Sandia National Laboratories

Results of the Technical Areas III and V RCRA Facility Investigation

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Environmental
Restoration
Project

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Albuquerque Operations Office

RESULTS OF THE TECHNICAL AREAS III AND V RCRA FACILITY INVESTIGATION

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Department 7582: Environmental Restoration for Technical Areas and Miscellaneous Sites

EXECUTIVE SUMMARY

A Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) was conducted in 1994 and 1995 at 21 Environmental Restoration (ER) sites within Technical Areas III and V (TA-III/V) at Sandia National Laboratories in Albuquerque, New Mexico (SNL/NM). This report details the investigations at each of the sites.

In the RFI Work Plan (SNL/NM 1993a, 1993b), the ER sites were grouped into five categories:

1. Sites proposed for No Further Action (NFA);
2. Potential petroleum-impacted sites;
3. Sites potentially impacted only by hazardous constituents of concern (COCs);
4. Sites potentially impacted only by radioactive constituents; and
5. Sites potentially impacted by both hazardous and radioactive compounds.

The sites were investigated separately and are discussed in the report in individual sections (Sections 3.0 through 23.0).

Three of the sites proposed for NFA (ER Sites 105, 188, and 195) were submitted to the U.S. Environmental Protection Agency (EPA) in 1995 for administrative NFA decisions. All three were granted NFA status in July 1995.

Based on confirmatory sampling, the following sites are proposed for NFA in this RFI report: Sites 26, 31, 34, 35, 36, 37, 51, 78, 100, 102, 107, 111, 196, and 241. A Class III permit modification request will be submitted following final determinations on sites addressed within this RFI report. This RFI report constitutes the NFA proposals for these sites. Most sites in this group exhibited no contamination above background levels; the remainder of these sites were contaminated at levels far below regulatory limits. Although Site 107 falls into this group, it has been identified as the preferred site for a future temporary unit and corrective action management unit (TU/CAMU) for the ER Project. Thus additional activities related to its TU/CAMU status will be conducted.

Several of the ER sites are still active (i.e., testing is currently being conducted at or immediately adjacent to the sites). Because of this, only limited investigations were conducted at Sites 26, 83, and 84 where ongoing testing significantly impacts thorough site characterization. Investigations at these sites included geophysical surveys to identify buried material at Sites 26 and 84 and surface radiation surveys (discussed below) at Sites 83 and 84. Investigations will be completed when these sites are decommissioned or placed in final inactive status. Site 240 was reactivated for testing after site characterization was completed. Thus, proposed geophysical investigations of Site 240 will be postponed until the site is placed in final inactive status.

A Voluntary Corrective Measure (VCM) was performed to survey and remove surface radiation hazards associated with testing conducted at several ER sites. Sites 18, 83, 84, 102, 240, and 241 were surveyed for radioactive anomalies. Removal activities were conducted at sites where anomalies were demonstrated to exist (Sites 18, 83, 84, and 240).

A VCM also was conducted at the Gas Cylinder Disposal Pit (Site 78) to mitigate the immediate hazard posed to human health and the environment. The site exhibited many unruptured gas cylinders containing hazardous and toxic gases, high-explosive (HE) residues, and radioactively contaminated soil and slag. The VCM was accelerated from the original schedule of site assessment, remedy selection, and full-scale remediation. The entire contents of the pit were removed and examined, the contaminants were identified, and hazardous, radioactive, and solid wastes were disposed in a manner appropriate to regulatory requirements. As indicated above, Site 78 is proposed for NFA based on the results of the VCM.

The investigation of Site 18 revealed limited chemical contamination for which a VCM is planned. Site 18 exhibited elevated levels of polychlorinated biphenyls (PCBs) in an area approximately 10 feet by 80 feet. The contamination is believed to be restricted to the upper few inches of soil; shallow excavation (scraping the soil) is proposed to remediate the hazard posed by the PCBs. The results of the VCM at Site 18 will be documented in an NFA proposal, and the adequacy of the cleanup will be evaluated in a Class 3 permit modification process.

ACRONYMS AND ABBREVIATIONS

AIP	Agreement in Principle
AMSL	above mean sea level
ASTM	American Society for Testing and Materials
CA	Corrective Action
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMS	corrective measures study
Cn	critical number
COC	constituent of concern
CWL	Chemical Waste Landfill
DCP	direct current plasma
DNT	dinitrotoluene
DOE	U.S. Department of Energy
DOE/AL	U.S. Department of Energy/Albuquerque Operations Office
DOT	U.S. Department of Transportation
DQO	Data Quality Objective
DU	depleted uranium
EA	Environmental Assessment
EDE	effective dose equivalent
EM	electromagnetic
EORC	Environmental Operations Records Center
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ES&H	Environment, Safety, and Health
FID	flame ionization detector
FOP	Field Operating Procedure
GC	gas chromatograph
GC/MS	gas chromatograph/mass spectrometer
GCDP	Gas Cylinder Disposal Pit
GIF	Gamma Irradiation Facility
GIS	Geographic Information System
GJPO	Grand Junction Projects Office (DOE)
GM	Geiger-Müller
GPS	Global Positioning System
HASP	Health and Safety Plan
HE	high explosive
HERMES	High-Energy Radiation Megavolt Electron Source
HPCA	High Pressure Container Access
HPGE	high purity germanium

HSWA	Hazardous and Solid Waste Amendment
HWMF	Hazardous Waste Management Facility
ICM	interim corrective measure
ICP	inductively coupled plasma
ID	inner diameter
IH	industrial hygiene
KAFB	Kirtland Air Force Base
KAO	Kirtland Area Office
LCS	laboratory control sample
LIHE	light-initiated high explosive
LLW	low-level waste
LWDS	Liquid Waste Disposal System
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MDA	minimum detectable activity
MDL	method detection limit
ms/msd	matrix spike/matrix spike duplicate
MSA	Mine Safety Appliances
MSD	mass selective detector
MSDS	Material Safety Data Sheet
MWL	Mixed Waste Landfill
NA	not applicable
ND	nondetect
NFA	No Further Action
NIST	National Institute of Standards and Testing
NMED	New Mexico Environment Department
NMUSTR	New Mexico Underground Storage Tank Regulations
NRC	Nuclear Regulatory Commission
OD	outer diameter
OP	Operating Procedure
OSI	on-site investigation
OVA	organic vapor analyzer
PA	preliminary assessment
PCB	polychlorinated biphenyl
PCE	tetrachloroethene (tetrachloroethylene or perchloroethylene)
PIC	pressurized ionization chamber
PID	photoionization detector
PIP	Project Implementation Plan
PLQ	practical limit of quantitation
PPE	personal protective equipment
PVC	polyvinyl chloride

QA	quality assurance
QC	quality control
QAP	Quality Assurance Program
QAPjP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RMMA	Radioactive Materials Management Area
SAP	Sampling and Analysis Plan
SASN	silver acetylyde-silver nitrate
SI	site investigation
SMO	Sample Management Office
SNL/NM	Sandia National Laboratories/New Mexico
SVOC	semivolatile organic compound
SWHC	Site-Wide Hydrogeologic Characterization
SWMU	Solid Waste Management Unit
TA	Technical Area
TAL	target analyte list
TCA	trichloroethane
TCE	trichloroethene (trichloroethylene)
TCLP	Toxicity Characteristic Leaching Procedure
TD/GC	thermal desorption/gas chromatography
TNT	trinitrotoluene
TPH	total petroleum hydrocarbon
TU-CAMU	temporary unit and corrective action management unit
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
UST	underground storage tank
UTL	upper tolerance limit
VCM	Voluntary Corrective Measure
VOC	volatile organic compound
WRS	Wilcoxon Rank Sum
XRF	X-ray fluorescence

ABBREVIATIONS

Ag	silver
Am-241	americium-241
As	arsenic
Ba	barium
Be	beryllium

Bldg	Building
bgs	below ground surface
°C	degrees Celsius
Cd	cadmium
cm	centimeter(s)
C_n	critical number
Co-60	cobalt-60
cpm	counts per minute
cps	counts per second
Cr	chromium
Cs-137	cesium-137
Cu	copper
°F	degrees Fahrenheit
ft	foot (or feet)
ft^2	square feet
ft^3	cubic feet
g	gram(s)
gal.	gallon(s)
hr	hour(s)
in.	inch(es)
kg	kilogram(s)
km	kilometer(s)
L	liter(s)
lb	pound(s)
MBK	2-hexanone
MEK	2-butanone
MIBK	methyl isobutyl ketone
m	meter(s)
m^2	square meter(s)
mg	milligram(s)
mg/L	milligrams per liter
mg/kg	milligrams per kilogram
µg	microgram
µg/kg	microgram(s) per kilogram
µR/hr	microroentgens per hour
mrem/yr	millirem per year
mi	mile(s)
min	minute(s)
mL	milliliter(s)
mm	millimeter(s)
mph	miles per hour

NaI	sodium iodide
Ni	nickel
Pb	lead
pCi/L	picocuries per liter
pCi/g	picocuries per gram
ppb	parts per billion
ppm	parts per million
psig	pounds per square inch, gauge
Se	selenium
sec	second(s)
Th	thorium
U	uranium
U_{tot}	total uranium
yd	yard(s)
yd^3	cubic yard(s)
yr	year
Zn	zinc

1.0 INTRODUCTION

1.1 Site Background

The Sandia National Laboratories/New Mexico (SNL/NM) Environmental Restoration (ER) Project is chartered with the assessment and cleanup of inactive waste sites at its facilities. This document presents the results of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) of the SNL/NM sites within Technical Areas III and V (TA-III/V). The sites were identified during a preliminary assessment/site investigation (PA/SI) (DOE 1987) as potential areas of concern or as solid waste management units (SWMUs) as a result of past practices in TA-III/V. Detailed descriptions of these sites are found in the TA-III/V RFI Work Plan (SNL/NM 1993a, 1993b). The purpose of the RFI was to determine the presence or absence of contamination at each of the TA-III/V ER sites.

Sandia Corporation, a subsidiary of Lockheed Martin Corporation, operates SNL/NM as a prime contractor to the U.S. Department of Energy (DOE), which owns SNL/NM. SNL/NM conducts research, development, design, and testing of nuclear and conventional weapons, energy systems, and other programs. Figure 1-1 identifies SNL/NM and its technical areas in relation to Kirtland Air Force Base (KAFB) and the city of Albuquerque, and several surrounding physical features. TA-III/V were established in 1953 for testing weapons components in a variety of natural and simulated environments. TA-III/V are located approximately 6 kilometers (km) south of the main laboratories and offices known as Technical Area I (TA-I) (Figure 1-1).

1.2 RFI Work Plan Overview and Objectives

This RFI has been conducted in accordance with the U.S. Environmental Protection Agency (EPA)-approved TA-III/V RFI Work Plan (SNL/NM 1993a) and its amendment (SNL/NM 1993b). A total of 19 sites in TA-III/V were originally identified as requiring investigation. Varying levels of investigation were conducted at all sites originally identified in the RFI Work Plan. Table 1-1 provides a summary of the sites, their status, and the field investigations conducted at each site and Figure 1-2 shows the location of each site.

Sites were classified as active and inactive, based on use at the time of this RFI. Both active and inactive sites were investigated but full investigation and remediation of active sites was postponed until facility decommissioning. Two sites that were originally grouped together in the Work Plan were subdivided based on physical separation and difference in historical activities: Site 18 was divided into Site 18 (Concrete Pad) and Site 241 (Storage Yard); Site 83 was divided into Site 83 (Long Sled Track) and Site 240 (Short Sled Track).

The objectives of the RFI were to identify the nature and extent of contamination at sites within TA-III/V, evaluate potential risks posed by the contamination, and provide guidance for selecting remedial alternatives. The objective of this RFI report is to document and transmit this information to all stakeholders, including SNL/NM, the DOE, the EPA, the New Mexico Environment Department (NMED), and the general public.

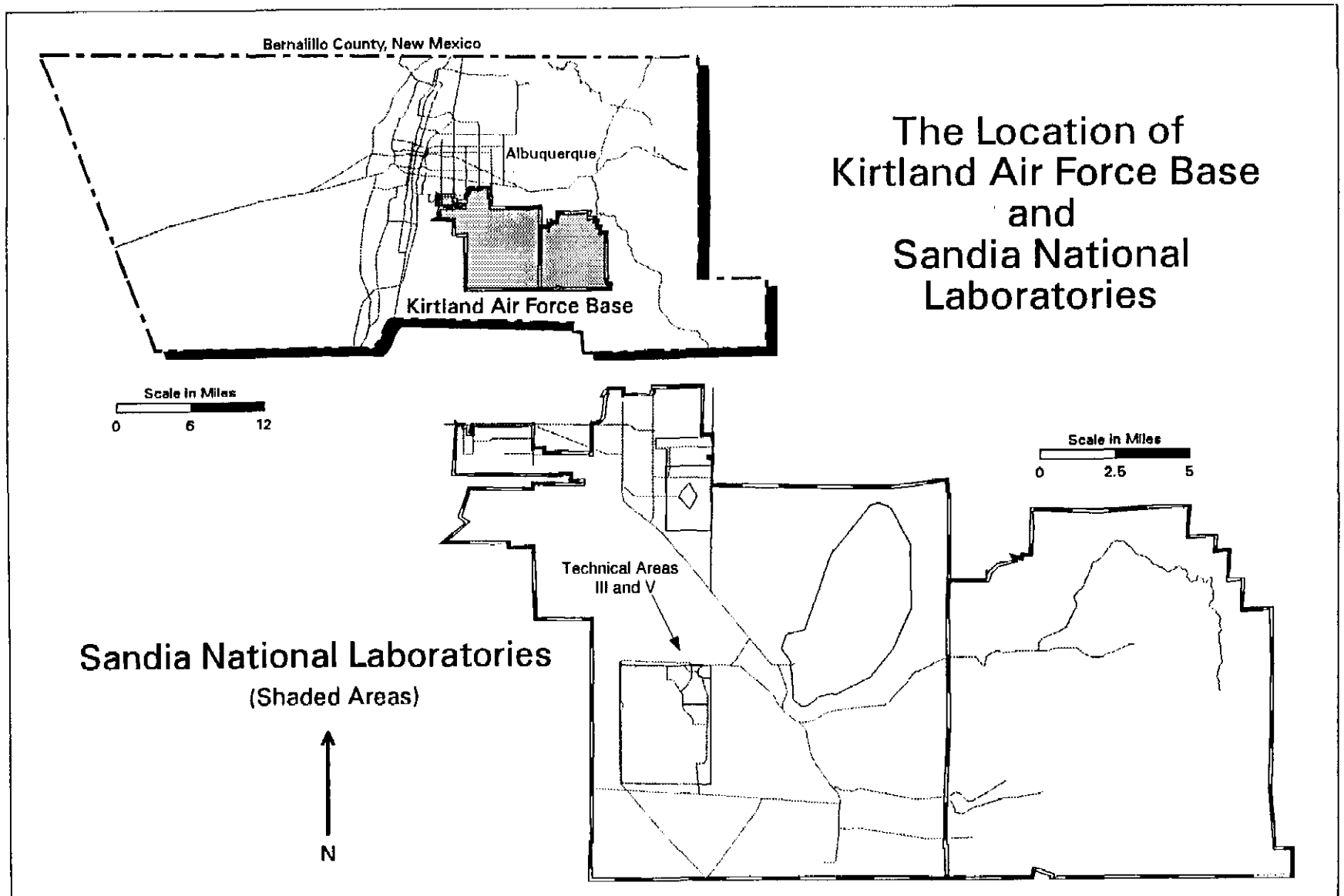


Figure 1-1 Location of Technical Areas III and V at Sandia National Laboratories, Albuquerque

