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DRAFT
TECHNICAL MEMORANDUM NO. 4
**SITE MODEL FOR HYDROGEOLOGIC/
CONTAMINATION DISTRIBUTION
FOR TRENCH T-3; IHSS 110; OU-2
OU-2 SUBSURFACE IM/IRA
SOIL VAPOR EXTRACTION PILOT TEST
SITE NO. 1**

**VOLUME 1
TEXT AND FIGURES**

Rocky Flats Environmental Technology Site

(Operable Unit No. 2)

U.S. DEPARTMENT OF ENERGY

**Rocky Flats Environmental Technology Site
Golden, Colorado**

March 1995

**DOCUMENT CLASSIFICATION
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EG&G ROCKY FLATS ENVIRONMENTAL	Manual:	RF/ER-95-000XX
TECHNOLOGY SITE	Revision No.:	Draft
Draft OU-2 Subsurface IM/IRA	Page:	i of xix
Technical Memorandum No. 4	Organization:	Operable Unit No. 2 Closure
	Effective Date:	

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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
EXECUTIVE SUMMARY	xvi
1.0 INTRODUCTION	1
1.1 PROJECT OVERVIEW	1
1.2 TECHNICAL MEMORANDUM OBJECTIVE	2
1.3 ORGANIZATION	2
2.0 SITE CHARACTERISTICS	4
2.1 SITE HISTORY	4
2.2 SITE INVESTIGATIONS	5
2.2.1 Additional Trench T-3 Drilling Characterization Field Activities and Sample Analyses	7
2.2.2 Well Abandonment of SVE Arapahoe Formation No.1 Sandstone SVE Extraction and Monitoring Wells	13
2.3 MICROBIAL ECOLOGY	14
2.4 GEOLOGY	15
2.4.1 OU-2 and Trench T-3 Stratigraphy	15
2.4.2 Geotechnical Testing	19
2.4.3 Geophysical Borehole Logs	21

2.5	HYDROGEOLOGY	22
2.5.1	Upper Hydrostratigraphic Unit	23
2.6	NATURE AND EXTENT OF CONTAMINATION	33
2.6.1	Subsurface Soils	34
2.6.2	Groundwater	41
2.6.3	Soil Gas	51
2.6.4	NAPL	53
2.6.5	Sample Collection for Distillate Test and Numbering Overview	58
2.7	GEOPHYSICAL SURVEY OF TRENCH T-3	67
2.7.1	Introduction	67
2.7.2	Description of Geophysical Methods	68
2.7.3	Field Testing of GPR	72
2.7.4	Field Operations	73
2.7.5	Results	74
2.8	THREE-DIMENSIONAL SITE VISUALIZATION	75
3.0	OVERVIEW OF POTENTIAL CONTAMINANT PATHWAYS	80
4.0	SUMMARY	82
5.0	REFERENCES	86

LIST OF APPENDIXES

APPENDIX A TRENCH T-3 GEOLOGIC DATA

APPENDIX A1 BOREHOLE LOGS

APPENDIX A2 GEOTECHNICAL DATA

APPENDIX B AQUIFER PUMPING TEST ANALYSES

APPENDIX C ANALYTICAL DATA

APPENDIX C1 TRENCH T-3 SUBSURFACE SOIL DATA

APPENDIX C2 OU-2 UHSU GROUNDWATER DATA

APPENDIX C3 GROUNDWATER SAMPLES FROM PILOT TEST

APPENDIX C4 UHSU GROUNDWATER FROM WARP SAMPLING

APPENDIX C5 LIQUID SAMPLE COLLECTED FROM BOREHOLE 25794

APPENDIX C5-1 NOVEMBER SAMPLING

APPENDIX C5-2 DECEMBER SAMPLING

APPENDIX C5-3 DISTILLATE EXPERIMENT

LIST OF TABLES

TABLE 2.2-1 TRENCH T-3 (IHSS 110) DRILLING AND SOIL SAMPLE COLLECTION AND ANALYSIS SUMMARY, NOVEMBER 1994

TABLE 2.2-2 SUMMARY OF REQUESTED ANALYSIS FOR LIQUID SAMPLES COLLECTED IN DECEMBER, 1994

TABLE 2.2-3 SUMMARY OF DISTILLATION ANALYSIS CONDUCTED ON LIQUID SAMPLE C0640 COLLECTED IN DECEMBER, 1994

EG&G ROCKY FLATS ENVIRONMENTAL	Manual:	RF/ER-95-000XX
TECHNOLOGY SITE	Revision No.:	Draft
Draft OU-2 Subsurface IM/IRA	Page:	v of xix
Technical Memorandum No. 4	Organization:	Operable Unit No. 2 Closure
	Effective Date:	

TABLE 2.2-4	UHSU GROUNDWATER SAMPLES COLLECTED FROM SVE ARAPAHOE NO. 1 SANDSTONE WELLS PRIOR TO WARP
TABLE 2.4-1	TRENCH T-3 (IHSS 110) STRATIGRAPHIC AND MONITORING WELL DATA
TABLE 2.4-2	SUMMARY OF SAMPLES COMBINED FOR LABORATORY GEOTECHNICAL ANALYSIS, RFETS, TRENCH T-3 (IHSS 110), MARCH 1995
TABLE 2.4-3	SUMMARY OF GEOTECHNICAL ANALYTICAL TESTS CONDUCTED, RFETS, TRENCH T-3 (IHSS 110), MARCH 1995
TABLE 2.4-4	SUMMARY OF GEOTECHNICAL TESTING, RFETS, TRENCH T-3 (IHSS 110), MARCH 1995
TABLE 2.4-5	SUMMARY OF MECHANICAL TESTING, SIEVE TEST DATA, RFETS, TRENCH T-3 (IHSS 110), MARCH 1995
TABLE 2.5-1	OU-2 GROUNDWATER ELEVATIONS FOURTH QUARTER 1993
TABLE 2.5-2	ESTIMATED HYDRAULIC CONDUCTIVITY OF ROCKY FLATS ALLUVIUM BASED ON RESULTS OF 1986 AND 1987 AQUIFER TESTS
TABLE 2.5-3	ESTIMATED HYDRAULIC CONDUCTIVITY OF ROCKY FLATS ALLUVIUM BASED ON RESULTS OF 1992 AQUIFER TESTS
TABLE 2.5-4	ESTIMATED HYDRAULIC CONDUCTIVITY OF ARAPAHOE FORMATION NO. 1 SANDSTONE BASED ON RESULTS OF 1987 AQUIFER TESTS
TABLE 2.5-5	ESTIMATED HYDRAULIC CONDUCTIVITY OF ARAPAHOE FORMATION NO. 1 SANDSTONE BASED ON RESULTS OF 1992 AQUIFER TESTS
TABLE 2.5-6	PUMPING TEST RESULTS
TABLE 2.6-1	ANALYTES DETECTED IN SUBSURFACE SOIL AT IHSS 110 (TRENCH T-3)

EG&G ROCKY FLATS ENVIRONMENTAL Manual:	RF/ER-95-000XX
TECHNOLOGY SITE	Revision No.: Draft
Draft OU-2 Subsurface IM/IRA	Page: vi of xix
Technical Memorandum No. 4	Organization: Operable Unit No. 2 Closure
	Effective Date:

TABLE 2.6-2 ANALYTES DETECTED IN UHSU GROUNDWATER SAMPLES COLLECTED PRIOR TO ABANDONMENT OF WELLS DURING WARP

TABLE 2.6-3 SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (97 to 98 Degrees Celsius)

TABLE 2.6-4 SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (98 to 100 Degrees Celsius)

TABLE 2.6-5 SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (100 to 105 Degrees Celsius)

TABLE 2.6-6 SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (100 to 106 Degrees Celsius)

TABLE 2.6-7 SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (106 to 109 Degrees Celsius)

TABLE 2.6-8 SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (109 to 120 Degrees Celsius)

TABLE 2.6-9 SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (180 to 205 Degrees Celsius)

TABLE 2.6-10 SUMMARY OF DETECTED ANALYTICAL RESULTS FROM DISTILLATION RESIDUE

LIST OF FIGURES

- FIGURE 1.1-1 LOCATION AND IDENTIFICATION OF IHSSs TRENCHES, AND IHSS AREAS
- FIGURE 2.2-1 LIQUID COLLECTED FROM BOREHOLE 25194
- FIGURE 2.4-1 BOREHOLE AND MONITORING WELL LOCATIONS IN THE VICINITY OF TRENCH T-3
- FIGURE 2.4-2 LOCAL STRATIGRAPHIC COLUMN OF THE OU-2 AREA, ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
- FIGURE 2.4-3 LOCATIONS OF CROSS-SECTION LOCATIONS MAP A-A', B-B', C-C' THROUGH TRENCH T-3
- FIGURE 2.4-4 LOCATION OF CROSS-SECTION LOCATIONS MAP D-D' THROUGH TRENCH T-3
- FIGURE 2.4-5 A-A' CROSS-SECTION BENEATH TRENCH T-3 (IHSS 110)
- FIGURE 2.4-6 B-B' CROSS-SECTION BENEATH TRENCH T-3 (IHSS 110)
- FIGURE 2.4-7 C-C' CROSS-SECTION BENEATH TRENCH T-3 (IHSS 110)
- FIGURE 2.4-8 D-D' CROSS-SECTION (IHSS 110)
- FIGURE 2.4-9 E-E' CROSS-SECTION BENEATH TRENCH T-3 (IHSS 110)
- FIGURE 2.4-10 AREAL EXTENT OF VOID SPACE, FLATTEN DRUMS AND NAPL OR LIQUID IN TRENCH T-3
- FIGURE 2.4-11 TOP OF ARAPAHOE FORMATION (NO. 1) SANDSTONE
- FIGURE 2.4-12 ARAPAHOE FORMATION (NO. 1) SANDSTONE CHANNEL LOCATION AND THICKNESS
- FIGURE 2.4-13 TOP OF ARAPAHOE FORMATION (NO. 1) SANDSTONE IN VICINITY OF TRENCH T-3
- FIGURE 2.4-14 ARAPAHOE FORMATION (NO. 1) SANDSTONE CHANNEL LOCATION AND THICKNESS IN VICINITY OF TRENCH T-3
- FIGURE 2.4-15 ARAPAHOE FORMATION (NO. 1) SANDSTONE SUBCROP LOCATIONS

EG&G ROCKY FLATS ENVIRONMENTAL	Manual:	RF/ER-95-000XX
TECHNOLOGY SITE	Revision No.:	Draft
Draft OU-2 Subsurface IM/IRA	Page:	viii of xix
Technical Memorandum No. 4	Organization:	Operable Unit No. 2 Closure
	Effective Date:	

FIGURE 2.4-16 TOP OF BEDROCK ELEVATION BENEATH ALLUVIAL/
COLLUVIAL COVER

FIGURE 2.4-17 TOP OF BEDROCK ELEVATION BENEATH ALLUVIAL/
COLLUVIAL COVER IN VICINITY OF TRENCH T-3

FIGURE 2.4-18 CROSS-SECTION SHOWING ALLUVIAL AND BEDROCK
FEATURES

FIGURE 2.4-19 GENERALIZED CORE LITHOLOGY AND GEOPHYSICAL LOGS
COMPOSITE FOR PILOT BOREHOLE 21693

FIGURE 2.5-1 SCHEMATIC CROSS-SECTION OF THE HYDROSTRATIGRAPHY
AT OU-2

FIGURE 2.5-2 ALLUVIAL/COLLUVIAL POTENTIOMETRIC SURFACE
ELEVATION, [SECOND QUARTER (MAY) 1992]

FIGURE 2.5-3 ALLUVIAL/COLLUVIAL POTENTIOMETRIC SURFACE,
[FOURTH QUARTER (OCTOBER) 1993]

FIGURE 2.5-4 WELL B218789 HYDROGRAPH

FIGURE 2.5-5 WELL 4286 HYDROGRAPH

FIGURE 2.5-6 POTENTIOMETRIC SURFACE ELEVATION WITHIN THE
ARAPAHOE FORMATION NO. 1 SANDSTONE [SECOND
QUARTER (MAY) 1992]

FIGURE 2.5-7 POTENTIOMETRIC SURFACE WITHIN THE ARAPAHOE
FORMATION NO. 1 SANDSTONE [FOURTH QUARTER
(OCTOBER) 1993]

FIGURE 2.5-8 WELL 12391 HYDROGRAPH

FIGURE 2.5-9 WELL 05391 HYDROGRAPH

FIGURE 2.6-1 ANALYTE ABBREVIATIONS, LABORATORY AND VALIDATION
QUALIFIERS

FIGURE 2.6-2 VOCS, SVOCS, AND PESTICIDES/PCBS IHSS 110 (TRENCH T-3)
SUBSURFACE SOILS

FIGURE 2.6-3 SOURCE BOREHOLE CROSS-SECTION LEGEND

- FIGURE 2.6-4 SOURCE BOREHOLE CROSS-SECTION G-G' IHSS 110
(TRENCH T-3)
- FIGURE 2.6-5 SOURCE BOREHOLE CROSS-SECTION H-H'
- FIGURE 2.6-6 SOURCE BOREHOLE CROSS-SECTION I-I'
- FIGURE 2.6-7 SHALLOW AND DEEP EXTRACTION/PRESSURE MONITORING
PROBES IN TRENCH T-3
- FIGURE 2.6-8 CARBON TETRACHLORIDE ISOCONCENTRATION MAP FOR
THE ALLUVIAL/COLLUVIAL UHSU GROUNDWATER FLOW
SYSTEM FOURTH QUARTER 1993
- FIGURE 2.6-9 CARBON TETRACHLORIDE ISOCONCENTRATION MAP FOR
THE NO. 1 SANDSTONE UNIT UHSU GROUNDWATER FLOW
SYSTEM FOURTH QUARTER 1993
- FIGURE 2.6-10 CHLOROFORM ISOCONCENTRATION MAP FOR THE
ALLUVIAL/COLLUVIAL UHSU GROUNDWATER FLOW
SYSTEM FOURTH QUARTER 1993
- FIGURE 2.6-11 CHLOROFORM ISOCONCENTRATION MAP FOR THE NO. 1
SANDSTONE UNIT UHSU GROUNDWATER FLOW SYSTEM
FOURTH QUARTER 1993
- FIGURE 2.6-12 TETRACHLOROETHENE ISOCONCENTRATION MAP FOR THE
ALLUVIAL/COLLUVIAL UHSU GROUNDWATER FLOW
SYSTEM FOURTH QUARTER 1993
- FIGURE 2.6-13 TETRACHLOROETHENE ISOCONCENTRATION MAP FOR THE
NO. 1 SANDSTONE UNIT UHSU GROUNDWATER FLOW
SYSTEM FOURTH QUARTER 1993
- FIGURE 2.6-14 TRICHLOROETHENE ISOCONCENTRATION MAP FOR THE
ALLUVIAL/COLLUVIAL UHSU GROUNDWATER FLOW
SYSTEM FOURTH QUARTER 1993

- FIGURE 2.6-15 TRICHLOROETHENE ISOCONCENTRATION MAP FOR THE NO. 1 SANDSTONE UNIT UHSU GROUNDWATER FLOW SYSTEM FOURTH QUARTER 1993
- FIGURE 2.6-16 TOTAL VOCS ISOCONCENTRATION MAP FOR THE ALLUVIAL/COLLUVIAL UHSU GROUNDWATER FLOW SYSTEM FOURTH QUARTER 1993
- FIGURE 2.6-17 TOTAL VOCS ISOCONCENTRATION MAP FOR THE NO. 1 SANDSTONE UNIT UHSU GROUNDWATER FLOW SYSTEM FOURTH QUARTER 1993
- FIGURE 2.6-18 IHSS 110 CARBON TETRACHLORIDE (CCL₄) SOIL GAS ISOCONCENTRATION CONTOUR MAP AT 5 FOOT DEPTH
- FIGURE 2.6-19 IHSS 110 TETRACHLOROETHENE (PCE) SOIL GAS ISOCONCENTRATION CONTOUR MAP AT 5 FOOT DEPTH
- FIGURE 2.6-20 IHSS 110 TRICHLOROETHENE (TCE) SOIL GAS ISOCONCENTRATION CONTOUR MAP AT 5 FOOT DEPTH
- FIGURE 2.6-21 IHSS 110 TOTAL VOCS SOIL GAS ISOCONCENTRATION CONTOUR MAP AT 5 FOOT DEPTH
- FIGURE 2.6-22 IHSS 110 CARBON TETRACHLORIDE (CCL₄) SOIL GAS ISOCONCENTRATION CONTOUR MAP AT 10 FOOT DEPTH
- FIGURE 2.6-23 IHSS 110 TETRACHLOROETHENE (PCE) SOIL GAS ISOCONCENTRATION CONTOUR MAP AT 10 FOOT DEPTH
- FIGURE 2.6-24 IHSS 110 TRICHLOROETHENE (TCE) SOIL GAS ISOCONCENTRATION CONTOUR MAP AT 10 FOOT DEPTH
- FIGURE 2.6-25 IHSS 110 TOTAL VOCS SOIL GAS ISOCONCENTRATION CONTOUR MAP AT 10 FOOT DEPTH
- FIGURE 2.6-26 SUMMARY OF THE LIQUID ANALYTICAL DATA COLLECTED FROM BOREHOLE 25194 IN NOVEMBER, 1994
- FIGURE 2.6-27 SUMMARY OF THE LIQUID ANALYTICAL DATA COLLECTED FROM EXTRACTION WELL 25194 IN DECEMBER, 1994

- FIGURE 2.6-28 DISTILLATE TEST VOLUME VS. TEMPERATURE PLOT
- FIGURE 2.6-29 DISTILLATION TEST PIE PLOT
- FIGURE 2.6-30 SAMPLE NUMBERING SCHEME FOR DECEMBER NAPL AND DISTILLATE FRACTIONS
- FIGURE 2.7-1 ELECTROMAGNETICS CONTOUR MAP EAST-WEST ORIENTATION QUADRATURE DATA
- FIGURE 2.7-2 ELECTROMAGNETICS CONTOUR MAP EAST-WEST ORIENTATION INPHASE DATA
- FIGURE 2.7-3 ELECTROMAGNETICS CONTOUR MAP NORTH-SOUTH ORIENTATION QUADRATURE DATA
- FIGURE 2.7-4 ELECTROMAGNETIC CONTOUR MAP NORTH-SOUTH ORIENTATION INPHASE DATA
- FIGURE 2.7-5 SAMPLE GROUND PENETRATING RADAR RAW DATA LINE 140
- FIGURE 2.7-6 SAMPLE GROUND PENETRATING RADAR RAW DATA LINE 120
- FIGURE 2.7-7 SAMPLE GROUND PENETRATING RADAR RAW DATA LINE 0
- FIGURE 2.7-8 SAMPLE GROUND PENETRATING RADAR RAW DATA LINE 20
- FIGURE 2.7-9 SAMPLE GROUND PENETRATING RADAR RAW DATA LINE 50
- FIGURE 2.7-10 SAMPLE GROUND PENETRATING RADAR RAW DATA LINE 60
- FIGURE 2.7-11 SAMPLE GROUND PENETRATING RADAR RAW DATA LINE 70
- FIGURE 2.7-12 SAMPLE GROUND PENETRATING RADAR RAW DATA LINE 100
- FIGURE 2.8-1 ROCKY FLATS IHSS 110 GEOLOGY AND VOC CONCENTRATIONS
- FIGURE 2.8-2 ROCKY FLATS IHSS 110 GEOLOGY AND VOC CONCENTRATIONS, OBLIQUE VIEW TO THE NORTHWEST
- FIGURE 2.8-3 ROCKY FLATS IHSS 110 GEOLOGY AND VOC CONCENTRATIONS, OBLIQUE VIEW TO THE NORTH

EG&G ROCKY FLATS ENVIRONMENTAL Manual:

RF/ER-95-000XX

TECHNOLOGY SITE

Revision No.:

Draft

Draft OU-2 Subsurface IM/IRA

Page:

xii of xix

Technical Memorandum No. 4

Organization:

Operable Unit No. 2 Closure

Effective Date:

FIGURE 3.0-1 SUMMARY OF THE NATURE AND EXTENT OF PRIMARY
CONTAMINANTS IN NE TRENCHES AREA

FIGURE 3.0-2 TRENCH T-3 (IHSS 110) CONTAMINANT MIGRATION
PATHWAYS

LIST OF PLATES

PLATE 2.5-1 OU-2 SEEP LOCATIONS AND GEOLOGIC FEATURES

LIST OF ACRONYMS

µg/l	micrograms per liter
1,1-DCE	1,1-dichloroethene
1,1,1-TCA	1,1,1-trichloroethane
1,2-DCA	1,2-dichloroethane
1,2-DCE	1,2-dichloroethene
ASTM	American Society for Testing and Materials
BGS	below ground surface
BH	borehole
Ca	calcium
CCl ₄	carbon tetrachloride
CEARP	Comprehensive Environmental Assessment & Response Program
CHCs	chlorinated hydrocarbons
CHCl ₃	chloroform
CH ₂ Cl ₂	methylene chloride
COCs	chemicals of concern
DNAPL	Dense Non-aqueous Phase Liquid
DOE	Department of Energy
EM	electromagnetics
EPA	Environmental Protection Agency
ERM	Environmental Restoration Management
GC/MS	gas chromatography/mass spectrometry
gpm	gallons per minute
GPR	ground-penetrating radar
GSSI	Geophysical Survey Systems, Inc.
HRR	Historical Release Report
HSU	hydrostratigraphic unit
IHSS	Individual Hazardous Substance Site

IM/IRAP	Interim Measures/Interim Remedial Action Plan
K	hydraulic conductivity
Ka	Arapahoe Formation
Kl	Laramie Formation
LHSU	lower hydrostratigraphic unit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
Mg	magnesium
MSL	mean sea level
Na	sodium
NA	not applicable
NAPL	Non-aqueous Phase Liquid
OVM	organic vapor monitor
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
pCi/g	picocuries per gram
PID	photoionization detector
ppm	parts per million
Pu-239/240	plutonium-239/240
Pu-239	plutonium-239
Qc	colluvium
Qrf	Rocky Flats Alluvium
RCRA	Resource Conservation and Recovery Act
RFA	Rocky Flats Alluvium
RFEDS	Rocky Flats Environmental Database System
RFETS	Rocky Flats Environmental Technology Site
RFFO	Rocky Flats Field Office
RFI/RI	RCRA Facility Investigation/Remedial Investigation

EG&G ROCKY FLATS ENVIRONMENTAL	Manual:	RF/ER-95-000XX
TECHNOLOGY SITE	Revision No.:	Draft
Draft OU-2 Subsurface IM/IRA	Page:	xv of xix
Technical Memorandum No. 4	Organization:	Operable Unit No. 2 Closure
	Effective Date:	

RFP	Rocky Flats Plant
RI	remedial investigation
SAP	Sampling and Analysis Plan
SGS	Soil Gas Survey
SPSH	Six Phase Soil Heating
SOP	Standard Operating Procedure
SVE	Soil Vapor Extraction
SVOC	semivolatile organic compound
TCE	trichloroethene
UHSU	Upper Hydrostratigraphic Unit
VOC	volatile organic compound
VOACL	Volatile Organic Analysis Contract Laboratory Procedure

EG&G ROCKY FLATS ENVIRONMENTAL	Manual:	RF/ER-95-000XX
TECHNOLOGY SITE	Revision No.:	Draft
Draft OU-2 Subsurface IM/IRA	Page:	xvi of xix
Technical Memorandum No. 4	Organization:	Operable Unit No. 2 Closure
	Effective Date:	

EXECUTIVE SUMMARY

Technical Memorandum No. 4 was prepared to assemble and evaluate historical, geological, hydrogeological, and chemical data collected for Trench T-3, Individual Hazardous Substance Site (IHSS) 110, in support of the Operable Unit Number 2 (OU-2) Subsurface Interim Measures/Interim Remedial Action (IM/IRA).

Based on information contained in the Historical Release Report (DOE 1992a), sanitary sewage sludge contaminated with uranium and plutonium and flattened drums potentially contaminated with uranium were reportedly buried in the east trenches, which included Trench T-3. On at least one occasion, it is also believed that 2,400 gallons of water and lathe coolant was possibly disposed of in the east trenches. It is unknown whether this disposal was a direct discharge or the waste was containerized. Trench T-3 was used for disposal purposes from 1955 to 1968 (DOE 1992a). Geological and geophysical data indicate that Trench T-3 is approximately 5 to 10 feet deep, 135 to 140 feet long, and ranges in width from 19 to 23 feet.

The uppermost geologic unit in the vicinity of Trench T-3 is the Rocky Flats Alluvium (RFA), an alluvial fan deposit approximately 15 feet thick beneath Trench T-3. A laterally extensive caliche layer exists in the RFA on the north side of Trench T-3. This caliche layer has the potential to minimize vertical migration of precipitation in this area. However, the caliche layer was disturbed during the excavation of Trench T-3 and could enhance the vertical migration of precipitation through the trench. The RFA is underlain by the Arapahoe Formation, which consists of claystone beneath the west end of Trench T-3, and sandstone (No. 1 Sandstone) beneath the east end. The Arapahoe Formation No. 1 Sandstone ranges in thickness from approximately 20 to 35 feet in the vicinity of Trench T-3. Results of hydraulic conductivity testing conducted on samples collected in the vicinity of Trench T-3 ranged from 6.60E-04 cm/sec to 9.40E-08 cm/sec.

The upper hydrostratigraphic unit (UHSU) in the vicinity of Trench T-3 consists of saturated portions of the RFA and/or the Arapahoe Formation No. 1 Sandstone. During most of the year, the RFA beneath Trench T-3 is dry, and the uppermost saturated unit of the UHSU is the Arapahoe Formation No. 1 Sandstone. However, during high groundwater level periods (such as second quarter of 1992), the RFA may become saturated beneath Trench T-3. Due to fluctuating groundwater levels, depth to UHSU groundwater beneath Trench T-3 varies between 10 to 30 feet bgs. The groundwater flow direction in the RFA in the vicinity of Trench T-3 is primarily to the northeast along the medial bedrock paleoscur. The groundwater flow direction in the No. 1 Sandstone in the vicinity of Trench T-3 is primarily to the north.

Void spaces and flattened drums were observed in boreholes which were drilled and abandoned during the Trench T-3 drilling and characterization investigation in November 1994. Void spaces were observed in boreholes 25194 and 25294 at depths from 4 to 5.3 feet bgs and 4 to 6.5 feet bgs, respectively. Flattened drums were encountered in boreholes 25294, 25494, 25594, and 25694. Electromagnetic geophysical surveying also identified potential metallic objects below grade.

Subsurface soil analytical data and soil gas survey data collected from Trench T-3 indicate that the trench contains volatile organic compound (VOC) contamination (1,1,1-TCA, 1,2-DCA, CCl₄, CHCl₃, PCE and TCE). Trench T-3 appears to be a source of CCl₄, CHCl₃, PCE and TCE to the UHSU groundwater. These VOCs are observed primarily in the No. 1 Sandstone groundwater flow system north of Trench T-3. Concentrations of VOCs in subsurface soils decrease with depth to the water table. The soil gas survey data collected in Trench T-3 indicate that a CCl₄ soil gas plume is located in the west end of the trench. PCE and TCE soil gas plumes are located in the west-central part of the trench.

Minor contamination consisting of polynuclear aromatic hydrocarbons (PAHs), other semivolatile organic compounds (SVOCs), and low concentrations of Aroclor-1254 also exists

at Trench T-3. Concentrations of arsenic, lead, and silver were observed above background in soil samples collected from within Trench T-3. Activities of Am-241, Pu-239/240, U-233,-234, U-235 and U-238 above background were observed in the soil samples collected from within Trench T-3.

Non-aqueous phase liquid (NAPL) was observed in subsurface materials at several locations within Trench T-3. During drilling of borehole 25194 in the western portion of Trench T-3, a void space filled with liquid was encountered from an approximate depth of 4 to 5.3 feet. Samples showed a stratified liquid in three distinct layers; a black floating layer on top; a yellowish-brown layering the middle; and a black sinking layer on the bottom. Analytical testing performed on the floating and middle layers indicated elevated concentrations (PCE concentrations ranged from 2,700 to 37,000 parts per millions) of chlorinated hydrocarbons (CHCs), PAHs, phenols, phthalates, and organic hydrocarbons in the gasoline range (C_6 through C_{12}) and the diesel range (C_{12} through C_{24}). In addition to these organic compounds, elevated activities (ranging from approximately 100 to 3,250 pCi/g) of the uranium-isotopes (U-233,-234, U-235, and U-238) were observed in the liquid collected from borehole 25194. Am-241 and Pu-239/240 activities were approximately 1 pCi/g in the liquid collected from borehole 25194.

NAPL was also observed in several additional boreholes. A yellowish-brown liquid suspected to consist of free-phase chlorinated hydrocarbons (CHCs) was observed in borehole 10191 at an approximate depth of 2.8 feet. This borehole is located in the western portion of Trench T-3. Residual NAPL was observed in borehole 24793 at a approximate depth of 6.5 to 10 feet. The liquid observed in borehole 10191 was similar in appearance to the liquid observed in 25194. Residual NAPL was also observed in boreholes 25594 and 25694 at depths of 7 to 16 feet BGS and 11.8 to 12 feet BGS, respectively. NAPL in these two borings appeared as black asphalt-like lumps that impregnated the soil matrix and coated the gravels. A clear liquid was encountered at an approximate depth of 2.5 feet on the downhole equipment during the installation of three monitoring probe locations (APM20, APM24 and APM25).

EG&G ROCKY FLATS ENVIRONMENTAL	Manual:	RF/ER-95-000XX
TECHNOLOGY SITE	Revision No.:	Draft
Draft OU-2 Subsurface IM/IRA	Page:	xix of xix
Technical Memorandum No. 4	Organization:	Operable Unit No. 2 Closure
	Effective Date:	

To evaluate possible remedial technologies that may be applicable to NAPL occurring at Trench T-3, a distillation test was conducted on a liquid sample collected from borehole 25194. The distillation test was conducted to identify the boiling range and chemical makeup of the liquid collected from borehole 25194 with respect to temperature.

Based on the field investigations and testing conducted at the site, an overview of potential contaminant pathways was developed for Trench T-3. The primary migration pathway for contaminants found in the trench occurs vertically through the vadose zone beneath the trench to the UHSU groundwater and then laterally within the saturated alluvium, when present, and within the No. 1 Sandstone. The VOCs in UHSU groundwater migrate to the north in the No. 1 Sandstone and potentially discharge at seeps in the South Walnut Creek Drainage. Contaminant migration in the South Walnut Creek Drainage may occur in groundwater seeps in the colluvium on the north facing slope towards Ponds B-1 and B-2. The contaminants may then discharge to the ground surface then flow downslope towards Ponds B-1 and B-2, or the contaminants may discharge directly from the No. 1 Sandstone into Ponds B-1 and B-2.

1.0 INTRODUCTION

1.1 PROJECT OVERVIEW

In September 1992, the U.S. Department of Energy/Rocky Flats Office (DOE/RFO) released a Final Subsurface Interim Measures/Interim Remedial Action Plan (IM/IRAP) for investigating the removal of suspected volatile organic compound (VOC) contamination in the subsurface within three areas of Operable Unit Number 2 (OU-2) at the Rocky Flats Plant (RFP), subsequently renamed the Rocky Flats Environmental Technology Site (RFETS). Specifically, the OU-2 Subsurface IM/IRAP identified Soil Vapor Extraction (SVE) as an applicable technology for remediation of VOCs at the 903 Pad, Mound and East Trenches Areas. The IM/IRAP specified activities for investigation of the effectiveness of the SVE technology by pilot testing conventional and enhanced systems, and was designed to gain site-specific remedial information to support final remedial actions at OU-2.

The location for Pilot Test Site No. 1 (Site No. 1), of the Pilot Test Program, was selected within Individual Hazardous Substance Site (IHSS) 110 (also known as Trench T-3) located in the East Trenches Area of OU-2. Figure 1.1-1 provides the locations of IHSS 110 in relation to the other IHSS's at OU-2 and the RFETS facility. The location was selected based on soil gas survey results that indicated subsurface VOC contamination was present at sufficient levels to provide a meaningful evaluation of the SVE technology performance. A series of pilot tests conducted at Site No. 1 employed a conventional SVE system utilizing granular activated carbon (GAC) as an off-gas treatment system. Individual pilot tests were conducted in the Rocky Flats Alluvium and the No. 1 Sandstone Unit geologic units at Site No. 1. The Draft Test Site No. 1 Test Report (DOE 1994a) provides the results of those tests.

1.2 TECHNICAL MEMORANDUM OBJECTIVE

The purpose of Technical Memorandum (TM) No. 4 is to assemble and provide an evaluation of the most current geologic and contamination distribution data for the Northeast Trenches, and particularly Trench T-3, IHSS 110.

1.3 ORGANIZATION

The following is a brief summary of the TM No. 4 document organization:

1.0 Introduction

This section presents a project overview, and includes the TM No. 4 objectives and organization.

2.0 Site Characteristics

This section contains background information on IHSS 110, and presents and evaluates the most current available data for the site.

3.0 Contaminant Migration Pathways

This section discusses potential contaminant migration pathways for IHSS 110 based on the available data for the site.

4.0 Summary

This section summarizes the physical parameters and chemical data for Trench T-3.

5.0 References

This section contains the references cited in this report.

2.0 SITE CHARACTERISTICS

Trench T-3 (IHSS 110) is located north of Central Avenue, east of the inner fence, and south of South Walnut Creek at the RFETS. The following sections present the trench operational history and field investigations performed to date to characterize the trench, including the Test Site No. 1 optimization drilling results; geology of the trench; hydrogeology; nature and extent of contamination; results of geophysical surveys conducted; and the three-dimensional visualization efforts conducted for the area around the trench.

2.1 SITE HISTORY

The site history presented in this section is based on information presented in the Historical Release Report (DOE 1992a).

Trench T-3 (IHSS 110) was used primarily for the disposal of sanitary wastewater treatment plant sludge and operated sometime during the period of July 2, 1955, through August 14, 1968. The sludge removed from the RFETS wastewater treatment plant was first placed on sludge drying beds and, once dried, was removed and placed in a number of disposal trenches on site (Trench T-2 and the East Trenches [Trenches T-3 through T-11]). The trenches are reported to be approximately 10 feet deep with two feet of soil cover. It was reported that the estimated amount of sludge disposed in Trenches T-2 through T-11 was 125,000 kilograms (kg). Some uranium and plutonium contamination was present in this sludge. It was reported that the older sludge had primarily uranium contamination with newer sludge having an increased amount of plutonium contamination. Total long-lived alpha activity present in the sludge was reported between a minimum of 382 picocuries per gram (pCi/g) in August 1964 and a maximum of 3,591 pCi/g in June 1960. It has not been determined whether the sanitary sludge contained other contaminants such as VOCs. Since the RFETS wastewater treatment plant received influent from the entire site, it is possible that VOCs (e.g., degreasing/cleaning solvents) were discharged to the treatment plant, introduced to the

system from direct disposal in sinks and drains in laboratory, production, and/or maintenance areas of the plant site resulting in potential VOC contamination of treatment plant sludge.

Past operational practices at RFETS also included the burning of oils contaminated with uranium in open pits located on the plant site. Drums were used and reused to transport waste oils from various facility operations on the plant site to the oil burn pits, where the oils were dumped and ignited. The materials contained in the drums were machining coolants, still bottoms, and waste oils from facility operations. Although Trench T-3 was not operated as an oil burn pit, the drums which transported the waste oils were flattened and buried in the trench. The total number of flattened drums disposed of in the trenches is estimated at up to 300, and could be present in any of the East Trenches or Trench T-2. It is unknown how much residual material may have remained in the drums at the time of burial, or whether machining and waste oils transported in the drums contained other waste constituents such as organic solvents used to clean machined parts and tools.

In addition, on at least one occasion, it is believed that 2,400 gallons of water and lathe coolant was also disposed of in either Trench T-3 or one of the other disposal trenches in the area. It is unknown whether or not the material was discharged directly or disposed of in drums. The waste coolant was generated in Building 444 from the machining of depleted uranium and had an average activity of 150,000 dpm/l, believed to be total alpha activity. The activity of this material was reported as 1.35×10^8 dpm with approximately 1.3 kg of depleted uranium present in the waste. The radionuclide screen performed on a NAPL sample collected from borehole 25194 in the western portion of the trench in November 1994 indicated a gross alpha activity of 749,000 pCi/L (1.65×10^6 dpm/l) and a gross beta activity of 803,000 pCi/L (1.77×10^6 dpm/l) (Refer to Section 2.6.4 for further discussion).

2.2 SITE INVESTIGATIONS

Numerous site investigations have been performed at OU-2 to define the nature and extent of contamination from past waste disposal practices discussed in Section 2.1. The

investigations have identified Trench T-3 as a source of VOCs to the surrounding subsurface soils and the upper hydrostratigraphic unit (UHSU) groundwater. These investigations included the following:

- Phase I Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) conducted in 1987.
- Phase II Alluvial and Bedrock RFI/RIs conducted in 1991, 1992, and 1993, respectively.
- Two soil gas surveys conducted in 1993.
- The SVE Pilot Test Site No. 1 program conducted in 1993 and 1994.
- Additional Trench T-3 drilling characterization investigation conducted in 1994.

The Phase I RFI/RI involved drilling and sampling of two boreholes in and around Trench T-3 (BH3897 and BH4087). The Phase II (Alluvial) RFI/RI included drilling and sampling of one borehole (10191) in Trench T-3 and the installation of two groundwater plume characterization wells (02991 and 12191) south of Trench T-3. The Phase II (Bedrock) RFI/RI investigation included drilling and sampling of one pilot borehole (21693), one lower hydrostratigraphic unit (LHSU) monitoring well (23293), and one abandoned monitoring well (22493) north of Trench T-3. The SVE Pilot Test Site No. 1 investigation consisted of drilling and sampling of two boreholes and nine groundwater monitoring wells installed near Trench T-3 (24093 through 25093). Constituents analyzed included VOCs, SVOCs, pesticides/PCBs, metals, and radionuclides. The two soil gas surveys included sampling of near-surface and deeper (5- to 10-foot sampling interval) subsurface soil gas in and around Trench T-3 (including IHSSs 109, 111.1, 112, and 113). Additional Trench T-3 drilling characterization investigation consisted of drilling and sampling six boreholes and the

conversion of one borehole to a NAPL extraction well in Trench T-3 (25194 through 25694). VOCs, SVOCs, TPH and selected radionuclide analyses were performed on the subsurface soil and NAPL samples collected during the Trench T-3 drilling characterization investigation conducted in 1994. Section 2.2.1 discusses the drilling and sampling during the Trench T-3 drilling characterization investigation. The evaluation of site geology (Section 2.4) and site hydrogeology (Section 2.5) presented in this document is based on information collected during the investigations listed above. Section 2.6 discusses the nature and extent of contamination identified from these investigations.

2.2.1 Additional Trench T-3 Drilling Characterization Field Activities and Sample Analyses

To investigate the NAPL, or liquids, encountered in Trench T-3 during previous field activities and to characterize the eastern portion of Trench T-3, six boreholes were drilled between Alluvial Pressure Monitor (APM) 25 and borehole 10191 in November 1994. One of the boreholes drilled was converted into a NAPL extraction well. Figure 2.4-1 shows the locations of these boreholes and the extraction well. Borehole logs are presented in Appendix A1.

Drilling and sampling of each soil borehole was performed using hollow-stem augers in compliance with RFETS SOP GT.02, Drilling and Sampling Using Hollow Stem Auger Techniques. Boreholes were to be drilled to an approximate depth of 10 feet BGS using 3.5-inch inside diameter (ID) hollow stem augers. Variation in the drilling depths are discussed in the borehole drilling summaries. Boreholes were continuously sampled to the total depth using a 2-foot split spoon sampler. Discrete samples were collected for volatile organic analysis (VOA) by EPA Method 8240 using stainless-steel liners inside the split spoon. The two VOA samples exhibiting the highest organic volatile meter (OVM) reading were selected for analysis from each borehole. If no organic compounds were detected by the OVM, VOA samples were planned for collection from the 5-foot and 10-foot intervals. One composite sample for total organic carbon (TOC) analysis was planned for collection from each borehole

over a 2-foot interval. Samples for radionuclide screening were collected for each sampling interval. Samples for semivolatile organic compounds (SVOCs) analysis by the EPA Method 8270 were planned for collection at 5-foot and 10-foot intervals in each borehole. Samples for total petroleum hydrocarbons (TPH) analysis by EPA Method 8015 were planned for collection if discolored or stained soil was encountered in the borings. The geotechnical analysis, soil moisture content was to be performed on selected samples depending on the amount of core recovered. All samples were collected in the field according to RFETS SOP FO.13, Containerization, Preservation, Handling, and Shipping of Soil and Water Samples. Table 2.2-1 provides a summary of soil samples collected and analyses requested. Laboratory analytical results are discussed in Section 2.6-4 and presented in Appendix C5-1 through C5-3.

Following the drilling and sampling, the boreholes were abandoned in accordance with RFETS SOP GT.5, Abandonment and Plugging of Boreholes. However, if void spaces were encountered or the borehole failed to be filled with the grout in the subsurface during the drilling of the borehole, the borehole was plugged at an approximate depth of 2 to 3 feet bgs. The plug was constructed by fabricating a 2- to 3-foot long metal rebar cage. The steel rebar cage was placed in the borehole to approximate depth of 2 feet below ground surface then a cement/bentonite grout was placed into the cage to the ground surface. The plug was intended to prevent the closing of the void space and to allow for later removal of the plug, if necessary.

The following is a description of the drilling and sampling of each borehole within Trench T-3 during the drilling characterization investigation that occurred in November 1994.

Borehole 25194

Borehole 25194 was drilled and sampled to a depth of 4 feet below ground surface (BGS). Upon removal of the core barrel from the 2- to 4-foot sampling interval, liquid was observed dripping from the core barrel (OVM reading of 659 ppm). The borehole was measured to

a depth of 5.3 feet BGS and liquid was observed to be dripping from the measuring tape when removed. The 1.3 feet difference between the drilling depth and the measure depth is believed to be due to a void space below grade in the trench. A four foot long, two-inch diameter clear teflon sample bailer was lowered down the borehole to collect a grab sample of the liquid. When the bailer was removed it was approximately half full with stratified liquid. Four stratified layers (Figure 2.2-1) were observed:

- very viscous black layer on the bottom
- yellowish-brown and less viscous layer in the middle
- clear layer above the yellowish-brown
- black layer on top

Additional grab samples of the liquid were collected from the borehole for chemical analysis. Field measurements of the liquid by the OVM were off the scale of the instrument (i.e., greater than 2,000 ppm). The radionuclide screen sample was submitted to Building 371 laboratory for analysis. Prior to shipment off-site, the radionuclide screen results showed total alpha activity of 749,000 pCi/L and total beta activity of 803,000 pCi/L. During shipment of the samples to the laboratory, the middle two layers of the sample mixed. The laboratory performed analytical testing using EPA Methods 8260, 8270, and modified 8015 on the top layer (i.e., floating) and the middle layer (i.e., aqueous layer) separately. Only two separate layers were observed in the sample when it arrived at the laboratory.

An extraction well was constructed in borehole 25194 with the installation of approximately 4 feet of 4-inch diameter schedule 40 PVC casing and two feet of 4-inch diameter screen with 0.50 slots. One centralizer was placed on the outside of the casing at a depth of 2 to 2.5 feet BGS, which was above the liquid in borehole 25194. Empty concrete bags were packed above the centralizers. Then approximately 1.5 feet of bentonite pellets were placed above the bags. The bentonite pellets were hydrated with 5 gallons of potable water. Concrete was then placed above the grout to the ground surface. No filter pack was placed in this borehole. Protective casing was installed.

The following is a summary of the additional sampling and analysis requested for the liquid collected in December 1994 from extraction well 25194:

- The liquid sample was collected from extraction well 25194 using a clear 4-foot, 2-inch diameter bailer. The liquid in the bailer was stratified into two distinct layers, a floating black layer on the top [referred to as the floating layer (1), sample number C0639] and a yellowish-brown layer on the bottom (referred to as the aqueous layer, sample number C0640). The two layers were decanted separately into the appropriate sample containers. A radionuclide screen analysis was performed prior to shipment.
- During shipment of sample number C0640 to the laboratory, the original aqueous sample stratified into a floating [referred to as floating (2)] and aqueous layers. These two layers were analyzed separately. Table 2.2-2 presents the sample number, corresponding laboratory sample number, sample description, and the requested analysis for the three different samples.
- In addition to the requested analysis, a distillation test was performed on sample number C0640 (both layers combined). No distillation tests were performed on sample number C0639. The following presents the procedures used to perform the distillation analysis.
 - The sample was delivered to the laboratory.
 - Two liters of initial sample were placed into the distillation unit.
 - The temperature was increased to predetermined increment and held for approximately 15 minutes. Samples at specific temperature ranges (i.e., 97° to 205°C) were distilled off, condensed, and tested.

- The volume which volatized from the initial sample was collected and measured, cooled to room temperature, and the sample was evaluated to identify if the liquid stratified into layers.
- If the fraction of the volatized material was stratified into layers, the volume of each stratified layer was also measured.
- Each distillation sample, and if present each stratified layer(s), in the distillation sample were analyzed for VOA (Method 8260), SVOA (Method 8270), and TPH (Modified Method 8015).
- Table 2.2-3 presents summary information on the distillation analysis (such as the sample description, temperature range, volume of distillate, miscibility in water, and laboratory analyses requested).

Results for analyses conducted on distillate samples are discussed in Section 2.6-5 and presented in Appendix C5-1 through C5-3.

Borehole 25294

Borehole 25294 was drilled to a depth of 8.0 feet BGS (Table 2.2-1). During drilling and sampling of borehole 25294, a large cobble was encountered near the ground surface which prevented the collection of a soil core in the borehole to an approximate depth of the 4 feet. The OVM reading was 11 ppm downhole at 4 foot depth. Muddy water was observed dripping from the core barrel at approximately the 4-foot depth. After the cobble was pushed aside, a drum was encountered which prevented the collection of soil core to a depth of 8 feet. At this depth, drilling was stopped and an attempt was made to abandon the borehole using a bentonite grout slurry (4 bags of bentonite, approximately 30 gallons). When the required amount of bentonite slurry failed to fill and seal the borehole, field personnel pulled the augers to investigate why the borehole was not sealed. Once the augers were removed,

a large void space was observed in the borehole from an approximate depth of 4 to 6.5 feet BGS. In addition to the large void space, three flattened drums were observed in the borehole at depths greater than 4 feet. A downhole camera was lowered into the borehole to view the void space. On Thursday, November 3, 1994, EG&G personnel videotaped borehole 25294 with the downhole camera. The camera clearly indicated a void space from 4 to 6.4 feet BGS. The borehole was plugged using a metal rebar plug filled with a cement/bentonite slurry.

Borehole 25394

Borehole 25394 was drilled and sampled to an approximate depth of 9 feet BGS (Table 2.2-1). A caliche layer was encountered at approximately 6 to 7 feet BGS indicating that the base or bottom of the trench is above this depth. Similar to conditions at borehole 25294, the bentonite grout slurry did not fill and seal the borehole. The borehole was then plugged using a metal rebar cage and concrete.

Borehole 25494

Borehole 25494 was drilled and sampled to an approximate depth of 3.5 feet (Table 2.2-1). A large void space was encountered at a depth of 3.5 feet. Due to limited recovery, no samples were collected for analytical testing. There was an OVM reading of 19 ppm at a depth of 3.5 feet. Upon removal of the augers, the field crew observed three flattened drums in the borehole. Cement/bentonite was poured into the borehole to the ground surface to abandon the borehole.

Borehole 25594

Borehole 25594 was drilled and sampled to a depth of 16 feet (Table 2.2-1). Drums were encountered at an approximate depth of 2.5 feet, which prevented the recovery of core. The center bit from the hollow stem auger was used to drill through the drums from a depth of

2.5 to 7 feet. Discolored soil was encountered at a depth of 9 to 9.25 feet (OVM reading of 1300 ppm). The discolored soil was described as an black asphalt-like which had impregnated the matrix and coated the gravels. Samples were collected from the discolored soil for laboratory analysis. No soil core was collected from 10 to 14 feet, so the center bit was used to drill from 14 to 15 feet. Bedrock described as clayey siltstone was encountered at a depth of 15.5 feet. Two five-gallon buckets of bentonite pellets were placed down the borehole and hydrated to seal the bottom of the hole to prevent potential vertical migration of contaminants. A metal rebar plug filled with a concrete/bentonite slurry was then placed at an approximate depth of 3 feet BGS.

Borehole 25694

Borehole 25694 was drilled and sampled to a depth of 14 feet (Table 2.2-1). No core was recovered from a depth of 7 to 8 feet BGS, so the center bit was used to drill from 8 to 10 feet. Black discolored soil was observed in the core from an approximate depth of 10 to 13 feet. Bentonite pellets were placed on the bottom of borehole and hydrated to prevent potential vertical migration of contaminants down the borehole. The borehole was abandoned using a metal rebar plug filled with a cement/bentonite slurry.

2.2.2 Well Abandonment of SVE Arapahoe Formation No.1 Sandstone SVE Extraction and Monitoring Wells

Prior to the abandonment of the SVE Arapahoe Formation No. 1 Sandstone wells (24193, 24393, 24993, and 25093) located near Trench T-3 (Figure 2.4-1), groundwater analytical samples were collected for analytical testing. A televiewer camera was also lowered down the casing in well 24193, 24393, and 24993 to document the condition of the well prior to abandonment.

The groundwater analytical samples were collected from each well at the bottom of the well and at the top of groundwater. Samples were collected at the bottom of the well using a

bottom sampling bailer, while the top of groundwater sample was collected with a 4-foot bailer. Table 2.2-4 shows where each sample was collected (i.e., top or bottom), the depth to groundwater from the top of the well casing and its elevation as measured from mean seal level (MSL). Groundwater samples were analyzed for VOCs by EPA Method 524.2 and dissolved metals. Analytical results are discussed in Section 2.6.2 and presented in Appendix C4.

2.3 MICROBIAL ECOLOGY

The microbial ecology of the Trench T-3 area has not been characterized to date. Information on the Trench T-3 area microbial population, and other factors, will assist in determining the use of biodegradation for the potential site remediation. Based on the results of numerous studies presented in the literature, it is known that chlorinated solvents such as those found in OU-2 are either oxidized or dechlorinated by microorganisms (Egli et al. 1988, Egli et al. 1990, Fogel et al. 1986, Gossett 1985, Janssen et al. 1988, Kastner 1992, Little et al. 1988, Nelson et al. 1987, Oldenhuis et al. 1989, Vogel et al. 1987, Wackett et al. 1989). Also, studies have shown that these solvents or similar solvents can be completely degraded to nonregulated products under controlled laboratory conditions (Norris et al. 1994).

However, there is a lack of information on successful application of biodegradation of chlorinated solvents in situ since this is a relatively new area of study. Therefore, at this time, it is not possible to predict the potential for successful biodegradation of chlorinated solvents using in situ treatment in OU-2.

Though it is biologically possible to degrade chlorinated solvents, the types of microorganisms, physical features, soil chemistry, contaminant concentration and availability, permeability of the soil matrix to water and nutrients, and redox conditions of OU-2 will determine whether microorganisms can be used to treat the solvents in OU-2. A thorough evaluation of these factors requires a treatability study and is beyond the scope of this

evaluation. However, a treatability study on the biodegradation of chlorinated solvents in OU-2 soil is underway at RFETS.

2.4 GEOLOGY

2.4.1 OU-2 and Trench T-3 Stratigraphy

The geology beneath Trench T-3 was evaluated based on the available information collected from the Phase I, Phase II (alluvial and bedrock), SVE Site No. 1 field, and the Trench T-3 drilling characterization investigation. Phase I and Phase II borehole and monitoring well construction logs are presented in the Preliminary Draft Phase II RFI/RI Report for OU-2 (DOE 1993a), while the SVE Site No. 1 and Trench T-3 drilling characterization investigation draft borehole and monitoring well construction logs are presented in Appendix A1 of this report. The locations used to evaluate the geology beneath Trench T-3 are listed in Table 2.4-1 and shown on Figure 2.4-1. Table 2.4-1 lists survey coordinates, ground surface elevations, stratigraphic, and well/borehole completion information. The main geologic units of concern beneath Trench T-3 are the Rocky Flats Alluvium, the Arapahoe Formation, and upper portion of the Laramie Formation (uppermost five feet). Figure 2.4-2 shows the generalized stratigraphy of these units in the vicinity of RFETS. Cross-sections have been constructed to illustrate the subsurface conditions around Trench T-3 (Figures 2.4-5 through 2.4-8). Figures 2.4-3 and 2.4-4 show the locations of those cross-sections (A-A', B-B', C-C', D-D', and E-E'). The cross-sections were constructed to show the geology of the geologic units of concern, including a caliche layer within the Rocky Flats Alluvium, the No. 1 Sandstone Unit within the Arapahoe Formation, and a highly friable saturated sandstone layer within the No. 1 Sandstone Unit. The cross-sections also show the approximate extent of Trench T-3, void space, and flatten drums area.

The East Trenches, including Trench T-3, are underlain by RFA that is the topographically highest and oldest unconsolidated deposit beneath RFETS (DOE 1993a), as shown on Figure 2.4-2. The RFA was deposited as large, laterally coalescing alluvial fans along the base of

the adjacent mountain front (Hurr 1976). The thickness of the RFA is approximately 15 feet in the vicinity of Trench T-3, and is comprised of clayey, silty, and sandy gravel (GC, GM, and GW) with interbedded clay lenses (CL), clayey silty, gravelly sands (SC and SM), and a laterally extensive caliche layer.

The gravel and sand layers in the vicinity of Trench T-3 range in grain size from fine-grained sands to cobbles, are angular to subrounded, have low plasticity, usually have a trace to some fines (clays and silts) or caliche as a binder in matrix, and are generally brown to reddish-brown in color.

The contact between the RFA and the underlying bedrock (Arapahoe and Laramie units) is highly irregular, due to the erosion of the top of bedrock surface, as shown on Figure 2.4-16. Figure 2.4-17 shows the enlarged view of the top of bedrock in the vicinity of Trench T-3. Therefore, the thickness and geometry of the Rocky Flats Alluvium is controlled by certain top of bedrock features.

The caliche layers, in general, contain about 50 percent calcium carbonate, range in grain size from fine-grained sand to cobbles, are angular to subrounded, have low plasticity, and are white to a very pale brown in color. The caliche was encountered in the boreholes around Trench T-3 at an approximate depth of 2 to 4 feet, with caliche thickness ranging from 1 to 6 feet, as shown on Figures 2.4-5, 2.4-6, and 2.4-8. However, the caliche layer was encountered at a depth of approximately 11 feet with a thickness of approximately 1.5 feet in well 24993, as shown on Figure 2.4-5. A caliche layer was encountered at a depth of approximately 6 feet in borehole 25394. The caliche in this borehole indicates that the base of the trench is above this depth in the vicinity of borehole 25394. The caliche layers may retard infiltration of precipitation to the vadose zone around Trench T-3. Likewise, where the caliche layers have been disturbed due to the excavation of Trench T-3, infiltration of precipitation may be enhanced relative to surrounding areas.

The material in Trench T-3 has been described as disturbed ground, primarily clayey or sandy gravels with some silt (GC, GM, or GW). Due to numerous flattened drums and void space, recovery of core was limited in the boreholes drilled within Trench T-3. Boreholes 25294, 25494, and 25594 encountered the void space and/or flattened drums at approximate depths from 2 to 7 feet BGS, as shown on Figures 2.4-9 and 2.4-10. A detailed discussion of the boreholes drilled into Trench T-3 is presented in Section 2.2.1 of this report. The void space encountered at an approximate depth of 4 feet BGS, extending to depth of 5.3 feet BGS in borehole 25194, was filled with a stratified liquid (NAPL) as shown on Figure 2.4-6.

The Arapahoe Formation unconformably underlies the RFA, and is comprised of sandstones, siltstones, and claystone, as shown on Figure 2.4-2. The Geological Characterization Report (DOE 1991a) states that the Arapahoe Formation beneath the RFETS site is a fluvial deposit comprised of channel, point bar, and overbank deposits. The sandstone channel sequence of the Arapahoe Formation beneath and around Trench T-3 is referred to as the No. 1 Sandstone Unit. Lithologically, the No. 1 Sandstone Unit consists predominantly of an interbedded sequence of sandstone, silty to clayey sandstones, and sandy claystone.

The No. 1 Sandstone Unit is heterogeneous, moderately to highly friable, pale olive to light gray in color (oxidized sections are yellowish orange), and has a range of grain size from very fine to medium-grained sand. Matrix grains are predominantly quartz with traces of feldspar, mafics, and micas. Stacked fining upward sequences in grain size are common in the No. 1 Sandstone Unit. A single fining upward sequence typically consists of a lower bed of sandstone or silty sandstone with sand grain size ranging from medium to very fine-grained, overlain by a bed of clayey sandstone or sandy claystone containing predominantly very fine-grained sand. Material from the highly friable saturated sandstone layers in the No. 1 Sandstone Unit commonly flows into the open borehole during drilling. The highly friable saturated sandstone layer is predominantly medium-grained sand with a trace of fine and coarse-grained sands, dusky yellow in color, and has pitted and frosted grains of quartz with some iron staining. Estimated porosity of this unit is approximately 25 percent porosity.

Figures 2.4-5 through 2.4-8 show the location and correlation of this highly friable sandstone (Ka No. 1) layer.

The geometry, lateral extent, and top of the No. 1 Sandstone Unit in OU-2 are shown on Figures 2.4-11 and 2.4-12. Figures 2.4-13 and 2.4-14 show enlarged views in the vicinity of Trench T-3. Thinner sections of sandstone generally occur towards the channel margins, and thicker sections occur toward the center of the channel. The thickness of the No. 1 Sandstone Unit ranges from about 20 to 35 feet in the vicinity of Trench T-3, with the thickness increasing toward the east end of Trench T-3, as shown on Figure 2.4-14. The No. 1 Sandstone Unit is believed to be in contact with the RFA (subcropping condition) in the areas south and east of Trench T-3 (DOE 1993a), as shown on Figure 2.4-15. Core logging of locations 24093 through 25093 and 25594 (Figure 2.4-1) indicates that the No. 1 Sandstone Unit subcrops beneath Rocky Flats Alluvium near the central and eastern parts of Trench T-3, as shown on Figure 2.4-15. However, in the western part of the trench (near borehole 10191), the Rocky Flats Alluvium and No. 1 Sandstone Unit are separated by approximately 10 feet of claystone and/or siltstone.

The basal contact between the No. 1 Sandstone Unit and the Upper Laramie Formation is usually abrupt and non-gradational. It is believed that the No. 1 Sandstone Unit was incised into the Laramie Formation during deposition. The presence of claystone clasts in the No. 1 Sandstone Unit similar to the underlying claystone appears to support this theory. The depth to the basal contact of the Arapahoe and Laramie Formations in the vicinity of Trench T-3 is approximately 45 to 50 feet.

The Upper Laramie Formation depositional environment has been defined by Weimer and Land (1975) to be part of a delta plain complex along the western edge of the Western Interior Seaway. The most common lithologies of the Upper Laramie Formation are claystones and silty claystones. In addition to the claystone, sandy and clayey siltstones, and alternating sequences of sandstone and siltstones are present in the Upper Laramie Formation. The claystones and silty claystones are light to medium olive-gray, and occasionally olive-

black. The sandstones are light gray and olive-gray, very fine to medium-grained, moderately sorted, subangular to subrounded, silty, clayey, and quartzic. These fine-grained sediments indicate a low-energy depositional environment. The Upper Laramie Formation underlies the No. 1 sandstone unit at Trench T-3 as shown on Figures 2.4-5 through 2.4-9.

In OU-2, prominent top of bedrock features include the north and south paleoridges and the west/east-trending medial paleoscour (DOE 1993b). The north and south paleoridges are generally southwest/northeast-trending bedrock high features that are indicated by borehole control, as shown on Figure 2.4-18. Trench T-3 is located above the southern flank of the north paleoridge. The medial paleoscour is a bedrock trough feature that is believed to originate in the 903 Pad Area and trends to the northeast between the paleoridges. This paleoscour takes a northward bend and is truncated along the north-facing hillside of the South Walnut Creek drainage. Where the paleoscour intersects the hillside, a well-developed surface drainage gully has developed (Figure 2.4-16).

2.4.2 Geotechnical Testing

To estimate the physical properties of the subsurface soils in the vadose zone around Trench T-3 (IHSS 110), samples were collected for geotechnical testing. The samples were selected from the SVE Site No. 1 cores during a visual inspection on August 12, 1994, and from locations: BH3987, 10191, 21693, and 24093 through 25093. The visual inspection of the core included a review of the stratigraphic logs and the existing core to obtain, at a minimum, a sample for each required analysis from each of the lithological layers in the vadose zone around Trench T-3 (i.e., GC, SC, and the No. 1 Sandstone). The geotechnical analyses performed and American Society of Testing and Materials (ASTM) or other method designations for testing the existing core are presented below:

- Geotechnical Analyses and ASTM or other Numbers
 - Soil porosity (COEEN 111021906)

- Soil permeability in principle directions (ASTM D2434)
- Relative permeability of soil as a function of liquid saturation (EPA 600/2-91/065)
- Relative permeability of soil as a function of gas saturation (EPA 600/2-92/065)
- Capillary pressure as a function of liquid saturation (ASTM D2325)
- Sieve analyses (ASTM 0422)
- Hydraulic conductivity (ASTM 5084)

Due to the limited quantity of intact core from existing boreholes, it was not possible to select a full suite of geotechnical analyses. Therefore, samples from similar lithological layers at the same or different locations were selected for the geotechnical testing. The geotechnical samples were submitted for analyses on August 24, 1994. Table 2.4-2 presents the original sample number, the borehole number, composite sample number, depth interval of the sample, and lithology by USCS or Wentworth as appropriate. The USCS codes and Wentworth scales were determined during logging of the core by the stratigrapher. The samples were combined to obtain enough samples to perform the required geotechnical analysis. Table 2.4-3 lists the geotechnical tests performed on each of the samples submitted. Preliminary laboratory geotechnical results are presented in summary Tables 2.4-4 and 2.4-5 of Appendix A-2.

Table 2.4-4 provides a summarized list of the specific gravity, effective porosity, moisture content, dry density, hydraulic conductivity, and ending with final geotechnical results. The remolding criteria required that the samples be remolded for permeability testing based on target dry densities and moisture contents. These target values were derived from field data obtained during previous investigations, and represent the average dry density and moisture content for a given material type. The remolding procedure was to premoisten each sample to the target moisture content. The mass of material required to fill a 2.5-inch diameter by 3.0-inch high mold at the target density was determined. This mass was placed in the mold in three 1.0-inch lifts. Each lift was compacted by kneading compaction with a tamper, followed by an application of hydraulic pressure to achieve the proper density for that lift.

The surfaces of the first two lifts were scarified prior to the addition of the next lift. After compaction, the remolded test specimen was removed from the mold, and its weight and dimensions were measured. The specimen was then mounted in the permeameter.

Vertical hydraulic conductivities for geologic materials in and beneath Trench T-3 ranged from 6.60E-04 cm/sec to 9.40E-08 cm/sec. The sample with the highest hydraulic conductivity was collected from location 12191 at a depth of 15.0 to 15.5 BGS and was described as sandy gravel (GW).

Table 2.4-5 provides results of the sieve analyses. No Atterberg Limits tests were performed on the samples submitted. Results for "Relative permeability of soil as a function of liquid saturation (EPA 600/2-91/065) and Relative permeability of soil as a function of gas saturation (EPA 600/2-92/065)", have not been provided by the laboratory at the time this report was issued.

2.4.3 Geophysical Borehole Logs

Geophysical borehole logging around Trench T-3 was performed during the 1993 revised bedrock field program on pilot borehole 21693, which is located north of Trench T-3. The following geophysical logs were run:

- Caliper
- Natural Gamma
- Short Normal Resistivity
- Neutron
- Tube Wave Amplitude
- Density

Figure 2.4-17 shows the correlation of the geophysical logs with the core lithology from pilot borehole 21693.

2.5 HYDROGEOLOGY

This section presents a summary of OU-2 hydrogeology, with emphasis on the Northeast Trenches Area and Trench T-3 (IHSS 110). The discussion is based on information presented in the Preliminary Draft Phase II RFI/RJ Report for OU-2 (DOE 1993b) and the field investigation conducted in 1994 as part of the SVE Pilot Test Site No. 1.

Past subsurface investigations in the OU-2 area focused on shallow saturated units within OU-2, including the saturated unconsolidated surficial deposits and the shallow (up to 200 feet deep) saturated bedrock units of the Arapahoe and Upper Laramie Formations.

Hydrogeologic conditions in the shallow units of OU-2 are strongly influenced by local geologic conditions, local areal recharge, and interactions with South Walnut and Woman Creeks. Groundwater flow is controlled to a high degree by the shape of the top of bedrock surface, and the geometry and lithology of geologic units. Groundwater recharge occurs primarily as a result of local infiltration of snowmelt, rainfall, and surface water within the OU-2 area. The majority of OU-2 groundwater discharges to surface seeps within the boundaries of OU-2 because the major shallow water-bearing units are completely truncated on the north, east, and south by South Walnut and Woman Creeks.

The hydrogeologic system at OU-2 is comprised of two distinct water-bearing zones: the Upper Hydrostratigraphic Unit (UHSU) and the Lower Hydrostratigraphic Unit (LHSU). The UHSU within OU-2 consists of saturated portions of unconsolidated surficial deposits, high terrace deposits, colluvium, disturbed ground, Arapahoe Formation No. 1 Sandstone that is in hydraulic communication with the saturated surficial materials, and weathered claystone of the Arapahoe and/or Laramie Formations. In addition, Laramie sandstones were considered part of the UHSU, where they subcrop in isolated areas beneath the No. 1 Sandstone Unit or hillside colluvium. The majority of groundwater flow in the UHSU of OU-2 occurs in saturated Rocky Flats Alluvium and in the Arapahoe No.1 Sandstone. In the Northeast Trenches Area, UHSU groundwater flow occurs primarily in the Arapahoe Formation No. 1

Sandstone, except during high groundwater conditions when the extent of saturated Rocky Flats Alluvium includes much of the Northeast Trenches Area. Beneath IHSS 110, the majority of UHSU groundwater flow occurs in the Arapahoe Formation No. 1 Sandstone. Under low groundwater conditions, UHSU groundwater flows only in the Arapahoe Formation No. 1 Sandstone. The hydrogeologic units of interest in OU-2, and the focus of this discussion, are the saturated surficial deposits in the Rocky Flats Alluvium (Section 2.5.1.1) and the No. 1 Sandstone Unit of the UHSU (Section 2.5.1.2). The conceptual boundary between the UHSU and LHSU is shown in Figure 2.5-1.

The LHSU is composed of Upper Laramie Formation clayey-silty sandstones, claystones, and siltstones that are not in substantial hydraulic communication with the UHSU. Because the LHSU is not in substantial hydraulic communication with the hydrogeologic units of interest, it is not described further in this document. A discussion of the LHSU can be found in the OU-2 Phase II RFI/RI (DOE 1993b).

