Sandia National Laboratories/New Mexico

# PROPOSALS FOR NO FURTHER ACTION ENVIRONMENTAL RESTORATION PROJECT

4 1 of 2

June 1998

Environmental
Restoration
Project

United States Department of Energy
Albuquerque Operations Office

## EXECUTIVE SUMMARY

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a Hazardous and Solid Waste Amendments (HSWA)/Corrective Action (CA) related permit modification based upon No Further Action (NFA) Proposals for Environmental Restoration (ER) Solid Waste Management Units (SWMU). SWMUs 27, 14, 17,103, and 108 are listed in the HSWA Module IV (EPA August 1993) of the SNL/NM Resource Conservation and Recovery Act (RCRA) Hazardous Waste Management Facility Permit (NM5890110518) (EPA August 1992).

### OPERABLE UNIT 1332

SNL/NM is proposing a risk-based NFA decision for SWMU 27, Building 9820 (Animal Disposal Pit), OU 1332. SWMU 27 is the former location of an animal disposal pit and other buried debris. Based upon historical and process knowledge, field investigation data, remediation and confirmatory sampling data, and human health and ecological risk screening assessments, an NFA decision is recommended for SWMU 27 for the following reasons.

- All debris was removed from SWMU 27 during the RCRA Facility Investigation (RFI)/Voluntary Corrective Measures (VCM) excavation activities and was confirmed by collection and analysis of confirmatory soil samples.
- No nonradiological or radiological constituents of concern (COC) at concentration or activity levels considered hazardous to human health for a recreational land-use scenario were present in soil remaining at the site.
- No volatile organic compounds (VOC) or radionuclides were detected during the RFI/VCM field-screening programs.
- The risk screening assessment for ecological receptors indicates that the ecological risks associated with SWMU 27 are insignificant.

### OPERABLE UNIT 1335

SNL/NM is proposing a risk-based NFA decision for SWMU 14, Burial Site, OU 1335. SWMU 14 is a burial site of glass debris resulting from an explosives above-ground test that involved 6,000 to 8,000 fluorescent light bulbs. Potential COCs are mercury, residual high explosives (HE) and depleted uranium (DU). A confirmatory sampling investigation conducted in the area determined that there was no significant debris or COC present in the area, thereby validating reports that an insignificant amount of material was buried. Based upon field investigation data and the human health risk screening assessment, an NFA is being recommended for SWMU 14 for the following reasons:

- All anomalous material (discolored soil) found in the trenches was sampled and excavated. The material was nonhazardous.

- There was no evidence of mercury from either the field screening or from laboratory analyses, and the total amount of mercury used in the test was insignificant (less than 1 pint).

- There was no evidence of explosives. All samples analyzed for explosives were nondetected.

- Human health and ecological risk screening assessments indicate no impact of the COCs to human health or the environment.

SNL/NM is proposing a risk-based NFA decision for SWMU 17, Scrap Yards, OU 1335. SWMU 17 contains eight inactive scrap yards used to support testing activities at South Thunder Range. Based upon historical and process knowledge, field investigation data, and human and ecological risk screening assessments, an NFA decision is recommended for SWMU 17 for the following reasons:

- All radiological anomalies detected at SWMU 17B were confirmed remediated following the VCM removal activities.

- No nonradiological or radiological COCs were present in soil at concentrations or activity levels considered hazardous to human health for an industrial land-use scenario.

- Risk screening assessment for ecological receptors indicates that the ecological risks associated with SWMU 17 are expected to be insignificant.

SNL/NM is proposing a risk-based NFA decision for SWMU 103, Scrap Yards, OU 1335. SWMU 103 encompasses SWMU 117 (Sodium Pit) and the buildings (including 9939) and structures associated with the Large-Scale Melt Facility. Based upon field investigation data and the human health and ecological risk screening assessment, an NFA is recommended for SWMU 103 for the following reasons:

- All radiological anomalies detected at SWMU 103 were confirmed remediated following the VCM removal activities.

- No nonradiological or radiological COCs were present in soil at concentrations or activity levels considered hazardous to human health for an industrial land-use scenario.

- Risk screening assessment for ecological receptors indicates that the ecological risks associated with SWMU 103 are expected to be low.

SNL/NM is proposing a risk-based NFA decision for SWMU 108, Firing Site (Building 9940), OU 1335. SWMU 108 consists of a bunker and several supporting structures (sheds and office trailers) that were used for explosives testing and reactor safety experiments. Based upon historical and process knowledge, field investigation data, and human health and ecological risk screening assessments, an NFA decision is recommended for SWMU 108 for the following reasons:

- All radiological anomalies detected at SWMU 108 are confirmed to be remediated following the VCM removal activities.
- No nonradiological or radiological COCs were present in soil at concentrations or activity levels considered hazardous to human health for an industrial land-use scenario.
- Risk screening assessment for ecological receptors indicates that the ecological risks associated with SWMU 108 are insignificant.

Based upon the evidence provided above, SWMUs 27, 14, 17, 103, and 108 are proposed for an NFA decision in conformance with Criterion 5 (NMED March 1998), which states that the SWMUs have been fully characterized and remediated in accordance with current and applicable state or federal regulations and that available data indicate that contaminants pose an acceptable level of risk under current and projected future land use.

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| bgs | below ground surface |
| BLM | Bureau of Land Management |
| CEARP | Comprehensive Environmental Assessment and Response Program |
| cm | centimeter(s) |
| $cm^2$ | square centimeter(s) |
| COC | constituent of concern |
| COPEC | constituent of potential ecological concern |
| cps | counts per second |
| DCF | dose conversion factor |
| DOE | U.S. Department of Energy |
| dpm | disintegration(s) per minute |
| DQO | Data Quality Objective |
| DU | depleted uranium |
| EOD | Explosive Ordnance Disposal |
| EPA | U.S. Environmental Protection Agency |
| ER | environmental restoration |
| FCI | fuel coolant interaction |
| FITS | Fully Instrumented Test System |
| FOP | field operating procedure |
| HASP | health and safety plan |
| HE | high explosives |
| HEAST | Health Effects Assessment Summary Tables |
| HI | hazard index |
| HMX | 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclooctane |
| HP | health physics |
| HRMB | Hazardous and Radioactive Materials Bureau |
| HQ | hazard quotient |
| ID | identification |
| IH | industrial hygiene |
| IRIS | Integrated Risk Information System |
| KAFB | Kirtland Air Force Base |
| kg | kilogram(s) |
| L | liter(s) |
| LAS | Lockheed Analytical Services |
| lb | pound(s) |
| LOAEL | lowest-observed-adverse-effect level |
| $m^3$ | cubic meter(s) |
| MDA | minimum detectable activity |
| MDC | Melt Development Corium |
| MDL | method detection limit |
| μg | microgram(s) |
| μR/hr | microroentgen(s) per hour |

## ACRONYMS AND ABBREVIATIONS (Concluded)

| | |
|---|---|
| mg | milligram(s) |
| mi | mile(s) |
| mrem | millirem(s) |
| NOAEL | no-observed-adverse-effect level |
| NFA | no further action |
| NMED | New Mexico Environment Department |
| NRC | U.S. Nuclear Regulatory Commission |
| OP | operating procedure |
| OU | operable unit |
| PCB | polychlorinated biphenyl |
| pCi/g | picocurie(s) per gram |
| PID | photoionization detector |
| PRG | Preliminary Remediation Goals |
| QA | quality assurance |
| QC | quality control |
| RAGS | Risk Assessment Guidance for Superfund |
| RCRA | Resource Conservation and Recovery Act |
| RCT | radiation control technician |
| RFI | RCRA facility investigation |
| RME | reasonable maximum exposure |
| RMMA | Radioactive Materials Management Area |
| RP | Radiation Protection |
| RPD | relative percent difference |
| RPSD | Radiation Protection Sample Diagnostics |
| SNL/NM | Sandia National Laboratories/New Mexico |
| SVOC | semivolatile organic compounds |
| SWHCP | Site-Wide Hydrogeologic Characterization Project |
| SWMU | solid waste management unit |
| TA | Technical Area |
| TAL | target analyte list |
| TCL | target compound list |
| TCLP | toxicity characteristic leaching procedure |
| TEDE | total effective dose equivalent |
| USFS | U.S. Forest Service |
| UXO | unexploded ordnance |
| VCM | voluntary corrective measure |
| VOC | volatile organic compounds |
| yr | year |

# 1.0 INTRODUCTION

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a Hazardous and Solid Waste Amendments (HSWA)/Corrective Action (CA) related permit modification based upon No Further Action (NFA) Proposals for Environmental Restoration (ER) Solid Waste Management Units (SWMU). The following SWMUs are listed in the HSWA Module IV (EPA August 1993) of the SNL/NM Resource Conservation and Recovery Act (RCRA) Hazardous Waste Management Facility Permit (NM5890110518) (EPA August 1992). Proposals for each SWMU are located in this document as follows:

Operable Unit 1332

- SWMU 27, Building 9820 (Animal Disposal Pit) (Section 2.0)

Operable Unit 1335

- SWMU 14, Burial Site (Building 9920) (Section 3.0)
- SWMU 17, Scrap Yards/Open Dump (Thunder Range) (Section 4.0)
- SWMU 103, Scrap Yard (Building 9939) (Section 5.0)
- SWMU 108, Firing Site (Building 9940) (Section 6.0)

These proposals each provide a site description, history, summary of investigatory activities, and the rationale for the NFA decision.

# 6.0 SOLID WASTE MANAGEMENT UNIT 108, FIRING SITE (BUILDING 9940)

## 6.1 Summary

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a risk-based no further action (NFA) decision for Solid Waste Management Unit (SWMU) 108, Firing Site (Building 9940), Operable Unit 1335. SWMU 108 consists of a bunker and several supporting structures (sheds and office trailers) that were used for explosives testing and reactor safety experiments. Review and analysis of all relevant data for SWMU 108 indicate that concentrations of constituents of concern (COC) at this site are less than applicable risk assessment action levels. Thus, SWMU 108 is being proposed for an NFA decision based upon confirmatory sampling data demonstrating that COCs that may have been released from this SWMU into the environment pose an acceptable level of risk under current and projected future land use, per NFA Criterion 5, which states "The SWMU has been characterized and remediated in accordance with current and applicable state and federal regulations, and that available data indicate that the contaminants pose an acceptable level of risk under current and projected future land use" (NMED March 1998).

## 6.2 Description and Operational History

### 6.2.1 Site Description

SWMU 108 is located in the Coyote Test Field Area east of Technical Area (TA) III (Figure 6.2.1-1). The site encompasses a bunker (Building 9940) and the Fully Instrumented Test System (FITS) building (Building 9940A, which is situated on top of the bunker), as well as miscellaneous storage sheds and office trailers (Figure 6.2.1-2). The site consists of soils on top of the bunker and surrounding the structures. Releases of radiological material and possible hazardous chemicals resulted from the fuel coolant interaction (FCI) experiments conducted at the site. The SWMU was originally a firing site where releases of high explosives (HE) may also have occurred.

SWMU 108 is on land owned by the U.S. Air Force that is permitted to DOE and SNL/NM and is located approximately 3,000 feet east of TA-III. It covers approximately 0.4 acre at an elevation of 5,530 feet above mean sea level (SNL/NM March 1996a). Current and projected land use for SWMU 108 is industrial (DOE and USAF March 1996).

SWMU 108 lies on the western margin of the Sandia Fault Zone. The geologic materials underlying the site consist of thick alluvial sediments that overlie deep bedrock. An alluvial fan and piedmont colluvium overly the Santa Fe Group Strata. The Santa Fe deposits are estimated to be approximately 3,000 feet thick beneath SWMU 108. Detailed descriptions of the regional geology are provided in the Site-Wide Hydrogeologic Characterization Project (SWHCP) 1994 Annual Report (SNL/NM March 1995).

SWHCP soil surveys and surficial mapping provide general soil characteristics for the area around SWMU 108. The dominant soil groups in the area include the Tome very fine sandy loam and the Tijeras gravelly fine sandy loam. The estimated recharge rate for soils in the area

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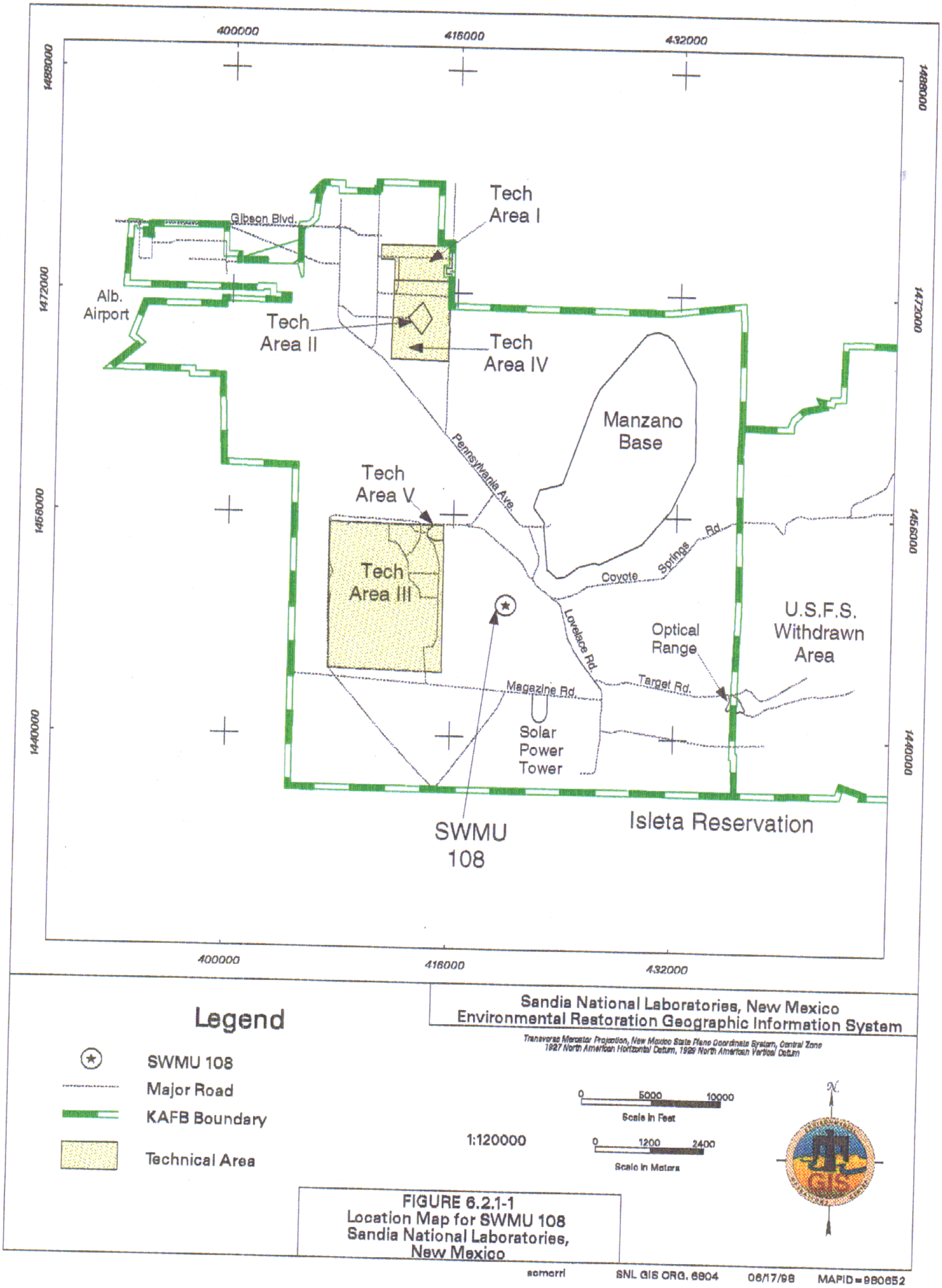


FIGURE 6.2.1-1
Location Map for SWMU 108
Sandia National Laboratories,
New Mexico

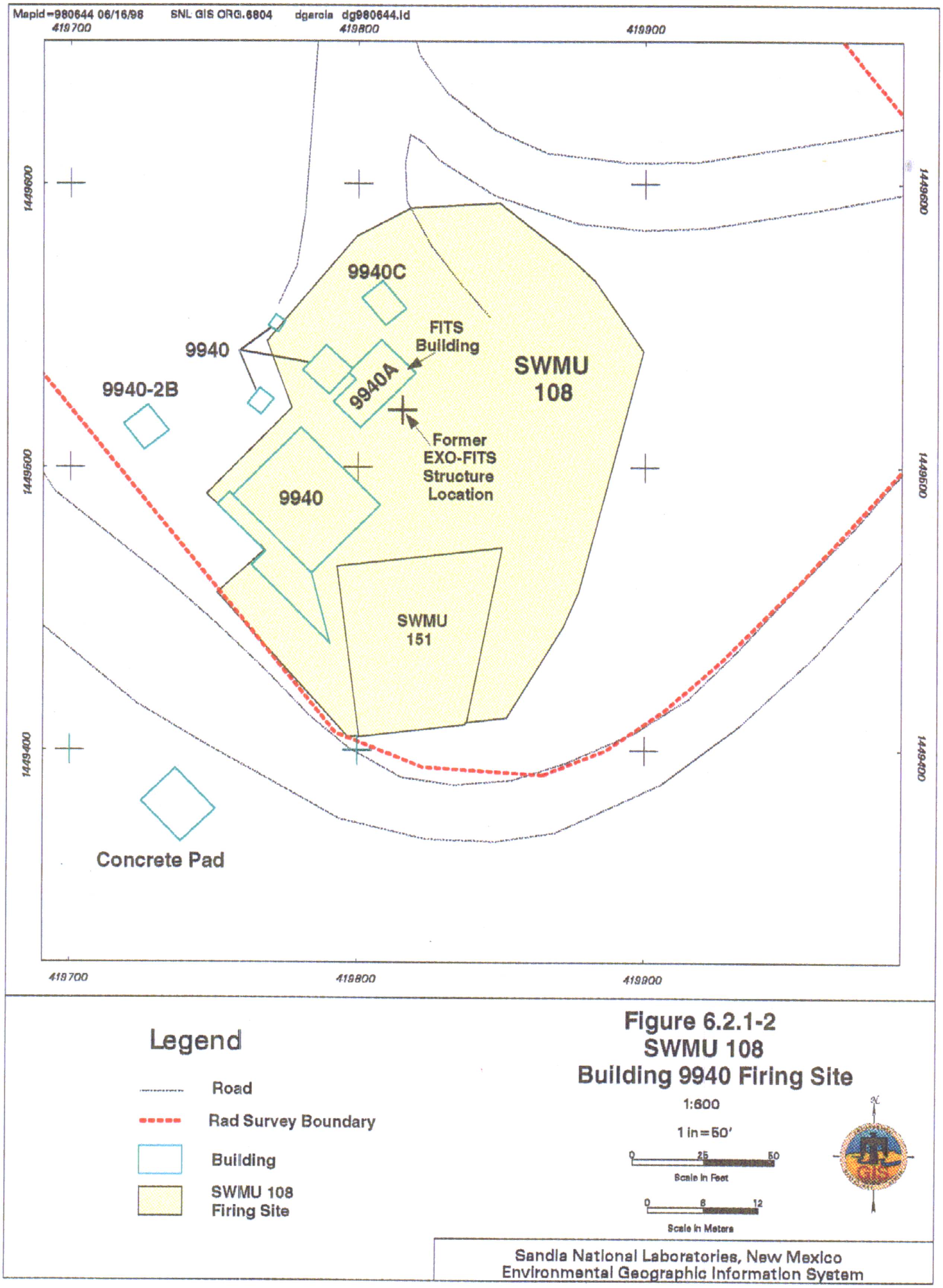


Figure 6.2.1-2
SWMU 108
Building 9940 Firing Site

range between 0.002 and 0.071 centimeters per year (cm/yr), which yields downward seepage velocities ranging between 0.03 and 11.8 cm/yr (SNL/NM October 1995).