Table 1-1
Summary of Environmental Restoration Sites Within Technical Areas III and V

Site Number	Site Name	Location	Areal Extent	Potential Contaminants[a]/ Detected During RFI?	Period of Operation (Status)	Sampling Method and Date	Total Samples	Field Screen Samples	Off-Site Analyses	Notes[b]
18	Concrete Pad	Central TA-III; South of Short Sled Track.	125 ft by 400 ft	Metals/Yes Radionuclides/Yes HEs/No Oil/Yes PCBs/Yes	1979 - present (Active).	Phase I: Surface, 04/27/94.	43	43	12	Rad. VCM completed. Extent of contamination defined for metals, PCBs, and TPH. VCM planned.
						Phase II: Auger, 01/24/95.	13	13	9	
26	Burial Site	West TA-III; West of Long Sled Track.	145 acres	Metals/NA[c] Radionuclides/Yes	Prior to 1989 (Inactive). Co-located with active Long Sled Track.	NA	NA	NA	NA	Geophysics done; found potential burials. These to be investigated with Site 83. Proposed for NFA.
31	Transformer Oil Spill	Central TA-III; Centrifuge Facility.	20 ft by 20 ft	Oil/No PCBs/No	1971 - present (Active).	Surface, 03/29/94.	11	3	11	No COCs above background. Proposed for NFA.
34	Centrifuge Oil Spill	Central TA-III; Centrifuge Facility.	90-ft diameter	Oil/No	1955 - present (Active).	Shallow subsurface, 05/20/95.	18	18	10	No COCs above background. Proposed for NFA.
35	Vibration Facility Oil Spill	Central TA-III.	20 ft by 50 ft	Oil/Yes PCBs/No	1955 - present (Active).	Phase I: Surface, 04/15/94.	4	0	4	Extent of oil defined. Proposed for NFA.
						Phase II: Shallow subsurface, 06/29/94.	13	13	4	

[a]Contaminants as follows: HEs = high explosives; PCBs = polychlorinated biphenyls; VOCs = volatile organic compounds.
[b]VCM = Voluntary Corrective Measure; TPH = Total petroleum hydrocarbons; NFA = No Further Action; COC = constituent of concern.
[c]NA = Not applicable. These sites were not sampled during the RCRA Facility Investigation (RFI); see Notes column.

Table 1-1
Summary of Environmental Restoration Sites Within Technical Areas III and V (Continued)

Site Number	Site Name	Location	Areal Extent	Potential Contaminants[a]/ Detected During RFI?	Period of Operation (Status)	Sampling Method and Date	Total Samples	Field Screen Samples	Off-Site Analyses	Notes[b]
36	HERMES Oil Spill	Central TA-V; North of Bldg 6596.	1 acre	Oil/Yes VOCs/Yes	1968 - 1989 (Inactive).	Phase I: Shallow subsurface, 07/6/94.	28	28	11	No oil detected in shallow subsurface. Defined extent of oil and VOCs.
						Phase II: Drilling, 03/10/95.	40	40	36	Proposed for NFA.
37	PROTO Oil Spill	Central TA-V; East of Bldg 6597.	1 acre	Oil/No	1978 - 1989 (Inactive).	Auger, 06/9/94.	23	23	8	No COCs above background. Proposed for NFA.
51	Bldg 6924 Pad, Tank, Pit	Southeast TA-III; Northwest of Site 241.	1/2 acre	Metals/Yes HEs/No VOCs/No	1963 - 1990 (Inactive).	Excavation, 09/6/94.	5	4	5	No COCs above background. Proposed for NFA.
78	Gas Cylinder Disposal Pit	Southeast TA-III; East of Chemical Waste Landfill.	80 ft by 180 ft	Toxic, corrosive, reactive, and flammable gases/Yes Radionuclides/Yes Metals/Yes HEs/Yes	1963 - 1984 (Inactive).	Phase I: Excavation - Radioactive.	94	386	91	Health and safety and geophysics surveys. Began VCM 07/94; finished 02/95.
						Phase I: Excavation - Chemical.	94	37	186	Detected chromium, thorium, gases, and reactive chemicals.
						Phase II: Gas analyses.	97	0	97	
						Phase II: Reactive chemicals.	32	32	0	No off-site analysis of reactive chemicals was feasible.
						Phase III: Confirmatory shallow subsurface.	20	0	20	No COCs above background during Phase III. Proposed for NFA.

[a]Contaminants as follows: HEs = high explosives; PCBs = polychlorinated biphenyls; VOCs = volatile organic compounds.
[b]VCM = Voluntary Corrective Measure; TPH = Total petroleum hydrocarbons; NFA = No Further Action; COC = constituent of concern.
[c]NA = Not applicable. These sites were not sampled during the RCRA Facility Investigation (RFI); see Notes column.

Table 1-1
Summary of Environmental Restoration Sites Within Technical Areas III and V (Continued)

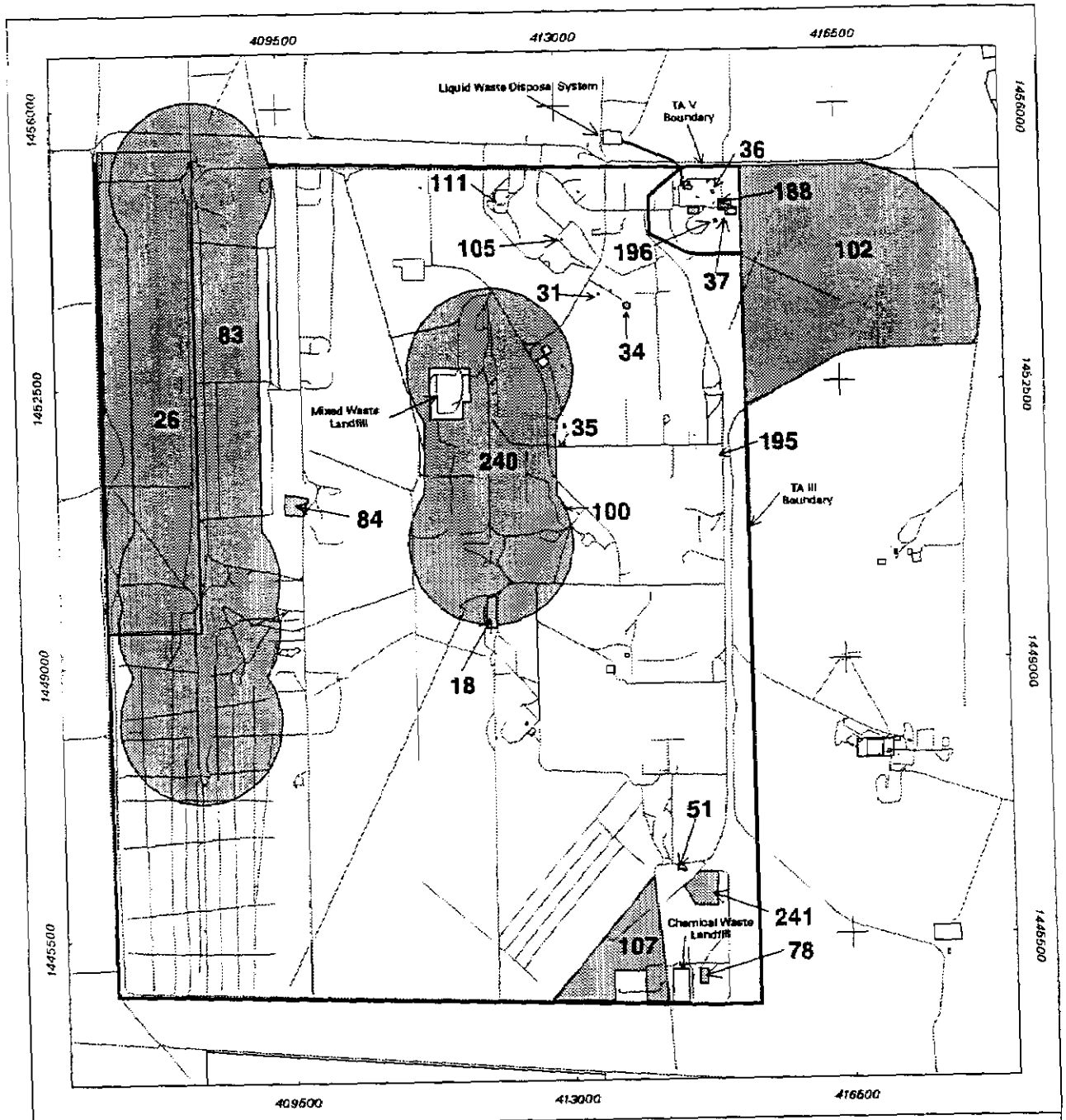
Site Number	Site Name	Location	Areal Extent	Potential Contaminants[a]/ Detected During RFI?	Period of Operation (Status)	Sampling Method and Date	Total Samples	Field Screen Samples	Off-Site Analyses	Notes[b]
83	Long Sled Track	West TA-III boundary.	350 acres	Metals/NA[c] HEs/NA Radionuclides/Yes	1966 - present (Active).	Surface, 04/15/94.	6	0	6	Minor surface sampling done. Rad. VCM completed. Full RFI when site deemed inactive.
84	Gun Facilities	West-central TA-III; East of Long Sled Track.	2 acres	Metals/NA HEs/NA Radionuclides/Yes	1965 - present (Active).	NA	NA	NA	NA	Rad. VCM completed. Full RFI when site deemed inactive.
100	Bldg 6620 Drain/Sump	Central TA-III, immediately southeast of Short Sled Track.	25 ft by 60 ft	Metals/NA HEs/NA	1958 - unknown (Inactive).	Exploratory trenching, 07/25/94.	0	0	0	Site not located during RFI. Proposed for NFA.
102	Radioactive Disposal Area	East of TA-V.	155 acres	Radionuclides/No	Unknown - 1967 (Inactive).	Excavation, 07/25/94.	3	0	3	Rad. survey done. No COCs above background. Proposed for NFA.
105	Mercury Spill at Bldg 6536	North-central TA-III.	20 ft by 20 ft	Mercury/NA	1972 - 1985 (Inactive).	Document search.	NA	NA	NA	Administrative NFA approved July 1995.
107	Explosives Test Area	Southeast TA-III; West of Chemical Waste Landfill.	25 acres	Metals/No HEs/No Nitrate and nitrite/No Radionuclides/No	1953 - 1972 (Inactive).	Surface, 05/17/94.	11	11	11	No COCs above background. Proposed for NFA. Future site of TU-CAMU.

[a]Contaminants as follows: HEs = high explosives; PCBs = polychlorinated biphenyls; VOCs = volatile organic compounds.
[b]VCM = Voluntary Corrective Measure; TPH = Total petroleum hydrocarbons; NFA = No Further Action; COC = constituent of concern.
[c]NA = Not applicable. These sites were not sampled during the RCRA Facility Investigation (RFI); see Notes column.

Table 1-1
Summary of Environmental Restoration Sites Within Technical Areas III and V (Concluded)

Site Number	Site Name	Location	Areal Extent	Potential Contaminants[a]/ Detected During RFI?	Period of Operation (Status)	Sampling Method and Date	Total Samples	Field Screen Samples	Off-Site Analyses	Notes[b]
111	Bldg 6715 Sump/Drain	North-central TA-III.	20 ft by 20 ft	Silver/No HEs/No VOCs/No	1971 - 1988 (Inactive).	Shallow subsurface, 06/17/94.	10	9	4	No COCs above background. Proposed for NFA.
188	Bldg 6597 Aboveground Spill Contain.	TA-V; co-located with Site 37.	15 ft by 25 ft	Used oil/NA[c]	1983 - 1986 (?) (Inactive).	Aerial photographs; confirmatory sampling.	37	22	22	Administrative NFA approved July 1995 - water tanks.
195	Experimental Test Pit	East-central TA-III.	6 ft by 6 ft	Cobalt-60/NA	1955 - 1956 (Inactive).	Document search.	NA	NA	NA	Administrative NFA approved July 1995.
196	TA-V Cistern	South TA-V; West of Bldg 6597.	25-ft diameter	Metals/Yes Oil/Yes VOCs/No	Unknown - 1989 (Inactive).	Phase I: Sludge sampling, 06/27/94 and 10/10/94.	4	3	1	Defined extent of metals in soil. No VOCs or PCBs. Proposed for NFA.
						Phase II: Excavation, 05/95.	2	0	2	
						Phase III: Auger, 06/5/95.	26	26	3	
240	Short Sled Track	Central TA-III.	160 acres	Metals/Yes HEs/No Radionuclides/Yes	1951 - 1966 (Inactive).	Surface, 06/13/94 and 06/22/94.	201	40	40	Rad. VCM completed. Detected rad. and lead.
241	Storage Yard	Southeast TA-III, North of Site 78.	3 acres	Metals/Yes HEs/No Radionuclides/No	1953 - 1994 (Inactive).	Surface, 05/24/94.	29	29	16	Defined extent of lead. Proposed for NFA.

[a]Contaminants as follows: HEs = high explosives; PCBs = polychlorinated biphenyls; VOCs = volatile organic compounds.
[b]VCM = Voluntary Corrective Measure; TPH = Total petroleum hydrocarbons; NFA = No Further Action; COC = constituent of concern.
[c]NA = Not applicable. *These sites were not sampled during the RCRA Facility Investigation (RFI); see Notes column.*



Legend

- TA-III/V ER Sites
- Technical Area Boundary
- Roads

Buildings, Elevation Contours and Drainages not shown.

