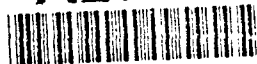
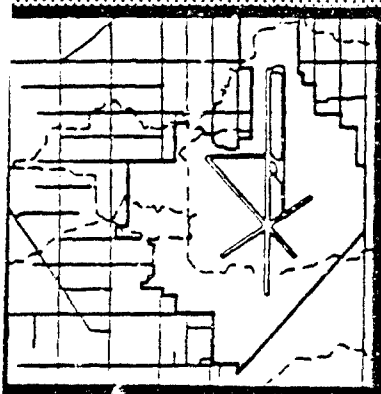


AD-A266 944



Handwritten signature/initials

INSTALLATION RESTORATION PROGRAM (IRP)



Operable Unit B1 Remedial Investigation/ Feasibility Study (RI/FS)

for McCLELLAN AFB, CALIFORNIA

TEXT

20030305208

FINAL

JULY 1993

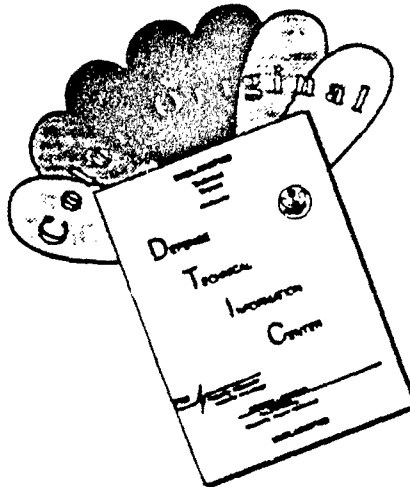
DTIC
ELECTE
JUL 21 1993
S A D

PREPARED FOR:
McCLELLAN AFB / EM
McCLELLAN AFB, CALIFORNIA 95652-5990

This document has been approved
for public release and sale; its
distribution is unlimited.

United States Air Force
Air Force Center for Environmental Excellence
Environmental Services Office
Environmental Restoration Division (AFCEE/ESR)
Brooks Air Force Base, Texas 78235-5000

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF COLOR PAGES WHICH DO NOT REPRODUCE LEGIBLY ON BLACK AND WHITE MICROFICHE.

INSTALLATION RESTORATION PROGRAM (IRP)

OPERABLE UNIT B1
REMEDIAL INVESTIGATION/FEASIBILITY STUDY

TEXT

FINAL

FOR

McCLELLAN AFB/EM
McCLELLAN AFB, CALIFORNIA 95652-5990

June 1993

Accession For	
NTIS CRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Availability for Special
A-1	

USAF CONTRACT NO. F33615-90-D-4013, DELIVERY ORDER NO. 0008
CONTRACTOR CONTRACT NO. 269-108, DELIVERY ORDER NO. 0008

United States Air Force
Air Force Center for Environmental Excellence
Environmental Services Office
Environmental Restoration Division (AFCEE/ESR)
Brooks AFB, Texas 78235-5000

02 7 20 116

93-16462



REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

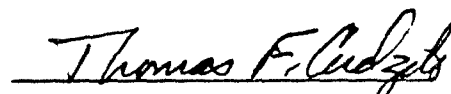
The reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding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

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 93/06/30		3. REPORT TYPE AND DATES COVERED Final	
4. TITLE AND SUBTITLE Operable Unit B1 Remedial Investigation and Feasibility Study Report				5. FUNDING NUMBERS C-(F33615-90-D-4013/0008)	
6. AUTHOR(S) Radian Corporation				7. PERFORMING ORGANIZATION REPORT NUMBER	
8. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Radian Corporation 10389 Old Placerville Road Sacramento, CA 95827				9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) AFCEE/ESR Brooks AFB, TX 78235-5000	
10. SPONSORING/MONITORING AGENCY REPORT NUMBER					
11. SUPPLEMENTARY NOTES					
12a. DISTRIBUTION/AVAILABILITY STATEMENT Unclassified/Unlimited				12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) This document presents the results from the remedial investigation and feasibility study for Operable Unit (OU) B1 at McClellan AFB, Sacramento, CA. Operable Unit B1 includes the Defense Reutilization and Marketing Office (DRMO) storage lot and Civil Engineering storage lot at McClellan AFB. The main chemicals of concern are PCBs, dioxins, and furans which may have leaked from transformers stored at OU B1 or were constituents of waste oil applied to soils to control dust. Sections 1.0 through 4.0 of the report present results from the RI, the potential for contaminant migration/transport from OU B1 and the current and future risks associated with OU B1. The FS begins in Section 5.0 identifying the remedial action objectives, in Sections 6.0 and 7.0, technologies are screened and potential remedial alternatives are developed. The final six remedial alternatives are analyzed and compared to each other using the criteria established in the NCP in Section 8.0.					
14. SUBJECT TERMS Remedial Investigation (RI); Feasibility Study (FS)				15. NUMBER OF PAGES 352	
				16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT Unlimited		

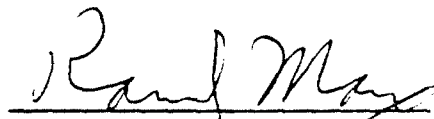
NOTICE

This report has been prepared for the Air Force by Radian Corporation for the purpose of aiding in the implementation of a final remedial action plan under the Air Force Installation Restoration Program (IRP). As the report relates to the initial screening of remedial action alternatives, its release prior to an Air Force final decision on remedial action may be in the public's interest. The limited objectives of this report and the ongoing nature of the IRP, along with the evolving knowledge of site conditions and chemical effects on the environmental and health, must be considered when evaluating this report, since subsequent facts may become known that may make this report premature or inaccurate. Acceptance of this report in performance of the contract under which it is prepared does not mean that the Air Force adopts the conclusions, recommendations, or other views expressed herein, which are those of the contractor only and do not necessarily reflect the official position of the Air Force.

This report has been prepared by the staff of Radian Corporation under our supervision. The presentation of information contained herein has been approved after thorough technical review. The conclusions and recommendations in this report are based upon the data collected in the field by Radian Corporation. We believe the data presented are of high quality. The interpretation of these data and the conclusions drawn were governed by our experience and professional judgement.

A handwritten signature in cursive script, reading "Thomas F. Cudzilo", written over a horizontal line.

Thomas F. Cudzilo, Ph.D
Registered Geologist 4473

A handwritten signature in cursive script, reading "Randy Marx", written over a horizontal line.

Randy Marx, P.E.
Professional Engineer, Civil C31936

TABLE OF CONTENTS

Section	Page
EXECUTIVE SUMMARY	S-1
REMEDIAL INVESTIGATION	
1.0 INTRODUCTION	1-1
1.1 Goals	1-1
1.2 How to Use This Report	1-1
2.0 SITE CHARACTERISTICS	2-1
2.1 History and Physical Characteristics	2-1
2.1.1 Operable Unit B1	2-1
2.1.2 Physical Characteristics of OU B1	2-4
2.2 Site Investigations	2-4
2.2.1 Previous Studies	2-4
2.2.2 Remedial Investigation	2-7
2.2.3 Extent of Contamination in Surface Soil	2-16
2.2.4 Extent of Contamination in the Vadose Zone	2-17
2.2.5 Extent of Contamination in Sediments and Surface Water	2-19
2.2.6 Extent of Contamination in Groundwater	2-26
3.0 EVALUATION OF CONTAMINANT TRANSPORT	3-1
3.1 Contaminant Properties	3-1
3.2 Mechanisms of Transport	3-4
3.3 Potential for Surface Transport	3-4
3.4 Potential for Subsurface Transport	3-8
3.5 Potential for Groundwater Transport	3-10
4.0 HEALTH RISK ASSESSMENT	4-1
4.1 Identification of Potential Contaminants of Concern	4-1
4.2 Exposure Assessment	4-2
4.2.1 Potentially Exposed Populations	4-2
4.2.2 Exposure Scenario Selection	4-3
4.2.3 Exposure Pathway Assessment	4-3
4.3 Quantitative Exposure and Intake Assessment	4-3
4.3.1 Exposure Concentrations	4-3
4.3.2 Intake Rates	4-8

TABLE OF CONTENTS (Continued)

Section	Page
4.4 Toxicity Assessment	4-11
4.5 Risk Characterization	4-11
4.5.1 Carcinogenic Risks	4-11
4.5.2 Noncarcinogenic Health Effects	4-13
4.5.3 Lead Evaluation	4-13
4.6 Uncertainty Analysis	4-14
4.6.1 Uncertainty in Identification of Chemicals of Concern	4-15
4.6.2 Uncertainty in the Exposure Assessment	4-15
4.6.3 Uncertainty in the Intake Assessment	4-16
4.6.4 Uncertainty in Toxicity Assessment	4-17
4.7 Ecological Evaluation	4-18
 FEASIBILITY STUDY	
5.0 REMEDIAL ACTION OBJECTIVES	5-1
5.1 General and Specific Remedial Action Objectives	5-1
5.2 Statutory Requirements, ARARs, and TBCs	5-1
5.3 Interim Remediation Goals	5-3
5.3.1 Soil and Stream Sediment	5-6
5.3.2 Surface Water	5-6
5.4 Areas and Volumes of Contaminated Soil Subject to Remedial Action	5-10
5.5 General Response Actions	5-10
 6.0 DEVELOPMENT AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS	6-1
6.1 Identification of General Response Actions and Remedial Technologies . . .	6-1
6.1.1 No Action	6-1
6.1.2 Institutional Controls	6-1
6.1.3 Containment	6-1
6.1.4 Excavation and Disposal	6-1
6.1.5 Excavation, Treatment, and Disposal	6-1
6.1.6 In-Situ Treatment	6-4
6.2 Evaluation and Selection of Process Options	6-4

TABLE OF CONTENTS (Continued)

Section	Page
7.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES	7-1
7.1 Alternative Development and Screening Process	7-1
7.2 Development and Screening of Alternatives	7-1
7.2.1 No Action	7-1
7.2.2 Institutional Controls	7-2
7.2.3 Capping	7-2
7.2.4 Excavation with Off-Site Disposal	7-3
7.2.5 Excavation, Off-Site Incineration, and Disposal	7-4
7.2.6 Excavation, On-Site Treatment, and Disposal	7-4
7.2.7 Capping and Treatability Studies with Potential On-Site Treatment	7-5
7.2.8 Excavation and Disposal of Principal Threat and Capping the Site	7-7
8.0 ANALYSIS OF REMEDIAL ACTION ALTERNATIVES	8-1
8.1 Analysis of Individual Alternatives	8-1
8.1.1 Alternative 1 — No Action	8-1
8.1.2 Alternative 2 — Capping	8-4
8.1.3 Alternative 3 — Excavation and Off-Site Disposal	8-6
8.1.4 Alternative 4 — Excavation, Off-Site Incineration, Disposal	8-7
8.1.5 Alternative 5 — Excavation, On-Site Treatment, Disposal	8-8
8.1.6 Alternative 6 — Capping and Treatability Studies with Potential On-Site Treatment	8-8
8.1.7 Alternative 7 — Excavation and Disposal of Principal Threat and Capping the Site	8-9
8.2 Sensitivity Analysis	8-10
8.3 Comparative Analysis	8-10
9.0 REFERENCES	9-1

TABLE OF CONTENTS (Continued)

APPENDICES

APPENDIX A — Remedial Investigation Data
APPENDIX B — Quality Assurance/Quality Control
APPENDIX C — Vadose Zone Modeling and Importance Ranking of Transport Mechanisms
APPENDIX D — Health Risk Assessment: Supporting Information
APPENDIX E — ARARs Identification
APPENDIX F — Backup for Cost Estimating
APPENDIX G — Response to Comments

PLATE A — Isopleths of PCB Concentrations in Near-Surface Soils

PLATE B — Cross Section B-B'

LIST OF FIGURES

Figure	Page
S-1 Locations Within OU B1	S-2
S-2 Comparative Analysis of Remedial Alternatives	S-9
1-1 Location of Operable Unit B1 at McClellan Air Force Base	1-2
1-2 Locations Within OU B1	1-3
2-1 Locations Within OU B1	2-2
2-2 History of OU B1	2-3
2-3 Land Uses Surrounding OU B1	2-5
2-4 Physical Features of OU B1	2-6
2-5 Previous Sampling Locations	2-10
2-6 Cross Section A-A' of OU B1	2-20
2-7 Sediment Sampling Locations at OU B1	2-21
2-8 Surface Water Sampling Locations in OU B1 and Drainage Ditches	2-25
2-9 Isopleths of Total VOC Concentrations and Water Level Contours in the A Zone at OU B1	2-27
3-1 Schematic Diagram of Potential Transport Mechanisms at OU B1	3-5
3-2 Potential Surface Transport Directions from OU B1	3-7
3-3 Transport of Arochlor 1260 Through the Vadose Zone (Vadose Zone Model Results — 30 Years)	3-11
3-4 Transport of 1,1-DCE Through the Vadose Zone (Vadose Zone Model Results — 30 Years)	3-11
3-5 Transport of PCE Through the Vadose Zone (Vadose Zone Model Results — 30 Years)	3-12
3-6 Transport of TCE Through the Vadose Zone (Vadose Zone Model Results — 30 Years)	3-12
3-7 Transport of Benzene Through the Vadose Zone (Vadose Zone Model Results — 30 Years)	3-13
3-8 Transport of cis-1,2-DCE Through the Vadose Zone (Vadose Zone Model Results — 30 Years)	3-13

LIST OF FIGURES (Continued)

Figure	Page
4-1 Current Scenario Map	4-4
4-2 Cancer Risk Assessment Summary	4-12
4-3 Areas of Significant Ecological Resources	4-15
5-1 Inorganic Cleanup Standard Determination for OU B1 Surface Soils and Sediments	5-7
8-1 Conceptual Design of the Capping Alternative	8-5
8-2 Comparative Analysis of Remedial Alternatives	8-13

LIST OF TABLES

Table	Page
2-1 Previous Studies at OU B1	2-8
2-2 Summary of Results from Previous Studies at OU B1	2-9
2-3 Chemicals of Concern at McClellan AFB OU B1	2-7
2-4 Average, Minimum, and Maximum Contaminant Concentrations Reported at OU B1	2-11
2-5 Summary of Completeness by Method	2-15
2-6 Contaminants Reported in Drainage Sediment Samples Collected April 1993 . . .	2-22
3-1 Maximum Concentrations and Physical and Chemical Properties (at 25 C) of Chemicals of Concern in OU B1	3-2
3-2 Mechanisms of COC Transport in OU B1	3-6
4-1 Exposure Pathways	4-5
4-2 Values Used for Intake Parameters for Current and Hypothetical Residential Scenarios	4-9
4-3 Values Used for Intake Parameters for Non-Residential Scenarios	4-10
4-4 Hazard Indices	4-13
4-5 Blood-Lead Levels Resulting from Exposures to OU B1 Soil	4-14
5-1 Specific Remedial Action Objectives for OU B1	5-2
5-2 Summary of Remediation Goals and General Response Actions for OU B1	5-4
5-3A Receiving Water Limitations from the Inland Surface Waters Plan: Protection of Aquatic Life	5-8
5-3B Receiving Water Limitations from the Inland Surface Waters Plan: Protection of Human Health	5-9
5-4 Area and Volume Calculations for PCB-Contaminated Soil at OU B1	5-11
6-1 Initial Screening of Remedial Technologies and Process Options for Soil	6-2
6-2 Summary of Evaluation of Process Options for Soil	6-5
8-1 Remedial Alternative Evaluation Criteria	8-2
8-2 Remedial Alternative Evaluation Criteria Rating System	8-3
8-3 Cost Sensitivity Analysis	8-11
8-4 Comparative Analysis of Remedial Alternatives	8-12

ACRONYM LIST

AFB	=	Air Force Base
Ag	=	Silver
ARARs	=	Applicable or Relevant and Appropriate Requirements
ATSDR	=	Agency for Toxic Substances and Disease Registry
AVOC	=	Aromatic Volatile Organic Compound
BCDP	=	Base-catalyzed Decomposition Process
BGS	=	Below ground surface
C	=	Degrees Celsius
Cd	=	Cadmium
CE	=	Civil Engineering
CERCLA	=	Comprehensive Environmental Response, Compensation, and Liability Act
CWA	=	Clean Water Act
COC	=	Chemical of concern
Cu	=	Copper
DCA	=	Dichloroethane
DCE	=	Dichloroethene
DNAPL	=	Dense nonaqueous phase liquid
DOT	=	Department of Transportation
DRMO	=	Defense Reutilization and Marketing Office
EE/CA	=	Engineering Evaluation/Cost Analysis
FS	=	Feasibility Study
H	=	Henry's Law constant
HDPE	=	High density polyethylene
HI	=	Hazard index
HpCDD	=	Heptachlorodibenzodioxin congeners
HpCDF	=	Heptachlorodibenzofuran congeners
HQ	=	Hazard quotient
HRA	=	Health risk assessment
HTTO	=	High temperature thermal oxidation
HVOC	=	Halogenated Volatile Organic Compound
HxCDD	=	Hexachlorodibenzodioxin congeners
HxCDF	=	Hexachlorodibenzofuran congeners
IRP	=	Installation Restoration Program
I-TEF	=	International Toxic Equivalency Factor
Kwh	=	Kilowatt hour

ACRONYM LIST (Continued)

LMS	=	Linearized multistage
LOC	=	Level of concern
MCL	=	Maximum contaminant level
mg/kg	=	Milligram per kilogram
msl	=	Mean sea level
NAPL	=	Nonaqueous phase liquid
NCP	=	National Oil and Hazardous Substances Pollution Contingency Plan
NHPA	=	National Historic Preservation Act
OCDD	=	Octachlorodibenzodioxin congeners
OCDF	=	Octachlorodibenzofuran congeners
O&M	=	Operations and maintenance
OU	=	Operable Unit
Pb	=	Lead
PCB	=	Polychlorinated biphenyl
PCDD	=	Pentachlorodibenzodioxin congeners
PCDF	=	Pentachlorodibenzofuran congeners
PCE	=	Tetrachloroethene
ppbv	=	Parts per billion by volume
PRG	=	Preliminary remediation goal
PSP	=	Perforated steel planking
PT	=	Principle threat
QA	=	Quality Assurance
QC	=	Quality Control
QAPP	=	Quality Assurance Project Plan
RCRA	=	Resource Conservation and Recovery Act
RI	=	Remedial Investigation
SACM	=	Superfund Accelerated Cleanup Model
SAP	=	Sampling and Analysis Plan
SDWA	=	Safe Drinking Water Act
SE	=	Selenium
SITE	=	Superfund Innovative Technologies Evaluation
SMAQMD	=	Sacramento Metropolitan Air Quality Management District
SVE	=	Soil vapor extraction
SVOC	=	Semivolatile organic compound

ACRONYM LIST (Continued)

TBC	= To be considered; guidance or criteria not promulgated (and therefore not an ARAR) that is nonetheless "to be considered" in developing remediation goals
TCB	= Trichlorobenzene
TCDD	= Tetrachlorodibenzodioxin congeners
TCDDeq	= TCDD equivalent
TCDF	= Tetrachlorodibenzofuran congeners
TCLP	= Toxicity Characteristic Leaching Procedure
TCE	= Trichloroethene
TPH	= Total petroleum hydrocarbon
TSCA	= Toxic Substances Control Act
U.S. EPA	= U.S. Environmental Protection Agency
VOC	= Volatile organic compound
µg/L	= Microgram per liter

EXECUTIVE SUMMARY

A Remedial Investigation/Feasibility Study (RI/FS) was undertaken in Operable Unit (OU) B1 of McClellan Air Force Base (AFB), California, from 1991 to 1993. Operable Unit B1 is a portion of the Defense Reutilization and Marketing Office (DRMO) storage yard, the Civil Engineering (CE) storage yard, and an unpaved area between them (Figure S-1). It is an area where transformers, which contained oil laden with polychlorinated biphenyls (PCBs), were handled. The surface soil at OU B1 has been contaminated with PCBs, dioxin and furan compounds, petroleum hydrocarbons, inorganic species, and semivolatile organic compounds. Volatile organic compounds (VOCs) are also present in the subsurface, where they have migrated after apparently being spilled on the surface. This RI/FS report documents the distribution of chemicals of concern (COCs) and evaluates technologies that could be applied to remediate the soil contaminated with PCBs, dioxins and furans, and metals. Volatile organic compounds will be addressed individually in separate OUs at McClellan AFB.

The remediation goals developed for this RI/FS incorporate current U.S. Environmental Protection Agency (U.S. EPA) Superfund Accelerated Cleanup Model (SACM) goals. These goals include the following:

- Performing early actions to reduce immediate risks to the public and the environment; and
- Committing to long-term cleanup to restore the environment and contaminated media.

How to Use This Report

At the back of this report is a map of OU B1 that can be unfolded and laid flat while the report binder is open. A series of overlays to the map, bound at the end of the report, show sampling locations and results for the OU B1 RI.

Site Background

The area now known as OU B1 consists of Potential Release Location 29, Study Areas 12A, 12B, and 13, and the drainage ditches that receive surface water runoff from the DRMO yard in OU B of McClellan AFB. Throughout this report, they will be referred to collectively as OU B1. This area has been used for open storage since approximately 1962. The DRMO yard is predominantly covered by perforated steel planking (PSP) and small areas of solid steel or solid aluminum planking (Figure S-1). The CE storage yard is paved. The open area between the two yards is grassland. Most of the materials stored on the lots are nonhazardous; however, at one time, transformers containing oil laden with PCBs were also stored and handled there. Used oils (including transformer oils) were also reportedly sprayed on the soils to suppress dust. In 1987, transformer oil was spilled onto the ground surface in a small area of the DRMO yard; the spill was subsequently cleaned up. In 1993, after PCBs were reported in surface soils during the OU B1 RI, a time-critical removal action was undertaken to reduce worker exposure to the PCBs. The areas with the highest concentration of PCBs were fenced and covered with a 45-mil high density polyethylene (HDPE) liner.

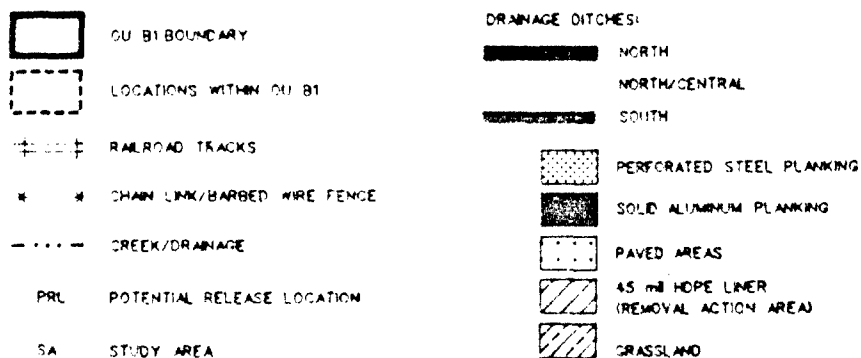
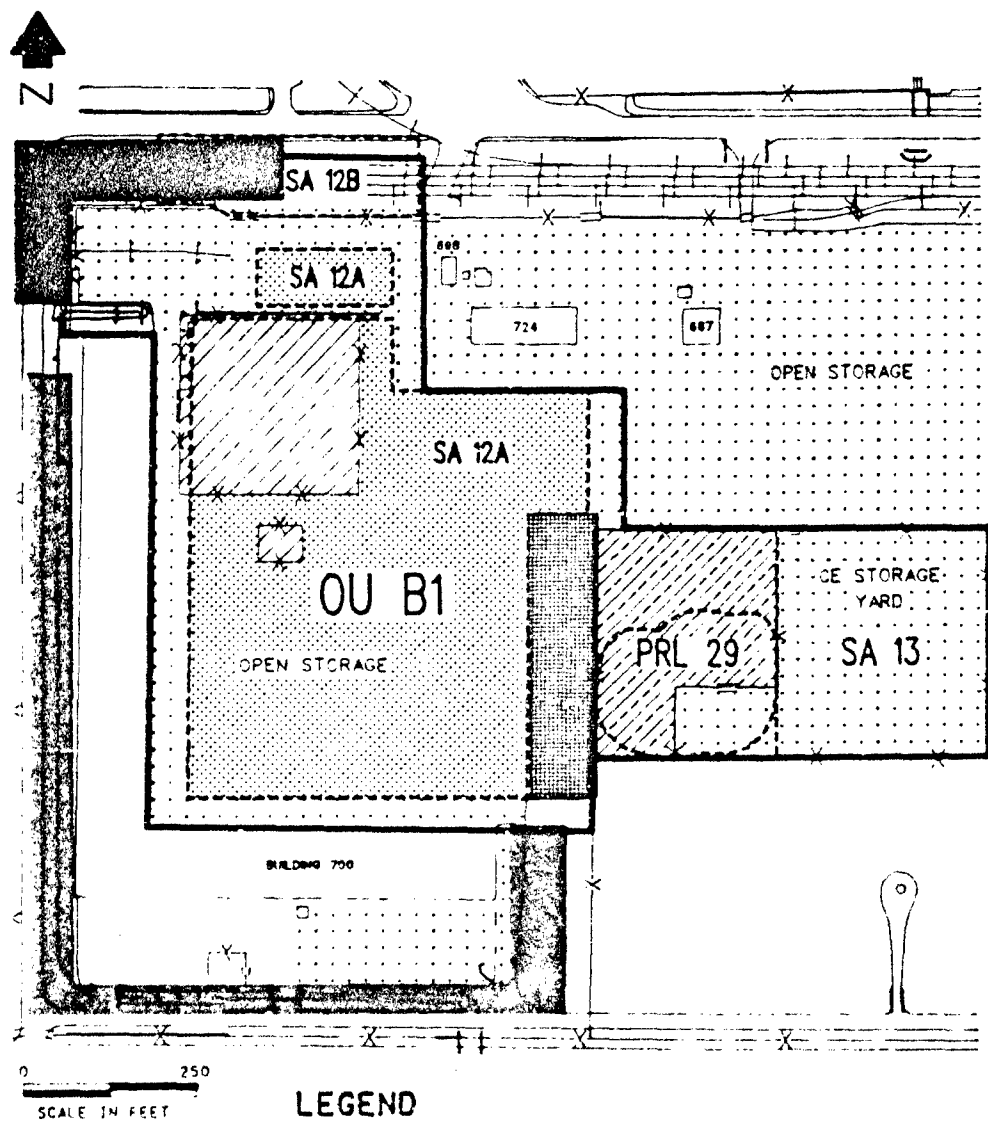


Figure S-1. Locations Within OU B1

The on-base areas surrounding OU B1 are industrial, warehouse, and aircraft operation areas (see Figure 2-3 in Section 2). Off-base, nearby land (within 500 feet) is zoned residential and light industrial.

The area of OU B1 is made up of relatively flat alluvial soils. Three ditches drain OU B1: two in the northwestern and one in the southern portions.

OU B1 Remedial Investigation

The RI of OU B1 included collecting soil and soil gas samples from 17 borings, 72 hand augers, and 1,745 surface scrapes (Overlay A). Soil samples were collected from the ground surface to approximately 100 feet below ground surface (BGS), 5 to 7 feet above the water table. Surface water samples were collected by McClellan AFB Environmental Management and the RWQCB in 1992. Sediment samples were collected during several sampling events since January 1989, most recently in April 1993.

Distribution of Contamination

For this RI/FS, the PCBs, dioxins and furans are considered the primary COCs: arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, selenium, silver, zinc, TCE, PCE, benzene, and 1,1-DCE are considered secondary COCs (see Table 2-5).

Surface Soils — Low-level (less than 10 milligrams per kilogram [mg/kg]) PCB contamination is widespread in OU B1 surface soils (less than 6 inches BGS) (Overlay B), probably as a result of the spraying of transformer oil to suppress dust. Concentrations of PCBs in the northwestern portion of OU B1 range as high as 240,000 mg/kg in the area where transformers were handled.

Dioxin and furan compounds have also been reported in surface soils (Overlay C). The contamination is widespread, and appears to generally correlate to the PCB contamination: as concentrations of PCBs increase, so do concentrations of dioxins and furans. To compare the concentrations among different isomers, reported results were converted to equivalent values (TCDDeq) of the most toxic form of dioxin (2,3,7,8-tetrachlorodibenzo-p-dioxin) by using International Toxic Equivalency Factors (I-TEF). The TCDDeq values are generally less than 1 microgram/kilogram ($\mu\text{g/kg}$), except in the areas of highest PCB concentrations.

Extractable petroleum hydrocarbons (TPH) and semivolatile organic compounds (SVOCs) were also reported in surface soils at OU B1. Contamination by these types of compounds appears to be caused by the oil spraying or by surface spills. Concentrations of less than 100 mg/kg TPH were reported over wide areas. In the areas of highest PCB concentrations, TPH concentrations ranged from 3,400 to 8,700 mg/kg. Semivolatile compounds commonly used as additives to oils were reported at concentrations generally less than 2 mg/kg. 1,2,4-Trichlorobenzene, which is used to thin PCB oils, was reported at 69 mg/kg in the area with the highest PCB concentrations.

Inorganic species in surface soils were reported above concentrations considered to be background concentrations in subsurface soils (McClellan AFB, 1993) throughout OU B1, probably as a result of surface spills or the spraying of oil. Overlays F through O show where arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, selenium, silver, and zinc were reported at concentrations greater than five times background.

Stream Sediments — In three sampling events, most recently in April 1993, sediment samples were collected from Magpie Creek and the bottom of drainage ditches that receive surface runoff from OU B1 (see Figure 2-7). Analytical results indicate that PCB-, dioxin-, pesticide-, and metal-contaminated soil has been transported in surface runoff from OU B1 into the drainage ditches.

Polychlorinated biphenyls (PCBs), dioxin/furan compounds, and metals were reported in sediments from all three ditches downstream from OU B1. Pesticide-contaminated soils were reported only in two samples from the ditch south of the DRMO storage yard.

The concentrations of PCBs reported in sediments decreased with distance from the DRMO storage yard, from 470 mg/kg in sediments in the yard to 4.2 mg/kg at the point where the runoff enters Magpie Creek. No PCB concentration was reported in Magpie Creek sediments.

Dioxin and furan compound concentrations ranged from 0.003 µg/kg to 0.037 µg/kg TCDDeq in the three drainages. No TCDDeq were reported in Magpie Creek sediments.

Inorganic species reported in ditch and creek sediments were compared to subsurface soil background concentrations because no surface or sediment background concentrations have been established. Arsenic (3.7 to 5.0 mg/kg), cadmium (0.74 to 11.0 mg/kg), lead (21 to 180 mg/kg), and zinc (70 to 330 mg/kg) were the most inorganic species frequently reported above subsurface soil background concentrations in drainage ditch sediments. Cadmium (3.6 mg/kg) and lead (11 mg/kg)

were reported above background in only one Magpie Creek sample.

Two sediment samples from Magpie Creek also had gross beta radiation (24 and 27 pc/g) slightly exceeding the background concentration. However, these radiation levels in sediments are unlikely to have originated from OU B1 because no drainage ditch sediments had reportable radionuclides above background levels.

Vadose Zone Contamination — The vadose, or unsaturated, zone at OU B1 extends from 6 inches to approximately 105 feet BGS, where the water table is encountered. Soil contamination in the vadose zone of OU B1 is limited:

- PCBs were reported to 6 feet BGS in the area where surface soil concentrations were the highest (Overlays P and Q). Most of the PCB contamination is restricted to the upper foot of soil.
- TPH concentrations from 1 to 3 feet BGS were generally less than 100 mg/kg. However, TPH was reported up to 8,700 mg/kg in surface soils and 300 mg/kg at 3 feet BGS. The vertical extent of TPH concentrations in the area of the 300 mg/kg result has not been determined.
- Very low concentrations (less than 10 µg/kg) of volatile organic compounds (VOCs) were reported in OU B1 soils in small, widely separated areas. This distribution suggests minor surface spills of VOCs.

In the soil gas, VOCs were reported in the central portion of OU B1 (Overlay S) at concentrations greater than 100,000 parts per

billion by volume (ppbv) halogenated VOCs (HVOCs) at 21 feet BGS. The HVOCs are not widely distributed, and decrease in concentration over short distances from the boring with the highest concentrations (B22). The HVOCs are primarily TCE, PCE, and cis-1,2-DCE. No HVOCs were reported between 30 and 80 feet BGS; however, HVOCs were reported at 11,600 ppbv in a sample collected at 80 feet BGS. The VOCs reported at 80 feet and deeper appear to be due to groundwater contamination (from other sources) that adsorbed to the soil as the water table declined. Volatile organic compounds in the soil gas are being addressed in a soil vapor extraction Engineering Evaluation/Cost Analysis (EE/CA) for McClellan AFB and only soil gas monitoring is recommended for OU B1.

Groundwater Contamination —

Although there are no monitoring wells in OU B1, and no groundwater samples were collected, analytical and flow direction data from nearby wells indicate that A-zone (the shallowest groundwater aquifer zone) monitoring wells both upgradient and downgradient of OU B1 contain TCE, cis-1,2-DCE, and chloroform. This suggests that the groundwater beneath OU B1 also contains these compounds. However, because these contaminants do not appear to originate in OU B1, they are not considered in this RI/FS report; groundwater contamination at McClellan AFB will be addressed in the Groundwater OU RI/FS.

Potential for Contaminant Transport

The migration of contaminants through different media — soil, soil gas, surface water — was evaluated to determine the potential that humans could be exposed to the COCs at OU B1. Modeling of the behavior of the

different COCs in surface and subsurface soils and soil gas indicated that:

- PCBs, dioxins/furans, and inorganic species would tend to adhere to surface soil particles. The particles have been carried in stormwater runoff; however, no PCBs were reported for Magpie Creek. The particles may also be moved by winds and equipment. The PCBs would only migrate approximately a few feet deeper into the soils in 30 years and, hence, would not reach the groundwater in that time. Some PCBs (approximately 0.24 grams per year) would volatilize into the air.
- The VOCs would migrate into the atmosphere. The VOCs below the surface will not reach groundwater in measurable concentrations in 30 years. The amount and rate depends on the individual contaminant and its initial concentration.

Health Risk Assessment

A Health Risk Assessment (HRA) was conducted to assess the potential health risks posed by the COCs at OU B1. Three current and one hypothetical scenarios were evaluated. Two post-remediation scenarios evaluated the effectiveness of remediation alternatives in reducing risks. The scenarios are:

- The Current Worker Scenario evaluated conditions as of December 1992. The forklift operators at the DRMO yard were judged to be the maximally exposed current receptors and were selected for evaluation in this scenario.
- The Visitor Scenario evaluated risks to adults who attend DRMO auctions.

- The Current Off-Site Residential Scenario evaluated exposures to the nearest current residents.
- The Hypothetical On-Site Residential Scenario evaluated the potential exposures to hypothetical residents living in the area of highest contamination if it were not remediated. It should be noted this scenario is not ever expected to occur.
- The Partial Cap Scenario evaluated future risks to workers if an asphalt cap were installed over areas where the PCB concentrations are greater than 10 mg/kg.
- The Full Cap Scenario evaluated future risks to workers if the entire area of OU B1 were capped.

Using average and reasonable maximum exposure cases, the HRA results indicate that excess cancer risks in the Current Off-Site Residential Scenario range between 1.3×10^{-5} and 1.2×10^{-4} . Calculated risks in the Current Worker Scenario range between 2.0×10^{-5} and 3.8×10^{-4} . Calculated risks in the Visitor Scenario are even lower: 2.7×10^{-6} .

Calculated risks in the Hypothetical On-Site Residential Scenario, if the area were not remediated and residences were built on it, are much higher: risks were calculated to be greater than 1.0, which, because these numbers are probabilities, is unrealistic. The risks in this scenario are due mostly to ingestion of homegrown produce. Dioxins and PCBs were the major contributors to risk in all scenarios.

The HRA also indicated that DRMO worker risks would be reduced by 90% by a partial cap, and 99% by a full cap.

The uncertainty analysis indicates that many of the individual parameters used to calculate risk contain health-conservative biases. When calculating risk, the use of multiple biased values causes additional bias in the final risk values (compounded bias). Therefore, it is likely that the calculated risk values in all scenarios are higher than the actual risks to the exposed populations.

An ecological risk assessment indicates that the area is highly disturbed and contains few significant biological resources that could be impacted by the contamination.

Remedial Action Objectives — The general objectives for the OU B1 remedial action are to:

- Protect human health by reducing the risk from the potential exposures identified in the human health evaluation;
- Protect environmental receptors;
- Restore contaminated media for present and future land use;
- Protect uncontaminated media.

Another goal of the remedial action is to keep DRMO operational. The DRMO is an integral part of the mission of McClellan AFB. Any significant disruption of DRMO's operations would adversely affect the ability of base personnel to carry out that mission.

Specific remediation goals included:

- Remediating soils and drainage ditch sediments to concentrations that either: are no greater than "background" concentrations; reduce excess cancer risk to receptors below 10^{-6} ; reduce non-carcinogenic Hazard Index below 1; reduce adverse impacts on ecologic receptors; or meet other U.S. EPA guidance standards (less than or equal to 10 mg/kg of PCB and 1 μ g/kg of PCB and 1 μ g/kg of TCDD equivalent).
- Containing soils that pose a long-term threat where treatment is not practicable;
- Prevent additional contaminant migration from OU B1 into Magpie Creek sediments and surface water; and
- Including potential for "dual track" remediation (i.e., perform an interim remedial action now and continue to evaluate options to further remediate contaminated soil in the future).

Remedial action objectives were not developed for contamination in the subsurface because: the contamination is not in an exposure pathway; migration of the contamination into exposure pathways would pose a much lower health risk than contaminants now in surface exposure pathways; and any remediation of surface soils will diminish future migration and decrease health risk potential in all pathways.

Applicable or Relevant and Appropriate Requirements — Depending upon the alternatives selected, the key ARARS that apply to OU B1 remediation efforts are:

- Toxics Substances Control Act (TSCA), which regulates the use, storage, treatment, and disposal of PCBs.
- California Code of Regulations, Title 22, which establishes standards for storage, treatment, and disposal of hazardous wastes. Because California has been authorized by the U.S. EPA to implement the Resource Conservation and Recovery Act (RCRA), these state requirements include all aspects of RCRA, as well as more stringent state requirements.
- OSWER Directive No. 9355.4-01, *Guidance on Remedial Actions for Superfund Sites with PCB Contamination*. (This document, a "To Be Considered" [TBC], carries less weight than an ARAR.) The guidance recommends that, for industrial sites, soils containing PCB concentrations exceeding 10 to 25 mg/kg, depending on Exposure Scenarios, generally require some type of remediation.
- California Code of Regulations Title 23, Division 3, Chapter 15, which regulates the discharge of waste to land.
- Sacramento Metropolitan Air Quality Management District regulations, which limit the discharge of hazardous constituents from excavations and place emission controls on treatment devices.

Estimated Volume of Soil — The areal extent of PCB soil contamination exceeding 10 mg/kg OU B1 plus the sediment in the drainage ditches is approximately 155,000 square feet (Overlay B). The volume of soil that contains contaminants in concentrations

above remediation goals is estimated to be about 12,650 cubic yards.

Screening of Technologies, Process Options, and Alternatives

General response actions to meet the above remedial action objectives were developed.

Within those response actions categories, various technologies and process options were identified and screened on the basis of the CERCLA criteria of effectiveness, implementability, and cost.

After this initial screening, candidate remedial technologies and process options were combined into a set of remedial action alternatives that are specific to remedial actions at OU B1. These alternatives were:

- No action;
- Capping;
- Excavation and off-site disposal;
- Excavation, off-site incineration, and disposal;
- Excavation, on-site treatment, and disposal;
- Capping and treatability studies with potential on-site treatment; and
- Excavation of the principal threat, off-site disposal, and capping.

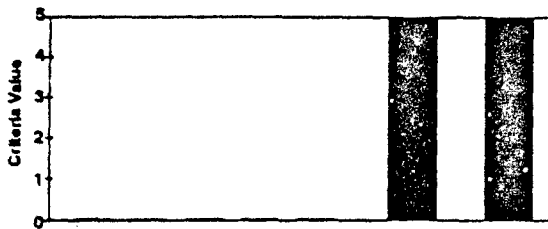
The screened alternatives then underwent a more detailed analysis applying the nine CERCLA criteria: protection of human health and the environment; compliance with

ARARs; long-term effectiveness; reduction in toxicity, mobility, and volume; short-term effectiveness; implementability; cost; regulatory agency acceptance; and community acceptance. The first seven are evaluated in this report. The last two will be applied in the final interim Record of Decision (ROD) for OU B1.

To evaluate the degree to which each alternative fulfills each evaluation criterion, a relative numerical rating system was developed (see Table 8-2). The sum of seven evaluation criteria values yields a completeness score for each alternative. All cost estimates were prepared for comparative purposes and were estimated to be accurate within -30% and +50%. An effectiveness-to-cost quotient was calculated for each alternative by adding the scores of the five effectiveness criteria (protectiveness of human health and the environment; compliance with ARARs; both long- and short-term effectiveness; and reduction in toxicity, mobility, and volume) and dividing by the alternative's cost in millions of dollars: the greater the quotient, the more cost-effective the alternative.

Results of this detailed analysis (Figure S-2) showed that the excavation, on- and off-site treatment, and disposal alternatives would all be very effective in reducing the toxicity, mobility, and volume of contaminants; however, the treatment costs are prohibitively high. The capping alternatives cost less, but do not eliminate the contaminants. Because installation of a full cap will reduce risks by 99%, there is no advantage to removing contaminated soils at this time. The alternative to cap OU B1 now to eliminate the immediate threat, and conduct treatability studies in the future, leaves the treatment option open, should a new treatment technology prove itself cost-effective for OU B1.

Alternative 1 - No Action (Score=10, Effectiveness/Cost=0)



Alternative 2 - Capping (Score=26, Effectiveness/Cost=9.0)

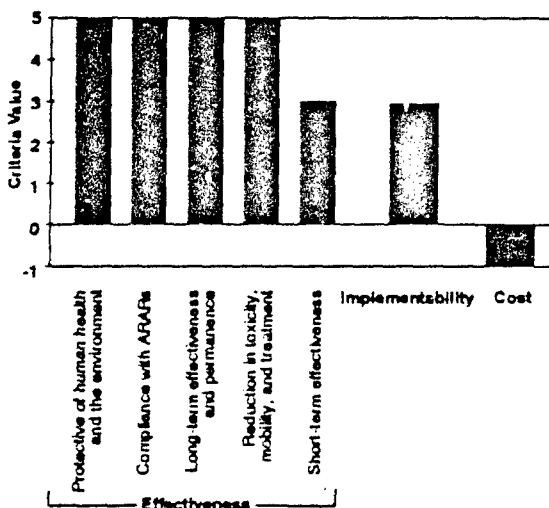


Alternative 3 - Excavation and Off-Site Disposal (Score=20, Effectiveness/Cost=2.3)



Alternative 4 - Excavation, Off-Site Incineration, and Disposal

(Score=25, Effectiveness/Cost=0.66)



KEY

Criteria values except cost

- 5 = Meets or exceeds definition/intent of criterion
- 3 = Conditionally meets definition/intent of criterion
- 0 = Does not meet the definition/intent of criterion

Cost criteria values

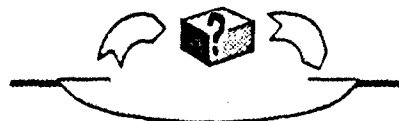
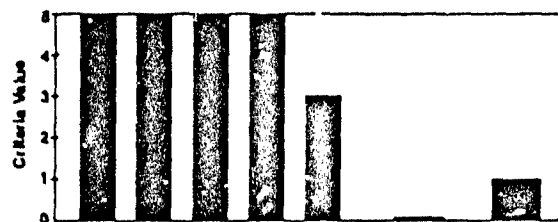
- 5 = <\$1.5 million
- 3 = \$1.5 to 5 million
- 1 = >\$5 to 20 million
- 1 = >\$20 million

Score = sum of 7 criteria values

Effectiveness/Cost = sum of 5 effectiveness values/cost in \$millions

Figure S-2. Comparative Analysis of Remedial Alternatives

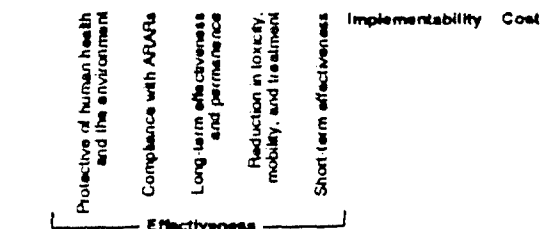
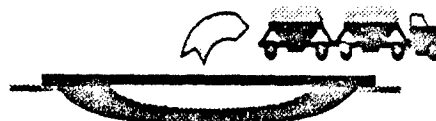
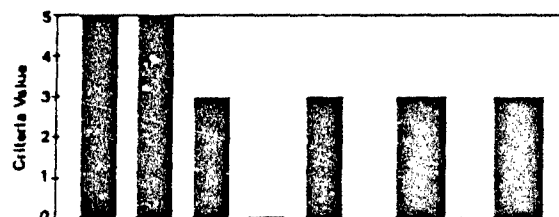
Alternative 5 - Excavation, On-Site Treatment, and Disposal (Score=24, Effectiveness/Cost=1.2)



Alternative 6 - Capping and Treatability Studies with Potential On-Site Treatment (Score=26, Effectiveness/Cost=6.9)



Alternative 7 - Excavation and Disposal of Principal Threat and Capping the Site (Score=22, Effectiveness/Cost=4.2)



KEY

Criteria values except cost

- 5 = Meets or exceeds definition/intent of criterion
- 3 = Conditionally meets definition/intent of criterion
- 0 = Does not meet the definition/intent of criterion

Cost criteria values

- 5 = <\$1.5 million
- 3 = \$1.5 to 5 million
- 1 = >\$5 to 20 million
- 1 = >\$20 million

Score = sum of 7 criteria values

Effectiveness/Cost = sum of 5 effectiveness values/cost in \$millions

Figure S-2. (Continued)

1.0 INTRODUCTION

An RI/FS has been conducted at OU B1 at McClellan AFB in Sacramento, California (Figure 1-1) under the U.S. Air Force Installation Restoration Program. The RI/FS documented here was performed in compliance with provisions of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA).

The area delineated as OU B1 consists of four previously identified sites, the area between them and the ditches that receive surface water runoff from the DRMO yard: Potential Release Location (PRL) 29, Study Area (SA) 12A, SA 12B, and SA 13 (Figure 1-2). Throughout this report these locations will be referred to collectively as OU B1.

1.1 Goals

The objective of the RI at OU B1 was to characterize the historical and current physical conditions and the distribution of chemicals of concern (COCs) in soils, sediments, and soil gas to the extent necessary for evaluating remedial alternatives. The primary objective of the FS was to identify and evaluate options for remediating PCB- and dioxin-contaminated soil at OU B1. Soil gas and groundwater contamination and the potential need for remediation of them will be addressed in the basewide Soil Gas EE/CA, Groundwater OU RI/FS, or OU B RI/FS/Record of Decision (ROD).

The U.S. EPA Superfund Accelerated Cleanup Model (SACM) goals have been incorporated into this RI/FS. These goals include the following:

- Performing early actions to reduce immediate risks to the public and the environment; and
- Committing to long-term cleanup to restore the environment and contaminated media.

1.2 How to Use This Report

In addition to the goals and objectives discussed above, another goal of this report is to concisely present the information pertaining to OU B1 using figures and tables wherever possible. Only information learned during the OU B1 RI is included in this report; previous reports and investigations are referenced to provide the reader with additional sources for background information.

At the back of this report is a map of OU B1 that can be unfolded and laid flat while the report binder is open. A series of overlays to the map, enclosed at the end of the report, show sampling locations and results for the OU B1 RI. This approach allows the reader to overlay any combination maps to look for trends, correlations, and to facilitate a better understanding of the nature and extent of contamination at OU B1.

This report is divided into two parts. Sections 2 through 4 present the results of the RI and Sections 5 through 8 present the FS.