No perennial surface-water bodies are present in the immediate vicinity of SWMU 108. The nearest principal ephemeral surface drainage is the Arroyo del Coyote, which is about 1 mile north of the site. Drainage of the Arroyo del Coyote and an unnamed arroyo about 500 feet to the south of the site flows westward toward the Rio Grande.

SWMU 108 lies in the HR-2 geohydrologic region described in the SWHCP report (SNL/NM March 1995). This region is an intermediate geohydrologic zone between the HR-1 zone to the west and the HR-2 zone to the east. This region is an intermediate geohydrologic zone between the HR-1 zone to the west and the HR-2 zone to the east. The uppermost interval of groundwater saturation in HR-2 will be found as unconfined to semiconfined aquifers in the alluvial facies of the Santa Fe Group and Piedmont alluvium and as semiconfined to confined aquifers in the local bedrock units. Examples of these two aquifer models are found in two wells located near the site. Monitoring well AVN-1 (7,000 feet northwest of Building 9940) is screened in the Santa Fe Group alluvial fan facies. Depth to groundwater in this well is 508 feet below ground surface (bgs). Monitoring well LMF-1 is 6,800 feet southeast of the site. Depth to groundwater in this well is 347 feet bgs. This well is screened in the Abo Sandstone (SNL/NM March 1996b).

For a detailed discussion regarding the local setting at SWMU 103, refer to the "RCRA [Resource Conservation and Recovery Act] Facility Investigation Work Plan for Operable Unit 1335, Southwest Test Area" (SNL/NM March 1996a).

### 6.2.2 Operational History

The Building 9940 complex was originally built in the 1960s to serve as an explosive testing complex and was originally owned by Organization 2510, the Explosives Components Organization. At that time, firing tests involved conventional explosives, but there are no records of the tests performed (Marshall August 1993). Outside the complex was a metal test chamber that was used for firing charges up to 2 pounds. The precise location of this chamber is unknown. The debris from these shots was placed in a dumpster (Martz October 1985).

In the late 1970s and early 1980s experiments at the Building 9940 complex shifted toward reactor safety issues (primarily hydrogen combustion and FCIs). From 1983 to 1988 FCI experiments were conducted, as were experiments with conventional HE. The various types of tests performed are described below.

#### *6.2.2.1 Conventional Explosives Tests*

Very little information is available regarding the HE tests performed at SWMU 108. Most of them were performed prior to 1978 before the current owners occupied the facility, and individuals involved with these tests could not be located. Based upon available information, except for the metal test chamber described above, the tests were conducted in the *boom room*, which is an underground tunnel inside Building 9940 complex that was specifically designed to contain these tests (Wrightson September 1994, February 1996a). The *boom room* is an active facility. Because the *boom room* was designed to fully contain the explosives, it is believed that no release to the environment occurred as a result of the *boom room* tests.

#### *6.2.2.2 Hydrogen Combustion Experiments*

The purpose of the hydrogen combustion experiments was to test the flammability limits created by igniting a mixture of hydrogen, air, and steam. Other than hydrogen, no other hazardous material was used in these tests (Wrightson February 1996b).

#### *6.2.2.3 FCI Experiments*

The FCI experiments involved the reaction of depleted uranium (DU) and corium thermite, which is essentially a compound of stainless steel, zirconium, iron-oxide, nickel-oxide, chromium oxide, and molybdenum-oxide powder. The intent of the experiments was to simulate the reaction of molten core materials and water.

Occasionally, a small detonator was used to trigger an explosion, but usually the interactions were not triggered in this fashion. The detonator typically had a charge of about 50 milligrams (mg) of explosives. The types of explosives used are unknown.

Experiments involving corium thermite at Building 9940 began in 1979 and continued until 1982. Most of the experiments conducted at the Building 9940 facility involved iron/alumina thermite melts.

Two structures at SWMU 108 were critical to the tests using corium thermite: the FITS tank, housed in Building 9940A (Marshall August 1993) (Figure 6.2.1-2) and the EXO-FITS facility located south of Building 9940A. The FITS tank is a 5.6-cubic-meter vessel standing about 5 meters tall and is approximately 1.5 meters in diameter. The EXO-FITS facility consisted of an angle-iron superstructure that suspended the thermite/melt crucible and a water chamber on a concrete pad. These structures were located on top of the bunker, Building 9940.

Two series of experiments were conducted using corium thermite: the Melt Development-Corium (MDC) Series and the FITS-C Series. The purpose of the MDC Series was to refine the experimental techniques to ensure repeatability in the subsequent FCI experiment. The MDC experiments were conducted in the EXO-FITS facility. The FITS-C Series was the FCI test with corium thermite using melt delivery techniques developed in the MDC Series.

COCs at the site include DU and chromium, which is derived from corium thermite used in the tests at the site (Marshall August 1993). The FCI tests were conducted on top of the bunker, Building 9940. According to personnel familiar with the experiments, chromium and DU would be co-located, and the fragments from the blast did not extend more than 50 to 100 feet from the test site (Marshall August 1993). Water used in the contained firing tests inside the FITS tank on top of the bunker was discharged onto the ground just outside the FITS building near the test pad (Marshall August 1993). The volume of water released was not documented. Other potential residues from the tests are nickel-oxide.

Because of the reported explosives testing in the early history of the site, there is also the potential for residual HE. Therefore, HE is a contaminant of concern at this site.

## 6.3 Land Use

### 6.3.1 Current

Building 9940 is active. However, the area on top of the Building 9940 bunker where releases occurred, the FITS and EXO-FITS units, are inactive.

### 6.3.2 Future/Proposed

SWMU 108 has been recommended for industrial land use (DOE and USAF March 1996).

## 6.4 Investigatory Activities

### 6.4.1 Summary

### 6.4.2 Investigation #1—Comprehensive Environmental Assessment and Response Program

#### *6.4.2.1 Nonsampling Data Collection*

The site was originally reported in the 1985 Comprehensive Environmental Assessment and Response Program (CEARP) interviews (DOE September 1987). Limited information from these interviews alludes only to the primary metal container that was used for explosives tests outside Building 9940 as discussed in Section 6.2.2. Also, this report indicates that DU may have been used.

#### *6.4.2.2 Sampling Data Collection*

No samples were collected during the CEARP.

#### *6.4.2.3 Data Gaps*

No data were available to confirm whether hazardous materials or wastes were stored or released to the surrounding environment.

#### *6.4.2.4 Results and Conclusions*

Insufficient data were available to calculate a Hazard Ranking System Score for the SWMU. Subsequent to the CEARP inspection, the U.S. Environmental Protection Agency (EPA) conducted a RCRA Facility Assessment. SWMU 108 associated with Building 9940 was not identified in this report.

### 6.4.3 Investigation #2—SNL/NM ER Preliminary Investigations

#### *6.4.3.1 Nonsampling Data Collection*

##### *6.4.3.1.1 Background Review*

A background review was conducted to collect available and relevant information regarding SWMU 108. Background information sources included interviews with SNL/NM staff and contractors familiar with site operational history and existing historical site records and reports. The study was completely documented and has provided traceable references that sustain the integrity of the NFA proposal. The following, presented in chronological order, lists these information sources that were used to assist in the evaluation of SWMU 108.

- Photographs and field notes from site inspections conducted by SNL/NM staff (Wrightson July 22, 1997).
- Miscellaneous information sources including SNL/NM personal correspondence (memorandums, letters, and notes regarding SWMU 108).
- Four interviews with two facility personnel (current and retired) (Martz October 1985, Wrightson September 1994, February 1996a, February 1996b).

Preliminary investigations and background reviews indicate that environmental releases may have occurred at the site. Corium thermite (DU and metals) may have been released from the EXO-FITS facility as a result of the steam reactions from the FCI tests and from water discharged from the FITS tests conducted inside Building 9940-A (Figure 6.2.1-2).

It is expected that contamination is present in the surface soils in these areas. Also, site history suggests that HE may be present in the soils, although specific locations of the reported tests are unknown.

##### *6.4.3.1.2 Unexploded Ordnance/HE Survey*

In September 1993, a 100-percent coverage unexploded ordnance survey was performed at SWMU 108 by SNL/NM Environmental Restoration (ER) personnel and Kirtland Air Force Base (KAFB) Explosive Ordnance Unit. The survey was conducted by visually inspecting the site for ordnance, HE, and ordnance debris. No ordnance material was found at SWMU 108 (Young and Byrd September 1994).

##### *6.4.3.1.3 Radiological Survey(s)*

A radiological survey was conducted at SWMU 108 in October 1993 by RUST Geotech Inc. (December 1994). A gamma scan survey was performed at 6-foot centers (100-percent coverage) over the surface of the site. Four point sources and eleven area sources of gamma activity 30 percent or greater than natural background levels were identified during this survey (RUST Geotech Inc. December 1994) (Figure 6.4.3-1).

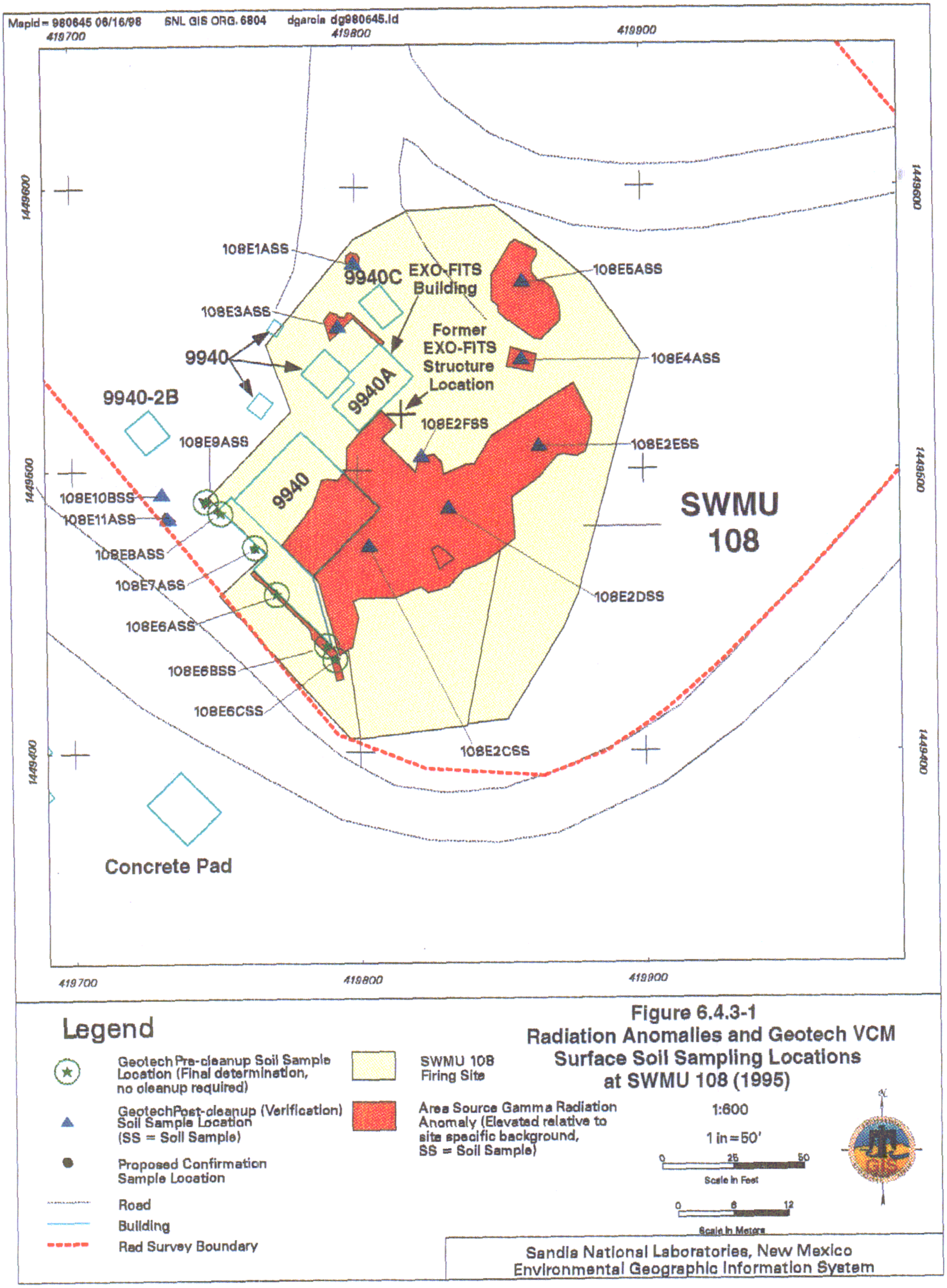


**Figure 6.4.3-1**
**Radiation Anomalies and Geotech VCM Surface Soil Sampling Locations at SWMU 108 (1995)**

#### 6.4.3.1.4 Cultural-Resources Survey

A cultural resources survey was performed at SWMU 108 in 1994. Findings from this survey indicate that no cultural resources were present on the site (Hoagland and Dello-Russo February 1995).

#### 6.4.3.1.5 Sensitive-Species Survey

A sensitive species survey was performed at SWMU 108 in 1994. Findings from this survey indicate that no sensitive species are present on the site (DOE March 1996).

#### 6.4.3.1.6 Geophysical Survey(s)

No geophysical surveys were performed at SWMU 108.

### 6.4.3.2 Sampling Data Collection

In July 1995, RUST Geotech Inc. conducted precleanup soil sampling for gamma spectroscopy analysis on 10 area sources to assess the need for remediation. In addition, the samples were analyzed for TAL metals using inductively coupled plasma methods (EPA Method 6010/7000) by Lockheed Analytical Services (LAS), SNL/NM's contract off-site laboratory.

The soil sampling was implemented as part of the RUST Geotech Inc. survey conducted in 1995. Sample locations were collected from radiological anomalies detected in the surface soils to determine if chromium was associated with the depleted uranium. The approach and methodology are described in the Final Report (SNL September 1997) (see Annex 6-A). The detection limits for these metals are shown on Table 6.4.3-1.

The purpose of this scoping sampling effort was to obtain preliminary analytical data to determine if chromium was associated with the depleted uranium contamination. No quality assurance/quality control (QA/QC) samples were collected.

### 6.4.3.3 Data Gaps

### 6.4.3.4 Results and Conclusions

When metals analyses were compared to the recommended background levels for metals in the Southwest Test Area (Dinwiddle September 24, 1997), results for arsenic (17.0 mg/kilogram [kg] maximum), barium (140 mg/kg maximum), cadmium (2.9 mg/kg maximum), chromium (48 mg/kg maximum), nickel (62 mg/kg maximum), and lead (97 mg/kg maximum) were above the approved SNL/NM maximum background concentration levels.

## Table 6.4.3-1
## Summary of Site 108—July 1995 Scoping Samples
## Inorganic Constituents (TAL Metals) and Project Reporting Limits

| Parameter | Method Detection Limit | Reporting Limit | Units |
|---|---|---|---|
| Aluminum | Not reported | 40 | mg/kg |
| Antimony | Not reported | 12 | mg/kg |
| Arsenic | Not reported | 2 | mg/kg |
| Barium | Not reported | 40 | mg/kg |
| Beryllium | Not reported | 1 | mg/kg |
| Cadmium | Not reported | 1 | mg/kg |
| Calcium | Not reported | 1000 | mg/kg |
| Chromium | Not reported | 2 | mg/kg |
| Cobalt | Not reported | 10 | mg/kg |
| Copper | Not reported | 5 | mg/kg |
| Iron | Not reported | 20 | mg/kg |
| Lead | Not reported | 0.58–0.60 | mg/kg |
| Magnesium | Not reported | 1000 | mg/kg |
| Manganese | Not reported | 3 | mg/kg |
| Mercury | Not reported | 0.091–0.10 | mg/kg |
| Nickel | Not reported | 8 | mg/kg |
| Potassium | Not reported | 1000 | mg/kg |
| Selenium | Not reported | 0.97–0.99 | mg/kg |
| Silver | Not reported | 2 | mg/kg |
| Sodium | Not reported | 1000 | mg/kg |
| Thallium | Not reported | 1.9–2.0 | mg/kg |
| Vanadium | Not reported | 10 | mg/kg |
| Zinc | Not reported | 4 | mg/kg |

mg/kg = Milligram per kilogram.
TAL = Target Analyte List.

## 6.4.4 Investigation #3—SNL/NM ER Project Voluntary Corrective Measure and Confirmatory Sampling

### *6.4.4.1 Nonsampling Data Collection*

No nonsampling data collection was performed.