2.5.1 Upper Hydrostratigraphic Unit

Groundwater in the UHSU of OU-2 exists under unconfined conditions except where portions of the No.1 Sandstone are overlain by claystone, resulting in confined and unconfined conditions within the sandstone. The hydrogeology of the Rocky Flats Alluvium and the No. 1 Sandstone Unit is discussed in Sections 2.5.1.1 and 2.5.1.2, respectively. The UHSU system interactions are discussed in Section 2.5.1.3. In each of these sections, a general discussion of OU-2 hydrogeologic conditions is followed by information more specific to the Northeast Trenches Area and IHSS 110.

Water level data presented in the following sections were collected as part of the Rocky Flats Site-Wide Groundwater Data Collection Program, with the exception of data from wells installed as part of the SVE Pilot Test Site No. 1. Water levels for the SVE wells were obtained after well development in the fourth quarter 1993. The site-wide water levels were used to construct potentiometric maps for second quarter 1992 and fourth quarter 1993.

Water levels from the SVE wells were used in the construction of the fourth quarter 1993 potentiometric maps only, because these wells had not yet been installed during 1992. Fourth quarter 1993 groundwater elevations are presented in Table 2.5-1. Second quarter 1992 groundwater elevations are presented in Appendix B of the OU-2 RFI/RI Report (DOE 1993b).

2.5.1.1 Rocky Flats Alluvium

Groundwater flow within the Rocky Flats Alluvium is strongly influenced by the top of bedrock features, and by the geometry and lithology of alluvial geologic units (Section 2.4). Saturated alluvial conditions within the Rocky Flats Alluvium occur predominantly within lows and scours in the top of the Arapahoe and/or Laramie Formation bedrock materials. The largest of the scours, the medial paleoscur contains and transmits most of the alluvial groundwater in OU-2. This paleoscur appears to originate in the vicinity of the 903 Pad and trends predominantly from southwest to northeast (Figure 2.4-14). The medial paleoscur is believed to truncate along the South Walnut Creek hillside. Alluvial groundwater flowing within the scour discharges along the head of a well-developed surface drainage gully on the hillside, probably as a result of this truncation of the paleoscur along the hillside. This discharge is indicated by seepage observed along the head of the surface drainage gully (Figure 2.4-14).

The areal extent of the saturated alluvium within the medial paleoscur varies considerably with the season. Alluvial groundwater levels are generally at their lowest level during the first quarter of the year. Figures 2.5-2 and 2.5-3 show the areal extent of the saturated alluvium during second quarter (May) 1992 and fourth quarter (October) 1993, respectively. Second quarter 1992 conditions represent the high groundwater level conditions for that year (DOE 1993b). Fourth quarter 1993 represents lower groundwater level conditions. The width of the saturated alluvial zone within the medial paleoscur, in the vicinity of the Northeast Trenches, ranged from approximately 175 feet to 250 feet during October 1993, while the

similar saturated alluvial zones width ranged from approximately 300 feet to 450 feet during May 1992. During May 1992, the zone of saturated alluvium included the area of IHSS 110.

It is important to note that the Rocky Flats Alluvium beneath the IHSS 110 is generally dry. The Rocky Flats Alluvium beneath the site becomes saturated only under high groundwater conditions, such as those which occurred during second quarter 1992.

The fourth quarter 1993 groundwater levels are significantly lower than the May 1992 conditions. For example, the difference in groundwater elevation between May 1992 and October 1993 was approximately 11 feet at wells 07891 and 4286, both of which are located in the Northeast Trenches area within the medial paleoscur. During second quarter 1992, the groundwater elevation at the west end of Trench T-3 was approximately 5,945 feet mean sea level (ft. MSL) (Figure 2.5-2). During fourth quarter 1993, the alluvium at this location is unsaturated (Figure 2.5-3). The groundwater elevation of the uppermost saturated unit (No. 1 Sandstone Unit) at this location is approximately 5,930 ft. MSL during fourth quarter 1993, indicating a significant drop in hydraulic head.

The approximate depth from the ground surface to the alluvial groundwater surface beneath Trench T-3 ranged from 10 to 15 feet during high groundwater conditions (May 1992). During October 1993, the estimated depth to groundwater in the No. 1 Sandstone Unit ranged from 20 to 30 feet.

In the Northeast Trenches Area, the flow direction of alluvial groundwater in May 1992 was generally to the northeast, following the medial paleoscur, with a hydraulic gradient of about 0.019 feet/foot (Figure 2.5-2). The alluvial groundwater flow direction during October 1993 was also generally to the northeast following the medial paleoscur, with a hydraulic gradient of approximately 0.015 feet/foot (Figure 2.5-3).

Recharge. Groundwater recharge to the Rocky Flats Alluvium within the OU-2 area occurs due to local direct infiltration of precipitation, and due to seepage from surface water features

such as ditches. The rate of recharge to the alluvium is generally highest during the spring, when precipitation is high and evapotranspiration is low. The effects of increased temperature and evapotranspiration tend to minimize the recharge rate during summer. Recharge is also minimal during fall and winter months, due to the low precipitation that occurs during those months.

The dominance of localized areal recharge on the OU-2 UHSU groundwater system is indicated by the large groundwater level fluctuations that occur in response to springtime precipitation events. Alluvial groundwater levels typically rise rapidly in the spring due to recharge and then decrease until spring of the following year when the seasonal cycle begins again, as shown in the hydrographs for wells B218789 and 4286 (Figures 2.5-4 and 2.5-5), located in the Northeast Trenches Area. The period of rapid water level rise in these wells is followed by a period in which water levels fall rapidly, presumably due to discharge from the alluvial system to seeps and to the No. 1 Sandstone Unit. This period is generally followed by a period of slower water level decline (beginning in early summer), during which discharge from alluvium occurs at a lower rate.

Hydraulic Properties and Estimated Flow Velocities. Estimates of hydraulic conductivity for the Rocky Flats Alluvium at OU-2 are based on aquifer testing activities (drawdown-recovery tests) on wells during the 1986 initial Comprehensive Environmental Assessment and Response Program (CEARP) Phase II site characterization, slug tests performed on 1986 and 1987 wells during the 1987 Phase I RFI/RI, and from aquifer pumping tests conducted in 1992 as part of the Phase II RFI/RI. Results of the 1986 and 1987 tests are summarized in Table 2.5-2. The results of the 1992 tests are summarized in Table 2.5-3.

Hydraulic conductivity values estimated for the Rocky Flats Alluvium from the 1986 and 1987 investigations ranged from 4×10^{-2} cm/s to 6×10^{-5} cm/s (Rockwell International 1987). Hydraulic conductivity estimates from pumping tests ranged from 4×10^{-5} cm/s to 9×10^{-5} cm/s, while those from slug tests ranged from 6×10^{-5} cm/s to 5×10^{-2} cm/s. The geometric mean for the 1986 and 1987 investigation results is 4×10^{-4} cm/s. Hydraulic conductivity

values estimated from the 1992 pumping test conducted at the well cluster, located in the Northeast Trenches Area (wells 05691, 11491, 20291, and 20491), range from 8×10^{-4} cm/s to 4×10^{-3} cm/s. Estimated values of hydraulic conductivity from the 1992 pump test at the cluster of wells 1787, 20591, and 20691, ranged from 1×10^{-4} cm/s to 9×10^{-4} cm/s. The geometric mean of the estimated values from the 1992 tests is 8×10^{-4} cm/s.

Potential average groundwater flow velocity (average linear velocity) was estimated for the Rocky Flats Alluvium based on the estimated mean hydraulic conductivity, estimated hydraulic gradient, and assumed effective porosity. Using the geometric mean value for estimated hydraulic conductivity from the 1986, 1987, and 1992 aquifer tests (6×10^{-4} cm/s); the estimated average hydraulic gradient for the alluvium from the 1992 water level measurements (about 0.020 feet/foot); and an assumed effective porosity of 10 percent; the estimated potential average linear groundwater flow velocity is about 120 feet/year in the area of Trench T-3.

Greater than expected groundwater yields experienced during bedrock SVE pilot tests in 1994 at Trench T-3 are believed to be due to the highly friable coarse grained sandstone unit of the No. 1 Sandstone. The Test Site No. 1 wells penetrate this unit (see Figures 2.4-5 through 2.4-9), which is believed to transmit the majority of groundwater in the No. 1 Sandstone in the vicinity of Trench T-3. See Section 2.4 for further discussion of lithology location and depth.

Rocky Flats Alluvium Seeps. Because the Rocky Flats Alluvium is completely truncated to the north, east, and south within the OU-2 area, all alluvial groundwater is discharged to surface and subsurface seeps along the slopes of the drainages, with the exception of alluvial groundwater which migrates vertically into the underlying No. 1 Sandstone Unit (Plate 2.5-1). Groundwater seepage from the Rocky Flats Alluvium occurs where saturated alluvium is truncated along the hillsides at the contact between Rocky Flats Alluvium and bedrock. At these locations, discharged seep water infiltrates the colluvium and the high terrace alluvium downslope from the seepage face. The resultant increase in soil moisture in these downslope

geologic materials allows characteristic vegetation (typically cattails, baltic rushes, woody bushes, and other phreatophytes) to develop that is distinct from the surrounding tall and short prairie grasses common to RFETS. The locations of these alluvial seeps and associated downslope vegetated areas were mapped by visual field observations during the summers of 1992 and 1993. High terrace alluvium and bedrock seep locations were also mapped.

An alluvial seep area occurs at the surface drainage gully northeast of the Northeast Trenches Area. This seep area is considered to be large relative to other OU-2 seeps. As discussed earlier, the majority of the alluvial groundwater within OU-2 is contained and transmitted along the medial paleoscour (a top of bedrock feature). This bedrock feature is believed to be truncated along the South Walnut Creek drainage at the head area of the above-mentioned surface drainage gully. This alluvial seep supplies surface water flow to the drainage gully. This surface water in turn flows downslope within the gully and discharges to South Walnut Creek approximately 300 feet west of Pond B-5.

Other alluvial seeps along the South Walnut Creek drainage are thought to occur east of the surface drainage gully. These seeps are considered to be of minor importance because they are not located in areas of known groundwater contamination.

2.5.1.2 Arapahoe Formation No. 1 Sandstone

The Arapahoe Formation No. 1 Sandstone is the uppermost sandstone unit within OU-2. The No. 1 Sandstone Unit is a fluvial sandstone channel which incised into the surrounding claystone bedrock deposits. The saturated No. 1 Sandstone Unit is bounded in areal and vertical extent by the surrounding bedrock deposits, which are mostly claystone, or by the South Walnut Creek drainage, which has eroded away the northern edge of the sandstone channel. Figures 2.5-6 and 2.5-7 show the areal extent of the No. 1 Sandstone Unit in the portion of OU-2 west of the East Spray Fields. East of that area, subsurface control for the No. 1 Sandstone Unit is limited or non-existent.

The No. 1 Sandstone Unit subcrops beneath the Rocky Flats Alluvium in some OU-2 locations and is separated from the alluvium by claystone in others (DOE 1993b, Figure 3.5-22). The No. 1 Sandstone Unit subcrops beneath the Rocky Flats Alluvium in much of the Northeast Trenches Area (Figure 2.4-13). IHSS 110 is located along the edge of such an area. Beneath IHSS 110, the thickness of the claystone layer separating the No.1 Sandstone from alluvium ranges from approximately 0 to 10 feet. Thickness of the claystone layer increases to the northwest.

The majority of groundwater in the No. 1 Sandstone Unit in OU-2 occurs under unconfined conditions, but it does occur under confined conditions in limited areas. Where the No. 1 Sandstone Unit subcrops beneath the alluvium, groundwater within the No. 1 Sandstone Unit is unconfined. Where the sandstone is separated from the alluvium by claystone, groundwater may occur under confined or unconfined conditions.

In the Northeast Trenches Area, groundwater within the No. 1 Sandstone Unit is believed to exist under unconfined conditions. As stated above, the No. 1 Sandstone Unit subcrops to alluvium in much of the area, thus providing a *direct means for hydraulic communication* between the units. In addition, the alluvium is primarily unsaturated beneath the Northeast Trenches Area, during most of the year, and the groundwater level falls below the top of the No.1 Sandstone providing for unconfined groundwater conditions. This condition exists beneath IHSS 110 during most of the year due to its location relative to the saturated alluvium zone.

Groundwater flow direction within the No. 1 Sandstone Unit is controlled by the geometry of the sandstone unit and its interaction with the overlying alluvium and South Walnut and Woman Creek drainages. Potentiometric maps for the No. 1 Sandstone unit for second quarter (May) 1992 and fourth quarter (October) 1993 (Figures 2.5-6 and 2.5-7) indicate that the primary flow direction within the sandstone is to the north-northeast, with some flow to the southeast. The hydraulic gradient in the No. 1 Sandstone Unit varies from approximately 0.028 feet/foot to as much as 0.1 feet/foot.

East of the 903 Pad, the potentiometric surface of the No. 1 Sandstone Unit appears to be mounded, causing flow in the sandstone to diverge, with most flow moving to the north and northeast and some flow moving to the southeast (Figures 2.5-6 and 2.5-7). Flow is primarily to the northeast or north in the area beneath and to the north of the medial paleoscour. Groundwater flowing north and northeast discharges to subsurface sandstone seeps where the sandstone subcrops beneath colluvium along the southern slope of the South Walnut Creek drainage.

Recharge. Recharge to the No. 1 Sandstone Unit in OU-2 probably occurs as a result of infiltration of precipitation and surface water through overlying unsaturated deposits, vertical flow from overlying saturated alluvium, and inflow to the area from upgradient portions of the sandstone west of OU-2. The No. 1 Sandstone Unit is believed to receive recharge from downward vertical flow from overlying saturated alluvium in areas where the alluvium and sandstone are in direct contact, or where they are separated by only a few feet of weathered and/or fractured claystone (Figure 2.4-13). Downward vertical flow between the alluvium and No. 1 Sandstone Unit is indicated by downward vertical gradients between the units in areas where the alluvium and No. 1 Sandstone Unit are not in direct contact (DOE 1993b). Evidence for recharge in the contact zone along the medial paleoscour northeast of the 903 Pad is indicated by a potentiometric high within the sandstone in that area and contaminant data that indicate migration of contamination from the alluvium to the sandstone (Section 2.6.2). In addition, evaluation of groundwater geochemical data for wells screened in the Rocky Flats Alluvium and wells screened in the No. 1 Sandstone Unit indicates that the two units have similar groundwater geochemistry (DOE 1993b).

Water level data indicate that recharge to the No. 1 Sandstone Unit within OU-2 also occurs as inflow from the west, where the No. 1 Sandstone Unit crosses the western boundary of OU-2. This groundwater flow is the only apparent source of groundwater recharge into the UHSU within OU-2 that is not directly related to infiltration from precipitation falling on OU-2.

Hydraulic Properties and Estimated Flow Velocities. Estimates of hydraulic conductivity for the No. 1 Sandstone Unit at the OU-2 site are based on aquifer testing activities conducted in 1987 and 1992, and on the 1994 pumping test results from Site No. 1 described in Appendix B. The results from the 1987 tests are summarized in Table 2.5-4. The results from the 1992 tests are summarized in Table 2.5-5. The Site No. 1 results are presented in Appendix B and summarized in Table 2.5-6.

Hydraulic conductivity values estimated for the No. 1 Sandstone Unit from the 1987 investigations (slug tests only) ranged from 3×10^{-3} cm/s to 2×10^{-4} cm/s (Rockwell International 1987). The geometric mean of the 1987 investigation results is 1×10^{-3} cm/s. Calculated values of hydraulic conductivity for the No. 1 Sandstone Unit, determined from the 1992 pumping test measurements conducted at the Site No. 1 well cluster (wells 3687, 20991, and 21091, and 20891), ranged from 3.7×10^{-4} to 6.2×10^{-4} cm/sec. The geometric mean of the 1992 investigation results is 4.8×10^{-4} cm/s.

Hydraulic conductivity estimates for the No. 1 Sandstone Unit from the 1994 pumping test range from 1×10^{-3} to 4×10^{-3} cm/s (Table 2.5-6). The geometric mean of the 1994 results is 2.3×10^{-3} cm/s.

Potential groundwater flow velocities (average linear velocities) were estimated for the No. 1 Sandstone based on the estimated mean hydraulic conductivity, estimated hydraulic gradient range, and assumed effective porosity. Based on the geometric mean value for estimated hydraulic conductivity from the 1987, 1992, and 1994 aquifer tests (1×10^{-3} cm/s), the measured hydraulic gradient range from the 1992 water level measurements (0.028 to 0.1 feet/foot; DOE 1993b), and an assumed effective porosity of 10 percent, the estimated potential average linear groundwater flow velocity ranged from 300 ft/year to 1,000 ft/year.

Arapahoe Formation No. 1 Sandstone Seeps. Because the No. 1 Sandstone is entirely truncated to the north, east, and south by the South Walnut and Woman Creek drainages, no direct off site groundwater pathway within the sandstone exists from OU-2 to off site

locations. Therefore, virtually all No. 1 Sandstone Unit groundwater within OU-2 is discharged to seeps along the slopes of the drainages.

It is believed that the No.1 Sandstone subcrops beneath colluvium along the South Walnut Creek hillside north of the Northeast Trenches. This is based on projections of elevations of the No. 1 Sandstone Unit encountered in monitoring wells and boreholes located on the pediment top, close to the hillside. Outcrops in some manmade ditches along the hillside also confirm the subcrop position of the sandstone. The location of the base of the No. 1 Sandstone Unit, projected into the hillside from nearby subsurface control, is shown in Figures 2.5-6 and 2.5-7. Seep areas and associated downslope vegetated areas that occur near this projected base are attributed to groundwater discharge from the sandstone (Plate 2.5-1). In contrast to the localized alluvial seep discharge from the previously discussed medial paleoscour, groundwater subsurface seepage associated with the No.1 Sandstone along the South Walnut Creek hillside tends to be spread over a wide area and discharges at a low flow rate.

2.5.1.3 UHSU System Interaction

Where the No. 1 Sandstone Unit and Rocky Flats Alluvium are in direct contact or are separated by a thin layer of claystone, their water levels are similar, indicating a substantial degree of hydraulic communication. Where the alluvium and sandstone are separated by a substantial thickness of claystone, they become less hydraulically connected and behave as more separate systems with different flow directions and water levels.

Saturated Rocky Flats Alluvium and the No. 1 Sandstone Unit appear to be in hydraulic communication in much of OU-2 where the sandstone and alluvium are in contact or in close vertical proximity. In the subcrop area northeast of the 903 Pad, along the medial paleoscour, paired wells 1991 (sandstone) and 13491 (alluvial) have very similar water levels and appear to be in hydraulic communication. Downward vertical gradients between the screened intervals of these two wells in second quarter 1992 were 0.019 feet/foot.

Groundwater elevation observations indicate that the Rocky Flats Alluvium and No. 1 Sandstone Unit are in less hydraulic communication in areas where they are separated by claystone (i.e., in the Northeast Trenches Area, several hundred feet northeast and downgradient of wells 01991 and 13491, along the paleosour). Water levels in wells 03191 (alluvial) and 12691 (sandstone) differ by 8 to 9 feet in May 1992 observations. At the well 05391 (alluvial) and well 12391 (sandstone) well pair, the observed water levels differed by 14 to 15 feet in May 1992. Several feet of claystone separates the sandstone and alluvium at both of these locations. Downward vertical gradients across these two well pairs in second quarter 1992 were approximately 0.2 feet/foot and 0.4 feet/foot, respectively. The higher vertical gradients for these two pairs, relative to the gradients reported for the pair above (i.e., pair 01991/13491), are also indicative of a lower degree of hydraulic communication. In addition, there appears to be a longer delay at well 12391 in the water level response to recharge events than occurs in well 05391 (see Figures 2.5-8 and 2.5-9, respectively). The response delay may result because well 05391 receives direct recharge from precipitation, while well 12391 receives recharge from upgradient areas of the No. 1 Sandstone Unit. This is further evidence that the sandstone and alluvium have limited vertical hydraulic communication in this area.

Interaction between the colluvium, Rocky Flats Alluvium, and the No. 1 Sandstone Unit occurs where the saturated alluvium is truncated upslope of colluvium and where sandstone subcrops beneath the colluvium. In most cases, flow is from the alluvium and sandstone to the colluvium. In limited areas, however, localized recharge of subcropping sandstones from colluvial water may occur.

2.6 NATURE AND EXTENT OF CONTAMINATION

The following discussion provides a description of the nature and extent of contamination within subsurface soils, the liquid collected from location 25194, UHSU groundwater, and soil gas in the vicinity of Trench T-3. In general, VOC and semivolatile organic compound (SVOC) analytical results for these media are discussed in greater detail than the remaining

chemical groups (i.e., metals, water quality parameters, radionuclides) because the OU-2 subsurface IM/IRA focuses on the removal of VOC contamination in the subsurface.

The only bedrock well (23293) in the vicinity of Trench T-3 was unable to be developed and, as a result, was not sampled. Therefore, the nature and extent of contamination in the LHSU will not be discussed in this section.

2.6.1 Subsurface Soils

Nine source boreholes, two plume characterization monitoring wells, one pilot borehole, one abandoned plume characterization monitoring well, and seven SVE boreholes (10191, 02991, 12191, 21693, 22493, BH3987, BH4087, 24093, 24193, 24493, 24593, 24693, 24793, 25093, 25194, 25294, 25394, 25494, 25594, and 25694) were drilled and sampled during Phase I, Phase II, and Site No. 1 investigations to characterize the vertical extent of contamination in Trench T-3. Subsurface soil analytical results for these boreholes and wells are summarized in Table 2.6-1. Table 2.6-1 presents the detection frequency, concentration or activity ranges, and mean concentration or activity, as well as the background mean plus two standard deviations for metals and radionuclides. Analytical results for samples collected from the above boreholes are presented in Appendix C1 of this report.

Detections of VOC, SVOC and pesticide/polychlorinated biphenyl (PCB) are shown on Figure 2.6-2 (Figure 2.6-1 is a legend for analyte abbreviations and laboratory and validation qualifiers). SVOC and pesticide/PCB analyses were performed only on samples collected from boreholes 10191, 25294, 25595, BH3987, and BH4087. Cross-sections (Figures 2.6-4 through 2.6-6) were constructed to illustrate the vertical extent of contamination for selected volatiles beneath Trench T-3. The VOCs selected for this evaluation were CCl₄, CHCl₃, PCE, TCE, and total VOCs because of their prevalence in the subsurface soils beneath Trench T-3. The cross-sections were constructed with the following information: the borehole log, generalized lithologic units, Trench T-3 location and approximate depth, initial and high groundwater levels, and analytical results on a logarithmic scale. The generalized lithologic

units include the Rocky Flats Alluvium, Arapahoe Formation, No. 1 Sandstone Unit, Laramie Formation, and the approximate contact between these units. Initial groundwater level information was collected in the field at the time of drilling and the high water level was measured in monitoring wells during second quarter 1992. Figure 2.6-3 presents the legend for the source borehole characterization cross-sections.

2.6.1.1 VOCs

Fourteen VOCs were detected in subsurface soil samples collected within Trench T-3 (IHSS 110), as shown on Table 2.6-1. Toluene, a suspected field contaminant (see the OU-2 Phase II RFI/RI report [DOE 1993b] for further discussion) was detected in approximately 72 percent of the subsurface soil samples. Chlorinated hydrocarbons (CHCs), including 1,1,1-trichloroethane (1,1,1-TCA), CCl₄, chloroform (CHCl₃), PCE, TCE, 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethene (1,2-DCE), and 1,2-dichloroethane (1,2-DCA) were detected at concentrations ranging from a few parts per billion to several parts per thousand, as shown on Figure 2.6-2. The vertical extent of selected VOC contaminants is presented on Figures 2.6-4 through 2.6-6. In addition to these chlorinated hydrocarbons (CHCs), five other VOCs (2-butanone, acetone, ethylbenzene, methylene chloride, and total xylenes) were detected in subsurface soil samples. Locations at which elevated levels of VOCs were encountered are described below.

Apparent NAPL was observed in subsurface materials at several locations in the vicinity of Trench T-3. Free product was observed in borehole 10191 at an approximate depth of 2.8 feet during drilling. Borehole 10191 was drilled in the trench in December of 1991 during the OU-2 Phase II RFI/RI alluvial program. The free product encountered in borehole 10191 was described as a yellowish-brown liquid with a high viscosity (thick consistency). No sample of the free product was collected for analysis. Source borehole 10191 exhibited elevated levels of 1,1,1-TCA, CCl₄, CHCl₃, PCE, and TCE in soil samples collected above the initial water at the time of drilling. In general, the concentrations of the CHCs decreased with depth in the vadose zone in source borehole 10191. Below the water table,

concentrations increased again, but to levels significantly lower than those seen in the vadose zone (see Section 2.6.2).

Two samples were collected for VOC analysis based on elevated organic readings in the field (using a photoionization detector [PID]) and the observation of discolored soil (black, tar-like) in the core from borehole 24793, at an approximate depth of 6.5 to 10 feet. The discolored core was described as a black, sticky substance that is coating the gravel surfaces, has impregnated the matrix, and occurs as dry asphaltic-like lumps. Elevated PCE (1,090,000 $\mu\text{g}/\text{kg}$) and TCE (8,100 $\mu\text{g}/\text{kg}$) concentrations were detected in the sample collected from borehole 24793 at depths of 7.2 to 7.5 feet and 7.5 to 7.8 feet.

A clear liquid was encountered during the installation of three pressure monitoring probe locations inside the trench. These three probe locations were APM20, APM24, and APM25, as shown on Figure 2.6-7. The clear liquid was encountered at an approximate depth of 2.5 feet at these locations. The clear liquid was dripping from the downhole equipment when removed at location APM24, and appeared as a sheen on the downhole equipment at locations APM24 and APM20. Probes APM20 and APM25 were installed to a total depth of 7 feet, while APM20 was installed to a total depth of 12 feet. A maximum PID field reading of 177 parts per million (ppm) was observed on the downhole equipment from location APM24.

Three VOC samples were collected from boreholes 25594 and 25694 based on elevated organic readings in the field (using a PID) and the observation of discolored soil (black, tar-like). Two of the three VOC samples were collected from borehole 25594 at approximate depths of 9.8 to 10 feet and 15.3 to 16 feet BGS, with resulting PCE concentrations of 510,000 $\mu\text{g}/\text{kg}$ and 730,000 $\mu\text{g}/\text{kg}$, respectively. Total xylenes were also detected at a concentration of 95,000 $\mu\text{g}/\text{kg}$ at a depth of 9.8 to 10 feet in borehole 25594. TCE and PCE were detected in the sample collected from borehole 25694 at concentrations of 280 $\mu\text{g}/\text{kg}$ and 38,000 $\mu\text{g}/\text{kg}$, respectively.

The analytical results for the stratified liquid collected from borehole 25194 in November and December 1994 are discussed in Sections 2.6.4 and 2.6.5 of this report.

Review of the soil gas analytical data collected from the SVE pilot tests (DOE 1994) indicate that approximately 90 percent of the VOCs detected were CHCl₃, CCl₄, PCE, and TCE. These four VOCs are the primary contaminants that were observed in the subsurface soil samples collected in and around Trench T-3. The following is a summary of the average concentration of extracted soil gas for CHCl₃, CCl₄, PCE, and TCE, and total VOCs observed during the SVE pilot test (DOE 1994):

Analyte	Average Concentration Range (ppm) in Extracted Soil Gas
CHCl ₃	Non-detected (ND) to 23
CCl ₄	12 to 941
PCE	ND to 1,379
TCE	ND to 30
Total VOCs	207 to 1,947

2.6.1.2 SVOCs

Fourteen SVOCs were detected in subsurface soil samples collected within Trench T-3, as shown on Table 2.6-1. Three were phthalates - bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, and di-n-butyl phthalate; and four were polyaromatic hydrocarbons (PAHs), 2-methylnaphthalene, naphthalene, phenanthrene and pyrene. The SVOCs detected, except for phthalates, are illustrated on Figures 2.6-2 and 2.6-3 (see the Preliminary Draft Phase II RFI/RI Report for OU-2 [DOE 1993b] for further discussion on phthalates). Of the 21 samples analyzed, phenanthrene was detected in one sample from source borehole 10191, at

a depth of 4.2 to 8 feet. Of 21 samples analyzed, 2-methylnaphthalene, 2-methylphenol, and 4-methylphenol were each detected once in a sample from source borehole 10191, at a depth of 4.2 to 8 feet. Of 21 samples analyzed, hexachlorobutadiene was detected once in a sample from borehole 10191 at a depth of 8 to 14.1 feet. Of 21 samples analyzed, hexachloroethane was detected twice in samples from borehole 10191 at two depths: 8 to 14.1 feet and 14.1 to 20.1 feet.

Five SVOCs were detected in soil samples collected at locations 25294 and 25594, none of which was detected in prior work. Butyl benzyl phthalate, detected in both boreholes at depths of 6 to 8 feet and 9 to 10 feet, respectively, ranged in concentrations from 1.1 to 3 mg/kg. The remaining four SVOCs, with one detection each, had lower concentrations, from 0.051 to 1.2 mg/kg.

2.6.1.3 Pesticides/PCBs

Aroclor-1254, a PCB, was detected at the depth of 4.2 to 8 feet at an estimated concentration of 6,900D $\mu\text{g/kg}$ in borehole 10191 in 1 of 19 samples analyzed, as shown on Table 2.6-1 and Figure 2.6-2.

2.6.1.4 Metals

Table 2.6-1 indicates that seven metals (arsenic, barium, cadmium, calcium, lead, manganese, silver) were detected at concentrations above the background mean plus two standard deviations (background) in subsurface soil samples from Trench T-3. Arsenic was detected above background in 4 out of 23 samples analyzed. All concentrations of arsenic above background were collected from boreholes BH3987 and BH4087. Barium exceeded the background in only one sample, collected from borehole BH3987 at a depth of 15 to 17 feet with a concentration of 413 mg/kg. Cadmium exceeded the background in 6 out of 23 samples analyzed. All concentrations above background were obtained from boreholes BH3987 and BH4087 at concentrations within the same order of magnitude as the

background. Calcium was detected above background in one sample collected at a depth of 7.2 to 7.5 feet from borehole 24793. The concentration of calcium above background is likely related to the presence of caliche, a calcium carbonate, in borehole 24793. Lead and silver were detected above background in one sample, collected from borehole 10191 at a depth of 4.2 to 8 feet. Manganese was detected in two samples, from boreholes BH3987 and 10191, at depths of 15 to 17 feet and 20 to 26 feet, respectively.

2.6.1.5 Radionuclides

Nine radionuclides (americium-241 [Am-241], plutonium-238 [Pu-238], plutonium-239/240 [Pu-239/240], Radium-226 [Ra-226], strontium-89,90 [Sr-89,90], tritium, uranium-233,234 [U-233,234], uranium-235 [U-235], and uranium-238 [U-238]), and gross beta were detected at activities above the background (see Table 2.6-1). Am-241 was detected at activities above background in 56 percent of the samples analyzed. Pu-239/240 was detected above background in 19 of 25 samples. Elevated activities of Am-241, gross beta, Pu-239/240, U-233,234, U-235, and U-238 were found in a sample collected at a depth of 4.2 to 8 feet from borehole 10191. The maximum activities of Am-241, Pu-238, and Pu-239/240 occurred in a sample collected at 0 to 4 feet in depth from borehole 25194. The maximum activity of Pu-239/240 (8.495 pCi/g) is nearly 500 times higher than the background. Elevated levels of radionuclides occurred in the 4.2 to 8-foot interval of borehole 10191 and generally decreased with depth, indicating the source of radionuclides to be within Trench T-3. Trench T-3 is estimated to be between 5 and 10 feet deep.

Ra-226 was detected above background in two samples collected at depths greater than 44 feet from borehole 10191. Sr-89,90 was detected above the background in 3 of 19 samples analyzed from boreholes BH3987 and BH4087. Tritium was detected above background in one sample collected from borehole BH3987 at a depth of 17 to 20 feet.

All samples analyzed from the latest drilling operations in Trench T-3 in 1994 had Am-241 and Pu-239/240 results higher than background. No background level for Pu-238 has been established and Pu-238 activities for all samples analyzed ranged from 0.006 to 0.1229 pCi/g.

2.6.1.6 Other Analytes and Parameters

The pH of subsurface soils in Trench T-3 ranged from 6.23 to 9.17. Ammonia concentrations ranged from 0.48 to 8.38 $\mu\text{g/g}$, and nitrate/nitrite ranged in concentration from 0.27 to 7.18 $\mu\text{g/g}$. Total organic carbon content ranged from 167 to 19,200 $\mu\text{g/g}$; the maximum concentration was found in a sample collected at a depth of 4.2 to 8 feet from borehole 10191. The maximum total organic carbon result may be associated with NAPL contamination in borehole 10191.

2.6.1.7 Summary

The subsurface soil analytical data collected from Trench T-3 indicate that it is a source of VOC contamination (1,1,1-TCA, CCl_4 , CHCl_3 , PCE, TCE, 1,1-DCE, 1,2-DCE, and 1,2-DCA) to the subsurface soil and potentially to UHSU groundwater. The concentrations of CHCs decrease with depth down to the water table. There is minor PCBs, PAHs, and SVOCs contamination. Arsenic, lead, and silver occur above background in Trench T-3. Activities of Am-241, gross beta, Pu-239/240, U-233,234, U-235, and U-238 are also above background. Apparent non-aqueous phase liquid (NAPL) was observed in subsurface materials at several locations in the vicinity of Trench T-3. A yellowish-brown liquid suspected to consist of one or more free-phase CHCs was observed in borehole 10191 at an approximate depth of 2.8 feet. NAPL was observed in borehole 24793 at an approximate depth of 6.5 to 10 feet. NAPL was also observed in borehole 25594 at approximate depths from 7 to 16 feet BGS. NAPL was also observed in borehole 25694 at an approximate depth of 11.8 to 12 feet BGS. This NAPL appeared as black asphalt-like lump that impregnated the soil matrix and coated the gravels. A clear liquid was encountered on the downhole equipment during the installation of three pressure monitoring probes (locations APM20, APM24, and APM25) at an

approximate depth of 2.5 feet. A stratified liquid sample with three distinct layers was extracted from borehole 25194 at an approximate depth of 4 to 5 feet BGS.

2.6.2 Groundwater

This section presents information on the nature and extent of VOC contamination in UHSU groundwater in the OU-2 area, specifically the Northeast Trenches Area, including IHSS 110. Other chemical concentrations were determined from samples collected in the Northeast Trenches Area during fourth quarter 1993. However, only VOCs are presented here, because VOCs are expected to be the only groundwater contaminants with the potential to significantly impact vadose zone chemical processes. To characterize VOC contamination in the area, fourth quarter 1993 analytical data from wells screened in RFA colluvium, Arapahoe Formation No. 1 Sandstone, and subcropping Laramie Formation sandstone were evaluated. Analytical results from groundwater sampling performed during SVE pilot tests (March 1994) are presented in Section 2.6.2.6. Analytical results from groundwater sampling performed prior to the abandonment of the Arapahoe Formation No. No. 1 Sandstone wells (24193, 24393, 24993, and 25093) in September, 1994 are presented in Section 2.6.2.7.

Isoconcentration maps for fourth quarter 1993 were prepared for the alluvial/colluvial and No. 1 Sandstone components of the UHSU. Isoconcentration maps were prepared for several analytes and total volatile organics. Concentrations shown on isoconcentration maps include results from 'real' and 'field duplicate' analyses. Real sample results are presented in all cases, except where the field duplicate concentrations for specific analytes are greater, in which case the field duplicate results are shown.

The lateral extent of the saturated zones for the alluvial/colluvial isoconcentration maps were established during the development of the alluvial/colluvial potentiometric map for fourth quarter 1993. Available data for wells sampled during fourth quarter 1993 are presented in Figures 2.6-8 to 2.6-17. Analytical results for UHSU groundwater sample are presented in

Appendix C2. Detected concentrations and laboratory or validation qualifiers are indicated in Appendix C2. Non-detected chemicals are indicated by the 'U' qualifier.

The occurrence of CCl_4 , CHCl_3 , PCE, TCE, and total VOCs in alluvial/colluvial and No. 1 Sandstone Unit groundwater is discussed in the following sections.

2.6.2.1 Carbon Tetrachloride

The highest concentrations of carbon tetrachloride (CCl_4) in OU-2 alluvial/colluvial groundwater during fourth quarter 1993 were detected at the 903 Pad (Figure 2.6-8). The maximum observed concentration during this period was 26,000 $\mu\text{g/l}$ at well 06691. CCl_4 is also present in colluvial groundwater to the south and southeast of the 903 Pad.

The alluvial/colluvial contaminant plume originating in the 903 Pad Area extends to the northeast along the medial paleoscur and toward the Northeast Trenches Area. In the vicinity of the Northeast Trenches, the concentration of CCl_4 ranges from less than 50 $\mu\text{g/l}$ to 360 $\mu\text{g/l}$. The zone of saturated alluvium does not extend to IHSS 110 during fourth quarter 1993; therefore, no CCl_4 contamination is indicated for the alluvium at that location. Based on the areal extent of the contaminant plume, the primary sources of CCl_4 to the saturated alluvial groundwater appear to be the 903 Pad and Trench T-2.

The isoconcentration map of CCl_4 for the No. 1 Sandstone Unit shows high concentrations west of the 903 Pad, in the Northeast Trenches Area, and in the area east of the 903 Pad (Figure 2.6-9). Migration of contaminated groundwater from the alluvium/colluvium to the No. 1 Sandstone Unit appears to have occurred in these areas west of the 903 Pad where the alluvium and No. 1 Sandstone Unit exhibit a high degree of hydraulic communication (Figures 2.5-1 and 2.5-5). Some migration of contaminated groundwater may have occurred from the saturated alluvium in the medial paleoscur to the No. 1 Sandstone Unit in the vicinity of wells 01991 (sandstone) and 13491 (alluvium), east of the 903 Pad where the sandstone subcrops to the alluvium. The primary source of contamination in the No. 1

Sandstone Unit in the Northeast Trenches Area is likely the trenches in that area. Hydraulically upgradient (south) of the trenches, the concentrations are significantly lower than observed concentrations in the vicinity and downgradient (north) of the trenches.

2.6.2.2 Chloroform

The highest concentrations of chloroform (CHCl_3) in OU-2 alluvial/colluvial groundwater during fourth quarter 1993 were detected at the 903 Pad (Figure 2.6-10). The maximum observed concentration during this period was 24,000 $\mu\text{g/l}$ at well 06691. CHCl_3 is also present in colluvial groundwater to the south (Trench T-2 area) and southeast of the 903 Pad.

It is believed that the contaminant plume originating at the 903 Pad is transported in the alluvium through the medial paleoscur to the northeast. However, the observed concentrations of CHCl_3 decrease dramatically just east of the 903 Pad. In the vicinity of the Northeast Trenches, the highest observed concentration during fourth quarter 1993 was 28 $\mu\text{g/l}$.

The highest CHCl_3 concentrations in the No. 1 Sandstone Unit (Figure 2.6-11) were detected in the areas west of the 903 Pad and the Northeast Trenches, particularly at IHSS 110. At well 24193, near the center of IHSS 110, the concentration of CHCl_3 was observed to be 220 $\mu\text{g/l}$ during October 1993. The 903 Pad and IHSS 110 are considered to be source areas for CHCl_3 .

2.6.2.3 Tetrachloroethene

The highest concentrations of tetrachloroethene (PCE) in OU-2 alluvial/colluvial groundwater during fourth quarter 1993 were detected at the 903 Pad (Figure 2.6-12). The maximum observed concentration during this period was 12,000 $\mu\text{g/l}$ at well 08891. PCE is also present in colluvial groundwater to the south (Trench T-2 Area) and southeast of the 903 Pad.

The contaminant plume originating at the 903 Pad is transported in alluvium through the medial paleosour to the northeast. This is indicated by the concentration of PCE at well 00191 (1,200 $\mu\text{g/l}$) northeast of the 903 Pad. The medial paleosour plume appears to extend to the Northeast Trenches Area where the concentrations range from less than 50 $\mu\text{g/l}$ to 71 $\mu\text{g/l}$ (wells 507891 and 4286, respectively).

The highest PCE concentrations in the No. 1 Sandstone Unit (Figure 2.6-13) were detected in the Mound Area, and in the Northeast Trenches, particularly IHSS 110. At well 02291, the concentration during fourth quarter 1993 was 2,400 $\mu\text{g/l}$. At well 24193, in the Northeast Trenches Area, the concentration of PCE was observed to be 880 $\mu\text{g/l}$ during October 1993. IHSS 110 is considered to be a source area for PCE. Concentrations of PCE north of the trenches indicate that contaminants migrate to the north in the No. 1 Sandstone Unit.

The contaminants shown east of the 903 Pad in the No. 1 Sandstone Unit may have been transported to that area within alluvial/colluvial groundwater originating at the pad. The 903 Pad is considered to be a source of PCE contamination to both alluvium/colluvium and the No. 1 Sandstone Unit.

2.6.2.4 Trichloroethene

The highest concentrations of trichloroethene (TCE) in OU-2 alluvial/colluvial groundwater during fourth quarter 1993 were detected at Trench T-2 (Figure 2.6-14). The maximum observed concentration during this period was 58,000 $\mu\text{g/l}$ at well 07391. TCE is also present in the 903 Pad Area, where the maximum observed concentration was 2,200 $\mu\text{g/l}$ (well 08891), and in the Northeast Trenches Area, where the maximum concentration was 37 $\mu\text{g/l}$ (well 4286).

The contaminant plume originating at Trench T-2 is transported in colluvium down the hillside to the south toward Woman Creek. The plume originating at the 903 Pad appears to migrate to the northeast in the paleosour, as indicated by the concentration of TCE at well

00191 (210 µg/l), east of the 903 Pad. The medial paleoscour plume appears to extend to the Northeast Trenches Area where TCE concentrations range from less than 5 µg/l to 370 µg/l (well 4286).

The highest TCE concentrations in the No. 1 Sandstone Unit (Figure 2.6-15) were detected in the Northeast Trenches, particularly north of Trench T-4. At well 3687, the concentration of TCE was observed to be 47,000 µg/l during October 1993. Trench T-4 is considered to be a source area for TCE groundwater contamination.

Concentrations of TCE from No. 1 Sandstone Unit wells in the vicinity of Trench T-3 ranged from 40 to 72 µg/l during fourth quarter 1993. This range is similar to the concentrations observed in samples from the period beginning first quarter 1992 through third quarter 1992, when concentrations ranged from 53 to 95 µg/l (DOE 1993b).

2.6.2.5 Total Volatile Organics

The highest concentrations of total VOCs in alluvial/colluvial groundwater are present in the 903 Pad Area and in the Trench T-2 Area (Figure 2.6-16). The maximum observed concentrations of total VOCs were approximately 60,000 µg/l at both well 07391, located in the Trench T-2 Area, and well 06691, located at the 903 Pad.

Contamination in alluvial groundwater at the 903 Pad is believed to migrate in the medial paleoscour to the northeast toward the southern edge of the Northeast Trenches. Concentrations decrease in the northeasterly direction. Contamination in the Trench T-2 Area migrates to the south in colluvium, as shown by decreasing concentrations in that direction.

The highest concentrations of total VOCs in the No. 1 Sandstone Unit were observed in the Northeast Trenches Area (Figure 2.6-17). Contaminants migrate to the north along the direction of groundwater flow in this unit. The highest concentrations have been observed at

well 3687, where the concentration was approximately 50,000 µg/l in fourth quarter 1993. Total VOC concentrations of approximately 5,000 µg/l were also observed at IHSS 110.

2.6.2.6 Groundwater Sampling Results from SVE Pilot Tests

Groundwater was extracted from the No. 1 Sandstone Unit at extraction well 24913, as part of SVE Pilot Tests 3 and 4 (Figure 2.4-1). Samples of the extracted groundwater were collected from a sample port on the transfer line that carried discharges from well 24193 to storage tanks. Fourth quarter 1993 samples were collected in accordance with Rocky Flats Standard Operating Procedures (SOPs), a process that involves purging wells by bailing, followed by sampling by bailer. The pilot test groundwater sampling was performed in conjunction with the pumping of thousands of gallons of water from the extraction well to the storage tanks. A total of four groundwater samples were collected in March 1994.

Groundwater concentrations for the VOCs described in Sections 2.6.2.1 to 2.6.2.4 were also evaluated for the pilot tests samples. These samples were analyzed by two methods, VOACL P and VOA524.2. The concentration ranges for the VOCs are described below. Analytical results are also presented in Appendix C3.

Carbon Tetrachloride

The concentrations for CCl₄ ranged from 290 to 1,800 µg/l for Method VOA524.2 for the March 1994 samples. The range for Method VOACL P was 390 to 170 µg/l. During fourth quarter 1993, the concentration of CCl₄ from well 24193 was 3,800 µg/l.

Chloroform

The concentration range for Method VOA524.2 detections of CHCl₃ was 14 to 160 µg/l during the March 1994 sampling. VOACL P results ranged from 15 to 140 µg/l during this period. The concentration of CHCl₃ at well 24193 during fourth quarter 1993 was 220 µg/l.

Tetrachloroethene

The concentration range for Method VOA524.2 analysis of PCE during March 1994 was 410 to 3,800 µg/l. The VOACL P analysis results indicated a concentration range from 670 to 2,400 µg/l. The fourth quarter well 24193 concentration of PCE was 880 µg/l.

Trichloroethene

The range for TCE detections was 45 to 140 µg/l for VOA524.2 analysis of March 1994 samples. The VOACL P analysis results indicate a range from 46 to 110 µg/l. The fourth quarter 1993 concentration of TCE was 72 µg/l at well 24193.

2.6.2.7 Groundwater Sampling Results from WARP Wells

Prior to abandonment during the well abandonment and replacement program (WARP), Arapahoe Formation No. 1 Sandstone wells 24193, 24393, 24993, and 25093, groundwater samples were collected as shown on Figure 2.4-1. The collection of the samples was in accordance with RFETS SOPs. The collection method and sampling intervals are discussed in Section 2.2.2 and are presented on Table 2.6-2. The analytical data are also presented in Appendix C3.

Eight VOCs (1,1,1-TCA, 1,1-DCE, CCl₄, CHCl₃, cis-1,2-DCE, methylene chloride, PCE, and TCE) were detected in the groundwater samples collected from Arapahoe Formation No. 1 Sandstone wells (24193, 24393, 24993, and 25093). Table 2.6-2 shows the number of detections, the minimum and maximum concentration, and the average concentration for each detected VOCs and depth of sample collection (i.e., top of groundwater or bottom of well). Concentration ranges for these VOCs are described below:

1,1,1-Trichloroethane

The concentrations for 1,1,1-TCA ranged from 14-140 $\mu\text{g/L}$ in the samples collected prior to abandonment of these wells. The maximum concentration of 1,1,1-TCA was detected in a sample collected from the top of groundwater in well 24193.

1,1-Dichloroethene

The concentrations for 1,1-DCE ranged from 9 to 180 $\mu\text{g/L}$ in the samples collected prior to abandonment of these wells. The maximum concentration of 1,1-DCE was detected in a sample collected from the bottom of well 24193.

Carbon Tetrachloride

The concentrations for CCl_4 ranged from 490 to 5,200 $\mu\text{g/L}$ in the samples collected prior to abandonment of these wells. The maximum concentration of CCl_4 was detected in a sample collected from the top of groundwater in well 24193.

Chloroform

Chloroform was detected in all samples collected from these wells prior to their abandonment and ranged in concentrations from 22 to 340 $\mu\text{g/L}$. The maximum concentration occurred in a sample collected from the top of groundwater in well 24193.

cis-1,2-Dichloroethene

cis-1,2-Dichloroethene was detected in 50% of the groundwater samples collected from these wells prior to their abandonment and ranged in concentrations from 8 to 11 $\mu\text{g/L}$. The maximum concentration occurred in the groundwater sample collected from the top of groundwater in well 24393.

Methylene Chloride

Methylene chloride was detected in approximately 63% of the groundwater samples analyzed from these wells prior to their abandonment and ranged in concentrations from 8 to 47 µg/L. The maximum concentration was occurred in the groundwater sample collected from the bottom of well 24193.

Tetrachloroethene

Tetrachloroethene was detected in all the groundwater samples collected from these wells prior to their abandonment and ranged from 250 to 1,600 µg/L. The maximum concentration occurred in the groundwater sample collected from the top of groundwater in well 24193.

Trichloroethene

Trichloroethene was detected in all the groundwater samples collected from these wells prior to their abandonment and ranged in concentration from 40 to 110 µg/L. The maximum concentration occurred in the groundwater sample collected from the top of groundwater in well 24193.

2.6.2.8 Summary

Isoconcentration contour maps were prepared for UHSU groundwater VOCs (1,1-DCE, CCl₄, CHCl₃, methylene chloride, PCE, and TCE). The isoconcentration maps show that the major areas of VOC (CCl₄, CHCl₃, 1,1-DCE, PCE, and TCE) occurrence in the alluvium/colluvium are beneath and east of the 903 Pad; in the vicinity of Trench T-2, south of the 903 Pad (CCl₄, CHCl₃, 1,1-DCE, PCE, and TCE); in the Mound Area at the Mound Site (PCE and TCE); in the vicinity and north of the Northeast Trenches (PCE and TCE); and to a lesser extent, the Southeast Trenches (PCE and TCE).

The major areas of VOC occurrence in the No.1 Sandstone are east and west of the 903 Pad (CCl₄, CHCl₃, 1,1-DCE, PCE, and TCE); two areas in the Mound Area (PCE and TCE); and the Northeast Trenches Area (CCl₄, CHCl₃, 1,1-DCE, PCE, and TCE).

The highest VOC concentrations detected in the UHSU groundwater were 140,000 µg/l (TCE, well 07391 in the colluvium south of Trench T-2); 39,000 µg/l (CHCl₃, well 06691 in the alluvium beneath the 903 Pad); 17,000 µg/l (CCl₄, well 08891 in the alluvium beneath the 903 Pad); and 14,000 µg/l (PCE, well 08891 in the alluvium beneath the 903 Pad).

The potential for the occurrence of VOC dense nonaqueous phase liquids (DNAPLs) in groundwater appear to be greatest for CCl₄, PCE, and TCE, based on the observation of groundwater concentrations that exceed 1 percent of the chemical solubility. Potential DNAPLs in groundwater could exist beneath the 903 Pad (CCl₄, PCE, and TCE), in the vicinity of Trench T-2 (PCE and TCE), north and northeast of the Mound Site (PCE), and north of Trench T-4 in the Northeast Trenches (TCE). Direct evidence of DNAPLs in groundwater was not observed during the Phase II RFI/RI programs.

VOCs are widely distributed across the portion of OU-2 between the western boundary and the East Spray Fields and are closely associated with identified IHSS areas. In particular, VOCs are prevalent in the 903 Pad Area (beneath and around Trench T-2 and the 903 Pad), in the Mound Area, and in the Northeast Trenches Area. The most prevalent VOCs appear to be 1,1,1-TCA, 1,1-DCA, and 1,2-DCE.

Detections of SVOCs in UHSU groundwater are limited to a few compounds: benzoic acid, bis(2-ethylhexyl)phthalate, diethyl phthalate, di-n-butyl phthalate, and heptachlorepoide. Those compounds are detected infrequently in a few wells generally at concentrations less than about 20 µg/l.

No pesticides or PCBs were detected in UHSU groundwater during the Phase II RFI/RI investigations.

Am-241, Pu-239/240, and U-238 are potential waste-related contaminants in UHSU groundwater. Am-241 and Pu-239/240 occurred in filtered and unfiltered UHSU groundwater samples collected in the vicinity of the 903 Pad. U-238 occurred in groundwater primarily in the vicinity of Trench T-2. Radionuclide contamination could be associated with high concentrations of VOCs observed in the UHSU in the 903 Pad Source Area.

2.6.3 Soil Gas

Two Soil Gas Surveys (SGSs) were performed in and around Trench T-3 (IHSS 110). Both a shallow (near surface, less than 5 feet deep) and a deeper (5 and 10 feet below grade) survey were performed in 1993, as discussed in the Soil Vapor Survey Report (DOE 1994b). Figures 2.6-18 through 2.6-23 illustrate the results for CCl₄, PCE and TCE from the deeper SGS. Findings of the SGSs are summarized below.

The shallow SGS survey included analyses for the following VOCs:

- 1,1-DCE
- trans-1,2-dichloroethene (trans-1,2-DCE)
- cis-1,2-dichloroethene (cis-1,2-DCE)
- 1,1-DCA
- 1,2-DCA
- CCl₄
- PCE
- TCE
- vinyl chloride
- Total VOCs

1,1-DCE, trans-1,2-DCE, cis-1,2-DCE, and 1,2-DCA were not detected in the soil vapor. 1,1-DCA was detected at 16 of 35 sampling locations, and concentrations ranged from 40 to 1,900 µg/l. CCl₄ was detected at 18 of the 35 sampling locations with concentrations ranging

from 0.36 to 111 µg/l. TCE was detected at 14 of the 35 sampling locations with concentrations ranging from 1.2 to 21 µg/l. PCE was detected at 22 of the 35 sampling locations with concentrations ranging from 0.11 to 410 µg/l. Vinyl chloride was detected at two sampling locations at concentrations less than 23 µg/l.

Review of the spatial distribution of the soil gas data in Trench T-3 indicates that CCl₄ was found only in the west end of the trench (west of borehole 10191). PCE in soil gas is located in the west central part of Trench T-3 (located east of borehole 10191 and around the SVE wells and boreholes). TCE in soil gas is similar in location to the PCE plume. Two elevated total VOC concentration areas were observed in and around Trench T-3. One area is located in the west central part of Trench T-3 (near the SVE wells and boreholes) and the second is located in the western end of Trench T-3 (west of borehole 10191).

The two deeper SGSs (depths of 5 and 10 feet) included analyses for the following VOCs:

- 1,1-DCA
- CCl₄
- PCE
- TCE
- Total VOCs

Based on the evaluation of soil gas results obtained from the 5-foot sampling interval, total VOCs appear to be prevalent in the western portion of Trench T-3 (around borehole 10191) (Figure 2.6-21). However, the CCl₄ soil vapor plume extends west of the Trench T-3 boundary, while 1,1-DCA, PCE, and TCE soil vapor plumes are located in the western portion of Trench T-3 (Figure 2.6-18 through 2.6-22).

Review of the soil gas data obtained from the of 10 foot depth interval indicates that total VOCs, CCl₄, and PCE were observed at higher concentrations than at the 5-foot depth and higher concentrations were generally located near sampling location 110-29. 1,1-DCA was

not detected at the 10-foot depth interval sample, and TCE was detected at relatively low concentrations (Figures 2.6-22 through 2.6-25).

2.6.4 NAPL

The analytical results of the liquid collected from location 25194 in November and December of 1994 are discussed in this section. The field sampling techniques and analytical methods and procedures are discussed in Section 2.2.1 and the analytical data are presented in Appendix C5-1 through C5-3. The analytical results are discussed by analytical method for each layer analyzed. Figures 2.6-28 and 2.6-29 present a summary of the analytical results by layer (i.e., floating, aqueous). Analytical results for each distillation sample and review of the distillation test results are discussed in Section 2.6.5.

2.6.4.1 VOCs

The grab liquid samples for analytical testing collected from borehole 25194 in November, 1994, were submitted for analysis by EPA Methods 8260 (VOA), 8270 (SVOA), modified 8015 (TPH) and a radionuclide screen. The two distinct layers (the floating phase and the aqueous phase) were analyzed separately by each method except for the radionuclide screen. Figure 2.6-26 presents the detected analytical results for each layer (i.e., floating and aqueous) collected from borehole 25194. Results for the gross alpha and gross beta radionuclide screen performed on the entire liquid sample were 749,000 pCi/L and 803,000 pCi/L, respectively.

Nine VOCs (1,1,1-TCA, 1,1-DCA, acetone, CHCl_3 , ethylbenzene, m,p-xylene, o-xylene, PCE and TCE) were detected in the floating layer. All of these VOCs were detected at concentration greater than 1 mg/kg with the exception of ethylbenzene (0.92 mg/kg). Due to the elevated concentrations, the results were reported in mass units (i.e., mg/kg) instead of liquid units (i.e., mg/L). The chlorinated hydrocarbons (CHCs) ranged in concentrations from 1.1 mg/kg to 37,000 mg/kg. The CHC with the highest concentration was PCE. Three

BTEX constituents were detected in the floating layer m,p-xylene, o-xylene and ethylbenzene, and ranged in concentrations of 0.92 to 8.2 mg/kg.

Ten VOCs (1,1,1-TCA, 1,1-DCA, 2-butanone, acetone, CHCl₃, m,p-xylene, methylene chloride, o-xylene, PCE and TCE) were detected in the aqueous layer of the grab sample collected from borehole 25194, as shown on Figure 2.6-26. The concentrations of the aqueous layer were approximately two orders of magnitude less than the floating layer. Five of the ten VOCs detected were CHCs (1,1,1-TCA, 1,1-DCA, CHCl₃, PCE and TCE) at concentrations which ranged from 0.092 mg/kg to 650 mg/kg. m,p-Xylene and o-xylene were detected at concentrations of 0.24 mg/kg and 0.084 mg/kg, respectively.

Two VOCs (PCE and TCE) were detected in the floating layer (1), as shown on Figure 2.6-27. TCE was detected at a concentration of 330,000 µg/kg. PCE was detected at a concentration of 2,800,000 µg/kg. Due to elevated concentrations in the NAPL, the results are reported in mass units (i.e., µg/kg) instead of liquid units (i.e., µg/L).

Two VOCs (PCE and TCE) were detected in the floating layer (2), as shown on Figure 2.6-27. TCE and PCE were detected at concentrations of 330,000 µg/kg and 2,800,000 µg/kg, respectively.

Two VOCs (TCE and PCE) were detected in the aqueous layer from the December, 1994 samples, as shown on Figure 2.6-27. TCE and PCE were detected at concentrations of 330,000 µg/kg and 2,700,000 µg/kg, respectively.

2.6.4.2 TPH

The floating layers (1 and 2) and the aqueous layer (3) of the December NAPL were submitted for analysis by modified Method 8015 (8015m). Although the TPH results were reported back as Gasoline Range Organics (GRO) (C₆ through C₁₂) and Diesel Range Organics (DRO) (C₁₂ through C₂₄), gasoline and diesel were not implicitly identified; this was

evident by the data qualifiers and the report narrative submitted by the laboratory. Each of the GRO and DRO results for these samples were qualified with a G or X to indicate that the sample peak patterns did not match the peak patterns of the gasoline or diesel standards. See Section 2.5.6.3 for further details regarding the identification and quantification of GRO and DRO components.

A report narrative was not available for the two layers of the November NAPL sample; however, the data qualifier assigned to the gasoline result was identical to that of the December sample (the data qualifier was G), indicating that although hydrocarbons were found in the same hydrocarbon range as gasoline, the peak pattern did not match the gasoline standard. The diesel result was not qualified. The data received for the November NAPL were preliminary (i.e., draft).

Hydrocarbons were quantitated in the C₆ through C₁₂ (C₆-C₁₂) range and C₁₂ through C₂₄ (C₁₂-C₂₄) range in the floating phase of the November sample at concentrations of 170,000 mg/kg and 370,000 mg/kg, respectively. The gasoline result was qualified with a G, indicating that the peak pattern did not match the peak pattern of the gasoline standard.

Hydrocarbons were quantitated in the C₆-C₁₂ range at a concentration of 3,100 mg/L in the floating layer (1) of the December, 1994 sample. Hydrocarbons were quantitated in the C₁₂-C₂₄ range at a concentration of 4,000 mg/L in the floating layer (1). Hydrocarbons were quantitated in the C₆-C₂₄ range at a concentration of 170,000 mg/kg in the floating layer (2). Hydrocarbons were quantitated in the C₁₂-C₂₄ range at a concentration of 480,000 mg/kg in the floating layer (2). Hydrocarbons were quantitated in the C₆-C₁₂ and C₁₂-C₂₄ ranges at concentrations of 2,900 and 1,700 mg/L in the aqueous layer. Each of these results was qualified with a G or X; these are discussed in more detail in Section 2.5.6.3.

2.6.4.3 SVOCs

Nine SVOCs (2,4-dimethylphenol, 2-methylnaphthalene, 2-methylphenol, 4-methylphenol, bis[2-ethylhexyl]phthalate, di-n-butyl phthalate, fluorene, naphthalene, and phenanthrene) were detected in the floating layer (sample number 95N0058, November 1994). Two of the nine SVOCs detected were phthalates: bis[2-ethylhexyl]phthalate and di-n-butyl phthalate with concentrations of 310 mg/kg and 120 mg/kg, respectively. Four of the nine SVOCs detected were PAHs: 2-methylnaphthalene, fluorene, naphthalene, and phenanthrene with concentrations ranging from 58 mg/kg to 450 mg/kg. The remaining three SVOCs detected were phenols: 2,4-dimethylphenol, 2-methylphenol, and 4-methylphenol at concentrations of 100 mg/kg, 20 mg/kg, and 74 mg/kg, respectively.

Five SVOCs (2-methylphenol, 4-methylphenol, bis[2-ethylhexyl]phthalate, di-n-butyl phthalate, and phenanthrene) were detected in the aqueous layer sample (sample number 95N0058, November 1994). The two phthalates: bis (2-ethylhexyl) and di-n-butyl were detected at concentrations of 0.87 mg/kg and 0.62 mg/kg, respectively. The phenols: 2-methylphenol and 4-methylphenol were detected at concentrations of 14 mg/kg and 9.5 mg/kg, respectively. The only PAH detected in the aqueous layer sample was phenanthrene at a concentration of 0.53 mg/kg.

Seven SVOCs (naphthalene, 2-methylnaphthalene, phenanthrene, di-n-butylphthalate, pyrene, chrysene, and bis[2-ethylhexyl]phthalate) were detected in the floating layer (1) from the December sampling event. Two of seven SVOCs detected were di-n-butyl and bis(2-ethylhexyl) with concentrations of 4,400 and 20,000 µg/L, respectively. The five remaining SVOCs detected were PAHs and ranged in concentrations from chrysene at 280 µg/L to Phenanthrene at 6,900 µg/L.

Six SVOCs (naphthalene, 2-methylnaphthalene, fluorene, phenanthrene, di-n-butylphthalate, bis[2-ethylhexyl]phthalate) were detected in the floating layer (2) from the December sampling event. Two of the six SVOCs detected were phthalates: di-n-butyl and bis(2-

ethylhexyl) with concentrations of 85,000 and 370,000 $\mu\text{g}/\text{kg}$, respectively. Due to the elevated concentrations in this sample, the results are reported in mass units (i.e., $\mu\text{g}/\text{kg}$) instead of liquid units (i.e., $\mu\text{g}/\text{L}$). The remaining four SVOCs detected were PAHs which ranged in concentrations from Fluorene at 26,000 $\mu\text{g}/\text{kg}$ to Phenanthrene at 140,000 $\mu\text{g}/\text{kg}$.

Eleven SVOCs (phenol, 2-methylphenol, 4-methylphenol, 2,4-dimethylphenol, naphthalene, 2-methylnaphthalene, fluorene, phenanthrene, di-n-butyl phthalate, chrysene, and bis[2-ethylhexyl]phthalate) were detected in the aqueous layer from the December sampling event. Two of the eleven SVOCs detected were phthalates: di-n-butyl and bis(2-ethylhexyl) with concentrations of 1,400 and 7,500 $\mu\text{g}/\text{L}$, respectively. Four of the eleven SVOCs detected were phenols: phenol, 2-methylphenol, 4-methylphenol, and 2,4-dimethylphenol. The concentrations of the phenols ranged from 1,000 to 26,000 $\mu\text{g}/\text{L}$. The phenol with the highest concentration was 4-methylphenol. The remaining five SVOCs detected were PAHs which ranged in concentrations from chrysene at 110 $\mu\text{g}/\text{L}$ to 2-methylphenol at 3,400 $\mu\text{g}/\text{L}$.

Semivolatile TICs were detected in the floating layer (1) (sample number C0639-03), the floating layer (2) (sample number C0640-05), and the aqueous layer (sample number C0670-05) from the December sampling event. See Section 2.6.5.2 for a discussion of the TICs.

2.6.4.4 Radionuclides

The radionuclide screen performed on the sample collected from borehole 25194 in November 1994 prior to shipment indicated a gross alpha activity of 749,000 pCi/L and a gross beta activity of 803,000 pCi/L.

The radionuclide screen performed on the floating layer (1) from the sample collected from extraction well 25194 in December, 1994 indicated a gross alpha activity of 19,400 pCi/L and gross beta activity of 42,000 pCi/L. Radionuclide analysis for Am-241, Pu-239/240, U-233/234, U-235, and U-238 were performed on the floating layer (1).

One radionuclide screen was performed on the floating (2) and aqueous layers. The gross alpha and gross beta activities were 22,600 and 39,400 pCi/L, respectively. Separate select radionuclide analyses were performed on the floating (2) (sample number C0640) and aqueous layers (sample number C0670) for Am-241, Pu-239/240, U-233/234, U-235, and U-238. Am-241 was detected at an activity of 0.008 pCi/g in the floating layer (2) and at an activity of 1.62 pCi/g in the aqueous layer. Pu-239/240 was detected at an activity of 0.029 pCi/g in the floating layer (2) and at an activity of 1.16 pCi/g in the aqueous layer. U-233/234 was detected at an activity of 1.96 pCi/g in the floating layer (2) and at an activity of 398 pCi/g in the aqueous layer. U-235 was detected at an activity of 0.35 pCi/g in the floating layer (2) and at an activity of 101 pCi/g in the aqueous layer. U-238 was detected at an activity of 15.5 pCi/g in the floating layer (2) and at an activity of 3,240 pCi/g in the aqueous layer. In general, the activities in the aqueous layer were two orders of magnitude higher than the floating layer (2).

2.6.5 Sample Collection for Distillate Test and Numbering Overview

The NAPL sample collected in the field on December 20, 1994, was biphasic. Each phase was bottled (4 liters of each phase was collected), labeled, and recorded on the chain of custody as separate sample numbers. The floating phase was labeled CO639 (1), and the bottom water phase was labeled CO640 (2).

While inroad to the laboratory, sample number CO640 separated again, into a top floating and bottom water phase. The laboratory separated the two phases (using 1 or 2 liters, and the VOC vials for CO640) and created a third sample, CO670. Sample CO640 was the top floating, and CO670 the bottom water phase. However, the sample aliquot contained in the VOC vial for CO640 was not biphasic, and the laboratory used that vial (not realizing it was one phase because the vial was amber) to create the third volatile sample (number CO670-04). The results for the volatile analysis on samples CO640-04 and CO670-04 are, therefore, nearly identical. Table 2.2-2 summarizes how these samples were numbered, and the

analytical testing that was performed for each sample. A description of the original sample and the phases is also provided in Section 2.2.1.