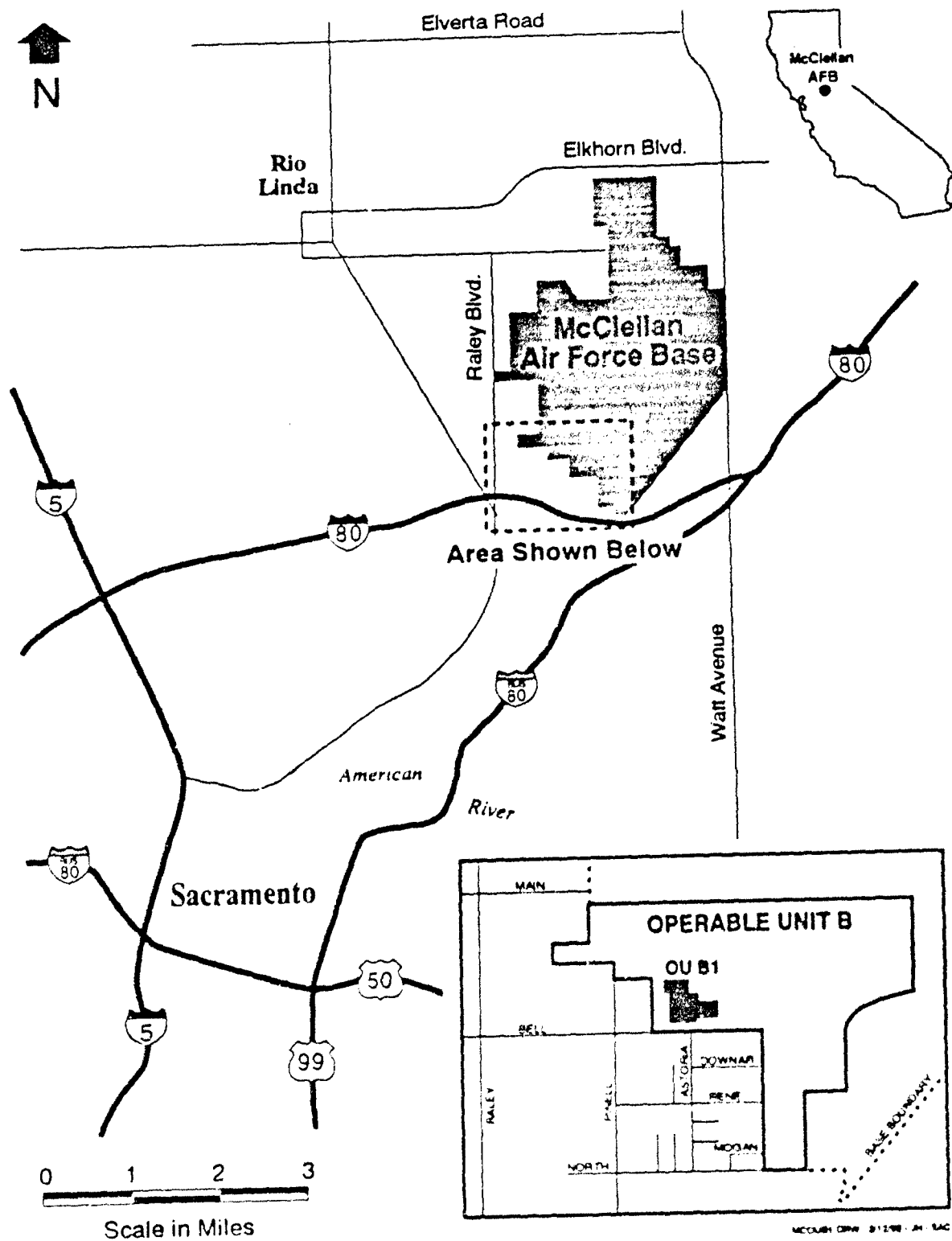


Figure 1-1. Location of Operable Unit B1 at McClellan Air Force Base

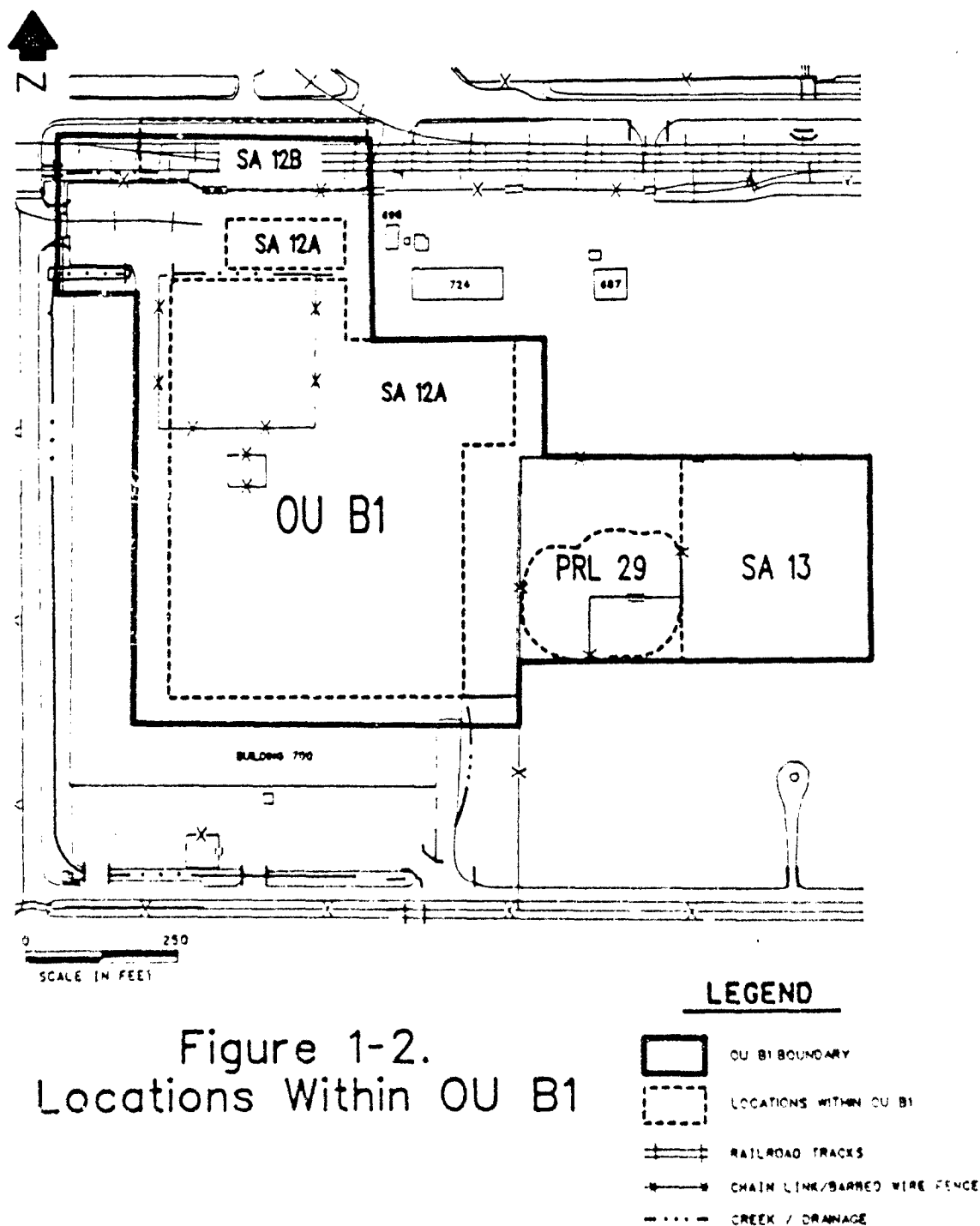


Figure 1-2.
Locations Within OU B1

2.0 SITE CHARACTERISTICS

A comprehensive RI was conducted at OU B1. The following sections describe the history, site characteristics, and results for OU B1.

Specific information regarding site history, conditions, previous studies, sampling procedures, and selection of sampling locations, are presented in the OU B Preliminary Assessment Summary Report (Radian, 1991c), the McClellan AFB Quality Assurance Project Plan (QAPP) (Radian, 1991b; Radian, 1992b), OU B RI SAP (Radian, 1991e), OU B Soil Gas Investigation (Radian, 1991a), and McClellan AFB Health and Safety Plan (Radian, 1991d).

2.1 History and Physical Characteristics

McClellan AFB comprises approximately 3,000 acres of land located 7 miles northeast of downtown Sacramento, California (see Figure 1-1).

2.1.1 Operable Unit B1

Operable Unit B1 is located in the southwest portion of McClellan AFB (see Figure 1-1). The OU consists of an open storage lot operated by the DRMO; a former transformer storage, loading, and unloading area; and the CE Storage Yard; and the drainage ditches that receive runoff from the DRMO storage lot (Figure 2-1). The OU is approximately 18 acres in size.

History

The area now known as OU B1 was open farm land and residences until about 1957. A chronologic history of the area is shown in Figure 2-2. Building 700, which

borders OU B1 on the south and west, was built in approximately 1962 (Figure 2-2A); the area northeast of the building (SA 12A) has been used as an open storage lot by the DRMO since the early 1960s. In the early 1960s waste oil was applied to OU B1 soils to suppress dust. The waste oil was collected from various facilities on base. The oil may have consisted of hydraulic oils, degreasing solvents, transformer oils, and automotive oils and fluids. Transformers were stored at the DRMO lot at various times from the 1960s through 1987.

In 1963, approximately 8 acres of perforated steel planking (PSP) was placed on the ground surface of the storage lot (Figure 2-2B) (Van Dyke, 1993). In the early 1970s, approximately 0.8 acres of solid aluminum planking was placed next to the PSP east of the storage lot. In 1987, 1.5 to 7 gallons of PCB-contaminated oil leaked from a transformer onto the ground in the northern portion of the DRMO storage lot. Contaminated soil in the area was excavated to approximately 10 inches, removed, and covered with clean gravel (Radian, 1991c). In 1992, after PCB contamination was reported in surface soil in the DRMO yard, a fence was constructed around the area containing at least 100 mg/kg of PCBs to restrict access, and solid metal planking was placed over the area to reduce fugitive dust emissions. In 1993, a 45-mil HDPE liner was placed over the area to control dust and to prevent runoff to a nearby drainage ditch. The fence and liner constitute a time-critical removal action to prevent worker exposure and transport of PCBs and dioxins in runoff (Figure 2-2D). Access to the DRMO yard was also restricted so that only adults may enter.

North of the storage lot along the railroad tracks, transformers containing oil

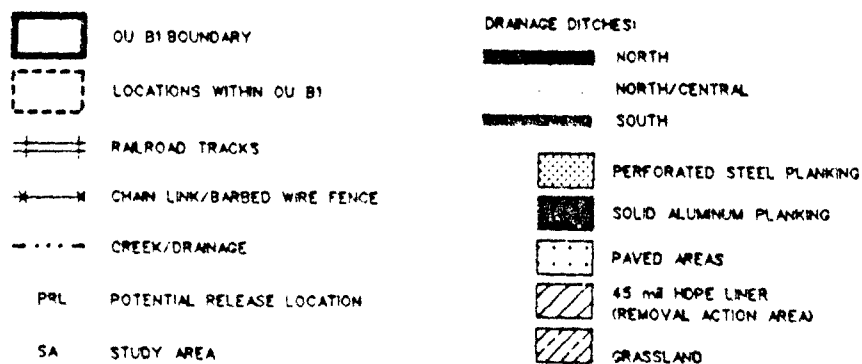
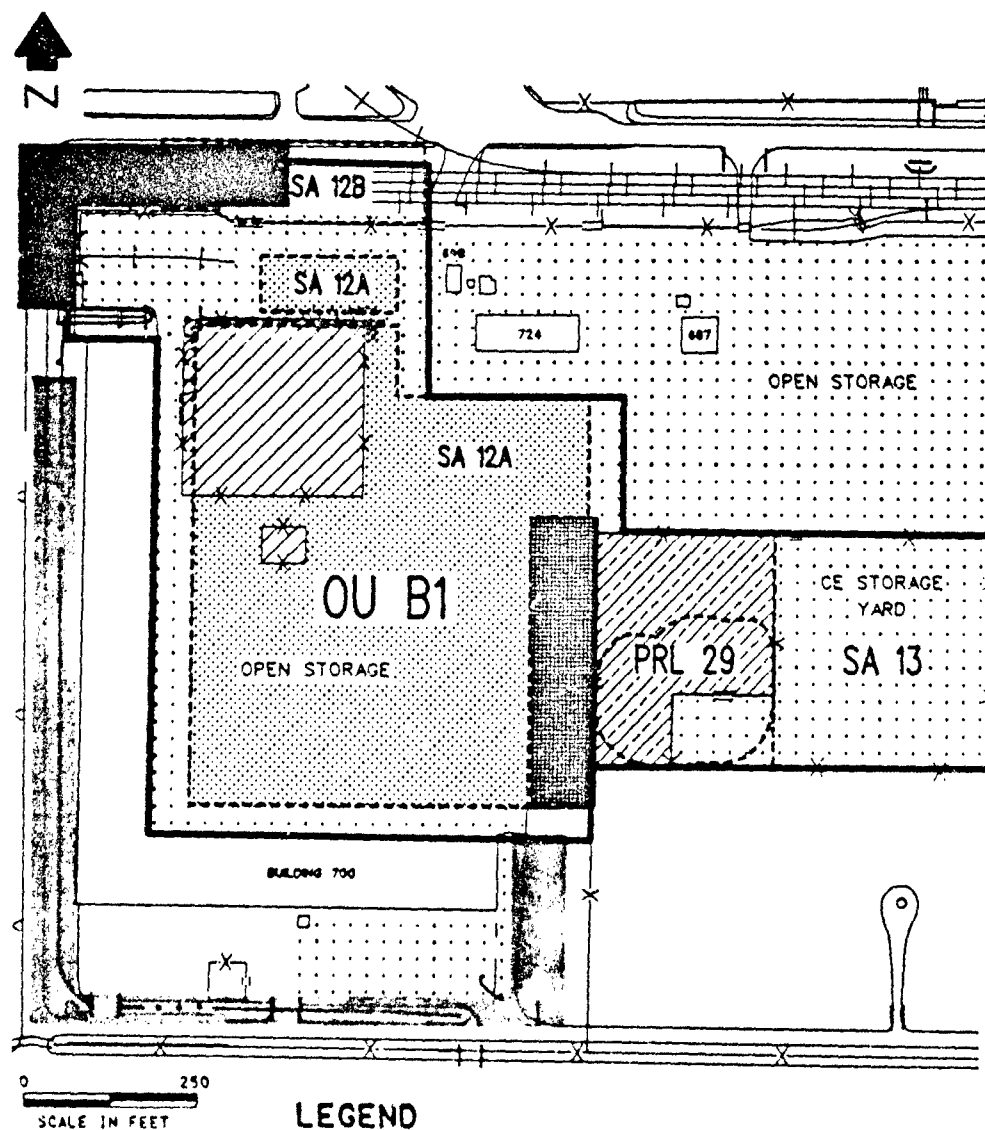


Figure 2-1. Locations Within OU B1

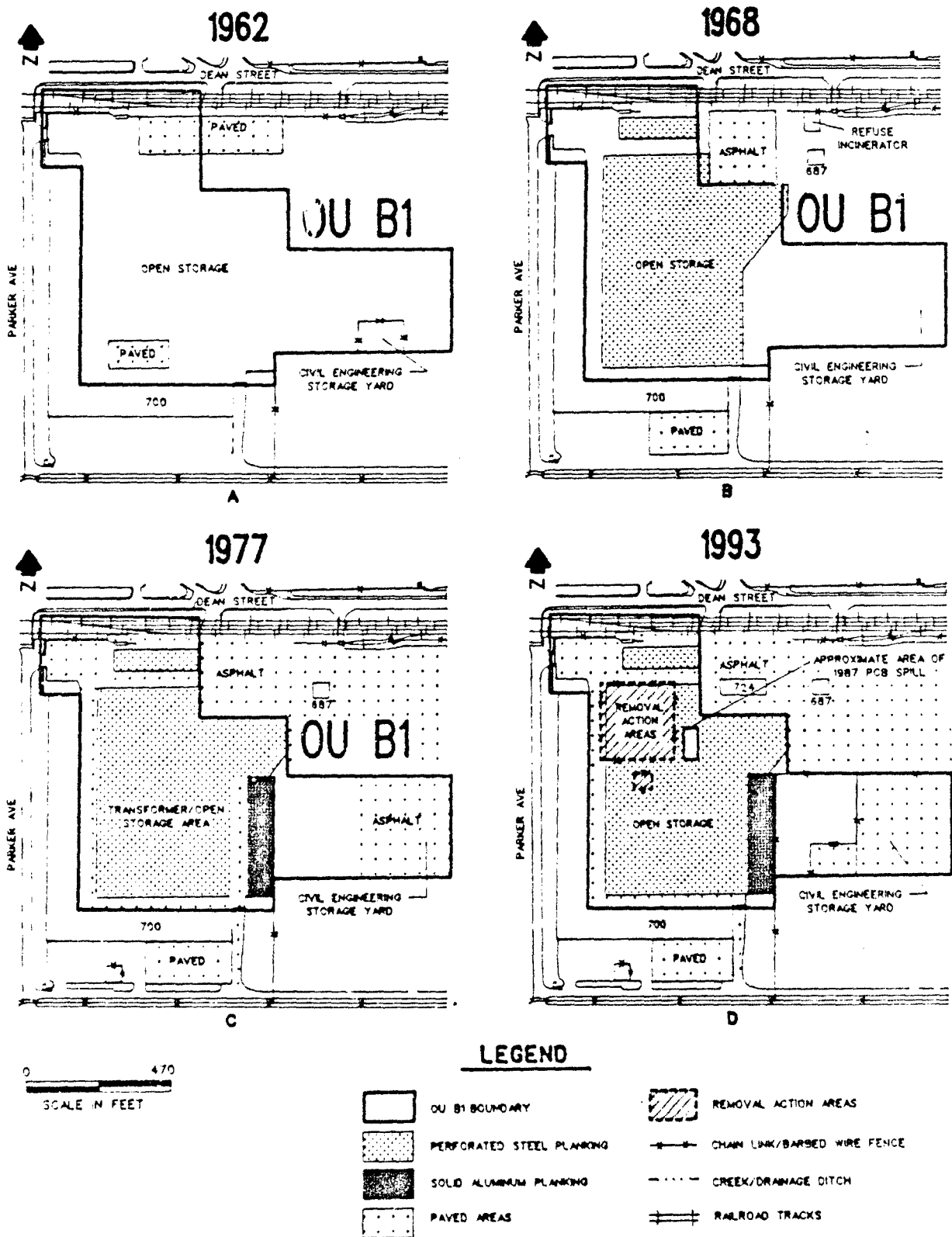


Figure 2-2. History of OU B1

with PCBs were loaded and unloaded from railroad cars (SA 12B). The CE storage yard (SA 13) has also been used since the 1960s. Most of the materials stored at the yard are nonhazardous; however, transformers containing PCBs were reportedly stored in the yard between 1960 and 1987. By 1977, the CE yard was paved with asphalt.

The area between the DRMO and CE storage yards (PRL 29) remains unpaved. This area reportedly was used as a transformer storage area.

Materials presently stored at OU B1 include nonhazardous material, such as appliances, office equipment, and miscellaneous parts. The DRMO storage yard is surrounded by a barbed wire fence, which restricts access.

Three open drainage ditches receive runoff from the DRMO storage lot and direct runoff toward the Maggie Creek channel. One carries runoff westward from the northernmost portion of OU B1 (northern ditch), adjacent to the railroad tracks. The second carries runoff from the north/central portion of the DRMO storage lot where the highest concentrations of PCBs were found (north/central ditch). This ditch was paved with asphalt in 1981; before that, it was unlined. The third ditch (unlined) collects rainwater from the southern portion of the DRMO storage yard, which contains low levels of PCBs (less than 10 mg/kg) (southern ditch). The three ditches only receive surface water runoff during the rainy season. During the summer months, the ditches are typically dry or contain small pools of water.

Lands Uses of Surrounding Area

The on-base areas surrounding OU B1 are industrial, warehouse, and aircraft opera-

tion areas (Figure 2-3). The off-base area surrounding OU B1 (within 500 feet) is residential, with some light industrial and commercial parcels. The nearest school is located on Bell Avenue, approximately 1,700 feet southwest of OU B1.

2.1.2 Physical Characteristics of OU B1

Operable Unit B1 consists of relatively flat, disturbed urban soils. The surface elevation is approximately 60 feet above mean sea level (msl). Forty-eight percent of the site is covered with PSP or aluminum planking. Thirty-seven percent is paved with asphalt. The remaining 15% is open grassland or exposed soil. Current features, including topography, surface drainage, rainfall, and wind directions, are shown on Figure 2-4.

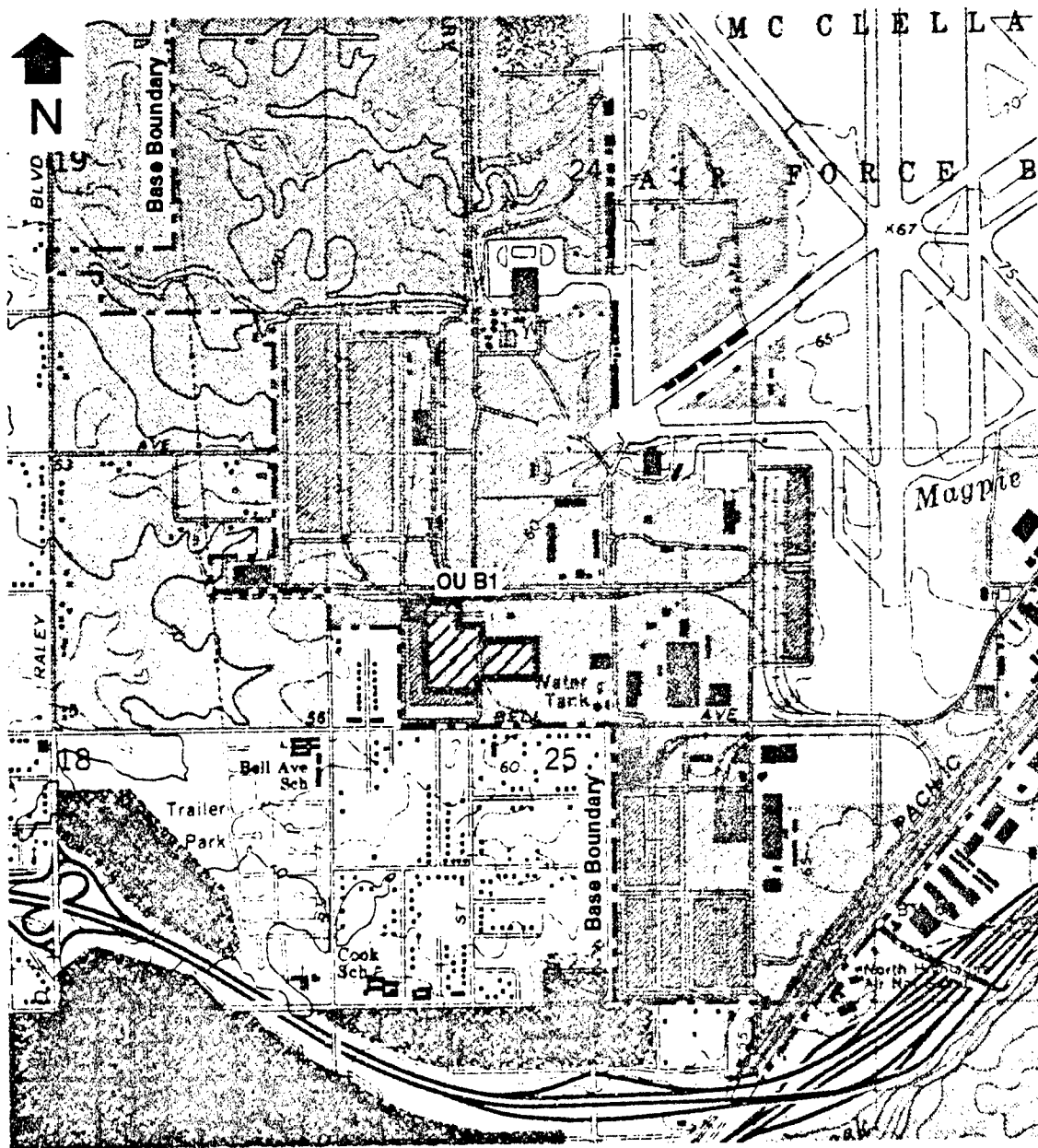
The water table beneath OU B1 is approximately 105 feet BGS, or -45 feet msl. Groundwater beneath OU B1 flows to the south/southeast toward a regional depression created by pumping from Base Well 18 and city and county municipal wells. Recharge of groundwater by surface water at McClellan AFB is limited due to the extensive paving and storm drainage system, and because of the relatively impermeable hardpan layers that are common in local soils.

2.2 Site Investigations

Several investigations have been conducted at OU B1: three previous studies and the OU B1 RI, which was conducted from November 1991 to November 1992.

2.2.1 Previous Studies

The three studies performed at OU B1 prior to the OU B RI mainly supported PCB



Source: McClellan AFB Comprehensive Plan, 1987,
and U.S.G.S. Quadrangle Topographic Map.
7.5 Minute Quadrangle Rio Linda

MC0U81 DRW - 3/12/82 JH - SAC

0 1000 2000
Scale in Feet

- | | | | |
|--|---|--|------------------------|
| | Aircraft Operations and Maintenance, Industrial | | Administrative |
| | Runways, Ramps, and Clear Zones | | Open Space |
| | Light Industrial | | Residential |
| | | | Community (commercial) |

Figure 2-3. Land Uses Surrounding OU B1



spill cleanup, construction, and pre-RI characterization. Tables 2-1, 2-2, and Figure 2-5 summarize the previous studies.

2.2.2 Remedial Investigation

The OU B1 RI had three primary objectives:

- Determine the presence or absence of PCB and other contaminants at OU B1;
- Determine if a source area exists and the extent of the source area so that remedial alternatives could be developed;
- Collect sufficient data to conduct a health risk assessment and evaluate engineering alternatives.

Approximately 3,098 soil and 32 soil gas samples were collected from 1,745 surface scrapes, 72 hand augers, and 17 borings during the OU B1 RI (Overlay A and Plate A). Table 2-4 lists the mean, minimum, and maximum concentrations of chemicals reported at OU B1. Appendix A contains maps showing all sampling locations, sample location numbers, and data tables listing contaminants reported at OU B1.

Based on their reported concentrations, toxicity, and frequency of detection, the 16 chemicals in Table 2-3 were identified as chemicals of concern (COCs) for OU B1.

The only PCB reported in OU B1 was Arochlor 1260. Therefore, in this report, the term "PCB" or "PCBs" refers to Arochlor 1260.

TABLE 2-3. CHEMICALS OF CONCERN
AT MCCLELLAN AFB OU B1

Arsenic
Benzene
Cadmium
Chromium
Copper
1,1-Dichloroethene (1,1-DCE)
Congeners of dioxin and furan compounds
Lead
Mercury
Molybdenum
The PCB Arochlor 1260
Selenium
Silver
Tetrachloroethene (PCE)
Trichloroethene (TCE)
Zinc

Quality Assurance/Quality Control (QA/QC) Summary

The OU B1 sample results produced by on-site laboratories (PCBs and VOCs) and off-site laboratories (other methods and confirmation analyses) were validated to determine whether they satisfied the criteria presented in the McClellan AFB RI/FS QAPP (Radian, 1991b; Radian, 1992b), and the Data Quality Objectives presented in the OU B RI SAP (Radian, 1991e). Standard procedures outlined in the QAPP were used to evaluate QC sample results reported for each method and assess data usability. Greater than 90% completeness was achieved for the aggregate dataset for OU B1.

Unqualified, screening level, and estimated results were used in the data assessment. Table 2-5 summarizes the data quality for each analytical method used on OU B1 samples. Appendix B contains a summary of the OU B1 QC data assessment, including sediment samples collected from the drainage ditches downstream from OU B1.

TABLE 2-1. PREVIOUS STUDIES AT OU BI

Year, Investigation	Objective	Scope of Investigation	Key Findings
1985, McLaren Environmental Engineering, Inc.	Determine the extent of contamination and verify the presence or absence of buried waste in the open grassy area between DRMO and the CE storage yard (PRL 29).	Seven borings were drilled and a ground penetrating radar survey was performed to determine the extent of soil disturbance.	Because no evidence of contamination or soil disturbance was reported, soil samples were not collected. Soil gas measurements were recorded from drill cuttings using a PID. All readings were less than 1 ppmv.
1987, McClellan AFB Environmental Management	Verify the cleanup of a PCB spill.	Thirteen borings were drilled and sampled to 10 feet BGS. Samples were analyzed for PCBs, VOCs, semivolatiles, and metals.	PCB concentrations were reported in 11 samples ranging from 0.2 to 12.9 mg/kg. Four different VOCs with concentrations ranging from 1 to 7 mg/kg and 20 different SVOCs ranging from not detected to 330 mg/kg were reported in 13 samples. Carbonaceous material was reported between 2 and 4 feet BGS in 8 of 13 borings.
1990, Radian Corporation	Locate areas of VOC contaminated soil gas to further define future RI activities.	Eleven soil gas probes were installed and sampled for halogenated and aromatic VOCs using a field gas chromatograph with ECD and FID detectors.	Total halogenated VOCs were less than 50 ppbv. Total aromatic VOCs were less than 300 ppbv. One probe (SA12D17) had blank contamination for aromatics.

TABLE 2-2. SUMMARY OF RESULTS FROM PREVIOUS STUDIES AT OU B1

Sample ID	PCBs (mg/kg)	Total SVOC (µg/kg)	Total HVOC (µg/kg)	Total AVOC (µg/kg)
Soil Samples				
EM2955	0.5	60.0	ND	1.0
EM2956	0.5	1,451	ND	2.0
EM2957	0.3	87.0	ND	14.0
EM2958	3.0	198	ND	11.0
EM2959	5.5	324	ND	5.0
EM2960	10.9	1,180	ND	4.0
EM2961	5.3	3,455	ND	6.0
EM2962	12.4	1,669	ND	12.0
EM2963	1.5	914	ND	5.0
EM2978	0.6	1,191	NS	39
EM2979	<0.1	57	NS	108
EM2980	0.2	247	NS	56
EM2981	<0.1	500	NS	68
Soil Gas Samples			(ppbv)	(ppbv)
SA12P10	NS	NS	8.5	NS
SA12P11	NS	NS	11.1	145
SA12P17	NS	NS	3.5	6,500 B
SA12P18	NS	NS	9.1	165
SA12P19	NS	NS	26.8	NS
SA12P25	NS	NS	7.0	298
SA12P26	NS	NS	5.9	NS
SA12P27	NS	NS	11.3	260
SA12P28	NS	NS	7.3	NS
SA12P29	NS	NS	5.8	NS
SA12P30	NS	NS	18.2	NS

PCB = PCB
 SVOC = Semivolatile Organic Compound
 HVOC = Halogenated Volatile Organic Compound
 AVOC = Aromatic Volatile Organic Compound
 mg/kg = Milligrams per kilogram
 µg/kg = Micrograms per kilogram
 ppbv = Parts per billion by volume
 B = Result suspect due to blank contamination
 ND = Not detected
 NS = Not sampled

Figure 2-5. Previous Sampling Location

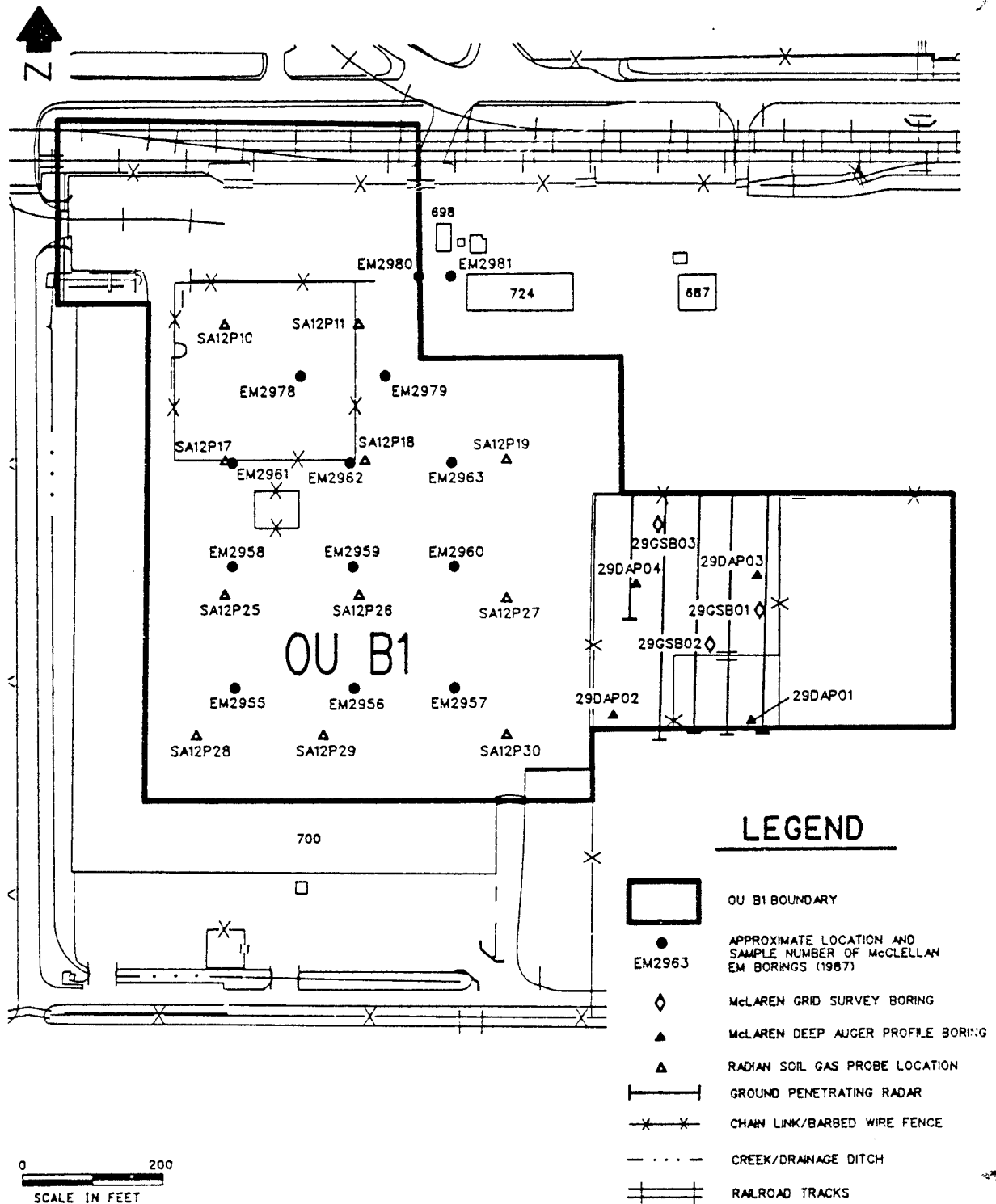


TABLE 2-4. AVERAGE, MINIMUM, AND MAXIMUM CONTAMINANT CONCENTRATIONS REPORTED AT OU B1*

Contaminant	Average Concentration	Minimum Concentration	Maximum Concentration	Units
SOIL				
Hydrocarbons TPH-E	374.8	12.0	8,700.0	mg/kg
PCB PCB-1260	649.6	0.017	240,000.0	mg/kg
Volatile Organic Compounds				
Benzene	0.0015	0.0021	0.0029	mg/kg
Methylene Chloride	0.0068	0.0068	0.0190	mg/kg
Tetrachloroethene	0.0014	0.016	0.0160	mg/kg
Toluene	0.0026	0.0052	0.0056	mg/kg
Trichloroethene	0.0014	0.0020	0.0120	mg/kg
Unknown	0.1886	0.1400	0.2600	mg/kg
cis-1,2-Dichloroethene	0.0011	0.0034	0.0035	mg/kg
m,p-Xylene	0.0015	0.0032	0.0042	mg/kg
o-Xylene	0.0014	0.0020	0.0026	mg/kg
SVOC				
1,2,4-Trichlorobenzene	1.3377	1.10	69.00	mg/kg
Benzo(a)anthracene	0.5410	0.68	0.68	mg/kg
Benzo(a)pyrene	0.5409	0.67	0.67	mg/kg
Benzo(b)fluoranthene	0.5851	2.00	2.50	mg/kg
Benzo(k)fluoranthene	0.5851	2.00	2.50	mg/kg
Bis(2-ethylhexyl)phthalate	1.0369	0.42	5.90	mg/kg
Butylbenzylphthalate	0.5872	0.74	3.20	mg/kg
Chrysene	0.5479	0.49	0.96	mg/kg
Dimethyl Phthalate	0.6041	1.20	1.20	mg/kg

(Continued)

TABLE 2-4. (Continued)

Contaminant	Average Concentration	Minimum Concentration	Maximum Concentration	Units
Fluorene	0.55	0.75	1.10	mg/kg
Pyrene	0.61	0.64	1.70	mg/kg
di-n-Butylphthalate	0.59	0.57	0.57	mg/kg
di-n-Octyl Phthalate	0.53	0.45	0.45	mg/kg
Dioxin/Furan				
TCDD	0.1710	0.6146	1.0000	µg/kg
TCDF	1.7532	0.0125	17.8000	µg/kg
1,2,3,4,6,7,8-HpCDD	0.2539	0.0650	1.9600	µg/kg
HpCDD	0.7320	0.0747	3.3800	µg/kg
1,2,3,4,6,7,8-HpCDF	0.2937	0.0261	4.1200	µg/kg
1,2,3,4,7,8,9-HpCDF	0.0957	0.0277	0.8020	µg/kg
HpCDF	1.1335	0.0306	7.8100	µg/kg
1,2,3,6,7,8-HxCDD	0.0740	0.0477	0.0477	µg/kg
1,2,3,7,8,9-HxCDD	0.0660	0.0306	0.0306	µg/kg
HxCDD	0.2929	0.0278	1.8000	µg/kg
1,2,3,4,7,8-HxCDF	0.3789	0.0422	7.8600	µg/kg
1,2,3,6,7,8-HxCDF	0.0860	0.0236	0.9750	µg/kg
1,2,3,7,8,9-HxCDF	0.0639	0.2800	0.4370	µg/kg
2,3,4,6,7,8-HxCDF	0.0974	0.0249	1.2000	µg/kg
HxCDF	1.9814	0.0363	20.9000	µg/kg
PeCDD	0.2218	0.0784	1.4500	µg/kg
1,2,3,7,8-PeCDF	0.0730	0.0203	0.6480	µg/kg
2,3,4,7,8-PeCDF	0.1796	0.0192	3.0000	µg/kg
PeCDF	2.2981	0.0327	19.1000	µg/kg
2,3,7,8-TCDD	0.1198	0.0146	1.0000	µg/kg
2,3,7,8-TCDF	0.2048	0.0125	3.8100	µg/kg
OCDD	1.9798	0.3200	10.9000	µg/kg
OCDF	0.7237	0.0777	6.2300	µg/kg

(Continued)

TABLE 2-4. (Continued)

Contaminant	Average Concentration	Minimum Concentration	Maximum Concentration	Units
Metals				
Aluminum	13,659.46	5,300.00	49,000.00	mg/kg
Antimony	5.59	3.00	40.00	mg/kg
Arsenic	5.47	1.40	47.00	mg/kg
Barium	174.52	53.00	1,700.00	mg/kg
Beryllium	0.27	0.11	0.79	mg/kg
Cadmium	8.63	6.40	49.00	mg/kg
Calcium	3,979.73	1,100.00	41,000.00	mg/kg
Chromium	90.16	13.00	590.00	mg/kg
Cobalt	10.54	5.40	41.00	mg/kg
Copper	51.74	6.90	410.00	mg/kg
Iron	23,881.08	7,400.00	97,000.00	mg/kg
Lead	347.63	3.30	2,500.00	mg/kg
Magnesium	4,615.00	810.00	23,000.00	mg/kg
Manganese	318.10	140.00	1,000.00	mg/kg
Mercury	0.52	0.04	7.50	mg/kg
Molybdenum	2.31	0.70	20.00	mg/kg
Nickel	39.73	7.80	160.00	mg/kg
Potassium	1,350.94	300.00	5,800.00	mg/kg
Selenium	5.55	0.45	52.00	mg/kg
Silver	4.79	0.80	74.00	mg/kg
Sodium	303.87	91.00	1,300.00	mg/kg
Thallium	4.46	3.90	34.00	mg/kg
Vanadium	45.86	26.00	180.00	mg/kg
Zinc	156.97	10.00	1,100.00	mg/kg
Other				
Total Cyanide	0.48	0.29	5.5	mg/kg
pH	7.1	6.5	8.0	pH units
Total organic carbon	9,375	6,900	16,000	mg/kg

(Continued)

TABLE 2-4. (Continued)

Contaminant	Average Concentration	Minimum Concentration	Maximum Concentration	Units
SOIL GAS				
1,1-Dichloroethene	1,410.3	50.0	9,100.0	ppbv
1,2,4-Trichlorobenzene	2.3	5.7	5.7	ppbv
1,2,4-Trimethylbenzene	18.6	1.9	53.0	ppbv
1,2-Dichlorobenzene	190.4	570.0	570.0	ppbv
1,3,5-Trimethylbenzene	6.1	17.0	17.0	ppbv
1,3-Dichlorobenzene	4.8	3.2	11.0	ppbv
1,4-Dichlorobenzene	28.8	85.0	85.0	ppbv
Tentatively Identified Hydrocarbons	N/A	100.0	670.0	ppbv
Acetone	19.7	9.3	38.0	ppbv
Benzene	6.2	2.4	36.0	ppbv
Carbon Tetrachloride	1,669.9	5.0	5.0	ppbv
Chlorobenzene	1.7	2.3	2.3	ppbv
Chloroform	276.9	2.1	2.1	ppbv
Cyclohexane	7.1	20.0	20.0	ppbv
Dichlorodifluoromethane	1.3	1.3	1.3	ppbv
Ethylbenzene	4.4	12.0	12.0	ppbv
Freon® 113	1,553.0	23.0	990.0	ppbv
Tetrachloroethene	1,047.9	1.3	30,000.0	ppbv
Toluene	9.0	3.3	51.0	ppbv
Trichloroethene	2,412.0	9.1	72,000.0	ppbv
Unknown	729.5	100.0	6,200.0	ppbv
cis-1,2-Dichloroethene	575.2	17.0	17,000.0	ppbv
m,p-Xylene	12.9	1.7	47.0	ppbv
n-Octane	12.1	35.0	35.0	ppbv
o-Xylene	9.0	19.0	20.0	ppbv
p-Xylene	7.4	19.0	20.0	ppbv
trans-1,2-Dichloroethene	5.6	22.0	22.0	ppbv

* Only usable data were included.

N/A = Not applicable.

NOTE: The entire OU B1 data set is summarized in this table (i.e., surface and subsurface soil results were combined).

TABLE 2-5. SUMMARY OF COMPLETENESS BY METHOD

Parameter	Method	Number of Samples	Number of Analytes	Total Number of Results	Estimated Results (%)	Unusable Results (%)	Unqualified Results (%)
HVOCs and AVOCs	SW8010/SW8020 (field)	42	11	462	6	0	94
Extractable TPH	SW8015-extractable	77	1	77	16	0	84
Volatile TPH	SW8015-volatile	13	5	65	0	0	100
Pesticide/PCB	SW8080	15	26	390	0	0	100
PCB	SW8080	597	7	4,179	2	1	97
Pesticides	SW8140	5	21	105	1	0	99
Herbicides	SW8150	5	10	50	72	0	28
VOCs	SW8240	13	35	455	1	0	99
SVOCs	SW8270	98	65	6,370	2	0	98
Dioxin/Furan	SW8280	70	11	770	0	0	100
Dioxins/Furans	SW8280*	5	25	125	0	0	100
Metals	SW6010	82	23	1,886	13	<1	86
Arsenic	SW7060	69	1	69	22	0	78
Cadmium	SW7130	14	1	14	0	0	100
Lead	SW7421	69	1	69	0	0	100
Mercury	SW7470/7471	69	1	69	0	0	100
Selenium	SW7740	69	1	69	22	0	78
Thallium	SW7841	60	1	60	8	0	92
Hexavalent Chromium	E218.6	14	1	14	0	0	100
Cyanide	SW9010/9012	69	1	69	0	0	100
Total Organic Carbon	SW9060/E410.1	8	1	8	0	0	100
Alkalinity	E310.1	4	4	16	0	0	100
Gross Alpha and Beta	SW9310	5	2	10	90	0	10
Gamma	E901.1	4	4	16	0	0	100
Soil Gas (GC/MS)	TO-14	3	52	2,704	0	0	100
PCB	Field PCB	1,827	7	12,789	1	0	99
HVOC and AVOC Soil Gas	Field Soil Gas	29	11-15*	380	19	10	71
Field Screen for VOCs	Field VOCs	136	11	1,496	2	0	98

* The analyte list was increased during the project.

* Total concentrations per isomer class and toxic isomer concentrations by Modified Method SW8280.

Total number of results = number of samples x number of analytes.

Data were qualified on the basis of results of the data review procedures, which included verification of chain-of-custody information at the time of sample transfer, holding times, verification of electronic data transfer, and review of analytical batch QC and field QC sample results for all samples. The QC sample results were then compared with the QA objectives established in the QAPP and used to determine whether the data could be used as intended. Exceptions or problems encountered with OU B1 data are described in Appendix B.

Data qualification flags were applied as follows: data were not qualified if all QC specifications were met, or the data were not influenced by slightly noncompliant QC results; estimated ("E") flags were assigned if QC samples showed noncompliant results that influenced analyte quantitation; data were flagged as unusable ("U") if multiple or critical QC checks were out of compliance, and neither analyte identification or quantitation could be verified. All data produced using Level II procedures were flagged with an "S" to indicate screening level results.

Overall precision and accuracy (average RPDs, spike recovery control limits, etc.) were not specifically calculated for the OU B1 data set because it is a subset of the larger OU B data set; the precision and accuracy for the OU B dataset are more representative of overall data quality, and indicate that the OU B data meet project specifications. This information is presented in the Operable Unit B Remedial Investigation Site Characterization Summary Report, Appendix B (Radian, October, 1992).

2.2.3 Extent of Contamination in Surface Soil

Surface soils (less than 6 inches BGS) in OU B1 are primarily altered or disturbed urban soils that do not contain natural soil horizons. Fill material (gravel, sand, and silt) covers the upper 6 to 8 inches of soil throughout most of OU B1.

Polychlorinated biphenyls (Arochlor 1260), dioxins, furans, petroleum hydrocarbons, SVOCs, and inorganic species were reported in OU B1 surface soils. Sampling locations are shown on Overlay A at the end of this report. The extent of surface contamination is primarily confined to unpaved areas, as shown by the distribution of PCB contamination at OU B1.

Widespread low-level (less than 10 milligrams per kilogram [mg/kg]) PCB contamination is present throughout the unpaved areas of OU B1 (Overlay B and Plate A). Waste oil, which contained transformer oil and PCBs, was reportedly applied to OU B1 soils to control dust during the 1960s. This probably accounts for the widespread low-level PCB contamination found at OU B1. The highest concentrations of PCBs (500 to 240,000 mg/kg) were reported in the northwest portion of the DRMO storage yard where transformers were unloaded and stored.

The extent of PCB contamination has not been fully defined in the northern part of the grassy area between the DRMO and CE storage yards (PRL 29). The extent will be determined prior to any remedial actions.

Low-level dioxin and furan contamination in surface soils is also widespread

throughout the unpaved areas at OU B1. There appears to be a relationship between PCB and dioxin/furan concentrations in soil: as concentrations of PCBs increase, so do concentrations of dioxin and furan congeners. Because several different dioxin and furan isomers were reported, the international toxic equivalency factor (I-TEF) method was applied (calculations provided in Appendix A) to convert the different isomers to the most toxic isomer, 2,3,7,8-TCDD. The 2,3,7,8-TCDD equivalents (TCDD_{eq}) (Overlay C) are less than 1 microgram per kilogram ($\mu\text{g}/\text{kg}$), except in the area of highest PCB contamination. Pentachlorodibenzodioxin (PeCDD) and pentachlorodibenzofuran (PeCDF) were found in four samples collected in the area of highest PCB contamination but could not be quantified due to PCB interference.

Petroleum hydrocarbon (motor oil and heavy hydrocarbons) contamination is widespread at concentrations less than 100 mg/kg in OU B1 (Overlay D). The widespread contamination is most likely due to the spraying of waste oil on the soils to control dust in the 1960s. Concentrations from 3,400 to 8,700 mg/kg were also reported in surface soils in the area of highest PCB contamination. This contamination was most likely discharged from transformer leaks or spills.

Semivolatile organic compound contamination coincides with the PCB and petroleum hydrocarbon contamination (Overlay E). 1,2,4-Trichlorobenzene (1,2,4-TCB) was reported up to 69 mg/kg in the area of highest PCB concentrations. This SVOC is commonly used to thin transformer oils and was most likely discharged through spills or leaks of transformer oils. Polynuclear aromatic compounds, found in waste oils or byproducts of combustion, were reported at concentrations less than 3 mg/kg.

Bis(2-ethylhexyl)phthalate was reported in most of the samples analyzed for semivolatiles. However, occurrences of this compound appear to be false positives, introduced to the sample through gloves and other plastics used in the field collection and laboratory analysis procedures. Therefore, phthalates are not considered to be chemicals of concern in soils at OU B1.

Ten inorganic species were reported above background concentrations for subsurface soils throughout OU B1. Overlays F through O show sampling locations where inorganics were reported at levels 5 times greater than the background concentrations for subsurface soils (McClellan AFB, 1993). Soil samples were not collected in the former CE storage yard (SA 13) because only low levels of PCBs were reported in surface scrapes, and metals contamination was not suspected.

The widespread distribution of cadmium, lead, selenium, and silver in surface soils suggests that inorganic constituents were not discharged in separate spills. This distribution may have been caused by the application of waste oils and/or by surface water transport of contaminated soil particles. Cadmium and selenium are common trace constituents in fuel hydrocarbons. Lead may accumulate in waste oils from engines using gasoline, and silver was commonly used as an engine bearing alloy (ATSDR, 1989-1990).

2.2.4 Extent of Contamination in the Vadose Zone

From the ground surface to the top of the water table (105 feet BGS), vadose zone deposits beneath OU B1 consist of interbedded sands, silt, and thin clay lenses. These sediments were deposited in a very complex fluvial environment of frequently shifting

streams on an alluvial plain that resulted in laterally and vertically discontinuous lithologic units. Iron-oxide cemented hardpan layers indicate periods of non-deposition. Silt layers have carbon coated root casts and organic debris from plant growth during periods of non-deposition. Carbonaceous material was reported in borings from 2 to 40 feet BGS. Some of the carbonaceous material has also been partially replaced by metals (e.g., iron or magnesium).

Soil

Soil samples were collected from 54 hand augers and 14 borings located throughout OU B1 (Overlay A). Based on these samples, soil contamination in the vadose zone at OU B1 is widespread laterally but limited in vertical extent.

The horizontal and vertical extent of PCB contamination is shown in overlays A, P, and Q. Most of the PCB contamination is concentrated within the upper foot of soil. The vertical extent of PCB-contaminated soils is estimated to be 6 feet BGS in the area of highest surface soil PCB concentrations, and from 1 to 2 feet in other areas of OU B1.

Petroleum hydrocarbons (motor oil and heavy hydrocarbons) were reported in soil samples from 1 to 4 feet BGS (Overlay R). The highest concentration (300 mg/kg) was reported in Hand Auger 54 and appears to have been discharged from a surface spill. The vertical extent of hydrocarbon contamination is not defined in Hand Augers 54 and 47, where concentrations of 300 mg/kg and 130 mg/kg, respectively, were reported in samples collected from the bottom of each hand auger (3 feet BGS). In other areas, petroleum hydrocarbon concentrations decrease to much lower values over short vertical distances.

Only two inorganic species were reported five times greater than background concentrations for subsurface soils (McClellan AFB, 1993). Selenium and/or silver were reported five times greater than background in borings 32, 33, 41, 42, 47 and 50. The maximum concentration of selenium was 22 mg/kg in B41 at 8.7 feet BGS. The maximum concentration of silver was 3.0 mg/kg in B50 at 10 feet BGS.

Low concentrations (100 µg/kg) of VOCs were reported in OU B1 soils. Distribution is limited to small non-continuous areas. This distribution of widely spaced low concentrations suggest that the VOCs were discharged from separate, minor surface spills. Low level contamination in B22 is present from 32 to 95 feet BGS. Concentrations of the VOCs generally increase toward the water table, indicating that the contamination may be residue from contaminated groundwater ("smear zone").

Soil Gas

Volatile organic compounds were reported in soil gas in the northern portion of OU B1 (Overlay S). The VOCs are not widely distributed. Concentrations are highest in B21 at 21 feet BGS: greater than 100,000 ppbv of HVOCs (TCE, PCE, cis-1,2-DCE) were reported at 21 feet BGS. Soil gas concentrations decrease with distance from B21 (Overlay S). Soil gas concentrations also decrease with depth. No HVOCs were reported in soil gas samples collected from 30 to 80 feet BGS in boring 22. However, HVOCs were reported at 11,600 ppbv at 81 feet BGS. The lack of HVOC soil gas contamination from 30 to 80 feet BGS suggests that there are two sources of soil gas contamination: small surface spills and residual groundwater contamination.

Cross section A-A' shows lithologies to 40 feet BGS through the north/central portion of OU B1, where the highest concentrations of PCBs and VOCs were reported (Figure 2-6 and Plate B). A discontinuous layer of clay is near the surface in Borings 21 and 22. Polychlorinated biphenyl contamination was reported only in samples collected from the upper 6 feet of soil (Overlay 2-6A). The highest concentrations coincide with the area of deepest PCB contamination. Soil gas contamination is limited in horizontal and vertical extent and is located in the eastern portion of OU B1 (Overlay 2-6A).

2.2.5 Extent of Contamination in Sediments and Surface Water

Stream Sediment

In three sampling events, the most recent of which occurred in April 1993, sediment samples were collected from Magpie Creek and the bottom of drainage ditches that receive runoff from OU B1 and analyzed for PCBs, dioxins, furans, semivolatiles, pesticides, herbicides, total petroleum hydrocarbons, radionuclides, and inorganic species (Figure 2-7 and Table 2-6). Analytical results indicate that PCB-, dioxin-, pesticide-, and metal- contaminated soil has been transported in surface runoff from OU B1 into these drainage ditches.

