion 290A
Gallons	1	2	3.0	3.5	4	

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA handled samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL UI-107 (Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/27 at 1012 a.m./p.m. Sample 130
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 70 Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH @ 30.16 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bladder
Volume Removed: 10 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

40
30
10
+ 2
12/2 = 6 gallons

Groundwater Sampling Record

Monitoring Well No. 11-107 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Bladder
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	105	115	10	120	125	Measured with
Temp (°C)	14.1	13.9	13.9	13.9	13.9	Orion 840
pH						
Cond (µS/cm)	1825	1819	1816	1816	1803	Orion 140
DO (mg/L)	0.5	0.1	0.1	0.1	0.1	Orion 840
Redox (mV)	103	103	93	90	83	Orion 290A
Gallons	4	6	7.5	9	10	

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA handled Samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL UI-108
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/17 at 830 a.m./p.m. 905 Sample
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: Rain 50
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 18.56 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Peristaltic
Volume Removed: ~~5.5~~ 5.0
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

$\frac{25 - 18.5}{6.5\text{ft}} = 3.75$

Groundwater Sampling Record

Monitoring Well No. MW-108 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Peristaltic
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	845	851	900	905		Measured with
Temp (°C)	9.9	9.6	9.4	9.5		Orion 840
pH	7.2	7.2	7.2	7.2		Orion
Cond (µS/cm)	838	838	830	837		Orion 140
DO (mg/L)	4.9	5.1	5.2	5.1		Orion 840
Redox (mV)	272	279	281	293		Orion 290A
Gallons	2	2.5	3.5	4.5		

7 [ ] SAMPLE CONTAINERS (material, number, size):_____
5 Gal

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA conducted sample obtainment and handling.

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL UI-108 (B)
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/22 at 940 a.m./p.m. sample 105
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 50 Sunny, windy
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH Distilled water
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: —

4 [ ] WELL EVACUATION:
Method: Bladder
Volume Removed: 5 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

25.0
- 18.6
6.4 / 2 = 3.2 gal

Groundwater Sampling Record

Monitoring Well No. U1-108 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type:_ Bladder
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	944	947	949	950	952	Measured with
Temp (°C)	10.3	10.2	10.2	10.2	10.2	Orion 840
pH						Orion
Cond (µS/cm)	844	844	841	840	837	Orion 140
DO (mg/L)	5.8	6.0	6.0	6.0	6.0	Orion 840
Redox (mV)	160	164	164	164	164	Orion 290A
Gallon	2	2.5	3	3.5	4	

7 [ ] SAMPLE CONTAINERS (material, number, size):_____
VOAs only

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL 61-111
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/15/97 at 1030 (a.m./p.m.
SAMPLE COLLECTED BY: (JH/RN/CM) of Parsons ES
WEATHER: Cloudy ~40-45°F, breezy
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[✓] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS (IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH DI H2O, Isopropyl alcohol
Items Cleaned (List): W.L. indicator

2 [ ] PRODUCT DEPTH N/A FT. BELOW DATUM
Measured with:

WATER DEPTH 10.63' TOC FT. BELOW DATUM
Measured with: elec water level indicator

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: None
Other Comments:

4 [ ] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 6.5 gal
Observations: Water (slightly) very) cloudy — almost clear
Water level (rose - fell - no change)
Water odors: None
Other comments: Clear to sl. cloudy

3 casing volumes = 6.2 gal

Time	Cal Removed	pH	Temp (°C)	Redox (mV)	DO (mg/L)	E.C. (umhos/cm)
0952	0.5	6.18	8.3	237	2.29	470

Groundwater Sampling Record

Monitoring Well No. MW-111 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[ ] Pump, type:_____
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	0952	0959	1016 *	1021	1028	Measured with
Temp (°C)	8.3	8.4	8.7	8.8	8.8	YSI Model 55
pH	6.18	6.40	6.62	6.63	6.67	Orion Model 250A
Cond (~~µS/cm~~ mmhos/cm)	470	460	470	475	490	YSI model 33
DO (mg/L)	2.29	2.12	1.91	1.22	1.37	YSI model 55
Redox (mV)	237	215	202	188	184	Oakton pH/mV/Temp meter
Vol. removed	0.5 gal	1.5 gal	3 gal	5.5	6	

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: * Check DO & Temp w/ EPA's Orion model 250 meter. DO = 1.4 mg/L ; Temp = 9.1 °C

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-112
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: ~~1039~~ 3/17 at 1039 (a.m./p.m.) 1110 Sampled
SAMPLE COLLECTED BY: ~~JHARP~~/CM of Parsons ES
WEATHER: Rain 55°
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled H_2O
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 7.78 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Peristaltic
Volume Removed: 5.0 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

U1-113 DTW 34.82

Groundwater Sampling Record

Monitoring Well No. U1-112 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Peristaltic
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	1046	1050	1055	1108		Measured with
Temp (°C)	5.8	5.6	6.5	6.1		Orion 840
pH				7.2		Orion
Cond (µS/cm)	920	915	914	912		Orion 140
DO (mg/L)	0.0	0.2	0.0	0.2		Orion 840
Redox (mV)	240	244	213	207		Orion 290A
gallons	2.5	3.0	4.0	5.0		

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA sampled

7.2 108
7.1 98

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-113
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/20 at 1200 a.m./p.m. Sample 1:00 pm
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 60° Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH Distilled water + isopropanol
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 34.80 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance:
Odor:
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bladder
Volume Removed: 9 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

50
-35
15
+ 2
17
17/2 = 8.5 ⇒ 9

Groundwater Sampling Record

Monitoring Well No. U1-113 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type:_ Bladder
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	1237	1241	1244	1249	1257	Measured with
Temp (°C)	12.3	12.2	12.3	12.5	12.4	Orion
pH						Orion
Cond (µS/cm)	853	857	862	866	869	Orion
DO (mg/L)	0.5	0.5	0.5	0.7	0.7	Orion
Redox (mV)	103	103	103	109	109	Orion
Gallons	5	6	7	8	9	

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA handled samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-115
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/18/97 at 9:40 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: breezy, sunny, 35° F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS / IS NOT) APPARENT
STEEL CASING CONDITION IS: good, but missing one bolt
INNER PVC CASING CONDITION IS: broken
WATER DEPTH MEASUREMENT DATUM (IS / IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH alcohol, distilled water
Items Cleaned (List): Water level meter

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 24.39 FT. BELOW DATUM
Measured with: Water level meter

3 [✓] 2" ϕ TD 35 ft PURGE VOL = 5.19 gallons
WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: cloudy
Odor: none
Other Comments:

4 [✓] WELL EVACUATION:
Method: pump
Volume Removed: 5.5 gallons
Observations: Water (slightly - very) cloudy
Water level (rose / fell / no change)
Water odors: none
Other comments:

Groundwater Sampling Record

Monitoring Well No. MW-115 (Continued)

5 [Y] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Bennett
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [Y] ON-SITE MEASUREMENTS:

Time	9:22	9:31	9:40			Measured with
Temp (°C)	11.5	11.5	11.7			
pH	6.56	6.98	7.12			
Cond (µS/cm)	600	650	650			
DO (mg/L)	1.01	10.83	10.66			
Redox (mV)	17.6	3.5	27.7			
Vol purged	1 gallon	3 gallons	5 gallons			

7 [ ] SAMPLE CONTAINERS (material, number, size): EPA sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-116 (Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/19 at 2:46 a.m./p.m) Sampled 330
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 70 Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 23.71 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Cloudy orange-brown
Odor: None
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bladder
Volume Removed: 7 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

$$\frac{33 - 23}{2} = \frac{10}{2} = 5 \text{ gallons}$$

Groundwater Sampling Record

Monitoring Well No. C1-116 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Bladder
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	250	256	301	309	316	Measured with
Temp (°C)	12.9	13.4	13.4	13.4	13.5	Orion 840
pH						Orion
Cond (µS/cm)	1580	1526	1499	1479	1474	Orion 140
DO (mg/L)	5.2	4.5	4.7	5.1	5.3	Orion 840
Redox (mV)	-109	-115	-110	-98	-94	Orion 290A
Gallons	2	3	4	5	6	

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA handled samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-117
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3-17-97 at 330 a.m. (p.m.)
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: Partly cloudy 55°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH isopropyl alcohol, distilled water
Items Cleaned (List):

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 40.61 FT. BELOW DATUM
Measured with: Water level meter

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments:

4 [✓] WELL EVACUATION:
Method: pump
Volume Removed: 8 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - (fell) - no change)
Water odors: none
Other comments:

Groundwater Sampling Record

Monitoring Well No. U1-117 (Continued)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type:_ Bennett

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

well pumped dry

Time	2:17	2:31	2:54	3:47		Measured with
Temp (°C)	12.3	12.3	12.2	12.1		
pH	6.83	7.28	7.22			
Cond (~~µS~~/cm)	1400	2800	3000			
DO (mg/L)	0.37	4.0 *	0.80			
Redox (mV)	40.	51.5	59.8			
purge vol.	1 gal	4 gal	6 gal			

mmhos/cm

* air bubbles into flask b/c well almost empty

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

4 VOA sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL 111-118
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/19/97 at 11:45 (a.m)/p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: sunny, 50°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS / IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS / IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH alcohol, distilled water
Items Cleaned (List): water level probe

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: —

WATER DEPTH 29.30 FT. BELOW DATUM
Measured with: water level meter

3 [✓] TD 37.5 Purge Volume 4 gallons
WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: silty, reddish brown
Odor: none
Other Comments: —

4 [✓] WELL EVACUATION:
Method: pump
Volume Removed: ~10 gallon
Observations: Water (slightly / very) cloudy
Water level (rose / fell / no change)
Water odors: none
Other comments: —

Groundwater Sampling Record

Monitoring Well No. MW-118 (Continued)

5 [X] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: Bennett

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS: well is almost dry - too much air in the line - don't trust DO or Redox

Time	11:32	11:39	11:43	11:45		Measured with
Temp (°C)	13.3	13.5	13.6	13.5		YSI 55
pH		7.33	7.32	7.31		ORION 250A
Cond (µS/cm)		750	750	750		YSI 33
DO (mg/L)		8.04	8.08	8.19		YSI 55
Redox (mV)		0.0	-20.9	-33.5		OAKTON
DO (mg/L)		7.0	7.0	7.2		ORION 810
Vol Purged						

7 [X] SAMPLE CONTAINERS (material, number, size):_____

EPA (Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL ill-123
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/18 at 830 a.m./p.m. Sampled 945
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 50 sunny.
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [ ] PRODUCT DEPTH - FT. BELOW DATUM
Measured with: -

WATER DEPTH 23.02 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: -

4 [ ] WELL EVACUATION:
Method: Peristaltic
Volume Removed:
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: air bubble

$\frac{34}{-23} = 6.5$

Groundwater Sampling Record

Monitoring Well No. MW-123 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Peristaltic
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	850	912	925	932	940	Measured with
Temp (°C)	12.0	12.4	12.5	12.4	12.5	Orion 840
pH						Orion
Cond (µS/cm)	1580	1583	1581	1581		Orion 140
DO (mg/L)	0.0	0.0	0.0	0.0	0.0	Orion 840
Redox (mV)	-243	-254	-254	-248	-248	Orion 290A
Gallons	2	3	4	5	6	

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA sampled

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1-123
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/24/97 at 1640 a.m./p.m.
SAMPLE COLLECTED BY: (JH/RN/CM) of Parsons ES
WEATHER: Clear, Mild, Calm
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Toc

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS / IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS / (IS NOT)) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH DI H2O, Isopropyl Alcohol
Items Cleaned (List):

2 [ ] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 23.03' FT. BELOW DATUM
Measured with: W.L. indicator

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Sl. Cloudy
Odor: None
Other Comments:

4 [ ] WELL EVACUATION:
Method: dedicated bladder pump
Volume Removed: 6 gal
Observations: Water (slightly) - very) cloudy
Water level (rose / (fell) no change)
Water odors: None
Other comments:

Groundwater Sampling Record

Monitoring Well No. MW-123 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: bladder

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

* change probe after this reading - probe malfunctioning

Time	1612	1619	1626	1632	1637	Measured with
Temp (°C)	10.6	11.8	11.5	11.4	11.5	YSI model 55
pH	7.61	7.11	6.96	7.17	6.95	Orion model 250A
Cond (µS/cm)	NM	→				X
DO (mg/L)	1.11	0.30	0.33	0.33	0.29	YSI model 55
Redox (mV)	26	-99*	99	28	35	Oakton pH/mV/oC meter
Vol. purged	3.0	4.0	5.0	5.5	6.0	

Note: redox = -29 after sample collection

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL 41-~~[illegible]~~ 126 (cm)
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/18/97 at 11:40 (a.m./p.m.) (cm)
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: sunny, clear, 50°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): —

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH alcohol, distilled water
Items Cleaned (List): water level meter

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 35.88 FT. BELOW DATUM
Measured with: water level meter

3 [✓] TD 50.5 - DTW 35.88 = 14.62' x 0.163 = 2.4 x 3 = 7 gallons
WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: —

4 [✓] WELL EVACUATION:
Method: pump
Volume Removed: 7 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

Groundwater Sampling Record

Monitoring Well No. W1-126 (Continued)

5 [M] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type:_ Bennett
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [M] ON-SITE MEASUREMENTS:

Time	10:59	11:13	11:39			Measured with
Temp (°C)	12.8	12.8	13.1			YSI DOMeter (55)
pH	7.28	7.39	7.55			ORION 250A
Cond (µS/cm)	500	450	450			YSI 33
DO (mg/L)	3.63	3.11	2.16			YSI 55
Redox (mV)	-68.3	-104.5	~~-120~~ -120			OAKTON
Vol purged	1 gal.	3 gal	7 gallons			5 gallon bucket

remarks/km

DO 0 1 0.4 ORION

7 [M] SAMPLE CONTAINERS (material, number, size): EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL 41-138
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/20 at 345 a.m./(p.m.) Sampled 8:50am 3/21
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 65 Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS / IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS / IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH Distilled Water
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 91.80 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Slightly cloudy to clear
Odor: None
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bladder
Volume Removed: 31 gallons
Observations: Water (slightly / very) cloudy
Water level (rose - fell - no change)
Water odors: None
Other comments:

45m × 3 = 1.5hr
10g × 3

107
92
15
× 2
30 gallons

Groundwater Sampling Record

Monitoring Well No. U1-138 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type:_ Bladder
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	510	520	528	540	548	Measured with
Temp (°C)	11.6	11.5	11.4	11.4	11.4	Orion 840
pH						Orion ~~840~~
Cond (µS/cm)	921	925	923	918	918	Orion 840
DO (mg/L)	0.3	0.3	0.4	0.5	0.5	Orion 840
Redox (mV)	98	100	96	95	93	Orion 290A
	20	23	25	28	30	

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA handled samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL ~~LL-~~ CM 143
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/18/97 at 4:05 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: sunny, 60°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC ~~[illegible]~~ CM
Stickup

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [X] EQUIPMENT CLEANED BEFORE USE WITH alcohol, distilled water
Items Cleaned (List): ~~Water~~ level probe

2 [ ] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: —

WATER DEPTH 27.29 FT. BELOW DATUM
Measured with: Solinst water level meter
TD 37.7 Appox Purge Vol 5 gallons

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: grey
Odor: rotten eggs
Other Comments: —

4 [X] WELL EVACUATION:
Method: pump
Volume Removed: 5 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: rotten eggs
Other comments: —

Groundwater Sampling Record

Monitoring Well No. MW-193 (Continued)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Bennett pump
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Time	3:42	3:49	3:55	4:05		Measured with
Temp (°C)	14.1	13.5	13.5	13.5		YSI 55
pH	7.07	7.15	7.15	7.15		ORION 250
Cond (µS/cm)	700	700	700	700		YSI 33
DO (mg/L)	5.20	3.76	3.44	3.32		YSI 55
Redox (mV)	-222.2	-223.3	-234.1	-240.3		OAKTON
vol purged	2 gal	3 gal	4 gal	5 gal		bucket
DO	0	0.5	0.2	0.1	0.1	ORION 840

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL U1 - 151
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling:
DATE AND TIME OF SAMPLING: 3/20/97 at 4:00 a.m. (p.m.)
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: sunny 70°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe):

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [Y] EQUIPMENT CLEANED BEFORE USE WITH alcohol distilled water
Items Cleaned (List): water level probe

2 [Y] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: —

WATER DEPTH 116.52 FT. BELOW DATUM
Measured with: Solinst water level meter

3 [Y] TD = 123.5 Appox Purge Vol. 7 gallons
WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: grey
Odor: none
Other Comments: —

4 [Y] WELL EVACUATION: Grundfos Redi-Flow II
Method: PUMP, (Bennett)
Volume Removed: 14 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: —

Groundwater Sampling Record

Monitoring Well No. MW-151 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: Grundfos Redi Flow II

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS: Generator stopped - restarted 3:00pm

Time	1:02	1:17	3:08	3:17	3:25	Measured with	3:30
Temp (°C)	15.1	17.6	15.6	15.7	16.9	YSI 55/ORION 840	16.3
pH	8.09	7.55	NM	—	—	ORION 250A	—
Cond (µS/cm)	650	650	NM	—	—	YSI 33	—
DO (mg/L)	3.87	1.76	2.44	2.08	1.78	YSI 55	2.26
Redox (mV)	-128	-170	-145	-160	-162	ORION 250A	-170
DO (mg/L)	1.2	0.5	0.7	0.5	0.5		0.9
Vol Purged (gal)	0.5	1.0	2gal	3gal	5gal		7gal

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

CPT Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL UI-154
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/15 at 202 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 50°-55° Cloudy
DATUM FOR WATER DEPTH MEASUREMENT (Describe):

MONITORING WELL CONDITION:

[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 17.18 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Peristaltic
Volume Removed: 35 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: no air bubbles

Groundwater Sampling Record

Monitoring Well No. 41-154 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of: _____

[X] Pump, type: Peristaltic

[ ] Other, describe: _____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

76
23 9

6 [ ] ON-SITE MEASUREMENTS:

Time	~~305~~	314	324	331	340	Measured with
Temp (°C)	11.1	10.9	10.9	10.9	10.9	Orion 840
pH						Orion ← Mike Cook
Cond (µS/cm)	844	839	836	831	835	Orion 140
DO (mg/L)	5.3	5.1	5.1	5.1	5.0	Orion 840
Redox (mV)	216.6	185	178	175	165	Orion 2 Star
Gallons	19	23	28	28	30	

7 [ ] SAMPLE CONTAINERS (material, number, size): _____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____

[ ] Preservatives added:

Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples collected by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL 41-155
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/15/97 at 1325 a.m./p.m.
SAMPLE COLLECTED BY: (JH/RN/CM) of Parsons ES
WEATHER: Sunny, mild (50's), SL. breeze
DATUM FOR WATER DEPTH MEASUREMENT (Describe):

MONITORING WELL CONDITION:
[✓] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS / IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good - 4" ID
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH DI H2O, Isopropanol
Items Cleaned (List): H2O level indicator

2 [ ] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 67.20' TOC FT. BELOW DATUM
Measured with: W.L. Indicator

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: None
Other Comments:

4 [ ] WELL EVACUATION:
Method: Grundfos Redi-Flo II
Volume Removed: 25 gal - well evacuated
Observations: Water (slightly) - very) cloudy - almost clear
Water level (rose - (fell) - no change)
Water odors: None
Other comments:

3 casing vol's = 99 gal

Groundwater Sampling Record

Monitoring Well No. MW-15 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[X] Bailer made of: Polyethylene, disposable, w/ vacuum bottom stopper
[ ] Pump, type:_
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	1213	1222	1229	1245	1302	Measured with
Temp (°C)	15.2	14.9	15.5	16.4	15.7	YSI model 55
pH	7.20	7.48	7.55	7.59	7.59	Orion Model 250A
Cond (~~µS/cm~~ mmhos/cm)	720	800	800	800	790	YSI model 33
DO (mg/L)	0.57	0.26	0.33	0.66	1.27	YSI model 55
Redox (mV)	[illegible]	-204	-193	-174	-6	Oakton pH/mV/°C meter
Vol. removed	3 gal	6 gal	8 gal	12 gal	16 gal	

jc

1312	1322	1332
16.6	18.1	18.3
7.62	7.67	7.61
800	790	790
1.53	2.70	3.19
-0.1	-1	-2
18 gal	20 gal	22 gal

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

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GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL ~~MW~~ U1-160
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/22/97 at _____ a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: mostly sunny, breezy, 60°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC flush mount

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): _____

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes
alconox, distilled water ⇒ Grundfos Pump

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: —

WATER DEPTH 29.72 FT. BELOW DATUM
Measured with: Solinst water level probe

3 [✓] TD ~~39.40~~ 39.40 4"Ø Purge Vol. ≈ 10 gallons
WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: —

4 [✓] WELL EVACUATION:
Method: Grundfos Pump
Volume Removed: _____
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: —

Groundwater Sampling Record

Monitoring Well No. 111-160 (Continued)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: Grundfos Redi Flow II

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	2:10	2:15	2:20	2:25	2:30	Measured with	Final 2:40
Temp (°C)	13.9	14.8	15.7	16.3	16.4	ORION 840	16.7
pH	7.62	7.67	7.69	7.72	7.76	ORION 250A	7.78
Cond (µS/cm)	700	700	700	700	700	YSI 33	800
DO (mg/L)	2.7	2.5	2.7	2.2	1.8	ORION 840	1.5
Redox (mV)	-18.9	-19.1	-19.8	-23.0	-19.1	ORION 250A	-19.5
Vol Purged	2.5 gal	3 gal	4 gal	5 gal	6 gal	5 gal bucket	10 gal

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-162
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/19 at 352 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: 70 Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

~~MW-11~~ sampled 3/20 800 am

MONITORING WELL CONDITION:
[X] LOCKED: [X] UNLOCKED
WELL NUMBER (IS / IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS / IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH Distilled Water
Items Cleaned (List): Probes

2 [ ] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 26.72 FT. BELOW DATUM
Measured with: Solinst

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Slightly cloudy
Odor: none
Other Comments:

4 [ ] WELL EVACUATION:
Method: Bladder
Volume Removed: 26 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

40
-27
13
13/2 = 6.5 gallon
× 4
260 gall

Groundwater Sampling Record

Monitoring Well No 11-162 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Bladder
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

438 (cm) 455

Time	403	409	413	438	455 (cm)	Measured with	439	504	15(
Temp (°C)	13.3	13.8	13.1	12.9	12.9	Orion 842	12.8	12.8	12.
pH						Orion			
Cond (µS/cm)	1150	1148	1150	1152	1154	Orion 140	1150	1154	115
DO (mg/L)	0.0	0.0	0.0	0.1	0.0	Orion 840	0.0	0.0	0.6
Redox (mV)	-126	-154	-161	-150	-155	Orion 290A	-131	-143	-14
Gallons	3.5	5	6	6.5	20		22	24	2(

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA handled sampling

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-162
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/19/97 at ____ a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: Sunny, 70°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC flush mount

Bladder Pump

MONITORING WELL CONDITION:

[ ] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: _____
INNER PVC CASING CONDITION IS: _____
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): _____

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH _____
Items Cleaned (List): _____

2 [ ] PRODUCT DEPTH _____ FT. BELOW DATUM
Measured with: _____

WATER DEPTH _____ FT. BELOW DATUM
Measured with: _____

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: _____
Odor: _____
Other Comments: _____

4 [ ] WELL EVACUATION:
Method: _____
Volume Removed: _____
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: _____
Other comments: _____

Groundwater Sampling Record

Monitoring Well No. _____ (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[ ] Pump, type:_
[ ] Other, describe:_____
_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time						Measured with
Temp (°C)						
pH						
Cond (µS/cm)						
DO (mg/L)						
Redox (mV)						

7 [ ] SAMPLE CONTAINERS (material, number, size):_____
_____
_____
_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____
_____
_____
_____
_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL LL1-647
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/19/97 at 9:25 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: Sunny, Windy 35°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH alcohol, distilled water
Items Cleaned (List): water level probe

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: —

WATER DEPTH 38.18 FT. BELOW DATUM
Measured with: water level probe

3 [✓] TD = 59.40 Purge ≥ 10.4 gallons
WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: —

4 [ ] WELL EVACUATION:
Method: pump
Volume Removed: 10 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors:
Other comments:

Groundwater Sampling Record

Monitoring Well No. MW-1647 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Bennett
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS: Well dry - too much air being pumped - shut down pump - will collect sample after recharge

Time	8:25	8:58	9:10	9:25		Measured with
Temp (°C)	11.2	11.2	11.3	11.3		
pH	7.08	7.56	7.5	7.63		
Cond (µS/cm)	750	700	700	700		
DO (mg/L)	7.25	6.23	6.2	6.35		
Redox (mV)	~~3.30~~	193.9	185	139.1		
Vol. Purged	3 gal	4 gal	5.5 gal	6 gal		

DO, ORION 2.9 3.0

7 [ ] SAMPLE CONTAINERS (material, number, size): EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL UI-1607
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3-17-97 at 5:10 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: sunny, 55°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe):

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS:
INNER PVC CASING CONDITION IS:
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH isopropyl alcohol, distilled water
Items Cleaned (List): water level meter

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

screen 15-25' bgs
Total Depth Unknown
WATER DEPTH 16.32 FT. BELOW DATUM
Measured with: water level meter
purge 4 to 9 gallons

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: silty
Odor: none
Other Comments:

4 [✓] WELL EVACUATION:
Method: pump
Volume Removed: 7 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors:
Other comments:

Groundwater Sampling Record

Monitoring Well No. U1-1607 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type:_ Bennett
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	4:55	5:04	5:15			Measured with
Temp (°C)	11.9	11.8	11.8	~~cm~~		
pH	7.75	7.69	~~cm~~	7.73		
Cond (µS/cm)	700	700	700			
DO (mg/L)	7.85	6.86	8.34			
Redox (mV)	113.5	115	117			
	2	5	7 gallons			

7 [ ] SAMPLE CONTAINERS (material, number, size):__EPA Sampled_____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MP5 (U1-1632)
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/22/97 at 10:45 (a.m)/p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: sunny 50°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): NM

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED but bolted
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [ ] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: —

WATER DEPTH NM ½" well (PVC) approx. 9' bgs (measured during drilling) FT. BELOW DATUM
Measured with: —

TD ~ 17' bgs Purge Vol. = 1 gallon

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: —

4 [ ] WELL EVACUATION:
Method: Masterflex Peristaltic
Volume Removed: 2 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: —

Groundwater Sampling Record

Monitoring Well No. MP5 (Continued)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: Masterflex Peristaltic

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	10:35	10:40	10:45	10:50	10:55	Measured with
Temp (°C)	10.0	9.9	10.0			ORION 840
pH	7.47	7.54	7.59			ORION 250A
Cond (µS/cm)	300	600	600			YSI 33
DO (mg/L)	2.1	1.8	1.9			ORION 840
Redox (mV)	-18.9	-19.0	-19.0			ORION 250A
Vol Purged	0.75g	1.0g	1.5g			5gal bucket

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MP7 (U1-1634)
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/21/97 at 11:05 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: Partly cloudy 45°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): 0 mm NM

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED but bolted
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT NA
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [Y] EQUIPMENT CLEANED BEFORE USE WITH NA
Items Cleaned (List): —

2 [Y] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH ~5.5' FT. BELOW DATUM
Measured with: measured while drilling

3 [Y] TD = 16.6 Approx Purge Volume 2/3 gallon
WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: —

4 [Y] WELL EVACUATION:
Method: pump Masterflex Peristaltic
Volume Removed:
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: —

Groundwater Sampling Record

Monitoring Well No. MP7 (Continued)

5 [M] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type:_ Masterflex Peristaltic

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [M] ON-SITE MEASUREMENTS:

11:05 (cm)

Time	10:53	10:56	10:59	11:05		Measured with
Temp (°C)	7.3	7.2	7.2	7.4		YSI 55/ORION 840
pH	7.97	7.82	7.76	7.72		ORION 250A
Cond (µS/cm)	350	350	350	350		YSI 33
DO (mg/L)	10.20	10.04	9.89	9.62		YSI 55
Redox (mV)	74.1	67.8	63.1	57.8		ORION 250A
DO (mg/L)	5.6	5.8	5.6	4.8		ORION 840
Vol Purged	1 gal	1.25 gal	1.5 gal	~~1.75 gal~~ 2 gal (cm)		

7 [✓] SAMPLE CONTAINERS (material, number, size):_____

EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MP8 (U1-1635)
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/21/97 at _____ a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: sunny 65°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): NM

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED but bolted
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: —

WATER DEPTH NM Approx 7' bgs during drilling FT. BELOW DATUM
Measured with: —

3 [✓] TD 14.9 Purge Vol. Approx. 0.5 gallons
WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: silty brown
Odor: none
Other Comments: —

4 [ ] WELL EVACUATION:
Method: Masterflex Peristaltic
Volume Removed: 3 gal
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

Groundwater Sampling Record

Monitoring Well No. MP3 (Continued)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type:_
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	2:16	2:18	2:20	2:23		Measured with
Temp (°C)	8.4	8.3	8.2	8.2		ORION 840
pH	7.33	7.37	7.41	7.43		ORION 250A
Cond (µS/cm)	800	800	800	800		VSI 33
DO (mg/L)	0.2	0.1	0.1	0.1		ORION 840
Redox (mV)	11.8	6.7	15.0	13.8		ORION 250A
Vol Purged	1 gal	1.25 gal	1.5 gal	2 gal		bucket

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MP9 (U1-1636)
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/21/97 at 11:45 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: Partly Cloudy 50°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe):

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED but bolted
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH NA
Items Cleaned (List): —

2 [✓] PRODUCT DEPTH NM FT. BELOW DATUM
Measured with: —

WATER DEPTH NM Approx. 6' FT. BELOW DATUM
Measured with: —

3 [✓] TD 10.8' bgs Purge Volume Approx. 1/3 gallon
WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: brownish tint
Odor: none
Other Comments: —

4 [✓] WELL EVACUATION:
Method: MasterFlex Peristaltic Pump
Volume Removed: 2.5 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

Groundwater Sampling Record

Monitoring Well No. MP9 (Continued)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: Masterflex Peristaltic

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Time	11:32	11:35	11:37	11:40	11:45	Measured with
Temp (°C)	7.8	7.3	7.1	7.1	7.0	YSI 55/ORION 840
pH	7.16	7.21	7.23	7.24	7.25	ORION 250A
Cond (µS/cm)	370	370	370	370	370	YSI 33
DO (mg/L)	7.47	7.14	6.81	6.55	6.41	~~ORION~~ YSI 55
Redox (mV)	-18.9	-18.9	-18.9	-18.9	-18.9	ORION 250A
DO (mg/L)	0.9	0.4	0.2	0.1	0.0	ORION 840
Vol Purged	1 gal	1.5 gal	2 gal	2.25 gal	2.5 gal.	5 gal bucket

7 [✓] SAMPLE CONTAINERS (material, number, size):_____

EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MP10 (U1-1637)
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/21/97 at _____ a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: sunny 70°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): NM

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS) - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [✓] PRODUCT DEPTH NM / NA FT. BELOW DATUM
Measured with: —

WATER DEPTH NM Approx 2.2' during drilling FT. BELOW DATUM
Measured with: —

3 [✓] TD 13 Purge Vol Approx. 3/3 gallon
WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: —

4 [✓] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 3gal
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: —

Groundwater Sampling Record

Monitoring Well No. MP10 (Continued)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: MasterFlex Peristaltic
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	2:59	3:04	3:09	3:14	3:19	Measured with
Temp (°C)	8.0	7.7	7.7	7.7	7.7	ORION 840
pH	7.55	7.64	7.67	7.68	7.69	ORION 250A
Cond (µS/cm)	600	600	600	600	600	YST 33
DO (mg/L)	6.1	6.1	6.0	5.8	6.0	ORION 840
Redox (mV)	-54	-123	140?	145?	12	ORION 250A
Vol. Purged (gal)	0.25	1 gal	1.5 gal	2.5 gal	3 gal	bucket

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MP 11S (UI-1638)
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/22/97 at 8:50 (a.m.)/p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: Partly cloudy 45°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): NM

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS) - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT NA tubing
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [ ] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: —

WATER DEPTH NM approx. 17' bgs FT. BELOW DATUM
Measured with: — diving dribble
TD = 29.5

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe): Purge Volume = approx. 3/4 gallon
Appearance: clear
Odor: none
Other Comments: —

4 [ ] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 3.5 gallons
Observations: Water (slightly) - very) cloudy
Water level (rose - (fell) no change)
Water odors: none
Other comments: —

Groundwater Sampling Record

Monitoring Well No. MP 11 S (Continued)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: Masterflex Peristaltic

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	8:32	8:37	8:42	8:47	8:52	Measured with
Temp (°C)	10.3	10.5	10.6	10.7		ORION 840
pH	7.68	7.75	7.76	7.76		ORION 250A
Cond (µS/cm)	500	500	500	500		YSI 33
DO (mg/L)	5.4	5.2	4.9	4.8		ORION 840
Redox (mV)	-18.9	-18.9	-18.9	-18.9		ORION 250A
Vol Purged	0.5 gal	1 gal	1.5 gal	2 gal		5 gal bucket

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

EPA sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MP11d (U1-1639)
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/22/97 at 9:25 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: partly cloudy 45°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC NM (tubing)

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [ ] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: —

WATER DEPTH NM tubing FT. BELOW DATUM approx. 17' bgs during drilling
Measured with: —

TD = 40.5 Purge Vol. 1.5 gallons

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: —

4 [ ] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 1.5 gallons
Observations: Water (slightly - very) cloudy
Water ~~level~~ (rose - fell) - no change)
Water odors: none
Other comments: —

Groundwater Sampling Record

Monitoring Well No. MP11d (Continued)

5 [M] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____
[X] Pump, type: Masterflex Peristaltic
[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	9:15	9:20	9:25			Measured with
Temp (°C)	9.1	9.5	9.8			
pH	7.91	7.92	7.91			
Cond (µS/cm)	NM	500	500			
DO (mg/L)	0.1	0.1	0.1			
Redox (mV)	-18.9	-18.8	-18.9			
Vol Purged	0.5 g	~~1.0~~ 0.75 (cm)	1.0 g			

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU 1
Sampling Dates 3/13/97 - 3/27/97

GROUND WATER SAMPLING RECORD - MONITORING WELL MP4d (UI-1640)
(Identification)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 3/21/97 at 3:55 a.m./p.m.
SAMPLE COLLECTED BY: JH/RN/CM of Parsons ES
WEATHER: Sunny, breezy, 100°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): NM

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH distilled water
Items Cleaned (List): probes

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with: —

WATER DEPTH NM (approx. 10' bgs) FT. BELOW DATUM
Measured with: —

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe): TD = 15' bgs Purge Vol. approx. 1/3 gallon
Appearance: clear
Odor: none
Other Comments: —

4 [ ] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 3 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell) - no change)
Water odors: none
Other comments:

Groundwater Sampling Record

Monitoring Well No. MP4d (Continued)

5 [Y] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:_____

[X] Pump, type: Peristaltic

[ ] Other, describe:_____

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	3:40	3:45	3:50	3:55		Measured with
Temp (°C)	9.8	9.7	9.8	9.8		ORION 840
pH	7.60	7.77	7.80	7.79		ORION 250A
Cond (µS/cm)	550	550	550	550		YSI 33
DO (mg/L) 5.0→	[illegible]	4.8	4.5	4.5		ORION 840
Redox (mV)	-18.9	-18.9	-18.9	-18.9		ORION 250A
Vol Purged	1 gal	1.5 gal	2 gal	2.5 gal		5 gallon bucket

7 [ ] SAMPLE CONTAINERS (material, number, size):_____

EPA Sampled

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

[ ] Preservatives added:

Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____
Method_____ Containers:_____

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:_____

APPENDIX C

LABORATORY ANALTYICAL DATA

MANTECH

Ref: 97JAD20

April 21, 1997

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

As requested in Service Request # SF-3-240, headspace GC/MS analysis of 66 Hill AFB water samples for chlorinated volatile organics was completed. The samples were received on April 1, 1997 and analyzed on April 14-17, 1997. RSKSOP-148 (Determination of Volatile Organic Compounds in Water by Automated Headspace Gas Chromatography/Mass Spectrometry (Saturn II Ion Trap Detector) was used for this analysis.

An internal standard calibration method was established for the 15 compounds. The standard curves were prepared from 1.0 to 4000 ppb. The lower calibration limits were 1.0 ppb.

A dilution corrected quantitation report for the samples, lab duplicates, field duplicates, QC standards and lab blanks is presented in table 1-5.

If you should have any questions, please feel free to contact me.

Sincerely,

John Allen Daniel

xc: R.L. Cosby
G.B. Smith
D.D. Fine
J.L. Seeley
J.T. Wilson

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Table 1. Quantitation Report for S.R. # SF-3-240 from Hill AFB.

Concentration = ppb

Compound	MP-5	S1	S2	U1-092	U1-101	U1-160	RINSE-1	U1-RINSE -2	MP-4D	MP-6	MP-7
VINYL CHLORIDE	ND	ND	ND	16.0	10.4	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
T-1,2-DICHLOROETHENE	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHANE	ND	ND	ND	7.8	2.1	ND	ND	ND	1.4	ND	ND
C-1,2-DICHLOROETHENE	ND	ND	3.7	1.7	2.4	4.6	ND	ND	124	ND	ND
CHLOROFORM	ND	---	---	ND	ND	ND	4.8	1.4	ND	ND	3.8
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	1.0	ND	---	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	6.2	---	3.1	---	1.3	---	ND	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	1.3	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	1.0	ND	ND	ND	---	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	7.2	ND	ND	ND	1.0	ND	ND	ND

	MP-7 Lab Dup	MP-8	MP-9	MP-10	MP-11S	MP-11D	MP-008	U1-61	U1-62	U1-065	U1-65 Lab Dup
VINYL CHLORIDE	ND	ND	ND	ND	---	ND	ND	11.6	ND	72.6	72.4
1,1-DICHLOROETHENE	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	ND
T-1,2-DICHLOROETHENE	ND	ND	ND	---	---	ND	ND	ND	ND	---	---
1,1-DICHLOROETHANE	ND	ND	ND	4.4	2.6	ND	ND	---	ND	3.1	3.2
C-1,2-DICHLOROETHENE	ND	---	ND	233	244	10.2	ND	ND	ND	17.6	18.0
CHLOROFORM	3.6	ND	ND	---	ND	ND	ND	ND	ND	ND	ND
1,1,1-TRICHLOROETHANE	ND	ND	ND	1.6	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	3.1	---	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	2.0	ND	3250	3190
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	---	ND	76.0	77.2
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	3.0	ND	344	345
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	1.9	ND	58.6	59.2

ND = None Detected --- = Below Calibration Limit(1.0 ppb) Dup = Duplicate

Table 2. Quantitation Report for S[illegible]. # SF–3–240 from Hill AFB.

Concentration = ppb

Compound	U1–065 Field Dup	U1–072	U1–073	U1–074	U1–77R	U1–078	U1–081	U1–084	U1–085	U1–089	U1–090
VINYL CHLORIDE	76.6	43.7	236	9.0	ND	ND	ND	ND	118	213	ND
1,1–DICHLOROETHENE	ND	2.1	3.9	4.7	ND	ND	ND	ND	2.8	ND	ND
T–1,2–DICHLOROETHENE	---	1.0	6.8	1.5	---	ND	ND	ND	63.4	1.2	ND
1,1–DICHLOROETHANE	3.0	95.7	187	101	5.3	1.9	ND	ND	18.3	10.0	ND
C–1,2–DICHLOROETHENE	20.2	524	1250	1550	61.6	20.5	ND	ND	118	5.8	4.9
CHLOROFORM	ND	---	1.4	---	ND	ND	ND	ND	ND	ND	ND
1,1,1–TRICHLOROETHANE	ND	179	257	32.4	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	18.9	27.7	ND	ND	ND	ND	ND	ND	ND	ND
1,2–DICHLOROETHANE	ND	4.8	18.0	8.5	---	ND	ND	ND	3.3	4.0	ND
TRICHLOROETHENE	ND	1.5	---	---	ND	ND	ND	ND	446	ND	1.9
TETRACHLOROETHENE	ND	3.0	1.1	2.0	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	3440	26.3	37.5	48.7	ND	ND	ND	ND	ND	1590	ND
1,3–DICHLOROBENZENE	78.9	17.7	30.2	33.0	---	ND	ND	ND	ND	28.4	ND
1,4–DICHLOROBENZENE	352	141	196	215	---	ND	ND	ND	ND	153	ND
1,2–DICHLOROBENZENE	59.7	1180	1280	1700	1.5	---	---	---	3.8	68.9	---

Compound	U1–90 Lab Dup	U1–90 Field Dup	U1–097	U1–098	U1–98 B	U1–99	U1–100	U1–103	U1–104	U1–105	U1–106
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	469
1,1–DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	4.7
T–1,2–DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	1.8	---	---	1.5
1,1–DICHLOROETHANE	ND	ND	ND	---	---	---	---	2.9	23.6	7.2	24.0
C–1,2–DICHLOROETHENE	4.7	5.0	ND	12.0	12.1	27.9	ND	335	59.0	648	1007
CHLOROFORM	ND	ND	5.3	1.6	1.5	ND	ND	---	1.0	---	---
1,1,1–TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	---	ND	---	---	6.6
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2–DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	---	1.4	1.0	166
TRICHLOROETHENE	1.7	1.8	ND	---	---	ND	---	---	---	3.4	27.3
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	14.6
1,3–DICHLOROBENZENE	ND	ND	---	ND	ND	ND	ND	ND	ND	ND	6.1
1,4–DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	14.8
1,2–DICHLOROBENZENE	---	---	ND	ND	ND	ND	ND	ND	ND	ND	91.4

ND = None Detected --- = Below Calibration Limit(1.0 ppb) Dup = Duplicate

Table 3. Quantitation Report for [redacted] # SF-3-240 from Hill AFB.

Concentration = ppb

Compound	U1-107	U1-107 Field Dup	U1-108	U1-108B	U1-111	U1-112	U1-113	U1-115	U1-116	U1-117	U1-118
VINYL CHLORIDE	26.6	25.9	ND	ND	ND	ND	ND	ND	ND	ND	62.9
1,1-DICHLOROETHENE	ND	ND	---	---	ND	ND	ND	ND	ND	ND	ND
T-1,2-DICHLOROETHENE	---	---	---	---	ND	ND	ND	ND	ND	ND	---
1,1-DICHLOROETHANE	13.7	13.2	8.0	7.5	ND	ND	---	ND	---	ND	29.3
C-1,2-DICHLOROETHENE	5.5	5.2	393	365	ND	5.9	5.5	7.1	133	ND	2.7
CHLOROFORM	ND	ND	1.4	1.4	3.0	ND	ND	ND	ND	ND	ND
1,1,1-TRICHLOROETHANE	ND	ND	4.1	3.8	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	1.1	1.3	---	---	ND	ND	ND	---	ND	ND	2.8
TRICHLOROETHENE	12.7	12.3	10.0	9.5	ND	---	---	---	ND	ND	---
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	16.3	15.7	ND	ND	ND	ND	ND	ND	ND	ND	681
1,3-DICHLOROBENZENE	---	---	ND	ND	ND	ND	ND	ND	ND	ND	14.5
1,4-DICHLOROBENZENE	5.0	5.1	ND	ND	ND	ND	ND	ND	ND	ND	85.2
1,2-DICHLOROBENZENE	4.6	5.0	ND	ND	ND	ND	ND	ND	ND	ND	46.0

	U1-123	U1-123 Lab Dup	U1-123 Field Dup	U1-126	U1-126 Field Dup	U1-138	U1-143	U1-151	U1-154	U1-155	U1-162
VINYL CHLORIDE	60.0	62.8	56.0	ND	ND	1.4	3.8	1.7	ND	ND	86.8
1,1-DICHLOROETHENE	---	---	---	ND	ND	---	ND	1.2	---	ND	ND
T-1,2-DICHLOROETHENE	ND	---	---	ND	ND	---	ND	---	---	ND	---
1,1-DICHLOROETHANE	8.1	8.0	7.4	ND	ND	4.0	2.0	11.8	3.2	ND	59.7
C-1,2-DICHLOROETHENE	99.1	96.8	88.9	ND	ND	547	7.8	747	198	16.7	3.9
CHLOROFORM	ND	ND	ND	ND	ND	---	ND	1.1	1.4	ND	ND
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	---	ND	3.5	1.6	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	1.3	1.2	1.1	ND	ND	1.0	ND	1.3	---	ND	5.4
TRICHLOROETHENE	ND	ND	ND	---	---	4.9	---	29.8	6.9	10.7	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	---	ND	26.4	ND	ND	ND	1410
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	25.4
1,4-DICHLOROBENZENE	ND	ND	ND	ND	---	ND	18.7	ND	ND	ND	157
1,2-DICHLOROBENZENE	---	---	---	ND	ND	ND	109	ND	ND	ND	62.5

ND = None Detected --- = Below Calibration Limit(1.0 ppb) Dup = Duplicate

ble 4. Quantitation Report for S SF-3-240 from Hill AFB.

Concentration = ppb

Compound	U1-647	U1-1607	U1-1607 Lab Dup	U1-1607 Field Dup	U1-106B	U1-123B	U1-067	U1-067 1/2 Dil Field Dup	S3	U1-074B	U1-053
VINYL CHLORIDE	ND	ND	ND	ND	346	49.5	205	196	ND	6.2	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	3.4	---	12.7	11.6	ND	2.4	ND
T-1,2-DICHLOROETHENE	ND	ND	ND	ND	1.1	---	8.3	8.2	ND	1.7	ND
1,1-DICHLOROETHANE	ND	ND	ND	ND	23.3	7.6	52.2	55.6	ND	84.4	ND
C-1,2-DICHLOROETHENE	ND	ND	ND	ND	944	91.0	*****	4000	1.4	1210	ND
CHLOROFORM	ND	---	---	---	---	ND	2.0	2.0	ND	---	ND
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	5.3	ND	52.2	35.0	ND	22.2	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	ND	252	1.3	3.5	3.8	ND	5.7	ND
TRICHLOROETHENE	ND	---	---	---	23.3	ND	1.3	---	ND	---	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	2.0	2.0	ND	1.9	ND
CHLOROBENZENE	ND	ND	ND	ND	11.4	ND	156	155	ND	39.5	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	7.2	ND	34.1	32.6	ND	26.6	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	12.6	ND	177	171	ND	170	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	71.2	---	1830	1760	1.5	1440	1.7

	U1-130 1/10 Dil ***	U1-130 Lab Dup ***	QC0414AA 20 ppb	QC0414B 200 ppb	QC0414C 20 ppb	QC0414D 200 ppb	QC0414E 20 ppb	QC0414F 200 ppb	QC0414G 20 ppb	QC0414H 200 ppb	QC0414I 20 ppb
VINYL CHLORIDE	17.8	14.9	20.7	199	19.0	201	19.9	194	18.9	193	20.4
1,1-DICHLOROETHENE	ND	ND	24.5	218	22.2	232	22.3	225	22.3	229	22.5
T-1,2-DICHLOROETHENE	ND	ND	20.2	198	20.3	199	20.1	193	19.9	194	19.7
1,1-DICHLOROETHANE	24.3	22.1	21.4	206	21.0	211	20.2	210	21.3	203	20.7
C-1,2-DICHLOROETHENE	132	116	19.7	209	19.7	205	20.0	200	20.4	201	19.1
CHLOROFORM	ND	ND	20.9	203	20.5	199	21.1	201	21.4	199	19.9
1,1,1-TRICHLOROETHANE	8.4	31.9	21.6	202	20.2	215	20.8	209	20.7	205	20.5
CARBON TETRACHLORIDE	ND	ND	21.2	193	19.5	204	21.0	200	20.7	198	20.8
1,2-DICHLOROETHANE	ND	ND	20.9	217	20.1	204	20.0	214	21.6	206	18.7
TRICHLOROETHENE	ND	---	20.0	187	18.2	193	18.0	183	18.5	186	18.4
TETRACHLOROETHENE	ND	1.8	21.8	200	18.7	201	19.3	192	18.9	189	19.4
CHLOROBENZENE	15.4	17.5	21.0	220	20.8	218	21.3	213	21.5	214	20.8
1,3-DICHLOROBENZENE	ND	ND	20.8	220	20.1	212	20.1	207	20.1	202	19.6
1,4-DICHLOROBENZENE	83.3	153	20.5	225	20.5	218	20.6	207	21.4	208	20.1
1,2-DICHLOROBENZENE	717	1160	20.8	224	20.3	223	22.2	219	22.0	215	20.7

ND = None Detected --- = Below Calibration Limit(1.0 ppb) QC = Quality Control Std. BL = Blank

*** = Free Product in VOA ***** = Above Calibration Limit(4000 ppb)

Table 5. Quantitation Report for S.R. # SF-3-240 from Hill AFB

Concentration = ppb

Compound	QC0414J 200 ppb	QC0414K 20 ppb	QC0414L 200 ppb	QC0414M 20 ppb	QC0414N 20 ppb	QC0414O 200 ppb	BL0414A	BL0414B
VINYL CHLORIDE	190	19.4	179	18.6	19.6	182	ND	ND
1,1-DICHLOROETHENE	224	22.7	222	22.3	23.0	223	ND	ND
T-1,2-DICHLOROETHENE	189	19.2	189	19.4	20.1	190	ND	ND
1,1-DICHLOROETHANE	198	20.2	198	20.0	20.9	200	ND	ND
C-1,2-DICHLOROETHENE	188	20.0	190	19.9	20.3	192	ND	ND
CHLOROFORM	189	20.5	193	19.6	20.5	195	ND	ND
1,1,1-TRICHLOROETHANE	203	20.3	207	21.0	21.8	206	ND	ND
CARBON TETRACHLORIDE	197	20.2	193	20.2	20.4	199	ND	ND
1,2-DICHLOROETHANE	191	20.8	193	19.2	20.9	205	ND	ND
TRICHLOROETHENE	183	18.0	180	17.4	17.9	179	ND	ND
TETRACHLOROETHENE	186	18.0	190	18.4	20.6	184	ND	ND
CHLOROBENZENE	207	20.4	204	20.2	21.4	208	ND	ND
1,3-DICHLOROBENZENE	196	19.4	202	18.6	20.8	198	ND	ND
1,4-DICHLOROBENZENE	198	19.5	205	19.0	21.1	196	ND	ND
1,2-DICHLOROBENZENE	205	20.3	207	19.5	19.5	209	ND	---

ND = None Detected --- = Below Calibration Limit(1.0 ppb) QC = Quality Control Std. BL = Blank

MANTECH

Ref: 97-BN18/vg

April 9, 1997

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

Please find attached the analytical results for Service Request #SF-3-240 requesting the analysis of Hill AFB groundwater samples to be analyzed by purge-and-trap/GC-FID:PID for Benzene, Toluene, Ethylbenzene, p-, m-, & o-Xylene, 1,3,5-, 1,2,4-, & 1,2,3-Trimethylbenzene, and Total Fuel Carbon. We obtained the 67 groundwater samples, in duplicate, in capped, 40 mL VOA autosampler vials March 25 and 27, 1997, and they were analyzed April 2-7, 1997. The samples were acquired and processed using the Millennium data system. A 5 place (1-1000 ppb) external standard curve was used to quantitate sample concentration for the compounds of interest. Since most of the samples had no analytes present, only the 29 samples that did were reported for total fuel carbon. These samples are on page 3 of the report.