The remaining 2 liters of CO640 was used for the distillation analysis. Each liter contained approximately 50% upper phase (floating) and 50% lower phase (bottom water phase). The distillation was performed on the combined phases, and resulted in 16 fractions, each of which, were analyzed by Methods 8260, 8270, and 8015M. Table 2.2-3 summarizes how the distillate fractions were numbered, and the analytical testing that was performed for each fraction. A brief description of the distillation procedure is also provided in Section 2.2.1.

In general, each phase of the original sample (samples CO639, CO640, and CO670), and the distillate fractions originating from the original sample CO640, were analyzed by Methods 8260, 8270, and 8015M. Radionuclides were also analyzed for samples CO640 and CO670. The following sections address the organic analyses only.

Tables 2.6-3 through 2.6-10 tabulates the target analytes that were detected in each of the distillate fractions. The following sections (2.6.5.1 through 2.6.5.4) provide a discussion of those results. Figure 2.6-30 depicts the sample numbering scheme for the original December NAPL sample, the top floating, the bottom water phase, and the distillate fractions from the combined phases of C640.

2.6.5.1 Analytical Data Review

The objective of this data review was to identify the major chemical components present in the December NAPL sample. This was accomplished by performing a cursory review of the data; it did not entail a full data validation. Data validation was still pending when this report was prepared. The review of the data included looking at the target compounds detected in each fraction, the tentatively identified compounds (TICs) from Methods 8260 and 8270, and the chromatograms from the modified Method 8015 analysis. (Radionuclide data are not addressed in this discussion)

The data reviewed were from the original NAPL collected on December 20, 1994 (sample numbers CO639, CO640 - top floating, and CO670 - bottom water phase) and the distillate fractions that were generated from the combined phases of sample CO640.

Electronic Data

Electronic data for Methods 8015M, 8260, and 8270 were received for the NAPL sample fractions collected on December 20, 1994, and the subsequent distillate samples. Due to dilutions performed for Methods 8260 and 8270, duplicate analytical records were present in the electronic deliverable. The duplicate records were eliminated, thus creating a working dataset, using the following selection criteria:

- Chemicals that were not detected in the undiluted analysis were retained in the working dataset. There were some exceptions of target analytes that were not detected in the undiluted run, but had a reported concentration in the diluted analysis. In these cases, the result in the diluted analysis was retained.
- Chemicals that exceeded calibration range (E qualified data) in the undiluted analysis were eliminated. The reported concentration from the diluted analysis was retained. There was one exception of 4-methylphenol that was E qualified in both the undiluted and diluted analysis. In this case, the highest reported concentration was retained.
- Chemicals that did not exceed the calibration range in the undiluted analysis, but had reported concentrations in both runs, were selected based on the highest concentration reported.

Hardcopy Data

Raw data (i.e., extraction logs, chromatograms, and mass spectra) for Methods 8015M, 8260, and 8270 were obtained for the NAPL sample collected on December 20, 1994, and the subsequent distillate samples. The raw data were primarily used to evaluate tentatively identified compounds (TICs) for Methods 8260 and 8270. The chromatograms generated by Method 8015M were also looked at in an effort to obtain additional information regarding the types of hydrocarbons potentially present in the NAPL sample. The raw data were not used to validate the data.

2.6.5.2 Methods 8260 and 8270 Overview

Target Compounds and Tentatively Identified Compounds (TIC)

Target compounds refer to a specific list of analytes to be quantified in an environmental sample. Analytical standards for target compounds are contained in the calibration standard for the method being performed. These standards are also measured in laboratory control samples and matrix spike samples. Therefore, it is possible to accurately quantitate target compounds in environmental samples (barring matrix interference or other anomalous analytical conditions). Similarly, the analytical standards provide mass spectral information which facilitates accurate identification of target compounds in environmental samples.

Tentatively identified compounds (TICs) apply to methods (i.e., Methods 8260 and 8270) which use gas chromatography/mass spectrometry (GCMS) instrumentation. TICs are non target compounds that can be detected in an environmental sample but do not meet the identification criteria of target compounds, internal standards, or surrogates. For each environmental sample, a mass spectral library search can be conducted to tentatively identify non target compounds. Contract Laboratory Program (CLP) protocol states that a mass spectral library search will be made for up to 20 extraneous compounds of the greatest apparent concentration. The mass spectral library is a compilation of spectra for 50,000 (or

more) compounds. Tentative identification is based on an electronic library search and/or a visual comparison of the TIC spectra in the environmental sample against a similar spectra found in the mass spectra library, and is not absolute. TIC quantitation is estimated because the mass spectra and reported concentration are not compared to a standard.

Target Compounds - Distillate Samples

The target compounds identified for this project included the CLP Target Compound List (TCL) for volatiles and semivolatiles; pesticides/PCBs were not included. TCL analytes that were frequently detected in the distillate fractions included tetrachloroethene (PCE), trichloroethene (TCE), acetone, phenol, 2,4-dimethylphenol, ortho and meta cresol, naphthalene, phenanthrene, and 2-methylnaphthalene. TCL analytes that were infrequently detected included bis(2-ethylhexyl)phthalate, di-n-butylphthalate, and methylene chloride; although these are common laboratory contaminants, the reported concentrations were not B qualified by the laboratory. That is, the associated method blanks did not have reported concentrations of these common laboratory contaminants. There was one occurrence of benzyl alcohol (160 ppb at a reporting limit of 250 ppb) in sample CO643.

Acetone was B qualified in two instances, however, the amount detected in the associated method blank was negligible (9.2 ppb with reporting limit of 10 ppb) by comparison to the concentration found in the samples (i.e., 22,000,000 ppb with a reporting limit of 12,000,000 ppb). Other samples showed similarly high concentrations of acetone that were not B qualified.

There were four instances of PCE sample results that were B qualified. The concentration in the associated liquid waste method blanks were 530 ppb and 560 ppb, both at a reporting limit of 635 ppb. The concentrations of PCE detected in three of the samples (CO644, CO647, and CO704) exceeded the amounts detected in the method blank by factors of 1000 or more. Sample CO703 had less than 5 times (1700 ppb at a reporting limit of 620 ppb) the amount of PCE detected in the associated method blank. The PCE detected in CO703,

therefore, may be considered suspect according to the Environmental Protection Agency (EPA) National Functional Guidelines for Organic Data Review.

Distillate sample CO647 had m,p-Xylenes below the reporting limit (e.g., J qualified). Sample CO648 reported all of the xylene isomers (o,m, and p) above the reporting limit, but at relatively low concentrations compared to the amounts of PCE and semivolatiles present. CO648 also had ethylbenzene below the reporting limit (e.g., J qualified). Sample CO703 was the only sample that had benzene, toluene, and ethylbenzene concentrations above the reporting limit; m,p-Xylenes were also present, but J qualified. Sample CO703 also had carbon disulfide detected at 9,400 ppb with a reporting limit of 620 ppb. These samples also showed significantly decreased concentrations of PCE, TCE, and the semivolatiles. Sample CO703, in particular, did not have any PCE detected and the TCE was J qualified. The traces of BTEX detected in these samples may not have been detected in other samples because of significant dilutions and/or matrix interferences. The BTEX components may also be breakdown products from the distillation process.

TICs - Distillate Samples

The total concentrations of volatile TICs ranged in concentration from 18,000 ppb in sample CO698 to 16,600,000 ppb in sample CO647. Volatile TICs were reported for samples CO645, CO647, CO648, CO649, CO698, CO703, CO704, and CO705. TICs were not detected in CO641, CO642, CO643, CO644, and CO646. The occurrence of TIC detections and reported concentrations (or lack of) for each of the samples appeared to be directly proportional to the amount of PCE and TCE present in the samples (i.e., higher concentrations of PCE and TCE resulted in lower concentrations and fewer detections of TICs). Samples containing high concentrations of PCE and/or TCE were probably diluted to the extent that the TICs were not measurable. Most of the volatile TICs were reported as unknown hydrocarbons (alkanes and alkenes). Some volatile TICs were identified as substituted benzenes.

Semivolatile TICs were detected in all of the distillate samples. PCE was tentatively identified in concentrations ranging from 46,000 ppb in sample CO643 to 1,000,000,000 ppb in sample CO644. Samples CO641, CO642, CO643, CO644, CO645, CO646, and CO647 had PCE tentatively identified in the semivolatile fractions. Most of the semivolatile TICs were reported as unknown hydrocarbons (alkanes, alkenes, and cyclo alkanes). There were some TICs that looked like remnants of target compounds; these included substituted benzenes, substituted naphthalenes, alcohols, and glycol. A small percentage of semivolatile TICs were tentatively identified as camphene and limonene (i.e., terpinenes).

As mentioned in the Method 8260 and 8270 overview, the reported concentrations for all TICs are estimated values, and do not reflect an exact quantitation.

December NAPL before Distillation

Volatile TICs were not detected in CO639-02, CO640-04, and CO670-04; however, due to extremely high concentrations of PCE and TCE, these samples were significantly diluted (i.e., dilution factors of 10,000). The samples were probably diluted to the extent that the TICs were not measurable. PCE and TCE were the only target compounds detected.

Semivolatile TICs were detected in CO639-03, CO640-05, and CO670-05. The TICs reported were similar to those found in the distillate samples, except that PCE was not identified and there were fewer instances of specific compound groups reported (i.e., most of the TICs were reported as unknown hydrocarbons).

Target compounds that were detected in samples CO639-03, CO640-05, and CO670-05 by Method 8270 included 2-Methylnaphthalene, Phenanthrene, bis(2-Ethylhexyl)phthalate, and di-n-Butylphthalate. Concentrations of Naphthalene and 2-Methylnaphthalene were greatest in CO640-05 and CO639-03 respectively; however, none was detected in CO670-05. Phenol, 2-Methylphenol, 4-Methylphenol, and 2,4-Dimethylphenol were detected only in sample CO670-05. However, these compounds were detected in some of the distillate fractions

originating from CO640. It is presumed that the original sample, before distillation, was diluted to the extent that these compounds (Phenol, 2-Methylphenol, 4-Methylphenol, and 2,4-Dimethylphenol) could not be measured.

2.6.5.3 Modified Method 8015 Overview

Modified Method 8015 is a gas chromatography (GC) method that was used to identify and quantitate gasoline range organics (GRO) (C_6 - C_{12}) and diesel range organics (DRO) (C_{12} - C_{24}). Simply stated, any hydrocarbon configuration, that fell within these ranges (C_6 - C_{24}) may have been detected. However, the hydrocarbon peak patterns must match the peak patterns of the gasoline or diesel calibration standard before it can be identified as gasoline or diesel.

The December NAPL samples contained C_6 - C_{24} hydrocarbons, but the hydrocarbon peak patterns did not match the peak patterns of the gasoline or diesel calibration standards. This was indicated by the qualifiers (X, Y, or G) that were added to each of the GRO and DRO results. As stated in the report from the laboratory, these qualifiers were included to indicate that although hydrocarbons were detected in the gasoline and diesel hydrocarbon ranges, the chromatograms did not match the gasoline or diesel calibration standards. A more reliable identification may be made by examining the results from the Methods 8260 and 8270.

The reported concentrations of the hydrocarbons that were present in these samples were based on the quantitation of those hydrocarbons that eluted within the C_6 - C_{12} and C_{12} - C_{24} range. Therefore, this method would not have necessarily detected, or reported, other hydrocarbons that were not within the C_6 - C_{24} range. However, based on sample chromatograms received from the laboratory, and conversations held with the laboratory's coordinator of petroleum analyses, it was possible to determine that some hydrocarbons heavier than diesel may be present in some of the fractions. This observation is based on hydrocarbon retention time markers (i.e., elution times for specific hydrocarbons) that have been established by the laboratory. These retention time markers (below) are based on gasoline and diesel calibration standards:

- C₆ hydrocarbons elute at 2 minutes and 47 seconds
- C₁₂ hydrocarbons elute at 12 minutes and 52 seconds
- C₂₄ hydrocarbons elute at 23 minutes and 40 seconds

For example, calibration standards for diesel do not elute after 23 minutes and 40 seconds. For this project, the laboratory performed the method allowing 29 minutes elution time for each sample. The chromatograms for samples CO639-04, CO670-06, and in particular CO640-06, show a definite broad based peak at 25 minutes which tapers off at 29 minutes. This peak, although less pronounced, is also present in some of the distillate fractions originating from CO640-06. The distillate fractions represent the top and bottom layers collected from 106 to 120 degrees centigrade (CO704, CO705, CO649 and CO698), and the residue (CO703) (Method 8015 data are not available for distillate samples collected after 120 degrees centigrade.) The presence of a motor oil or industrial lubricant is indicated by these observations

2.6.5.5 Summary of Analytical Results

This section summarizes the results of Methods 8260, 8270, and 8015M for the December NAPL sample and distillate fractions originating from the oil phase of the NAPL.

The predominant component of the December NAPL sample appears to be PCE, followed by TCE, naphthalene, 2-methylnaphthalene, and the cresols.

PCE and TCE are known for their uses as industrial solvents. PCE can also be used as a drying agent for metals and certain other solids (The Condensed Chemical Dictionary, Tenth Edition, Hawley 1981a).

Naphthalenes and cresols are commonly associated with petroleum products or coal tar. Cresols may also originate from toluene by sulfonation or oxidation. Some uses for cresols

include disinfectants, ore flotation, textile scouring agent, and surfactants. Uses for naphthalene include cutting fluid and lubricants (Hawley 1981b).

The results of the GRO analysis do not indicate the presence of gasoline. However, the presence of BTEX components in some of the distillate fractions may be indicative of gasoline. It is important to note that the concentrations of BTEX were negligible by comparison to the PCE and TCE, which appear to be the primary components of the NAPL. For example 660,000,000 ppb PCE was reported in sample CO642 compared to 6,640 ppb total BTEX reported in sample CO703. It is also possible that the occurrence of BTEX components originated from break down products during the distillation process. For instance, although xylenes are commonly related to fuel products, they may be derived from fractional distillation of petroleum (Hawley 1981c).

The results of the DRO analysis do not indicate the presence of diesel, and the discussion included in the report from the laboratory indicated that the hydrocarbon pattern did not look like diesel. As discussed in the overview for Modified Method 8015, the presence of hydrocarbons heavier than diesel are indicated.

2.7 GEOPHYSICAL SURVEY OF TRENCH T-3

2.7.1 Introduction

Surface geophysical survey methods were used as part of the investigation of Trench T-3 within IHSS 110 at the SVE Test Site No. 1 (shown in Figure 1.1-1). The primary objective of the geophysics survey was to obtain subsurface information to help delineate the areal extent of Trench T-3 excavation and the trench edges if possible. An additional objective of the geophysics was to identify the potential existence of metallic debris within the trench. The geophysical methods used were electromagnetics (EM) and ground penetrating radar (GPR).

2.7.2 Description of Geophysical Methods

2.7.2.1 Electromagnetics

EM methods provide a rapid means of measuring the electrical conductivity of subsurface soil, rock, and groundwater. EM can be useful for assessing subsurface conditions such as depth and orientation of bedrock, presence of ferrous and nonferrous materials, thickness and lateral variations of subsurface units or lateral extent of paleochannels. Specifically at the SVE Test Site, EM was used to assess the variation of conductivity across the site; to obtain information on the potential area of excavation associated with the construction of Trench T-3; and to delineate potential areas of buried metallic debris.

The EM method involves the induction of electrical current into the subsurface. A small alternating current passing through a transmitter coil produces a primary, time-varying magnetic field into the ground. Through inductive coupling, the primary magnetic field produces small eddy currents in the subsurface which, in turn, create their own secondary magnetic field. The receiver coil senses both the primary and secondary fields. Changes in magnitude and phase of the individual currents are converted to voltages and output as ground conductivity values in millimhos (mmhos)/meter on the instrument and recorded manually or by a digital data logger.

The selection of EM instrumentation is dependent on the desired penetration depth. For all available EM instruments, the depth of investigation is related to the separation between the transmitter and receiver coils and the mode of coil orientation (horizontal or vertical). By using multiple coil spacings or orientations, several penetration depths can be achieved, allowing vertical variations of conductivity to be assessed. For shallow less than 15 feet investigations, EM data can be collected with a Geonics EM-31 terrain conductivity meter. The EM-31, which has a fixed spacing of 12 feet, has an effective penetration depth of approximately 15 feet using the vertical dipole mode.

The EM-31 measures both the quadrature phase component and the inphase component of the induced magnetic field. The quadrature phase is linearly related to the ground conductivity and thus interpretable in terms of subsurface geology, and more specifically in terms of disturbed versus non-disturbed soil. The inphase measurement is the ratio of the induced secondary magnetic field to the primary magnetic field, and is more sensitive to metallic objects than the quadrature phase measurement.

Individual conductivity values are not necessarily diagnostic in themselves. However, the variations in conductivity can indicate changes in subsurface conditions. As an example, trench materials can sometimes produce a conductivity low (depending on the trench fill properties). However, in trenches that contain metallic objects such as drums, a conductivity high might be observed. In some trenches, where significant constituent inhomogeneity exists, the associated EM anomaly can appear as a dipole characterized by both high and low values in close proximity to each other. This is because the EM response can be affected by the interaction between the anomaly-producing body in the subsurface and the orientation of the instrument. Although dipoles can be observed with quadrature data, they are more common with inphase data.

Conductivity values can be plotted and contoured to estimate lateral conductivity variations. Variations in the subsurface conductivity due to buried metallic trench materials generally produce relatively large (greater than 20 mmhos/meter) anomalies (areas where the measured conductivity varies significantly from some background level). However, these anomalies or smaller ones can be masked by the interfering effects of surface debris, buried utilities, overhead utilities and communications apparatus, or any large metal structures close to the survey area.

Interpretation of an EM contour map requires that the basic characteristics and causes of conductivity anomalies be kept in mind. Most types of soil and rock are electrical insulators of high resistivity. The electrical conduction that takes place in the subsurface is primarily electrolytic and occurs through the moisture-filled pores and fracture contained in the matrix.

If a conductive body such as a metal drum is placed in the matrix, ion flow and conduction occurs preferentially through the metal, thus increasing the bulk conductivity. Conversely, if non-conductive materials such as unreinforced concrete are placed in the matrix, ion flow and conduction occur around the resistor, thus reducing the bulk conductivity. Therefore, landfill areas, which may have buried metallic objects, sludge, or leachate, are generally revealed as conductivity highs, while landfill or hardfill areas, which may have buried concrete, asphalt, wood, or dry backfill soil materials, are generally revealed as conductivity lows. All these facets are superimposed on the geologic framework of the site. Variability of clay and sand layers will produce small conductivity anomalies due to the variable ion flow between the two rock types.

2.7.2.2 Ground Penetrating Radar

GPR using impulse radar technology has been applied for the non-intrusive investigation of shallow subsurface materials. The method has been used for locating voids in concrete or limestone, finding buried pipelines or reinforcement bars, mapping shallow geologic interfaces, and delineating near-surface soil layering. GPR has been shown to be a successful tool for resolving soil stratigraphy, thus allowing the potential delineation of excavation areas associated with buried trenches.

GPR involves transmitting a relatively high-frequency electromagnetic pulse using a transducer antenna into the medium, and recording reflected electromagnetic energy with a receiving antenna. Electromagnetic reflections occur whenever the dielectric constant of the material(s) changes (i.e., metal versus soil). As the antenna is towed along a survey line, the reflected electromagnetic signals are converted to analog (or with some instrumentation digital) signals, processed, and displayed as travel times on a graphic recorder as output. As the transducer is pulled along a transect line, the graphic recorder prints an approximation of the interfaces one would see in cross-section. The display is similar to a geologic section, except that the record is a time section rather than a depth section.

An important step in a successful GPR survey is to clearly define the objective target(s) to the degree possible. Fundamental questions must be answered before implementing GPR. Approximate target depths must be evaluated, because at most soil sites typically encountered, GPR is a very shallow investigation tool. Approximate target geometry must also be evaluated to aid in the selection of appropriate data collection density and proper antennas. Electrical properties of the medium must be evaluated to estimate how well the radar signals will penetrate, and to judge whether a sufficient dielectric contrast exists for the target to be detected. And finally, the site environment must be evaluated, such as the presence of metal structures or utility wires, accessibility, the amount of surface vegetation, and the site topography, all of which can contribute to the success or failure of a GPR survey.

The ultimate effectiveness of GPR at a given site is directly proportional to the dielectric properties of the medium through which the signal is transmitted. GPR allows the greatest resolution of subsurface features when favorable conditions exist. However, properties of the medium can effect penetration depths. These depths are primarily controlled by the electrical conductivity of the surveyed medium because the electromagnetic pulses lose energy in the form of heat when transmitted through electrically conductive units. Conductivity of a particular medium is predominantly governed by the water content, amount of salt in solution, and the percentage of conductive clay. Typical penetration depths of GPR are:

- Less than 4 feet through clay
- Over 75 feet through freshwater saturated sands
- Over 30 feet in clean limestone
- Over 230 feet through ice
- Less than 1 foot in seawater

Thus, the depth of penetration and ultimate effectiveness of GPR is highly site specific. As a result, a feasibility or test study is often conducted to identify the usefulness of GPR on a project-by-project basis.

2.7.3 Field Testing of GPR

An initial test for conducting GPR at the Trench T-3 site was conducted prior to full implementation over the entire site. The study was conducted to test the applicability of GPR specifically to delineate trench edges. Prior to conducting the GPR field test, several questions were answered to aid in the selection of appropriate survey design. The depth of penetration desired was estimated to be 6 to 9 feet, which was the approximate depth of the excavated trenches. Penetration of 3 to 6 feet was thought to be sufficient however, to detect trench edges.

GPR data were collected with a Geophysical Survey Systems, Inc. (GSSI) Subsurface Interface Radar (SIR) System-3. The system included a profiling recorder, control cable, and transmitting and receiving antenna. This system provided instantaneous and continuous profile records of the radar response.

Testing of various GPR data acquisition parameters was conducted as part of the test study. Two antenna frequencies were available for testing, the 300 Mhz and 500 Mhz. During testing, it was concluded that the 300 Mhz would not provide the resolution required for discerning the targets of interest, so the 500 Mhz antenna was used for the rest of the survey. Other data acquisition parameters were tested for optimum data resolution given survey objectives. The following recording parameters were tested:

- Time range for recording
- Signal range gain
- High and low pass filter settings (given time range for recording)
- Printer speed
- Antenna towing speed

These recording parameters were tested on multiple lines over the western part of Trench T-3. Final data acquisition parameters allowed GPR penetration depths of approximately 4 feet.

This minimal penetration was likely due to the significant amount of clay and clayey fill in the upper several feet. However, this penetration was sufficient to detect potential targets associated with the sides of the excavated trench.

After optimization of the data parameters, several test lines with a five foot separation were conducted to determine potential correlation from line to line. Several potentially anomalous areas were observed in the upper 3 to 4 feet of soil material and could be correlated over several lines. Based on the results of the feasibility study, the decision was made to implement GPR data collection over the entire Trench T-3 area.

2.7.4 Field Operations

Subsurface conductivities were measured using the Geonics EM-31 with a data logger over a grid pattern. EM data were collected using a nominal 5-foot station spacing, with a 10-foot separation between transects. Labeling of the lines was from -30 feet to 140 feet. Line 0 was conducted just east of Boring 10191. Transects were conducted in a general north-south direction, perpendicular to the suspected east-west orientation of the trench. Data were collected in the vertical dipole mode (0 to 15 feet penetration) for both the quadrature and inphase data. Readings were collected in a general east-west orientation (parallel to the suspected trench orientation) and north-south (perpendicular to the suspected trench orientation). EM data were input to the computer software GEOSOFT, which was used to grid and contour the data.

GPR data were collected along north-south trending transects separated by a distance of 10 feet. The GPR lines were conducted along the same transects as the EM. Additionally, a cross line was conducted for correlation purposes. The GPR data acquisition parameters used were derived from the field test, and remained the same for the entire implementation phase. Along each GPR transect, a marker signal was used at each survey flag (nominally 5 feet) during antenna towing to aid correlation of printed records with actual location in the field. Each printed GPR record was annotated with line number, and footage marker (shown

by vertical dashed line) along each completed transect. Also shown on the GPR records are horizontal lines for time scaling. Using the time range setting used during data collection, each division between scaling lines is approximately 6 nanoseconds. Based on the approximate velocity of the medium each scaling division would represent an approximate thickness of 3/4 to 1-1/4 feet.

2.7.5 Results

Results of the EM survey are shown in the contour maps of Figures 2.7-1 through 2.7-4. Figures 2.7-1 and 2.7-2 depict results for the quadrature and inphase data for the east-west orientation, respectively. Figures 2.7-3 and 2.7-4 depict the results for the quadrature and inphase data for the north-south orientation, respectively. Also shown on the figures are the interpreted trench edges based on the GPR data (discussed below).

Quadrature values for both orientations varied from 15 to 69 mmhos/meter. Inphase values for both orientations varied from 32 to 33 parts/thousand. The highest quadrature values are observed from Line 10 to Line 30 (Figure 2.7.1). This zone also displays the most widely fluctuating inphase values. This combination of observations is likely indicative of buried metallic objects. There are also isolated anomalies further east (see Figure 2.7-3) along Line 50 ($x = 50$ and $y = 20$) and along line 80 ($x = 80$ and $y = 15$). These shallower anomalies could be due to localized areas of buried metallic debris. Anomalies that are associated with surface metals include those in Figure 2.7-3 at coordinate (30,0) and (120,30).

Variations in conductivity due solely to trench excavation and emplacement of fill are not readily apparent on the EM plots. The conductivity variations and associated anomalies indicative of metallic objects appear to supersede any variations due to excavation.

Sample copies of a portion of the GPR raw data are shown in Figures 2.7-5 through 2.7-12. Figures 2.7-5 and 2.7-6 are selected GPR record sections in which evidence of a buried trench is not apparent. Reflections are relatively continuous, except for areas where surface cobbles

were encountered beneath the GPR antenna. Figures 2.7-7 through 2.7-12 depict GPR transects in which the edges of a potential buried trench were interpreted. An interpretation for the trench was made from the GPR data for one or more of several observed anomalies. These were:

- A disruption in the continuity of near-surface layering, with the disruption usually offsetting the layering downward near the suspected location of the trench (e.g., Figures 2.7-7, 2.7-9, 2.7-10, 2.7-11, and 2.7-12)
- An increase in GPR reflection energy relative to surrounding areas (e.g., Figures 2.7-8 and 2.7-9)
- An absorption of GPR energy relative to surrounding areas (e.g., Figures 2.7-11 and 2.7-12)

The edges of both the north side and the south side of the trench were estimated from interpretation of each GPR transect. Those interpreted locations were then marked in the field for later surveying. The surveyed position of the interpreted trench edges along each transect were connected together to allow inclusion on the EM contour maps.

2.8 THREE-DIMENSIONAL SITE VISUALIZATION

A series of three-dimensional geologic and contaminant concentration models (Figures 2.8-1 through 2.8-3) were constructed for the area around IHSS 110 (Trench T-3). The purpose of the models was to integrate existing geologic data and provide an evaluation tool for assessing contamination in and around IHSS 110. The models present a three-dimensional visualization of the geology and the contaminant distributions for total VOCs beneath the area. The geologic model consists of four layers representing the Rocky Flats Alluvium, the No. 1 Sandstone Unit, and claystone overlying and underlying the No. 1 Sandstone Unit. The

total VOC contamination is presented in several views that are color coded to represent total VOC concentration ranges.

Software Selection

The software products used in the construction of the IHSS 110 area geologic and contaminant distribution models was geologic visualization software, Earth Vision (produced by Dynamic Graphics, Inc.). The visualization software provides two and three-dimensional modeling capabilities for geologic media. Two-dimensional grids from XYZ data were constructed and then used to produce solid graphical bodies. These solid bodies were then merged into the geologic model.

Earth Vision uses a minimum tension gridding technique to construct grids from scattered data sets. Gridding is necessary to estimate values of a property surface (usually elevation or concentrations) at regularly spaced locations (Davis 1986). Minimum tension gridding uses a spline function to connect the irregularly spaced data with a smooth continuous surface (Davis 1986). The values at the regular space points comprising the grid are taken from this splined surface. The particular function used in Earth Vision is known as Brigg's Bicubic spline function.

Model Construction

The geologic model was constructed using grids of the surfaces of each of the following four geologic units: the Rocky Flats Alluvium, No. 1 Sandstone Unit, and claystones overlying and underlying the No. 1 Sandstone Unit. Topography forms the top surface of the model, with the bottom of the model formed arbitrarily at 5,700 feet in elevation for the area modeled and 5,850 feet for the IHSS 110-specific model. In addition, a surface was included in the model to represent the groundwater level in the No. 1 Sandstone Unit during March 1992. This period was chosen because it represents a relatively high groundwater level.

The major source of data to delineate the top and bottom surfaces of these geologic units was contained in the Preliminary Draft Phase II RFI/RI Report for OU-2 (DOE 1993b). These data consisted of digitized contour maps constructed by Woodward-Clyde Federal Services (WCFS) for the RFI/RI report. The following figures were delivered to EG&G in July 1994 during preparation of this report:

- Top of Bedrock Map
- Top of No. 1 Sandstone Unit Map
- Base of No. 1 Sandstone Unit Map
- First Quarter of 1992 Alluvial/Colluvial Potentiometric Map
- First Quarter of 1992 No. 1 Sandstone Unit Potentiometric Map
- Second Quarter of 1992 Alluvial/Colluvial Potentiometric Map
- Second Quarter of 1992 No. 1 Sandstone Unit Potentiometric Map

XYZ coordinate files corresponding to the location of contours on maps for the top of each of the respective units were then used to construct surface grids for each of these units.

When the grids were calculated by the software, they were extrapolated over the entire study area. The grids were then edited to represent the actual extent of the geologic units. Furthermore, the spatial limits of the sandstone were used to constrain the extent of this geologic unit in the model. All gridded values outside the spatial limits of the No. 1 Sandstone Unit were set to a null value. Grid cells with this value were considered to be blank, accounting for the absence of the geologic units in these areas.

Analytical results for VOCs (CCl₄, CHCl₃, PCE, TCE, Total VOCs) for subsurface soil collected from locations in the Northeast Trenches Area of OU-2 were provided for the three-dimensional visualization model.

Only total VOCs, however, were used to produce the visualizations presented in Figures 2.8-1 through 2.8-3.

Spreadsheets were prepared and included the northing, easting, elevation of the midpoint of the sampling interval, analyte, results in $\mu\text{g}/\text{kg}$, and the sample location. Using the results, a three-dimensional grid of total VOC concentrations was constructed, representing concentrations of various VOCs present in the soil in the area around IHSS 110. These data were obtained from analytical results for soil borings conducted for the OU-2 RFI/RI and SVE studies. In order to limit interpolation error due to the large spread of data values over several orders of magnitude, the initial data files were converted to logarithmic values. Limiting the spread of data values reduced error in the model resulting from the interpolation of a value from adjacent values that exhibited large numerical differences. Three-dimensional grids were then constructed from these three-dimensional data files. The resulting logarithmic three-dimensional grids were then converted back to the actual values.

Solid geologic bodies were constructed from these contaminant concentration three-dimensional grids, using the surfaces constructed previously. The Rocky Flats Alluvium was constructed from the topography grid and the base of bedrock grid; the overlying claystone was constructed from the base of bedrock grid and the top of No. 1 Sandstone Unit grid, and the underlying claystone was constructed from the base of the No. 1 Sandstone Unit grid and the model base grid (set arbitrarily at 5,700 or 5,850 feet). These bodies represent three-dimensional visualizations of the geologic units in the model. The base of the model is well below the zone of interest (with respect to contaminant distribution) and does not interfere with the visualization. These bodies were then merged to produce complete geologic/contaminant distribution models of the area around IHSS 110 which display not only the geology, but also contamination concentrations of the selected VOCs in soil.

Model Results

The resulting diagrams illustrate the geology and contaminant distribution beneath the area around IHSS 110. Visualizations for total VOC concentrations are shown on Figures 2.8-1 through 2.8-3. These figures present various views of the contaminant distributions (for total VOC concentrations) and the geology. It is apparent from the model results that elevated

total VOC concentrations are present in the west end of Trench T-3. The models also indicate that the elevated concentrations most likely do not extend below the potentiometric surface or are limited to just below the high water table. Downward migration of the contaminants is apparently restricted by the bedrock claystones underlying the alluvium beneath Trench T-3.

3.0 OVERVIEW OF POTENTIAL CONTAMINANT MIGRATION PATHWAYS

Contaminant fate and transport through groundwater, surface water, and air pathways at OU-2 have been evaluated in the Preliminary Draft Phase II RFI/RI Report for OU-2 (DOE 1993b) to assess the potential for on-site and off-site migration of selected contaminants. The transport of contaminants in various environmental media including surface soils, groundwater, surface water, air, and biota was also evaluated for the 903 Pad, Mound, and East Trenches Areas of OU-2 in the Preliminary Draft Phase II RFI/RI Report for OU-2.

This section will limit the discussion of fate and transport to an overview of the potential migration pathways of contaminants found at IHSS 110 (Trench T-3). The Preliminary Draft Phase II RFI/RI Report for OU-2 presents a thorough discussion of fate and transport of selected chemicals throughout OU-2. A summary of contaminants found at Trench T-3 is provided on Figure 3.0-1. Contaminant migration pathways for Trench T-3 are shown schematically on Figure 3.0-2.

The primary pathway for contamination originating in the trench occurs through vertical migration through the vadose zone beneath the trench to groundwater and then laterally within the saturated alluvium, when present, and within the No. 1 Sandstone Unit.

VOCs (CCl_4 , CHCl_3 , 1,1-DCE, PCE, and TCE) have the potential to be released to the subsurface from Trench T-3 as dissolved constituents or as NAPLs. Pooled NAPL was encountered in borehole 10191 in Trench T-3 during the OU-2 Phase II alluvial field investigation. NAPL-saturated soil was also encountered in borehole 24793 (near Trench T-3) during the ongoing SVE Pilot Test Program. Most recently, NAPL was observed during installation of subsurface pressure monitoring probes inside the trench in August of 1994. Dissolved VOCs and possibly NAPLs have the potential to migrate vertically through the vadose to contaminate groundwater. Subsequently, leaching of residual contamination (adsorbed and possibly NAPL) from the vadose zone could continue to contaminate groundwater.

High concentrations of VOCs have been detected in groundwater in well 3687, which is screened in the No. 1 Sandstone Unit, located hydraulically downgradient (north) of Trench T-4. VOCs appear to have migrated in groundwater from source areas by advection and dispersion processes to form contaminant plumes within the No. 1 Sandstone Unit, and to a lesser extent, within the alluvium. Groundwater contaminant plumes in the sandstone migrate toward the north-northeast, and appear to discharge at seeps on the hillside of the South Walnut Creek drainage. Contaminated groundwater in the alluvium flows along the medial paleoscour, northeastward toward the surface drainage gully. To date, discharge of contaminants at the surface drainage gully appears to be minimal, based on groundwater concentrations that are at or below the method detection limits.

Volatilization to form soil gas potentially occurs beneath Trench T-3, due to the presence of residual contamination in vadose zone soils. Volatilization from groundwater to form soil gas may also occur in association with groundwater contaminant plumes in the No. 1 Sandstone Unit and Rocky Flats Alluvium. The resulting soil gas may reach the atmosphere, depending on the depth of the residual contamination or water table.

Volatilization may also occur from seeps and surface water directly to the atmosphere. A portion of the contaminants not volatilized at seeps migrate downslope with water in the colluvium and potentially discharge to South Walnut Creek. Once in the creek, a portion of the VOCs are volatilized to the atmosphere or transported by streamflow advection/dispersion/sediment transport processes.

Elevated activities of radionuclides (Am-241, Pu-239/240) have been observed in source boreholes drilled in Trench T-3. Activity levels decrease rapidly below the trenches, indicating that these species are relatively immobile in the vadose zone in this area. These contaminants have not been observed at high activities in groundwater in these areas, and are not expected to be discharged with the groundwater at seeps.

4.0 SUMMARY

The thickness of the RFA in the vicinity of Trench T-3 is approximately 15 feet. The RFA consists of primarily sandy and clayey gravels with some clay layers. In general, caliche layers have been identified on the north side of Trench T-3. The caliche layers may retard infiltration of precipitation to the vadose zone around Trench T-3. Where the caliche layers have been disturbed due to excavation of Trench T-3, infiltration of precipitation may be enhanced relative to surrounding areas. The thickness of the No. 1 Sandstone Unit beneath Trench T-3 ranges from 20 to 35 feet. The No. 1 Sandstone Unit is separated from the bottom of the trench by approximately 10 feet of claystone on the western end of Trench T-3 and is in direct contact with the base of the trench on the eastern end. The approximate depth to the high groundwater was 15 feet BGS (May 1992). The primary flow direction of the groundwater in the No. 1 Sandstone Unit is to north-northeast. The majority of groundwater is believed to flow in the highly friable, coarse-grained sandstone unit of the No. 1 Sandstone Unit.

The evaluation of the geological and geophysical data indicate that Trench T-3 is approximately 5 to 10 feet in depth, ranges from 19 to 23 feet wide, and 135 to 140 feet long. Borehole 25394 which is located on the eastern end of Trench T-3 encountered a caliche layer at an approximate depth of 6 feet BGS. The caliche layer indicates that the base of the trench in the vicinity of borehole 25394 is less than 6 feet.

The Historical Release Report (DOE 1992a) indicated that sanitary sewage sludge contaminated with uranium and plutonium and flattened drums with uranium were reportedly buried in this trench. During drilling of boreholes in and around Trench T-3 void spaces, flattened drums, NAPL, and residual NAPL were encountered. Void spaces were encountered in boreholes 25194, 25294, and 25494 at depths generally above 6 feet. The void space in borehole 25194 was encountered at an approximate depth from 4 to 5.3 feet and was filled with a stratified liquid. The stratified liquid was observed to have three distinct layers (a black floating layer on top, a yellowish brown layer in the middle, and a black sinking layer

on the bottom) from a sample collected before grouting the borehole. Flattened drums were observed in boreholes 25294, 25494, 25594, and 25694 at approximate depths of 3 to 7 feet BGS. NAPL was encountered in boreholes 10191 and 25194 at approximate depth of 2 to 5 feet BGS. Residual NAPL was observed in boreholes 24793, 25594, and 25694 at approximate depths of 7 to 14 feet BGS. In general, void spaces and flattened drums are located in the western and central portions, NAPL is located in the western portion, and residual NAPL is located in the central portion of Trench T-3.

The primary contaminants groups detected in subsurface samples collected at Trench T-3 include CHCs, BTEX constituents, TPHs described as gasoline and diesel, PAHs, phenols, phthalates, and actinides (Am-241, Pu-239/240, U-233,-234, U-235, and U-238). Subsurface soil samples collected from Trench T-3 indicated the presence of CHCs (primarily CCl₄, CHCl₃, PCE, and TCE) at concentrations ranging from parts per million to parts per thousands. In general, the elevated concentrations of CHCs were observed in samples collected from the residual or NAPL saturated soils. PAHs and phthalates were detected in the subsurface soil samples collected from Trench T-3 at concentrations up to parts per million levels. Actinides (Am-241, Pu-239/240, U-233,-234, U-235, and U-238) were detected at activities at approximately a pCi/g in the subsurface soil samples. Soil gas surveys indicate that the CHCs (CCl₄, PCE, and TCE) were the most frequently detected and the total VOCs concentration ranged from 50 to 600 µg/L.

Analysis of liquid samples collected from location 25194 indicated the presence of CHCs, BTEX constituents, TPHs described as gasoline and diesel, PAHs, phthalates, phenols, and the U-isotopes. CHCs detected in the liquid sample at concentrations greater than one part per million (ppm) were 1,1-DCA (1.1 ppm), CHCl₃ (5.5 ppm), 1,1,1-TCA (18 ppm), TCE (7,100 ppm), and PCE (37,000 ppm). The four BTEX constituents detected were toluene (1.2 ppm), ethylbenzene (0.92 ppm), m,p-xylene (8.2 ppm), and o-xylene (2.2 ppm). PAHs (naphthalene, 2-methylnaphalene, phenanthrene, anthracene, pyrene, chrysene and fluorene) were detected at concentrations up to 450 ppm. Phthalates (di-n-butylphthalate and bis[2-ethylhexyl]phthalate) were detected at concentrations up to 410 ppm. Phenols (phenol, 2-

methylphenol, and 4-methylphenol) were detected at concentrations up to 26 ppm. The TPHs described as having carbons in the gasoline and diesel ranges were detected at concentrations up to 170 ppm and 480 ppm, respectively. Am-241 and Pu-239/240 were detected at activities up to a pCi/g and U-233, -234, U-235, and U-238 were detected at activities up to 398 pCi/g, 101 pCi/g, and 3240 pCi/g, respectively,

Review of the groundwater isoconcentration maps (Figures 2.6-8 through 2.6-17) indicated that Trench T-3 is a likely source of contamination to groundwater within the No. 1 Sandstone. The upgradient wells (i.e., 2587 and 01991) from Trench T-3 in the No. 1 Sandstone had total VOC concentrations of 259 µg/L and 273 µg/L, respectively, as measured in fourth quarter of 1993. While the downgradient wells in the No. 1 Sandstone (i.e., 24193, 03391, and 03691) from Trench T-3 had total VOCs concentration of 5,174 µg/L, 1,041 µg/L, and 1,021 µg/L, respectively, as measured in fourth quarter of 1993.

Potential contaminant migration pathways from Trench T-3 include the following:

- Leakage into subsoil from buried waste materials and possibly by direct discharge of waste into the trench.
- NAPL and aqueous liquids in the western portion of Trench T-3 are believed to be perched. Possible reasons for this could be the presence of an impermeable layer within the trench or directly beneath the trench. The claystone bedrock beneath the western portion and above the No. 1 Sandstone could retard vertical migration of NAPL and aqueous liquids in this area of the trench.
- Residual NAPL observed in the boreholes in the central portion of the trench and presence of void spaces combined with the subcropping No. 1 Sandstone provides a contaminant pathway to groundwater.

- Contaminants entering the groundwater in the No. 1 Sandstone are then controlled by the groundwater flow direction (north and northeast). Contaminated groundwater in the No. 1 Sandstone is believed to extend to the north facing slope of the South Walnut Creek Drainage and then seeps directly into Ponds B-1 and B-2 or into the colluvium above the ponds then downhill to the ponds.



5.0 REFERENCES

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Draft OU-2 Subsurface IM/IRA	Page:	87 of 89
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Draft OU-2 Subsurface IM/IRA	Page:	88 of 89
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**TABLE 2.2-1
TRENCH T-3 (IHSS110)
DRILLING AND SOIL SAMPLE COLLECTION AND ANALYSIS SUMMARY
November 1994**

Location Number	Location Type	Start Date	End Date	Total Depth (ft)(BGS)	Top of Bedrock	RFEDS Sample Number	Waste Sample Number	Sample Start Depth (ft)(BGS)	Sample End Depth (ft)(BGS)	Analysis Requested	Comment
25194	BH/EW	11/2/94	11/10/94	5.3	NE	BH20665WC DR00010WC DR00016WC	95N0058	3.6 0 0	5.3 4 4	VBR, BDR, WW, RH RH, V, B, M, RA, RB, RC RH, V, B, M, RA, RB, RC	Liquid Sample Drum Composite Drum Composite
25294	BH	11/2/94	11/4/94	8	NE	BH20654WC BH20655WC DR00011WC		6.75 6 0	7 8 8	RH, VBR RH, BDR RH, V, B, M, RA, RB, RC	Discrete VOA Composite Drum Composite
25394	BH	11/4/94	11/4/94	9	NE	BH20651WC BH20650WC BH20653WC DR00012WC		4 5.75 6 0	6 6 8 8	RH, WH, VBR RH, VBR RH, GQB RH, V, B, M, RA, RB, RC	Composite Discrete VOA Composite Drum Composite
25494	BH	11/7/94	11/7/94	3.5	NE	DR00013WC		0	3.5	RH, V, B, M, RA, RB, RC	Drum Composite
25594	BH	11/7/94	11/8/94	16	15.5	BH20658WC BH20659WC BH20660WC DR00014WC		15.75 9 9.8 0	16 10 10 16	RH, VBR RH, BDR, WW RH, VBR RH, V, B, M, RA, RB, RC	Discrete VOA Composite Discrete VOA Drum Composite
25694	BH	11/8/94	11/9/94	14	NE	BH20652WC BH20656WC BH20657WC DR00015WC		10 11.8 4 0	12 12 6 14	RH, GQB RH, VBR RH, GQB RH, V, B, M, RA, RB, RC	Composite Discrete VOA Composite Drum Composite

Explanations:

- BH - Borehole
- EW - Extraction well
- NE - Not encountered
- BGS - Below ground surface
- RH - Radionuclide screen
- RA - Gross alpha and beta
- RB - Plutonium-239/240, Americium-241
- RC - Uranium-233,234, Uranium-235, Uranium-238
- V - VOA-CLP
- VBR - VOA (8240)
- B - BNA-CLP
- BDR - BNA (8270)
- M - Total Metals-CLP
- GQB - Soil moisture content
- WH - Total organic carbon
- WW - Total petroleum hydrocarbons (8015 modified)

TABLE 2.2-2

SUMMARY OF REQUESTED ANALYSIS

EG&G Sample Number	Laboratory Sample Number	Date Sampled	Sample Description	VOA Method (8260)	SVOA Method (8270)	Modified Method (8015)	Select Radionuclide	Special Sample Prep
C0639	C0639-02	12-20-94	Floating Layer (1)	X				
C0639	C0639-03	12-20-94	Floating Layer (1)		X			
C0639	C0639-04	12-20-94	Floating Layer (1)			X		
C0639	C0639-05	12-20-94	Floating Layer (1)					X
C0640	C0640-04	12-20-94	Top Floating Layer (2)	X				
C0640	C0640-05	12-20-94	Top Floating Layer (2)		X			
C0640	C0640-06	12-20-94	Top Floating Layer (2)			X		
C0640	C0640-07	12-20-94	Top Floating Layer (2)					X
C0640	C0640-08	12-20-94	Top Floating Layer (2)				X	
C0640	C0670-04	12-20-94	Bottom Water	X				
C0640	C0670-05	12-20-94	Bottom Water		X			
C0640	C0670-06	12-20-94	Bottom Water			X		
C0640	C0670-07	12-20-94	Bottom Water					X
C0640	C0670-08	12-20-94	Bottom Water				X	

TABLE 2.2-3

**SUMMARY OF DISTILLATION ANALYSIS CONDUCTED ON LIQUID SAMPLE C0640
COLLECTED IN DECEMBER 1994**

Sample Fraction After Distillation	Miscible with water?	Miscible with methylene chloride?	Distillation Temperature Range (°C)	Distillate Sample Number	Volume (mL)	Density (g/mL)	Analyses Requested
A-Top	Yes	No	97-98	C0641-01	13	0.967	Volatiles Semivolatiles TPH
A-Bottom	No-heavier	Yes	97-98	C0642-01	27	1.539	Volatiles Semivolatiles TPH
B-Top	Yes	No	98-100	C0643-01	200	0.966	Volatiles Semivolatiles TPH
B-Bottom	No-heavier	Yes	98-100	C0644-01	100	1.475	Volatiles Semivolatiles TPH
C-Top	Yes	No	100-105	C0645-01	156	0.960	Volatiles Semivolatiles TPH

TABLE 2.2-3
SUMMARY OF DISTILLATION ANALYSIS
(continued)

Sample Fraction After Distillation	Miscible with water?	Miscible with methylene chloride?	Distillation Temperature Range (°C)	Distillate Sample Number	Volume (mL)	Density (g/mL)	Analyses Requested
C-Bottom	No-heavier	Yes	100-105	C0645-01	39	1.270	Volatiles Semivolatiles TPH
D-Top	No-lighter	Yes	100-106	C0647-01	48	0.835	Volatiles Semivolatiles TPH
D-Bottom	Yes	No	100-106	C0648-01	437	1.004	Volatiles Semivolatiles TPH
E-Top	No-lighter	Yes	106-109	C0704-01	4	0.888	Volatiles Semivolatiles TPH
E-Bottom	Yes	No	106-109	C0649-01	100		Volatiles Semivolatiles TPH
F-Top	No-lighter	Yes	109-120	C0705-01	2	0.865	Volatiles Semivolatiles TPH

TABLE 2.2-3
SUMMARY OF DISTILLATION ANALYSIS
(continued)

Sample Fraction After Distillation	Miscible with water?	Miscible with methylene chloride?	Distillation Temperature Range (°C)	Distillate Sample Number	Volume (mL)	Density (g/mL)	Analyses Requested
F-Bottom	Yes	No	109-120	C0698-01	50	0.965	Volatiles Semivolatiles TPH
G	Yes	No	120-140	C0699-01	9	--	Volatiles Semivolatiles TPH
H	Yes	No	140-160	C0700-01	3.5	--	Volatiles Semivolatiles TPH
I	Yes	No	160-180	C0701-01	2	--	Volatiles Semivolatiles TPH
J	No-lighter	Yes	180-205	C0702-01	0.5	1.020	Volatiles Semivolatiles TPH
K	No-lighter	Yes	N/A (Residue)	C0703-01	785	0.875	Volatiles Semivolatiles TPH

**TABLE 2.2-4
UHSU GROUNDWATER SAMPLES COLLECTED FROM SVE ARAPAHOE NO. 1 SANDSTONE WELLS PRIOR TO WARP
(September 1994)**

Well Number	Sample Number	Collection	Depth to Top of Groundwater (ft BTC)	Sample Collection Interval
24193	GW01389GA	9/6/94	26.6	Bottom of casing sample
24193	GW01431GA	9/6/94	26.6	Top of groundwater sample
24393	GW01390GA	9/6/94	26.79	Top of groundwater sample
24993	GW01391GA	9/7/94	26.79	Bottom of casing sample
24993	GW01392GA	9/6/94	26.91	Top of groundwater sample
24993	GW01393GA	9/7/94	26.91	Bottom of casing sample
25093	GW01394GA	9/6/74	26.75	Top of groundwater sample
25093	GW01395GA	9/7/94	26.75	Bottom of casing sample

Explanation:

BTC = Below top of casing

UHSU = upper hydrostratigraphic unit

SVE = soil vapor extraction

WARP = Well Abandonment and Replacement Program

TABLE 2.4-1
TRENCH T-3 (IHSS 110)
STRATIGRAPHIC AND
MONITORING WELL DATA

Location Number	Northing (ft)	Easting (ft)	Ground Surface Elevation (ft)	Location Type	Stratigraphy of Screened Interval	Borehole Total Depth (ft BGS)	Elevation of Total Depth (ft BGS)	Depth to Top of Bedrock (ft BGS)	Elevation Top of Bedrock (ft)	Depth to Top of Ka (No.1) (ft BGS)	Elevation Top of Ka (No.1) (ft)	Depth to Base of Ka (No.1) (ft BGS)	Elevation Base of Ka (No.1) (ft)	Top of Well Casing Elevation (ft)	Screen Interval		Elevation of Base of (ft)	
															Depth to Top (ft BGS)	Depth to Base (ft BGS)		
2487	749751	2086746	5958.0	MW	Qrf	18.5	5939.5	15.1	5942.9	NE	NE	NE	NE	5959.6	3.5	13.6	5954.8	5944.7
2587	749719	2086748	5960.0	MW	Ka (No.1)	47.0	5913.0	16.5	5943.5	17.5	5942.5	44.7	5915.3	5961.0	17.5	43.5	5942.0	5916.0
BH3987	749760	2086905	5957.0	BH	NA	22.0	5935.0	14.5	5942.5	NE	NE	NE	NE	NA	NA	NA	NA	NA
BH4087	749850	2087026	5954.0	BH	NA	14.5	5939.5	8.0	5946.0	NE	NE	NE	NE	NA	NA	NA	NA	NA
02891	749777	2086970	5956.0	MW	Ka (No.1)	57.9	5898.1	15.8	5940.2	15.8	5940.2	50.1	5905.9	5957.9	42.0	52.0	5914.3	5904.3
10191	749789	2086868	5958.0	BH	NA	54.0	5920.1	14.5	5943.5	24.6	5943.4	48.0	5910.0	NA	NA	NA	NA	NA
12191	749774	2086949	5957.0	MW	Ka (No.1)	36.9	5920.1	15.7	5941.3	15.7	5941.3	NE	NE	5958.2	18.0	33.0	5938.5	5923.5
21693	749826	2086867	5955.0	BH	NA	163.0	5792.0	15.6	5939.4	19.4	5935.6	48.1	5906.9	NA	NA	NA	NA	NA
22493	749825	2086857	5955.0	BH	NA	52.3	5902.7	15.6	5939.4	19.8	5935.2	44.1	5910.9	NA	NA	NA	NA	NA
23293	749823	2086846	5956.0	MW	KI (slst,cs)	89.5	5866.5	15.5	5940.5	24.0	5932.0	44.5	5911.5	5958.0	77.9	86.0	5877.8	5867.6
24093	749808	2086899	5956.0	AV1	Qrf	18.3	5937.7	13.4	5942.6	NE	NE	NE	NE	5957.9	5.4	15.4	5950.6	5940.6
24193	749808	2086905	5956.0	SV1	Ka (No.1)	75.0	5881.0	13.0	5943.0	13.0	5943.0	NA	NA	5959.0	22.0	72.0	5934.0	5884.0
24293	749786	2086903	5957.0	A11	Qrf	17.6	5939.4	15.1	5941.9	15.1	5941.9	NE	NE	5957.3	5.0	15.0	5952.0	5942.0
24393	749789	2086907	5957.0	S11	Ka (No.1)	74.5	5882.5	15.1	5941.9	15.1	5941.9	NA	NA	5959.1	22.0	72.0	5935.0	5885.0
24493	749807	2086896	5956.0	APM1	Qrf	15.2	5940.8	13.0	5943.0	NE	NE	NE	NE	5958.0	8.1	11.1	5947.9	5944.9
24593	749781	2086904	5956.0	APM2	Qrf	14.2	5941.8	13.4	5942.6	NE	NE	NE	NE	5957.7	8.3	11.3	5947.7	5944.7
24693	749787	2086918	5956.0	APM3	Qrf	16.4	5939.6	13.7	5942.3	13.7	5942.3	NE	NE	5957.0	9.0	12.0	5947.0	5944.0
24793	749803	2086910	5956.0	BH	NA	10.0	5946.0	NE	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA
24893	749784	2086908	5957.0	BH	NA	17.1	5939.9	13.5	5943.5	13.5	5943.5	NE	NE	NA	NA	NA	NA	NA
24993	749800	2086910	5956.0	SPM1	Ka (No.1)	76.0	5880.0	14.2	5941.8	16.7	5939.3	49.3	5906.7	5958.0	23.0	68.0	5933.0	5888.0
25093	749787	2086912	5957.0	SPM2	Ka (No.1)	71.0	5886.0	15.1	5941.9	NA	NA	NA	NA	5957.9	23.0	68.0	5934.0	5889.0
25194	749789	2086874	5958.1	EW	Qrf	5.3	5952.8	NE	NE	NE	NE	NE	NE	NA	2.5	4.5	5955.6	5953.6
25294	749789	2086911	5957.5	BH	NA	9.0	5946.5	NE	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA
25394	749805	2086950	5956.7	BH	NA	16.0	5940.7	15.5	5941.2	15.5	5941.2	NE	NE	NA	NA	NA	NA	NA
25494	749803	2086914	5956.9	BH	NA	8.0	5948.9	NE	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA
25594	749792	2086917	5957.2	BH	NA	14.0	5943.2	NE	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA
25694	749803	2086929	5956.7	BH	NA	4.0	5952.7	NE	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA

EXPLANATION:

- A11 Alluvial injection well
- APM1 Alluvial pressure monitor
- APM2 Alluvial pressure monitor
- APM3 Alluvial pressure monitor
- AV1 Alluvial extraction well
- BGS Depth below ground surface
- BH Borehole
- EW Extraction well
- Ka (No.1) Arapehoe Formation No.1 Sandstone
- KI (slst,cs) Laramie Formation siltstone and claystone
- MW Monitoring well
- NA Not available
- NE Not encountered
- Qrf Rocky Flats Alluvium
- S11 Sandstone injection well
- SPM1 Sandstone pressure monitor
- SPM2 Sandstone pressure monitor
- SV1 Sandstone extraction well

TABLE 2.4-2
SUMMARY OF SAMPLES COMBINED FOR LABORATORY GEOTECHNICAL ANALYSIS
RFETS, TRENCH T-3 (IHSS110)
MARCH, 1995

Sample Number	Borehole Number	Composite Sample Number	Sample Depth		USCS Code (2)	Wentworth Scale (3)	Lithology -
			From Ft. (BGS)	to Ft. (BGS)			
BH00001EG	10191	BH00014EG	17.6	18.1	N/A		Silty Claystone
BH00002EG	10191	BH00014EG	18.7	19.3	N/A		Silty Claystone
BH00003EG	12191	(1)	15.0	15.5	GW		N/A
BH00004EG	24193	BH00015EG	2.9	3.5	Caliche		N/A
BH00005EG	24193	BH00016EG	13.3	13.6	N/A		Sandstone
BH00006EG	24193	(1)	13.0	13.4	N/A		Siltstone
BH00007EG	24593	BH00015EG	1.2	1.5	Caliche		N/A
BH00008EG	24593	BH00017EG	11.6	12.4	GM		N/A
BH00009EG	24693	BH00017EG	10.5	11.6	CL/GM		N/A
BH00010EG	24893	(1)	4.0	4.5	CL		N/A
BH00011EG	24893	BH00016EG	14.7	15.2	N/A		Sandstone
BH00012EG	24993	BH00018EG	10.2	10.8	SC		N/A
BH00013EG	24993	BH00018EG	12.7	13.6	SM		N/A

Explanation:

- (1) This sample was not combined with any other samples and retained the same sample number for geotechnical analysis.
- (2) Uniform Soil Classification System
- (3) A logarithmic grade scale for size classification of sediment particles. Applies to detrital sediments.

TABLE 2.4-3
SUMMARY OF GEOTECHNICAL ANALYTICAL TESTS CONDUCTED
RFETS, TRENCH T-3 (IHSS110)
MARCH, 1995

GEOTECHNICAL TESTS PERFORMED										
Sample Number	Borehole Number	Depth BGS (Ft.)	Permeability		Permeability		Capillary Moisture Retention Tests	Mechanical Analysis - Sieve - Tests	Specific Gravity Tests	
			Back pressure, Constant Head	Back pressure, Saturated, Flow Pump Method	Back pressure	Saturated, Flow Pump Method				
BH00003EG	12191	15.0 - 15.5	X					X		X
BH00006EG	24493	13.0 - 13.4		X				X		X
BH00010EG	24893	4.0 - 4.5		X				X		X
BH00014EG	10191	Composite (2)		X			X	X		X
BH00015EG	Composite (1)	Composite (2)		X			X	X		X
BH00016EG	Composite (1)	Composite (2)		X			X	X		X
BH00017EG	Composite (1)	Composite (2)	X				X	X		X
BH00018EG	Composite (1)	Composite (2)		X			X	X		X

Explanation:

- (1) Multiple boring location samples of the same lithology combined.
- (2) Multiple depth samples of the same lithology combined.

TABLE 2.4-4

SUMMARY OF GEOTECHNICAL TESTING
RFETS, TRENCH T-3 (IHSS110)
MARCH 1995

Sample Number	Boring Number	Depth BGS (2) (Ft.)	Specific Gravity (Unitless)	Effective Porosity, n (3) (%)	Dry Density (4) (pcf)	Moisture Content (4) (%)	Initial Void Ratio, e (5) (Unitless)	Initial Saturation (%)	Coefficient of				Final Void Ratio, e (Unitless)	Final Saturation (%)	
									Permeability, k (6) (cm/sec)	Confining Pressure (psi)	Hydraulic Gradient (Unitless)	Moisture Content (%)			
BH00003EG (1)	12191	15.0 - 15.5	2.66	26.18	110.0	8.0	0.46	26.0	6.60E-04	5.000	18.510	13.9	117.6	0.43	89.7
BH00006EG (1)	24493	13.0 - 13.4	2.71	39.08	120.0	11.5	0.44	84.0	1.40E-08	3.865	21.029	22.7	107.3	0.60	106.8
BH00010EG (1)	24893	4.0 - 4.5	2.65	27.39	122.0	13.0	0.35	91.6	9.40E-08	4.795	3.805	13.6	125.4	0.34	113.0
BH00014EG	10191	Composite	2.63	32.84	118.0	13.0	0.38	84.5	2.10E-06	4.991	0.166	17.3	118.3	0.40	117.2
BH00015EG	Composite	Composite	2.53	37.55	107.0	16.0	0.48	82.3	1.70E-07	4.894	2.005	21.9	106.9	0.49	115.9
BH00016EG	Composite	Composite	2.68	29.88	121.0	15.0	0.40	93.9	4.70E-08	4.593	7.397	15.8	117.7	0.44	100.6
BH00017EG	Composite	Composite	2.67	35.65	122.0	10.0	0.31	79.8	2.30E-07	5.000	18.380	17.3	128.7	0.31	156.0
BH00018EG	Composite	Composite	2.62	34.04	118.0	13.0	0.37	84.4	9.40E-08	4.809	3.556	18.6	114.2	0.45	112.7

Explanation:

- (1) Composite samples BH00003EG, BH00006EG & BH00010EG were analyzed for soil porosity, hydraulic conductivity and sieve analysis.
- (2) Below Ground Surface
- (3) Ratio of the volume of voids to the total volume of the mass.
- (4) Target densities & moisture contents were derived from field data obtained during previous investigations.
Remolding was based on these target values.
- (5) e: Ratio of the volume of voids to the volume of solid particles.
- (6) k: Coefficient of permeability where permeability is that property of a solid allowing it to transmit water.
- (7) pcf is "Pounds per cubic feet".
- (8) Target densities and moisture contents were derived from field data obtained during previous investigations.

TABLE 2.4-5
SUMMARY OF MECHANICAL TESTING
- SIEVE TEST DATA -
RFETS, TRENCH T-3 (IHSS110)
MARCH, 1995

Sample Number	Boring Number	Depth BGS (Ft.)	Lithology	Gravel (1) (%)	Sand (2) (%)	Silt (3) (%)	Clay (4),(5) %
BH00003EG	12191	15.0 - 15.5	GW	17	46	25	13
BH00006EG	24493	13.0 - 13.4	Siltstone	0	8	45	47
BH00010EG	24893	4.0 - 4.5	CL	0	45	32	23
BH00014EG	10191	Composite	Silty Claystone	0	38	44	18
BH00015EG	Composite	Composite	Caliche	28	32	24	16
BH00016EG	Composite	Composite	Sandstone	0	40	42	18
BH00017EG	Composite	Composite	CL/GM	24	46	16	14
BH00018EG	Composite	Composite	SC/SM	27	43	13	17

Explanation:

- (1) Partical sizes of sieve number 4 and larger are identified as gravel.
- (2) Partical sizes less than sieve number 4 and larger than sieve size number 200 are identified as sand.
- (3) Partical sizes less than sieve number 200 and larger than 0.002mm are identified as silt.
- (4) Partical sizes less than 0.002mm are identified as clay.
- (5) Atterbery limits were not run.