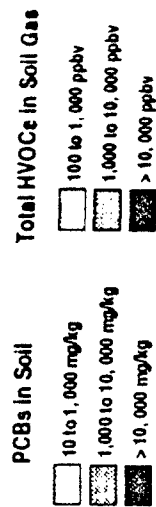
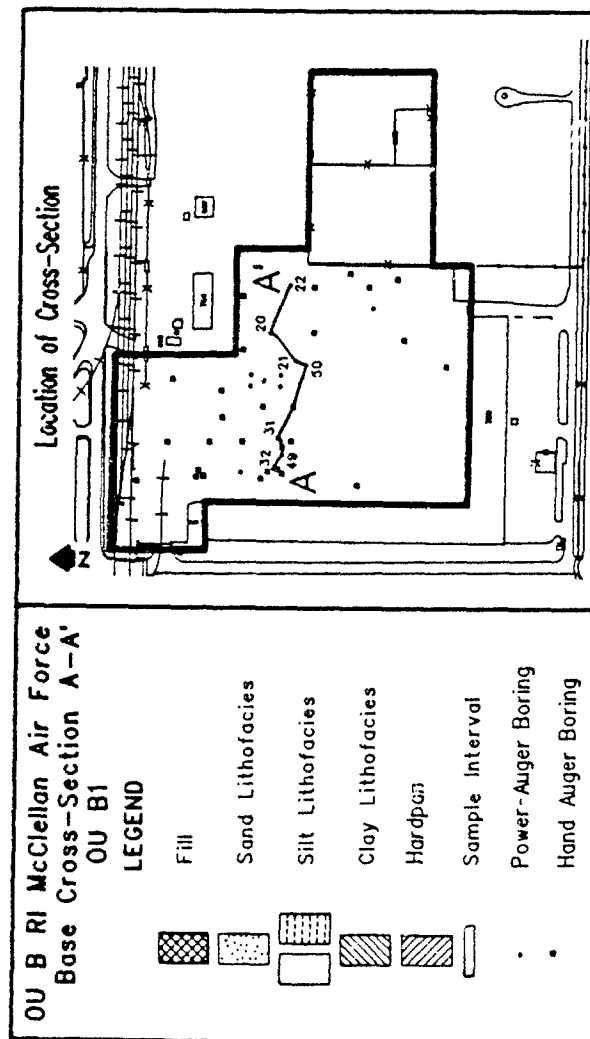
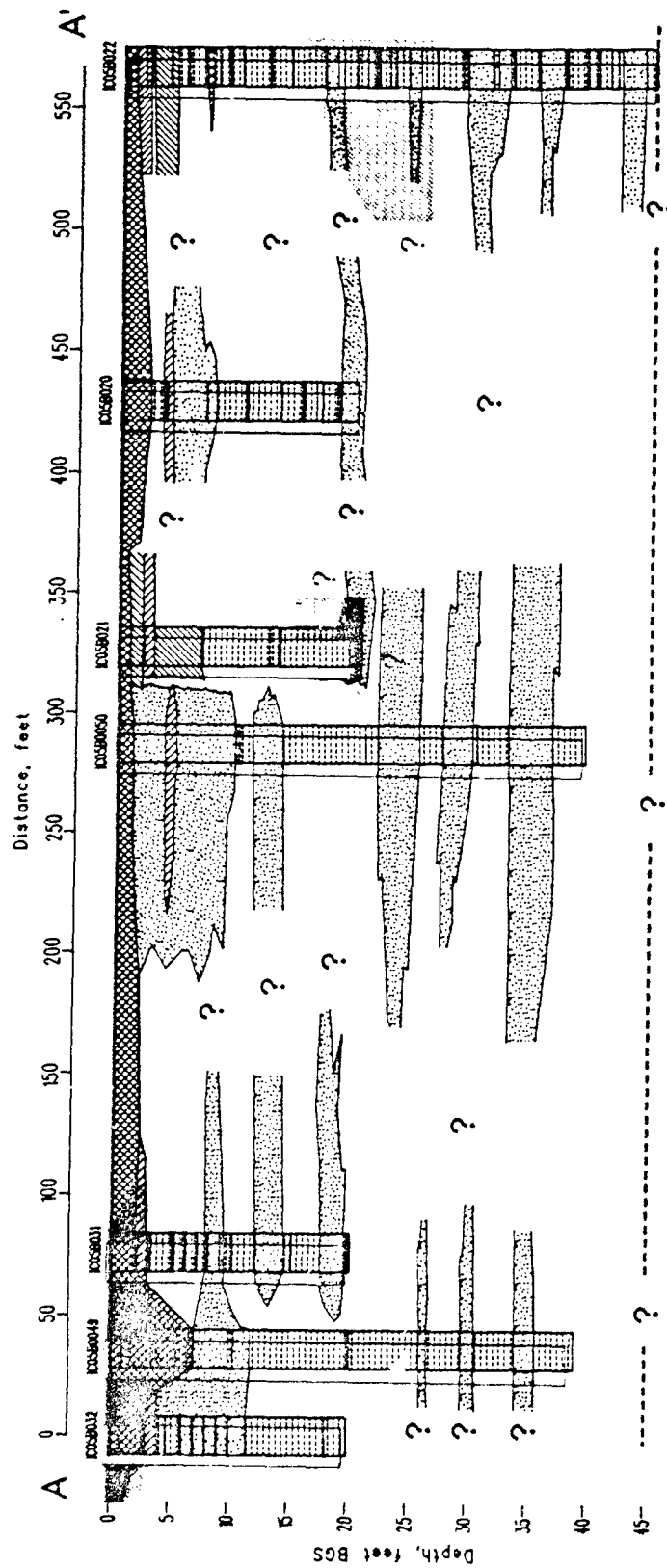
Polychlorinated biphenyls, dioxin/furan compounds, and inorganic species were reported in all three of the drainage ditches that receive runoff from OU B1 (Figure 2-7).

Northern Ditch — Three sediment samples collected in the northern ditch, adjacent to the railroad tracks, contained PCBs at concentrations from 2.4 to 19 mg/kg. PCB concentrations decrease with distance from the

DRMO yard. Location IC05H262, which was sampled and analyzed for dioxin and furans, had a TCDDeq concentration of 0.037 $\mu\text{g/kg}$. Arsenic, cadmium, lead, and zinc at concentrations exceeding background concentrations in subsurface soils were also detected at location IC05H262. Inorganic species concentrations were compared to background in subsurface soils because background concentrations for surface soils or sediments have not been established.

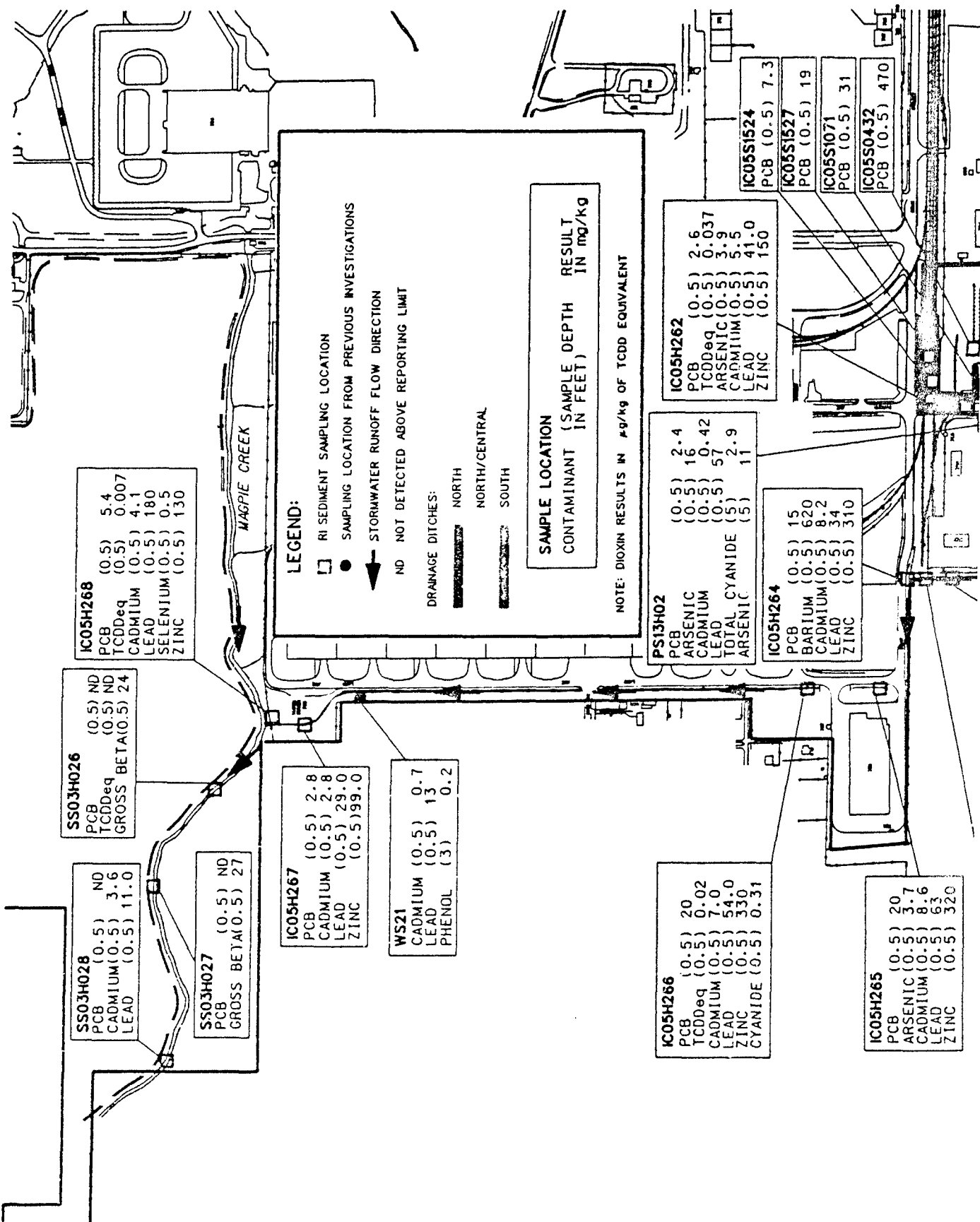
Southern Ditch — Five out of six sediment samples collected from the southern ditch contained PCB concentrations less than 1 mg/kg. PCBs were reported in one sample at 6.4 mg/kg (IC05S1749). Location IC05H260, which was sampled and analyzed for dioxin and furans, had a TCDDeq concentration of 0.0003 $\mu\text{g/kg}$. In sediments from locations IC05H260 and IC05H261, arsenic, cadmium, lead, and zinc concentrations exceeding subsurface background concentrations were reported along with the pesticides 4,4'-DDE and 4,4'-DDT. One of the sediment samples in this ditch also had a reportable concentration of the pesticide, 4,4'-DDD.

North/Central Ditch — Two sediment samples collected from the French drain in the north/central ditch at the DRMO yard contained PCB concentrations up to 470 mg/kg. Eleven samples were also collected in the ditch between the DRMO yard and Magpie Creek. PCB concentrations ranged from 2 to 18 mg/kg. Dioxin/furan concentrations ranged from 0.007 to 0.02 $\mu\text{g/kg}$ TCDDeq, generally decreasing with distance from the DRMO yard. The highest concentrations were reported where the Gunite[®] lining in the ditch ended. Cadmium, lead, and zinc were reported at concentrations greater than background for subsurface soils in all sediment samples between IC05H263 and IC05H268.



Overlay 2-6A. Contaminants at OU B1
in Cross Section

Figure 2-6. Cross-Section A-A'
of OU B1



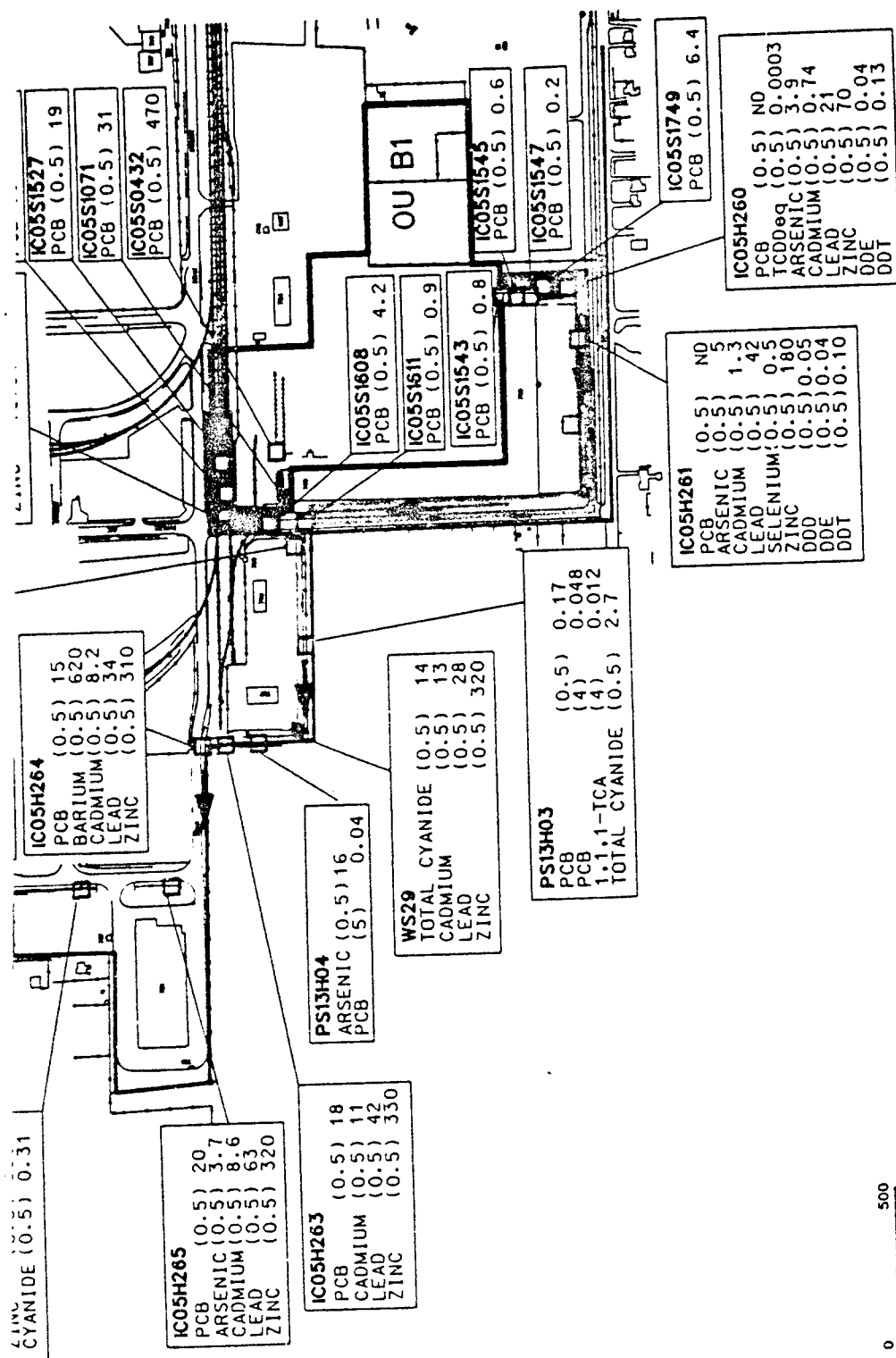


Figure 2-7. Sediment Sampling Locations at OU B1

TABLE 2-6. CONTAMINANTS REPORTED* IN DRAINAGE SEDIMENT SAMPLES COLLECTED APRIL 1993

Sample No.	Analyte Reported	Concentration	Units	Subsurface Background ^b
IC05H260	Arsenic	3.90	mg/kg	3.7-6.5
	Cadmium	0.74	mg/kg	0.4-0.4
	Lead	21.00	mg/kg	6.8-15.9
	Zinc	70.00	mg/kg	58.6-85.8
	4,4'-DDE ^c	0.045	mg/kg	0
	4,4'-DDT ^c	0.13	mg/kg	0
	TCDD equivalent	0.0003	µg/kg	0
IC05H261	Arsenic	5.00	mg/kg	3.7-6.5
	Cadmium	1.30	mg/kg	0.4-0.4
	Lead	42.00	mg/kg	6.8-15.9
	Selenium	0.50	mg/kg	0.5-0.5
	Zinc	180.00	mg/kg	58.6-85.8
	4,4'-DDD ^c	0.51	mg/kg	0
	4,4'-DDE ^c	0.39	mg/kg	0
IC05H262	4,4'-DDT ^c	0.10	mg/kg	0
	Arsenic	3.9	mg/kg	3.7-6.5
	Cadmium	5.5	mg/kg	0.4-0.4
	Lead	41.0	mg/kg	6.8-15.9
	Zinc	150.0	mg/kg	58.6-85.8
	PCB	2.6	mg/kg	0
	TCDD equivalent	0.037	µg/kg	0
IC05H263	Cadmium	11.00	mg/kg	0.4-0.4
	Lead	42.00	mg/kg	6.8-15.9
	Zinc	330.00	mg/kg	58.6-85.8
	PCB	18.00	mg/kg	0
IC05H264	Barium	620.00	mg/kg	413-342
	Cadmium	8.20	mg/kg	0.4-0.4
	Lead	34.00	mg/kg	6.8-15.91
	Zinc	310.00	mg/kg	58.6-85.8
	PCB	15.00	mg/kg	0

(Continued)

TABLE 2-6. CONTINUED

Sample No.	Analyte Reported	Concentration	Units	Subsurface Background ^b
IC05H265	Arsenic	3.70	mg/kg	3.7-6.5
	Cadmium	8.60	mg/kg	0.4-0.4
	Lead	63.0	mg/kg	6.8-15.9
	Zinc	320.00	mg/kg	58.6-85.8
	PCB	20.00	mg/kg	0
IC05H266	Cadmium	7.00	mg/kg	0.4-0.4
	Lead	54.00	mg/kg	6.8-15.9
	Zinc	330.00	mg/kg	58.6-85.8
	Cyanide Total	0.31	mg/kg	0
	PCB	20.00	mg/kg	0
	TCDD equivalent	0.02	µg/kg	0
IC05H267	Cadmium	2.80	mg/kg	0.4-0.4
	Lead	29.00	mg/kg	6.8-15.9
	Zinc	99.00	mg/kg	0
	PCB	2.80	mg/kg	0
IC05H268	Cadmium	4.10	mg/kg	0.4-0.4
	Lead	180.00	mg/kg	6.8-15.9
	Selenium	0.53	mg/kg	0.5-0.5
	Zinc	130.00	mg/kg	58.6-85.5
	PCB	5.4	mg/kg	0
	TCDD equivalent	0.007	mg/kg	0
SS03H026	Gross beta	24.00	pc/g	20.4-21.6
SS03H027	Gross beta	27.00	pc/g	20.4-21.6
SS03H028	Cadmium	3.60	mg/kg	0.4-0.4
	Lead	11.00	mg/kg	6.8-15.9

^aInorganic analytes are listed only if reported concentration exceeded background concentration for subsurface soils; background concentrations for surface soils and sediments have not been established.

^bSubsurface background concentrations may differ with principal lithology; concentrations for sand lithologies are listed on the left, for silt or clay on the right.

^cPesticide compounds: DDD = 1,1-dichloro-2,2-bis(p-chlorophenyl)ethane;

DDE = dichloro-diphenyl-dichloroethene; and

DDT = dichloro-diphenyl-trichloroethane.

(Figure 2-7). Arsenic, selenium, and barium exceeding the subsurface soil background concentration were reported in one sediment sample each. Total cyanide was detected above the reporting limit in one sample.

Magpie Creek — Three sediment samples (SS03H026 through SS03H028) were collected in the creek channel between the entry point of the north/central ditch to the creek and the base boundary (Figure 2-7). Analytical results for the three samples were quite different; however, no PCB or TCDD equivalent dioxins were reported in any of the sample. Cadmium and lead concentrations exceeded subsurface background in one samples; and gross beta radiation slightly exceeded its background level in two samples. Because gross beta concentrations were not reported in any sediment samples from the north, south, and north/central ditches, OU B1 is unlikely to be the source of the beta radiation in the two sediments samples.

Polychlorinated biphenyl concentrations decrease by two orders of magnitude from the DRMO yard (470 mg/kg) to where the ditches empty into Magpie Creek (4.2 mg/kg).

Surface Water

Surface water grab samples were also collected from the drainage ditches during three storm events between October and December 1992 by Environmental Management (10/29/92 and 12/9/92) and the RWQCB (12/21/92) before the HDPE liner was placed over the soils. Samples were collected from five locations originating at OU B1 and ending where the drainage ditch empties into Magpie Creek (Figure 2-8). Not every location was sampled in each storm event. Locations where samples were not collected in a particular

event are designated as not sampled (NS) in the figure. If no contaminants were detected above reporting limits, they are designated as not detected (ND). Based on the data collected for the three storm events (in some cases with just one sampling location), the following conclusions can be made:

- Surface water runoff from the southern part of OU B1 is not contaminated with PCBs, dioxins, or furans (sample location EM-3);
- Surface water runoff from the north/central portion of OU B1, which includes the area of highest PCB concentrations, contains the highest concentrations of PCBs (190 µg/L) and dioxins (829 pg/L TCDDeq) in the runoff (sample location EM-5).
- Surface water collected from 500 feet downstream of OU B1 contained PCBs (83 µg/L) and dioxins (535 pg/L TCDDeq) at about half the concentrations reported at the DRMO storage lot (sample location EM-4).
- Polychlorinated biphenyls were not reported in surface water collected where the drainage ditch flows into Magpie Creek. Dioxins (0.45 pg/L TCDDeq) were reported. However, dioxins were reported at the detection limit (sample location EM-8).

It is possible that in other storm events sample results may be different and could result in different conclusions. However, because the PCBs and dioxins are carried with stream sediment and the sediments have been sampled, sufficient data are available to determine if the drainage ditches are contaminated.

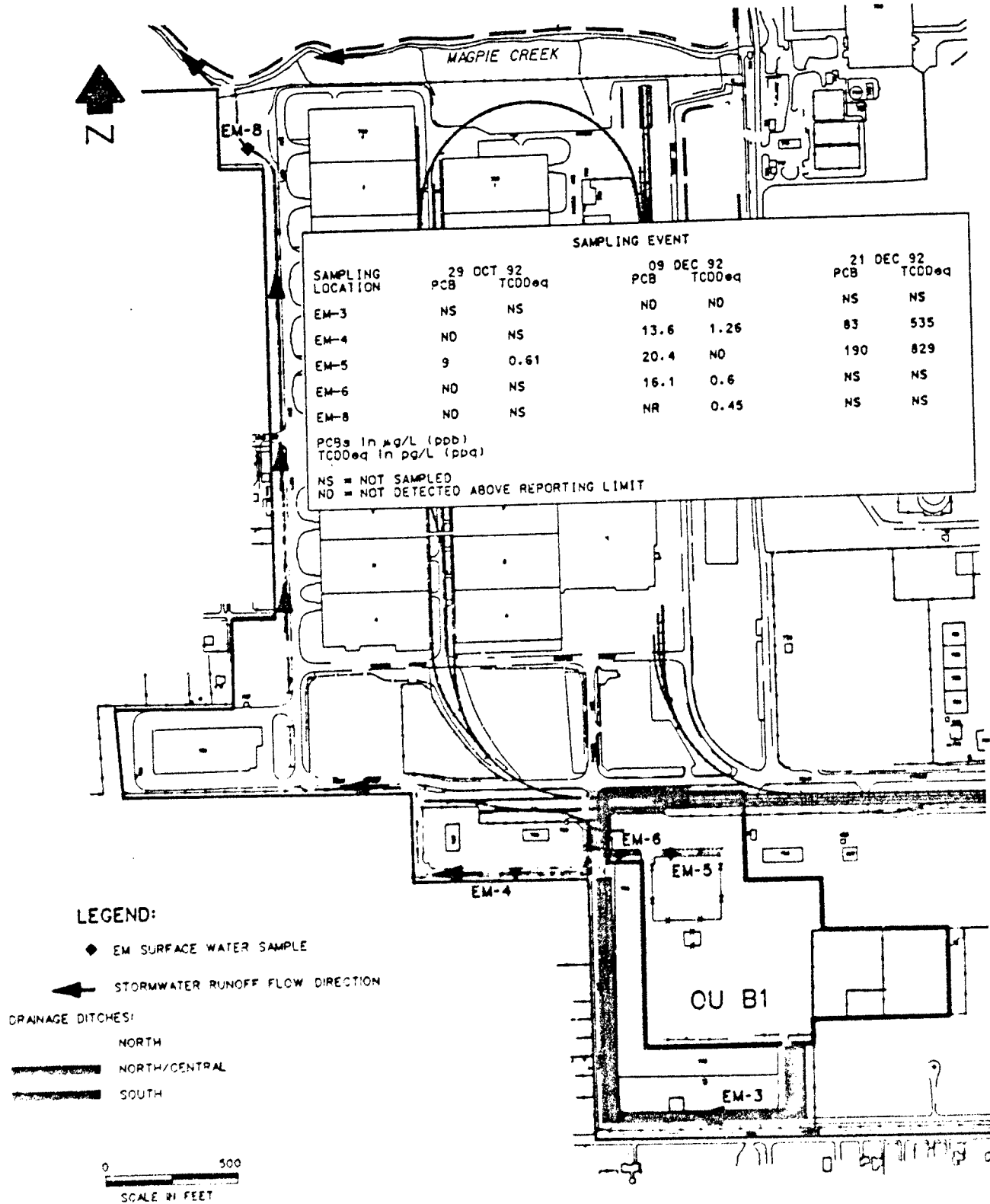


Figure 2-8. Surface Water Sampling Locations in OU B1 and Drainage Ditches

2.2.6 Extent of Contamination in Groundwater

The water table is currently at 105 feet BGS. Historically, the water table was shallower. In the 1960s (when storage activities began in OU B1) the water table was at 55 feet BGS. The water table has declined approximately 1.5 feet per year.

Groundwater samples have not been collected for PCB, dioxin, or furan analysis in monitoring wells downgradient of OU B1. However, it is unlikely that the groundwater is contaminated with PCBs, dioxins or furans because the vertical extent of contamination determined by soil sampling is 6 feet BGS in OU B1, and these compounds are not likely to migrate to groundwater (current or historic depth) (see Section 3.0). Therefore, OU B1 does not appear to be a current source of groundwater contamination.

Analytical results from monitoring wells to the north (upgradient) and south (downgradient) of OU B1 indicate that VOCs are present in the groundwater beneath OU B1 (Figure 2-9) (Radian, 1992c). However, results from previous groundwater investigations indicate that the sources of HVOC groundwater contamination are upgradient of OU B1, possibly in the northern part of OU B or in OU C.

Well/ Bar	Date Sampled	ICE mean/ range	Chloroform mean/ range	1,1-DCE mean/ range	1,1-DCA mean/ range
MW-1	2/89- 4/92	29/ 19-47	2/ 0.9-3.4	16/ 13-19	
MW-115	10/89- 4/92	19/ 8.1-30	0.9/ 0.3-1.6	0.6/ 0.1-2.5	
MW-145	3/89- 3/91	2/ 1.3-2.9			
MW-155	2/90- 4/92	31/ 18-48	2/ 0.7-3.9	18/ 18-19	0.7/ 0.2-1.3
MW-164	4/89- 3/91	15/ 12-25	2/ 0.9-2.1		2/ 1.4-3.9
MW-214	2/90- 4/92	9/ 6.6-15	0.7/ 0.1-2.3		9/ 3.9-15
IC02B012	5/92	7.1	1.1	3.2	19
IC02B042	2/92	9.1	2.3		21
IC02B058	5/92	29	2.3		16
IC02B059	3/92	6	2	5.2	15
IC02B060	4/92	19	2.5	8.3	8.9
					0.4

LEGEND

— OU B1 BOUNDARY

(27) CONTAMINANT CONCENTRATION IN $\mu\text{g/L}$

--- 44 --- WATER LEVEL CONTOURS (FEET MSL)

--- 10 --- VOC CONCENTRATIONS IN $\mu\text{g/L}$

• MONITORING WELLS AND
PIEZOMETERS

■ HYDROPUNCH® LOCATION

NOTE: WATER LEVELS SHOWN WHERE MEASURED;
CONTAMINANT DATA REFLECTS MOST RECENT
SAMPLING EVENT FOR THE WELL

WATER LEVEL DATA COLLECTED
SEPTEMBER 30, OCTOBER 1 AND 2, 1992

GROUNDWATER SAMPLES WERE NOT COLLECTED
FROM THE PIEZOMETERS (PZ)

HYDROPUNCH® SAMPLES COLLECTED ONLY ONCE EACH

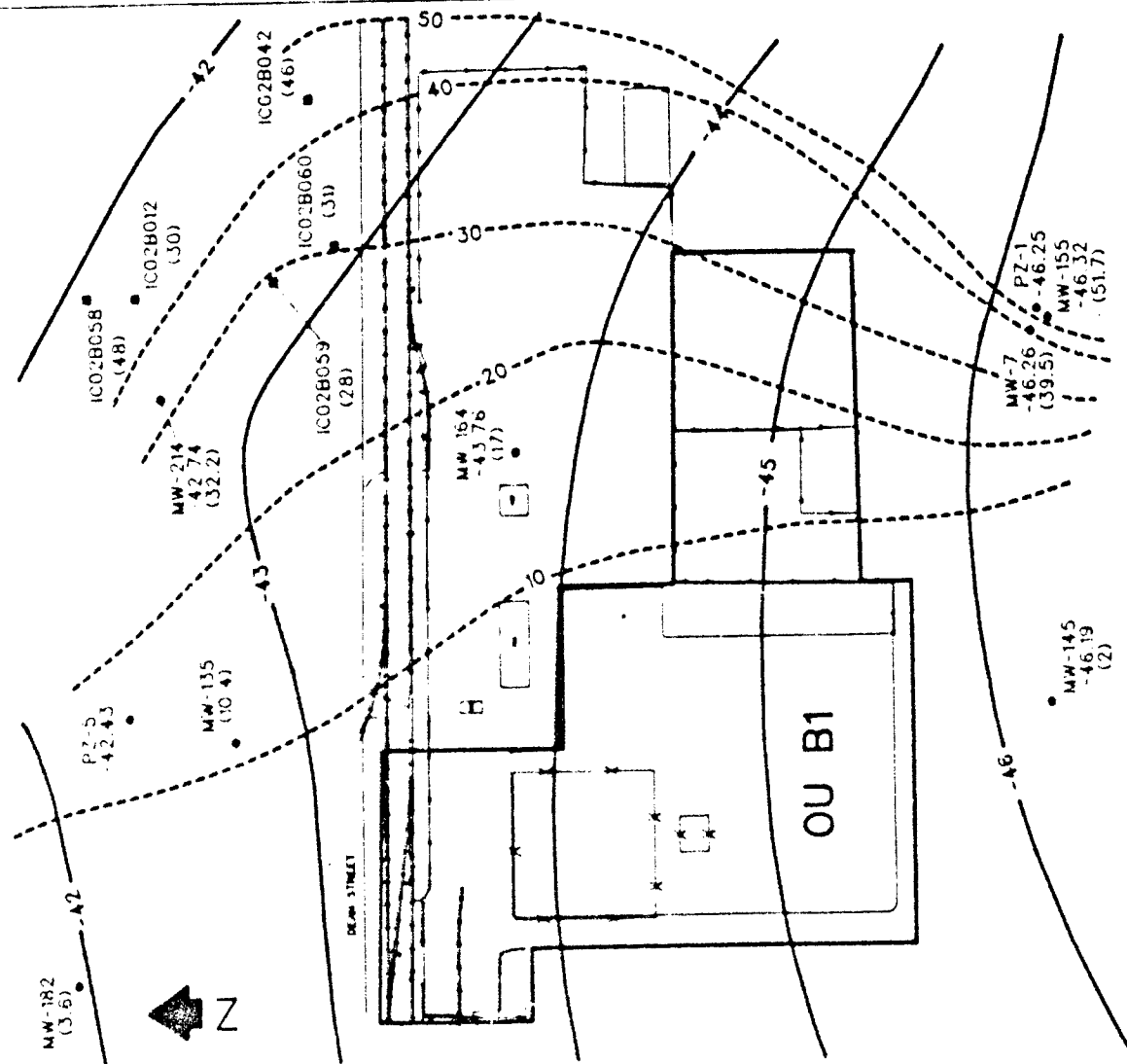


Figure 2-9. Isopleths of Total VOC Concentrations and Water Level Contours in the Zone at OU B1

3.0 EVALUATION OF CONTAMINANT TRANSPORT

Potential transport pathways that may carry contaminants from OU B1 to human or ecologic receptors are the surface air, surface water, groundwater, and soil gas. However, analytical data, site conditions, and model calculations indicate that only the surface water and surface air pathways are complete. PCBs, several dioxin and furan compounds, and inorganic species have been reported in surface water or sediment samples. Vapor from PCB and VOCs and soil particulates carrying contaminants reported in OU B1 are likely to be present in the surface air, although no ambient air samples were analyzed. Neither the soil gas nor groundwater pathways are likely to be complete within the next 30 years, if current site conditions are maintained.

3.1 Contaminant Properties

The potential for transport of contaminants in the environment is largely determined by the chemical and physical properties of the COCs.

The properties of the most frequently detected or most toxic COCs in OU B1 that affect their ability to be transported (mobility) in a pathway are listed in Table 3-1.

Vapor pressure indicates the potential for the COCs to enter the vapor phase from the liquid phase in soils and to be transported in soil gas. Because of higher vapor pressures at 25 degrees Centigrade (C), VOCs, have greater potential to enter the vapor phase than PCBs or dioxin and furan compounds. Of the inorganic species, only metallic mercury, if present in soils, would have a measurable vapor pressure at 25 C.

Aqueous solubility indicates the maximum concentration (in $\mu\text{g/kg}$ of water) that the organic compounds or inorganic species can attain at 25 C. Surface or groundwater in contact with liquid, solid, or vapor phases of any of the contaminants listed in Table 3-1 can dissolve the contaminant up to this limit at this temperature. Solubility limits for inorganic constituents are presented as broad ranges because the compounds in which they occur have not been identified, and the aqueous solubility of each inorganic species is dependent on the specific compound or organic complex it has formed in the soil.

The solid phase partitioning coefficients, K_{oc} and K_d , in Table 3-1 are indicators of contaminant properties that decrease the mobility of contaminants in liquids. Inorganic species may be adsorbed to organic material or inorganic minerals grains (clays or iron oxides) in soils. Adsorption to soil grains can hold contaminants in soils even though surface or groundwater that has not reached the solubility limit is moving through the soils. Solid phase partitioning retards the movement of contaminants in the liquid phase. However, if the soil grains are transported by water or wind, the adsorbed contaminants will also be transported.

Henry's Law Constants (H) are indicators of the behavior of the organic contaminants when their vapor phases are in contact with water in the soil. Higher values of H indicate which contaminants are more likely to partition to the vapor phase after being dissolved in water. The H values are most indicative of exchanges between a VOC vapor phase in soil gas and subsurface water.

The relative persistence of the COCs in the environment is indicated in the last column of Table 3-1. Of the COCs in OU B1,

TABLE 3-1. MAXIMUM CONCENTRATIONS AND PHYSICAL AND CHEMICAL PROPERTIES (AT 25 C)
OF CONTAMINANTS OF CONCERN IN OU B1*

	Maximum Concentration Reported in Soil or Soil Gas ($\mu\text{g/kg}$)	Vapor Pressure (mm Hg)	Aqueous Solubility ($\mu\text{g/kg}$)	Solid Phase Partitioning Coefficients K_{oc} or K_d (L/Kg)	Henry's Law Constant ($\frac{\mu\text{g/L in gas}}{\mu\text{g/L in water}}$)	Relative Persistence
ORGANIC COMPOUNDS						
PCB Arochlor 1260	2.4×10^4	4.1×10^{-3}	27	$6 \times 10^5 - 1 \times 10^6$	0.013	P
Dioxin Congeners						
TCDD	1.0	7.4×10^{-10}	1.9×10^{-2}	1.6×10^5 b	7×10^{-4}	
PCDD	1.45	$< 7.4 \times 10^{-10}$	---	---	$< 7 \times 10^{-4}$	
HxCDD	1.8	$< 7.4 \times 10^{-10}$	4×10^{-3} c	$> 1.6 \times 10^5$	$< 7 \times 10^{-4}$	
HpCDD	3.38	$< 7.4 \times 10^{-10}$	2.4×10^{-3} c	$> 1.6 \times 10^5$	$< 7 \times 10^{-4}$	
OCDD	10.9	$< 7.4 \times 10^{-10}$	4×10^{-4} c	$> 1.6 \times 10^5$	$< 7 \times 10^{-5}$	P
TCDF	17.8	5.4×10^{-8} d	4.2×10^{-1} c	$3.5 \times 10^4 - 4 \times 10^6$	2.3×10^{-3}	
PCDF	19.1	$< 5.4 \times 10^{-8}$	---	$> 3.5 \times 10^4 - 4 \times 10^6$	$< 2.3 \times 10^{-3}$	
HxCDF	20.9	$< 5.4 \times 10^{-8}$	8.2×10^{-3} c	$> 3.5 \times 10^4 - 4 \times 10^6$	$< 2.3 \times 10^{-3}$	
HpCDF	7.8	$< 5.4 \times 10^{-8}$	1.4×10^{-3} c	$> 3.5 \times 10^4 - 4 \times 10^6$	$< 2.3 \times 10^{-3}$	
OCDF	6.23	$< 5.4 \times 10^{-8}$	1.2×10^{-3} c	$> 3.5 \times 10^4 - 4 \times 10^6$	$< 2.3 \times 10^{-3}$	P
1,1-DCE	9,100 ppbv	600	2.25×10^6	65	1.42	
Benzene	37 ppbv	95.2	1.8×10^6	83	0.23	
TCE	72,000 ppbv	57.9	1.1×10^6	126	0.38	
cis-1,2-DCE	17,000 ppbv	208	3.5×10^6	72.4	0.32	
PCE	30,000 ppbv	17.9	1.5×10^5	364	1.25	

(Continued)

TABLE 3-1. (Continued)

	Maximum Concentration Reported in Soil or Soil Gas ($\mu\text{g/kg}$)	Vapor Pressure (mm Hg)	Aqueous Solubility ($\mu\text{g/kg}$)	Solid Phase Partitioning Coefficients K_{oc} or K_d (L/Kg)	Henry's Law Constant ($\frac{\mu\text{g/L in gas}}{\mu\text{g/L in water}}$)	Relative Persistence
INORGANIC SPECIES						
Arsenic Species	47,000	N/A	$0 - 302 \times 10^7$ ^f	Strongly sorbed. ^{fa}	N/A	
Cadmium Species	49,000	N/A	$0 - 1.4 \times 10^9$ ^f	Sorbed to organic material; forms mobile aqueous complexes. ^{fa}	N/A	P
Chromium Species	590,000	N/A	$\text{Cr}^{+6} 40 - 238 \times 10^7$ ^f $\text{Cr}^{+3} 0 - 120 \times 10^7$ ^f	Cr VI reduced to Cr III by Fe II and organic material; Cr III sorbed/complexed by organic material. ^{g,h}	N/A	P
Mercury Species	7,500	2.3×10^{-3} ^f (Hg metal)	$0 - 2 \times 10^3$ ^f	Strongly sorbed to organic material. ^{fa}	N/A	P
Lead Species	2,500,000	N/A	$0 - 4.2 \times 10^4$ ^f	Strongly sorbed to organic material. ^{fa}	N/A	P
Selenium Species	52,000	N/A	$0 - 1.1 \times 10^9$ ^f	$5.9 - 14.9$ ^f	N/A	P
Silver Species	74,000	N/A		$10 - 100$ ^f	N/A	P

^a Values from Hazardous Substances Data Bank (1992) or U.S. EPA (1986) unless otherwise noted.

^b Value estimated from $\log K_{oc} = 0.544 \log K_{ow} + 1.377$ (Kanaga and Goring, 1980).

^c Values from Friesen, Vilka, and Muir (1990).

^d Value estimated from Henry's Law constant and aqueous solubility.

^e Value estimated from $\log K_{oc} = 0.72 \log K_{ow} + 0.49$

(Schwarzenbach and Westall, 1981).

^f From Toxicological Profiles (ATSDR, 1989a, 1989b, 1989c, 1989d, 1990, 1991).

^g From Palmer and Wittbrodt (1991).

^h No K value found.

K_{oc} = Organic Carbon/Water Partition Coefficient

K_d = Soil/Water Partition Coefficient

L/kg = Liters per kilogram.

mm/Hg = Millimeters of mercury.

N/A = Not available or not applicable.

P = Compound or inorganic species will persist longer than other COCs of the same type.

$\mu\text{g/kg}$ = Micrograms per kilogram.

$\mu\text{g/L}$ = Micrograms per liter.

the PCB, dioxin, and furan compounds having the largest number of chlorine or fluorine atoms in their structure (e.g., PCBs, OCDD, or OCDF) are the most persistent. The VOCs will degrade naturally in less time than PCB. All inorganic species are persistent because they are not transformed or mineralized, in spite of changes in their physical or chemical state.

3.2 Mechanisms of Transport

The principal mechanisms that may affect the movement of contaminants in OU B1 are shown schematically in Figure 3-1. Table 3-2 summarizes the COCs affected by each mechanism, properties that may limit mobility, pathways potentially impacted by the mechanism, pathways known to be impacted by each mechanism under current conditions in OU B1.

Site conditions and the distribution of COCs in OU B1 indicate the transport mechanisms that may be active and the transport pathways that may be complete. The site conditions and COC distributions that indicate complete pathways are described in the following discussions of surface, subsurface, and groundwater transport.

3.3 Potential for Surface Transport

Two surface transport pathways, air and water, have been impacted by COCs from OU B1. Approximately 27% of the soil surface area has remained uncovered since COCs were discharged (including the perforations in the PSP); therefore, transport pathways are complete for the COCs on surface and near-surface soils.

Surface soil analytical results indicate that PCBs, arsenic, cadmium, chromium, lead, mercury, selenium, and silver are widespread

and present in greater concentrations than other COCs. Dioxin and furan congeners are widespread in surface soils, but are present at one one-thousandth to one one-billionth of the concentration of other COCs. Volatile organic compound concentrations were only reported in subsurface soils; however, they potentially impact the surface air pathway through upward migration of vapor in soil gas.

Surface Air Transport Pathway

Although no analyses were performed in this pathway, mathematical modeling results for PCBs and VOCs indicate that this pathway is complete. Vapor phase PCBs and VOCs, carried in soil gas, are likely to be emitted from the soil surface for 30 years or more. Concentrations in soil gas reaching the surface are diluted in surface air.

Vapor concentrations of approximately 9×10^{-7} grams per liter (g/L) of PCBs entering the atmosphere through uncovered soil surfaces. Concentrations of VOCs in soil gas that will reach the soil surface over the next 30 years as a result of upward diffusion from the subsurface are estimated to be: 8×10^{-8} g/L of 1,1-DCE, 3×10^{-9} g/L of benzene, 1×10^{-6} g/L of TCE, 9×10^{-7} g/L of PCE, and 2×10^{-7} g/L of cis-1,2-DCE. Concentrations in soil gas were determined from vadose zone modeling (Section 3.4).

Fine soil particles may carry adsorbed COCs from the soils covered by planking. Under current conditions, equipment operation, vehicle traffic, and winds cause fine soil particles to rise into the air transport pathway. The predominant southerly and southeasterly wind directions across OU B1 are shown in Figure 3-2. There are no analytical data with which to determine COC concentrations on the particles or the distance that COC-contami

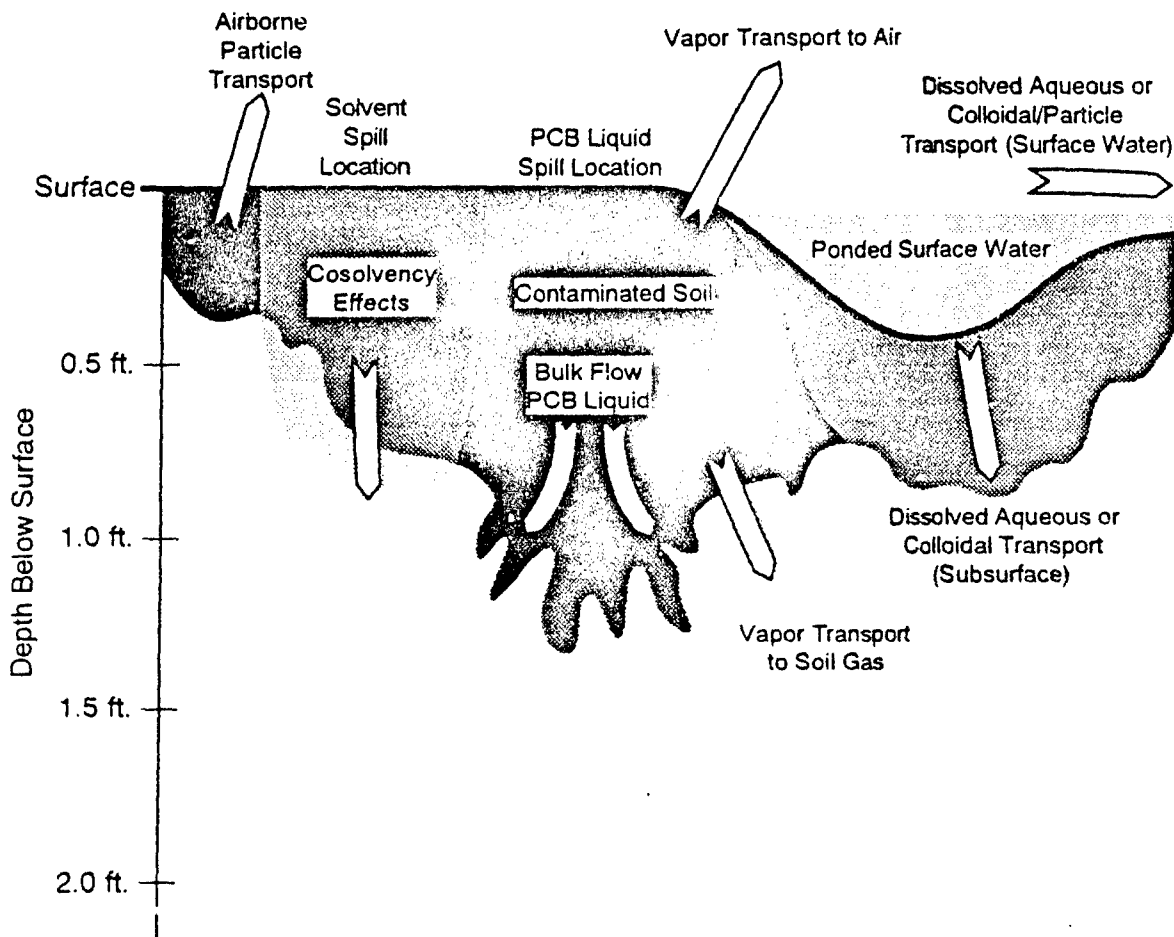


Figure 3-1. Schematic Diagram of Potential Transport Mechanisms at OU B1

TABLE 3-2. MECHANISMS OF COC TRANSPORT IN OU B1

Mechanism	COCs Mobilized	Mobility Limited By	Pathways Potentially Impacted	Pathways Known to be Impacted
Volatilization	VOCs PCBs Dioxins/furans	Low vapor pressure Low vapor pressure	Surface air Groundwater	
Bulk flow (nonaqueous phase transport)	PCBs	High liquid viscosity; high adsorption	Groundwater	
Dissolved aqueous transport	VOCs Inorganic species PCBs Dioxins/furans	High Henry's constant Absorption Low solubility; adsorption Low solubility; adsorption		Surface water Groundwater (migration from another source area)
Colloidal/fine (0.01 to 5 micron) particle aqueous transport	PCBs Dioxins/furans Inorganic species	Water flow velocity for larger particles	Groundwater	Surface water sediments
Airborne particle transport	PCBs Dioxins/furans Inorganic species	Surface covering; wind speed	Surface air	
Cosolvency effects	PCBs	Volume and concentration of cosolvent	Groundwater	

COCs = Contaminants of Concern
 K_{oc} = Organic carbon/water partitioning coefficient
 PCB = Polychlorinated biphenyl
 VOCs = Volatile organic compounds

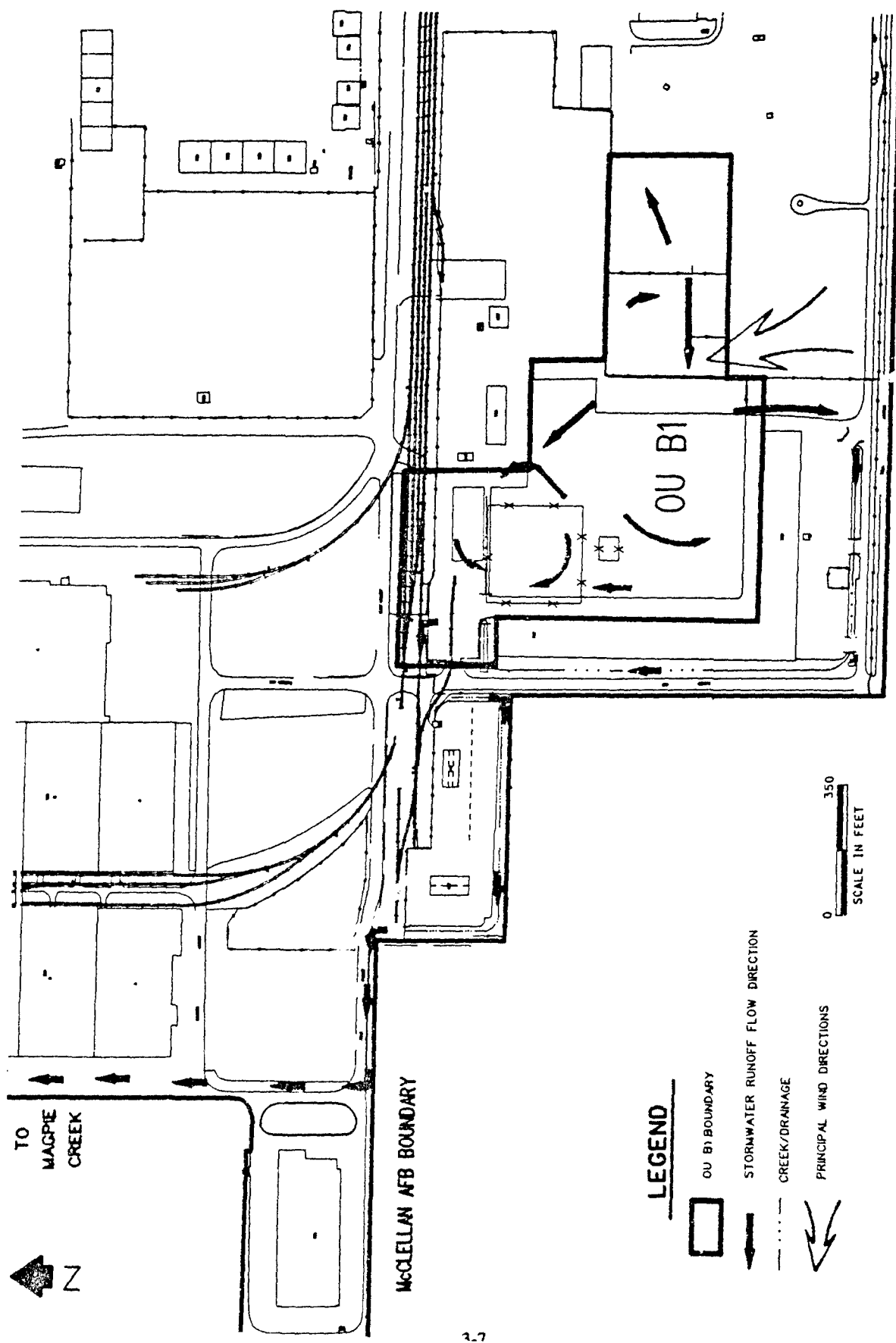


Figure 3-2. Potential Surface Transport Directions from OU B1

nated airborne particles may have been transported from OU B1.