### *6.4.4.2 Sampling Data Collection*

#### *6.4.4.2.1 Voluntary Corrective Measure Activities*

A radiological voluntary corrective measure (VCM) was conducted to remove anomalies identified during the preliminary investigation activities. Point sources and small area sources were removed in September 1995, and large area sources were remediated in October 1995. The soils containing elevated metals that had been identified during the preliminary investigation activities were removed as part of the radiological VCM. Details of the VCM, including areas remediated and soil volumes removed, are described in Annex 6-A, the exerpts from the VCM Report (SNL/NM September 1997).

#### *6.4.4.2.2 Confirmatory Sampling*

On August 12, 1997, surface soil samples were collected at 25 locations at SWMU 108 (Figure 6.4.4-1). The samples were collected in areas of known radiological contamination that had been excavated in the RUST Geotech Inc. VCM to verify clean-up levels and in areas outside the defined anomalies to determine whether any potential hazardous constituents are present outside the known radiological contaminated areas. The samples were collected according to the procedures described in the ER Site 108 sampling plan (SNL/NM July 1997) using approved SNL/NM field operating procedures.

The samples at 21 of the locations were collected at depth intervals of 0 to 6 inches. The remaining samples at locations ER-108-GR-021, ER-108-GR-022, ER-108-GR-023, ER-108-GR-024, and ER-108-GR-025 were sediment samples collected from a ditch along the road south of the site. Except for location ER-108-GR-023, these samples were also collected from soils at depth intervals of 1 to 2 feet in the bottom of the ditch to determine whether COCs were present.

All soil samples were analyzed for metals using EPA Method 6010/7000, for HE using EPA Method 8330, and for radiological activity using gamma spectroscopy (Annex 6-B). All chemical samples were analyzed at SNL/NM's off-site contract laboratory (LAS) at Level III data quality. Radiological samples were analyzed at SNL/NM's on-site radiological laboratory.

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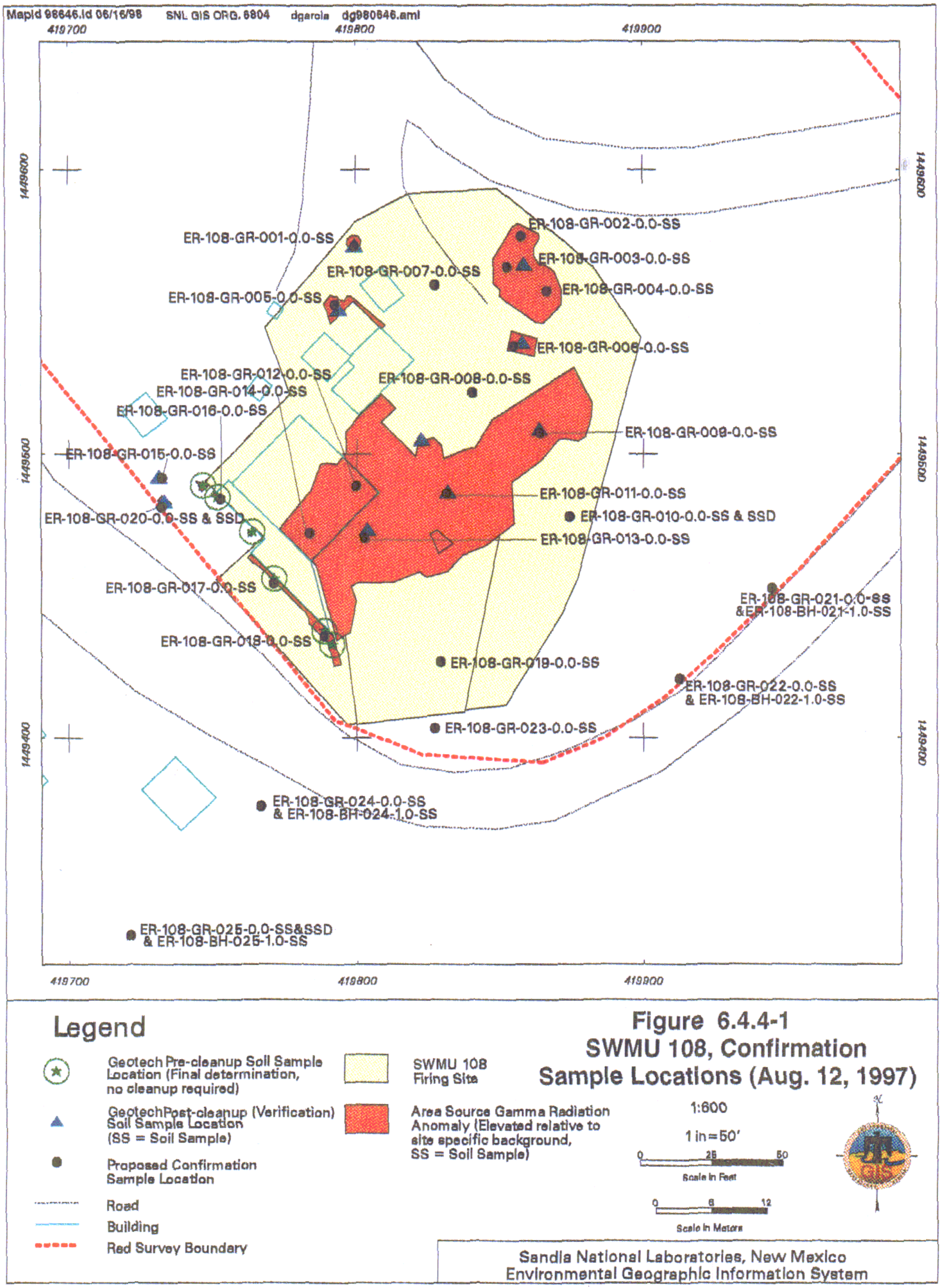


**Figure 6.4.4-1**
**SWMU 108, Confirmation Sample Locations (Aug. 12, 1997)**

### 6.4.4.3 *Data Gaps*

Although radiological anomalies were defined as part of the radiological VCM conducted by RUST Geotech Inc., no confirmation samples were collected for chemical analyses for the COCs at SWMU 108. For this reason, chemical environmental samples were analyzed at SWMU 108 as part of the confirmatory sampling activities. Additional radiological analyses on soils were conducted to fully confirm cleanup of the radiological VCM. The nature and extent of metals, radionuclides, and HE in the soils was characterized for this site in order to develop human and environmental risk scenarios and to make an NFA determination.

### 6.4.4.4 *Results and Conclusions*

After the radiological VCM activities, 10 post cleanup samples were collected from areas exhibiting the highest residual gamma radiation readings (108E-001A-SS,108E-002C-SS, 108E-002D-SS, 108E-002E-SS, 108E-002F-SS, 108E-003A-SS, 108E-004A-SS, 108E-005A-SS, 108E-010B-SS, and 108E-011A-SS). The maximum levels of residual radiological COCs in the soil are presented in Table 6.4.4-1 and Figure 6.4.3-1. Samples 108E-006A-SS, 108E-006B-SS, 108E-006C-SS, 108E-007A-SFS, 108E-008A-SS, and 108E-009A-SS (shown in this table) were precleanup samples with radiological activities below cleanup levels. Complete results of gamma spectroscopy are contained in Annex 6-B. Results of confirmatory sampling are presented in Tables 6.4.4-2, 6.4.4-3, and 6.4.4-4.

Metals

Review and analyses of the relevant Level III chemical data for SWMU 108 surface soils indicate that the concentration levels of metals at this site are below the SNL/NM and New Mexico Environment Department (NMED) agreed-upon sitewide levels at all locations with the exception of barium, cadmium, lead, and silver (Dinwiddie September 24, 1997). Mercury and selenium do not have quantified maximum background screening levels. Therefore, it is not known whether these constituents exceed background. However, neither pose significant risk to human health or the environment.

Three barium samples were at greater than the agreed-upon values of 130 mg/kg for surface soils at locations ER-108-GR-006-0.0-SS, ER-108-GR-013-0.0-SS, and ER-108-GR-019-0.0-SS. The maximum concentration level for barium in surface soils is 363 mg/kg. One cadmium sample at location ER-108-GR-017-0.0-SS (1.63 mg/kg) was above the nonquantified background level of <1.0 mg/kg. Three lead samples were above the background levels of 21.4 mg/kg for surface soils: at locations ER-108-GR-008-0.0-SS (362 mg/kg), ER-108-GR-017-0.0-SS (25.7 mg/kg), and ER-108-GR-020-0.0-SS (23.4 mg/kg). Finally, in one sample, silver was above the nonquantified background level of <1.0 mg/kg (at location ER-108-GR-012-0.0-SS [5.56 mg/kg]).

No subsurface soils samples showed metals above the agreed-upon background levels except for barium at location ER-108-BH-021-1.0-SS (at the 1.0-foot depth) with a concentration of 384 mg/kg over a background level of 214 mg/kg.

## Table 6.4.4-1
## Summary of SWMU 108 Post-VCM Verification Soil Sampling Gamma Spectroscopy Analytical Results, July–October 1995

| Sample Attributes | | | Gamma Spectroscopy Activity (pCi/g) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Record Number[a] | ER Sample ID (Figure 6.4.3-1) | Sample Depth (ft) | Uranium-238 | Thorium-234 | Thorium-232 | Radium-228 | Thorium-228 | Uranium-235 | Cesium-137 |
| 01308 | 108E-001A-SS | 0–0.5 | 4.07E+00 | ND (7.98E–01) | 4.77E–01 | 4.50E–01 | ND (1.37E+00) | 3.66E–01 | 2.48E–02 |
| 04376 | 108E-002C-SS | 0–0.5 | 2.15E+01 | 2.07E+01 | 5.52E–01 | 3.84E–01 | 5.65E–01 | 2.54E–01 | 5.04E–02 |
| 04376 | 108E-002D-SS | 0–0.5 | ND (2.45E+00) | ND (6.78E–01) | 5.27E–01 | 4.98E–01 | 4.95E–01 | ND (1.77E–01) | 1.74E–02 |
| 04376 | 108E-002E-SS | 0–0.5 | 6.61E+00 | 3.47E+00 | 3.42E–01 | 4.40E–01 | 3.95E–01 | ND (1.78E–01) | 4.21E–02 |
| 04376 | 108E-002F-SS | 0–0.5 | 5.40E+01 | 6.44E+01 | 4.26E–01 | 4.50E–01 | 5.37E–01 | 8.43E–01 | 2.30E–02 |
| 01308 | 108E-003A-SS | 0–0.5 | 1.48E+00 | 2.14E+00 | 4.36E–01 | 3.95E–01 | 6.06E–01 | ND (3.36E–01) | 5.42E–02 |
| 01310 | 108E-004A-SS | 0–0.5 | 1.53E+01 | 1.50E+01 | 4.01E–01 | 4.03E–01 | 3.50E–01 | ND (4.16E–01) | ND (5.81E–02) |
| 01310 | 108E-005A-SS | 0–0.5 | 6.87E+00 | 6.65E+00 | 5.00E–01 | 3.96E–01 | 7.12E–01 | ND (3.83E–01) | 8.13E–02 |
| 04319 | 108E-006A-SS | 0–0.5 | 5.00E+00 | 5.64E+00 | 5.62E–01 | 5.70E–01 | ND (1.48E+00) | ND (3.62E–01) | 8.94E–02 |
| 04319 | 108E-006B-SS | 0–0.5 | 1.12E+00 | 9.61E–01 | 5.36E–01 | 3.80E–01 | 4.18E–01 | ND (3.39E–01) | 4.30E–01 |
| 04376 | 108E-006C-SS | 0–0.5 | ND (2.44E+00) | ND (6.29E–01) | 3.64E–01 | 4.03E–01 | 4.89E–01 | ND (1.69E–01) | 1.35E–01 |
| 04376 | 108E-007A-SS | 0–0.5 | ND (2.27E+00) | ND (4.05E–01) | 3.70E–01 | 4.98E–01 | 3.07E–01 | ND (1.63E–01) | ND (2.45E–02) |
| 04376 | 108E-008A-SS | 0–0.5 | ND (2.44E+00) | ND (5.73E–01) | 3.01E–01 | 4.19E–01 | 3.05E–01 | ND (1.74E–01) | 1.43E–02 |
| 04376 | 108E-009A-SS | 0–0.5 | ND (2.26E+00) | ND (5.01E–01) | 3.75E–01 | 2.61E–01 | 3.51E–01 | ND (1.61E–01) | ND (2.47E–02) |
| 04376 | 108E-010B-SS | 0–0.5 | ND (2.34E+00) | ND (6.71E–01) | 4.18E–01 | 2.99E–01 | 6.06E–01 | ND (1.67E–01) | 1.84E–01 |
| 04376 | 108E-011A-SS | 0–0.5 | 4.26E+00 | 4.10E+00 | 5.38E–01 | 5.51E–01 | 5.94E–01 | ND (1.91E–01) | ND (2.84E–02) |
| SNL/NM SWTA Surface Soil Background UTL or 95th-Percentile[b] | | | 1.4 | 1.4 | 1.01 | 1.01 | 1.01[c] | 0.16 | 0.664 |

[a]Chain of custody record.
[b]Dinwiddie September 24, 1997.
[c]Brown January 14, 1998.
ER = Environmental Restoration.
ft = Foot (feet).
ID = Identification.
ND ( ) = Not detected at or above the minimum detectable activity, shown in parenthesis.
pCi/g = Picocuries per gram.
SNL/NM = Sandia National Laboratories/New Mexico.
SS = Surface soil sample.
SWMU = Solid waste management unit.
SWTA = Southwest Test Area
UTL = Upper tolerance limit.
VCM = Voluntary corrective measure.

## Table 6.4.4-2
## Summary of SWMU 108 Confirmatory Soil Sampling Metals Analytical Results, August 1997
## (Off-Site Laboratory Only)

| Sample Attributes | | | Metals (EPA 6010/7470)[a] (mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Record Number[b] | ER Sample ID (Figure 6.4.4-1) | Sample Depth (ft) | Arsenic | Barium | Beryllium | Cadmium | Chromium | Mercury | Nickel | Lead | Selenium | Silver |
| 06346 | ER-108-GR-001-0.0-SS | 0–0.5 | 2.39 | 65.5 | 0.361 J (0.498) | 0.391 J (0.498) | 7.37 | 0.0257 J (0.0332) | 5.91 | 6.87 | 0.607 | ND (0.031) |
| 06346 | ER-108-GR-002-0.0-SS | 0–0.5 | 2.40 | 80.7 | 0.321 J (0.464) | 0.214 J (0.464) | 6.71 | 0.0265 J (0.0319) | 5.02 | 4.30 | 0.684 | 0.0827 J (0.464) |
| 06346 | ER-108-GR-003-0.0-SS | 0–0.5 | 3.06 | 93.1 | 0.375 J (0.484) | 0.269 J (0.484) | 9.47 | 0.0294 | 9.38 | 6.13 | 0.740 | ND (0.031) |
| 06346 | ER-108-GR-004-0.0-SS | 0–0.5 | 2.66 | 93.1 | 0.324 J (0.496) | 0.225 J (0.496) | 6.67 | 0.0268 J (0.0322) | 5.21 | 5.37 | 0.560 | 0.0924 J (0.496) |
| 06346 | ER-108-GR-005-0.0-SS | 0–0.5 | 2.59 | 76.1 | 0.325 J (0.467) | 0.484 | 7.57 | 0.0394 | 5.71 | 12.9 | 0.753 | 0.816 |
| 06346 | ER-108-GR-006-0.0-SS | 0–0.5 | 3.08 | 184 | 0.338 J (0.499) | 0.361 J (0.499) | 6.57 | 0.0285 J (0.0326) | 7.24 | 8.90 | 0.758 | 0.0823 J (0.499) |
| 06346 | ER-108-GR-007-0.0-SS | 0–0.5 | 2.57 | 84.3 | 0.295 J (0.465) | 0.411 J (0.465) | 9.25 | 0.0237 J (0.0320) | 5.40 | 6.19 | 0.806 | 0.115 J (0.465) |
| 06346 | ER-108-GR-008-0.0-SS | 0–0.5 | 2.89 | 102 | 0.292 J (0.490) | 0.341 J (0.490) | 6.06 | 0.0211 J (0.0324) | 9.99 | 362 | 0.464 J (0.490) | 0.0769 J (0.490) |
| 06346 | ER-108-GR-009-0.0-SS | 0–0.5 | 2.97 | 92 | 0.339 J (0.491) | 0.247 J (0.491) | 7.35 | 0.0252 J (0.0324) | 5.28 | 4.70 | 0.594 | ND (0.031) |
| 06346 | ER-108-GR-010-0.0-SS | 0–0.5 | 3.01 | 110 | 0.383 J (0.496) | 0.313 J (0.496) | 6.58 | 0.0274 J (0.0326) | 6.18 | 10.0 | 0.727 | 0.0833 J (0.496) |
| 06346 | ER-108-GR-010-0.0-SSD | 0–0.5 | 3.09 | 111 | 0.403 J (0.478) | 0.375 J (0.478) | 8.70 | 0.0525 | 6.84 | 8.26 | 0.874 | 0.119 J (0.478) |
| 06346 | ER-108-GR-011-0.0-SS | 0–0.5 | 2.47 | 65.9 | 0.334 J (0.483) | 0.192 J (0.483) | 5.75 | 0.0222 J (0.0328) | 4.92 | 3.94 | 0.432 J (0.483) | ND (0.031) |
| 06346 | ER-108-GR-012-0.0-SS | 0–0.5 | 2.12 | 80.1 | 0.330 J (0.487) | 0.220 J (0.487) | 6.52 | 0.0234 J (0.0325) | 4.61 | 4.54 | 0.621 | 5.56 |
| 06346 | ER-108-GR-013-0.0-SS | 0–0.5 | 2.87 | 363 | 0.311 J (0.497) | 0.203 J (0.497) | 5.92 | 0.0253 J (0.0311) | 4.59 | 4.17 | 0.710 | ND (0.031) |
| 06346 | ER-108-GR-014-0.0-SS | 0–0.5 | 1.65 | 87.0 | 0.350 J (0.459) | 0.256 J (0.459) | 6.24 | 0.0272 J (0.0329) | 4.89 | 5.32 | 0.625 | 0.502 |
| 06346 | ER-108-GR-015-0.0-SS | 0–0.5 | 2.26 | 61.9 | 0.271 J (0.484) | 0.442 J (0.484) | 6.26 | 0.0374 | 4.97 | 14.1 | 0.490 | 0.149 J (0.484) |
| 06346 | ER-108-GR-016-0.0-SS | 0–0.5 | 1.75 | 45.3 | 0.198 J (0.495) | 0.666 | 4.50 | ND (0.0173) | 3.23 | 5.47 | 0.524 | ND (0.031) |
| 06346 | ER-108-GR-017-0.0-SS | 0–0.5 | 2.07 | 63.5 | 0.326 J (0.500) | 1.63 | 6.30 | 0.0249 J (0.0329) | 5.88 | 25.7 | 0.941 | ND (0.031) |
| 06346 | ER-108-GR-018-0.0-SS | 0–0.5 | 3.08 | 81.6 | 0.338 J (0.466) | 0.562 | 7.44 | 0.0221 J (0.0330) | 5.81 | 14.8 | 0.757 | ND (0.031) |
| 06346 | ER-108-GR-019-0.0-SS | 0–0.5 | 2.68 | 188 | 0.300 J (0.463) | 0.315 J (0.463) | 5.68 | 0.0251 J (0.0332) | 4.22 | 5.97 | 0.502 | 0.144 J (0.463) |
| 06346 | ER-108-GR-020-0.0-SS | 0–0.5 | 2.03 | 58.9 | 0.221 J (0.467) | 0.606 | 4.81 | 0.0477 | 4.73 | 23.4 | 0.534 | 0.259 J (0.467) |
| 06346 | ER-108-GR-020-0.0-SSD | 0–0.5 | 2.32 | 59.1 | 0.289 J (0.500) | 0.712 | 7.01 | 0.0574 | 5.02 | 18.6 | 0.753 | 0.223 J (0.500) |
| 06346 | ER-108-GR-021-0.0-SS | 0–0.5 | 2.89 | 53.5 | 0.239 J (0.467) | 0.208 J (0.467) | 7.32 | ND (0.0173) | 5.00 | 10.5 | 0.684 | ND (0.031) |
| 06346 | ER-108-GR-022-0.0-SS | 0–0.5 | 2.25 | 40.9 | 0.247 J (0.481) | 0.188 J (0.481) | 6.24 | ND (0.0173) | 5.23 | 3.47 | 0.806 | ND (0.031) |
| 06346 | ER-108-GR-023-0.0-SS | 0–0.5 | 2.24 | 58.1 | 0.354 J (0.463) | 0.303 J (0.463) | 4.47 | ND (0.0173) | 3.99 | 6.09 | 0.569 | 0.111 J (0.463) |
| 06346 | ER-108-GR-024-0.0-SS | 0–0.5 | 2.37 | 94.9 | 0.280 J (0.490) | 0.161 J (0.490) | 4.57 | ND (0.0173) | 4.37 | 4.32 | 0.586 | ND (0.031) |
| 06346 | ER-108-GR-025-0.0-SS | 0–0.5 | 2.49 | 113 | 0.303 J (0.485) | 0.210 J (0.485) | 5.64 | ND (0.0173) | 4.84 | 7.33 | 0.612 | ND (0.031) |
| 06346 | ER-108-GR-025-0.0-SSD | 0–0.5 | 2.77 | 119 | 0.346 J (0.490) | 0.224 J (0.490) | 6.48 | 0.0257 J (0.0326) | 5.42 | 7.12 | 0.625 | ND (0.031) |
| 06346 | ER-108-BH-021-1.0-SS | 1.0–1.5 | 2.89 | 384 | 0.304 J (0.463) | 0.195 J (0.463) | 6.20 | ND (0.0173) | 5.31 | 4.24 | 0.515 | ND (0.031) |
| 06346 | ER-108-BH-022-1.0-SS | 1.0–1.5 | 2.39 | 96.0 | 0.275 J (0.495) | 0.166 J (0.495) | 6.15 | ND (0.173) | 4.94 | 3.63 | 0.879 | ND (0.031) |
| 06346 | ER-108-BH-024-1.0-SS | 1.0–1.5 | 2.50 | 93.9 | 0.318 J (0.495) | 0.314 J (0.495) | 7.14 | ND (0.0173) | 6.25 | 5.50 | 0.600 | ND (0.031) |
| 06346 | ER-108-BH-025-1.0-SS | 1.0–1.5 | 2.98 | 120 | 0.356 J (0.463) | 0.235 J (0.463) | 7.30 | ND (0.0173) | 5.83 | 8.30 | 0.705 | ND (0.031) |