Sandia National Laboratories, New Mexico
Environmental Restoration Geographic Information System

Figure 1-2
ER Sites within
Technical Areas III/V

0 1000 2000
Scale in Feet

0 240 480
Scale in Meters

Unclassified

FINAL

1:24000

Transverse Mercator Projection, New Mexico State Plane Coordinate System, Central Zone
1927 North American Horizontal Datum, 1929 North American Vertical Datum

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This RFI report consists of an executive summary, an introduction, a discussion of the Sampling and Analysis Program, descriptions of investigations conducted at individual sites, Voluntary Corrective Measures (VCMs) conducted at several sites, a summary and conclusion, a list of references, and supporting documentation in several appendices.

1.3 Facility Setting

SNL/NM consists of 2,820 acres of research laboratories and office facilities entirely contained within the 52,223-acre confines of KAFB (Figure 1-1). KAFB is bounded on the north and northwest by the city of Albuquerque, on the east by the Cibola National Forest, on the south by the Isleta Indian Reservation, and on the west by land owned by the State of New Mexico, the KAFB buffer zones, and the Albuquerque International Airport. Cibola National Forest access is controlled by the U.S. Forest Service (USFS) and is restricted within the buffer zones on the southwest corner of the base and within the Isleta Indian Reservation.

KAFB is located on a high, arid mesa (mean elevation of 5,350 feet [ft]) approximately 5 miles (mi) east of the Rio Grande. The mesa is cut by Tijeras Arroyo, which runs east-west and ultimately drains into the Rio Grande. The east side of KAFB is bounded by the southern end of the Sandia Mountains and the Manzanita Mountains. Most of the area is relatively flat, although the eastern portions of KAFB and SNL/NM extend into the Manzanita Mountains where some of the terrain is precipitous, rough, and cut by numerous arroyos (ERDA 1977).

1.4 Climate

The climate for SNL/NM is typical of high altitude, dry continental climates with a normal daily winter temperature range of 23 degrees Fahrenheit (°F) to 52°F and a normal daily summer temperature range of 57°F to 91°F (Bonzon et al. 1974). The average annual precipitation for the Albuquerque area is 8.54 inches (in.), and most rain occurs in the summer months (Williams 1986). Wind speeds seldom exceed 32 miles per hour (mph) but strong east winds, often accompanied by blowing dust, can occur (Bonzon et al. 1974).

1.5 Geology

The Albuquerque-Belen structural basin is one of the largest north- to south-trending basins in the Rio Grande Rift. The basin is a compound graben measuring 90 mi long and 30 mi wide, bordered by uplifted fault blocks to the east and west (Bjorklund and Maxwell 1961). The eastern boundary is marked by the Sandia, Manzanita, and Manzano mountains. The western side of the basin is bounded by the Lucero uplift, with the Ladron Mountains to the south and minor physiographic relief on the northwest side of the basin.

During the Miocene and Pliocene epochs, erosion from the surrounding highlands filled the Albuquerque Basin with up to 10,000 ft of sediments. This sequence of sediments is called the Santa Fe Group and consists of debris flows and channel, floodplain, and aeolian deposits; the Santa Fe Group thins toward the edges of the basin and is truncated by the bounding uplifts. The Santa Fe Group sediments are

interbedded with Tertiary and Quaternary basalts and pyroclastics, and are overlain in places by the Pliocene-age Ortiz gravel deposits and Rio Grande fluvial deposits (Bjorklund and Maxwell 1961).

1.6 Soil Characteristics

According to the Bernalillo County Soil Survey (USDA 1977), soils in TA-III/V consist of the Tijeras Series. The Tijeras Series is a deep, well-drained soil formed in decomposed granitic alluvium on old alluvial fans. The surface layer is a 4-in.-thick, brown, gravelly, sandy loam. The subsoil consists of 15 in. of brown, sandy loam, with some accumulation of calcium carbonate in the lower part. Below 19 in. is a pale brown, very gravelly, loamy sand extending to a depth of 5 ft. The gravel is angular and derived from granite (USDA 1977).

The Tijeras Series is a level to gently sloping soil (0 to 5 percent) subject to moderate runoff and water erosion. Permeability is moderate, with an available water capacity of 0.10 to 0.16 in. This soil is moderately alkaline and the effective rooting depth is 5 ft deep or more (USDA 1977).

1.7 Hydrogeology

The Rio Grande flows in a southerly direction and is the primary surface drainage feature in the Albuquerque-Belen Basin. In the basin, the ground-water system is controlled by the Rio Grande and its floodplain, tributary inflow, mountain front runoff, and recharge.

The principal aquifer in the area occurs in the unconsolidated and semiconsolidated sands, gravels, silts, and clays of the Santa Fe Group. The aquifer is generally unconfined, although semiconfined conditions may exist locally because of discontinuous, lenticular silt and clay-rich deposits.

Beneath KAFB, the regional aquifer generally flows toward the Rio Grande at an average gradient of approximately 10 ft/mi; however, local perturbations in the water table exist near municipal wells and as a result of lithologic and structural controls. Prior to extensive development of the regional aquifer by the city of Albuquerque and KAFB, the predominant ground-water flow direction in the SNL/NM KAFB area was west-southwest (Bjorklund and Maxwell 1961); however, pumping by the city of Albuquerque and KAFB has substantially affected the natural ground-water flow regime (Reeder et al. 1967; Kues 1987). The production wells have a substantial effect on the hydraulic gradient in the area, creating a depression in the potentiometric surface in the northern portion of KAFB. U.S. Geological Survey (USGS) projections indicate that, by the end of the century, the water table in the Albuquerque area will drop an estimated 30 to 50 ft from 1989 levels (Reeder et al. 1967).

Major structural controls on the local flow regime are in the form of a complex assemblage of faults along the margin of the basin. These fault systems include the Manzano, Hubbell Springs, Sandia, and Tijeras faults, all of which are expressed within a zone 1.5 mi east of TA-V. The specific impact of local faulting on ground-water flow is largely unknown; however, the Tijeras and Hubbell Springs faults may control ground-water movement. It has been postulated that travertine deposition (precipitation of calcium carbonate from solution in ground water) within fault fractures has reduced permeabilities such that the faults act as barriers to ground-water movement. Springs have been observed along the fault alignments, and there is a shallow water table east of the faults. The primary regional aquifer, the valley

fill, underlies KAFB west of the Hubbell Springs fault at a depth of 400 to 600 ft and east of the fault at a depth of 50 to 150 ft (DOE 1987).

The primary source of ground water in the TA-III/V area is the unconsolidated and semiconsolidated sedimentary deposits of the basin-fill aquifer. A relatively thick unsaturated zone of approximately 460 ft overlies the Santa Fe Group deposits. The basin-fill aquifer underlying TA-III/V is recharged primarily by inflow from the mountain areas to the east. Recharge resulting from direct infiltration of precipitation is inferred to be minor because of high surface coverage, high evaporation, low precipitation, and an extensive vadose zone.

Based on water levels measured in monitoring wells near the Liquid Waste Disposal System (LWDS) in TA-V and near the Chemical Waste Landfill (CWL) and MWL in TA-III, the depth to ground water is approximately 480 to 490 ft below ground surface (bgs) in TA-III/V. Water levels measured in all wells in TA-III indicate the general ground-water flow direction is west-northwest.

2.0 SAMPLING AND ANALYSIS PROGRAM

The sampling and analysis program for the sites in TA-III/V followed standard EPA procedures for sample collection (EPA 1987a), quality assurance/quality control (QA/QC) protocols (EPA 1987b, 1980), and statistical analysis (EPA 1992a). Each of these is discussed in the following sections.

2.1 Field Methods

Field investigations at the ER sites within TA-III/V followed phased approaches according to those proposed in the RFI Work Plan (SNL/NM 1993a, 1993b), except at six sites. Field conditions dictated that methods other than those specified in the Work Plan be used at Sites 34, 36, 78, 102, 111, and 196. Deviations from the Work Plan are noted in the individual descriptions of site activities (Sections 6.0, 8.0, 11.0, 15.0, 18.0, and 21.0).

The methods of investigation used during the TA-III/V RFI included the following:

- Aerial photograph analysis and ground-truthing;
- Nonintrusive geophysical investigations;
- Radiological surveying and scrap/debris removal;
- Surface soil sampling;
- Shallow subsurface soil sampling and deep subsurface soil sampling; and
- Trenching and excavation.

Protocols for sampling and analysis at SNL/NM followed the methodologies in the ER Project Quality Assurance Project Plan (QAPjP) and Operating Procedures (OPs) developed specifically for the ER Project. A complete list of OPs used during this project is provided in Table 2-1. Although much of the field work was done before the formal issuance of the SNL/NM ER OPs, activities were conducted in accordance with generally accepted practices and professional experience and judgment (i.e., American Society for Testing and Materials [ASTM] procedures, best engineering practices, and draft OPs), which ultimately formed the basis of the final OPs. All work was conducted following the requirements of site-specific Health and Safety Plans (HASPs), which are available for review in the Environmental Operations Records Center (EORC).

The following activities were conducted at the sites noted:

- Aerial photographic interpretation—all sites;

- Geophysical surveys—Sites 26, 78, and 84;

- Radiation surveys and associated removal of radioactive anomalies—Sites 18, 83, 84, 102, 240, and 241;

Table 2-1
Sandia National Laboratories/New Mexico Environmental Restoration Project Operating Procedures Applicable to Technical Areas III and V RFI Work

Operating Procedure (OP) Number	Title
AOP 94-40	ER Project Site Posting and Security
FOP 94-01	Safety Meetings, Inspections, and Pre-Entry Briefings
FOP 94-05	Borehole Lithologic Logging
FOP 94-22	Deep Soil Gas Sampling
FOP 94-23	Hand Auger and Thin-Wall Tube Sampler
FOP 94-25	Documentation of Field Activities
FOP 94-26	General Equipment Decontamination
FOP 94-27	Thin-Walled Tube Sampling of Soils
FOP 94-28	Health and Safety Monitoring of Organic Vapors (Flame Ionization Detector [FID] and Photoionization Detector [PID])
FOP 94-30	Health and Safety Monitoring of Combustible Gas Levels
FOP 94-34	Field Sample Management and Custody
FOP 94-38	Drilling Methods and Drill Site Management
FOP 94-39	Excavating Methods
FOP 94-40	Test Pit Logging, Mapping, and Sampling
FOP 94-52	Spade and Scoop Method for Collection of Soil Samples
FOP 94-57	Decontaminating Drilling and Other Field Equipment
FOP 94-68	Field Change Control
FOP 94-69	Personnel Decontamination (Level D, C & B Protection)
FOP 94-71	Land Surveying
FOP 94-78	Environmental Restoration Project Waste Management and Characterization Procedure
FOP 94-81	Establishment and Management of Less-Than-90-Day Accumulation Areas for Environmental Restoration Project Sites
FOP 95-23	Shallow Subsurface Drilling and Soil Sampling Using Mechanized Hydraulic Augers or the Geoprobe® Soil Core Sampler

Source: SNL/NM (1995a).

- Sampling of surface soils—Sites 18, 31, 35, 78, 107, 240, and 241;
- Subsurface sampling using augers, a hydraulic probe, or a full-size drill rig—Sites 18, 34, 35, 36, 37, 78, and 111;
- Trenching, excavation, and other cleaning—Sites 51, 78, 100, 102, 196, and 241; and
- Voluntary removal actions or cleanups (excluding the radiological removals)—Site 78.

Further investigation of Sites 26, 83, 84, and 240 (active sites) will be postponed until site decommissioning in the future. Site 26 is proposed in this RFI report (Section 4.0) to be combined with Site 83 for future investigation. No schedule for decommissioning or corrective action at these sites has been identified at this time.

Two VCMs were conducted during the course of the RFI. One was performed to survey and remove radiological constituents at the six sites listed above; details of this VCM are provided in Section 24.0. The second was performed at Site 78 to remove gas cylinders and mitigate health and safety hazards; the details of this VCM are provided in Section 11.0.

Subsurface and ground-water investigations conducted at the neighboring LWDS in TA-V are detailed in the RFI report submitted for that site in September 1995 (SNL/NM 1995b). Because no ground-water investigations were conducted during the TA-III/V RFI, the LWDS RFI report should be consulted for information on this subject. Reports on the ongoing investigation at the CWL in TA-III also should be consulted for ground-water information.

2.1.1 Aerial Photograph Analysis and Ground-Truthing

An examination of aerial photographs was conducted to locate possible additional ER sites within TA-III/V and to gather supplemental data on existing sites. Aerial photographs from 1973 to 1990 were assembled and digitized using an Arc/Info Geographic Information System (GIS) and were used to produce a set of year-specific overlays. A base photographic image was combined with the year-specific overlays to illustrate the changes in surface features over time (Plate I). All of the sites were evaluated within 1,000 ft of the site boundaries (unless noted otherwise) for signs of soil disturbance, vegetation changes, or new construction. Surface features were grouped into eight categories including cleared or disturbed surface, concrete pad, landfill, pile, possible excavation, tank/concrete target, trench, and unknown. An attempt was made to further subcategorize features, but no additional or valuable information was revealed.

After the aerial photograph interpretation was completed, ground-truthing (field verification) was performed to determine whether the interpretations were valid. Field personnel inspected the suspect areas for evidence of potential site impacts; e.g., cleared or disturbed surfaces were located to within 10 ft of the area seen on the photographs and were examined for signs of burning, scraping, or blading for road or facility construction, and were validated as such. In a few instances, revegetation and cultural activities did not permit the unequivocal verification of features identified in early photographs. Site-specific discussions of the aerial photograph interpretation are included in each site section.

2.1.2 Nonintrusive Geophysical Investigations

Nonintrusive electromagnetic (EM) conductivity (metal detection) and vertical-gradient magnetometer surveys were conducted at ER Sites 26, 78, and 84 to locate any potential subsurface objects. The sites were gridded to detect objects of a certain size and are listed below.

- Site 26, Northern Portion—Locate and map any objects equivalent to or larger than two 55-gallon (gal.) drums buried at a depth of 5 ft.

- Site 26, Southern Portion—Locate and map any objects equivalent to or larger than one 55-gal. drum buried at a depth of 5 ft.

- Site 78—Locate and map subsurface concentrations of metal, particularly cylinders with dimensions of 12 in. by 2 in.

- Site 84—Locate major fragments of depleted uranium (DU), lead, and metallic materials larger than 3 in. by 3 in. buried to a depth of 1.5 ft; and significant burials equivalent to a 5-gal. bucket buried to a depth of 3 ft.

Wooden stakes and plastic pin flags were used to delineate the traverse spacings. Electromagnetic data were gathered using a Geonics Ltd.™ EM-61 high-precision metal detector; magnetic data were gathered using a Geometrics™ G-856-AX proton precession magnetometer deployed in the vertical mode. A brief description of each follows.