Surface Water Pathway

Surface water and drainage ditch sediment sample analyses indicate that some of the COCs are entering this pathway. This pathway is complete. The COCs may be carried to Magpie Creek in stormwater runoff. Surface water drainage directions in OU B1 are shown in Figure 3-2.

Fine particles of soil, coated with waste oil and natural organic carbon, carrying adsorbed PCBs, dioxin and furan compounds, and inorganic species may be suspended in runoff that cannot infiltrate OU B1 soils. Colloidal and fine soil particles with adsorbed COCs, suspended in runoff or pooled rainfall, may be transported in runoff, deposited as dust on the PSP as water in depressions evaporates, or carried back into surface soil with infiltration. Analytical results from stream sediment samples collected downstream from OU B1 indicate that PCBs, dioxins and furans, arsenic, cadmium, and lead have been transported in runoff.

The very low aqueous solubilities of the organic COCs, and the tendency of all COCs to adsorb to organic material, suggest that the total mass of COCs transported as a dissolved aqueous phase is much less than the mass transported by colloidal or fine particle transport.

The potential for surface transport of COCs in the soils of OU B1 would be reduced if a low permeability cover were placed over contaminated soils. The placement of the cover would stop the exchange between soils and surface transport pathways.

3.4 Potential for Subsurface Transport

Subsurface transport of COCs in OU B1 is controlled by the downward migration of surface water, soil gas advection, and soil gas diffusion. Covering over 73% of the soil surface area of OU B1 increases rainfall runoff, decreases the average percent soil saturation, and decreases potential for downward subsurface transport of liquids containing COCs. Conversely, soil gas diffusion and advection are increased in soils with lower percent saturation because there is a greater percentage of air-filled volume through which vapors may migrate. The vapor phase of COCs in OU B1 migrate more readily through soils in the unsaturated zone when percent saturation is relatively low, and liquid phase COCs migrate more readily when percent saturation is relatively high.

The volatilization mechanism allows PCBs and several VOCs (TCE, PCE, 1,1-DCE, cis-1,2-DCE, and benzene) to enter soil gas. Soil gas is not a complete pathway in OU B1 because a vapor phase COC must enter surface air or groundwater to reach a human or ecologic receptor. Results of vadose zone modeling indicate that subsurface soil gas transport will not impact the groundwater pathway for at least 30 years, although the surface air pathway is impacted (see Section 3.3).

Downward migration of COCs in liquids beneath most of the OU B1 area are also limited by the physical properties of surface and subsurface soils. Soil borings in OU B1 indicate that cemented hardpan and 5- to 15-foot thick silt layers that impede downward migration are present beneath the site (Cross section A-A'). Bertoldi (1974) assigned a conductivity of 0 to 7×10^{-6} meters per second (m/s) to surface soils and hardpan

of the type underlying OU B1. Open root bores and cracks observed in fine-grained subsurface layers suggest that much greater conductivities could exist under saturated conditions. However, tension and capillary effects reduce conductivities under unsaturated conditions. Subsurface silt layers are estimated to have conductivities of 1×10^{-9} to 1×10^{-11} m/s under unsaturated conditions. Assuming a conservative average conductivity of 2×10^{-9} m/s and potential gradient of 1, surface water carrying COCs may not reach the saturated zone (currently 30 meters below surface) within 500 years. This very slow rate of migration applies to most of the area of OU B1, where saturated conditions are unlikely to occur because surface coverings reduce infiltration and increase runoff.

The COCs in surface and subsurface soils may be dissolved, up to their aqueous solubility limit, or be suspended as colloids in rain water passing downward through the soils. On the basis of vadose zone modeling, dissolved VOCs and PCBs will have no measurable impact on the groundwater pathway within the next 30 years. The COCs that may be carried as colloidal particles are also unlikely to have any impact on the groundwater pathway beneath OU B1, if current conditions are maintained.

The enhancement of migration by cosolvent effects requires concentrations of 1% or more of suitable solvent. The greatest solvent concentration in soils in the area of high PCB concentration was 69 mg/kg of 1,2,4-trichlorobenzene. This concentration is one thousand times less than the concentration needed to increase transport of Arochlor 1260. Therefore, this mechanism does not increase the potential for PCB migration to groundwater beneath OU B1.

Vadose Zone Modeling

To evaluate the potential transport of organic COCs through the mechanisms of vapor phase migration and dissolved aqueous phase migration in the subsurface of OU B1, the mathematical model VAPOUR-T (Mendoza, 1992) was used. Subsurface transport by the bulk flow and aqueous colloidal transport mechanisms cannot be evaluated with the model. Transport of PCBs, 1,1-DCE, PCE, TCE, cis-1,2-DCE, and benzene was modeled for a period of 30 years. A transport duration of 30 years was selected to provide maximum and mean concentrations for calculation of health risks in 25-year (occupational) or 30-year (residential) exposure periods. The transport of each COC was evaluated without a surface covering and with low permeability surface covering. All parameters used in the modeling and the conceptual framework are provided in Appendix C.

Assumptions made in developing the conceptual framework of the model were:

- Current vadose zone conditions will not change within 30 years;
- Concentrations of VOCs reported in samples collected below 60 feet were attributed to emissions from previously contaminated groundwater and were not included in the model cases;
- In the uncovered case, the PSP covering over the contaminated soils does not impede or accelerate the rate of surface soil gas emissions or surface water infiltration;
- In the covered case, mean permeability and infiltration rates held constant for

30 years represent the effects of the aging of the cover;

- No additional COC concentrations are introduced to the soils in the modeled period.

Model Results — Figures 3-3 through 3-8 illustrate the conceptual geologic framework, the initial distribution of COCs in the vadose zone, and the results of simulated migration after 30 years, with no cover over the site. Quantitative results are provided in Appendix C. With no cover over the surface of the contaminated areas, concentrations of PCBs and each VOC will reach the air transport pathway through vapor phase diffusion in soil gas within 5 years; however, no measurable concentration of any of the compounds will reach the groundwater pathway within 30 years, if current conditions are maintained. If a low permeability cover is placed over the contaminated soils, COCs in the vapor phase may be emitted in unmeasurable concentrations at the surface as the cover ages. No measurable concentrations of COCs will enter the groundwater transport pathway in 30 years with a cover.

Migration through the vadose zone was not modeled beyond 30 years because uncertainties regarding the constancy of site conditions (land use, infiltration rate, depth to groundwater) increase with extrapolation into the future. On the basis of migration predicted by the model in 30 years, approximations of migration-time intervals that could result in measurable concentrations of COCs in groundwater are: PCBs, more than 400 years; TCE, 60 to 70 years; PCE, 70 to 80 years; cis-1,2-DCE, 40 to 50 years; and 1,1-DCE, 40 to 45 years; and benzene, never.

Dioxin and furan compound migration was not modeled; however, it is anticipated that none of the congeners will reach the air or groundwater pathways in measurable concentrations because of their low initial concentrations, low vapor pressures, and low aqueous solubilities. Inorganic species were not modeled; however, if the conservative estimate of the vertical migration rate of 2.0×10^{-9} meters/second is assumed, dissolved or colloidal inorganic species in surface water will require approximately 500 years to migrate through the vadose zone to groundwater. If inorganic species are retarded by organic carbon in the soils, the time period for migration would be increased. The transport of dioxin and furan compounds and inorganic species to the surface or groundwater transport pathways would be reduced if low permeability cover is placed over the contaminated soils.

3.5 Potential for Groundwater Transport

Groundwater beneath OU B1 is contaminated by VOCs (See Section 2.2.6). However, the available data indicate that the contaminants have migrated beneath the site from another location to the north. Results of subsurface modeling of organic compound migration and calculations of inorganic species migration suggest that contaminants discharged in OU B1 will not reach groundwater in measurable concentrations for 30 years or more under current site conditions.

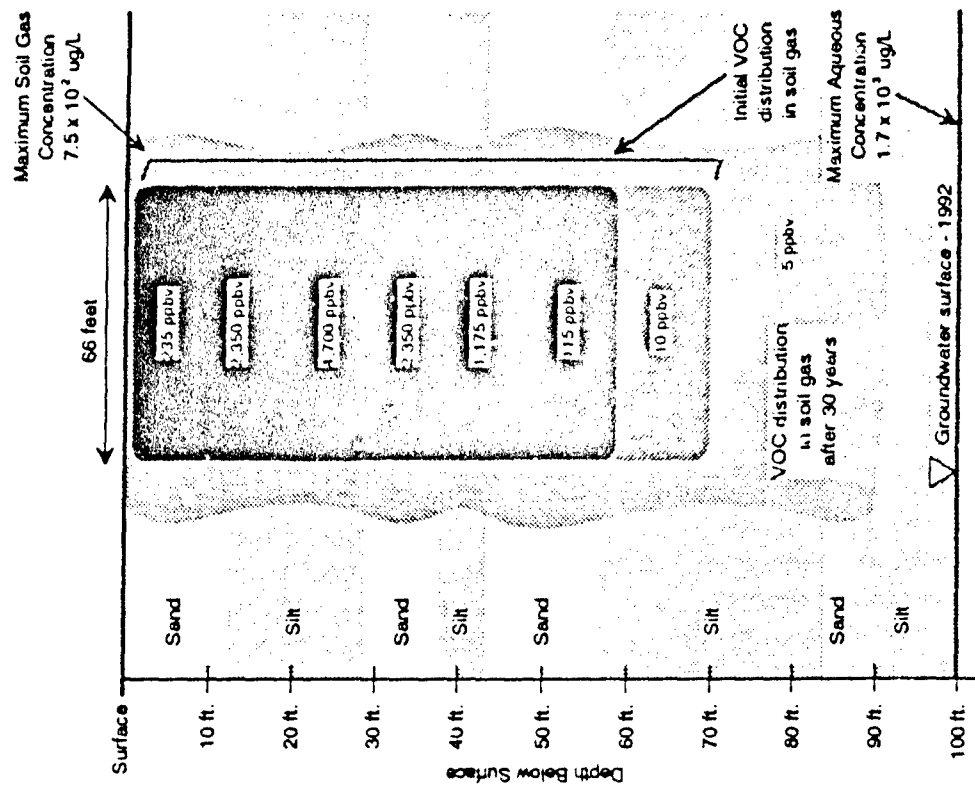


Figure 3-4. Transport of 1,1-DCE Through the Vadose Zone (Vadose Zone Model Results - 30 Years)

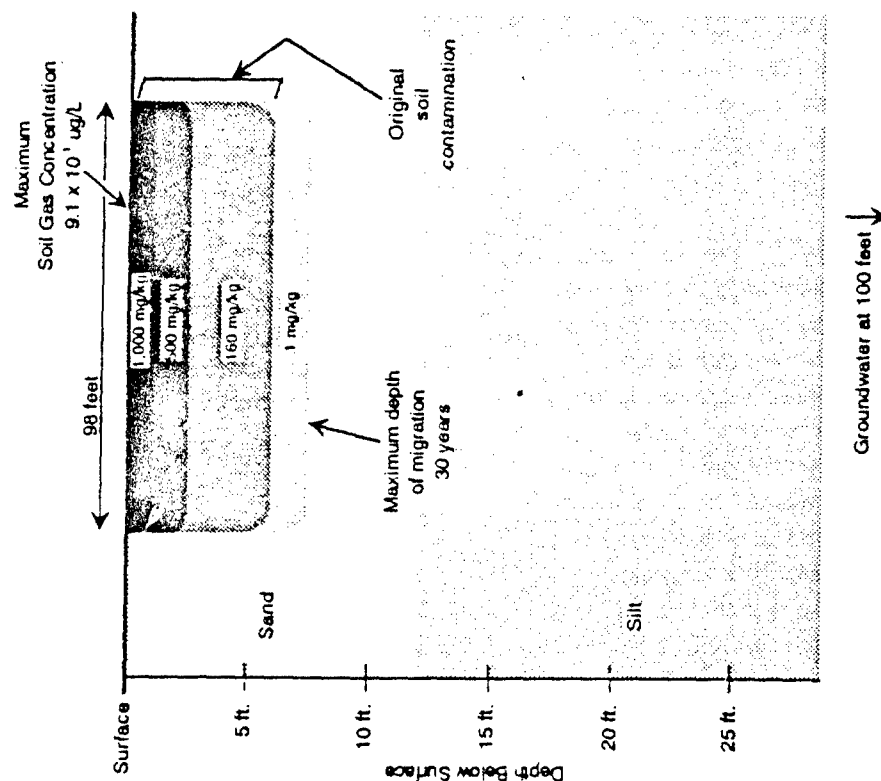


Figure 3-5. Transport of Arochlor 1260 Through the Vadose Zone (Vadose Zone Model Results - 30 Years)

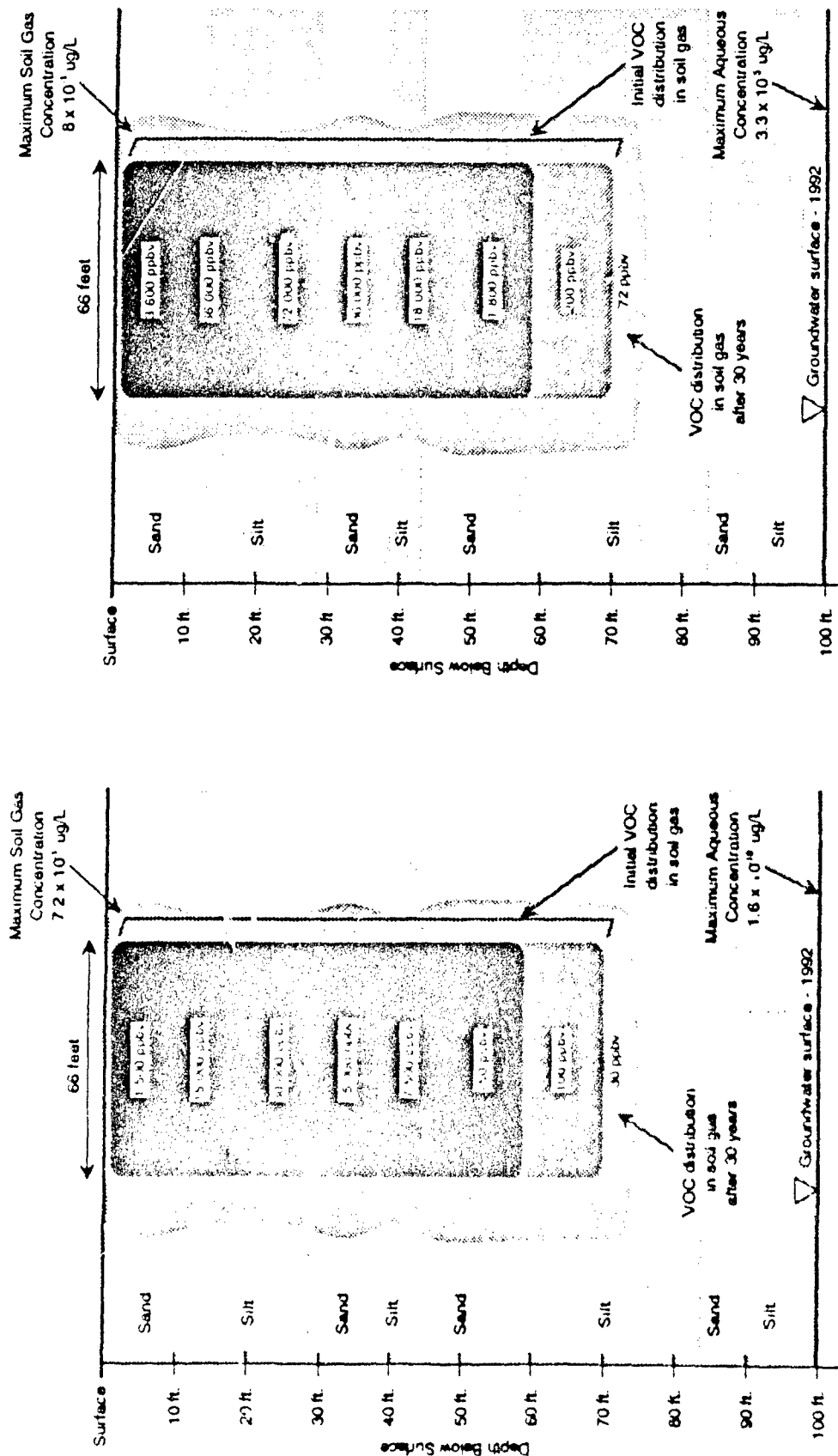


Figure 3-5. Transport of PCE Through the Vadose Zone (Vadose Zone Model Results - 30 Years)

Figure 3-6. Transport of TCE Through the Vadose Zone (Vadose Zone Model Results - 30 Years)

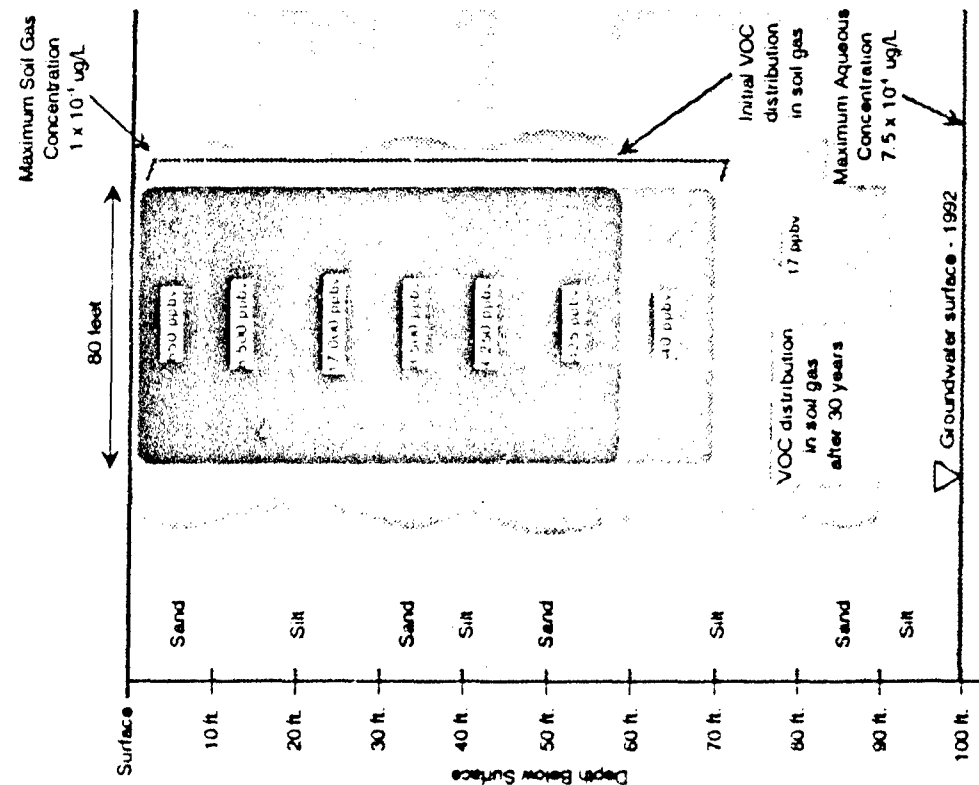


Figure 3-7. Transport of Benzene Through the Vadose Zone
(Vadose Zone Model Results - 30 Years)

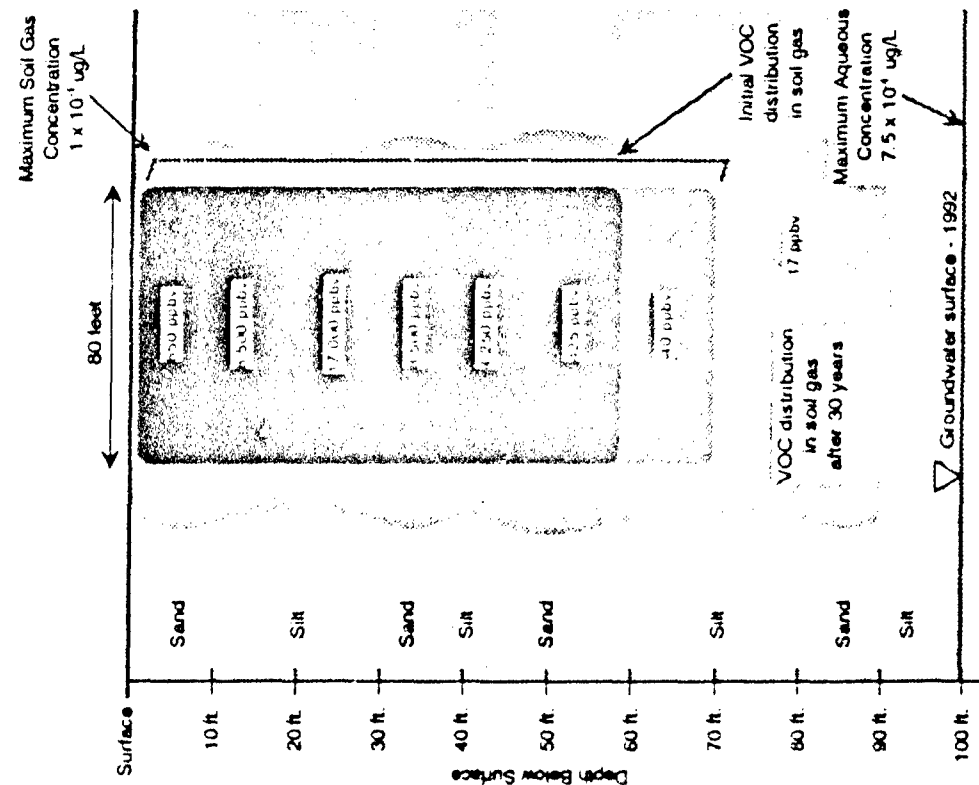


Figure 3-8. Transport of cis-1,2-DCE Through the Vadose Zone
(Vadose Zone Model Results - 30 Years)

4.0 HEALTH RISK ASSESSMENT

This HRA evaluates potential current and future human health risks associated with the exposure to potential COCs in the soil at OU B1. Following U.S. EPA (1989b) Superfund risk assessment guidelines, analytical data from the OU B1 RI were combined with site-specific exposure information and predictive environmental fate models to quantify potential carcinogenic and noncarcinogenic health effects. Exposure pathways evaluated included soil and sediment ingestion, dermal contact with soil, surface water, and sediment, consumption of homegrown produce, and inhalation of emitted vapors and airborne dust.

The HRA evaluated health risks to current off-site residents, on-site workers, site visitors; and potential future hypothetical on-site residents. Post-remediation risks were evaluated for two of the remedial action alternatives discussed in Section 8.0. The analysis concludes with an evaluation of the numerous uncertainties in the HRA process and their effects on the calculated results. Supporting calculations and information are included in Appendix D.

4.1 Identification of Potential Chemicals of Concern

It was first necessary to determine which of the chemicals reported in soil and soil gas during the OU B1 RI should be included in the HRA.

After reviewing the analytical results from the RI and the QA/QC assessment (Appendix B), the following compounds were selected as COCs at OU B1:

- PCBs, dioxins and furans, arsenic, cadmium, chromium, copper, lead,

mercury, molybdenum, selenium, silver, and zinc in soil;

- TCE, PCE, benzene, 1,1-DCE, in soil vapor; and
- PCBs and dioxins/furans in surface water and sediments.

Reported results of dioxins and furans were converted to 2,3,7,8 tetrachlorodibenzo-p-dioxin equivalents (TCDDeq) using the International Toxic Equivalency Factors. Summaries of analytical results of soil gas and soil samples are presented in Tables D-1 and D-2.

All inorganic species that were reported at concentrations greater than five times the background concentration for subsurface soil (McClellan AFB, 1993) were included in the HRA (Overlays F through O). These subsurface (greater than 6 inches BGS) background concentrations may not be representative of surface (0 to 6 inches BGS) background.

Hexavalent chromium was not reported in any of the 22 OU B samples collected. If it was assumed to be present at half the reporting limit, the average percentage of total chromium in the hexavalent form would be 0.11%. This value was used to calculate hexavalent chromium concentrations in soil.

To focus the HRA on the organic compounds that were most likely to contribute significantly to risks, an expanded version of the U.S. EPA (1989b) concentration-toxicity screening procedure was used. Levels of Concern (LOC) had been previously developed: chemical-specific concentrations that produced a one-in-one million cancer risk or Hazard Index of 1.0 in a generic residential

scenario. This conservative scenario evaluated exposures of VOCs via the inhalation of ambient air pathway and SVOCs via the soil ingestion, dermal contact, and home-grown produce pathways. VOCs in soil gas and SVOCs in soil whose maximum reported concentration significantly exceeded their LOC were included as COCs. In this case, any contaminant whose concentration exceeded its LOC by 300 times or more was included as a COC. All chemicals not selected as COCs were determined by this process not to contribute significantly to risks in OU B1. A comparison of the LOC and maximum reported concentrations is presented in Table D-3.

Carbon tetrachloride, chloroform, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and benzo(k)fluoranthene were not included because of their low LOC exceedances (all were less than 12 times higher) and low frequency of detection (all were 4% or less).

Although benzene had a relatively low LOC exceedance (6 times higher) and frequency of detection (7%), it was included as a COC because it is a Group A carcinogen.

4.2 Exposure Assessment

The exposure assessment identifies existing and potential:

- Exposed populations (receptors);
- Exposure scenarios; and
- Exposure pathways.

Potential receptors were identified based on current and reasonably likely potential land use on, and in the vicinity of, OU B1. Exposure scenarios were selected on the basis of their likelihood to occur and their potential for significant adverse health impacts.

4.2.1 Potentially Exposed Populations

The current potentially exposed people at OU B1 include on-site workers at the DRMO, other base personnel who work in the vicinity, and residents in the off-base neighborhoods, the nearest of which are located approximately 250 feet west and 750 feet south of OU B1. The surrounding residential area is low density and could be described as suburban or semi-rural (Figure 2-1). Some of the residents maintain gardens and small numbers of farm animals. The nearest on-base residential areas are located more than one mile to the east.

Sensitive receptors are sub-populations that have an above average probability of being adversely affected by toxic chemicals. Hospital patients, elderly people, and children are considered sensitive populations. Sensitive populations can be found in hospitals, retirement homes, schools, and day care centers. The nearest school, the Bell Avenue Elementary School, is located 1,700 feet southwest of OU B1. No hospitals are located within one mile of OU B1. The on-base hospital and on-base day care center is located more than one mile from OU B1. Based on information provided by the State of California Department of Social Services Community Care Licensing Division and drive-by surveys, no child day-care facilities are located within one-quarter mile of OU B1. Although not specifically addressed in this HRA, no sensitive receptors would directly contact the OU B1 contamination. Therefore, any potential health effects for sensitive receptors would be lower than those calculated in this HRA.

The general public attends occasional auctions at the DRMO. Access during these auctions is restricted to areas with less than 100 mg/kg of PCBs. Children under 18 are

not allowed into the yard. Because of the brief exposure duration and limited exposure frequency, these potential receptors were evaluated separately in the Visitor Scenario.

As described in Section 2.0, OU B1 has been used for military purposes for the past 30 years and is expected to continue operating for such purposes in the future. Therefore, the most likely exposed future receptors consist of the same populations that are currently potentially exposed. Because the current base boundaries are not expected to change, future off-base residential developments could not occur any closer to OU B1 than existing residences.

4.2.2 Exposure Scenario Selection

Four exposure scenarios were evaluated in the baseline HRA: three currently existing scenarios and one hypothetical scenario. The scenarios were selected based on current land use and potential land uses that may lead to significant exposures. In addition, two post-remediation scenarios evaluated the risk reducing effectiveness of remediation alternatives. The scenarios are:

- **Current Worker Scenario.** Evaluated DRMO worker exposures under the conditions that existed in the DRMO yard in December 1992. The effect of the recently installed HDPE liner was not evaluated.
- **The Visitor Scenario.** Evaluates potential risks to adults who attend DRMO auctions.
- **The Current Off-Site Residential Scenario.** Evaluated exposures to the nearest current residents.

- **The Hypothetical On-Site Residential Scenario.** Evaluated exposures to hypothetical on-site residents. Residents were assumed to live on a one-eighth acre lot (U.S. EPA, 1989b) in the area that contains the highest reported PCB soil concentrations (Figure 4-1).

Post-Remediation

- **The Partial Cap Scenario.** Evaluates risks to DRMO workers if an asphalt cap were installed over areas where the PCB concentration is greater than 10 mg/kg.
- **The Full Cap Scenario.** Evaluates risks to DRMO workers if the entire area of OU B1 were capped.

4.2.3 Exposure Pathway Assessment

An exposure pathway describes the route by which an individual is or could be exposed to the contamination in the identified scenarios. Initially, many potential exposure pathways and transport mechanisms were considered in each scenario. Table 4-1 presents the rationales for including or excluding pathways in each scenario.

4.3 Quantitative Exposure and Intake Assessment

The methodologies used to calculate each medium's exposure concentrations and intake rates of each COC for the receptors in each scenario are discussed below.

4.3.1 Exposure Concentrations

Exposure levels are the concentration in each medium to which the receptors are exposed. These are calculated using either measured concentrations in soil and soil gas,

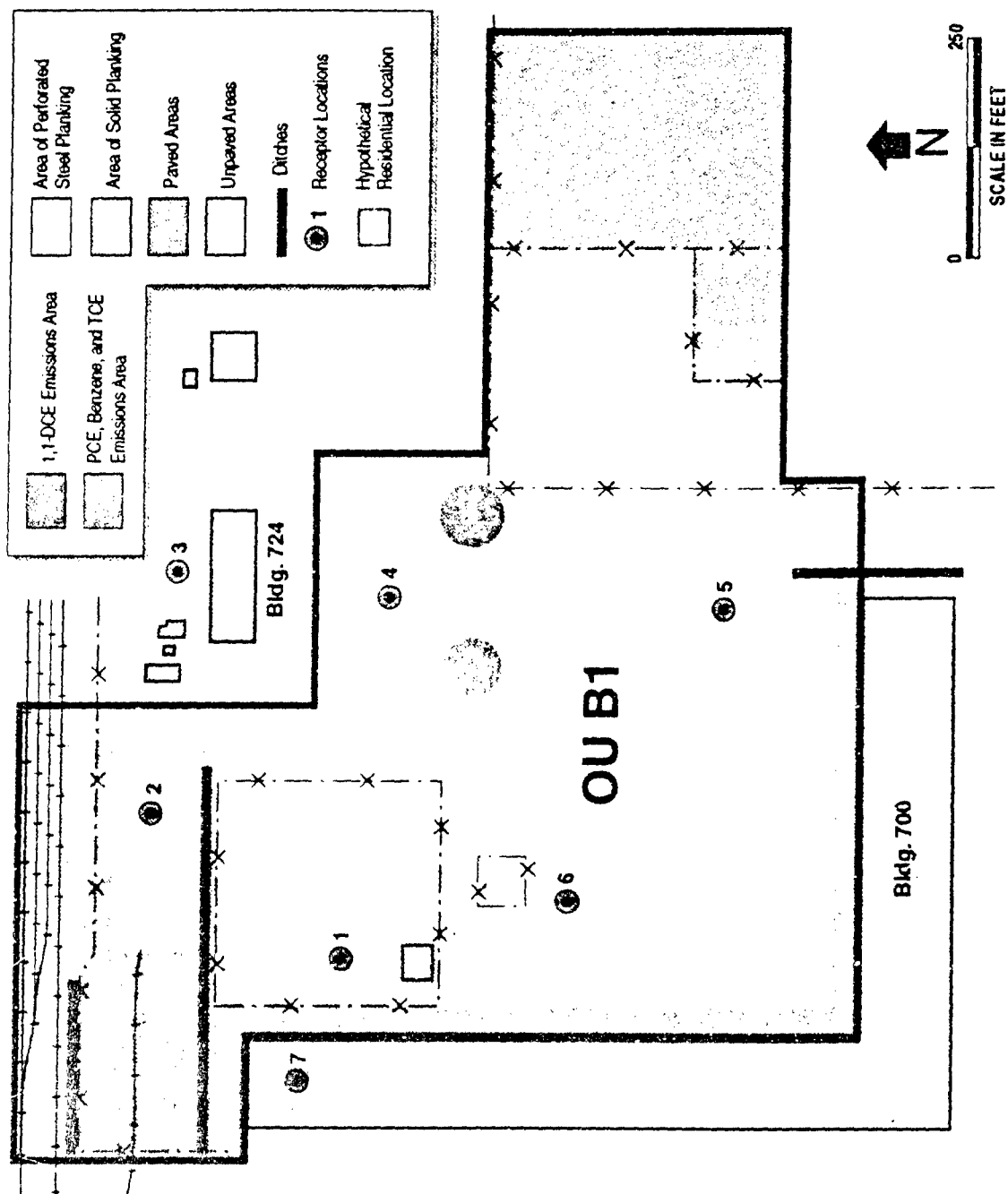


Figure 4-1. Current Scenario Map

TABLE 4-1. EXPOSURE PATHWAYS

Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Worker Scenarios		
Soil ingestion	Yes	Potential for direct contact exposure.
Dermal contact with soil	Yes	Potential for direct contact exposure.
Inhalation of soil vapors emitted to the atmosphere	Yes	Vadose zone modeling indicated PCBs and VOCs would be emitted at the soil surface.
Inhalation of suspended soil particulates	Yes	On-site interviews indicated traffic dust was generated.
Dermal contact with surface water	No	Workers are generally on forklifts and would not regularly contact puddled rain water.
Groundwater ingestion, inhalation and dermal contact during showing	No	Vadose modeling results indicated extremely small to zero amounts of contaminants would reach groundwater in the next 30 years.
Current Off-Site Residential Scenario		
Soil Ingestion	Yes	Off-site soil could receive particulate deposition.
Dermal Contact with Soil	Yes	Off-site soil could receive particulate deposition.
Inhalation of soil gas emitted to the atmosphere	Yes	Emitted soil gas could migrate off site.
Inhalation of suspended soil particulates	Yes	Suspended particulates could migrate off site.
Direct contact with surface water and sediments	No	Restricted access prevents contact. No PCBs or dioxins/furans were reported in samples from Magpie Creek.
Groundwater ingestion, inhalation, and dermal contact during showering	No	Vadose modeling results indicated extremely small to zero amounts of contaminants would reach groundwater in the next 30 years.
Home-grown produce ingestion	Yes	Off-site garden soil could receive particulate deposition.
Hypothetical On-Site Residential Scenario		
Soil ingestion	Yes	Potential for direct contact.
Dermal contact with soil	Yes	Potential for direct contact.
Inhalation of soil gas emitted to the atmosphere	Yes	Vadose zone model indicated PCBs and VOCs would be emitted at the soil surface.

(Continued)

TABLE 4-1. (Continued)

Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Inhalation of suspended soil particulates	No	Exposed soil not likely in residential.
Direct contact with surface water and sediments	Yes	Children potentially exposed to stormwater runoff.
Groundwater ingestion, inhalation, and dermal contact during showering	No	Vadose modeling results indicated extremely small to zero amounts of contaminants would reach groundwater in the next 30 years.
Home-grown produce ingestion	Yes	Home-grown produce is possible in residential scenario.
Visitor Scenario		
Soil Ingestion	Yes	Potential for direct contact.
Dermal contact with soil	Yes	Potential for direct contact.
Inhalation of soil gas emitted to the atmosphere	Yes	Vadose zone model indicated PCBs and VOCs would be emitted at the soil surface.
Inhalation of suspended soil particulates	Yes	Traffic-generated dust occurs at OU B1.
Direct contact with surface water and sediments	No	Visitors unlikely to experience contact with surface water.
Groundwater ingestion, inhalation, and dermal contact during showering	No	Vadose modeling results indicated extremely small to zero amounts of contaminants would reach groundwater in the next 30 years.
Home-grown produce ingestion	No	Visitors don't grow produce on site.

or environmental fate models that predict future concentrations or concentrations in media that were not directly measured.

Concentrations in Soil

Direct measurements of semivolatile and inorganic COC concentrations in soil were used as the exposure concentrations in the dermal contact and soil ingestion pathways for the Current Worker, Hypothetical On-site Residential, and Visitor Scenarios (Table D-4). Because soil exposures would originate primarily from the upper soil layers, only results from samples taken in the top 6 inches of the soil were used to calculate soil exposure concentrations. For the Reasonable Maximum Exposure (RME) case, the 95% upper confidence limit (95UCL) of the mean concentration (assuming a log normal distribution of contaminant concentrations) of all surface samples in the entire DRMO storage yard was calculated for each COC using the method described in U.S. EPA (1992a). If the 95UCL was greater than the maximum concentration, the latter number was used in the calculations. In the "average" case the mean of the concentrations was used.

For the Hypothetical On-Site Residential scenario, COC soil concentrations from the one-eighth acre area shown in Figure 4-1 were used. The lowest of the 95UCL and maximum concentration was used in the RME case. The mean concentrations were used in the "average" case.

Because the DRMO auctions are restricted to the southern portion of the site, only results from the southern portion of the DRMO yard were used to evaluate direct contact exposures in the Visitor Scenario for exposure and risk calculations.

Reported concentrations of PCB and dioxins/furans in on-site sediments and surface water (Table D-5) were used to evaluate risks in the Hypothetical On-site Residential Scenario. The maximum reported concentrations in samples taken near the hypothetical residential area were used.

Surface Emissions and Ambient Air Concentrations

Surface emissions of TCE, PCE, 1,1-DCE, benzene, and PCBs (Arochlor 1260) were obtained from the vadose zone modeling (Section 3.0). Emission rates in micrograms per square meter per second were back-calculated from the total amounts emitted over the next 30 years (Table D-6).

Although TCDD/F are classified as semivolatile, TCDD/F vapor phase emissions were not evaluated because of their low vapor pressure (1.7×10^{-6} millimeters of mercury [U.S. EPA, 1986]). Vapor phase emissions of compounds with vapor pressures less than 1.0×10^{-5} millimeters of mercury are generally not evaluated in risk assessments (California Department of Health Services, 1986). Paustenbach (1989) cited five studies indicating that inhalation of TCDD/F from waste sites does not pose significant health risks compared to direct exposure pathways.

As indicated by the vadose zone modeling, the predicted PCB emission rate would be uniform throughout the entire DRMO yard. The TCE, PCE, benzene, and 1,1-DCE emissions would occur in localized areas (Figure 4-1) where these compounds were reported at elevated levels.

Forklift-generated particulate emissions (Table D-6) were calculated using algorithms for PM_{10} emissions from gravel roads (U.S.

EPA, 1991b). Any reduction, or enhancement, of emissions resulting from the PSP were not factored into the calculations. The concentration of COCs on the PM₁₀ were assumed to be the same as those in the surface soils.

The ambient air concentrations of VOCs, PM₁₀, and PCBs were calculated using the "box model" combined with site-specific wind data (Table D-7). Average ambient concentrations were calculated at seven locations at the DRMO facility, which were then weighted by the fraction of time the forklift operators spend at each location to calculate average exposure concentrations during the workday. Time-location information on the forklift operators were obtained from interviews with the DRMO yard supervisor (Van Dyke, 1993). A more detailed explanation of these calculations is presented in Appendix D.

In the Current Off-Site Residential Scenario, the U.S. EPA atmospheric dispersion model SCREEN was used to calculate worst-case off-site concentrations of suspended dust and PCB vapors in ambient air. Ambient air concentrations were calculated at the nearest current residence, which is approximately 140 meters south-southwest of OU B1. Off-site VOC concentrations were not evaluated because they were a relatively minor contributor (less than 0.01%) to on-site cancer risks in the Current Worker Scenario. The results of the dispersion modeling are presented in Appendix D. Concentrations (70-year averages) of SVOCs and inorganic species in soils at the nearest residence were calculated using a conservative particulate deposition velocity of 0.02 meters per second and a simple soil mixing model that assumes no loss mechanisms (e.g., erosion). Soil mixing depths of 1 centimeter (cm) and 15 cm were used for the direct contact pathways and

homegrown produce pathways, respectively. Exposure concentrations in homegrown produce were calculated using root uptake factors developed from Baes et al, 1984 (Table D-8).

For the Partial and Full Cap Scenarios, areas not covered by the cap were assumed to be emitting VOCs and PCBs at the same rate as in the Current Worker Scenario. The low permeability asphalt cap was assumed to be 100% effective in reducing dust emissions. The cap's effect on PCB and VOC vapor was evaluated over 30 years with VAPOUR-T (Section 3.0). The cap reduced PCB fluxes by approximately one order of magnitude, and VOC fluxes by 50%. Since VOC contributions to total risk was small (less than 0.01% in the Current Worker Scenario), they were not evaluated in the Partial or Full Cap Scenarios.

4.3.2 Intake Rates

Both "average" and RME case intakes were calculated in each scenario. Average intakes were calculated by using average values in the calculations whenever they were available. However, when information was unavailable for a parameter, health-conservative assumptions were typically used to arrive at a value. This approach is consistent with the RME case defined in the Superfund Guidelines.

The RME intakes were calculated by using several parameter values that are "reasonable maximums" from the upper percentiles (90th or 95th) of the range of possible values or were taken from several U.S. EPA risk assessment guidance documents. Tables 4-2 and 4-3 present the parameter values used in the residential and non-residential scenarios, respectively.

TABLE 4-2. VALUES USED FOR INTAKE PARAMETERS FOR CURRENT AND HYPOTHETICAL RESIDENTIAL SCENARIOS

Parameter	Value ^a	
	Adult	Child
Body weight	70 kg ^b	16 kg ^b
Inhalation rate	20 m ³ /day ^b	15 m ³ /day ^b
Soil ingestion	100 mg/day ^b	200 mg/day ^b
Soil loading on skin	0.2 mg/cm ² -day (1.0) ^c	0.2 mg/cm ² -day (1.0) ^c
Exposed skin surface area	5,000 cm ² (5,800) ^c	3,910 cm ² ^b
Exposure duration	9 yrs (30) ^b	6 yrs ^b
Homegrown produce ingestion rate	0.041 kg/meal ^d	0.0094 kg/meal
Meals per year	1,095 ^b	1,095 ^b
Exposure frequency (sediment and surface water)	NA	1.25 days/yr ^e
Exposure frequency (ambient air)	24 hrs/day	24 hrs/day
Averaging time (carcinogens)	25,550 days ^b	25,550 days ^b
Averaging time (noncarcinogens)	NA	2,190 days ^a
Exposure frequency (soil ingestion, soil dermal absorption, inhalation)	350 days/yr (365) ^b	350 days/yr (365) ^b

^a Average case values; values in parentheses were used in the RME case analysis.

^b U.S. EPA, 1989b.

^c U.S. EPA, 1992a.

^d U.S. EPA 1991b.

^e Professional estimate.

NA = Not applicable

TABLE 4-3. VALUES USED FOR INTAKE PARAMETERS FOR NON-RESIDENTIAL SCENARIOS

Parameter	Current Worker	
	Partial Cap and Full Cap Scenarios ^a	Visitor Scenario ^a
Body Weight	70 kg ^b	70 kg ^b
Inhalation Rate	10 m ³ /8 hr workday (20) ^b	20 m ³ /day ^b
Soil Ingestion Rate	50 mg/8 hr workday ^c (100) ^b	100 mg/day ^b
Soil Loading on Skin	0.2 mg/cm ² -day ^c (1.0) ^c	1.0 mg/cm ² -day ^c
Exposed Skin Surface Area	1,765 cm ² ^c (3,120) ^b	3,120 cm ² ^b
Exposure Duration	9 years (25) ^d	30 years ^b
Exposure Frequency	8 hours/day, 5 days/ week, 50 weeks/year	8 hours/day, 26 days/year

^a Values in parentheses were used in the RME case analysis. Only RME case was evaluated for the Visitor Scenario.

^b U.S. EPA, 1989b

^c U.S. EPA, 1992a

^d U.S. EPA, 1991b

^e Van Dyke, 1993

The amount of exposed skin was calculated from site-specific information (Van Dyke, 1993), which indicated that workers wear long pants year-round, tee-shirts for half the year, and gloves one fourth of the time. Skin surface areas of various arms and hands (U.S. EPA, 1989b) were used to calculate an average exposed skin surface area of 1,765 square centimeters (cm²). The reasonable maximum surface area (3,120 cm²) was calculated by assuming that arms and hands were constantly exposed.

Averages of reported ranges of chemical-specific soil absorption rates (U.S. EPA, 1992a) were used. The maximum of each reported range was used in the RME case (Table D-9).

4.4 Toxicity Assessment

The toxicological properties of the compounds evaluated in this risk assessment are presented in Appendix D. These profiles provide information on the potential adverse effects of these compounds including carcinogenicity, short-term (acute), and long-term (chronic) toxicity. Cancer potency factors and Reference Doses are presented in Appendix Table D-10. For each potency factor, the highest of the current U.S. EPA (IRIS on-line) and California EPA (Cal/EPA, 1992b) factors was used. IRIS On-Line Reference Doses were used (Table D-11).

4.5 Risk Characterization

Risk characterization uses the results of the intake analysis and toxicity assessment to calculate cancer risk values and Hazard Indices (HI) (for noncarcinogens) for each of the four scenarios.

4.5.1 Carcinogenic Risks

Chemical-specific cancer risks were calculated by multiplying the average lifetime intake rate (Section 4.3) by the cancer potency value. These risks were then summed across chemicals and pathways to calculate the total cancer risk in each scenario.

Figure 4-2 shows the results of the carcinogenic risk assessment, including:

- Total excess cancer risk in each scenario and case;
- Cancer risk by COC in each scenario and case; and
- Cancer risk by pathway in each scenario and case.

Complete results of the carcinogenic risk assessment are presented in Tables D-12 through D-15.

The calculated RME case risks are just above the U.S. EPA acceptable risk level of 1×10^{-4} (40 CFR 300.430) in the Current Worker and Current Off-Site Residential Scenarios. Risks in these scenarios' average cases and in the Visitor Scenario are less than this level. The Current Off-Site Residential Scenario evaluated risks at the nearest residential area using screening-level models to calculate concentrations in ambient air and soil. If more sophisticated models had been used, the calculated risks would probably be below the acceptable level in the RME case. Risks in more distant current residential areas would be less than the acceptable level.

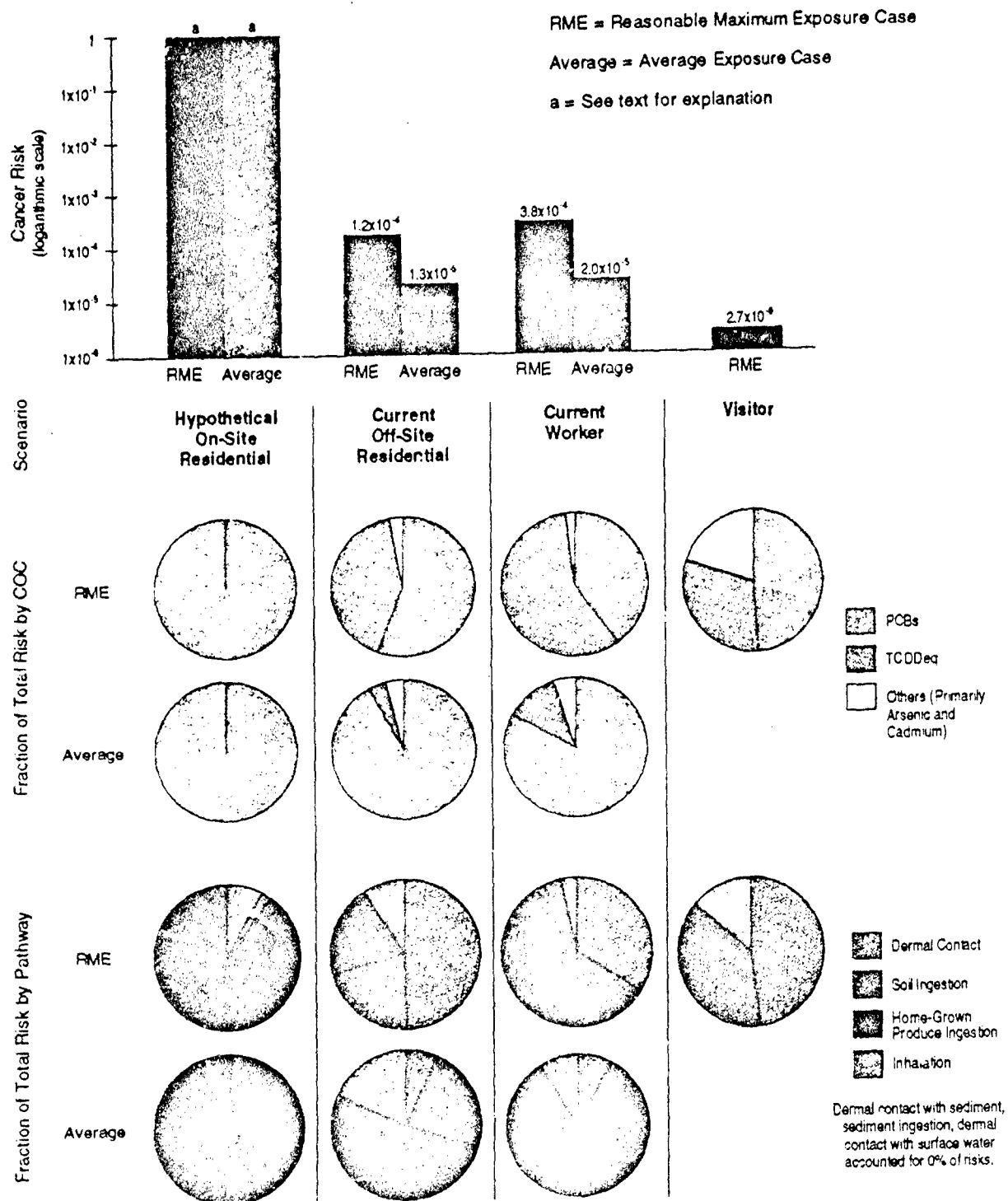


Figure 4-2. Cancer Risk Assessment Summary

Risk to hypothetical on-site residents living in the worst-case location exceed the acceptable level. It is highly unlikely that anyone will experience this risk because remediation would be conducted prior to residential construction. Hypothetical residents in other areas of the site would experience risks as much as several orders of magnitude lower and possibly below the acceptable level.

Although the calculated cancer risks in the Hypothetical On-Site Scenario exceeded 1.0 (23 and 1.3 in the RME and average cases respectively), they were reported as 1.0 because a probability cannot realistically exceed 1.0. The calculated risks are the result of the conservative nature of the calculations. The reasons for this exceedance (of 1.0) are discussed in the uncertainty analysis (Section 4.6.4).

4.5.2 Noncarcinogenic Health Effects

The potential for adverse chronic noncarcinogenic effects were characterized by comparing the calculated intake rates (doses) to an intake rate that is considered to be the threshold for significant adverse effects in sensitive individuals (reference dose). The Hazard Quotient (HQ) is the ratio of the calculated dose to the reference dose. If a compound's HQ exceeds 1.0, there is the potential for an adverse health effect to occur. As a screening procedure (assuming that all COCs produce the same noncarcinogenic effects), HQs were summed to obtain the Hazard Index (HI). The HI for all cases in all four scenarios are presented in Table 4-4.

If the HI is less than 1.0, chronic noncarcinogenic effects are not likely to occur. If the HI exceeded 1.0, a more refined analysis was performed to determine if noncarcinogenic are likely.

TABLE 4-4. HAZARD INDICES

Scenario	Average Case	RME Case
Current Worker	0.012	0.049
Current Residential	0.29	0.61
Hypothetical Residential	1.4	1.7
Visitor	NE	0.0018

NE = Not evaluated.