Refer to footnotes at end of table.

## Table 6.4.4-2 (Concluded)
## Summary of SWMU 108 Confirmatory Soil Sampling Metals Analytical Results, August 1997
## (Off-Site Laboratory Only)

| Sample Attributes | | | Metals (EPA 6010/7470)[a] (mg/kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Record Number[b] | ER Sample ID (Figure 6.4.4-1) | Sample Depth (ft) | Arsenic | Barium | Beryllium | Cadmium | Chromium | Mercury | Nickel | Lead | Selenium | Silver |
| Quality Assurance/Quality Control Sample (in mg/L) | | | | | | | | | | | | |
| 06346 | ER-108-GR-025-0.0-SS (Equipment Blank) | NA | ND (0.00298) | 0.000417 J (.000332) | ND (0.000223) | ND (0.000208) | 0.00326 J (.000729) | ND (0.000104) | ND (0.00227) | 0.00105 J (.000678) B | ND (0.0014) | ND (0.00062) |
| SNL/NM SWTA Surface Soil Background UTL or 95th-Percentile Concentrations[c] | | | 5.6 | 130 | 0.65 | <1 | 17.3 | <0.25 | 11.5 | 21.4 | <1 | <1 |
| SNL/NM SWTA Subsurface Soil Background UTL or 95th-Percentile Concentrations[c] | | | 4.4 | 214 | 0.65 | 0.9 | 15.9 | <0.1 | 11.5 | 11.8 | <1 | <1 |

[a]Chain of custody record.
[b]EPA November 1986.
[c]Dinwiddie September 24, 1997.

B = Detected in associated blank with a concentration greater than the practical quantitation limit.
BH = Borehole.
EPA = U.S. Environmental Protection Agency.
ER = Environmental Restoration.
ft = Foot (feet).
GR = Grab sample.
ID = Identification.
J ( ) = The reported value is below the reporting limit, shown in parenthesis, but equal to or above the effective detection limit.
mg/kg = Milligrams per kilogram.
mg/L = Milligrams per liter.
NA = Not applicable.
ND ( ) = Not detected at or above the effective detection limit, shown in parenthesis.
SNL/NM = Sandia National Laboratories/New Mexico.
SS = Surface soil sample.
SSD = Duplicate surface soil sample.
SWMU = Solid waste management unit.
SWTA = Southwest Test Area
UTL = Upper tolerance limit.

## Table 6.4.4-3
## Summary of SWMU 108 Confirmatory Soil Sampling HE Analytical Results, August 1997
## (Off-Site Laboratory Only)

| Sample Attributes | | | Explosives, Method 8330[a] (µg/kg) | | | | | |
|---|---|---|---|---|---|---|---|---|
| Record Number[b] | ER Sample ID (Figure 6.4.4-1) | Sample Depth (ft) | 2,4,6-Trinitrotoluene | 2,4-Dinitrotoluene | 2,6- Dinitrotoluene | 2-Amino, 4,6-Dinitrotoluene | 4-Amino, 2,6-dinitrotoluene | HMX |
| 06346 | ER-108-GR-001-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-002-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | 71.7 J (75.0) |
| 06346 | ER-108-GR-003-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | 348 |
| 06346 | ER-108-GR-004-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | 4230 |
| 06346 | ER-108-GR-005-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | 247 |
| 06346 | ER-108-GR-006-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-007-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-008-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-009-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-010-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-010-0.0-SSD | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-011-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-012-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-013-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-014-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-015-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-016-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-017-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-018-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-019-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-020-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-020-0.0-SSD | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-021-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-022-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-023-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-024-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-025-0.0-SS | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-GR-025-0.0-SSD | 0–0.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-BH-021-1.0-SS | 1.0–1.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-BH-022-1.0-SS | 1.0–1.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-BH-024-1.0-SS | 1.0–1.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| 06346 | ER-108-BH-025-1.0-SS | 1.0–1.5 | ND (5.67) | ND (6.18) | ND (6.48) | ND (6.6) | ND (5.45) | ND (5.27) |
| Quality Assurance/Quality Control Sample (in µg/L) | | | | | | | | |
| 06346 | ER-108-GR-025-0.0-SS (Equipment Blank) | NA | ND (.029) | ND (0.014) | ND (0.043) | ND (0.019) | ND (0.02) | ND (0.046) |

Refer to footnotes at end of table.

## Table 6.4.4-3 (Continued)
## Summary of SWMU 108 Confirmatory Soil Sampling HE Analytical Results, August 1997
## (Off-Site Laboratory Only)

| Sample Attributes | | | Explosives, Method 8330[a] (μg/kg) | | |
|---|---|---|---|---|---|
| Record Number[b] | ER Sample ID (Figure 6.4.4-1) | Sample Depth (ft) | Nitrobenzene | RDX | Tetryl |
| 06346 | ER-108-GR-001-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-002-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-003-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-004-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-005-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-006-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-007-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-008-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-009-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-010-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-010-0.0-SSD | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-011-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-012-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-013-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-014-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-015-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-016-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-017-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-018-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-019-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-020-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-020-0.0-SSD | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-021-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-022-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-023-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-024-0.0-SS | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-GR-025-0.0-SSD | 0–0.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-BH-021-1.0-SS | 1.0–1.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-BH-022-1.0-SS | 1.0–1.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-BH-024-1.0-SS | 1.0–1.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| 06346 | ER-108-BH-025-1.0-SS | 1.0–1.5 | ND (5.21) | ND (9.71) | ND (7.55) |
| Quality Assurance/Quality Control Sample (in μg/L) | | | | | |
| 06346 | ER-108-GR-025-0.0-SS (Equipment Blank) | NA | ND (0.016) | ND (0.019) | ND (0.022) |

Refer to footnotes at end of table.

## Table 6.4.4-3 (Concluded)
## Summary of SWMU 108 Confirmatory Soil Sampling HE Analytical Results, August 1997
## (Off-Site Laboratory Only)

| Sample Attributes | | | Explosives, Method 8330[a] (µg/kg) | | | | |
|---|---|---|---|---|---|---|---|
| Record Number[b] | ER Sample ID (Figure 6.4.4-1) | Sample Depth (ft) | 1,3-Dinitrobenzene | 2-Nitrotoluene | 3-Nitrotoluene | 4-Nitrotoluene | 1,3,5-Trinitrobenzene |
| 06346 | ER-108-GR-001-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-002-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-003-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-004-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-005-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-006-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-007-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-008-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-009-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-010-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-010-0.0-SSD | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-011-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-012-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-013-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-014-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-015-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-016-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-017-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-018-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-019-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-020-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-020-0.0-SSD | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-021-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-022-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-023-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-024-0.0-SS | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-GR-025-0.0-SSD | 0–0.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-BH-021-1.0-SS | 1.0–1.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-BH-022-1.0-SS | 1.0–1.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-BH-024-1.0-SS | 1.0–1.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| 06346 | ER-108-BH-025-1.0-SS | 1.0–1.5 | ND (4.05) | ND (11.1) | ND (7.83) | ND (10.6) | ND (6.62) |
| Quality Assurance/Quality Control Sample (in µg/L) | | | | | | | |
| 06346 | ER-108-GR-025-0.0-SS (Equipment Blank) | NA | ND (0.02) | ND (0.031) | ND (0.024) | ND (0.034) | ND (0.21) |

[a]EPA November 1986.
[b]Chain of custody record.
BH = Borehole.
EPA = U.S. Environmental Protection Agency.
ER = Environmental Restoration.
ft = Foot (feet).
GR = Grab sample.
HE = High explosives.
HMX = 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclooctane.
ID = Identification.
J ( ) = The reported value is below the reporting limit, shown in parentheses, but equal to or above the effective detection limit.
µg/kg = Microgram(s) per kilogram.
µg/L = Microgram(s) per liter.
NA = Not applicable.
ND ( ) = Not detected at or above the effective detection limit, shown in parenthesis.
RDX = 1,3,5-trinitro-1,3,5-triazacyclohexane.
SS = Surface soil sample.
SSD = Duplicate surface soil sample.
SWMU = Solid waste management unit.
TETRYL = 2,4,6-trinitrophenylmethylnitramine.

## Table 6.4.4-4
## Summary of SWMU 108 Confirmatory Soil Sampling Gamma Spectroscopy Analytical Results, August 1997

| Sample Attributes | | | Gamma Spectroscopy Activity (pCi/g) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Record Number[a] | ER Sample ID (Figure 6.4.4-1) | Sample Depth (ft) | Uranium-238 | Thorium-234 | Thorium-232 | Radium-228 | Thorium-228 | Uranium-235 | Cesium-137 |
| 06347 | ER-108-GR-001-0.0-SS | 0–0.5 | 4.15E+00 | 6.43E+00 | 5.25E–01 | 5.52E–01 | 5.85E–01 | 1.58E–01 | 1.82E–02 |
| 06347 | ER-108-GR-002-0.0-SS | 0–0.5 | ND (3.49E+00) | 9.78E–01 | 7.09E–01 | 6.78E–01 | 8.07E–01 | ND (2.57E–01) | 2.56E–02 |
| 06347 | ER-108-GR-003-0.0-SS | 0–0.5 | 2.30E+00 | 1.98E+00 | 6.25E–01 | 6.83E–01 | 8.00E–01 | ND (2.37E–01) | 3.55E–02 |
| 06347 | ER-108-GR-004-0.0-SS | 0–0.5 | 6.05E+00 | 5.83E+00 | 5.19E–01 | 6.50E–01 | 8.05E–01 | 6.60E–02 | 1.61E–02 |
| 06349 | ER-108-GR-005-0.0-SS | 0–0.5 | 1.27E+00 | 1.89E+00 | 5.02E–01 | 5.75E–01 | 6.16E–01 | ND (2.25E–01) | 2.11E–02 |
| 06347 | ER-108-GR-006-0.0-SS | 0–0.5 | 2.24E+00 | 2.02E+00 | 5.99E–01 | 6.45E–01 | 5.28E–01 | ND (2.50E–01) | 2.44E–02 |
| 06347 | ER-108-GR-007-0.0-SS | 0–0.5 | 6.66E+00 | 6.04E+00 | 5.36E–01 | 6.64E–01 | ND (8.13E–01) | 1.43E–01 | ND (3.61E–02) |
| 06347 | ER-108-GR-008-0.0-SS | 0–0.5 | 4.67E+00 | 6.37E+00 | 5.30E–01 | 4.55E–01 | 4.59E–01 | 1.13E–01 | 1.51E–02 |
| 06347 | ER-108-GR-009-0.0-SS | 0–0.5 | ND (3.17E+00) | 1.27E+00 | 5.52E–01 | 5.75E–01 | 6.80E–01 | 1.57E–01 | 3.12E–02 |
| 06349 | ER-108-GR-010-0.0-SS | 0–0.5 | 2.18E+00 | 2.75E+00 | 6.47E–01 | 7.55E–01 | 5.30E–01 | ND (2.26E–01) | 6.41E–02 |
| 06347 | ER-108-GR-010-0.0-SSD | 0–0.5 | ND (3.47E+00) | 3.44E+00 | 6.00E–01 | 6.39E–01 | 7.24E–01 | ND (2.40E–01) | 7.31E–02 |
| 06347 | ER-108-GR-011-0.0-SS | 0–0.5 | 1.89E+00 | 2.39E+00 | 6.71E–01 | 4.86E–01 | 6.70E–01 | 1.17E–01 | 1.37E–02 |
| 06347 | ER-108-GR-012-0.0-SS | 0–0.5 | ND (3.56E+00) | ND (7.25E–01) | 7.23E–01 | 5.62E–01 | 6.15E–01 | ND (2.51E–01) | ND (3.82E–02) |
| 06347 | ER-108-GR-013-0.0-SS | 0–0.5 | ND (3.35E+00) | ND (7.92E–01) | 5.41E–01 | 5.50E–01 | 4.21E–01 | ND (2.39E–01) | 1.65E–02 |
| 06347 | ER-108-GR-014-0.0-SS | 0–0.5 | ND (3.85E+00) | 9.09E–01 | 6.33E–01 | 5.69E–01 | 6.47E–01 | ND (2.68E–01) | 3.27E–02 |
| 06349 | ER-108-GR-015-0.0-SS | 0–0.5 | ND (1.37E+00) | 1.14E+00 | 5.60E–01 | 6.94E–01 | ND (4.08E–01) | ND (1.89E–01) | 1.80E–01 |
| 06347 | ER-108-GR-016-0.0-SS | 0–0.5 | ND (3.26E+00) | 6.30E–01 | 3.89E–01 | 3.46E–01 | 3.19E–01 | ND (2.30E–01) | 2.04E–02 |
| 06347 | ER-108-GR-017-0.0-SS | 0–0.5 | 2.05E+00 | 2.40E+00 | 5.33E–01 | 6.53E–01 | 5.89E–01 | ND (2.30E–01) | 2.11E–01 |
| 06347 | ER-108-GR-018-0.0-SS | 0–0.5 | ND (3.27E+00) | 9.69E–01 | 6.22E–01 | ND (1.43E–01) | 6.36E–01 | ND (2.37E–01) | 3.55E–02 |
| 06347 | ER-108-GR-019-0.0-SS | 0–0.5 | ND (3.20E+00) | 1.23E+00 | 5.50E–01 | 5.43E–01 | 7.32E–01 | ND (2.26E–01) | 4.44E–02 |
| 06349 | ER-108-GR-020-0.0-SS | 0–0.5 | 2.92E+00 | 3.58E+00 | 5.00E–01 | 5.17E–01 | 5.17E–01 | ND (2.55E–01) | 5.80E–02 |
| 06347 | ER-108-GR-020-0.0-SSD | 0–0.5 | ND (3.69E+00) | 2.71E+00 | 5.76E–01 | 5.15E–01 | 7.69E–01 | ND (2.69E–01) | 6.24E–02 |
| 06347 | ER-108-GR-021-0.0-SS | 0–0.5 | ND (3.15E+00) | 8.34E–01 | 7.55E–01 | 8.74E–01 | 7.37E–01 | ND (2.38E–01) | ND (3.26E–02) |
| 06347 | ER-108-GR-022-0.0-SS | 0–0.5 | ND (2.61E+00) | 5.44E–01 | 5.15E–01 | 5.29E–01 | 5.75E–01 | ND (2.03E–01) | ND (2.87E–02) |
| 06347 | ER-108-GR-023-0.0-SS | 0–0.5 | ND (2.98E+00) | 5.12E–01 | 4.03E–01 | 4.56E–01 | 6.81E–01 | ND (2.20E–01) | 2.42E–02 |
| 06347 | ER-108-GR-024-0.0-SS | 0–0.5 | ND (3.59E+00) | ND (8.70E–01) | 4.93E–01 | 5.84E–01 | 5.02E–01 | ND (2.60E–01) | ND (4.02E–02) |
| 06349 | ER-108-GR-025-0.0-SS | 0–0.5 | ND (2.28E+00) | 8.28E–01 | 6.67E–01 | 5.85E–01 | ND (5.17E–01) | ND (2.35E–01) | 2.91E–02 |
| 06347 | ER-108-GR-025-0.0-SSD | 0–0.5 | ND (3.28E+00) | ND (8.03E–01) | 5.55E–01 | 7.16E–01 | 5.09E–01 | ND (2.45E–01) | 4.19E–02 |
| 06347 | ER-108-BH-021-1.0-SS | 1.0–1.5 | ND (4.02E+00) | ND (9.63E–01) | 6.48E–01 | 5.33E–01 | 7.06E–01 | ND (3.03E–01) | ND (4.22E–02) |
| 06347 | ER-108-BH-022-1.0-SS | 1.0–1.5 | ND (3.36E+00) | 1.18E+00 | 6.42E–01 | 5.36E–01 | 5.64E–01 | ND (2.47E–01) | ND (3.31E–02) |
| 06347 | ER-108-BH-024-1.0-SS | 1.0–1.5 | ND (3.17E+00) | 6.77E–01 | 6.02E–01 | 5.68E–01 | 5.35E–01 | ND (2.45E–01) | 1.33E–02 |
| 06349 | ER-108-BH-025-1.0-SS | 1.0–1.5 | ND (1.79E+00) | ND (7.11E–01) | 5.84E–01 | 5.88E–01 | 7.67E–01 | ND (2.33E–01) | 8.04E–02 |

Refer to footnotes at end of table.