**TABLE 2.5-1
OU2 GROUNDWATER ELEVATIONS
FOURTH QUARTER 1993**

Well Number	Lithologic Unit	Measurement Date	Depth to Water (ft)	Ground Surface Elevation	Top of Casing Elevation	Groundwater Elevation
191	Qrf	7-Oct-93	21.3	5968.9	5970.44	5949.14
291	Ka (No.1)	7-Oct-93	29.95	5966.2	5967.57	5937.62
386	Kl(ss)	5-Oct-93	16.41	5676.2	5677.86	5661.45
391	Kl(ss)	6-Oct-93	9.43	5920.8	5922.4	5912.97
491	Qc/Ka(cs)	6-Oct-93	19.38	5903.5	5904.97	5885.59
691	Qc	8-Oct-93	-1	5894.5	5896.13	dry
791	Qc	8-Oct-93	21.59	5907.1	5908.27	5886.68
891	Qc	8-Oct-93	21.77	5868.4	5869.95	5848.18
987	Ka(No.1)	5-Oct-93	20.38	5980.2	5981.7	5961.32
991	Kl(cs)	8-Oct-93	-1	5867	5868.56	dry
1087	Qrf	5-Oct-93	13	5982	5983.52	5970.52
1187	Kl(ss)	8-Oct-93	20.12	5913.6	5915.12	5895
1287	Ka(no.1)	5-Oct-93	-1	5934.8	5936.3	dry
1291	Qc	8-Oct-93	17.4	5851.2	5852.85	5835.45
1391	Qrf	5-Oct-93	13.49	5973.7	5975.3	5961.81
1487	Kl(ss,cs)	8-Oct-93	15.77	5855	5856.56	5840.79
1491	Ka (No.1)	5-Oct-93	16.24	5970.4	5972.03	5955.79
1587	Qrf	7-Oct-93	22.54	5971.3	5972.79	5950.25
1791	Ka (No.1)	1-Oct-93	14.89	5965.8	5967.41	5952.52
1891	Ka (No.1)	1-Oct-93	18.8	5971.8	5973.37	5954.57
1987	Qrf	1-Oct-93	13.75	5968.4	5969.91	5956.16
1991	Ka?(cs)	5-Oct-93	25.74	5962.2	5963.61	5937.87
2091	Qrf/Ka(No.1)	1-Oct-93	22.94	5965.2	5966.65	5943.71
2187	Qvf	4-Oct-93	8.44	5928.4	5929.69	5921.25
2191	Qrf	1-Oct-93	-1	5965.8	5967.51	dry
2291	Ka(No.1)	1-Oct-93	15.05	5936.7	5938.26	5923.21
2387	Ka(No.1)	1-Oct-93	18.76	5972.8	5974.49	5955.73
2391	Qrf	5-Oct-93	-1	5956.8	5958.43	dry
2487	Qrf	5-Oct-93	15.7	5958.3	5959.69	5943.99
2491	Ka(No.1)	1-Oct-93	17.68	5944.5	5946.21	5928.53
2587	Ka(No.1)	5-Oct-93	28.59	5959.5	5960.98	5932.39
2591	Ka (No. 1?)	5-Oct-93	40.81	5923.6	5925.34	5884.53
2687	Qrf	7-Oct-93	15.38	5954.3	5955.9	5940.52
2787	Qrf	7-Oct-93	-1	5947.8	5949.65	dry
2791	Qrf	5-Oct-93	-1	5954.3	5955.79	dry

**TABLE 2.5-1
OU2 GROUNDWATER ELEVATIONS
FOURTH QUARTER 1993**

Well Number	Lithologic Unit	Measurement Date	Depth to Water (ft)	Ground Surface Elevation	Top of Casing Elevation	Groundwater Elevation
2891	Qrf	5-Oct-93	12.84	5953.1	5954.61	5941.77
2987	Qc	8-Oct-93	17.6	5812.6	5814.29	5796.69
2991	Ka (No.1)	6-Oct-93	27.91	5956.3	5957.9	5929.99
3091	Ka (No.1)	5-Oct-93	37.15	5952.9	5954.23	5917.08
3191	Qrf	6-Oct-93	25.24	5950.4	5952.02	5926.78
3287	Qrf	7-Oct-93	47.97	5946.4	5947.97	5900
3387	Qrf	7-Oct-93	-1	5945.8	5947.22	dry
3391	Ka (No.1)	5-Oct-93	26.95	5944.5	5946.22	5919.27
3586	Qvf	1-Oct-93	9.51	5910.8	5912.76	5903.25
3587	Qrf	6-Oct-93	-1	5950	5951.39	dry
3591	Qrf	6-Oct-93	33.8	5949	5950.8	5917
3686	Qvf	5-Oct-93	-1	5883.7	5885.22	dry
3687	Ka(No.1)	6-Oct-93	37.14	5949.7	5951.11	5913.97
3691	Ka (No.1)	5-Oct-93	34.05	5932.6	5934.43	5900.38
3786	Qvf	5-Oct-93	8.27	5796.6	5798.26	5789.99
3791	Ka (No.1)	5-Oct-93	39.38	5936.8	5938.24	5898.86
3891	Qrf	5-Oct-93	-1	5940.9	5942.95	dry
3986	Qrf	5-Oct-93	28.88	5908.2	5909.41	5880.53
3991	Qrf	6-Oct-93	35.79	5935.2	5936.87	5901.08
4091	Qrf	6-Oct-93	37.44	5928.5	5930.14	5892.7
4186	Qrf	7-Oct-93	46.65	5942.6	5944.36	5897.71
4191	Qrf	7-Oct-93	20.2	5955.6	5956.99	5936.79
4286	Qrf	5-Oct-93	25.6	5956.3	5957.87	5932.27
4291	Ka?(cs)	7-Oct-93	-1	5952.5	5953.9	dry
4386	Qrf	1-Oct-93	-1	5972.9	5974.46	dry
4487	Qc	4-Oct-93	-1	5949.6	5951.1	dry
4491	Qrf	7-Oct-93	31.24	5949.5	5951.15	5919.91
4591	Qrf	7-Oct-93	45.28	5948.7	5950.25	5904.97
4691	Qrf	7-Oct-93	47.75	5944.7	5946.43	5898.68
4891	Qrf	8-Oct-93	-1	5939.2	5940.76	dry
4991	Qrf	8-Oct-93	41.82	5936.9	5938.63	5896.81
5091	Qrf	8-Oct-93	44.05	5937.6	5939.24	5895.19
5191	Qrf	8-Oct-93	44.72	5938.4	5939.85	5895.13
5291	Qrf	7-Oct-93	37.18	5941.2	5943	5905.82
5391	Qrf	6-Oct-93	36.24	5940.2	5941.67	5905.43

**TABLE 2.5-1
OU2 GROUNDWATER ELEVATIONS
FOURTH QUARTER 1993**

Well Number	Lithologic Unit	Measurement Date	Depth to Water (ft)	Ground Surface Elevation	Top of Casing Elevation	Groundwater Elevation
5691	Qrf	6-Oct-93	31.69	5947.6	5948.99	5917.3
5991	Qc	8-Oct-93	25.48	5908.3	5909.91	5884.43
6091	Qrf	6-Oct-93	37.67	5930.1	5931.6	5893.93
6191	Qrf	5-Oct-93	35.76	5919.2	5920.72	5884.96
6286	Kl(ss)	4-Oct-93	28.9	5902	5903.18	5874.28
6291	Ka?(cs)	5-Oct-93	34.05	5897.9	5899.28	5865.23
6386	Qc	4-Oct-93	16.96	5901.1	5902.01	5885.05
6391	Qrf	5-Oct-93	26.33	5903.6	5905.17	5878.84
6486	Qvf	7-Oct-93	11.36	5839.1	5841.05	5829.69
6491	Kl(ss)	5-Oct-93	17.7	5671.5	5673.25	5655.55
6586	Qvf	6-Oct-93	6.28	5786.7	5788.27	5781.99
6591	Ka (No.1)	7-Oct-93	20.61	5978.3	5979.78	5959.17
6691	Qrf	7-Oct-93	22.03	5978.3	5979.94	5957.91
6786	Qc	6-Oct-93	16.72	5802.3	5803.97	5787.25
6791	Qrf	7-Oct-93	-1	5978.9	5980.38	dry
6891	Qrf	7-Oct-93	13.1	5974.1	5975.62	5962.52
6991	Qrf	7-Oct-93	20.94	5972.9	5974.57	5953.63
7191	Qrf	7-Oct-93	22.46	5974.8	5976.34	5953.88
7291	Qrf	7-Oct-93	22.62	5977.3	5978.8	5956.18
7391	Qc	5-Oct-93	9.82	5949.1	5950.61	5940.79
7891	Qrf	6-Oct-93	29.5	5957.8	5959.45	5929.95
7991	Qrf	7-Oct-93	27.75	5954.9	5956.78	5929.03
8091	Qrf	7-Oct-93	-1	5947.9	5949.51	dry
8291	Qrf	7-Oct-93	16.46	5950.2	5951.94	5935.48
8391	Qrf	7-Oct-93	41.9	5947.2	5948.65	5906.75
8491	Qrf	7-Oct-93	18.28	5950.6	5952.16	5933.88
8591	Qrf	7-Oct-93	46.08	5948.6	5950.12	5904.04
8891	Qrf	7-Oct-93	23.73	5976.4	5978.06	5954.33
9091	Qrf	7-Oct-93	23.54	5975.2	5976.79	5953.25
9691	Ka(No.1)	5-Oct-93	13.4	5935.6	5937.05	5923.65
10991	Ka(No.1)	8-Oct-93	44.75	5940	5941.64	5896.89
11291	Qrf	6-Oct-93	-1	5930.6	5932.12	dry
11491	Qrf	6-Oct-93	-1	5948.2	5949.76	dry
11691	Ka (No.1)	5-Oct-93	34.73	5938.6	5939.91	5905.18
11791	Kl(cs)	6-Oct-93	9.13	5923.3	5925.03	5915.9

**TABLE 2.5-1
OU2 GROUNDWATER ELEVATIONS
FOURTH QUARTER 1993**

Well Number	Lithologic Unit	Measurement Date	Depth to Water (ft)	Ground Surface Elevation	Top of Casing Elevation	Groundwater Elevation
11891	Ka (No.1)	5-Oct-93	26.23	5945.5	5947.44	5921.21
12091	Ka (No.1)	1-Oct-93	19.03	5971.6	5973.27	5954.24
12191	Ka (No.1)	6-Oct-93	28.26	5956.5	5958.19	5929.93
12291	Ka (No.1)	5-Oct-93	16.27	5971	5972.73	5956.46
12391	Ka (No.1) & Kl(ss)	6-Oct-93	50.1	5940.1	5941.7	5891.6
12491	Ka (No.1)	6-Oct-93	31.54	5946.8	5948.35	5916.81
12691	Ka (No.1)	6-Oct-93	35.8	5949.7	5951.08	5915.28
12891	Qrf	7-Oct-93	38.12	5946.8	5948.35	5910.23
12991	Ka (No.1)	7-Oct-93	24.52	5965.7	5967.22	5942.7
13091	Qrf	7-Oct-93	21.47	5973.7	5975.2	5953.73
13191	Ka (No.1)	7-Oct-93	20.24	5978.3	5979.9	5959.66
13291	Qrf	8-Oct-93	-1	5978.5	5979.97	dry
13391	Qrf	5-Oct-93	38.47	5923.8	5925.35	5886.88
13491	Qrf	5-Oct-93	25.43	5961.9	5963.42	5937.99
13591	Qrf	7-Oct-93	-1	5965.9	5967.55	dry
20191	Ka (No.1)	6-Oct-93	32.52	5946.9	5948.49	5915.97
20291	Qrf	6-Oct-93	31.66	5947.2	5948.58	5916.92
20491	Qrf	6-Oct-93	31.74	5947.2	5948.71	5916.97
20591	Qrf	7-Oct-93	22.4	5968	5969.61	5947.21
20691	Ka (No.1)	7-Oct-93	22.52	5968.1	5969.63	5947.11
20791	Ka?(cs)	7-Oct-93	32.35	5967.9	5969.49	5937.14
21091	Qrf	6-Oct-93	36.18	5948.6	5950.12	5913.94
21191	Ka (No.1)	6-Oct-93	31.6	5946.9	5948.52	5916.92
23193	Kl(ss, cs)	6-Oct-93	37.69	5948.2	5950.46	5912.77
24093	Qrf	30-Sep-93	-1	5956	5957.4	dry
24193	Ka (No.1)	22-Oct-93	29.02	5956	5959	5929.98
24293	Qrf		-1	5957	5957.3	dry
24393	Ka (No.1)	26-Oct-93	29.44	5957	5959.1	5929.66
24493	Qrf	30-Sep-93	-1	5956	5957.95	dry
24593	Qrf	30-Sep-93	-1	5956	5957.7	dry
24693	Qrf	30-Sep-93	-1	5956	5957	dry
24993	Ka (No.1)	30-Sep-93	27.58	5956	5958	5930.42
25093	Ka (No.1)	30-Sep-93	27.42	5957	5957.9	5930.48
34591	Qc	5-Oct-93	-1	5952.2	5954.63	dry
34791	Qc	5-Oct-93	7.76	5951.4	5953.91	5946.15

**TABLE 2.5-1
OU2 GROUNDWATER ELEVATIONS
FOURTH QUARTER 1993**

Well Number	Lithologic Unit	Measurement Date	Depth to Water (ft)	Ground Surface Elevation	Top of Casing Elevation	Groundwater Elevation
40491	Qvf	5-Oct-93	-1	5677.3	5678.66	dry
40791	Qvf	5-Oct-93	-1	5688.5	5690.24	dry
41591	Qvf	5-Oct-93	11.91	5725.5	5727.27	5715.36
41691	Qvf	5-Oct-93	10.51	5644	5645.88	5635.37
B218789	Qrf	5-Oct-93	26.34	5962.8	5964.52	5938.18

Note: -1 indicates dry well.

**TABLE 2.5-2
ESTIMATED HYDRAULIC CONDUCTIVITY OF
ROCKY FLATS ALLUVIUM
BASED ON RESULTS OF 1986 AND 1987 AQUIFER TESTS**

Site/Well Number	Hydraulic Conductivity from 1986 Pump Tests (cm/sec)	Hydraulic Conductivity from 1987 Slug Tests (cm/sec)
3986	4E-05	
4186	9E-05	
4286		5E-02
1787		6E-05
3287		1E-03

Source: Rockwell International 1987. Draft Remedial Investigation Report for 903 Pad, Mound, and East Trenches Areas.



TABLE 2.5-3
ESTIMATED HYDRAULIC CONDUCTIVITY OF
ROCKY FLATS ALLUVIUM
BASED ON RESULTS OF 1992 AQUIFER TESTS

Site/Well Number	Hydraulic Conductivity from Pump Test (cm/sec)
<u>Site 2</u>	
11491 (Alluvial)	1.6E-3 to 1.8E-3
05691 (Alluvial)	1.8E-03
20491 (Alluvial)	3.1E-3 to 3.6E-3
20291 (Alluvial)	8.1E-4 to 8.8E-4
<u>Site 3</u>	
1787 (Alluvial)	1.6E-4 to 9.2E-4
20591 (Alluvial)	1.4E-4 to 8.6E-4
20691 (Alluvial)	1.2E-4 to 4.4E-4

Source: DOE 1992. Phase II RFI/RI Aquifer Test Report.
Volume I.

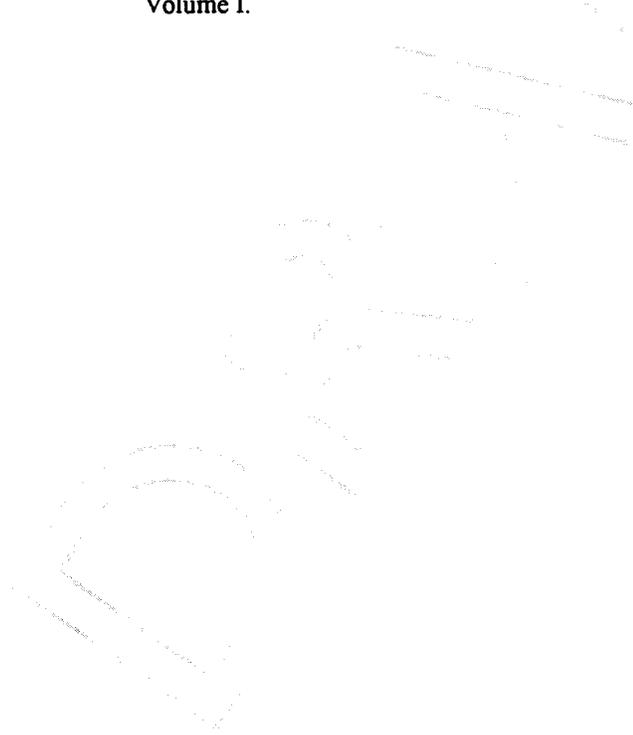


TABLE 2.5-4
ESTIMATED HYDRAULIC CONDUCTIVITY OF
ARAPAHOE NO. 1 SANDSTONE
BASED ON RESULTS OF 1987 AQUIFER TESTS

Well Number	Hydraulic Conductivity from Slug Tests (cm/s)
987	3E-03
2387	2E-04
2587	2E-03
3687	1E-03

Source: Rockwell International 1987. Draft Remedial Investigation Report for 903 Pad, Mound, and East Trenches Areas.

TABLE 2.5-5
ESTIMATED HYDRAULIC CONDUCTIVITY OF ARAPAHOE NO. 1
SANDSTONE BASED ON RESULTS OF 1992 AQUIFER TESTS

SITE/WELL NUMBER	HYDRAULIC CONDUCTIVITY FROM PUMP TEST (cm/s)
Site 1	
3687 (Bedrock)	4.2E-04 to 4.8E-04
20991 (Bedrock)	3.7E-04 to 6.2E-04
21091 (Bedrock)	4.1E-04 to 5.1E-04
20891 (Bedrock)	4.7E-04 to 6.0E-04

Source: DOE 1992. Phase II RFI/FI Aquifer Test Report.
Volume I.

**TABLE 2.5-6
PUMPING TEST RESULTS
1994**

WELL/METHOD	DISTANCE FROM PUMPING WELL (ft)	TRANSMISSIVITY (ft²/min)	SATURATED THICKNESS (ft.)	HYDRAULIC CONDUCTIVITY (ft/min) (cm/sec)	STORATIVITY (S)
24193 (Pumping Well)	0.17*	6.7 x 10 ⁻²	23	2.9 x 10 ⁻³	6.6 x 10 ⁻³
Theis (Unconfined)		7.5 x 10 ⁻²		3.3 x 10 ⁻³	1.2 x 10 ⁻³
Cooper-Jacob (Unconfined)					
24993	5.1	1.0 x 10 ⁻¹	23.9	4.2 x 10 ⁻³	2.4 x 10 ⁻³
Theis (Unconfined)		1.3 x 10 ⁻¹		5.4 x 10 ⁻³	5.2 x 10 ⁻⁴
25093	22.1	1.2 x 10 ⁻¹	28.5	4.2 x 10 ⁻³	9.1 x 10 ⁻⁴
Theis (Unconfined)		1.2 x 10 ⁻¹		4.2 x 10 ⁻³	7.6 x 10 ⁻⁴
12191	55.6	1.6 x 10 ⁻¹	23.5	6.8 x 10 ⁻³	3.1 x 10 ⁻³
Theis (Unconfined)		1.7 x 10 ⁻¹		7.2 x 10 ⁻³	2.4 x 10 ⁻³
Cooper-Jacob (Unconfined)					

TABLE 2.6-1
ANALYTES DETECTED IN SUBSURFACE SOILS AT IHSS 110 (Trench T-3)

Analyte	Background Mean plus two standard deviations	Number of Samples	Number of Detections(5)	Percent Detections	Concentration or Activity Range(1)	Mean Concentration or Activity(2)
Volatile Organic Compounds (µg/kg)						
1,1,1,-Trichloroethane	NA	57	9	15.8%	6-27,000J	8,046
1,1-Dichloroethene	NA	57	1	1.8%	9	9
1,2-Dichloroethane	NA	57	2	3.5%	6J-14J	10
1,2-Dichloroethene	NA	45	1	2.2%	1J	1
2-Butanone	NA	53	7	13.2%	40J-88	60
Acetone	NA	57	15	26.3%	36-86,000	10,233
Carbon tetrachloride	NA	57	19	33.3%	3J-700,000	62,964
Chloroform	NA	57	17	29.8%	1J-8,800	534
Ethylbenzene	NA	57	1	1.8%	2J	2
Methylene chloride	NA	57	21	36.8%	4J-55,000B-RV	5,792
Tetrachloroethene	NA	57	28	49.1%	1J-13,000,000D	543,280
Toluene	NA	57	41	71.9%	5J-7,600J	484
Trichloroethene	NA	57	7	12.3%	1J-120,000	18,302
Semivolatile Organic Compounds (µg/kg)(6)						
2-Methylnaphthalene	NA	19	1	5.3%	8,100D	8,100
2-Methylphenol	NA	19	1	5.3%	450	450
4-Methylphenol	NA	19	1	5.3%	2,900	2,900
Bis(2-ethylhexyl)phthalate	NA	18	18	100.0%	51J-5,500	523
Di-n-butyl phthalate	NA	19	1	5.3%	1,300	1,300
Hexachlorobutadiene	NA	19	1	5.3%	170J	170
Hexachloroethane	NA	19	2	10.5%	370-1,100	735
Naphthalene	NA	19	1	5.3%	2,000	2,000
Phenanthrene	NA	19	1	5.3%	2,700	2,700
Pesticides/PCBs (µg/kg)						
Aroclor-1254	NA	19	1	5.3%	6,900J	6,900

TABLE 2.6-1
ANALYTES DETECTED IN SUBSURFACE SOILS AT IHSS 110 (Trench T-3)

Analyte	Background Mean plus two standard deviations	Number of Samples	Number of Detections(5)	Percent Detections	Concentration or Activity Range(1)	Mean Concentration or Activity(2)
PCOC Metals above background (mg/kg)(3)						
Arsenic	13.2	23	4	17.4%	15-26	20.75
Barium	289	23	1	4.3%	413	413
Cadmium	1.7	23	6	26.1%	2.1-6.2	3.48
Calcium	39,393.6	23	1	4.3%	67,300	67,300
Lead	24.9	23	1	4.3%	86.4	86.4
Manganese	901.6	23	2	8.7%	1,440B-3,090	2,265
Silver	24.6	23	1	4.3%	96.5	96.5
PCOC Radionuclides above background (pCi/g)(3)(4)						
Americium-241	0.012	19	8	42.1%	0.01523J-0.5983	0.124
Gross beta	36.839	19	1	5.3%	56.74	56.74
Plutonium-239/240	0.018	19	13	68.4%	0.02-3.12	0.31
Radium-226	1.208	5	2	40.0%	1.226-1.275	1.251
Strontium-89,90	0.747	19	3	15.8%	0.8-1.1	0.97
Tritium (pCi/l)	395.211	19	1	5.3%	400	400
Uranium-233,-234	2.643	9	1	11.1%	14.35	14.35
Uranium-235	0.114	9	1	11.1%	0.7509	0.7509
Uranium-238	1.485	19	3	15.8%	1.611-26.37	9.93

Locations: 02991, 10191, 12191, 21693, 22493, 24093, 24193, 24493-24793, 24993, 25093, BH3987, BH4087

NA - Not Applicable

(1) J qualifier represents estimated result, D qualifier represents dilution result, B qualifier for organics indicates analyte was detected in blank sample, and B qualifier for metals represents estimated result.

(2) The calculation for the mean concentration includes all J, D, and B qualified data.

(3) For metals and radionuclides, only potential chemicals of concern (PCOCs) have been reviewed and are presented on this table.
(See Background discussion in Section 4.0 for list of PCOCs.)

TABLE 2.6-1
ANALYTES DETECTED IN SUBSURFACE SOILS AT IHSS 110 (Trench T-3)

Analyte	Background Mean plus two standard deviations	Number of Samples	Number of Detections(5)	Percent Detections	Concentration or Activity Range(1)	Mean Concentration or Activity(2)
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- (4) Radionuclide activities less than or equal to zero are considered to be non-detections.
- (5) Radionuclide and metal results less than the background mean plus 2 standard deviations are considered to be non-detections.
- (6) Background concentrations do not exist and are not applicable for organic compounds.

TABLE 2.6-2
ANALYTES DETECTED IN UHSU GROUNDWATER SAMPLES COLLECTED PRIOR TO ABANDONMENT
OF WELLS DURING WARP
(September 1994)

Analyte	Number of Samples	Number of Detections	Percent Detections	Concentration Range (µg/l)	Mean Concentration (µg/l)
Volatile Organic					
Top of Groundwater Sampling Interval⁽¹⁾					
1,1,1-Trichloroethane	4	4	100%	53 - 190	126
1,1-Dichloroethene	4	4	100%	35 - 76	59
Carbon tetrachloride	4	4	100%	1500 - 5200	3350
Chloroform	4	4	100%	82 - 340	216
cis-1,2-Dichloroethene	4	2	50%	9 - 11	10
Tetrachloroethene	4	4	100%	780 - 1600	1395
Trichloroethene	4	4	100%	64 - 110	94
Methylene chloride	4	2	50%	29 - 36	33
Bottom of Well Sampling Interval⁽¹⁾					
1,1,1-Trichloroethane	4	4	100%	14 - 180	76
1,1-Dichloroethene	4	4	100%	9 - 180	35
Carbon tetrachloride	4	4	100%	490 - 4500	2020
Chloroform	4	4	100%	22 - 310	131
cis-1,2-Dichloroethene	4	2	50%	8 - 9	8.5
Methylene Chloride	4	3	75%	8 - 47	22
Tetrachloroethene	4	4	100%	250 - 1500	748
Trichloroethene	4	4	100%	40 - 100	69

(1) See text for discussion on sample collection.

TABLE 2.6-3

SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (97 to 98 Degrees Celsius)

Phase	Temperature Range	Sample ID	Analyte	Less Than	Result	Detection Limit	Lab Qualifier	Units	Distilled Volume (mL)	Method Number		
Top Layer Water	97-98	C0641	Acetone		230,000	50,000		ug/L	13	8260		
		C0641	Tetrachloroethene		120,000	25,000		ug/L		8260		
		C0641	Trichloroethene		120,000	25,000		ug/L		8260		
		C0641	2,4-Dimethylphenol		4,000	2,700		ug/L		8270		
		C0641	2-Methylnaphthalene		1,400	2,700	J	ug/L		8270		
		C0641	2-Methylphenol		5,000	2,700		ug/L		8270		
		C0641	4-Methylphenol		33,000	2,700		ug/L		8270		
		C0641	D-n-butylphthalate		350	2,700	J	ug/L		8270		
		C0641	Naphthalene		1,200	2,700	J	ug/L		8270		
		C0641	Phenol		2,200	2,700	J	ug/L		8270		
		C0641	Diesel Range Organics	<	270	270		mg/Kg		8015M		
		C0641	Gasoline Range Organics		400	270		mg/Kg		8015M		
		Bottom Layer DNAPL	97-98	C0642	1,1,1-Trichloroethane		2,200,000	6,000,000	J	ug/L	27	8260
				C0642	Acetone		22,000,000	12,000,000	B	ug/L		8260
C0642	Tetrachloroethene				660,000,000	24,000,000		ug/L		8260		
C0642	Trichloroethene				120,000,000	6,000,000		ug/L		8260		
C0642	2,4-Dimethylphenol				57,000	152,400	J	ug/L		8270		
C0642	2-Methylnaphthalene				170,000	76,200		ug/L		8270		
C0642	2-Methylphenol				26,000	76,200	J	ug/L		8270		
C0642	4-Methylphenol				130,000	76,200		ug/L		8270		
C0642	Naphthalene				110,000	76,200		ug/L		8270		
C0642	Diesel Range Organics				11000	3600	Y	mg/Kg		8015M		
C0642	Gasoline Range Organics		170000	9000	X	mg/Kg		8015M				

DNAPL - dense non-aqueous phase liquid

LNAPL - light non-aqueous phase liquid

NA - not applicable

X - the data does not match the gasoline peak pattern as seen in the standard

Y - the data does not match the diesel peak pattern as seen in the standard

J - estimated value

B - associated method blank contains this compound

E - exceeds calibration range

* - same phase - not biphasic

X assigned to diesel - sample contained HC throughout the range - result may be biased high

G assigned to gasoline - the sample is not gasoline or diesel, but believed to be some other HC

**TABLE 2.6-4
SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (98 to 100 Degrees Celsius)**

Phase	Temperature Range	Sample ID	Analyte	Less Than	Result	Detection Limit	Lab Qualifier	Units	Distilled Volume (mL)	Method Number		
Top Layer Water	98-100	C0643	Acetone		9,800	10,000	J	ug/L	200	8260		
		C0643	Tetrachloroethene		130,000	5,000		ug/L		8260		
		C0643	Trichloroethene		65,000	5,000		ug/L		8260		
		C0643	2,4-Dimethylphenol		9,900	6,250		ug/L		8270		
		C0643	2-Methylphenol		10,000	6,250		ug/L		8270		
		C0643	4-Methylphenol		64,000	6,250		ug/L		8270		
		C0643	Benzyl alcohol		160	250	J	ug/L		8270		
		C0643	Phenol		4,400	6,250	J	ug/L		8270		
		C0643	Diesel Range Organics	<	26	26		mg/Kg		8015M		
		C0643	Gasoline Range Organics		470	26	X	mg/Kg		8015M		
		Bottom Layer DNAPL	98-100	C0644	Acetone		34,000,000	11,750,000	B	ug/L	100	8260
				C0644	Tetrachloroethene		640,000,000	23,500,000		ug/L		8260
				C0644	Trichloroethene		49,000,000	23,500,000		ug/L		8260
				C0644	2,4-Dimethylphenol		120,000	72,500		ug/L		8270
C0644	2-Methylnaphthalene				370,000	72,500		ug/L		8270		
C0644	2-Methylphenol				48,000	72,500	J	ug/L		8270		
C0644	4-Methylphenol				250,000	72,500		ug/L		8270		
C0644	Naphthalene				240,000	145,000		ug/L		8270		
C0644	Diesel Range Organics				29000	3600	Y	mg/Kg		8015M		
C0644	Gasoline Range Organics				250000	18000	X	mg/Kg		8015M		

DNAPL - dense non-aqueous phase liquid

LNAPL - light non-aqueous phase liquid

NA - not applicable

X - the data does not match the gasoline peak pattern as seen in the standard

Y - the data does not match the diesel peak pattern as seen in the standard

J - estimated value

B - associated method blank contains this compound

E - exceeds calibration range

* - same phase - not biphasic

X assigned to diesel - sample contained HC throughout the range - result may be biased high

G assigned to gasoline - the sample is not gasoline or diesel, but believed to be some other HC

TABLE 2.6-5

SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (100 to 105 Degrees Celsius)

Phase	Temperature Range	Sample ID	Analyte	Less Than	Result	Detection Limit	Lab Qualifier	Units	Distilled Volume (mL)	Method Number			
Top Layer Water	100-105	C0645	Acetone		6,000	10,000	J	ug/L	156	8260			
		C0645	Tetrachloroethene		150,000	5,000		ug/L		8260			
		C0645	Trichloroethene		3,600	2,500		ug/L		8260			
		C0645	2,4-Dimethylphenol		20,000	6,800		ug/L		8270			
		C0645	2-Methylnaphthalene		3,600	6,800	J	ug/L		8270			
		C0645	2-Methylphenol		13,000	6,800		ug/L		8270			
		C0645	4-Methylphenol		84,000	6,800		ug/L		8270			
		C0645	Di-n-butylphthalate		27	137	J	ug/L		8270			
		C0645	Naphthalene		2,700	6,800	J	ug/L		8270			
		C0645	Phenanthrene		30	137	J	ug/L		8270			
		C0645	Phenol		4,700	6,800	J	ug/L		8270			
		C0645	Diesel Range Organics		330	70	Y	mg/Kg		8015M			
		C0645	Gasoline Range Organics		1700	70	X	mg/Kg		8015M			
		Bottom Layer DNAPL	100-105	C0646	Tetrachloroethene		320,000,000	10,500,000			ug/L	39	8260
				C0646	Trichloroethene		3,500,000	5,250,000		J	ug/L		8260
				C0646	2,4-Dimethylphenol		410,000	320,000			ug/L		8270
C0646	2-Methylnaphthalene				1,200,000	320,000		ug/L	8270				
C0646	2-Methylphenol				100,000	64,000		ug/L	8270				
C0646	4-Methylphenol				470,000	320,000		ug/L	8270				
C0646	Naphthalene				890,000	320,000		ug/L	8270				
C0646	Phenanthrene				14,000	64,000	J	ug/L	8270				
C0646	Diesel Range Organics				150000	45000	Y	mg/Kg	8015M				
C0646	Gasoline Range Organics				600000	45000	X	mg/Kg	8015M				

DNAPL - dense non-aqueous phase liquid

LNAPL - light non-aqueous phase liquid

NA - not applicable

X - the data does not match the gasoline peak pattern as seen in the standard

Y - the data does not match the diesel peak pattern as seen in the standard

J - estimated value

B - associated method blank contains this compound

E - exceeds calibration range

* - same phase - not biphasic

X assigned to diesel - sample contained HC throughout the range - result may be biased high

G assigned to gasoline - the sample is not gasoline or diesel, but believed to be some other HC

TABLE 2.6-6

SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (100 to 106 Degrees Celsius)

Phase	Temperature Range	Sample ID	Analyte	Less Than	Result	Detection Limit	Lab Qualifier	Units	Distilled Volume (mL)	Method Number			
Top Layer LNAPL	100-106	C0647	m,p-Xylene		28,000	125,000	J	ug/L	48	8260			
		C0647	Tetrachloroethene		5,300,000	500,000	B	ug/L		8260			
		C0647	2,4-Dimethylphenol		710,000	415,000		ug/L		8270			
		C0647	2-Methylnaphthalene		3,500,000	415,000		ug/L		8270			
		C0647	2-Methylphenol		97,000	415,000	J	ug/L		8270			
		C0647	4-Methylphenol		560,000	415,000		ug/L		8270			
		C0647	Di-n-butylphthalate		20,000	41,500	J	ug/L		8270			
		C0647	Naphthalene		2,400,000	415,000		ug/L		8270			
		C0647	Phenanthrene		74,000	415,000	J	ug/L		8270			
		C0647	Diesel Range Organics		980000	90000	Y	mg/Kg		8015M			
		C0647	Gasoline Range Organics		1000000	90000	X	mg/Kg		8015M			
		Bottom Layer Water	100-106	C0648	Acetone		4,400	2,000			ug/L	437	8260
				C0648	Ethylbenzene		200	1,000		J	ug/L		8260
				C0648	m,p-Xylene		2,600	1,000			ug/L		8260
C0648	o-Xylene				1,700	1,000		ug/L	8260				
C0648	Tetrachloroethene				42,000	2,500		ug/L	8260				
C0648	Trichloroethene				220	1,000	J	ug/L	8260				
C0648	2,4-Dimethylphenol				24,000	8,700		ug/L	8270				
C0648	2-Methylnaphthalene				3,700	8,700	J	ug/L	8270				
C0648	2-Methylphenol				10,000	8,700		ug/L	8270				
C0648	4-Methylphenol				81,000	8,700		ug/L	8270				
		C0648	Di-n-butylphthalate		270	43		ug/L	8270				
		C0648	Naphthalene		2,400	8,700	J	ug/L	8270				
		C0648	Phenanthrene		610	43		ug/L	8270				
		C0648	Phenol		3,600	8,700	J	ug/L	8270				
		C0648	Diesel Range Organics		8800	860	Y	mg/Kg	8015M				
		C0648	Gasoline Range Organics		100000	860	X	mg/Kg	8015M				

DNAPL - dense non-aqueous phase liquid

LNAPL - light non-aqueous phase liquid

N/A - not applicable

X - the data does not match the gasoline peak pattern as seen in the standard

Y - the data does not match the diesel peak pattern as seen in the standard

J - estimated value

B - associated method blank contains this compound

E - exceeds calibration range

* - same phase - not biphasic

X assigned to diesel - sample contained HC throughout the range - result may be biased high

G assigned to gasoline - the sample is not gasoline or diesel, but believed to be some other HC

TABLE 2.6-7
SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (106 to 109 Degrees Celsius)

Phase	Temperature Range	Sample ID	Analyte	Less Than	Result	Detection Limit	Lab Qualifier	Units	Distilled Volume (mL)	Method Number
Top Layer LNAPL	106-109	C0704	Acetone		140,000	100,000		ug/L	4	8260
		C0704	Methylene Chloride		1,200,000	50,000		ug/L		8260
		C0704	Tetrachloroethene		490,000	50,000	B	ug/L		8260
		C0704	2-Methylnaphthalene		3,300,000	500,000	J	ug/L		8270
		C0704	4-Methylphenol		320,000	500,000		ug/L		8270
		C0704	bis(2-Ethylhexyl)phthalate		59,000	50,000		ug/L		8270
		C0704	Di-n-butylphthalate		40,000	50,000	J	ug/L		8270
		C0704	Naphthalene		2,100,000	500,000		ug/L		8270
		C0704	Phenanthrene		100,000	500,000	J	ug/L		8270
		C0704	Diesel Range Organics		1000000	108000	Y	mg/Kg		8015M
		C0704	Gasoline Range Organics		650000	108000	X	mg/Kg		8015M
		Bottom Layer Water	106-109	C0649	Naphthalene		2,000	2,440		J
C0649	Phenanthrene				69	244	J	ug/L	8270	
C0649	Phenol				860	2,440	J	ug/L	8270	
C0649	Diesel Range Organics				1800	96	Y	mg/Kg	8015M	
C0649	Gasoline Range Organics				1500	96	X	mg/Kg	8015M	

DNAPL - dense non-aqueous phase liquid

LNAPL - light non-aqueous phase liquid

NA - not applicable

X - the data does not match the gasoline peak pattern as seen in the standard

Y - the data does not match the diesel peak pattern as seen in the standard

J - estimated value

B - associated method blank contains this compound

E - exceeds calibration range

* - same phase - not biphasic

X assigned to diesel - sample contained HC throughout the range - result may be biased high

G assigned to gasoline - the sample is not gasoline or diesel, but believed to be some other HC

TABLE 2.6-8

SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (109 to 120 Degrees Celsius)

Phase	Temperature Range	Sample ID	Analyte	Less Than	Result	Detection Limit	Lab Qualifier	Units	Distilled Volume (mL)	Method Number	
Top Layer LNAPL	109-120	C0705	Methylene Chloride		430,000	25,000		ug/L	50	8260	
		C0705	Tetrachloroethene		97,000	25,000	B	ug/L		8260	
		C0705	2-Methylnaphthalene		3,600,000	500,000		ug/L		8270	
		C0705	4-Methylphenol		380,000	500,000	J	ug/L		8270	
		C0705	bis(2-Ethylhexyl)phthalate		49,000	50,000	J	ug/L		8270	
		C0705	Di-n-butylphthalate		38,000	50,000	J	ug/L		8270	
		C0705	Naphthalene		2,200,000	500,000		ug/L		8270	
		C0705	Phenanthrene		110,000	500,000	J	ug/L		8270	
		C0705	Diesel Range Organics		1100000	108000	Y	mg/Kg			8015M
		C0705	Gasoline Range Organics		700000	108000	X	mg/Kg			8015M
Bottom Layer Water	109-120	C0698	2-Butanone		290	200		ug/L	50	8260	
		C0698	Acetone		2,800	200		ug/L		8260	
		C0698	Tetrachloroethene		63	100		ug/L		8260	
		C0698	2,4-Dimethylphenol		18,000	4,500		ug/L		8270	
		C0698	2-Methylnaphthalene		7,900	4,500		ug/L		8270	
		C0698	2-Methylphenol		4,400	4,500	J	ug/L		8270	
		C0698	4-Methylphenol		52,000	4,500		ug/L		8270	
		C0698	bis(2-Ethylhexyl)phthalate		96	454	J	ug/L		8270	
		C0698	Di-n-butylphthalate		100	454	J	ug/L		8270	
		C0698	Naphthalene		4400	4,500	J	ug/L		8270	
C0698	Phenanthrene		170	454	J	ug/L		8270			
C0698	Phenol		1,800	4,500	J	ug/L		8270			
C0698	Diesel Range Organics		1700	180	Y	mg/Kg			8015M		
C0698	Gasoline Range Organics		2200	180	X	mg/Kg			8015M		

DNAPL - dense non-aqueous phase liquid

LNAPL - light non-aqueous phase liquid

NA - not applicable

X - the data does not match the gasoline peak pattern as seen in the standard

Y - the data does not match the diesel peak pattern as seen in the standard

J - estimated value

B - associated method blank contains this compound

E - exceeds calibration range

* - same phase - not biphasic

X assigned to diesel - sample contained HC throughout the range - result may be biased high

G assigned to gasoline - the sample is not gasoline or diesel, but believed to be some other HC

**TABLE 2.6-9
SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE (180 to 205 Degrees Celsius)**

Phase	Temperature Range	Sample ID	Analyte	Less Than	Result	Detection Limit	Lab Qualifier	Units	Distilled Volume (mL)	Method Number
NA	180-205	C0702	2,4-Dimethylphenol		66,000	50,000		ug/L	0.5	8270
		C0702	2-Methylnaphthalene		160,000	100,000		ug/L		8270
		C0702	2-Methylphenol		16,000	50,000	J	ug/L		8270
		C0702	4-Methylphenol		210,000	100,000		ug/L		8270
		C0702	Naphthalene		94,000	100,000	J	ug/L		8270
		C0702	Phenol		56,000	100,000	J	ug/L		8270

DNAPL - dense non-aqueous phase liquid
LNAPL - light non-aqueous phase liquid

NA - not applicable

X - the data does not match the gasoline peak pattern as seen in the standard

Y - the data does not match the diesel peak pattern as seen in the standard

J - estimated value

B - associated method blank contains this compound

E - exceeds calibration range

* - same phase - not biphasic

X assigned to diesel - sample contained HC throughout the range - result may be biased high

G assigned to gasoline - the sample is not gasoline or diesel, but believed to be some other HC

**TABLE 2.6-10
SUMMARY OF ANALYTICAL RESULTS FOR DISTILLATION SAMPLE RESIDUE**

Phase	Temperature Range	Sample ID	Analyte	Less Than	Result	Detection Limit	Lab Qualifier	Units	Distilled Volume (mL)	Method Number
NA	RESIDUE	C0703	2-Butanone		1,700	1,240		ug/L	785	8260
		C0703	Acetone		9,600	1,240		ug/L		8260
		C0703	Benzene		830	620		ug/L		8260
		C0703	Carbon Disulfide		9,400	620		ug/L		8260
		C0703	Ethylbenzene		1,300	620		ug/L		8260
		C0703	m,p-Xylenes		230	620	J	ug/L		8260
		C0703	Tetrachloroethene		1,700	620	B	ug/L		8260
		C0703	Toluene		4,100	620	J	ug/L		8260
		C0703	Trichloroethene		470	620	J	ug/L		8260
		C0703	2,4-Dimethylphenol		23,000	85,600	J	ug/L		8270
		C0703	2-Methylnaphthalene		380,000	85,600		ug/L		8270
		C0703	4-Methylphenol		28,000	85,600	J	ug/L		8270
		C0703	bis(2-Ethylhexyl)phthalate		350,000	85,600		ug/L		8270
		C0703	Di-n-butylphthalate		100,000	85,600		ug/L		8270
		C0703	Naphthalene		97,000	428,000	J	ug/L		8270
		C0703	Phenanthrene		180,000	428,000	J	ug/L		8270
		C0703	Diesel Range Organics		660000	180000	Y	mg/Kg		8015M
C0703	Gasoline Range Organics		180000	180000	X	mg/Kg	8015M			

DNAPL - dense non-aqueous phase liquid

LNAPL - light non-aqueous phase liquid

NA - not applicable

X - the data does not match the gasoline peak pattern as seen in the standard

Y - the data does not match the diesel peak pattern as seen in the standard

J - estimated value

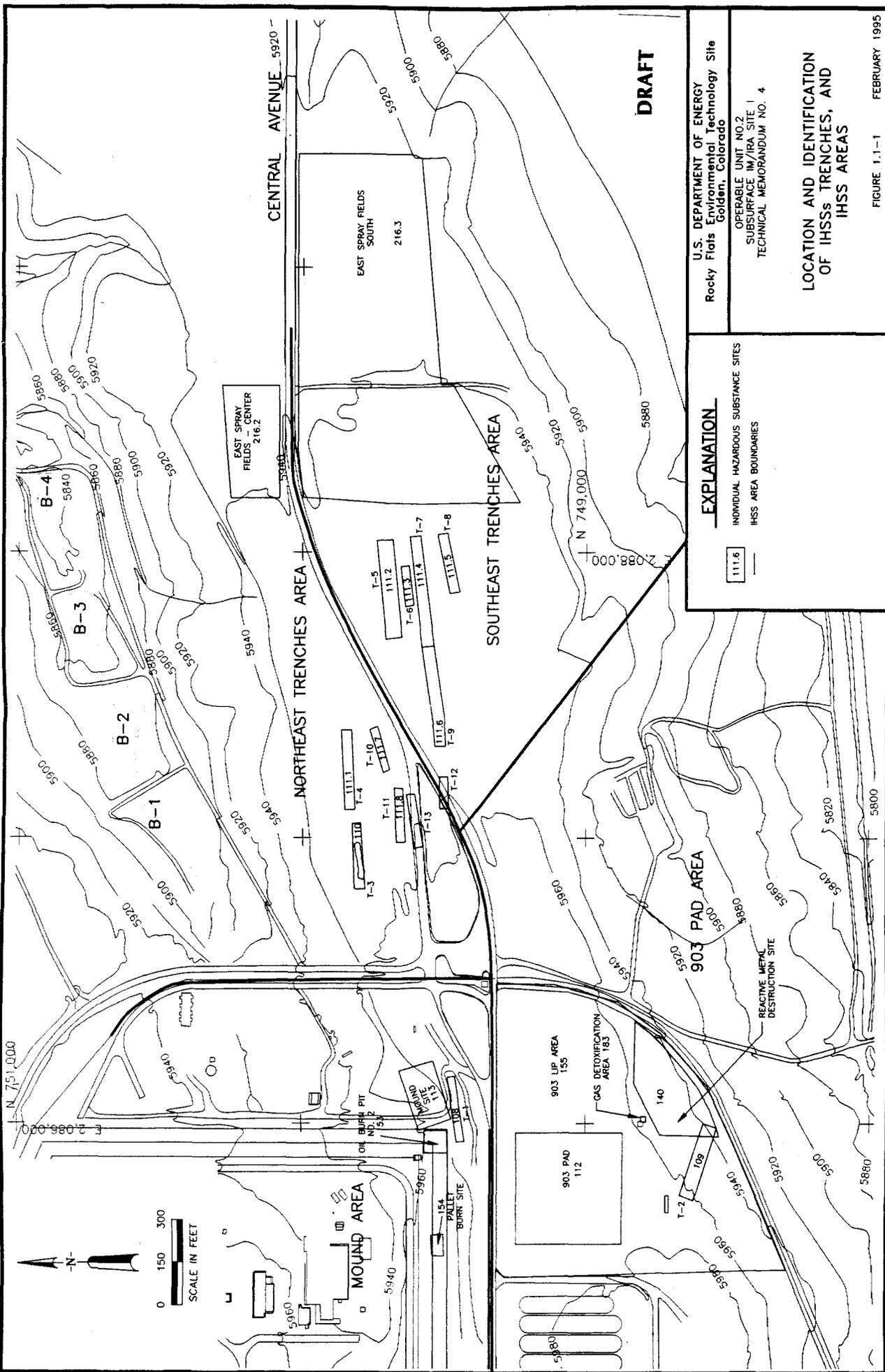
B - associated method blank contains this compound

E - exceeds calibration range

* - same phase - not biphasic

X assigned to diesel - sample contained HC throughout the range - result may be biased high

G assigned to gasoline - the sample is not gasoline or diesel, but believed to be some other HC



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 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

EXPLANATION

[Symbol]	INDIVIDUAL HAZARDOUS SUBSTANCE SITES
[Symbol]	IHSS AREA BOUNDARIES

**LOCATION AND IDENTIFICATION
 OF IHSS TRENCHES, AND
 IHSS AREAS**

FIGURE 1.1-1 FEBRUARY 1995
 SVE1M071 1-300



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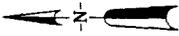
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TECHNICAL MEMORANDUM NO. 4

LIQUID COLLECTED FROM
BOREHOLE 25194

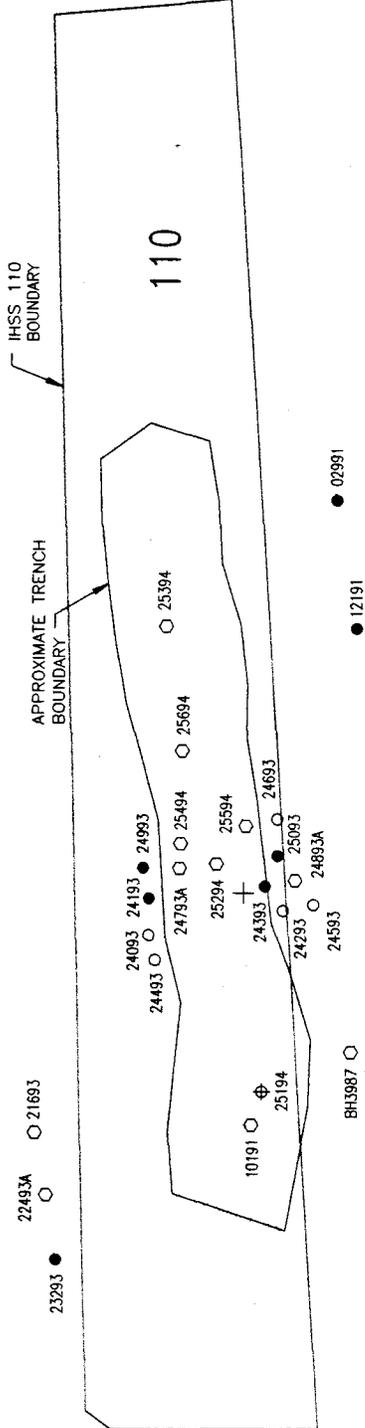
FIGURE 2.2-1 FEBRUARY 1995

SVETM070 1-1



BH4087 ϕ

02791 \circ



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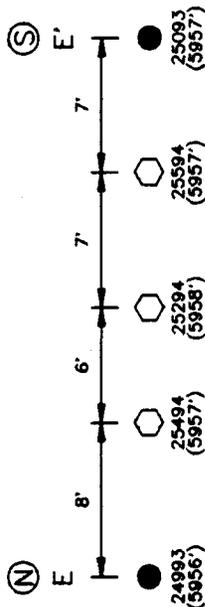
BOREHOLE AND MONITORING WELL
 LOCATIONS IN THE VICINITY OF TRENCH T-3

FIGURE 2.4-1 FEBRUARY 1995

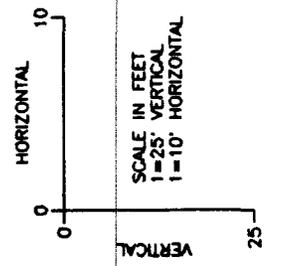
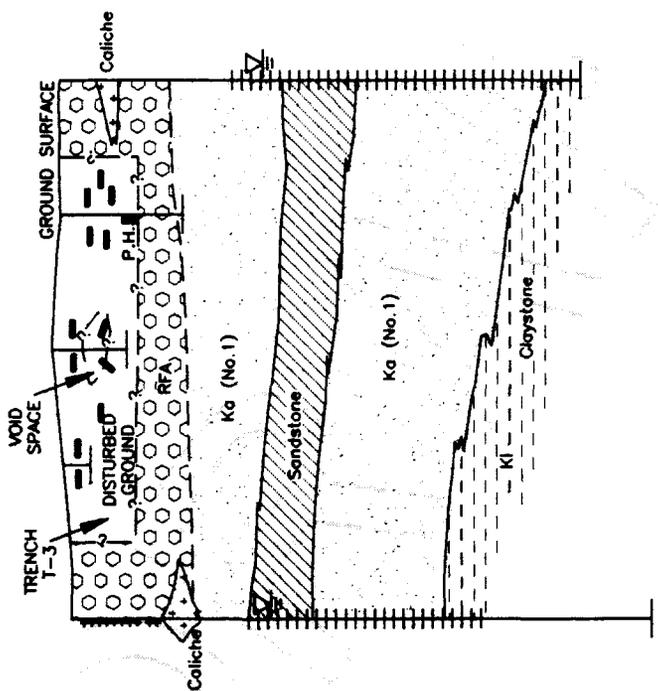
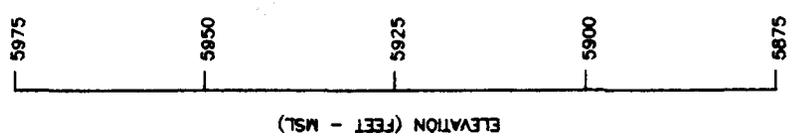
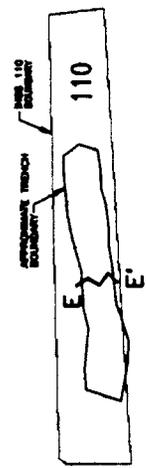
SVEIND14 1=20

EXPLANATION

- 10191 \circ SOURCE BOREHOLE LOCATION
- 2487 \circ ALLUVIAL MONITORING WELL LOCATION
- 12191 \bullet BEDROCK MONITORING WELL LOCATION
- 22493A \circ ABANDONED MONITORING WELL LOCATION
- 25194 ϕ EXTRACTION WELL LOCATION
- 110 INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION



CROSS-SECTION LOCATION MAP



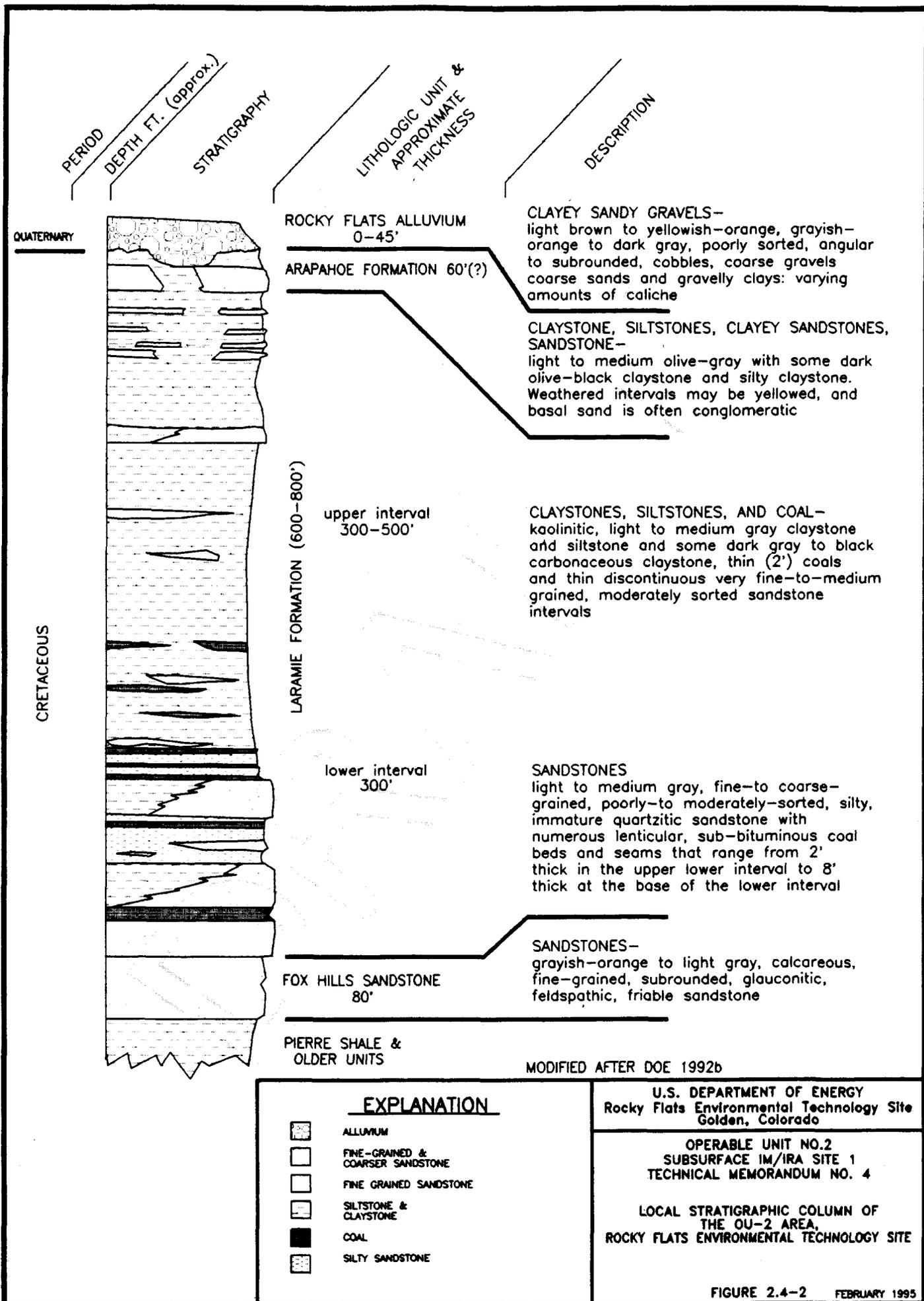
EXPLANATION

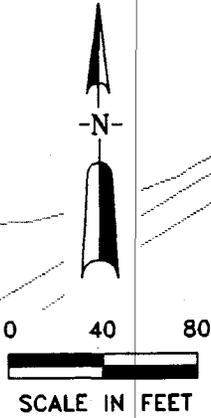
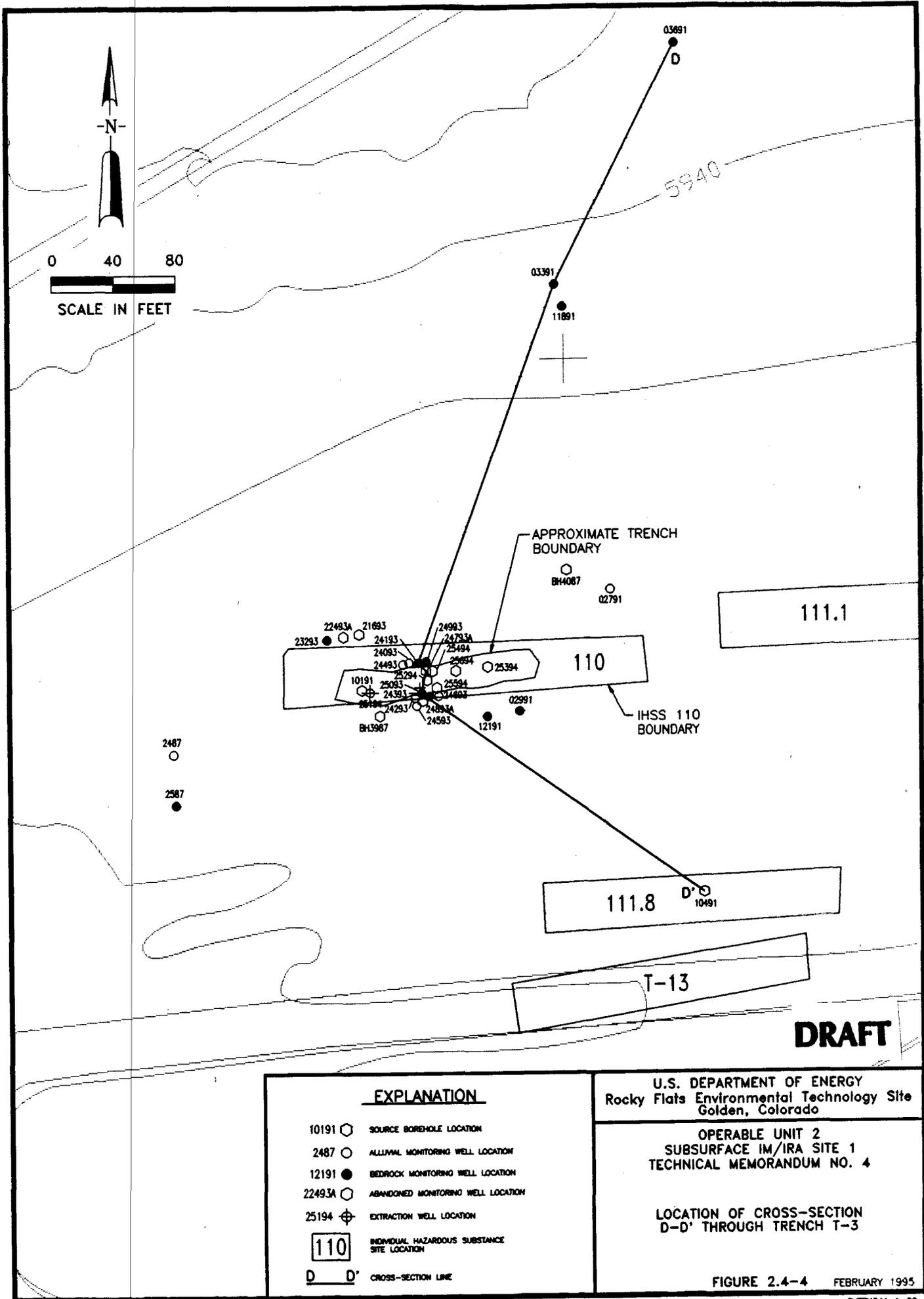
	MONITORING WELL		P.H.		ROCKY FLATS ALLUVIUM
	SCREEN INTERVAL		FLATTENED DRUM		CLAYSTONE
	TOTAL DEPTH OF BOREHOLE		LOCATION SYMBOL		KA (No.1)
	INITIAL WATER LEVEL IN BOREHOLE DURING DRILLING		LOCATION NUMBER		HIGH POROSITY, HIGHLY FRAGILE SANDSTONE LAYER OF THE ARAPAHOE
	HIGH WATER LEVEL (SECOND QUARTER 1992)		BOREHOLE LOCATION		NO. 1 SANDSTONE
	LOW WATER LEVEL (FOURTH QUARTER 1993)		ALLUVIAL MONITORING WELL LOCATION		BEDROCK MONITORING WELL LOCATION
	TRACE TO SOME CALICHE IN MATRIX				

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E-E' CROSS-SECTION
BENEATH TRENCH T-3
(IHSS 110)





EXPLANATION	
10191 ○	SOURCE BOREHOLE LOCATION
2487 ○	ALLUVIAL MONITORING WELL LOCATION
12191 ●	BEDROCK MONITORING WELL LOCATION
22493A ○	ABANDONED MONITORING WELL LOCATION
25194 ⊕	EXTRACTION WELL LOCATION
110	INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
D—D'	CROSS-SECTION LINE

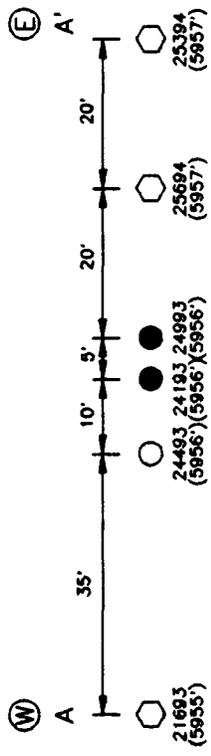
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 TECHNICAL MEMORANDUM NO. 4

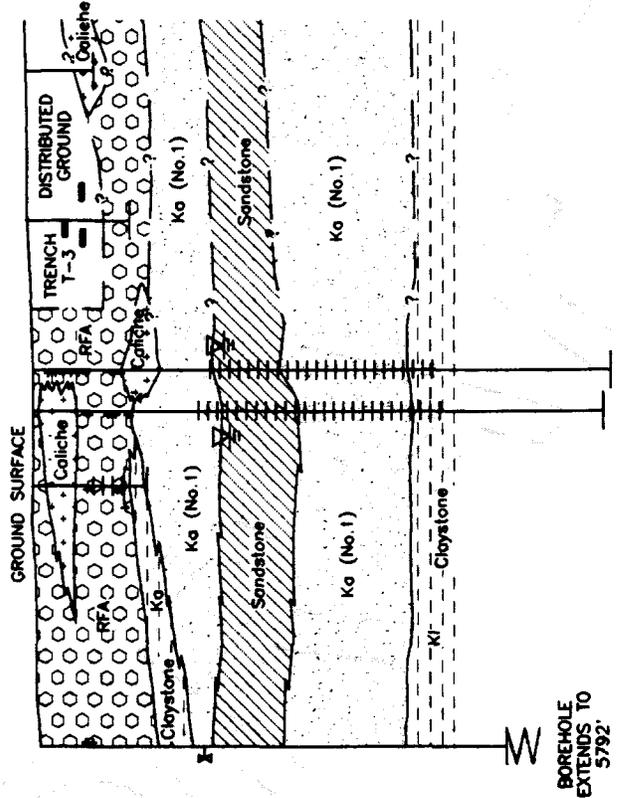
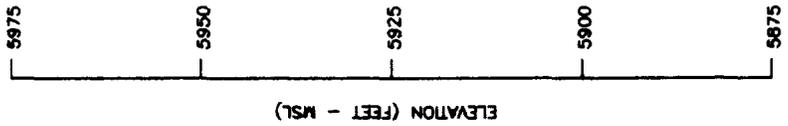
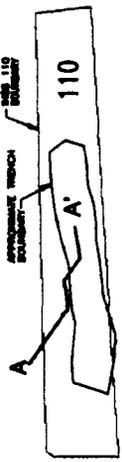
LOCATION OF CROSS-SECTION
 D-D' THROUGH TRENCH T-3

FIGURE 2.4-4 FEBRUARY 1995

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CROSS-SECTION LOCATION MAP

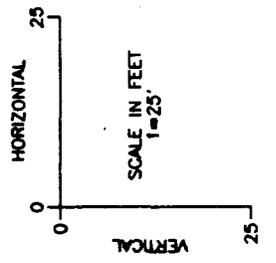


NOTES:

1. ONLY INITIAL WATER LEVEL ENCOUNTERED WAS RECORDED ON BOREHOLE LOG FOR 1993 WELLS.
2. HIGH WATER LEVELS COULD NOT BE DETERMINED BECAUSE INSTALLED AS WELLS.

EXPLANATION

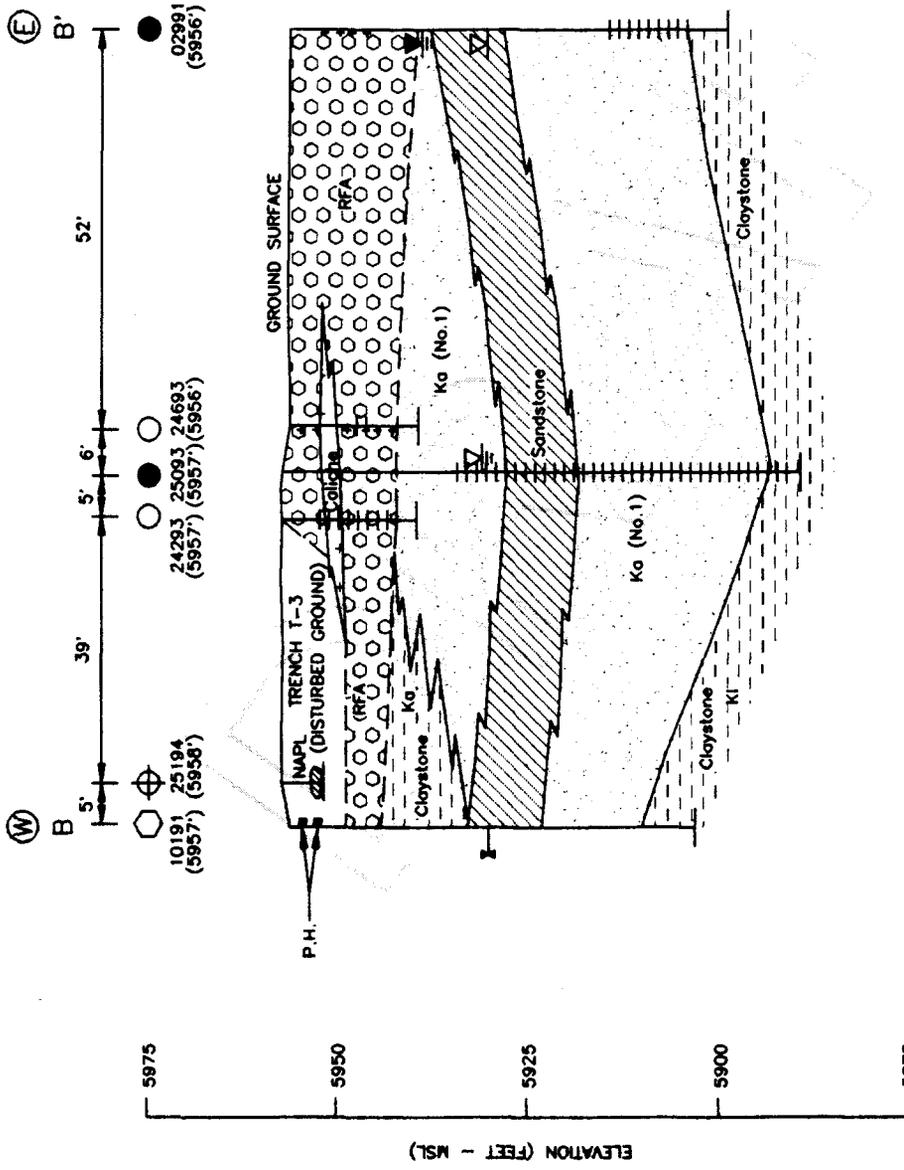
	FLATTENED DRUM		ROCKY FLATS ALLUVIUM
	LOCATION SYMBOL		CALICHE
	LOCATION NUMBER		CLAYSTONE
	LOCATION ELEVATION (ft)		Ka - ARAPAHOE FORMATION
	BOREHOLE LOCATION		Ki - LARAME FORMATION
	ALLUVIAL MONITORING WELL LOCATION		ARAPAHOE FORMATION NO. 1 SANDSTONE
	BEDROCK MONITORING WELL LOCATION		HIGH POROSITY, HIGHLY FRIABLE SANDSTONE WITH WATER APPEARANCE NO. 1 SANDSTONE
	MONITORING WELL SCREEN INTERVAL		
	TOTAL DEPTH OF BOREHOLE		
	INITIAL WATER LEVEL IN BOREHOLE DURING DRILLING (SECOND QUARTER 1992)		
	HIGH WATER LEVEL (FOURTH QUARTER 1993)		
	LOW WATER LEVEL (FOURTH QUARTER 1993)		
	TRACE TO SOME CALICHE IN MATRIX		



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OPERABLE UNIT 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

A-A' CROSS-SECTION
 (IHSS 110)



NOTES:

1. ONLY INITIAL WATER LEVEL ENCOUNTERED WAS RECORDED ON BOREHOLE LOG FOR 1993 WELLS.
2. HIGH WATER LEVELS COULD NOT BE DETERMINED BECAUSE INSTALLED AS WELLS.