The results indicate that the HI is greater than 1.0 only in the Hypothetical On-Site Residential Scenario. No chemical-specific HQs exceeded 1.0 in this scenario (Table D-16). Using the CAPCOA (1992) procedure to evaluate organ and systemic Hazard Indices, no organ or system-specific Hazard Indices exceeded 1.0 in the RME case of this scenario (Table D-17).

4.5.3 Lead Evaluation

California EPA's (1992b) blood-lead model, which evaluates lead exposures based on a calculated blood-lead concentration, was applied in the Residential and Current Worker Scenarios. The model was run in two modes: the first only evaluated the lead exposures from OU B1; the second included the default background concentrations in air, water, and produce that are recommended by the model.

The lead soil concentrations used as model inputs are shown in Table D-4. Because only one soil concentration can be entered into the model, it was conservatively assumed that produce was grown in soils with a mixing depth of 1 centimeter in the Current Off-Site Residential Scenario.

Only adult exposures were evaluated for the current worker scenario. It was assumed that half of the worker's ingested lead originates from OU B1. The background soil

concentrations for workers was conservatively assumed to be equal the on-site concentrations.

As shown in Table 4-5, child and adult exposures to lead from OU B1 generally resulted in blood-lead levels less than the 10 micrograms per deciliter ($\mu\text{g}/\text{dL}$) reference concentration. Only when using the residential on-site maximum concentration was the reference concentration exceeded by the child's blood-lead level. Complete results of the blood-lead analysis, including results for pica children, are presented in Appendix D.

TABLE 4-5. BLOOD-LEAD LEVELS RESULTING FROM EXPOSURES TO OU B1 SOIL

Scenario	Blood-lead levels ($\mu\text{g}/\text{dL}$)	
	Adults	Child
Current Worker	0.8	NE
Current Off-Site Residential	0.1	0.5
Hypothetical On-Site Residential (average soil concentration)	1.1	6.9
Hypothetical On-Site Residential (maximum soil concentration)	2.0	13

NE = Not evaluated.

Reference concentrations = 10 $\mu\text{g}/\text{dL}$.

4.6 Uncertainty Analysis

To evaluate and apply the results of risk assessment, it is important to identify and understand the primary variables and assumptions that contribute most to the uncertainty. An uncertainty analysis allows the risk assessment findings to be placed in proper perspective for making risk management decisions. Although a degree of uncertainty occurs in virtually every step of the risk assessment process, even in nonquantitative assumptions, this section focuses on the areas of uncertainty that significantly affected the calculated results.

Uncertainty analyses evaluate three general concepts: uncertainty, variability, and bias. Uncertainty occurs when the accuracy of a value is not well known. Uncertainty in HRAs can result from inaccurate measurements or (more commonly) from the use of predictive models, especially dose-response models, that are not well verified.

Variability affects calculated results when a single number is used to represent a parameter that contains a well known range of possible values. This causes the results to be representative of only certain conditions.

Bias can occur unintentionally or intentionally when the selected values are either greater or less than the actual value. Intentional bias occurs when conservative values are selected for uncertain or variable parameters. This can result in an overestimation of health effects. Unintentional biases can cause the predicted results to be either higher or lower than the average results, and in general, may tend to cancel each other out.

Compounding bias occurs when than one several intentionally biased values are used in the same calculation. This causes the results to be more biased than any of the individual values. Compounded bias affects both the "average" and RME cases.

In typical health risk assessment methods, uncertainty and variability are accounted for in ways that can produce significant intentional bias (conservativeness), even in "average" case results. This is done so that the calculated health risks are unlikely to underestimate actual risks. Because the lack of data makes it difficult to quantify the amount of intentional bias in the results, the best estimate of actual risk is not well characterized.

4.6.1 Uncertainty in Identification of Chemicals of Concern

In general, the Hazard Identification process is the least uncertain of the steps in an HRA. Detailed analytical QA/QC procedures produce data that are suitable for the identification and quantification of the compounds used in the risk assessment. The area of significant uncertainty in this HRA was the inability to quantify dioxin and furan concentrations in areas that had the highest reported PCB concentrations. The average TCDDeq was calculated without including areas that may have had relatively high levels. This probably caused an underestimation of risk in several scenarios. Although the maximum reported concentration was assumed to occur in the hypothetical on-site residential area, the actual concentrations may be higher.

4.6.2 Uncertainty in the Exposure Assessment

The Partial Cap Scenario probably leads to higher exposure than most other industrial or occupational scenarios because of the amount of exposed soil and airborne dust generated at OU B1. At many industrial or occupational locations, the grounds are completely paved or covered with buildings, thus virtually eliminating most exposure pathways. Thus, airborne dust levels in a more generic occupational would probably have been lower.

The selected current scenarios are no longer current because the area of highest PCB contamination has been recently covered with a plastic liner, and all DRMO activity in this area has been eliminated. The current scenarios do not even represent pre-remediation conditions. The reduced forklift access and solid steel planking covering areas of high

PCB concentrations are previously enacted removal measures that served to reduce risks. As a result, the current scenarios' risks probably underestimate the pre-remediation risk and overestimate risks based on the "more current" conditions at the site.

The elimination of exposure pathways or transport mechanisms could lead to underestimates of the risk. The wind-blown dust pathway was not evaluated because interviews (Van Dyke, 1993) indicated that forklift traffic generated more dust than the wind. In addition, wind-generated dust would occur primarily at high wind speeds which would tend to quickly disperse the dust and move it off of OU B1. The risk calculations indicate that even if the wind generated an equal amount (i.e., doubling of the forklift generated dusts), the calculated risks would not significantly change because the risk from forklift-generated dusts was less than 6% of the total risk.

The predicted surface fluxes of VOC and PCB vapors from the vadose zone model are uncertain because the model has not been thoroughly validated by field measurements. However, because the maximum detected concentrations of VOCs were used as inputs and the risk contribution of these chemicals in this pathway was minimal (less than 2% in all cases) this probably does not contribute significantly to the uncertainty in this HRA.

The air dispersion analysis used a modified "box model" that allowed it to be sensitive to variations in wind direction. Although this is not as conservatively biased as the normal box model (U.S. EPA, 1991b), which assumes a constant wind direction, it is still conservative in that it assumes that dispersion in the vertical direction is limited to 2 meters (breathing zone height). This bias would be relatively insignificant because the

inhalation pathway accounts for only between 3 and 16% of the total risks.

The use of the 95%UCL of the mean for soil concentrations instead of the arithmetic mean caused an intentional conservative bias in the results. The arithmetic mean is a statistically unbiased estimator of the average, independent of what the underlying distribution may be (Gilbert, 1987). This bias was especially significant for TCDDeq, whose wide range of values and high standard deviation caused the 95% UCL to exceed the maximum reported value.

Another intentional bias was the assumption that the COC concentrations in soil that is directly contacted by the DRMO workers is equal to the concentrations in the soil beneath the PSP and gravel. The soil and dust leading to direct contact is probably a mixture of ground up gravel, dusts from off site, and underlying soils. The lack of analytical data on the surface dusts necessitated the conservative assumption that all directly contacted soil and dust originates from the underlying soil.

4.6.3 Uncertainty in the Intake Assessment

The use of "average" and RME cases is a commonly used technique to address uncertainty. The "average" case was designed to produce an estimate of the average risk. However, as described throughout this uncertainty analysis, the use of conservatively biased, worst-case, or upper bound estimates (e.g., cancer slope factors) was unavoidable even in the "average" case. This occurred when standardized conservative regulatory default values were used and when assumptions were made for parameters with limited data. The net result is a conservatively biased calculated risk in the "average" cases that is

probably in the upper percentiles of the actual risk distribution.

The RME cases used additional conservatively biased values to calculate a risk value that is probably outside the range of actual risks. Although each value may be a reasonable maximum value for that parameter, compounding bias can cause the calculated risk values to be bounding estimates rather than high-end or reasonable maximum estimates (Burmaster and Harris, 1993).

The soil ingestion rate is a highly uncertain parameter because of the limited sample size and uncertain applicability of the studies used to produce the value used in this HRA. The selected value (50 mg/8-hour work day) contains conservative bias originating from two sources. The original study (Calabrese et al, 1990) reported an average soil ingestion rate of 39.25 mg/day. U.S. EPA (1991b) cites this as 50 mg/day and indicates that it should be applied to an 8-hour work day. If soil consumption is assumed to occur uniformly during waking hours (16 hours per day) and Calabrese's reported value is used, the resulting soil consumption rate would be 20 mg/8-hour workday.

Although gastrointestinal absorption factors were not used in this HRA, this is equivalent to assuming that the absorption fraction of each chemical absorbed was the same as that in the studies used to derive the dose-response values. This assumption could bias the results in either direction.

Empirical data on the dermal absorption fraction of compounds from a soil matrix is very limited and therefore uncertain. The values for inorganic species and semivolatiles used in this HRA were obtained from the studies summarized in U.S. EPA (1992a).

McKone's (1990) theoretical model could also have been used to calculate dermal uptake fractions for PCBs and TCDDeq from soil.

4.6.4 Uncertainty in Toxicity Assessment

In general, the dose-response factors are the most uncertain parameters in the HRA. Some of the major sources of uncertainty associated with these values include:

- Using observed high-dose response frequencies (from human or rodent studies) to predict response frequencies that would occur at relatively low environmental doses;
- Using a dose-response extrapolation model (linearized multistage) that is always linear at low doses and assumes there is no threshold to a cancer response (i.e., any dose, no matter how small, has some risk of cancer);
- Using rodents or other animals to predict responses in humans;
- Using studies on genetically homogeneous rodent populations to predict responses in human populations with variable sensitivities; and
- Assuming that dose schedule is not a factor in the development of cancer.

Since numerous conservative assumptions are used to derive slope factors, best estimates for slope factors are not readily available and would require a significant effort to determine.

There is also uncertainty in the decision to classify a chemical as a human carcinogen. This uncertainty is reflected to a

certain degree in the U.S. EPA's weight-of-evidence classifications. Dioxins and furans, although not currently listed on U.S. EPA's IRIS on-line database, were previously classified as B2 carcinogens. PCBs are also classified as B2 carcinogens. The B2 classification indicates that there is sufficient evidence of carcinogenicity in animals and inadequate or lack of evidence in humans.

The parameter whose uncertainty may have had the greatest impact on the calculated cancer risks is the cancer potency factor for TCDDeq. The U.S. EPA is updating this potency factor and has removed it from its IRIS on-line database. This HRA used the most recently published IRIS potency factor of $1.5 \times 10^5 \text{ (mg/kg-day)}^{-1}$.

There is considerable controversy about the potency factor for TCDDeq. There is even some indication that there is a threshold for its carcinogenic effects. Recognizing threshold effects, other countries have developed "safe" doses of TCDDeq.

Conservative bias in the cancer potency value for PCBs originated from several procedures. Only data from the most sensitive species (rat), strain (Sprague-Dawley), and sex (female) were used to derive the slope factor. The use of the upper confidence limit from the linearized multistage model also adds to the bias.

Calculated cancer risks that exceeded 1.0 in the Hypothetical On-Site Scenario resulted from the assumed linearity of the PCB dose-response relationship. According to U.S. EPA (1988a), the use of the PCB potency factor is appropriate only when calculated risks are less than 0.1. U.S. EPA does not publish an appropriate cancer potency factor for the PCB doses calculated in this scenario.

Significant sources of uncertainty in the PCB potency that could be biased in either direction include: rodent to human dose extrapolation; the use of only one dose level in the bioassay; and the assumption that the dose schedule in the bioassay is applicable to the exposures in this HRA.

4.7 Ecological Evaluation

U.S. EPA (1993) has indicated that a Phase I ecological risk assessment (as described in U.S. EPA, 1992b) for McClellan AFB should be completed as part of the ongoing remedial investigations, and should have

a basewide scope. The basewide scope will allow the simultaneous evaluation all potential ecological impacts. This section describes the available OU B1 information on stressor characteristics, ecosystems potentially at risk, and potential exposure pathways that could be incorporated into a basewide Phase I ecological risk assessment.

Stressor Characteristics

The COCs identified in Section 4.1 are the compounds at OU B1 most likely to potentially impact ecosystems. Ecosystem impacts from PCBs, PCDD/F and mercury may be significant because of their elevated concentrations and bioaccumulation potential. Most non-COCs would be unlikely to cause significant ecosystem impacts because of their low concentrations or low human toxicities. However, because chemicals with low human toxicities do not necessarily have minor ecosystem effects, all chemicals reported at OU B1 should be initially screened for potential ecological impacts.

Ecosystems Potentially at Risk

In a preliminary ecological survey (U.S. EPA, 1993) of McClellan AFB, four critical habitats were identified: Don Julio Creek and adjacent grasslands with vernal pools; the Western Collection Ponds; Magpie Creek; and Robla Creek.

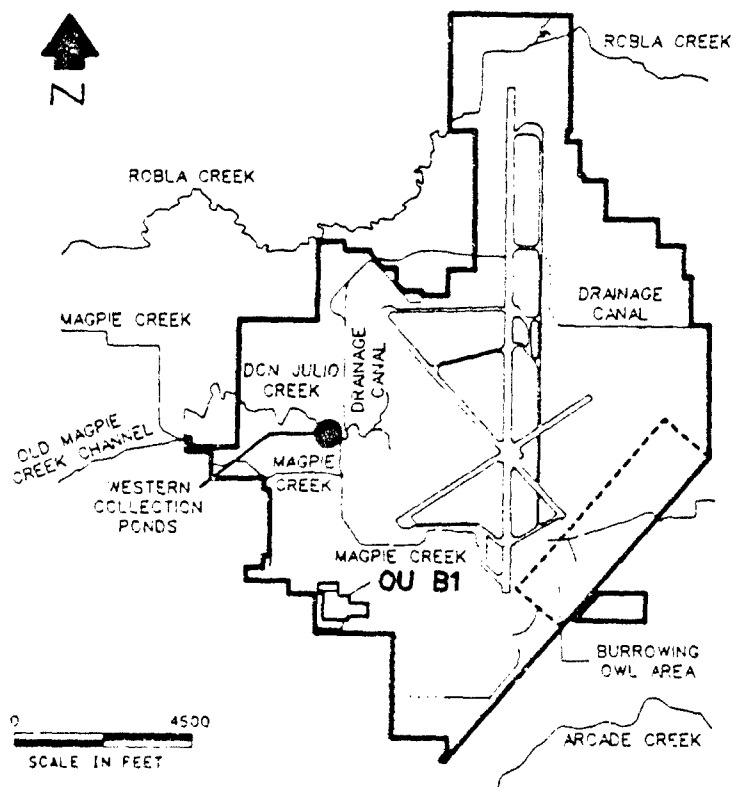


Figure 4-3. Areas of Significant Ecological Resources

In addition, the burrowing owl, designated a "species of special concern" by California Department of Fish and Game, was identified at McClellan AFB. The locations of these significant ecological resources are ecological resources in adjacent off-base areas were not addressed.

No significant ecological resources on OU B1 were specifically identified in the U.S. EPA report (1993). Most of this highly developed area is covered with perforated steel planking, buildings, and asphalt. Vegetation or wildlife food sources are essentially non-existent except in the grass areas between the DRMO and CE yards. The only wildlife that may be present at the DRMO are small mammals and birds that are typically found in non-natural areas. The drainage ditches from the DRMO yard may occasionally be used by wildlife as a water source but their importance is minimized by fences restricting access and the ephemeral nature of the drainages. Some sections of these ditches contain small patches of grasses and weedy plant species, but are not considered to be a useful ecological resource.

Potential Exposure Pathways

Magpie Creek is the primary ecological resource that could be significantly affected by contaminants at OU B1. The temporary plastic liner that was recently installed at DRMO should significantly reduce the amount of PCBs and PCDD/F that could run off into these ditches. The more permanent, low permeability cap, described in Section 8.0, would reduce contaminant runoff even further.

Burrowing owls could also be affected by the OU B1 contamination if they inhabit the grassy area between the storage yards, the grassy fields immediately south of OU B1, or the drainage ditches. Although this is not the

primary burrowing owl habitat on base, the recommended burrowing owl census (U.S. EPA, 1993) would determine if the owls occur in this area. The potential exposure pathways would be direct contact with soil, ingestion of contaminated food (primarily insects), and inhalation of vapors in burrows and ambient air. Potential exposures to contamination at PRL-29 would be virtually eliminated if the contaminated soils are excavated and buried beneath the low permeability cap.

5.0 REMEDIAL ACTION OBJECTIVES

Sections 5.0 through 8.0 comprise the FS portion of this report. The site characterization information, together with the evaluation of the contaminant transport and risk analysis, i.e., Sections 1.0 through 4.0, have defined the problem. The FS will now evaluate potential solutions to the problem.

5.1 General and Specific Remedial Action Objectives

Overall goals for the OU B1 remedial action are to:

- Protect human health by reducing the risk from the potential exposures identified in the human health evaluation;
- Protect environmental receptors;
- Restore contaminated media for present and future land use;
- Protect uncontaminated media; and
- Expedite site cleanup by applying the U.S. EPA Superfund Accelerated Cleanup Model goals.

Another goal of the remedial action is to keep DRMO operational. The DRMO is an integral part of the mission of McClellan AFB. Any significant disruption of DRMO's operations would adversely affect the ability of base personnel to carry out that mission.

Specific remedial action objectives derived from these goals are identified in Table 5-1. To meet these specific objectives, a range of remedial alternatives have been

developed to allow an appropriate, cost-effective remedial action to be selected.

5.2 Statutory Requirements, ARARs, and TBCs

The NCP established a general requirement that remedial response actions "attain or exceed applicable or relevant and appropriate federal requirements (ARARs)." An ARAR is any standard, requirement, criterion, or limitation under a federal or state law that either addresses a specific hazardous substance, pollutant, remedial action, location or other Superfund site circumstance; or addresses problems or situations sufficiently similar to those at a Superfund site for which their use is well suited. All ARARs must be identified on a site-specific basis from information about specific chemicals at the site, specific features of the site, and actions that are being considered as remedies. "To-Be-Considered" (TBCs) are guidance documents and other non-regulatory directives that carry less regulatory weight than ARARs, but can be used to help direct remedial actions.

Key ARARs and TBCs considered in this FS are as follows:

- Toxics Substances Control Act (TSCA)
 - For PCB cleanup, contaminated soil regulated under TSCA must be disposed into a landfill meeting TSCA standards or treated to an incineration equivalent of 2 mg/kg.
- California Code of Regulations, Title 22
 - These state requirements regulate the management of hazardous wastes. California has been authorized by the U.S. EPA to

TABLE 5-1. SPECIFIC REMEDIAL ACTION OBJECTIVES FOR OU B1

-
- Prevent contaminant exposure to the public and the environment through the protection of groundwater, surface water, air, and direct contact pathways.
 - Reduce the site's cancer risk to less than 1×10^{-6} , and reduce the noncarcinogenic hazard index to less than one.
 - Meet ARARs.
 - Remediate soils containing > 10 mg/kg PCBs from the surface to 3 feet BGS, > 100 mg/kg PCBs for soils > 3 feet BGS, and > 1 $\mu\text{g/kg}$ dioxin/furan (2,3,7,8-TCDD equivalent).
 - Remediate drainage sediments to the extent that one of the following is met: contaminant concentrations in sediments are equal to or less than background levels; excess cancer health risk is less than 1×10^{-6} ; or noncarcinogenic Hazard Index is less than 1.
 - Select alternatives that include treatment, where applicable and practicable, particularly for principal threats, i.e., for soils containing > 500 mg/kg PCBs.
 - Contain soils that pose a long-term threat where treatment is not practicable.
 - Prevent the migration of contaminated soil particles to OU B1 ditches and Magpie Creek.
 - Ensure that discharges from OU B1 ditches cannot cause the receiving water to exceed any of the listed concentrations in the California Inland Surface Waters Plan or McClellan AFB stormwater discharge permit.
 - For capping alternatives, cap must:
 - Hold up under current DRMO operations;
 - Allow minimal rainwater infiltration;
 - Have a design life span of 30 years;
 - Allow for potential future treatment of PCB principal threats;
 - Prevent erosion of soil beneath cap; and
 - Be maintained throughout its design life to eliminate direct contact and inhalation pathways.
 - Optimize cost/risk reduction quotient.
 - Include potential for "dual track" remediation (i.e., perform expedited remedial action now and continue to evaluate options to further remediate contaminated soil in future).
 - Implement institutional controls to 1) mitigate short-term impacts and/or 2) supplement engineering controls.
 - Consolidate contaminated soils and sediment from discrete areas (PRL 29, PRL 50, drainage ditches) at OU B1 to optimize remediation.
 - Reduce potential for VOC migration and construct wells to monitor VOCs in soil gas.
-

ARARs = Applicable or Relevant and Appropriate Requirements.
 DRMO = Defense Reutilization and Marketing Office.
 PCBs = Polychlorinated biphenyls.
 2,3,7,8-TCDD = 2,3,7,8-Tetrachlorodibenzo-p-dioxin.
 mg/kg = Milligrams per kilogram.
 $\mu\text{g/kg}$ = Micrograms per kilogram.

implement RCRA; these requirements, therefore, include all aspects of RCRA as well as more stringent state requirements, such as the inclusion of PCBs in the definition of hazardous wastes. Although Title 22 regulates hazardous wastes, it has broad implications for site cleanups.

- Sacramento Metropolitan Air Quality Management District (SMAQMD) Regulations
 - The SMAQMD regulations would limit discharge of hazardous constituents during excavations as well as place controls on emissions from treatment devices used to treat OU B1 soils.
- OSWER Directive No. 9355.4-01 (the "U.S. EPA PCB Cleanup Guidance") (U.S. EPA, 1990)
 - This document is a TBC recommends that, for industrial sites, soils containing PCB concentrations exceeding 10 mg/kg will generally require some type of remediation. Additionally, soils with PCBs exceeding 500 mg/kg are defined as principal threats, which are expected to be treated, if practicable.
- California Code of Regulations, Title 23, Division 3, Chapter 15.
 - These state requirements regulate the discharge of waste to land. Construction standards for engineered caps can be exempted if performance standards, i.e., protection of groundwater, are achieved.

Additional information on these and other potentially applicable OU B1 ARARs is presented in Appendix E.

5.3 Interim Remediation Goals

The primary COCs for OU B1 soils are PCBs and dioxins. Secondary COCs include metals and volatile organic compounds (e.g., TCE and 1,1-DCE). The FS is designed to address primary COCs, though the effect on secondary COCs, which can still be addressed under other CERCLA actions, is considered. The primary media of concern are soils and drainage ditch sediments. The exposure pathways that pose the most risk are soil ingestion and dermal contact with contaminated soils, as discussed in Section 4.0.

An interim remediation goal for OU B1 is to reduce OU B1's excess cancer risk less than 1×10^{-6} and to reduce the noncarcinogenic hazard index (HI) to less than one. Media- and chemical-specific ARARs and TBCs have been identified addressing the chemicals of concern and the desire to meet these goals.

The Agency for Toxic Substances and Disease Registry (ATSDR) has released a Public Health Assessment report for McClellan AFB, which was discussed at public meetings in March and May 1993. After that report is finalized, it may be considered a "TBC" document.

Interim remediation goals and general response actions are summarized for soil, surface water, sediment, and groundwater in Table 5-2.

The soil, sediment, and surface water cleanup standards were selected based on protectiveness criteria and the requirements of law.

TABLE 5-2. SUMMARY OF INTERIM REMEDIATION GOALS AND GENERAL RESPONSE ACTIONS FOR OU B1,
McClellan AFB

Media	COC	Remediation Goals	General Response Action	Comment
Surface Soil (0-3) feet BGS)	PCBs	10 mg/kg	No Action	Cleanup level based on Guidance on Remedial Actions for Superfund Sites with PCB contamination ^a
	Dioxin and furans	1 µg/kg TCDDeq ^b	Institutional Control Containment	Cleanup level based on approved dioxin clean-up levels at similar sites.
	Inorganics	To be determined	Excavate and dispose Excavate, treat, and dispose	Inorganic cleanup levels will be established using the decision logic shown on Figure 5-1. The cleanup level will be based on a 10 ⁻⁴ cancer risk, an HI < 1, or surface soil background concentrations.
Subsurface Soil (> 3 feet BGS)	PCBs	100 mg/kg	In-situ treatment	Cleanup level based on Guidance on Remedial Actions for Superfund Sites with PCB contamination ^a
	Dioxin and furans	1 µg/kg TCDDeq ^b	Same as above.	Cleanup level based on approved dioxin clean-up levels at similar sites.
	Inorganics	To be determined		Inorganic cleanup levels will be established using the decision logic shown on Figure 5-1. The cleanup level will be based on a 10 ⁻⁴ cancer risk, an HI < 1, or subsurface soil background concentrations.
Stream Sediment	PCBs	To be determined	Same as for soil.	Inorganic cleanup levels will be established using the decision logic shown on Figure 5-1. The cleanup level will be based on a 10 ⁻⁴ cancer risk, an HI < 1, or sediment soil background concentrations.
	Dioxin and furans	1 µg/kg TCDDeq ^b		Cleanup level based on approved dioxin clean-up levels at similar sites.
	Inorganics	To be determined		Inorganic cleanup levels will be established using the decision logic shown on Figure 5-1. The cleanup level will be based on a 10 ⁻⁴ risk, a HI < 1, or sediment soil background concentrations.

(Continued)

TABLE 5-2. (Continued)

Media	COC	Remediation Goals	General Response Action	Comment
Surface Water	PCBs; dioxins and furans; inorganics	Varies	Same as for soil.	Discharges from OU B1 ditches cannot cause receiving waters to exceed criteria established in the California Inlands Surface Water Plan and McClellan AFB Storm Water Discharge Permit (NPDES No. CA0004359). A monitoring program will be established to confirm this.
Groundwater	PCBs; dioxins and furans	None identified.	None.	No remediation goals will be developed for groundwater. The need for remedial action for groundwater impacts from OU B1 sources will be considered in a separate groundwater Operable Unit. Modeling has indicated that PCBs and dioxins will not migrate to groundwater at OU B1.

* Based on CSWWR Directive No. 9355.4-01 (U.S. EPA), 1990.

^b The 1 $\mu\text{g/kg}$ concentration is the sum of all dioxin and furan isomers, reported as a 2,3,7,8-TCDD-equivalent concentration.

BGS = Below ground surface

COC = Contaminant of concern

mg/kg = Milligram per kilogram

PCB = Polychlorinated biphenyls

TCDD = TCDD equivalents

$\mu\text{g/kg}$ = Microgram per kilogram

5.3.1 Soil and Stream Sediment

PCBs — Interim cleanup standards have been set at 10 mg/kg for soils from 0 to 3 feet BGS and 100 mg/kg for soils greater than 3 feet BGS. This is consistent with soil cleanup standards for PCB spills at industrial facilities as described in the *Guidance on Remedial Actions for Superfund Sites With PCB Contamination* (Oswer Directive No. 9355.4-01, August 1990).

An interim cleanup standard for PCB in drainage sediments has not been determined; however, it will be based on a PCB concentration that either: is equal to a background concentration in sediments; results in 10^{-6} or less excess carcinogenic risk to receptors; results in an HI less than 1.0; or has no potential to adversely impact downstream ecologic receptors.

Dioxins and Furan Compounds — The cleanup standard has been set at 1 $\mu\text{g/kg}$ TCDDeq using I-TEFs for all soil and sediment. This cleanup standard is based on approved dioxin cleanup standards at similar Superfund sites.

Inorganic Species — Cleanup standards for inorganic species have not been established for OU B1. Figure 5-1 shows the decision logic that will be used to select cleanup standards for the inorganic species of concern at OU B1. The cleanup standard for individual inorganic species will be based on the concentration of the species that either: is equal to background concentration in surface, subsurface, or sediments; results in 10^{-6} or less excess risk to receptors; results in an HI less than 1.0; or has no potential to impact ecologic receptors.

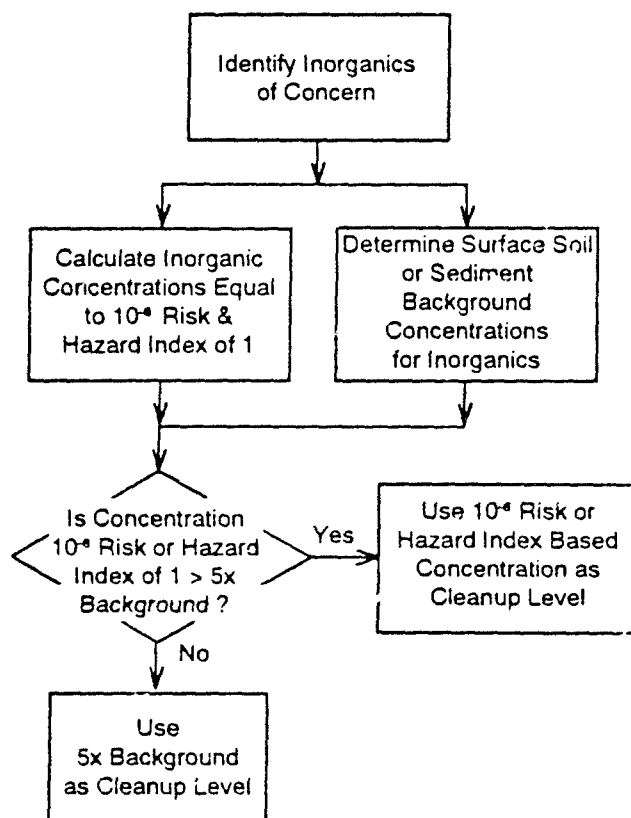
Operable Unit B1 ditches contain contaminated soil particles that were transported with surface water runoff from the DRMO storage yard. Therefore, any contaminated sediments requiring remediation will be brought back to the DRMO and consolidated with OU B1 soils. Since these sediments are within the "Area of Contamination," they can be consolidated at DRMO without invoking LDRs.

5.3.2 Surface Water

Specific cleanup standards have not been established for surface water in OU B1 drainage ditches. Any discharges of contaminated surface water from OU B1 must, however, comply with the overall guidance in the:

- *California Inlands Surface Water Plan (ISWP)*. Discharges from the OU B1 ditches cannot cause the receiving waters to exceed any of the listed concentrations (Tables 5-3 A and B).
- *McClellan AFB stormwater discharge permit (National Pollution Discharge Elimination System [NPDES] No. CA0004359)*. Discharge from the OU B1 ditches must comply with the NPDES permit and not cause exceedances of water quality objectives.

Any remedial actions taken at OU B1 will be designed to prevent contaminated sediment from being transported via surface water off OU B1. Any actions taken in ditches will be conducted to limit ecologic impacts in the ditches and downstream. Surface water concentrations should be monitored to determine if surface water runoff from OU B1 will cause exceedance of the ISWP or NPDES permit for McClellan AFB. A surface water monitoring program will be documented



NOTE: Risk concentrations based on Current Worker Scenario

Figure 5-1. Inorganic Cleanup Standard Determination for OU B1 Surface Soils and Sediments

MCCUB625 PM4 - VMG 5/25/93 SAC

TABLE 5-3A. RECEIVING WATER LIMITATIONS FROM THE INLAND SURFACE
WATERS PLAN: PROTECTION OF AQUATIC LIFE

Constituent	Unit	4-Day Average	Daily Average	1-Hour Average	Instantaneous Maximum
Arsenic	µg/L	190	—	360	AR
Cadmium	µg/L	a	—	a	—
Chromium (VI) ^b	µg/L	11	—	16	—
Copper	µg/L	c	—	c	—
Lead	µg/L	d	—	d	—
Mercury	µg/L	—	—	2.4	—
PCBs*	ng/L	—	14	—	—
Selenium	µg/L	5.0	—	20	—
Silver	µg/L	—	—	—	e
Zinc	µg/L	f	—	f	—

* See Appendix 1 in the Inland Surface Waters Plan for definition of terms.

• 4-Day Average cadmium, $e^{0.7852H - 3.490}$; 1-Hour Average cadmium, $e^{1.128H - 3.828}$. For example, where hardness is 50 mg/L, the 4-Day Average cadmium = 0.66 µg/L and the 1-Hour Average cadmium = 1.8 µg/L.

• Dischargers may, at their option, meet this limitation as total chromium.

• 4-Day Average copper = $e^{0.8545H - 1.465}$; 1-Hour Average copper = $e^{0.9422H - 1.464}$. For example, where hardness is 50 mg/L, the 4-Day Average copper = 6.5 µg/L and the 1-Hour Average copper = 10 µg/L.

• 4-Day Average lead = $e^{1.273H - 4.705}$; 1-Hour Average lead = $e^{1.273H - 1.480}$. For example, where hardness is 50 mg/L, the 4-Day Average lead = 1.3 µg/L and the 1-Hour Average lead = 34 µg/L.

• Instantaneous Maximum silver = $e^{1.72H - 6.52}$. For example, where hardness is 50 mg/L, Instantaneous Maximum silver = 1.2 µg/L.

• 4-Day Average zinc = $e^{0.8473H + 0.7614}$; 1-Hour Average zinc = $e^{0.8473H + 0.9604}$. For example, where hardness is 50 mg/L, the 4-Day Average zinc = 59 µg/L and the 1-Hour Average zinc = 65 µg/L.

**TABLE 5-3B. RECEIVING WATER LIMITATIONS FROM THE INLAND SURFACE
WATERS PLAN: PROTECTION OF HUMAN HEALTH**

Constituent	Existing or Potential Sources of Drinking Water		Other Waters	
	Unit	30-Day Average	Unit	30-Day Average
<u>Noncarcinogens**</u>				
Cadmium	µg/L	10	—	—
Chromium (VI)*	mg/L	0.05	—	—
Copper	µg/L	1,000.0***	—	—
Lead	µg/L	50.0	—	—
Mercury	ng/L	12	ng/L	12
Selenium	µg/L	10	—	—
Silver	mg/L	0.05	—	—
Zinc	mg/L	5.0***	—	—
<u>Carcinogens**</u>				
Arsenic	µg/L	5.0	—	—
Benzene	µg/L	0.34	µg/L	21
PCBs*	pg/L	70	pg/L	70
TCDD* equivalents	pg/L	0.013	pg/L	1 0.014

* Dischargers may, at their option, meet this limitation as total chromium.

* = See Appendix 1 in the Inland Surface Waters Plan for definition of terms.

** = Certain discharges may be subject to more stringent requirements pursuant to Chapter 6-6 of Div. 20 of the California Health & Safety Code.

*** = Taste and/or odor-based objectives.

mg/L = Milligram(s) per liter; µg/L = microgram(s) per liter; ng/L = Nanogram(s) per liter.

pg/L = Picogram(s) per liter; "—" = not applicable.

in the Remedial Design/Remedial Action (RD/RA) Work Plan, approved by the agencies, and enforceable.

Remediation goals for VOCs were not identified because the migration of VOC contamination in the vadose zone and to the groundwater are being considered in a separate SVE Operable Unit.

5.4 Areas and Volumes of Contaminated Soil Subject to Remedial Action

The areal extent of contaminated soils in OU B1 is shown in Overlay B for PCBs, and Overlay C for dioxins.

Polychlorinated Biphenyls

The PCB contamination at OU B1 is primarily located in the DRMO yard. Widespread, low-level PCB contaminated soils have also been reported in the drainage ditches receiving runoff from the DRMO yard. The areas with soils exceeding 10 mg/kg PCB on Overlay B are those areas potentially needing remedial action. The areas with soils exceeding 100-500 mg/kg PCB in Overlay B are those considered the PCB "hot spot" or principal threat.

Dioxins and Furans

The areal extent of dioxin- and furan-contaminated soils in OU B1 is primarily confined to the DRMO yard, and correlates to some extent with PCB contaminated soils. Dioxin/furan contamination in ditch sediments is in generally the same area of the ditches as the PCB contamination.

Area and Soil Volume Estimates

The areal and vertical extent of PCB-contaminated soils are based on sampling results (see Section 2.0) from the RI. Table 5-4 summarizes the area and volume of PCB-contaminated soils in OU B1.

5.5 General Response Actions

The identification of remedial action objectives and ARARs, together with the evaluation of media and COC-specific remediation goals, has led to the selection of the following potential general response actions:

- 1) No action
- 2) Institutional controls
- 3) Containment
- 4) Excavate and dispose
- 5) Excavate, treat and dispose
- 6) In-situ treatment

The remainder of the FS will now examine technologies, process options and alternatives that can implement these response actions.

**TABLE 5-4. AREA AND VOLUME CALCULATIONS FOR PCB-CONTAMINATED
SOIL AT OU B1**

Area of Interest	Areal Extent (ft ²)	Depth of Contamination (ft)	Volume (cubic yards)	Volume Plus 15% Swell Factor (cubic yards)
PCBs > 500 mg/kg	12,000	7	3,111	3,578
PCBs > 100 mg/kg	18,800	1.5-7	3,826	4,400
PCBs 10-500 mg/kg	124,000	1.5	6,889	7,922
Drainage ditches (4,775 feet long*)	27,050	1	1,002	1,152
TOTAL Volume:				12,652

* Width varies from 4 feet to 7 feet.

6.0 DEVELOPMENT AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

Preliminary screening of the general response actions, remedial technologies, and process options that could be used to remediate OU B1 are discussed below.

6.1 Identification of General Response Actions and Remedial Technologies

The six proposed response actions and the remedial technologies associated with each are shown in Table 6-1.

6.1.1 No Action

This response action consists of leaving OU B1 as it is. Presently the areas with the highest PCB concentrations within OU B1 are fenced and access is restricted to DRMO workers and other personnel on a "permission basis."

6.1.2 Institutional Controls

Institutional controls would consist of deed and land use restrictions and additional controls to restrict access. Monitoring would be performed to determine if migration is occurring. Physical controls would prevent access to the site and would include fencing and hazardous waste warning placards.

6.1.3 Containment

Containment prevents migration by capping or installing vertical barriers. Capping would reduce the infiltration of rain water, prevent direct contact with and inhalation of contaminated soil, and prevent contaminant migration to surface water. The cap could be constructed of asphaltic concrete,

concrete, and/or a synthetic liner. Proper sub-base preparation and grading to drain rain water would be incorporated into the cap design. Vertical barriers would prevent lateral migration of contaminants.

6.1.4 Excavation and Disposal

This action would remove contaminated soil from the site and dispose of it in a landfill. Disposal options include off-site disposal in a TSCA-permitted landfill, off-site disposal in a non-TSCA landfill, or on-site (at McClellan AFB) reburial.

6.1.5 Excavation, Treatment, and Disposal

Contaminated soil would be excavated, treated either on or off site, and the treated soil would be disposed. This action includes technologies that remove and/or destroy the COCs in the soil. Within the response action, several treatment technology groups were identified. These include:

- Extraction with subsequent destruction or disposal;
- Stabilization/solidification;
- Chemical treatment;
- Biological treatment; and
- Thermal destruction.

Extraction removes the contaminants by either thermal desorption or solvent extraction. Thermal extraction technologies heat the waste to volatilize the COCs. Solvent extraction involves introducing solvents, surfactants, or acidic or caustic aqueous solutions so that they contact the contaminated soil. Washing and rinsing fluids are needed to complete the extraction process. The soil is dewatered and

Table 6-1. Initial Screening of Remedial Technologies and Process Options for Soil

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No Action	Evaluation required by NCP
Institutional Controls	Access Restrictions	Deed Restrictions	Restricts property transfer	Potentially applicable
		Land Use Restrictions	Restricts property use	Potentially applicable
		Fencing	Restricts access	Potentially applicable
	Monitoring	Groundwater Soil Pore Moisture Collection and Analysis Soil Gas Monitoring	Monitors for impact Monitors for migration Monitors for migration	Potentially applicable Potentially applicable Not applicable to semivolatiles. Excavation systems not effective
Containment	Capping	Asphalt	Isolates waste with asphalt	Potentially applicable
		Concrete	Isolates waste with concrete	Potentially applicable
		Multimedia	Isolates waste with a composite of materials	Potentially applicable
	Vertical Barrier	Slurry Wall Grout Curtain Sheet Piles	Reduces lateral permeability of soil Reduces lateral permeability of soil Reduces lateral permeability of soil	Small amount of migration will be lateral. Contaminants will migrate mostly downward. Small amount of migration will be lateral. Contaminants will migrate mostly downward. Small amount of migration will be lateral. Contaminants will migrate mostly downward.
Excavation and Disposal	Off-Site Disposal	RCRA/TSCA Landfill	Direct disposal in a hazardous/TSCA landfill	Potentially applicable
		Industrial Landfill	Disposal in an industrial waste landfill	Applicable only to treated soil. Direct disposal not applicable under current regulations.
	On-Site (McClellan AFB) Disposal	Backfill	Reburial of treated soil	Applicable only to treated soil. Direct disposal not applicable under current regulations.
Excavation, Treatment, and Disposal	Extraction	Solvent Extraction	Extraction with a solvent	Potentially applicable
		Low Temperature Thermal	Desorbs contaminants	Potentially applicable
		Soil Washing	Extraction with water	Contaminants have low solubility. Extraction in washing fluid not effective.
		Ultrasonic	Extraction using ultrasonic waves	Potentially applicable
		Acid Leaching	Extraction with an acid solution	Contaminants not acid extractable
		Electro-Osmosis	Extraction using electrodes and purge solution	Not applicable to PCBs/dioxins

BOLD BLUE TYPE denotes process options or remedial technologies that have been selected for further analysis.

Table 6-1. (Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Excavation, Treatment, and Disposal (Cont.)	Stabilization/Solidification	Stabilization	Immobilizes with Stabilizing Agents	Potentially applicable
		Fixation	Immobilizes with Fixating Agents	Potentially applicable
		Glycolate Dechlorination	Removes chlorine from compounds	Potentially applicable
	Chemical	Catalytic Wet Air Oxidation	Oxidizes contaminants	Potentially applicable
		Reduction	pH shift/precipitation	Not applicable to PCBs/dioxins
		Base-Catalyzed Decomposition	Hydrolyzes chlorine, volatilize PCB	Potentially applicable
		Gas-Phase Thermo-Chemical Reduction	Reduction of contaminants	Potentially applicable
		Solvated Electron Solution Dehalogenation	Destroys chlorinated compounds	Potentially applicable
	Biological	Land treatment	Biologically breaks down contaminants	Not applicable to PCBs Breakdown rate very slow.
		Composting	Biologically breaks down contaminants	Not applicable to PCBs Breakdown rate very slow.
		Slurry Phase Bioreactor	Biologically breaks down contaminants	Not applicable to PCBs Breakdown rate very slow.
		Rotary Kiln	Thermally destroys contaminants	Potentially applicable
		Rotary Kiln	Thermally destroys contaminants	Potentially applicable
	Off-Site Incineration	Infrared	Thermally destroys contaminants	Potentially applicable
		RCRA/TSCA Landfill	Direct disposal in a hazardous/TSCA landfill	Not applicable. Soil will have been treated and no longer be hazardous.
		Industrial Landfill	Disposal in an industrial waste landfill	Applicable to treated soil
In-Situ Treatment	On-Site Disposal	Backfill	Reburial of treated soil	Applicable to treated soil
		Soil Vapor Extraction	Extracts with vacuum	Contaminants low volatility. Extraction with a vacuum system not effective.
		Soil Washing	Extracts with water	Contaminants have low solubility. Contaminants not extractable with washing fluids.
	Extraction	Solvent Extraction	Extracts with a solvent	Potentially applicable
		Landfarming	Biologically breaks down contaminant	Not applicable to PCBs. Very slow breakdown rate.
		Vitrification	Oxidizes organics, stabilizes inorganics in vitreous solid	Potentially applicable
	In-Situ Thermal Destruction	Stabilization	Immobilizes with stabilizing agents	Potentially applicable
		Fixation	Immobilizes with fixating agents	Potentially applicable
		Stabilization/Solidification		
	Stabilization/Solidification	Stabilization	Immobilizes with stabilizing agents	Potentially applicable
		Fixation	Immobilizes with fixating agents	Potentially applicable
		Stabilization/Solidification		

BOLD BLUE TYPE denotes process options or remedial technologies that have been selected for further analysis.

MOU-5-5148-21-54C

used as backfill. Solvents and other process fluids containing the COCs must be collected and treated.

Stabilization/solidification is the fixation of the contaminants in a matrix that greatly reduces their leaching potential. The additives used to stabilize contaminants are typically cement, fly ash, vitrified carbon, asphalt, or lime. The technology does not change the chemistry of the contaminants or their toxicity; however, contaminant concentrations are reduced by dilution with the stabilizing agent. The solid residual typically must be monitored to confirm that no leaching is occurring.

Chemical treatment changes the chemistry of the COCs, creating non-toxic or less-toxic residuals. Most chemical processes remove the chlorine atoms from PCBs and dioxins, and may also break down the biphenyl and dibenzo rings. The process typically requires drying, mixing dechlorination compounds, heating, reacting, washing, and dewatering. Process fluids may require additional treatment.

Biological treatment uses biological organisms to metabolize the contaminants, breaking them down into non-toxic substances (typically carbon dioxide and water). Compound-targeted organisms, nutrients, and proper moisture conditions are needed for this technology. The time required to achieve remediation objectives depends upon the target clean-up concentration, the organism population, and the metabolism rate.

Thermal destruction involves the high temperature oxidation or pyrolysis of organic compounds. Air emission controls are needed to prevent discharges to the atmosphere. The treated soil or ash is typically used as backfill

after testing to demonstrate that the destruction of organics did not concentrate or mobilize inorganic compounds.

6.1.6 In-Situ Treatment

In-situ treatment is the destruction, removal, or stabilization of contaminants at the site without excavation. Treatment is done at and below grade. Except for chemical treatment, the technologies described under the excavation, treatment, and disposal response action are potentially applicable as in-situ processes.

6.2 Evaluation and Selection of Process Options

For each remedial technology, specific process options were identified and a first level screening was conducted. The screening considered the applicability of the technology and the specific process option. If a process option was not applicable, the option was dropped. The process options eliminated from further consideration and the reasons for elimination are shown on Table 6-1.

The process options remaining were evaluated by applying the following three CERCLA criteria:

Effectiveness — The ability of the process option to protect human health and the environment. "Effectiveness" includes the amount of hazardous material treated and/or destroyed; the amount remaining on site; the degree of expected reduction in mobility, toxicity, or volume of contaminants; the short-term reductions of risk during construction and implementation; and the long-term reduction of risk once the remedial actions are completed.

Table 6-2. Summary of Evaluation of Process Options for Soil

General Response Action	Remedial Technology	Process Option	Effective?	Implementable?	Cost
No Action	None	None	Not effective	Yes	Minimal monitoring costs
Institutional Controls	Access Restrictions	Deed Restrictions	Limited effectiveness, subject to deed conditions	Yes	<\$50/ton
		Land use Restrictions	Limited effectiveness, subject to use restrictions	Yes	<\$50/ton
		Fencing	Limited effectiveness, prevents access	Yes	<\$50/ton
	Monitoring	Groundwater	Identifies migration only after release to groundwater has occurred	Yes	<\$50/ton
Containment	Capping	Soil Pore Moisture Collection and Analysis	Provides early warning on migration of contaminants, before impact on groundwater	Yes	<\$50/ton
		Asphalt	Conditionally effective; cap requires maintenance	Yes	<\$100/ton
		Concrete	Conditionally effective; cap requires maintenance	Yes	\$100-250/ton
		Multimedia	Conditionally effective; cap requires maintenance	Yes	\$100-250/ton
Excavation and Disposal	Off-Site Disposal	RCRA/TSCA Landfill	Conditionally effective; landfill requires monitoring	Yes	\$250-500/ton
Excavation, Treatment, and Disposal	Extraction	Solvent Extraction	Effective on soil, secondary waste produced	Yes	\$100-200/ton
		Low Temperature Thermal	Effective on soil, secondary waste produced	Yes	\$100-200/ton
		Ultrasonic	Effective on soil, secondary waste produced	Conditional; requires significant pilot testing	Unknown
	Thermal On- or Off-Site Incineration	Rotary Kiln	Yes	Yes	>\$750/ton
		Infrared	Yes	Yes	\$250-500/ton
	Stabilization/Solidification	Stabilization	Conditionally; waste left on site, migration controlled	Yes	\$100-250/ton
		Fixation	Conditionally; waste left on site, migration controlled	Yes	\$100-250/ton
	Chemical	Glycolate Dechlorination	Yes, contaminants destroyed, secondary waste produced	Conditional; requires significant pilot testing	\$250-500/ton
		Catalytic Wet Air Oxidation	Yes, contaminants destroyed, secondary waste produced	Conditional; requires significant pilot testing	\$100-250/ton

MOUSE: 21102 24-24C

BOLD BLUE TYPE denotes process options or remedial technologies that have been selected as representative for further analysis.

Table 6-2. (Continued)

General Response Action	Remedial Technology	Process Option	Effective?	Implementable?	Cost
Excavation, Treatment, and Disposal (cont.)	Chemical (cont.)	Base-Catalyzed Decomposition	Yes, contaminants destroyed, secondary waste produced	Conditional; requires significant pilot testing	\$100-250/ton
		Solvated Electron Solution Dehalogenation	Destroys chlorinated compounds	Conditional; requires significant pilot testing	\$345/ton
	Off-Site Disposal	Gas-Phase Thermo-Chemical Reduction	Yes, contaminants destroyed, secondary waste produced	Conditional; requires significant pilot testing	\$400-1000/ton
	On-Site Disposal	Industrial Waste Landfill	Yes	Yes	<\$100/ton
In-Situ Treatment	Extraction	Backfill	Yes	Yes	<\$100/ton
		Solvent Extraction	Conditionally; remediates soil, contaminants groundwater; must capture and treat groundwater	Marginally; requires groundwater collection system	\$250-500/ton
	In-Situ Thermal Destruction	Vitrification	Yes, destroys contaminants	Poor; would have long-term effect on DRMO (cooling time for melt and DRMO shut down during implementation)	\$200/ton
		Stabilization	Effective on soil; residual remains	Marginally implementable; significant impact on DRMO	\$100-300/ton
	Stabilization/Solidification	Fixation	Effective on soil; residual remains	Marginally implementable; significant impact on DRMO	\$100-300/ton

BOLD BLUE TYPE denotes process options or remedial technologies that have been selected as representative for further analysis.

Implementability — The technical and administrative feasibility of the option, as well as the availability of the various services and materials that will be required. Technical feasibility generally refers to the ability to construct and reliably operate the process until the remedial goal is achieved. The administrative criteria include the ability to secure necessary permits for construction, operation, and disposal from the regulating agencies. Administrative feasibility also includes evaluation of the availability of treatment, storage and disposal facilities, technical specialists, and any special equipment that may be required.

Cost — Capital and/or lease costs, miscellaneous costs, and annual operations and maintenance (O&M) costs.

The results of the evaluation are shown on Table 6-2. To focus the identification of remedial alternatives in Section 7.0, representative process options were identified. The representative options reflect how other similar processes would score in the evaluation of alternatives and include:

- Access restrictions, soil pore liquid monitoring, and land use restrictions for the institutional controls option.
- An asphaltic cap for the capping option.
- Disposal in a TSCA landfill for the excavate and dispose option.
- Incineration for the treatment technology options. Both on- and off-site treatment were considered. Incineration is an effective, proven technology

that typically does not produce hazardous secondary wastes (although the ash could be hazardous depending upon metal content and leachability).

7.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

This section presents the results of the remedial action alternatives screening using the representative process options identified in Section 6.0.