RSKSOP-133, "Simultaneous Analysis of Aromatics and Total Fuel Carbon by Dual Column-Dual Detector for Ground Water Samples" was used for these analyses. Autosampling was performed using a Dynatech Precision autosampler system in line with a Tekmar LSC 2000 concentrator.

Sincerely,

Bryan Newell

Bryan Newell

xc: R.L. Cosby
G.B. Smith
J.T. Wilson
J.L. Seeley
L. Black

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

SF-3-240 BTEX [redacted] and Total Fuel Carbon Data for Dr. Kampbell

Units = ng/ml Analyst [redacted]

SampleName	BENZENE	TOLUENE	ETHYLBENZENE	p-XYLENE	m-XYLENE	o-XYLENE	1,3,5-TMB	1,2,4-TMB	1,2,3-TMB
QC, OBSERVED, PPB	18.7	18.7	19.6	18.9	19.2	18.7	19.8	19.1	18.9
QC, TRUE VALUE, PPB	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
10 PPB	9.6	9.2	9.9	8.9	9.5	9.0	9.5	9.2	9.7
MP-5	ND	ND	ND	ND	ND	ND	ND	ND	ND
S1	ND	ND	ND	ND	ND	ND	ND	ND	ND
S2	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-092	2	1	1	BLQ	1	1	ND	1	ND
LAB BLANK, PPB	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-101	5	2	28	24	2	7	64	402	370
U1-101 DUPLICATE	4	2	26	24	2	7	67	403	361
LAB BLANK, PPB	ND	ND	ND	ND	ND	ND	ND	1	1
U1-160	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1 RINSE 1	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1 RINSE 2	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-4D	ND	ND	ND	ND	ND	ND	ND	ND	ND
1 PPB	1.0	1.3	1.0	0.9	1.0	1.0	1.0	1.0	1.0
MP-6	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-7	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-8	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-9	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-10	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-11S	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-11D	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-008	ND	1	ND	ND	ND	ND	ND	ND	ND
U1-61	1	ND	ND	ND	ND	ND	ND	ND	ND
U1-062	ND	ND	ND	ND	ND	ND	ND	ND	ND
100 PPB	98.4	94.9	104.4	95.2	98.2	94.3	101.8	95.5	104.4
U1-065	2	25	28	37	34	63	124	206	175
U1-065 DUPLICATE	2	23	26	34	32	59	112	195	166
LAB BLANK, PPB	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-072	4	346	12	27	47	94	58	90	127
QC, OBSERVED, PPB	18.0	18.5	18.4	17.7	18.5	18.1	18.4	18.3	18.0
QC, TRUE VALUE, PPB	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
QC, OBSERVED, PPB	19.4	19.1	19.7	18.9	19.4	19.1	20.3	19.6	19.4
100 PPB	101.6	98.0	108.0	98.6	100.2	97.0	105.0	102.2	108.4
U1-073	10	620	21	27	71	133	43	36	88
LAB BLANK, PPB	ND	1	ND	ND	ND	ND	ND	ND	ND
U1-077R	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-078	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-081	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-084	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-085	13	ND	ND	ND	ND	ND	ND	ND	ND
U1-089	4	28	38	26	35	46	13	43	43
U1-089 DUPLICATE	3	27	36	25	33	44	12	41	41
LAB BLANK, PPB	ND	ND	ND	ND	ND	ND	ND	ND	ND
1 PPB	1.0	1.4	1.0	0.9	0.9	1.0	1.0	0.9	1.0

ND denotes None Detected.
BLQ denotes Below Limit of Quantitation of 1.0 ng/ml

SF-3-[redacted] XXXTMB and Total Fuel Carbon Data for Dr. Kampbell

Units = ng/ml [redacted] owell

SampleName	BENZENE	TOLUENE	ETHYLBENZENE	p-XYLENE	m-XYLENE	o-XYLENE	1,3,5-TMB	1,2,4-TMB	1,2,3-TMB
U1-90	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-97	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-98	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-98B	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-99	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-100	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-103	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-104	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-105	ND	ND	ND	ND	ND	ND	ND	ND	ND
10 PPB	10.2	9.8	10.7	9.5	9.6	9.6	9.8	9.5	10.4
U1-107	5	1	1	BLQ	ND	1	1	ND	ND
U1-108	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-108B	ND	ND	ND	ND	ND	ND	ND	ND	ND
QC, OBSERVED, PPB	20.1	20.1	20.7	19.7	19.9	20.0	20.8	20.3	19.9
LAB BLANK, PPB	ND	ND	ND	ND	ND	ND	ND	ND	ND
QC, OBSERVED, PPB	20.9	20.7	21.8	20.6	20.7	20.8	21.8	20.8	20.7
QC, TRUE VALUE, PPB	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
10 PPB	10.7	10.2	10.8	9.7	9.8	10.0	10.5	9.8	10.6
U1-111	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-112	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-113	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-115	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-116	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-117	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-118	5	4	6	3	3	7	5	15	11
U1-118 DUPLICATE	5	4	5	2	2	6	4	13	10
U1-123	4	ND	ND	1	ND	ND	ND	ND	ND
U1-126	ND	ND	ND	ND	ND	ND	ND	ND	ND
100 PPB	109.7	106.2	116.4	106.4	106.9	104.7	112.6	107.4	116.5
U1-138	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-143	ND	1	38	23	46	28	54	160	88
U1-143 DUPLICATE	ND	1	32	19	39	23	45	136	73
U1-151	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-154	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-155	ND	1	ND	ND	ND	ND	ND	ND	ND
U1-162	8	109	18	16	27	33	18	41	47
U1-162 DUPLICATE	7	92	15	13	23	27	15	34	39
U1-647	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-1607	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-106B	7	2	ND	ND	ND	1	ND	ND	ND
U1-123B	4	ND	ND	1	ND	ND	ND	ND	ND
1 PPB	1.0	1.5	1.1	1.0	0.9	1.0	0.9	1.0	1.1
U1-053	ND	ND	ND	ND	ND	ND	ND	ND	ND
U1-067	6	314	57	61	157	119	117	296	231
U1-074-B	16	930	91	95	227	221	83	169	170
S3	ND	1	ND	ND	BLQ	ND	ND	ND	ND

ND denotes None Detected.
BLQ denotes Below Limit of Quantitation of 1.0 ng/ml

SF-3-240 BTEXXXTMB and Total Fuel Carbon Data for Dr. Kampbell

Units = ng/ml Analyst: B. Newell

SampleName	BENZENE	TOLUENE	ETHYLBENZENE	p-XYLENE	m-XYLENE	o-XYLENE	1,3,5-TMB	1,2,4-TMB	1,2,3-TMB
U1-130	ND	79	39	47	133	88	106	277	249
QC, OBSERVED, PPB	21.5	21.2	21.8	20.7	21.1	20.7	21.9	21.4	21.0
QC, TRUE VALUE, PPB	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
QC, OBSERVED, PPB	18.4	18.3	18.8	18.1	18.8	18.1	18.9	18.8	18.1
10 PPB	9.4	8.9	9.7	8.7	9.1	8.7	9.1	8.8	9.5
U1-074	16	936	84	86	207	203	80	158	161
U1-106	7	4	ND	ND	ND	1	ND	1	1
100 PPB	95.1	91.2	99.0	90.9	93.2	89.8	96.9	92.0	100.6
LAB BLANK, PPB	ND	ND	ND	ND	ND	ND	ND	ND	ND
LAB BLANK, PPB	ND	ND	ND	ND	ND	ND	ND	ND	ND

SampleName	TOTAL FUEL CARBON
U1-092	20
U1-101	1523
U1-101 DUPLICATE	1554
U1-008	4
U1-61	7
U1-065	3806
U1-065 DUPLICATE	3581
U1-072	1620
U1-073	1827
U1-085	115
U1-089	1647
U1-089 DUPLICATE	1522
U1-107	48
U1-118	694
U1-118 DUPLICATE	591
U1-123	18
U1-143	939
U1-143 DUPLICATE	796
U1-155	30
U1-162	1631
U1-162 DUPLICATE	1368
U1-106B	22
U1-123B	16
U1-067	3442
U1-074-B	3001
S3	8
U1-130	2682
U1-074	2860
U1-106	38

ND denot[redacted]e Detected.
BLQ de[redacted]ow Limit of Quantitation of 1.0 ng/ml

MANTECH

Ref: 97-MW23/vg
97-LP30/vg

April 4, 1997

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift

Dear Don:

Attached are the results of 58 Hill AFB samples submitted to MERSC as part of Service Request #SF-3-240. The samples were received on March 19, 20, and 25 and analyzed immediately. The methods used for analysis were 353.1 for NO_2 and NO_3, 350.1 for NH_3 and Waters capillary electrophoresis Method N-601 for Cl and SO_4. Quality assurance measures performed on this set of samples included spikes, duplicates, known AQC samples and blanks.

If you have any questions concerning these results, please feel free to contact us.

Sincerely,

Mark White

Lynda Pennington

xc: R.L. Cosby
G.B. Smith
J.L. Seeley

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Sample	mg/l Cl^-	mg/l SO_4^{-2}	mg/l NO^-_2+NO^-_3(N)	mg/l NH_3(N)
MP-4D	43.0	38.7	.66	<.05
MP-5	42.4	36.4	.71	<.05
MP-6	108	15.8	.10	1.37
MP-6 Dup	-----	-----	.10	1.37
MP-7	31.0	31.6	1.15	<.05
MP-8	79.9	83.1	<.05	<.05
MP-8 Dup	80.3	83.5	-----	-----
MP-9	88.3	4.38	<.05	.85
MP-10	46.9	45.6	13.2	<.05
MP-11S	39.4	36.0	.37	<.05
MP-11D	45.1	43.5	.09	1.52
UI-8	47.0	30.8	4.51	.11
UI-53	------NO SAMPLE------		3.61	<.05
UI-53 Dup	-----	-----	3.58	<.05
UI-61	52.1	109	<.05	1.10
3/17/UI-62	44.5	<.1	<.05	2.08
3/24/UI-62	61.7	1.24	<.05	<.05
UI-65	69.4	<.1	<.05	.78
UI-67	-------NO SAMPLE------		<.05	1.78
UI-72	51.4	<.1	<.05	2.61
UI-73	75.2	<.1	<.05	3.28
UI-74	67.5	<.1	<.05	3.68
UI-77R	51.0	26.2	5.29	<.05
UI-78	51.1	13.1	2.32	<.05
UI-81	52.2	127	19.4	<.05
UI-81 Dup	51.7	127	-----	-----
UI-84	72.9	17.8	.66	4.35
UI-85	94.9	78.7	<.05	<.05
UI-89	67.2	<.1	<.05	1.21
UI-90	52.5	47.7	.51	<.05
UI-90 Dup	52.0	46.9	-----	-----
UI-92	51.7	38.5	.79	<.05
UI-97	27.8	28.8	1.38	<.05
UI-97 Dup	27.7	29.1	1.43	<.05
UI-98	41.1	34.5	2.89	<.05
UI-99	43.7	49.4	5.47	.66
UI-100	46.9	82.7	12.5	<.05
UI-101	59.2	6.58	<.05	9.95
UI-101 Dup	-----	-----	<.05	9.78
UI-103	129	31.3	7.65	<.05
UI-103	130	31.0	-----	-----
UI-104	58.8	37.5	1.65	<.05
UI-105	48.8	43.1	.45	<.05

Sample	mg/l Cl^-	mg/l SO_4^{-2}	mg/l NO^-_2+NO^-_3(N)	mg/l NH_3(N)
3/17/UI-106	52.1	45.3	.57	.79
3/22/UI-106	49.0	57.1	.40	.39
UI-107	107	176	1.89	3.36
UI-108	46.2	38.8	.95	<.05
UI-111	43.2	42.9	4.35	<.05
UI-112	44.4	42.9	2.95	.12
UI-113	55.6	40.8	.75	.30
UI-115	66.3	37.5	5.16	<.05
UI-115 Dup	-----	-----	5.11	<.05
UI-116	135	41.1	20.8	<.05
UI-117	931	266	2.87	<.05
UI-118	75.2	23.0	1.55	1.42
3/14/UI-123	153	21.4	<.05	.31
3/14/UI-123 Dup	151	21.4	-----	.31
3/18/UI-123	149	22.7	<.05	.29
3/18/UI-123 Dup	-----	-----	<.05	-----
UI-126	35.5	18.3	.10	1.50
UI-138	51.6	57.0	.15	<.05
UI-143	38.5	3.64	.06	.49
UI-151	48.9	46.6	.16	.06
UI-151 Dup	48.7	46.4	-----	-----
UI-154	40.5	38.5	1.32	<.05
UI-155	58.6	11.4	.10	2.68
UI-160	159	44.1	.57	.19
UI-162	------ NO SAMPLE ------		.08	2.02
UI-162 Dup	-----	-----	.06	2.00
UI-647	53.9	74.8	3.38	<.05
UI-1607	86.0	43.3	2.53	<.05
Unlabeled 3/20/97	62.7	14.4	-----	-----
Blank	<.1	<.1	<.05	<.05
AQC	34.8	44.4	2.03	10.1
	33.8	43.5	1.96	10.2
	33.3	43.0	2.02	-----
True Value	34.8	44.0	2.10	10.0
Spike Rec.	98%	96%	100%	103%
	101%	102%	101%	98%
	98%	98%	98%	-----

MANTECH

Ref: 97-DF13

April. 3, 1997

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

As requested in Service Request SF-3-240, GC/MS analysis for phenols and aliphatic/aromatic acids was done on four water samples from Hill AFB. These samples were labeled: U1-072, U1-073, U1-106 and U1-154. The samples were received on Mar. 19, 1997 and were extracted and derivatized by Amy Zhao on Mar. 28, 1997. The extracts were analyzed by GC/MS on April 1, 1997. A 100 ml sample of unpreserved U1-072 was run for comparison of unpreserved and trisodium phosphate (TSP) preserved samples. RSKERL SOP 177 was used for the extraction, derivatization and GC/MS analysis of the samples.

Table I provides the concentrations of the phenols and aliphatic/aromatic acids found in water samples. Derivative and extraction blanks and recoveries of 50 ppb blank water spiked samples and 100 ppb check standards are also included in the table. Attached please find chromatograms of the acid/phenol profile for samples U1-072 (TSP preserved), U1-072(not preserved) and U1-073 (TSP preserved). The largest peaks in these three chromatograms are the octanoic acids which we have seen in other samples. In addition decanoic acids are also present. The comparison of chromatograms of unpreserved and TSP preserved sample U1-072 shows that the octanoic acids are not an artefact caused by basic TSP.

If you should have any questions, please feel free to contact me.

Sincerely,

Dennis D. Fine

Dennis D. Fine

xc: J. Seeley
G. Smith
R. Cosby
D. Fine
J. Wilson

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Table I. Quantitative Report and QC Data for Phenols and Aliphatic and Aromatic Acids in Water Samples from Hill AFB for Service Request SF-3-240.

Concentration ppb

File Name:	700U1072.TXT	708U1072.TXT	701U1073.TXT	702U106.TXT	703U1154.TXT	689MTHBL.TX	705MTHBL.TX	699EXTBL.TXT	716EXTBL.TXT
	TSP Preserved	Not Preserved	TSP Preserved	TSP Preserved	TSP Preserved				
Compound Sample Name:	U1-072	U1-072	U1-073	U1-106	U1-154	Method Blk	Method Blk	Extr. Blk	Extr. Blk
Propanoic Acid	537	120	755	***	***	***	***	***	***
2-Methylpropanoic Acid	341	140	299	***	***	***	***	***	***
Trimethylacetic Acid	23	25	22	10	11	***	***	14	13
Butyric Acid	145	23	150	***	***	***	***	7	6
2-Methylbutyric Acid	267	75	175	***	***	*	*	***	***
3-Methylbutryic Acid	561	350	343	***	***	***	***	***	***
3,3-Dimethylpropanoic Acid	34	39	30	*	*	*	*	*	***
Pentanoic Acid	165	7	114	***	***	***	***	***	***
2,3-Dimethybutyric Acid	35	63	73	*	***	*	*	***	***
2-Ethylbutyric Acid	16	25	14	*	*	*	*	*	*
2-Methylpentanoic Acid	69	32	53	*	***	*	*	***	*
3-Methylpentanoic Acid	123	105	169	*	*	*	*	*	*
4-Methylpentanoic Acid	82	51	48	*	*	*	*	*	*
Hexanoic Acid	23	***	20	***	3	***	***	3	3
2-Methylhexanoic Acid	4	*	***	*	*	*	*	*	*
Phenol	6	17	10	9	***	***	***	***	11
Cyclopentanecarboxylic Acid	4	***	5	*	*	*	*	*	*
5-Methylhexanoic Acid	14	***	4	*	*	*	*	*	*
o-Cresol	5	13	8	*	*	*	***	***	***
2-Ethylhexanoic Acid	*	68	39	***	***	*	*	***	***
Heptanoic Acid	46	***	6	***	***	***	***	***	***
m-Cresol	52	103	12	*	*	*	***	*	*
p-Cresol	61	12	99	*	*	*	*	*	*
1-Cyclopentene-1-carboxylic Acid	*	***	*	*	*	*	*	*	*
o-Ethylphenol	***	4	***	*	*	*	*	*	*
Cyclopentaneacetic Acid	6	4	7	*	*	*	*	*	*
2,6-Dimethyphenol	***	***	***	*	*	*	*	*	*
2,5-Dimethylphenol	4	9	6	*	*	*	*	*	*
Cyclohexanecarboxylic Acid	12	9	16	*	*	*	*	*	*
3-Cyclohexene-1-carboxylic Acid	*	*	*	*	***	*	*	*	*
2,4-Dimethylphenol	5	8	7	*	*	*	*	*	*
3,5-Dimethylphenol & m-Ethylphenol	7	14	9	*	*	*	*	*	*
Octanoic Acid	12	***	8	***	***	3	***	3	***
2,3-Dimetholphenol	***	3	***	*	*	*	*	*	*
p-Ethylphenol	*	***	***	*	*	*	*	*	*
Benzoic Acid	14	12	8	***	***	***	***	12	10
3,4-Dimethyphenol	***	4	***	*	*	*	*	*	*
m-Methylbenzoic Acid	589	510	801	*	*	*	*	*	*
1-Cyclohexene-1-carboxylic Acid	*	*	*	*	*	*	*	*	*
Cyclohexaneacetic Acid	7	5	6	*	*	*	*	*	*
2-Phenylpropanoic Acid	***	***	***	*	*	*	*	*	*
o-Methylbenzoic Acid	7	6	8	*	*	*	*	*	*
Phenylacetic Acid	8	***	8	*	*	*	***	*	*
m-Tolylacetic Acid	25	23	19	*	*	*	*	*	*
o-Tolylacetic Acid	20	20	24	*	*	*	*	*	*
2,6-Dimethylbenzoic Acid	***	***	***	*	*	*	*	*	*
p-Tolylacetic Acid	31	28	21	*	*	*	*	*	*
p-Methylbenzoic Acid	8	5	9	*	*	*	*	*	*
3-Phenylpropanoic Acid	6	6	6	*	*	*	*	*	*
2,5-Dimethylbenzoic Acid	***	***	***	*	*	*	*	*	*
Decanoic Acid	6	***	21	***	***	***	*	***	***
2,4-Dimethylbenzoic Acid	***	*	4	*	*	*	*	*	*
3,5-Dimethylbenzoic Acid	***	***	***	*	*	*	*	*	*
2,3-Dimethylbenzoic Acid	***	***	***	*	*	*	*	*	*
4-Ethylbenzoic Acid	5	3	4	*	*	*	*	*	*
2,4,6-Trimethylbenzoic Acid	13	9	12	***	*	*	*	*	*
3,4-Dimethylbenzoic Acid	7	6	13	*	*	*	*	*	*
2,4,5-Trimethylbenzoic Acid	***	***	***	*	*	*	*	*	*

*** indicates concentration of extract was below lowest calibration standard (3 ppb)

* indicates not found.

Printed: 7:50 AM 4/7/97

Table I. Quantitative Report and QC Data for Phenols and Aliphatic and Aromatic Acids in Water Samples from Hill AFB for Service Request SF-3-240.

Concentration ppb

Compound	File Name: 727EXTBL.TX Sample Name: Extr. Blk.	698EXTRE.TX 50 ppb Extr. % Recovery	715EXTRE.TX 50 ppb Extr. % Recovery	704100AA.TX 100 ppb Std % Recovery	707100AA.TX 100 ppb Std % Recovery	717100AA.TX 100 ppb Std % Recovery
Propanoic Acid	***	8	8	99	86	100
2-Methylpropanoic Acid	***	31	28	99	87	101
Trimethylacetic Acid	12	107	108	154	87	101
Butyric Acid	6	29	22	117	84	97
2-Methylbutyric Acid	***	72	69	109	86	98
3-Methylbutryic Acid	***	70	66	115	84	98
3,3-Dimethylpropanoic Acid	***	90	98	142	86	97
Pentanoic Acid	***	76	72	103	83	96
2,3-Dimethybutyric Acid	***	91	97	137	85	96
2-Ethylbutyric Acid	***	95	101	114	85	97
2-Methylpentanoic Acid	***	90	97	112	86	97
3-Methylpentanoic Acid	***	87	91	108	83	95
4-Methylpentanoic Acid	*	91	93	105	84	96
Hexanoic Acid	***	102	101	109	83	95
2-Methylhexanoic Acid	*	90	95	97	90	101
Phenol	***	78	87	91	86	93
Cyclopentanecarboxylic Acid	*	75	74	85	84	94
5-Methylhexanoic Acid	*	89	94	102	82	92
o-Cresol	***	85	96	112	89	97
2-Ethylhexanoic Acid	***	90	99	93	87	96
Heptanoic Acid	***	92	97	107	82	94
m-Cresol	***	86	96	58	87	96
p-Cresol	*	82	91	75	87	96
1-Cyclopentene-1-carboxylic Acid	*	70	60	104	85	94
o-Ethylphenol	*	84	96	67	87	95
Cyclopentaneacetic Acid	*	87	89	102	82	92
2,6-Dimethyphenol	*	70	76	92	86	95
2,5-Dimethylphenol	*	81	84	106	85	94
Cyclohexanecarboxylic Acid	*	90	94	111	83	94
3-Cyclohexene-1-carboxylic Acid	*	79	77	148	84	94
2,4-Dimethylphenol	*	56	61	70	87	96
3,5-Dimethylphenol & m-Ethylphenol	***	85	93	81	86	94
Octanoic Acid	***	97	101	105	81	92
2,3-Dimetholphenol	*	79	85	92	85	98
p-Ethylphenol	*	90	94	88	85	88
Benzoic Acid	10	114	93	99	82	91
3,4-Dimethyphenol	*	79	86	114	84	92
m-Methylbenzoic Acid	*	82	69	102	82	89
1-Cyclohexene-1-carboxylic Acid	*	85	86	113	82	92
Cyclohexaneacetic Acid	*	88	95	98	81	94
2-Phenylpropanoic Acid	*	92	89	103	82	93
o-Methylbenzoic Acid	*	94	85	101	78	92
Phenylacetic Acid	*	93	82	97	79	90
m-Tolylacetic Acid	*	95	85	92	78	77
o-Tolylacetic Acid	*	97	81	81	85	86
2,6-Dimethylbenzoic Acid	*	93	84	87	81	76
p-Tolylacetic Acid	*	95	86	84	78	77
p-Methylbenzoic Acid	*	92	80	100	80	89
3-Phenylpropanoic Acid	*	90	82	95	77	84
2,5-Dimethylbenzoic Acid	*	91	84	96	77	87
Decanoic Acid	*	99	96	110	80	86
2,4-Dimethylbenzoic Acid	*	104	100	101	74	88
3,5-Dimethylbenzoic Acid	*	91	81	99	80	91
2,3-Dimethylbenzoic Acid	***	96	86	98	78	89
4-Ethylbenzoic Acid	5	96	86	96	77	87
2,4,6-Trimethylbenzoic Acid	13	95	84	103	81	95
3,4-Dimethylbenzoic Acid	7	91	84	100	78	87
2,4,5-Trimethylbenzoic Acid	***	96	91	99	71	89

*** indicates concentration of extract was below lowest calibration standard (3 ppb)

* indicates not found.

Printer: 4:40 PM 4/2/97

MANTECH

Ref: 97-NV49/vg

April 24, 1997

Dr. Don Kampbell/Mr. Mike Cook
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: J.L. Seeley

Dear Don/Mike:

Attached is the metal analysis report (4773.LIS) for nine samples analyzed in response to Service Request No. 110 under EPA Contract No. 68-C3-0322. Acidified samples were received on April 11 and analyzed on April 16 and 18, 1997 by Cherri Adair and Nohora Vela. The samples did not receive any further treatment and they were analyzed for total metal content using the ICAP system. SOP for the ICAP and sample calculations were according to SOP # 181. Samples were also analyzed for arsenic using the GF-AAS system, following SOP-183, and the results are in report AS70416.Lis;1. Quality assurance measures performed on this set of samples included spikes, measurement duplicates, known AQC and blanks.

If you have any questions, please feel free to contact me.

Sincerely,

Nohora Vela

Nohora Vela

xc: R.L. Cosby
R. Puls

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198. 919 Research Drive
Ada. Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

ELEMENTAL CONSTITUENTS ANALYSIS BY: ICAP (DATA.DAT)
THIS REPORT (USER$DISK:[CLARK.ICAP]LIST.LST;4773) WAS GENERATED FROM USER$DISK:[CLARK.ICAP]OUTPUT.DAT;3317

PROJECT: AQ FIELD FILTERED SAMPLES.HILL AIR FORCE BASE.DIRECT READING
KAMPBELL/COOK
SR110

CONCENTRATION IN: MG/L

TAG NO.	17432		17433		17434		17435		
STATION	UI-081		UI-155		UI-117		UI-103		
TIME	09:29		09:07		09:11		09:13		
DATE	18-APR-97		18-APR-97		18-APR-97		18-APR-97		
PR DIL	1.0000		1.0000		1.0000		1.0000		
DIL	1.0000		1.0000		1.0000		1.0000		
ELEMENT	VALUE	STDV +/-	VALUE	STDV +/-	VALUE	STDV +/-	VALUE	STDV +/-	LOD
Na-1	28.2	2.8	104.	10.	517.	51.	84.1	8.4	0.0262
K	3.38	0.60	21.4	2.0	36.1	3.3	3.40	0.59	0.5879
Ca	144.	14.	49.7	4.9	122.	12.	127.	12.	0.0103
Mg	36.7	3.6	45.5	4.5	169.	16.	39.0	3.8	0.0339
Fe	<0.0078	0.0078	<0.0078	0.0078	<0.0092	0.0092	0.877	0.088	0.0077
Mn	<0.0046	0.0046	0.206	0.020	0.0852	0.0088	<0.0046	0.0046	0.0046
Co	<0.0046	0.0046	<0.0046	0.0046	<0.0046	0.0046	<0.0046	0.0046	0.0046
Mo	<0.029	0.029	<0.029	0.029	<0.029	0.029	<0.029	0.029	0.0297
Al	<0.010	0.010	<0.010	0.010	<0.010	0.010	0.064	0.010	0.0103
As	<0.010	0.010	0.020	0.010	<0.010	0.010	<0.010	0.010	0.0104
Se	<0.019	0.019	<0.019	0.019	<0.019	0.019	<0.019	0.019	0.0198
Cd	<0.0018	0.0018	0.0030	0.0018	0.0182	0.0020	<0.0018	0.0018	0.0018
Be	<0.0023	0.0023	<0.0020	0.0020	<0.0022	0.0022	<0.0022	0.0022	0.0020
Cu	<0.0023	0.0023	<0.0023	0.0023	<0.0023	0.0023	<0.0023	0.0023	0.0023
Cr	<0.0037	0.0037	<0.0037	0.0037	<0.0037	0.0037	0.0823	0.0081	0.0037
Ni	<0.014	0.014	<0.014	0.014	<0.014	0.014	0.275	0.028	0.0148
Zn	<0.0013	0.0013	<0.0013	0.0013	0.0041	0.0017	<0.0013	0.0013	0.0012
Ag	<0.016	0.016	<0.016	0.016	<0.016	0.016	<0.016	0.016	0.0162
Tl	<0.020	0.020	<0.020	0.020	<0.020	0.020	<0.020	0.020	0.0208
Pb	<0.014	0.014	<0.014	0.014	<0.014	0.014	<0.014	0.014	0.0145
Sr	0.387	0.039	0.288	0.028	0.564	0.056	0.549	0.055	0.0002
V	<0.012	0.012	<0.012	0.012	<0.012	0.012	<0.012	0.012	0.0127
Ba	0.234	0.023	0.306	0.030	0.0463	0.0041	0.289	0.029	0.0025
B	0.094	0.031	0.366	0.037	0.535	0.052	0.134	0.031	0.0310
Ti	0.0008	0.0030	<0.0030	0.0030	<0.0030	0.0030	<0.0030	0.0030	0.0029

< VALUE=LIMIT OF DETECTION DETERMINED BY INSTRUMENT SENSITIVITY, SAMPLE DILUTION, AND MATRIX INTERFERENCE.
RESULTS ACCURATE TO 2 SIGNIFICANT DIGITS

EPA/RSKERL/ADA, OK

ELEMENTAL CONSTITUENTS ANALYSIS BY: ICAP (DATA.DAT)
THIS REPORT (USER$DISK:[CLARK.ICAP]LIST.LST;4773) WAS GENERATED FROM USER$DISK:[CLARK.ICAP]OUTPUT.DAT;3317

PROJECT: AQ FIELD FILTERED SAMPLES.HILL AIR FORCE BASE.DIRECT READING
KAMPBELL/COOK
SR110

CONCENTRATION IN: MG/L

TAG NO.	17436		17437		17438		17439		
STATION	UI-151		UI-162		MP-9		UI-106		
TIME	09:32		09:18		09:21		09:23		
DATE	18-APR-97		18-APR-97		18-APR-97		18-APR-97		
PR DIL	1.0000		1.0000		1.0000		1.0000		
DIL	1.0000		1.0000		1.0000		1.0000		
ELEMENT	VALUE	STDV +/-	VALUE	STDV +/-	VALUE	STDV +/-	VALUE	STDV +/-	LOD
Na-1	65.1	6.6	28.9	2.8	57.6	5.7	60.0	6.0	0.0262
K	7.08	0.59	4.09	0.60	7.12	0.60	9.14	0.76	0.5879
Ca	66.8	6.7	175.	17.	148.	14.	133.	13.	0.0103
Mg	38.7	3.9	34.2	3.4	45.3	4.5	38.6	3.8	0.0339
Fe	1.66	0.16	16.8	1.6	6.45	0.64	0.208	0.021	0.0077
Mn	0.695	0.069	0.324	0.032	1.77	0.17	0.182	0.018	0.0046
Co	0.0011	0.0046	<0.0046	0.0046	<0.0046	0.0046	<0.0046	0.0046	0.0046
Mo	<0.029	0.029	<0.029	0.029	<0.029	0.029	<0.029	0.029	0.0297
Al	0.217	0.011	<0.010	0.010	<0.010	0.010	<0.010	0.010	0.0103
As	<0.010	0.010	0.166	0.018	<0.010	0.010	<0.010	0.010	0.0104
Se	<0.019	0.019	<0.027	0.027	<0.020	0.020	<0.019	0.019	0.0198
Cd	<0.0018	0.0018	<0.0018	0.0018	<0.0018	0.0018	<0.0018	0.0018	0.0018
Be	<0.0021	0.0021	<0.0024	0.0024	<0.0023	0.0023	<0.0023	0.0023	0.0020
Cu	<0.0023	0.0023	<0.0023	0.0023	<0.0023	0.0023	<0.0023	0.0023	0.0023
Cr	0.0128	0.0037	<0.0037	0.0037	0.0040	0.0037	<0.0037	0.0037	0.0037
Ni	<0.014	0.014	<0.014	0.014	<0.014	0.014	<0.014	0.014	0.0148
Zn	0.0016	0.0013	0.0046	0.0013	<0.0013	0.0013	<0.0013	0.0013	0.0012
Ag	<0.016	0.016	<0.016	0.016	<0.016	0.016	<0.016	0.016	0.0162
Tl	<0.020	0.020	<0.020	0.020	<0.020	0.020	<0.020	0.020	0.0208
Pb	<0.014	0.014	<0.014	0.014	<0.014	0.014	<0.014	0.014	0.0145
Sr	0.373	0.037	0.428	0.043	0.584	0.058	0.379	0.038	0.0002
V	<0.012	0.012	<0.012	0.012	<0.012	0.012	<0.012	0.012	0.0127
Ba	0.198	0.020	0.884	0.088	0.290	0.029	0.356	0.035	0.0025
B	0.238	0.031	0.124	0.031	0.099	0.031	0.272	0.031	0.0310
Ti	0.0105	0.0030	<0.0030	0.0030	<0.0030	0.0030	<0.0030	0.0030	0.0029

< VALUE=LIMIT OF DETECTION DETERMINED BY INSTRUMENT SENSITIVITY, SAMPLE DILUTION, AND MATRIX INTERFERENCE.
RESULTS ACCURATE TO 2 SIGNIFICANT DIGITS

EPA/RSKERL/ADA, OK

ELEMENTAL CONSTITUENT: ...ISIS BY: ICAP (DATA.DAT)
THIS REPORT (USER$DISK:[CLARK.ICAP]LIST.LST;4773) ... ...ENERATED FROM USER$DISK:[CLARK.ICAP]OUTPUT.DAT;3317

PROJECT: AQ FIELD FILTERED SAMPLES.HILL AIR FORCE BASE.DIRECT READING
KAMPBELL/COOK
SR110

CONCENTRATION IN: MG/L

		ZSTD5		IECCHK2		
TAG NO.	17440					
STATION	UI-092					
TIME	09:26	16:14		16:17		
DATE	18-APR-97	18-APR-97		18-APR-97		
PR DIL	1.0000	1.0000		1.0000		
DIL	1.0000	1.0000		1.0000		

ELEMENT	VALUE	STDV +/-	VALUE	STDV +/-	VALUE	STDV +/-	LOD
Na-1	125.	12.	<0.026	0.026	<0.026	0.026	0.0262
K	5.07	0.59	0.92	0.59	2.64	0.67	0.5879
Ca	108.	10.	0.011	0.011	302.	30.	0.0103
Mg	43.9	4.3	<0.43	0.43	287.	28.	0.0339
Fe	0.399	0.041	94.2	9.4	<0.016	0.016	0.0077
Mn	0.117	0.011	93.3	9.3	<0.0047	0.0047	0.0046
Co	<0.0046	0.0046	<0.0046	0.0046	<0.013	0.013	0.0046
Mo	<0.029	0.029	<0.029	0.029	<0.029	0.029	0.0297
Al	<0.010	0.010	95.3	9.5	<0.045	0.045	0.0103
As	<0.010	0.010	<0.12	0.12	<0.019	0.019	0.0104
Se	<0.019	0.019	<0.14	0.14	0.025	0.020	0.0198
Cd	<0.0018	0.0018	0.0021	0.0018	<0.0019	0.0019	0.0018
Be	<0.0022	0.0022	0.0027	0.0020	<0.0096	0.0096	0.0020
Cu	<0.0023	0.0023	<0.0031	0.0031	<0.0079	0.0079	0.0023
Cr	<0.0037	0.0037	<0.0037	0.0037	<0.0037	0.0037	0.0037
Ni	<0.014	0.014	<0.014	0.014	<0.014	0.014	0.0148
Zn	<0.0013	0.0013	<0.0019	0.0019	<0.0021	0.0021	0.0012
Ag	<0.016	0.016	<0.016	0.016	<0.019	0.019	0.0162
Tl	<0.020	0.020	0.126	0.034	<1.2	1.2	0.0208
Pb	<0.014	0.014	<0.050	0.050	<0.015	0.015	0.0145
Sr	0.372	0.037	0.0004	0.0003	0.0013	0.0004	0.0002
V	<0.012	0.012	<0.013	0.013	18.0	1.8	0.0127
Ba	0.144	0.014	<0.0025	0.0025	0.0169	0.0029	0.0025
B	0.316	0.031	<0.031	0.031	0.063	0.031	0.0310
Ti	<0.0030	0.0030	<0.0030	0.0030	51.6	5.1	0.0029

< VALUE=LIMIT OF DETECTION DETERMINED BY INSTRUMENT SENSITIVITY, SAMPLE DILUTION, AND MATRIX INTERFERENCE.
RESULTS ACCURATE TO 2 SIGNIFICANT DIGITS

EPA/RSKERL/ADA, OK

ELEMENTAL CONSTIT[redacted]NALYSIS BY: ICAP (DATA.DAT)
THIS REPORT (USER$DISK:[CLARK.ICAP]LIST.LST;4[redacted]WAS GENERATED FROM USER$DISK:[CLARK.ICAP]OUTPUT.DAT;3[redacted]

PROJECT: AQ FIELD FILTERED SAMPLES.HILL AIR FORCE BASE.DIRECT RE23-APR-97 16:06:58
KAMPBELL/COOK
SR110

THIS REPORT WAS GENERATED WITH THE FOLLOWING INFORMATION:

ERROR LEVEL PERCENTAGE : 10%

STATISTICAL SENSITIVITIES WITH A 2.0 SIGMA INTERVAL WERE USED

CONCENTRATION IN: MG/L

THE CONSTANT FILES USED:

USER$DISK:[CLARK.ICAP]TYPE1.AMAX;1
USER$DISK:[CLARK.ICAP]TYPE1.XQCA;1
USER$DISK:[CLARK.ICAP]TYPE1.XQCB;1
USER$DISK:[CLARK.ICAP]TYPE1.XQCC;1
USER$DISK:[CLARK.ICAP]TYPE1.STD1;1
USER$DISK:[CLARK.ICAP]TYPE1.STD2;1
USER$DISK:[CLARK.ICAP]TYPE1.STD3;1
USER$DISK:[CLARK.ICAP]TYPE1.STD4;1
USER$DISK:[CLARK.ICAP]TYPE1.STD5;1
USER$DISK:[CLARK.ICAP]TYPE1.XSS1;1
USER$DISK:[CLARK.ICAP]TYPE1.XSS2;1
USER$DISK:[CLARK.ICAP]TYPE1.FIXX;1
USER$DISK:[CLARK.ICAP]TYPE1.LCN;48
LCN TIME: 16:52:17 LCN DATE: 21-APR-97 FILTER FACTOR: 0.000002

THE DATA FILES USED:

USER$DISK:[CLARK.ICAP]DATA.DAT;379 (INSTRUMENT RAW DATA)
USER$DISK:[CLARK.ICAP]IC0001.DAT;4027 (INSTRUMENT CALC. DATA)
USER$DISK:[CLARK.ICAP]TAG.DAT;5243 (ORIGINAL TAG FILE)
USER$DISK:[CLARK.ICAP]TAG.DAT;5248 (TAG FILE FOR CALC.)
USER$DISK:[CLARK.ICAP]OUTPUT.DAT;3317
USER$DISK:[CLARK.ICAP]OUTPUT.LST;3232
USER$DISK:[CLARK.ICAP]ARCH.DAT;16
USER$DISK:[CLARK.ICAP]LIST.LST;4773
USER$DISK:[CLARK.ICAP]TRAILER.LST;926

ELEMENTAL CONSTITUENTS . TS BY AA MEASUREMENTS
THIS REPORT ([.REPORT]AS70416.LIS;1) WAS ... ATED FROM DATASET [.DATA]AS70416.DAT;2

PROJECT: AQ FIELD FILTERED SAMPLES. HILL AIR FORCE BASE.

METHOD: GF-AAS FOR ARSENIC DETERMINATION.

CONCENTRATION UNITS: MG/L

TAG NUMBER	SAD #	STATION IDENT	MACHINE READING	PRIMARY DILUTION	REGULAR DILUTION	FINAL CONCENTRATION
17432	17432	UI-081	0.001	1.000	1.000	0.001
17432RB	17432	UI-081	0.002	1.000	1.000	0.002
17433	17433	UI-155	0.035	1.000	1.000	0.035
17433RB	17433	UI-155	0.036	1.000	1.000	0.036
17434	17434	UI-117	0.000	1.000	1.000	0.000
17435	17435	UI-103	0.000	1.000	1.000	0.000
17435SPK5	17435	UI-103	0.007	1.000	1.000	0.007
17436	17436	UI-151	0.003	1.000	1.000	0.003
17436RB	17436	UI-151	0.003	1.000	1.000	0.003
17437	17437	UI-162	0.193	1.000	1.000	0.193
17437RB	17437	UI-162	0.202	1.000	1.000	0.202
17437	17437	UI-162	0.099	2.000	1.000	0.198
17437	17437	UI-162	0.050	4.000	1.000	0.200
17437RB	17437	UI-162	0.050	4.000	1.000	0.200
17438	17438	MP-9	0.015	1.000	1.000	0.015
17438RB	17438	MP-9	0.016	1.000	1.000	0.016
17439	17439	UI-106	0.003	1.000	1.000	0.003
17440	17440	UI-092	0.016	1.000	1.000	0.016
17440RB	17440	UI-092	0.016	1.000	1.000	0.016
17440SPK5	17440	UI-092	0.021	1.000	1.000	0.021
BLANK	%%%%%	**********	0.000	1.000	1.000	0.000
BLANK	%%%%%	**********	0.001	1.000	1.000	0.001
BLANK	%%%%%	**********	0.000	1.000	1.000	0.000
STD 1PPB	%%%%%	**********	0.000	1.000	1.000	0.000
STD 1PPB	%%%%%	**********	0.000	1.000	1.000	0.000
STD 2PPB	%%%%%	**********	0.002	1.000	1.000	0.002
STD 2PPB	%%%%%	**********	0.001	1.000	1.000	0.001
STD 2PPB	%%%%%	**********	0.001	1.000	1.000	0.001
STD 5PPB	%%%%%	**********	0.005	1.000	1.000	0.005
STD 5PPB	%%%%%	**********	0.004	1.000	1.000	0.004
STD 5PPB	%%%%%	**********	0.005	1.000	1.000	0.005
STD10PPB	%%%%%	**********	0.009	1.000	1.000	0.009
STD10PPB	%%%%%	**********	0.010	1.000	1.000	0.010
STD10PPB	%%%%%	**********	0.011	1.000	1.000	0.011
STD20PPB	%%%%%	**********	0.021	1.000	1.000	0.021
STD20PPB	%%%%%	**********	0.020	1.000	1.000	0.020
STD20PPB	%%%%%	**********	0.022	1.000	1.000	0.022
STD50PPB	%%%%%	**********	0.052	1.000	1.000	0.052
STD50PPB	%%%%%	**********	0.053	1.000	1.000	0.053
STD50PPB	%%%%%	**********	0.053	1.000	1.000	0.053
STD70PPB	%%%%%	**********	0.069	1.000	1.000	0.069
STD70PPB	%%%%%	**********	0.071	1.000	1.000	0.071

ELEMENTAL CONSTIT[redacted]ALYSIS BY AA MEASUREMENTS
THIS REPORT ([.REPORT]AS70416.LIS;[redacted]S GENERATED FROM DATASET [.DATA]AS70416.DAT;2

PROJECT: AQ FIELD FILTERED SAMPLES. HILL AIR FORCE BASE.

METHOD: GF-AAS FOR ARSENIC DETERMINATION.

CONCENTRATION UNITS: MG/L

TAG NUMBER	SAD #	STATION IDENT	MACHINE READING	PRIMARY DILUTION	REGULAR DILUTION	FINAL CONCENTRATION
STD70PPB	%%%%%	**********	0.068	1.000	1.000	0.068
STD100PPB	%%%%%	**********	0.103	1.000	1.000	0.103
STD100PPB	%%%%%	**********	0.099	1.000	1.000	0.099

MANTECH ENVIRONMENTAL TECHNOLOGY

Ref: 97-MAB3/vg
March 31, 1997

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Enviornmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

As per Service Request #SFTA-3-117, hydrogen analysis was performed on site at Hill AFB, UT using a RGA3 Reduction Gas Analyzer. The analysis began March 14, 1997 and concluded March 20, 1997. A total of seven (7) wells were sampled for dissolved hydrogen. A six place (0.0 to 10.0 PPM) external standard curve was used to quantitate the samples. The following data represents the concentration in the dissolved phase.

Hill AFB, UT

Well	H_2 concentration (nM)
U1-085	.68 nM
U1-111	1.40 nM
U1-154	.77 nM
U1-154 (Dup)	.79 nM
LTM8	10.25 nM
LTM8 (Dup)	9.41 nM
U1-108	.47 nM

LTM8 and LTM8 (Dup) > out of

NOTE: The wells which were intended to be sampled for dissolved hydrogen demonstrated low yields in which case the flow was not continous and dissolved hydrogen sampling could not be completed.

If you have any questions, please see me at your convenience.

Sincerely,

Mark Blankenship

Mark Blankenship

xc: R.L. Cosby
G.B. Smith
J.T. Wilson
J.L. Seeley

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

MANTECH

Ref: 97-LH3/vg

April 10, 1997

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

As requested in Service Request #SF-3-240, gas analysis was performed for methane, ethylene, and ethane on samples from Hill AFB, Utah. The samples were received on March 19, 20, and 25, 1997. The analyses were performed on March 26, 27, and 28, 1997. These analyses were performed as per RSKSOP-194, and the calculations were done as per RSKSOP-175.

If you should have any questions, please feel free to contact me.

Sincerely,

Lisa Hopkins

Lisa Hopkins

xc: R.L. Cosby
J.W. Wilson
G.B. Smith
J.L. Seeley JS

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Sample	Methane	Ethylene	Ethane
100ppm CH4	92.7	**	**
100ppm C2H4	**	96.4	**
100ppm C2H6	**	**	107.9
Helium Blank	**	**	**
Lab Blank	**	**	**
U1-081	**	**	**
U1-100	**	**	**
U1-154	**	**	**
U1-155	0.171	*	**
U1-062	0.335	**	**
U1-062	0.323	**	**
Lab Dup			
U1-008	0.001	**	**
U1-078	**	**	**
U1-085	0.336	0.016	**
U1-98	0.001	**	**
U1-084	0.210	**	**
U1-084	0.214	**	**
Field Dup		**	
10ppm CH4	11.7	**	**
U1-99	*	**	**
U1-106	0.150	*	**
U1-108	*	**	**
U1-111	**	**	**
U1-112	0.003	**	**
U1-112	0.002	**	**
Lab Dup		**	
U1-117	**	**	**
U1-123	3.595	0.050	**
U1-1607	0.066	**	**
U1-1607	*	**	**
Field Dup			
100ppm CH4	105.1	**	**
100ppm C2H4	**	97.5	**
100ppm C2H6	**	**	103.0
Lower Limit of Quantitation			
	0.001	0.003	0.002

Units for the samples are in mg/L.
Units for the standards are in parts per million.

* denotes Below Limit of Quantitation.
** denotes None Detected.

Sample	Methane	Ethylene	Ethane
100ppm CH4	102.3	**	**
100ppm C2H4	**	99.4	**
100ppm C2H6	**	**	104.4
Helium Blank	**	**	**
Lab Blank	**	**	**
U1-073	0.641	0.003	**
U1-77R	**	**	**
U1-089	1.341	0.006	**
U1-103	**	**	**
U1-107	0.602	**	**
U1-107	0.554	**	**
Lab Dup			
U1-115	**	**	**
U1-123	1.046	0.013	**
U1-126	0.005	**	**
U1-143	0.626	**	**
U1-61	0.536	**	**
U1-61	0.558	**	**
Field Dup			
1000ppm CH4	1069.3	**	**
U1-072	0.694	0.005	**
U1-104	**	**	**
U1-116	**	**	**
U1-118	0.044	0.011	**
U1-647	**	**	**
100ppm CH4	97.3	**	**
100ppm C2H4	**	93.3	**
100ppm C2H6	**	**	109.2
Lower Limit of Quantitation	0.001	0.003	0.002

Units for the samples are in mg/L.
Units for the standards are in parts per million.

* denotes Below Limit of Quantitation.
** denotes None Detected.