The EM-61 generates EM pulses by passing a current through a 1-square-meter (m^2) coil. These pulses penetrate the subsurface and briefly induce secondary EM fields; soil has relatively low conductivity, and the secondary fields dissipate rapidly. Buried metallic objects have essentially infinite conductivity when compared to soil, and their secondary fields persist much longer. The EM-61 measures the strength of the secondary fields during the "off time" between the primary pulses. The measurement is delayed until the response from the soil has dissipated and only the response of buried metal is present. The secondary EM fields are measured by a 1-m^2 main sensor which is coincident with the transmitter coil, and by a second focusing coil positioned 40 centimeters (cm) above the main coil. Each sensor coil measures the secondary field strength during a time period between the primary pulses. Two sensor coils are used to allow differentiation between shallow objects and deeper objects. The EM-61 was deployed in the trailer mode, towed on wheels behind the operator, with data acquisition triggered by the wheel approximately every 20 cm.

The G-856-AX consists of two magnetic sensors mounted on the same vertical staff separated by a known distance. The instrument generates a pulse and registers the difference in time for the return magnetic pulse to be recorded by the top and bottom sensors. This difference is then converted to a standard reading. The G-856-AX was held vertically, and moved along the traverse manually, from grid node to grid node. Data acquisition was performed manually or programmed to be collected at regular intervals (every few seconds [sec]).

2.1.3 Surface Radiological Survey and Scrap/Debris Removal

Nonintrusive surface radiological surveys were performed at 64 sites at SNL/NM including six sites within TA-III/V, as part of a coordinated facility-wide assessment and removal VCM. Surveys were conducted in a manual sweep pattern using a line of five to six 2-in. by 2-in. sodium iodide (NaI) detectors optimized to detect DU. Gridded areas were surveyed by technicians in straight traverses, each covering a 6-ft-wide swath.

A list of radioactive anomalies (both point and area sources) at each site was compiled. After the surveys were complete, all the point sources and the majority of the area sources were removed by hand and placed in a container. Subsequent to the removal action, soil samples were collected to confirm effective cleanup. Brief discussions of results are included in the individual site sections, and a more detailed description of the radiological surveys conducted at the sites within TA-III/V that were suspected of exhibiting radioactive soil contamination is provided in Section 24.0.

2.1.4 Surface Soil Sampling

Surface soil samples were collected from a depth of 0 to 1 ft bgs using a stainless-steel trowel and bowl. All sampling equipment was cleaned between samples using dry decontamination methods (i.e., paper towels, brushing, etc.) where possible or rinsed with distilled water. Sample location coordinates are provided in Appendix A.

2.1.5 Shallow Subsurface Soil Sampling

Shallow subsurface soil sampling was accomplished using either hand or power augers or a small-diameter hydraulic probe. Discussions of these techniques follow.

Auger Sampling

Augering using a hand bucket or power auger and thin-walled stainless-steel samplers was generally performed at sites where sampling depth was a maximum of 10 ft bgs. Soil augering was performed to a predetermined depth approximately 6 in. above the level to be sampled, and the bucket auger was extracted. Loose soil was removed, and a separate sampling auger was used to collect the sample. All augering and sampling equipment was cleaned between sample locations using dry decontamination methods where possible or rinsed with distilled water.

Small-Diameter Boring

At sites where augering techniques would not attain the desired depths (generally greater than 10 ft bgs), a vehicle-mounted, hydraulically powered soil probing machine that uses static force and a percussion hammer was utilized to advance small-diameter sampling tools into the subsurface to collect soil samples to 30 ft bgs. The unit used was manufactured by Geoprobe™. The probe produced no drill cuttings and obtained samples through probe holes of 1 to 1.5 in. diameter with typical penetration rates of 1 to 2 ft per minute.

Small quantities of soil were obtained by driving the probe to a predetermined depth, disengaging an expendable drive point at the target depth and pulling back 3 to 6 in. on the probe rods, and then redriving the hollow rods. The end of the rod was filled with soil cut from the wall of the hole.

2.1.6 Deep Subsurface Sampling

Drilling was conducted at Site 36 using an air rotary casing hammer rig to drill to depths of greater than 300 ft bgs. A more detailed discussion of the drilling and sampling procedures used at the site is included with the Site 36 activity description in Section 8.0.

2.1.7 Excavation and Trenching

Excavation, trenching, and cleanouts were accomplished using a backhoe, trackhoe, clamshell, or front-end loader at several sites. Details of the excavations and cleanouts are provided in the individual site sections for Sites 51, 78, 100, 102, 196, and 241.

2.2 Field Screening and On-Site Laboratory Analysis Methods

Where feasible, field screening was conducted on approximately 100 percent of the collected soil samples from all sites investigated in TA-III/V. At least 20 percent of these were submitted for confirmatory analysis at an EPA-approved Contract Laboratory Program (CLP) laboratory (Section 2.3). The field screening data for each site are included in Appendix B. Discussions of the following field-screening methods used during the RFI are included in subsequent sections:

- Photoionization detection (PID) and flame ionization detection (FID) of volatile organic compounds (VOCs);
- Soil vapor detection of VOCs;
- Thermal desorption detection of mineral oil;
- Immunoassay detection of polychlorinated biphenyls (PCBs) and high explosives (HEs);
- X-ray fluorescence (XRF) analysis of metals;
- Direct current plasma (DCP) and inductively coupled plasma (ICP) analysis of metals; and
- Gamma spectroscopic analysis of radionuclides.

2.2.1 Photoionization Detection and Flame Ionization Detection of Volatile Organic Compounds

Screening for VOCs in the field was generally accomplished using hand-held PIDs and FIDs. The units used were manufactured by HNU and Foxboro. Soil samples were placed in a glass jar, sealed, agitated, and warmed to allow volatile constituents to develop in the headspace of the jar. The PID or FID sample probe was placed in the headspace, where a sample of vapor was drawn into a chamber, ionized, and interpreted by the instrument. The low sample rate allowed for only very localized readings. Monitoring for health and safety levels was also performed during drilling activities at 5-ft intervals downhole, as well as in the breathing zone. Where elevated organic vapor levels were encountered, monitoring was

performed continuously in the breathing zone. The instrument calibrations and readings were recorded in the field logbook.

2.2.2 Soil Vapor Analysis

Soil samples were collected for on-site analysis of soil vapor for the presence of VOCs during drilling activities at Site 36 and were immediately transported to the TA-III ER Field Laboratory for analysis. Soil vapors were collected by polyethylene tubing connected to a glass bulb using a pump under vacuum.

Soil vapor analyses were conducted by purging a 500-milliliter (mL) gas bulb for 20 minutes (min) with helium onto a trap and desorbing the trap onto a gas chromatograph equipped with a mass selective detector (MSD). Purging the entire contents of the sample bulb allowed attainment of lower detection levels for the sensitive soil vapor analysis. All analyses were performed on an HP 5972 MSD with an HP 5890 Series II plus gas chromatograph. EPA Methods 8240/8260 (EPA 1986) procedures were used for calibration and quantitation. The target analyte list (TAL) for EPA Method 8240 was used. For heavily contaminated soils, a smaller aliquot of gas was subsampled from the 500-mL bulb.

2.2.3 Thermal Desorption/Gas Chromatography

SNL/NM ER personnel conducted an investigation of available technologies to locate an alternative heavy-end total petroleum hydrocarbon (TPH) field-screening technique that was more reliable than the Hanby Method. Neither the Hanby Method nor field screening using immunoassay kits was effective because neither is sensitive to the nonaromatic High Energy Radiation Megavolt Electron Source (HERMES) transformer oil (discussed below). As a response to these ineffective screening methods, SNL/NM developed a technique that employs thermal desorption/gas chromatography (TD/GC) to rapidly quantify non-PCB-containing transformer oil in soil.

The transformer oil used at the HERMES-II facility is primarily a mixture of aliphatic and alicyclic hydrocarbons, and contains no significant quantities of EPA-regulated hazardous constituents as manufactured (e.g., PCBs or VOCs). Indeed, any appreciable amount of VOCs in the dielectric oil would have significantly altered the insulating properties of the oil. The boiling point for the mineral oil ranges from approximately 120 degrees Celsius (°C) to 365°C; its relatively low volatility makes it undetectable by real-time field monitoring instruments such as PIDs and FIDs, which rely on volatilization of contaminants at ambient conditions.

TD/GC has been used to characterize fuel-contaminated soils (i.e., those containing volatile and/or semivolatile constituents) and soils containing PCBs (Goldsmith 1994). The technique utilizes the direct injection of organic contaminants from soil onto a GC column, avoiding the use of environmentally harmful solvents. The method detection limit (MDL) is 10 milligrams per kilogram (mg/kg). The low MDL is a result of direct sample analysis without the potential dilution problems associated with sample preparation. Method sensitivity is also enhanced by analysis of the soil sample within hours of field collection, which minimizes potential storage loss and cross-contamination.

TD/GC analyses for mineral oil were performed using an SRI Model 8610 GC equipped with a TD oven and a manual sampling valve. The system was equipped with an FID that was used for the detection and quantitation of the oil after it had passed through the TD/GC sequence. An aliquot of soil

(approximately 1.0 gram [g]) was placed in the desorption chamber for 1 min at 325°C to vaporize organic constituents. The vapors were then swept onto the GC column for separation. A relatively nonpolar megabore capillary column (J&W Scientific, DB-5, 8 ft by 0.53 millimeter [mm]) was used for constituent separation and quantitation. A five-point calibration curve was generated by spiking clean sand with a mixture of HERMES oil in toluene (10 to 500 mg/kg). The curve was linear with a correlation coefficient of $r^2 = 0.998$. TPH in soil was quantified by "pattern recognition" using the total area under the distinctive mineral oil chromatogram. An external standard (dodecane) was added to determine sample matrix interference and injection efficacy. QA samples included replicate analyses for every 10 samples and a mid-range calibration check standard prior to daily sample analyses, after every 20 samples, or at the end of a 12-hour (hr) period.

2.2.4 Immunoassay Tests for Polychlorinated Biphenyls and High Explosives

Immunoassay tests for chemical constituents are based on the antibody response of mammalian immune systems to the introduction of chemical contaminants. To produce the desired antibodies in the kit, predetermined concentrations of specific chemicals are introduced into a test animal, causing the animal's immune system to produce antibodies to that chemical. Antibodies are extracted, separated, purified, and encapsulated for test kits. The antibodies in the test kits respond to varying concentrations of chemical compounds by giving varying responses. The test kits for PCBs and HEs, both manufactured by EnSys Inc., are discussed below.

PCBs

The protocol for PCB test kits conforms to SW-4020, immunoassay-based field screening for PCBs in soil. Detection limits range from 400 microgram per kilogram (µg/kg) for Aroclors 1254 and 1260 (prevalent Aroclors in dielectric fluids at SNL/NM) to 1, 2, 4, and 4 mg/kg for Aroclors 1248, 1242, 1016, and 1232, respectively. The test is specific to PCBs and has no anticipated interferences. The field test is positively biased for PCBs. Rigorous testing against lab-GC SW-8080 (prior to commercial availability of the test kit) resulted in false negatives in less than 1 percent of field tests performed. When testing samples, the method requires standard replicate analysis with each environmental sample analyzed; the relative standard deviation must be within ±20 percent, or the sample analysis will be repeated.

HEs

The field test kit for HE conforms to proposed SW-8515 for field screening for trinitrotoluene (TNT) in soil and can detect TNT, dinitrotoluene (DNT) isomers, and trinitrobenzene at concentrations of approximately 1 mg/kg in soil as measured by colorimetric reaction. The test is positively biased for HEs. Prior to commercialization of the test kit, false negatives were identified by SW-8515 in less than one percent of the field samples.

2.2.5 X-Ray Fluorescence

XRF was conducted using a Spectrace® 6000 Spectrometer. XRF is a whole-rock quantitation method for analyzing concentrations of elemental metals in environmental samples. Characteristic X-ray spectra are emitted when a specimen is irradiated with a beam of sufficiently short wavelength X-radiation. Standard reference materials of the National Institute of Standards and Testing (NIST) are used to verify the accuracy of the calibration. XRF can analyze metals with detection limits of 10 to 60 mg/kg. XRF is

a nondestructive method for analyzing environmental samples and generates no waste; samples are dried and ground prior to analysis. XRF was used during sampling activities as a field-screening tool for metals to direct the sampling for off-site laboratory analyses.

2.2.6 Direct Current Plasma/Inductively-Coupled Plasma

DCP and ICP elemental analyses for metals concentrations were conducted in accordance with SW-6010A using a Leeman PS 1000 sequential ICP. Soil samples were prepared by microwave-assisted acid digestion (EPA Methods 3051 and 6010 QA requirements). An aerosolized sample is introduced into a plasma of argon gas, producing characteristic spectra.

2.2.7 Mercury Analysis

Soil samples were analyzed for mercury content following EPA SW-7471A, "Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique)" (EPA 1994). The instruments used were a Leeman AP200 Automated Mercury Preparation System and a Leeman PS200 Automated Mercury Analyzer. A 0.1-g aliquot of soil was used for sample preparation and analysis. The practical limit of quantitation (PLQ) was 0.3 µg/kg.

2.2.8 Gamma Spectroscopy

All soil samples collected from areas suspected to be impacted by radioactive compounds were screened for radiological constituents using gamma spectroscopy. In some instances, these screens were mandatory to allow samples to be shipped to an off-site laboratory for chemical analysis. In other cases, the only analysis of the samples was the gamma spectroscopy.

Soil samples were collected in 500-mL Marinelli beakers, sealed, swiped, and counted in the field for loose, surface, radioactive contamination. Upon completion of the field check, the samples were transported to the SNL/NM 7715 laboratory for fixed gamma spectroscopic analysis.

The equipment used by the SNL/NM 7715 laboratory consists of a Canberra high purity germanium (HPGE) detector shielded by 4 in. of lead lined with cadmium and copper sheets. Twelve samples in Marinelli beakers can be run unattended using an autosampler. A typical sample is counted for 600 sec. Peaks generated during the gamma spectroscopy are matched against a user-defined library to identify individual radionuclides. Laboratory control sample (LCS) analyses are performed for americium-241, cesium-137, and cobalt-60 with identical analytical methods to monitor routine sample analysis data usability.

2.3 Off-Site Laboratory Chemical Analyses

Off-site laboratory analyses for constituents of concern (COCs) from each site were conducted in accordance with the EPA-approved protocols listed in SW-846 (EPA 1986). The COCs, field-screening techniques, laboratory analysis methods, and the corresponding method numbers are listed in Table 2-2. The data are provided in electronic format in Appendix C.