7.1 Alternative Development and Screening Process

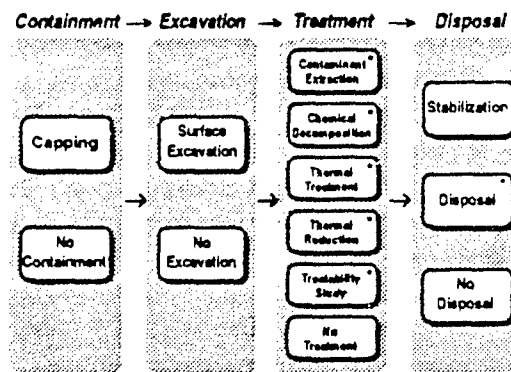
Potential risks to human health and the environment can be reduced by treating the contaminated media to clean-up standards, by eliminating migration pathways to receptors, or by a combination of these methods. In this section, the representative process options identified in Section 6.0 were assembled into alternatives to represent a full range of general response actions, from no action to excavation, treatment, and disposal.

The assembled alternatives were evaluated for effectiveness, implementability, and cost, per CERCLA guidance. The definitions of these criteria are the same as described in Section 6.2; however, unlike the evaluation of individual process options, the assembled alternatives were evaluated for the complete sequence of process steps required to complete the remedial action (e.g., excavation of the soils, mobilization of treatment equipment, treatment by solvent extraction, backfilling the treated soils, and incineration of the liquid extract).

7.2 Development and Screening of Alternatives

By combining the representative process options selected in Section 6.0, the following seven remedial alternatives were assembled. Two alternatives utilize the same

process options: excavation, treatment and disposal. The distinction between these alternatives is the treatment facility location on site (at McClellan AFB) or off site. The other alternatives utilize the same process option: capping. They differ in that one incorporates a commitment to continued evaluation of promising treatment process options. One alternative combines excavation and disposal of the principal threat (> 500 mg/kg PCBs) with capping.



NOTES: Alternatives are created by selecting one or more process options from each category: Containment, Excavation, Treatment, and Disposal. Institutional actions, such as deed and land use restrictions, or fencing with placard and/or security, may be implemented alone or in addition to the above process options.

* Indicates the option may be executed on- or off-site.

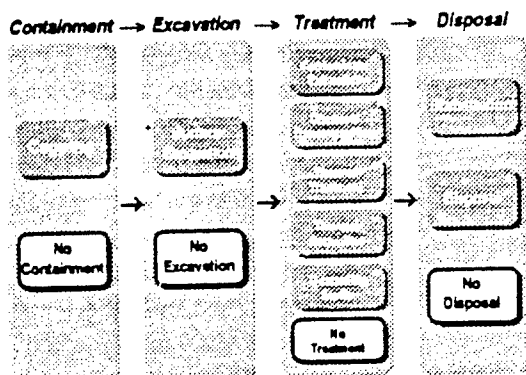
Remedial Process Options

Descriptions of the alternatives and the screening results are provided below.

7.2.1 No Action

Description — The no action alternative relies on natural physical, chemical, and biological processes to reduce contaminant concentrations over an extended period of time. No containment, disposal, or treatment process options are included in this alternative. This alternative includes monitoring of vadose zone, groundwater, and surface water.

Effectiveness — This alternative is not effective at protecting human health and the



* Indicates the option may be executed on- or off-site.

No Action Alternative

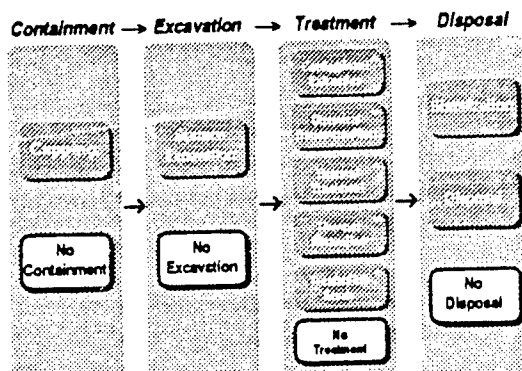
environment. Pathways for exposure via ingestion, dermal contact, and inhalation are not eliminated or reduced. No reduction in toxicity, mobility or volume is achieved. This alternative extends the time frame of potential exposure.

Implementability — The processes for approving no action alternatives are defined and have been implemented at contaminated sites. No obstacles to implementing this alternative are identified. The existing fence will continue to interfere with DRMO operations, restricting the free movement of vehicles, and limiting storage space.

Cost — Minimal costs are associated with this alternative.

7.2.2 Institutional Controls

Description — This alternative involves monitoring and access controls. Access controls include land use restrictions and installation of a perimeter fence with warning placards to prevent human and/or animal contact with contaminated soil. Vadose zone and groundwater monitoring are included to verify no migration is occurring. This alternative relies on the elimination of direct contact to reduce risks to human health and the



* Indicates the option may be executed on- or off-site.

Institutional Controls Alternative

environment, while only natural physical, chemical, and biological processes treat contaminants over time.

Effectiveness — This alternative partially protects human health and the environment. Inhalation exposure and off-site transport pathways are not reduced. This alternative extends the time frame of potential exposure.

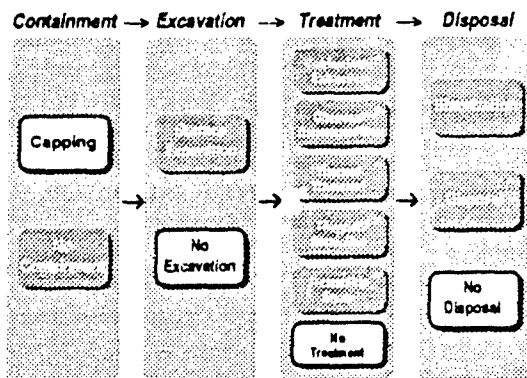
Implementability — The processes for acquiring deed and land use restrictions are known. Institutional control alternatives have been implemented at many contaminated sites. Except for fencing, this alternative will not interfere with DRMO operations.

Cost — The costs associated with this alternative range from \$20,000 to \$60,000 annually (\$1.24 to \$3.48 per ton, per year [\$37 to \$112/ton over 30 years]).

7.2.3 Capping

Description — This alternative involves the installation of an asphaltic concrete cap over all soil contaminated above the clean-up standards, including sediment from the ditches. It closes several migration pathways to reduce risks to human health and the

environment, and allows natural physical, chemical and biological processes to achieve the clean-up standards. For this alternative and all subsequent alternatives, the PSP would have to be removed and decontaminated.



* Indicates the option may be executed on- or off-site.

Capping Alternative

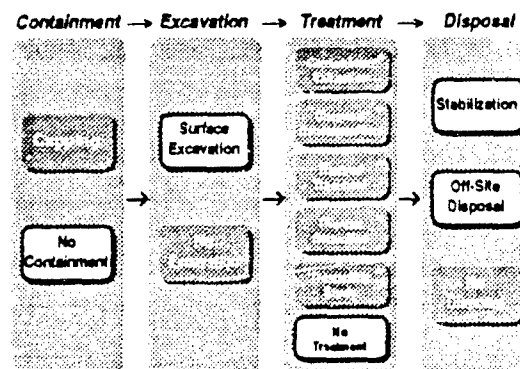
Effectiveness — Capping provides a significant reduction in the exposure potential via ingestion, dermal contact, and inhalation pathways. The long-term effectiveness of this alternative is dependant upon cap integrity. Minimization of exposure to contaminants is achieved very quickly.

Implementability — Capping is a proven technology. All materials and trained personnel are available to conduct this alternative and capping has been implemented at other contaminated sites. While OU B1 is being capped, DRMO operations will be affected; however, there is no long-term affect on DRMO.

Cost — The cost for capping the contaminated area is estimated to be between \$1,500,000 and \$2,500,000 (\$93/ton to \$155/ton), depending upon the amount of site preparation required and the selected design standards.

7.2.4 Excavation with Off-Site Disposal

Description — For this alternative, approximately 11,500 cubic yards of soil and sediment containing contaminants greater than the clean-up standards would be excavated and loaded into transport vehicles, weighed to ensure compliance with Department of Transportation (DOT) load requirements, properly manifested, and transported to a TSCA-permitted hazardous waste disposal facility. Additionally, for costing purposes, it is assumed that 20% of the soils must be stabilized to meet RCRA land disposal restrictions (LDRs) prior to disposal. Clean soil would be backfilled to restore the original grade of the site and all unpaved areas would be paved to allow DRMO operations to continue. This paving of unpaved areas applies to all subsequent alternatives that do not include capping.



* Indicates the option may be executed on- or off-site.

Excavation with Off-Site Disposal

Effectiveness — Contaminated soil above the clean-up standards is removed and isolated. Pathways for exposure are removed from the site and transferred to a permitted landfill that has engineering controls to minimize exposure risks.

Implementability — The presence of dioxins, PCBs, and potentially RCRA-hazardous levels of metals in the soil limits disposal

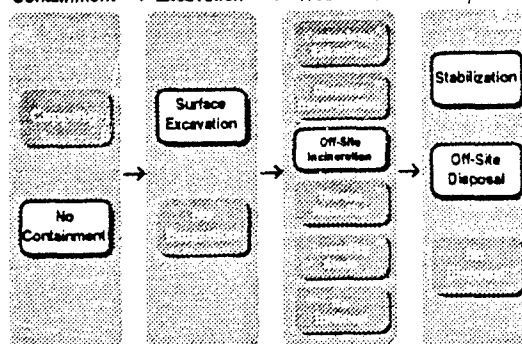
options to a few facilities. If TCLP concentrations are exceeded for metals, then the soils would require stabilization at the landfill to meet LDRs. Additionally, if total halogenated organic compounds (HOCs) exceed 1,000 mg/kg, incineration is required, and this landfill alternative would not be implementable. Polychlorinated biphenyls are included in the definition of HOCs for this LDR. Dioxins/furans do not cause LDRs to take effect unless the dioxins are from listed sources. Since dioxins are not the result of listed chemical waste processing activities, the OU B1 soils are not listed wastes for dioxin and LDRs do not take effect. This would apply to any alternative involving excavation. During excavation and backfilling, DRMO operations will be affected. Other significant potential problems include the need to control the generation and release of dust during excavation and to decontaminate excavation equipment. However, the alternative is relatively quickly implemented, and there are no long lasting effects on DRMO.

Cost — The cost is estimated to range from \$4,500,000 to \$6,000,000 (\$280/ton to \$373/ton), depending on permits required, facility disposal fees, and amount of soil requiring stabilization.

7.2.5 Excavation, Off-Site Incineration, and Disposal

Description — Approximately 11,500 cubic yards of contaminated soil and sediment would be excavated and transported to an off-site facility for destruction organic chemicals and stabilization. Incineration in a TSCA-permitted incinerator has been selected as representative of the applicable treatment process options. Treated soil exceeding LDR standards will require stabilization prior to disposal. Clean soil would be brought to OU

Containment → Excavation → Treatment → Disposal



* Indicates the option may be executed on- or off-site.

Excavation, Off-Site Incineration, and Disposal

B1 and backfilled. This alternative utilizes removal and treatment of the contaminated media and destruction of the contaminants to achieve clean-up standards.

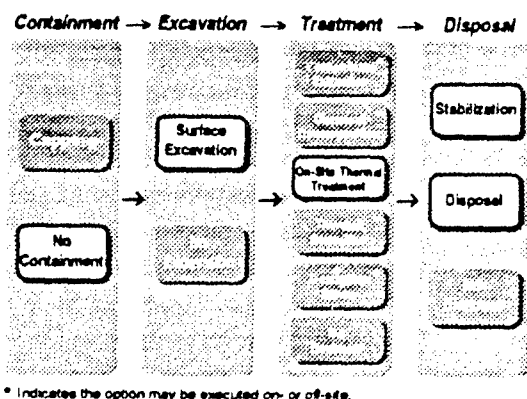
Effectiveness — Contaminated soil above clean-up levels is removed and destroyed. Potential groundwater and surface water impacts and the ingestion, dermal contact, and inhalation risks are removed.

Implementability — As with the disposal alternative, the presence of dioxins in the soil limits treatment options to a few facilities. There may be difficulties permitting excavation and transport of dioxins. While executing this alternative, DRMO operations will be affected. However, the alternative is relatively quickly implemented, and there are no long lasting affects on DRMO.

Cost — The cost for this alternative is considered to be high. The cost is estimated to exceed \$30,000,000 (\$1,860/ton).

7.2.6 Excavation, On-Site Treatment, and Disposal

Description — This alternative involves excavation and on-site treatment of approximately 9,200 cubic yards of conta-



Excavation, On-Site Treatment, and Disposal

minated soil. This alternative assumes that the other 20% of the contaminated soils (2,300 cubic yards) exceed RCRA LDRs for metals and should be sent directly to a RCRA disposal facility, since PCB treatment may not reduce metal concentrations. For costing purposes, this alternative assumes that a temporary incinerator meeting TSCA requirements would be brought on site for the duration of treatment. Contaminated soil would be excavated and processed through the incinerator; the resulting treated soil would be backfilled on-site. All combustion gasses would be collected and treated to SMAQMD emission standards. This alternative destroys contaminants to achieve clean-up standards.

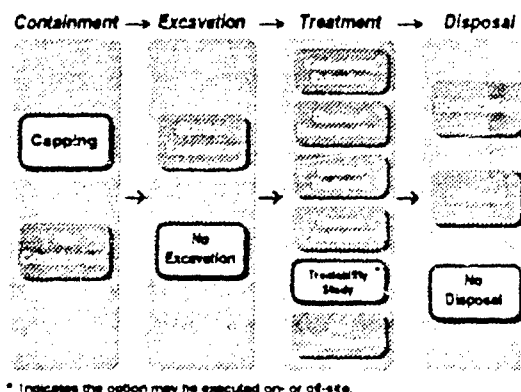
Effectiveness — This alternative removes and treats contaminated soil shown to be a threat to human health and the environment. Long-term, groundwater and surface water impacts, and the ingestion, dermal contact, and inhalation pathways are removed.

Implementability — There may be difficulty permitting an on-site treatment process due to the dioxins and PCBs in the soil. Also, it may not be possible to dispose the treatment residuals on-site because of the presence of dioxins, if treatment performance standards cannot be met. The availability of

an off-site disposal facility for the residuals may be limited. While executing this alternative DRMO operations will be affected. It is expected that approximately 1 to 3 years will be required to implement this alternative, due to community concerns and permitting barriers.

Cost — The cost for this alternative are considered to be high. The cost is estimated to range from \$15,000,000 to \$20,000,000 (\$932/ton to \$1,240/ton).

7.2.7 Capping and Treatability Studies with Potential On-Site Treatment



Capping with Continued Evaluation of On-Site Treatment

Description — This alternative involves capping OU B1 along with a commitment to continue evaluation of on-site treatment technologies. This would enable the Air Force to determine if potential technologies mature to the extent that they can be effectively utilized to meet the CERCLA preference for treatment of contaminated soil. Evaluation of potential treatment technologies may involve bench scale and/or pilot-scale testing with the soil matrix from OU B1.

Potential treatment technologies, bench-scale, and/or pilot-scale treatability

studies must meet the following performance criteria to be evaluated further for OU B1:

- The ability to initially achieve a PCB cleanup level of less than 500 mg/kg, with a further reduction to 10 mg/kg possible;
- The ability to destroy contaminants, leaving less than 10% of the original contaminant mass as a by-product; and
- The ability to achieve a cleanup level of less than 1 µg/kg for TCDDeq.

An annual report will also be prepared to document any results of treatability studies performed, new technology review, and recommendations for future treatability studies or selection of a treatment process for OU B1 soils.

The potential on-site treatment technologies that appear appropriate for continued evaluation include the following:

- **High Temperature Thermal Oxidation** involves the combustion of organic materials to produce carbon dioxide and water, which leave the process as flue gas, and ash residues derived from the non-combustible material in the soil matrix.
- **Base-Catalyzed Decomposition Process** is used to dechlorinate hydrocarbons, including PCBs and dioxin/furan compounds. The process replaces the chlorine ions with hydrogen, producing biphenyl and sodium chloride. Key variables in the reaction are temperature, base catalyst (i.e., sodium hydroxide) concentration and hydrogen donor concentration.

- **Gas-Phase Thermo-Chemical Reduction** is used to destroy chlorinated hydrocarbons such as PCBs, dioxins, and chlorinated pesticides. This process utilizes a proprietary soil/contaminant separation process followed by reduction of the separated contaminant phase in a thermal reactor in the presence of hydrogen (reducing agent).
- **Solvated Electron Solution Dehalogenation** selectively converts halogenated organic compounds, such as PCBs, to metal-halide salts and organic residuals. Contaminated soil is washed first with anhydrous ammonia to solubilize halogenated and nonhalogenated contaminants. Calcium metal is then used as the solvating agent to destroy halogenated compounds. Nonhalogenated compounds are recovered from the ammonia solution for separate treatment and/or disposal.
- **Solvent Extraction** is a type of soil washing technology utilizing a solvent as the contact medium to remove the COCs from the soil and concentrate them in a liquid phase. Various solvents can be used (e.g., triethylamine or propane). This process produces a liquid phase containing the COCs that requires further treatment.
- **Thermal Desorption** utilizes a rotary kiln to thermally desorb the hydrocarbon from the soil matrix. Light and heavy hydrocarbons are separated; the light hydrocarbons are recycled to the process as combustion fuel, and the heavy hydrocarbons containing the COCs are collected as an oil by-product. The oil by-product requires additional treatment.

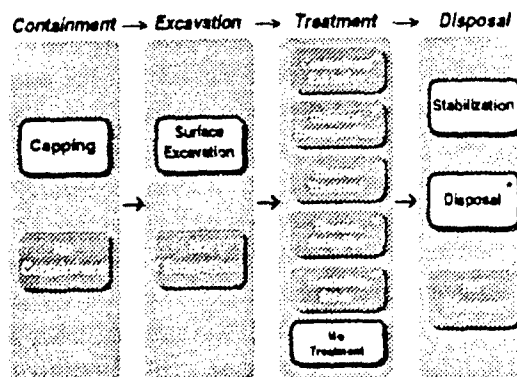
- **In Situ Biodegradation** utilizes indigenous microbes to biodegrade PCB and dioxins without disturbing the soil. Anaerobic bacteria would be used to dechlorinate higher PCB congeners through reductive dechlorination. Aerobic bacteria would then degrade the dechlorinated PCB congeners to carbon dioxide and water. Nitrogen, air, nutrients, and water would be introduced to achieve the desired environment under the cap.

Effectiveness — This alternative controls the migration of contaminants. Capping prevents infiltration of surface water, reducing the risk of contaminant transport to groundwater. Pathways for ingestion of contaminated soil, dermal exposure, and inhalation of contaminated dust are eliminated. Minimization of exposure to contaminants is achieved very quickly.

Implementability — Capping is a proven technology. All materials and trained personnel are available to achieve this alternative. Capping alternatives have been implemented at contaminated sites. Capping will not affect the execution of treatability studies or performing treatment at a later date. While executing this alternative DRMO operations will be affected. However, the alternative is relatively quickly implemented and there are no long lasting affects on DRMO.

Cost — For costing purposes, this alternative assumes six treatability studies will be performed over a 3-year period, with one of the studies proceeding as far as a pilot study. The cost for this alternative is estimated to range from \$2,000,000 to \$3,000,000 (\$124/ton to \$186/ton).

7.2.8 Excavation and Disposal of Principal Threat and Capping the Site



* Indicates the option may be executed on- or off-site

Excavation of Principal Threat Plus Capping

Description — This alternative combines excavating the site and capping, although only soils defined as "hot spots" or "principal threats" (i.e., PCB-contaminated soils greater than 100-500 mg/kg) would be excavated (approximately 4,400 cubic yards). As in Alternative 3, soil would be excavated and transported to a TSCA-permitted hazardous waste disposal facility to be stabilized and landfilled. Low level PCB-contaminated soils would be backfilled into the excavation to consolidate soils from discrete areas of OU B1. Approximately 35% (1,525 cubic yards) of the soils are assumed to require stabilization. Clean soil would also be backfilled to restore the original grade of the site and all unpaved areas would be paved to allow DRMO operations to continue.

Effectiveness — Contaminated soil above the principal threat is removed and isolated. Pathways for exposure are removed by the cap. The receiving landfill would be a permitted facility, engineered to minimize the risk of releases or exposures at the landfill site.

Implementability — The presence of dioxins and lead in the soil limits the disposal options to a few facilities. There also may be difficulties in meeting ARARs during the excavation and transport of the soils. If the wastes are determined to be RCRA hazardous wastes (i.e., TCLPs for metals are exceeded), LDRs must be complied with. Meeting SMAQMD requirements to suppress dust emissions and not create a nuisance could also create barriers to compliance and increase costs. During excavation, backfilling, and capping, DRMO operations will be affected. This alternative is relatively quickly implemented, so there are no long lasting effects on DRMO.

Cost — The cost for this alternative is considered moderate. The estimated cost is estimated to range from \$3,000,000 to \$4,500,000 (\$186/ton to \$280/ton), depending upon permits required and disposal fees.

This screening indicates that there is no significant difference between the no action and institutional controls alternatives. Therefore, the institutional controls alternative has been dropped from further consideration, and the no action alternative, with the addition of vadose monitoring to detect migration, is used as the base line case for the detailed evaluation in Section 8.0. The other alternatives do show significant benefit if implemented and have been carried forward for detailed analysis in Section 8.0.

8.0 ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

The seven remedial alternatives selected for detailed analysis in Section 7.0 are evaluated in this section. The evaluation is followed by a cost sensitivity analysis, in Section 8.2, and a comparative analysis, in Section 8.3. The cost sheets to support the cost estimates in this section are presented in Appendix F.

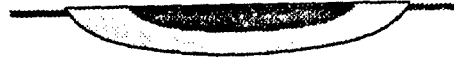
8.1 Analysis of Individual Alternatives

The evaluation criteria used in this analysis, and brief definitions of each, are shown on Table 8-1. The criteria are divided categorically into threshold factors, balancing factors, and modifying considerations. Threshold factors are those conditions that must be met for the alternative to be viable. Balancing factors are the conditions that are heavily weighed when comparing alternatives. Modifying considerations factor in agency and community concerns. An alternative could be effective and technically implementable, but not viable based on these concerns.

To evaluate the degree to which each alternative fulfills each evaluation criterion, a relative numerical rating system was developed (Table 8-2). The sum of seven evaluation criteria values yields a completeness score for each alternative. All cost estimates were prepared for comparative purposes and were estimated to be accurate within -30% and +50%. An effectiveness-to-cost quotient was calculated for each alternative by adding the scores of the five effectiveness criteria (protectiveness of human health and the environment; compliance with ARARs; both long- and short-term effectiveness; and reduction in toxicity, mobility, and volume) and dividing by the alternative's cost in

millions of dollars: the greater the quotient, the more cost-effective the alternative.

8.1.1 Alternative 1 — No Action



This alternative only partially meets the threshold factors. Airborne emissions and the dermal contact pathway are not eliminated, and surface water impacts are still possible without engineered controls. However, the existing fencing, PSP, and plastic liner over portions of OU B1 will reduce the potential for dermal contact.

The alternative would not comply with ARARs because it provides inadequate protection of human health and the environment. Toxicity or mobility of the contaminants is not reduced because no treatment is performed. Potential short-term exposures are not produced. However, there is no short-term

ALTERNATIVE 1 – NO ACTION

Criteria	Numerical Value
Protection of Human Health and the Environment	0
Compliance with ARARs	0
Long-Term Effectiveness and Permanence	0
Reduction in Toxicity, Mobility, and Volume	0
Short-Term Effectiveness	0
Implementability	5
Cost	5

TABLE 8-1. REMEDIAL ALTERNATIVE EVALUATION CRITERIA

Criterion Type	Evaluation Criterion	Definition
Threshold Factors	Protective of human health and the environment	Protection of human health and the environment is achieved through the elimination, reduction, or control of contaminated media. All migration pathways must be addressed.
	Compliance with ARARs	Complies with applicable or relevant and appropriate requirements of TSCA, RCRA, CWA, SDWA, state and local regulations and codes, and TBCs.
	Long-term effectiveness and permanence	Protects human health and the environment after the remedial objectives have been met.
Balancing Factors	Reduction in toxicity, mobility, and volume through treatment	Treats the soil and reduces the toxicity, mobility, and/or volume of the contaminated soil.
	Short-term effectiveness	Protects human health and the environment during construction and implementation. Degree of threat and the time period to achieve remedial action objectives are also considered.
	Implementability	There are no administrative barriers (no permits, zoning limitations). The availability of materials and personnel, site features such as available space and topography, and impacts upon on-going operations at DRMO are considered. The technical status of alternatives is also considered; theoretical technologies with only limited bench-scale evaluation are considered less implementable than fully proven processes.
Modifying Considerations	Cost	Costs include design, construction, start-up, monitoring, and maintenance.
	State acceptance	The state's (or other regulatory agency's) preference among or concern about alternatives.
	Community acceptance	The community's apparent preferences among or concerns about alternatives.

TABLE 8-2. REMEDIAL ALTERNATIVE EVALUATION CRITERIA RATING SYSTEM

Evaluation Criterion	Condition	Value
Protective of Human Health and the environment	Is protective	5
	Is not protective	0
Compliance with ARARs	Complies with ARARs	5
	Does not comply	0
Long-Term Effectiveness and Permanence	Contaminants destroyed	5
	Contaminants encapsulated	3
	Contaminants not removed or encapsulated	0
Reduction in Toxicity, Mobility, and Volume through Treatment	Eliminates toxicity, mobility, and volume	5
	Reduces toxicity, mobility, and volume	3
	No reduction	0
Short-Term Effectiveness	Minimal exposure risk during implementation	5
	Risks associated only with excavation and transport of soil	3
	Risks associated with management of toxic byproduct of treatment	0
Implementability	Alternative proven, all materials and personnel available, permitting available or in place, little effect on DRMO operations.	5
	Alternative requires significant space, some action-specific ARAR compliance issues, some effect on DRMO operations	3
	Uncertain permitting, major impact on DRMO operations	0
Cost	<\$1.5 million	5
	\$1.5 to 5 million	
	\$5 to 20 million	1
	>\$20 million	-1
State Acceptance ^a	NA	NA
Community Acceptance ^a	NA	NA

^a These final two criteria are typically evaluated following comment on the RI/FS report and the proposed plan. They will be addressed when the ROD is prepared.

benefit protecting human health or the environment. This alternative can be implemented quickly so it would have no scheduling difficulties, but the existing fence would continue to limit DRMO operations.

The long-term monitoring would cost approximately \$23,000 annually, with a present value of approximately \$400,000 (\$25/ton). The effectiveness/cost quotient is calculated to be zero.

8.1.2 Alternative 2 — Capping



Capping protects human health and the environment by greatly reducing the infiltration of surface water, and by preventing ingestion, dermal exposure, and inhalation of contaminated dust. Migration of contaminants from OU B1 in surface water is eliminated. Capping is a proven, widely applied technology. It addresses all potential contaminants at OU B1. All materials and trained personnel are available to perform this alternative.

To comply with ARARs, the cap must prevent migration of contaminants to groundwater, per U.S. EPA PCB guidance. This is the case at OU B1, since modeling indicates that PCBs and dioxins will not migrate to groundwater, even without a cap.

A cap must be maintained and periodically repaired. Failure of the cap could result in ingestion of contaminated soil, dermal exposure, and inhalation of contaminated dust. With maintenance, this alternative is effective long term. To ensure proper maintenance, a detailed monitoring and maintenance plan

would have to be developed. This plan would specify the inspection requirements, sealant repair specifications, and the vadose zone and groundwater monitoring needed to monitor the effectiveness of the cap. The plan would be approved by the agencies prior to acceptance and enforceable.

The use of the site would have to be restricted to activities compatible with a cap, such as an open area, storage, or parking. Monitoring of the vadose zone, surface water, and groundwater would be needed to document long-term effectiveness of capping.

No treatment is performed, so the toxicity and volume of contaminants are not reduced. Except for removal of the PSP, no excavation is planned, so there is little potential for short-term exposure to contaminated dust and gas-phase contaminants. A cap is very effective in the short term, eliminating exposure pathways, protecting human health and the environment, and reducing contaminant mobility.

This alternative would have a relatively small, short-term impact on DRMO as operating portions would have to be relocated during construction. When completed, capping would have no long term effect on DRMO. The time needed to complete the cap is relatively short, estimated to be approximately four months.

A conceptual cap design is shown on Figure 8-1. Only areas of the site where the PCB and dioxin contamination exceed the clean-up levels would have to be capped; however, partially capping the DRMO area would impact DRMO operations. A continuous asphaltic concrete covering over the entire DRMO yard would have the least impact on the operations. Therefore, if the

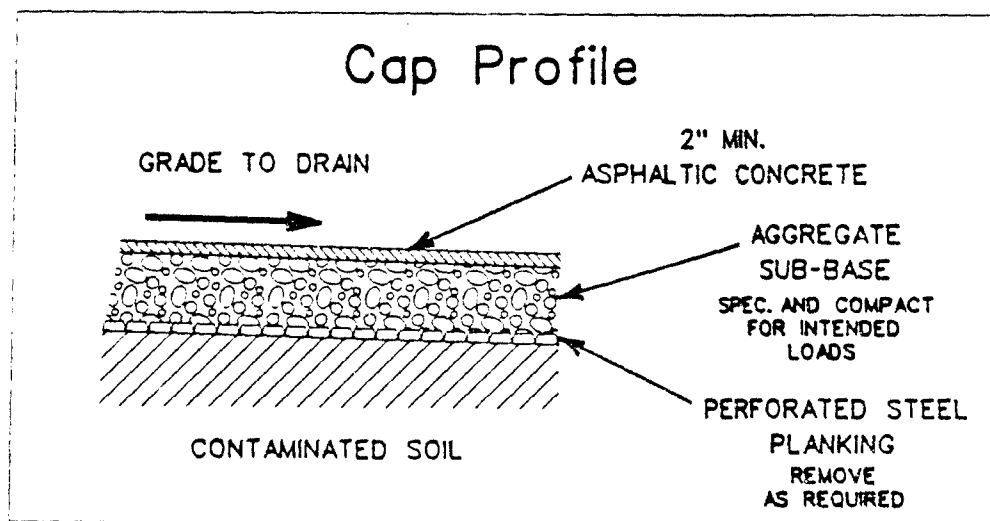
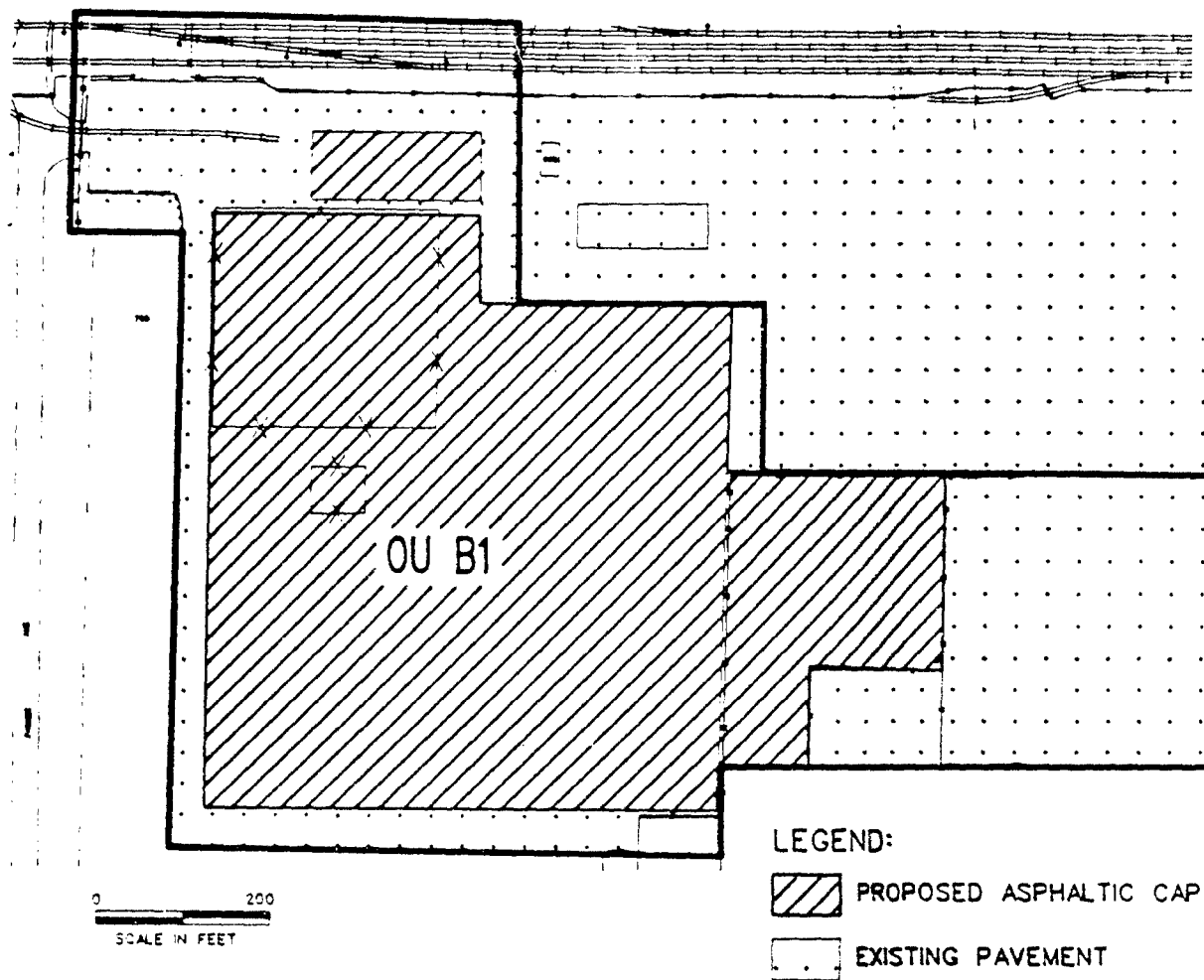


Figure 8-1. Conceptual Design of the Capping Alternative

capping alternative is selected, a cap over the entire OU B1 area would be constructed.

ALTERNATIVE 2 — CAPPING

Criterion	Numerical Value
Protection of Human Health and the Environment	5
Compliance with ARARs	5
Long-Term Effectiveness and Permanence	3
Reduction in Toxicity, Mobility, and Volume	0
Short-Term Effectiveness	5
Implementability	5
Cost	3

The estimated cost to implement this alternative is \$2.20 million (\$127/ton), including the present value of long-term monitoring. The effectiveness/cost quotient of capping is estimated to be 9.0.

8.1.3 Alternative 3 — Excavation and Off-Site Disposal



The alternative could be implemented quickly using standard construction equipment and techniques. The excavated materials would be isolated in a permitted landfill thereby reducing the contaminant exposure pathways.

However, excavation activities would have potential to spread dust-borne and airborne contaminants when the soils are

disturbed, increasing the risk of exposure for the construction workers and nearby community. The PSP must be removed and decontaminated to implement this alternative; this could also create significant short-term exposure risks to workers. The alternative must meet SMAQMD air quality requirements and TSCA landfill requirements. Soils that have Toxicity Characteristic Leaching Procedure concentrations (TCLPs) exceeding RCRA LDRs would have to be stabilized at the Class I site prior to landfilling, significantly increasing costs. As explained in Section 7.2.4, this alternative would not be implemented due to LDRs if both TCLPs are exceeded and halogenated organic compounds (HOCs) (including PCBs) are greater than 1,000 mg/kg. Because landfilling does not reduce the toxicity, mobility, or volume of the contaminants, the objective for permanent solutions involving treatment is not met. The long-term effectiveness depends on the continued careful operation and maintenance of the landfill by its operator. Failure of containment at the disposal facility could affect groundwater and surface water quality, result in dermal contact, or inhalation of the contaminants at the disposal facility.

Excavation and disposal would have a short-term impact on DRMO operations. Areas of DRMO would have to be relocated while excavation took place and backfill was placed and compacted. The schedule is relatively short, estimated to be six months. Uncertainty about transport of the dioxin-containing soil reduces implementability, as do concerns related to equipment decontamination. The removal and decontamination of the PSP also increases the difficulty of implementing this alternative. The cost of transporting and disposing 11,500 cubic yards of contaminated soil is expected to be approximately \$5.6 million (\$349/ton).

The effectiveness/cost quotient is approximately 2.8.

ALTERNATIVE 3 — EXCAVATION AND OFF-SITE DISPOSAL

Criterion	Numerical Value
Protection of Human Health and the Environment	5
Compliance with ARARs	5
Long-Term Effectiveness and Permanence	3
Reduction in Toxicity, Mobility, and Volume	0
Short-Term Effectiveness	3
Implementability	3
Cost	1

8.1.4 Alternative 4 — Excavation, Off-Site Incineration, Disposal



This alternative destroys the PCBs, dioxins, and furans, permanently reducing their toxicity, mobility, and volume. The alternative could be implemented relatively quickly using proven excavation and incineration techniques. The inorganic residuals could contain concentrations of metals that would make it necessary to stabilize and dispose of the residual in a hazardous waste landfill. No long-term operation or maintenance is expected for this alternative.

The alternative meets ARARs for soils; for treatment of PCB and dioxin contamination, SMAQMD air quality requirements for the excavation must be met. The alternative meets RCRA/TSCA incinerator performance

standards. A landfill disposal facility for incinerator ash would be selected in accordance with the RCRA/TSCA regulations.

Excavation activities would have the potential to spread dust-borne and airborne contaminants when the soils are disturbed, increasing the risk of exposure for the construction workers and nearby community. Although incineration is a proven and reliable method for destroying organic contaminants such as PCBs and dioxins, very few commercial facilities will accept wastes with these contaminants. Also, there is uncertainty that permits can be easily obtained to excavate the dioxin-containing soil. Therefore, the implementability of this alternative is low.

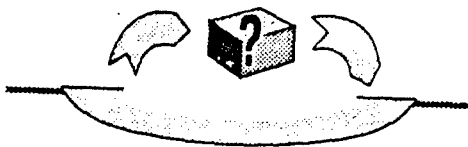
This alternative has approximately the same impact on DRMO as the excavation and disposal alternative. The schedule is estimated to be 12 months to allow for selecting a facility, a possible trial burn, excavation, and off-site transportation.

The cost of transporting and incinerating over 11,500 cubic yards of contaminated soil is expected to be approximately \$35 million (\$2,156/ton). The effectiveness/cost quotient is approximately 0.66.

ALTERNATIVE 4 — EXCAVATION, OFF-SITE INCINERATION, AND DISPOSAL

Criterion	Numerical Value
Protection of Human Health and the Environment	5
Compliance with ARARs	5
Long-Term Effectiveness and Permanence	5
Reduction in Toxicity, Mobility, and Volume	5
Short-Term Effectiveness	3
Implementability	3
Cost	41

8.1.5 Alternative 5 — Excavation, On-Site Treatment, Disposal



This alternative is the same as the off-site treatment alternative, except that all processes are performed on site and treated soil is reburied at the site. However, any soil which exceeds TCLP limits for metals must be transported to a Class I site for stabilization to meet LDRs prior to landfilling. All of the same negative factors of alternatives 3 and 4 involving excavation would be present. The alternative must meet chemical-specific ARARs and action-specific ARARs for treatment of soil for PCBs and dioxin. The alternative must also meet incinerator performance standards. The representative technology (incineration) is available and implementable. However, because of the dioxin contamination, there is significant uncertainty that permits could be obtained to conduct both the on-site trial burns and long-term operation.

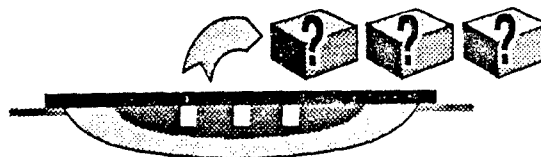
This alternative would affect DRMO to the same extent that excavation and disposal, assuming that the treatment facility will be located on adjacent land. The schedule is estimated to be 24 months to accommodate treatability studies, on-site trial burn, permitting, and a relatively slow treatment throughput.

The estimated cost of this alternative is \$19 million (\$1175/ton), and effectiveness/cost quotient is 1.2.

ALTERNATIVE 5 — EXCAVATION, ON-SITE TREATMENT, AND DISPOSAL

Criterion	Numerical Value
Protection of Human Health and the Environment	5
Compliance with ARARs	5
Long-Term Effectiveness and Permanence	5
Reduction in Toxicity, Mobility, and Volume	5
Short-Term Effectiveness	3
Implementability	0
Cost	1

8.1.6 Alternative 6 — Capping and Treatability Studies with Potential On-Site Treatment



This alternative has the same benefits as capping, but includes the option to implement treatment of principal threats in the future, should the benefits of such treatment be shown to outweigh the risks and costs involved. Capping is protective of human health and the environment. Treatment technologies are developing rapidly; this alternative provides the time to properly evaluate and design technologies appropriate to OU B1. This dual-track approach to remediation meets the U.S. EPA's Superfund Accelerated Cleanup Model goals to perform expedited action to eliminate immediate threats while continuing to pursue other long-term actions. Ongoing treatability studies for soils are also consistent with CERCLA program requirements, which

support assessing the need for additional future action at sites where contaminants above health-based levels remain on site.

The effects on DRMO operation from this alternative are the same as capping with the addition of short-term access required to obtain soil for treatability studies. The access requirement would be relatively small and of short (less than one week) duration. The capping would require approximately four months. Treatability studies would take from three to four years. For costing purposes, it is estimated that six treatability studies, including those ongoing, would take place over a three year period. Annual progress reports would be prepared and one pilot study would be performed for the most promising technology. All treatability studies must meet the performance criteria listed in Section 7.2.7.

The estimated cost of this alternative is \$2.6 million (\$161/ton). The effectiveness/cost quotient for this alternative is 6.9. This quotient could increase if treatment is eventually selected, since treatment would increase the reduction in toxicity and long-term effectiveness values, though the cost value could increase.

ALTERNATIVE 6 — CAPPING AND TREATABILITY STUDIES WITH POTENTIAL ON-SITE TREATMENT

Criterion	Numerical Value
Protection of Human Health and the Environment	5
Compliance with ARARs	5
Long-Term Effectiveness and Permanence	3
Reduction in Toxicity, Mobility, and Volume	0
Short-Term Effectiveness	5
Implementability	5
Cost	3

8.1.7 Alternative 7 — Excavation and Disposal of Principal Threat and Capping the Site



This alternative blends the benefits of capping and excavation. The principal threat is removed (soil with a PCB concentration exceeding 100 mg/kg, to be certain to capture all PCBs exceeding 500 mg/kg), as is the potential for dermal contact or inhalation of the remaining soil.

Excavation would have a potential to spread dust-borne and air-borne contaminants when the soil is disturbed. Since the excavation would focus on the principal threat, the potential affects of exposure are high. The PSP must be removed and decontaminated to implement this alternative, which also creates a potential exposure concern for workers. The alternative must meet SMAQMD air quality requirements and TSCA disposal requirements. If TCLP analytical testing indicates that the OU B1 soils are RCRA characteristic wastes, and if the total HOC concentrations (including PCBs) exceeds 1,000 mg/kg, then incineration would be required prior to land disposal to meet RCRA LDRs (i.e., this alternative would not be implementable). Also, meeting SMAQMD requirements to suppress dust emissions and not create a nuisance could involve substantial costs and barriers to compliance. The toxicity, mobility, and volume of the contaminants are not reduced by this alternative.

The long-term effectiveness and permanence of this alternative is contingent upon

proper management of the landfill and the cap. A cap maintenance program similar to the one described for the capping alternative would have to be developed. DRMO would be affected in the short term by this alternative, but there would be no long-lasting impact. The time required to implement this alternative is estimated to be 6 months.

The uncertainty of meeting LDRs and permitting the transportation phase of this alternative reduces its implementability, as do concerns related to equipment and PSP decontamination. The cost of excavating, transporting, and disposing of 4,400 cubic yards of soil, and capping the entire site is estimated to be approximately \$3.8 million (\$239/ton). The effectiveness/cost quotient is approximately 4.2.

ALTERNATIVE 7 — EXCAVATION AND DISPOSAL OF PRINCIPAL THREAT AND CAPPING

Criteria	Numerical Value
Protection of Human Health and the Environment	5
Compliance with ARARs	5
Long-Term Effectiveness and Performance	3
Reduction in Toxicity, Mobility, and Volume	0
Short-Term Effectiveness	3
Implementability	3
Cost	3

8.2 Sensitivity Analysis

A cost sensitivity analysis was performed for the remedial alternatives in order to determine how slight changes in some of the key variables would affect the cost estimates. To determine the sensitivity of the cost estimates to unknown factors affecting the cost calculations the volume of soil, present worth

interest rate, and the percentage of capital costs used to estimate long-term operations and maintenance expenses were varied and the resulting affect on cost was calculated. The results of the analysis are shown on Table 8-3.

No Action, Capping, and Capping with Treatability Studies are not highly sensitive to unknowns. There is no volume sensitivity, and capping is only slightly sensitive to interest rates. The alternatives involving soil excavation are sensitive to the volume of soil. The alternatives involving excavation are not sensitive to long-term management factors such as interest rates and O&M.

8.3 Comparative Analysis

A comparative analysis of the alternatives is shown on Table 8-4 and Figure 8-2. The relative numerical values for each criteria are shown with a resulting total score. It is important to note that all criteria are weighted the same at this time.

Protection of Human Health and the Environment — All alternatives, except the No Action alternative, are protective of human health and the environment.

Post remediation health risks of a partial cap (covering all areas with PCB concentrations greater than 10 mg/kg) and a full cap (covering all unpaved areas of the DRMO yard) were evaluated using the pathways and exposure parameters in the HRA's Current Worker Scenario (Section 4.2). The asphalt cap was assumed to be 100% effective in reducing dust emissions. The cap's effect on PCB vapor emissions were evaluated by incorporating a low permeability layer (a simulation of weathered asphalt) into the VAPOUR-T model. The results indicated that the partial and full caps would reduce the

TABLE 8-3. COST SENSITIVITY ANALYSIS

Alternative	Volume Increase 25%	Doubled Interest Rate	Doubled O&M Percentage	Sensitivity Assessment
Alt 1 — No Action	No cost impact	No cost impact	No cost impact	Not Sensitive.
Alt 2 — Capping	No cost impact	12% decrease in cost	28% increase in cost	Sensitive to factors affecting long-term management. Not volume sensitive.
Alt 3 — Excavate and off-site disposal	14% cost increase	No cost impact	No cost impact	Sensitive to volume. Not sensitive the issues affecting long-term management.
Alt 4 — Excavate, off-site incineration, and disposal.	24% cost increase	No cost impact	No cost impact	Very sensitive to volume. Not sensitive the issues affecting long-term management.
Alt 5 — Excavate, on-site treatment, disposal	17% cost increase	No cost impact	No cost impact	Sensitive to volume. Not sensitive the issues affecting long-term management.
Alt 6 — Capping and treatability studies	No cost impact unless treatment implemented	10% decrease in cost	22% increase in cost	Sensitive to factors affecting long-term management. Not volume sensitive.
Alt 7 — Excavation of principal threat and capping	9% cost increase	7% decrease in cost	15% increase in cost	Limited volume sensitivity, sensitive to factors affecting long-term management.

TABLE 8-4. COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Remedial Alternatives	Effectiveness Criteria										Effective-ness/Cost Quotient
	Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effective-ness and Persistence	Reduction in Toxicity, Mobility, and Treatment	Short-Term Effectiveness	Implementa-bility	Cost	State Acceptance*	Community Acceptance*	Total Score	
Alt 1 No Action	0	0	0	0	0	5	5			10	0
Alt 2 Capping	5	5	3	0	5	5	3			26	9.0
Alt 3 Excavate and Off-Site Disposal	5	5	3	0	3	3	1			20	2.8
Alt 4 Excavate, Off-Site Incineration, and Disposal	5	5	5	5	3	3	-1			25	0.66
Alt 5 Excavate, On-Site Treatment, and Disposal	5	5	5	5	3	0	1			24	1.2
Alt 6 Capping and Treatability Studies with On-Site Treatment Potential	5	5	3	0	5	5	3			26	6.9
Alt 7 Excavate and dispose of principal threat and capping	5	5	3	0	3	3	3			22	4.2

* These two criteria will be evaluated after the public comment period.

* This ratio provides an indication of the benefit provided in relation to the cost of each alternative. The effectiveness is the sum of the five effectiveness scores. The cost denominator is the estimated cost of each alternative, in \$ millions.

ARARs = Applicable or relevant and appropriate requirements.

Key

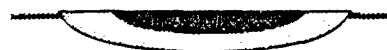
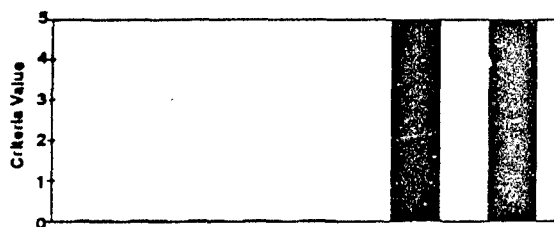
Criteria Except Cost

5 = Meets or exceeds definition/intent of criterion
3 = Conditionally meets definition/intent of criterion
0 = Does not meet the definition/intent of criterion

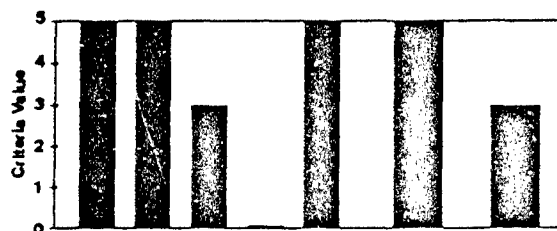
Cost Aspects

5 = <\$1.5 million
3 = \$1.5 to 5 million
1 = >\$5 to 20 million
-1 = >\$20 million

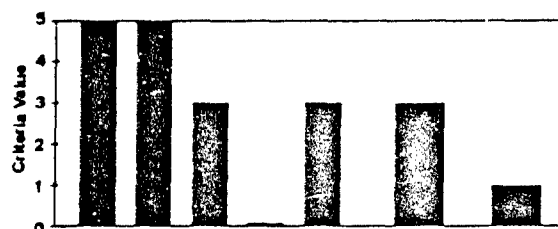
Alternative 1 - No Action (Score=10, Effectiveness/Cost=0)



Alternative 2 - Capping (Score=26, Effectiveness/Cost=9.0)

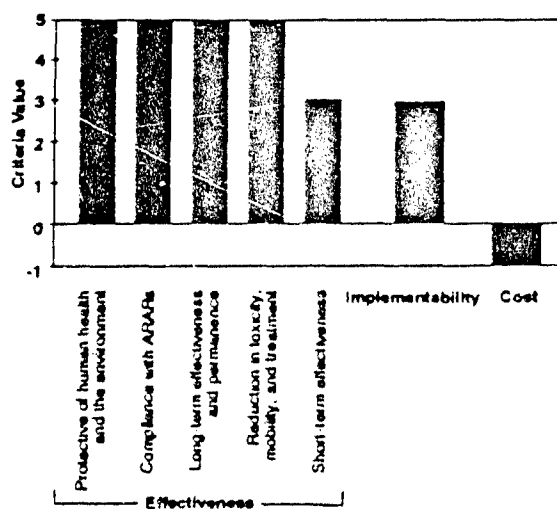


Alternative 3 - Excavation and Off-Site Disposal (Score=20, Effectiveness/Cost=2.8)



Alternative 4 - Excavation, Off-Site Incineration, and Disposal

(Score=25, Effectiveness/Cost=0.66)



KEY

Criteria values except cost

- 5 = Meets or exceeds definition/intent of criterion
- 3 = Conditionally meets definition/intent of criterion
- 0 = Does not meet the definition/intent of criterion

Cost criteria values

- 5 = <\$1.5 million
- 3 = \$1.5 to 5 million
- 1 = >\$5 to 20 million
- 1 = >\$20 million

Score = sum of 7 criteria values

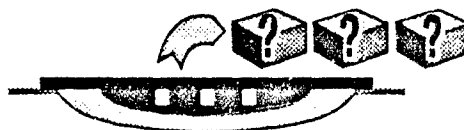
Effectiveness/Cost = sum of 5 effectiveness values/cost in \$millions

Figure 8-2. Comparative Analysis of Remedial Alternatives

Alternative 5 - Excavation, On-Site Treatment, and Disposal (Score=24, Effectiveness/Cost=1.2)



Alternative 6 - Capping and Treatability Studies with Potential On-Site Treatment (Score=26, Effectiveness/Cost=6.9)



Alternative 7 - Excavation and Disposal of Principal Threat and Capping the Site (Score=22, Effectiveness/Cost=4.2)



Protective of human health and the environment
Compliance with ADARs
Long term effectiveness and permanence
Reduction in toxicity, mobility, and treatment
Short-term effectiveness
Implementability
Cost

Effectiveness

KEY

Criteria values except cost

- 5 = Meets or exceeds definition/intent of criterion
- 3 = Conditionally meets definition/intent of criterion
- 0 = Does not meet the definition/intent of criterion

Cost criteria values

- 5 = <\$1.5 million
- 3 = \$1.5 to 5 million
- 1 = >\$5 to 20 million
- 1 = >\$20 million

Score = sum of 7 criteria values

Effectiveness/Cost = sum of 5 effectiveness values/cost in \$millions

Figure 8-2. (Continued)

calculated cancer risk by approximately 90% and 99%, respectively.