## Table 6.4.4-4 (Concluded)
## Summary of SWMU 108 Confirmatory Soil Sampling Gamma Spectroscopy Analytical Results, August 1997

| Sample Attributes | | | Gamma Spectroscopy Activity (pCi/g) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Record Number[a] | ER Sample ID (Figure 6.4.4-1) | Sample Depth (ft) | Uranium-238 | Thorium-234 | Thorium-232 | Radium-228 | Thorium-228 | Uranium-235 | Cesium-137 |
| Quality Assurance/Quality Control Sample (in pCi/mL) | | | | | | | | | |
| 06347 | ER-108-GR-025-0.0-SS (Equipment Blank) | NA | ND (1.86E+00) | ND (4.35E-01) | ND (1.66E-01) | ND (1.48E-01) | ND (5.33E-01) | ND (1.66E-01) | ND (2.38E-02) |
| SNL/NM SWTA *Surface Soil* Background UTL or 95th Percentile Concentrations[b] | | | 1.4 | 1.4 | 1.01 | 1.01 | 1.01[c] | 0.16 | 0.664 |
| SNL/NM SWTA Subsurface Soil Background UTL or 95th Percentile Concentrations[b] | | | 1.4 | 1.4 | 1.01 | 0.93 | 0.93[c] | 0.16 | 0.079 |

[a]Chain of custody record.
[b]Dinwiddie September 24, 1997.
[c]Brown January 14, 1998.

BH = Borehole.
ER = Environmental Restoration.
ft = Foot (feet).
GR = Grab sample.
ID = Identification.
NA = Not applicable.
ND ( ) = Not detected at or above the minimum detectable activity, shown in parenthesis.
pCi/g = Picocurie(s) per gram.
pCi/mL = Picocurie(s) per milliliter.
SS = Surface soil sample.
SSD = Duplicate surface soil sample.
SNL/NM = Sandia National Laboratories/New Mexico.
SWTA = Southwest Test Area.
UTL = Upper tolerance limit.

HE

All explosives were below detectable limits in both surface and subsurface soils except for four samples from locations ER-108-GR-002-0.0-SS, ER-108-GR-003-0.0-SS, ER-108-GR-004-0.0-SS, and ER-108-GR-005-0.0-SS, which yielded 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclooctane (HMX) concentration levels ranging from 71.7 micrograms (µg)/kg to 4,230 µg/kg.

The chemical constituents for metals and HE have been evaluated for human health and ecological risk, as discussed in Section 6.6.3.

Radionuclides

Surface and subsurface soil radiological data for SWMU 108 have been compared to the SNL/NM and NMED agreed-upon background levels for the Southwest Test Area for the primary radiological constituents, uranium-238, thorium-234, thorium-232, radium-228, uranium-235, and cesium-137. This includes the 16 post-VCM verification sampling results collected from July to October 1995 (Table 6.4.4-1) and the 32 confirmatory results collected in August 1997 (Table 6.4.4-4). Although the minimum detectable activity for gamma-emitting radionuclides was sometimes higher than the background level for that radionuclide, they were nevertheless orders of magnitude less than a risk-based preliminary remediation goal, which is based upon a 15—millirem-per-year (mrem/yr) effective dose equivalent maximum dose limit found in EPA's OSWER Directive No. 9200.4-18, "Establishment of Cleanup Levels for CERCLA Sites with Radioactive3 Contamination" (EPA 1997). Therefore the analytical results are acceptable. All confirmatory radiological data for gamma activity are presented in Annex 6-B. For evaluation purposes, these constituents are representative of DU contamination or its daughter. Additionally, cesium-137 is reported because it has been detected at some SWMUs. The justification for evaluating these constituents is discussed in Brown (January 14, 1998). Of these constituents, thorium-232, cesium-137, and radium-228 were not detected at above-background levels for surface or subsurface soils, although cesium-137 was detected slightly above background in one subsurface soil sample. Nineteen surface samples yielded above-background uranium-238 (maximum 5.4E+01 picocuries per gram [pCi/g]), but no subsurface samples yielded elevated uranium-238. Nineteen surface samples and one subsurface sample yielded elevated thorium-234 (at maximum 6.44E+01 pCi/g and maximum 1.18E+00 pCi/g, respectively). Uranium-235 was present above background levels in three surface samples, with maximum gamma activity of 8.93E–01 pCi/g. The elevated gamma activities for radiological constituents have been evaluated for human health and ecological risk, discussed in Section 6.6.3.

QA/QC Results

Three soil duplicates and an equipment blank were analyzed for metals and HE (Tables 6.4.4-2, and 6.4.4-3). No HE compounds were detected in either the duplicates or the field blanks. Barium (0.000417 *J* mg/liter [L]), chromium (0.00326 *J* mg/L), and lead (0.00105 *JB* mg/L) were detected below the reporting limit in the equipment blanks. None of these metal concentration levels indicated potential problems with the soil data.

Level III data validation was performed on all chemical data reported for confirmation analyses. Some of the soil sample results were influenced by matrix interference for cadmium, lead, selenium, and silver. However, data were determined to be acceptable and within quality control limits.

## 6.5 Site Conceptual Model

### 6.5.1 Nature and Extent of Contamination

Corium thermite, the reaction product of the FCI tests at SWMU 108, is a metal alloy of depleted uranium and chromium-bearing stainless steel. The metals, chromium and nickel and organics, HE, possibly from earlier firing tests, are the only hazardous constituents along with depleted uranium and its daughter products that were known to have been used at Building 9940.

HMX is confined to approximately a 900-square-foot area in the northeastern quadrant of the SWMU. HMX was detected in four samples (ER-108-GR-002-0.0-SS, ER-108-GR-003-0.0-SS, ER-108-GR-004-0.0-SS, and ER-108-GR-005-0.0-SS). All other explosives were less than detection limits.

Elevated gamma activities occur across the site. Activities exceeding background were detected in the surface soils for uranium-238, thorium-234, and uranium-235. Radiological contamination areas were identified by the RUST Geotech Inc. radiation survey in conjunction with the post-VCM and SNL/ER confirmation sampling (Figure 6.4.4-1). These areas are confined to a 0.4-acre area within a 2.2-acre survey area identified by the Rad Survey Boundary line in Figure 6.4.3-1.

One sample slightly exceeded background for cesium-137 for subsurface soil (Table 6.5.1-1). This sample was collected in the ditch on the southern side and downhill of the test area (Figure 6.4.4-1). Additionally, this was the only constituent collected from the ditch, both chemical and radiological, that was above background level. The fact that no contaminants were detected in the ditch downhill from the site indicates that contamination has not been transported off site by surface runoff. Because radiological contamination is confined to the 0.4-acre area defined by the RUST Geotech Inc. radiation survey and does not appear to have migrated off site, the lateral extent of contamination has been defined.

Because of the nature of the tests and the manner in which the contaminants were distributed, metals contamination would be co-located with radiological contamination at SWMU 108. The suspected metal COCs (chromium and nickel) were not present above background in the soils associated with the radiological anomalies.

The elevated metals (barium, cadmium, lead, and silver) appear to occur sporadically in the surface soils across the site. Elevated barium concentrations occur at four locations, and elevated lead concentrations occur at three locations (see Table 6.5.1-1 and Figure 6.4.4-1). While these metals concentrations are elevated above approved background levels in the soils, there is no evidence they were used at Building 9940. This variance is the result of natural variations of soil metal concentrations, which should be expected in natural soil environments.

All releases of COCs and surface discharges at SWMU 108 would have been to the surface soils. Because of the relative low solubility of the radionuclides and organic compounds occurring at SWMU 108, limited precipitation, and high evapotranspiration, the vertical rate of contamination is expected to be low. The vertical extent of contamination would, therefore, be expected to be insignificant. Based upon the premise that radiological contamination and HE contamination are confined to the areas identified by the RUST Geotech Inc. survey and

Table 6.5.1-1
Summary of COCs for SWMU 108

| SWMU | Number of Samples | COCs Greater than Background | Maximum Background Limit/SWTA[a] (mg/kg except where noted) | Maximum Concentration (mg/kg except where noted) | Average Concentration[b] (mg/kg except where noted) | Sampling Locations Where Background Concentration Limit Exceeded |
|---|---|---|---|---|---|---|
| 108 | 32 | Barium | 130 surface<br>214 subsurface | 384 | 106.8 | GR-006-0.0-SS<br>GR-013-0.0-SS<br>GR-019-0.0-SS<br>BH-021-1.0-SS |
| | | Cadmium | <1 surface<br>0.9 subsurface | 1.63 | 0.363 | GR-017-0.0-SS[c] |
| | | Lead | 21.4 surface<br>11.8 subsurface | 362 | 19.4 | GR-008-0.0-SS<br>GR-017-0.0-SS<br>GR-020-0.0-SS |
| | | Silver | <1 surface<br><1 subsurface | 5.56 | 0.279 | GR-012-0.0-SS[c] |
| | 32 | HMX | NA[e] | 4230 µg/kg | 157.6<br>(.132) µg/kg | GR-002-0.0-SS<br>GR-003-0.0-SS<br>GR-004-0.0-SS<br>GR-005-0.0-SS |
| | 48[d] | U-235 | 0.16 pCi/g surface<br>0.16 pCi/g subsurface | 0.843 pCi/g | Not Calculated[b] | For activities greater than MDAs—none exceeded. For activities less than MDAs—All MDAs were greater than background. |
| | | Cs-137 | 0.664 pCi/g surface<br>0.079 pCi/g subsurface | 0.084 pCi/g subsurface (maximum concentration for surface soil is 0.43 pCi/g is less than background) | Not Calculated | BH-025-1.0-SS |
| | | U-238 | 1.4 pCi/g surface<br>1.4 pCi/g subsurface | 54.0 pCi/g | Not Calculated | 108E-001A-SS<br>108E-002C-SS<br>108E-002E-SS<br>108E-002F-SS<br>108E-003A-SS<br>108E-004A-SS<br>108E-011A-SS<br>GR-001-0.0-SS<br>GR-003-0.0-SS<br>GR-004-0.0-SS<br>GR-006-0.0-SS<br>GR-007-0.0-SS<br>GR-008-0.0-SS<br>GR-010-0.0-SS<br>GR-011-0.0-SS<br>GR-017-0.0-SS<br>GR-020-0.0-SS<br><br>All MDAs except GR-015-0.0-SS were greater than background. |

Refer to footnotes at end of table.

## Table 6.5.1-1 (Concluded)
## Summary of COCs for SWMU 108

| SWMU | Number of Samples | COCs Greater than Background | Maximum Background Limit/SWTA[a] (mg/kg except where noted) | Maximum Concentration (mg/kg except where noted) | Average Concentration[b] (mg/kg except where noted) | Sampling Locations Where Background Concentration Limit Exceeded |
|---|---|---|---|---|---|---|
| 108 | 48 | Th-234 | 1.4 pCi/g surface<br>1.4 pCi/g subsurface | 64.4 pCi/g | Not Calculated | 108E-002C-SS<br>108E-002E-SS<br>108E-002F-SS<br>108E-003A-SS<br>108E-004A-SS<br>108E-005A-SS<br>108E-006A-SS<br>108E-011A-SS<br>GR-001-0.0-SS<br>GR-003-0.0-SS<br>GR-004-0.0-SS<br>GR-005-0.0-SS<br>GR-006-0.0-SS<br>GR-007-0.0-SS<br>GR-008-0.0-SS<br>GR-010-0.0-SS<br>GR-011-0.0-SS<br>GR-017-0.0-SS<br>GR-020-0.0-SS<br>BH-022-1.0-SS |

[a]No background for explosives since they are not naturally occurring.

[b]An average minimum detectable activity is not calculated due to the variability of the counting error—and the number of reported nondetectable activities. These nondetectable activities are solely a function of instrument counting duration and not an indication of presence or absence of a specific radionuclide in the environment.

[c]Background levels for these constituents are not quantified.

[d]Includes postverification VCM verification soil sampling, July to October 1995 (see Table 6.4.4-1) and confirmation samples collected in August 1997 (see Table 6.4.4-4).

the SNL/ER confirmation sampling, the extent of contamination at SWMU 108 has been delineated.

### 6.5.2 Environmental Fate

The primary sources of COCs at SWMU 108 were primarily DU and metals from surface spills associated with the FCI tests. The explosives residues may have been generated from firing tests. Specific COCs detected above background include uranium-238, thorium-234, uranium-235, and cesium-137. Specific metals detected above background include barium, cadmium, lead, and silver. HMX was the only explosive constituent detected at SWMU 108.

Figure 6.5.2-1 diagrams the environmental fate for the constituents at SWMU 108. The current and future land use for SWMU 108 is industrial (DOE and USAF March 1996). The potential human receptor is the industrial worker. The primary pathways of the COCs to the industrial worker would be through dust emissions and direct exposure. Indirect pathways to the industrial worker are from surface runoff of total suspended solids and dissolved solids or by entry of the contaminants into the food chain by biota uptake.

The contaminant pathways are surficial—primarily surface dust emissions, direct exposure, and potential uptake by biota and ingestion by animals. Samples collected from the drainage ditch downhill from the SWMU indicate there is no significant mobilization of the COCs by runoff.

Several factors preclude a groundwater pathway as a potential exposure route. The infiltration rates have been determined to be on the order of 0.002 to 0.071 cm/yr, and seepage rates from 0.03 to 11.8 cm/yr (see Section 6.2.1). Depth to groundwater has been estimated to be at depths ranging from 155 to 347 feet bgs. High partitioning coefficients and low mobility of these ions in the transporting medium would even further dilute the low concentrations of these constituents. For these reasons, groundwater was not evaluated as a contaminant migration pathway. Additional discussion of the exposure routes and receptors at SWMU 108 is provided in Annex 6-C.

## 6.6 Site Assessments

### 6.6.1 Summary

The site assessment concludes that SWMU 108 has no significant potential to affect human health under an industrial land-use scenario. After consideration of the uncertainties associated with the available data and modeling assumptions, ecological risks associated with SWMU 108 were found to be insignificant. Brief descriptions of the site assessments are provided below and detailed in Annex 6-C.