EXPLANATION

EXTRACTION OR MONITORING WELL	P.H.	NAPL	EXTRACTION WELL LOCATION
TOTAL DEPTH OF BOREHOLE	10191 (5958)	10191 (5958)	ROCKY FLATS ALLUVIUM
INITIAL WATER LEVEL IN BOREHOLE DURING DRILLING	10191 (5958)	10191 (5958)	CAULICHE
HIGH WATER LEVEL (SECOND QUARTER 1992)	10191 (5958)	10191 (5958)	CLAYSTONE K _g - ARAPAHOE FORMATION K _i - LARAMIE FORMATION
LOW WATER LEVEL (FOURTH QUARTER 1993)	10191 (5958)	10191 (5958)	ARAPAHOE FORMATION NO. 1 SANDSTONE
TRACE TO SOME CAULICHE IN MATRIX	10191 (5958)	10191 (5958)	HIGH POROSITY, HIGHLY FRAGILE SANDSTONE LAYER OF THE ARAPAHOE NO. 1 SANDSTONE

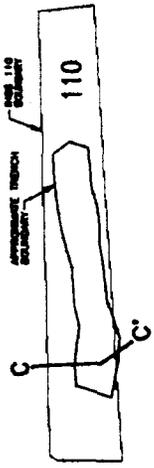
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TECHNICAL MEMORANDUM NO. 4

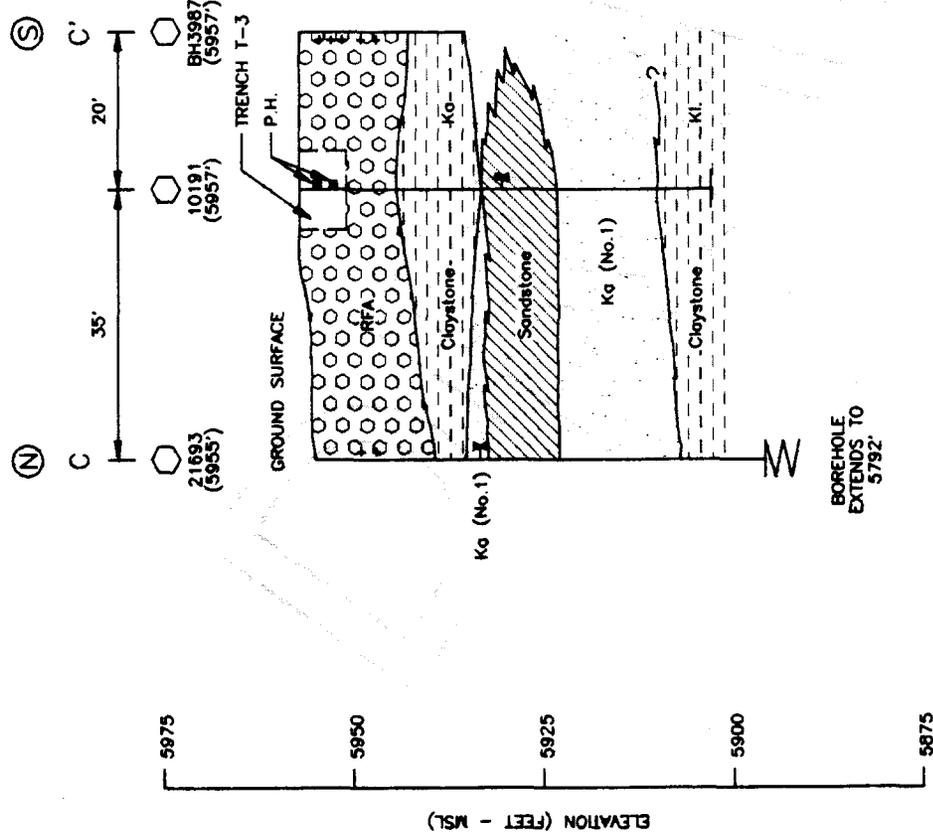
B-B' CROSS-SECTION
BENEATH TRENCH T-3
(IHSS 110)

FIGURE 2.4-6 FEBRUARY 1995
SHEET 030 1-1

111.1



CROSS-SECTION LOCATION MAP



NOTES:

1. ONLY INITIAL WATER LEVEL ENCOUNTERED WAS RECORDED ON BOREHOLE LOG FOR 1993 WELLS.
2. HIGH WATER LEVELS COULD NOT BE DETERMINED BECAUSE INSTALLED AS WELLS.

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 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

C-C' CROSS-SECTION
 BENEATH TRENCH T-3
 (IHSS 110)

FIGURE 2.4-7 FEBRUARY 1995
 SNETM036 1-1

EXPLANATION	
MONITORING WELL SCREEN INTERVAL	P.H. ■
TOTAL DEPTH OF BOREHOLE	○
INITIAL WATER LEVEL IN BOREHOLE DURING DRILLING	10191 (5958)
HIGH WATER LEVEL (SECOND QUARTER 1992)	○
LOW WATER LEVEL (FOURTH QUARTER 1993)	○
TRACE TO SOME CALICHE IN MATRIX	+
P.H. PETROLEUM HYDROCARBONS IN SAMPLE MATRIX	○
LOCATION SYMBOL	○
LOCATION NUMBER	10191 (5958)
LOCATION ELEVATION (ft)	○
BOREHOLE LOCATION	○
ALLUMINUM MONITORING WELL LOCATION	○
BEDROCK MONITORING WELL LOCATION	●
RFA	○
CALICHE	○
CLAYSTONE	○
Kg - ARAPAHO FORMATION	○
Kl - LARAMIE FORMATION	○
ARAPAHO FORMATION NO.1 SANDSTONE	○
HIGH POROSITY, HIGHLY FRAGILE SANDSTONE LAYER OF THE ARAPAHO	○
NO. 1 SANDSTONE	○

⑤ D' 200'

5' 15"

240'

180'

④ D 240'

● 03681 (5833)

● 03391 (5845)

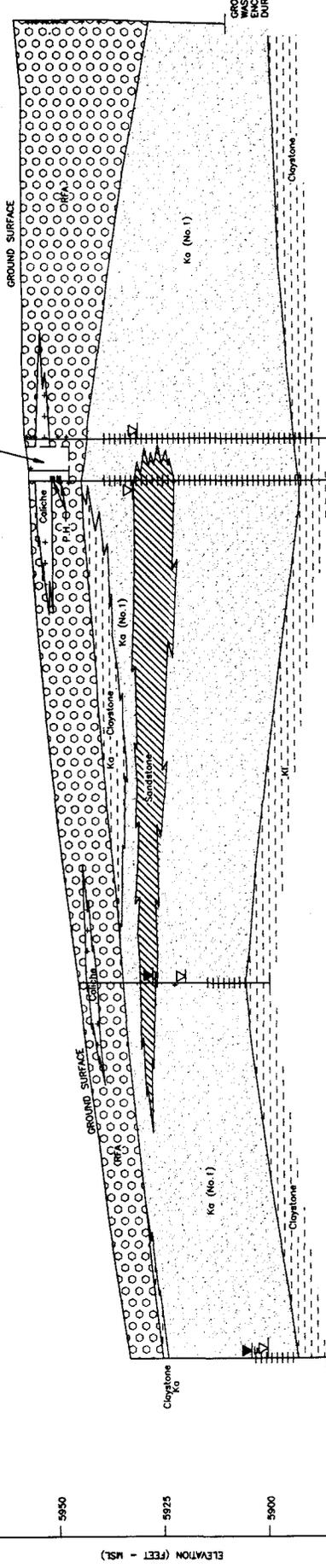
● 24183 (5853)

● 24793 (5857)

● 24961 (5861)

○ 10481 (5835)

TRENCH T-3



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- NOTES:**
1. ONLY INITIAL WATER LEVEL ENCOUNTERED WAS RECORDED ON BOROHOLE LOG FOR 1983 WELLS. OTHER WATER LEVELS COULD NOT BE DETERMINED BECAUSE INSTALLED AS WELLS.

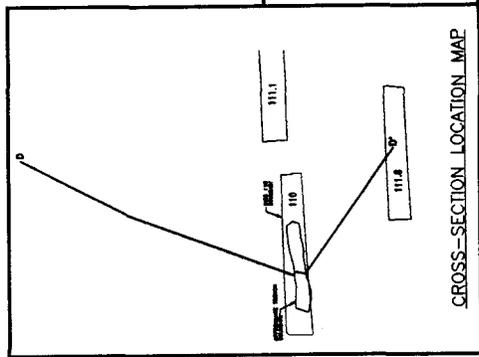
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OPERABLE UNIT 2
SURFACE AREA IN/RA SITE 1
TECHNICAL MEMORANDUM NO. 4

D-D' CROSS-SECTION
BENEATH TRENCH T-3
(HSS 110)

FIGURE 2.4-8 FEBRUARY 1985
SHEET 9 OF 11

EXPLANATION	
Monitoring Well Screen Interval	Rocky Flats Allium
Total Depth of Borohole	Caliche
Initial Water Level in Borohole during Drilling	Claystone
High Water Level (Second Quarter 1982)	Ke - Laramie Formation
Low Water Level (Fourth Quarter 1983)	Ke (No. 1)
Trace to Same Caliche in Matrix	High Porosity, Heavy No. 1 Sandstone
P.H. #	Location Symbol
10181	Location Elevation (ft)
5958	Borohole Location
Location	Caliche Monitoring Well
Location	Ke (No. 1) Monitoring Well
Location	Screen Monitoring Well
Location	Location



CROSS-SECTION LOCATION MAP

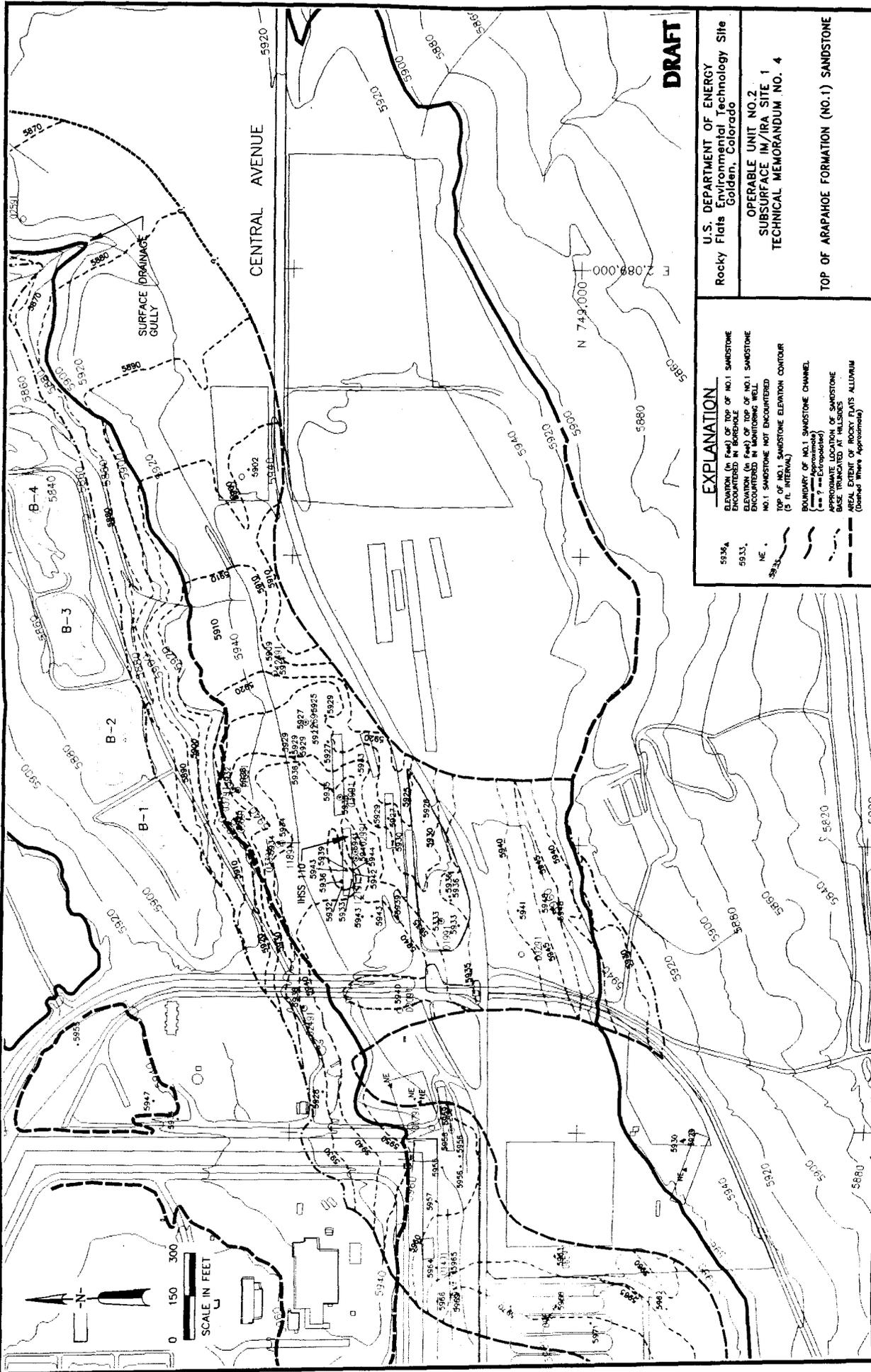
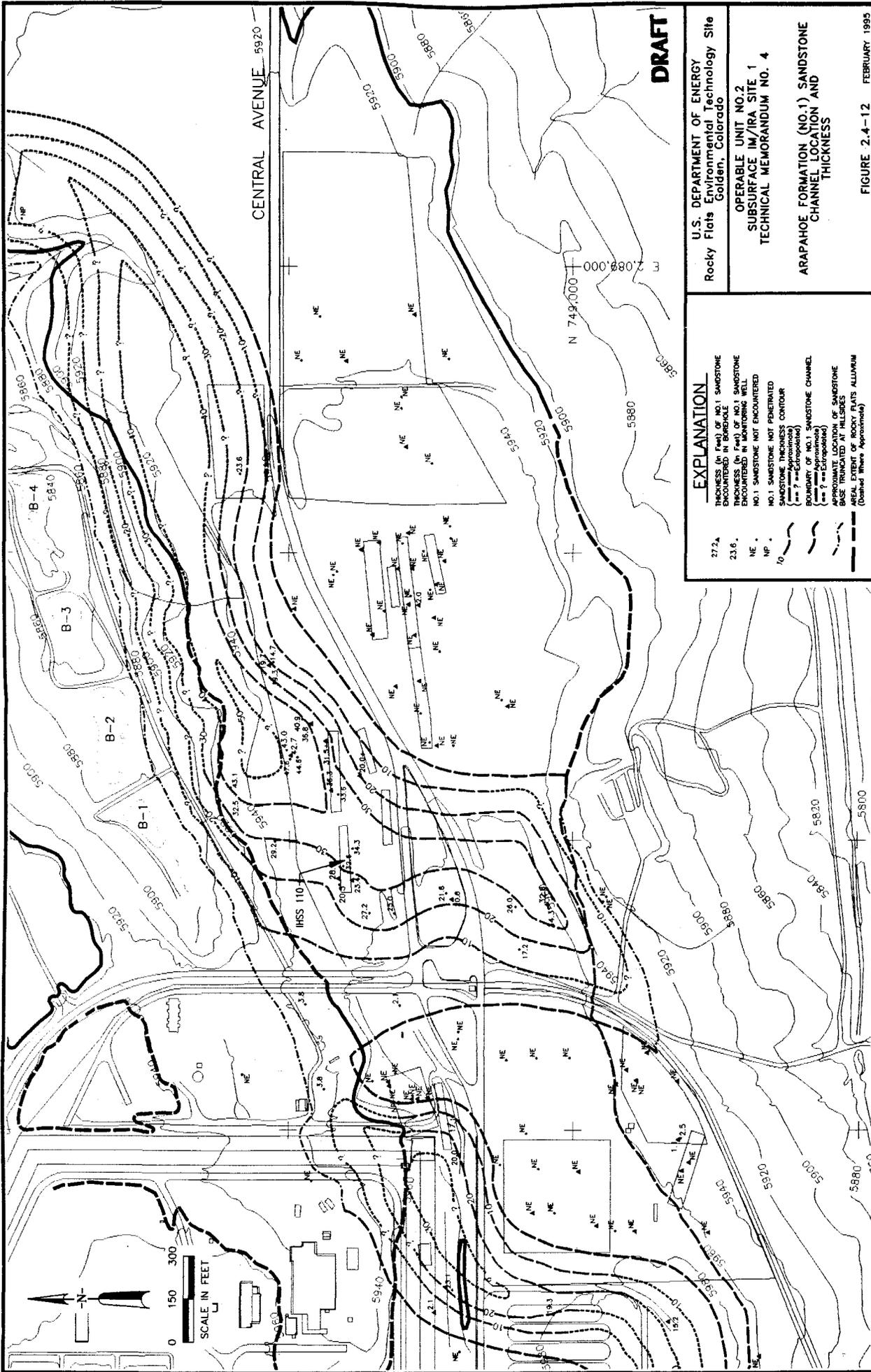


FIGURE 2.4-11 FEBRUARY 1995
SICM019 1-300



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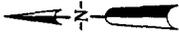
OPERABLE UNIT NO. 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

ARAPAHOE FORMATION (NO. 1) SANDSTONE
 CHANNEL LOCATION AND
 THICKNESS

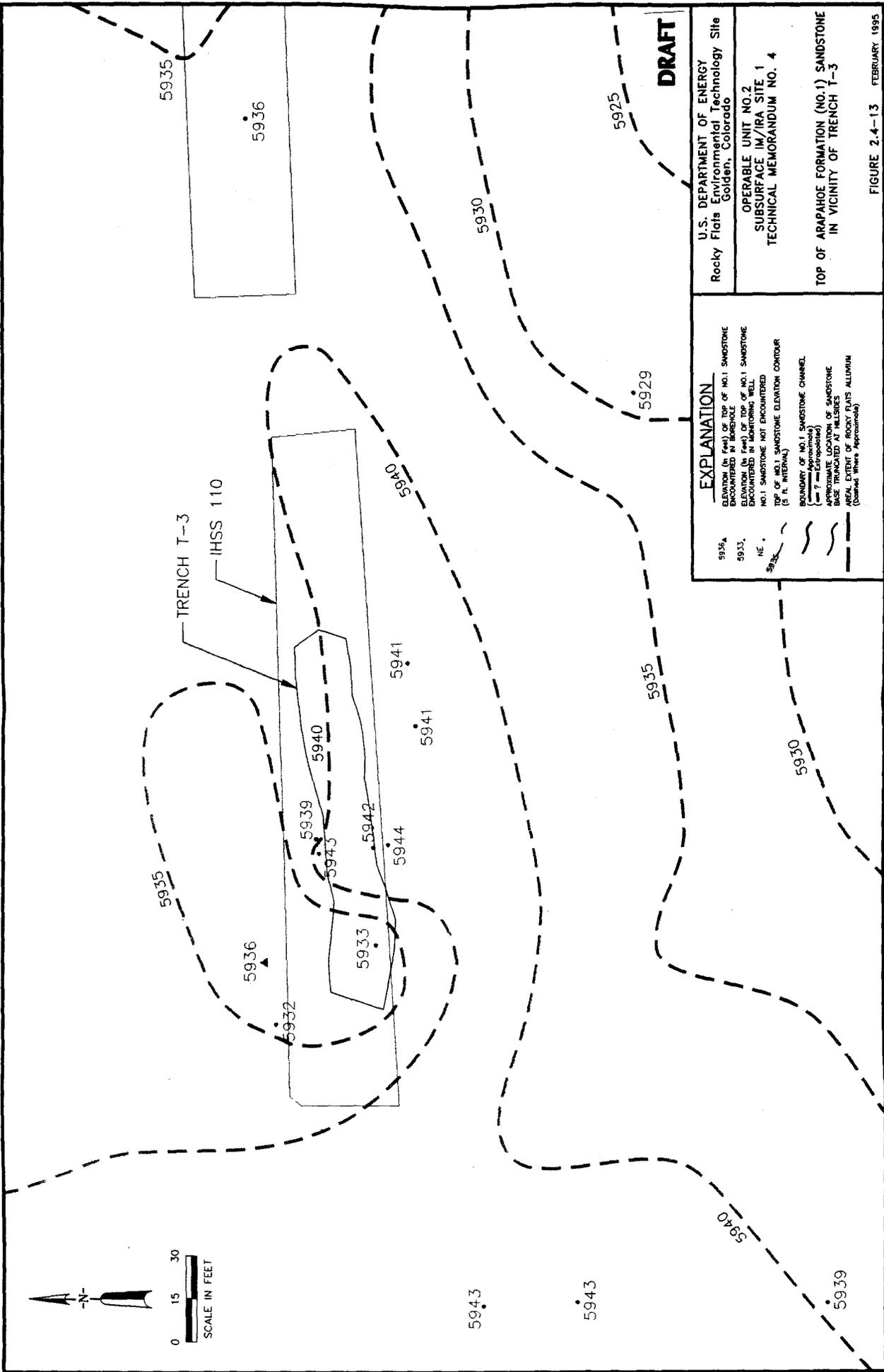
EXPLANATION

272a	THICKNESS (in Fw4) OF NO. 1 SANDSTONE ENCOUNTERED IN BOREHOLE
23.6	THICKNESS (in Fw4) OF NO. 1 SANDSTONE ENCOUNTERED IN MONITORING WELL
NE	NO. 1 SANDSTONE NOT ENCOUNTERED
NP	NO. 1 SANDSTONE NOT PENETRATED
10	SANDSTONE THICKNESS CONTOUR
(---)	BOUNDARY OF NO. 1 SANDSTONE CHANNEL
(---)	BOUNDARY OF NO. 2 SANDSTONE CHANNEL
(---)	APPROXIMATE LOCATION OF SANDSTONE CHANNEL
(---)	APPROXIMATE LOCATION OF SANDSTONE CHANNEL
(---)	AREAL EXTENT OF ROCKY FLATS ALLUVIUM (Dashed Where Approximate)

FIGURE 2.4-12 FEBRUARY 1985
 SKETM018 1-300



0 15 30
SCALE IN FEET



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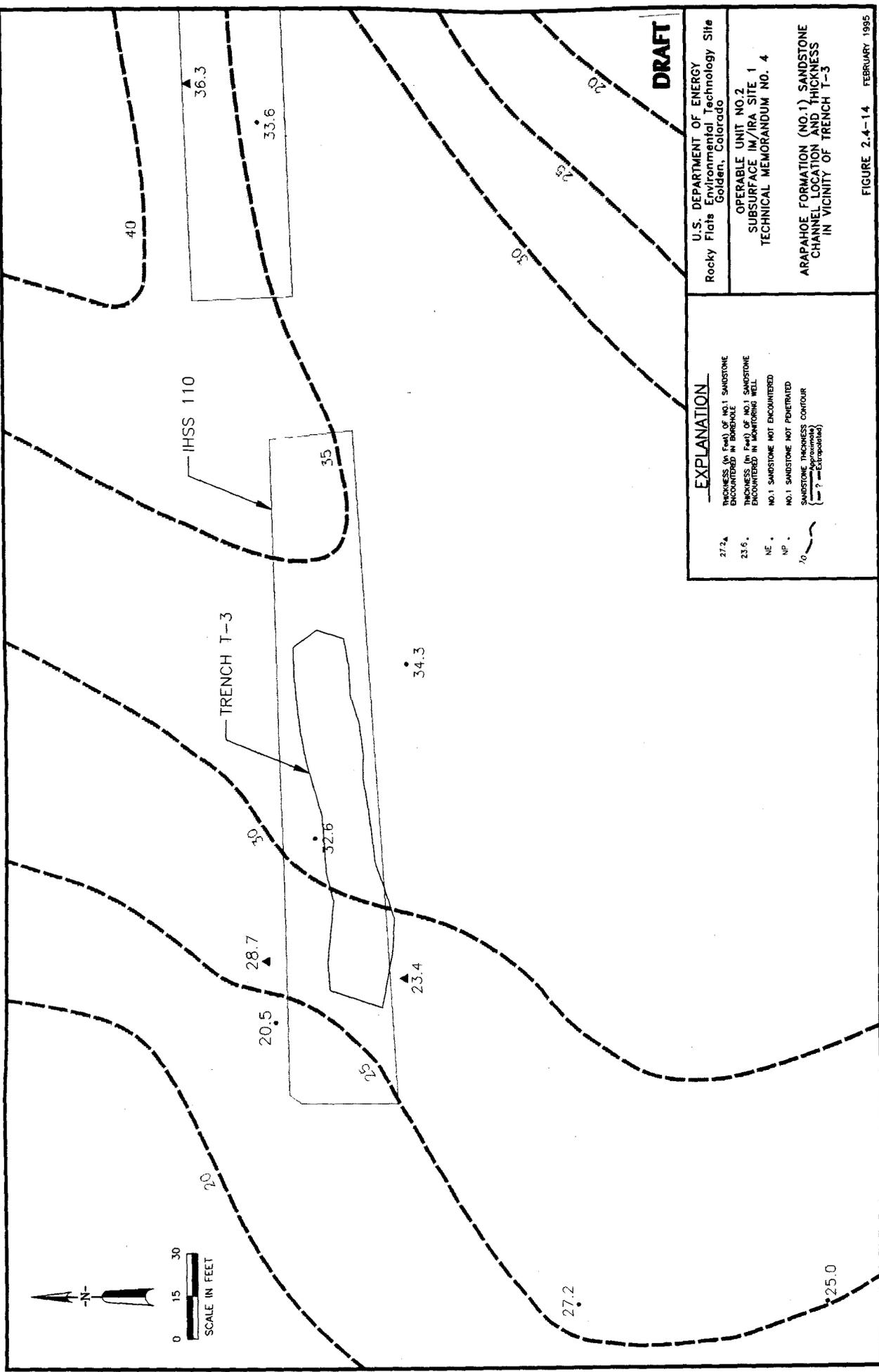
OPERABLE UNIT NO. 2
SUBSURFACE IM/IRA SITE, 1
TECHNICAL MEMORANDUM NO. 4

TOP OF ARAPAHOE FORMATION (NO.1) SANDSTONE
IN VICINITY OF TRENCH T-3

EXPLANATION

- 5934. ELEVATION (in Feet) OF TOP OF NO.1 SANDSTONE ENCOUNTERED IN BOREHOLE
- 5933. ELEVATION (in Feet) OF TOP OF NO.1 SANDSTONE ENCOUNTERED IN MONITORING WELL
- NE. NO.1 SANDSTONE NOT ENCOUNTERED
- 5935. TOP OF NO.1 SANDSTONE ELEVATION CONTOUR (5 ft. INTERVAL)
- BOUNDARY OF NO.1 SANDSTONE CHANNEL
- (---) Approximate
- (---?) Extrapolated
- Boundary of Sandstone
- Boundary of Sandstone
- Boundary of Sandstone
- AREA EVENT OF ROCKY FLATS ALLUVIUM (Boundaries Where Approximate)

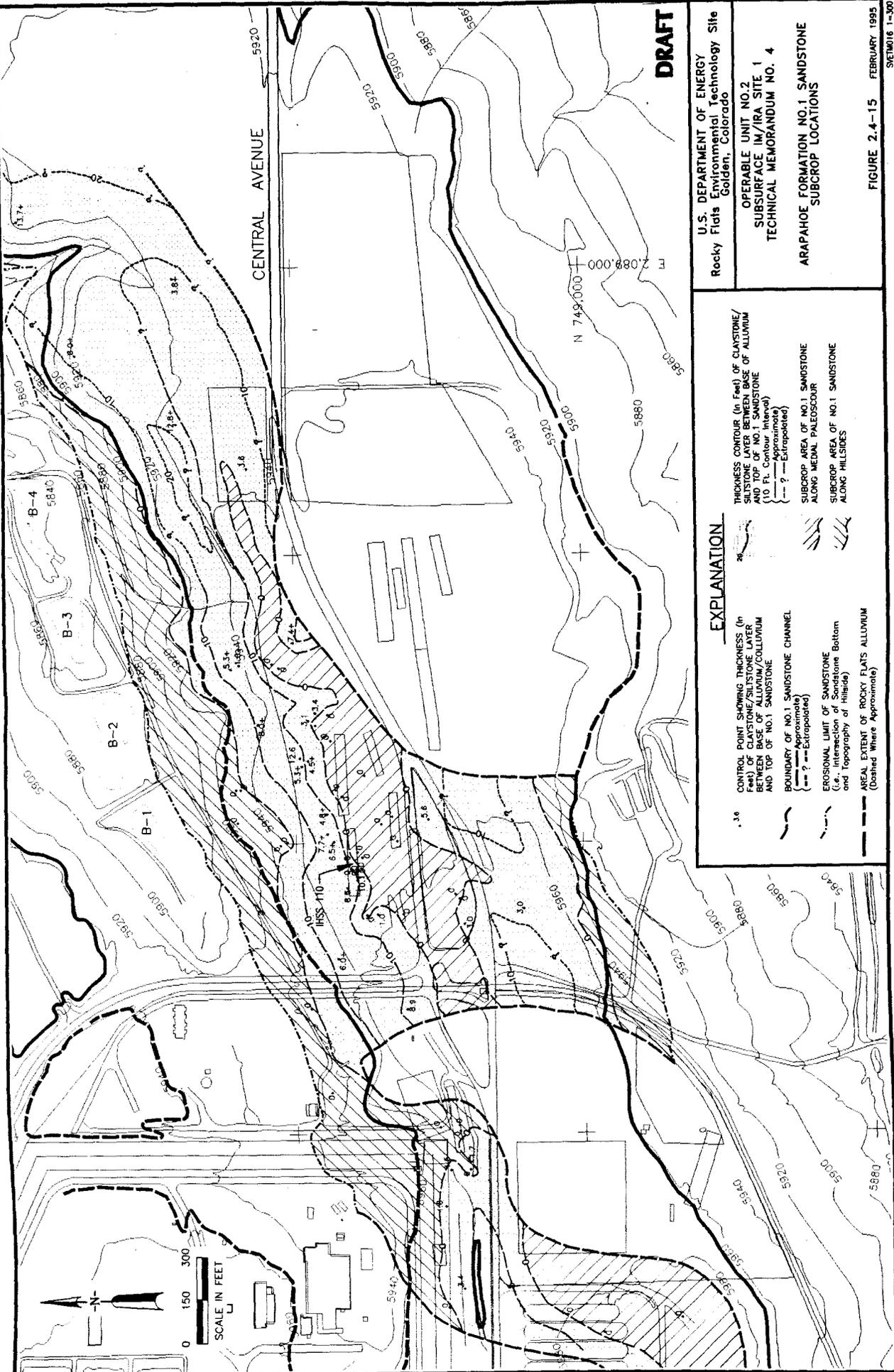
FIGURE 2.4-13 FEBRUARY 1995
SHEIM022 1-30



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<p>U.S. DEPARTMENT OF ENERGY Rocky Flats Environmental Technology Site Golden, Colorado</p>	<p>OPERABLE UNIT NO. 2 SUBSURFACE IM/JRA SITE 1 TECHNICAL MEMORANDUM NO. 4</p>
<p>EXPLANATION</p> <p>THICKNESS (IN FEET) OF NO. 1 SANDSTONE ENCOUNTERED IN BOREHOLE THICKNESS (IN FEET) OF NO. 1 SANDSTONE ENCOUNTERED IN MONITORING WELL NO. 1 SANDSTONE NOT ENCOUNTERED NO. 1 SANDSTONE NOT PENETRATED SANDSTONE THICKNESS CONTOUR (--- ? --- Extrapolated)</p>	

FIGURE 2.4-14 FEBRUARY 1995
SVC/M021 1-30



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OPERABLE UNIT NO. 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

ARAPAHOE FORMATION NO. 1 SANDSTONE
 SUBCROP LOCATIONS

FIGURE 2.4-15 FEBRUARY 1995
 SKEM1016 1-300

EXPLANATION

CONTROL POINT SHOWING THICKNESS (in Feet) OF CLAYSTONE/SILTSTONE LAYER BETWEEN BASE OF ALUMINUM/COLLUMINUM AND TOP OF NO. 1 SANDSTONE

BOUNDARY OF NO. 1 SANDSTONE CHANNEL

EROSIONAL LIMIT OF SANDSTONE (Location of Sandstone Bottom and Topography of Hillside)

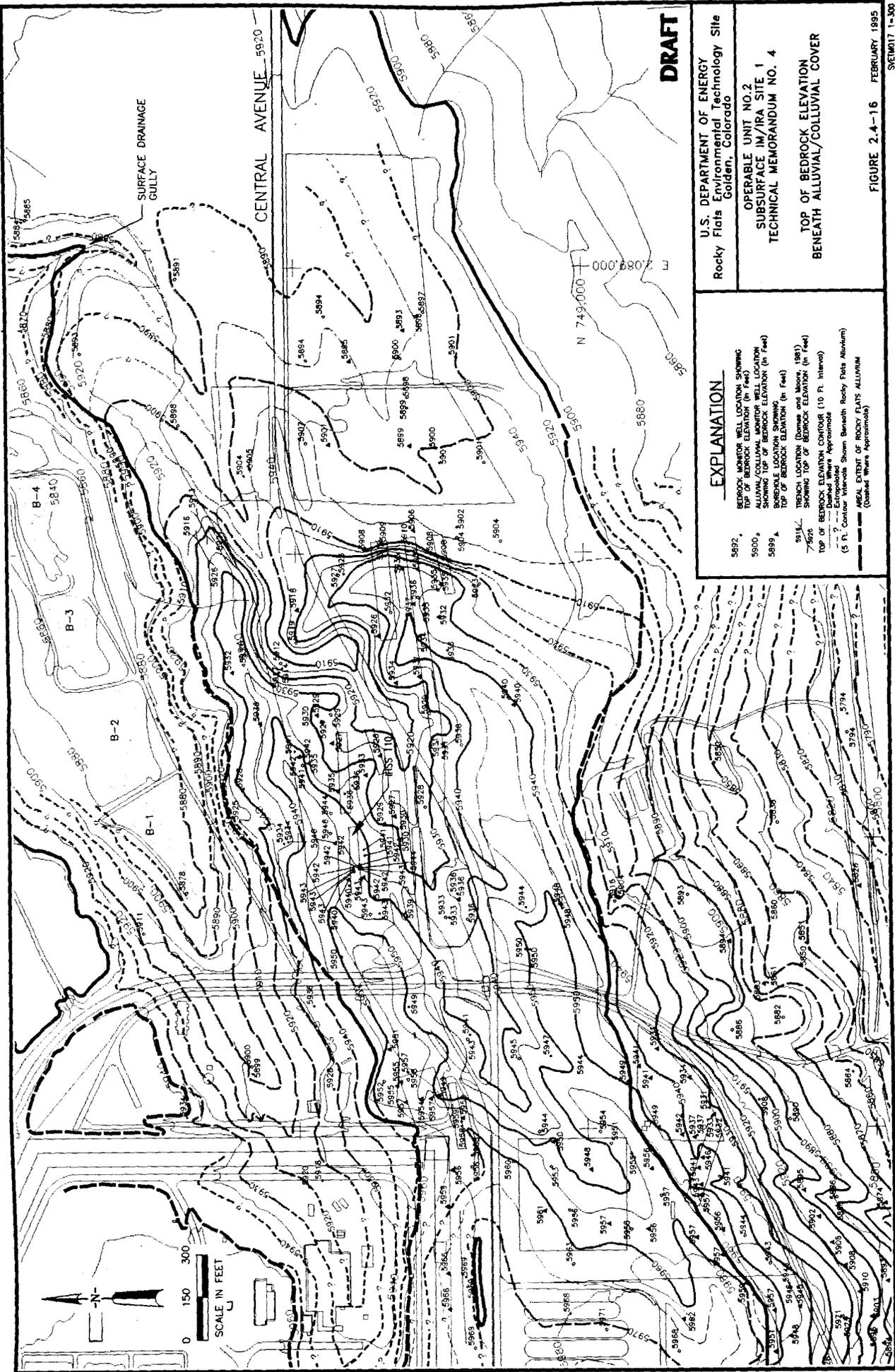
AREAL EXTENT OF ROCKY FLATS ALUMINUM (Dashed Where Approximate)

THICKNESS CONTOUR (in Feet) OF CLAYSTONE/SILTSTONE LAYER BETWEEN TOP OF NO. 1 SANDSTONE AND TOP OF NO. 2 SANDSTONE (10 Ft. Contour Interval)

SUBCROP AREA OF NO. 1 SANDSTONE ALONG MEDIAL PALEOSOL

SUBCROP AREA OF NO. 1 SANDSTONE ALONG HILLSIDES

Approximate
 Extrapolated



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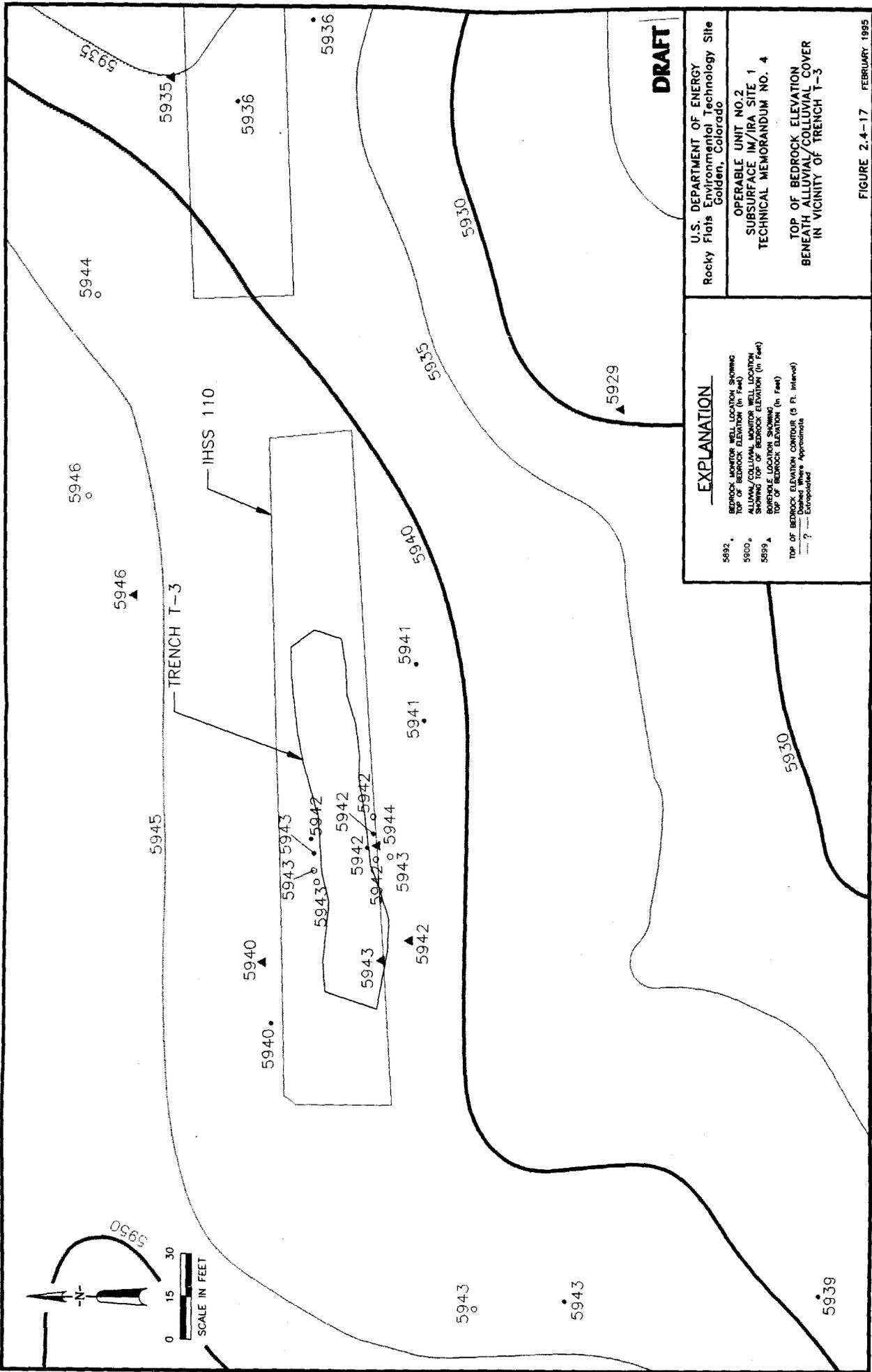
OPERABLE UNIT NO. 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

TOP OF BEDROCK ELEVATION
 BENEATH ALLUVIAL/COLLUVIAL COVER

FIGURE 2.4-16 FEBRUARY, 1995
 SVEW017 1-500

EXPLANATION

- 5892. BEDROCK MONITOR WELL LOCATION SHOWING TOP OF BEDROCK ELEVATION (in Feet)
- 5900. ALLUVIAL/COLLUVIAL MONITOR WELL LOCATION SHOWING TOP OF BEDROCK ELEVATION (in Feet)
- 5899. TOP OF BEDROCK ELEVATION (in Feet)
- 5911. TRENCH LOCATION (Dames and Moore 1981) SHOWING TOP OF BEDROCK ELEVATION (in Feet)
- 5876. BEDROCK ELEVATION CONTOUR (10 Ft. Interval) (Dashed Where Approximate)
- 5 Ft. Contour Interval Shown Beneath Rocky Flats Alluvium (Contour Where Approximate)



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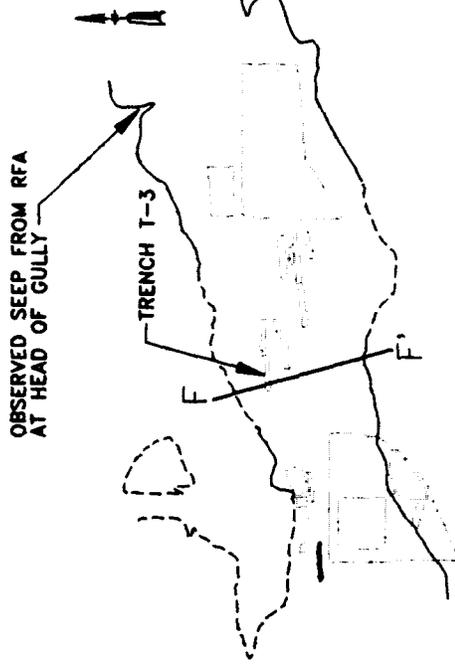
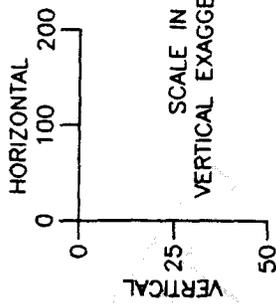
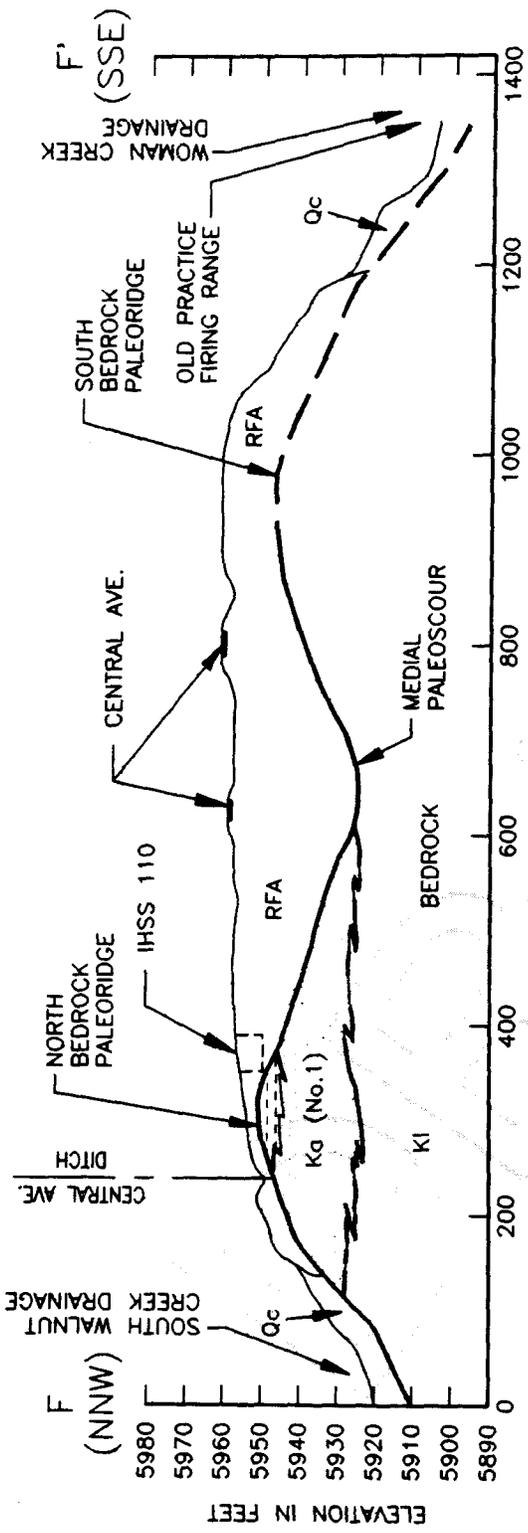
OPERABLE UNIT NO. 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

TOP OF BEDROCK ELEVATION
 BENEATH ALLUVIAL/COLLUVIAL COVER
 IN VICINITY OF TRENCH T-3

EXPLANATION

- 5942, BEDROCK MONITOR WELL LOCATION SHOWING TOP OF BEDROCK ELEVATION (in Feet)
- 5940, SLURRY WALL LOCATION SHOWING TOP OF BEDROCK ELEVATION (in Feet)
- 5943, BEDROCK MONITOR WELL LOCATION SHOWING TOP OF BEDROCK ELEVATION (in Feet)
- 5944, TOP OF BEDROCK ELEVATION (in Feet)
- 5946, TOP OF BEDROCK ELEVATION (5 Ft. Interval)
- ? --- Extrapolated

FIGURE 2.4-17 FEBRUARY 1995
 SKETW020 1-30



EXPLANATION

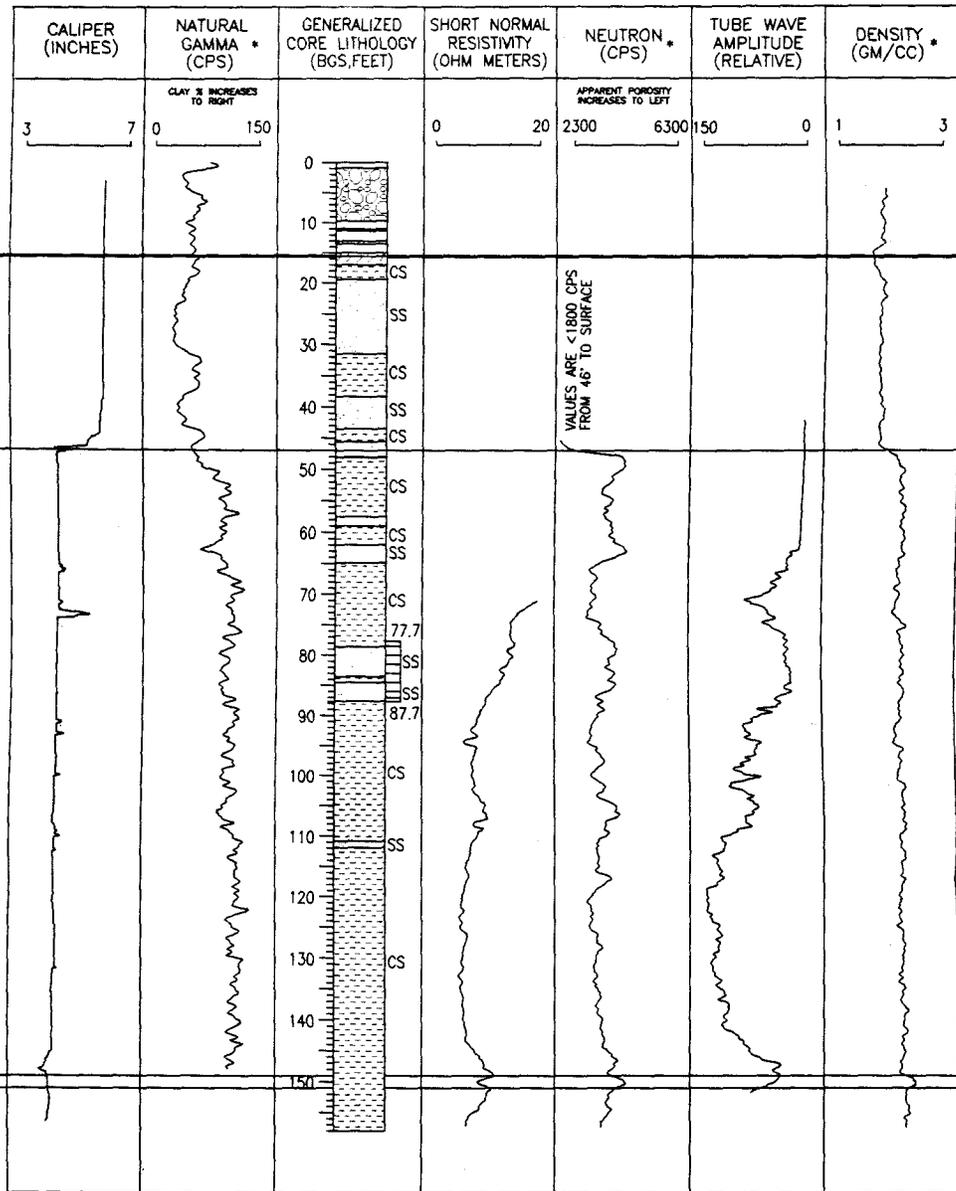
—	TOP OF BEDROCK SURFACE
- - -	Dashed Where Approximate
- - -	Extrapolated
RFA	ROCKY FLATS ALLUVIUM
Qc	COLLUVIUM
Ka (No.1)	ARAPAHOE FORMATION No.1 SANDSTONE
KI	LARAMIE FORMATION

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OPERABLE UNIT 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO.4

CROSS SECTION SHOWING
 ALLUVIAL AND BEDROCK
 FEATURES

CROSS-SECTION LOCATION MAP



NOTE: FOR SHORT-NORMAL RESISTIVITY THE TOP OF WIRELINE IS ISOLATED, RESULTING IN SHALLOWEST READING APPROX. 30 FT. BELOW CASING.

NOTE: IN MANY ENVIRONMENTS, THE TUBE WAVE AMPLITUDE CAN BE USED AS A RELATIVE PERMEABILITY INDICATOR (INCREASES TO RIGHT); CORE ANALYSIS DATA IS NEEDED TO VALIDATE THE VALUES.

0
 VERTICAL SCALE
 1" = 20'
 20

LEGEND

- UNCONSOLIDATED SEDIMENTS (QUATERNARY)
- SANDSTONE
- SILTSTONE
- CLAYSTONE
- NO RECOVERY INTERVAL OR NOT SAMPLED
- SCREENED INTERVAL FROM WELL 23293 PROJECTED ONTO PILOT BOREHOLE LITHOLOGIC COLUMN

* LOG VALUES ABOVE 47' ARE ATTENUATED BY ISOLATION CASING.

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EXPLANATION

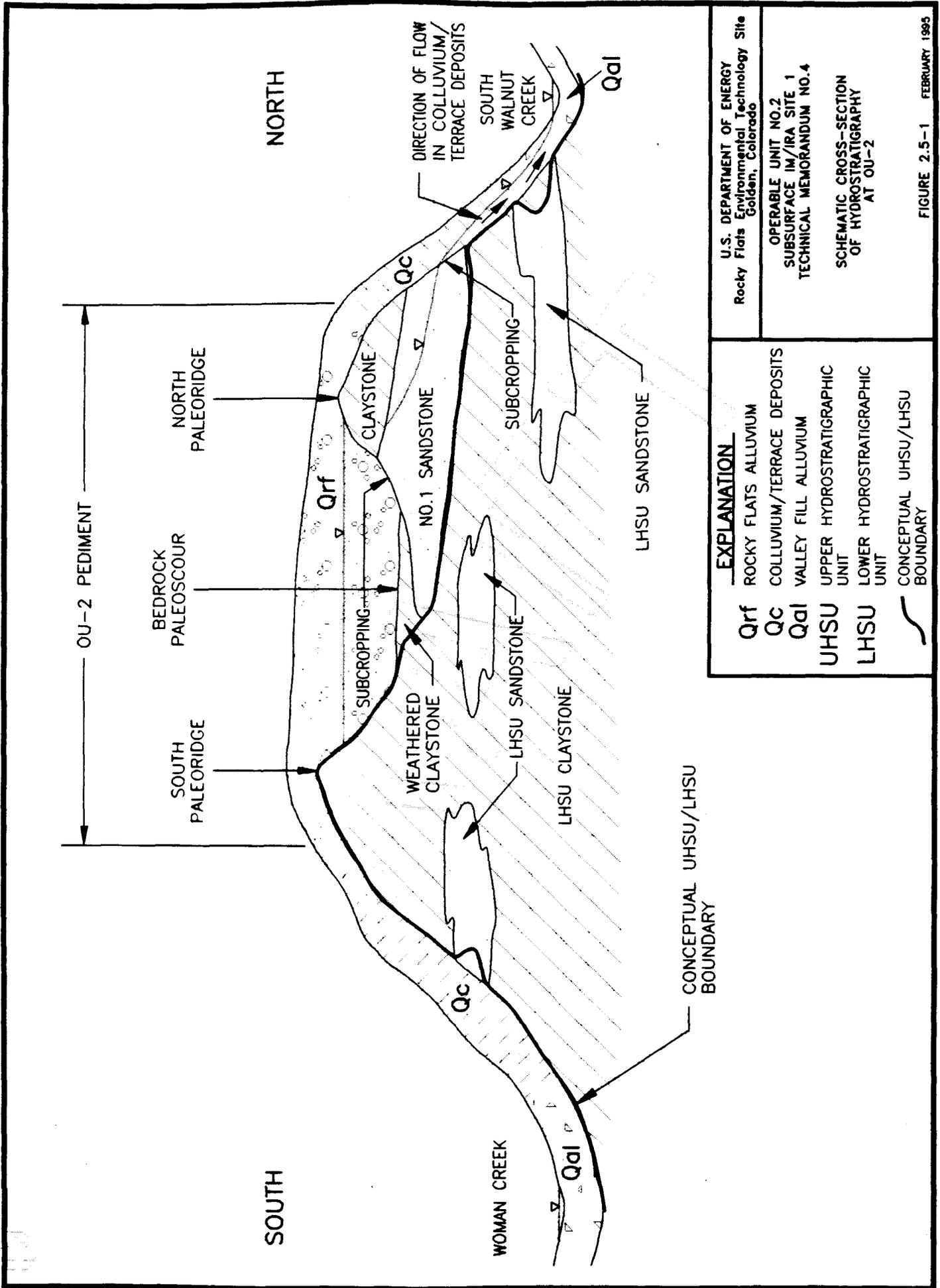
- BGS BELOW GROUND SURFACE
- (CPS) COUNTS PER SECOND
- (GM/CC) GRAMS PER CUBIC CENTIMETER
- SS SANDSTONE
- SLT SILTSTONE
- CS CLAYSTONE

U.S. DEPARTMENT OF ENERGY
 Rocky Flats Environmental Technology Site
 Golden, Colorado

OPERABLE UNIT NO.2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

GENERALIZED CORE LITHOLOGY AND
 GEOPHYSICAL LOGS COMPOSITE FOR
 PILOT BOREHOLE 21693

FIGURE 2.4-19 FEBRUARY 1995



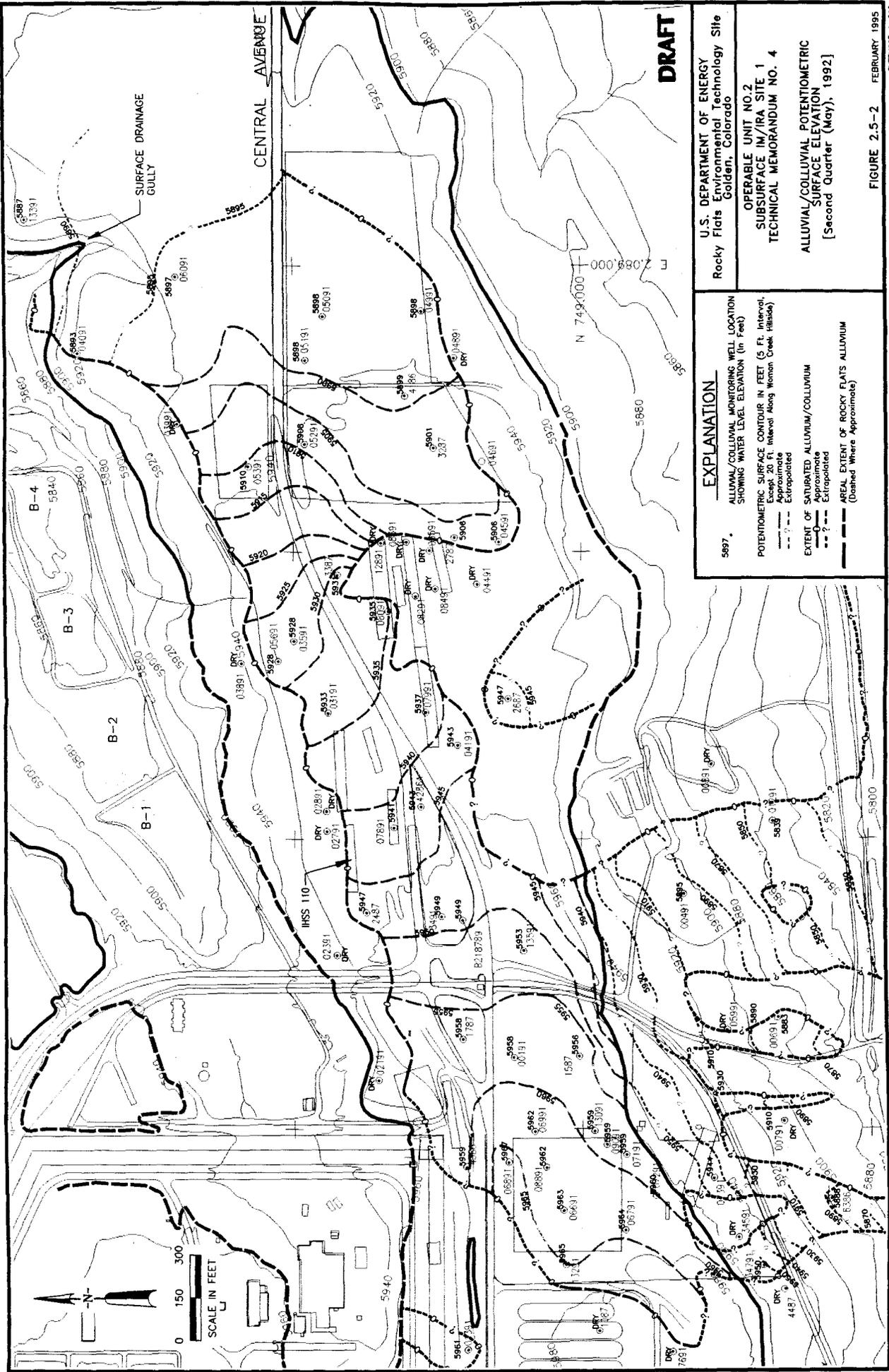
U.S. DEPARTMENT OF ENERGY
 Rocky Flats Environmental Technology Site
 Golden, Colorado

OPERABLE UNIT NO. 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

SCHEMATIC CROSS-SECTION
 OF HYDROSTRATIGRAPHY
 AT OU-2

EXPLANATION	
Qrf	ROCKY FLATS ALLUVIUM
Qc	COLLUVIUM/TERRACE DEPOSITS
Qdl	VALLEY FILL ALLUVIUM
UHSU	UPPER HYDROSTRATIGRAPHIC UNIT
LHSU	LOWER HYDROSTRATIGRAPHIC UNIT
—	CONCEPTUAL UHSU/LHSU BOUNDARY

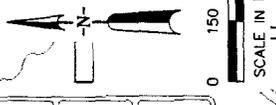
FIGURE 2.5-1 FEBRUARY 1995
 SVEIM059 1-1



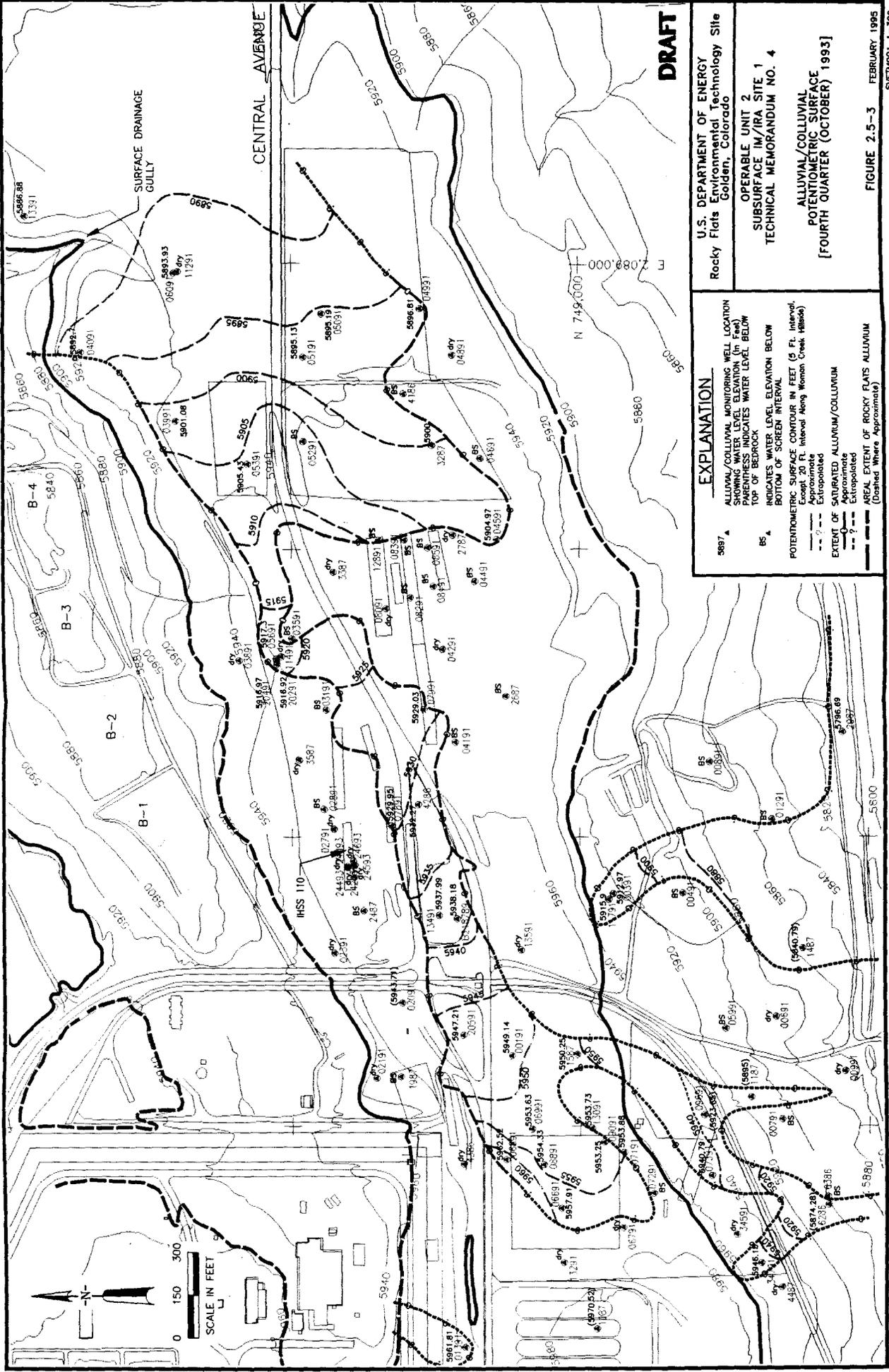
DRAFT

<p>EXPLANATION</p> <p>5897. ALLUVIAL/COLLUVIAL MONITORING WELL LOCATION SHOWING WATER LEVEL ELEVATION (in Feet)</p> <p>POTENTIOMETRIC SURFACE CONTOUR IN FEET (5 FT. Interval, Approximate)</p> <p>EXTENT OF SATURATED ALLUVIUM/COLLUVIUM</p> <p>AREAL EXTENT OF ROCKY FLATS ALLUVIUM (Dashed Where Approximate)</p>	<p>U.S. DEPARTMENT OF ENERGY Rocky Flats Environmental Technology Site Golden, Colorado</p>
	<p>OPERABLE UNIT NO. 2 SUBSURFACE IM/IRA SITE 1 TECHNICAL MEMORANDUM NO. 4</p> <p>ALLUVIAL/COLLUVIAL POTENTIOMETRIC SURFACE ELEVATION [Second Quarter (May), 1992]</p>