Sample	Methane	Ethylene	Ethane
100ppm CH4	101.1	**	**
100ppm C2H4	**	95.1	**
100ppm C2H6	**	**	106.4
Helium Blank	**	**	**
Lab Blank	**	**	**
MP-4D	**	**	**
MP-5	**	**	**
MP6	0.005	**	**
MP-7	**	**	**
MP-8	0.016	**	**
MP-8	0.006	**	**
Lab Dup			
MP-9	1.194	**	**
MP-10	0.002	**	**
MP-11S	*	**	**
MP-11D	0.003	**	**
U1-065	10.493	**	**
U1-065	10.229	**	**
Field Dup			
10ppm CH4	10.1	**	**
U1-067	1.246	0.009	**
U1-074	0.689	*	**
U1-90	**	**	**
U1-092	1.513	0.022	**
U1-101	6.482	**	**
U1-101	5.864	**	**
Lab Dup			
U1-105	*	**	**
U1-106	0.193	0.003	**
U1-113	0.016	**	**
U1-138	0.010	**	**
U1-151	0.007	**	**
U1-151	0.007	**	**
Field Dup			
10pm C2H4	**	9.0	**
U1-131	0.010	**	**
U1-160	0.002	**	**
U1-162	3.325	0.274	**
No Label	**	**	**
100ppm CH4	95.6	**	**
100ppm C2H4	**	89.7	**
100ppm C2H6	**	**	97.8
Lower Limit or Quantitation.			
	0.001	0.003	0.002

Units for the samples are in mg/L.
Units for the standards are in parts per million.
* denotes Below Limit of Quantitation.
** denotes None Detected.

MANTECH

April 2, 1997

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift

Dear Don:

Attached are TOC results for 62 Hill liquids submitted March 30,1997 under Service Request #SF-3-240. Sample analysis was begun April 1, 1997 and completed April 2, 1997 using RSKSOP-102.

Blanks, duplicates, and AQC samples were analyzed along with your samples, as appropriate, for quality control. If you have any questions concerning this data, please feel free to ask me.

Sincerely,

Sharon Hightower

Sharon Hightower

xc: R.L. Cosby
G.B. Smith
J.L. Seeley

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Kerr Research Drive
Ada, Oklahoma 74821-1198 405-436-8660 FAX 405-436-8501

KAMPBELL HILL LIQUIDS SF-3-240

SAMPLE	MG/L TOC
U1-008	61.5
U1-61, REP 1	12.1
U1-61, REP 2	4.16
U1-062	3.63
U1-065	16.1
U1-067, REP 1	104
U1-067, REP 2	108
U1-072	136
U1-073	122
U1-074	122
U1-074 DUP	122
U1-077	6.95
U1-078	10.2
U1-081	5.15
U1-084	3.49
U1-085	6.82
U1-089	24.8
U1-090	3.46
U1-092	8.37
U1-098	2.94
U1-098 DUP	3.03
U1-099	5.68
U1-100	6.91
U1-101	75.5
U1-103	2.62
U1-104	4.58
U1-105	2.89
U1-106, REP 1	7.21
U1-106, REP 2	7.32
U1-107	9.18
U1-108	3.10
U1-111	1.75
U1-111 DUP	1.72
U1-112	6.32
U1-113	2.74
U1-115	6.70
U1-116, REP 1	3.79
U1-116, REP 2	2.90
U1-117	5.59
U1-118	27.8
U1-123, REP 1	8.85
U1-123, REP 2	4.84
U1-126, REP 1	2.33
U1-126 DUP	2.22
U1-126, REP 2	4.93
U1-131	2.43
U1-138	1.94

SAMPLE	MG/L TOC
U1-143	15.7
U1-151, REP 1	3.24
U1-151, REP 2	2.76
U1-154	4.06
U1-155	3.17
U1-160	2.09
U1-162	24.4
U1-647	2.61
U1-1607	1.77
MP-4D	1.31
MP-5	1.04
MP-6	6.46
MP-7	.753
MP-8	5.82
MP-9	8.22
MP-10	3.56
MP-11D	1.41
MP-115	1.22
UNMARKED	2.74
WS595	5.93
WS595	5.68
WS595	5.90

WS595 std. t.v.=5.85

HILL AIR FORCE BASE
Field Data

Sample	Date	Carbon Dioxide mg/l	Total Alkalinity mg/l $CaCo_3$	Ferrous Iron mg/l	Hydrogen Sulfide mg/l
U1-085	3-14-97	180	564	.6	
U1-081	3-14-97	172	273	<.05	
U1-100	3-14-97	120	327	<.05	
U1-123	3-14-97	280	626	3.0	.1
U1-97	3-15-97	110	224	<.05	
U1-111	3-15-97	92	226	<.05	
U1-155	3-15-97	122	450	<.05	
U1-154	3-15-97	150	355	<.05	
U1-99	3-15-97	210	345	<.05	
U1-108	3-17-97	124	349	<.05	
U1-008	3-17-97	84	302	<.05	
U1-98	3-17-97	90	340	<.05	
U1-112	3-17-97	132	353	<.05	
U1-084	3-17-97	252	444	<.05	
U1-062	3-17-97	58	265	<.05	
U1-117	3-17-97	350	610	<.05	
U1-078	3-17-97	150	311	<.05	
U1-106	3-17-97	206	477	<.05	
U1-1607	3-17-97	220	360	<.05	
U1-123	3-18-97	260	615	2.8	.1
U1-115	3-18-97	94	304	<.05	
U1-126	3-18-97	120	232	.7	<.1
U1-103	3-18-97	140	397	<.05	
U1-077R	3-18-97	140	371	<.05	
U1-143	3-18=97	380	470	6.0	
U1-089	3-18-97	460	371	14.0	<.1

Hill Air Force Base
Field Data

Sample	Date	Carbon Dioxide mg/l	Total Alkalinity mg/l	Ferrous Iron mg/l	Hydrogen Sulfide mg/l
U1-647	3-19-97	92	371	<.05	
U1-104	3-19-97	150	405	.4	<.1
U1-61	3-19-97	580	500	10.5	<.1
U1-118	3-19-97	210	445	2.3	<.1
U1-107	3-19-97	400	675	1.8	<.1
U1-073	3-19-97		625	26.4	<.1
U1-116	3-19-97	150	460	.3	
U1-072	3-19-97		525	34.8	<.1
U1-162	3-20-97		472	8.8	<.1
U1-074	3-20-97		600	8.7	<.1
U1-065	3-20-97		570	8.7	<.1
U1-113	3-20-97	204	345	<.05	
U1-90	3-20-97	96	290	<.05	
U1-151	3-20-97	144	310	1.4	<.1
U1-138	3-21-97	110	392	<.05	
MP-7	3-21-97	56	197	<.05	
MP-9	3-21-97	500	525	8.9	<.1
MP-8	3-21-97	100	400	1.8	<.1
MP-10	3-21-97	140	301	<.05	
MP-4D	3-21-97	184	302	<.05	
U1-106	3-22-97	120	406	<.05	
MP-11S	3-22-97	158	312	<.05	
MP-11D	3-22-97	162	325	2.5	
MP-5	3-22-97	204	317	<.05	
U1-092	3-22-97	280	560	.1	
U1-160	3-22-97	180	190	.5	
U1-101	3-22-97	NA	825	10.5	
U1-067	3-24-97	NA	505	11.0	
U1-053	3-24-97			<.05	

MANTECH ENVIRONMENTAL TECHNOLOGY

April 30, 1997

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

Attached are TOC results for 9 Hill soils submitted March 28, 1997 under Service Request #SF-3-240. Sample analysis was begun April 21, 1997 and completed April 30, 1997 using RSKSOP-102 and RSKSOP-120.

Blanks, duplicates, and AQC samples were analyzed along with your samples, as appropriate, for quality control. If you have any questions concerning this data, please feel free to ask me.

Sincerely,

Sharon Hightower

Sharon Hightower

xc: R.L. Cosby
G.B. Smith
J.L. Seeley JS

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

KAMPBELL HILL SOILS SF-3-240

SAMPLE	SOIL FILTRATE % O.C.	SOLIDS % TOC	TOTAL SOIL % TOC	MEAN %TOC
MP-3,1-1	.004	.044	.048	.047
1-2	.007	.039	.046	
MP-4,1-1	<.00004	.018	.018	.022
1-2	.002	.023	.025	
MP-5,1-1	.004	.039	.043	.045
1-2	.008	.039	.047	
MP-8,1-1	.014	.107	.121	.102
1-2	.013	.070	.083	
MP-9,1-1	.021	.093	.114	.115
1-2	.023	.093	.116	
MP-10,1-1	.005	.012	.017	.018
1-2	.004	.015	.019	
MP10-2,1-1	.012	.063	.075	.084
1-2	.020	.072	.092	
MP11-1,1-1	.006	.081	.087	.081
1-2	.006	.069	.075	
MP11-2,1-1	.010	.070	.080	.072
1-2	.009	.055	.064	
LECO STD		.927		
WSO38	4.81			

Leco soil std t.v.=.90+/-.04
WSO38 std t.v.=4.92

MANTECH ENVIRONMENTAL TECHNOLOGY

Ref: 97-DK13/vg

April 17, 1997

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Dr. Kampbell:

This report contains the results of my GC/MSD analysis of three "floating product" samples for compound identification from Hill AFB-OU1 under service request #SF-3-240. The samples were analyzed in scan mode at m/z = 39-250 as 1:20 methylene chloride dilutions.

The analytical method was a modification of RSKSOP-124. Cool on-column injection (0.1 µl) was used with electronic pressure control set for a constant flow of 1.0 ml/min. The capillary GC column consisted of a 30m X 0.25mm Restek Stabilwax (Crossbonded Carbowax-PEG, 0.5µm film) in series with a 26m X 0.25mm J&W DB-VRX (1.4um film) plus a 4" X 0.53 mm ID uncoated capillary precolumn. A complete report detailing the acquisition method has been recorded. The analyses, for compound identification, were performed April 9, 1997.

Special Note: The samples were received on April 2, 1997, in pint "canning jars" with rubber lined lids. The rubber was in contact with the floating product and the rubber was partially dissolved. I transferred 3-5 ml of each floating product sample to a glass vial with teflon lined screw cap and the samples were stored in the freezer until analysis.

I have attached an example scan mode chromatogram, including serial expansion and a mass spectral library search report for each "floating product" sample. If you require further information, please feel free to contact me.

Sincerely,

David A. Kovacs

xc: R.L. Cosby
J.L. Seeley
G.B. Smith

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Sample Name: U1-101 ... Floating Product

Information from Data File:
File : 04089719.D
Operator : David A. Kovacs
Acquired : 9 Apr 97 4:34 am using AcqMethod SCN240
Misc Info : SR #SF-3-240, D. Kampbell, Hill AFB
Vial Number: 19
Search Libraries: C:\DATABASE\NBS75K.L Minimum Quality: 0
Unknown Spectrum: Apex minus start of peak
Integration Params: events.e

Pk#	RT	Area%	Library/ID	Ref#	CAS#	Qual
1	8.34	0.03	C:\DATABASE\NBS75K.L			
			Pentane, 2,3-dimethyl-	63432	000565-59-3	83
			Pentane, 2,3-dimethyl-	63430	000565-59-3	78
			Pentane, 2,3-dimethyl-	1597	000565-59-3	74
2	8.66	0.22	C:\DATABASE\NBS75K.L			
			Pentane, 2,2,4-trimethyl-	3093	000540-84-1	72
			Pentane, 2,2,4-trimethyl-	64220	000540-84-1	64
			Heptane, 2,2,4,6,6-pentamethyl-	68260	013475-82-6	56
3	11.58	0.07	C:\DATABASE\NBS75K.L			
			Cyclohexane, 1,4-dimethyl-, trans-			
4	12.16	0.05	C:\DATABASE\NBS75K.L			
			Cyclohexane, 1,2-dimethyl-, trans-	2673	006876-23-9	93
5	12.22	0.06	C:\DATABASE\NBS75K.L			
			Heptane, 2,5-dimethyl-			
6	13.09	0.41	C:\DATABASE\NBS75K.L			
			Cyclohexane, 1,1,4-trimethyl-			
7	13.21	0.35	C:\DATABASE\NBS75K.L			
			Octane, 2-methyl-	5142	003221-61-2	59
8	13.45	0.41	C:\DATABASE\NBS75K.L			
			Octane, 3-methyl-	65130	002216-33-3	52
9	13.75	0.09	C:\DATABASE\NBS75K.L			

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-101 ... Floating Product

Pentane, 2,2,3,4-tetramethyl- 5164 001186-53-4 50
Octane, 2,2-dimethyl- 8097 015869-87-1 42
Decane, 2,2,6-trimethyl- 18995 062237-97-2 42

10 13.94 0.05 C:\DATABASE\NBS75K.L
Cyclopentane, 1-methyl-3-(1-methyleth 4644 053771-88-3 59
Cyclohexane, octyl- 69529 001795-15-9 38
3-Undecene, 5-methyl- 14689 000000-00-0 38

11 14.16 0.77 C:\DATABASE\NBS75K.L
Nonane 65144 000111-84-2 81
Nonane 65145 000111-84-2 76
Nonane 65142 000111-84-2 68

12 14.40 0.25 C:\DATABASE\NBS75K.L
1-Ethyl-3-methylcyclohexane (c,t) 4658 003728-55-0 90
Cyclohexane, 1-ethyl-4-methyl-, trans 64954 006236-88-0 90
Cyclohexane, 1-ethyl-4-methyl-, cis- 64933 004926-78-7 86

13 14.48 0.42 C:\DATABASE\NBS75K.L
Cyclohexane, 1,1,2-trimethyl-

14 14.62 0.36 C:\DATABASE\NBS75K.L
Hexane, 2,4-dimethyl- 64212 000589-43-5 86
Hexane, 2,4-dimethyl- 64213 000589-43-5 78
Undecane, 3,7-dimethyl- 19002 017301-29-0 64

15 14.74 0.03 C:\DATABASE\NBS75K.L
Heptane, 2,2,3,4,6,6-hexamethyl- 19044 062108-32-1 50
Heptane, 3-ethyl-2-methyl- 66212 014676-29-0 50
Heptane, 3-ethyl- 65116 015869-80-4 42

16 14.81 0.56 C:\DATABASE\NBS75K.L
Octane, 3,5-dimethyl- 66229 015869-93-9 64
Nonane, 4-methyl- 66223 017301-94-9 58
Octane, 2,3-dimethyl- 8085 007146-60-3 53

17 14.90 0.25 C:\DATABASE\NBS75K.L
2H-Pyran-2-one, 6-heptyltetrahydro- 69622 000713-95-1 53
Acetamide, N-ethenyl-N-methyl- 1399 003195-78-6 47
Glycocyanidine 1373 000503-86-6 43

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-101 ... Floating Product

18 15.09 1.89 C:\DATABASE\NBS75K.L

Octane, 2,6-dimethyl-	66227	002051-30-1 90
Nonane, 3-methyl-	8075	005911-04-6 90
Octane, 3,6-dimethyl-	8109	015869-94-0 90

19 15.25 0.19 C:\DATABASE\NBS75K.L

Octane, 3,3-dimethyl-

20 15.29 0.21 C:\DATABASE\NBS75K.L

Heptane, 2,2,4,6,6-pentamethyl-	68261	013475-82-6 39
Octane, 2,6-dimethyl-	66227	002051-30-1 38
Heptane, 2,2,4,6,6-pentamethyl-	68259	013475-82-6 36

21 15.41 1.77 C:\DATABASE\NBS75K.L

Heptane, 3-ethyl-2-methyl-	66211	014676-29-0 78
Heptane, 4-(1-methylethyl)-	8084	052896-87-4 72
Heptane, 3-ethyl-2-methyl-	8080	014676-29-0 64

22 15.62 0.42 C:\DATABASE\NBS75K.L

Cyclohexane, (1-methylethyl)-	4682	000696-29-7 58

23 15.85 2.46 C:\DATABASE\NBS75K.L

Cyclopentane, 1-methyl-2-propyl-	4666	003728-57-2 47
1-Octene, 3,4-dimethyl-	7533	056728-11-1 35
Octane, 3,4-dimethyl-	8107	015869-92-8 35

24 15.94 1.79 C:\DATABASE\NBS75K.L

Nonane, 4-methyl-	66223	017301-94-9 86
Octane, 3,5-dimethyl-	66229	015869-93-9 59
Octane, 2,5-dimethyl-	66225	015869-89-3 56

25 15.98 2.25 C:\DATABASE\NBS75K.L

Nonane	65143	000111-84-2 59
Heptane, 2,4-dimethyl-	65120	002213-23-2 43
Pentane, 2-methyl-	62865	000107-83-5 38

26 16.28 2.11 C:\DATABASE\NBS75K.L

Nonane, 3-methyl-	66200	005911-04-6 87
Nonane, 3-methyl-	66201	005911-04-6 87
Nonane, 3-methyl-	66203	005911-04-6 81

27 16.46 0.12 C:\DATABASE\NBS75K.L

Hexane, 2,4-dimethyl-	3089	000589-43-5 47
Hexyl octyl ether	26415	000000-00-0 38
Hexane, 2,2,3,3-tetramethyl-	8106	013475-81-5 35

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: UI-101 ... Floating Product

28 16.55 0.22 C:\DATABASE\NBS75K.L
Cyclohexane, 2-ethyl-1,3-dimethyl- 7532 007045-67-2 68
Cyclooctane, butyl- 14729 016538-93-5 53
Cyclohexane, 1-ethyl-2,4-dimethyl- 7575 061142-69-6 50

29 16.67 0.20 C:\DATABASE\NBS75K.L
Cyclohexane, 1-ethyl-2,3-dimethyl- 7562 007058-05-1 91
Cyclohexane, diethyl- 7603 001331-43-7 90
Cyclooctane, (1-methylpropyl)- 14711 016538-89-9 78

30 16.77 0.62 C:\DATABASE\NBS75K.L
Cyclohexane, 1-ethyl-1,3-dimethyl-, t 7539 062238-29-3 72
Cyclohexane, 1-ethyl-1,4-dimethyl-, c 7547 062238-30-6 72
Cyclohexane, 1-ethyl-2,4-dimethyl- 7575 061142-69-6 72

31 16.96 1.79 C:\DATABASE\NBS75K.L
2-Octene, 2,6-dimethyl- 66054 004057-42-5 90
2-Octene, 2,6-dimethyl- 7538 004057-42-5 76
1-Hexene, 3,3,5-trimethyl- 64967 013427-43-5 58

32 17.25 1.75 C:\DATABASE\NBS75K.L
Decane 66205 000124-18-5 93
Decane 66206 000124-18-5 64
Decane 66208 000124-18-5 62

33 17.36 1.41 C:\DATABASE\NBS75K.L
Cyclohexane, 1-methyl-4-(1-methylethy 66080 001678-82-6 50
Cyclopentane, 1,2-dimethyl-3-(1-methy 7606 000489-20-3 50

34 17.48 1.86 C:\DATABASE\NBS75K.L
Cyclohexane, 1-methyl-3-propyl- 7596 004291-80-9 64
Cyclohexane, 1-methyl-2-propyl- 7590 004291-79-6 64
Cyclohexane, 1,4-dimethyl-, cis- 64036 000624-29-3 64

35 17.63 2.58 C:\DATABASE\NBS75K.L
Dotriacontane 74490 000544-85-4 50
Undecane, 2,9-dimethyl- 18994 017301-26-7 50
Nonadecane 37469 000629-92-5 47

36 17.82 1.55 C:\DATABASE\NBS75K.L
3-Hexanone, 2,4-dimethyl- 65053 018641-70-8 64
Decane, 2,4-dimethyl- 15360 002801-84-5 53
Heptane, 2-methyl- 3092 000592-27-8 53

37 17.94 4.70 C:\DATABASE\NBS75K.L

Note: Identified compounds in bold print have been verified with actual standard

Decane, 4-methyl- 67323 002847-72-5 94
Decane, 4-methyl- 11615 002847-72-5 91
Octane, 3,3-dimethyl- 8088 004110-44-5 86

38 18.11 1.43 C:\DATABASE\NBS75K.L
Cyclohexane, 1-methyl-2-propyl- 66075 004291-79-6 56
Cyclohexane, 1-methyl-2-propyl- 66072 004291-79-6 53
Cyclohexane, 1,3-dimethyl-, cis- 2677 000638-04-0 50

39 18.20 1.30 C:\DATABASE\NBS75K.L
Octane, 6-ethyl-2-methyl- 11609 062016-19-7 64
Nonane, 2,3-dimethyl- 11613 002884-06-2 47
Octane, 3,3-dimethyl- 66216 004110-44-5 47

40 18.41 1.65 C:\DATABASE\NBS75K.L
Hexatriacontane 74636 000630-06-8 64
Hexatriacontane 59136 000630-06-8 59
Tetratetracontane 61068 007098-22-8 59

41 18.51 0.50 C:\DATABASE\NBS75K.L
Cycloheptene, 1-(1,1-dimethylethoxy)- 14668 049565-07-3 23
2-Propyl-1-pentanol 5527 058175-57-8 22
Nonane, 4-methyl-5-propyl- 19021 062185-55-1 17

42 18.62 1.36 C:\DATABASE\NBS75K.L
Decane, 3-methyl- 67315 013151-34-3 87
Dodecane, 3-methyl- 69025 017312-57-1 72
Decane, 2,4,6-trimethyl- 19032 062108-27-4 72

43 18.71 0.35 C:\DATABASE\NBS75K.L
1-Undecene 67190 000821-95-4 45
Cyclotetradecane 69524 000295-17-0 39
Pyridine, 3-fluoro- 63151 000372-47-4 38

44 18.83 0.72 C:\DATABASE\NBS75K.L
Cyclohexane, 1,2,4-trimethyl- 4649 002234-75-5 72
1-Hexene, 3,3,5-trimethyl- 4683 013427-43-5 58
Cyclooctane, butyl- 14729 016538-93-5 50

45 18.92 0.55 C:\DATABASE\NBS75K.L
Tridecane, 6-methyl- 22532 013287-21-3 45
Decane, 2,6,6-trimethyl- 19023 062108-24-1 42
Octadecane, 6-methyl- 37465 010544-96-4 36

46 19.05 1.09 C:\DATABASE\NBS75K.L
1-Undecene, 4-methyl- 14797 074630-39-0 50

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-101 ... Floating Product

Nonane, 5-(1-methylpropyl)- 19016 062185-54-0 35
Decane, 3-methyl- 67315 013151-34-3 35

47 19.21 3.95 C:\DATABASE\NBS75K.L
Decane, 5-methyl- 11605 013151-35-4 90
Decane, 5-methyl- 67316 013151-35-4 72
Heptane, 3-ethyl-2-methyl- 66212 014676-29-0 50

48 19.35 2.82 C:\DATABASE\NBS75K.L
Decane, 4-methyl- 67324 002847-72-5 50
1,2-Cyclohexanediol, 1-methyl-, trans 5409 019534-08-8 47
Decane, 4-methyl- 11615 002847-72-5 45

49 19.43 3.31 C:\DATABASE\NBS75K.L
Decane, 2-methyl- 67320 006975-98-0 90
Decane, 2-methyl- 67322 006975-98-0 72
Dodecane 68250 000112-40-3 72

50 19.64 1.25 C:\DATABASE\NBS75K.L
2-Hexanone, 5-methyl-3-methylene- 4540 001187-87-7 49
Cyclohexane, 1,1,2-trimethyl- 4685 007094-26-0 49
4-Octene, 2,3,6-trimethyl- 11063 063830-65-9 46

51 19.74 2.63 C:\DATABASE\NBS75K.L
Decane, 3-methyl- 67314 013151-34-3 94
Decane, 3-methyl- 67315 013151-34-3 90
Octane, 3-ethyl-2,7-dimethyl- 15359 062183-55-5 78

52 19.90 0.35 C:\DATABASE\NBS75K.L
Undecane, 4-ethyl- 19022 017312-59-3 50
Decane 66207 000124-18-5 50
Heptane, 2,4-dimethyl- 65120 002213-23-2 47

53 20.12 0.96 C:\DATABASE\NBS75K.L
Cyclohexane, 1,2,4-trimethyl- 4649 002234-75-5 80
4-Octene, 2,3,7-trimethyl-, [s-(E)]- 11091 052763-13-0 64
Cyclohexane, 1-ethyl-2-propyl- 11062 062238-33-9 59

54 20.24 0.45 C:\DATABASE\NBS75K.L
1(2H)-Naphthalenone, octahydro-8a-met 14100 000770-62-7 45
5,5-Dimethyl-1,3-hexadiene 2323 001515-79-3 38
trans-3,5-Dimethylcyclohexene 2357 056021-63-7 38

55 20.40 0.71 C:\DATABASE\NBS75K.L
Bicyclo[4.1.0]heptane, 3,7,7-trimethy 7067 000554-59-6 42
4-Methyl-1,3-heptadiene (c,t) 2395 017603-57-5 30

Note: Identified compounds in bold print have been verified with actual standard

3,5-Dimethylcyclohexene 2315 000000-00-0 30

56 20.64 0.74 C:\DATABASE\NBS75K.L
Cyclopentane, 1-methyl-3-(2-methylpro 7554 029053-04-1 47
Dodecane 68249 000112-40-3 35
Tridecane 69019 000629-50-5 35

57 20.76 1.10 C:\DATABASE\NBS75K.L
Undecane 67317 001120-21-4 95
Undecane 67318 001120-21-4 94
Tridecane 69019 000629-50-5 90

58 20.89 2.20 C:\DATABASE\NBS75K.L
1-Ethyl-2,2,6-trimethylcyclohexane 11030 000000-00-0 58
Cyclopentanone, 2-methyl-4-(2-methylp 10992 069770-96-3 53
Cyclopentane, 2-isopropyl-1,3-dimethy 7525 032281-85-9 53

59 21.05 1.53 C:\DATABASE\NBS75K.L
Cyclohexane, 1-ethyl-4-methyl-, trans 64954 006236-88-0 59
Cyclohexane, 1-ethyl-4-methyl-, cis- 64933 004926-78-7 45
Cyclohexane, 1-ethyl-1-methyl- 4665 004926-90-3 45

60 21.27 2.32 C:\DATABASE\NBS75K.L
Undecane, 5,7-dimethyl- 19013 017312-83-3 80
Undecane, 5-methyl- 15363 001632-70-8 72
Dodecane 68252 000112-40-3 72

61 21.38 1.71 C:\DATABASE\NBS75K.L
Naphthalene, decahydro-, trans- 65957 000493-02-7 93
Naphthalene, decahydro- 7045 000091-17-8 91
Naphthalene, decahydro- 65933 000091-17-8 91

62 21.51 1.97 C:\DATABASE\NBS75K.L
Undecane, 2-methyl- 15356 007045-71-8 53
Dodecane, 1-iodo- 41998 004292-19-7 49
Undecane, 4,7-dimethyl- 19020 017301-32-5 46

63 21.61 0.56 C:\DATABASE\NBS75K.L
Thiophene, 2-pentyl- 67064 004861-58-9 9
2-Fluoropyridine 1161 000372-48-5 9
Cyclohexane, 1-ethyl-2-methyl-, cis- 4648 004923-77-7 9

64 21.71 1.18 C:\DATABASE\NBS75K.L
Decane, 3-methyl- 11604 013151-34-3 59
Undecane, 2,8-dimethyl- 18991 017301-25-6 53
Undecane, 2,3-dimethyl- 18990 017312-77-5 53

Note: Identified compounds in bold print have been verified with actual standard

65 21.92 1.07 C:\DATABASE\NBS75K.L
Hexyl octyl ether 26415 000000-00-0 50
Decane 66206 000124-18-5 46
Tetradecane, 2,5-dimethyl- 29256 056292-69-4 38

66 22.14 1.43 C:\DATABASE\NBS75K.L
Benzene, 1,2,4-trimethyl- 64578 000095-63-6 95
Benzene, 1,2,4-trimethyl- 64577 000095-63-6 94
Benzene, 1,2,3-trimethyl- 64573 000526-73-8 94

67 22.28 0.84 C:\DATABASE\NBS75K.L
Benzene, 1-methyl-3-(1-methylethyl)- 65579 000535-77-3 68

68 22.51 0.23 C:\DATABASE\NBS75K.L
Undecane, 4-ethyl- 19022 017312-59-3 64
Octane 64208 000111-65-9 53
Undecane, 2,4-dimethyl- 18999 017312-80-0 50

69 22.68 1.62 C:\DATABASE\NBS75K.L
Undecane, 5-methyl- 15363 001632-70-8 59
2,6-Dimethyldecane 15357 013150-81-7 58
Undecane, 5-methyl- 68258 001632-70-8 53

70 22.84 0.95 C:\DATABASE\NBS75K.L
Undecane, 4-methyl- 15354 002980-69-0 87
Undecane, 4-methyl- 68256 002980-69-0 83
Tridecane, 6-methyl- 22532 013287-21-3 64

71 23.03 1.33 C:\DATABASE\NBS75K.L
Cyclohexane, pentyl- 11044 004292-92-6 91
Cyclohexane, pentyl- 67185 004292-92-6 91
Cyclohexane, butyl- 7540 001678-93-9 78

72 23.19 0.89 C:\DATABASE\NBS75K.L
Pulegone 66995 000089-82-7 68
Pulegone 66992 000089-82-7 59
Cyclohexanone, 2-methyl-5-(1-methylet 10308 007764-50-3 53

73 23.26 1.16 C:\DATABASE\NBS75K.L
Decane, 3,8-dimethyl- 15351 017312-55-9 78
Undecane, 3-methyl- 15362 001002-43-3 78
Dodecane, 3-methyl- 69025 017312-57-1 72

74 23.47 0.60 C:\DATABASE\NBS75K.L

Note: Identified compounds in bold print have been verified with actual standard

Benzene, 1-methyl-4-propyl- 6216 001074-55-1 87
Benzene, 1-methyl-2-propyl- 65583 001074-17-5 80
Benzene, 1-methyl-2-propyl- 6230 001074-17-5 80

75 23.63 0.21 C:\DATABASE\NBS75K.L
Benzene, butyl- 65550 000104-51-8 72
Benzene, butyl- 65548 000104-51-8 72
Benzene, (2-methylpropyl)- 65547 000538-93-2 64

76 23.80 1.28 C:\DATABASE\NBS75K.L
Benzene, 1,2,3-trimethyl- 64576 000526-73-8 70

77 23.95 0.64 C:\DATABASE\NBS75K.L
Naphthalene, decahydro-2-methyl- 67008 002958-76-1 93
Naphthalene, decahydro-2-methyl- 67009 002958-76-1 89
1,4-Pentadiene, 3-propyl- 2388 000996-83-8 49

78 24.11 0.22 C:\DATABASE\NBS75K.L
Benzene, 1,2-diethyl- 6213 000135-01-3 83
Benzene, 1,2-diethyl- 65562 000135-01-3 72

79 24.18 0.13 C:\DATABASE\NBS75K.L
Cyclohexanone, 2-methyl-5-(1-methylet 66973 005948-04-9 64
Cyclohexanone, 2-methyl-5-(1-methylet 10308 007764-50-3 59
Spiro[3.5]nonan-1-one, 5-methyl-, tra 10377 065147-56-0 50

80 24.32 0.63 C:\DATABASE\NBS75K.L
Benzene, 1-methyl-2-n-propyl- 65583 001074-17-5 93
Benzene, 1-methyl-2-n-propyl- 6230 001074-17-5 93

81 24.49 0.15 C:\DATABASE\NBS75K.L
4-Undecene, 4-methyl-, (Z)- 14768 074630-57-2 55
Cyclododecane 68128 000294-62-2 46
6-Dodecene, (E)- 14720 007206-17-9 46

82 24.65 1.14 C:\DATABASE\NBS75K.L
Dodecane, 6-methyl- 19006 006044-71-9 90
Undecane, 2,6-dimethyl- 69033 017301-23-4 70
Undecane, 3,6-dimethyl- 19000 017301-28-9 50

83 24.73 0.58 C:\DATABASE\NBS75K.L
Benzene, 1,3-dimethyl-2-ethyl-

84 24.84 0.24 C:\DATABASE\NBS75K.L
Heptane, 4-ethyl-2,2,6,6-tetramethyl- 19042 062108-31-0 38
Undecane, 2,2-dimethyl- 19038 017312-64-0 38

Note: Identified compounds in bold print have been verified with actual standard

Hexane, 2,2,4-trimethyl- 65103 016747-26-5 38

85 24.92 0.73 C:\DATABASE\NBS75K.L
Benzene, 4-ethyl-1,2-dimethyl-

86 25.17 0.69 C:\DATABASE\NBS75K.L
Benzene, 1-methyl-4-(1-methylethyl)- 65535 000099-87-6 95
Benzene, 1-methyl-3-(1-methylethyl)- 65579 000535-77-3 95
Benzene, 1-ethyl-2,4-dimethyl- 6221 000874-41-9 94

87 25.27 0.26 C:\DATABASE\NBS75K.L
Benzene, 1-(1,1-dimethylethyl)-3-methyl- 9395 001075-38-3 72

88 25.42 0.06 C:\DATABASE\NBS75K.L
Naphthalene, decahydro-2-methyl- 67008 002958-76-1 50
Bicyclo[3.1.1]heptane, 2,6,6-trimethy 7100 000473-55-2 46
Dodecanal 69002 000112-54-9 43

89 25.58 0.27 C:\DATABASE\NBS75K.L
Carbamic acid, (.alpha.-methylbenzyl) 41370 032589-48-3 25
Benzene, (1,2-dimethylpropyl)- 9366 004481-30-5 25
Benzene, (1,2-dimethylpropyl)- 66608 004481-30-5 18

90 25.67 0.19 C:\DATABASE\NBS75K.L
Benzene, (2-methyl-2-propenyl)- 65427 003290-53-7 91
Benzene, (1-methyl-1-propenyl)-, (Z)- 5904 000767-99-7 87
Benzene, (2-methyl-2-propenyl)- 5895 003290-53-7 81

91 25.73 0.17 C:\DATABASE\NBS75K.L
Benzene, 1-methyl-2-(1-methylethyl)- 6228 000527-84-4 86
Benzene, 1-methyl-3-(1-methylethyl)- 6225 000535-77-3 86
Benzene, 1-methyl-4-(1-methylethyl)- 6201 000099-87-6 86

92 25.89 0.14 C:\DATABASE\NBS75K.L
1H-Indene, 2,3-dihydro-1,1-dimethyl- 8945 004912-92-9 94
1H-Indene, 2,3-dihydro-1,3-dimethyl- 8968 004175-53-5 91
Benzene, (1,1-dimethyl-2-propenyl)- 8972 018321-36-3 86

93 26.04 0.34 C:\DATABASE\NBS75K.L
Benzene, 1-methyl-2-(2-propenyl)- 65419 001587-04-8 50
Benzene, 2-ethenyl-1,3-dimethyl- 5883 002039-90-9 45
Benzene, (2-methyl-1-propenyl)- 65428 000768-49-0 43

94 26.14 0.30 C:\DATABASE\NBS75K.L
Nonane, 5-butyl- 69028 017312-63-9 35

Note: Identified compounds in bold print have been verified with actual standard

Ethanone, 1-(3-ethylcyclobutyl)- 4560 056335-71-8 30
Pentane, 3-ethyl-2-methyl- 3098 000609-26-7 27

95 26.30 0.22 C:\DATABASE\NBS75K.L
2,6-Nonadienal, (E,Z)- 65916 000557-48-2 38
Trifluoroacetyl-citronellol 34254 000000-00-0 35
Triallylsilane 10280 000000-00-0 30

96 26.44 0.48 C:\DATABASE\NBS75K.L
Benzene, 1,2-dimethyl-3-ethyl-

97 26.50 0.21 C:\DATABASE\NBS75K.L
Benzene, 1,4-dimethyl-2-(2-methylprop 67717 055669-88-0 40
Benzene, (1,1-dimethylpropyl)- 66629 002049-95-8 12
Pyrazine, isopropenyl- 3734 034413-32-6 12

98 26.62 0.54 C:\DATABASE\NBS75K.L
Decane, 2,6,7-trimethyl- 19027 062108-25-2 83
Nonane, 3-methyl- 8075 005911-04-6 78
Octane, 2,6-dimethyl- 8103 002051-30-1 72

99 26.78 0.25 C:\DATABASE\NBS75K.L
Benzene, 2,4-dimethyl-1-(1-methylethy 9376 004706-89-2 87
Benzene, 1,4-diethyl-2-methyl- 9393 013632-94-5 87
Benzene, ethyl-1,2,4-trimethyl- 9394 054120-62-6 83

100 26.86 0.39 C:\DATABASE\NBS75K.L
Benzene, 1,4-diethyl- 65560 000105-05-5 74
Benzene, 1-methyl-2-(1-methylethyl)- 65581 000527-84-4 64
Benzene, 1-methyl-2-(1-methylethyl)- 6228 000527-84-4 64

101 27.14 0.52 C:\DATABASE\NBS75K.L
Benzene, 1,2,4,5-tetramethyl- 65576 000095-93-2 94
Benzene, 1,2,3,4-tetramethyl- 65541 000488-23-3 91
Benzene, 1-methyl-4-(1-methylethyl)- 65534 000099-87-6 91

102 27.25 0.09 C:\DATABASE\NBS75K.L
Acetic acid, [(1,1-dimethylethyl)thio 9177 024310-22-3 16
1-Hexanol, 3,5,5-trimethyl- 66355 003452-97-9 14
t-Butyl ethyl malonate 19762 000000-00-0 10

103 27.32 0.28 C:\DATABASE\NBS75K.L
Benzene, (1,1-dimethylpropyl)- 66630 002049-95-8 47
Benzene, 1-ethyl-2,4-dimethyl- 6221 000874-41-9 43
Benzene, 1-methyl-3-(1-methylethyl)- 65579 000535-77-3 43

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-101 ... Floating Product

104 27.45 0.10 C:\DATABASE\NBS75K.L
Benzene, pentamethyl- 66637 000700-12-9 43
Benzene, 1,4-dimethyl-2-(1-methylethy 9382 004132-72-3 43
Benzene, 1-ethyl-4-(1-methylethyl)- 66622 004218-48-8 43

105 27.68 0.27 C:\DATABASE\NBS75K.L
Benzene, (1,1-dimethylpropyl)- 66630 002049-95-8 58
Benzene, 1,2,3,5-tetramethyl- 65571 000527-53-7 53
Benzene, 1,2,3,4-tetramethyl- 65541 000488-23-3 53

106 27.76 0.23 C:\DATABASE\NBS75K.L
Benzene, (1-methylbutyl)- 66610 002719-52-0 38
Benzene, (1-methylbutyl)- 9368 002719-52-0 38
Benzene, (1,2-dimethylpropyl)- 9366 004481-30-5 37

107 27.84 0.23 C:\DATABASE\NBS75K.L
Benzene, (1-chloroethyl)methyl- 10742 072403-15-7 27
6-Azaspiro[2.5]octa-4,7-diene, 6-acet 16946 034995-43-2 16
Benzene, 2,4-dimethyl-1-(1-methylethy 9376 004706-89-2 12

108 28.02 0.35 C:\DATABASE\NBS75K.L
Benzene, 2-ethyl-1,3-dimethyl- 65532 002870-04-4 87
Benzene, (1,1-dimethylpropyl)- 9392 002049-95-8 87
Benzene, 1-ethyl-2,4-dimethyl- 6221 000874-41-9 87

109 28.28 0.18 C:\DATABASE\NBS75K.L
Undecane, 3,5-dimethyl- 19003 017312-81-1 72
Undecane, 5-ethyl- 19036 017453-94-0 72
Undecane, 3,6-dimethyl- 19000 017301-28-9 64

110 28.33 0.24 C:\DATABASE\NBS75K.L
Azulene, 1,2,3,3a-tetrahydro- 5886 033877-87-1 38
Benzene, 2-ethenyl-1,4-dimethyl- 5879 002039-89-6 30
2,3-Dihydro-1-methylindene 5901 027133-93-3 30

111 28.79 0.45 C:\DATABASE\NBS75K.L
Benzene, 1,2,4,5-tetramethyl- 65576 000095-93-2 97
Benzene, 1,2,3,5-tetramethyl- 6220 000527-53-7 95
Benzene, 1,2,3,4-tetramethyl- 6202 000488-23-3 94

112 28.96 0.20 C:\DATABASE\NBS75K.L
Octane, 6-ethyl-2-methyl- 11609 062016-19-7 50
Undecane, 4-methyl- 15354 002980-69-0 47
Decane, 3,3,8-trimethyl- 19033 062338-16-3 43

113 29.13 0.31 C:\DATABASE\NBS75K.L

Note: Identified compounds in bold print have been verified with actual standard

1H-Indene, 2,3-dihydro-5-methyl- 5885 000874-35-1 70
Benzene, 2-ethenyl-1,3-dimethyl- 5883 002039-90-9 62
Benzene, 1-methyl-2-(2-propenyl)- 65419 001587-04-8 62

114 29.36 0.26 C:\DATABASE\NBS75K.L
Benzene, 1-(1,1-dimethylethyl)-3-meth 66631 001075-38-3 43
1,5,6,7-Tetramethylbicyclo[3,2,o]hept 9363 000000-00-0 43
Benzene, 1,4-dimethyl-2-(1-methylethy 9382 004132-72-3 43

115 29.49 0.20 C:\DATABASE\NBS75K.L
Benzene, diethylmethyl- 9372 025550-13-4 38
Benzene, 2,4-diethyl-1-methyl- 9384 001758-85-6 25
Benzene, 1-ethyl-4-(1-methylethyl)- 9383 004218-48-8 25

116 29.67 0.23 C:\DATABASE\NBS75K.L
1H-Indene, 2,3-dihydro-1,2-dimethyl- 8947 017057-82-8 90
1H-Indene, 2,3-dihydro-1,3-dimethyl- 8968 004175-53-5 90
1H-Indene, 2,3-dihydro-5,6-dimethyl- 8944 001075-22-5 89

117 29.82 0.13 C:\DATABASE\NBS75K.L
Benzene, 4-(2-butenyl)-1,2-dimethyl-, 12581 054340-86-2 72
Benzene, 1-(1-methylethenyl)-2-(1-met 12568 005557-93-7 68
1H-Indene, 2,3-dihydro-1,1,5-trimethy 12567 040650-41-7 64

118 29.92 0.24 C:\DATABASE\NBS75K.L
Naphthalene, 1,2,3,4-tetrahydro- 65416 000119-64-2 60
Naphthalene, 1,2,3,4-tetrahydro- 65415 000119-64-2 60
Naphthalene, 1,2,3,4-tetrahydro- 65414 000119-64-2 60

119 30.17 0.43 C:\DATABASE\NBS75K.L
Dodecane, 2,7,10-trimethyl- 26005 074645-98-0 86
Dodecane, 2,6,10-trimethyl- 25995 003891-98-3 80
Nonane, 2-methyl-5-propyl- 19052 031081-17-1 72

120 30.43 0.03 C:\DATABASE\NBS75K.L
Octane, 2,4,6-trimethyl- 11606 062016-37-9 47
Pentadecane 70274 000629-62-9 47
Tridecane 69020 000629-50-5 47

121 30.51 0.09 C:\DATABASE\NBS75K.L
2,5-Dimethyl-6,7-dihydro-(5H)-cyclope 9298 000000-00-0 58
Benzene, ethyl-1,2,4-trimethyl- 9394 054120-62-6 58
Benzene, pentamethyl- 66638 000700-12-9 52

122 31.09 0.10 C:\DATABASE\NBS75K.L
Decane, 6-ethyl-2-methyl- 19010 062108-21-8 59

Note: Identified compounds in bold print have been verified with actual standard

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Undecane, 5-ethyl- 19036 017453-94-0 53
Decane, 2,3,7-trimethyl- 19048 062238-13-5 50

123 31.27 0.06 C:\DATABASE\NBS75K.L
Naphthalene, 1,2,3,4-tetrahydro-2-met 66496 003877-19-8 43
2-Pentanone, 5-phenyl- 12997 002235-83-8 35
Cartap hydrochloride 38219 015263-52-2 32

124 31.65 0.04 C:\DATABASE\NBS75K.L
Cyclohexane, 1-methyl-4-(1-methylethy 66076 006069-98-3 25
1-Methyl-4-(1-methylethyl)-cyclohexan 7605 000099-82-1 22
Cyclohexane, 1-methyl-4-(1-methylethy 7600 001678-82-6 22

125 32.60 0.07 C:\DATABASE\NBS75K.L
1-Octanol, 2-butyl- 69109 003913-02-8 47
Pentatriacontane 58743 000630-07-9 38
Hexatriacontane 74635 000630-06-8 38

126 32.91 0.19 C:\DATABASE\NBS75K.L
Heptadecane 71191 000629-78-7 86
Eicosane 72323 000112-95-8 86
Tetradecane 69661 000629-59-4 80

127 33.05 0.02 C:\DATABASE\NBS75K.L
1-Hexacosanol 52385 000506-52-5 64
Octadecane, 1-(ethenyloxy)- 42184 000930-02-9 50
Tridecane, 6-methyl- 22532 013287-21-3 38

128 34.45 0.06 C:\DATABASE\NBS75K.L
Decahydro-4,4,8,9,10-pentamethylnapht 24990 000000-00-0 53
Cyclohexane, 1-(cyclohexylmethyl)-2-e 25005 054934-92-8 35
1-Decene 66065 000872-05-9 30

129 34.94 0.14 C:\DATABASE\NBS75K.L
Naphthalene 65151 000091-20-3 97
Naphthalene 65150 000091-20-3 97
Naphthalene 65149 000091-20-3 97

130 38.28 0.07 C:\DATABASE\NBS75K.L
Naphthalene, 2-methyl- 66237 000091-57-6 95

131 38.59 0.08 C:\DATABASE\NBS75K.L
Undecane, 5-ethyl- 19036 017453-94-0 78
Heptadecane 32063 000629-78-7 72
Tridecane, 2-methyl- 69663 001560-96-9 64

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-101 ... Floating Product

132 39.21 0.04 C:\DATABASE\NBS75K.L

Naphthalene, 1-methyl-	66233	000090-12-0	93
Naphthalene, 1-methyl-	66234	000090-12-0	93
Naphthalene, 1-methyl-	66230	000090-12-0	93

133 40.19 0.22 C:\DATABASE\NBS75K.L

Tridecane, 5-propyl-	29268	055045-11-9	90
Pentadecane, 2,6,10,14-tetramethyl-	71951	001921-70-6	90
Heptadecane, 2,6-dimethyl-	37466	054105-67-8	83

134 43.14 0.17 C:\DATABASE\NBS75K.L

Hexadecane, 2,6,10,14-tetramethyl-	72328	000638-36-8	90
Heptadecane, 2,6,10,14-tetramethyl-	42200	018344-37-1	86
Heptadecane	71193	000629-78-7	83

135 50.43 0.12 C:\DATABASE\NBS75K.L

Docosane	44318	000629-97-0	76
Hexatriacontane	74635	000630-06-8	74
Nonadecane, 2-methyl-	72322	001560-86-7	72

Thu Apr 10 12:59:08 1997

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-130 ... Floating Product

Information from Data File:
File : 04089720.D
Operator : David A. Kovacs
Acquired : 9 Apr 97 5:48 am using AcqMethod SCN240
Sample Name: U1-130 1/20 Product
Misc Info : SR #SF-3-240 D. Kampbell
Vial Number: 20
Search Libraries: C:\DATABASE\NBS75K.L Minimum Quality: 0
Unknown Spectrum: Apex minus start of peak
Integration Params: events.e

Pk#	RT	Area%	Library/ID	Ref#	CAS#	Qual
1	8.34	0.10	C:\DATABASE\NBS75K.L			
			Pentane, 2,3-dimethyl-	63430	000565-59-3	91
			Pentane, 2,3-dimethyl-	63431	000565-59-3	86
			Pentane, 2,3-dimethyl-	63432	000565-59-3	86
2	8.52	0.05	C:\DATABASE\NBS75K.L			
			Hexane, 2,2-dimethyl-	64217	000590-73-8	56
			Carbonic acid, bis(2-methylpropyl) es	16195	000539-92-4	40
			Decane, 2,2,4-trimethyl-	18998	062237-98-3	40
3	8.65	0.46	C:\DATABASE\NBS75K.L			
			Pentane, 2,2,4-trimethyl-	64220	000540-84-1	78
			Hexane, 2,2-dimethyl-	64216	000590-73-8	64
			Hexane, 2,2-dimethyl-	64217	000590-73-8	56
4	8.95	0.07	C:\DATABASE\NBS75K.L			
			Heptane	63438	000142-82-5	91
			Heptane	63440	000142-82-5	90
			Heptane	1600	000142-82-5	87
5	11.08	0.18	C:\DATABASE\NBS75K.L			
			Hexane, 2,2,5-trimethyl-	65129	003522-94-9	78
			Hexane, 2,2,5-trimethyl-	65128	003522-94-9	78
			Hexane, 2,2,5-trimethyl-	65127	003522-94-9	72
6	11.58	0.31	C:\DATABASE\NBS75K.L			
			Octane	3084	000111-65-9	53
			Octane	64208	000111-65-9	52
			Octane	64207	000111-65-9	52
7	11.98	0.06	C:\DATABASE\NBS75K.L			
			Heptane, 3-methyl-	3099	000589-81-1	64
			Hexane, 2,3,5-trimethyl-	5161	001069-53-0	59

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-130 ... Floating Product

Hexane, 1-propoxy- 8516 053685-78-2 59

8 12.17 0.04 C:\DATABASE\NBS75K.L
Cyclohexane, 1,2-dimethyl-, trans- 2673 006876-23-9 81

9 12.22 0.10 C:\DATABASE\NBS75K.L
Decane, 2-methyl- 67320 006975-98-0 78
Hexadecane 70789 000544-76-3 78
Decane, 2-methyl- 67322 006975-98-0 64

10 13.09 0.36 C:\DATABASE\NBS75K.L
Cyclohexane, 1,1,4-trimethyl-

11 13.21 0.29 C:\DATABASE\NBS75K.L
Octane, 2-methyl-

12 13.45 0.35 C:\DATABASE\NBS75K.L
Octane, 3-methyl- 65130 002216-33-3 52

13 13.63 0.04 C:\DATABASE\NBS75K.L
Decane, 2,2,8-trimethyl- 19012 062238-01-1 78
Heptane, 2,2,3,4,6,6-hexamethyl- 19044 062108-32-1 64
Decane, 2,2,6-trimethyl- 18995 062237-97-2 59