Table 2-2
Field Screening and Laboratory Analyses for Constituents of Concern[a]

Constituent of Concern	Field-Screening Techniques	On-Site Laboratory Analysis Methods	Off-Site Laboratory Analysis Methods	EPA Method Number
Metals	NA[a]	X-ray Fluorescence/ Directly Coupled Plasma	Inductively Coupled Plasma/Atomic Absorption	6010/7000
Volatile Organic Compounds (VOCs)	Photoionization Detector/ Flame Ionization Detector	Gas Chromatography/ Mass Spectrometry	Gas Chromatography/ Mass Spectrometry/ Toxicity Characteristic Leaching Procedure	8240 1311
Total Petroleum Hydrocarbons (TPH)	NA	Thermal Desorption/Gas Chromatography	Infrared	418.1
High Explosives (HEs)	Colorimetry	High-Performance Liquid Chromatography	High-Performance Liquid Chromatography	8330
Polychlorinated Biphenyls (PCBs)	Immunoassay	NA	Gas Chromatography	8080
Nitrates/Nitrites	NA	Colorimetry	Colorimetry	353.2
Radionuclides	G-M Pancake Probe/Sodium Iodide (NaI) Scintillometer	Gamma Spectroscopy	Gamma Spectroscopy/ Isotopic Analyses	6010

Source: EPA 1986.
[a]NA = Not applicable.

2.4 Summary of Quality Assurance/Quality Control Activities

As part of the sampling activities conducted in support of the RFI, a plan for QA/QC was developed to ensure that sampling procedures and laboratory analyses were performed to a rigid standard. The following QA/QC soil and water samples were collected to assure sampling procedure integrity and laboratory quality:

- Field Blank—Water poured directly from a freshly opened bottle of distilled water into laboratory-prepared sample bottles to determine whether any field conditions affected sample collection.

- Trip Blank—Laboratory-prepared water sample for analysis of VOCs to determine whether any VOCs were inadvertently introduced during sampling or shipment.

- Equipment Blank—Water sample prepared in the field after decontaminating equipment to determine whether any contaminants were introduced from improperly cleaned equipment.

- Duplicate—Soil sample split from an original field sample to determine reproducibility of laboratory analytical results.

- Matrix Spike/Matrix Spike Duplicate—Soil sample split from an original field sample to determine effects of matrix (e.g., soil) on laboratory results (i.e., whether any interference occurred); sample is spiked with a known concentration of a reference chemical, then analyzed to ascertain recovery of that chemical.

Results of the QA/QC program indicated very few problems with the collection of the data. Some general trends in laboratory QC were noted. The off-site laboratory used for the chemical analyses has consistently shown levels of VOCs (primarily acetone and methylene chloride) in their method blanks; however, this mainly impacted the data collected for Site 36, where elevated levels of several VOCs were noted (see Section 8.0). Independent analyses conducted by the on-site SNL/NM laboratory confirmed the presence of contamination in the samples, however, so the impact of laboratory contamination is somewhat lessened.

Some elevated levels of VOCs were noted in some soil trip blanks submitted for Site 78. Preparation of the soil trip blanks involved collection of soil from an area known to be uncontaminated, followed by heating of the sample to drive off any potential VOCs, which effectively removed any moisture that might have been in the sample. It is believed that, because the sample was dehydrated, when it reached the laboratory, the ambient humidity and vapor-phase VOCs typical of many laboratories (i.e., those VOCs commonly used for sample preparation [acetone, methylene chloride, toluene, etc.]) caused rapid adsorption of the laboratory chemicals onto the soil matrix, producing erroneous results. The process for preparing soil blanks on-site is currently under review, because it does not appear to be a useful tool in its present form, given the problems cited above. Regardless of the results of the trip blanks for Site 78, no elevated VOCs were noted in the soil samples collected for confirmatory analyses.

The same laboratory exhibited low concentrations of lead in their blanks, affecting the data for the rinsate and field blanks from Sites 18 and 107, but at concentrations too low to account for the concentrations detected above the statistical background levels for Site 18.

Matrix spike/matrix spike duplicate (ms/msd) data indicated occasional elevated recoveries for some metals (antimony, barium, beryllium, and zinc) that are ubiquitous in the surrounding granite-derived soils. No general problems with the laboratory's recovery were noted, however. The single exception is for the ms/msd data for antimony at Site 241. Because of apparent erroneous recovery data, the sample that had been split for a ms/msd had an anomalously high antimony concentration (29.6 mg/kg). The location (plus two others) was resampled and found to have nondetectable antimony. The results of the QA/QC program are provided in electronic format in Appendix D.

2.5 Statistical Analysis of Background Data

To determine whether the soil sampling results for potentially contaminated sites within TA-III/V indicated the presence of COCs, the results were compared to the samples collected from TA-III and TA-V during the site-wide investigation of background concentrations at SNL/NM (IT 1994a). Thus, a subset of the full site-wide background data set was selected for the TA-III/V evaluation. The COCs for

evaluation (barium, beryllium, cadmium, chromium, copper, lead, nickel, silver, uranium, and zinc) were chosen based on site knowledge and their likelihood of being a site contaminant within TA-III/V. At the time the statistical tests were completed, no site-wide background data sets existed for other COCs of interest (e.g., antimony, mercury, PCBs, etc.); thus a direct comparison to the applicable site-wide upper tolerance limits (UTLs, discussed below) updated in January 1996 was made for those COCs.

2.5.1 Background Concentration Determinations

To determine the range of background concentrations, the 95th UTL and 95th percentile were calculated for parametric and nonparametric data sets, respectively. The following steps were completed: (1) a priori screening of the data; (2) determination of the percentage of nondetects in the data sets, with a cutoff level of 15 percent; (3) distribution analysis of the portion of the data set that exhibited less than 15 percent nondetects, including coefficients of skewness, histograms, and probability plots; (4) a second screening of the data performed by the calculation of the T_n statistic for parametric data; and finally (5) calculation of the UTL for parametric data sets or the 95th percentile for nonparametric data sets. Each is discussed in the following sections, and example calculations, together with histograms and probability plots, are provided in Appendix E.

A Priori Screening

The a priori test involved a visual inspection of the data to eliminate any outliers. The data values were sorted from highest to lowest to facilitate the inspection. Maximum values that were a factor of three higher than their nearest neighbor were removed from the data set before the next test in the sequence was applied.

Determination of Parametric Versus Nonparametric Data

The data sets were divided into parametric or nonparametric by this process (discussed in the following paragraphs):

- Initial division based on the percentage of nondetect data; and
- Subdivision of the data sets with fewer than 15 percent nondetect values into normal, lognormal, or nonparametric.

First, the percentage of nondetect data in each of the data sets was determined. Raw nondetect data were not equated with "zero" values; rather, they were replaced with a coded value of one-half of the PLQ (EPA 1992a). Those sets with fewer than 15 percent nondetect values were identified as eligible for parametric distribution analysis; those sets with greater than 15 percent nondetect values were identified as eligible for nonparametric analysis. Coded data sets tend to skew the data toward zero and decrease the effectiveness of reporting the mean. Therefore, the median is reported as the measure of central tendency when greater than 15 percent of the data are nondetects (i.e., the data set appears nonparametric).

Distribution analyses then were conducted on the data to determine whether the data were parametric (normal or lognormal) or nonparametric. The distribution analyses included computing the coefficients of skewness and producing the histograms and probability plots for each COC for normal and lognormal (i.e., log transformed) data; the histograms and probability plots for each tested COC are included in Appendix E.

Calculation of T_n Statistic

The T_n statistic test was performed on data determined to be parametric (normal or lognormal) after the distribution analysis was completed to verify that no other statistical outliers existed. The datum was considered an outlier if the T_n statistic exceeded the critical number (C_n) identified in the EPA guidance for a given sample size (EPA 1992a). The test was run iteratively until the largest value in the data set passed. A new mean and standard deviation were calculated for each data set that had outliers removed in the T_n statistic analysis before the test was run again.

Calculation of UTL and 95th Percentile

Basic statistical parameters, including the mean, standard deviation, and UTL, were calculated for each normal or lognormal parametric population data set. The UTL establishes a concentration range that is constructed to contain a specified proportion of the population with a specified confidence. The proportion of the population included is referred to as the coverage, and the probability with which the tolerance interval includes the proportion is referred to as the tolerance coefficient. The EPA-recommended coverage value of 95 percent and tolerance coefficient value of 95 percent were used to calculate the UTLs (EPA 1992a). Most elementary statistical textbooks provide detailed descriptions of basic parametric statistics.

Nonparametric statistics were used when data sets did not exhibit normal or lognormal distributions, or when the percentage of nondetects exceeded 15 percent. The data sets examined exhibited fewer than 90 percent nondetects, so the median (50th percentile) was used to describe central tendency, and the 95th percentile was used for background comparison. Most elementary statistical textbooks provide detailed descriptions of basic nonparametric statistics.

Results

Table 2-3 presents the results of the a priori tests conducted on the data sets. None of the COCs examined were determined a priori to be outliers.

Table 2-4 provides the results of the probability plot, coefficient of skewness, and histogram for determination of the distribution type for each TA-III/V background data set. Background distributions for barium, beryllium, cadmium, copper, lead, nickel, and zinc were lognormal. The data set for silver was nonparametric, and the data set for total uranium (U_{tot}) was normally distributed.

Tests were performed for outliers using the T_n statistic (Table 2-5). Only the nickel data set was censored for the calculation of TA-III/V background values by removing the three highest values for nickel (30.9, 30.0, and 29.5 mg/kg. Three possible reasons for the anomalously high nickel data are noted. Nickel might exhibit a wide natural variation, and this sampling effort happened to access areas that were relatively mineral rich. Alternatively, laboratory error might have produced elevated analytical results. It is also possible that the higher nickel concentrations are anthropogenic, although these higher concentrations are well below the proposed RCRA Subpart S soil action level for nickel (2,000 mg/kg). To be conservative, these values were removed from the data set, and the censored data set was used for all subsequent comparisons for TA-III/V sites.

The natural logs of the means and standard deviations of the TAL metals and their corresponding UTLs or 95th percentiles are provided in Table 2-6. Proposed RCRA Subpart S soil action levels for the COCs detected during the RFI sampling effort are provided in Table 2-7. As stated earlier, only those COCs

Table 2-3
Technical Areas III and V Background Samples - A Priori Sampling

Parameter	Maximum Value	Next Maximum	X Factor[a]	Result
Barium	730	320	2.28	Pass
Beryllium	1.1	1.1	1.00	Pass
Cadmium	8.5	7.7	1.10	Pass
Chromium	58.1	57.3	1.01	Pass
Copper	29	27.5	1.05	Pass
Lead	73	73	1.00	Pass
Nickel	30.9	30	1.03	Pass
Silver	10	9.7	1.03	Pass
Uranium (total)	4.66	4.61	1.01	Pass
Zinc	59.9	56	1.07	Pass

[a]X factor is the ratio of the maximum value to the next maximum. If the ratio is greater than or equal to 3, it indicates the maximum value is anomalously high.

Table 2-4
Results of the Distribution Analysis for Technical Areas III and V

Parameter	Probability Plot	Coefficient of Skewness[a]	Histogram	Distribution Type
Barium	Lognormal	-2.3	Lognormal	Lognormal
Beryllium	Lognormal	-0.30	Lognormal	Lognormal
Cadmium	Lognormal	0.49	Lognormal	Lognormal
Chromium	Lognormal	-1.72	Lognormal	Lognormal
Copper	Lognormal	-0.15	Lognormal	Lognormal
Lead	Lognormal	0.50	Lognormal	Lognormal
Nickel	Lognormal	-0.48	Lognormal	Lognormal
Silver	Nonparametric	-0.59	Nonparametric	Nonparametric
Uranium (total)	Normal	-0.23	Lognormal	Normal
Zinc	Lognormal	0.69	Lognormal	Lognormal

[a]Critical Coefficient of Skewness is -1 to 1.

Table 2-5
Technical Areas III and V T_n Statistic Analysis for Target Analyte List Metals

Parameter	Distribution	Natural Log (Ln) of Maximum Value	Natural Log Mean	Natural Log Standard Deviation	T_n Statistic	Number of Samples	Critical Value[a]	Pass or Fail T_n Statistic
Barium	Lognormal	6.59	3.84	1.13	2.44	503	3.74	Pass
Beryllium	Lognormal	0.10	-1.14	0.43	2.87	331	3.60	Pass
Cadmium	Lognormal	2.14	-0.89	0.99	3.06	176	3.39	Pass
Chromium	Lognormal	4.06	1.86	0.8	2.75	538	3.76	Pass
Copper	Lognormal	3.37	1.82	0.48	3.22	392	3.66	Pass
Lead	Lognormal	4.29	1.89	0.73	3.29	259	3.52	Pass
Nickel (first iteration)	Lognormal	3.43	1.84	0.43	3.70	403	3.67	Fail
Nickel (second iteration)	Lognormal	3.40	1.83	0.42	3.74	402	3.67	Fail
Nickel (third iteration)	Lognormal	3.38	1.83	0.42	3.70	401	3.67	Fail
Nickel (fourth iteration)	Lognormal	3.31	1.83	0.41	3.62	400	3.67	Pass
Silver	Nonparametric	ND[b]	ND	ND	ND	247	ND	ND
Uranium (total)	Normal	4.66[c]	2.05[c]	0.99[c]	2.64	81	3.13	Pass
Zinc	Lognormal	4.09	3.1	0.34	2.89	158	3.36	Pass

[a]One-sided critical values for the upper 5 percent significance level; critical values derived from Table 8 (EPA 1992a) for given number of samples.
[b]ND = Not determined.
[c]Normal maximum values (i.e., actual values) provided for normally distributed uranium.

Table 2-6
Upper Tolerance Limits for Target Analyte List Metals in Technical Areas III and V Soil

Target Analyte List (TAL) Metal	Distribution	Censored?	Natural Log Mean	Natural Log Standard Deviation	Mean	Standard Deviation	One-Sided Tolerance Factor (K)	Natural Log UTL	UTL	Number of Samples
Barium	Lognormal	No	3.84	1.13	NA[a]	NA	1.76	5.83	341.0	503
Beryllium	Lognormal	No	-1.14	0.43	NA	NA	1.79	-0.37	0.7	331
Cadmium	Lognormal	No	-0.89	0.99	NA	NA	1.85	0.94	2.6	176
Chromium	Lognormal	No	1.86	0.8	NA	NA	1.76	3.27	26.2	538
Copper	Lognormal	No	1.82	0.48	NA	NA	1.78	2.67	14.5	392
Lead	Lognormal	No	1.89	0.73	NA	NA	1.81	3.21	24.8	259
Nickel	Lognormal	Yes	1.83	0.4	NA	NA	1.78	4.40	81.3	400
Silver[a]	Nonparametric	NA	NA	NA	NA	NA	NA	NA	NA	247
Uranium (total)	Normal	No	NA	NA	2.05	0.99	1.96	NA	4.0	81
Zinc	Lognormal	No	3.1	0.34	NA	NA	1.86	3.73	41.8	158

[a]NA = Not applicable.
[b]For silver, the 50th percentile value was 1 mg/kg and the 95th percentile value was 4 mg/kg; these describe the central tendency for nonparametrically distributed parameters.