FIGURE 2.5-2 FEBRUARY 1995
SHEETS 1-300



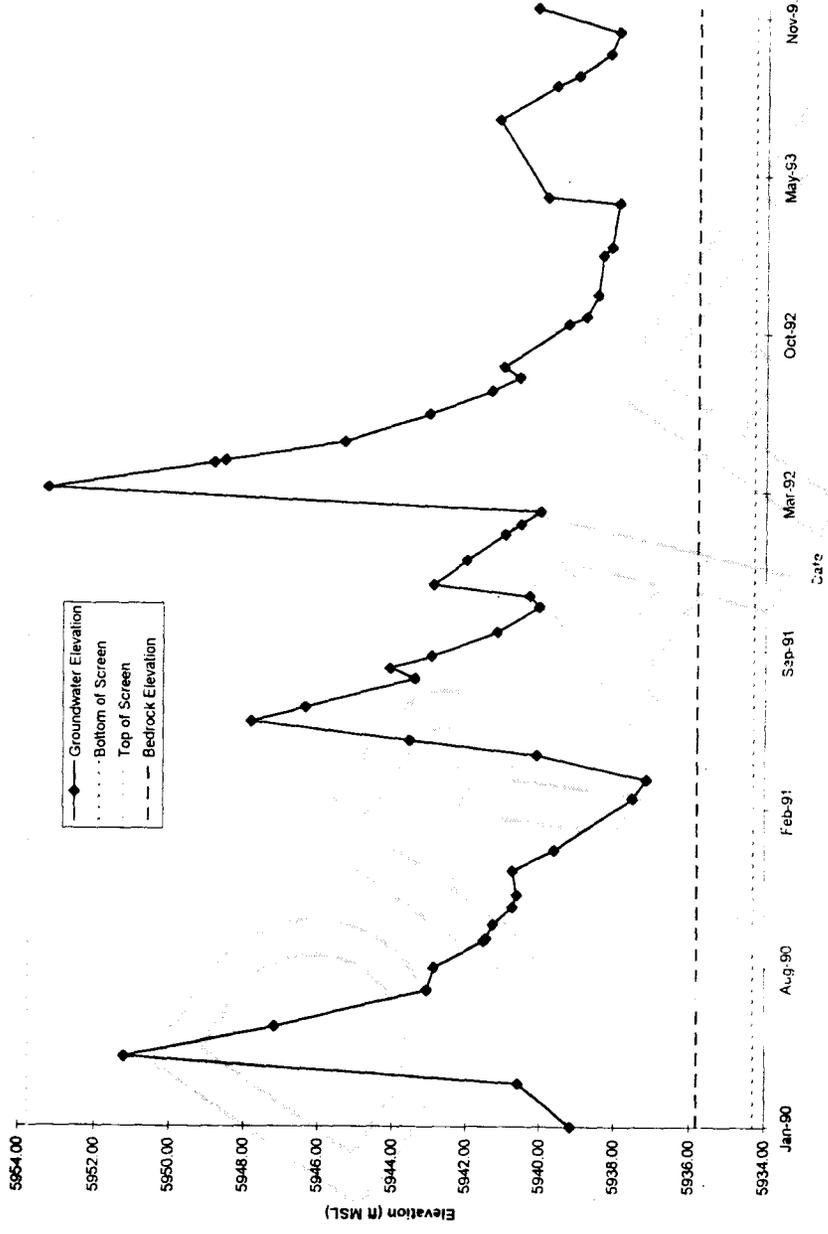
SCALE IN FEET



DRAFT

<p>U.S. DEPARTMENT OF ENERGY Environmental Technology Site Rocky Flats Golden, Colorado</p>	<p>OPERABLE UNIT 2 SUBSURFACE IN/IRA SITE 1 TECHNICAL MEMORANDUM NO. 4</p>
<p>ALLUVIAL/COLLUVIAL MONITORING WELL LOCATION IN PARENTHESES INDICATES WATER LEVEL BELOW TOP OF BEDROCK</p> <p>POTENTIOMETRIC SURFACE ELEVATION BELOW BOTTOM OF SCREEN INTERVAL Elevated 20 Ft. Interval (Newly Monon Creek Hills)</p> <p>EXTENT OF SATURATED ALLUVIUM/COLLUVIUM Approximate Extrapolated</p> <p>AREAL EXTENT OF ROCKY FLATS ALLUVIUM (Dashed Where Approximate)</p>	
<p>ALLUVIAL/COLLUVIAL MONITORING WELL LOCATION IN PARENTHESES INDICATES WATER LEVEL BELOW TOP OF BEDROCK</p> <p>POTENTIOMETRIC SURFACE ELEVATION BELOW BOTTOM OF SCREEN INTERVAL Elevated 20 Ft. Interval (Newly Monon Creek Hills)</p> <p>EXTENT OF SATURATED ALLUVIUM/COLLUVIUM Approximate Extrapolated</p> <p>AREAL EXTENT OF ROCKY FLATS ALLUVIUM (Dashed Where Approximate)</p>	

FIGURE 2.5-3 FEBRUARY 1995
SVETM001 1-300



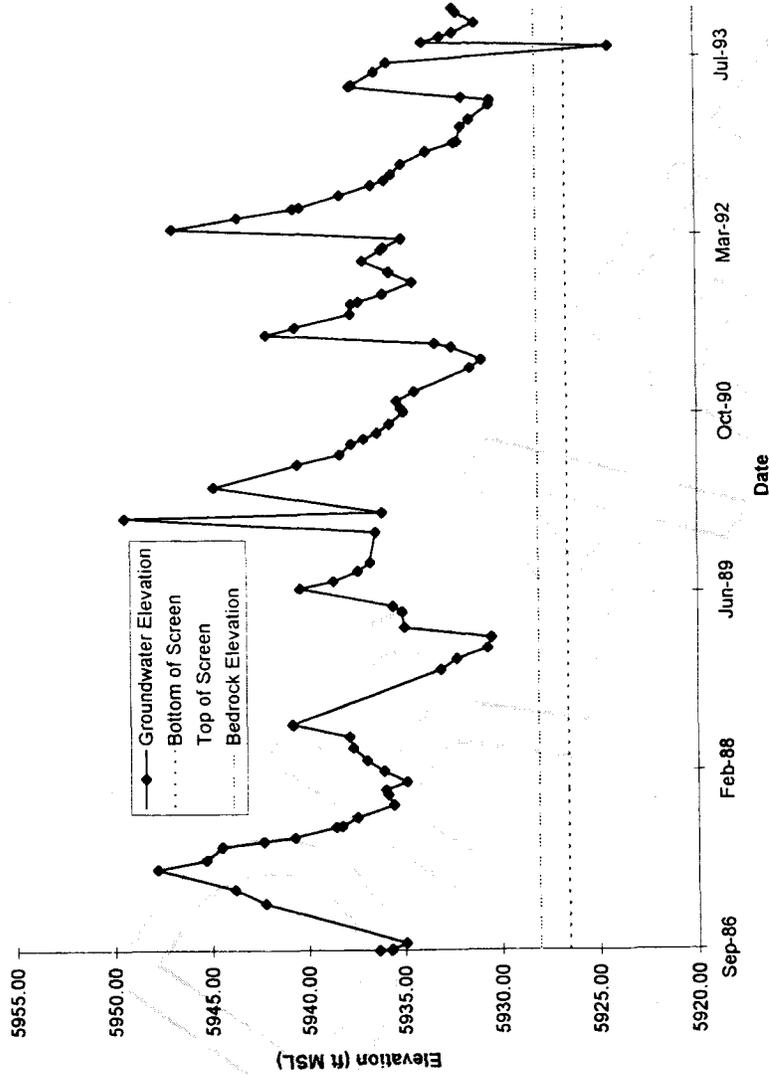
U.S. DEPARTMENT OF ENERGY
 Rocky Flats Environmental Technology Site
 Golden, Colorado

OPERABLE UNIT 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

WELL B218789
 HYDROGRAPH

FIGURE 2.5-4 FEBRUARY 1995

SVETM052 1=1



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OPERABLE UNIT 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

WELL 4286
 HYDROGRAPH

FIGURE 2.5-5 FEBRUARY 1995

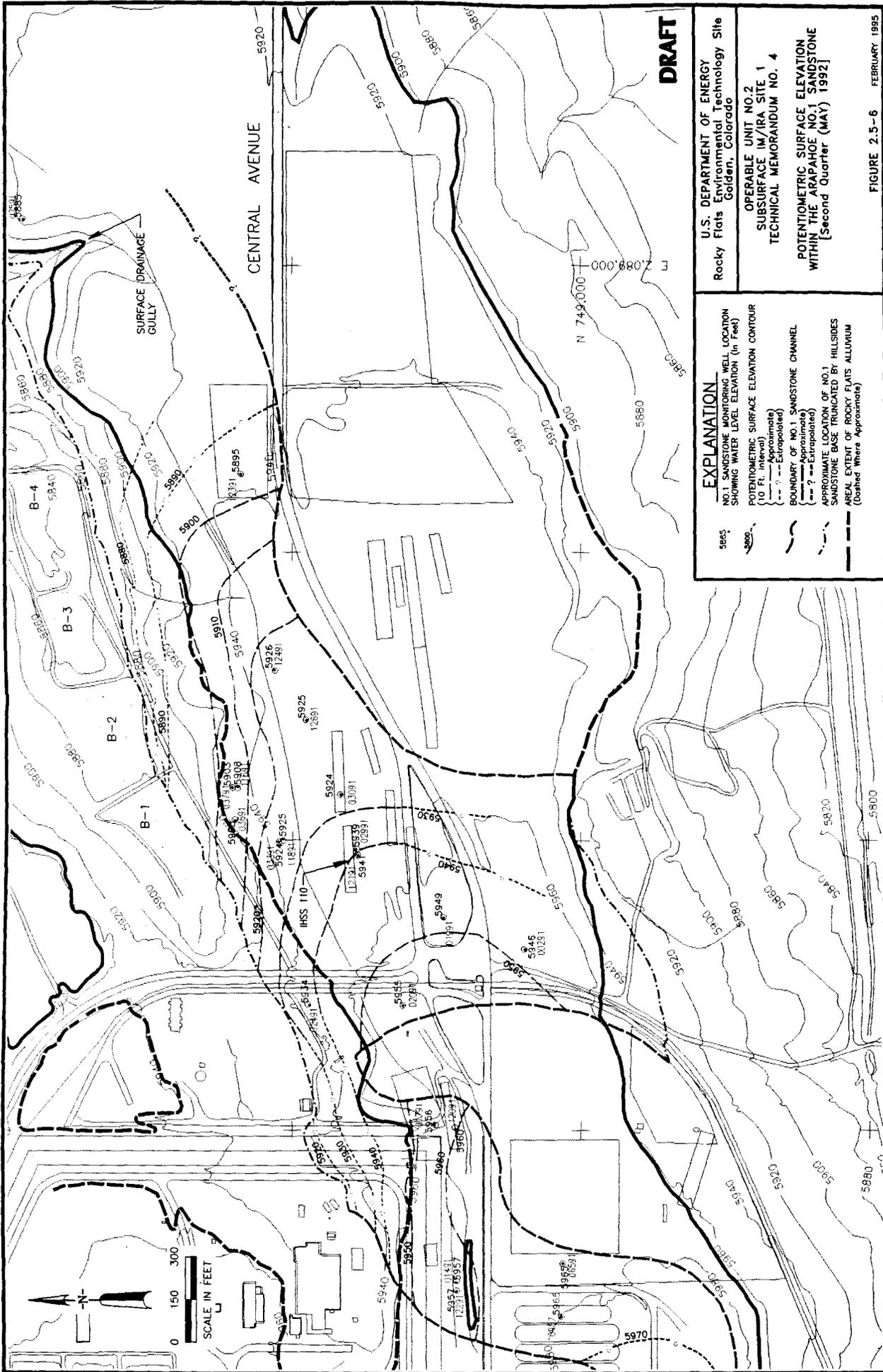
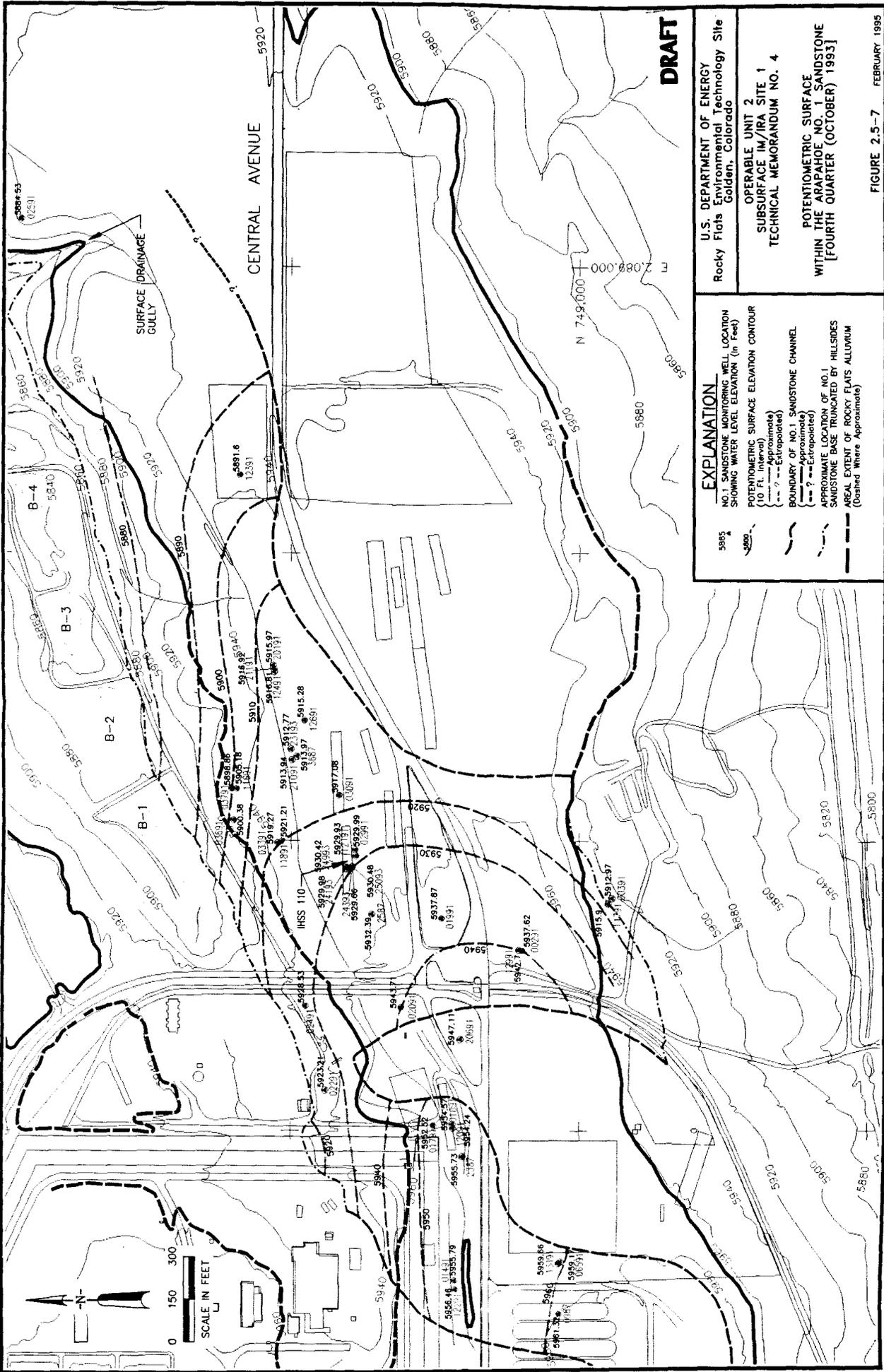


FIGURE 2.5-6 FEBRUARY 1995
SKETCH 1-300



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 Rocky Flats Environmental Technology Site
 Golden, Colorado

OPERABLE UNIT 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

POTENTIOMETRIC SURFACE
 WITHIN THE ARAPAHOE NO. 1 SANDSTONE
 [FOURTH QUARTER (OCTOBER) 1993]

EXPLANATION

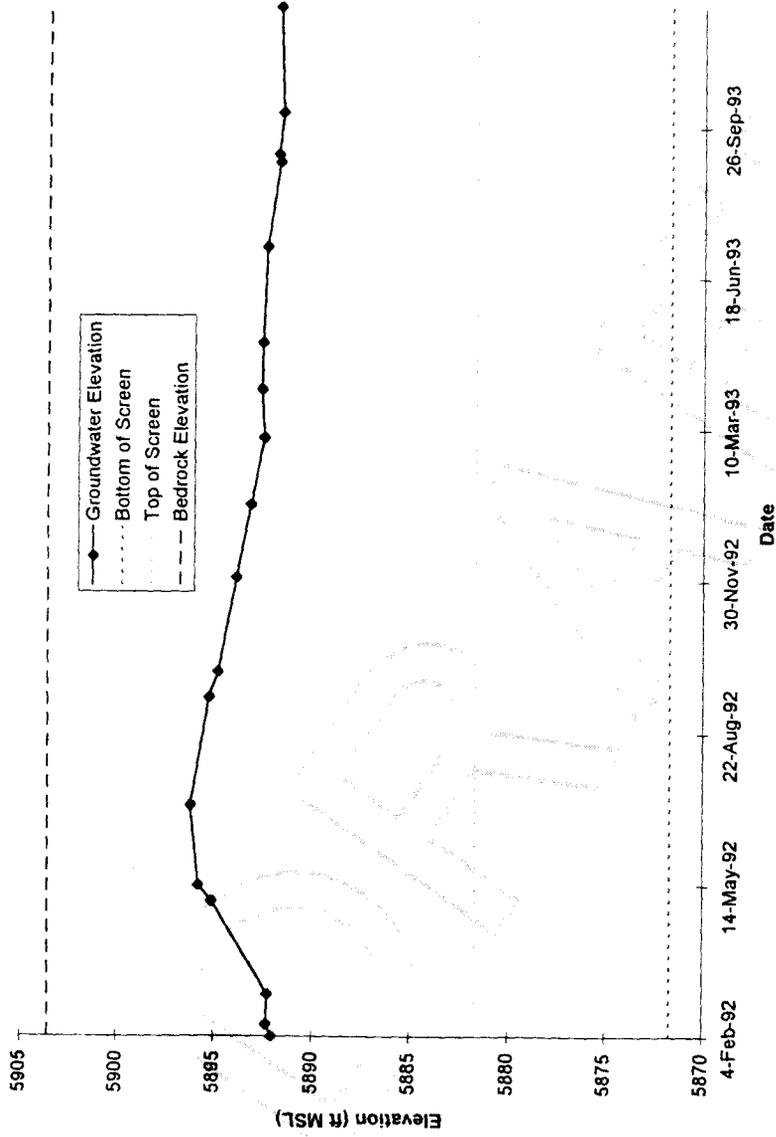
NO.1 SANDSTONE MONITORING WELL LOCATION
 SHOWING WATER LEVEL ELEVATION (in Feet)

POTENTIOMETRIC SURFACE ELEVATION CONTOUR
 (10 Ft. Interval)

BOUNDARY OF NO.1 SANDSTONE CHANNEL

APPROXIMATE LOCATION OF NO.1 SANDSTONE BASE TRUNCATED BY HILLSIDES
 (Dashed Where Approximate)

FIGURE 2.5-7 FEBRUARY 1995
 S/ETM002 1-300

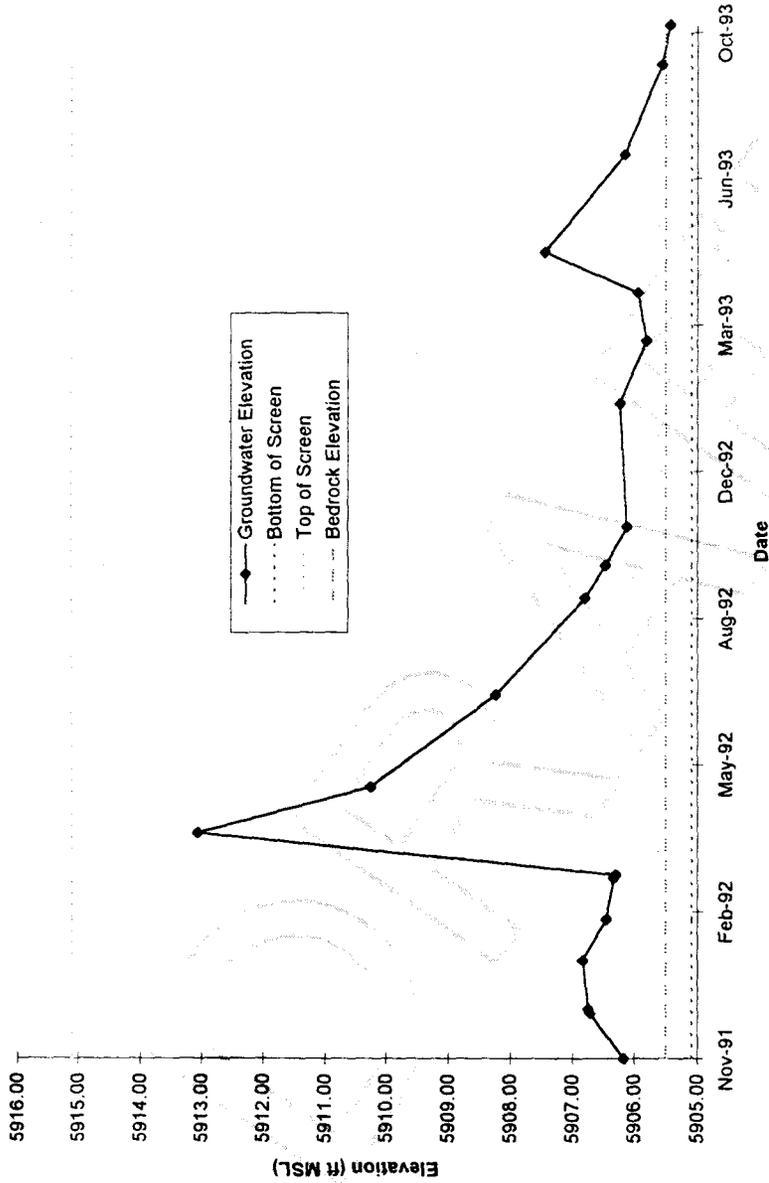


U.S. DEPARTMENT OF ENERGY
 Rocky Flats Environmental Technology Site
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OPERABLE UNIT 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

WELL 12391
 HYDROGRAPH

FIGURE 2.5-8 FEBRUARY 1995



U.S. DEPARTMENT OF ENERGY
 Rocky Flats Environmental Technology Site
 Golden, Colorado

OPERABLE UNIT 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

WELL 05391
 HYDROGRAPH

FIGURE 2.5-9 FEBRUARY 1995

SOIL SYMBOLS

	GW WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	GP POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	GM SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
	GC CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SW WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	SP POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	SM SILTY SANDS, SAND-SILT MIXTURES
	SC CLAYEY SANDS, SAND-CLAY MIXTURES
	ML INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
	CL INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, SILTY OR CLAYEY CLAYS, LEAN CLAYS
	CH INORGANIC CLAYS OR HIGH PLASTICITY, FAT CLAYS

BEDROCK SYMBOLS

	SANDSTONE
	SILTY SANDSTONE
	CLAYEY SANDSTONE
	SILTSTONE
	SANDY SILTSTONE
	CLAYEY SILTSTONE
	CLAYSTONE
	SANDY CLAYSTONE
	SILTY CLAYSTONE
	CALICHE
	NO RECOVERY OR SAMPLED INTERVAL NOT LOGGED

WATER LEVEL AND LOCATION SYMBOLS

5/92		MEASURED HIGH WATER LEVEL AND DATE
		INITIAL WATER AT TIME OF DRILLING
		ALLUVIAL/COLLUVIAL MONITORING WELL LOCATION
		BEDROCK MONITORING WELL LOCATION
		SOURCE BOREHOLE LOCATION
		SOURCE BOREHOLE AND MONITORING WELL LOCATION
08991		LOCATION NUMBER. LAST 2 DIGITS INDICATE YEAR IN WHICH LOCATION WAS DRILLED

GROUNDWATER ANALYTE DATA

●	CCl ₄	CARBON TETRACHLORIDE
■	CHCl ₃	CHLOROFORM
◆	TCE	TRICHLOROETHENE
▲	PCE	TETRACHLOROETHENE
○	TOTAL Xylenes	
□	TOTAL VOCs	

280	CONCENTRATION (ug/kg)
---	LINE CONNECTING CONCENTRATION VALUES AT SAMPLE POINTS ABOVE WATER LEVEL AT THE TIME OF DRILLING. INFERRED WHERE LIMITED DATA EXISTS.
---	LINE CONNECTING CONCENTRATION VALUES AT SAMPLE POINTS BELOW WATER LEVEL AT THE TIME OF DRILLING. INFERRED WHERE LIMITED DATA EXISTS.
---	INFERRED GEOLOGICAL CONTACT

LIST OF CROSS-SECTION UNITS

Qrf	ROCKY FLATS ALLUVIUM
QC	COLLUVIUM
Kg	ARAPAHOE FORMATION
Kq(No. 1)	ARAPAHOE FORMATION NO. 1 SANDSTONE
Kg(K)	ARAPAHOE OR LARAMIE FORMATION
Kl(ss)	LARAMIE FORMATION SANDSTONE

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OPERABLE UNIT NO.2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4

SOURCE BOREHOLE
CROSS-SECTION LEGEND

G' NORTH

35'

22483
MAY 74

10181
MAY 74

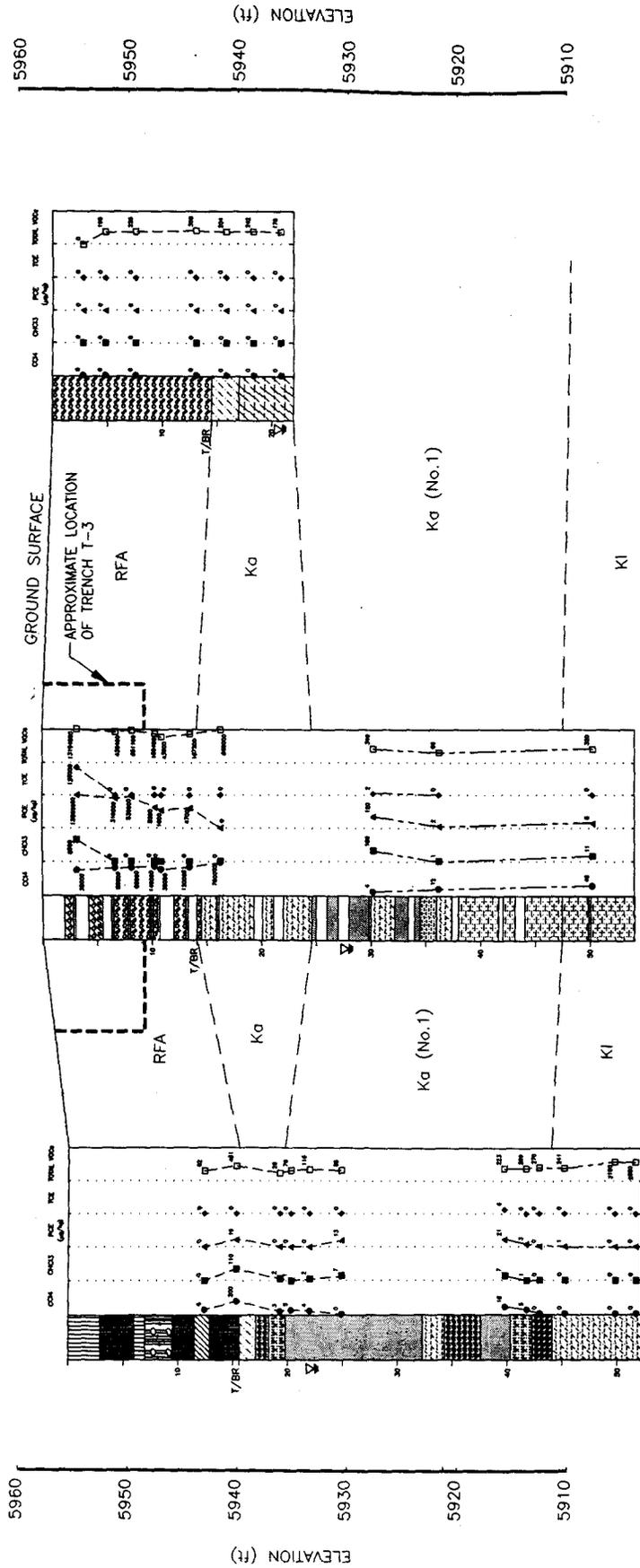
22483
MAY 74

G' SOUTH

20'

22483
MAY 74

10181
MAY 74



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OPERABLE UNIT 2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4

SOURCE BOREHOLE
CROSS-SECTION G-G'
IHSS 110 (TRENCH T-3)

FIGURE 2.6-4 FEBRUARY 1995

SYNTH062 1-1

EXPLANATION

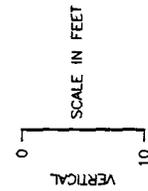
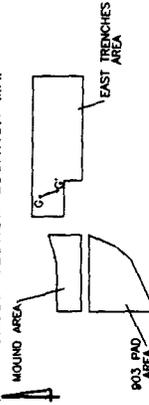
- T/BR = TOP OF BEDROCK
- = LOCATION SYMBOL
- 3-486 = LOCATION NAME
- 9912.00 = GROUND SURFACE ELEVATION (ft)

EACH CHEMICAL IS PLOTTED ON A LOGARITHMIC SCALE (INCREASING TO RIGHT) FROM 1 TO 100,000 (µg/kg). DATA POINT REPRESENTS TOP OF SAMPLING INTERVAL.



(SEE FIGURE 2.6-3, SOURCE BOREHOLE CHARACTERIZATION LEGEND, FOR SOIL, BEDROCK AND LOCATION SYMBOLS)

CROSS-SECTION LOCATION MAP

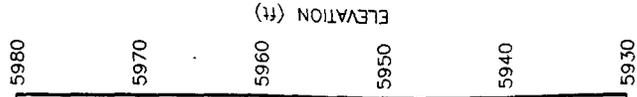


NOTE: HORIZONTAL DISTANCE NOT TO SCALE.

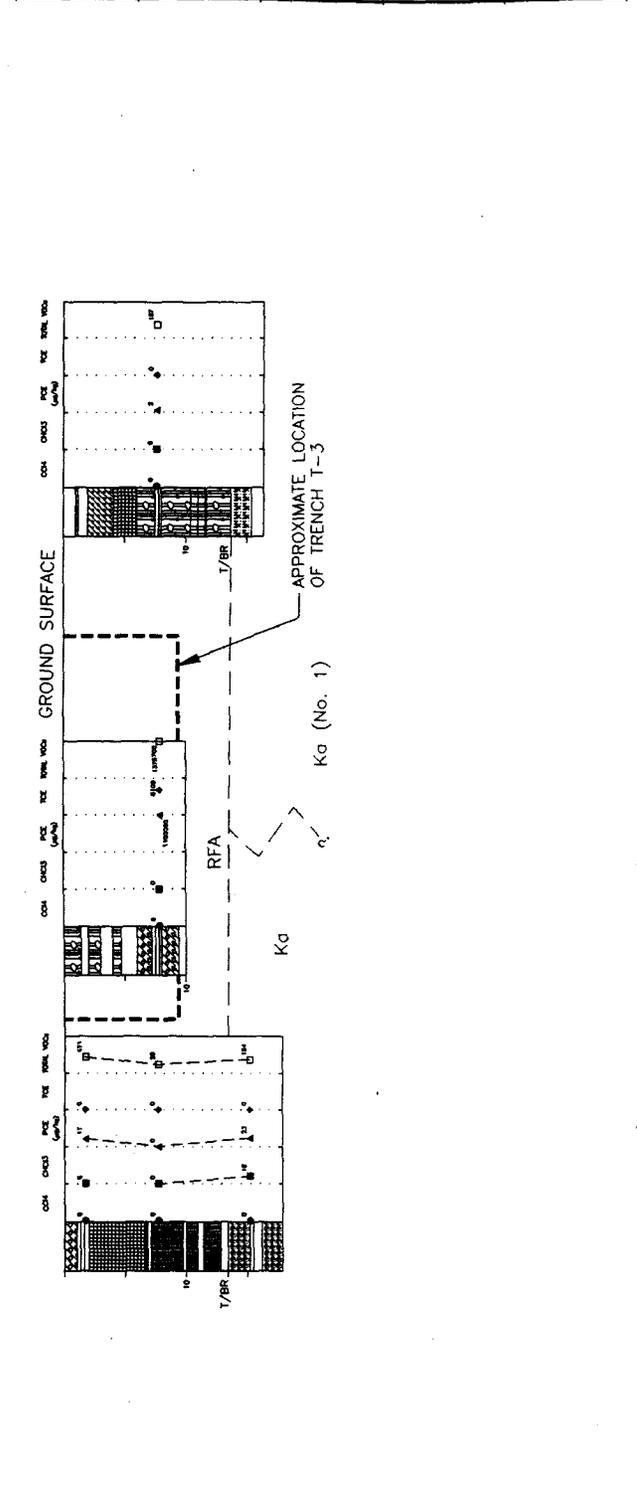
H NORTH



H' SOUTH



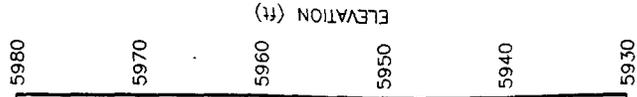
ELEVATION (ft)



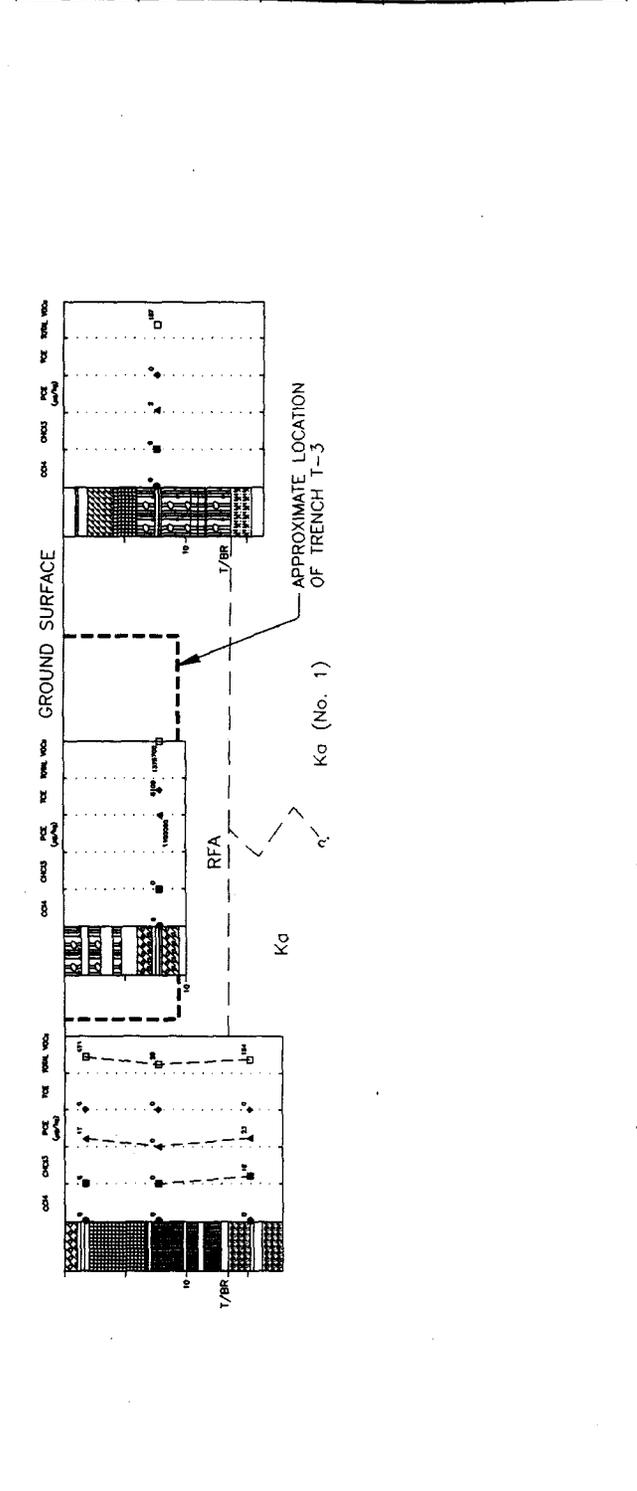
H NORTH



H' SOUTH



ELEVATION (ft)



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Rocky Flats Environmental Technology Site
Golden, Colorado

OPERABLE UNIT 2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4

SOURCE BOREHOLE
CROSS-SECTION H-H'
IHSS 110 (TRENCH T-3)

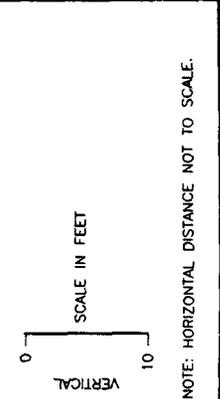
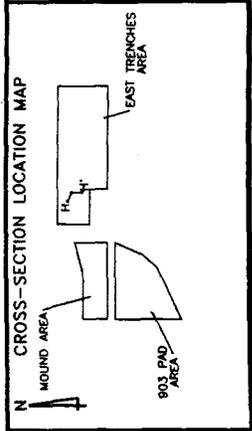
FIGURE 2.6-5 FEBRUARY 1995

EXPLANATION

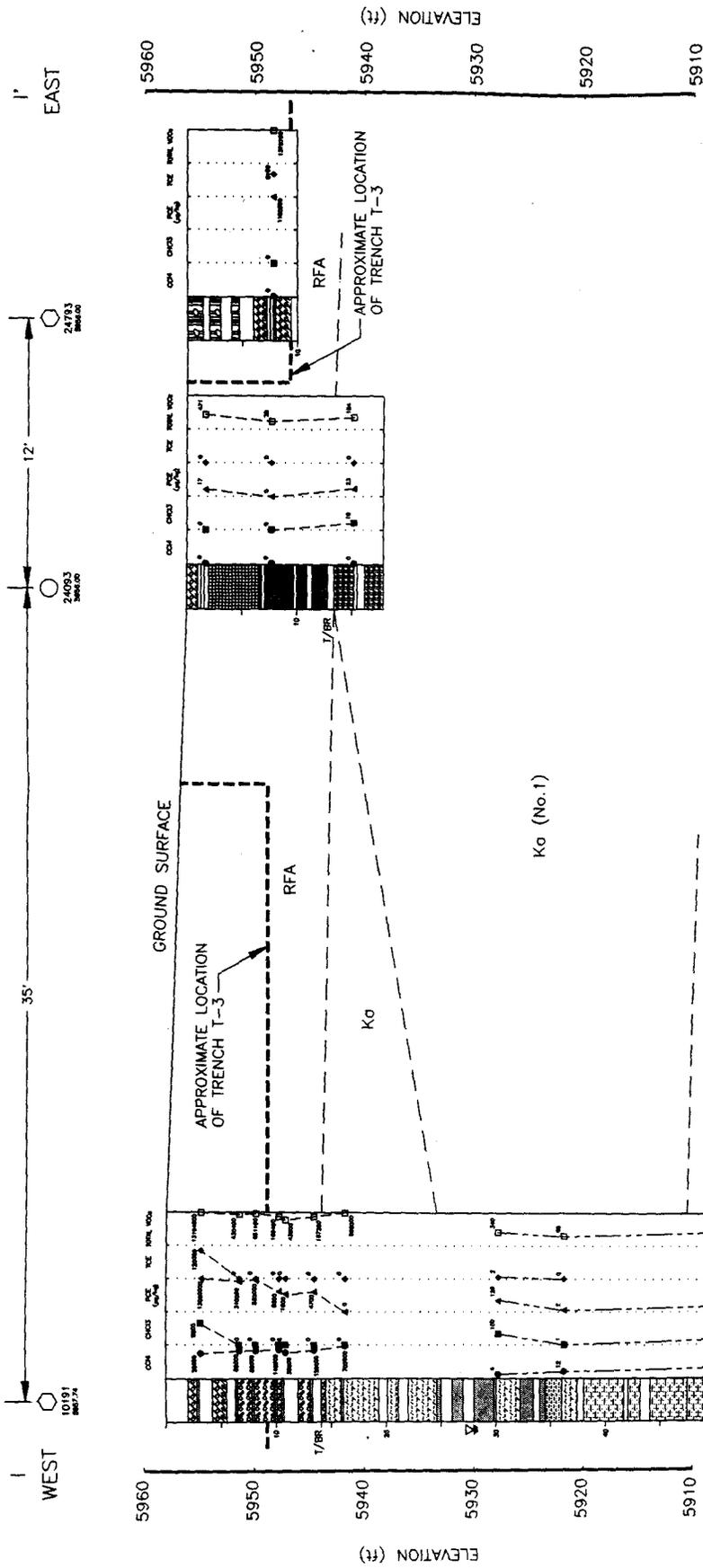
T/BR = TOP OF BEDROCK
○ = LOCATION SYMBOL
3486 = LOCATION NAME
9912.00 = GROUND SURFACE ELEVATION (ft)

EACH CHEMICAL IS PLOTTED ON A LOGARITHMIC SCALE (INCREASING TO RIGHT) FROM 1 TO 1,000,000 (µg/kg). DATA POINT REPRESENTS TOP OF SAMPLING INTERVAL.

(SEE FIGURE 2.6-3, SOURCE BOREHOLE CHARACTERIZATION LEGEND, FOR SOIL, BEDROCK AND LOCATION SYMBOLS)



SVE/M084 1-1



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 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

**SOURCE BOREHOLE
 CROSS-SECTION I-1'
 IHSS 110 (TRENCH T-3)**

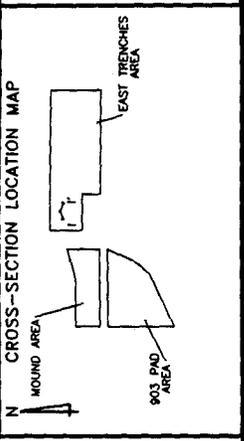
FIGURE 2.6-6 FEBRUARY 1995
 SVE1M063 1-1

EXPLANATION

T/BR = TOP OF BEDROCK
 ○ = LOCATION SYMBOL
 3486 = LOCATION NAME
 9912.00 = GROUND SURFACE ELEVATION (ft)

EACH CHEMICAL IS PLOTTED ON A LOGARITHMIC SCALE (INCREASING TO RIGHT) FROM 1 TO 1,000,000 (ug/kg). DATA POINT REPRESENTS TOP OF SAMPLING INTERVAL.

(SEE FIGURE 2.6-3, SOURCE BOREHOLE CHARACTERIZATION LEGEND, FOR SOIL, BEDROCK AND LOCATION SYMBOLS)



SCALE IN FEET

VERTICAL

0 10

NOTE: HORIZONTAL DISTANCE NOT TO SCALE.

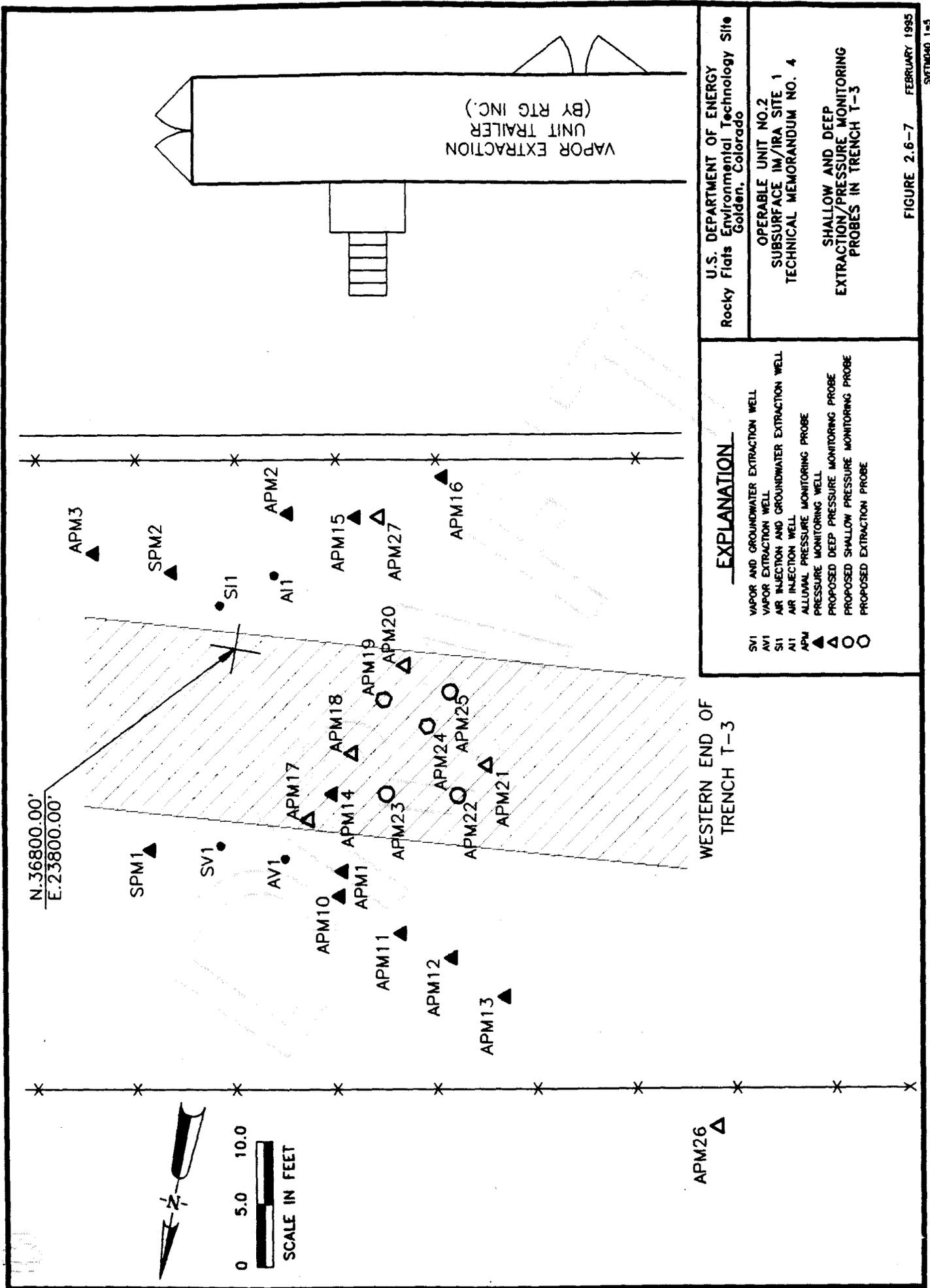
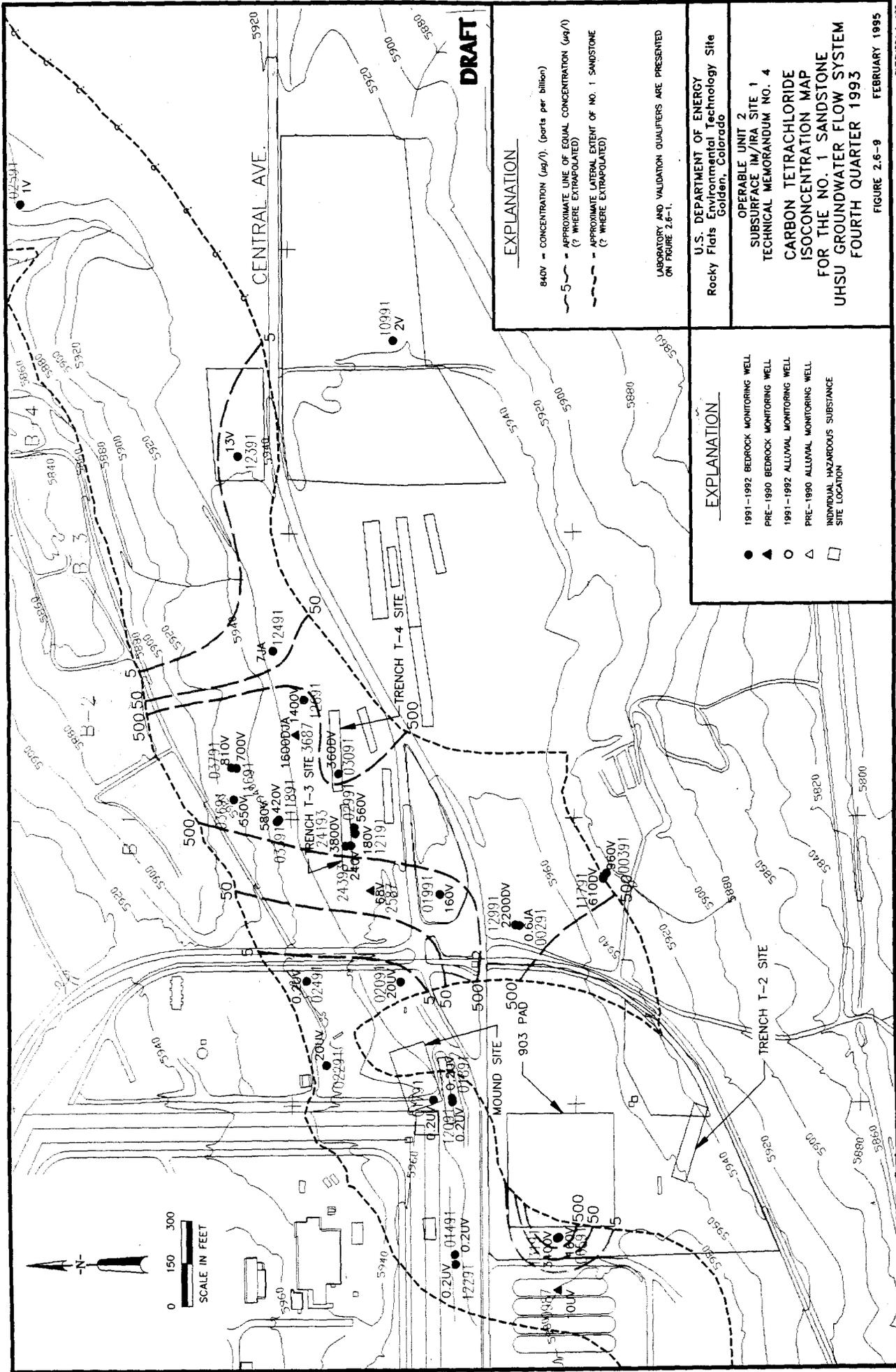


FIGURE 2.6-7 FEBRUARY 1995
SVE/MO40 1-5



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EXPLANATION

- 840V - CONCENTRATION ($\mu\text{g/l}$). (parts per billion)
- 5- - APPROXIMATE LINE OF EQUAL CONCENTRATION ($\mu\text{g/l}$)
(? WHERE EXTRAPOLATED)
- - - - APPROXIMATE LATERAL EXTENT OF NO. 1 SANDSTONE
(? WHERE EXTRAPOLATED)

LABORATORY AND VALIDATION QUALIFIERS ARE PRESENTED ON FIGURE 2.6-1.

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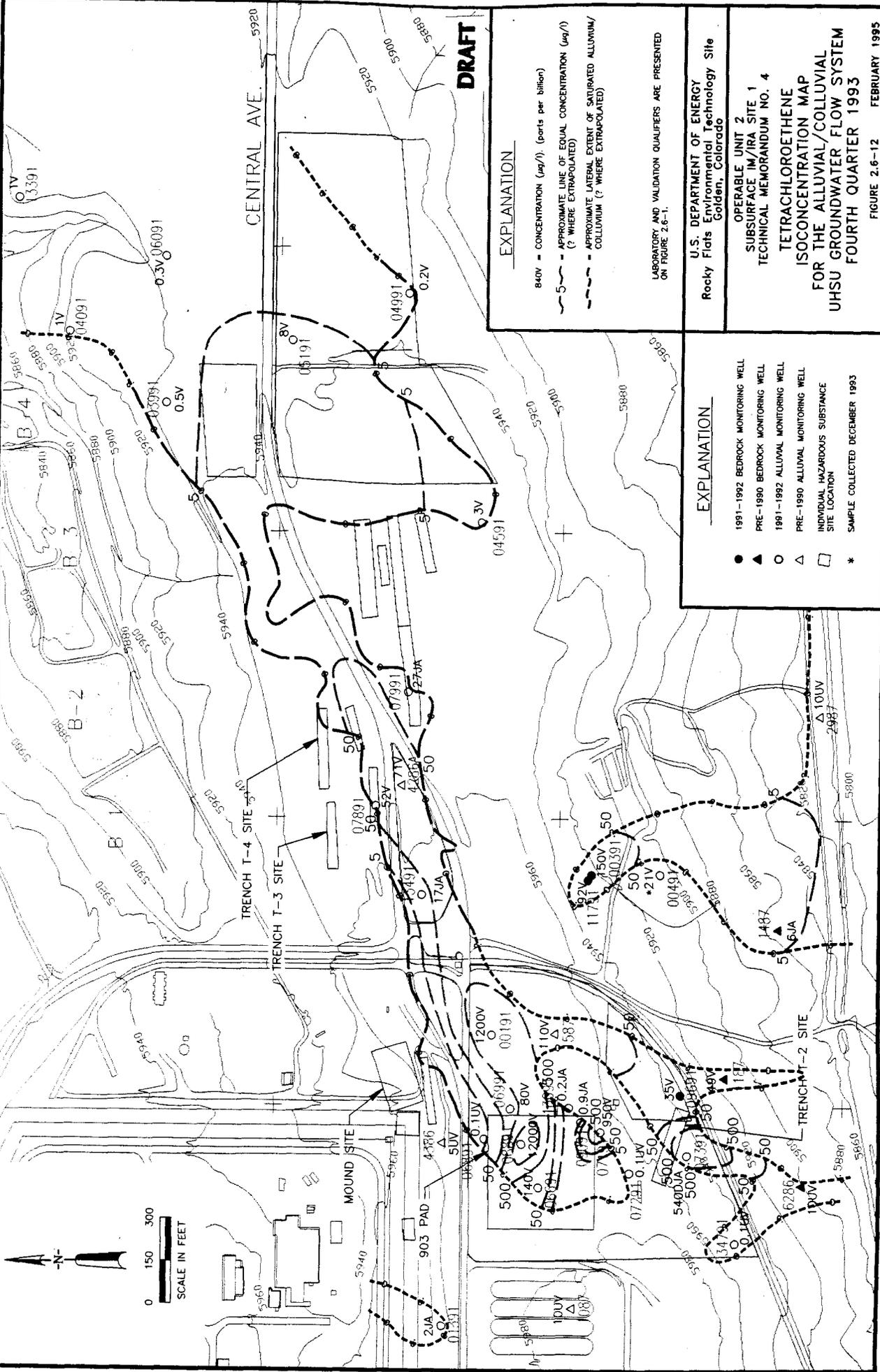
OPERABLE UNIT 2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4
CARBON TETRACHLORIDE
ISOCENTRATION MAP
FOR THE NO. 1 SANDSTONE
UHSU GROUNDWATER FLOW SYSTEM
FOURTH QUARTER 1993

FIGURE 2.6-9 FEBRUARY 1995

EXPLANATION

- 1991-1992 BEDROCK MONITORING WELL
- ▲ PRE-1990 BEDROCK MONITORING WELL
- 1991-1992 ALLUVIAL MONITORING WELL
- △ PRE-1990 ALLUVIAL MONITORING WELL
- INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION

SVETM004 11-00



DRAFT

EXPLANATION

- 840V - CONCENTRATION (µg/l). (parts per billion)
- - APPROXIMATE LINE OF EQUAL CONCENTRATION (µg/l) (? WHERE EXTRAPOLATED)
- - - APPROXIMATE LATERAL EXTENT OF SATURATED ALLUVIUM/COLLUVIUM (? WHERE EXTRAPOLATED)

LABORATORY AND VALIDATION QUALIFIERS ARE PRESENTED ON FIGURE 2.6-1.

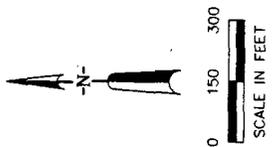
U.S. DEPARTMENT OF ENERGY
 Rocky Flats Environmental Technology Site
 Golden, Colorado

OPERABLE UNIT 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4
**TETRACHLOROETHENE
 ISOCONCENTRATION MAP
 FOR THE ALLUVIAL/COLLUVIAL
 UHSU GROUNDWATER FLOW SYSTEM
 FOURTH QUARTER 1993**

FIGURE 2.6-12 FEBRUARY 1995
 SITEM010 1a-300

EXPLANATION

- 1991-1992 BEDROCK MONITORING WELL
- ▲ PRE-1990 BEDROCK MONITORING WELL
- 1991-1992 ALLUVIAL MONITORING WELL
- △ PRE-1990 ALLUVIAL MONITORING WELL
- INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
- * SAMPLE COLLECTED DECEMBER 1993



TRENCH T-4 SITE

TRENCH T-3 SITE

MOUND SITE

903 PAD

TRENCH T-2 SITE

4376

50V

20.1UV

00191

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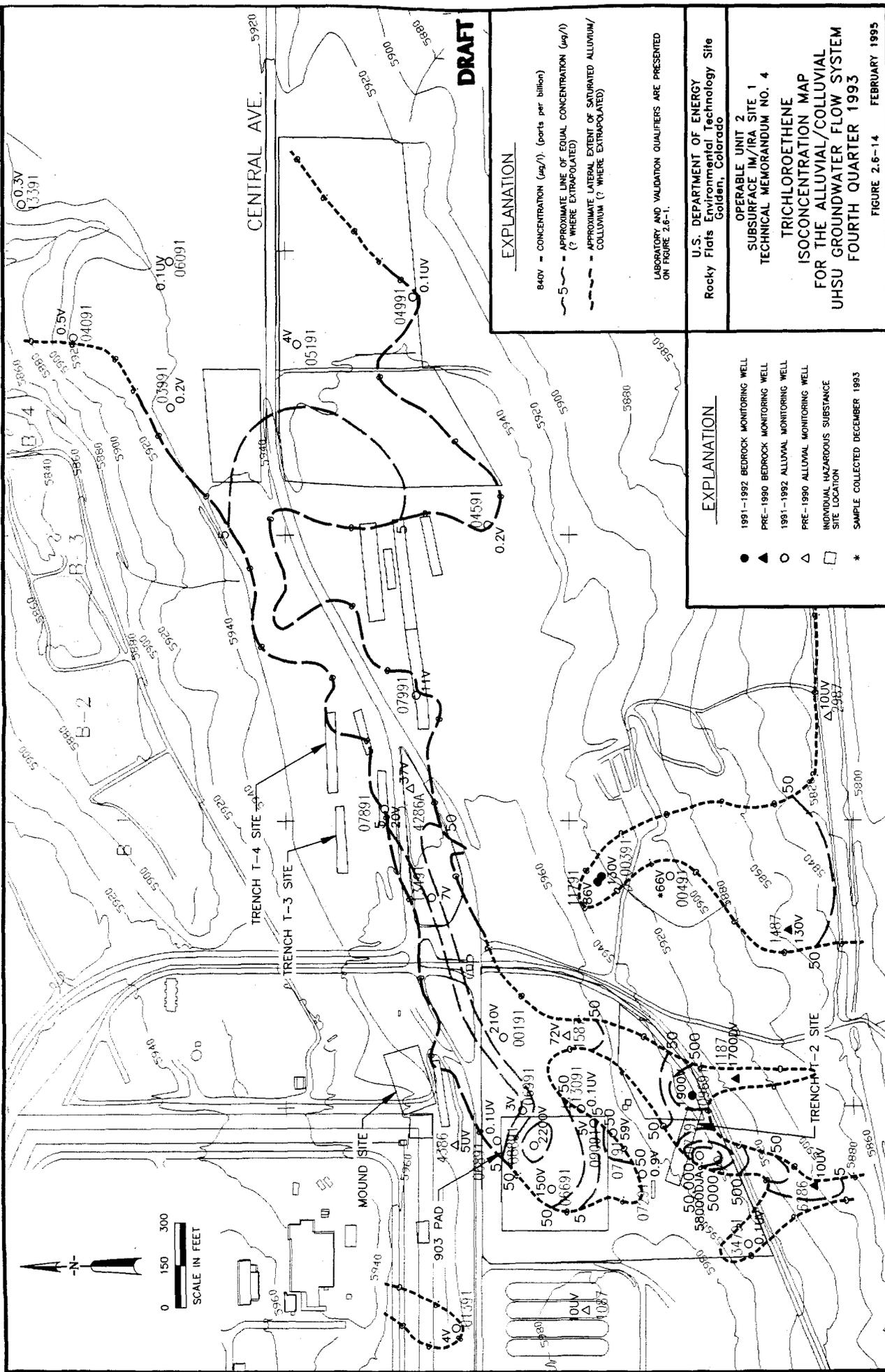
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DRAFT

EXPLANATION

- 840V - CONCENTRATION ($\mu\text{g/l}$) (parts per billion)
- - APPROXIMATE LINE OF EQUAL CONCENTRATION ($\mu\text{g/l}$)
(? WHERE EXTRAPOLATED)
- - - APPROXIMATE LATERAL EXTENT OF SATURATED ALLUVIUM/
COLLUVIUM (? WHERE EXTRAPOLATED)

LABORATORY AND VALIDATION QUALIFIERS ARE PRESENTED
ON FIGURE 2.6-1.

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado

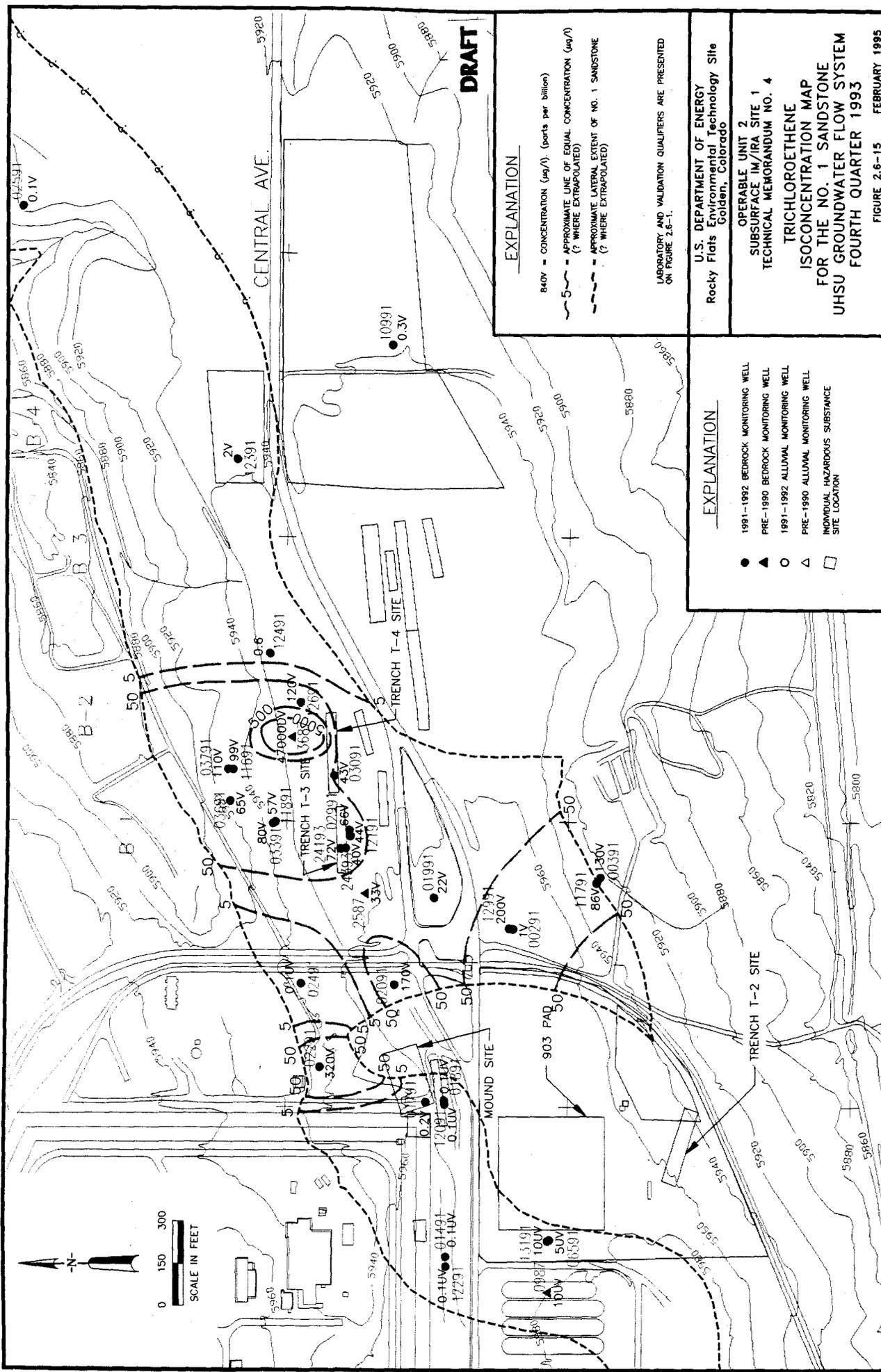
OPERABLE UNIT 2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4
**TRICHLOROETHENE
ISOCONCENTRATION MAP
FOR THE ALLUVIAL/COLLUVIAL
UHSU GROUNDWATER FLOW SYSTEM
FOURTH QUARTER 1993**

FIGURE 2.6-14 FEBRUARY 1995
SFTM011 1-500

EXPLANATION

- 1991-1992 BEDROCK MONITORING WELL
- ▲ PRE-1990 BEDROCK MONITORING WELL
- 1991-1992 ALLUVIAL MONITORING WELL
- △ PRE-1990 ALLUVIAL MONITORING WELL
- INDIVIDUAL HAZARDOUS SUBSTANCE
SITE LOCATION
- * SAMPLE COLLECTED DECEMBER 1993

0 150 300
SCALE IN FEET



DRAFT

EXPLANATION

- 840V - CONCENTRATION (µg/l). (parts per billion)
 - 5 - APPROXIMATE LINE OF EQUAL CONCENTRATION (µg/l) (? WHERE EXTRAPOLATED)
 - - - APPROXIMATE LATERAL EXTENT OF NO. 1 SANDSTONE (? WHERE EXTRAPOLATED)
- LABORATORY AND VALIDATION QUALIFIERS ARE PRESENTED ON FIGURE 2.6-1.

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado

OPERABLE UNIT 2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4
TRICHLOROETHENE
ISOCONCENTRATION MAP
FOR THE NO. 1 SANDSTONE
UHSU GROUNDWATER FLOW SYSTEM
FOURTH QUARTER 1993

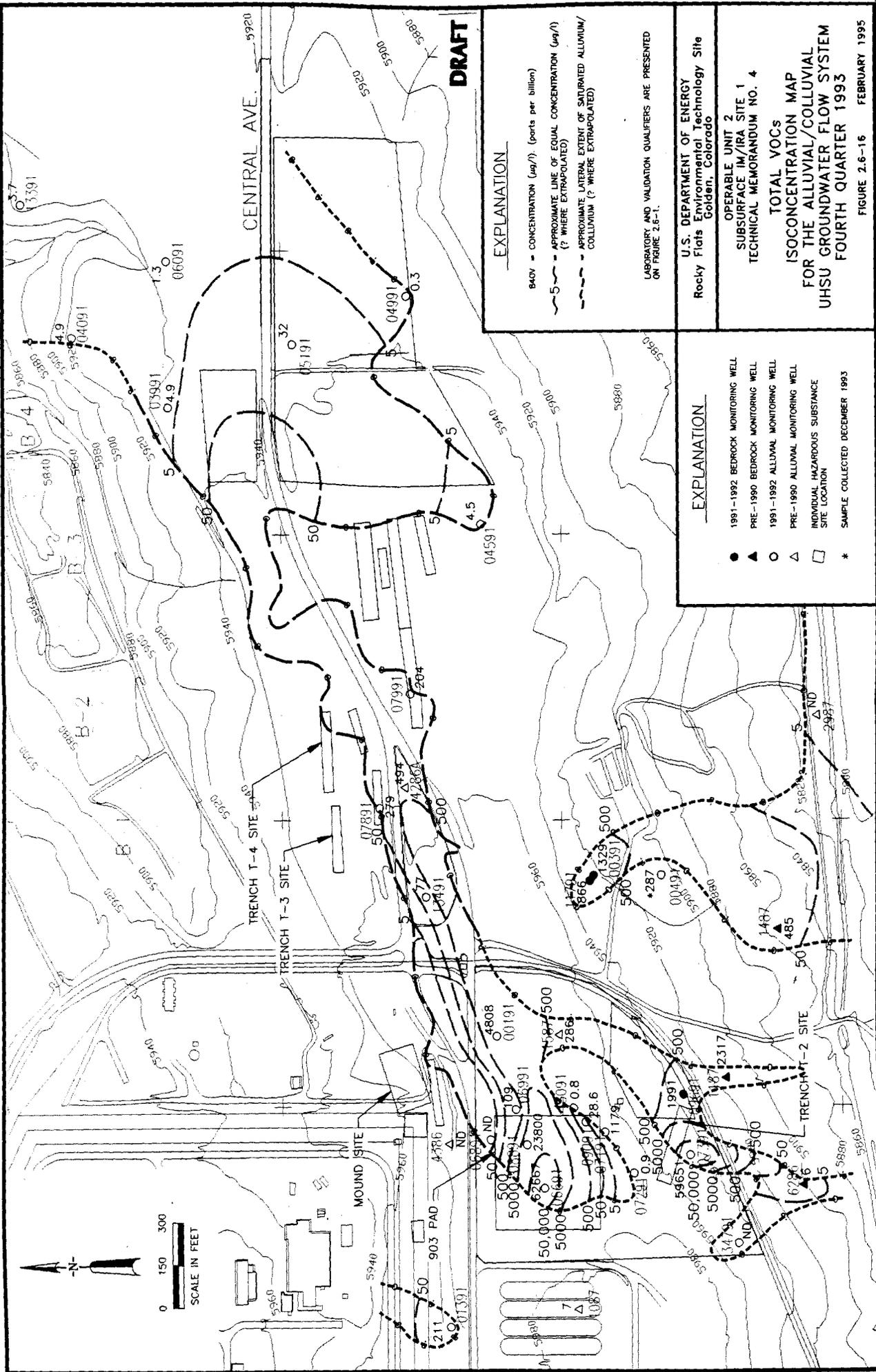
FIGURE 2.6-15 FEBRUARY 1995

SYM006 1-300

EXPLANATION

- 1991-1992 BEDROCK MONITORING WELL
- ▲ PRE-1990 BEDROCK MONITORING WELL
- 1991-1992 ALLUVIAL MONITORING WELL
- △ PRE-1990 ALLUVIAL MONITORING WELL
- INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION





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EXPLANATION

- 840Y - CONCENTRATION ($\mu\text{g/l}$) (parts per billion)
- - - - - APPROXIMATE LINE OF EQUAL CONCENTRATION ($\mu\text{g/l}$)
(? WHERE EXTRAPOLATED)
- - - - - APPROXIMATE LATERAL EXTENT OF SATURATED ALLUVIUM/
COLLUVIUM (? WHERE EXTRAPOLATED)

LABORATORY AND VALIDATION QUALIFIERS ARE PRESENTED
ON FIGURE 2.6-1.