14 13.74 0.14 C:\DATABASE\NBS75K.L
Decane, 2,2,5-trimethyl- 18992 062237-96-1 64
Heptane, 4-ethyl-2,2,6,6-tetramethyl- 19042 062108-31-0 64
Decane, 2,2,6-trimethyl- 18995 062237-97-2 64

15 14.16 1.04 C:\DATABASE\NBS75K.L
Nonane 65145 000111-84-2 91
Nonane 65142 000111-84-2 91

16 14.40 0.11 C:\DATABASE\NBS75K.L
1-Ethyl-3-methylcyclohexane (c,t) 4658 003728-55-0 87
Cyclohexane, 1-methyl-2-propyl- 7590 004291-79-6 78
3,5-Dimethyl-3-heptene 4628 059643-68-4 72

17 14.47 0.17 C:\DATABASE\NBS75K.L
Cyclohexane, 1,1,2-trimethyl- 4685 007094-26-0 81
Cyclohexane, 1,1,2-trimethyl- 64970 007094-26-0 81

18 14.63 0.16 C:\DATABASE\NBS75K.L
Heptane, 3-ethyl-2-methyl- 8080 014676-29-0 86
Decane, 2,5,6-trimethyl- 19019 062108-23-0 72
Octane, 3-methyl- 5150 002216-33-3 59

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-130 ... Floating Product

19 14.81 0.16 C:\DATABASE\NBS75K.L
Octane, 3,5-dimethyl- 8108 015869-93-9 59
Octane, 2,5-dimethyl- 8101 015869-89-3 58

20 14.90 0.08 C:\DATABASE\NBS75K.L
Octane, 2,7-dimethyl- 66209 001072-16-8 33
Octane, 2,7-dimethyl- 8078 001072-16-8 25
Homopiperazine 1492 000505-66-8 25

21 15.09 0.69 C:\DATABASE\NBS75K.L
Octane, 3,3-dimethyl-

22 15.29 0.11 C:\DATABASE\NBS75K.L
Octane, 3,6-dimethyl- 8109 015869-94-0 81
Nonane, 3-methyl- 8075 005911-04-6 72
Nonane, 3-methyl- 66202 005911-04-6 59

23 15.41 0.34 C:\DATABASE\NBS75K.L
Heptane, 3-ethyl-2-methyl- 66212 014676-29-0 59
Heptane, 3-ethyl-2-methyl- 8080 014676-29-0 53
Heptane, 4-(1-methylethyl)- 8084 052896-87-4 50

24 15.63 0.10 C:\DATABASE\NBS75K.L
Cyclohexane, (1-methylethyl)- 4682 000696-29-7 87

25 15.92 2.07 C:\DATABASE\NBS75K.L
Nonane, 2-methyl-

26 16.28 0.54 C:\DATABASE\NBS75K.L
Nonane, 3-methyl- 66201 005911-04-6 91
Nonane, 3-methyl- 66200 005911-04-6 90
Octane, 3,6-dimethyl- 8109 015869-94-0 87

27 16.42 0.13 C:\DATABASE\NBS75K.L
Pentane, 3-methyl- 62868 000096-14-0 39
Pentane, 3-methyl- 62867 000096-14-0 39
Pentane, 3-methyl- 734 000096-14-0 9

28 16.77 0.06 C:\DATABASE\NBS75K.L
Cyclohexane, 1-ethyl-2,3-dimethyl- 7562 007058-05-1 72
Cyclohexane, 1,3,5-trimethyl-, (1.alp 64953 001795-27-3 64
Cyclohexane, 1-ethyl-2,4-dimethyl- 7575 061142-69-6 64

29 16.96 0.33 C:\DATABASE\NBS75K.L
2-Octene, 2,6-dimethyl- 66054 004057-42-5 76

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-130 ... Floating Product

2-Octene, 2,6-dimethyl- 7538 004057-42-5 68
1-Hexene, 3,3,5-trimethyl- 64967 013427-43-5 58

30 17.25 2.66 C:\DATABASE\NBS75K.L
Decane 66205 000124-18-5 95
Decane 66208 000124-18-5 95
Decane 66204 000124-18-5 90

31 17.35 0.36 C:\DATABASE\NBS75K.L
Cyclohexane, 1-methyl-4-(1-methylethy 66078 006069-98-3 52
m-Menthane, (1S,3S)-(+)- 7550 013837-67-7 50
1-Methyl-4-(1-methylethyl)-cyclohexan 7605 000099-82-1 46

32 17.49 0.57 C:\DATABASE\NBS75K.L
Benzene, 1,3-dimethyl- 63695 000108-38-3 92 (m-xylene)

33 17.63 0.52 C:\DATABASE\NBS75K.L
Decane, 2,5,6-trimethyl- 19019 062108-23-0 50
Dodecane, 3-methyl- 69025 017312-57-1 50
Octane, 2,4,6-trimethyl- 11606 062016-37-9 47

34 17.94 2.02 C:\DATABASE\NBS75K.L
Decane, 4-methyl- 67323 002847-72-5 91
Decane, 4-methyl- 11615 002847-72-5 90
Nonane, 2,6-dimethyl- 11598 017302-28-2 90

35 18.10 0.23 C:\DATABASE\NBS75K.L
t-1-methyl-2-propylcyclohexane

36 18.21 0.32 C:\DATABASE\NBS75K.L
Butane, 2-iodo-2-methyl- 22156 000594-38-7 78
Nonane, 3,7-dimethyl- 11601 017302-32-8 78
Decane, 2-methyl- 67322 006975-98-0 72

37 18.41 0.38 C:\DATABASE\NBS75K.L
Tetratetracontane 61068 007098-22-8 59
Hexatriacontane 59136 000630-06-8 59
Tetratetracontane 74745 007098-22-8 53

38 18.61 0.97 C:\DATABASE\NBS75K.L
Nonane, 3,7-dimethyl- 11601 017302-32-8 90
Heptane, 2,6-dimethyl- 5156 001072-05-5 64
Dodecane, 2,6,11-trimethyl- 25998 031295-56-4 64

39 18.80 0.27 C:\DATABASE\NBS75K.L
Benzene, 1,2-dimethyl- 63706 000095-47-6 91 (o-xylene)

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-130 ... Floating Product

40 18.93 0.15 C:\DATABASE\NBS75K.L
Nonane, 5-(1-methylpropyl)- 19016 062185-54-0 40
Tetracontane, 3,5,24-trimethyl- 60914 055162-61-3 38
Octane, 2,4,6-trimethyl- 11606 062016-37-9 36

41 19.06 0.28 C:\DATABASE\NBS75K.L
1-Dodecanol, 3,7,11-trimethyl- 70849 006750-34-1 49
Cyclohexane, 1,2,3-trimethyl-, (1.alp 4642 007667-55-2 42
Cyclopentane, butyl- 4645 002040-95-1 38

42 19.21 1.47 C:\DATABASE\NBS75K.L
Decane, 5-methyl- 67316 013151-35-4 72
Heptane, 4-ethyl- 65124 002216-32-2 53
Heptane, 2,2,3,3,5,6,6-heptamethyl- 69655 007225-67-4 50

43 19.34 1.33 C:\DATABASE\NBS75K.L
Decane, 4-methyl- 11615 002847-72-5 76
Octane, 1,1'-oxybis- 32426 000629-82-3 72
Decane, 4-methyl- 67324 002847-72-5 62

44 19.43 1.75 C:\DATABASE\NBS75K.L
Undecane 67319 001120-21-4 78
Tetradecane 69661 000629-59-4 78
1-Iodo-2-methylundecane 41997 073105-67-6 72

45 19.64 0.45 C:\DATABASE\NBS75K.L
Decane, 3-methyl- 11604 013151-34-3 70
Nonane, 5-butyl- 19037 017312-63-9 50
Hexane, 2,3,4-trimethyl- 5147 000921-47-1 43

46 19.74 1.25 C:\DATABASE\NBS75K.L
Decane, 3-methyl- 67314 013151-34-3 90
Decane, 3-methyl- 67315 013151-34-3 86
Octane, 3-ethyl-2,7-dimethyl- 15359 062183-55-5 78

47 20.12 0.78 C:\DATABASE\NBS75K.L
2-Decene, 4-methyl-, (Z)- 11065 074630-30-1 83
Nonane, 2-methyl-3-methylene- 11051 055499-08-6 64
Cyclohexane, 1,1-dimethyl-2-propyl- 11086 081983-71-3 55

48 20.24 0.23 C:\DATABASE\NBS75K.L
Bicyclo[3.1.1]heptane, 2,6,6-trimethy 65949 000473-55-2 43
1(2H)-Naphthalenone, octahydro-8a-met 14100 000770-62-7 42
1,1'-Bicyclohexyl, 2-ethyl-, trans- 21412 050991-13-4 38

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-130 ... Floating Product

49 20.45 0.46 C:\DATABASE\NBS75K.L
Benzene, 1-ethyl-?-methyl-
Benzene, 1-ethyl-2-methyl- 64558 000611-14-3 94
Benzene, 1-ethyl-3-methyl- 3769 000620-14-4 94
Benzene, 1-ethyl-2-methyl- 64557 000611-14-3 94

50 20.65 0.50 C:\DATABASE\NBS75K.L
1-Octadecanol 72029 000112-92-5 43
2-Decene, 4-methyl-, (Z)- 11065 074630-30-1 38
Nonane, 2-methyl-3-methylene- 11051 055499-08-6 38

51 20.78 9.41 C:\DATABASE\NBS75K.L
Undecane 67318 001120-21-4 97
Undecane 67317 001120-21-4 94
Undecane 11611 001120-21-4 93

Note: ***1,3,5-trimethylbenzene*** is found on the tail of this peak at 20.92 minutes

52 21.06 1.07 C:\DATABASE\NBS75K.L
Cyclohexane, 1-ethyl-4-methyl-, trans 64954 006236-88-0 53
Cyclohexane, 1-ethyl-2-methyl- 4657 003728-54-9 50
Cyclohexane, 1-methyl-2-propyl- 7590 004291-79-6 50

53 21.28 1.91 C:\DATABASE\NBS75K.L
Undecane, 5-methyl- 68258 001632-70-8 68
Undecane, 5-methyl- 15363 001632-70-8 58
Octane, 3-ethyl-2,7-dimethyl- 15359 062183-55-5 53

54 21.38 0.67 C:\DATABASE\NBS75K.L
Naphthalene, decahydro-, trans- 65957 000493-02-7 94
Naphthalene, decahydro-, trans- 65956 000493-02-7 93
Naphthalene, decahydro-, trans- 7108 000493-02-7 90

55 21.52 1.77 C:\DATABASE\NBS75K.L
1-Decene, 2,4-dimethyl- 14795 055170-80-4 46
Undecane 11611 001120-21-4 43
Hexane, 3,3-dimethyl- 64223 000563-16-6 38

56 21.71 1.16 C:\DATABASE\NBS75K.L
Undecane, 3,8-dimethyl- 19009 017301-30-3 83
Heptadecane 71191 000629-78-7 78
Undecane, 5-methyl- 15363 001632-70-8 64

57 21.91 0.80 C:\DATABASE\NBS75K.L
Cyclopropane, 1-butyl-2-pentyl-, cis- 14779 074663-88-0 30
Cyclooctane, 1,5-dimethyl- 7584 021328-57-4 30

Note: Identified compounds in bold print have been verified with actual standard

2-Undecene, 10-methyl- 14688 000000-00-0 30

58 22.14 0.87 C:\DATABASE\NBS75K.L
Benzene, 1,2,4-trimethyl-

59 22.30 0.46 C:\DATABASE\NBS75K.L
Dodecane, 6-methyl- 19006 006044-71-9 35
Undecane, 2,6-dimethyl- 69033 017301-23-4 35
cis-2-Tert-butylcycloheptanol 15302 019790-11-5 23

60 22.68 1.71 C:\DATABASE\NBS75K.L
Octane, 4-ethyl- 8095 015869-86-0 78
2,6-Dimethyldecane 15357 013150-81-7 58
Undecane, 5-methyl- 68258 001632-70-8 58

61 22.86 0.83 C:\DATABASE\NBS75K.L
Undecane, 4-methyl- 15354 002980-69-0 90
Undecane, 4-methyl- 68256 002980-69-0 81
Dodecane, 4-methyl- 19025 006117-97-1 64

62 22.98 1.88 C:\DATABASE\NBS75K.L
Undecane, 2-methyl- 15356 007045-71-8 90
Pentacosane 73718 000629-99-2 72
Decane, 2,9-dimethyl- 15361 001002-17-1 64

63 23.19 0.69 C:\DATABASE\NBS75K.L
Naphthalene, decahydro-2-methyl- 67009 002958-76-1 91
Bicyclo[4.1.0]heptan-3-one, 4,7,7-tri 10380 004176-04-9 58
Pulegone 66993 000089-82-7 52

64 23.27 0.97 C:\DATABASE\NBS75K.L
Undecane, 3-methyl- 15362 001002-43-3 90
Decane, 3,8-dimethyl- 68255 017312-55-9 68
Nonane, 3,7-dimethyl- 11601 017302-32-8 64

65 23.47 0.22 C:\DATABASE\NBS75K.L
Benzene, 1-methyl-4-propyl-

66 23.53 0.16 C:\DATABASE\NBS75K.L
Cyclopentane, 1-butyl-2-ethyl- 11043 072993-32-9 38
Cyclohexane, (1,2-dimethylbutyl)- 14741 061142-37-8 32
2,6-Octadienal, 3,7-dimethyl- 66945 005392-40-5 30

67 23.63 0.13 C:\DATABASE\NBS75K.L
Benzene, butyl- 65551 000104-51-8 60
Benzene, butyl- 65548 000104-51-8 49

Note: Identified compounds in bold print have been verified with actual standard

68 23.80 0.70 C:\DATABASE\NBS75K.L
Benzene, 1,2,3-trimethyl-

69 23.96 0.54 C:\DATABASE\NBS75K.L
Naphthalene, decahydro-2-methyl- 67008 002958-76-1 95
Naphthalene, decahydro-2-methyl- 67009 002958-76-1 91
Bicyclo[2.2.1]heptan-2-one, 1,7,7-tri 66961 000464-48-2 64

70 24.12 0.15 C:\DATABASE\NBS75K.L
Benzene, 1,2-diethyl-

71 24.30 2.86 C:\DATABASE\NBS75K.L
Dodecane 68249 000112-40-3 97
Dodecane 68254 000112-40-3 93
Dodecane 68250 000112-40-3 93

72 24.50 0.19 C:\DATABASE\NBS75K.L
1-Hexadecanol 71249 036653-82-4 83
1-Methyl-2-(4-methylpentyl)cyclopenta 14700 000000-00-0 83
trans-1-Methyl-2-(4-methylpentyl)cycl 14695 000000-00-0 64

73 24.66 1.60 C:\DATABASE\NBS75K.L
Undecane, 2,6-dimethyl- 69033 017301-23-4 90
Undecane, 2,6-dimethyl- 19058 017301-23-4 89
Dodecane, 6-methyl- 19006 006044-71-9 81

74 24.85 0.13 C:\DATABASE\NBS75K.L
Hexane, 2,2,5-trimethyl- 65126 003522-94-9 47
Hexane, 2,2,5-trimethyl- 5149 003522-94-9 38
Heptane, 2,2,3,4,6,6-hexamethyl- 19044 062108-32-1 38

75 24.92 0.34 C:\DATABASE\NBS75K.L
Benzene, 4-ethyl-1,2-dimethyl-

76 25.00 0.23 C:\DATABASE\NBS75K.L
Undecane, 3-methyl- 15362 001002-43-3 64
Nonane, 3,7-dimethyl- 11601 017302-32-8 64
Decane, 3-methyl- 67314 013151-34-3 64

77 25.18 0.39 C:\DATABASE\NBS75K.L
Benzene, 1-ethyl-2,3-dimethyl- 65556 000933-98-2 93
Benzene, 4-ethyl-1,2-dimethyl- 6218 000934-80-5 93
Benzene, 1-ethyl-2,4-dimethyl- 65572 000874-41-9 93

78 25.27 0.19 C:\DATABASE\NBS75K.L

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-130 ... Floating Product

Benzene, 1-(1,1-dimethylethyl)-3-methyl-
(1-methyl-3-tert-butylbenzene)

79 25.44 0.04 C:\DATABASE\NBS75K.L
Naphthalene, decahydro-2-methyl- 67008 002958-76-1 43
Oxirane, tetradecyl- 71189 007320-37-8 43
Tridecanal 22498 010486-19-8 38

80 25.59 0.31 C:\DATABASE\NBS75K.L
Hexadecane, 1-bromo- 43438 000112-82-3 47
Octane, 1,1'-oxybis- 32426 000629-82-3 35
Cyclohexanol, 5-methyl-2-(1-methyleth 11522 023283-97-8 35

81 25.68 0.24 C:\DATABASE\NBS75K.L
Furan, 2-pentyl- 6987 003777-69-3 22
Methyl ethyl cyclopentene 2377 019780-56-4 22
Benzene, 2-butenyl- 5905 001560-06-1 20

82 25.89 0.13 C:\DATABASE\NBS75K.L
1H-Indene, 2,3-dihydro-1,1-dimethyl- 8945 004912-92-9 70
Benzene, (1,1-dimethyl-2-propenyl)- 8972 018321-36-3 53
Benzene, 1-(chloromethyl)-4-(2-propen 13988 036875-10-2 52

83 26.04 0.34 C:\DATABASE\NBS75K.L

Overlap 1,4-dichlorobenzene with
Benzene, 1,3-diethyl-5-methyl- 9397 002050-24-0 52
Benzene, 2-ethyl-1,4-dimethyl- 6219 001758-88-9 38
Benzene, 2-ethyl-1,4-dimethyl- 65570 001758-88-9 38

84 26.14 0.38 C:\DATABASE\NBS75K.L
10-Methylnonadecane 39858 000000-00-0 64
Hexadecane, 7,9-dimethyl- 34818 021164-95-4 59
Tetracosane 73543 000646-31-1 59

85 26.24 0.18 C:\DATABASE\NBS75K.L
Decane, 3-methyl- 11604 013151-34-3 53
Heptane, 3,3,5-trimethyl- 8090 007154-80-5 47
Undecane, 3,3-dimethyl- 19040 017312-65-1 38

86 26.31 0.36 C:\DATABASE\NBS75K.L
Cyclopentane, pentyl- 7536 003741-00-2 81
Cyclopentane, 1-butyl-2-propyl- 14780 062199-50-2 72
Cyclohexane, 2-butyl-1,1,3-trimethyl- 18489 054676-39-0 68

87 26.44 1.00 C:\DATABASE\NBS75K.L

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-130 ... Floating Product

Overlap ***1,2-dimethyl-3-ethylbenzene*** with
Undecane, 2,9-dimethyl- 18994 017301-26-7 53
Undecane, 3-methyl- 15362 001002-43-3 53
Undecane, 3,9-dimethyl- 19014 017301-31-4 43

88 26.63 0.90 C:\DATABASE\NBS75K.L
Decane, 2,6,7-trimethyl- 19027 062108-25-2 83
Nonane, 3-methyl- 66202 005911-04-6 68
Nonane, 3-methyl- 66203 005911-04-6 64

89 26.75 0.49 C:\DATABASE\NBS75K.L
Benzoic acid, 2,4-dimethyl-, (2,4-dim 37425 055000-43-6 47
Benzene, 1-methyl-4-(1-methylethyl)- 65534 000099-87-6 42
Benzene, 2-ethyl-1,3-dimethyl- 65533 002870-04-4 38

90 26.87 0.46 C:\DATABASE\NBS75K.L
Benzene, 1,3-diethyl- 65566 000141-93-5 60
Benzene, 1,4-diethyl- 65558 000105-05-5 60
Benzene, 1,3-diethyl- 6215 000141-93-5 55

91 26.99 0.20 C:\DATABASE\NBS75K.L
Borinic acid, diethyl-, methyl ester 1503 007397-46-8 43
Octane, 3,3-dimethyl- 8088 004110-44-5 42
Pentadecane, 2,6,10,14-tetramethyl- 37470 001921-70-6 32

92 27.14 0.64 C:\DATABASE\NBS75K.L
Benzene, 1,2,3,4-tetramethyl- 65540 000488-23-3 81
Benzene, 1,2,3,5-tetramethyl- 65571 000527-53-7 81
Benzene, 1,2,3,4-tetramethyl- 65541 000488-23-3 81

93 27.27 0.21 C:\DATABASE\NBS75K.L
Heptane, 2,2,3,4,6,6-hexamethyl- 19044 062108-32-1 35
Octane, 2,6-dimethyl- 66228 002051-30-1 32
Hexane, 2,2,4-trimethyl- 65103 016747-26-5 27

94 27.32 0.39 C:\DATABASE\NBS75K.L
Benzene, (1,1-dimethylpropyl)- 66630 002049-95-8 59
Benzene, 1,1'-(1,1,2,2-tetramethyl-1, 71140 001889-67-4 53
Benzene, 1-ethyl-2,4-dimethyl- 65572 000874-41-9 53

95 27.47 0.70 C:\DATABASE\NBS75K.L
Benzene, 1,2-dichloro- 8725 000095-50-1 96

96 27.74 1.98 C:\DATABASE\NBS75K.L
Tridecane 69020 000629-50-5 97
Tridecane 69019 000629-50-5 96

Note: Identified compounds in bold print have been verified with actual standard

Tridecane 69021 000629-50-5 95

97 27.84 0.63 C:\DATABASE\NBS75K.L
Benzene, 1,4-diethyl-2-methyl- 9393 013632-94-5 25
Benzene, (1-chloroethyl)methyl- 10742 072403-15-7 18
Pyridine, 5-ethenyl-2-methyl- 3656 000140-76-1 14

98 28.02 0.33 C:\DATABASE\NBS75K.L
Benzene, (1,1-dimethylpropyl)- 9392 002049-95-8 86
Benzene, 2-ethyl-1,3-dimethyl- 65532 002870-04-4 80
Benzene, 1-ethyl-3,5-dimethyl- 65554 000934-74-7 78

99 28.10 0.46 C:\DATABASE\NBS75K.L
Cyclopentane, (2-methylbutyl)- 7553 053366-38-4 50
Decane, 1,1'-oxybis- 42526 002456-28-2 38
3-Heptene, 2,6-dimethyl- 4620 002738-18-3 38

100 28.29 0.81 C:\DATABASE\NBS75K.L
Nonadecane 71949 000629-92-5 72
Pentadecane 70274 000629-62-9 72
Tridecane 69020 000629-50-5 64

101 28.44 0.36 C:\DATABASE\NBS75K.L
Cyclopentane, 3-hexyl-1,1-dimethyl- 18486 061142-65-2 47
1-Heptene, 2-pentyl- 14722 017799-46-1 36
1-Hexene, 5-methyl- 63239 003524-73-0 9

102 28.60 0.24 C:\DATABASE\NBS75K.L
Cyclopentene, 5-hexyl-3,3-dimethyl- 17939 061142-66-3 64
trans,cis-2,10-Dimethylspiro[5.5]unde 17927 000000-00-0 30
trans,trans- and trans,cis-1,10-Dimet 17923 000000-00-0 30

103 28.70 0.19 C:\DATABASE\NBS75K.L
Tetracontane, 3,5,24-trimethyl- 60914 055162-61-3 47
Decane, 2,5,6-trimethyl- 19019 062108-23-0 42
2-Methyl-1-undecanol 19529 010522-26-6 36

104 28.79 0.52 C:\DATABASE\NBS75K.L
Benzene, 1,2,3,4-tetramethyl- 6202 000488-23-3 95
Benzene, 1,2,3,5-tetramethyl- 65571 000527-53-7 94
Benzene, 1,2,4,5-tetramethyl- 65574 000095-93-2 94

105 28.97 0.84 C:\DATABASE\NBS75K.L
Nonane, 3-methyl-5-propyl- 19054 031081-18-2 78
Heptane, 3-ethyl-5-methyl- 8092 052896-90-9 72
Nonane, 3,7-dimethyl- 11601 017302-32-8 64

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-130 ... Floating Product

106 29.12 0.47 C:\DATABASE\NBS75K.L
1H-Indene, 2,3-dihydro-4-methyl- 5893 000824-22-6 83
Indan, 1-methyl- 65418 000767-58-8 81
1H-Indene, 2,3-dihydro-5-methyl- 5885 000874-35-1 81

107 29.18 0.36 C:\DATABASE\NBS75K.L
2-Butene, 1-methoxy-, (E)- 727 010034-14-7 43
3-Nonen-2-one, 3-ethyl- 14680 056312-56-2 43
1-Propene, 1-methoxy-2-methyl- 717 017574-84-4 43

108 29.37 0.97 C:\DATABASE\NBS75K.L
Undecane, 3,9-dimethyl- 19014 017301-31-4 50
Dodecane, 3-methyl- 69025 017312-57-1 47
Undecane, 2,9-dimethyl- 18994 017301-26-7 47

109 29.53 0.85 C:\DATABASE\NBS75K.L
Dodecane 68254 000112-40-3 53
Heptane, 2,2,3,3,5,6,6-heptamethyl- 69656 007225-67-4 50
Tridecane, 3-methyl- 22540 006418-41-3 50

110 29.69 0.61 C:\DATABASE\NBS75K.L
2-Hexyl-1-decanol 32422 000000-00-0 53
Hexane, 3-ethyl-4-methyl- 65141 003074-77-9 50
1-Octanol, 2-butyl- 69110 003913-02-8 43

111 29.74 0.34 C:\DATABASE\NBS75K.L
Hexanoic acid, 3-hydroxy-, ethyl este 67537 002305-25-1 12
Hexanoic acid, 3-hydroxy-, ethyl este 67536 002305-25-1 12
2-Hexyl-1-octanol 26413 000000-00-0 10

112 29.83 0.46 C:\DATABASE\NBS75K.L
5,6-Dimethyltetrahydro-1,3-oxazine-2- 8592 085333-97-7 50
4,5-Dimethyltetrahydro-1,3-oxazine-2- 8590 085333-95-5 50
Naphthalene, 1,2,3,4-tetrahydro-1,5-d 12577 021564-91-0 27

113 29.94 0.68 C:\DATABASE\NBS75K.L
Naphthalene, 1,2,3,4-tetrahydro- 5880 000119-64-2 86
Benzene, 1-isocyanato-3-methyl- 5981 000621-29-4 70
Benzene, 1-isocyanato-3-methyl- 65449 000621-29-4 62

114 30.19 1.77 C:\DATABASE\NBS75K.L
Dodecane, 2,6,11-trimethyl- 25998 031295-56-4 90
Dodecane, 2,7,10-trimethyl- 26005 074645-98-0 90
Dodecane, 2,6,10-trimethyl- 25995 003891-98-3 90

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-130 ... Floating Product

115 30.43 0.57 C:\DATABASE\NBS75K.L

Eicosane	72323	000112-95-8	72
Pentadecane	70278	000629-62-9	72
Heptadecane	71191	000629-78-7	64

116 30.55 0.78 C:\DATABASE\NBS75K.L

3,4-Nonadiene	4261	037050-03-6	35
1,12-Dodecanediol	23388	005675-51-4	32
Cycloheptanemethanol	5124	004448-75-3	32

117 30.64 0.45 C:\DATABASE\NBS75K.L

5-Hepten-3-one, 5-ethyl-2-methyl-	11022	049833-97-8	46
Decane, 2,3,5-trimethyl-	19043	062238-11-3	43
3-Cyclohexen-1-ol, 4-methyl-1-(1-meth	67104	000562-74-3	38

118 30.83 0.34 C:\DATABASE\NBS75K.L

2-Ethyl-1-dodecanol	26412	000000-00-0	64
1-Dodecanol, 2-methyl-, (S)-	23010	057289-26-6	53
Undecane, 3,9-dimethyl-	19014	017301-31-4	50

119 31.08 1.87 C:\DATABASE\NBS75K.L

Tetradecane	22534	000629-59-4	90

120 31.24 0.91 C:\DATABASE\NBS75K.L

Oxirane, (bromomethyl)-	74493	003132-64-7	32
Heptane, 2,2-dimethyl-	65135	001071-26-7	27
Hexane, 2,2,4-trimethyl-	65103	016747-26-5	27

121 31.41 0.34 C:\DATABASE\NBS75K.L

Decane, 2,2,6-trimethyl-	18995	062237-97-2	59
Decane, 2,2,7-trimethyl-	19001	062237-99-4	59
Decane, 2,2,9-trimethyl-	19007	062238-00-0	59

122 31.47 0.58 C:\DATABASE\NBS75K.L

Cyclohexane, (1,3-dimethylbutyl)-	14770	061142-19-6	43
Cyclohexane, 1,2,4,5-tetraethyl-, (1.	21979	061142-24-3	38
6-Tridecene, 7-methyl-	69534	024949-42-6	35

123 31.66 0.72 C:\DATABASE\NBS75K.L

Cyclopropanemethanol, 2,2,3,3-tetrame	5066	002415-96-5	18
Cycloheptane, methyl-	64002	004126-78-7	16
2(1H)-Benzocyclooctenone, decahydro-1	21390	055103-68-9	12

124 31.81 0.81 C:\DATABASE\NBS75K.L

Undecane, 4-methyl-	15354	002980-69-0	47
Hexane, 3-methyl-	63422	000589-34-4	47

Note: Identified compounds in bold print have been verified with actual standard

Hexane, 3-methyl- 63421 000589-34-4 45

125 32.05 0.64 C:\DATABASE\NBS75K.L
Hydroxylamine, O-decyl- 15973 029812-79-1 53
Tetradecane 69659 000629-59-4 53
Undecane, 2,10-dimethyl- 18997 017301-27-8 50

126 32.21 0.77 C:\DATABASE\NBS75K.L
Dodecane, 2,6,11-trimethyl- 70272 031295-56-4 47
Undecane, 3,9-dimethyl- 19014 017301-31-4 43
Dodecane, 2,6,10-trimethyl- 25995 003891-98-3 43

127 32.44 0.83 C:\DATABASE\NBS75K.L
Decane, 3-methyl- 67314 013151-34-3 58
Heptadecane 71193 000629-78-7 53
Undecane, 3,9-dimethyl- 19014 017301-31-4 53

128 32.64 0.84 C:\DATABASE\NBS75K.L
Decane, 2,2,8-trimethyl- 19012 062238-01-1 56
Octane, 2,4,6-trimethyl- 11606 062016-37-9 50
Heptane, 3-ethyl-2-methyl- 66212 014676-29-0 50

129 32.76 0.33 C:\DATABASE\NBS75K.L
2-Hexyl-1-octanol 26413 000000-00-0 32
1-Octanol, 2-butyl- 69109 003913-02-8 32
Heptane, 2,2,4,6,6-pentamethyl- 68259 013475-82-6 27

130 32.92 1.39 C:\DATABASE\NBS75K.L
Heptadecane, 2,6,10,14-tetramethyl- 42200 018344-37-1 90
Undecane, 4,6-dimethyl- 19008 017312-82-2 81
Tridecane 69019 000629-50-5 81

131 33.06 0.55 C:\DATABASE\NBS75K.L
1-Octanol, 2-butyl- 69110 003913-02-8 49
Cyclopentane, 1,2-dimethyl-3-(1-methy 7606 000489-20-3 43
Dodecane 68249 000112-40-3 38

132 33.16 0.56 C:\DATABASE\NBS75K.L
Heptane, 3,3,5-trimethyl- 66218 007154-80-5 43
1-Methylcycloheptanol 5031 003761-94-2 38
Heptane, 3,3,5-trimethyl- 66217 007154-80-5 37

133 33.37 0.67 C:\DATABASE\NBS75K.L
Hexatriacontane 74636 000630-06-8 59
Tetratetracontane 74745 007098-22-8 59
Decane, 2,3,7-trimethyl- 19048 062238-13-5 59

Note: Identified compounds in bold print have been verified with actual standard

134 33.67 0.86 C:\DATABASE\NBS75K.L
Cyclohexane, octyl- 69530 001795-15-9 72
Cyclohexane, octyl- 21971 001795-15-9 64
Cyclohexane, decyl- 70722 001795-16-0 64

135 33.82 0.37 C:\DATABASE\NBS75K.L
Bacchotricuneatin c 48377 066563-30-2 47
Dodecane, 2,7,10-trimethyl- 26005 074645-98-0 38
Tridecane, 5-propyl- 29268 055045-11-9 38

136 33.92 0.18 C:\DATABASE\NBS75K.L
Pentadecane, 3-methyl- 29258 002882-96-4 59
Octane, 4-ethyl- 8095 015869-86-0 59
Undecane, 2,9-dimethyl- 18994 017301-26-7 59

137 33.99 0.14 C:\DATABASE\NBS75K.L
Cyclotetradecane 69525 000295-17-0 42
Cyclohexane, 1-(cyclohexylmethyl)-3-m 21411 054823-96-0 35
Cycloheptanemethanol 5124 004448-75-3 35

138 34.03 0.30 C:\DATABASE\NBS75K.L
Hexadecane, 3-methyl- 32062 006418-43-5 38
Butanoic acid, 2-methyl-, 2-methylpro 11961 002445-67-2 32
Nonane, 3,7-dimethyl- 11601 017302-32-8 32

139 34.29 0.73 C:\DATABASE\NBS75K.L
Pentadecane 70278 000629-62-9 91
Pentadecane 70274 000629-62-9 91

140 34.45 0.60 C:\DATABASE\NBS75K.L
Decahydro-4,4,8,9,10-pentamethylnapht 24990 000000-00-0 55
2-Dodecen-1-yl(-)succinic anhydride 36989 019780-11-1 45
Cyclohexane, 1-(cyclohexylmethyl)-4-e 25009 054934-95-1 35

141 34.77 0.28 C:\DATABASE\NBS75K.L
Decane, 5-ethyl-5-methyl- 19055 017312-74-2 27
2,4,4-Trimethyl-1-hexene 4681 051174-12-0 22
Methylamine, N-(1-methylheptylidene)- 7741 018641-72-0 22

142 34.86 0.08 C:\DATABASE\NBS75K.L
Naphthalene, 1,2,3,4-tetrahydro-5-met 66493 002809-64-5 18
Naphthalene, 1,2,3,4-tetrahydro-5-met 8949 002809-64-5 16
Naphthalene, 1,2,3,4-tetrahydro-6-met 66500 001680-51-9 14

143 34.95 0.45 C:\DATABASE\NBS75K.L

Note: Identified compounds in bold print have been verified with actual standard

Naphthalene	65150	000091-20-3 97
Naphthalene	65151	000091-20-3 97
Naphthalene	65148	000091-20-3 95

144 35.66 0.52 C:\DATABASE\NBS75K.L

1-Hentetracontanol	60755	040710-42-7 49
1-Nonadecene	71890	018435-45-5 49
2-Ethyl-1-dodecanol	26412	000000-00-0 49

145 35.79 0.27 C:\DATABASE\NBS75K.L

1-Heptanol, 2-propyl-	12078	010042-59-8 53
Undecane, 4,8-dimethyl-	19026	017301-33-6 43
Octane, 2-methyl-	65117	003221-61-2 35

146 35.87 0.33 C:\DATABASE\NBS75K.L

1,2-Dodecanediol	23385	001119-87-5 27
2H-1,6-Benzoxazocin-5(6H)-one, 3,4-di	16898	051110-93-1 22
11-Dodecen-2-one, 7,7-dimethyl-	25451	035194-22-0 22

147 36.21 0.29 C:\DATABASE\NBS75K.L

Pentacosane	73718	000629-99-2 87
Dotriacontane	74491	000544-85-4 86
Hexatriacontane	59136	000630-06-8 86

148 36.48 0.27 C:\DATABASE\NBS75K.L

Diallyldivinylsilane	13505	000000-00-0 43
Cyclopentane, 2-isopropyl-1,3-dimethy	7525	032281-85-9 27
1-Hexadecene	28779	000629-73-2 22

149 36.95 0.22 C:\DATABASE\NBS75K.L

n-Nonylcyclohexane	25487	002883-02-5 64
Cyclohexane, undecyl-	31654	054105-66-7 64
Cyclohexane, 1,1'-(1,3-propanediyl)bi	24996	003178-24-3 59

150 37.36 0.37 C:\DATABASE\NBS75K.L

Hexadecane	70789	000544-76-3 96
Hexadecane	70787	000544-76-3 94

151 38.28 0.14 C:\DATABASE\NBS75K.L

Naphthalene, 2-methyl-	66236	000091-57-6 95
Naphthalene, 2-methyl-	66237	000091-57-6 95

152 38.60 0.26 C:\DATABASE\NBS75K.L

Undecane, 5-ethyl-	19036	017453-94-0 78
Heptadecane	71191	000629-78-7 72
Undecane, 2,6-dimethyl-	69033	017301-23-4 72

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-130 ... Floating Product

153 38.70 0.10 C:\DATABASE\NBS75K.L
3-Butene-1,2-diol, 1-(2-furanyl)-2-me 14476 018927-20-3 40
1,2-Butanediol, 1-(2-furyl)- 11388 004208-60-0 37
Cyclohexane, 1-ethyl-2-methyl- 4657 003728-54-9 25

154 39.21 0.12 C:\DATABASE\NBS75K.L
Naphthalene, 1-methyl- 66230 000090-12-0 94
Naphthalene, 1-methyl- 8111 000090-12-0 91

155 40.19 0.37 C:\DATABASE\NBS75K.L
Dodecane, 2,7,10-trimethyl- 26005 074645-98-0 86
Dodecane, 2,6,10-trimethyl- 25995 003891-98-3 80
Heptadecane, 2,6-dimethyl- 37466 054105-67-8 78

156 40.29 0.22 C:\DATABASE\NBS75K.L
Heptadecane 32063 000629-78-7 91
Heptadecane 71191 000629-78-7 91
Heptadecane 71194 000629-78-7 90

157 41.43 0.14 C:\DATABASE\NBS75K.L
Naphthalene, 2,6-dimethyl- 67335 000581-42-0 97
Naphthalene, 2,6-dimethyl- 67336 000581-42-0 96

158 43.11 0.36 C:\DATABASE\NBS75K.L
Eicosane 72326 000112-95-8 91
Heptadecane 71193 000629-78-7 90
Pentadecane 70273 000629-62-9 86

159 45.76 0.13 C:\DATABASE\NBS75K.L
Heptadecane 71191 000629-78-7 86
Hexadecane 70789 000544-76-3 86
Pentadecane 70274 000629-62-9 80

160 48.32 0.15 C:\DATABASE\NBS75K.L
Hexadecane 70789 000544-76-3 90
Heneicosane 42201 000629-94-7 90
Eicosane 72326 000112-95-8 90

161 50.45 0.12 C:\DATABASE\NBS75K.L
Decane, 2-methyl- 67320 006975-98-0 80
Nonadecane, 2-methyl- 72322 001560-86-7 78
2-Methyloctadecane 37460 000000-00-0 72

162 51.12 0.14 C:\DATABASE\NBS75K.L
Tridecane 69021 000629-50-5 93

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-130 ... Floating Product

Eicosane	72326	000112-95-8 86
Heptacosane	74082	000593-49-7 86

163 54.55 0.11 C:\DATABASE\NBS75K.L

Hexadecane	70788	000544-76-3 80
Eicosane	72324	000112-95-8 72
Octadecane	71559	000593-45-3 72

Thu Apr 10 13:11:01 1997

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-161 ... Floating Product

Information from Data File:
File : 04089721.D
Operator : David A. Kovacs
Acquired : 9 Apr 97 7:01 am using AcqMethod SCN240
Sample Name: U1-161 1/20 Product
Misc Info : SR #SF-3-240 D. Kampbell
Vial Number: 21
Search Libraries: C:\DATABASE\NBS75K.L Minimum Quality: 0
Unknown Spectrum: Apex minus start of peak
Integration Params: events.e

Pk#	RT	Area%	Library/ID	Ref#	CAS#	Qual
1	8.66	0.22	C:\DATABASE\NBS75K.L			
			Pentane, 2,2,4-trimethyl-	64220	000540-84-1	64
			Hexane, 2,2-dimethyl-	64216	000590-73-8	50
			Butane, 2,2,3,3-tetramethyl-	64215	000594-82-1	39
2	12.17	0.02	C:\DATABASE\NBS75K.L			
			Cyclohexane, 1,2-dimethyl-, trans-	64014	006876-23-9	95
			Cyclohexane, 1,2-dimethyl-, trans-	2673	006876-23-9	94
3	13.09	0.33	C:\DATABASE\NBS75K.L			
			Cyclohexane, 1,1,4-trimethyl-			
4	13.22	0.24	C:\DATABASE\NBS75K.L			
			Octane, 2-methyl-	5142	003221-61-2	64
5	13.45	0.31	C:\DATABASE\NBS75K.L			
			Octane, 3-methyl-	65130	002216-33-3	52
			Octane, 3-methyl-	5150	002216-33-3	43
6	13.74	0.13	C:\DATABASE\NBS75K.L			
			Decane, 2,2,7-trimethyl-	19001	062237-99-4	78
			Decane, 2,2,8-trimethyl-	19012	062238-01-1	78
			Decane, 2,2,4-trimethyl-	18998	062237-98-3	64
7	14.17	0.67	C:\DATABASE\NBS75K.L			
			Nonane	65142	000111-84-2	72
			Nonane	65145	000111-84-2	58
8	14.40	0.14	C:\DATABASE\NBS75K.L			
			cis-1-Ethyl-3-methyl-cyclohexane	4636	019489-10-2	90
			1-Ethyl-3-methylcyclohexane (c,t)	4658	003728-55-0	90
			Cyclohexane, 1-ethyl-4-methyl-, trans	64954	006236-88-0	90

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-161 ... Floating Product

9 14.48 0.25 C:\DATABASE\NBS75K.L
Cyclohexane, 1,1,2-trimethyl-

10 14.63 0.19 C:\DATABASE\NBS75K.L
Hexane, 2,4-dimethyl- 64213 000589-43-5 59
Hexane, 2,4-dimethyl- 64212 000589-43-5 59
Nonane 5163 000111-84-2 59

11 14.82 0.25 C:\DATABASE\NBS75K.L
Dotriacontane 74492 000544-85-4 59
1-Octanol, 2-butyl- 69110 003913-02-8 59
Nonane, 2-methyl- 8093 000871-83-0 58

12 14.91 0.12 C:\DATABASE\NBS75K.L
Glycocyanidine 1373 000503-86-6 50
Hexane, 2-methyl- 63435 000591-76-4 38
Hexane, 2-methyl- 1598 000591-76-4 38

13 15.09 1.11 C:\DATABASE\NBS75K.L
Nonane, 3-methyl- 8075 005911-04-6 93
Octane, 3,6-dimethyl- 8109 015869-94-0 93
Octane, 2,6-dimethyl- 66228 002051-30-1 87

14 15.30 0.18 C:\DATABASE\NBS75K.L
Octane, 3,6-dimethyl- 8109 015869-94-0 72
Nonane, 3-methyl- 8075 005911-04-6 72
Octane, 2,6-dimethyl- 66228 002051-30-1 72

15 15.42 0.70 C:\DATABASE\NBS75K.L
Heptane, 4-(1-methylethyl)- 8084 052896-87-4 53
Heptane, 3-ethyl-2-methyl- 66211 014676-29-0 53
Octane, 2,3-dimethyl- 66214 007146-60-3 47

16 15.63 0.16 C:\DATABASE\NBS75K.L
Cyclohexane, (1-methylethyl)- 64965 000696-29-7 49
Cyclohexane, (1-methylethyl)- 4682 000696-29-7 47
Cyclohexane, (1-methylethyl)- 64966 000696-29-7 46

17 15.86 0.69 C:\DATABASE\NBS75K.L
Cyclopentane, 1-methyl-2-propyl- 4666 003728-57-2 50
1-Ethyl-2-(4-methylpentyl)cyclopentan 18480 000000-00-0 47
Octane, 3,4-dimethyl- 8107 015869-92-8 38

18 15.93 1.86 C:\DATABASE\NBS75K.L
Octane, 2,5-dimethyl- 66225 015869-89-3 80
Octane, 3,5-dimethyl- 66229 015869-93-9 80

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-161 ... Floating Product

Nonane, 4-methyl- 66223 017301-94-9 72

19 16.29 0.69 C:\DATABASE\NBS75K.L
Nonane, 3-methyl- 66200 005911-04-6 81
Nonane, 3-methyl- 66203 005911-04-6 76

20 16.67 0.04 C:\DATABASE\NBS75K.L
Cyclohexane, diethyl- 7603 001331-43-7 90
Cyclohexane, 1-ethyl-2,3-dimethyl- 7562 007058-05-1 86
Cyclooctane, ethyl- 7529 013152-02-8 83

21 16.78 0.13 C:\DATABASE\NBS75K.L
Cyclohexane, 1,3,5-trimethyl-, (1.alp 64952 001795-26-2 64
Cyclooctane, ethyl- 7529 013152-02-8 64
Cyclohexane, 1-ethyl-1,3-dimethyl-, c 7551 062238-31-7 64

22 16.96 0.71 C:\DATABASE\NBS75K.L
Cyclohexane, 1,1,2,3-tetramethyl- 7580 006783-92-2 91
2-Octene, 2,6-dimethyl- 66054 004057-42-5 90
2-Octene, 2,6-dimethyl- 7538 004057-42-5 76

23 17.25 0.96 C:\DATABASE\NBS75K.L
Decane 66205 000124-18-5 93
Decane 66206 000124-18-5 70

24 17.36 0.49 C:\DATABASE\NBS75K.L
m-Menthane, (1S,3S)-(+)- 7550 013837-67-7 38
Cyclohexane, 1,1'-(1,2-dimethyl-1,2-e 28269 054889-87-1 38
Cyclopentane, 1,2-dimethyl-3-(1-methy 7606 000489-20-3 38

25 17.49 0.68 C:\DATABASE\NBS75K.L
Cyclohexane, 1-methyl-3-propyl- 7596 004291-80-9 50
Cyclohexane, 1-methyl-2-propyl- 66073 004291-79-6 50
Cyclohexane, 1,3-dimethyl-, trans- 64000 002207-03-6 47

26 17.64 0.84 C:\DATABASE\NBS75K.L
Dodecane, 3-methyl- 19011 017312-57-1 53
Pentatriacontane 58743 000630-07-9 53
Decane, 3-methyl- 67314 013151-34-3 52

27 17.84 0.38 C:\DATABASE\NBS75K.L
Dodecane, 3-methyl- 69025 017312-57-1 64
Tetradecane, 2,5-dimethyl- 29256 056292-69-4 64
Undecane, 2,9-dimethyl- 18994 017301-26-7 64

28 17.95 2.32 C:\DATABASE\NBS75K.L

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-161 ... Floating Product

Decane, 4-methyl- 67323 002847-72-5 91
Decane, 4-methyl- 11615 002847-72-5 90
Octane, 1,1'-oxybis- 71251 000629-82-3 78

29 18.11 0.35 C:\DATABASE\NBS75K.L
Cyclohexane, t-1-methyl-2-propyl-

30 18.21 0.41 C:\DATABASE\NBS75K.L
Dodecane, 2,6,11-trimethyl- 70271 031295-56-4 72
Dodecane, 4,6-dimethyl- 69666 061141-72-8 56
Dodecane, 4,6-dimethyl- 22539 061141-72-8 56

31 18.42 0.52 C:\DATABASE\NBS75K.L
Tetratetracontane 74745 007098-22-8 58
Pentatriacontane 58743 000630-07-9 58
Hexatriacontane 59136 000630-06-8 58

32 18.52 0.14 C:\DATABASE\NBS75K.L
2,4-Hexadiene, 1,6-bis(1,1-dimethylet 29182 000000-00-0 25
Undecane, 2,5-dimethyl- 19056 017301-22-3 17
1-Decene, 4-methyl- 11046 013151-29-6 10

33 18.62 0.97 C:\DATABASE\NBS75K.L
Nonane, 3,7-dimethyl- 11601 017302-32-8 91
Decane, 3-methyl- 67315 013151-34-3 91
Decane, 3-methyl- 67314 013151-34-3 90

34 18.81 0.21 C:\DATABASE\NBS75K.L
Benzene, 1,2-dimethyl- 63707 000095-47-6 51 (o-Xylene)

35 18.89 0.67 C:\DATABASE\NBS75K.L
Benzene, chloro- 63934 000108-90-7 90
Benzene, chloro- 63935 000108-90-7 90
Benzene, chloro- 2491 000108-90-7 87

36 19.06 0.30 C:\DATABASE\NBS75K.L
Octadecane, 1-chloro- 72489 003386-33-2 58
Octadecane, 1-(ethenyloxy)- 42184 000930-02-9 47
Ethanone, 1-(3-ethylcyclobutyl)- 4560 056335-71-8 43

37 19.22 1.53 C:\DATABASE\NBS75K.L
Decane, 5-methyl- 11605 013151-35-4 81
Decane, 5-methyl- 67316 013151-35-4 70
1-Octyn-3-ol, 4-ethyl- 10973 005877-42-9 53

38 19.36 1.11 C:\DATABASE\NBS75K.L

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-161 ... Floating Product

Decane, 4-methyl- 11615 002847-72-5 93
1,2-Cyclohexanediol, 1-methyl-, trans 5409 019534-08-8 59
Octane, 1,1'-oxybis- 71251 000629-82-3 59

39 19.44 1.32 C:\DATABASE\NBS75K.L
Tetradecane 69661 000629-59-4 83
Decane, 2,9-dimethyl- 15361 001002-17-1 78
Decane, 2-methyl- 67322 006975-98-0 78

40 19.65 0.45 C:\DATABASE\NBS75K.L
Undecane, 3,4-dimethyl- 18993 017312-78-6 59
Octane, 3-ethyl-2,7-dimethyl- 15359 062183-55-5 59
Decane, 3-methyl- 67315 013151-34-3 53