### 6.6.2 Risk Screening Assessments

SWMU 108 had minor impacts consisting of some radioactive material, metals, and HE. Because of the location of the site on KAFB, the designated industrial land-use scenario, and

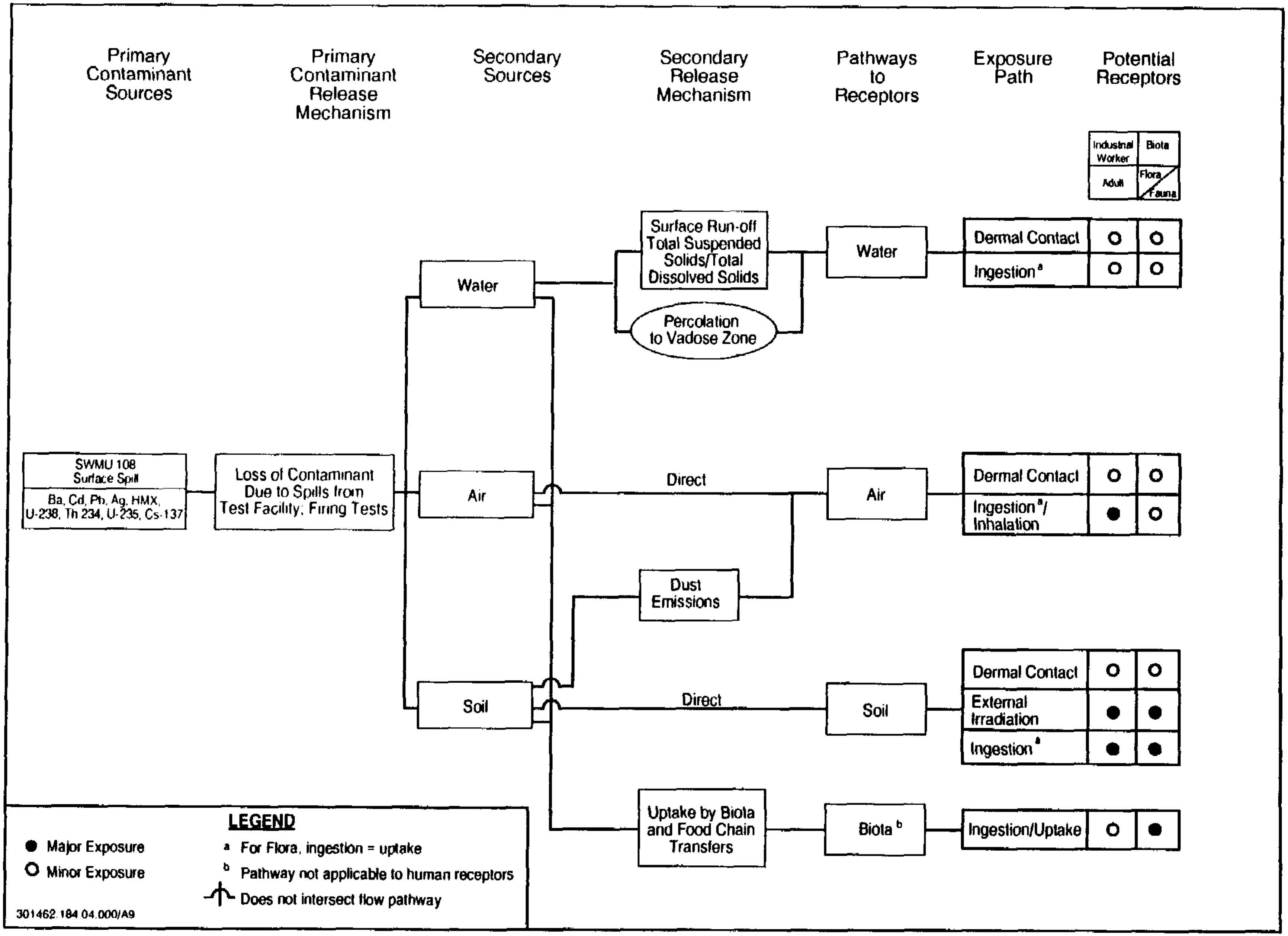


**Figure 6.5.2-1**

**Conceptual Model Flow Diagram for SWMU 108, Firing Site (Building 9440)**

the nature of contamination, the potential exposure pathways identified for this site included soil ingestion and dust inhalation for chemical constituents as well as dust inhalation and direct exposure for radionuclides. Plant uptake was included as an exposure pathway for the residential land-use scenario. This site is designated for industrial land use for human health evaluation (DOE and USAF March 1996); the residential land-use scenario is provided for perspective only. The results are summarized below, and the detailed assessment parameters and assumptions are presented in Annex 6-C.

### 6.6.2.1 *Human Health*

SWMU 108 has been recommended for industrial land use (DOE and USAF March 1996). A complete discussion of the risk assessment process, results, and uncertainties is provided in Annex 6-B. Due to the presence of several metals in concentration levels greater than background levels, the presence of organics (HMX), and the presence of radiological material at activities greater than background, it was necessary to perform a human health risk assessment analysis for the site. In addition to metals, any volatile or semivolatile organic compounds detected above their reporting limits and any radionuclide compounds either detected above background levels and/or minimum detectable activities were included in this assessment. The risk assessment process provides a quantitative evaluation of the potential adverse human health effects caused by constituents in the site's soil. The risk assessment report calculated the Hazard Index and excess cancer risk for both an industrial and residential land-use setting. The excess cancer risk from nonradioactive COCs and the radioactive COCs is not additive (EPA 1989).

In summary, the Hazard Index calculated for SWMU 108 nonradiological COCs is 0.01 for an industrial land-use setting, which is less than the numerical standard of 1.0 suggested by risk assessment guidance (EPA 1989). Incremental risk is determined by subtracting risk associated with background from potential nonradiological COC risk. The incremental Hazard Index is 0.01. The excess cancer risk for SWMU 108 nonradiological COCs is $5 \times 10^{-10}$ for an industrial land-use setting. Guidance from the NMED indicates that excess lifetime risk of developing cancer by an individual must be less than $10^{-6}$ for Class A and B carcinogens and less than $10^{-5}$ for Class C carcinogens (NMED March 1998). The excess cancer risk is driven by cadmium, which is a Class B1 carcinogen. Thus, the excess cancer risk for this site is below the suggested acceptable risk value ($10^{-6}$). The incremental excess cancer risk for SWMU 108 is $5 \times 10^{-10}$. The incremental total effective dose equivalent for radionuclides for an industrial land-use setting is 1.5 millirems (mrem)/year (yr), which is well below the standard dose limit of 15 mrem/yr (EPA 1997). The incremental excess cancer risk for radionuclides is $1.7 \times 10^{-5}$ for industrial land-use scenario, which is much less than risk values calculated due to naturally occurring radiation and from intakes considered background concentration values.

The residential land-use scenarios for this site are provided only for comparison in the risk assessment report (Annex 6-C). The report concludes that SWMU 108 does not have significant potential to affect human health under an industrial land-use scenario.

### 6.6.2.2 *Ecological*

As set forth by the NMED Risk-Based Decision Tree (NMED March 1998), an ecological screening assessment that corresponds with the screening procedures in the EPA's Ecological

Risk Assessment Guidance for Superfund (EPA 1997) was performed. An early step in the evaluation is comparison of COC concentrations and identification of potentially bioaccumulative constituents. This is presented in Annex 6-C. This methodology also requires the development of a site conceptual model and food web model, and selection of ecological receptors. Each of these items is presented in the "Predictive Ecological Risk Assessment Methodology for SNL/NM ER Program, Sandia National Laboratories/New Mexico" (IT June 1998) and will not be duplicated here. The screen also includes the estimation of exposure and ecological risk.

The results of the ecological risk assessment screen are presented in Tables 14, 15, 16, and 17 of Annex 6-C. Site-specific information was incorporated into the screening assessment when such data were available. Hazard quotients greater than unity were originally predicted; however, closer examination of the exposure assumptions revealed an overestimation of risk primarily attributed to exposure concentration (maximum COC concentration was used in the estimation of risk), exposure setting (area use factors of one were assumed), background risk, quality of analytical data, and the use of detection limits as exposure concentrations. Based upon an evaluation of these uncertainties, ecological risks associated with this site are expected to be low.

### 6.6.3 Baseline Risk Assessments

#### *6.6.3.1 Human Health*

Based upon the screening assessment summarized in Section 6.6.2.1, a baseline human health risk assessment is not required for SWMU 108.

#### *6.6.3.2 Ecological*

Based upon the screening assessment summarized in Section 6.6.2.2, a baseline ecological risk assessment is not required for SWMU 108.

### 6.6.4 Other Applicable Assessments

No other applicable assessments have been performed at SWMU 108.

## 6.7 No Further Action Proposal

### 6.7.1 Rationale

Based upon historical and process knowledge, field investigation data, and human health and ecological risk assessments, an NFA decision is recommended for SWMU 108 for the following reasons:

- All radiological anomalies detected at SWMU 108 are confirmed remediated following the VCM removal activities.

- No nonradiological or radiological COCs were present in soil at concentrations or activity levels considered hazardous to human health for an industrial land-use scenario.

- Risk assessment for ecological receptors indicates that the ecological risks associated with SWMU 108 are insignificant.

### 6.7.2 Criterion

Based upon the evidence provided above, SWMU 108 is proposed for an NFA decision in conformance with Criterion 5 (NMED March 1998), which states that the SWMU has been fully characterized and remediated in accordance with current and applicable state or federal regulations and that available data indicate that contaminants pose an acceptable level of risk under current and projected future land use.

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**ANNEX 6-A**
**Final Report, Survey and Removal of Radioactive Surface Contamination at Environmental Restoration Sites Sandia National Laboratories/New Mexico Volume 1 (SNL/NM September 1997, pp. 5-149 through 5-158)**

### 5.8.6. Building 9940 - Firing Site (ER Site 108)

#### Overview

The Phase I survey at ER Site 108 was conducted during October 1993 and covered a total of 2.2 acres of flat alluvial terrain encompassing Building 9940. A gamma scan survey was performed at 6-foot centers (100 percent coverage) over the surface of the site. Four point sources and eleven area sources of gamma activity 30 percent or greater than the natural background were identified during this survey. A detailed summary of the surface radiological survey and anomalies found at the site is presented in Section 5.8.7 of the Surface Gamma Radiation Surveys Final Report (Geotech 1994b).

Figure 5.8.12 shows the site, surface radiological survey boundaries, and anomalies found during the Phase I survey.

In July 1995, pre-cleanup soil sampling for gamma spectroscopy analysis was conducted on 10 area sources to assess the need for remediation. VCM activities were conducted during September to October 1995 and required a total of 18.5 days. Point sources and small area sources were removed in September 1995. Large area sources were remediated in October 1995. Cleanup activities included radiation scanning to verify anomaly location, removal of fragment

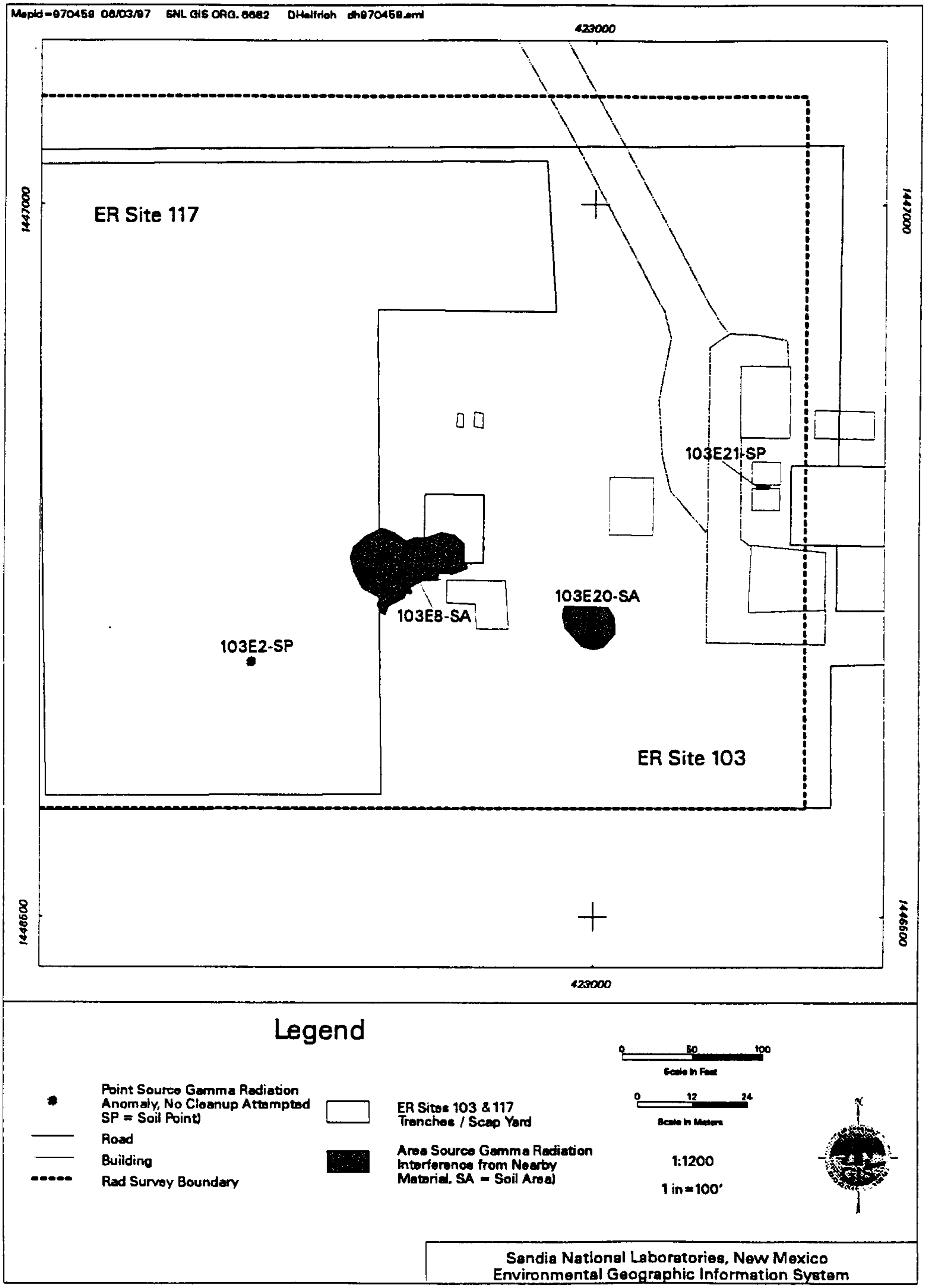


**Figure 5.8.11 Radiation Anomalies Remaining After Completion of the VCM at ER Sites 103 & 117**

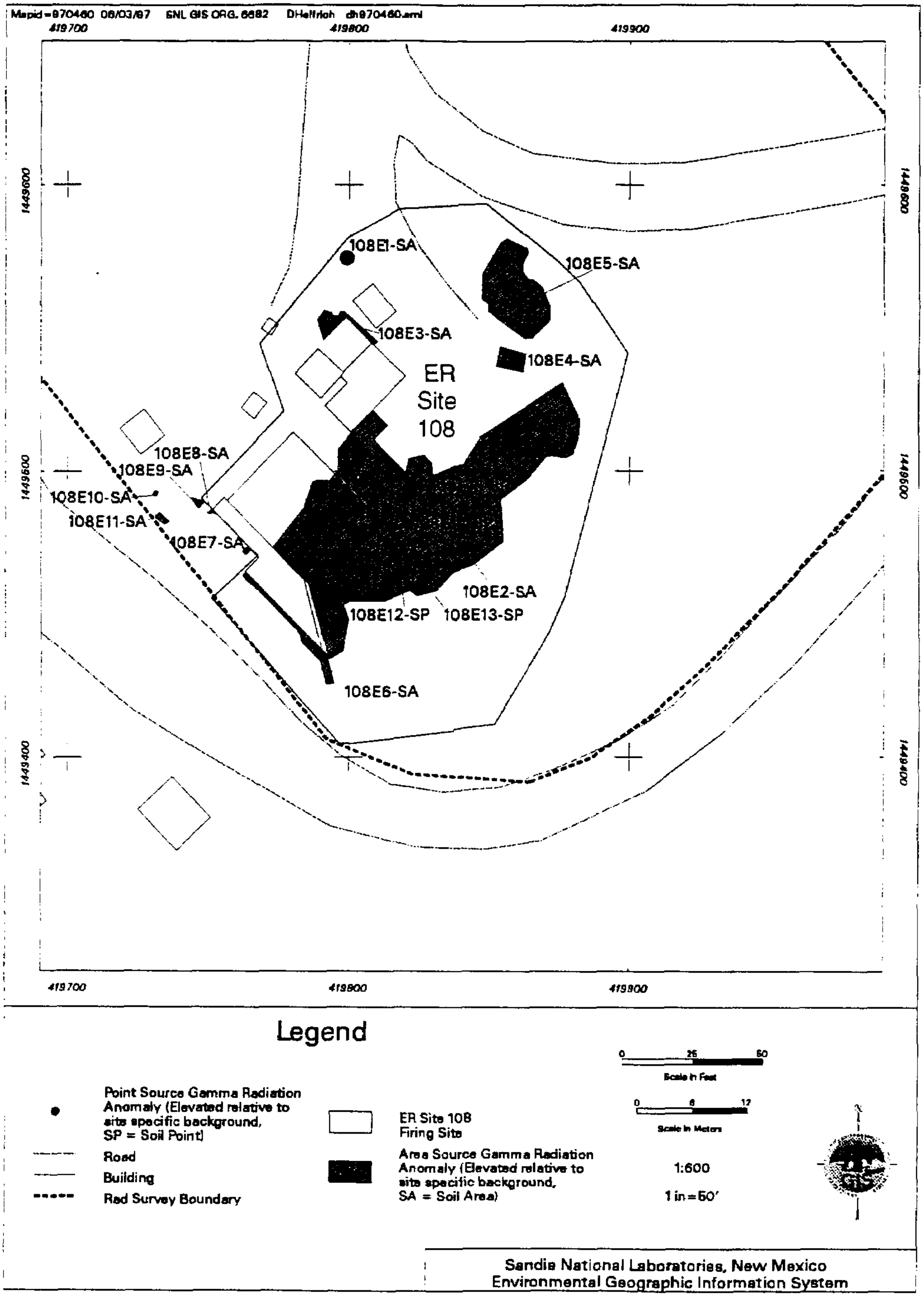


**Figure 5.8.12 Phase I Survey Radiation Anomalies at ER Site 108**

and/or soil until readings were less than 1.3 times site-specific background levels, and post-cleanup (verification) soil sampling for gamma spectroscopy analysis (see Section 3.1). Table 5.8.32 summarizes field activities during the VCM.

**Table 5.8.32 Summary of Field Activities at ER Site 108**

| | | Removal Action Procedures | | | | |
|---|---|---|---|---|---|---|
| Actual Acreage Surveyed | Duration of Cleanup (days) | Verify Anomaly Location | Rad Removal[a] | Post-Cleanup Sampling | Pre-Cleanup Sampling (area sources) | Comments |
| 2.20 | 18.50 | X | X | X | X | Pre-cleanup sampling of original area sources adjacent to concrete and asphalt areas |

[a] Removal of fragment and/or soil until readings are less than 1.3 times site-specific background

## Findings and Observations

### Point and Area Source Status

Before cleanup was initiated on the sources identified during the Phase I survey, pre-cleanup soil sampling for gamma spectroscopy analysis was performed on ten area sources to assess if remediation is required. Due to the close proximity and similar appearance of two area sources (108E10 and 108E11), only one area source (108E10) was sampled.

For six small area sources (108E1, 108E2, 108E3, 108E4, 108E5, and 108E10), results of the gamma spectroscopy analysis from pre-cleanup samples indicated the elevated radiation was related to anthropogenic (man-made) material. During the initial cleanup, remediation was completed on four of these area sources and the four point sources identified during the Phase I survey. Remediation of two of these area sources (108E4 and 108E5) showed them to be linked to one large area source. Cleanup was not completed on one area source (108E2) and will require additional remediation because radioactive contaminated soil extended under the concrete pad and exceeded the capabilities of manual cleanup procedures. The remediation of two area sources (108E10 and 108E11) was completed during subsequent cleanup activities.