U.S. DEPARTMENT OF ENERGY
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OPERABLE UNIT 2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4

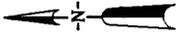
**TOTAL VOCs
ISOCONCENTRATION MAP
FOR THE ALLUVIAL/COLLUVIAL
UHSU GROUNDWATER FLOW SYSTEM
FOURTH QUARTER 1993**

FIGURE 2.6-16 FEBRUARY 1995

EXPLANATION

- 1991-1992 BEDROCK MONITORING WELL
- ▲ PRE-1990 BEDROCK MONITORING WELL
- 1991-1992 ALLUVIAL MONITORING WELL
- △ PRE-1990 ALLUVIAL MONITORING WELL
- INDIVIDUAL HAZARDOUS SUBSTANCE
SITE LOCATION
- * SAMPLE COLLECTED DECEMBER 1993

SVCTM012 1-300



EXPLANATION

10-1
+
Soil Vapor Survey
Sampling Locations
CCI₄ (ug/L)

5 FOOT SAMPLE DEPTH

0374
▲
Boreholes

Edge of Road

○—○
Fence

Drainage

Contour Interval = 20 ug/L

NOTE: THE CONTOURS HAVE
BEEN COMPUTER GENERATED
FROM A LIMITED NUMBER
OF POINTS AND MAY NOT
REPRESENT ACTUAL FIELD
CONCENTRATIONS.

10 0 10 20 FEET



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SUBSURFACE IM/IRA SITE, 1
TECHNICAL MEMORANDUM NO. 4

IHSS 110 CARBON TETRACHLORIDE (CCI₄)
SOIL GAS ISOCENTRATION
CONTOUR MAP AT 5 FOOT DEPTH

FIGURE 2.6-18 FEBRUARY 1995

SKEM029 1-1

0220189
▲
0374

0474
▲

02891
▲

02791
▲

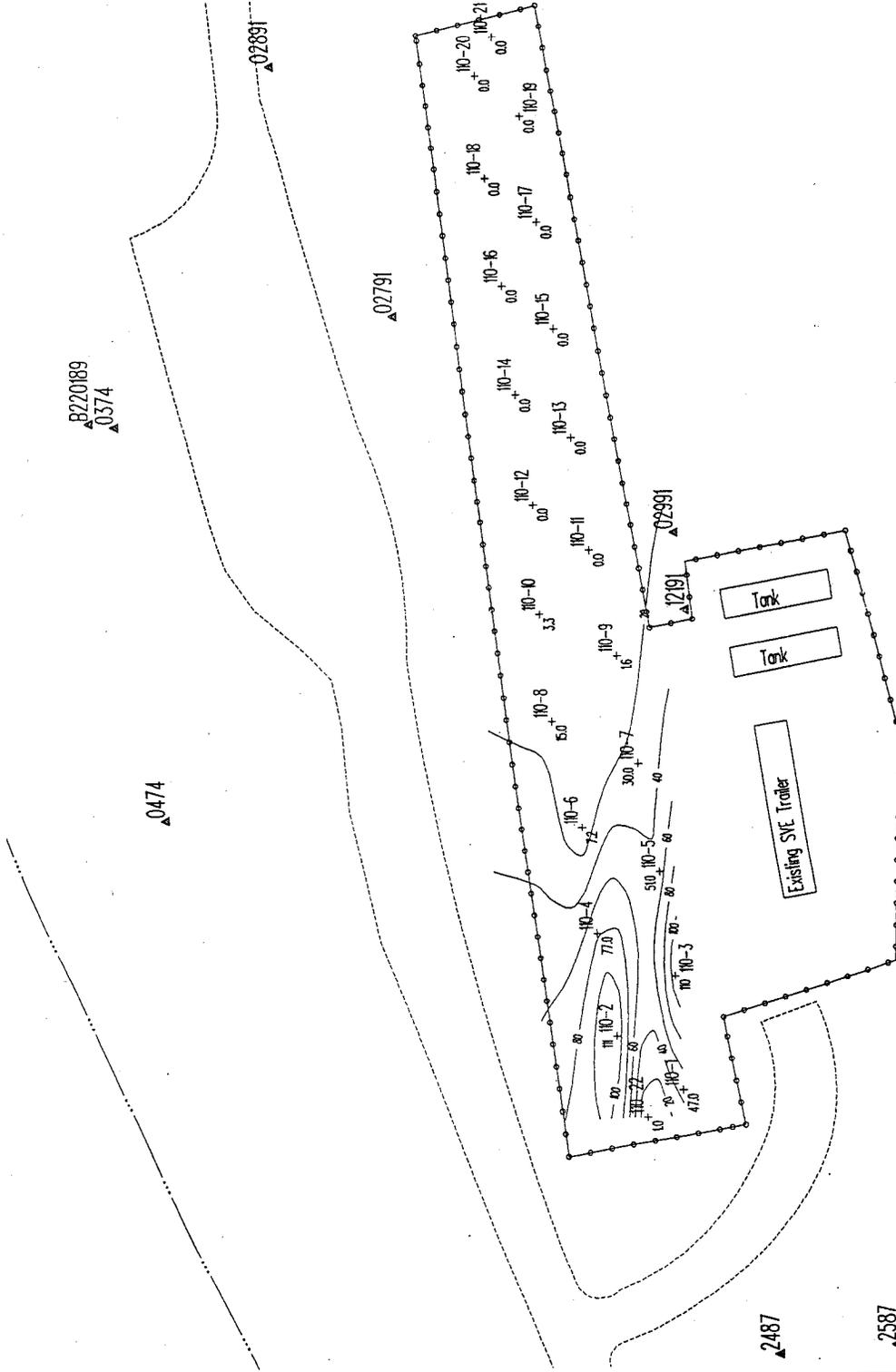
02991
▲

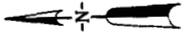
12191
▲

2487
▲

2587
▲

SOURCE:
DRAFT SUBSURFACE INTERIM MEASURES/INTERIM REMEDIAL
ACTION SOIL VAPOR EXTRACTION PILOT TEST PLAN, TEST
SITE NO. 2, ENHANCED VAPOR EXTRACTION OF ORGANIC
COMPOUNDS WITH SIX-PHASE SOIL HEATING, OPERABLE
UNIT NO. 2, EAST TRENCHES AREA (DOE, JULY 6, 1994)





EXPLANATION

10-1
+
00
Soil Vapor Survey
Sampling Locations
PCE, (ug/L)

5 FOOT SAMPLE DEPTH

0374
▲
Boreholes

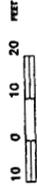
Edge of Road

—○—
Fence

Drainage

Contour Interval = 50 ug/L

NOTE: THE CONTOURS HAVE
BEEN COMPUTER GENERATED
FROM A LIMITED NUMBER
OF POINTS AND MAY NOT
REPRESENT ACTUAL FIELD
CONCENTRATIONS.



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IHSS-110 TETRACHLOROETHENE (PCE)
SOIL GAS ISOCONCENTRATION
CONTOUR MAP AT 5 FOOT DEPTH

FIGURE 2.6-19 FEBRUARY 1995
S/ETM027 1-1

B220189
▲
0374

▲
0474

▲
02891

▲
02791

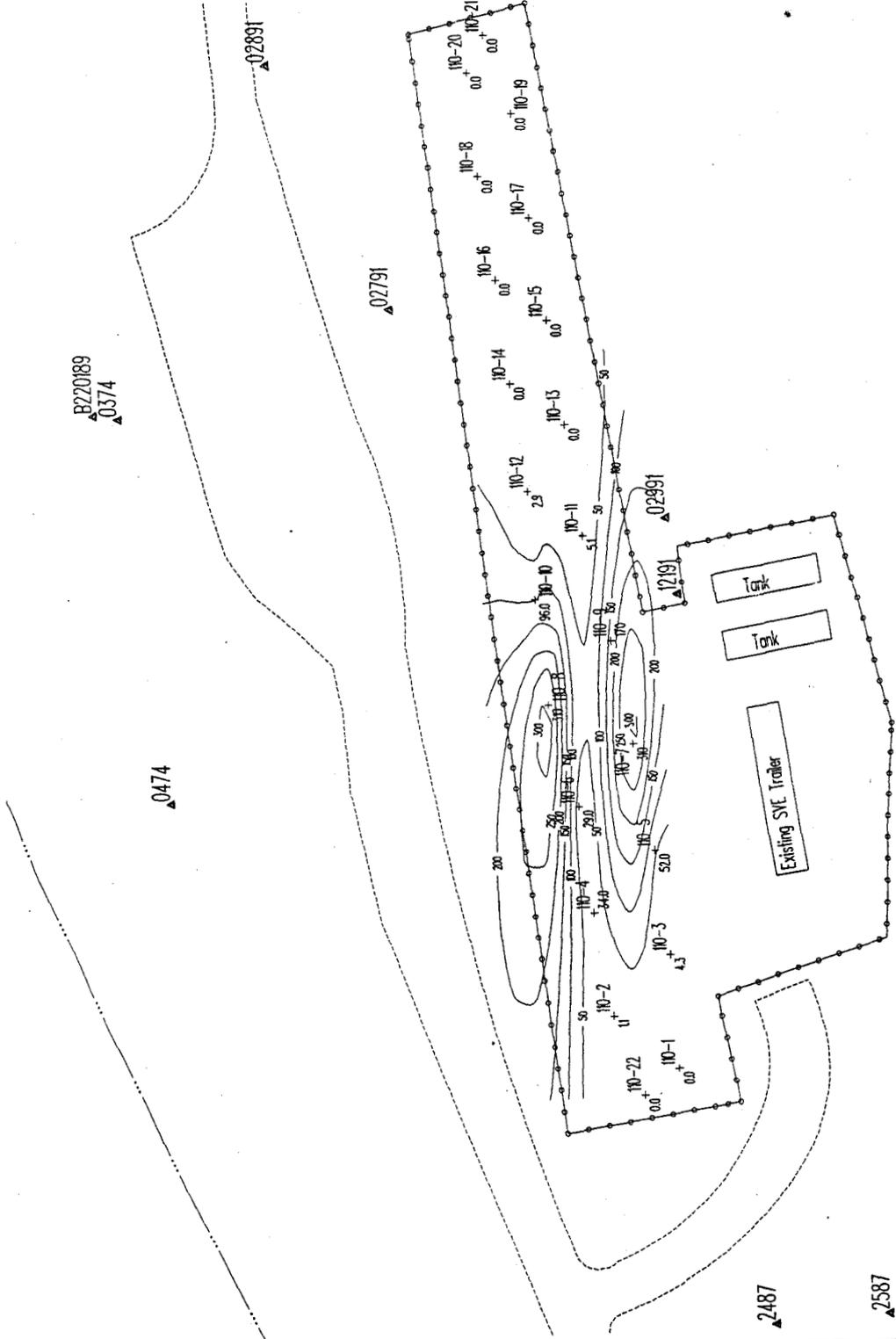
▲
02991

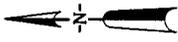
▲
02191

▲
2487

▲
2587

SOURCE:
DRAFT SUBSURFACE INTERIM MEASURES/INTERIM REMEDIAL
ACTION SOIL VAPOR EXTRACTION PILOT TEST PLAN, TEST
SITE NO. 2, ENHANCED VAPOR EXTRACTION OF ORGANIC
COMPOUNDS WITH SIX-PHASE SOIL HEATING, OPERABLE
UNIT NO. 2, EAST TRENCHES AREA (DOE, JULY 6, 1994)





EXPLANATION

- 10-1
+
0.0 Soil Vapor Survey Sampling Locations TCE, (ug/L)
- 5 FOOT SAMPLE DEPTH
- 0374
▲ Boreholes
- Edge of Road
- Fence
- Drainage
- Contour interval = 4 ug/L

NOTE: THE CONTOURS HAVE BEEN COMPUTER GENERATED FROM A LIMITED NUMBER OF POINTS AND MAY NOT REPRESENT ACTUAL FIELD CONCENTRATIONS.



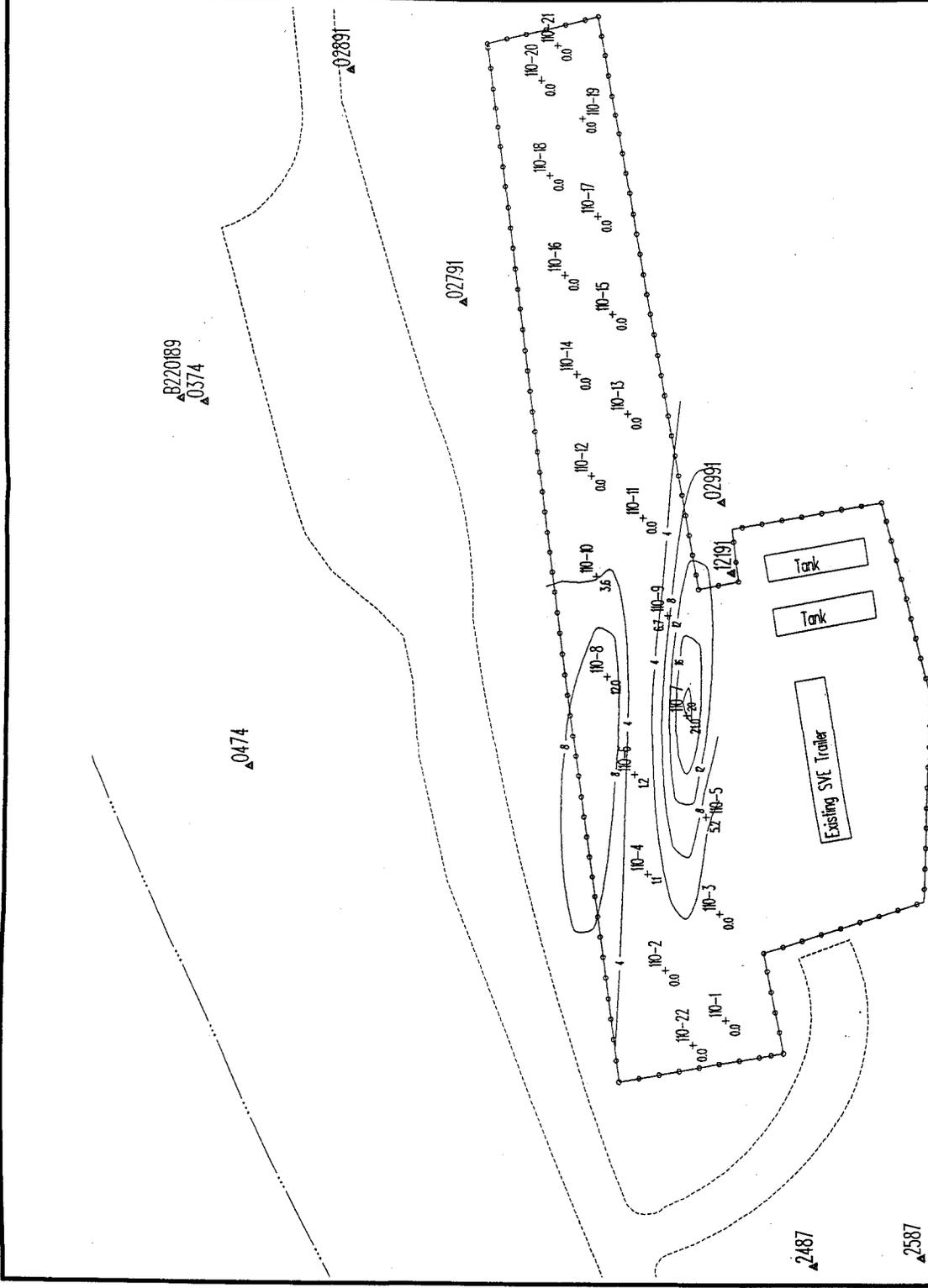
DRAFT

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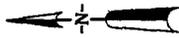
OPERABLE UNIT NO. 2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4

IHSS 110 TRICHLOROETHENE (TCE)
SOIL GAS ISOCONCENTRATION
CONTOUR MAP AT 5 FOOT DEPTH

FIGURE 2.6-20 FEBRUARY 1995
SVETW028 1-1



SOURCE:
DRAFT SUBSURFACE INTERIM MEASURES/INTERIM REMEDIAL ACTION SOIL VAPOR EXTRACTION PILOT TEST PLAN, TEST SITE NO. 2, ENHANCED VAPOR EXTRACTION OF ORGANIC COMPOUNDS WITH SIX-PHASE SOIL HEATING, OPERABLE UNIT NO. 2, EAST TRENCHES AREA (DOE, JULY 6, 1994)



EXPLANATION

10-1
+
0.0
Soil Vapor Survey
Sampling Locations
Total VOCs, (ug/L)

5 FOOT SAMPLE DEPTH

0374
▲
Boreholes

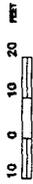
Edge of Road

Fence

Drainage

Contour Interval = 100 ug/L

NOTE: THE CONTOURS HAVE
BEEN COMPUTER GENERATED
FROM MINED DATA AND
POINTS AND MAY NOT
REPRESENT ACTUAL FIELD
CONCENTRATIONS.



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OPERABLE UNIT NO. 2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4

IHSS 110 TOTAL VOCs
SOIL GAS ISOCONCENTRATION
CONTOUR MAP AT 5 FOOT DEPTH

FIGURE 2.6-21 FEBRUARY 1995
SKETCH 1-1

822089
▲
0374

0474
▲

02791
▲

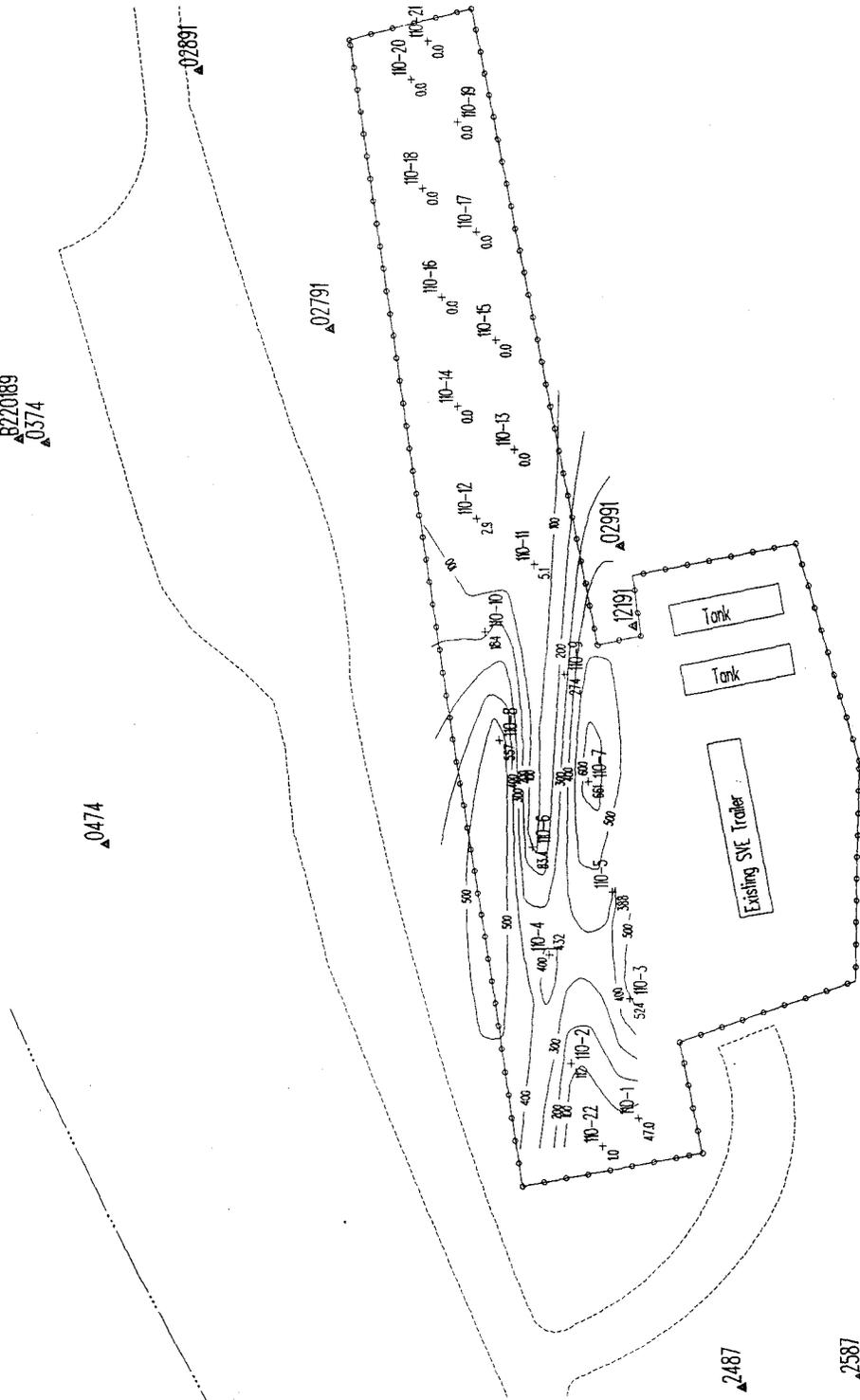
02991
▲

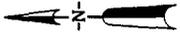
02991
▲

2487
▲

2587
▲

SOURCE:
DRAFT SUBSURFACE INTERIM MEASURES/INTERIM REMEDIAL
ACTION SOIL VAPOR EXTRACTION PILOT TEST PLAN, TEST
SITE NO. 2, ENHANCED VAPOR EXTRACTION OF ORGANIC
COMPOUNDS WITH SIX-PHASE SOIL HEATING, OPERABLE
UNIT NO. 2, EAST TRENCHES AREA (DOE, JULY 6, 1994)





EXPLANATION

0.0 10-23 Soil Vapor Survey Sampling Locations PCE, (ug/L)

10 FOOT SAMPLE DEPTH

△ 0374 Boreholes

--- Edge of Road

○—○ Fence

--- Drainage

Contour Interval = 150 ug/L

NOTE: THE CONTOURS HAVE BEEN COMPUTER GENERATED FROM A LIMITED NUMBER OF POINTS AND MAY NOT REPRESENT ACTUAL FIELD CONCENTRATIONS.



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OPERABLE UNIT NO.2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4

IHSS 110 TETRACHLOROETHENE (PCE)
SOIL GAS ISOCENTRATION
CONTOUR MAP AT 10 FOOT DEPTH

FIGURE 2.6-23 FEBRUARY 1995

SHEET NO. 1-1

△ B220189
△ 0374

△ 0474

△ 02891

△ 02791

0.7 10-24

1.5 10-25

△ 02991

△ 12191

Tank

Tank

0.0 10-26

0.5 10-26

1.0 10-26

1.5 10-26

2.0 10-26

2.5 10-26

3.0 10-26

3.5 10-26

4.0 10-26

4.5 10-26

5.0 10-26

5.5 10-26

6.0 10-26

6.5 10-26

7.0 10-26

7.5 10-26

8.0 10-26

8.5 10-26

9.0 10-26

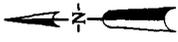
9.5 10-26

10.0 10-26

△ 2487

△ 2587

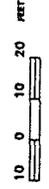
SOURCE:
DRAFT SUBSURFACE INTERIM MEASURES/INTERIM REMEDIAL ACTION SOIL VAPOR EXTRACTION PILOT TEST PLAN, TEST SITE NO. 2, ENHANCED VAPOR EXTRACTION OF ORGANIC COMPOUNDS WITH SIX-PHASE SOIL HEATING, OPERABLE UNIT NO. 2, EAST TRENCHES AREA (DOE, JULY 6, 1994)



EXPLANATION

- 00 10-23 Soil Vapor Survey Sampling Locations TCE, ug/L
- 10 FOOT SAMPLE DEPTH
- 0374 Boreholes
- Edge of Road
- Fence
- Drainage
- Contour Interval = 3 ug/L

NOTE: THE CONTOURS HAVE BEEN COMPUTER GENERATED FROM A LIMITED NUMBER OF POINTS AND MAY NOT REPRESENT ACTUAL FIELD CONCENTRATIONS.



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OPERABLE UNIT NO. 2
SUBSURFACE IM/IRA, SITE 1
TECHNICAL MEMORANDUM NO. 4

IHSS 110 TRICHLOROETHENE (TCE)
SOIL GAS ISOCONCENTRATION
CONTOUR MAP AT 10 FOOT DEPTH

FIGURE 2.6-24 FEBRUARY 1995
SHEEPMOST 1-1

8220189
0374

0474

02891

02791

72 10-25

00 10-26

00 10-24

02991

12191

Tank

Tank

10-28

10-27

10-23

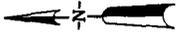
10-29

Existing SVE Trench

2487

2587

SOURCE:
DRAFT SUBSURFACE INTERIM MEASURES/INTERIM REMEDIAL ACTION SOIL VAPOR EXTRACTION PILOT TEST PLAN, TEST SITE NO. 2, ENHANCED VAPOR EXTRACTION OF ORGANIC COMPOUNDS WITH SIX-PHASE SOIL HEATING, OPERABLE UNIT NO. 2, EAST TRENCHES AREA (DOE, JULY 6, 1994)



EXPLANATION

00 10-23
+ Soil Vapor Survey
Sampling Locations
TOTAL VOCs, (ug/L)

10 FOOT SAMPLE DEPTH

▲ 0374
Boreholes

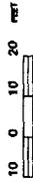
----- Edge of Road

○-○-○ Fence

--- Drainage

Contour Interval = 200 ug/L

NOTE: THE CONTOURS HAVE
BEEN COMPUTER GENERATED
FROM A LIMITED NUMBER
OF DATA POINTS. THE DATA
POINTS REPRESENT ACTUAL FIELD
CONCENTRATIONS.



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OPERABLE UNIT NO. 2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4

IHSS 110 TOTAL VOCs
SOIL GAS ISOCONCENTRATION
CONTOUR MAP AT 10 FOOT DEPTH

FIGURE 2.6-25 FEBRUARY 1995
SKETCH 1-1

▲ B220189
▲ 0374

▲ 0474

▲ 02891

▲ 0791

▲ 21 10-24

▲ 62 10-25

▲ 35 10-26

▲ 10-23

▲ 10-20

▲ 10-21

▲ 02991

▲ 12191

▲ 10-28

▲ 93 10-27

▲ 2487

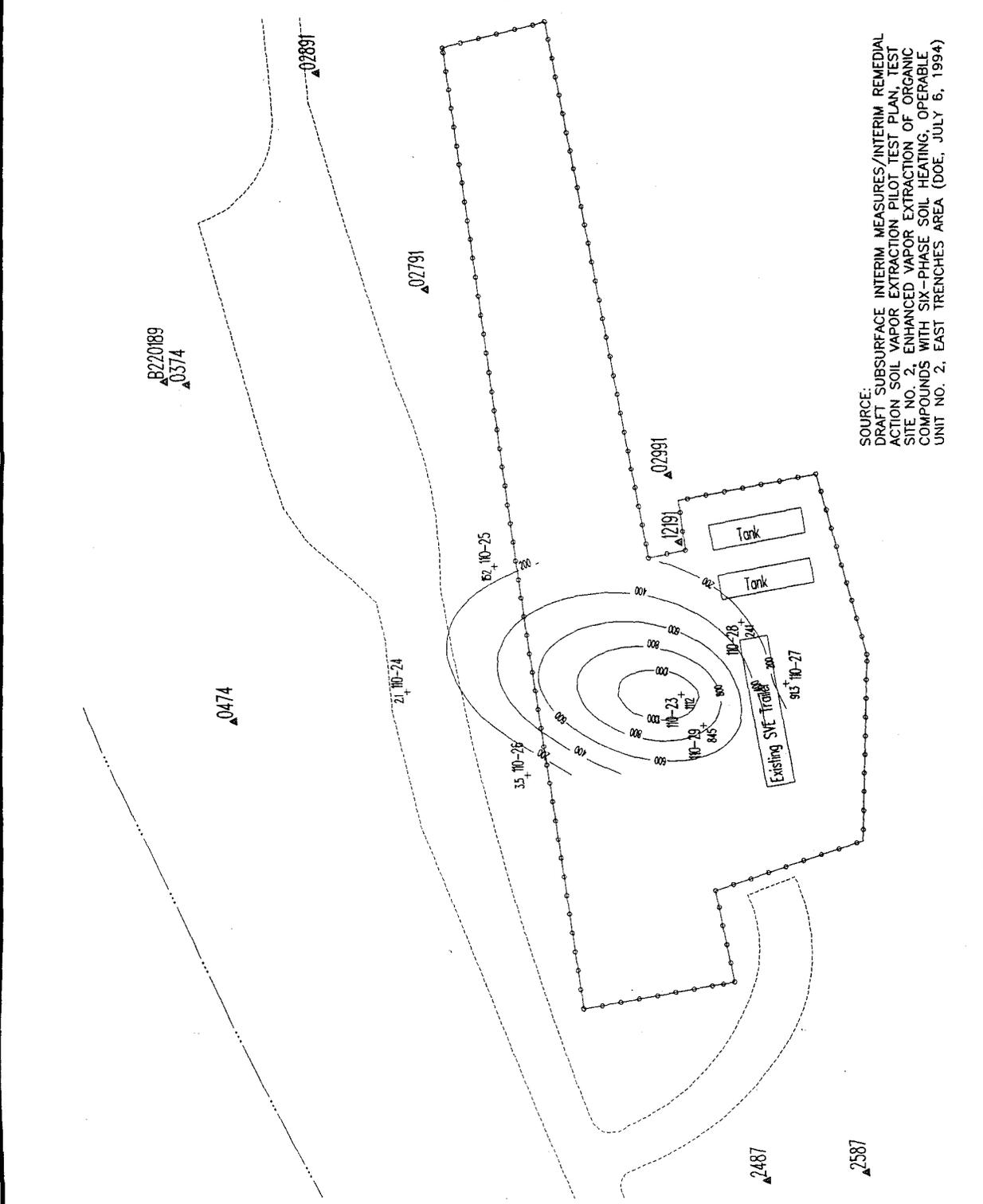
▲ 2587

SOURCE:
DRAFT SUBSURFACE INTERIM MEASURES/INTERIM REMEDIAL
ACTION SOIL VAPOR EXTRACTION PILOT TEST PLAN, TEST
SITE NO. 2, ENHANCED VAPOR EXTRACTION OF ORGANIC
COMPOUNDS WITH SIX-PHASE SOIL HEATING, OPERABLE
UNIT NO. 2, EAST TRENCHES AREA (DOE, JULY 6, 1994)

Tank

Tank

Existing SVF Trailer



FLOATING LAYER (LNAPL)

DETECTED VOC ANALYTE	CONCENTRATION (ug/kg)(1)	DETECTED SVOC ANALYTE	CONCENTRATION (ug/kg)(1)	DETECTED TPH ANALYTE	CONCENTRATION (mg/kg)(1)	RADIONUCLIDE SCREEN ANALYTE(2)	ACTIVITY (pci/L)
ACETONE 1,1-DCE METHYLENE CHLORIDE 1,1-DCA CHCl ₃ 1,1,1-TCA TCE TOLUENE PCE ETHYLBENZENE M,P-XYLENE O-XYLENE	3,100 260 310 1,100 5,500 18,000 7,100,000E 1,200 37,000,000E 920 8,200 2,200	2-METHYLPHENOL 4-METHYLPHENOL NAPHTHALENE 2-METHYLNAPHTHALENE N-NITROSODIPHENYLAMINE PHENANTHRENE ANTHRACENE DI-N-BUTYLPHTHALATE BIS(2-ETHYLHEXYL)PHTHALATE	20,000 74,000 220,000 450,000 380,000 200,000 190,000 120,000 310,000	GASOLINE(3) DIESEL(4)	170,000 370,000	GROSS BETA GROSS ALPHA	803,000 749,000

AQUEOUS LAYER

DETECTED VOC ANALYTE	CONCENTRATION (ug/L)	DETECTED SVOC ANALYTE	CONCENTRATION (ug/L)	DETECTED TPH ANALYTE	CONCENTRATION (mg/L)	RADIONUCLIDE SCREEN ANALYTE(2)	ACTIVITY (pci/L)
ACETONE METHYLENE CHLORIDE 1,1-DCA 2-BUTANONE CHCl ₃ 1,1,1-TCA TCE PCE ETHYLBENZENE M,P-XYLENE O-XYLENE	52,000 57 92 650 420 420 97,000 650,000 24 240 84	2-METHYLPHENOL 4-METHYLPHENOL 2-METHYLNAPHTHALENE PHENANTHRENE DI-N-BUTYLPHTHALATE BIS(2-ETHYLHEXYL)PHTHALATE	14,000E 9,500E 100 530 620 870	GASOLINE(3) DIESEL(4)	1,900 3,700	GROSS BETA GROSS ALPHA	803,000 749,000

SINKING LAYER (DNAPL)

DNAPL LAYER DISSOLVED DURING SHIPMENT TO LABORATORY

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- (1) DUE TO ELEVATED CONCENTRATIONS, RESULTS WERE REPORTED IN MASS UNITS (ie.,ug/kg) INSTEAD OF LIQUID UNITS (ie., ug/L).
- (2) ONE RADIONUCLIDE SCREEN WAS PERFORMED PRIOR TO SHIPMENT ON THE FLOATING, OIL AND WATER LAYERS.
- (3) GASOLINE RANGE ORGANICS (C₆ THROUGH C₁₂).
- (4) DIESEL RANGE ORGANICS (C₁₂ THROUGH C₂₄).

EXPLANATION

ug/kg = MICROGRAM PER KILOGRAM (PARTS PER BILLION)
 mg/kg = MILLIGRAM PER KILOGRAM (PARTS PER MILLION)
 ug/L = MICROGRAM PER LITER (PARTS PER MILLION)
 mg/L = MILLIGRAM PER LITER (PARTS PER MILLION)
 pci/L = PICO-CURIE PER LITER (PARTS PER MILLION)
 LNAPL = LIGHT NON-AQUEOUS PHASE LIQUID
 DNAPL = DENSE NON-AQUEOUS PHASE LIQUID
 VOC = VOLATILE ORGANIC COMPOUND
 SVOC = SEMI-VOLATILE ORGANIC COMPOUND
 TPH = TOTAL PETROLEUM HYDROCARBON

NOTE: ANALYTE ABBREVIATIONS ARE PRESENTED ON FIGURE 2.6-1

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OPERABLE UNIT 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

SUMMARY OF ANALYTICAL RESULTS FOR
 LIQUIDS COLLECTED FROM BOREHOLE 25194
 IN NOVEMBER 1994

FIGURE 2.6-26 FEBRUARY 1995
 SYEM068 1-1

FLOATING LAYER (1) (LNAPL 1)

DETECTED VOC ANALYTE	CONCENTRATION (ug/kg)(4)	DETECTED SVOC ANALYTE	CONCENTRATION (ug/L)	DETECTED TPH ANALYTE	CONCENTRATION (mg/L)	RADIONUCLIDE SCREEN ANALYTE	ACTIVITY (pCi/L)	SELECTED RADIONUCLIDE	ACTIVITY (pCi/g)	SAMPLE NUMBER
TCE	330,000	NAPHTHALENE	2,700	GASOLINE(6)	3,100	GROSS BETA	42,000	Am-241	NA	C0639
PCE	2,800,000	2-METHYLNAPHTHALENE	4,700	DIESEL(7)	4,000	GROSS ALPHA	19,400	Pu-239/240 U-233/234 U-235 U-238	NA NA NA NA	
		PHENANTHRENE	6,900							
		DI-N-BUTYLPHTHALATE	4,400							
		CHRYSENE	280							
		BIS(2-ETHYLHEXYL)PHTHALATE	20,000							

FLOATING LAYER (2) (LNAPL 2)

DETECTED VOC ANALYTE	CONCENTRATION (ug/kg)(4)	DETECTED SVOC ANALYTE	CONCENTRATION (ug/L)	DETECTED TPH ANALYTE	CONCENTRATION (mg/kg)(4)	RADIONUCLIDE SCREEN ANALYTE(5)	ACTIVITY (pCi/L)	SELECTED RADIONUCLIDE	ACTIVITY (pCi/g)	SAMPLE NUMBER
TCE	330,000	NAPHTHALENE	110,000	GASOLINE(6)	170,000	GROSS BETA	39,400	Am-241	0.008	C0640
PCE	2,800,000	2-METHYLNAPHTHALENE	380,000	DIESEL(7)	480,000	GROSS ALPHA	22,600	Pu-239/240 U-233/234 U-235 U-238	0.029 1.96 0.35 15.5	
		FLUORENE	26,000							
		PHENANTHRENE	140,000							
		DI-N-BUTYLPHTHALATE	85,000							
		BIS(2-ETHYLHEXYL)PHTHALATE	370,000							

AQUEOUS LAYER

DETECTED VOC ANALYTE	CONCENTRATION (ug/kg)(4)	DETECTED SVOC ANALYTE	CONCENTRATION (ug/L)	DETECTED TPH ANALYTE	CONCENTRATION (mg/L)	RADIONUCLIDE SCREEN ANALYTE(5)	ACTIVITY (pCi/L)	SELECTED RADIONUCLIDE	ACTIVITY (pCi/g)	SAMPLE NUMBER
TCE	330,000	PHENOL	1,000	GASOLINE(6)	1,700	GROSS BETA	39,400	Am-241	1.62	C0670
PCE	2,700,000	2-METHYLPHENOL	3,400	DIESEL(7)	2,500	GROSS ALPHA	22,600	Pu-239/240 U-233/234 U-235 U-238	1.16 398.0 101.0 3,240.0	
		4-METHYLPHENOL	26,000							
		2,4-DIMETHYLPHENOL	2,800							
		NAPHTHALENE	1,000							
		2-METHYLNAPHTHALENE	3,400							
		FLUORENE	420							
		PHENANTHRENE	2,500							
		DI-N-BUTYLPHTHALATE	1,400							
		CHRYSENE	110							
		BIS(2-ETHYLHEXYL)PHTHALATE	7,500							

SINKING LAYER (DNAPL)

NO SAMPLE WAS COLLECTED IN FIELD

- (1) FLOATING LAYER SEPARATED DURING SAMPLING (SAMPLE NUMBER C0639)
- (2) FLOATING LAYER SEPARATED AT LABORATORY (SAMPLE NUMBER C0640)
- (3) AQUEOUS LAYER SEPARATED AT LABORATORY (SAMPLE NUMBER C0670)
- (4) DUE TO ELEVATED CONCENTRATIONS, RESULTS WERE REPORTED IN MASS UNITS (ie., ug/kg) INSTEAD OF LIQUID UNITS (ie., ug/L).
- (5) ONE RADIONUCLIDE SCREEN WAS PERFORMED PRIOR TO SHIPMENT ON THE FLOATING(2) AND AQUEOUS LAYERS.
- (6) GASOLINE RANGE ORGANICS (C₆ THROUGH C₁₂).
- (7) DIESEL RANGE ORGANICS (C₁₂ THROUGH C₂₄).

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Golden, Colorado

OPERABLE UNIT 2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4

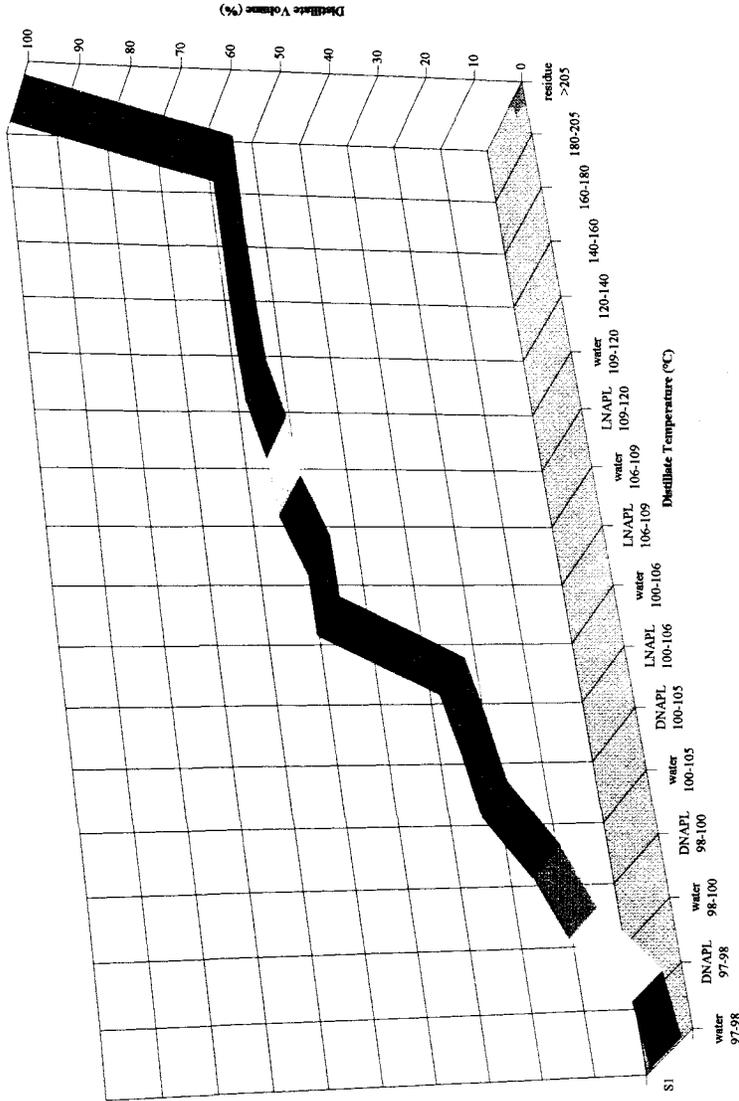
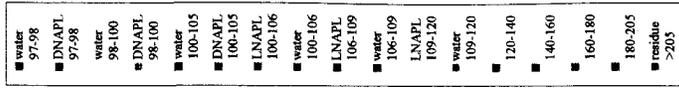
SUMMARY OF ANALYTICAL RESULTS FOR LIQUID
COLLECTED FROM EXTRACTION WELL 25194
IN DECEMBER 1994

EXPLANATION

ug/kg = MICROGRAM PER KILOGRAM (PARTS PER BILLION)
 mg/kg = MILLIGRAM PER KILOGRAM (PARTS PER MILLION)
 ug/L = MICROGRAM PER LITER (PARTS PER BILLION)
 mg/L = MILLIGRAM PER LITER (PARTS PER MILLION)
 pCi/L = PICOCURIE PER LITER
 pCi/g = PICOCURIE PER GRAM
 LNAPL = LIGHT NON-AQUEOUS PHASE LIQUID
 DNAPL = DENSE NON-AQUEOUS PHASE LIQUID
 VOC = VOLATILE ORGANIC COMPOUND
 SVOC = SEMI-VOLATILE ORGANIC COMPOUND
 TPH = TOTAL PETROLEUM HYDROCARBON
 NA = NOT AVAILABLE

NOTE: ANALYTE ABBREVIATIONS ARE PRESENTED ON FIGURE 2.6-1.

FIGURE 2.6-27
FEBRUARY 1995
STEM089 1-1



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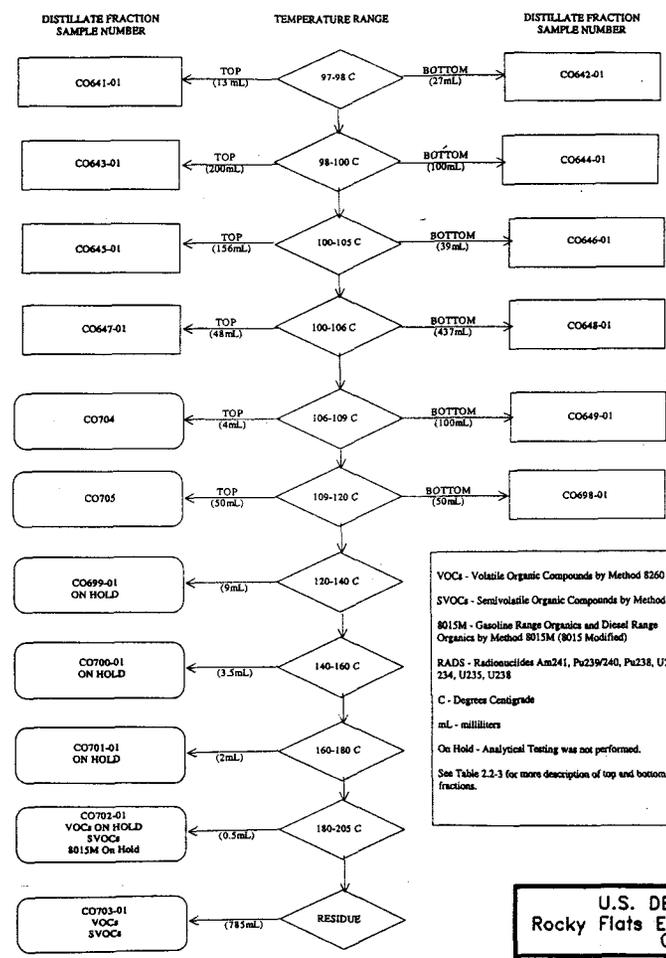
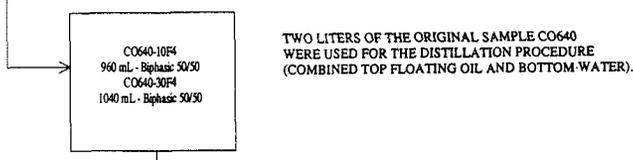
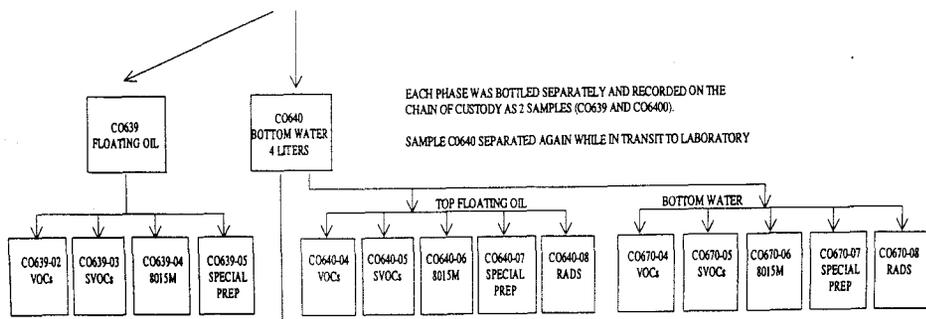
OPERABLE UNIT 2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4

DISTILLATE TEST
VOLUME VS. TEMPERATURE PLOT

FIGURE 2.6-28 FEBRUARY 1995
SVETM072 1-1

BIPHASIC 12-20-94 NAPL

THE ORIGINAL NAPL COLLECTED 12-20-94 WAS BIPHASIC



VOCs - Volatile Organic Compounds by Method 8260
 SVOCs - Semivolatile Organic Compounds by Method 8270
 8015M - Gasoline Range Organics and Diesel Range Organics by Method 8015M (8015 Modified)
 RADS - Radionuclides Am241, Pu239/240, Pu238, U235/234, U235, U238
 C - Degree Centigrade
 mL - milliliters
 On Hold - Analytical Testing was not performed.
 See Table 2.2-3 for more description of top and bottom fractions.

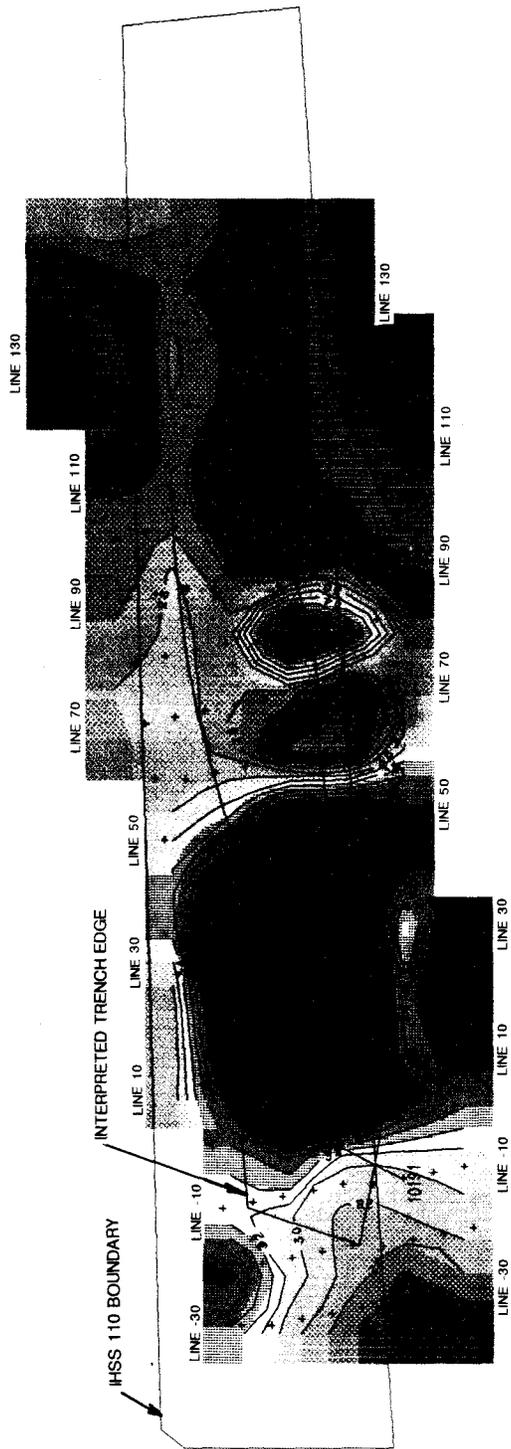
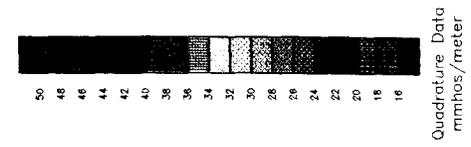
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SAMPLE NUMBERING SCHEME FOR
 DECEMBER NAPL AND DISTILLATE FRACTIONS

FIGURE 2.6-30 FEBRUARY 1995

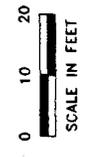


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CONTOUR INTERVAL = 2mmt/meter

EXPLANATION

- 10191 ○ SURFACE MONITORING WELL LOCATION
- 12191 ● SURFACE MONITORING WELL LOCATION
- 22193A ○ MONITORED MONITORING WELL LOCATION

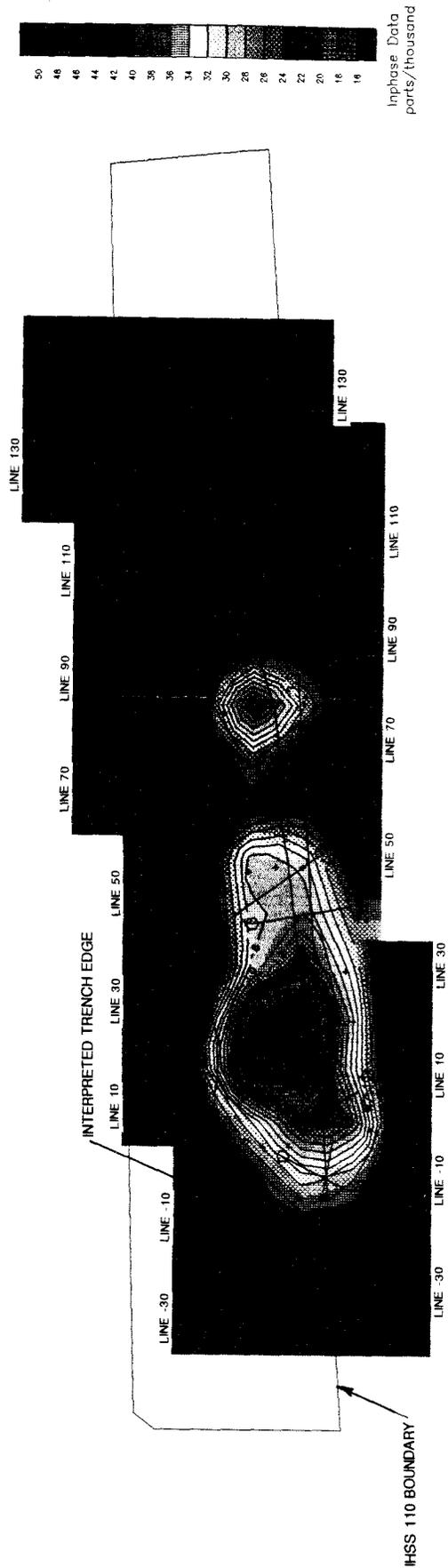


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ELECTROMAGNETICS CONTOUR MAP
EAST-WEST ORIENTATION
QUADRATURE DATA

FIGURE 2.7-1 FEBRUARY 1995



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CONTOUR INTERVAL = 2 PARTS/THOUSAND

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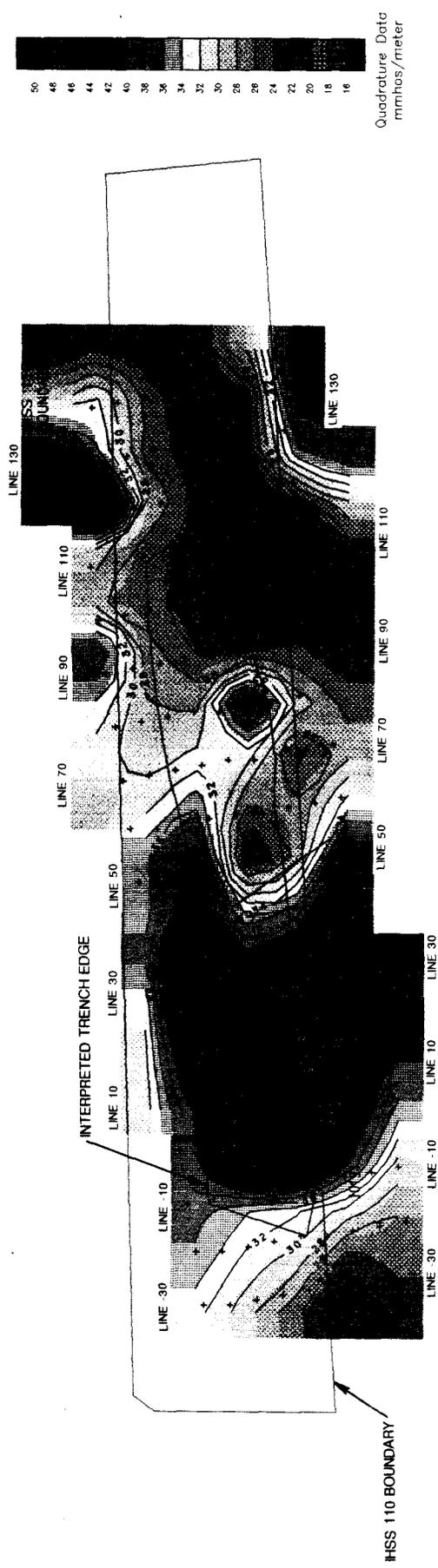
ELECTROMAGNETICS CONTOUR MAP
 EAST-WEST ORIENTATION
 INPHASE DATA

EXPLANATION

10191 ○ SOURCE MONITORING WELL LOCATION
 12191 ● SOURCE MONITORING WELL LOCATION
 2243A ○ REMEDIATION MONITORING WELL LOCATION



FIGURE 2.7.2 FEBRUARY 1995



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CONTOUR INTERVAL = 2mmt/mhos/meter

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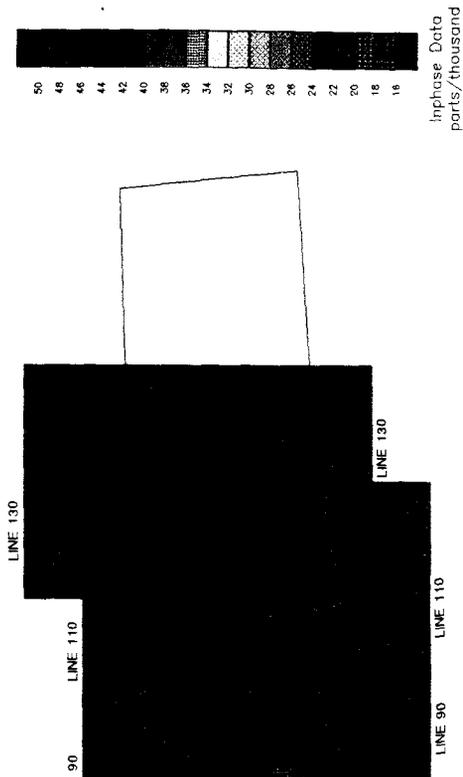
ELECTROMAGNETICS CONTOUR MAP
 NORTH-SOUTH ORIENTATION
 QUADRATURE DATA

EXPLANATION

10191 ○ SOURCE BOREHOLE LOCATION
 12191 ● SOURCE MONITORING WELL LOCATION
 22433A ○ AERIALBORNE MONITORING WELL LOCATION



FIGURE 2.7-3
 FEBRUARY 1995



IHSS 110 BOUNDARY

INTERPRETED TRENCH EDGE

Inphase Data
parts/thousand

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CONTOUR INTERVAL = 2 PARTS/THOUSAND

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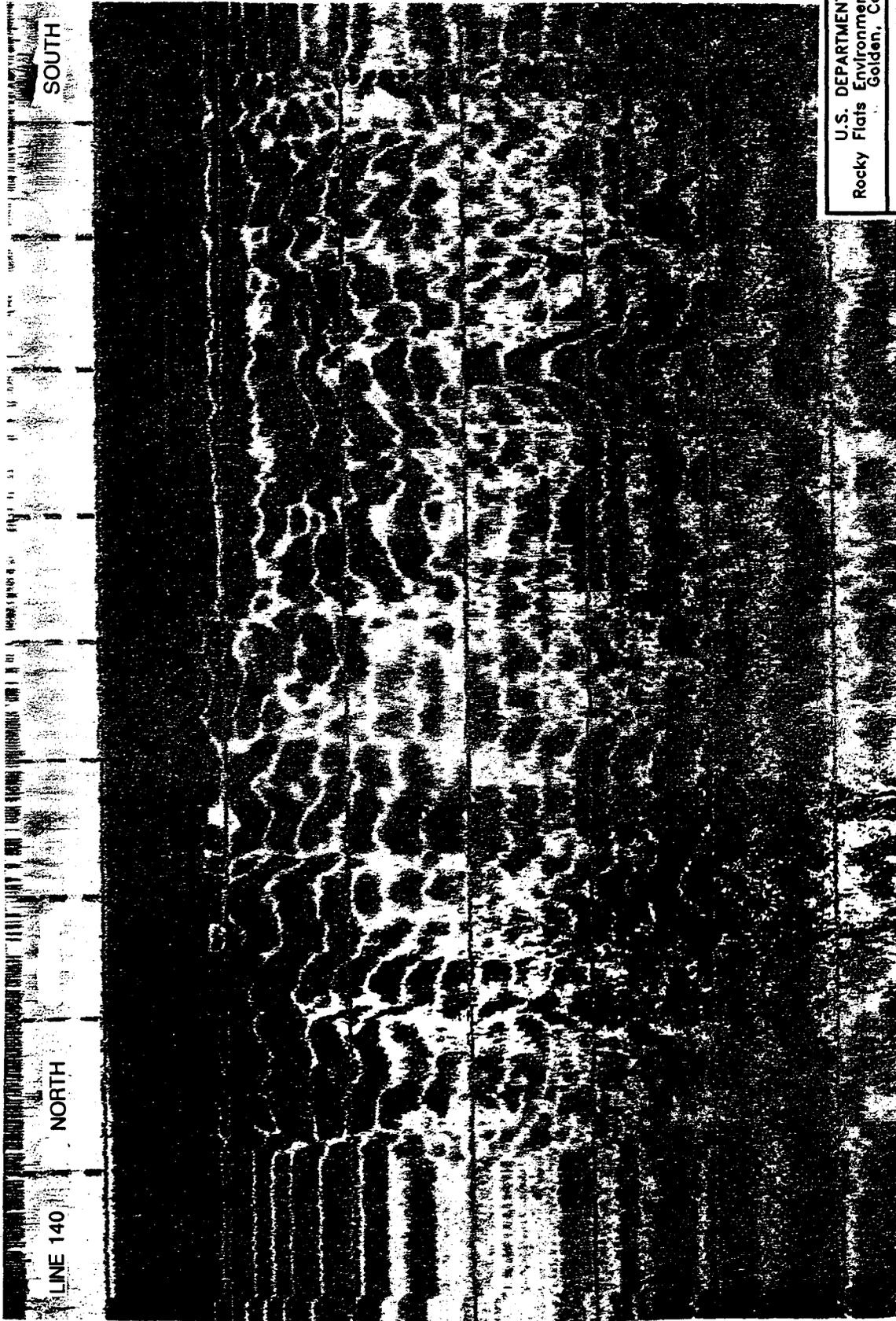
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TECHNICAL MEMORANDUM NO. 4

ELECTROMAGNETICS CONTOUR MAP
NORTH-SOUTH ORIENTATION
INPHASE DATA

FIGURE 2.7.4 FEBRUARY 1995

EXPLANATION	
10191 ○	SOURCE MONITORING LOCATION
12191 ●	RECORD MONITORING WELL LOCATION
22493A ○	ANNOUNCED MONITORING WELL LOCATION





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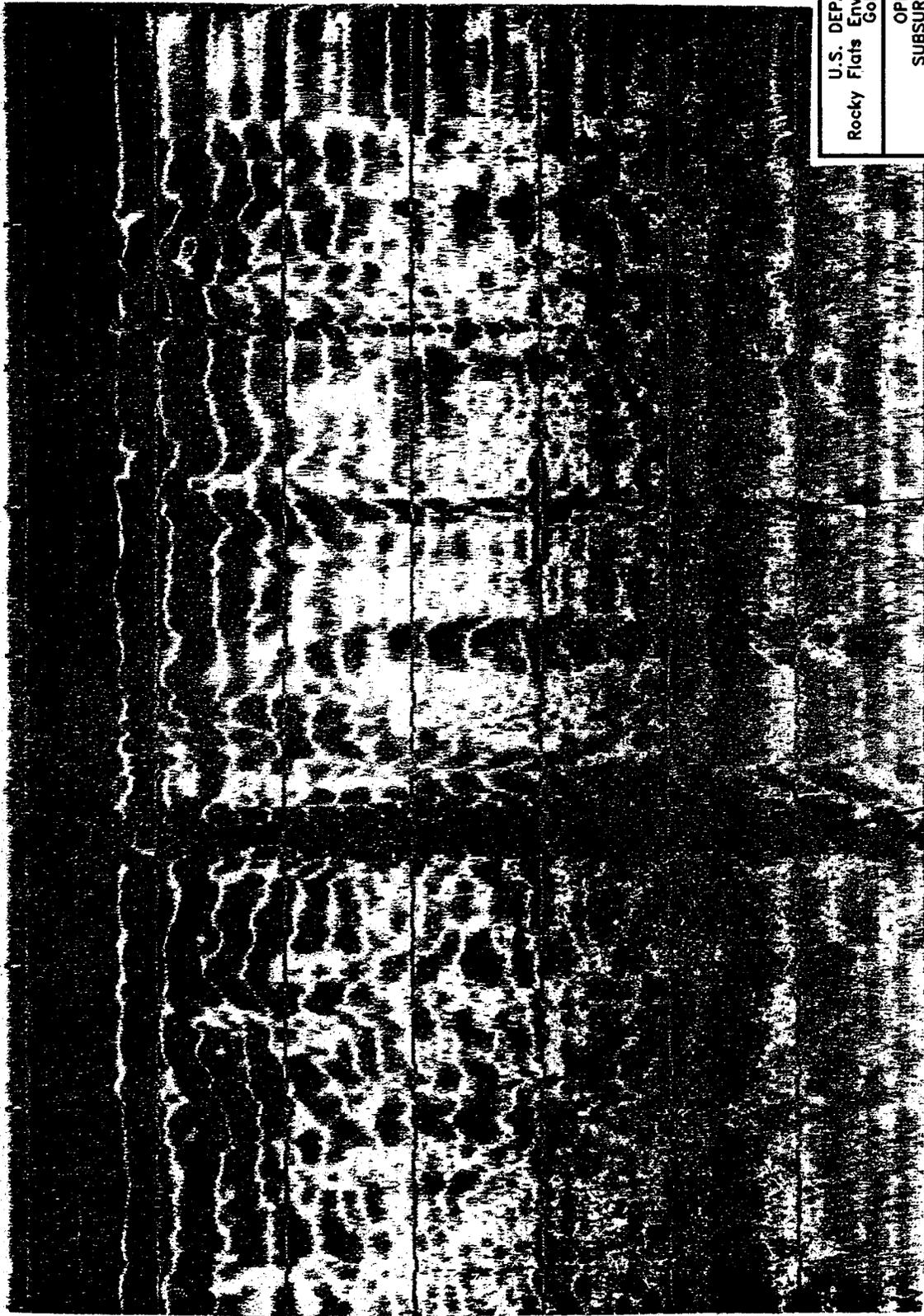
OPERABLE UNIT 2
SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4