41 19.75 1.03 C:\DATABASE\NBS75K.L
Decane, 3-methyl- 67315 013151-34-3 87
Nonane, 3,7-dimethyl- 11601 017302-32-8 72
Nonane, 5-(1-methylpropyl)- 19016 062185-54-0 59

42 20.13 0.71 C:\DATABASE\NBS75K.L
Cyclohexane, 1,1-dimethyl-2-propyl- 11086 081983-71-3 90
2-Decene, 4-methyl-, (Z)- 11065 074630-30-1 72
Nonane, 2-methyl-3-methylene- 11051 055499-08-6 68

43 20.25 0.17 C:\DATABASE\NBS75K.L
2-Aminopyrimidin-1-oxide 2401 035034-15-2 38
Oxazole, trimethyl- 2421 020662-84-4 38
4(1H)-Pyridinone, 2,3-dihydro-1-methy 2418 035488-00-7 38

44 20.45 0.45 C:\DATABASE\NBS75K.L
Benzene, 1-ethyl-?-methyl-
Benzene, 1-ethyl-2-methyl- 64558 000611-14-3 93
Benzene, 1-ethyl-4-methyl- 3770 000622-96-8 93
Benzene, 1-ethyl-3-methyl- 64562 000620-14-4 93

45 20.66 0.51 C:\DATABASE\NBS75K.L
3-Eicosene, (E)- 39521 074685-33-9 38
1-Octadecanol 72029 000112-92-5 38
1-Tetracosanol 49775 000506-51-4 35

46 20.78 1.60 C:\DATABASE\NBS75K.L
Undecane 11611 001120-21-4 97
Undecane 67318 001120-21-4 97
Undecane 67317 001120-21-4 94

47 20.91 1.42 C:\DATABASE\NBS75K.L

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-161 ... Floating Product

Benzene, 1,3,5-trimethyl- 64571 000108-67-8 92

48 21.06 0.80 C:\DATABASE\NBS75K.L
Cyclohexane, 1-ethyl-4-methyl-, trans 64954 006236-88-0 53
Cyclohexane, 1-methyl-2-propyl- 7590 004291-79-6 50
5-Octen-4-one, 7-methyl- 7454 032064-78-1 43

49 21.28 1.53 C:\DATABASE\NBS75K.L
Undecane, 5-methyl- 15363 001632-70-8 72
Decane, 3,6-dimethyl- 15348 017312-53-7 64
Undecane, 5-methyl- 68258 001632-70-8 62

50 21.38 0.61 C:\DATABASE\NBS75K.L
Naphthalene, decahydro- 7045 000091-17-8 95
Naphthalene, decahydro- 65933 000091-17-8 95
Naphthalene, decahydro-, trans- 65955 000493-02-7 93

51 21.53 1.65 C:\DATABASE\NBS75K.L
Benzene, 1-ethyl-2-methyl- 3765 000611-14-3 25
Benzene, 1-ethyl-2-methyl- 64558 000611-14-3 25
Benzene, (1-methylethyl)- 64552 000098-82-8 25

52 21.72 0.97 C:\DATABASE\NBS75K.L
Undecane, 3,8-dimethyl- 19009 017301-30-3 78
Undecane, 4,7-dimethyl- 19020 017301-32-5 72
Undecane, 5-methyl- 68258 001632-70-8 72

53 21.92 0.57 C:\DATABASE\NBS75K.L
1-Pentene, 3,3-dimethyl- 1351 003404-73-7 38
1-Undecene, 10-methyl- 14799 022370-55-4 35
Cyclopropane, 1,2-dimethyl-1-pentyl- 7541 062238-04-4 30

54 22.15 0.80 C:\DATABASE\NBS75K.L
1,2,4-Trimethylbenzene 3771 000095-36-3 93

55 22.31 0.27 C:\DATABASE\NBS75K.L
6-Octen-1-ol, 3,7-dimethyl-, acetate 22399 000150-84-5 25
Undecane, 2,6-dimethyl- 69033 017301-23-4 22
Dodecane, 6-methyl- 19006 006044-71-9 12

56 22.69 1.09 C:\DATABASE\NBS75K.L
Undecane 67318 001120-21-4 53
Decane 66205 000124-18-5 53
Dodecane 68252 000112-40-3 50

57 22.87 0.63 C:\DATABASE\NBS75K.L

Note: Identified compounds in bold print have been verified with actual standard

Undecane, 4-methyl- 15354 002980-69-0 70
Octane, 6-ethyl-2-methyl- 11609 062016-19-7 50
Nonane, 5-butyl- 19037 017312-63-9 47

58 22.99 1.01 C:\DATABASE\NBS75K.L
3-Dodecene, (Z)- 14732 007239-23-8 93
1-Nonene 4675 000124-11-8 64
1-Nonene 64957 000124-11-8 64

59 23.20 0.53 C:\DATABASE\NBS75K.L
Naphthalene, decahydro-2-methyl- 67009 002958-76-1 86
Pulegone 66994 000089-82-7 70
Pulegone 66995 000089-82-7 58

60 23.28 0.77 C:\DATABASE\NBS75K.L
Undecane, 3-methyl- 15362 001002-43-3 72
Undecane, 3,9-dimethyl- 19014 017301-31-4 64
Decane, 6-ethyl-2-methyl- 19010 062108-21-8 64

61 23.54 0.24 C:\DATABASE\NBS75K.L
Thymol 66818 000089-83-8 12
Tetradecane, 1-chloro- 70963 002425-54-9 12
2-Ethyl-1-dodecanol 26412 000000-00-0 12

62 23.64 0.06 C:\DATABASE\NBS75K.L
Benzene, butyl- 65549 000104-51-8 27
Benzene, (butoxymethyl)- 13535 000588-67-0 25
Bicyclo[3.1.0]hexan-3-ol, 4-methylene 10354 000471-16-9 12

63 23.81 0.83 C:\DATABASE\NBS75K.L
Benzene, 1,2,3-trimethyl-

64 23.97 0.49 C:\DATABASE\NBS75K.L
Naphthalene, decahydro-2-methyl- 67009 002958-76-1 89
9-Octadecyne 34017 035365-59-4 72
Naphthalene, decahydro-2-methyl- 67008 002958-76-1 53

65 24.31 1.00 C:\DATABASE\NBS75K.L
Dodecane 68252 000112-40-3 70
Dodecane 68250 000112-40-3 70

66 24.66 1.78 C:\DATABASE\NBS75K.L
Undecane, 2,6-dimethyl- 19058 017301-23-4 93
Dodecane, 6-methyl- 19006 006044-71-9 91
Undecane, 2,6-dimethyl- 69033 017301-23-4 91

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-161 ... Floating Product

67 24.87 1.06 C:\DATABASE\NBS75K.L
Decane, 2,2,8-trimethyl- 19012 062238-01-1 72
Hexane, 2,2,5-trimethyl- 5149 003522-94-9 64
Undecane, 2,2-dimethyl- 19038 017312-64-0 64

68 25.02 0.97 C:\DATABASE\NBS75K.L
Heptane, 2,2,3,4,6,6-hexamethyl- 19044 062108-32-1 59
Hexane, 2,2,4-trimethyl- 65103 016747-26-5 53
Decane, 2,2,6-trimethyl- 18995 062237-97-2 53

69 25.18 0.29 C:\DATABASE\NBS75K.L
Benzene, 1-ethyl-2,4-dimethyl- 65572 000874-41-9 89
Benzene, 2-ethyl-1,3-dimethyl- 65532 002870-04-4 76
Benzene, 2-ethyl-1,3-dimethyl- 65533 002870-04-4 76

70 25.45 0.07 C:\DATABASE\NBS75K.L
Dodecane, 3-methyl- 19011 017312-57-1 47
Octane, 2,4,6-trimethyl- 11606 062016-37-9 47
Tetradecane, 6,9-dimethyl- 29253 055045-13-1 43

71 25.62 0.98 C:\DATABASE\NBS75K.L
Decane, 3,3,6-trimethyl- 19028 062338-14-1 64
Decane, 3,3,5-trimethyl- 19024 062338-13-0 64
Decane, 3,3,8-trimethyl- 19033 062338-16-3 64

72 25.75 0.35 C:\DATABASE\NBS75K.L
Undecane, 2,6-dimethyl- 19058 017301-23-4 64
Octane, 3,5-dimethyl- 8108 015869-93-9 64
Dodecane, 2,6,11-trimethyl- 25998 031295-56-4 64

73 25.92 0.32 C:\DATABASE\NBS75K.L
Decane, 2,3,5-trimethyl- 19043 062238-11-3 53
Pentadecane, 6-methyl- 29255 010105-38-1 53
Undecane, 5-ethyl- 19036 017453-94-0 50

74 26.05 0.47 C:\DATABASE\NBS75K.L
Benzene, 1,4-dichloro-

75 26.15 1.04 C:\DATABASE\NBS75K.L
Heptadecane, 2,6,10,15-tetramethyl- 42196 054833-48-6 86
Octadecane 71560 000593-45-3 78
Heneicosane 42201 000629-94-7 72

76 26.25 0.64 C:\DATABASE\NBS75K.L
Nonane, 5-methyl-5-propyl- 19057 017312-75-3 59
4-Heptanone, 3-methyl- 65063 015726-15-5 49

Note: Identified compounds in bold print have been verified with actual standard

Nonane, 5-(2-methylpropyl)- 19015 062185-53-9 36

77 26.31 0.83 C:\DATABASE\NBS75K.L
Cyclohexane, 2-butyl-1,1,3-trimethyl- 18489 054676-39-0 93
Cyclohexane, 2-butyl-1,1,3-trimethyl- 68868 054676-39-0 87
4-Dodecene 14801 002030-84-4 72

78 26.45 2.16 C:\DATABASE\NBS75K.L
Hexane, 2,2,5,5-tetramethyl- 66226 001071-81-4 53
Undecane, 3-methyl- 15362 001002-43-3 50
Decane, 2,2,7-trimethyl- 19001 062237-99-4 50

79 26.64 1.62 C:\DATABASE\NBS75K.L
Nonane, 3-methyl- 66200 005911-04-6 87
Undecane, 2,6-dimethyl- 19058 017301-23-4 83
Nonane, 3-methyl- 66202 005911-04-6 81

80 26.75 0.70 C:\DATABASE\NBS75K.L
Benzene, 4-ethyl-1,2-dimethyl- 65569 000934-80-5 50
Benzene, 1-methyl-2-(1-methylethyl)- 65581 000527-84-4 46
Benzene, 2-ethyl-1,4-dimethyl- 65570 001758-88-9 46

81 26.87 0.35 C:\DATABASE\NBS75K.L
Benzene, 1-methyl-4-(1-methylethyl)- 65535 000099-87-6 86
Benzene, 1,2,3,4-tetramethyl- 65540 000488-23-3 50
Benzene, 1,3-diethyl- 65563 000141-93-5 50

82 27.00 0.89 C:\DATABASE\NBS75K.L
Dodecane, 2,6,10-trimethyl- 25995 003891-98-3 72
Heptane, 3,3,5-trimethyl- 8090 007154-80-5 64
Dodecane, 2,7,10-trimethyl- 26005 074645-98-0 64

83 27.14 1.19 C:\DATABASE\NBS75K.L
Decane, 3,3,6-trimethyl- 19028 062338-14-1 47
Decane, 2,7,7-trimethyl- 19031 062338-15-2 47
Decane, 3,3,8-trimethyl- 19033 062338-16-3 47

84 27.27 1.01 C:\DATABASE\NBS75K.L
2,2,7,7-Tetramethyloctane 15365 001071-31-4 59
Decane, 2,2-dimethyl- 15358 017302-37-3 59
Octane, 2,2,6-trimethyl- 11599 062016-28-8 53

85 27.49 1.06 C:\DATABASE\NBS75K.L
Benzene, 1,2-dichloro- 66413 000095-50-1 95
Benzene, 1,2-dichloro- 8725 000095-50-1 95

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-161 ... Floating Product

86 27.75 1.61 C:\DATABASE\NBS75K.L
Tridecane

87 27.86 1.02 C:\DATABASE\NBS75K.L
Heptane, 2,2,3,4,6,6-hexamethyl- 19044 062108-32-1 47
Hexane, 1-(hexyloxy)-5-methyl- 23021 074421-19-5 47
Dodecane, 3-methyl- 69025 017312-57-1 43

88 27.97 0.29 C:\DATABASE\NBS75K.L
Octane, 2,2-dimethyl- 8097 015869-87-1 33
1-Octadecanol 72028 000112-92-5 32
Decane, 2,2,6-trimethyl- 18995 062237-97-2 28

89 28.02 0.38 C:\DATABASE\NBS75K.L
Benzene, (1,1-dimethylpropyl)- 66630 002049-95-8 59
Benzene, (1,1-dimethylpropyl)- 9392 002049-95-8 59
Benzene, (1,1-dimethylpropyl)- 66629 002049-95-8 59

90 28.11 0.92 C:\DATABASE\NBS75K.L
Cyclohexane, 1,1,2-trimethyl- 64970 007094-26-0 43
3,5-Dimethyl cyclohexanone 64915 002320-30-1 43
Cyclopentane, ethyl- 1350 001640-89-7 38

91 28.29 1.23 C:\DATABASE\NBS75K.L
Decane, 2,5,9-trimethyl- 19017 062108-22-9 80
Undecane, 5-ethyl- 19036 017453-94-0 78
Dodecane, 2,6,10-trimethyl- 25995 003891-98-3 72

92 28.45 0.81 C:\DATABASE\NBS75K.L
Cyclohexane, (1,1-dimethylethyl)- 66082 003178-22-1 25
1-Hexene, 5-methyl- 63238 003524-73-0 9
1-Decene, 2-methyl- 11039 013151-27-4 9

93 28.62 0.42 C:\DATABASE\NBS75K.L
Cyclopentene, 5-hexyl-3,3-dimethyl- 17939 061142-66-3 49
1,3-Dimethyl-1-cyclohexene 2371 002808-76-6 42
trans,cis-2,10-Dimethylspiro[5.5]unde 17927 000000-00-0 30

94 28.72 0.36 C:\DATABASE\NBS75K.L
Heptane, 3-ethyl-2-methyl- 8080 014676-29-0 50
Decane, 2,5,6-trimethyl- 19019 062108-23-0 45
1-Pentanol, 2-ethyl-4-methyl- 5549 000106-67-2 38

95 28.80 0.44 C:\DATABASE\NBS75K.L
Benzene, 4-ethyl-1,2-dimethyl- 65568 000934-80-5 90
Benzene, 1,2,3,5-tetramethyl- 6220 000527-53-7 90

Note: Identified compounds in bold print have been verified with actual standard

Benzene, 1,2,3,4-tetramethyl- 65541 000488-23-3 90

96 28.97 1.36 C:\DATABASE\NBS75K.L
Nonane, 3-methyl-5-propyl- 19054 031081-18-2 78
Nonane, 2-methyl-5-propyl- 19052 031081-17-1 72
Nonane, 3,7-dimethyl- 11601 017302-32-8 64

97 29.12 0.40 C:\DATABASE\NBS75K.L
1H-Indene, 2,3-dihydro-4-methyl- 5893 000824-22-6 70
Indan, 1-methyl- 5882 000767-58-8 70
1H-Indene, 2,3-dihydro-5-methyl- 5885 000874-35-1 68

98 29.20 0.62 C:\DATABASE\NBS75K.L
Undecane, 6-ethyl- 19029 017312-60-6 72
Nonane, 3-methyl- 66200 005911-04-6 64
Undecane, 2,6-dimethyl- 19058 017301-23-4 64

99 29.37 1.32 C:\DATABASE\NBS75K.L
Dodecane, 3-methyl- 69025 017312-57-1 59
Undecane, 3,9-dimethyl- 19014 017301-31-4 59
Undecane, 3-methyl- 15362 001002-43-3 53

100 29.55 1.11 C:\DATABASE\NBS75K.L
Undecane, 2,9-dimethyl- 18994 017301-26-7 53
Undecane 67319 001120-21-4 53
Pentadecane 70278 000629-62-9 50

101 29.74 1.12 C:\DATABASE\NBS75K.L
Octane, 2,2-dimethyl- 8097 015869-87-1 64
Decane, 2,2,7-trimethyl- 19001 062237-99-4 53
Decane, 2,2,6-trimethyl- 18995 062237-97-2 53

102 29.84 0.61 C:\DATABASE\NBS75K.L
1-Heptene, 2-pentyl- 68117 017799-46-1 30
Cyclopropane, 1-butyl-2-(2-methylprop 11036 041977-35-9 22
1-Pentadecene, 2-methyl- 28778 029833-69-0 16

103 29.96 0.57 C:\DATABASE\NBS75K.L
Iron, dicarbonyl[(1,2,3,4,5-.eta.)-2, 27996 106251-36-9 38
Octane, 2,2,6-trimethyl- 11599 062016-28-8 25
Butane, 1-chloro-2-methyl- 63678 000616-13-7 9

104 30.20 2.05 C:\DATABASE\NBS75K.L
Dodecane, 2,7,10-trimethyl- 26005 074645-98-0 91
Dodecane, 2,6,10-trimethyl- 25995 003891-98-3 90
Dodecane, 2,6,11-trimethyl- 25998 031295-56-4 90

Note: Identified compounds in bold print have been verified with actual standard

105 30.44 0.60 C:\DATABASE\NBS75K.L
Heptadecane, 8-methyl- 34816 013287-23-5 72
Heptadecane 71191 000629-78-7 64
Pentadecane 70278 000629-62-9 64

106 30.56 1.21 C:\DATABASE\NBS75K.L
1,1'-Bicyclohexyl 68010 000092-51-3 37
1,1'-Bicyclohexyl 68011 000092-51-3 37
Bicyclo[3.1.1]heptane, 2,6,6-trimethy 7100 000473-55-2 35

107 30.82 0.36 C:\DATABASE\NBS75K.L
Tridecane, 1-iodo- 44187 035599-77-0 47
Tridecane, 2-methyl- 69663 001560-96-9 47
Tridecane 69019 000629-50-5 47

108 31.10 1.15 C:\DATABASE\NBS75K.L
Tetradecane 69659 000629-59-4 64

109 31.24 0.80 C:\DATABASE\NBS75K.L
Undecane, 2,5-dimethyl- 19056 017301-22-3 43
Hexane, 3-ethyl-4-methyl- 5162 003074-77-9 40
Decane, 2,5,9-trimethyl- 19017 062108-22-9 38

110 31.42 0.27 C:\DATABASE\NBS75K.L
Decane, 2,2,3-trimethyl- 19005 062338-09-4 47
Hexane 62874 000110-54-3 43
Pentane, 2,2,3,4-tetramethyl- 65146 001186-53-4 43

111 31.47 0.52 C:\DATABASE\NBS75K.L
Cyclopentane, 1-butyl-2-pentyl- 21986 061142-52-7 49
Cyclotetradecane 69525 000295-17-0 43
Cyclotetradecane 21964 000295-17-0 38

112 31.66 0.62 C:\DATABASE\NBS75K.L
3-Heptyne, 5-methyl- 2341 061228-09-9 22
Cyclohexane, 1-(cyclohexylmethyl)-2-e 25007 054934-93-9 16
Thujone 66997 000546-80-5 16

113 31.81 0.76 C:\DATABASE\NBS75K.L
Cyclohexane, 1,1,2,3-tetramethyl- 7580 006783-92-2 49
Cyclohexane, 1,1,2-trimethyl- 4685 007094-26-0 38
4-Nonene, 2-methyl- 7531 055724-84-0 38

114 32.06 0.59 C:\DATABASE\NBS75K.L
Decane, 3,8-dimethyl- 68255 017312-55-9 50

Note: Identified compounds in bold print have been verified with actual standard

Dodecane, 2-methyl-6-propyl- 29264 055045-08-4 50
Tridecane, 7-propyl- 29265 055045-09-5 50

115 32.21 0.61 C:\DATABASE\NBS75K.L
Undecane, 4,6-dimethyl- 19008 017312-82-2 14
Cyclohexane, 1-ethyl-4-methyl-, cis- 64933 004926-78-7 14
Cyclohexane, 1-methyl-4-(1-methylbuty 14802 054411-00-6 14

116 32.45 0.77 C:\DATABASE\NBS75K.L
Dodecane, 2,6,10-trimethyl- 25995 003891-98-3 50
Tetratetracontane 61068 007098-22-8 50
Decane, 5-ethyl-5-methyl- 19055 017312-74-2 50

117 32.64 0.71 C:\DATABASE\NBS75K.L
Decane, 2,2,8-trimethyl- 19012 062238-01-1 47
1-Pentanol, 2-ethyl-4-methyl- 5549 000106-67-2 45
Hexatriacontane 74635 000630-06-8 43

118 32.76 0.31 C:\DATABASE\NBS75K.L
Cyclopropane, 1,1-dichloro-2,3-diisop 21143 024551-89-1 23
Hexane, 2,2-dimethyl- 3091 000590-73-8 10
Pentane, 2,2,4-trimethyl- 64221 000540-84-1 10

119 32.93 1.41 C:\DATABASE\NBS75K.L
Undecane, 2,6-dimethyl- 19058 017301-23-4 86
Heptadecane, 2,6,10,15-tetramethyl- 42196 054833-48-6 80
Heptadecane 71191 000629-78-7 80

120 33.06 0.52 C:\DATABASE\NBS75K.L
Hexadecane, 1-chloro- 35935 004860-03-1 38
Cetylpyridinium Chloride 50020 006004-24-6 38
Cyclohexane, 1-(cyclohexylmethyl)-2-m 21408 054823-94-8 30

121 33.17 0.45 C:\DATABASE\NBS75K.L
Propanoic acid, 2-methyl-, 3-methylbu 67439 002050-01-3 16
1-Pentanol, 2-methyl- 1775 000105-30-6 16
Cyclohexanol, 4-pentyl- 15319 054410-90-1 16

122 33.38 0.70 C:\DATABASE\NBS75K.L
Hexadecane, 2,6,10,14-tetramethyl- 72328 000638-36-8 59
Dodecane, 2,6,11-trimethyl- 70272 031295-56-4 50
Octane, 3,5-dimethyl- 8108 015869-93-9 50

123 33.64 0.36 C:\DATABASE\NBS75K.L
Heptadecane, 2,6,10,15-tetramethyl- 42196 054833-48-6 53
Dodecane, 2,7,10-trimethyl- 26005 074645-98-0 53

Note: Identified compounds in bold print have been verified with actual standard

Octane, 1,1'-oxybis- 32426 000629-82-3 53

124 33.68 0.33 C:\DATABASE\NBS75K.L
8-Azabicyclo[3.2.1]octane-3-carbonitr 9755 005911-81-9 42
Cyclohexane, 1,1'-(1-methyl-1,2-ethan 25013 041851-34-7 40
Cyclopentane, 1-hexyl-3-methyl- 14762 061142-68-5 38

125 33.82 0.33 C:\DATABASE\NBS75K.L
Bacchotricuneatin c 48377 066563-30-2 38
Undecane, 2,5-dimethyl- 69031 017301-22-3 22
Hexadecane 70789 000544-76-3 22

126 33.99 0.37 C:\DATABASE\NBS75K.L
Decane, 5,6-bis(2,2-dimethylpropylide 39224 000000-00-0 38
Cyclohexane, 1-(cyclohexylmethyl)-4-m 21413 054823-97-1 30
Cyclohexane, 1-(cyclohexylmethyl)-4-m 21416 054823-98-2 30

127 34.30 0.26 C:\DATABASE\NBS75K.L
Pentadecane

128 34.46 0.59 C:\DATABASE\NBS75K.L
Decahydro-4,4,8,9,10-pentamethylnapht 24990 000000-00-0 64
Cyclopentane, 1,1,3,4-tetramethyl-, c 4652 053907-60-1 27
Cyclopentane, 1,1,3,4-tetramethyl-, t 4623 020309-77-7 27

129 34.57 0.31 C:\DATABASE\NBS75K.L
1-Ethyl-2,2,6-trimethylcyclohexane 11030 000000-00-0 74
Cyclopentane, butyl- 64938 002040-95-1 58
Cyclooctane 63993 000292-64-8 55

130 34.77 0.20 C:\DATABASE\NBS75K.L
Cyclopentadecanone 28755 000502-72-7 25
Cyclopentadecanone 70717 000502-72-7 22
3-Undecene, 5-methyl- 14689 000000-00-0 18

131 34.95 0.30 C:\DATABASE\NBS75K.L
Naphthalene 65149 000091-20-3 94
Naphthalene 5167 000091-20-3 94
Naphthalene 65150 000091-20-3 93

132 35.56 0.21 C:\DATABASE\NBS75K.L
Cyclohexane, 1,1-dimethyl- 64012 000590-66-9 35
Cyclopentane, (2-methylbutyl)- 7553 053366-38-4 27
Cyclopropane, 1-ethyl-2-heptyl- 14774 074663-86-8 22

133 35.67 0.32 C:\DATABASE\NBS75K.L

Note: Identified compounds in bold print have been verified with actual standard

2-Hexyl-1-octanol	26413	000000-00-0 52
2-Hexyl-1-decanol	32422	000000-00-0 49
Decane, 1,1'-oxybis-	72724	002456-28-2 38

134 35.79 0.36 C:\DATABASE\NBS75K.L

Heptane, 2,6-dimethyl-	5156	001072-05-5 87
Tetradecane	69662	000629-59-4 86
Undecane, 3,8-dimethyl-	19009	017301-30-3 80

135 35.88 0.43 C:\DATABASE\NBS75K.L

Decahydro-4,4,8,9,10-pentamethylnapht	24990	000000-00-0 60
p-Menthon-8-thiol	19373	033281-91-3 35
7-Tetradecanol	26414	000000-00-0 12

136 36.22 0.33 C:\DATABASE\NBS75K.L

Pentadecane	70273	000629-62-9 59
Tetradecane	69659	000629-59-4 53
Undecane, 2,8-dimethyl-	18991	017301-25-6 53

137 36.49 0.33 C:\DATABASE\NBS75K.L

2,6-Naphthalenedione, octahydro-1,1,8	24932	057289-17-5 68
Cyclopentene, 1,3-dimethyl-2-(1-methy	7047	061142-32-3 47
Benzoyl chloride, 4-fluoro-	11820	000403-43-0 47

138 36.95 0.28 C:\DATABASE\NBS75K.L

Cyclohexane, 1,1'-(1-methyl-1,2-ethan	25013	041851-34-7 49
Cyclohexane, decyl-	70722	001795-16-0 47
Cyclohexane, 1,1'-(1,4-butanediyl)bis	28274	006165-44-2 47

139 37.38 0.04 C:\DATABASE\NBS75K.L

Octadecane, 6-methyl-	37465	010544-96-4 64
Dodecane, 3-methyl-	69025	017312-57-1 59
Pentatriacontane	58743	000630-07-9 59

140 38.29 0.17 C:\DATABASE\NBS75K.L

Naphthalene, 2-methyl-	66237	000091-57-6 93
Naphthalene, 2-methyl-	66236	000091-57-6 90

141 38.51 0.09 C:\DATABASE\NBS75K.L

Cyclopentane, 1,1,3-trimethyl-3-(2-me	14156	074421-09-3 47
Cyclohexane, (1,2-dimethylbutyl)-	14741	061142-37-8 43
cis,trans,cis-1-Isobutyl-2,5-dimethyl	14698	000000-00-0 38

142 38.61 0.55 C:\DATABASE\NBS75K.L

Undecane, 3,6-dimethyl-	19000	017301-28-9 72
Eicosane	72326	000112-95-8 64

Note: Identified compounds in bold print have been verified with actual standard

Sample Name: U1-161 ... Floating Product

Heptadecane 71191 000629-78-7 64

143 38.71 0.20 C:\DATABASE\NBS75K.L
Cyclopropanemethanol, 2,2,3,3-tetrame 5066 002415-96-5 37
3-Acetonylcyclohexanone 10818 000937-45-1 32
Cyclohexane, 1-(cyclohexylmethyl)-3-m 21411 054823-96-0 30

144 39.22 0.20 C:\DATABASE\NBS75K.L
Naphthalene, 1-methyl- 8111 000090-12-0 87

145 39.87 0.13 C:\DATABASE\NBS75K.L
Triacontane 55461 000638-68-6 25
Nonacosane 54526 000630-03-5 25
Pentatriacontane 58743 000630-07-9 22

146 40.20 1.09 C:\DATABASE\NBS75K.L
Octadecane, 2,6-dimethyl- 39863 075163-97-2 90
Heptadecane, 2,6-dimethyl- 37466 054105-67-8 90
Hexadecane, 2,6,11,15-tetramethyl- 39867 000504-44-9 87

147 40.48 0.24 C:\DATABASE\NBS75K.L
7-Tetradecene 21970 010374-74-0 76
3-Tetradecene, (E)- 21967 041446-68-8 64
Cyclopentane, propyl- 64026 002040-96-2 58

148 42.15 0.27 C:\DATABASE\NBS75K.L
most likely 1,3 & 1,7-dimethylnaphthalene (DAK)
Naphthalene, 1,7-dimethyl- 67343 000575-37-1 59
Naphthalene, 2,6-dimethyl- 67337 000581-42-0 59
Naphthalene, 1,5-dimethyl- 67354 000571-61-9 56

149 42.34 0.28 C:\DATABASE\NBS75K.L
Naphthalene, 1,6-dimethyl- 67351 000575-43-9 96

150 43.16 0.85 C:\DATABASE\NBS75K.L
Dodecane, 2,6,10-trimethyl- 25995 003891-98-3 86
Dodecane, 2,7,10-trimethyl- 26005 074645-98-0 86
Tritetracontane 60913 007098-21-7 83

151 45.05 0.15 C:\DATABASE\NBS75K.L
Mesityl oxide semicarbazone 11144 003780-62-9 38
Cyclopropanemethanol, 2,2,3,3-tetrame 5066 002415-96-5 22
Ethyl 3-thiopheneacetate 15048 037784-63-7 22

152 46.12 0.20 C:\DATABASE\NBS75K.L
1-Pyrroline, 3-ethyl- 1176 001192-29-6 50

Note: Identified compounds in bold print have been verified with actual standard

Zinc, bis[2-(1,1-dimethylethyl)-3,3-d 44808 074793-36-5 25
1,7-Dimethyl-4-(1-methylethyl)cyclode 25489 000645-10-3 16

153 50.09 0.34 C:\DATABASE\NBS75K.L
Pentadecane 70277 000629-62-9 60
Tridecane 69021 000629-50-5 60
Tetradecane 69660 000629-59-4 60

154 50.45 0.50 C:\DATABASE\NBS75K.L
Hexadecane, 2,6,10,14-tetramethyl- 72328 000638-36-8 86
Pentadecane, 4-methyl- 70784 002801-87-8 81
Hexadecane 29267 000544-76-3 80

155 52.26 0.12 C:\DATABASE\NBS75K.L
1-Decanol, 2-hexyl- 32429 002425-77-6 49
Dodecane, 1-fluoro- 19931 000334-68-9 38
Cyclododecanone 68858 000830-13-7 27

Thu Apr 10 13:20:30 1997

Note: Identified compounds in bold print have been verified with actual standard

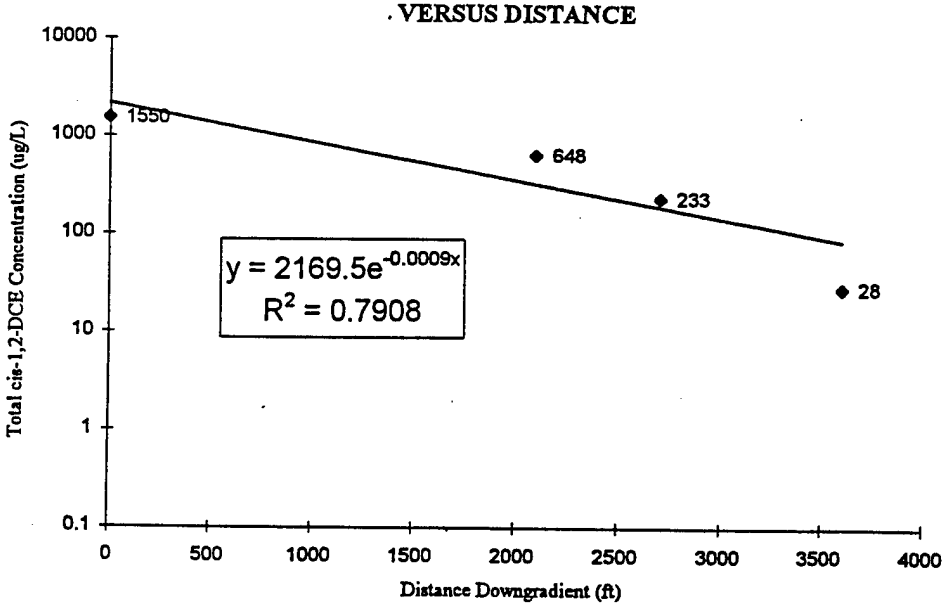
APPENDIX D

SUPPORTING DATA AND CALCULATIONS FOR GROUNDWATER/FATE AND TRANSPORT MODELING

FIRST-ORDER DECAY RATE CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)
OU 1 RNA TS
HILL AFB, UTAH

Point	Distance (ft) Downgradient	cis-1,2-DCE (µg/L) Mar-97
U1-074	0	1550
U1-155	2100	648
U1-1637	2700	233
U1-099	3600	28

PLOT OF cis-1,2-DCE CONCENTRATION VERSUS DISTANCE



$$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$$

where $v_c = 0.2$ ft/day
$\alpha_x = 360$ feet
$k/v = 0.0009$

therefore $\lambda = 2.38E\text{-}04$ $days^{-1}$

REDUCTIVE DECHLORINATION RATE
MOUTOUX et al. METHOD (1995)
U1-074>U1-105>U1-1637>U1-099
OU 1 RNA TS
HILL AFB, UTAH

Step 1: Enter Observed Contaminant Concentration (µg/L)

Well	PCE	TCE	DCE	VC	Ethene	Total CAHs
U1-074	2.0	0.5	1556.2	9.0	3.0	1570.7
U1-105	0.0	3.4	649.0	0.5	0.0	652.9
U1-1637	0.0	3.1	234.0	0.0	0.0	237.10
U1-099	0.0	0.0	27.9	0.0	0.0	27.9

Step 2: Compute Molar Concentrations (micromoles/Liter)

Well	M_{PCE}	M_{TCE}	M_{DCE}	M_{VC}	M_{Ethene}	Total M_{CAHs}
U1-074	0.01	0.00	16.05	0.14	0.11	16.32
U1-105	0.00	0.03	6.69	0.01	0.00	6.73
U1-1637	0.00	0.02	2.41	0.00	0.00	2.44
U1-099	0.00	0.00	0.29	0.00	0.00	0.29

Step 3: Compute Carbon Equivalents

Well	Total M_{CAHs}	x 2	= Ceqi
U1-074	16.32		32.64
U1-105	6.73		13.46
U1-1637	2.44		4.87
U1-099	0.29		0.58

Step 4: Compute Chlorine Equivalents

Well	M_{PCE} x 4	M_{TCE} x 3	M_{DCE} x 2	M_{VC}	Σ = $Cleq_i$
U1-074	0.05	0.01	32.11	0.14	32.31
U1-105	0.00	0.08	13.39	0.01	13.48
U1-1637	0.00	0.07	4.83	0.00	4.90
U1-099	0.00	0.00	0.58	0.00	0.58

Step 5: Compute Corrected CAH Concentrations

$C_{i,corr} = C_{i-1,corr} \times (Cleq_i / Cleq_{i-1}) \times (Ceq_{i-1} / Ceq_i)$

Well	$C_{i-1,corr}$	$Cleq_i / Cleq_{i-1}$	Ceq_{i-1} / Ceq_i	$C_{i,corr}$
U1-074	1570.70			1570.70
U1-105	1570.70	0.42	2.43	1588.85
U1-1637	1588.85	0.36	2.76	1594.42
U1-099	1594.42	0.12	8.47	1586.74

Step 6: Plot Exponential Trendline of Contaminant Concentration vs. Time

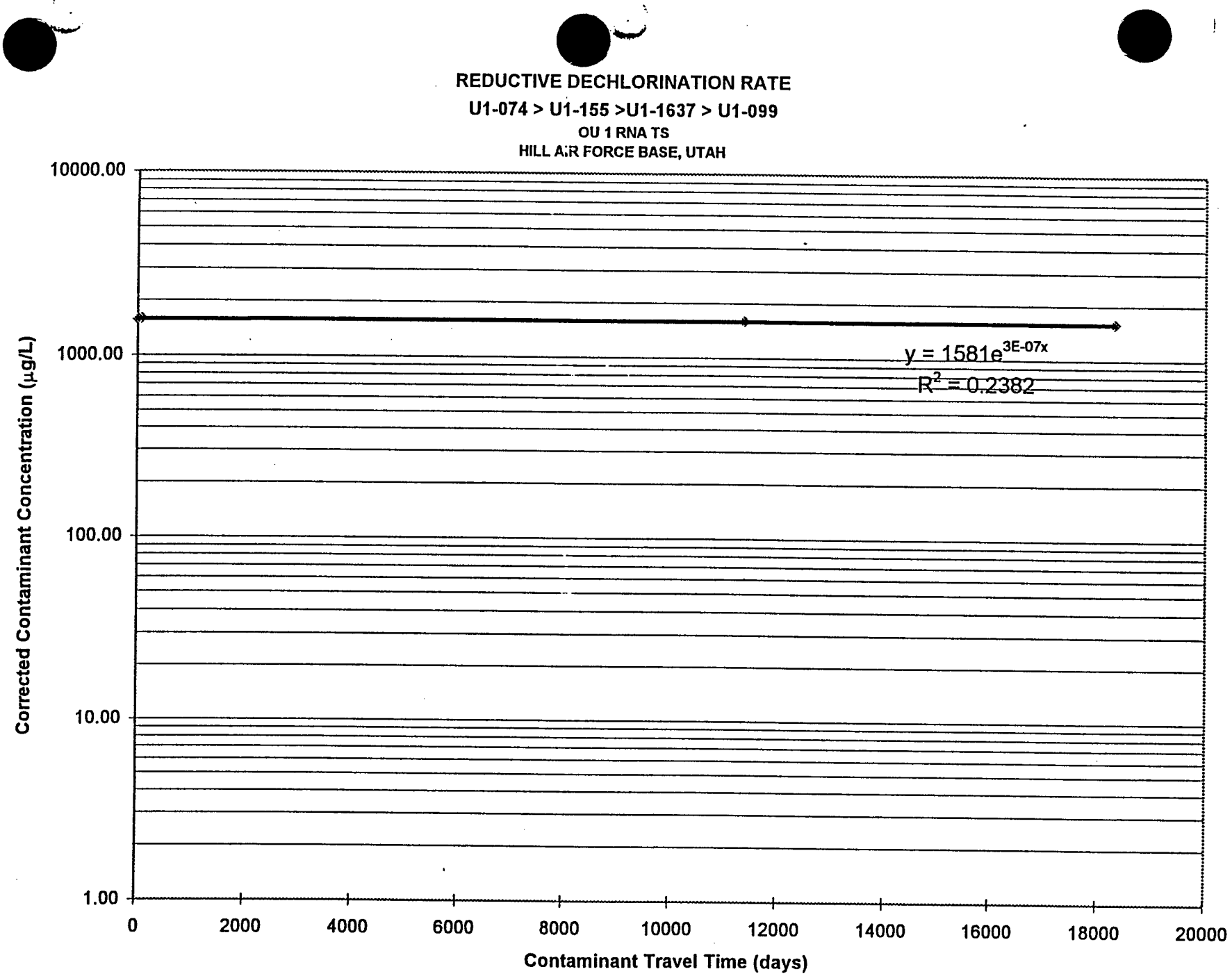
Well	Distance From Source (ft)	CAH avg. velocity (ft/day)	CAH Travel Time (day)	$C_{i,corr}$
U1-074	0		0	1570.70
U1-105	2100	29.000	72	1588.85
U1-1637	2700	0.053	11393	1594.42
U1-099	3600	0.130	18316	1586.74

Reductive Dechlorination Rate

$C = C_0 e^{-kt}$ where:

C = Corrected Contaminant Concentration (µg/L) at time t (days)
C_0 = Initial Contaminant Concentration (µg/L)
k = Reductive Dechlorination Rate ($days^{-1}$)

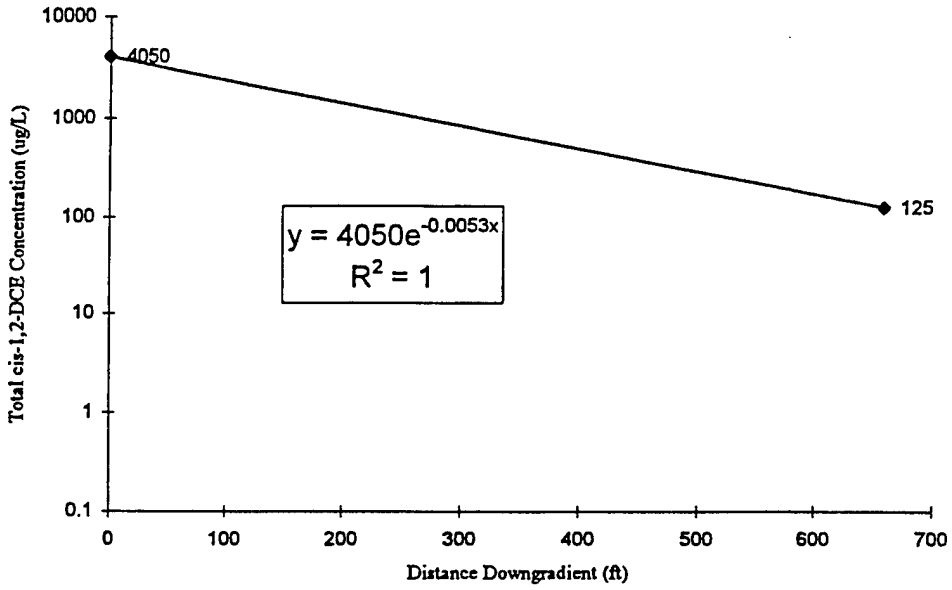
from plot: $y = 1581e^{3E-07x}$ λ = NA
Note: graph has positive slope—calculated decay rate is invalid.


REDUCTIVE DECHLORINATION RATE
U1-074 > U1-155 >U1-1637 > U1-099
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH
10000.00
1000.00
100.00
10.00
1.00
Corrected Contaminant Concentration (µg/L)
y = 1581e3E-07x
R2 = 0.2382
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Contaminant Travel Time (days)

FIRST-ORDER DECAY RATE CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)
OU 1 RNA TS
HILL AFB, UTAH

Point	Distance (ft) Downgradient	cis-1,2-DCE (µg/L) Mar-97
U1-667	0	4050
U1-123	660	125

PLOT OF cis-1,2-DCE CONCENTRATION VERSUS DISTANCE



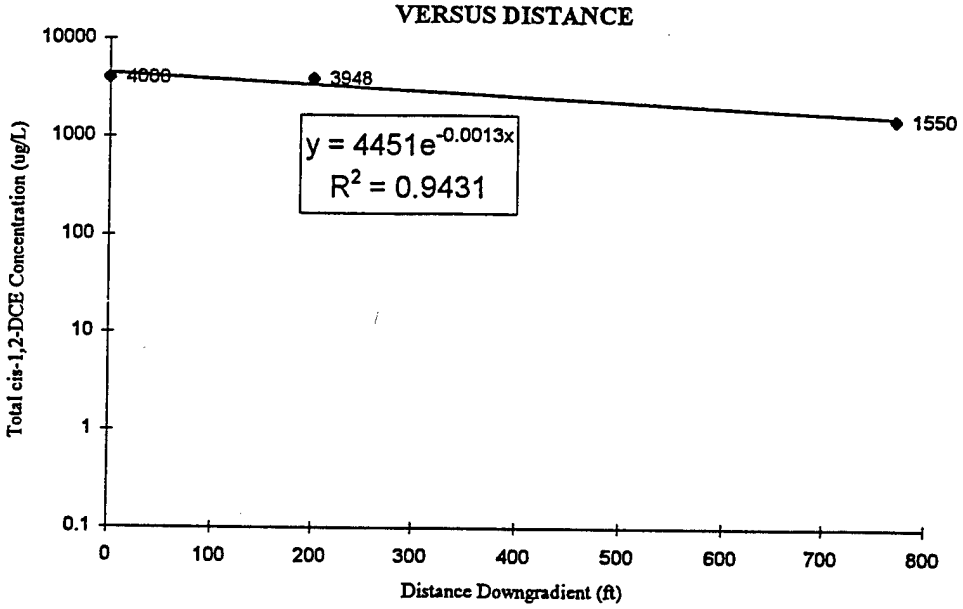
$$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$$

where	v_c = 0.02	ft/day
	α_x = 66	feet
	k/v = 0.0053	
therefore	λ = 1.43E-04	$days^{-1}$

FIRST-ORDER DECAY RATE CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)
OU 1 RNA TS
HILL AFB, UTAH

Point	Distance (ft) Downgradient	cis-1,2-DCE (µg/L) Mar-97
U1-067	0	4000
U1-070	200	3948
U1-074	770	1550

PLOT OF cis-1,2-DCE CONCENTRATION VERSUS DISTANCE



$$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$$

where $v_c = 0.3$ ft/day
$\alpha_x = 77$ feet
$k/v = 0.0013$

therefore $\lambda = 4.29E\text{-}04$ $days^{-1}$

Computation of corrected contaminant concentrations using conservative tracers and correcting for retardation (method presented in Wiedemeier et al., 1996)							
input variables:							
C(i, corr)	unknown						
C(i-1, corr	4000					1,3,5 +	
C(i)	3948			Well	cis-1,2-DCE	1,2,4 TMB	
C(i-1)	4000			U1-067	4000	413	
T(i)	144			U1-070	3948	144	
T(i-1)	413			U1-074	1550	246	
R(c)	1.15						
R(t)	3.25						
intermediate calculations:							
c(i)/c(i-1)	0.987						
R(c)/R(t)	0.353846						
T(i)/T(i-1)	0.348668						
c(i-1,corr) X [c(i)/C(i-1)]			3948				
R(c)/R(t)[1-T(i)/T(i-1)]			0.230471				
Final Calculation:							
C(i,corr)=	5130.412						

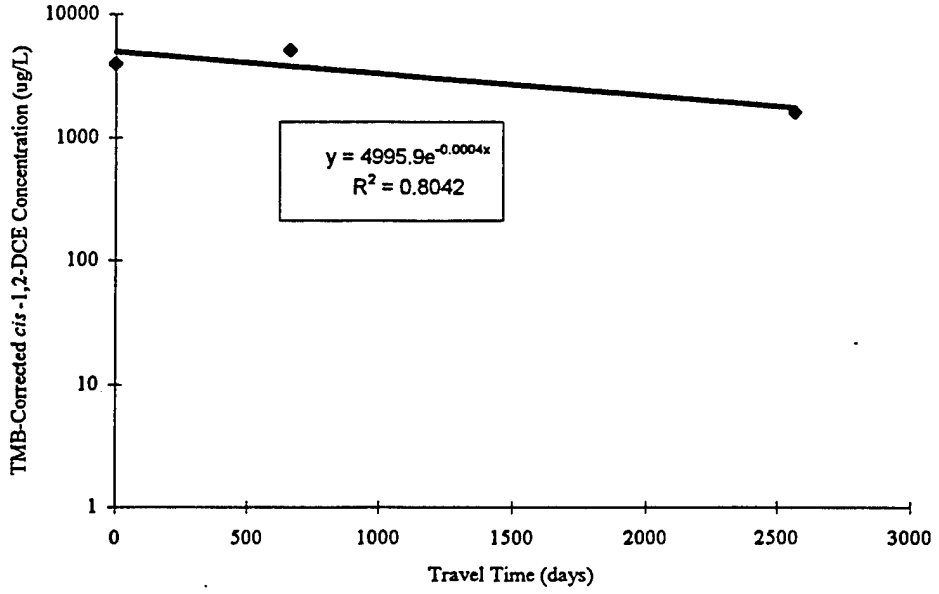
Computation of corrected contaminant concentrations using conservative tracers and correcting for retardation (method presented in Wiedemeier et al., 1996)							
input variables:							
C(i, corr)	unknown						
C(i-1, corr	5130					1,3,5 +	
C(i)	1550			Well	cis-1,2-DCE	1,2,4 TMB	
C(i-1)	3948			U1-067	4000	413	
T(i)	246			U1-070	3948	144	
T(i-1)	144			U1-074	1550	246	
R(c)	1.15						
R(t)	3.25						
intermediate calculations:							
c(i)/c(i-1)	0.392604						
R(c)/R(t)	0.353846						
T(i)/T(i-1)	1.708333						
c(i-1,corr) X [c(i)/C(i-1)]			2014.058				
R(c)/R(t)[1-T(i)/T(i-1)]			-0.25064				
Final Calculation:							
C(i,corr)=	1610.42						

FIRST-ORDER RATE CONSTANT CALCULATION
USING TMB AS A CONSERVATIVE TRACER
OU 1 RNA TS
HILL AFB, UTAH

Point	Distance Downgradient (ft)	Travel Time Between Upgradient and Downgradient Point (days)	Measured *cis*-1,2-DCE Concentration (µg/L)	Total Trimethylbenzene Concentration (µg/L)	Trimethylbenzene-Corrected *cis*-1,2-DCE Concentration (µg/L)
U1-067	0	0	4000	413	4000
U1-070	200	667	3948	144	5130
U1-074	770	2567	1550	246	1610

v_c = 0.3 ft/day

PLOT OF TMB-CORRECTED *cis*-1,2-DCE CONCENTRATION VERSUS TIME



REDUCTIVE DECHLORINATION RATE
MOUTOUX et al. METHOD (1995)
U1-067>U1-070>U1-074
OU 1 RNA TS
HILL AFB, UTAH

Step 1: Enter Observed Contaminant Concentration (µg/L)

Well	PCE	TCE	DCE	VC	Ethene	Total CAHs
U1-067	2.0	1.3	4021.0	205.0	9.0	4238.3
U1-070	0.0	0.0	3948.0	25.0	0.0	3973.0
U1-074	2.0	0.5	1556.2	9.0	3.0	1570.70

Note: VC concentration for U1-070 was estimated to be one-half the reporting limit.