In order to allow continued DRMO operation, all unpaved areas will be paved after implementation of any of the alternatives. Therefore, the post-remediation risks to on-site workers for all alternatives would also be reduced by greater the 99% calculated for the full cap in Alternative 2. Alternatives 3, 4, and 5 would achieve greater risk reduction by reducing the amount of PCBs available to permeate the cap. Alternative 6 would also achieve greater risk reduction when a successful treatment technology is implemented.

Surface fluxes of vapor phase PCBs are uniform throughout most of the PCB contaminated areas because the PCB vapor concentrations in soil gas are the same for all near surface soil with PCB concentrations greater than 27 $\mu\text{g/kg}$. This is because the soil air space is saturated with PCBs even when concentrations in soil are relatively low. Since all of the cancer risk in the Full Cap Scenario is from PCB vapors passing through the asphalt cap, excavation and disposal or localized "hot spots" (Alternative 7) would not significantly reduce risk. Because PCB surface fluxes are not greater in the "hot spot" soils, the risk reduction would be proportional to the size of the excavated (and backfilled) area and not the concentration of PCBs in the excavated soil.

The alternatives that involve excavation (3, 4, 5, and 7) would have the potential to cause short-term increased exposures to contaminants in suspended dust and ambient air. Alternatives 4, 5, and 6 could lead to short-term increased exposure in the vicinity of the incinerator or treatment facility. The magnitude of potential exposures from a treatment system would be highly dependent on the treatment method and could be insignificant.

Compliance with ARARs — All alternatives, except no action, have the potential to comply with ARARs. However, off-site alternatives (i.e., disposal and incineration) must be performed at a permitted facility and on-site treatment will have to meet TSCA storage and treatment standards. Disposal alternatives would not be implementable, due to LDRs, if TCLPs and HOC levels are both exceeded. All alternatives applying excavation will likely have to meet stringent SMAQMD air quality requirements for dust emissions.

Long-Term Effectiveness — The excavate-and-treat alternatives are more effective in the long term because the contaminants are destroyed. Capping, disposal, and capping with treatability studies are not as effective in the long term because the contaminants continue to exist, and management controls must be used to maintain their effectiveness. Metals, which are secondary COCs, were not emphasized in the feasibility study. However, all of the alternatives, except no action, would be effective on metals. The capping alternatives isolate the metals and prevent their migration, and the disposal alternative removes the metals from the site and contains them in an engineered disposal site. The treatment alternatives remove the metals from the site and concentrates them in an ash. The ash may have to be stabilized or disposed in a hazardous waste landfill depending upon the metal concentrations and leaching potential.

Reduction of Toxicity, Mobility, and Volume — Only the treatment alternatives reduce the toxicity, mobility, and volume of contaminants. Though the inherent mobility of COCs is not affected by a cap, capping does greatly reduce the potential migration of COCs.

Short-Term Effectiveness — The two capping alternatives are very effective, protecting human health in the short-term. No Action does not create short-term exposure threats; however, there is no short-term benefit to human health or the environment. The other alternatives create significant short-term exposure risks through excavation and transport of contaminated soil.

Implementability — The alternatives are relatively quickly implemented, but short-term exposure potential occurs when the contaminated soil is moved. The capping alternative protects human health and the environment in the shortest timeframe because it can be implemented quickly. There are significant permitting uncertainties with the excavate/treat/excavate dispose alternatives. The soil contains dioxins, and it may not be possible to obtain permits to excavate, transport, or treat the soil because of the dioxin contamination. The three capping alternatives have much less effect on DRMO operations.

Costs — The no action and capping alternatives have the lowest overall costs. The treatment alternatives have the highest costs.

While the totaling of the scores for each criteria does not lead to conclusion as to the "best" alternative, since that would assume assigning equal weight to each criterion, it does provide a qualitative means to compare alternatives. Analysis of the total scores shows that the two capping alternatives have the highest scores (26). The major differences between these alternatives is in the reduction of toxicity, mobility, and volume of the contaminants, and cost. Off-site incineration follows closely with a score of 25, and on-site treatment has a score of 24. Treatment (e.g., incineration) has the benefit of eliminating the contaminants; however, the cost is much

higher than capping. The only difference between the capping and capping and treatability study alternative is an increase in cost and the added benefit of leaving the treatment option open. Therefore, the potential exists for the cap and treatability study score to rise significantly should any of the treatment options eventually be implemented. The excavation and off-site disposal alternatives have scores of 22. No action scored lowest (10). No action has the lowest cost, but would not be protective of human health and the environment nor comply with ARARs.

The three capping alternatives have the highest effectiveness/cost quotients. The capping plus removal of principal threat scores the lowest among the three capping alternatives since the increased costs do not result in a corresponding increase in effectiveness. The principal threat soils have simply been transferred to another location, rather than treated. The capping-only alternative scores slightly higher since the additional costs for treatability studies are not included. However, as with the comparison of total scores, the capping plus treatability studies score could increase if treatment is eventually implemented.

9.0 REFERENCES

- 40 Code of Federal Regulations (CFR), Parts 261-268: Hazardous Waste Management Regulation.
- 40 CFR 300.430. National Contingency Plan.
- 40 CFR, Part 761: Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce and Use Prohibitions.
- ATSDR, 1989a. "Toxicological Profile for Cadmium." Prepared for Agency for Toxic Substances and Disease Registry. Prepared by Clement Associates, Inc. Contract 205-88-0608.
- , 1989b. "Toxicological Profile for Arsenic." Prepared for Agency for Toxic Substances and Disease Registry. Prepared by Clement Associates, Inc. Contract 205-88-0608.
- , 1989c. "Toxicological Profile for Silver." Prepared for Agency for Toxic Substances and Disease Registry. Prepared by Clement Associates, Inc. Contract 205-88-0608. October.
- , 1989d. "Toxicological Profile for Mercury." Prepared for Agency for Toxic Substances and Disease Registry. Prepared by Clement Associates, Inc. Contract 205-88-0608. December.
- , 1990. "Toxicological Profile for Selenium." Prepared for Agency for Toxic Substances and Disease Registry. Prepared by Clement Associates, Inc. Contract 205-88-0608.
- , 1991. "Toxicological Profile for Lead." Prepared for Agency for Toxic Substances and Disease Registry. Prepared by Clement Associates, Inc. Contract 205-88-0608. October.
- Baes, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shore, 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. Prepared for the U.S. Department of Energy. ORNL-5786. September 1984.
- Bertoldi, G.L., 1974. "Estimated Permeabilities for Soils in the Sacramento Valley, California." *U. S. Geological Survey Water-Resources Inv.* 51-73.
- Briggs, G.G., R.H. Bromilow, and A.A. Evans, 1982. "Relationship Between Lipophilicity and Root Uptake and Translocation of Nonionized Chemicals by Barley." *Pesticide Science* 13:495-504.
- Burmaster, D.E., and R.H. Harris, 1993. "The Magnitude of Compounding Conservatism in Superfund Risk Assessments." *Risk Analysis* 13 No. 2.
- Calabrese, E., et al, 1990. "Preliminary Adult Soil Ingestion Estimates: Results of a Pilot Study." *Regulatory Toxicology and Pharmacology*. 12:88-95.
- California Department of Health Services, 1986. The California State

Mitigation Decision Tree Manual.
Toxic Substances Control Division.
May 1986.

California EPA, 1992a. California
Cancer Potency Factors. Memorandum to Cal/EPA Departments, Boards
and Offices from Standards and
Criteria Work Group. June 18, 1992.

———, 1992b. "Guidance for Site
Characterization and Multimedia Risk
Assessment for Hazardous Substances
Release Sites." July.

California Regional Water Quality
Control Board, Central Valley Region,
1991. "Wastewater Discharge Requirements for McClellan AFB."

EMCON Associates, 1991. "Remedial
Investigation and Feasibility Study
Report." Final. Prepared for the
Westinghouse Electric Corporation,
Sunnyvale facility. Project B51-04.09.
Superfund Records Center 0594-
00214. June.

Gale Research, 1980. *Climates of the
States*. Volume I. Second edition.
Detroit, MI: Gale Research.

Gilbert, R.O. 1987. *Statistical
Methods for Environmental Pollution
Monitoring*. Van Nostrand Reinhold
Company Inc. New York, NY.

DWR, 1993. Department of Water
Resources. Personal communication,
5 February 1993.

FEMA, 1988. Flood Insurance Rate
Map for Sacramento County, California
(unincorporated areas). Com-

munity Panel Number 060262 0070 C.
Panel 70 of 705. Federal Emergency
Management Agency. Revised
September 30, 1988.

Friesen, K.J., J. Vilks, and D.C.G.
Muir, 1990. "Aqueous Solubilities of
Selected 2,2,7,8-Substituted Polychlorinated Dibenzofurans (PCDFs)." *Chemosphere* 20:1-2, pp. 27-32.

Hazardous Substances Data Bank,
1992. Prepared by the National
Library of Medical Toxicology Data
Network. On line.

Kenaga, E.E., and C.A.I. Goring,
1980. "Relationship Between Water
Solubility, Soil-Sorption, Octanol-
Water Partitioning, and Bioconcentration of Chemicals in Biota." In *Aquatic Toxicology*. ASTM STP 707.
Philadelphia, PA: American Society
for Testing and Materials.

McClellan AFB, 1987. *Sacramento
Air Logistics Center, McClellan Air
Force Base Comprehensive Plan*.
Prepared by GRW Engineers, Inc.
June.

———, 1993. "Consensus Statement
on Background Inorganic Constituents
in Subsurface Soils at McClellan
AFB." February.

McKone, T.E., 1990. "Dermal
Uptake of Organic Chemicals from a
Soil Matrix." *Risk Analysis* 10:3.

Mendoza, C.A., 1992. *VapourT,
Version 2.11 User's Guide*. University
of Waterloo, Ontario, Canada.

NATO/CCMS, 1988. "International Toxicity Equivalency Factor (I-TEF) Method of Risk Assessment for Complex Mixtures of Dioxins and Related Compounds." Prepared by the North Atlantic Treaty Organization Committee on the Challenges of Modern Society. Report No. 176.

Palmer, C.D., and P.R. Wittbrodt, 1991. "Processes Affecting the Remediation of Chromium-Contaminated Sites." *Environmental Health Perspectives*. Vol. 92. pp. 25-40.

Paustenbach, D.J., 1989. "Methodology for Evaluating the Environmental and Public Health Risks of Contaminated Soil." In *Petroleum Contaminated Soils*. Vol 1. P.T. Kostecki and E. J. Calabrese, eds. Lewis Publications: Chelsea, MI.

———, 1991. "The Potential Inhalation Hazard Posed by Dioxin Contaminated Soil." *Journal of the Air and Waste Management Association*. 41:10.

Radian Corporation, 1988. "Technical Approach: Selection and Evaluation of ARARs and Other Cleanup Levels." Final. August.

———, 1991a. "Soil Gas Data Summary." Prepared for McClellan AFB Environmental Management. February.

———, 1991b. "Installation Restoration Program McClellan Air Force Base: Quality Assurance Project Plan." Draft. Prepared for McClellan AFB Environmental Management. September.

———, 1991c. "Installation Restoration Program McClellan Air Force Base: Operable Unit B Preliminary Assessment Summary Report." Final. Prepared for McClellan AFB Environmental Management. October.

———, 1991d. "Operable Unit B Health and Safety Plan." Prepared for McClellan AFB Environmental Management. October.

———, 1991e. "Installation Restoration Program McClellan Air Force Base: Operable Unit B Remedial Investigation Sampling and Analysis Plan." Final. Prepared for McClellan AFB Environmental Management. November.

———, 1992a. "Soil Remedial Technologies Screening Technical Memorandum." Prepared for McClellan Air Force Base Environmental Management. January.

———, 1992b. "Installation Restoration Program McClellan Air Force Base: Quality Assurance Project Plan." Final. Prepared for McClellan AFB Environmental Management. August.

———, 1992c. "Installation Restoration Program McClellan Air Force Base: Preliminary Groundwater Operable Unit Remedial Investigation Technical Report." Final. Prepared for McClellan AFB Environmental Management. September.

———, 1993. "Installation Restoration Program McClellan Air Force Base: Groundwater Sampling and Analysis

Program: Data Summary October - December 1992." Final. Prepared for McClellan AFB Environmental Management. February.

Schwarzenbach, R.P., and J. Westall, 1981. "Transport of Nonpolar Organic compounds from Surface Water to Groundwater." Laboratory Sorption Studies. *Environmental Science and Technology*. 15:1360-1367.

Smit, 1993. *Means Sitework and Landscape Cost Data*. 12th Annual Edition. K. Smit, senior editor. Kingston, MA: R.S. Means Company, Inc.

U.S. Air Force, 1991. "Handbook to Support the Installation Restoration Program (IRP) Statements of Work." Volume 1, Remedial Investigation/Feasibility Studies (RI/FS).

———, 1992. OU B1 Action Plan. Memorandum from F. Slavich, McClellan AFB, to K. Moore, U.S. EPA; M. Malinowski, DTSC; and A. MacDonald, RWQCB. 23 December.

U.S. EPA, 1986. "Superfund Public Health Evaluation Manual." EPA 540/1-86/060. October.

———, 1988a. "Drinking Water Health Criteria Document on PCB." PB89-192256. April.

———, 1988b. "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA." Interim Final. October.

———, 1988 and 1989. "CERCLA Compliance With Other Laws." Volumes I and II. August.

———, 1989a. "Superfund LDR Guide #6A: Obtaining a Soil and Debris Treatability Variance for Remedial Actions." OSWER Directive 9347.3-O6FS. July.

———, 1989b. "Risk Assessment Guidance for Superfund." Volume 1: Human Health Evaluation Manual (Part A). EPA/540/1-89/002. December.

———, 1990. "A Guide on Remedial Actions at Superfund Sites With PCB Contamination." OSWER Directive 9355.4-01. August.

———, 1991a. "Supplement D to Compilation of Air Pollutant Emissions Factors." Vol. 1. Document AP-42.

———, 1991b. "Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors." OSWER Directive 9285.6-03. March.

———, 1991c. "Risk Assessment Guidance for Superfund: Volume 1—Human Health Evaluation Manual." Part B. PB92-963333 Publication 9285.7-01B. December.

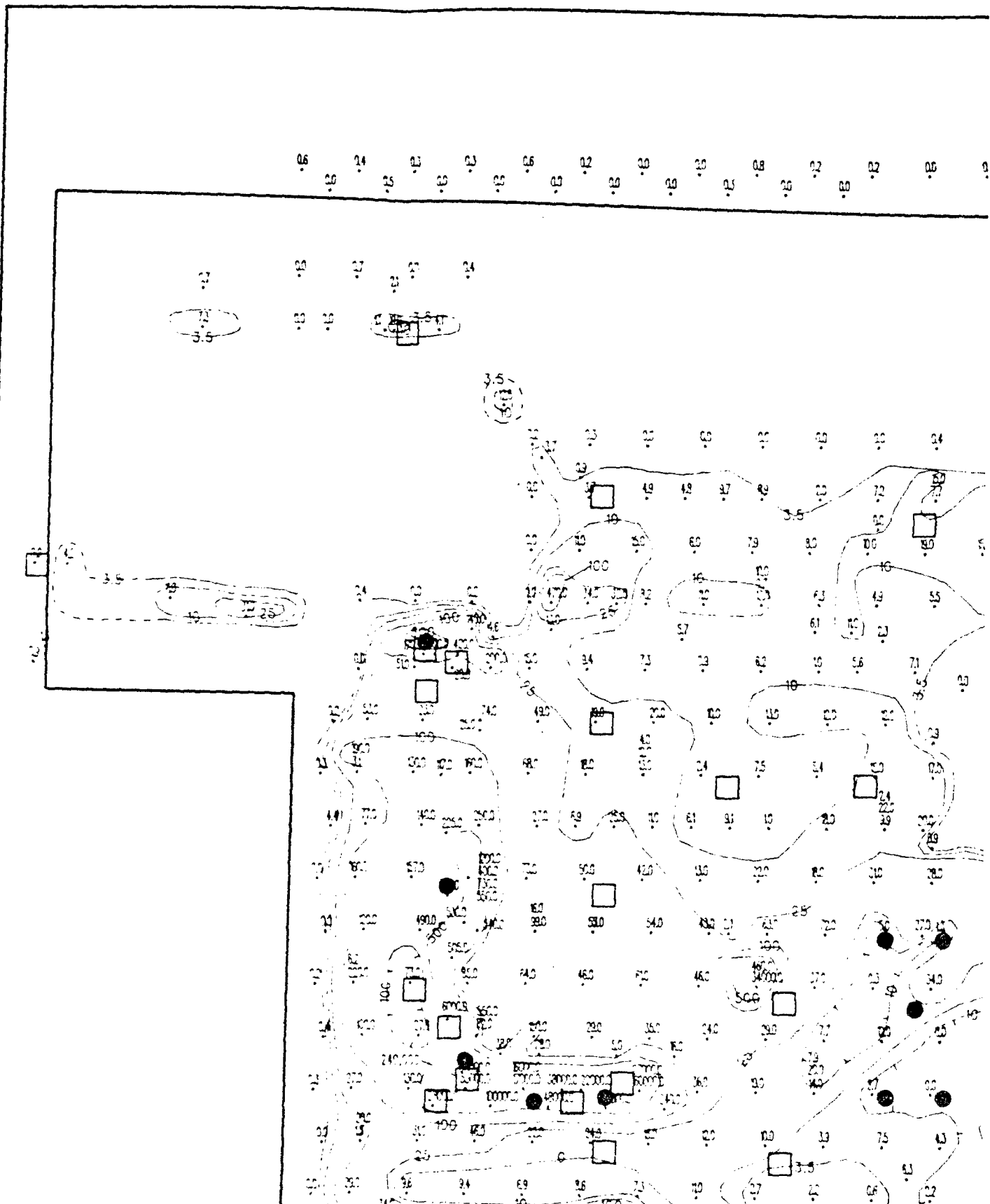
———, 1992a. "Dermal Exposure Assessment: Principles and Applications." EPA/600/8-91/011B. January.

———, 1992b. "Framework for Ecological Risk Assessment." EPA/630/R-92/001. February.

———, 1992c. "Supplemental Guidance to RAGS: Calculating the Concentration Term." Publication 9285.7-081. May.

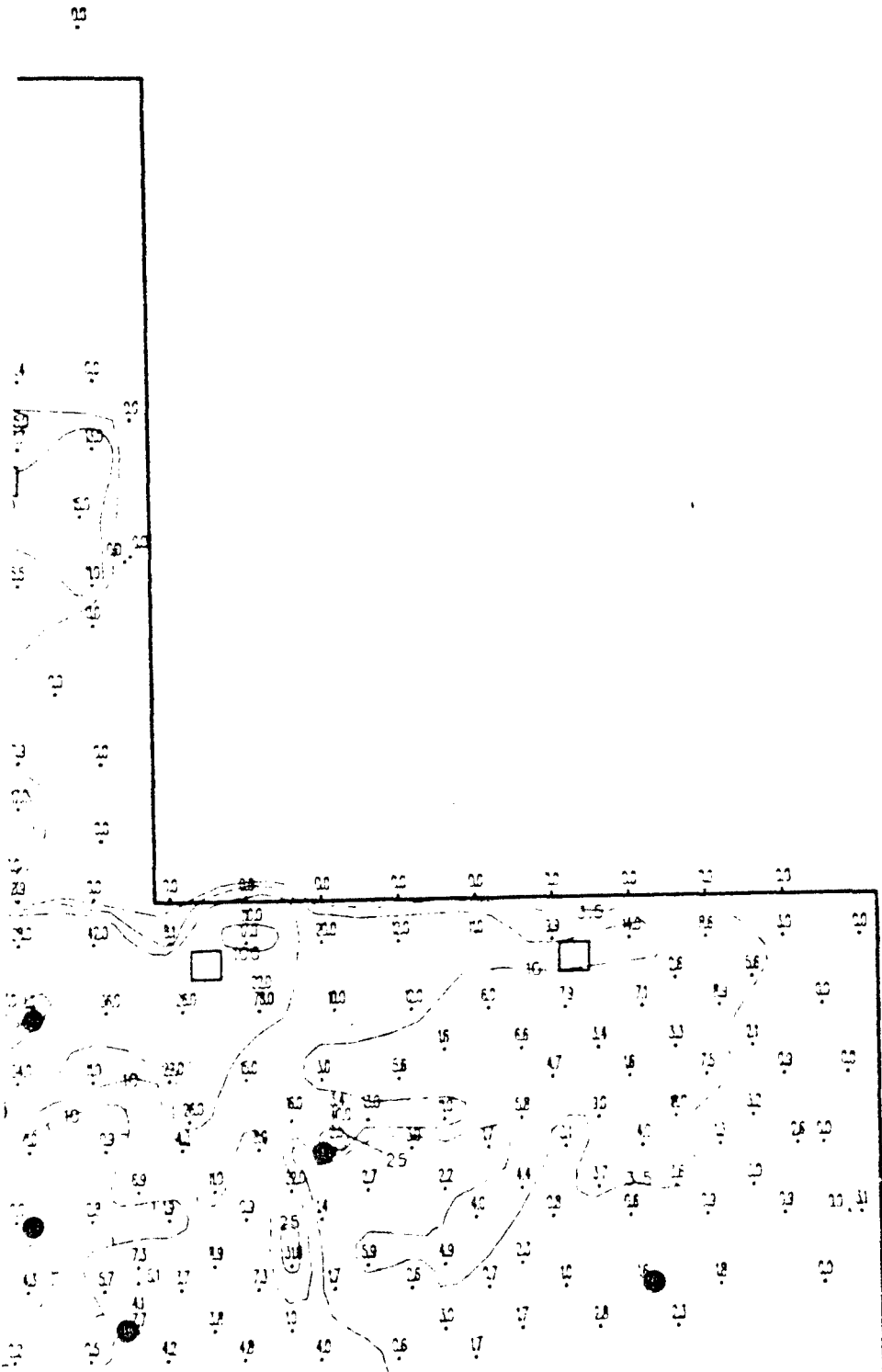
———, 1993. "Preliminary Ecological Survey, McClellan Air Force Base." Prepared by R.A. Barnett, Toxicologist, U.S.EPA Region IX. Jan. 1993.

Van Dyke, 1993. Personal communication with Don Van Dyke, DRMO yard foreman. 09 and 17 February 1993.



26

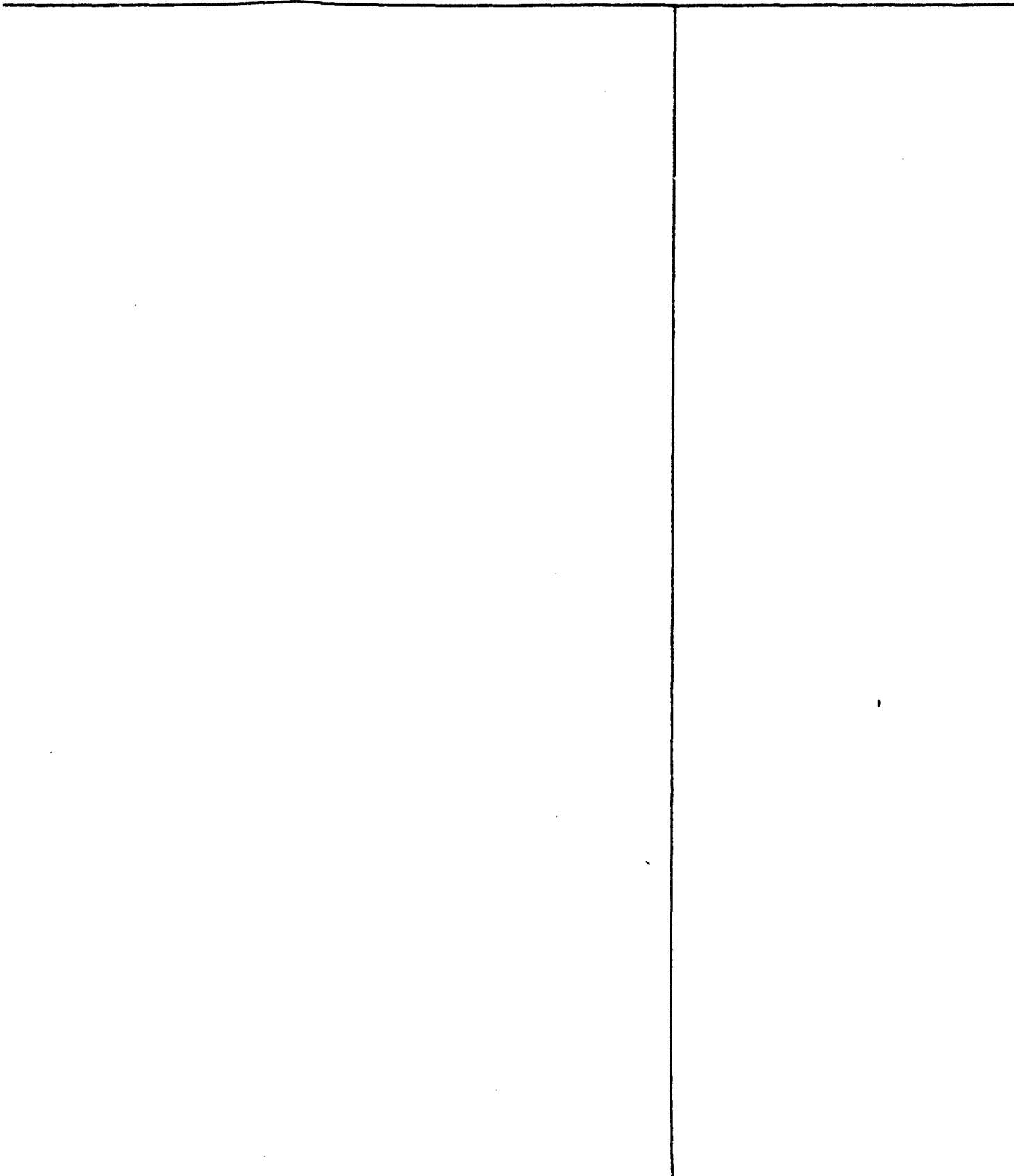
U
O

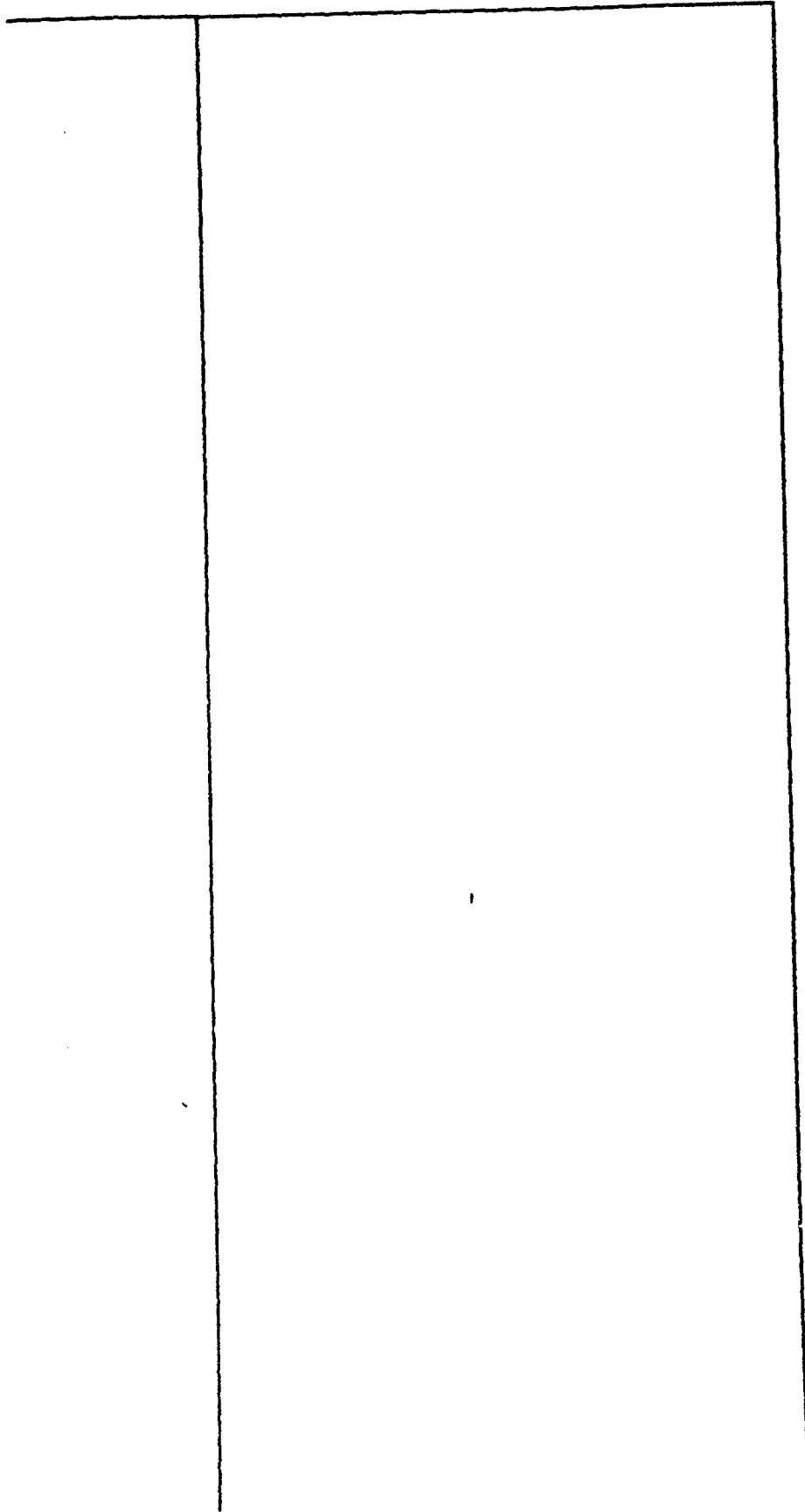


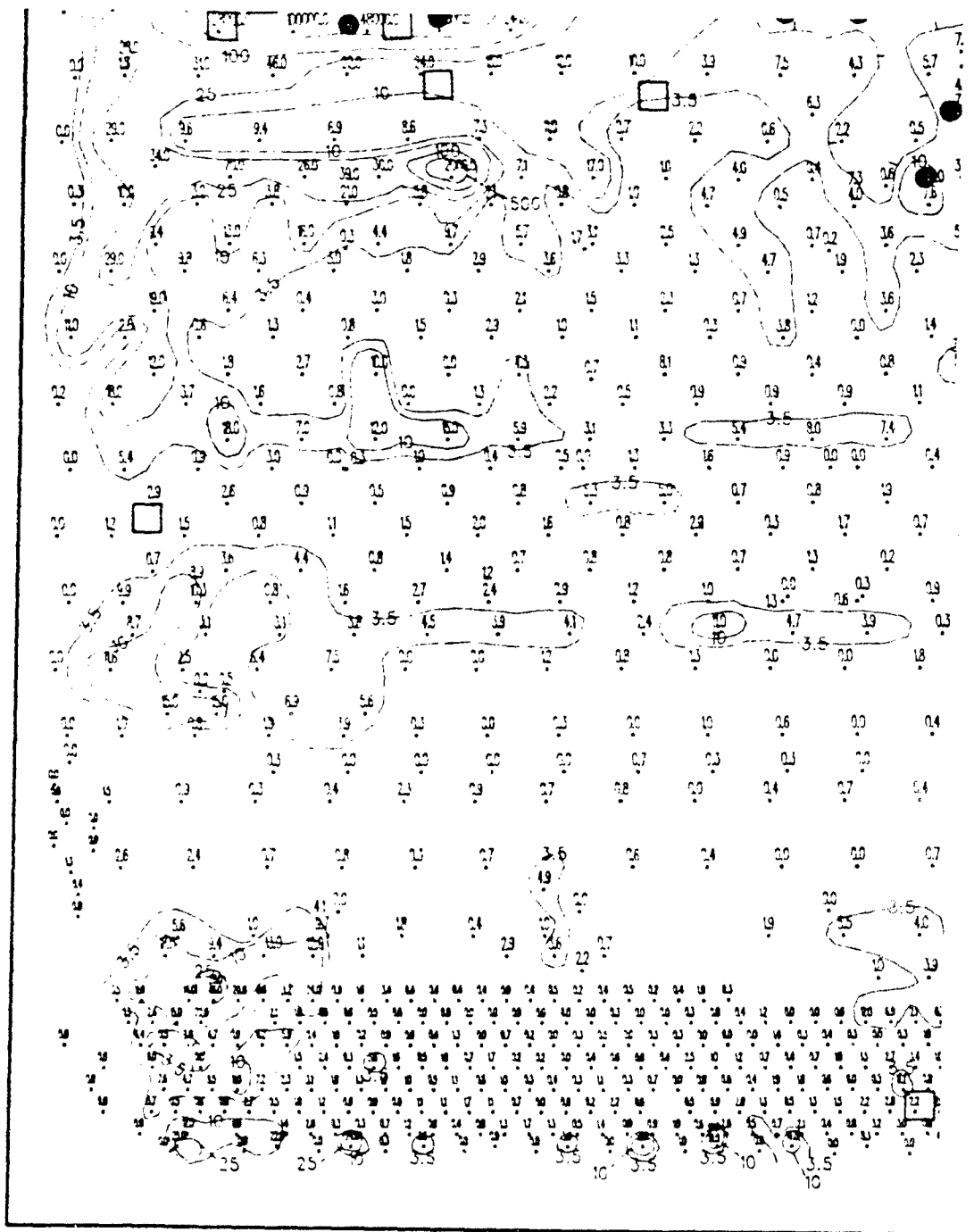
3

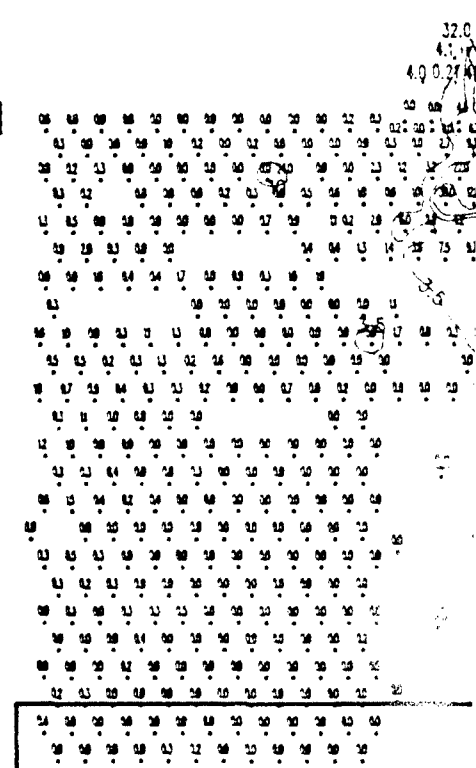
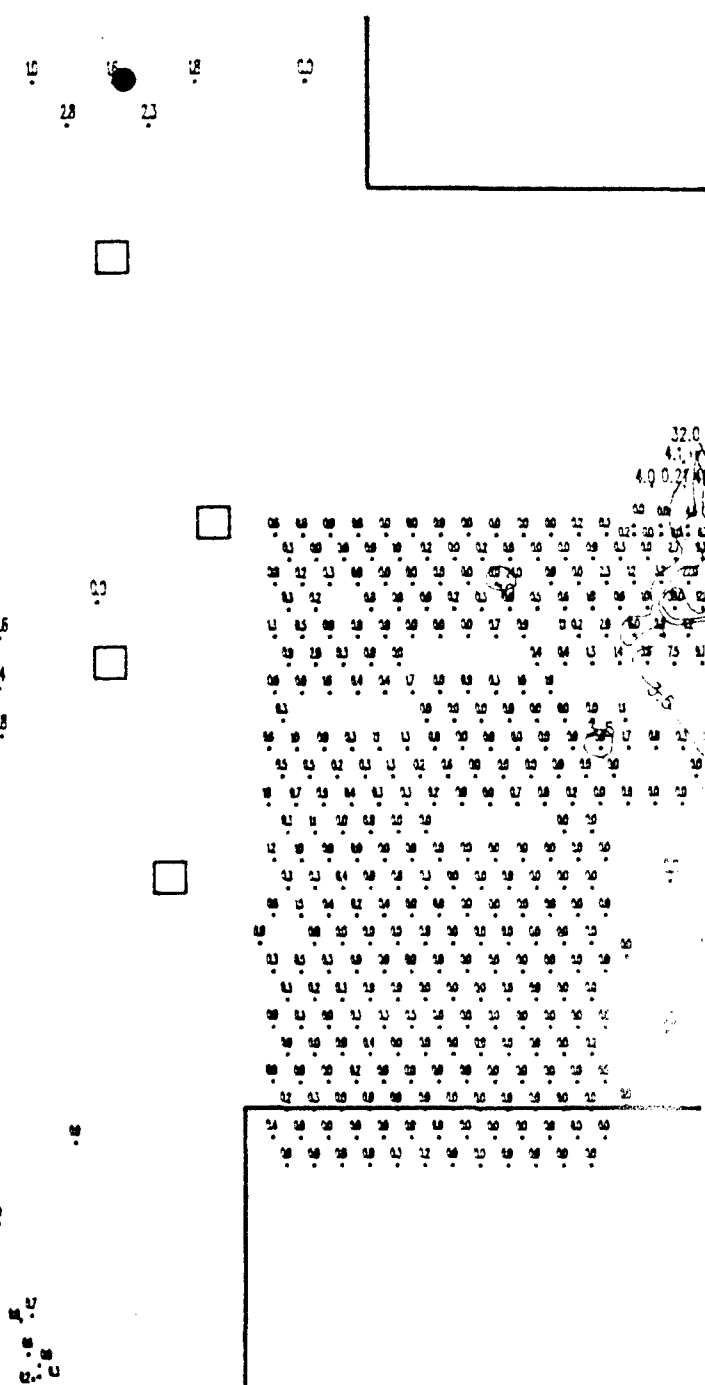
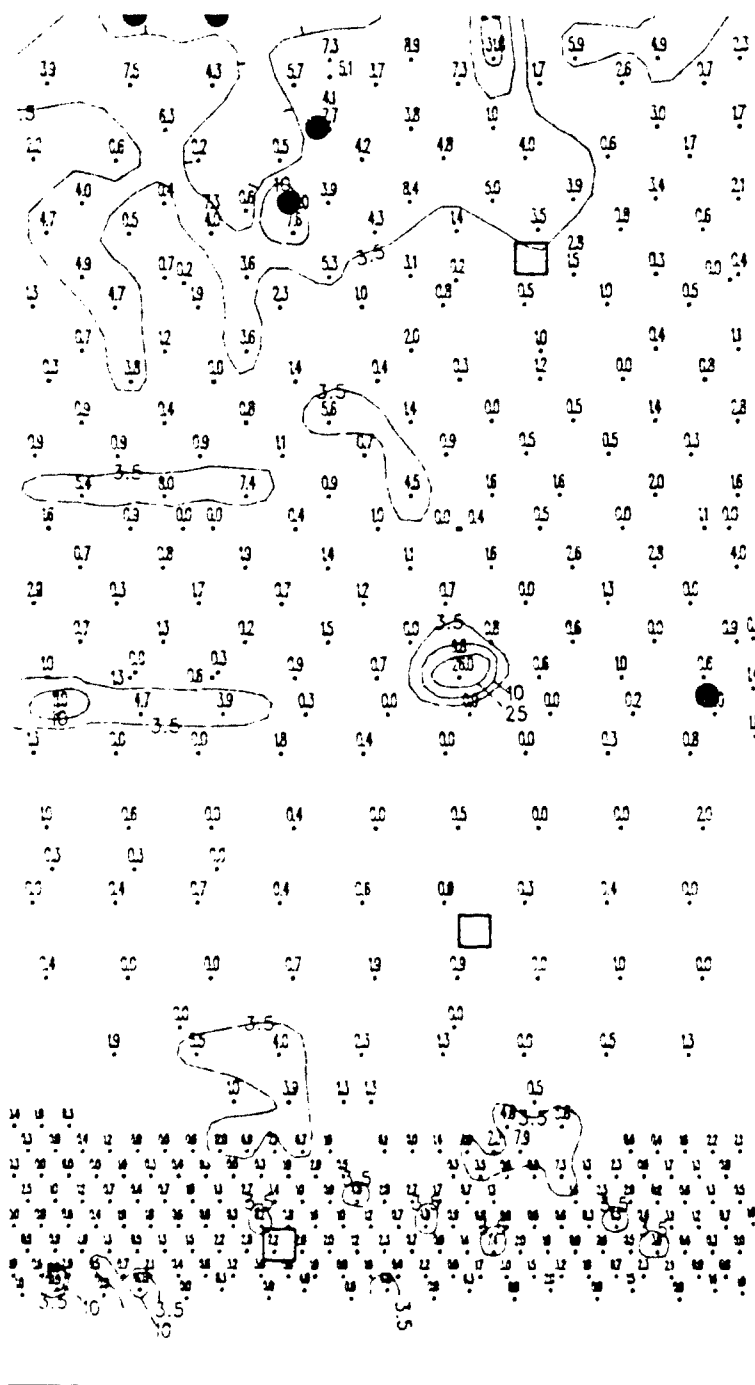
| B1

4









2.5
3.5
4.5

[illegible]

Legend:

- COE
- SURF
- 25 PCB
- HANE
- SOIL
- PCB
ISOF



Isop
Con
Near

N

Legend:

- OU B1 BOUNDARY
- SURFACE SCRAPE SAMPLING LOCATION
- 25 PCB CONCENTRATION IN MG/KG
- HAND AUGER
- SOIL BORING
- PCB CONCENTRATION ISOPLETH IN MG/KG
ISOPLETH INTERVALS 3.5, 10, 25, 100, 500



0 63.5
SCALE IN FEET

Plate A.

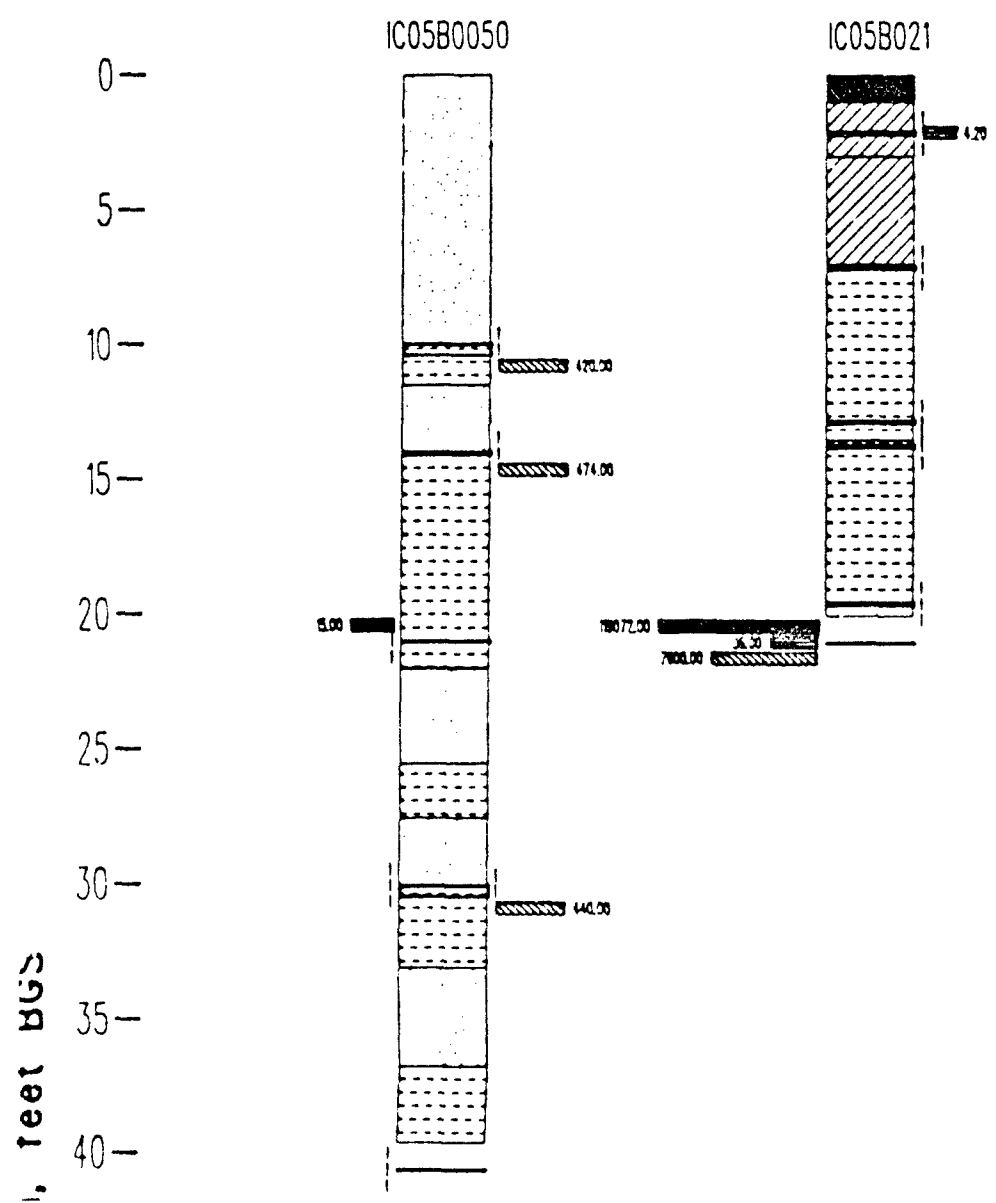
Isopleths of PCB Concentrations in Near-Surface Soils

McCLELLAN AFB

OU B1 RI



A



2
Distance, feet

100

150

200

IC05B020



130.00

3

200

250

OU
E

A'

IC05B022

1932.00

00.00



Note

(rig
of

S
(le
of

OU B RI McClellan Air Force Base Cross-Section A-A' OU B1

LEGEND



Asphalt



Fill



Sand Lithofacies



Silt Lithofacies



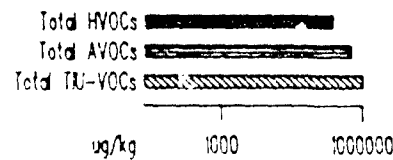
Clay Lithofacies



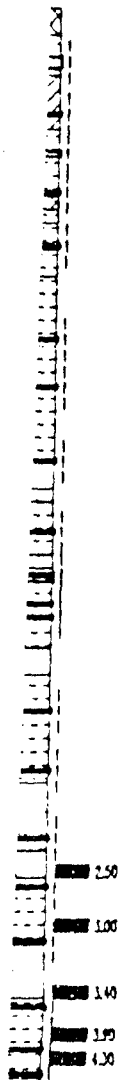
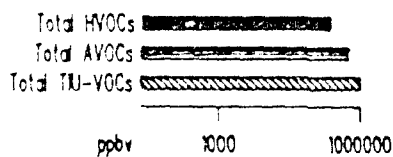
Sample Interval

Note: Concentration bars plotted on logarithmic scale. Soil units are ug/kg. Soil gas units are ppbv.