Table 2-7
Generic Proposed Soil Action Levels Under Proposed RCRA Subpart S

Analyte	Proposed RCRA Subpart S Soil Action Level (mg/kg)
1,2-Dichloroethane	8
Acetone	8,000
Aluminum	NA[a]
Antimony	30
Arsenic	20
Barium	6,000
Beryllium	0.2
Bis (2-Ethylhexyl) Phthalate	50
2-Butanone	50,000
Cadmium	80
Calcium	NA
Chromium (VI)	400
Cobalt	NA
Copper	NA
2-Hexanone	NA
Iron	NA
Lead	2,000[b]
Lithium	NA
Magnesium	NA
Manganese	NA
Mercury	20
Nickel	2,000
Nitrate	100,000
Nitrite	8,000
Polychlorinated Biphenyls	0.1
Potassium	NA
Selenium	400
Silver	400
Sodium	NA
Toluene	20,000
Total Petroleum Hydrocarbon	100[c]
Uranium	NA
Vanadium	600
Xylenes (total)	200,000
Zinc	20,000

[a]NA = No proposed RCRA Subpart S soil action level is currently listed for the analyte.
[b]Lead action level not formally promulgated; proposed 2,000 mg/kg (EPA 1996).
[c]Not EPA-regulated. Standard from New Mexico Environmental Improvement Board Underground Storage Tank Regulations (NMEIB/USTR 1990).

for which site-wide background data sets existed (at the time of this RFI) were analyzed for statistical significance. The proposed RCRA Subpart S soil action levels for the remaining COCs are provided for comparison to site sampling data.

2.5.2 Comparison Tests: Background Data Versus Environmental Restoration Site Data

Two nonparametric, two parametric tests, and one test that utilized both parametric and nonparametric analyses were used to compare TA-III/V background data to data from potentially contaminated TA-III/V ER sites (Appendix E). The nonparametric tests included the Wilcoxon Rank Sum (WRS) Test and the Quantile test. The parametric tests included Student's t-tests using assumptions of equal and of unequal variance. The hot-measurement comparison uses either the 95th UTL calculation (for parametric data) or the 95th percentile calculation (in the case of nonparametric data) as recommended by the EPA (EPA 1992a). Nonparametric tests were applied to all soil data; however, parametric tests were not applied to nonparametric data.

The WRS test is performed by ordering all observations from background and the potentially contaminated site according to their magnitude and then assigning a rank from lowest to highest. The ranks in the potentially contaminated area are summed and compared to a table of critical values to determine whether the site is contaminated.

The WRS test is a nonparametric test more powerful than the Quantile test (described below) in determining whether the potentially contaminated area has concentrations uniformly higher than background (EPA 1992a). However, the WRS test allows for fewer less-than measurements than the Quantile test. As a general rule, the WRS test should be avoided if more than 40 percent of the measurements taken at the potentially contaminated area or at background areas are nondetects. All soil analytical data were subjected to the WRS test in this analysis, although the test power was known to be greatly reduced when the nondetect percent was greater than 40.

The Quantile test is performed by separating background data and individual site data. The data are then ordered from highest to lowest. The number of background and individual site data points are calculated. The number of data points for background and the selected potentially contaminated site is then compared to a table that identifies how many of the highest measurements must come from the potentially contaminated site versus background to indicate contamination.

The Quantile test is a nonparametric test that has more power than the WRS test to detect when only a small portion of the remediated site has not been completely cleaned up. Also, the Quantile test can be used even when a fairly large proportion of the measurements is below the limit of detection (EPA 1992a).

The hot-measurement comparison consists of comparing each measurement from the potentially contaminated area with an upper-limit concentration value. This upper-limit concentration value is such that any measurement from the potentially contaminated area that is equal to or greater than this value indicates an area of relatively high concentrations that must be further investigated (EPA 1992a). Concentrations exceeding the upper-limit value may indicate inappropriate sample collection, handling, or analysis procedures, or actual contamination. The upper-limit concentration value was calculated as previously described based on the 95th percentile for nonparametric data and the 95th UTL for parametric data.

The t-test is a parametric test that compares the means of two samples. To use the t-test statistic, both sampled populations must be approximately normally (or lognormally) distributed with approximately equal population variances, and the random samples must be selected independently of each other. The equations and methodology for applying the t-test are explained in most statistics books, including McClave and Dietrich (1982) and Mendenhall (1975).

Results

Comparison tests between background data and the maximum concentrations for TA-III/V site data were performed for metals at Sites 18, 51, 107, 111, 240, and 241 in accordance with the RFI Work Plan (SNL/NM 1993a). In the case of Site 78, a simple comparison of maximum metal concentrations to the TA-III/V background UTLs were made for the samples collected during the confirmatory sampling event. These were the only sites where metals were regarded as suspect contamination. The respective text sections herein contain discussions of the significance of the statistical tests on data for each site and comparisons to the relevant proposed RCRA Subpart S soil action levels (Table 2-7) for each constituent.

2.6 Contaminant Fate and Transport/Risk Assessment

The majority of contaminants detected at sites in TA-III/V were restricted to the upper 2 ft of surface soils. No conclusive evidence has been found that any sites investigated during this RFI have had an impact on the local ground water (at depths of 480 to 500 ft bgs).

For those sites at which contaminants were elevated with respect to background, a comparison was made of each elevated constituent relative to its proposed RCRA Subpart S soil action level. All COCs were at least one to two orders of magnitude below their corresponding action levels, except at Site 18 (which displayed PCBs above the proposed RCRA Subpart S soil action level). As indicated in the individual section for this site, the efficacy of conducting a VCM was evaluated. Three other sites (35, 36, and 196) also exhibited TPH above the New Mexico Underground Storage Tank Regulations (NMUSTR) standard, but each of these is proposed for NFA because TPH is in the form of a nonhazardous mineral oil.

8.0 ER SITE 36: HERMES OIL SPILL

The High-Energy Radiation Megavolt Electron Source (HERMES) Oil Spill is a 1-acre site located in the eastern portion of TA-V near Building 6596, which housed the HERMES II Facility (Figure 8-1). Oil was stored in five 35,000-gal. underground storage tanks (USTs) north of Building 6596 and was pumped in a circulating system between the building and the tanks. Several large spills of oil from the tanks occurred throughout the course of operation of the facility from 1968 to 1989, when the facility was permanently closed.

Potential COCs include mineral oil, VOCs, and PCBs. A discussion of the field investigation protocols and results is presented in the following sections.

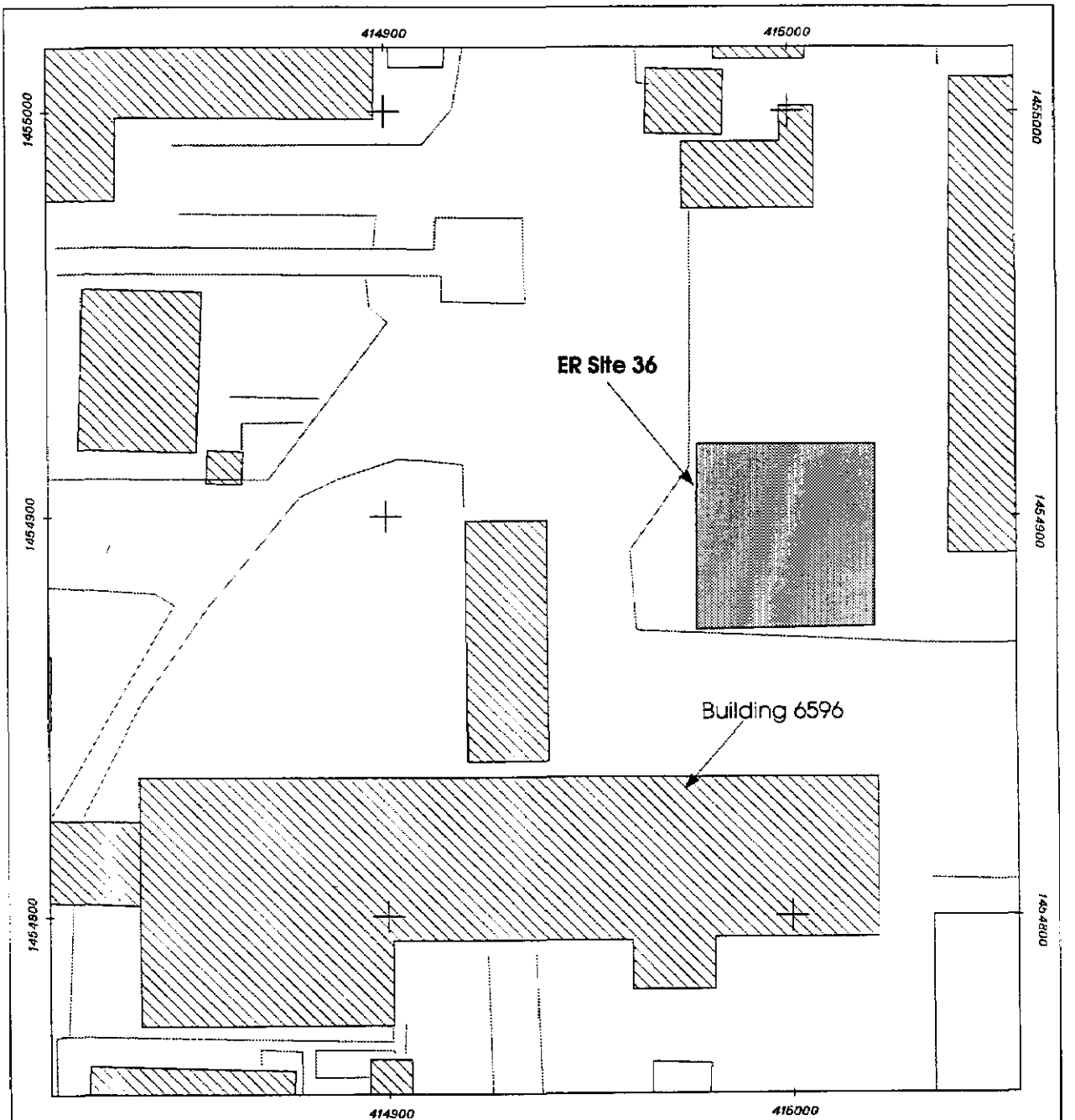
8.1 Site History

In August 1991, the five USTs and associated piping at the HERMES II Facility were excavated and removed. During these removal activities, soil stains were observed throughout the excavated pit area. In accordance with NMUSTRs, an on-site investigation (OSI) was conducted: six boreholes were drilled within, and adjacent to, the backfilled UST excavation in November and December 1991 to assess the extent of petroleum hydrocarbons in the subsurface soil underlying the former UST site. The first borehole (HERMES-C, Figure 8-2) was drilled to a depth of 280 ft, which was the lower extent of soil contamination based on field screening with the Hanby Method. The borehole was abandoned prior to receipt of off-site laboratory analytical results that indicated TPH concentrations in excess of the state regulatory standard of 100 mg/kg at 280 ft. As a result of this experience and that of other investigations, the Hanby Method was demonstrated to be an inadequate field-screening method for heavy-end petroleum hydrocarbons because it frequently underestimates the concentrations of contamination by two or more orders of magnitude.

The analytical results of soil samples collected from three boreholes to the northwest, northeast, and southeast of the UST pit (Figure 8-2) indicated no TPH contamination from the surface to a depth of approximately 280 ft, thereby defining the horizontal extent of mineral oil at these locations. The horizontal extent of contamination in the southwest direction, however, was not completely defined because TPH was present at depths ranging from 30 to 230 ft in the HERMES-SW borehole.

Based on the results of this investigation, the site required further characterization to determine the horizontal extent of mineral oil to the southwest as well as the vertical extent of oil beneath Borehole HERMES-C. Therefore, drilling was conducted at the site during the RFI in February and March 1995. In April 1995, based on the OSI results and prior to receipt of the RFI sampling results, NMED/UST Bureau issued a determination of NFA for the site (NMED 1995).

In addition to the OSI conducted specifically for the HERMES site, a RFI was conducted at the nearby LWDS. During ground-water sampling at the LWDS, trichloroethylene (TCE) and other VOCs were noted that were demonstrated not to have emanated from the LWDS. A search for another possible source within TA-V revealed the existence of another site, the TA-V Seepage Pits, which has since been designated ER Site 275. The Seepage Pits are located approximately 200 yards (yd) to the southwest of the HERMES site.