Step 2: Compute Molar Concentrations (micromoles/Liter)

Well	M_{PCE}	M_{TCE}	M_{DCE}	M_{VC}	M_{Ethene}	Total M_{CAHs}
U1-067	0.01	0.01	41.48	3.28	0.32	45.10
U1-070	0.00	0.00	40.73	0.40	0.00	41.13
U1-074	0.01	0.00	16.05	0.14	0.11	16.32

Step 3: Compute Carbon Equivalents

Well	Total M_{CAHs}	x 2	= Ceqi
U1-067	45.10		90.20
U1-070	41.13		82.25
U1-074	16.32		32.64

Step 4: Compute Chlorine Equivalents

Well	M_{PCE} x 4	M_{TCE} x 3	M_{DCE} x 2	M_{VC}	$\Sigma = Cleq_i$
U1-067	0.05	0.03	82.96	3.28	86.32
U1-070	0.00	0.00	81.45	0.40	81.85
U1-074	0.05	0.01	32.11	0.14	32.31

Step 5: Compute Corrected CAH Concentrations

$C_{i,corr} = C_{i-1,corr} \times (Cleq_i / Cleq_{i-1}) \times (Ceq_{i-1} / Ceq_i)$

Well	$C_{i-1,corr}$	$Cleq_i / Cleq_{i-1}$	Ceq_{i-1} / Ceq_i	$C_{i,corr}$
U1-067	4238.30			4238.30
U1-070	4238.30	0.95	1.10	4407.64
U1-074	4407.64	0.39	2.52	4384.42

Step 6: Plot Exponential Trendline of Contaminant Concentration vs. Time

Well	Distance From Source (ft)	CAH avg. velocity (ft/day)	CAH Travel Time (day)	$C_{i,corr}$
U1-067	0		0	4238.30
U1-070	200	0.300	667	4407.64
U1-074	770	0.300	2567	4384.42

Reductive Dechlorination Rate

$C = C_0 e^{-kt}$ where:

C = Corrected Contaminant Concentration (µg/L) at time t (days)
C_0 = Initial Contaminant Concentration (µg/L)
k = Reductive Dechlorination Rate ($days^{-1}$)

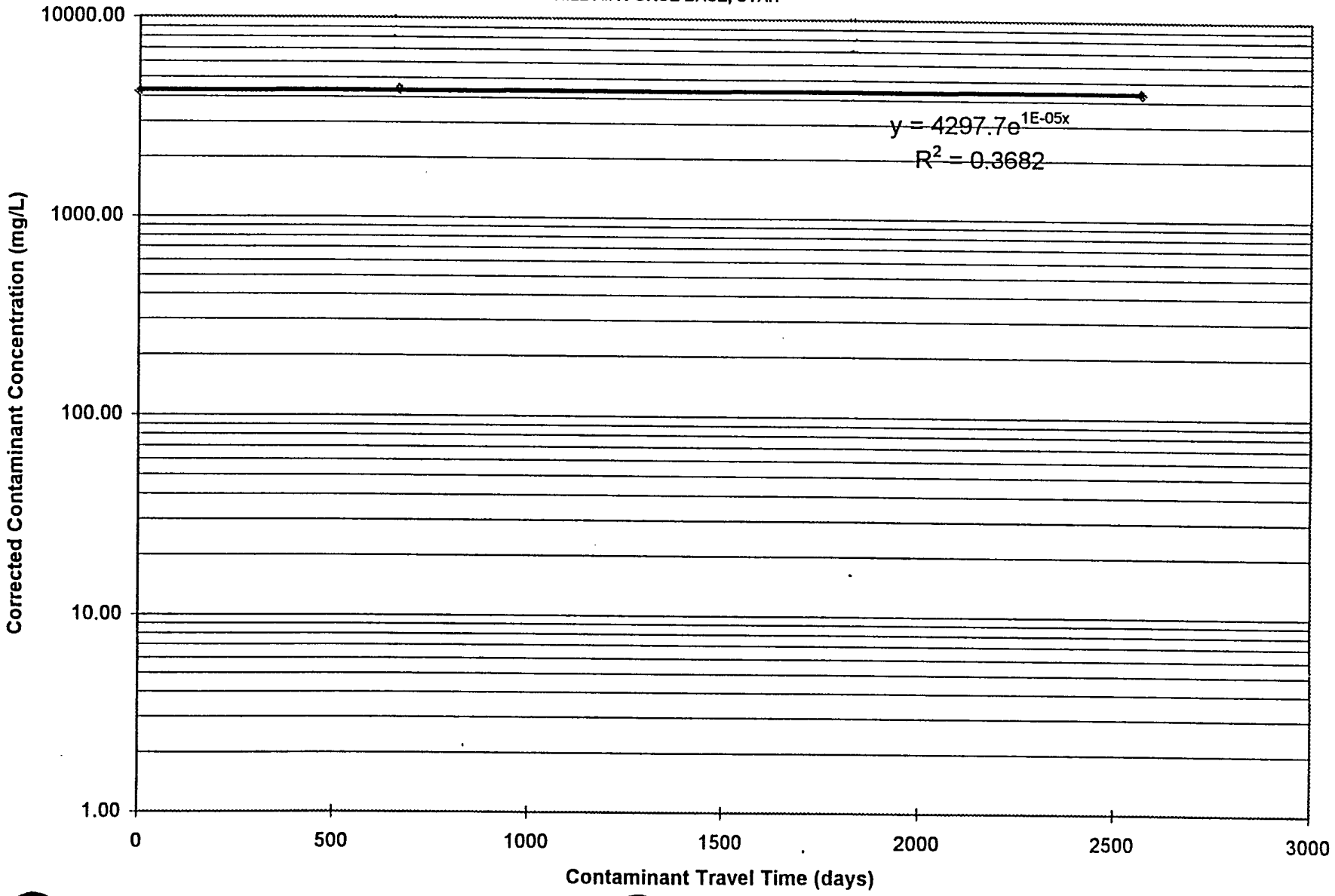
from plot: $y = 4297.7e^{1E-05x}$ λ = NA
Note: graph has positive slope--calculated decay rate is invalid.

REDUCTIVE DECHLORINATION RATE

U1-067 > U1-070 >U1-074

OU 1 RNA TS

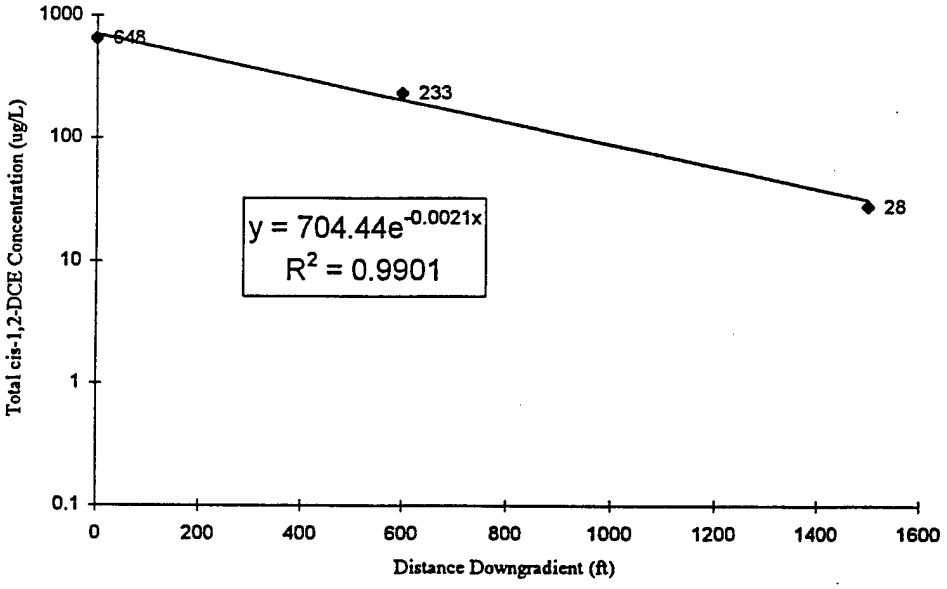
HILL AIR FORCE BASE, UTAH



FIRST-ORDER DECAY RATE CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)
OU 1 RNA TS
HILL AFB, UTAH

Point	Distance (ft) Downgradient	cis-1,2-DCE (µg/L) Mar-97
U1-105	0	648
U1-1637	600	233
U1-099	1500	28

PLOT OF cis-1,2-DCE CONCENTRATION VERSUS DISTANCE



$$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$$

where $v_c = 0.1$ ft/day
$\alpha_x = 150$ feet
$k/v = 0.0021$

therefore $\lambda = 2.76E\text{-}04$ $days^{-1}$

REDUCTIVE DECHLORINATION RATE
MOUTOUX et al. METHOD (1995)
U1-105>U1-1637>U1-099
OU 1 RNA TS
HILL AFB, UTAH

Step 1: Enter Observed Contaminant Concentration (µg/L)

Well	PCE	TCE	DCE	VC	Ethene	Total CAHs
U1-105	0.0	3.4	649.0	0.5	0.0	652.9
U1-1637	0.0	3.1	234.0	0.0	0.0	237.1
U1-099	0.0	0.0	27.9	0.0	0.0	27.90

Step 2: Compute Molar Concentrations (micromoles/Liter)

Well	M_{PCE}	M_{TCE}	M_{DCE}	M_{VC}	M_{Ethene}	Total M_{CAHs}
U1-105	0.00	0.03	6.69	0.01	0.00	6.73
U1-1637	0.00	0.02	2.41	0.00	0.00	2.44
U1-099	0.00	0.00	0.29	0.00	0.00	0.29

Step 3: Compute Carbon Equivalents

Well	Total M_{CAHs}	x 2	= Ceqi
U1-105	6.73		13.46
U1-1637	2.44		4.87
U1-099	0.29		0.58

Step 4: Compute Chlorine Equivalents

Well	M_{PCE} x 4	M_{TCE} x 3	M_{DCE} x 2	M_{VC}	$\Sigma = Cleq_i$
U1-105	0.00	0.08	13.39	0.01	13.48
U1-1637	0.00	0.07	4.83	0.00	4.90
U1-099	0.00	0.00	0.58	0.00	0.58

Step 5: Compute Corrected CAH Concentrations

$$C_{i,corr} = C_{i-1,corr} \times (Cleq_i / Cleq_{i-1}) \times (Ceq_{i-1} / Ceq_i)$$

Well	$C_{i-1,corr}$	$Cleq_i / Cleq_{i-1}$	Ceq_{i-1} / Ceq_i	$C_{i,corr}$
U1-105	652.90			652.90
U1-1637	652.90	0.36	2.76	655.19
U1-099	655.19	0.12	8.47	652.03

Step 6: Plot Exponential Trendline of Contaminant Concentration vs. Time

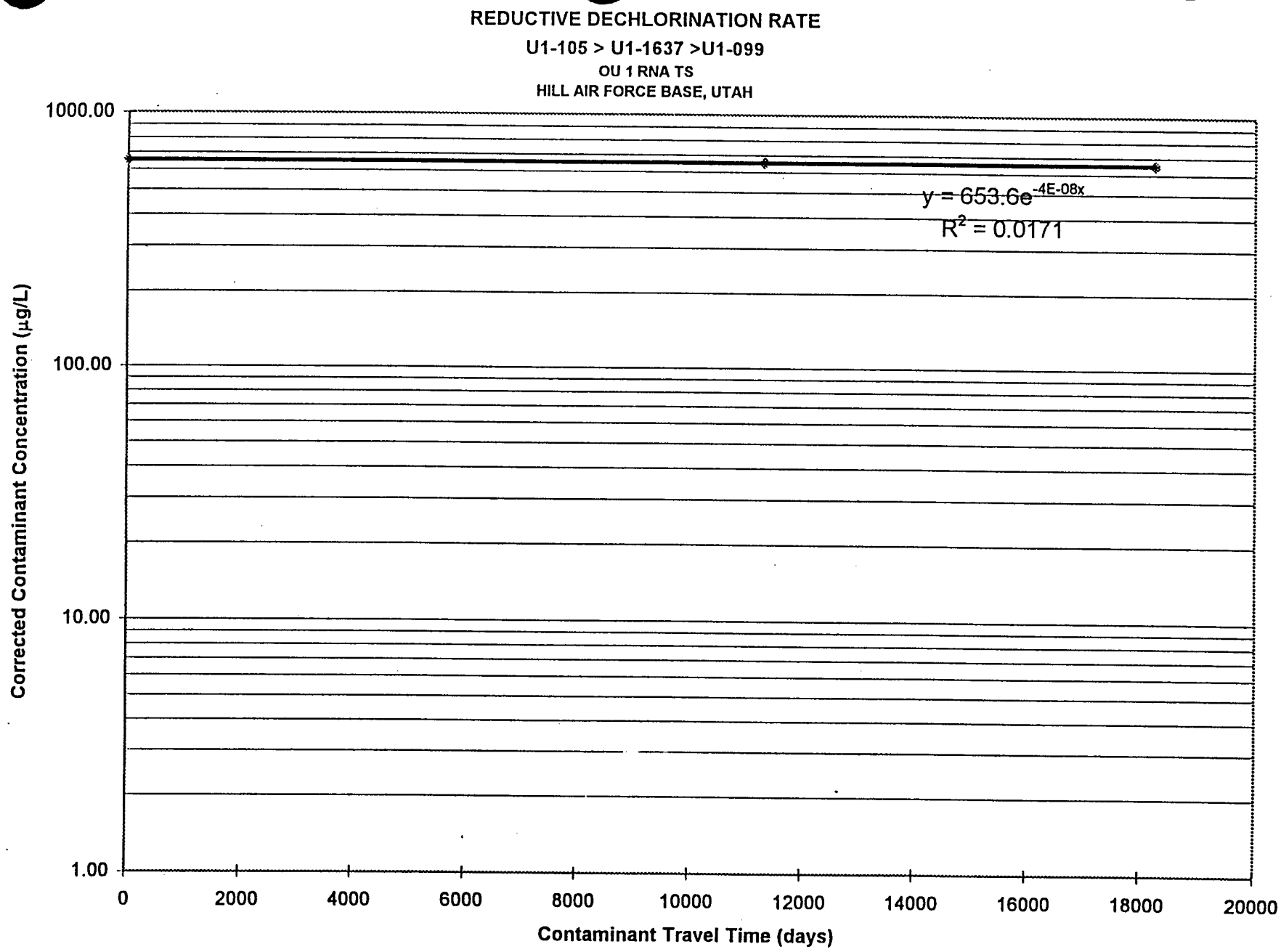
Well	Distance From Source (ft)	CAH avg. velocity (ft/day)	CAH Travel Time (day)	$C_{i,corr}$
U1-105	0		0	652.90
U1-1637	600	0.053	11321	655.19
U1-099	1500	0.130	18244	652.03

Reductive Dechlorination Rate

$C = C_0 e^{-kt}$ where:

C = Corrected Contaminant Concentration (µg/L) at time t (days)
C_0 = Initial Contaminant Concentration (µg/L)
k = Reductive Dechlorination Rate ($days^{-1}$)

from plot: $y = 653.6e^{-4E-08x}$ $\lambda = 4E\text{-}08\ day^{-1}$


REDUCTIVE DECHLORINATION RATE
U1-105 > U1-1637 >U1-099
OU 1 RNA TS
HILL AIR FORCE BASE, UTAH
1000.00
100.00
10.00
1.00
Corrected Contaminant Concentration (µg/L)
y = 653.6e-4E-08x
R2 = 0.0171
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Contaminant Travel Time (days)

ES ENGINEERING-SCIENCE

Client AFCEE / Hill AFB | Job No. 729691.02250 | Sheet 1 of 5
Subject GW & CAH Velocity Calcs. to support decay rate calc., ou1 | By JRH | Date 11/3/97
Checked CH | Rev.

① Hydraulic Conductivity

From RI rpt. Table 5-5:

For upper sand & gravel unit (on-Base)
k = 28.4 – 425.3 ft/d
arith. Mean = 145 ft/d
median = 113 ft/d
geo. mean = 103 ft/d

For off-Base shallow soil
k = 0.02 – 11.3 ft/d
arith. Mean = 1.9 ft/d
median = 1.7 ft/d
geo. mean = 0.6 ft/d

For hillside deposits – not defined – assume is equal to avg of on-Base sand & gravel & off-Base shallow unit (1.7 ft/d)

② Hydraulic gradient

Pathway 1: U1-074 → U1-155 → U1-1637 → U1-099

Well	GW Elev	Distance (ft)	Gradient (ft/ft)	
U1-074	4474.28	0		
U1-105	4481.49	2,100	0.14	0.007
U1-1637	4477.77	2,700		
U1-099	(4462.42)	3,600	0.017	

4469.62
– 7.20
4462.42

③ Effective Porosity

Upper (on-Base) sand & gravel – assume 0.25
off-Base shallow soil – assume 0.20
Hillside deposits – assume 0.20

ES ENGINEERING-SCIENCE

Client AFCEE / Hill AFB | Job No. 7Z9691.0225G | Sheet 2 of 5
Subject GW / CAH velocities | By JRH | Date 11/3/97
Checked CH | Rev.

GW Velocity Calc.

U1-074 → U1-105 (upper sand & gravel unit & hillside deposits)

$V = Ki/n_e = \frac{(64\ ft/d)(0.140)}{0.22} = 40.7\ ft/d$

$K = \frac{500'}{2100'}(103\ ft/d) + \frac{1600'}{2100'}(52\ ft/d) = 64\ ft/d$

U1-105 → U1-1637 (off-Base shallow unit)

$V = Ki/n_e = \frac{(0.6\ ft/d)(0.007)}{0.20} = 0.02\ ft/d$

U1-1637 - U1-099 (off-Base shallow unit)

$V = Ki/n_e = \frac{(0.6)(0.017)}{0.2} = 0.05\ ft/d$

CAH Velocity Estimate (cis-1,2-DCE)

Retardation Coefficients (avg.) = 1.15 for on Base sand/gravel
= 1.26 for shallow valley alluvium
Toc of Hillside deposits not measured - assume R = 1.5

U1-074 → U1-105 $V_{GW} = 40.7\ ft/d$

$V_c = 40.7/1.4 = 29.1\ ft/d$

$R = \frac{500'}{2100'}(1.15) + \frac{1600'}{2100'}(1.5) = 1.42$

U1-105 → U1-1637 $V_{GW} = 0.02\ ft/d$

$V_c = 0.02/1.26 = 0.016\ ft/d$

U1-1637 → U1-099 $V_{GW} = 0.034\ ft/d$

$V_c = 0.05/1.26 = 0.040\ ft/d$

Compute Avg. V_c along entire flowpath U1-074 → U1-105 → U1-1637 → U1-09

U1-074 → U1-105 : DCE travels 2100' @ 29.1 ft/d = 72 days

U1-105 → U1-1637 : DCE travels 600' @ 0.016 ft/d = 37,500 days (= 103 yrs)

This is obviously too slow ∴ use of geometric mean K for off-Base shallow soil is not valid. Use arithmetic mean K (1.9 ft/d) & re-compute V_c.

U1-105 → U1-1637

$$V_{GW} = \frac{(1.9\ ft/d)(0.007)}{0.20} = 0.066\ ft/d$$

$V_c = 0.066 / 1.26 = 0.053\ ft/d$

$600' \text{ (travel distance)} / 0.053 = 11,320 \text{ days} = 31 \text{ years}$

U1-1637 → U1-099

$$V_{GW} = \frac{(1.9)(0.017)}{0.2} = 0.16\ ft/d$$

$V_c = 0.16 / 1.26 = 0.13\ ft/d$

900' travel distance / 0.13 ft/d = 6,923 days = 19 yrs

Average V_c from U1-105 to U1-099 = $\frac{600}{1500}(0.053) + \frac{900}{1500}(0.13) = \boxed{0.1\ ft/d}$

U1-074 to U1-099: Total travel time = ~50 yrs → (72 days + 31 yrs + 19 yrs)

3600' travel distance / 50 yrs = 72 ft/yr = 0.2 ft/day.

Earliest known waste disposal at OU1 began in 1940 at LF3, 57 years ago. Distance from LF3 to S. Weber Dr. along paleochannel pathway = ~4700'. Travel time for DCE to migrate from LF-3 to S. Weber Dr. is estimated to be ⟹ 4700'/57yr = 82 ft/yr = 0.23 ft/d

Another way to compute V_c (avg):

2 100' @ 29.1 ft/d = 58% of pathway

600' @ 0.053 ft/d = 17% " "

900' @ 0.13 ft/d = 25% " "

V_c (avg) = 29.1 (0.58) + 0.053 (0.17) + 0.13 (0.25) = 16.9 ft/d

At this rate, plume would have traveled 3,600' in 213 days — This V_c is too high.

Compute GW/CAH Velocities for Pathway:

U1-067 → U1-070 → U1-074

U1-067	Not measured — assume = 4773.05 (data from nearby U1-106)
U1-070	not measured — assume = 4774.76 (data from nearby U1-32)
U1-074	4774.30

Hydraulic Gradient (i) from U1-067 → U1-074 appears to be minimal to non-existent. Assume that head drop over this pathway is V. small (0.1')
This would tend to make the GW velocity smaller, which will result in lower decay rate, which is conservative.

$i = 0.1'/770' = 0.00013$ ft/ft

$$V_c = \frac{(103\ ft/d)(0.00013\ ft/ft)}{0.25} \Big/ 1.15$$

$= 0.05$ ft/d

Using this velocity, DCE would take 42 years to migrate from U1-067 to U1-074. This is unrealistically slow based on historical data. ∴ Assume $i = 0.00013 \times 4 = 0.00052$, & $V = 0.2$ ft/d. Resulting pathway DCE travel time = 10 yrs. This is probably still low given the fact that LNAPL has migrated about 1400', probably since mid 1950's when FTA 1 began to be used. 1400'/42 yr = 33 ft/yr = 0.09 ft/d. LNAPL should migrate much slower than dissolved DCE due to greater viscosity.

ES ENGINEERING-SCIENCE

Client Hill AFB/ HFCEE | Job No. 729691.02250 | Sheet 5 of 5

Subject GW/CAH Velocities | By JCH | Date 7/13/97

Checked CH | Rev.

Compute GW/CAH velocities for pathways

41-667 → 41-065 → i = 0.0054

41-667 → 41-123 → i = 0.000045

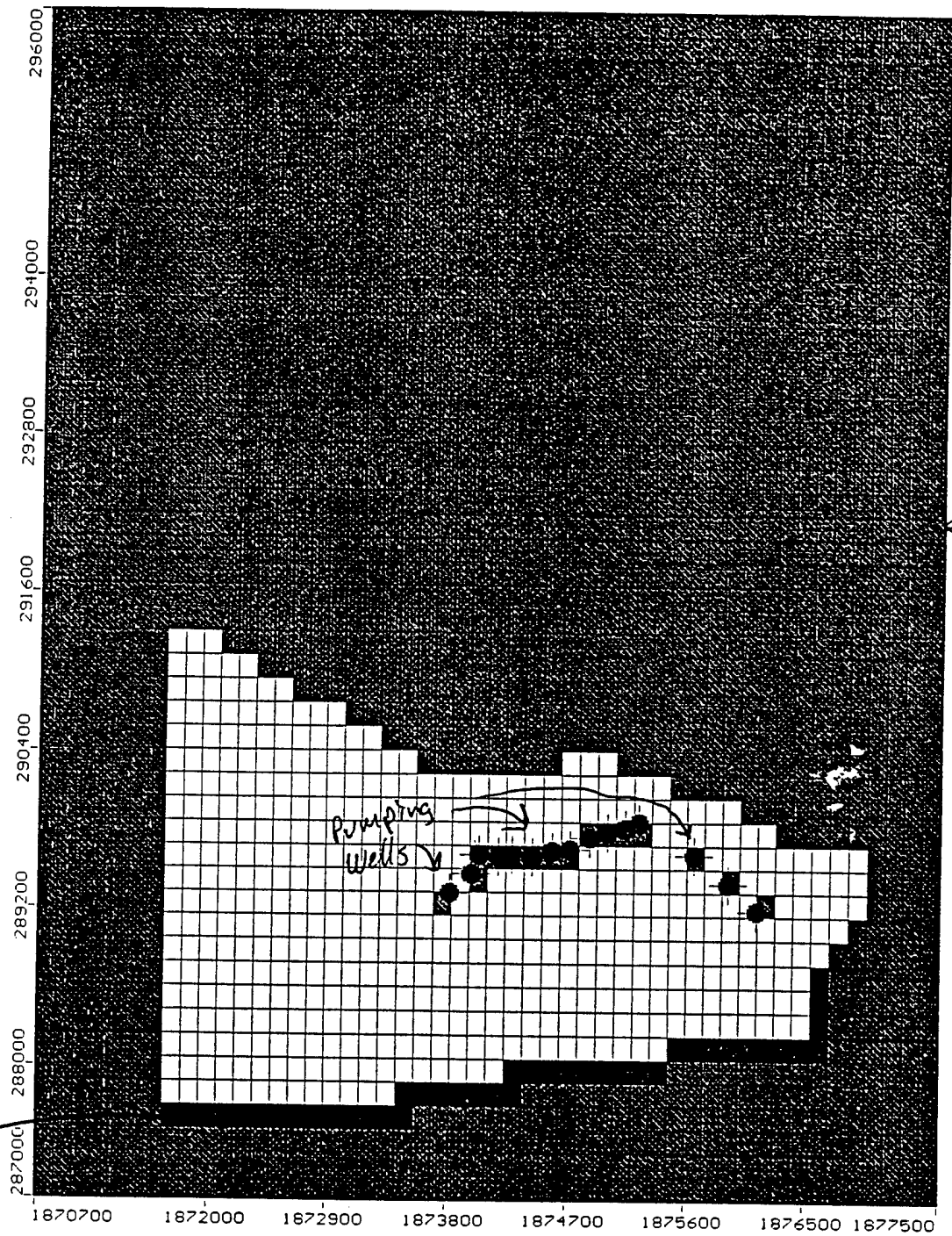
	GW elev.	Distance from 41-667
41-667	4767.44	-
41-065	4764.97	460'
41-123	4767.41	660'

V_c (cis-1,2-DCE) = $\frac{(103)(0.0054)}{0.25} / 1.15 = 1.9$ ft/d

(41-667 → 41-065)

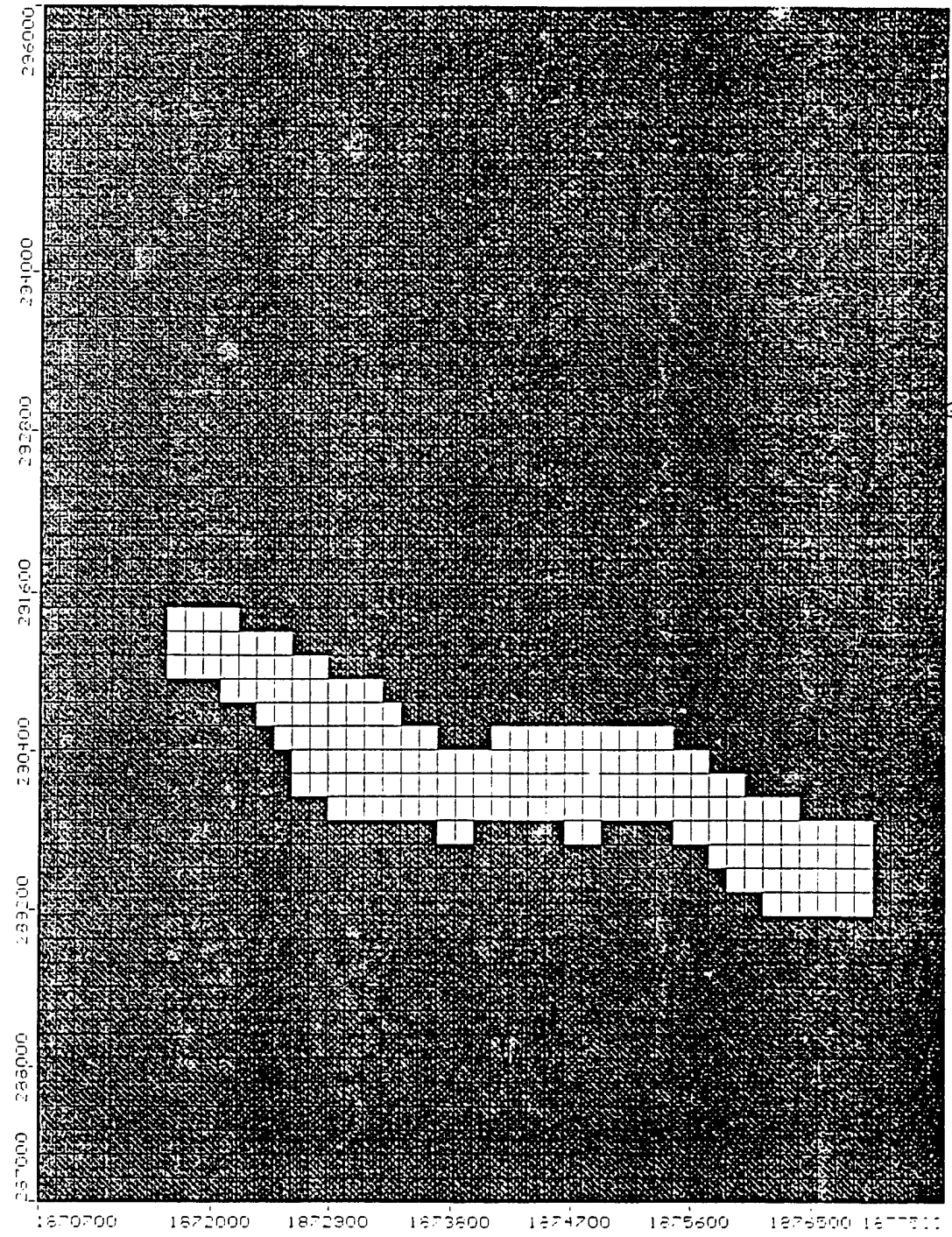
$= \frac{(103)(0.000045)}{0.25} / 1.15 = 0.02$ ft/d

(41-667 → 41-123)



Parsons Eng Science, Inc – Denver, CO
Description: Hillp2
14 Jan 98
Layer 1 Boundaries & Pumping Wells

Visual MODFLOW v.2.50. (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 1



no-flow cells

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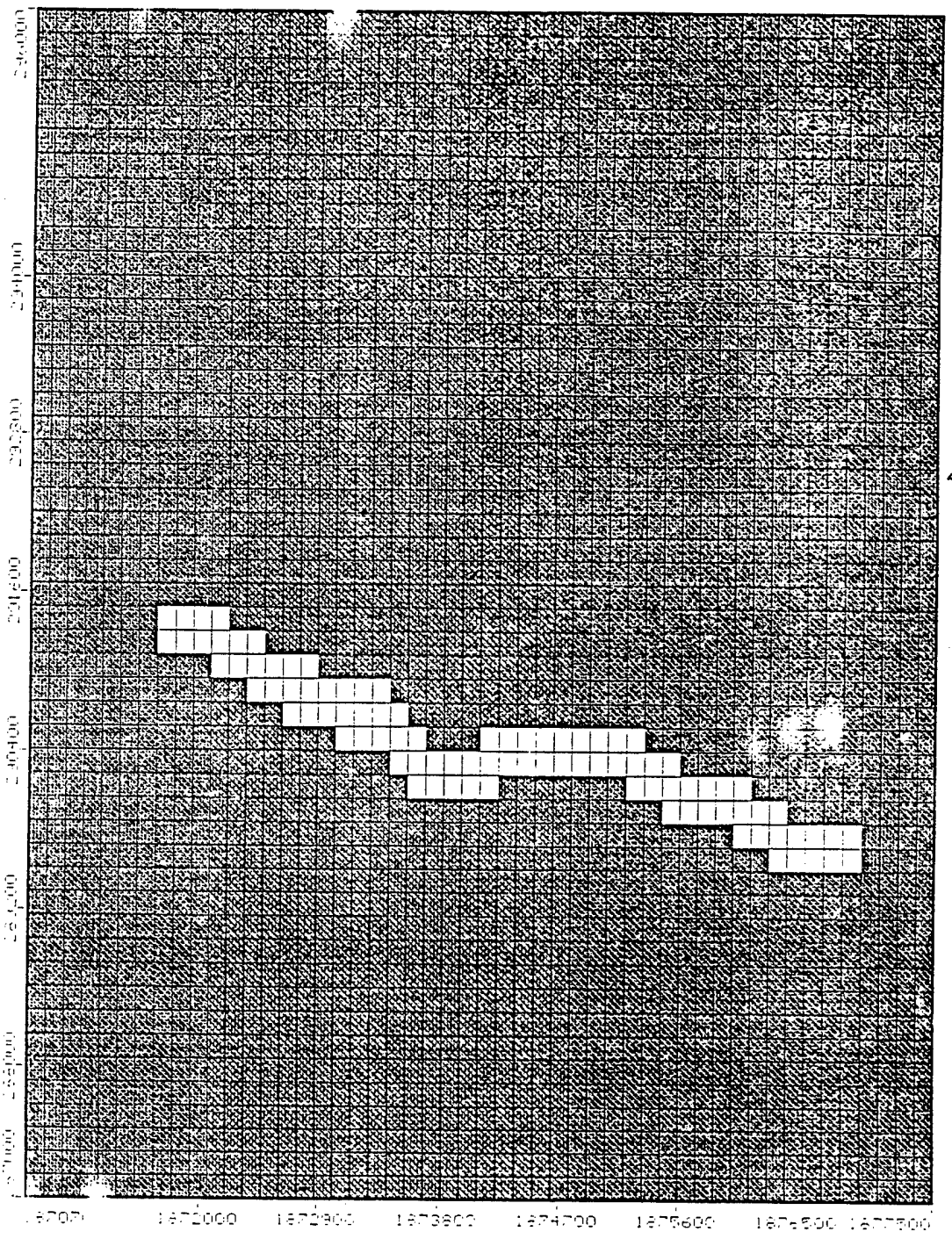
14 Jan 98

Layer 2 Boundaries

Visual MODFLOW v.2.50, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 2



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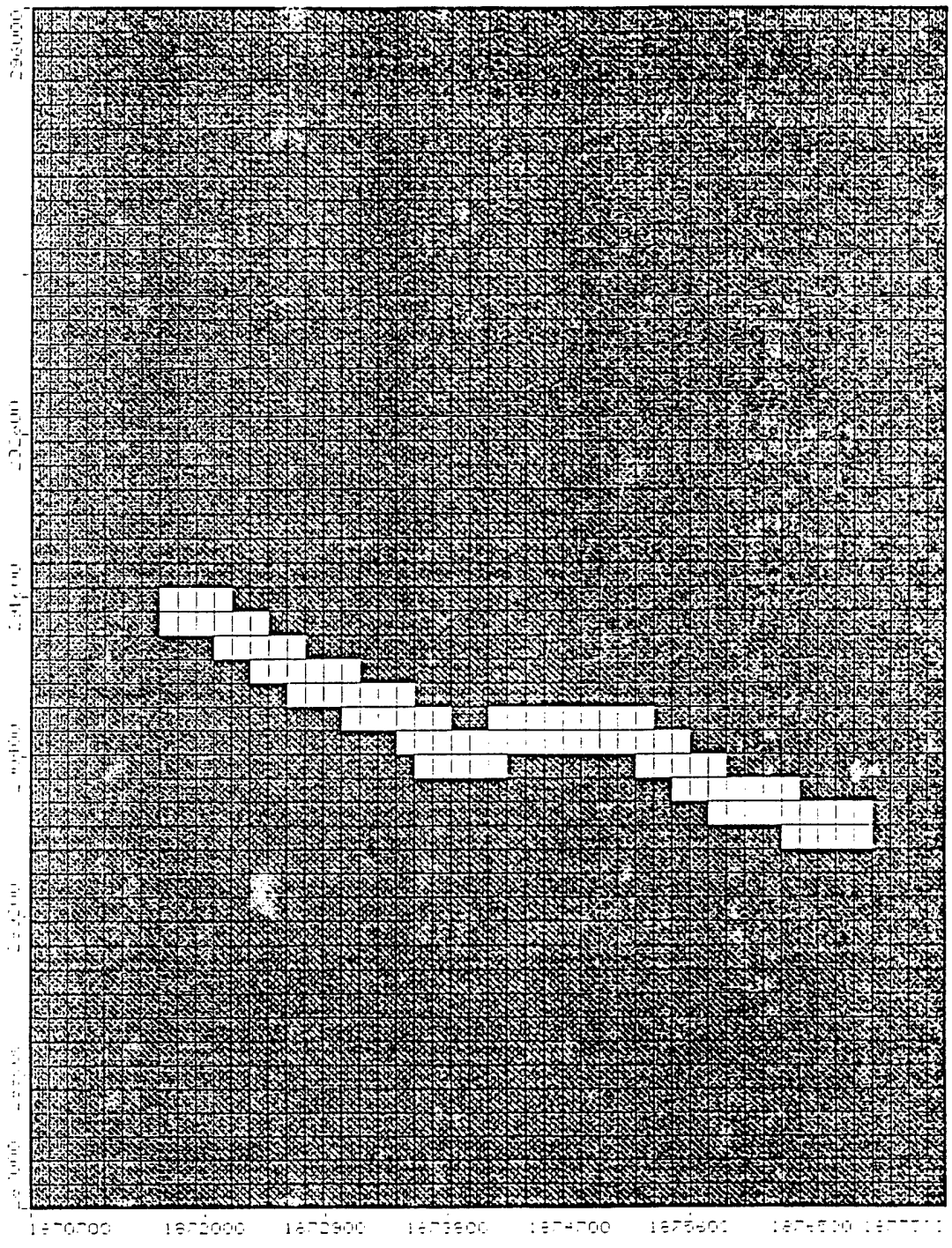
14 Jan 98

Layer 3 Boundaries

Visual MODFLOW v.2.50. (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 3



no CC

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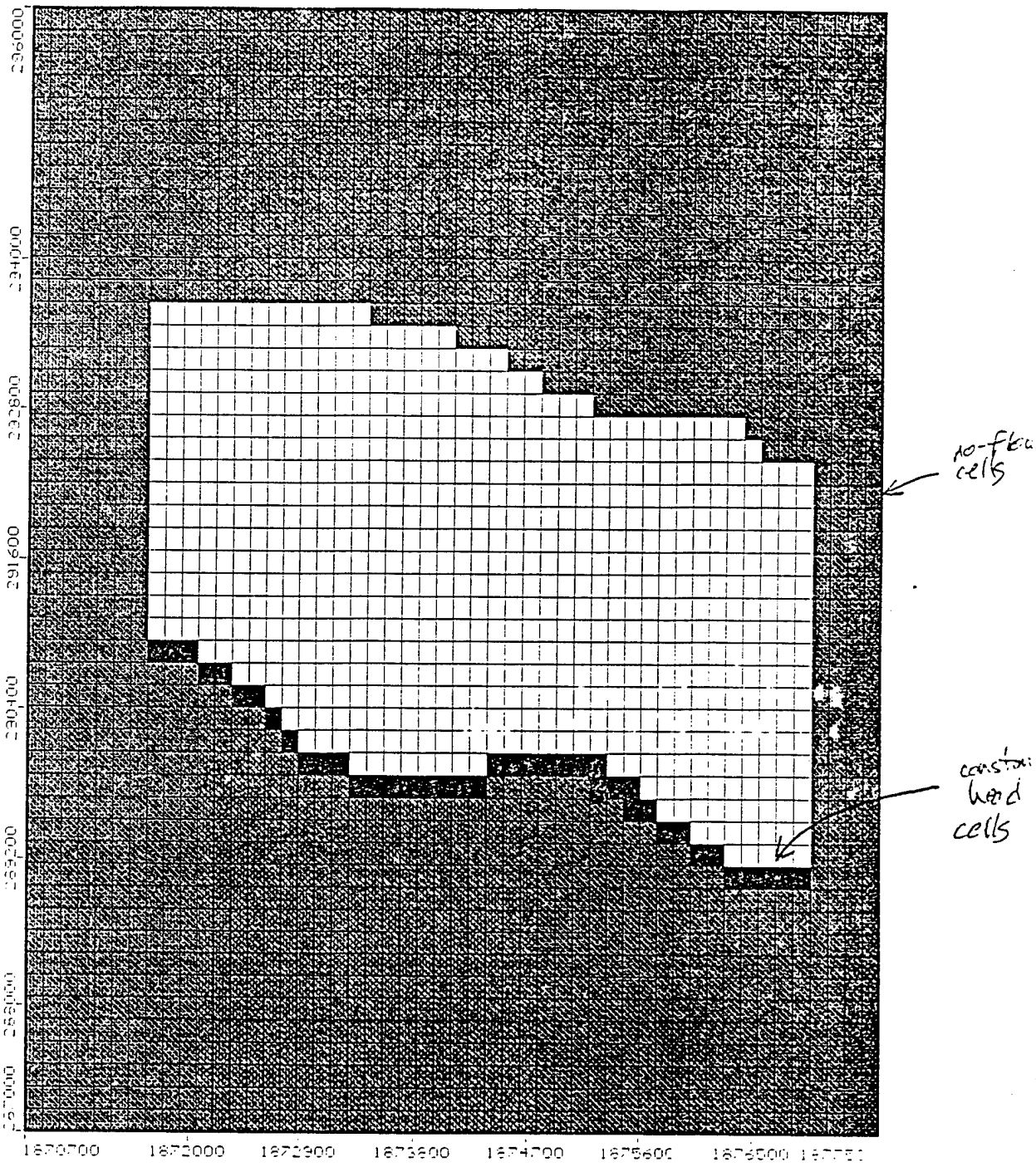
14 Jan 98

layer 4 Boundaries

Visual MODFLOW v.2.50, (C) 1995-1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 4



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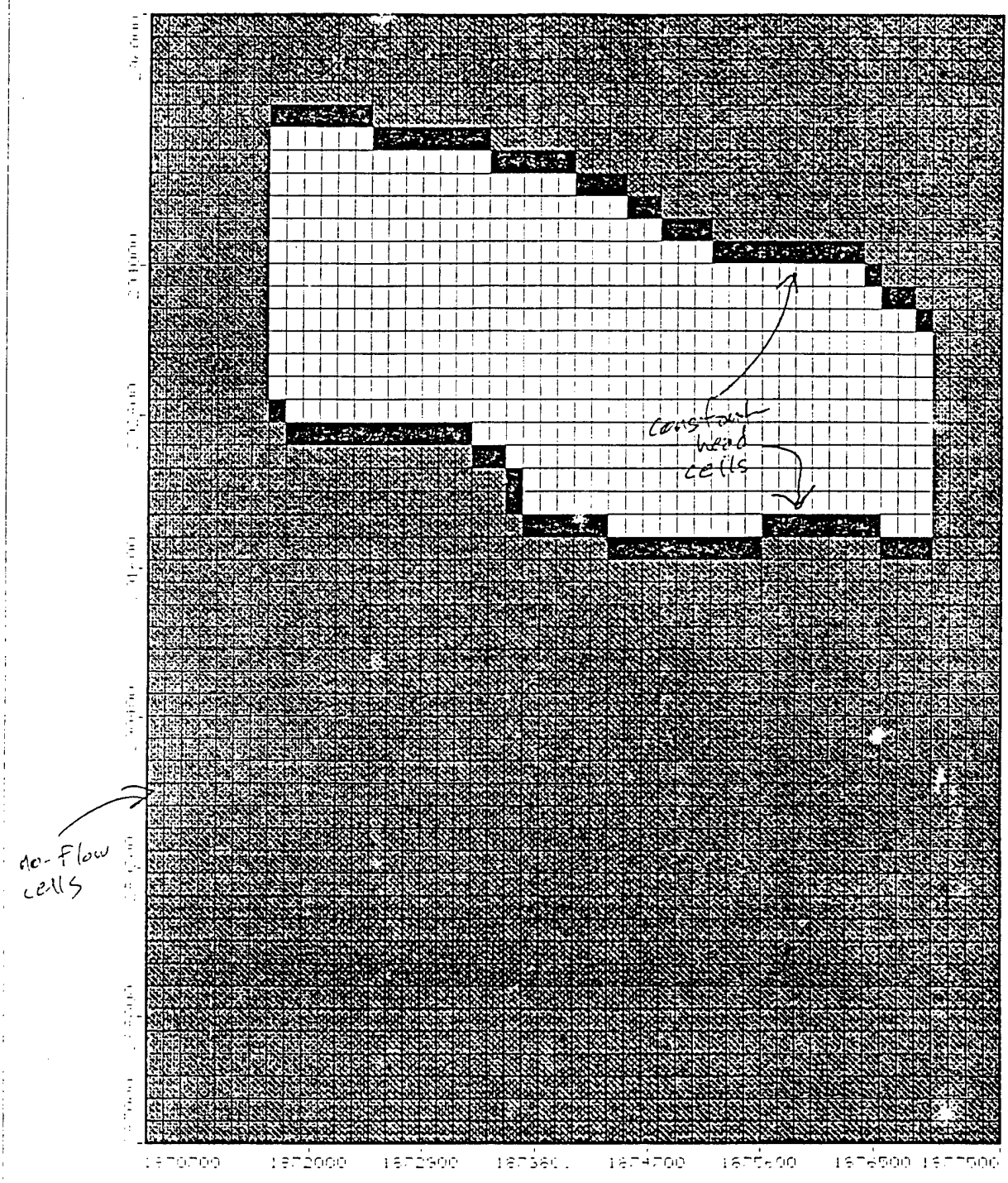
Layer 5 Boundaries

Visual MODFLOW v.2.50, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 5



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Layer 6 Boundaries

Visual MODFLOW v.2.50, (C) 1995–1997
Waterloo Hydrogeologic Software
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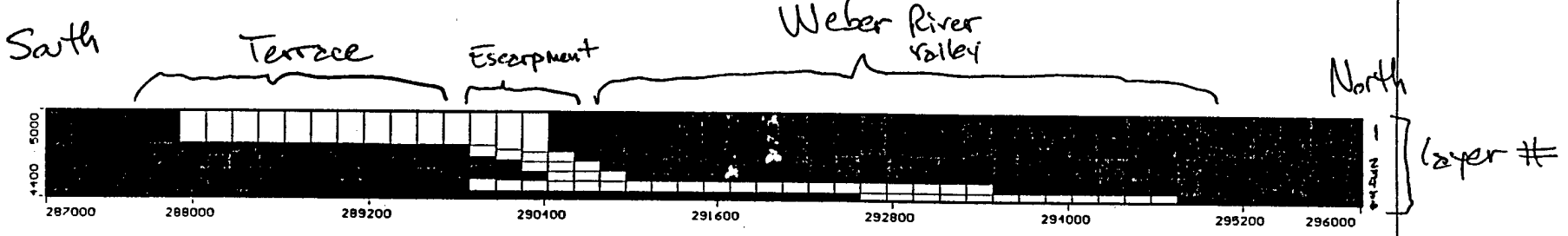
Current Layer: 6



Model cross-section

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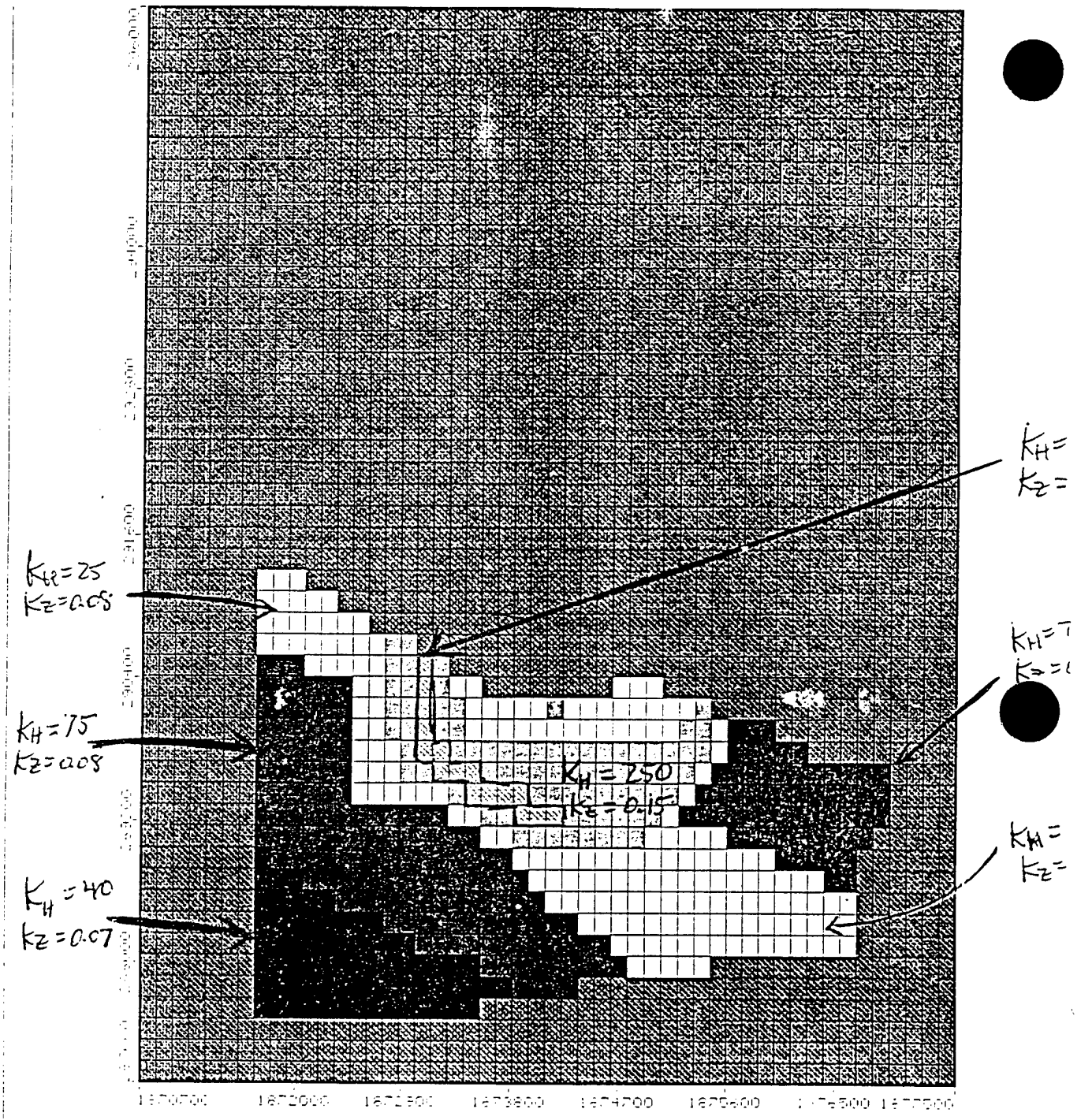