The gamma spectroscopy results from pre-cleanup samples on four area sources (108E6, 108E7, 108E8, and 108E9) showed the elevated radiation was related to "shine" (gamma interference) from adjacent buildings, and no remediation is required. No additional point or area sources were identified during this VCM. Table 5.8.33 shows the pre-cleanup samples collected from these sources, and Figure 5.8.13 shows VCM verification sampling locations (pre-cleanup and post-cleanup).

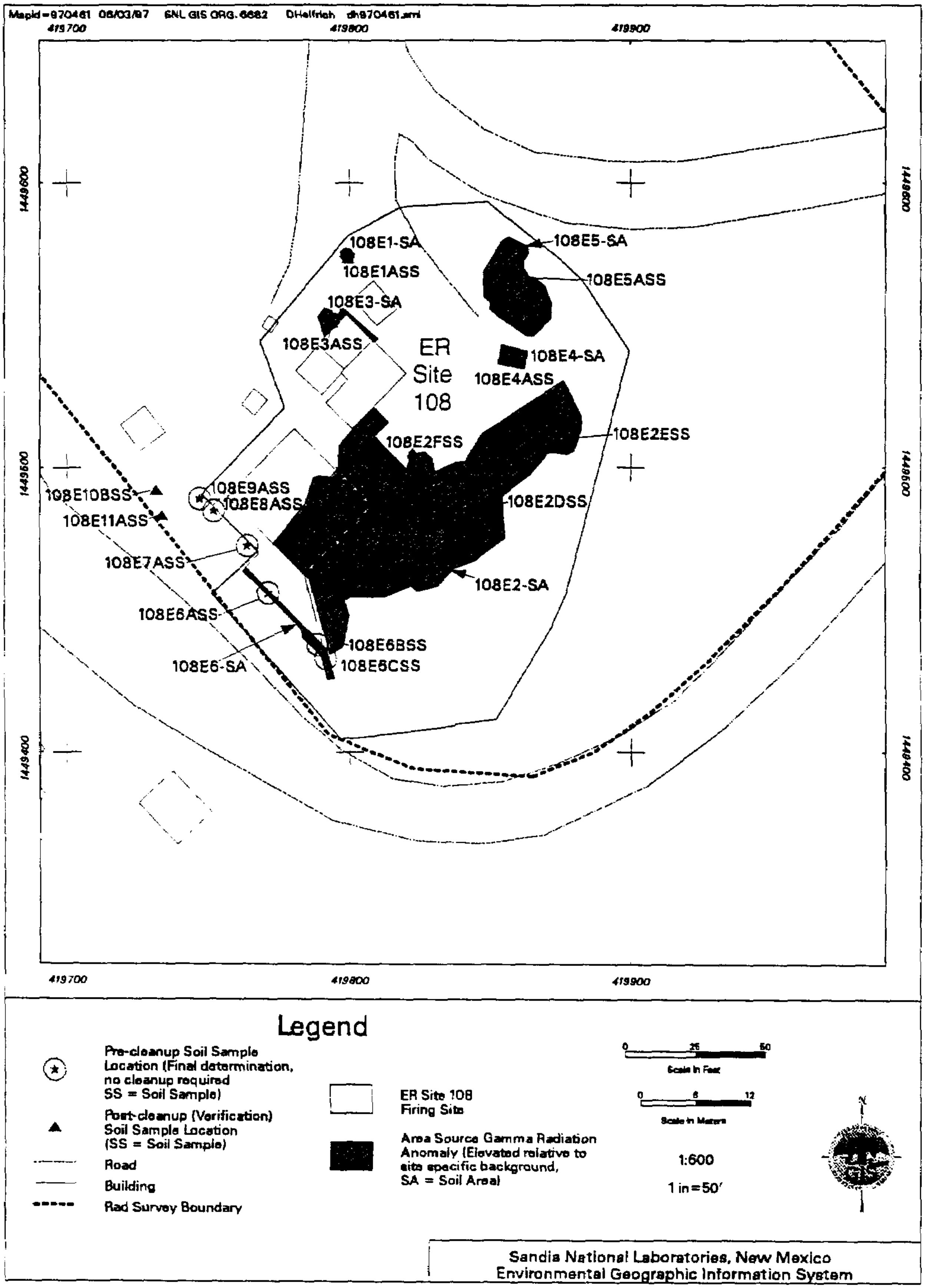


**Figure 5.8.13 VCM Surface Soil Sampling Locations at Site 108**

Table 5.8.33 Pre-Cleanup (Final Determination) Samples Collected at ER Site 108

| Area Source Sample Number | | |
|---|---|---|
| 108E6ASS | 108E6BSS | 108E6CSS |
| 108E7ASS | 108E8ASS | 108E9ASS |

### Post-Cleanup (Verification) Sample Results

After the removal of radiologically contaminated soils, ten post-cleanup (verification) samples were collected from areas exhibiting the highest residual gamma radiation readings. Gamma spectroscopy analysis was performed on the samples to verify that the residual radionuclide concentrations met risk-based action levels. The radiological COC was DU (U-238, U-235, and U-234). Table 5.8.34 summarizes the post-cleanup (verification) samples collected at the site, and the maximum level of residual radiological COC in soils is presented in Table 5.8.35.

Table 5.8.34 Post-Cleanup (Verification) Samples Collected at ER Site 108

| Area Source Sample Number | | |
|---|---|---|
| 108E1ASS | 108E2CSS | 108E2DSS |
| 108E2ESS | 108E2FSS | 108E3ASS |
| 108E4ASS | 108E5ASS | 108E10BSS |
| 108E11ASS | | |

Table 5.8.35 Maximum Residual Radionuclide Levels in ER Site 108 Soils

| Radionuclide | Maximum Activity (pCi/g) | Background Activity (pCi/g) |
|---|---|---|
| U-238 | 54.0 | 1.4 |
| U-235 | 0.84 | 0.16 |
| U-234 | 6.75 | 1.6 |

### Risk Assessment Results

A risk assessment, using the DOE computer code RESRAD, was performed on ER Site 108 assuming both an industrial and a residential (loss of active control measures) land-use scenario, consistent with Section 3.3.2. The RESRAD input parameters that were not site specific are provided for both land-use scenarios in Section 3.3.2. Site-specific input parameters were developed based on information provided by the Task Leader responsible for the site and were as follows:

- Area of Contaminated Zone: 1,600 $m^2$
- Thickness of contaminated zone: 0.15 m
- Length Parallel to Aquifer Flow: 60 m
- Density of Contaminated Zone: 1.85 $g/cm^3$
- Contaminated Zone Total Porosity: 0.4
- Contaminated Zone Effective Porosity: 0.35
- Contaminated Zone Hydraulic Conductivity: 3,650 m/yr
- Contaminated Zone b Parameter: 4.9 (Silty Sand)
- Runoff Coefficient: 0.4

Site-specific risk assessment resulted in the following TEDEs to the RME individual:

- Industrial Land-Use: 2.1 mrem/yr
- Residential Land-Use: 5.8 mrem/yr

The calculated TEDEs for both scenarios are well below the proposed EPA guidance discussed in Section 2.2.2 of 15 mrem/yr maximum TEDE for industrial land-use and 75 mrem/yr for residential land-use. The average radiation exposure due to natural sources (radon, internal radiation, cosmic radiation, and terrestrial radiation) in the U.S. is approximately 295 mrem/yr TEDE (NCRP 1987). Given the above, the potential effects on human health due to exposure to radionuclides at the site are well within proposed standards when considering both an industrial land-use scenario and a residential land-use scenario.

The uncertainties associated with this assessment are considered small because of the location and history of the site. There is low uncertainty in the future land-use and the potentially affected populations considered in making the risk assessment analysis. An RME approach was used to calculate the risk assessment values. As a result, the parameter values used in the calculations were conservative, and the calculated intakes are likely overestimates. Maximum measured concentrations of the COCs were used to provide conservative results. Because the COCs were found in the surface soils and because of the location and physical characteristics of the site, there is little uncertainty in the exposure pathways relevant to the analysis.

### Waste Management

The cleanup activities produced soil and PPE wastes. No metal fragment waste was generated. All waste was containerized in 55-gallon drums. A total of 273 waste drums were generated during cleanup activities: 272 soil drums and 1 PPE drum. The number of waste drums produced at the site is shown in Table 5.8.36.

Five composite soil samples were collected from the waste drums and analyzed for gamma emitters using standard laboratory gamma spectroscopy methods and for leachable RCRA metals using TCLP analytical procedures. Mercury was not identified as a COC and was not included in

**Table 5.5.36 Summary of Waste Drums for ER Site 108**

| Soil Waste | | Metal Fragment Waste | | PPE Waste | | | |
|---|---|---|---|---|---|---|---|
| 30 Gallon Drums | 55 Gallon Drums | 30 Gallon Drums | 55 Gallon Drums | 30 Gallon Drums | 55 Gallon Drums | TCLP/ Gamma Spec Samples | Comments |
| 0 | 272 | 0 | 0 | 0 | 1 | 6 Soil | |

the TCLP analysis. All samples passed the TCLP tests, and all waste was characterized as "Radioactive-Low Level Only." A summary of radiological activity for the waste is presented in Appendix G.

Disposal of regulated VCM waste was handled by SNL/NM Department 7577 (Waste Operations), which packaged and secured waste drums for transfer to Envirocare of Utah. Nonregulated waste was disposed of using standard SNL/NM-approved waste disposal methods.

## Conclusions

All point and area sources of gamma activity 30 percent or greater than the natural background were removed from the site with the exceptions of five area sources. Four area sources were related to "shine" (gamma interference) from adjacent buildings, and one area source exceeded the capabilities of manual cleanup procedures (beneath concrete pad). A radiological risk assessment was performed assuming both an industrial and a residential (loss of active control measures) land-use scenario, and using site-specific input parameters. The risk assessment shows the potential effects on human health due to exposure to radionuclides at the site are within proposed standards when considering both land-use scenarios.

Source removal is summarized in Table 5.8.37, and sources remaining after completion of the VCM are shown in Figure 5.8.14.

**Table 5.8.37 Summary of Point and Area Source Removal at ER Site 108**

| Anomaly Type | Total Identified | Total Removed | Comments |
|---|---|---|---|
| Point Sources | 4 | 4 | Cleanup complete and no further action is required. |
| Area Sources | 11 | 6 | One source extends beneath concrete pad. Four sources are related to "shine " (gamma interference) from adjacent buildings. |

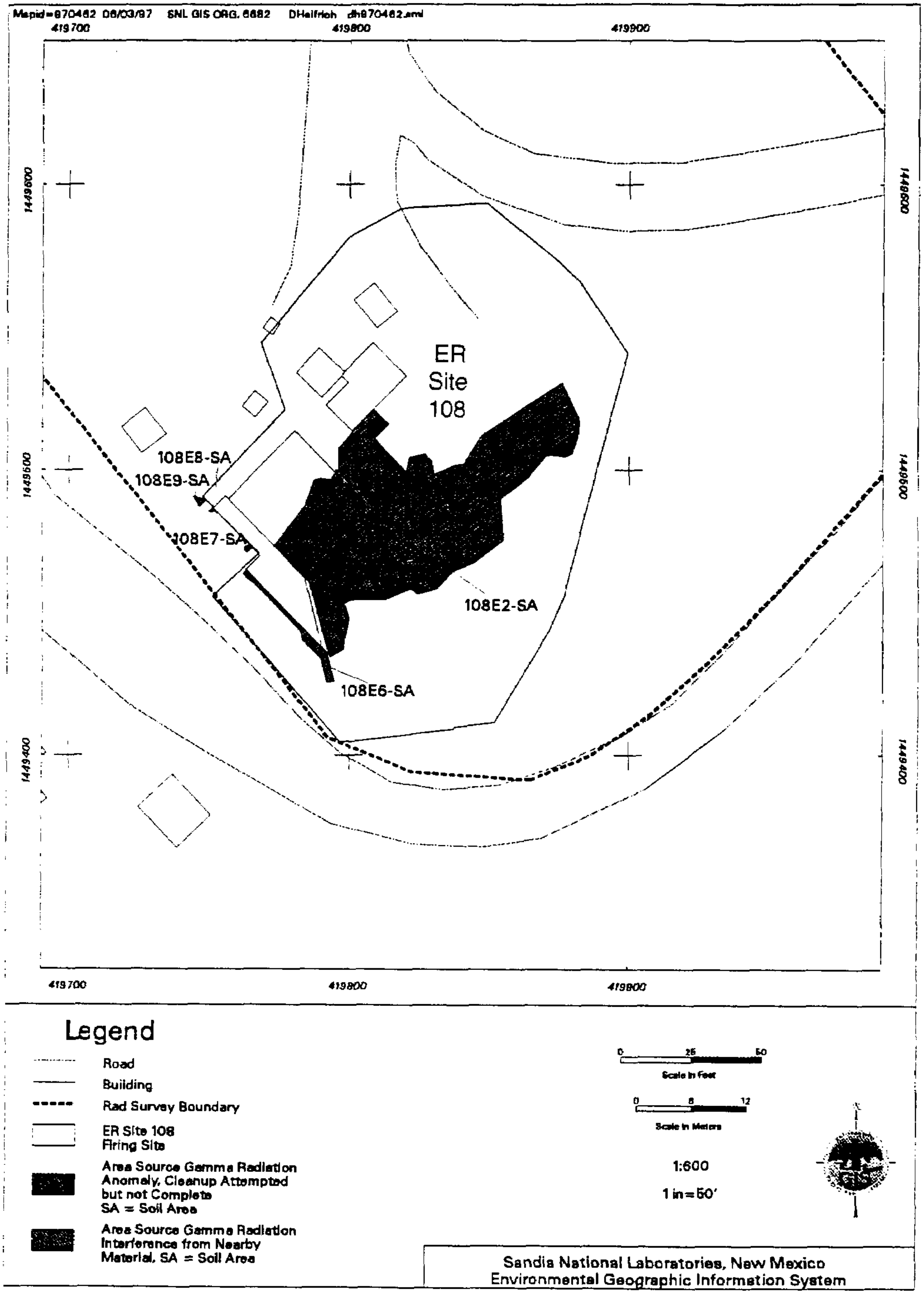


**Figure 5.8.14 Radiation Anomalies Remaining After Completion of the VCM at ER Site 108**

No additional cleanup activities were performed during this VCM. The status of other possible COCs is not addressed in this report.

All waste was characterized as "Radioactive-Low Level Only" and managed in accordance with SNL/NM Department 7572 (Waste Management) procedures.

# ANNEX 6-C
# SWMU 108 Risk Screening Assessment Report

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# SWMU 108: RISK SCREENING ASSESSMENT

## I. Site Description and History

Sandia National Laboratories/New Mexico (SNL/NM) Solid Waste Management Unit (SWMU) 108, the Firing Site (Building 9940), is located approximately 1.1 miles north of Magazine Road and 0.8 mile east of Technical Area (TA) III. The total size of the site is approximately 0.4 acre. This site is on Kirtland Air Force Base (KAFB) land permitted to the U.S. Department of Energy (DOE). Building 9940 is an active site managed by Organization 6423, the Reactor Safety Experiments Department. However, the area on top of the bunker where releases occurred, the Fully Instrumented Test System (FITS) and EXO-FITS units, are inactive. The terrain is generally flat with a gentle slope to the west. Vegetation is primarily desert grasses.

The Building 9940 complex was built in the 1960s as an explosive testing complex and was originally owned by Organization 2510, an explosive components organization. Firing tests at this time involved conventional explosives, but no records exist of the tests performed. In the 1970s and 1980s, tests were performed to investigate reactor safety designs. Two types of tests from these experiments were hydrogen combustion tests and fuel coolant interactions (FCI). The hydrogen combustion tests were conducted to test flammability limits of a mixture of hydrogen/air and steam. Other than hydrogen, no other hazardous material was used in these tests.

The FCI experiments involved the reaction of depleted uranium and corium thermite, which is essentially a compound of stainless steel, zirconium, iron oxide, nickel-oxide, chromium-oxide, and molybdenum-oxide powder. The intent of the experiments was to simulate the reaction of molten core materials and water. Experiments involving corium thermite at Building 9940 began in 1979 and continued until 1982.

Two structures at SWMU 108 were critical to the tests using corium thermite; the EXO-FITS facility located to the south of Building 9940A, and the FITS tank housed in Building 9940A. The FITS tank is a 5.6-meter vessel standing about 5 meters tall and is approximately 1.5 meters in diameter. The EXO-FITS facility consisted of an angle-iron superstructure that suspended the thermite/melt crucible and a water chamber on a concrete pad.

The constituents of concern (COCs) at the site include depleted uranium and chromium. These materials were probably released from disposal onto the ground from the FITS tank and from the release of contaminated steam in the thermite/steam reaction of the EXO-FITS unit.

Because of reported explosives testing in the early history of the site, there is also the potential for residual high explosives (HE). Therefore, HE is a contaminant of concern at this site.

A radiological survey was conducted at SWMU 108 in October 1993 by RUST-Geotech. Four point sources and eleven area sources of gamma activity 30 percent or greater than natural background were identified during this survey. Point sources and small area sources were removed in September 1995, and large area sources were remediated in October 1995.

After the radiological voluntary corrective measures (VCM) activities, 10 post-cleanup samples were collected from areas exhibiting the highest residual gamma readings. The maximum level of residual radiological COCs are 54.0 picocuries per gram (pCi/g) for uranium (U)-238, 0.84 pCi/g for U-235, 6.75 pCi/g for U-234, and 64.4 pCi/g for thorium (Th)-234.

## II. Comparison of Results to Data Quality Objectives

The confirmatory sampling conducted at SWMU 108 was designed to collect adequate samples to:

- *Determine whether hazardous waste or hazardous constituents have been released* at the site
- Characterize the nature and extent of any releases
- Provide sufficient Level 3 analytical data to support risk screening assessments.

Table 1 summarizes the sample location design for SWMU 108. The source of potential COCs at SWMU 108 was from spills and discharges from FCI tests.