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Environmental Restoration Geographic Information System

Figure 8-1 ER Site 36
HERMES Oil Spill, TA-V

Legend

- ER Site 36
- Buildings
- Roads

0 20 40
Scale in Feet

0 4.8 9.6
Scale in Meters

Unclassified

FINAL

1:480

Transverse Mercator Projection, New Mexico State Plane Coordinate System, Central Zone
1927 North American Horizontal Datum, 1929 North American Vertical Datum

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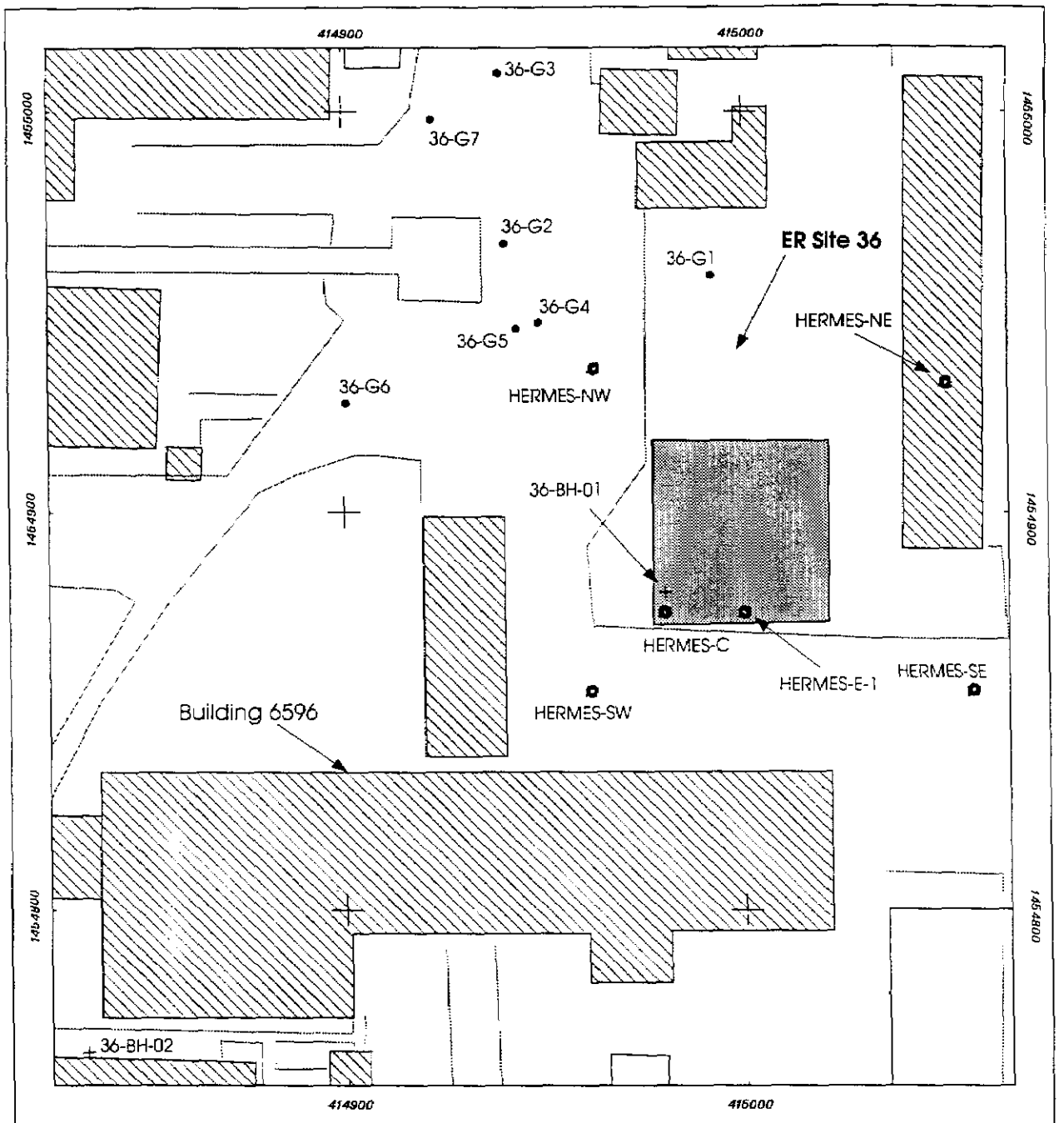

Legend

- ER Site 36
- Buildings
- Roads
- 36-G6 Shallow RFI Borehole Location
- 36-BH-01 Deep RFI Borehole Location
- HERMES-SW 1991 UST Investigation Borehole Location

Sandia National Laboratories, New Mexico
Environmental Restoration Geographic Information System

Figure 8-2 ER Site 36
Location of Shallow- and Deep-Subsurface Soil Boreholes, TA-V

0 20 40 Scale in Feet

0 4.8 9.6 Scale in Meters

Unclassified

FINAL

1:480

Transverse Mercator Projection, New Mexico State Plane Coordinate System, Central Zone
1927 North American Horizontal Datum, 1929 North American Vertical Datum

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Investigations of the Seepage Pits site were conducted to determine whether it could have been the source of the VOCs detected in ground water beneath TA-V and to better define the extent of any possible contamination. The investigation at the HERMES site was conducted at the same time as that at the Seepage Pits and was modified to include sampling protocols to help define the horizontal extent of any Seepage Pits contamination.

8.2 Field Investigation Protocols

Field investigation protocols included aerial photograph analysis (Plate I) and subsurface sampling. A sampling and analysis plan was developed based on the area that had been identified in the RFI Work Plan (SNL/NM 1993a) as a possible source of contamination. The subsurface sampling strategy included shallow investigation with a hydraulic probe and deep investigation using a drilling rig.

8.2.1 Aerial Photograph Analysis

Aerial photographs from 1973 to 1990 were assembled, digitized, and compared for changes in surface features during successive years at the HERMES site. The area within 1,000 ft of the site boundaries was studied for signs of soil disturbance, vegetation changes (indicating soil disturbance), or new construction.

8.2.2 Sampling Strategies

Shallow subsurface soil investigations were conducted with a small-diameter hydraulic probe, and deep subsurface soil sampling was conducted using an air rotary casing hammer drilling rig. Each of these strategies is discussed in greater detail in the following sections.

8.2.2.1 Shallow Subsurface Soil

Seven shallow boreholes were advanced with a small-diameter hydraulic probe in the vicinity of the former HERMES tanks within the pathway most likely followed by spilled oil, i.e., adjacent to and northwest of the former USTs (Figure 8-2; shallow borehole location coordinates are provided in Appendix A). Soil samples were collected from depths of 1, 5, 10, and 15 ft bgs from each shallow borehole (36-G1 through 36-G7), for a total of 28 samples. Sampling protocols followed appropriate FOPs (Table 2-1). Field screening of all samples included PID screening for VOCs and immunoassay kits for PCBs. Based on field screening results, 17 soil samples were analyzed at an off-site laboratory for TPH, and a select number were also analyzed for VOCs and PCBs in accordance with the EPA methods discussed in Table 2-2.

8.2.2.2 Deep Subsurface Soil Boreholes

Two deep soil boreholes were drilled to define vertical and horizontal extent of mineral oil contamination detected in the 1991 OSI (Figure 8-2). One borehole (36-BH-01) was drilled to a total depth of 340 ft bgs, next to the HERMES-C borehole (which had contained the greatest concentrations of TPH detected during the OSI) to define the vertical extent of contamination. The second borehole (36-BH-02) was drilled to a total depth of 320 ft at the southwest corner of Building 6596, approximately 300 ft east and 50 ft north of the Seepage Pits, to define the horizontal extent of contamination for both the HERMES and the Seepage Pits sites. Location coordinates for the deep boreholes are included in Appendix A.

Each borehole was drilled with a CP-650 drill rig using an air rotary casing hammer with 10.5-in. outer diameter (OD) steel casing. The boreholes were lithologically logged from drill cuttings and drive samples. Detailed borehole logs, including lithology descriptions of each borehole, are illustrated in Appendix F. Soil samples were collected at 10- and 20-ft intervals with a 2-in. inner diameter (ID) split-spoon sampler driven through an 8.6-in. OD open-center button bit. All soil samples were collected in steam-cleaned stainless-steel liners, sealed with Teflon® tape and plastic end caps, wrapped with duct tape, labeled, and immediately placed on ice. The boreholes were backfilled with their drill cuttings.

Because the investigation at the neighboring Seepage Pits site centered on defining the source of a variety of VOCs in the subsurface, particularly TCE, the original sampling plan for Site 36 identified in the TA-III/V RFI Work Plan (SNL/NM 1993a) was modified to include active soil vapor sampling and soil sampling for VOCs. Soil samples were collected at intervals of 10 to 20 ft for analysis of TPH and VOCs, and active soil gas samples were collected at intervals of approximately 40 ft to determine relative concentrations of VOCs in the vadose zone (Table 8-1).

Field screening was conducted on all samples collected during drilling at the HERMES site. A total of 10 active soil vapor samples from Borehole 36-BH-01 and 11 active soil vapor samples from 36-BH-02 were collected for on-site analysis of VOCs. Active soil vapor samples were collected at 10- and 20-ft intervals from a hollow steel rod lined with Teflon® tubing capped with a slotted drive point driven about 1 ft beyond the drill bit. A constant flow sample pump was connected to the surface end of the tubing. After purging a minimum of three tubing volumes (approximately 1,500 mL), a 500-mL sample of soil vapor was collected and submitted to SNL/NM's 7584 on-site laboratory for analysis of VOCs in accordance with EPA Method 8240.

A total of 13 samples from 36-BH-01 and 23 samples from 36-BH-02 were collected for screening of TPH by thermal desorption to determine concentrations of mineral oil throughout the soil column. Soil samples were collected from the areas of highest oil concentration and from the total depth of the boreholes for rapid (24-hr turnaround) off-site analysis of TPH by EPA Method 418.1 to verify that the vertical extent of contamination had been determined prior to closing the boreholes.

Based on the field screening results, additional soil samples were submitted for off-site laboratory analysis of VOCs and TPH. A total of 11 samples from 36-BH-01 and 13 samples from 36-BH-02 (including duplicates) were submitted for laboratory analysis of VOCs in accordance with EPA Method 8240. Thirteen samples from 36-BH-01 and 23 samples (including duplicates) from 36-BH-02 were submitted for off-site analysis of TPH in accordance with EPA Method 418.1.

Table 8-1
Summary of Soil Samples Collected From Boreholes 36-BH-01 and 36-BH-02

Sample Depth (ft)	Soil Vapor Sample		VOCs by 8240		TPH by TD/GC		TPH by 418.1	
	BH-01	BH-02	BH-01	BH-02	BH-01	BH-02	BH-01	BH-02
10		X		X		X		
20	X	X	X (D[a])	X	X		X	X
30		X				X		
40	X				X	X		
50		X				X		
60	X	X			X	X		
70		X		X		X		X (D)
80	X		X	X	X	X	X	X (D)
90				X		X		X (D)
100	X	X	X	X (D)		X (D)	X	X (D)
120	X		X	X		X (D)	X	X (D)
140	X	X				X		
160					X	X		
180					X	X		
200	X	X	X (D)	X (D)		X (D)	X (D)	X (D)
220					X	X		
240		X		X		X		X (D)
250	X							
260						X	X	X (D)
280			X		X	X	X	X (D)
300	X		X	X	X	X	X	X (D)
310					X		X	
320		X	X	X	X	X	X	X (D)
330					X		X	
340			X		X		X	
Total Samples by Type	10	11	11	13	13	23	13	23

[a]D = Duplicate sample.

8.3 Field Investigation Results

8.3.1 Aerial Photograph Interpretation

No new site features (other than those previously noted for the area) were identified within 1,000 ft of the site boundaries in any of the aerial photographs from 1973 to 1990 (Plate I). Lower altitude aerial photographs of TA-V over the same time frame show oil spills around the HERMES site, but no new sites or potential impacts from other sites were noted.

8.3.2 Shallow Subsurface Soil

All field screening and laboratory analytical results for the shallow subsurface soil samples are provided in electronic format in Appendices B and C, and the QA/QC data are provided in electronic format in

Appendix D. Only two samples exhibited TPH above the MDL of 20 mg/kg, and both of these contained asphalt fragments; TPH concentrations for these two samples were approximately 2,200 to 2,500 mg/kg. No samples contained any PCBs above the MDL of 33 μg/kg. No VOCs were detected above their respective MDLs.

8.3.3 Deep Subsurface Soil

A summary of those deep, subsurface soil samples containing organic analytes above the respective MDLs is provided in Table 8-2; detailed results for field screening, laboratory analyses, and QA/QC data are provided in electronic format in Appendices B, C, and D, respectively.

Table 8-2
Summary of Detected Constituents of Concern in Borehole 36-BH-01

Analyte	Range (mg/kg)	Detection Limit[a]	Total Samples	Number of Nondetects
2-Butanone	0.010-2.9	0.010-1.0	11	9
2-Hexanone	0.014-1.6	0.010-1.0	11	7
Acetone	0.005-12.0	0.010-1.0	11	6
Toluene	0.001-0.016	0.005-0.5	11	10
Xylene	0.005-0.044	0.005-0.5	11	9
TPH	20-36,000	20-1,000	21	9

[a]Detection limits for some samples were raised because of high TPH concentrations.

The general lithologies noted in Boreholes 36-BH-01 and 36-BH-02 (Appendix F) were brown to yellow-brown, medium-grained silty and gravelly sands. Occasional lenses of gravel, with diameters greater than 3 in., were encountered. The estimated permeability of the soils was generally moderate to high, with the gravel lenses expected to have the highest permeabilities.

8.3.3.1 Extent of Mineral Oil

Mineral oil contamination in the subsurface is profiled in Figure 8-3 by the thermal desorption screening and 24-hour turnaround TPH results from Borehole 36-BH-01 (the point of the highest contamination); results from the two methods agree well. Elevated oil concentrations begin at a depth of approximately 30 ft bgs (just below the 20-ft backfill depth) and range from 9,000 mg/kg to 36,000 mg/kg, with the highest concentrations occurring at a depth of 200 ft bgs. The levels quickly decrease from this point, however, and remain below 100 mg/kg from a depth of 200 ft bgs to the total depth of the borehole (340 ft).