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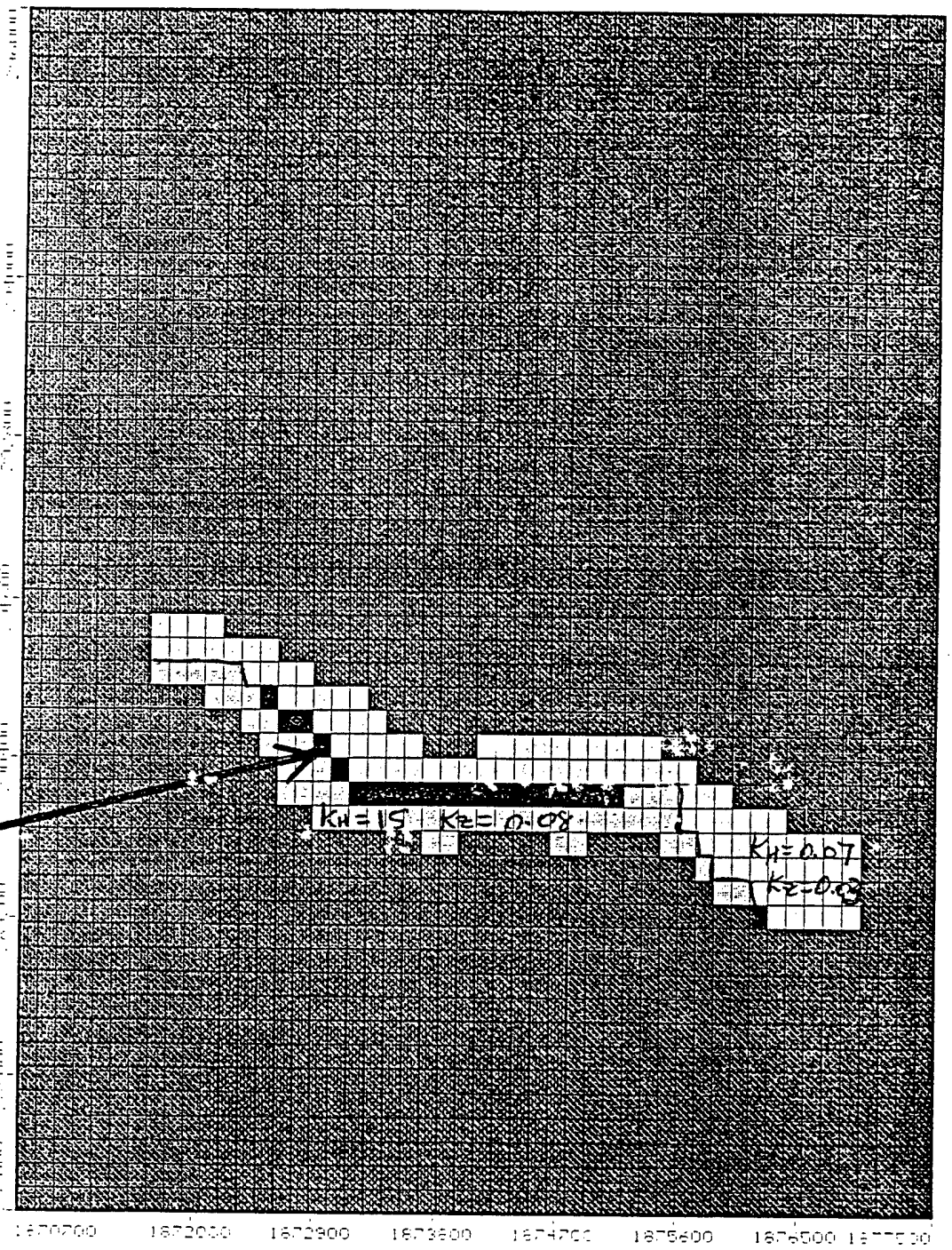
14 Jan 98
Layer 1 – K distribution
(K in ft/day)

Visual MODFLOW v.2.50. (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 1

K_H = horizontal hydraulic conductivity
K_Z = vertical " "



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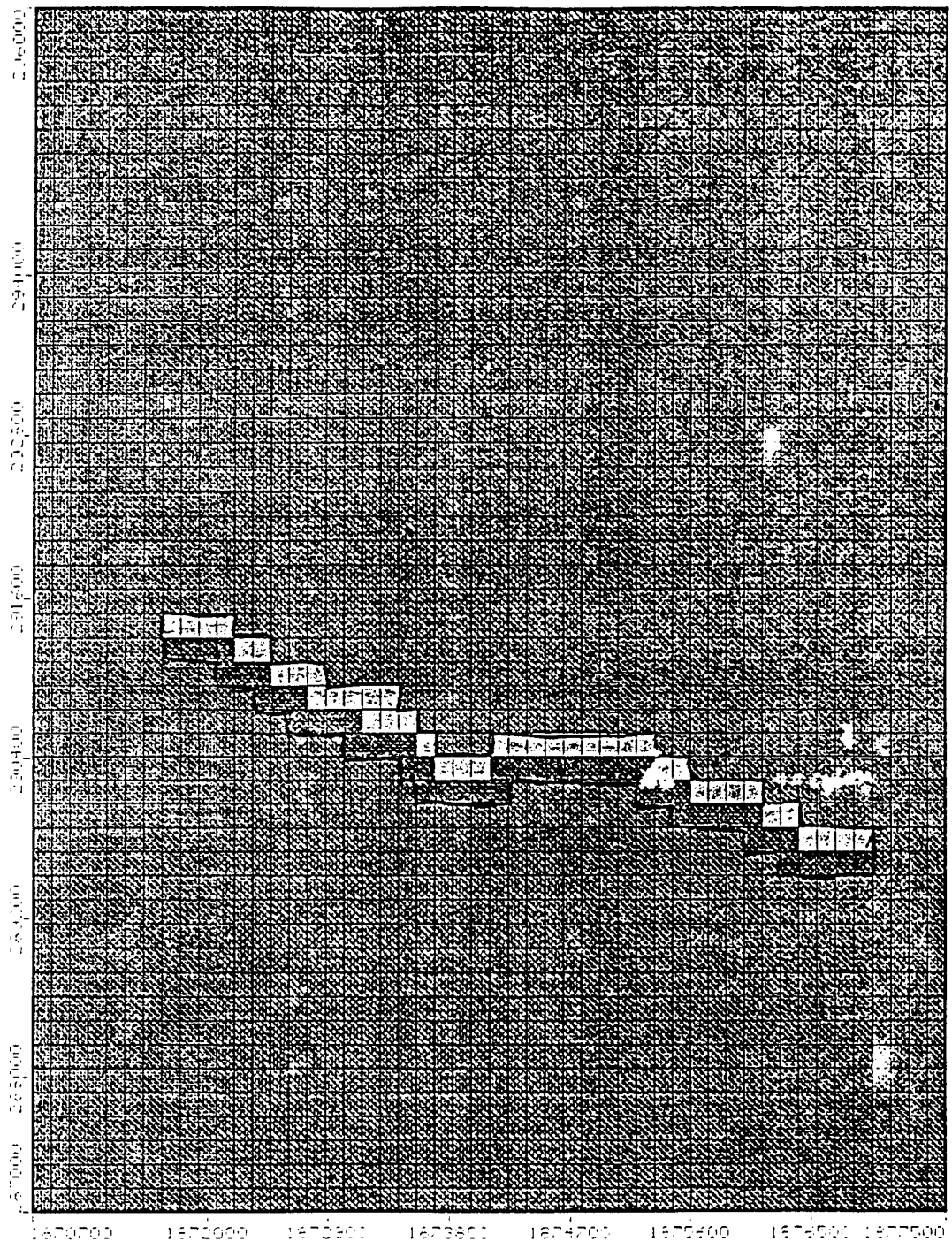
14 Jan 98

Layer 2 K distribution

Visual MODFLOW v.2.50, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 2



light =
K_H =
K_Z =

dark =
K_H =
K_Z =

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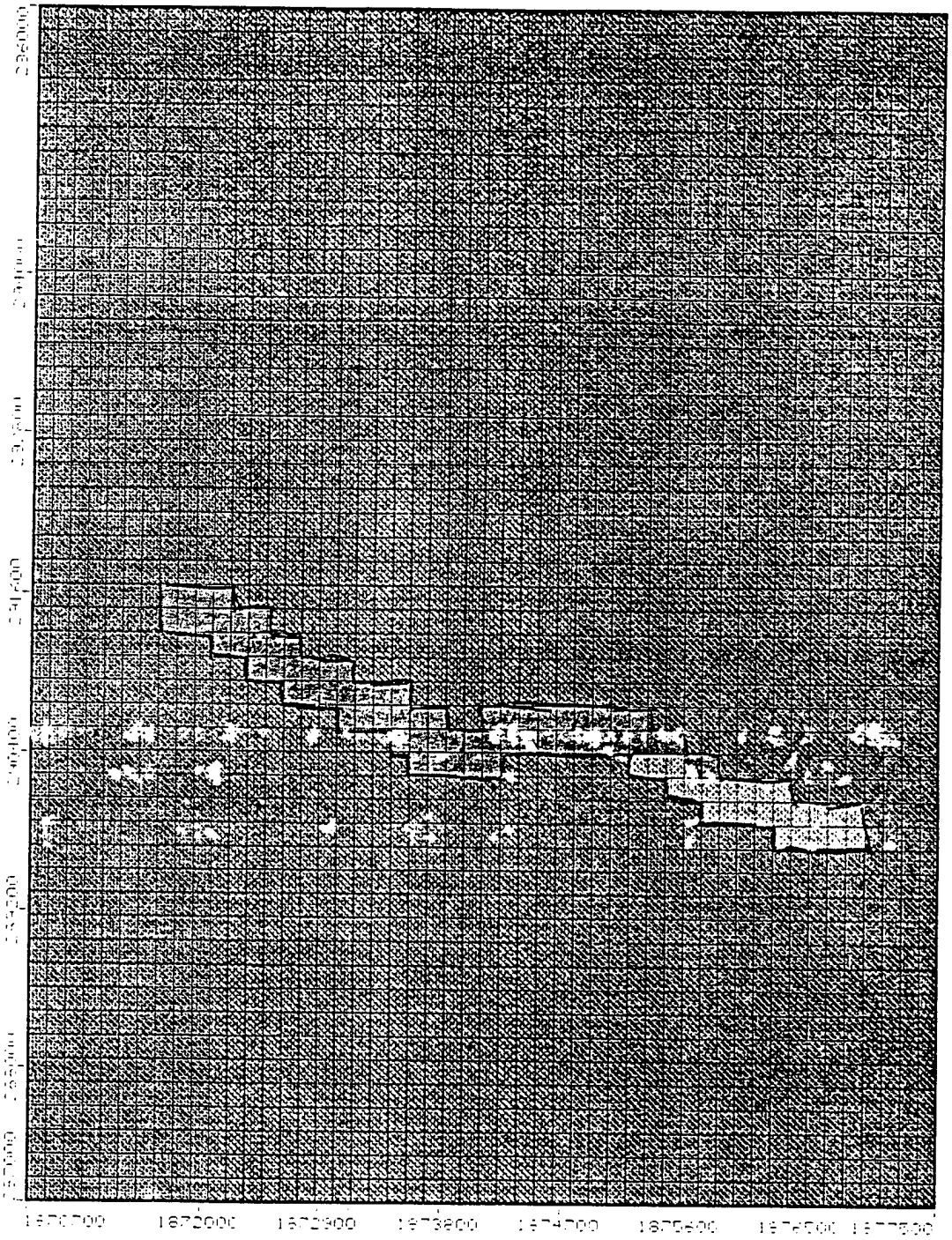
14 Jan 98

Layer 3 K distribution

Visual MODFLOW v.2.50, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 3



light:
$K_H = 25$
$K_z = 0.2$

dark:
$K_H = 25$
$K_z = 0.06$

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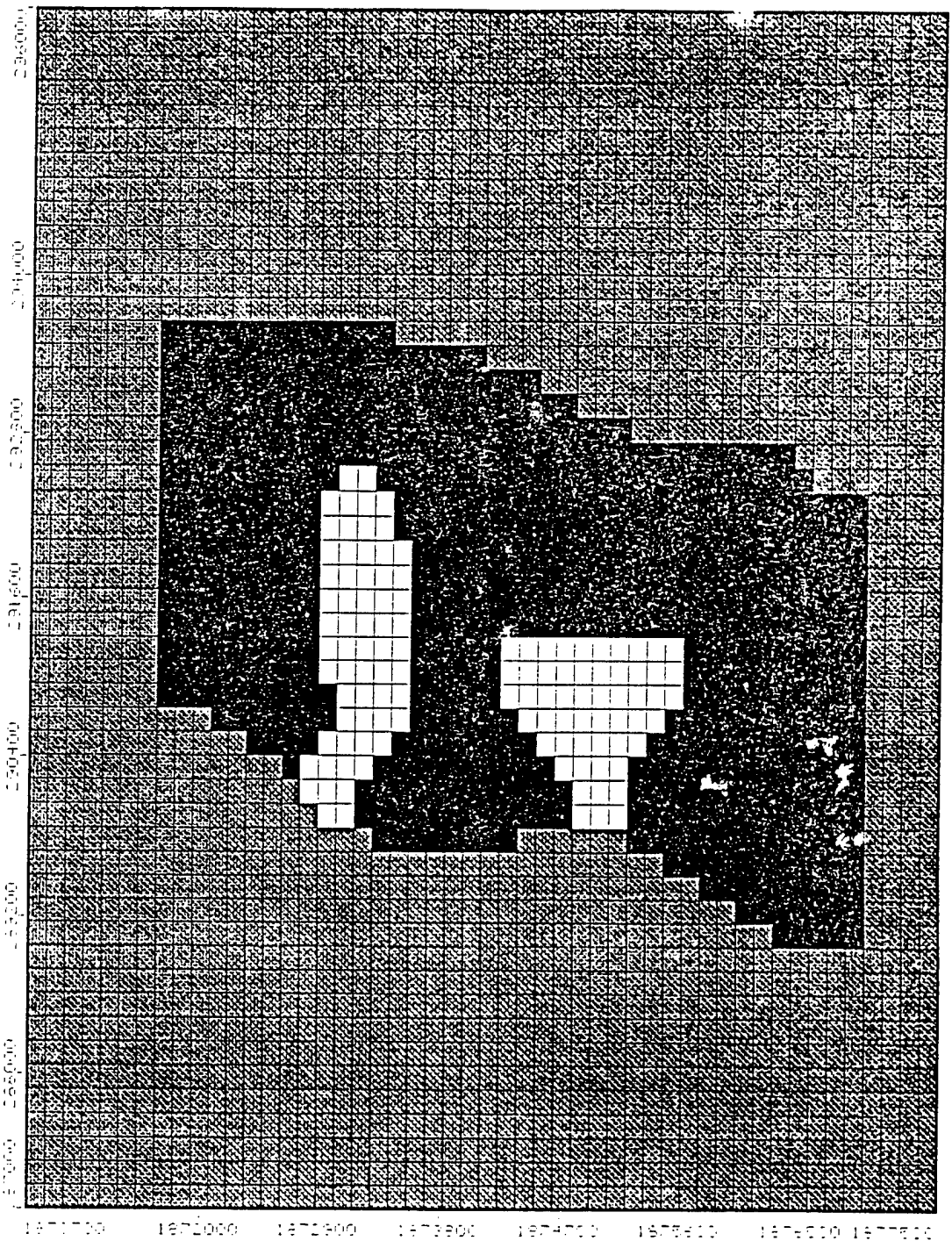
14 Jan 98
layer 4 K distribution

Visual MODFLOW v.2.50. (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 4



Dark:
$K_H = 10$
$K_Z = 0.07$

Light:
$K_H = 25$
$K_Z = 0.08$

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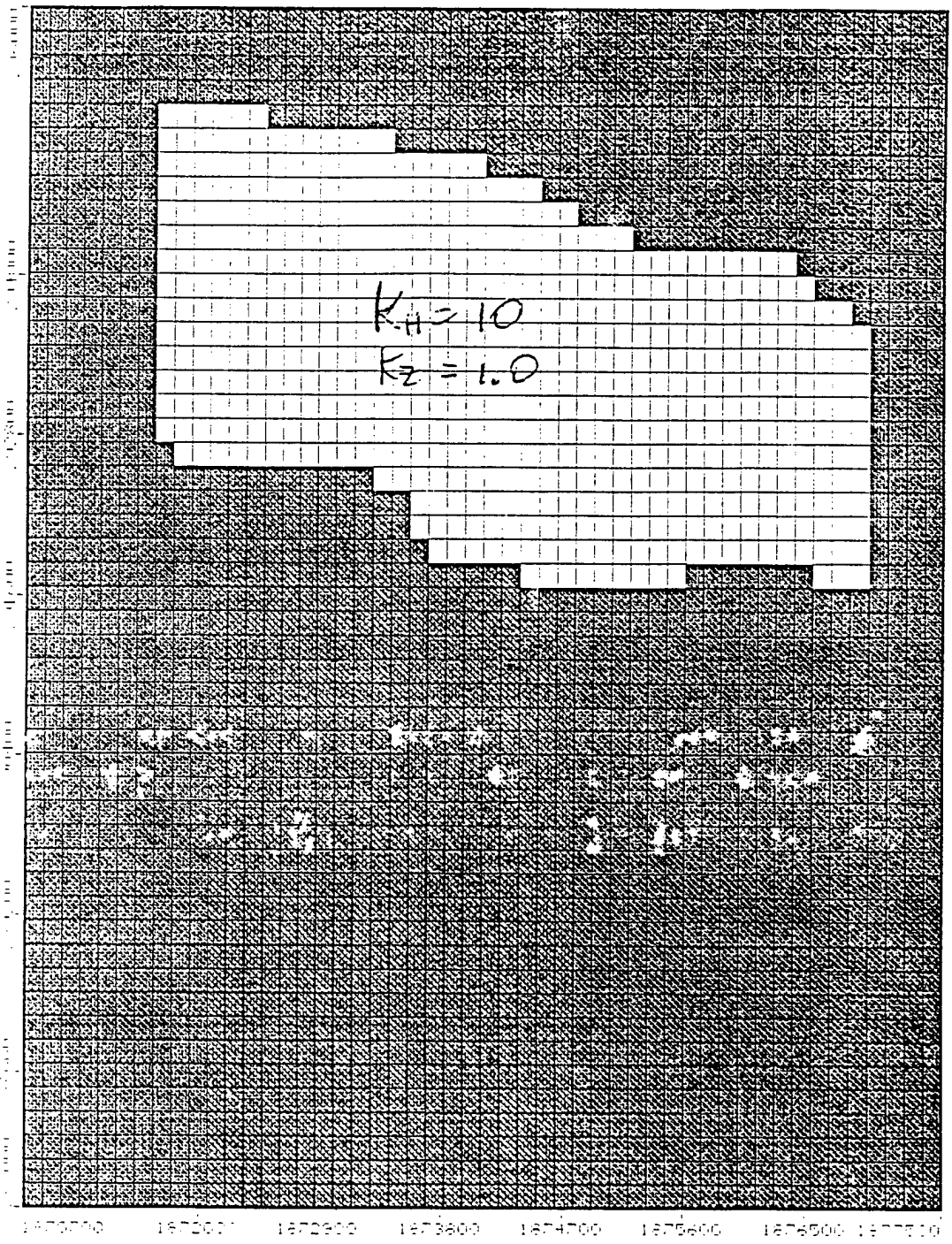
14 Jan 98

Visual MODFLOW v.2.50. (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 5

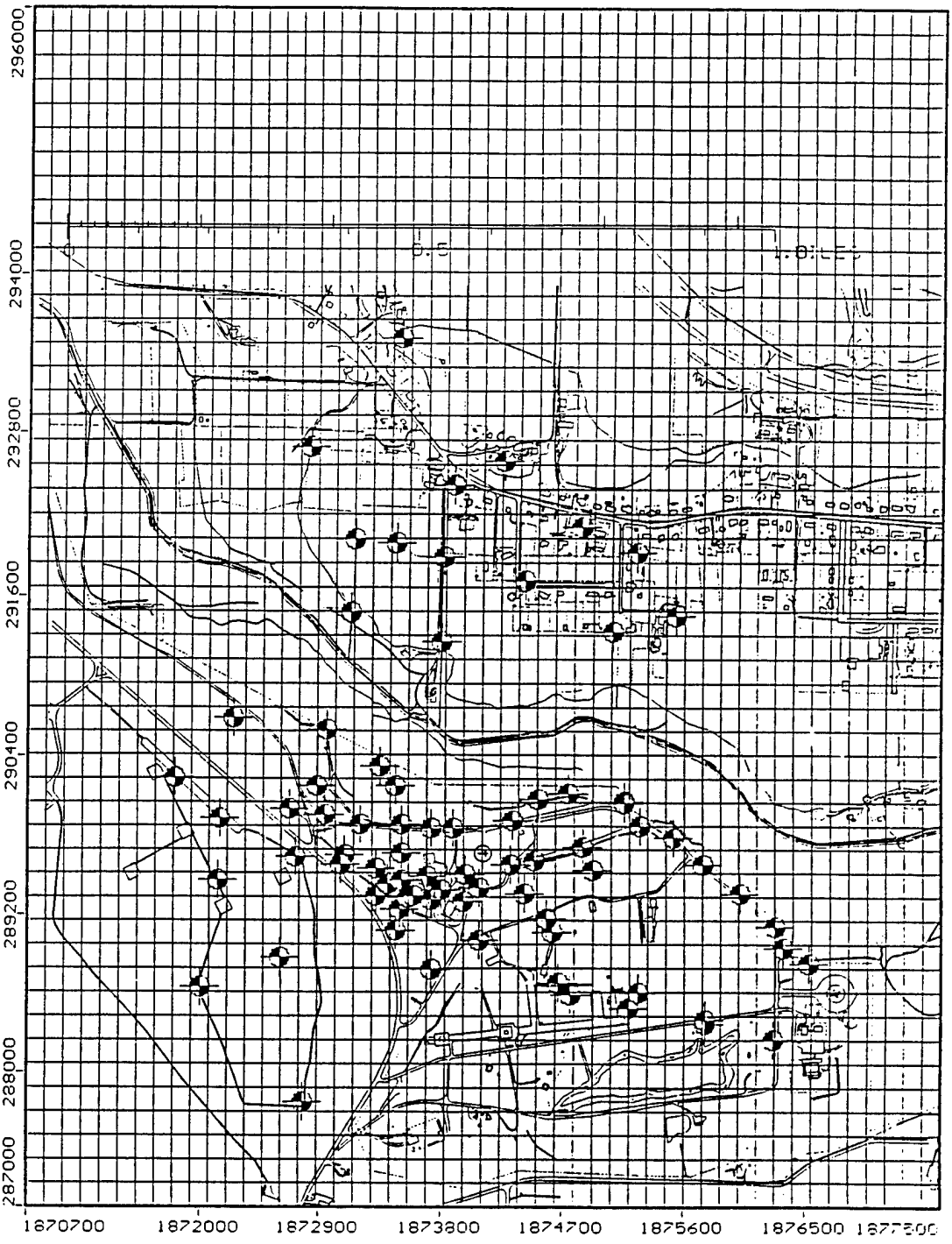
Layer 5 K distribution



Parsons Eng Science, Inc – Denver, CO
Project: Hill AFB OU 1
Description: ALTS3_3
14 Jan 98

Visual MODFLOW v.2.50, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 6

Layer 6 K distribution



Parsons Eng Science, Inc – Denver, CO
Project: Hill AFB OU 1
Description: ALTS3_3
14 Jan 98

Visual MODFLOW v.2.50, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 6

Locations of Wells used for flow model calibration

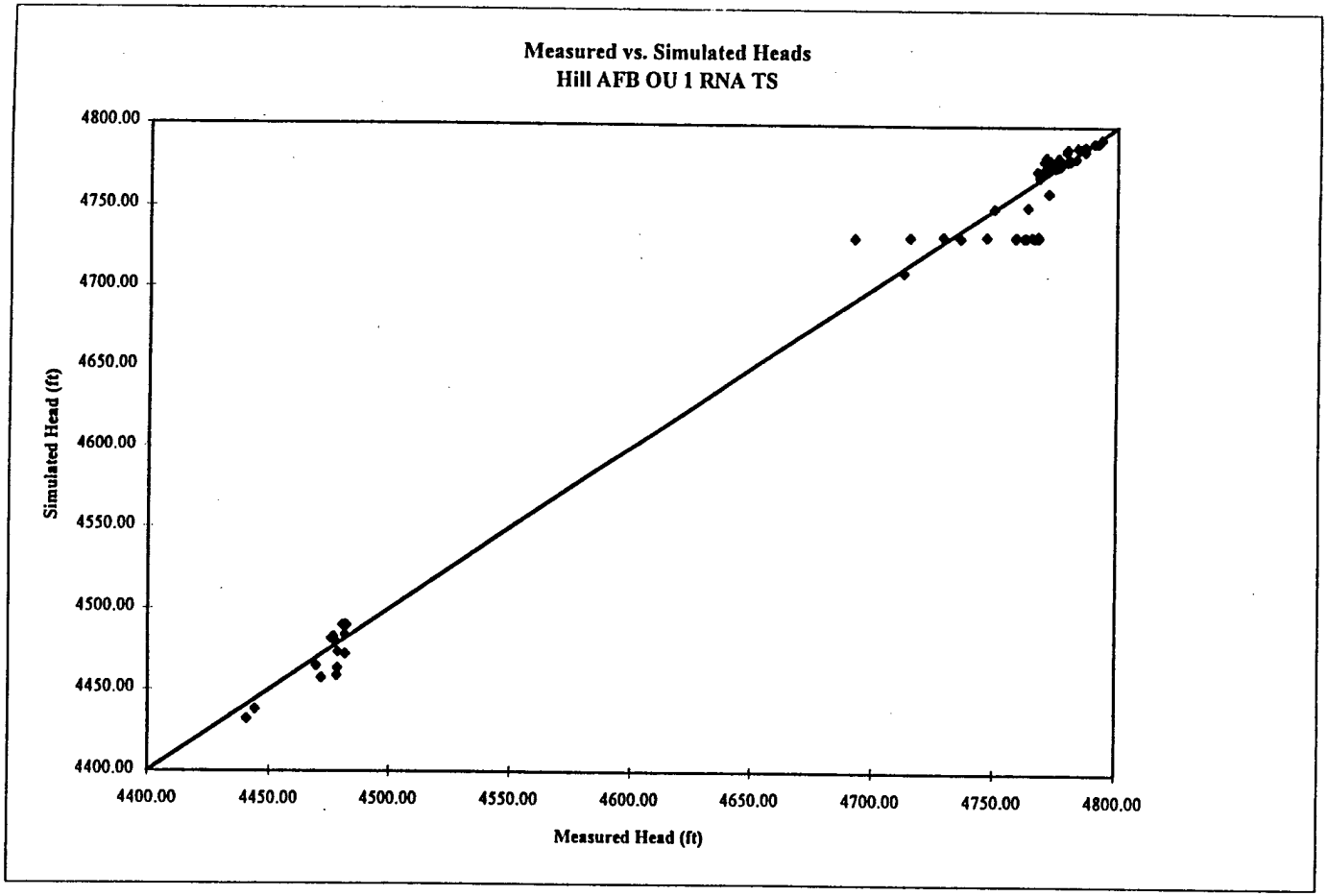
Data for Flow Model Calibration
Hill AFB OU 1

Well	Easting	Northing	Screen	Head
U1-006	1874084.68	289000.91	4774.2	4780.3
U1-008	1873733.12	288780.27	4780	4780.93
U1-021	1876270.96	288253.25	4793	4793.52
U1-027	1875191.73	288487.17	4785	4786.76
U1-041*	1873322.57	289347.33	4771	4774.9
U1-042	1873083.28	289647.67	4767	4770.84
U1-045	1874757.56	288586.28	4766	4785.46
U1-046	1874673	288685	4786	4786.68
U1-049	1875756	288377	4790	4792.12
U1-051	1875754	288403	4786	4790.5
U1-053	1875255	288607	4778	4786.47
U1-060	1876345.72	288945.9	4779	4783.48
U1-061	1876016	289353	4774	4779.05
U1-062	1873463	289081	4760	4774.41
U1-064	1873493	289233	4774	4776.19
U1-065	1873051	289570	4769	4770.18
U1-066	1873730.38	289314.39	4775	4775.12
U1-069	1873407	289432	4767	4774.19
U1-071*	1873975	289500.13	4772	4772.47
U1-073	1873510	289661	4770	4770.91
U1-074	1873320	289545	4774	4774.26
U1-076	1873504.59	289886.22	4757	4761.83
U1-077R	1872941.57	289954.2	4762	4766.09
U1-078	1872881	290179	4735	4735.85
U1-079	1873471.15	290176.43	4713	4714.94
U1-080	1874625.27	289063.78	4782	4782.95
U1-084	1874528	290083	4723	4728.73
U1-085	1875149	290060	4762	4764.97
U1-086	1874743	290123	4726	4735.08
U1-087	1874329	289918	4739	4746.29
U1-089	1872725.28	289634.39	4766	4769.87
U1-092	1875273.79	289865.35	4766	4770.44
U1-093	1876536.11	288823.36	4781	4785.1
U1-097	1875072	291345.5	4479	4481.53
U1-098	1873813	291898.2	4472	4478.6
U1-100	1874576.69	289160.18	4777	4780.08
U1-103	1872681.55	290002.6	4765	4766.67
U1-104	1872948.1	290606.19	4704	4712.38
U1-105	1873127.65	291482	4479	4481.49
U1-106	1874178.36	289396.02	4770	4773.05
U1-107	1874921.03	289528.49	4773	4775.66
U1-108	1873807.44	291262.87	4479	4482.18
U1-109	1875533.93	291457	4474	4476.66
U1-110	1875251.24	291924.55	4473	4478.31

L:\hill\ou1\model\gwelev.xls

Data for Flow Model Calibration
Hill AFB OU 1

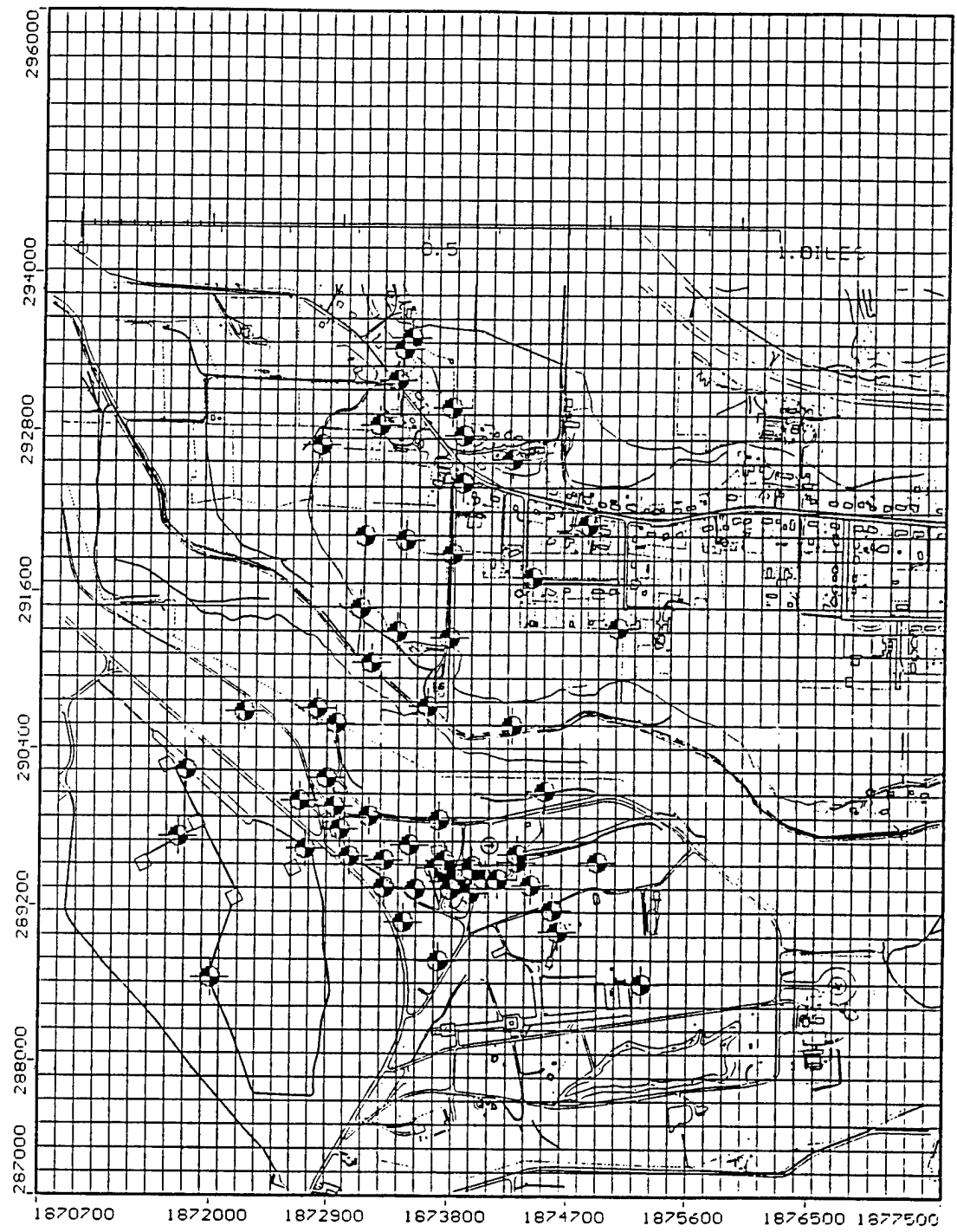
Well	Easting	Northing	Screen	Head
U1-111	1874839.89	292115.01	4475	4478.02
U1-112	1873896.61	292422.03	4467	4471.57
U1-115	1871746.17	289715.93	4759	4766.53
U1-116	1871802.62	290242.74	4760	4763.1
U1-121*	1875747.04	289582.25	4758	4771.61
U1-123	1875520.1	289782.72	4756	4767.41
U1-124	1875155.17	290050.71	4750	4758.37
U1-125	1876290.4	289103.89	4760	4779.45
U1-127	1874499.1	289608.23	4770	4770.53
U1-130*	1873698.62	289483.11	4773	4773.7
U1-131	1873515.2	289463.1	4771	4776.19
U1-132*	1873804.31	289384.09	4773	4774.75
U1-133*	1873961.41	289301.97	4773	4772.95
U1-139	1873367.89	289439.26	4728	4761.69
U1-143	1873558.76	289327.31	4770	4775.43
U1-154	1873807.85	291268.64	4470	4480.55
U1-158	1873892.95	289852.1	4761	4761.66
U1-160	1873732.64	289860.47	4762	4762.79
U1-1602	1873346.83	290322.33	4680	4692.15
U1-1605	1872780.4	287781.2	4773	4779.3
U1-1607	1871992.81	288646.13	4770	4775.07
U1-161	1872938.1	289956.04	4758	4758.26
U1-162	1873207.03	289887.43	4767	4767.57
U1-1631	1873158.07	292022.26	4473	4475.84
U1-1632	1872826.9	292702.85	4464	4469.41
U1-1634	1874424.63	291721.67	4472	4481.51
U1-1635	1873493.05	293511.86	4435	4440.57
U1-1636	1874254.42	292603.12	4441	4443.99
U1-1637	1873464.77	291992.24	4469	4477.37
U1-644	1872605.73	288875.43	4768	4773.46
U1-645	1872128.21	289453.84	4765	4770.54
U1-646	1872146.75	289924.11	4763	4767.77
U1-647	1872248.34	290697.59	4733	4749.36
U1-664	1874315.45	289582.64	4768	4769.7
U1-667*	1874850.18	289709.73	4767	4767.44
U1-118	1872983.65	289787.08	4767	4469.86
U1-101	1874419.85	289349.88	4772	4772.22
U1-067	1874077	289404	4772	4772.84
U1-134	1873802.1	289380.1	4773	4774.77
U1-068	1873601	289347	4775	4775.23



RMS Error = 13.48 feet

Mean Error = -2.78 feet

Mean Absolute Error = 8.65 feet



Parsons Eng Science, Inc – Denver, CO
Project: Hill AFB OU 1
Description: ALTS3_3
14 Jan 98

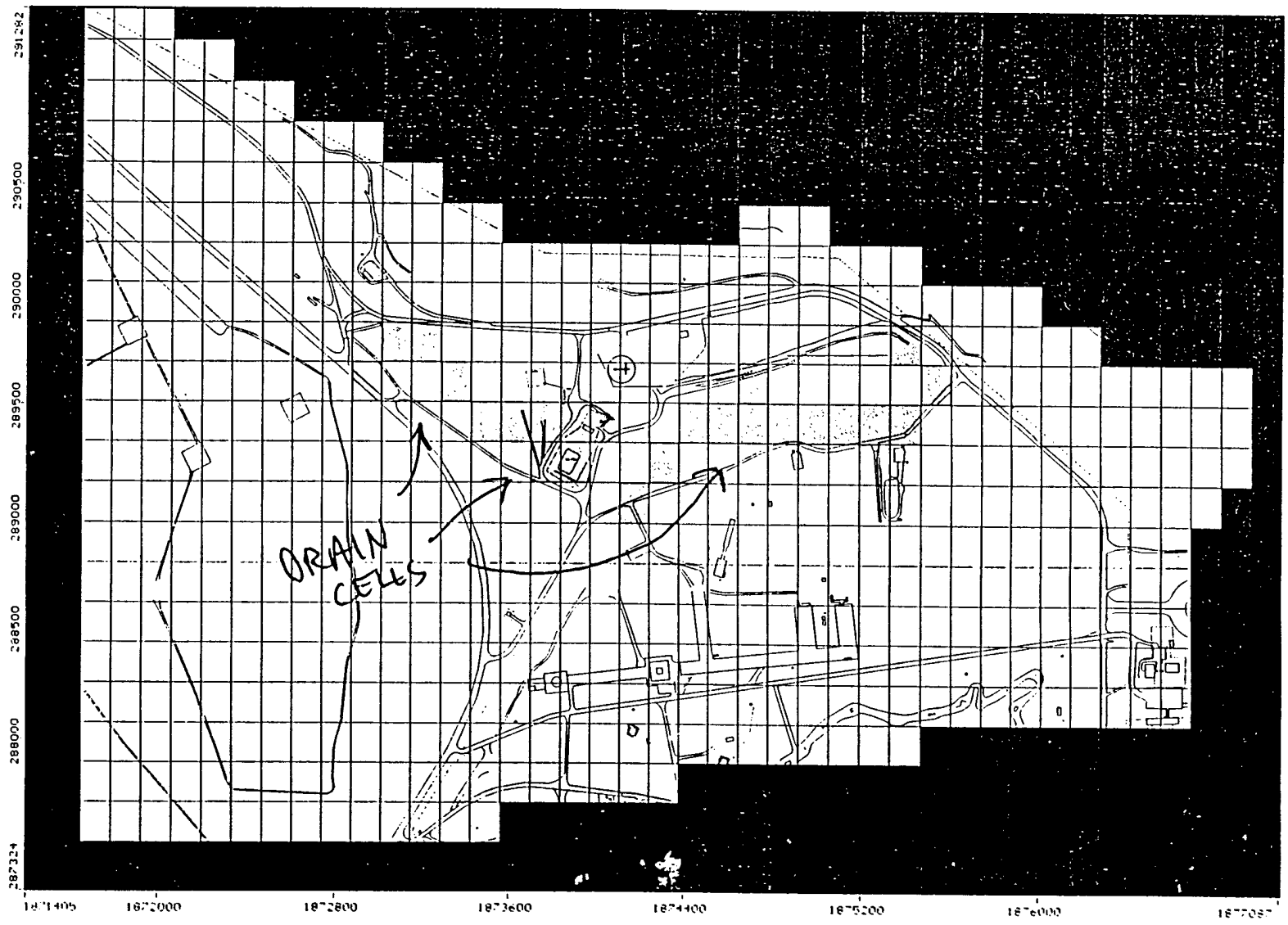
Visual MODFLOW v.2.50. (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 6

Locations of wells used for plume calibration

L:\hill\ou1\model\plumecal.xls

Data for transport model calibration
Hill AFB OU 1

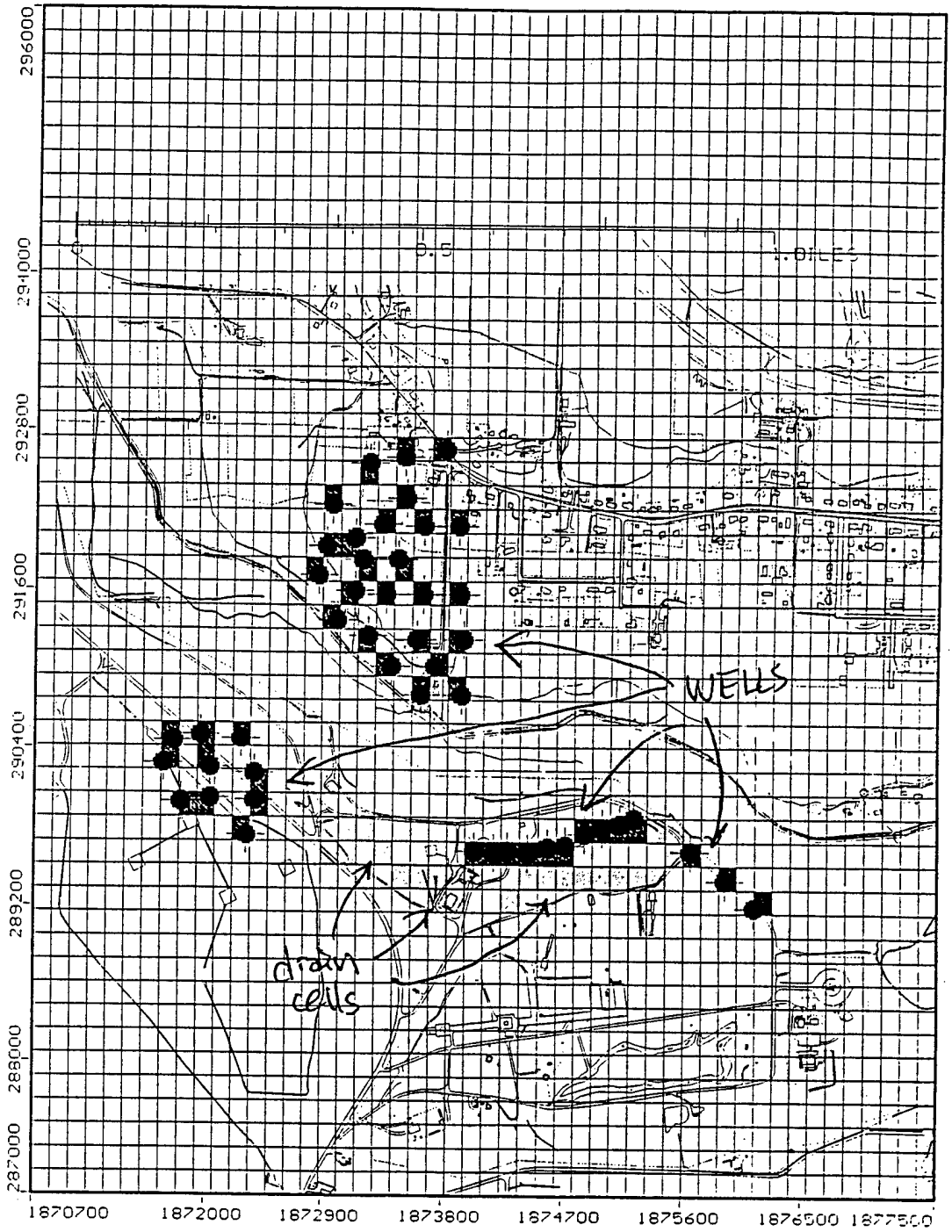
Well	Coordinates		Screen	Time (days)	Conc. (ug/L)
U1-008	1873733.1	288780.3	4780	20805	0.001
U1-041*	1873322.6	289347.3	4771	20805	48
U1-053	1875255.0	288607.0	4784	20805	0.001
U1-062	1873463.0	289081.0	4774	20805	0.001
U1-065	1873051.0	289570.0	4769	20805	18.6
U1-071*	1873975.0	289500.1	4772	20805	7083
U1-073	1873510.0	289661.0	4770	20805	1250
U1-074	1873320.0	289545.0	4774	20805	1550
U1-077R	1872941.6	289954.2	4762	20805	92
U1-078	1872881.0	290179.0	4735	20805	20.5
U1-084	1874528.0	290083.0	4723	20805	0.001
U1-089	1872725.3	289634.4	4768	20805	5.8
U1-097	1875072.0	291345.5	4479	20805	0.001
U1-098	1873813.0	291898.2	4472	20805	12.1
U1-100	1874576.7	289160.2	4777	20805	0.001
U1-103	1872681.6	290002.6	4766.9	20805	335
U1-104	1872948.1	290606.2	4704	20805	59
U1-105	1873127.7	291482.0	4479	20805	648
U1-107	1874921.0	289528.5	4775	20805	5.4
U1-111	1874839.9	292115.0	4475	20805	0.001
U1-112	1873896.6	292422.0	4467	20805	5.9
U1-116	1871802.6	290242.7	4760	20805	133
U1-130*	1873698.6	289483.1	4773	20805	338
U1-132*	1873804.3	289384.1	4773	20805	593
U1-133*	1873961.4	289302.0	4773	20805	1125
U1-143	1873558.8	289327.3	4772	20805	7.8
U1-154	1873807.9	291268.6	4470	20805	198
U1-160	1873732.6	293860.5	4762	20805	4.6
U1-1607	1871992.8	288646.1	4773	20805	0.001
U1-162	1873207.0	289887.4	4767	20805	3.9
U1-1632	1872826.9	292702.9	4464	20805	0.001
U1-1634	1874424.6	291721.7	4472	20805	0.001
U1-1635	1873493.1	293511.9	4435	20805	0.5
U1-1636	1874254.4	292603.1	4441	20805	0.001
U1-1637	1873464.8	291992.2	4469	20805	233
U1-647	1872248.3	290697.6	4733	20805	0.001
U1-070	1873868.0	289395.0	4776	20805	3948
U1-201	1873815.0	289323.7	4772	20805	1470
U1-081	1874628.0	289008.4	4784	20805	0.001
U1-101	1874419.9	289349.9	4775	20805	2.4
U1-067	1874077.0	289404.0	4778	20805	4000
U1-106	1874178.4	289396.0	4770	20805	1285
U1-661	1874312.4	289532.7	4763	20805	2.5
U1-202	1873988.1	289475.1	4772	20805	3930
U1-203	1874312.8	289593.3	4767	20805	240
U1-129	1873792.2	289512.8	4775	20805	480
U1-090	1874272.4	290590.1	4475	20805	4.9
U1-072	1873780.0	289543.0	4778	20805	524
U1-115	1871744.1	289716.4	4760	20805	7.1
U1-118	1872983.7	289787.1	4768	20805	2.7
U1-117	1871136.8	290890.3	4732	20805	0.001
U1-307	1872801.0	290725.2	4708	20805	526
U1-138	1873210.8	291080.2	4488	20805	547
U1-151	1873645.4	290741.2	4472	20805	747
U1-113	1873891.2	292424.7	4432	20805	5.5
U1-099	1873267.8	292852.7	4458	20805	27.9
U1-1633	1873393.8	293189.7	4439	20805	0.001
U1-1639	1873404.0	291314.6	4458	20805	10.2



Parsons Eng Science, Inc – Denver, CO
Project: Hill AFB OU 1
Description: ALTS3_3
14 Jan 98