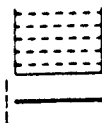
Soil
(right side
of column)



Soil Gas
(left side
of column)



40—



45—

40—

45—

50—

55—

60—

65—

70—

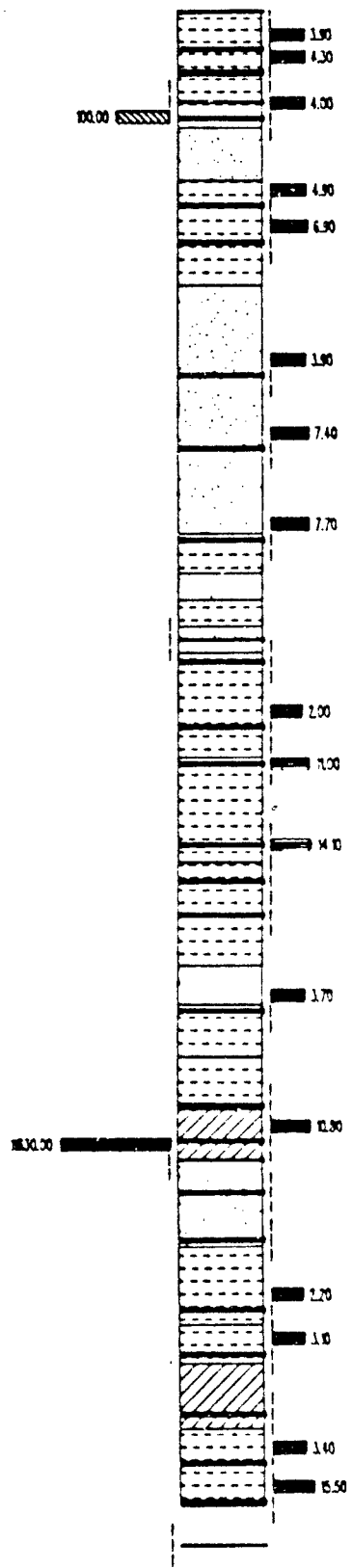
75—

80—

85—

90—

95—



Data

Location De

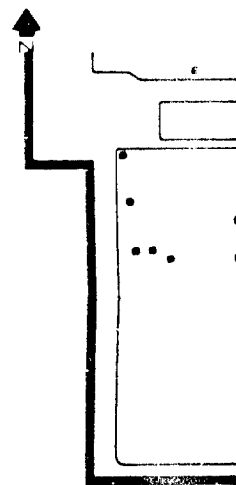
Lithologic E

Soil FVOC

Soil Gas De

Note: These

Location



RA
CORP

ppbv

1000

1000000

Data Downloads

Location Data: 02/22/93

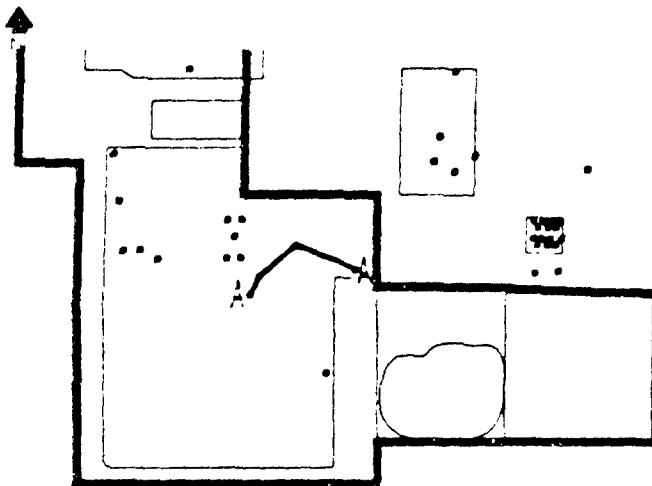
Lithologic Data: 02/10/93

Soil FVOC Data: 02/23/93

Soil Gas Data: 02/23/93

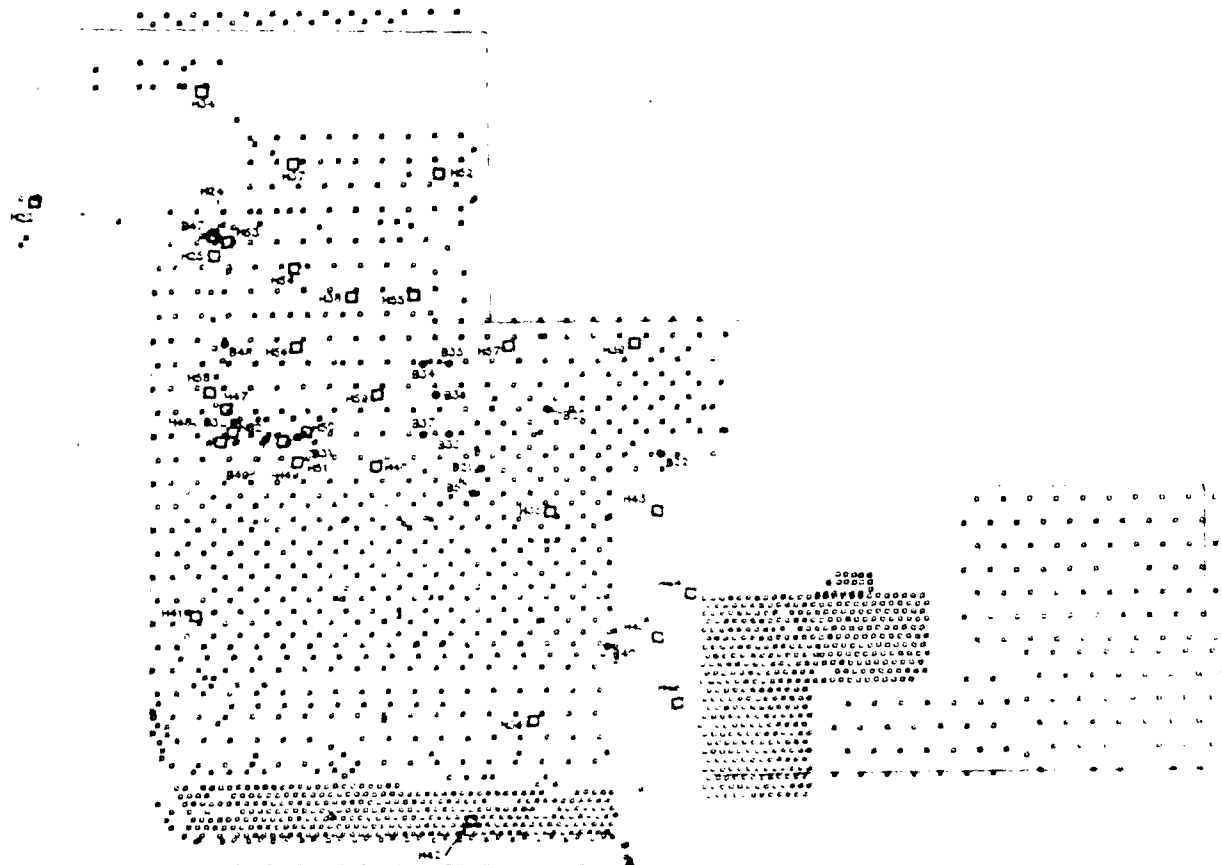
Note: These are preliminary data

Location of Cross-Section



RADIAN
CORPORATION

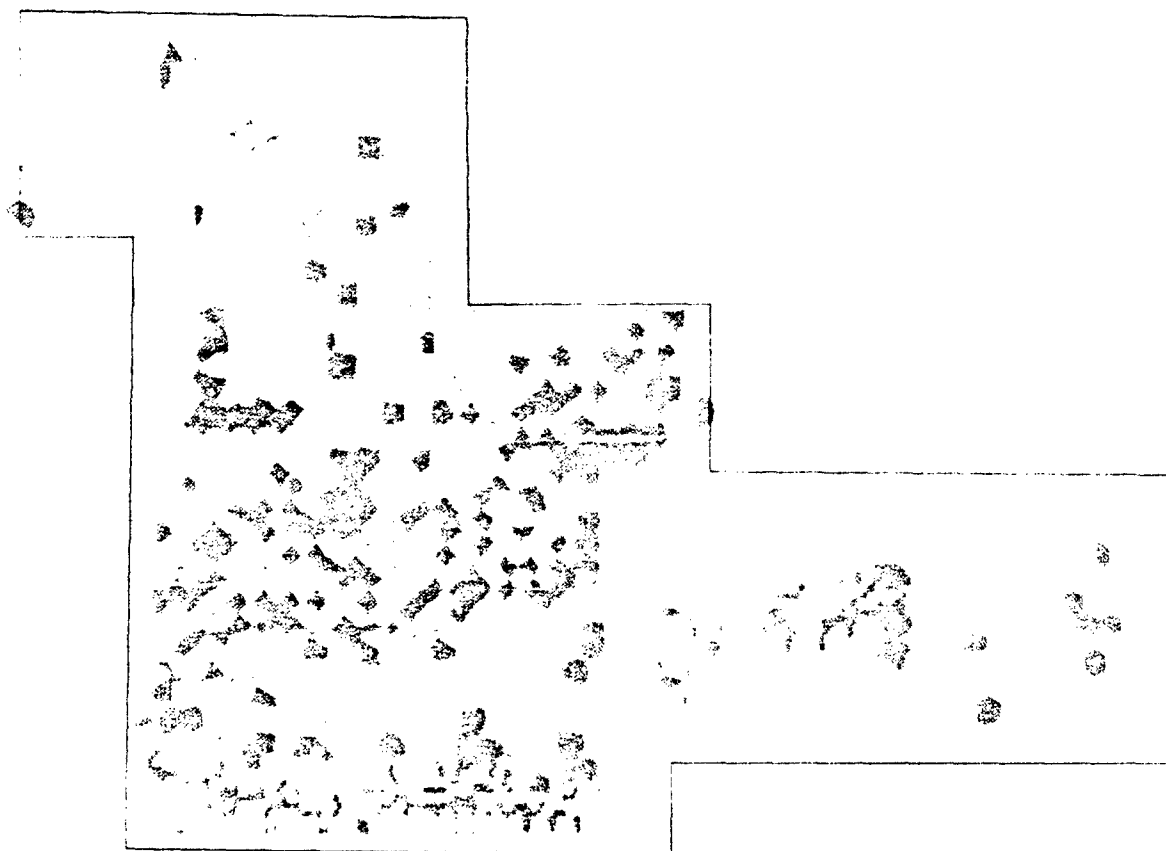
OVERLAYS



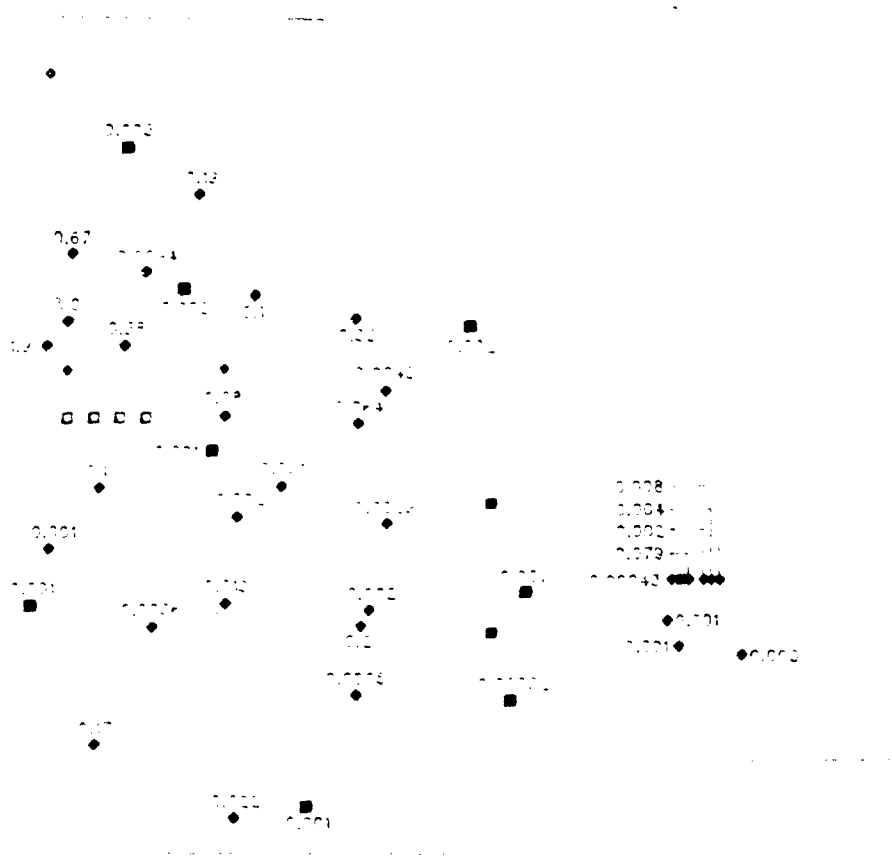
Overlay A. Sample Locations at OU B1

PCBs - Concentration (mg/kg)

to 3.5 10 to 100 > 500
3.5 to 10 100 to 500



Overlay B. PCB Concentrations in Surface Soil







Overlay E. SVOC Concentrations in Surface Soil

■ POLYPHTHALATES REPORTED
 ◆ LABORATORY CONTAMINATION SUSPECTED

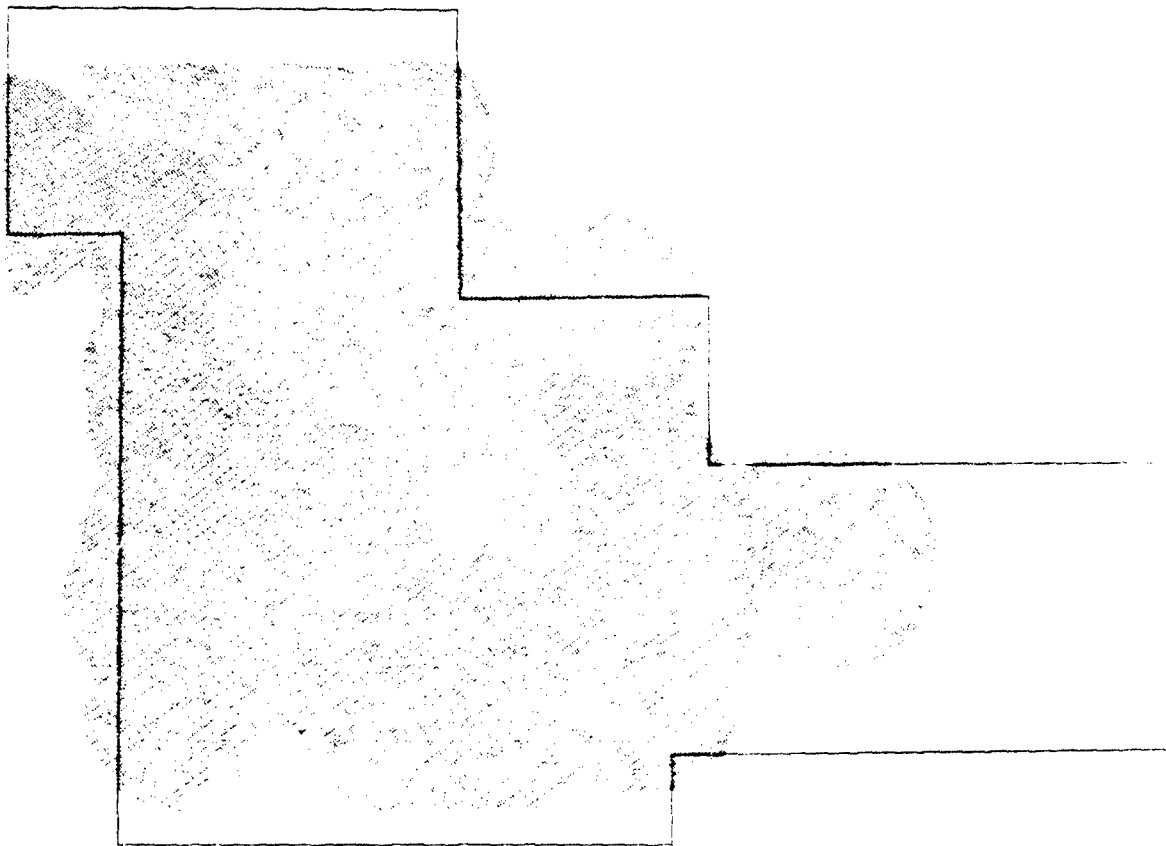
- 3 to 19 mg/kg
- 19 to 37 mg/kg
- > 37 mg/kg



Overlay F. Arsenic Concentrations in Surface Soil

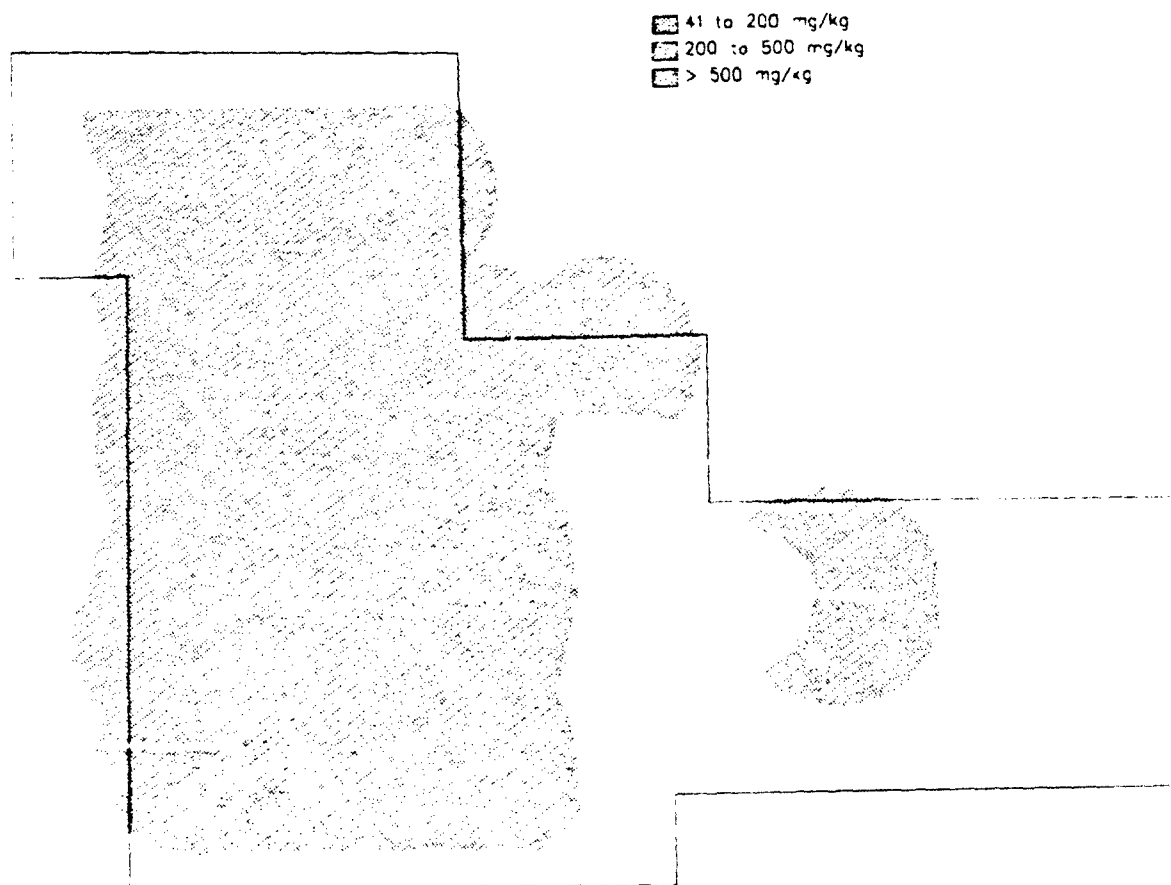
SURFACE BACKGROUND CONCENTRATION: 3.7 mg/kg

- 0.4 to 2 mg/kg
- 2 to 10 mg/kg
- > 10 mg/kg



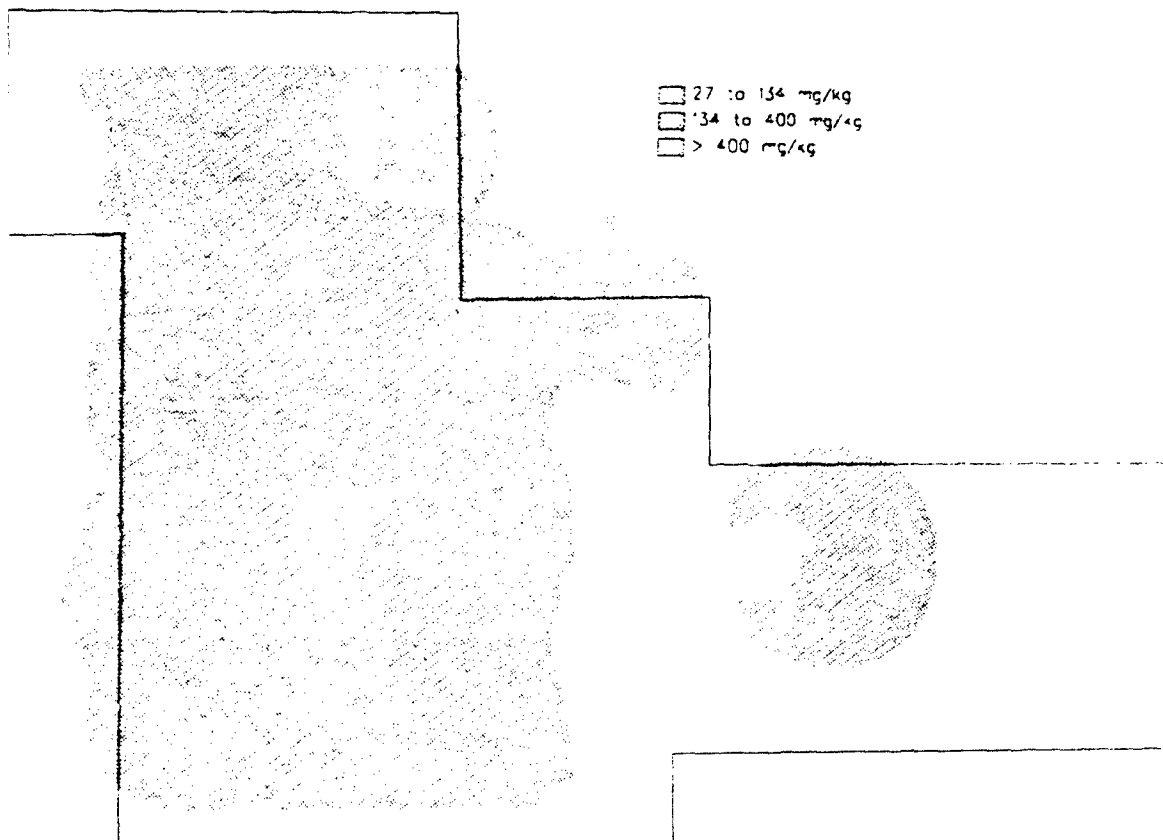
Overlay G. Cadmium Concentrations in Surface Soil

RELATIVE BACKGROUND CONCENTRATION: 0.4 mg/kg



Overlay H. Chromium Concentrations in Surface Soil

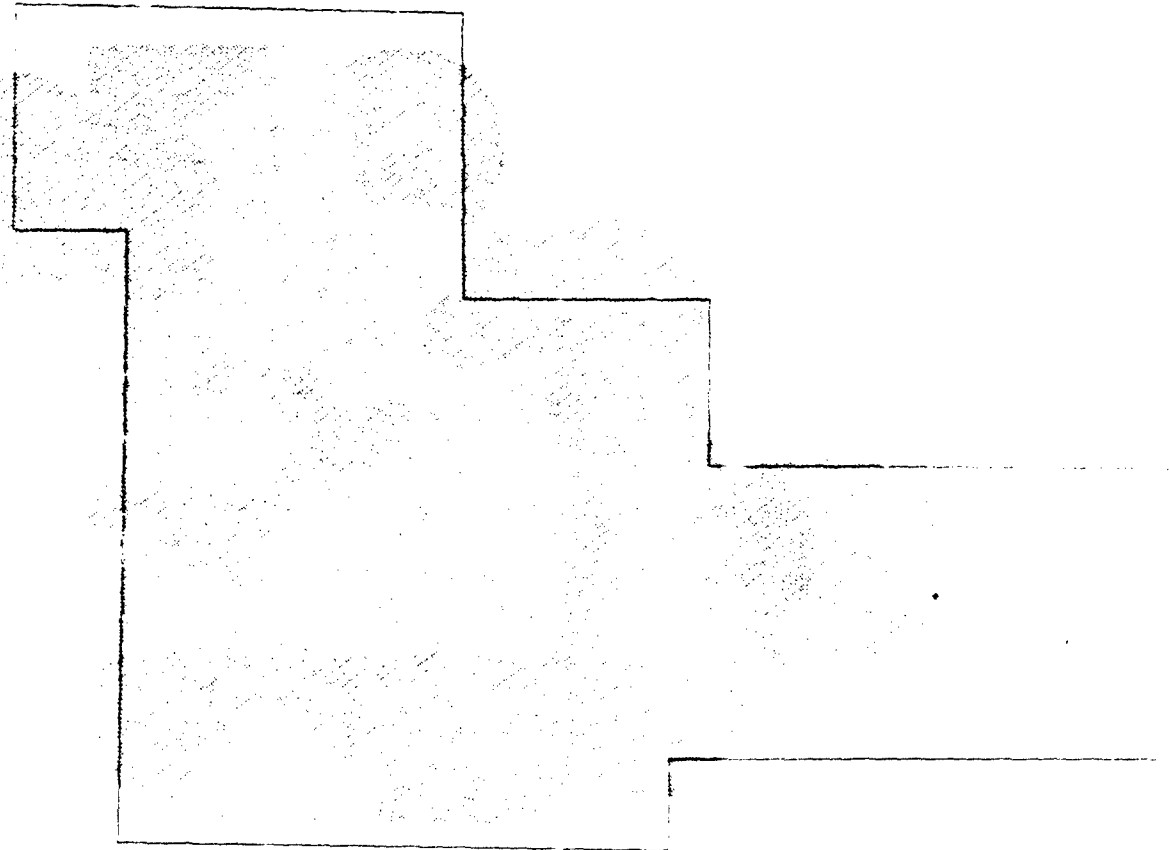
SUBSURFACE BACKGROUND CONCENTRATION: 41 mg/kg



Overlay I. Copper Concentrations in Surface Soil

SUBSURFACE BACKGROUND CONCENTRATION: 27 mg/kg

- 0.8 to 34 mg/kg
- 34 to 340 mg/kg
- > 340 mg/kg



Overlay J. Lead Concentrations in Surface Soil

USEPA REGIONAL BACKGROUND CONCENTRATION (RBC) FOR LEAD



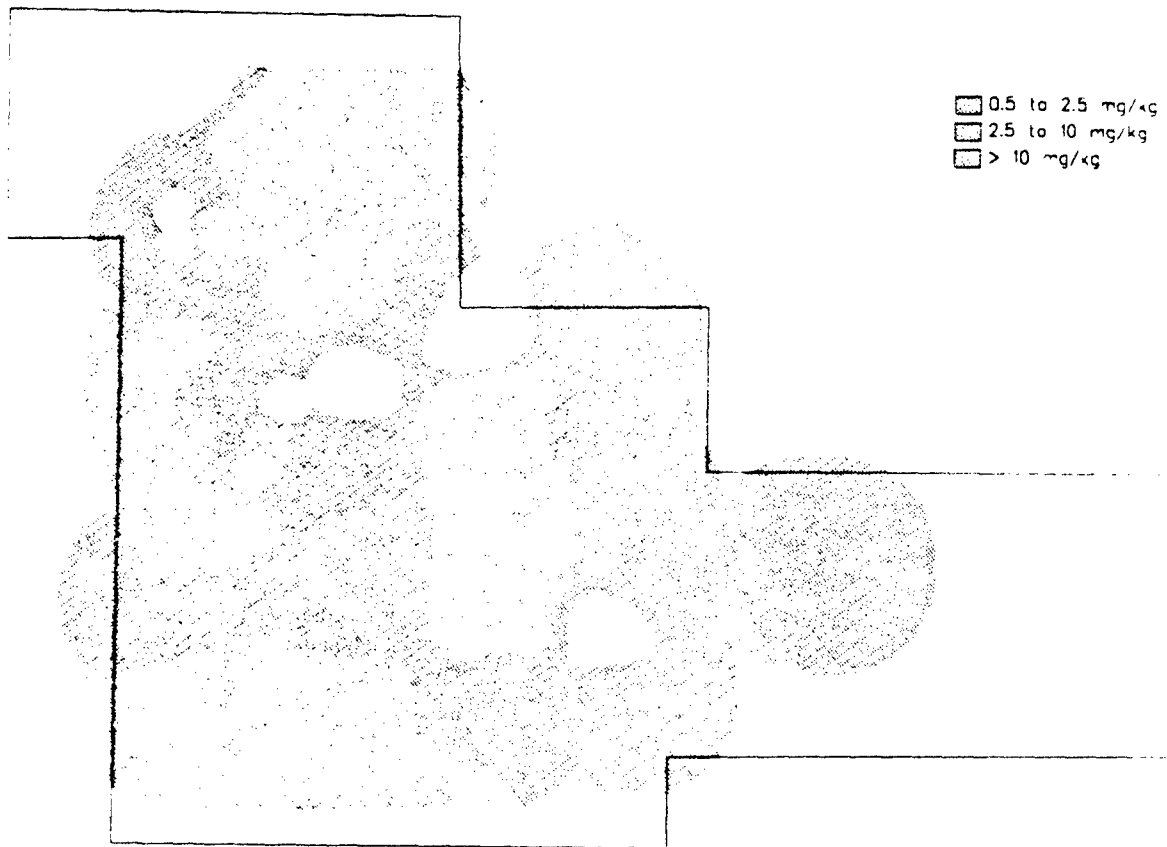
Overlay K. Mercury Concentrations in Surface Soil

< 0.2 mg/kg BACKGROUND CONCENTRATION



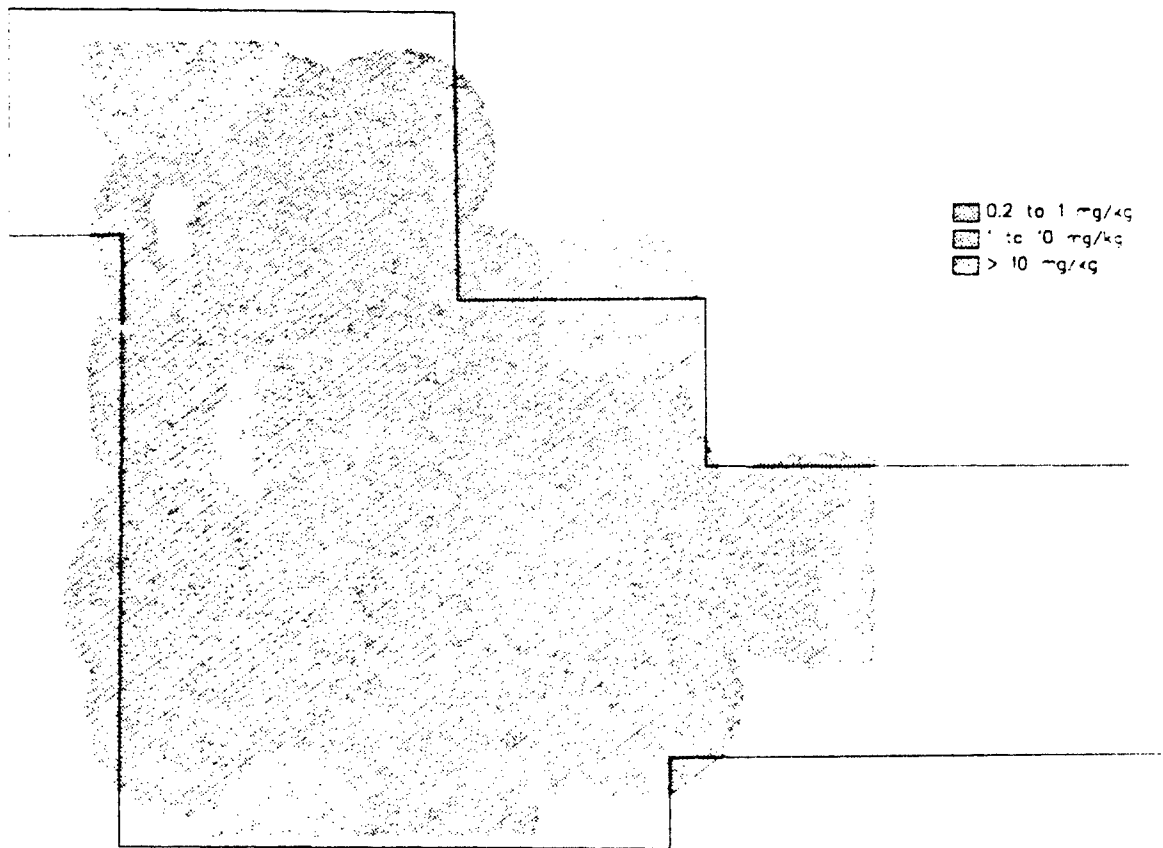
Overlay L. Molybdenum Concentrations in Surface Soil

SURFACE BACKGROUND CONCENTRATION: 4 mg/kg



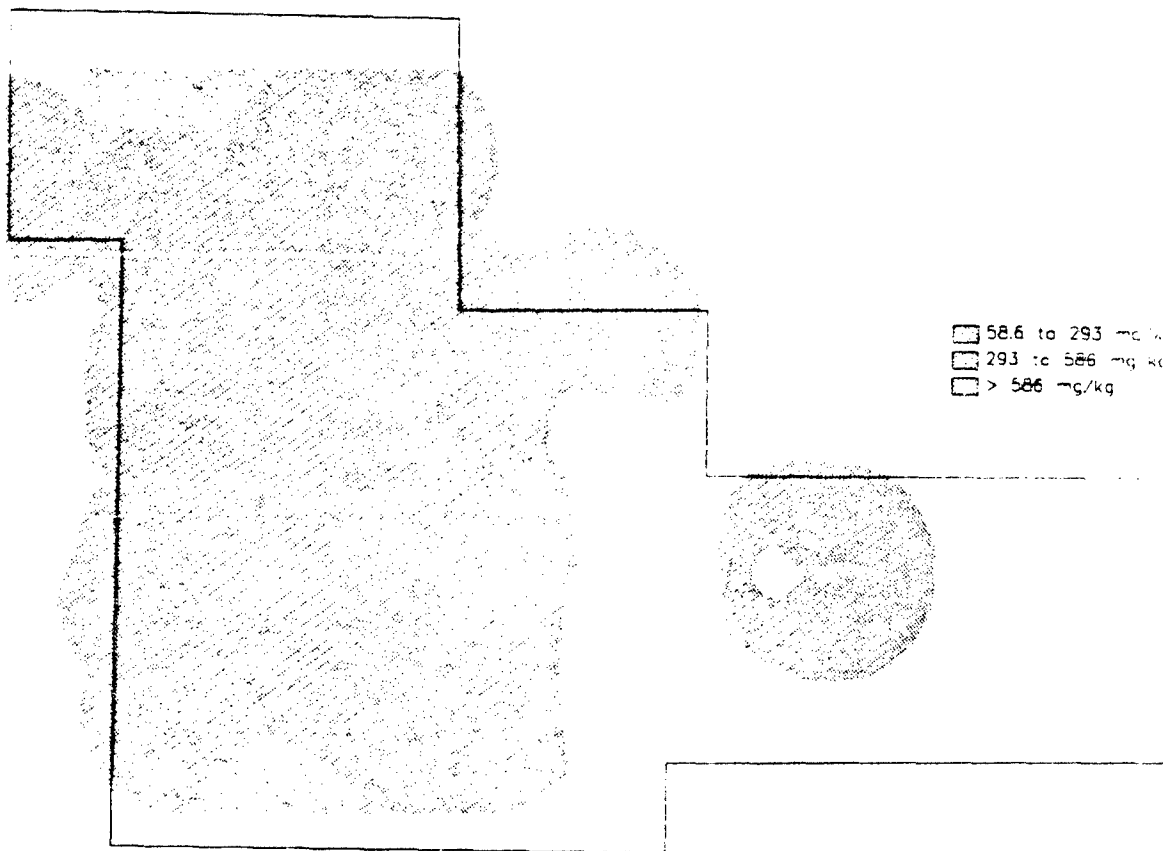
Overlay M. Selenium Concentrations in Surface Soil

SUBSURFACE BACKGROUND CONCENTRATION (mg/kg)



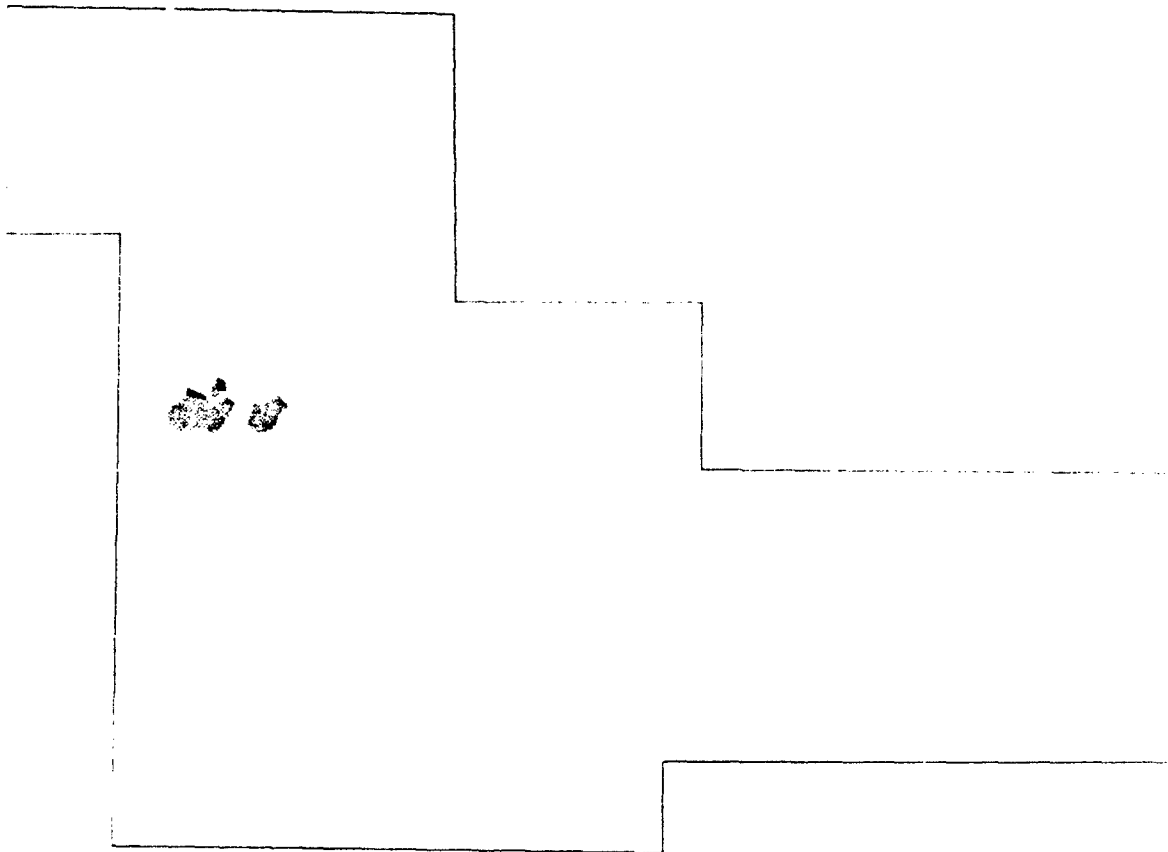
Overlay N Silver Concentrations in Surface Soil

SUBSURFACE BACKGROUND CONCENTRATION: 0.1 mg/kg

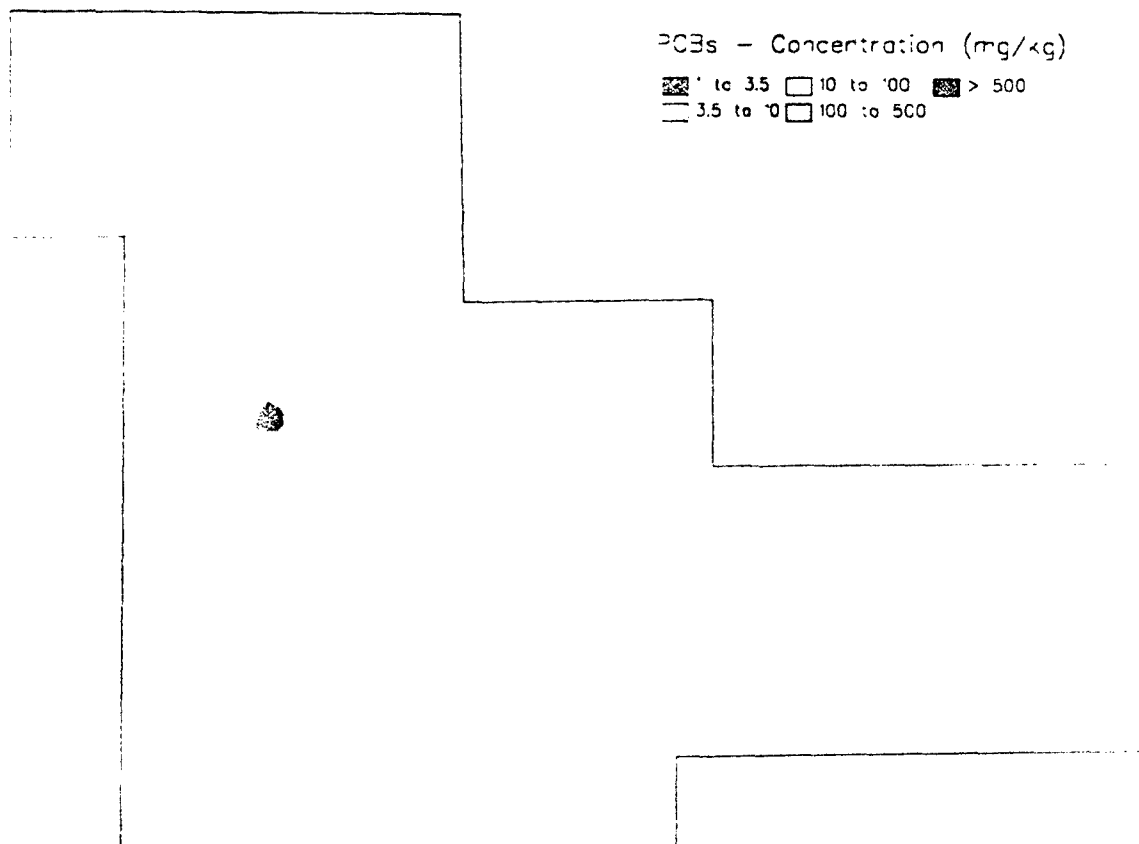


PCBs - Concentration (mg/kg)

■ 1 to 3.5 □ 10 to 100 ■ > 500
□ 3.5 to 10 □ 100 to 500

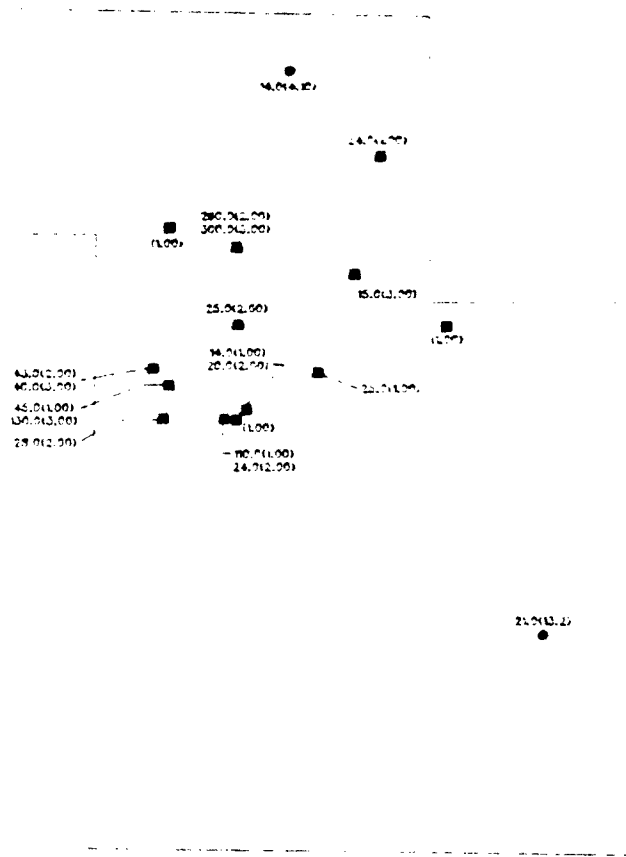


Overlay P. PCB Concentrations in Soil 1 to 3 feet BGS

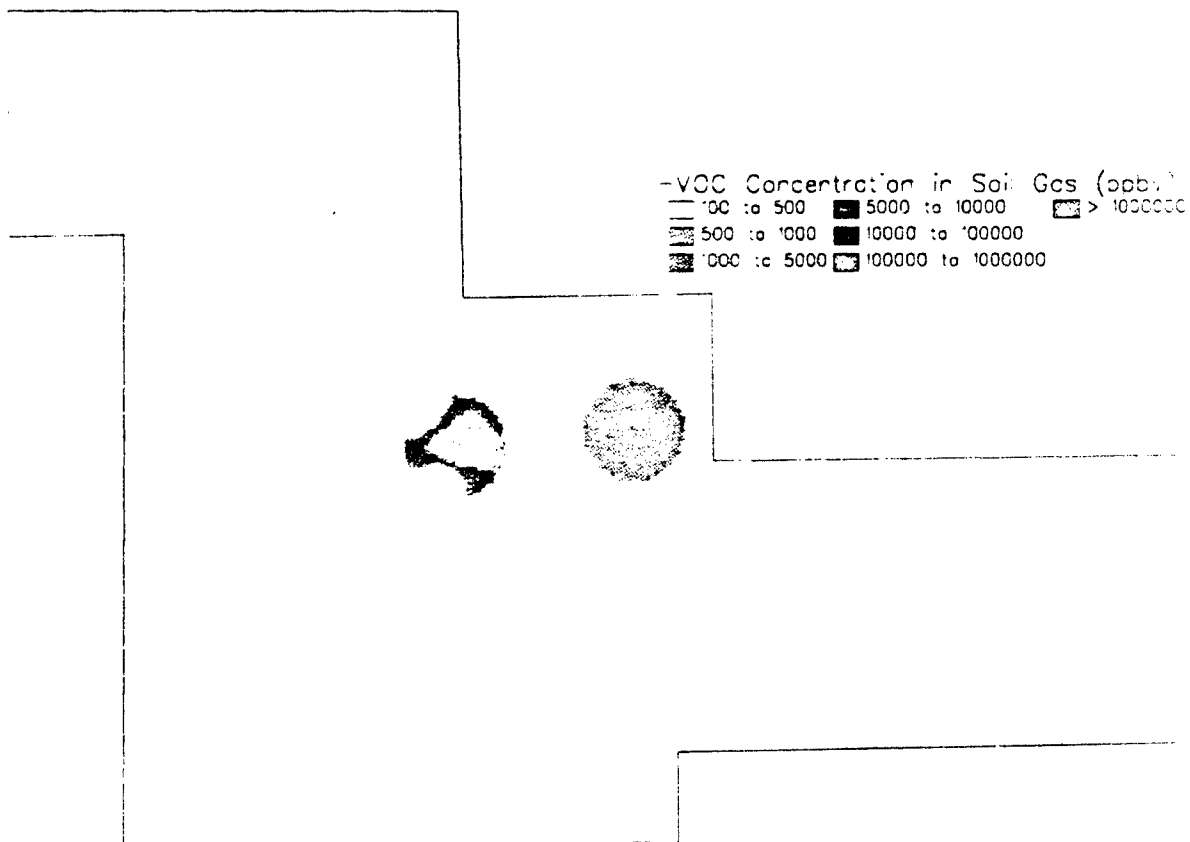


Overlay Q. PCB Concentrations in Soil 3 to 6 feet BGS

NO PCBs REPORTED BELOW 6 FEET BGS

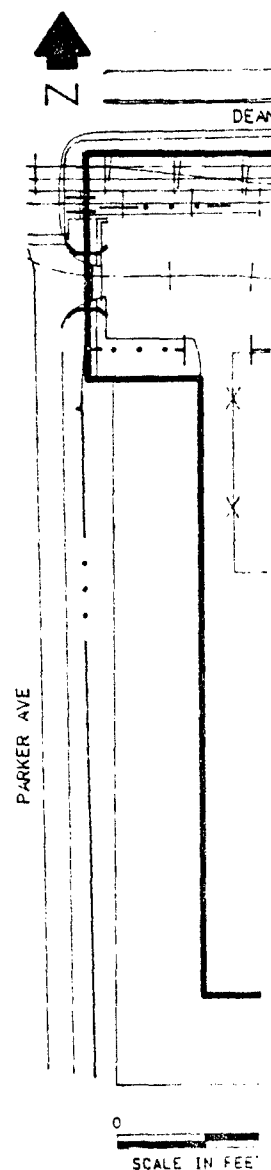


Overlay R. TPH Concentrations in Soils greater than
1 foot BGS

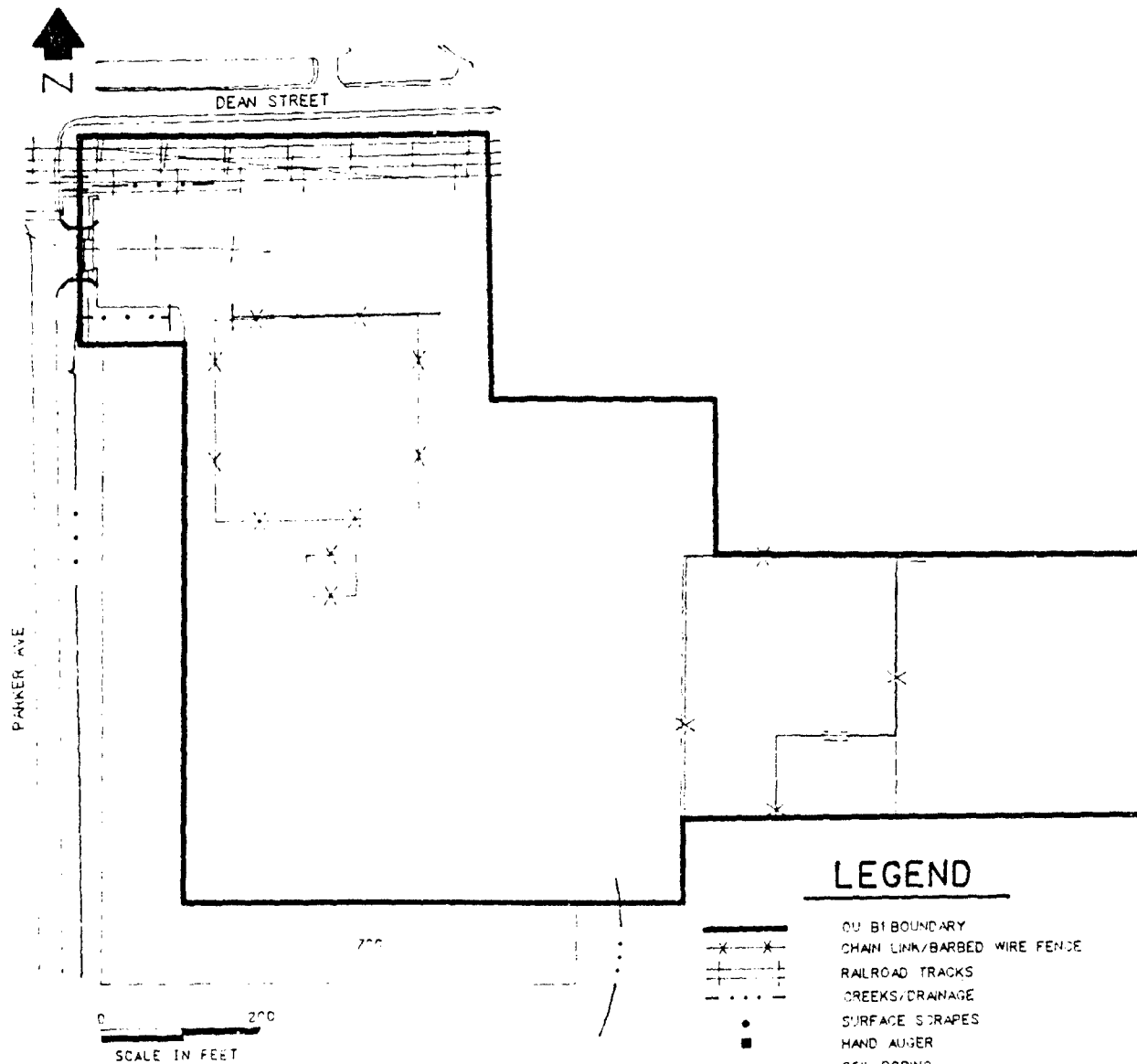


-VOC Concentrations in Soil Gas 21 feet BGS

- Overlay A. Sample Locations at OU B1
- Overlay B. PCB Concentrations in Surface Soil
- Overlay C. Dioxin/furan Concentrations in Surface Soil
- Overlay D. TPH Concentrations in Surface Soil
- Overlay E. SVOC Concentrations in Surface Soil
- Overlay F. Arsenic Concentrations in Surface Soil
- Overlay G. Cadmium Concentrations in Surface Soil
- Overlay H. Chromium Concentrations in Surface Soil
- Overlay I. Copper Concentrations in Surface Soil
- Overlay J. Lead Concentrations in Surface Soil
- Overlay K. Mercury Concentrations in Surface Soil
- Overlay L. Molybdenum Concentrations in Surface Soil
- Overlay M. Selenium Concentrations in Surface Soil
- Overlay N. Silver Concentrations in Surface Soil
- Overlay O. Zinc Concentrations in Surface Soil
- Overlay P. PCB Concentrations in Soil 1 to 3 feet BGS
- Overlay Q. PCB Concentrations in Soil 3 to 6 feet BGS
- Overlay R. TPH Concentrations in Soils greater than 1 foot BGS
- Overlay S. VOC Concentrations in Soil Gas 21 feet BGS



OPERABLE UNIT



OPERABLE UNIT B1

COLOR ON OVERLAYS INDICATES POSITIVE ANALYTICAL RESULTS. SAMPLES SHOWN WHERE COLLECTED. ALL RESULTS IN mg/kg EXCEPT WHERE NOTED.