SAMPLE GROUND PENETRATING
RADAR RAW DATA
LINE 140

NORTH

LINE 120

SOUTH



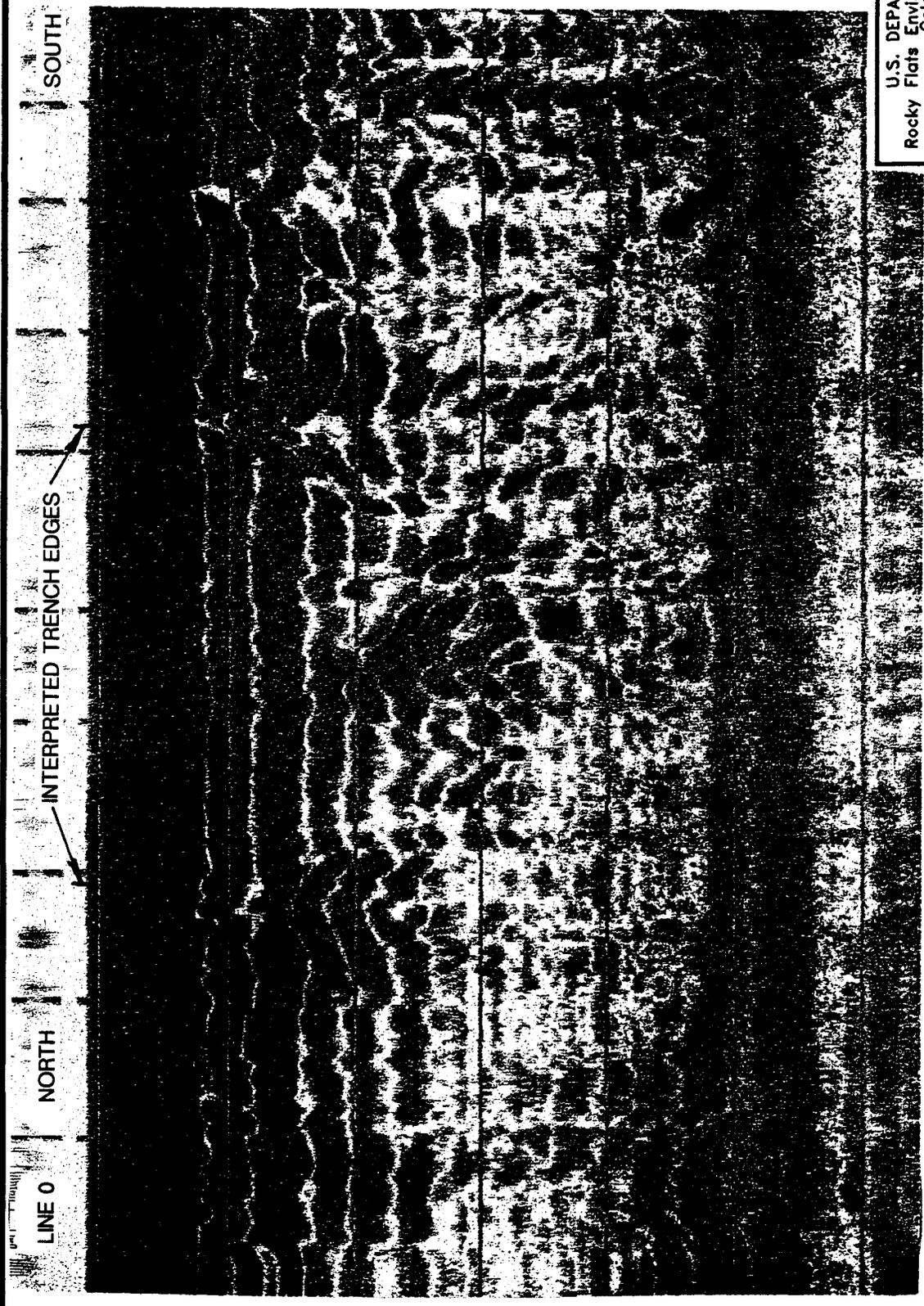
ROCKS AT GROUND SURFACE

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SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO. 4

SAMPLE GROUND PENETRATING
RADAR RAW DATA
LINE 120

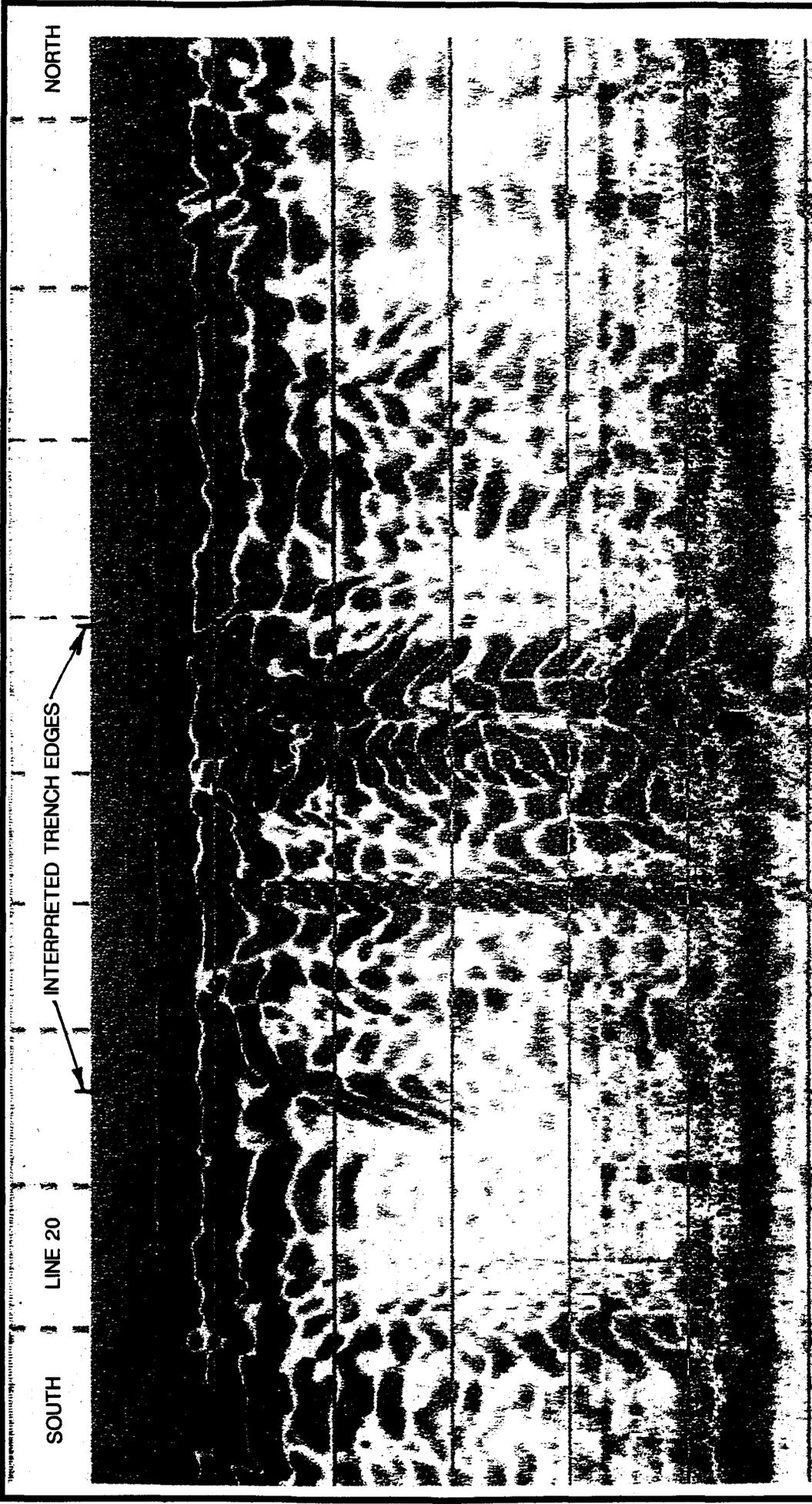


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SAMPLE GROUND PENETRATING
RADAR RAW DATA
LINE 0

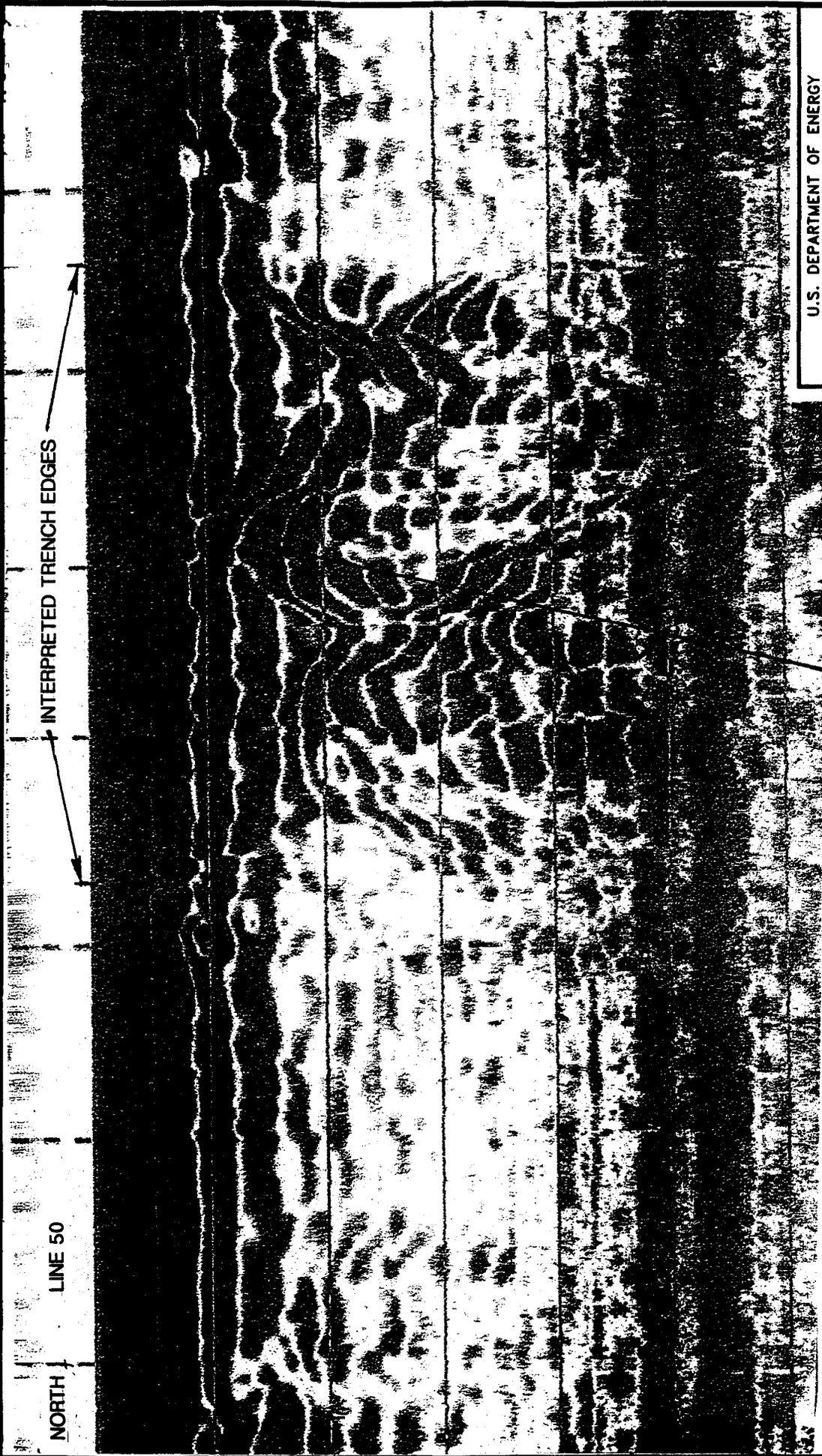


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 SUBSURFACE IM/IRA SITE 1
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SAMPLE GROUND PENETRATING
 RADAR RAW DATA
 LINE 20

DRAFT



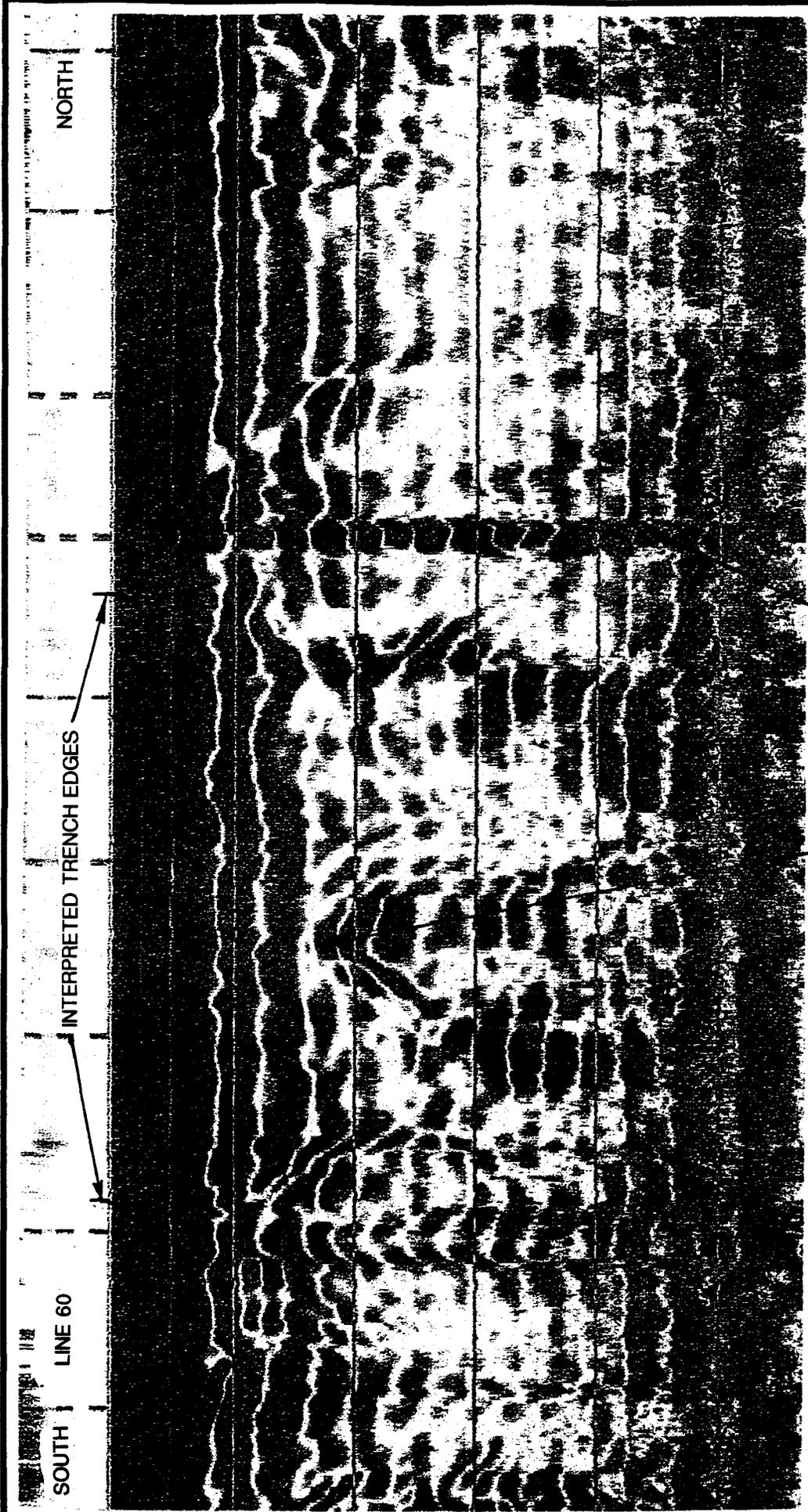
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SUBSURFACE IM/IRA SITE 1
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SAMPLE GROUND PENETRATING
RADAR RAW DATA
LINE 50

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POTENTIAL OBJECT IN TRENCH



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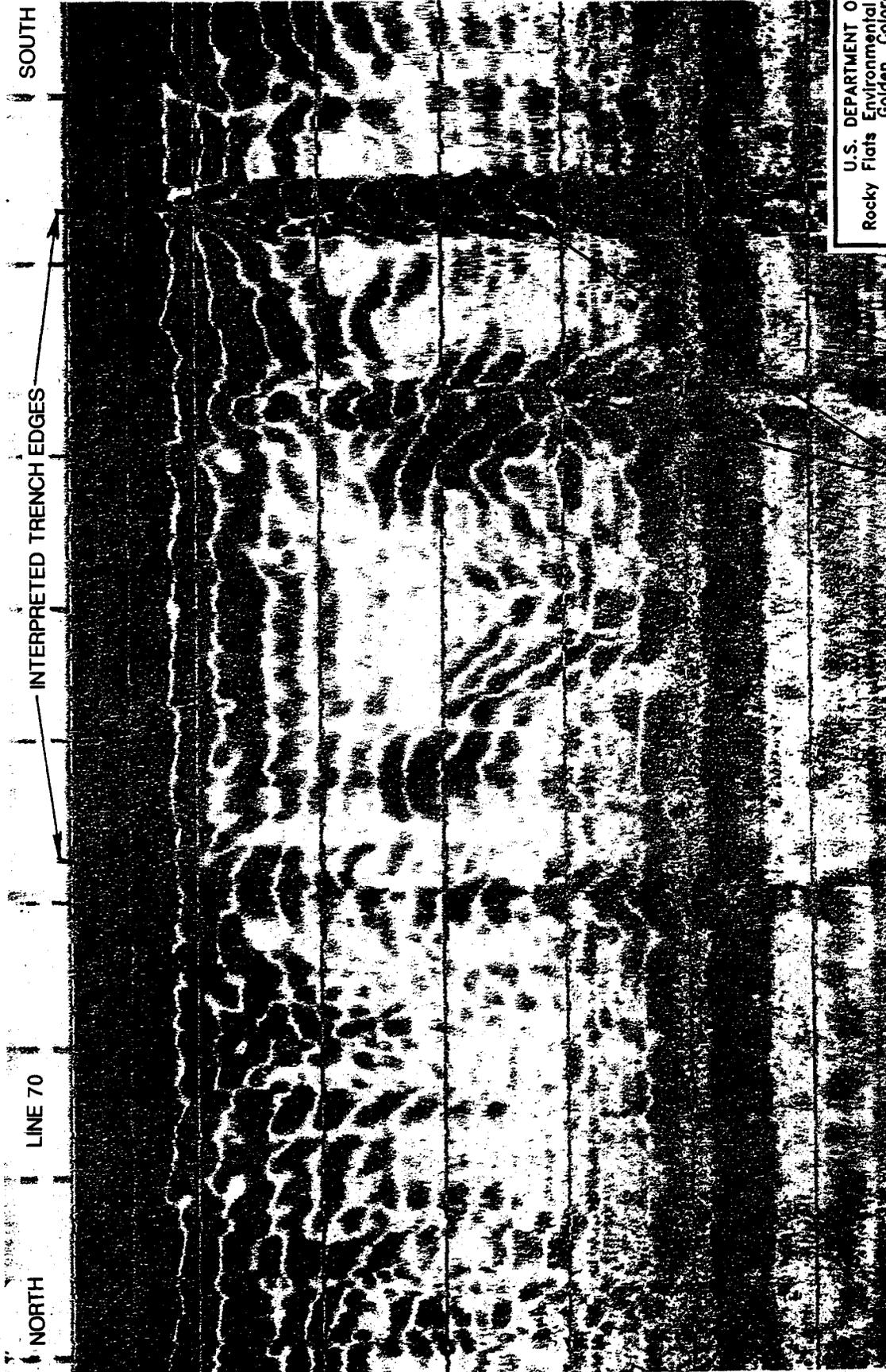
OPERABLE UNIT 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

SAMPLE GROUND PENETRATING
 RADAR RAW DATA
 LINE 60

ROCK AT
 GROUND SURFACE

POTENTIAL OBJECT IN TRENCH

DRAFT

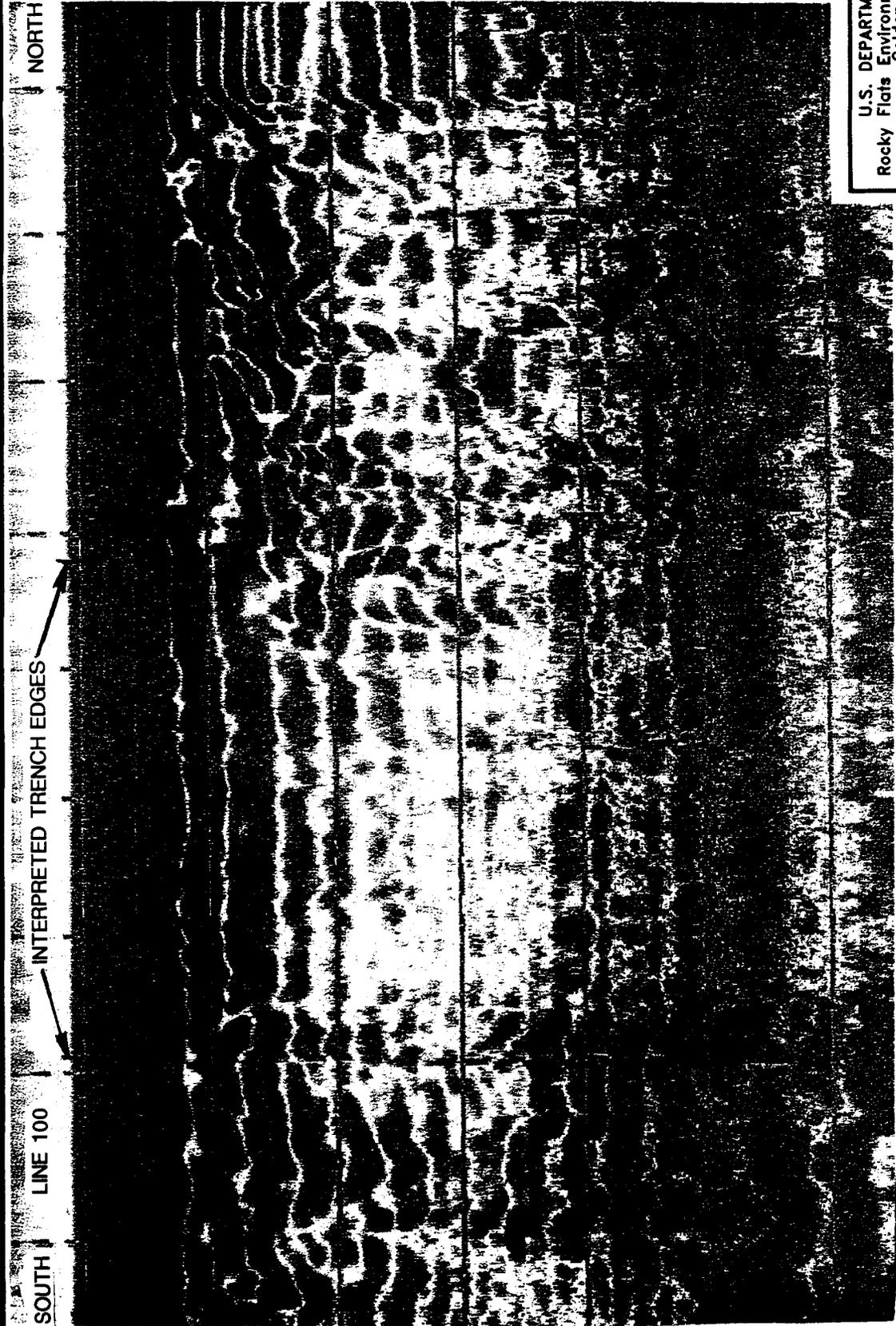


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OPERABLE UNIT 2
 SUBSURFACE IM/IRA SITE 1
 TECHNICAL MEMORANDUM NO. 4

SAMPLE GROUND PENETRATING
 RADAR RAW DATA
 LINE 70



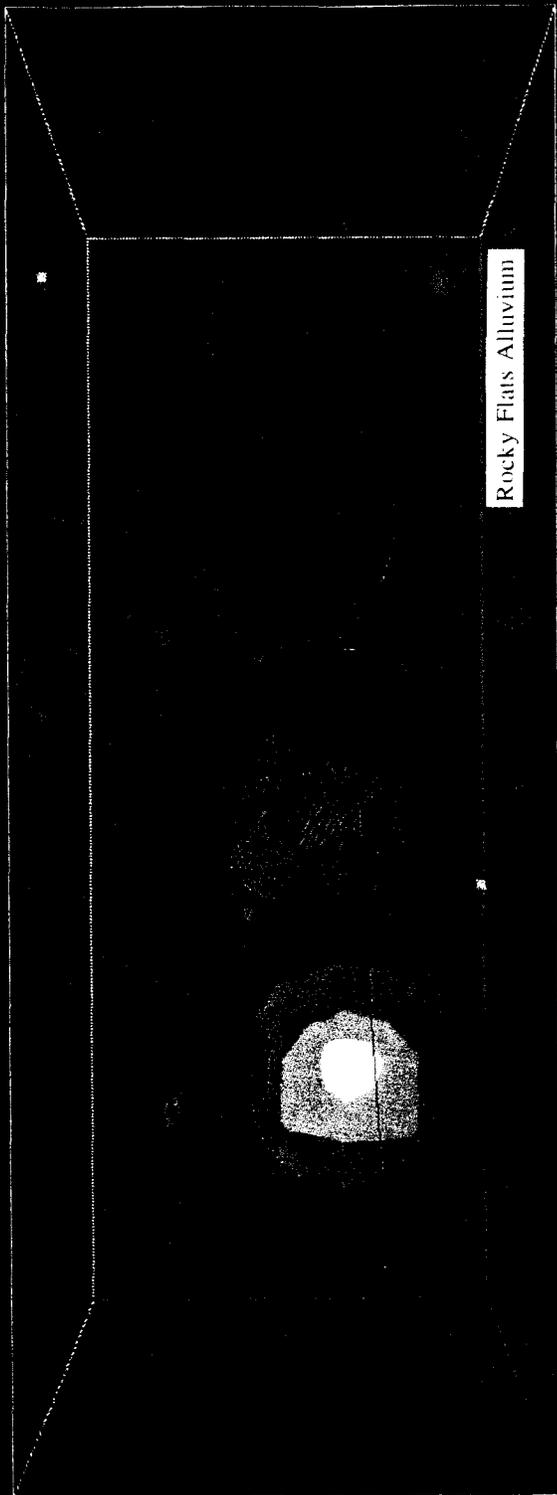
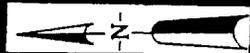
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TECHNICAL MEMORANDUM NO. 4

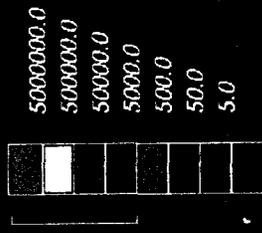
SAMPLE GROUND PENETRATING
RADAR RAW DATA
LINE 100

Rocky Flats IHSS 110 Geology and VOC Concentrations



Rocky Flats Alluvium

Units: ug/kg

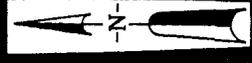
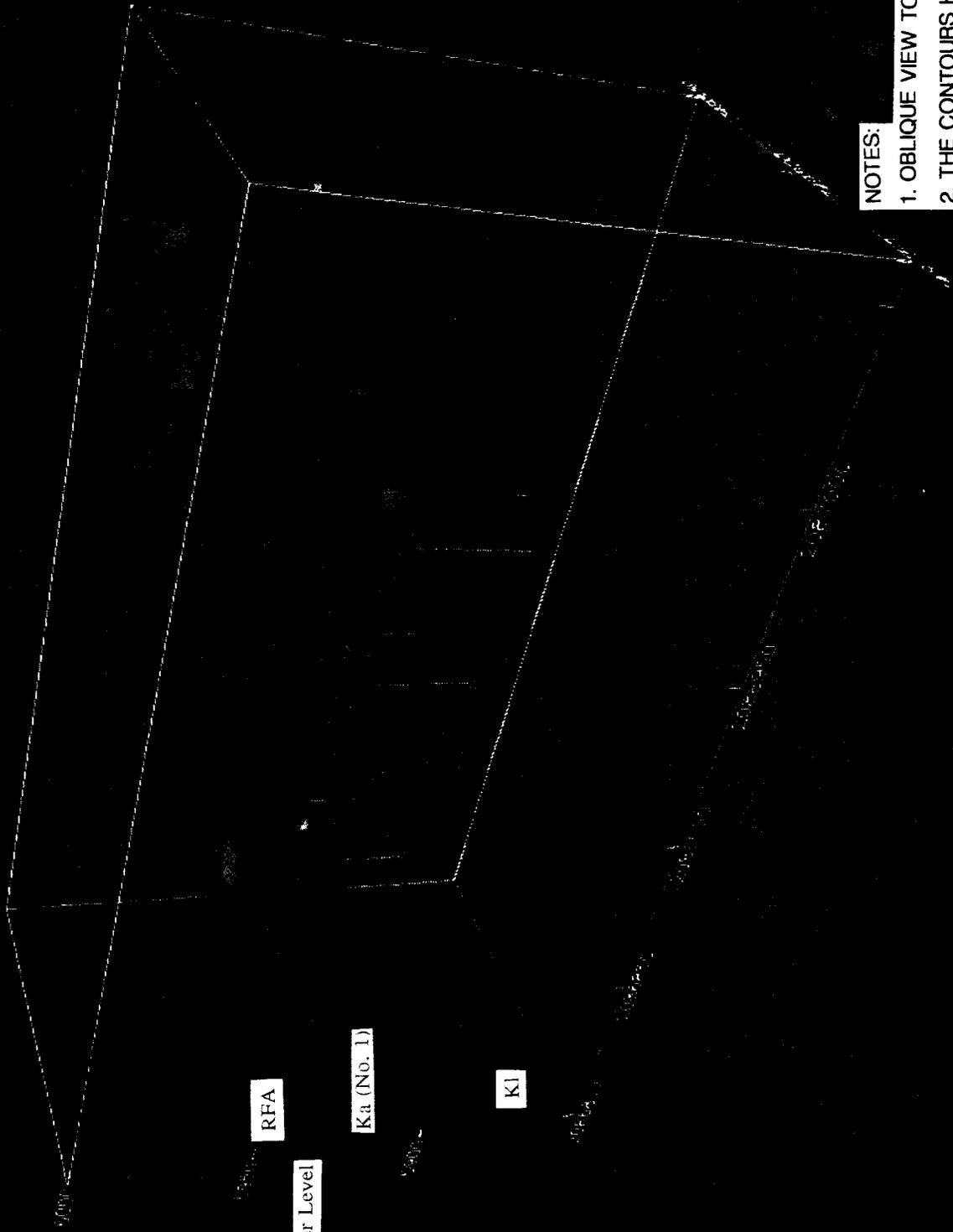


Z exaggeration: 1.0

NOTE:

THE CONTOURS HAVE BEEN
COMPUTER GENERATED FROM
A LIMITED NUMBER OF POINTS
AND MAY NOT REPRESENT
ACTUAL FIELD CONCENTRATIONS

Rocky Flats IHSS 110 Geology and VOC Concentrations



NOTES:

1. OBLIQUE VIEW TO THE NORTHWEST.
2. THE CONTOURS HAVE BEEN COMPUTER GENERATED FROM A LIMITED NUMBER OF POINTS AND MAY NOT REPRESENT ACTUAL FIELD CONCENTRATIONS.

Units: ug/kg

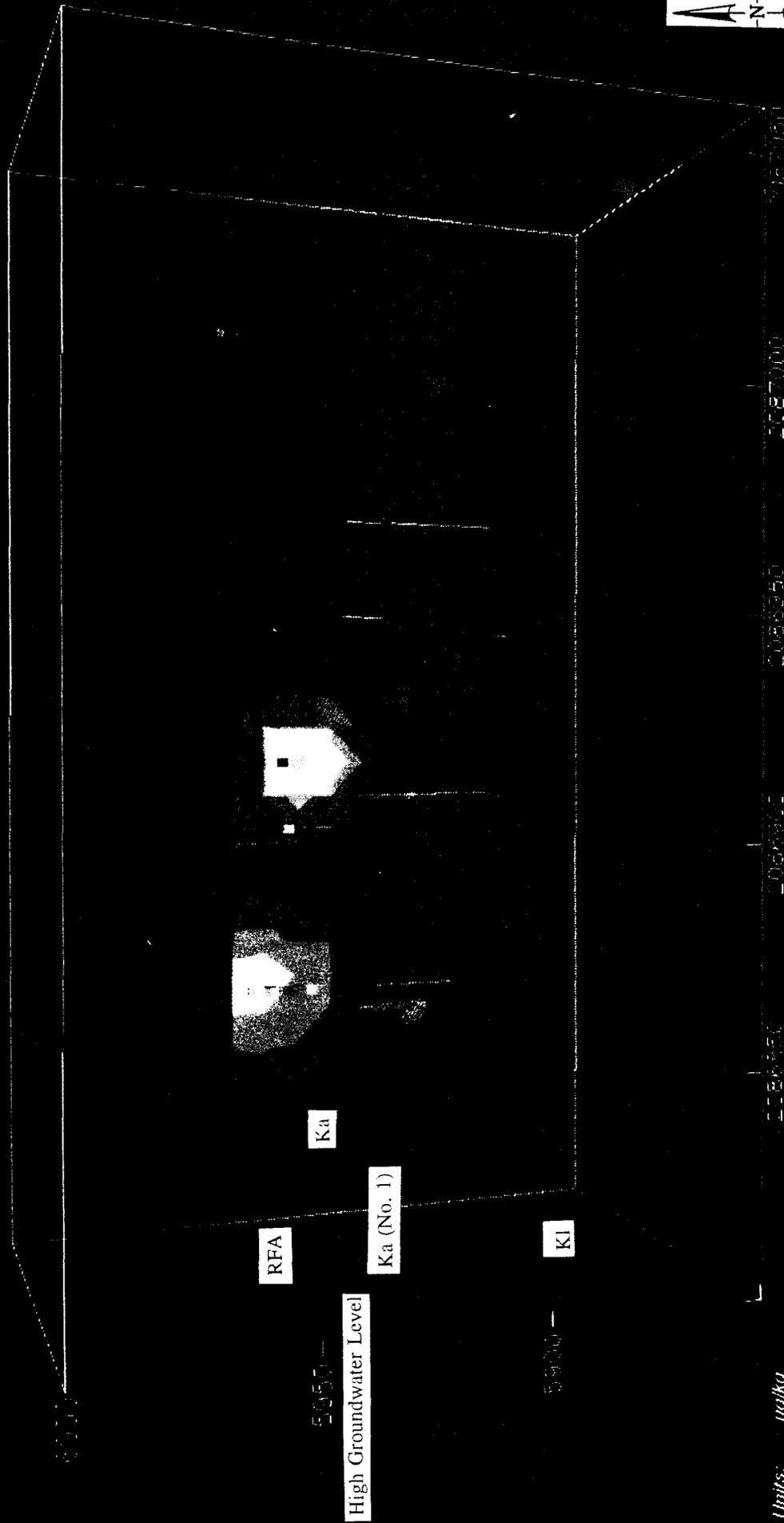
5000000.0
500000.0
50000.0
5000.0
500.0
50.0
5.0

Z Exaggeration: 1.0

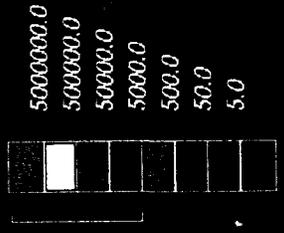
RFA - Rocky Flats Alluvium
 Ka - Arapahoe Formation
 Ka (No. 1) - Arapahoe (No. 1 Sandstone) Formation
 KJ - Laramie Formation

FIGURE 2.8-2

Rocky Flats IHSS 110 Geology and VOC Concentrations



Units: ug/kg



Z exaggeration: 1.0

NOTES:

1. OBLIQUE VIEW TO THE NORTH.
2. THE CONTOURS HAVE BEEN COMPUTER GENERATED FROM A LIMITED NUMBER OF POINTS AND MAY NOT REPRESENT ACTUAL FIELD CONCENTRATIONS.

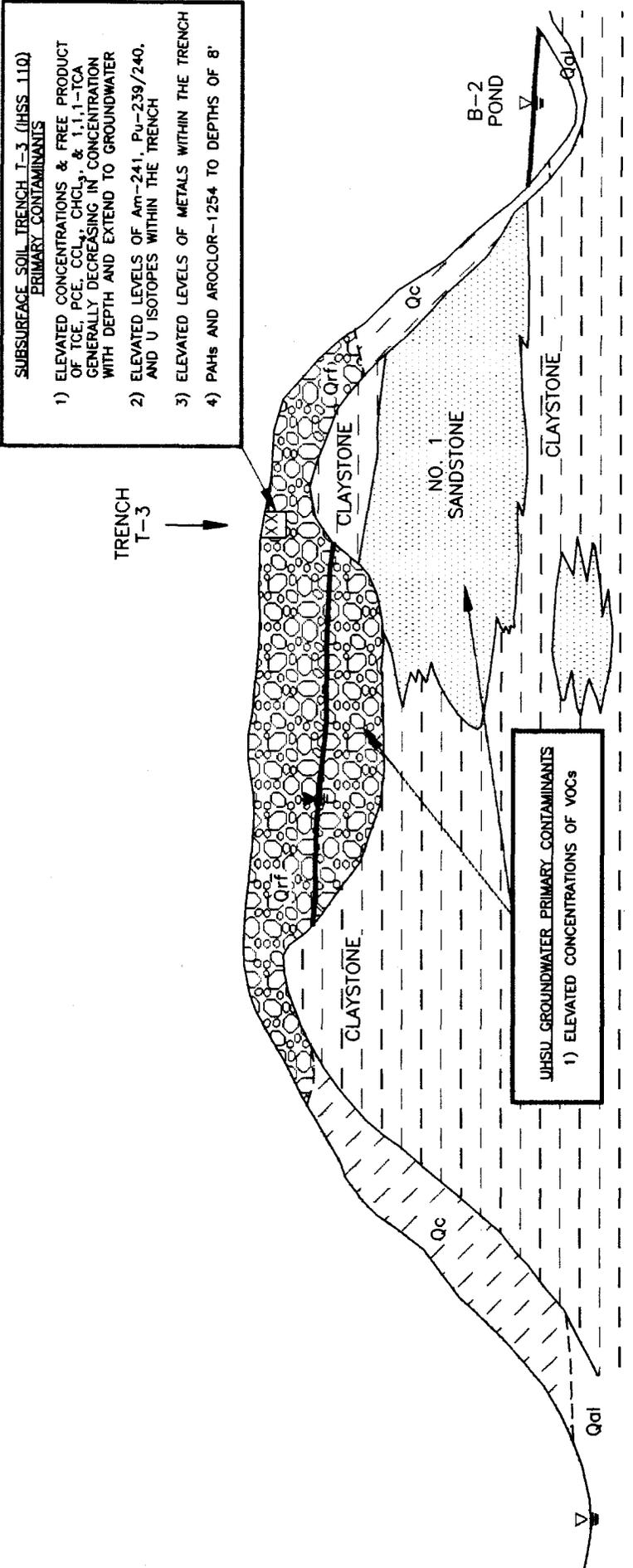
RFA - Rocky Flats Alluvium
 Ka - Arapahoe Formation
 Ka (No. 1) - Arapahoe (No. 1 Sandstone) Formation
 K1 - Laramie Formation

SE TRENCHES AREA

NE TRENCHES AREA

SOUTH

NORTH



SUBSURFACE SOIL TRENCH T-3 (IHSS 110) PRIMARY CONTAMINANTS

- 1) ELEVATED CONCENTRATIONS & FREE PRODUCT OF TCE, PCE, CCL₄, CHCL₃, & 1,1,1-TCA GENERALLY DECREASING IN CONCENTRATION WITH DEPTH AND EXTEND TO GROUNDWATER
- 2) ELEVATED LEVELS OF Am-241, Pu-239/240, AND U ISOTOPES WITHIN THE TRENCH
- 3) ELEVATED LEVELS OF METALS WITHIN THE TRENCH
- 4) PAHs AND AROCLOR-1254 TO DEPTHS OF 8'

UHSU GROUNDWATER PRIMARY CONTAMINANTS

- 1) ELEVATED CONCENTRATIONS OF VOCs

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NOTE: NOT TO SCALE

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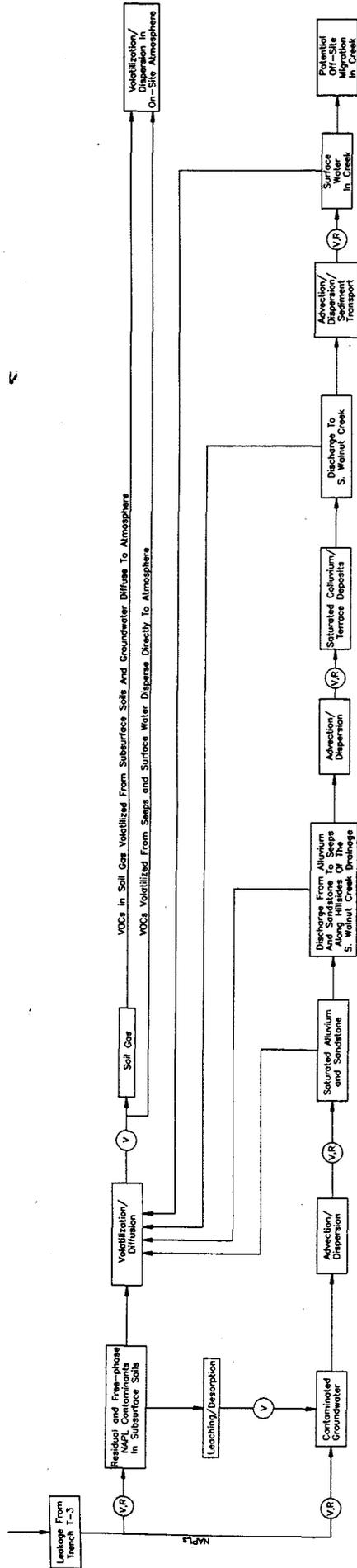
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TECHNICAL MEMORANDUM NO.4

SUMMARY OF THE
NATURE AND EXTENT OF
PRIMARY CONTAMINANTS
IN NE TRENCHES AREA

EXPLANATION	
	SANDSTONE
	CLAYSTONE
	Qrf-ROCKY FLATS ALLUVIUM
	COLLUVIUM
	IHSS BOUNDARY
	GROUNDWATER SURFACE
	CREEK WATER SURFACE

EXPLANATION	
	SUBSURFACE SOIL
	UHSU GROUNDWATER

Primary Sources Secondary Sources Release Mechanisms And Transport Processes Transport Media Interim On-Site Fate of Contaminants Transport Processes Interim On-Site Fate of Contaminants Transport Media Fate of Contaminants



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TRENCH T-3 (IHSS 110)
 CONTAMINANT MIGRATION PATHWAYS

FIGURE 3.0-2 FEBRUARY 1985

Legend

- (VR) Analyte Groups Affected
- V Volatile Organic Compounds
- R Radionuclides

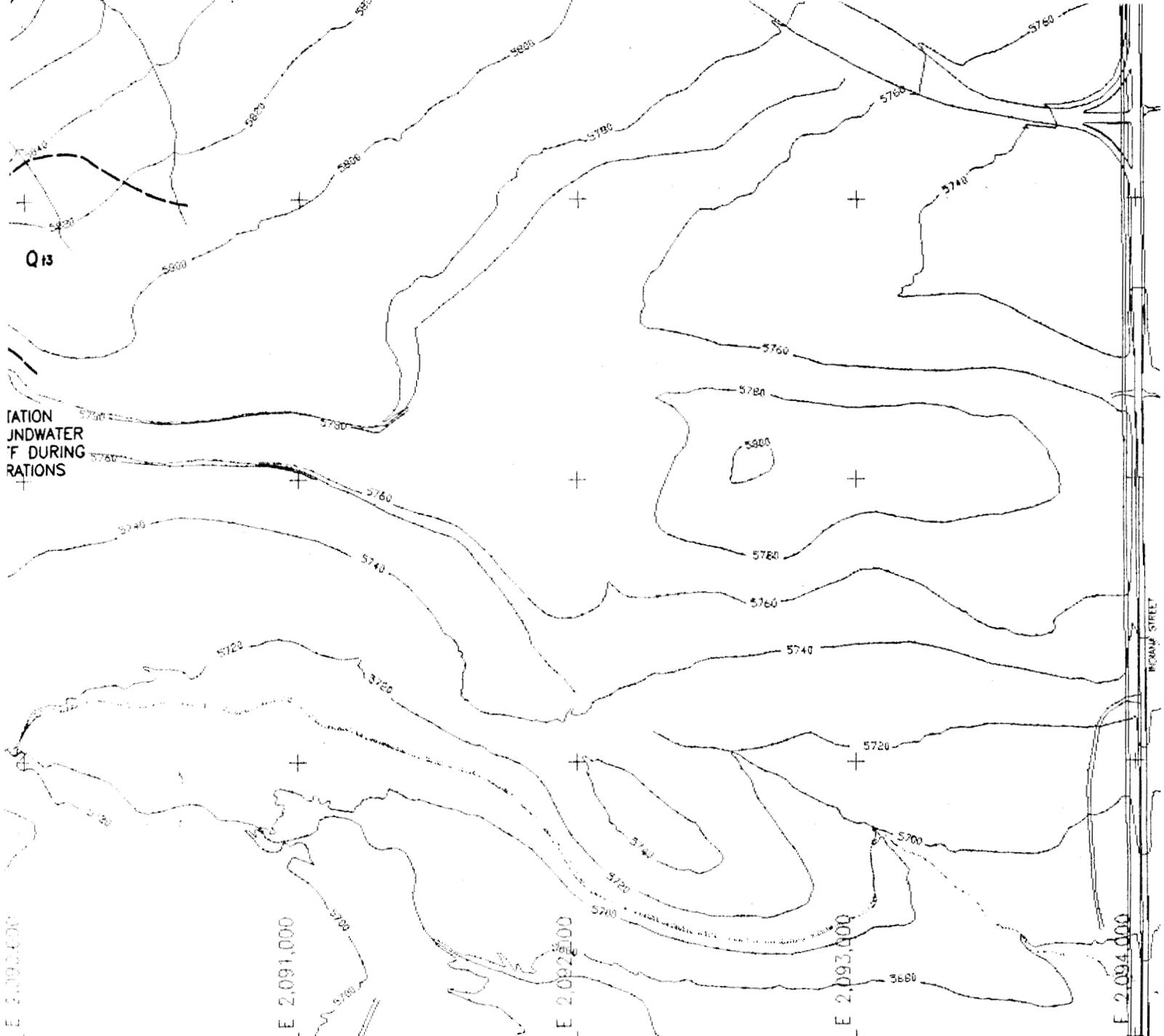
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SUBSURFACE IM/IRA SITE 1
TECHNICAL MEMORANDUM NO.4

OU-2 SEEP LOCATIONS
AND GEOLOGIC FEATURES

PLATE 2.5-1 SEPTEMBER 1994

SVETM058 1=500

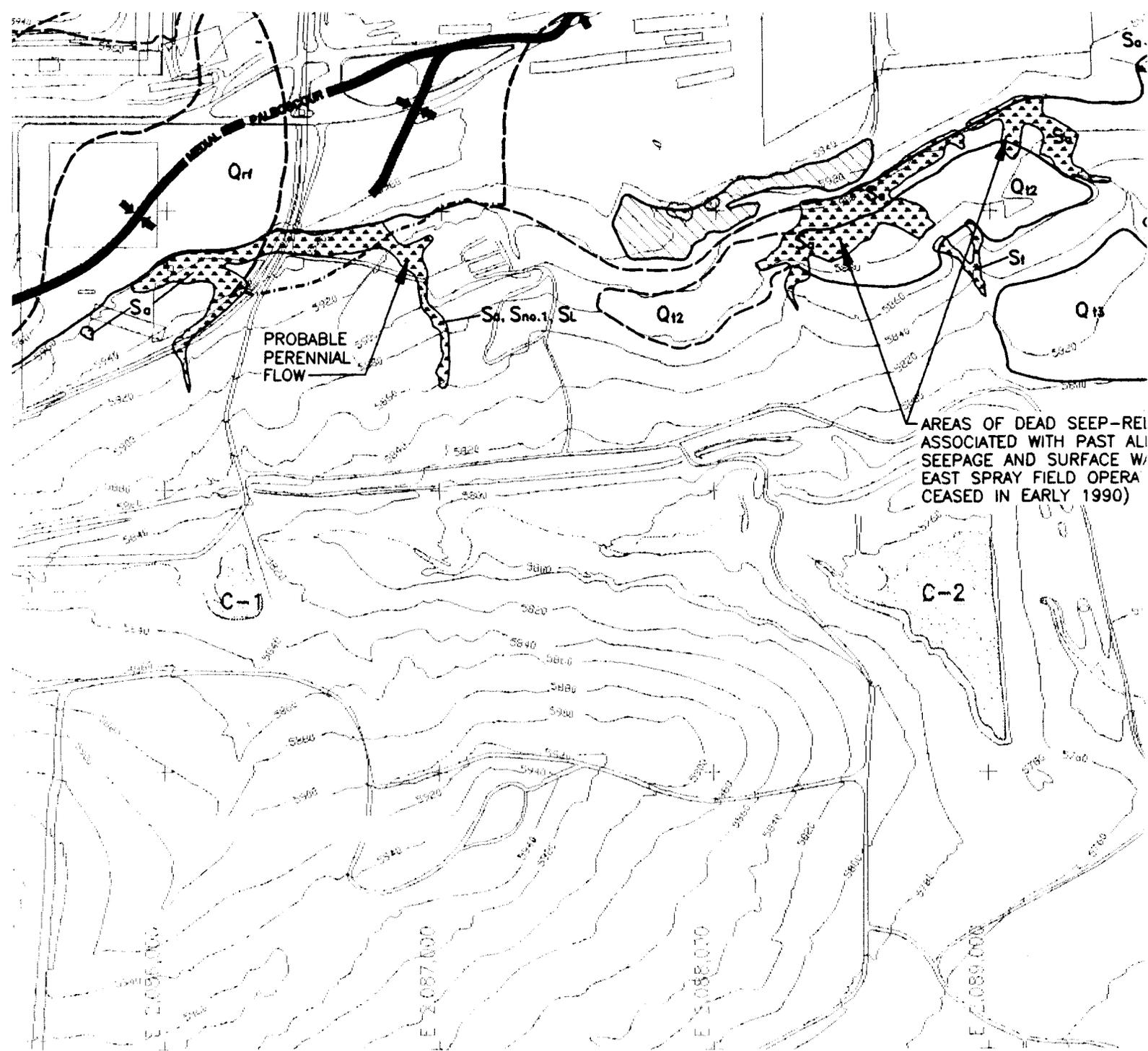


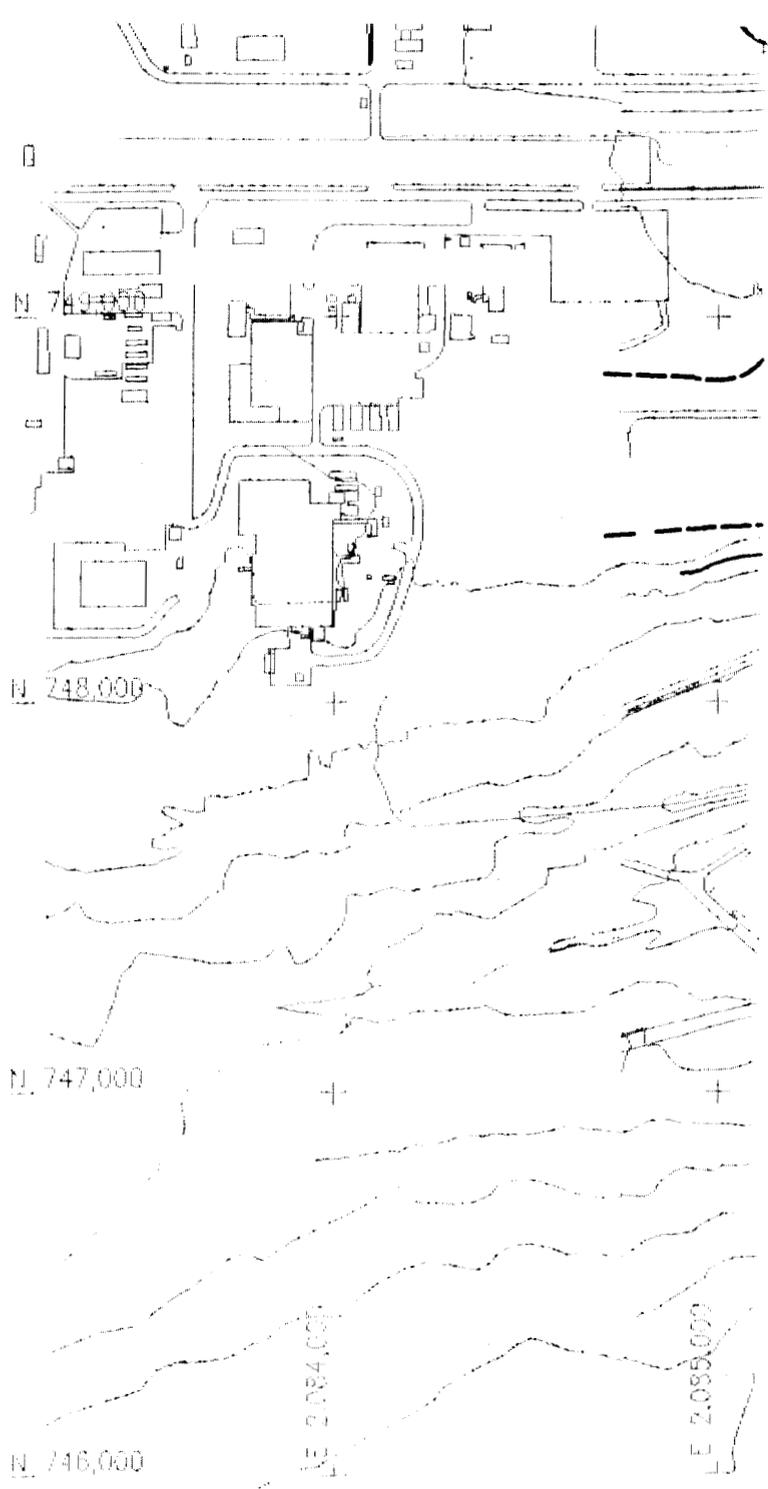
Q13

STATION
JNDWATER
F DURING
RATIONS

REMAN STREET

E 2,090,000
E 2,091,000
E 2,092,000
E 2,093,000
E 2,094,000





N 754,000

N 753,000

N 752,000

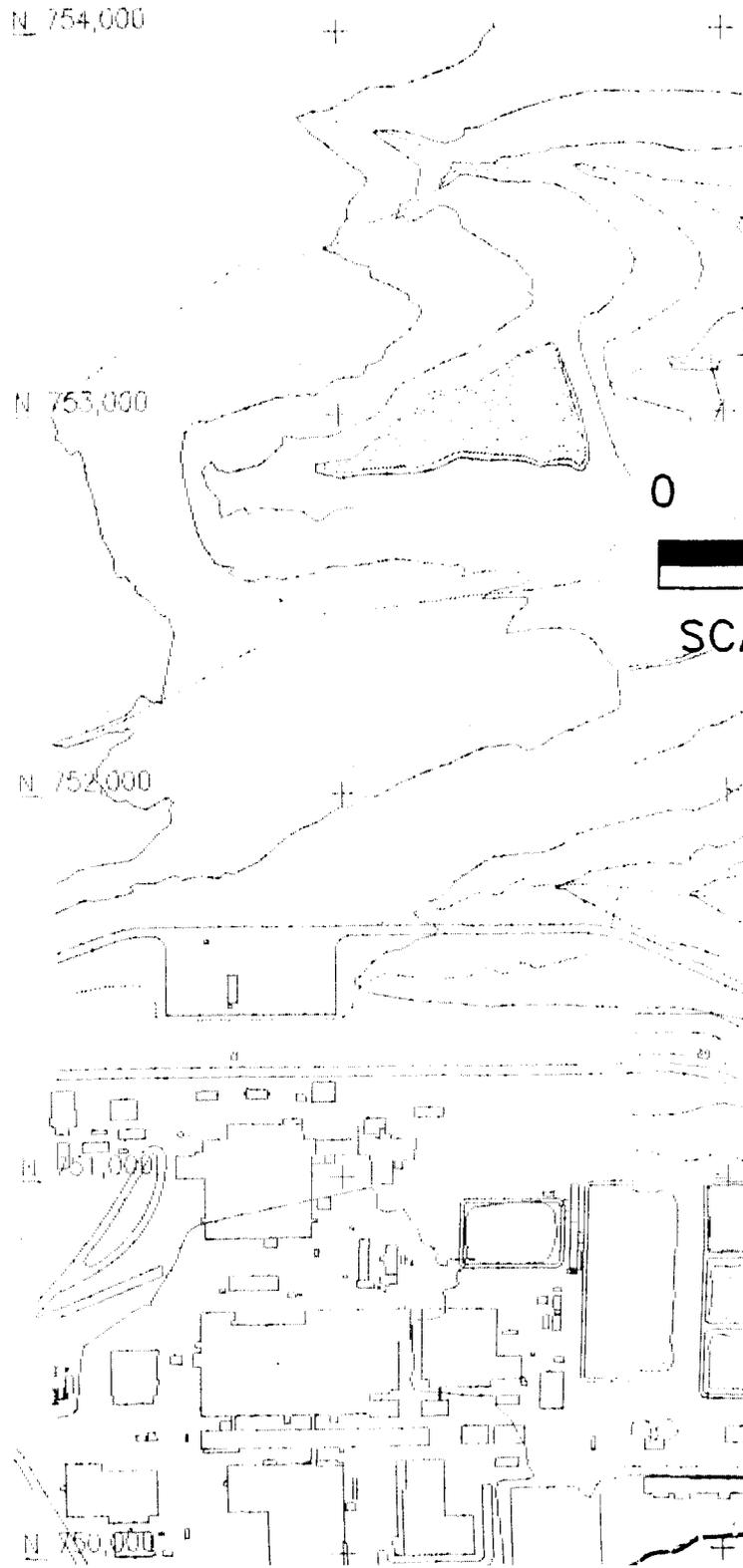
N 751,000

N 750,000

0

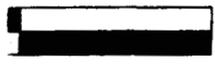


SC

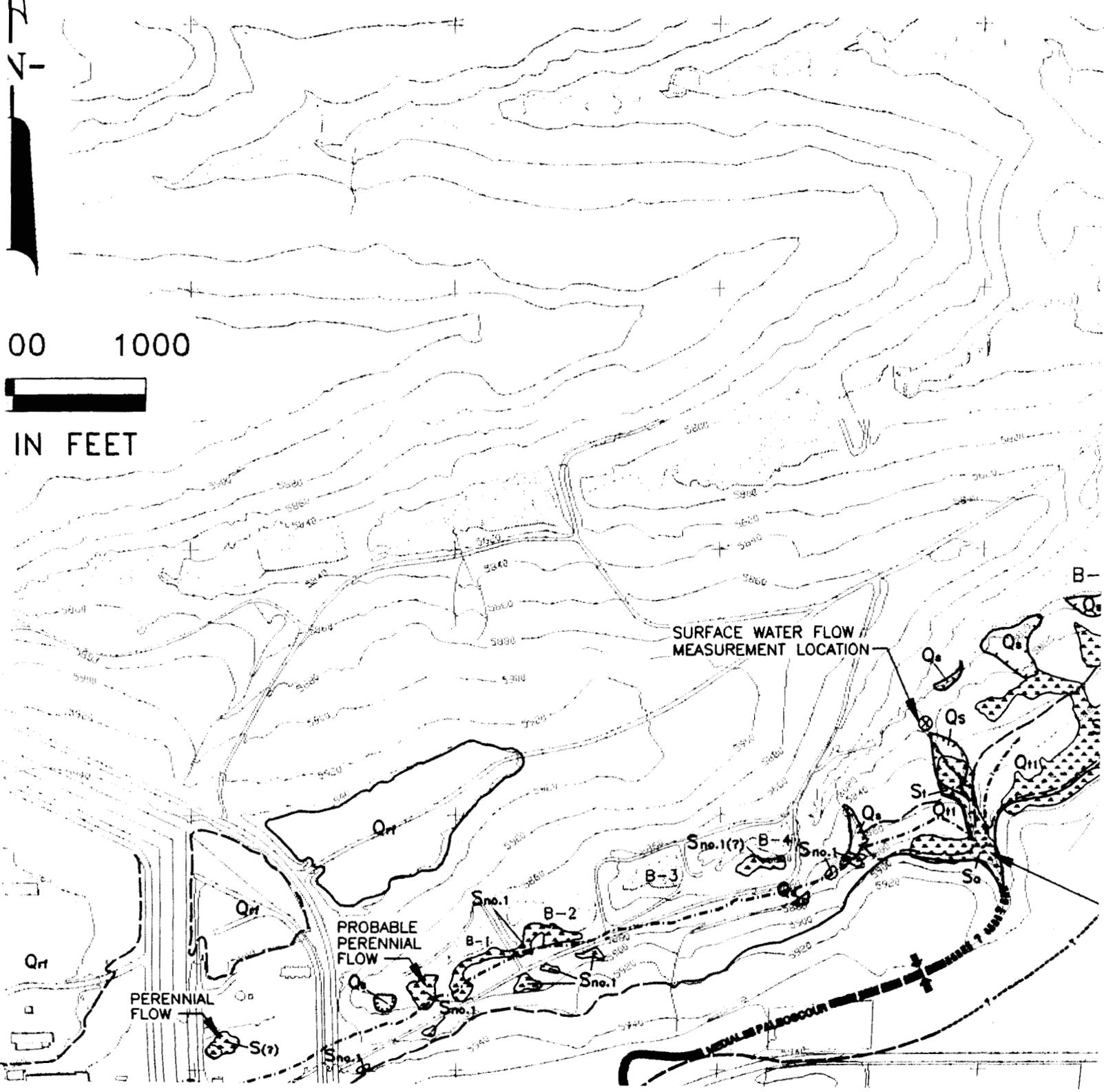


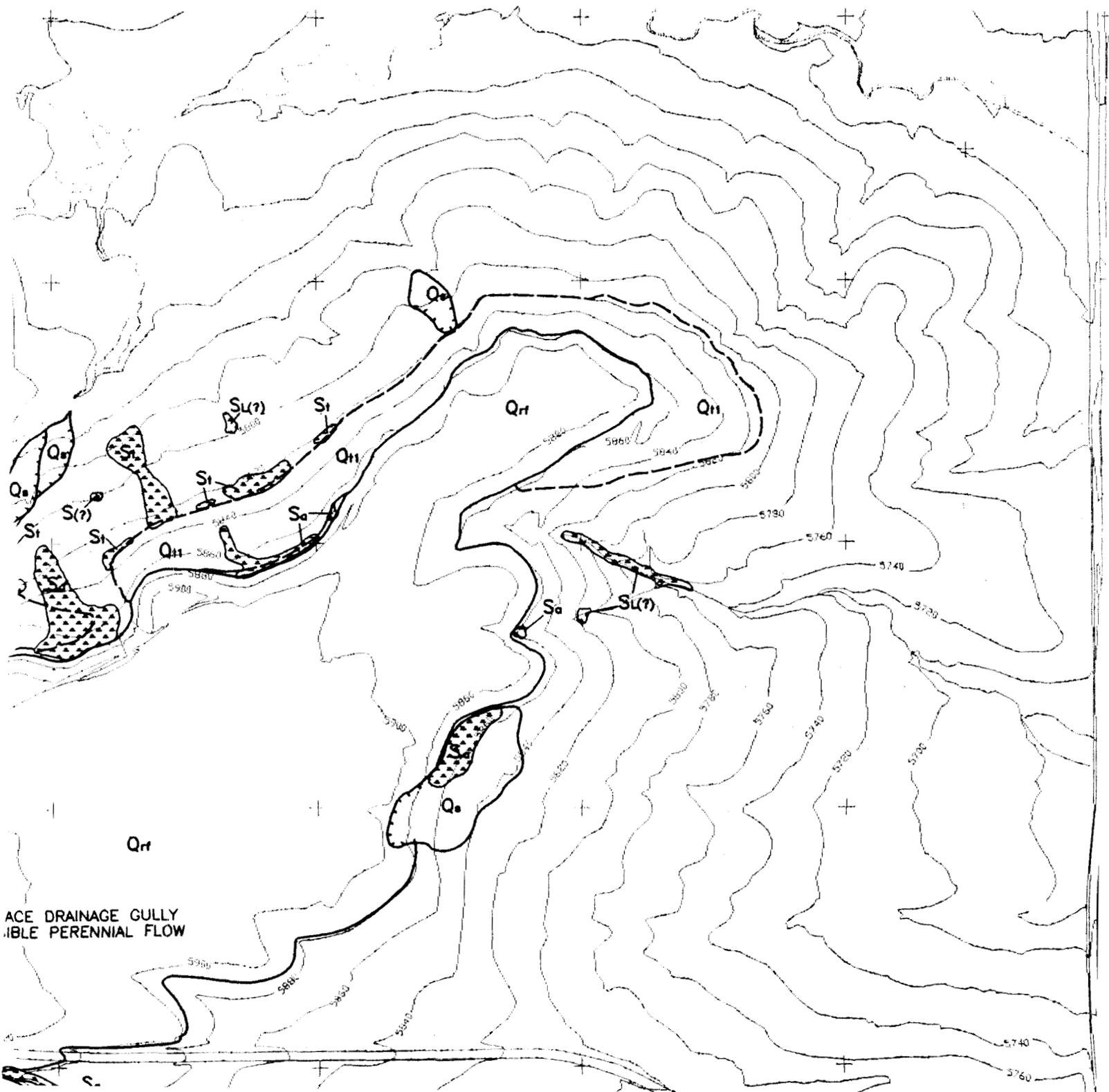


00 1000



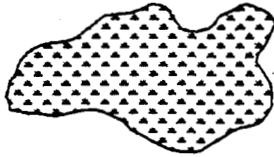
IN FEET





ACE DRAINAGE GULLY
(IBLE PERENNIAL FLOW)

EXPLANATION



Vegetated Area Associated With Groundwater Seepage (Vegetation consists of cattails, baltic rushes, and some woody bushes). Seepage Face Along Uphill Boundary of Vegetated Area.



Tree



Rocky Flats Alluvium Groundwater Seepage



High Terrace Alluvium Groundwater Seepage



Arapahoe Formation No.1 Sandstone Groundwater Seepage



Laramie Formation Sandstone Groundwater Seepage

GEOLOGIC CONTACTS



Dashed Where Approximate



Extrapolated



Erosional Limit of Sandstone (i.e. Intersection of Sandstone Bottom and Topography of Hillside)



Gravel Quarry

QUATERNARY DEPOSITS



Slumps (Hatched Where Head Scarps Are Developed)



Terrace Alluvium No.3



Terrace Alluvium No.2



Terrace Alluvium No.1



Rocky Flats Alluvium