Visual MODFLOW v.2.50, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 1

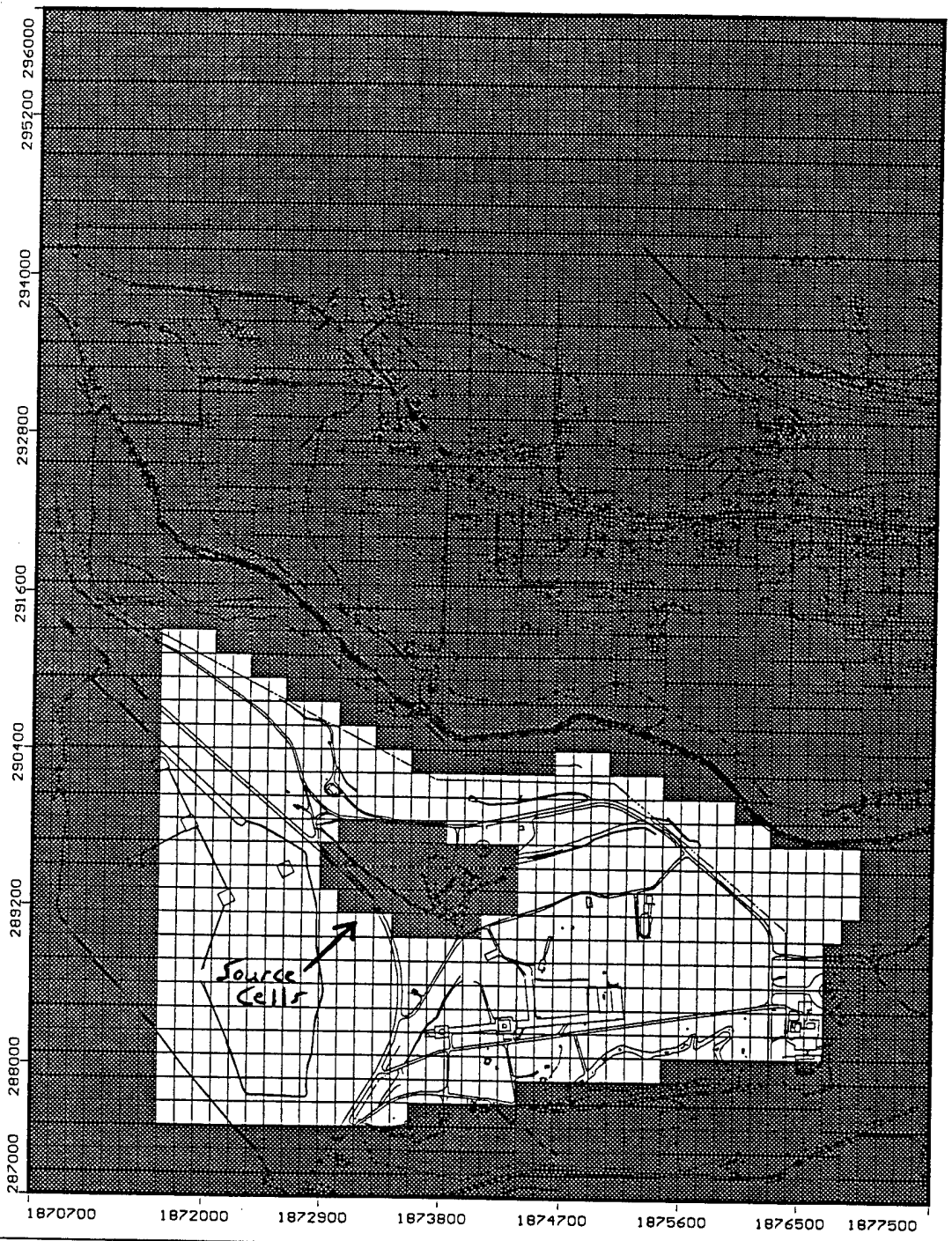
ALTS3-3 Drain locations



Parsons Eng Science, Inc – Denver, CO
Description: ~~Hill-2~~
14 Jan 98

Visual MODFLOW v.2.50, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 50 NR: 50 NL: 6
Current Layer: 1

ALTS 3-6: WELLS & TRENCHES
(drain cells)



Parsons Engineering Science, Inc.
Project: Hill AFB OU1
Description: Source Cells
Modeller: Parsons ES
8 Jul 99

Visual MODFLOW v.2.8.0, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 50 NR: 50 NL: 6
Current Layer: 1

APPENDIX E

CONCENTRATION VERSUS TIME GRAPHS FOR SELECTED WELLS

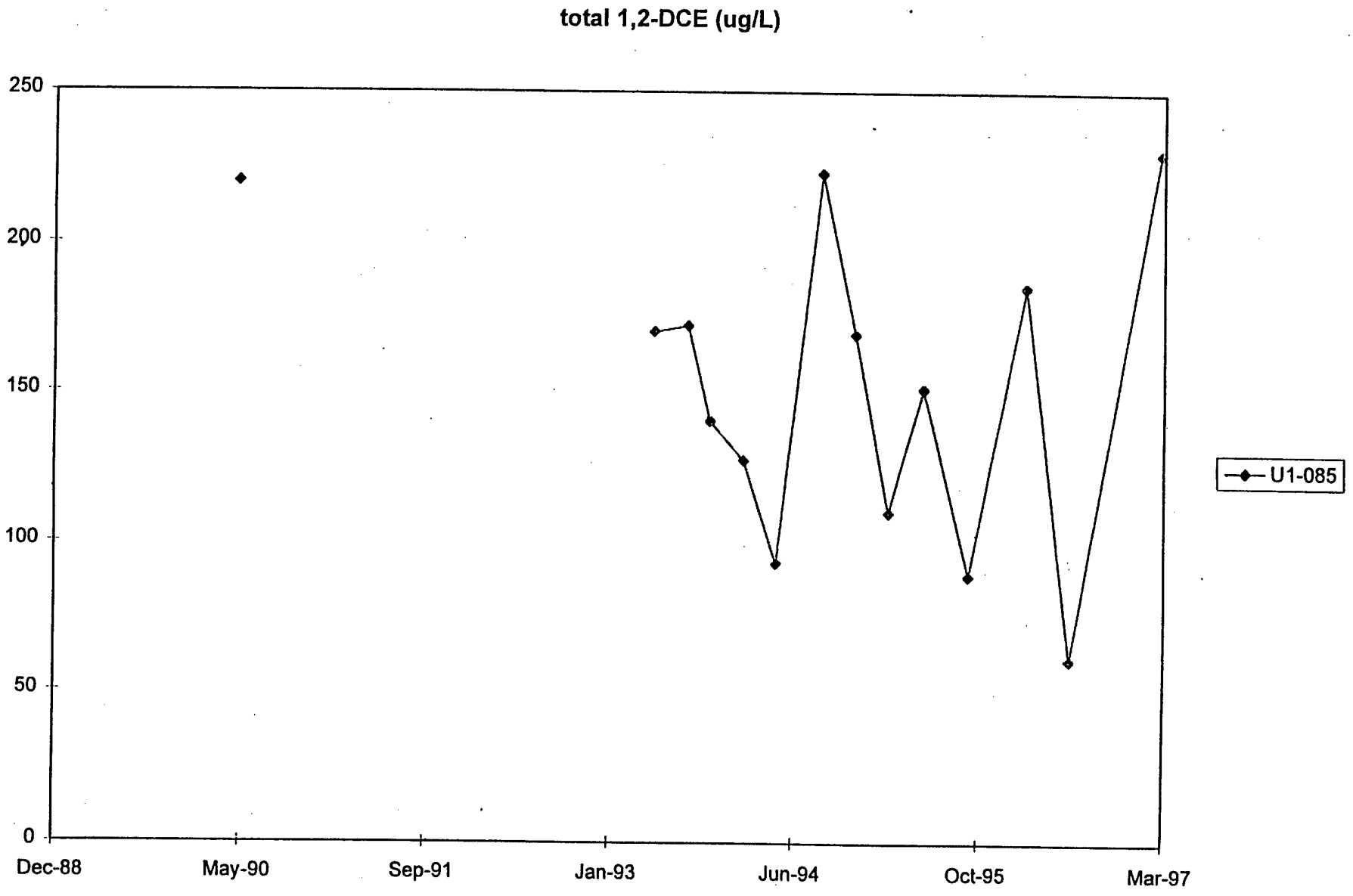
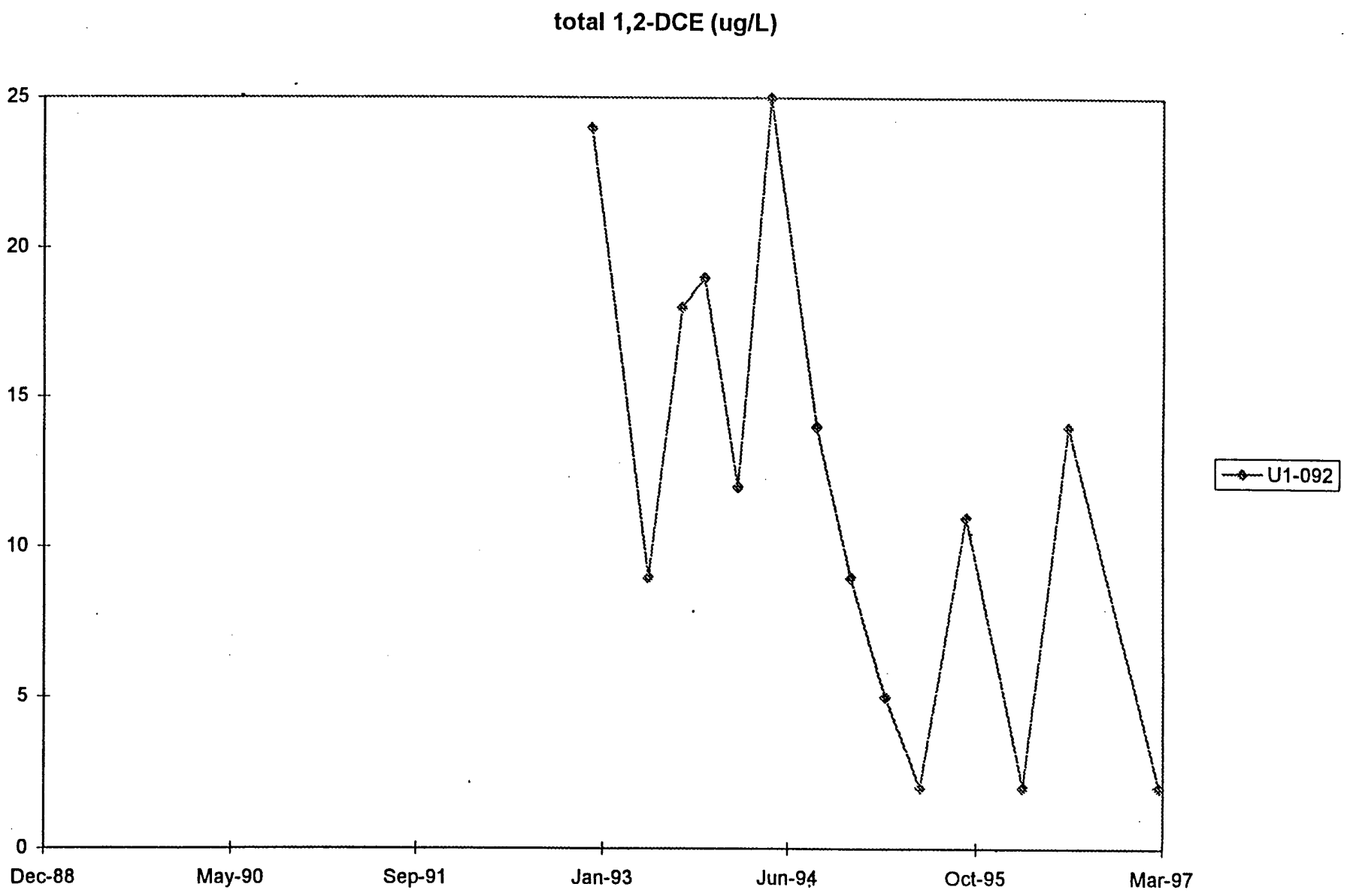
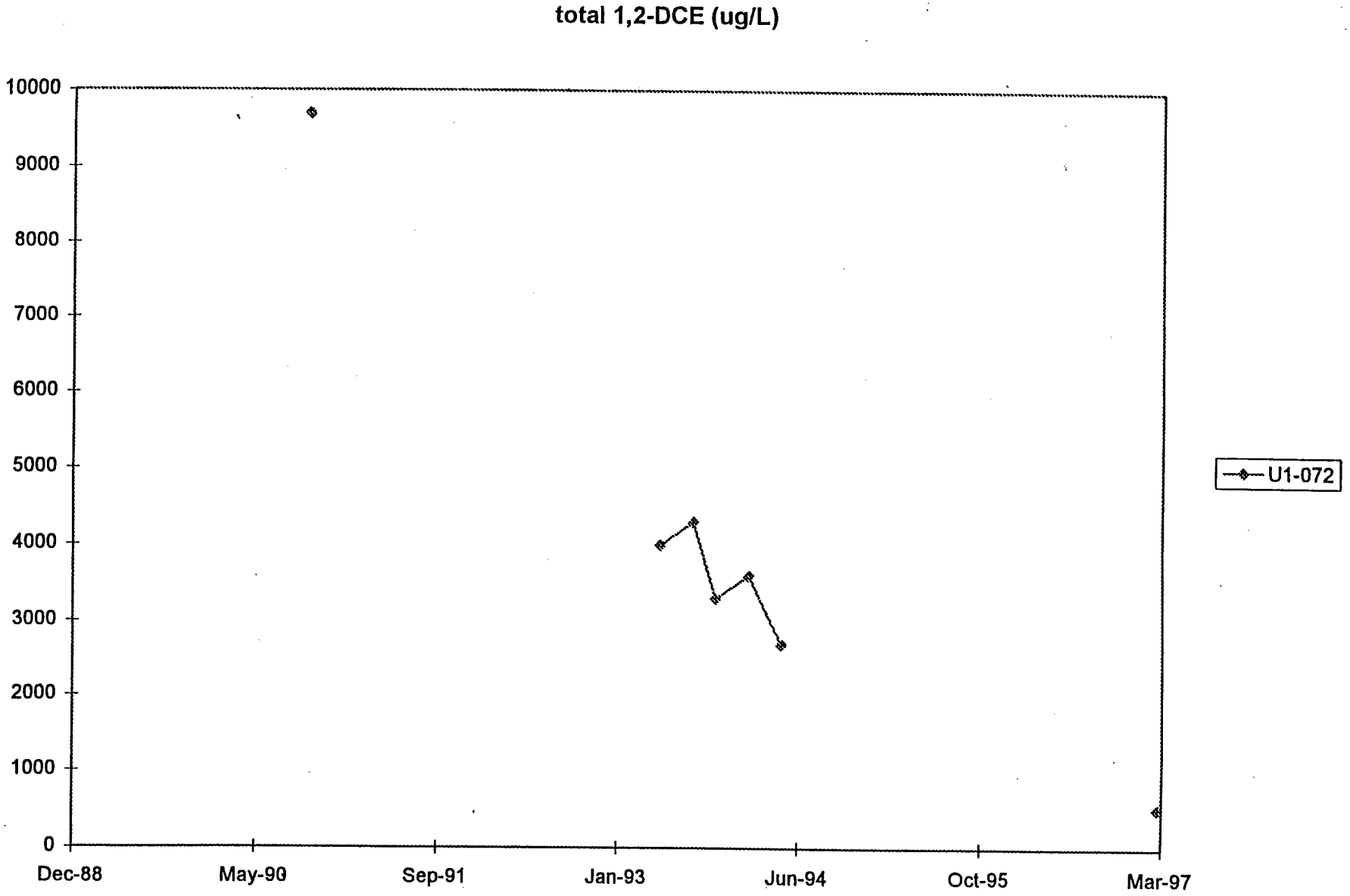
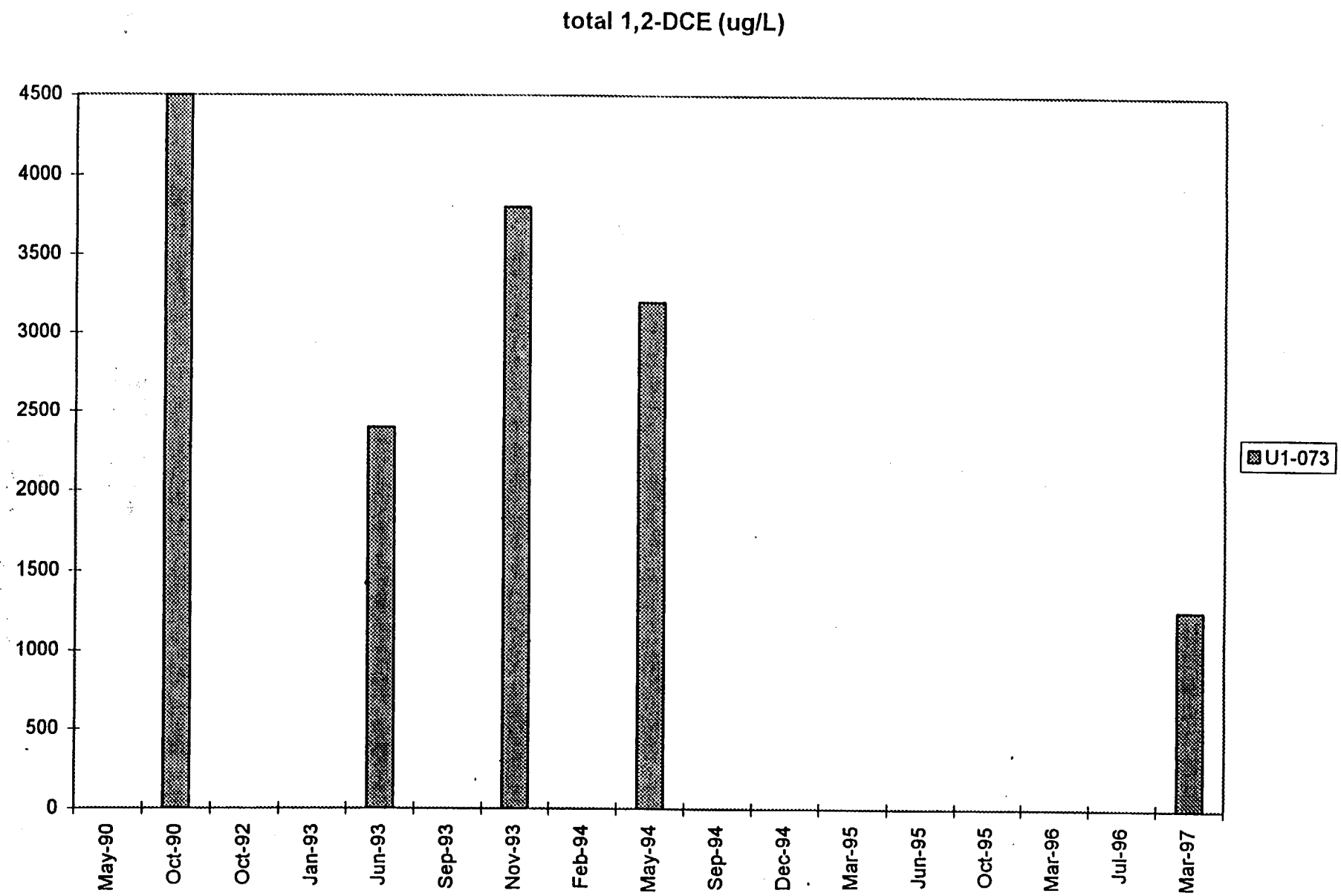

total 1,2-DCE (ug/L)
250
200
150
100
50
0
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
U1-085

Chart12


total 1,2-DCE (ug/L)
25
20
15
10
5
0
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
U1-092


total 1,2-DCE (ug/L)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
U1-072


total 1,2-DCE (ug/L)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
May-90
Oct-90
Oct-92
Jan-93
Jun-93
Sep-93
Nov-93
Feb-94
May-94
Sep-94
Dec-94
Mar-95
Jun-95
Oct-95
Mar-96
Jul-96
Mar-97
U1-073

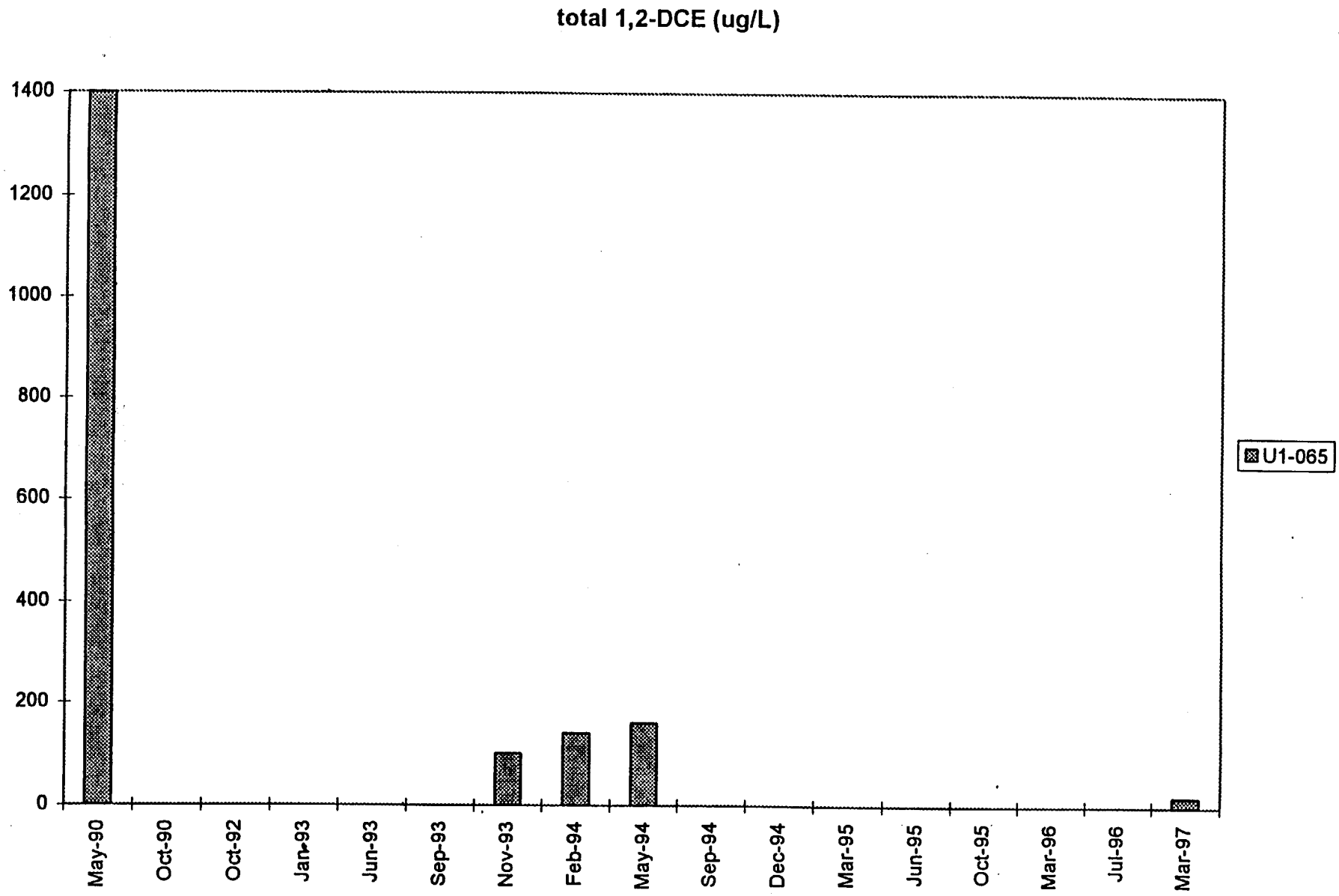
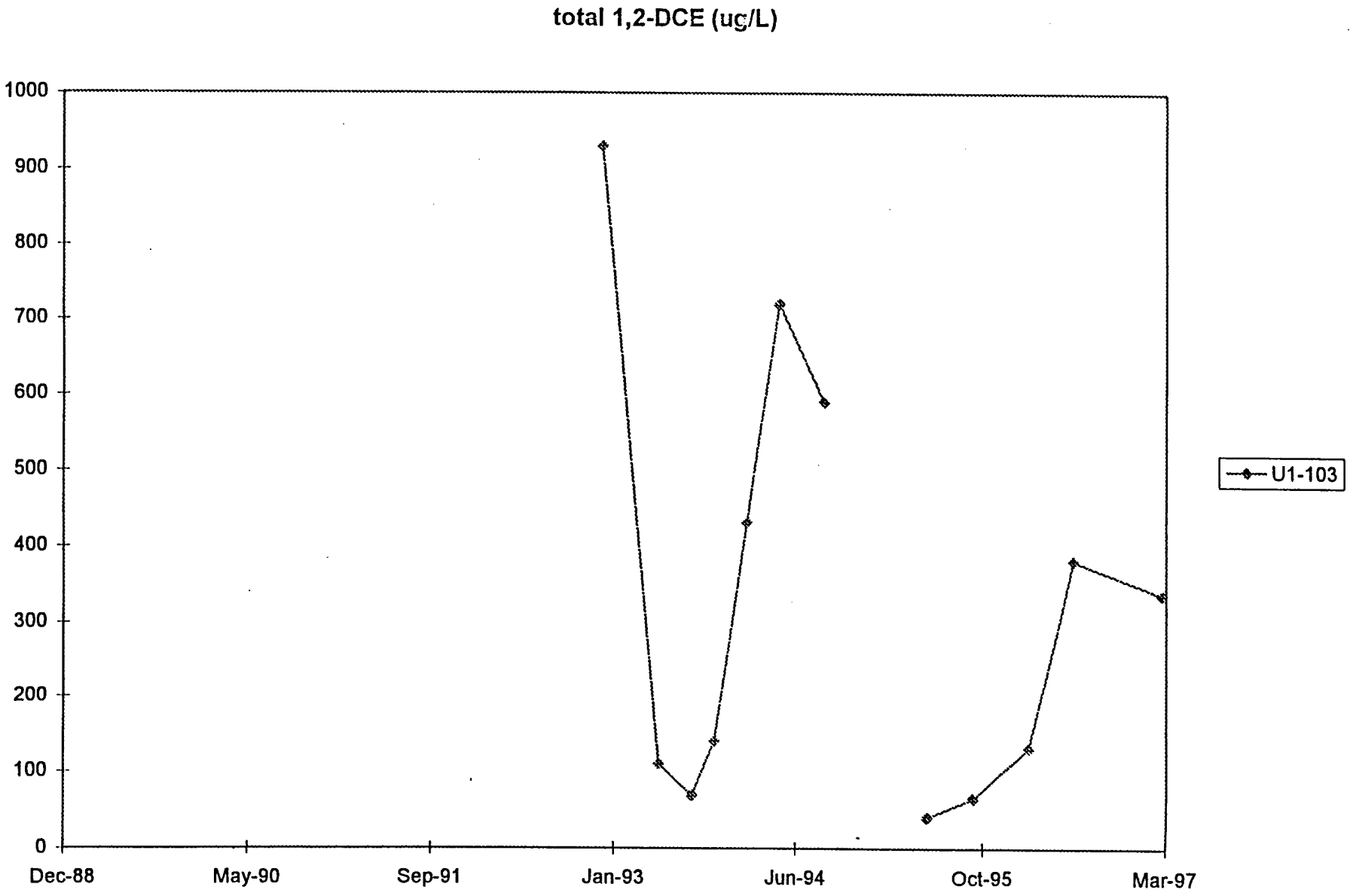

total 1,2-DCE (ug/L)
1400
1200
1000
800
600
400
200
0
May-90
Oct-90
Oct-92
Jan-93
Jun-93
Sep-93
Nov-93
Feb-94
May-94
Sep-94
Dec-94
Mar-95
Jun-95
Oct-95
Mar-96
Jul-96
Mar-97
U1-065

Chart10


total 1,2-DCE (ug/L)
1000
900
800
700
600
500
400
300
200
100
0
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
U1-103

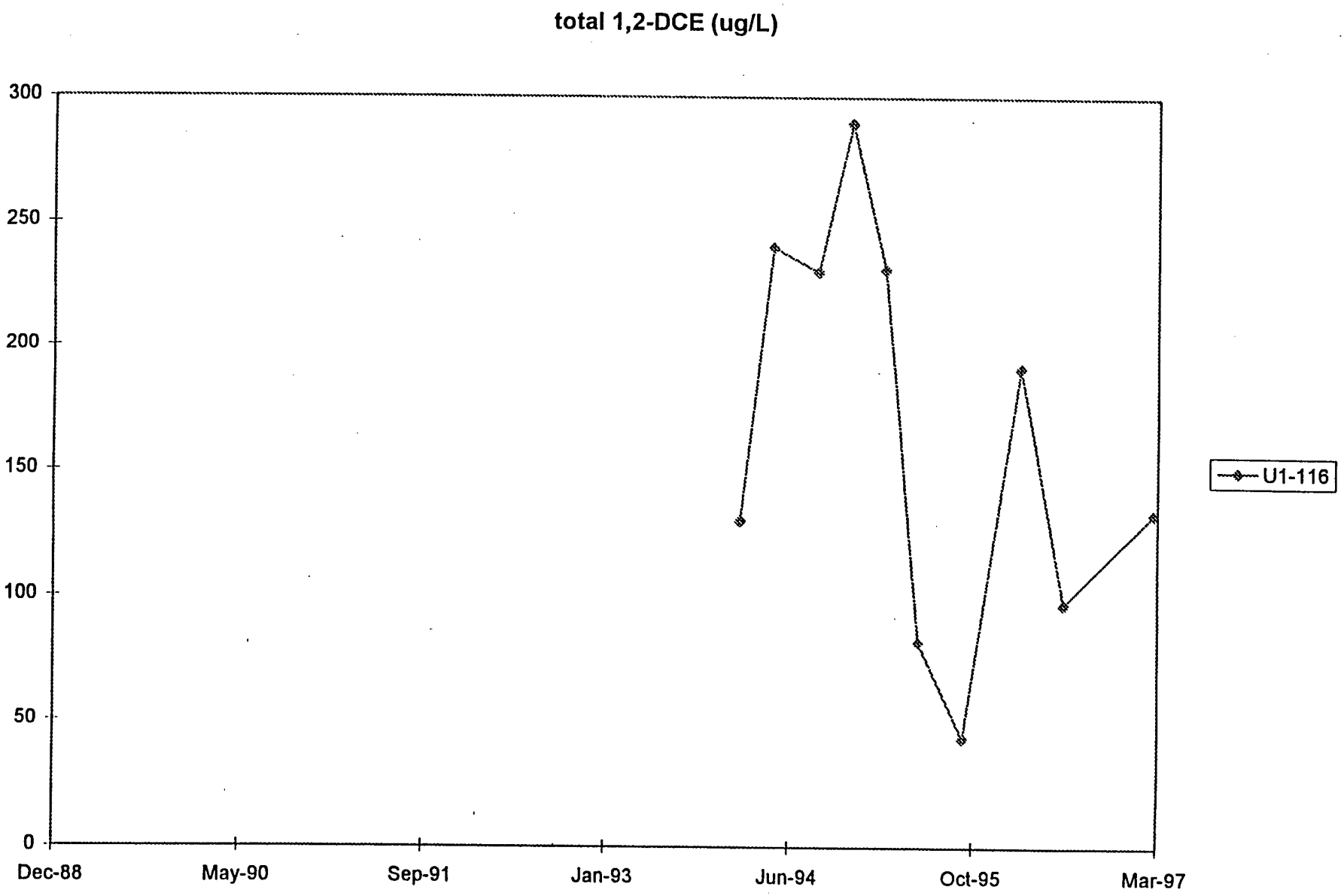
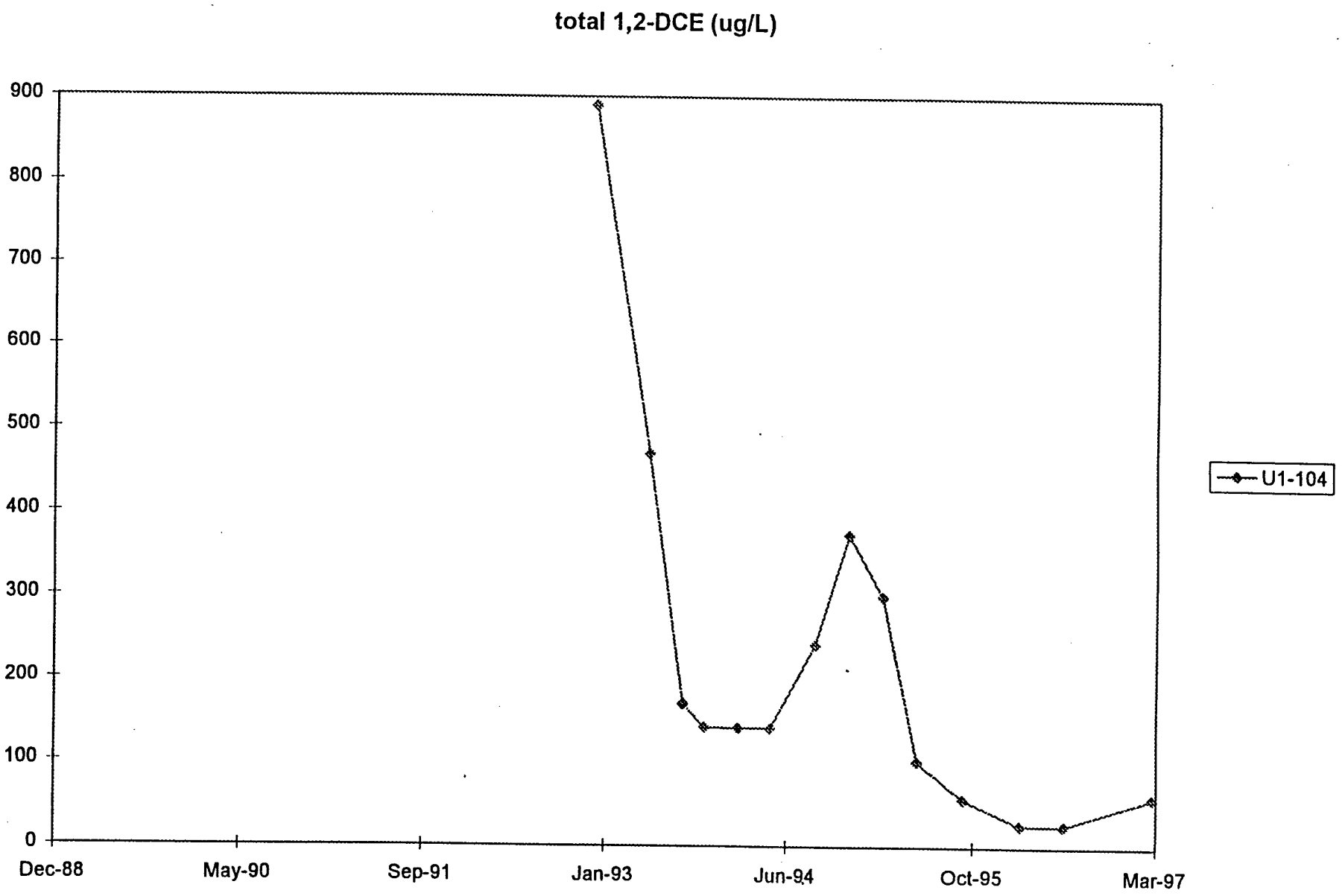

total 1,2-DCE (ug/L)
300
250
200
150
100
50
0
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
U1-116

Chart8


total 1,2-DCE (ug/L)
900
800
700
600
500
400
300
200
100
0
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
U1-104

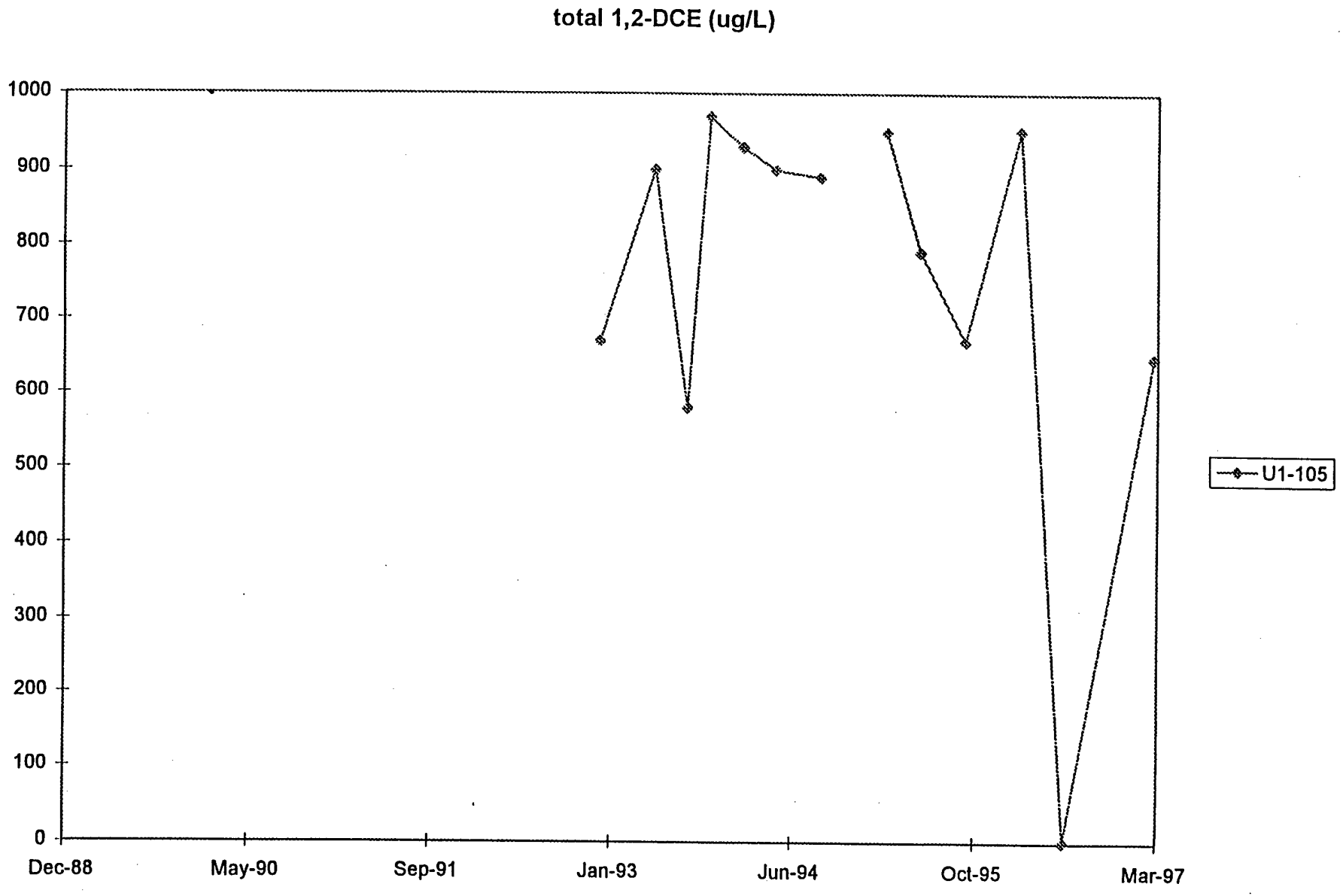
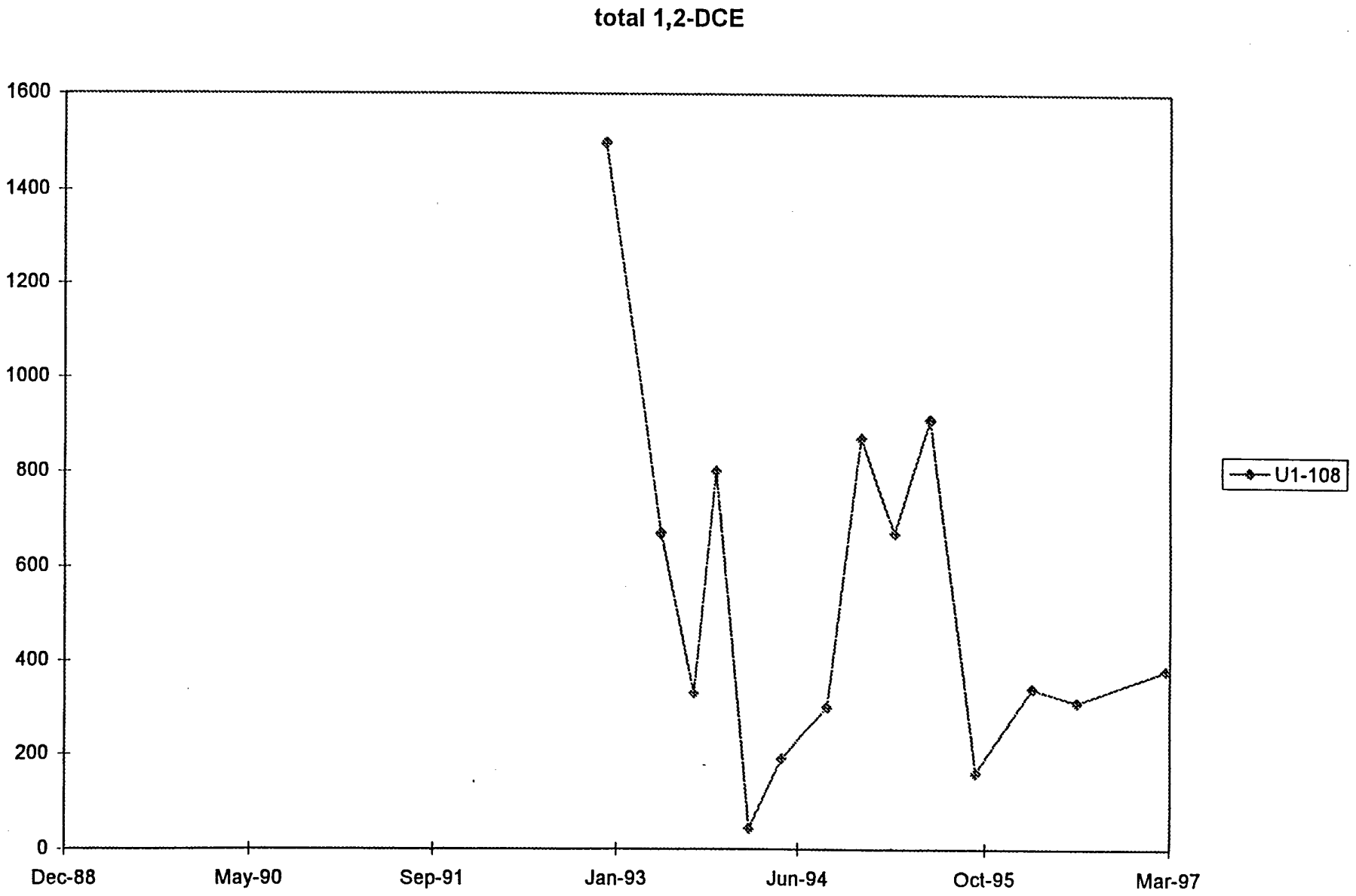
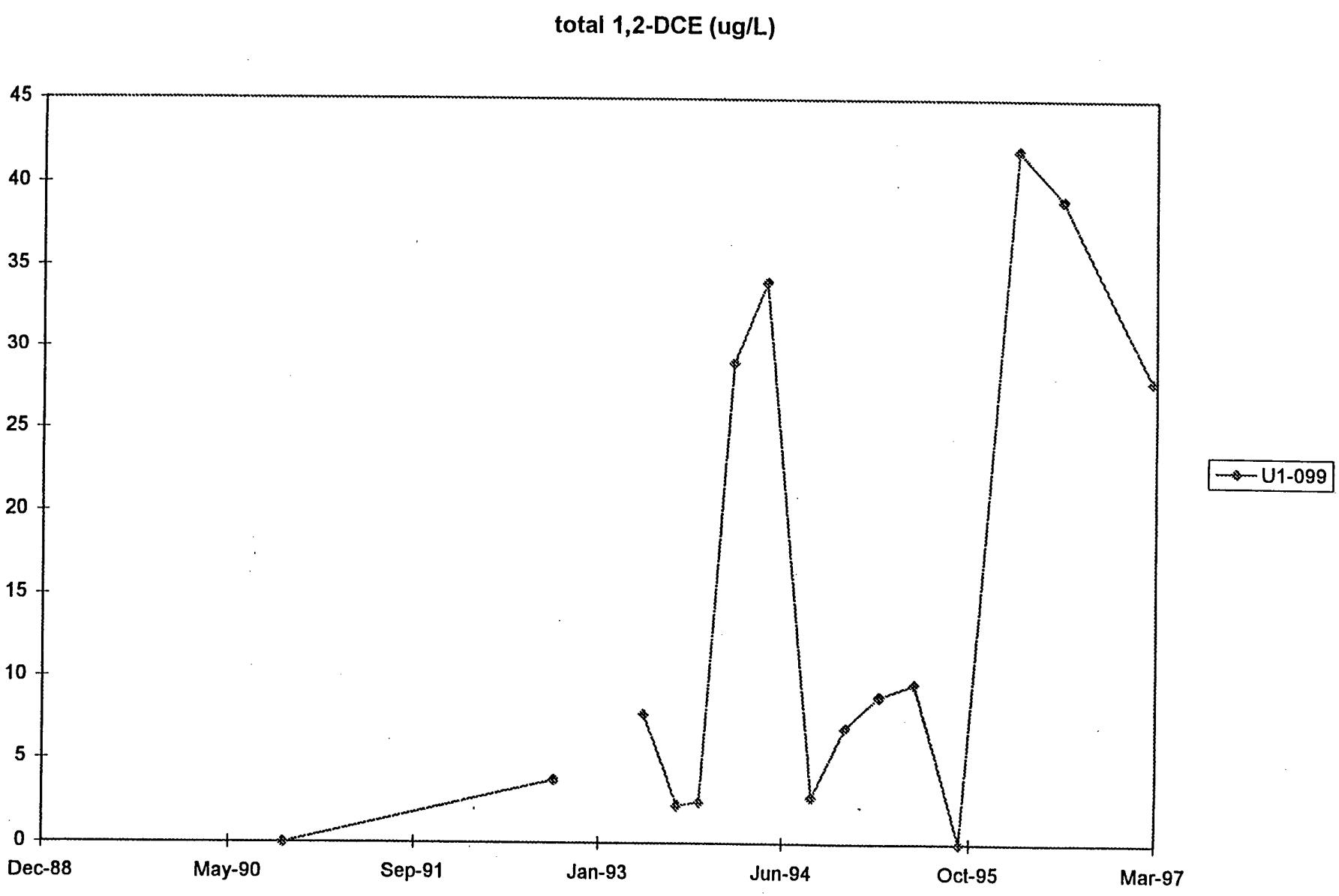
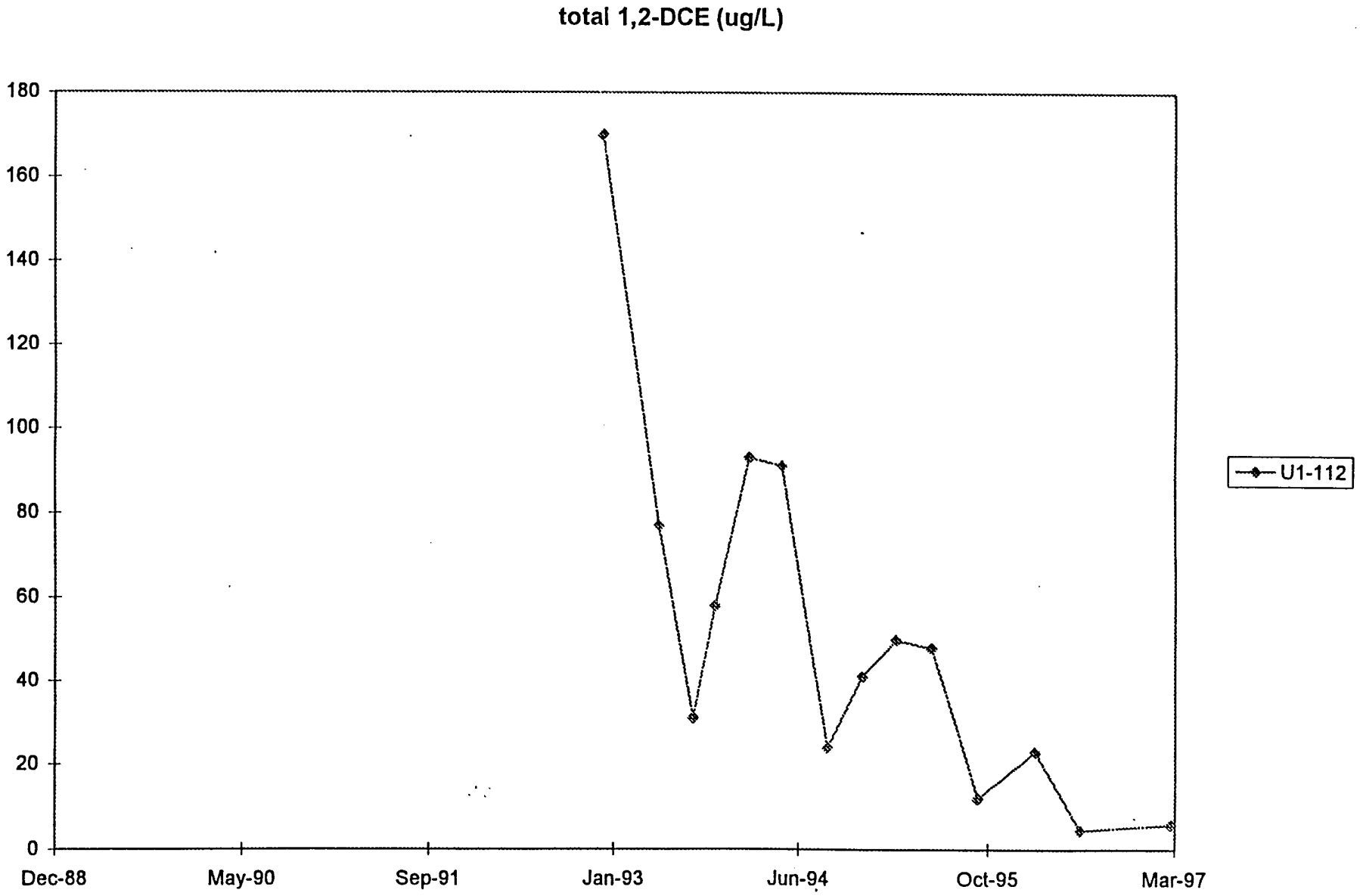

total 1,2-DCE (ug/L)
1000
900
800
700
600
500
400
300
200
100
0
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
U1-105

Chart4


total 1,2-DCE
1600
1400
1200
1000
800
600
400
200
0
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
U1-108


total 1,2-DCE (ug/L)
45
40
35
30
25
20
15
10
5
0
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
U1-099


total 1,2-DCE (ug/L)
180
160
140
120
100
80
60
40
20
0
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
U1-112

APPENDIX F

MODEL INPUT FILES