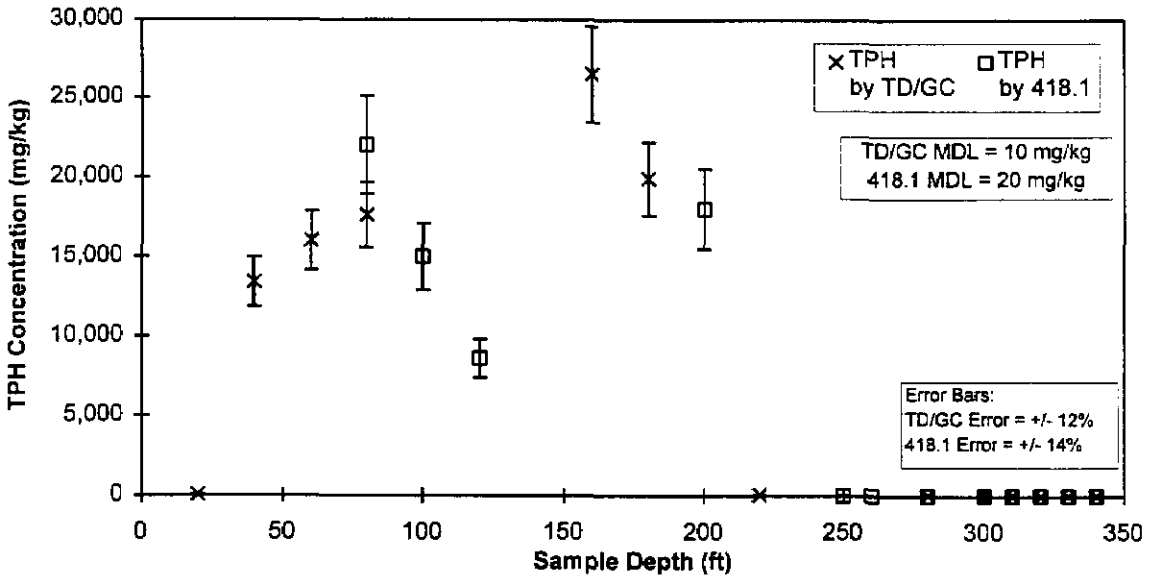

Figure 8-3a. Comparison of TPH Concentrations by Thermal Desorption/ Gas Chromatography and EPA Method 418.1 for Borehole 36-BH-01

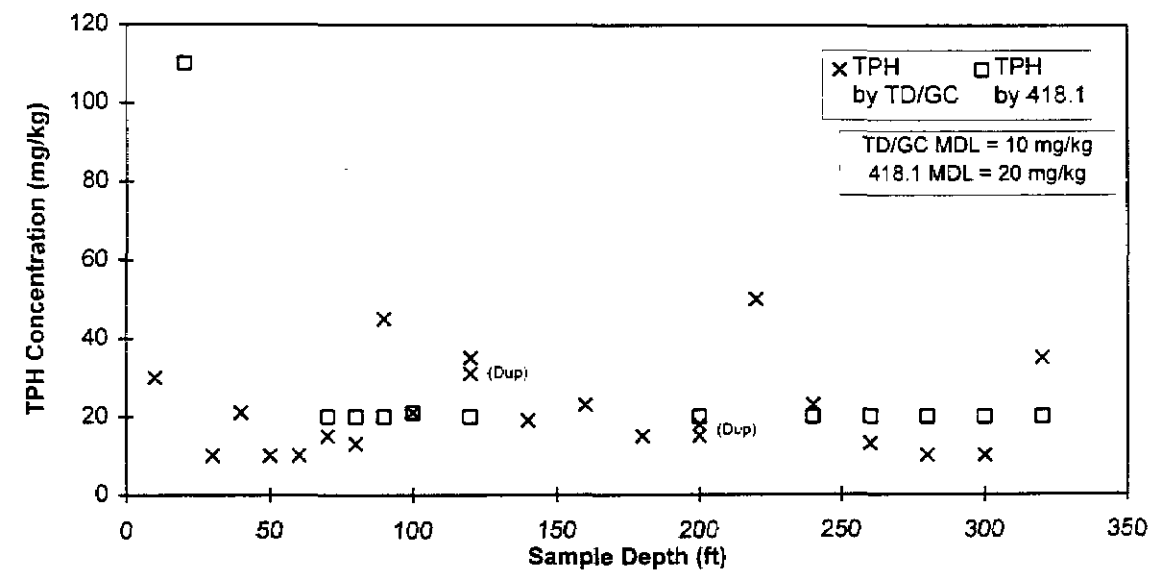

Figure 8-3b. Comparison of TPH Concentrations by Thermal Desorption/ Gas Chromatography and EPA Method 418.1 for Borehole 36-BH-02

The southwest extent of mineral oil, as profiled by the TPH results from Borehole 36-BH-02, appears to occur somewhere beneath Building 6596. Only one sample (at a depth of 20 ft bgs) contained TPH above 100 mg/kg (at a concentration of 110 mg/kg); all other samples indicated nondetect for TPH or ranged from 20 to 60 mg/kg.

8.3.3.2 Extent of Volatile Organic Compounds

The pattern of VOC concentrations is considerably more complex than the TPH concentration profiles (Figure 8-4). Levels of toluene and a variety of ketones, including acetone, 2-butanone (MEK), 2-hexanone (MBK), and methyl isobutyl ketone (MIBK), were indicated in both the active soil vapor and off-site soil sample analytical results.

The active soil vapor profile (included in Appendix B) for Borehole 36-BH-01 generally followed that for mineral oil: detectable concentrations of ketones were noted at a depth of 80 ft, increasing to higher levels at a depth of 200 ft, then dropping off at 250 ft bgs. A single occurrence of TCE in soil vapor was noted in the sample from 300 ft. In the second borehole (36-BH-02), a low level of xylene only was seen at a depth of 30 ft; a low level of MEK was noted at a depth of 200 ft. No VOCs in soil vapor were detected below this depth in the second borehole.

Off-site laboratory analytical results for the soil samples collected from Borehole 36-BH-01 indicated low concentrations of toluene, xylenes, and ketones throughout the soil column, but again, peaking at a depth of 200 ft bgs. At this depth, acetone concentrations reached 12,000 µg/kg. Initially believed to be a result of laboratory contamination, a soil sample split for the SNL/NM on-site laboratory was run for VOCs by EPA Method 8240, and acetone was confirmed in the sample because the on-site laboratory does not use acetone for any sample preparation processes. Three samples that similarly showed elevated ketones were reanalyzed, and the results for both the original analyses and the reanalyses are provided in Appendix C; the affected samples were all in Borehole 36-BH-01 and were from depths of 80.75, 201.00, and 201.25 ft bgs. All reanalysis results were within the same order of magnitude as the original analyses.

Concentrations of toluene were generally "J" values (i.e., an estimated value below the practical quantitation limit), except for a sample from a depth of 320 ft bgs, which had a concentration of 16 µg/kg toluene. Similarly, xylene concentrations were "J" values, except for one concentration of 13 µg/kg at a depth of 280 ft.

In Borehole 36-BH-02, a single occurrence of acetone (21 µg/kg) was noted at 20 ft; a single occurrence of methylene chloride (8.8 µg/kg) was noted at 320 ft bgs. No other VOCs were detected in Borehole 36-BH-02 above their respective MDLs.

Comparative profiles for TPH by thermal desorption and EPA Method 418.1, and for VOCs by soil vapor and EPA Method 8240, are illustrated for each of the boreholes in Figures 8-3 and 8-4, respectively.

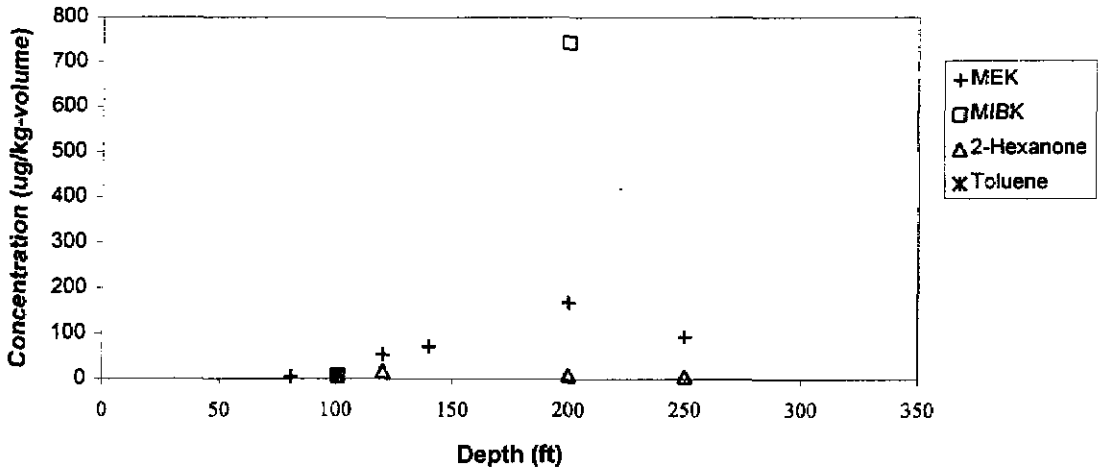

Figure 8-4a. Site 36 - On-Site Active Soil Vapor VOC Results (EPA 8240) for Borehole 36-BH-01

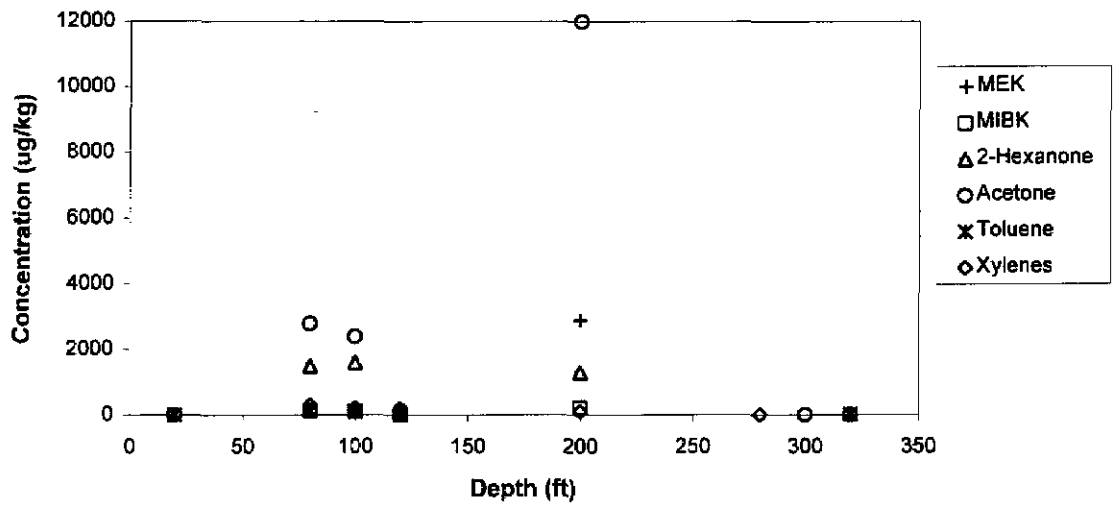

Figure 8-4b. Site 36 - Off-Site Soil Analytical VOC Results (EPA 8240) for Borehole 36-BH-01

8.4 Evaluation of Data

8.4.1 Shallow Subsurface

The data collected during the investigation of the shallow subsurface (i.e., less than 15 ft bgs) indicate that no shallow oil contamination exists at the site in the pathways most likely followed by the spilled oil. As indicated earlier, the only two samples that exhibited TPH above the MDL (20 mg/kg) were collected from a depth of 0 to 1 ft bgs and contained visible asphalt, the presence of which accounts for the elevated concentrations (approximately 2,000 mg/kg) observed in the two samples.

The QA/QC data collected for this sampling event indicate no off-normal occurrences in the off-site laboratory analyses.

8.4.2 Deep Subsurface

The variety of analytical methods employed during the investigation of the deep subsurface have generated a clearer, albeit more complex, profile of the organic contamination beneath the HERMES site than that provided by the OSI conducted in 1991.

The thermal desorption field screening for oil content, coupled with rapid off-site laboratory analysis, enabled a more detailed profile of oil contamination than previously delineated. In Borehole 36-BH-01, drilled in the area of highest contamination, oil concentrations increased dramatically from 20 ft to 40 ft bgs. Concentrations ranged from 9,000 mg/kg to 36,000 mg/kg at 40 ft to 200 ft bgs, then dropped off sharply to less than 100 mg/kg at a depth of 220 ft bgs. Good correlation was noted between the thermal desorption and off-site analytical TPH results (Figure 8-3).

Because it was initially believed that the high concentrations of acetone seen at a depth of 200 ft bgs were the result of laboratory contamination, the samples were reanalyzed at the off-site laboratory, and splits were analyzed at the SNL/NM on-site laboratory for VOCs per EPA Method 8240. The presence of acetone was confirmed. Thus, the COCs that are identified for the site are mineral oil, toluene, xylenes, and ketones.

Attempts were made to identify possible origins for the ketones and toluene. The mineral oil, as manufactured, contains no ketones. Any significant quantities of VOCs in the mineral oil would have adversely altered the insulating properties for which the oil was used. The oil does contain butylated hydroxy toluene in a concentration of less than 0.2 percent (by weight). This level is enough to produce the toluene concentrations seen in the soil column, approximately 5 to 16 µg/kg.

The origin of the ketones, however, is more problematic. There is no record of anyone using ketones in any quantity around the site.

One possible reason for the elevated levels of ketones observed in the first borehole is bacterial fermentation of aliphatic hydrocarbons by beta oxidation, which has been shown to produce acetone and other ketones (Cookson 1995; Britton 1984). This could account for the profile of VOCs roughly matching that of the TPH. Had the ketones been added from the surface, one would expect to see higher concentrations near the surface than at depths of 200 ft bgs. The volatility of acetone, in particular, is so

high that it would not be expected to have persisted to show high concentrations at depth, unless very high volumes of material had been introduced, no record of which activity exists. If fermentation of the oil produced the ketones, however, the concentration profile of the VOCs would reasonably be expected to approximate that of the oil, which is illustrated in Figures 8-3 and 8-4.

The low concentrations of xylenes are not readily explicable by either the site history or mineral oil formulation. Regardless of the origin of the VOCs beneath HERMES, none of them exceeds its respective proposed RCRA Subpart S soil action level (Table 8-3).

Table 8-3
Comparison of Maximum Constituents of Concern Concentrations to Proposed RCRA Subpart S Soil Action Levels

Analyte	Maximum Concentration (mg/kg)	Proposed RCRA Subpart S Soil Action Level (mg/kg)	Exceeds Proposed RCRA Subpart S Soil Action Level?
2-Butanone	2.9	50,000	No
2-Hexanone	1.6	NA[a]	NA
Acetone	12.0	8,000	No
Toluene	0.016	20,000	No
Xylene	0.044	200,000	No
TPH	36,000	100[b]	Yes

[a]NA = Not applicable. No proposed RCRA Subpart S soil action level is currently promulgated for this constituent.
[b]NMUSTR Standard.

8.5 Summary and Conclusions

The vertical and horizontal extent of contamination at the HERMES Oil Spill site has been defined by the activities undertaken in this RFI. The shallow subsurface has been demonstrated to have had no impact from the oil spilled over the years at the facility. The asphalt at the site slopes away to the northwest from the former location of the USTs, and would be the most likely pathway for the oil to have traveled. None was detected during the shallow subsurface investigation, however. It is probable that the initial UST and soil excavation removed the majority of the shallow soil that was impacted by the mineral oil spills.

Contamination in the deep subsurface has been more closely defined by this investigation. The vertical extent of mineral oil at the site is approximately 220 ft bgs, based on the results from Borehole 36-BH-01. Horizontal extent in the southwest direction was defined by the lack of contamination in Borehole 36-BH-02 and is bracketed (as closely as physically possible) by this borehole and the HERMES-SW borehole drilled during the OSI at the southwest corner of the site immediately next to Building 6596.

The highest levels of oil and VOCs are at a depth of 200 ft bgs, then decrease abruptly below this depth. The origin of the most of VOCs is postulated to be bacterial fermentation of the mineral oil. Furthermore, all are several orders of magnitude below their proposed RCRA Subpart S soil action levels. Because of this, and because the NMED/UST Bureau issued a finding of NFA in April 1995, Site 36 is proposed for NFA in accordance with Criterion 4 listed in Section 4.4 of this RFI report.

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