**Table 1**
**Summary of Sampling Performed to Meet Data Quality Objectives**

| SWMU | Potential COC Source | Area of Site (acres) | Number of Sampling Locations | Sample Density (samples/acre) | Sampling Location Rationale |
|---|---|---|---|---|---|
| 108 | Spills and discharges from FCI tests | 0.4 | 25 chemical<br>41 radiological* | 62 chemical<br>102 radiological | To confirm Geotech VCM and assure no chemical constituents were present at these locations |

* Includes RUST–Geotech VCM Samples

Surface soils were collected from areas of known releases as determined from background investigations, and known radiation anomalies as determined by the RUST-Geotech Radiation survey in 1994 and the radiological VCM activities performed by RUST-Geotech in 1995.

Because the nonradiological COCs are considered to be co-located with the radiological COCs by the nature of the composition of HE selenium thermite, the number and locations of the samples depended upon the location and aerial extent of the radiation anomalies. Some sample locations were selected outside the anomalous areas to further define these boundaries. Sediments and subsurface soils were collected from a ditch downhill from the site to investigate the potential for offsite migration.

Table 2 summarizes the analytical and data quality requirements necessary to 1) adequately characterize hazardous waste or hazardous constituents associated with the releases from the FCI tests, and 2) support risk screening assessments.

**Table 2**
**Summary of Data Quality Requirements**

| Analytical Requirement | Data Quality Level | General Engineering Laboratory, Charleston SC | Radiation Protection Sample Diagnostics Laboratory Department 713 SNL/NM |
|---|---|---|---|
| RCRA metals plus Be, Hg, and Ni, EPA Method | Level 3 | 27 Samples including 2 Duplicates | Not Applicable |
| Explosives EPA Method 8330 | Level 3 | 27 Samples including 2 Duplicates | Not Applicable |
| Gamma Spectroscopy | Level 2 | Not Applicable | 27 Samples including 2 Duplicates |

A total of 25 locations were sampled at SWMU 108 and analyzed for RCRA metals including nickel, beryllium and mercury, and explosives by General Engineering Laboratory (GEL) Charleston South Carolina. No gross contamination of metals was present in the soils at SWMU 108. Concentrations above background were present in one barium sample and three lead samples in the surface soil. In the subsurface soil, barium was present above background in one sample. All other metals were below approved maximum background levels, including the suspected COC, chromium, from the corium thermite tests.

Residual explosives in four surface soil samples (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine [HMX]) appeared to be confined to one area in the northeast portion of the site. No explosives were present at the four borehole locations in the ditch downhill from the site.

Radiological constituents with activities greater than background appear to be confined to the immediate test area, although, not necessarily to the anomalous areas. No radiological activities greater than background were detected downslope from the site on the southern SWMU boundary.

The SNL/NM Sample Management Office conducted a Level 3 Data Validation review in accordance with Technical Operating Procedure 94-03. Rev.) (SNL/NM July 1994). This review has confirmed that the data are acceptable for use in the no further action (NFA) proposal for Site 108. The data quality objectives for SWMU 108 have been met.

## III. Determination of Nature, Rate, and Extent of Contamination

### III.1 Introduction

The determination of the nature, rate, and extent of contamination at SWMU 108 was based upon an initial conceptual model validated by confirmatory sampling at the site. The initial conceptual model was developed from historical background information including numerous site inspections, personal interviews, historical photographs, geophysical and radiological surveys. The data quality objectives contained in the OU 1335 RFI Work Plan (SNL/NM March 1996) which was modified in the Confirmatory Sampling Plan, July 1997. The data quality objectives contained in the Confirmatory Sampling Plan (SNL/NM, July 1997) identified the sample locations, sample density, sample depth, and analytical requirements. The sample data used to characterize SWMU 108 were collected in accordance with the rationale and procedures described in the Confirmatory Sampling Plan (SNL/NM July 1997). The data were subsequently used to develop the final conceptual model for SWMU 108, which is presented in Section 6.5 of the associated No Further Action (NFA) proposal. The quality of the data specifically used to determine the nature, rate, and extent of contamination are described below.

## III.2 Nature of Contamination

The nature of contamination at SWMU 108 was determined with analytical testing of soil and media and the potential for degradation of relevant COCs (Section V). The analytical requirements include RCRA metals, plus beryllium, mercury and nickel (EPA Method 6010/7000) to characterize metal contamination in the soil, particularly chromium associated with the corium thermite tests. Also, analyses for explosives were performed to determine if residual explosives from aboveground testing could be located (EPA Method 8330). Gamma spectrometry was used to identify any residual radiological contamination from the FCI tests.

## III.3 Rate of Contaminant Migration

The rate of COC migration is dependent predominantly on site meteorological and surface hydrologic processes as describe in Section V. Data available from the Site-Wide Hydrogeologic Characterization Project (published annually), numerous SNL/NM air, surface water, radiological monitoring programs, biological surveys, and other governmental atmospheric monitoring at the Kirtland Air Force Base (i.e., National Oceanographic and Atmospheric Administration) are adequate to characterize the rate of COCs migration at SWMU 108.

## III.4 Extent of Contamination

The compound HMX is confined to a 900-square-foot area in the northeastern portion of the site, and the extent of radiological contamination has been defined by the RUST Geotech survey (RUST Geotech Inc. December 1994). Corium thermite, the reaction product of the FCI tests at SWMU 108, is a metal alloy of depleted uranium and chromium- and nickel-bearing stainless steel. Because of the nature of the tests, metals contamination would be co-located with radiological contamination at SWMU 108. Therefore, soil samples were collected in both the known areas of radiological contamination at SWMU 108, and downslope of the site to verify the extent of contamination determined by the RUST-Geotech radiation survey and VCM. Chromium and nickel, the suspected COCs, were not found in the soils above approved background levels. Therefore, the lateral extent of contamination appears to be defined.

The sample density is a function of the size of the anomalous areas in SWMU 108, and the direction and distance of potential offsite migration. The sample number was deemed sufficient to establish the presence of contaminants in the soil generated from the operations at SWMU 108. The sample density was 12-samples/ acre for chemical analyses and 18 samples/acre for radiological analyses. This sample density is consistent with comparable U.S. Environmental Protection Agency (EPA) RCRA investigations/feasibility studies (Selman et al., 1994).

Because of the relatively low solubility of most metals and organic compounds, limited precipitation, and high evapotranspiration, the vertical rate of contamination migration is expected to be extremely low. Therefore, samples were collected from the ground surface to a depth of 6-inches bgs, except in the ditch downslope from the test area. At this area, samples were collected from sediments in the ditch from the surface to a depth of 1-foot, and in the *in-situ* soil, at the original bottom of the ditch at a depth interval from one to two feet. Any former release of metals and radionuclides from the soils and surface discharges at SWMU 108 would have been to the surface soils. There is no historical information that any subsurface disturbance, testing, or disposal ever occurred at the site, which would mix surface soils beneath the six-inch depth. Therefore, the six-inch surface sample depth and the two-foot depth for subsurface samples are representative of the media potentially impacted by site activities and is sufficient to determine the vertical extent of COCs migration.

In summary, the design of the confirmatory sampling was appropriate and adequate to determine the nature, rate, and extent of contamination.

## IV. Comparison of COCs to Background Screening Levels

Site history and characterization activities are used to identify potential COCs. The identification of COCs and the sampling to determine the concentration levels of those COCs across the site are described in the SWMU 108 No Further Action (NFA) proposal. Generally, COCs evaluated in this risk assessment include all detected organics and relevant radiological contaminants and all inorganic COCs that were analyzed for. If the detection limit of an organic compound was too high (could possibly cause an adverse effect to human health or the environment), the compound was retained. Nondetect organics that were not included in this assessment were determined to have low enough detection limits to ensure protection of human health and the environment. In order to provide conservatism in this risk assessment, the calculation uses only the maximum concentration value of each COC determined for the entire site. The approved SNL/NM maximum background concentration (Dinwiddie September 24, 1997) was selected to provide the background screen in Tables 3 and 4. Human health nonradiological COCs were also compared to SNL/NM proposed Subpart S action levels (Table 1) (IT 1994).

Nonradiological inorganics that are essential nutrients such as iron, magnesium, calcium, potassium, and sodium are not included in this risk assessment (EPA 1989). Both radiological and nonradiological COCs are evaluated. The nonradiological COCs evaluated in this risk assessment include high explosives and inorganics.

Nonradiological COCs for human health and ecological risk assessment at SWMU 108 are listed in Table 3. Radiological COCs are listed in Table 4. All tables show the associated

## Table 3
## Nonradiological COCs for Ecological Risk Assessment at SWMU 108 with Comparison to the Associated SNL/NM Background Screening Value, Bioconcentration Factor, and Log $K_{ow}$

| COC Name | Maximum Concentration (mg/kg) | SNL/NM Background Concentration (mg/kg)[a] | Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background Screening Value? | Bioconcentration Factor (BCF) (maximum aquatic) | Log $K_{ow}$ (for organic COCs) | Bioaccumulator?[h] (BCF>40, log $K_{ow}$>4) | Subpart S Screening Value[b] | Is Individual COC less than 1/10 of the Action Level? |
|---|---|---|---|---|---|---|---|---|
| Arsenic | 3.09 | 4.4 | Yes | 44[c] | | **Yes** | 0.5 | **No** |
| Barium | 384 | 130 | **No** | 170[d] | | **Yes** | 6000 | Yes |
| Beryllium | 0.403 | 0.65 | Yes | 19[c] | | No | 0.2 | **No** |
| Cadmium | 1.63 | <1 | **No** | 64[c] | | **Yes** | 80 | Yes |
| Chromium, total[e] | 9.47 | 15.9 | Yes | 16[c] | | No | 400 | Yes |
| Lead | 362 | 11.8 | **No** | 49[c] | | **Yes** | -- | -- |
| Mercury | 0.0574 | <0.1 | **Unknown** | 5500[c] | | **Yes** | 20 | Yes |
| Nickel | 9.99 | 11.5 | Yes | 47[c] | | **Yes** | 2000 | Yes |
| Selenium | 0.941 | <1 | **Unknown** | 800[f] | | **Yes** | 400 | Yes |
| Silver | 5.56 | <1 | **No** | 0.5[c] | | No | 400 | Yes |
| HMX | 4.23 | NA | **NA** | | 0.26[g] | No | -- | -- |

[a]IT (1997), Southwest Test Area.
[b]IT (1994).
[c]Bioconcentration factor and/or Log $K_{ow}$ from Yanicak (March 1997).
[d]Bioconcentration factor from Neumann (1976).
[e]Assumed to be chromium VI for Subpart S screening procedure.
[f]Bioconcentration factor from Callahan et al. (1979).
[g]Log $K_{ow}$ from Maxwell and Opresko (1996).
[h]NMED (March 1998)
-- Information not available.
$K_{ow}$ = Octanol-water coefficient
Log = Logarithm (base 10).
mg/kg = Milligrams per kilogram.
NA = Not applicable (organic COCs do not have accepted background concentrations).

**Table 4**
**Nonradiological COCs for Ecological Risk at SWMU 108 with Comparison to the Associated SNL/NM Background Screening Value, Bioconcentration Factor, and Log $K_{ow}$**

| COC Name | Maximum Activities (pCi/g) | SNL/NM Background Activities (pCi/g)[a] | Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background[a] Screening Value? | Bioconcentration Factor (BCF) (maximum aquatic) | Bioaccumulator? (BCF>40, log $K_{ow}$>4) |
|---|---|---|---|---|---|
| Cs-137 | 0.43 | 0.664 | Yes | 3000[c] | **Yes** |
| Ra-228 | 0.87 | 1.01 | Yes | 30,000[d] | No[e] |
| Th-234 | 64.4 | 1.4 | **No** | --- | No[e] |
| U-235 | 0.84 | 0.16 | **No** | 900[d] | **Yes** |
| U-234[b] | 6.75 | 1.6 | **No** | 900[d] | **Yes** |
| U-238 | 54.0 | 1.4 | **No** | 900[d] | **Yes** |

[a]Dinwiddie (September 24, 1997), Southwest Test Area.
[b]U-234 values were calculated using the U-238 concentration and assuming that the U-238 to U-234 ratio was equal to that detected during waste characterization of depleted uranium-contaminated soils generated during the radiological voluntary corrective measures project, where U-234=U-238/8 (Brown January 1998).
[c]Bioconcentration factor from Yanicak (March 1997).
[d]Baker and Soldat 1992
[e]Not considered a bioaccumulator (Yanicak March 1997).

Log = Logarithm (base 10).
pCi/g = Picocuries per gram.
--- = Insufficient data.

approved SNL/NM maximum background concentration values (Dinwiddie September 24, 1997). Discussion of Tables 3 and 4 is provided in Section VI.4 and Sections VII.2 and VII.3. Since background levels for mercury, selenium, and silver are not quantifiable, the maximum concentration of these analytes are considered for Risk Screening Assessment even though they may be below the nonquantified background level.

## V. Fate and Transport

The primary release of COCs at SWMU 108 was to the surface soil. Wind, water, and biota are natural mechanisms of COC transport from the primary release point. Excavation and removal of soil are potential human-caused mechanisms of transport. Winds can be strong in the open grassland environment at SWMU 108. Moderate winds can transport soil particles with adsorbed COCs (or COCs in particulate form) as suspended dust, capable of dry or wet deposition. Strong winds may move larger (sand-sized) particles by saltation. Wind erosion is reduced if the soil surface is moist or if it is protected by vegetation or other cover; however, most of SWMU 108 is either sparsely vegetated or bare soil.

Water at SWMU 108 is received as precipitation (rain or occasionally snow). The average annual precipitation in this area is about 8 inches (NOAA 1990), and the evapotranspiration value is 95 percent of the total rainfall (Thomson and Smith 1985). Precipitation will either infiltrate or form runoff. Infiltration at the site is enhanced by the sandy nature of the soil (the soil in the area of the site is primarily Wink fine sandy loam [USDA 1977]) and the nearly flat (leveled) relief over portions of the site; however, the natural surface has a gentle slope to the west, and site development has created sloping surfaces in the site that will tend to shed water rather than allow it to infiltrate. Runoff from the site to adjacent areas is probably significant only during intense rainfall events and during extended rainfall periods when soils are near saturation from previous rainfall. Surface runoff in the area of SWMU 108 is to the west, toward an internal drainage basin, but no major surface drainage features occur on the site. Runoff may carry soil particles with adsorbed COCs. The distance of transport will depend on the size of the particle and the velocity of the water (generally be low due to the low slope of the local terrain).

Water that infiltrates into the soil will continue to percolate through the soil until field capacity is reached. COCs desorbed from the soil particles into the soil solution may be leached into the subsurface soil with this percolation. The effective rooting depths of the soil at SWMU 108 is about 60 inches (USDA 1977), indicating the depth of the system's transient water cycling zone defined by the dynamic balance between percolation/infiltration and evapotranspiration. Because groundwater at this site is approximately 347 feet bgs, the potential for COCs to reach groundwater through the unsaturated zone above the water table is very small. As water from the surface evaporates, the direction of COC movement may be reversed with capillary rise of the soil water. Vegetation increases the rate of water loss from the soil through transpiration.

Plant roots can take up COCs that are in the soil solution. This may be a passive process, but active (i.e., requiring energy expenditure on the part of the plant) uptake or exclusion of some constituents in the soil solution may also take place. COCs taken up by the roots may be transported to the aboveground tissues with the xylem stream. Aboveground tissues can also take up constituents directly from the air by contact with dust particles. Organic constituents in plant tissues may be metabolized or released through volatilization. That which remains in the tissue may be consumed by herbivores or eventually returned to the soil as litter. Aboveground litter is capable of transport by wind until consumed by decomposer organisms in the soil. Constituents in plant tissues that are consumed by herbivores may pass through the gut and be returned to the soil in feces (at the site or transported from the site in the herbivore) or absorbed to be held in tissues, metabolized, or excreted. The herbivore may be eaten by a primary carnivore or scavenger and the constituent still held in the consumed tissues will repeat the sequence of absorption, metabolization, excretion, and consumption by higher predators, scavengers, and decomposers. The potential for transport of the constituents within the food chain is dependent upon the mobility of the species that comprise the food chain and the potential for the constituent to be transferred across the links in the food chain.

Degradation of COCs at SWMU 108 may result from biotic or abiotic processes. Most COCs at SWMU 108 are inorganic and elemental in form and are, therefore, not considered to be degradable. Radiological COCs, however, undergo decay to stable isotopes or radioactive daughter elements. Other transformations of inorganics may include changes in valence (oxidation/reduction reactions) or incorporation into organic forms (e.g., the conversion of selenite or selenate from soil to seleno-amino acids in plants). Degradation processes for organic COCs may include photolysis, hydrolysis, and biotransformation. Photolysis requires light and therefore takes place in the air, at the ground surface, or in surface water. Hydrolysis includes chemical transformations in water and may occur in the soil solution. Biotransformation is the metabolization of COCs in biota, including microorganisms, plants, and animals.

Table 5 summarizes the fate and transport processes that may occur at SWMU 108. COCs at this site are primarily inorganics (metals and depleted uranium) in surface soil. Because this site is disturbed, vegetative cover is low. Therefore, the potential for transport of COCs by wind is possible at this site. Transport by surface-water runoff is moderated by the low slope and high infiltration of the soil. Significant leaching into the subsurface soil is unlikely for most inorganics, and leaching to the groundwater is highly unlikely. Degradation of the inorganic COCs is insignificant, and methylation of selenium is unlikely due to low biological activity. HMX (a HE) is the only organic COC detected at this site. Degradation of HMX in soil is expected to be low and it may leach into the soil with percolation; however, uptake and bioconcentration of this compound by biota is low (Maxwell and Opresko 1996). The potential for food-chain uptake of COCs at this site is low due to the degree of disturbance and the consequent lack of significant contact with ecological receptors.

**Table 5**
**Summary of Fate and Transport at SWMU 108**

| Transport and Fate Mechanism | Existence at Site | Significance |
|---|---|---|
| Wind | Yes | Moderate |
| Surface runoff | Yes (to local internal basin) | Low |
| Migration to groundwater | No | None |
| Food chain uptake | Yes | Low |
| Transformation/degradation | Yes | Low |

## VI. Human Health Risk Screening Assessment

### VI.1 Introduction

Human health risk screening assessment of this site includes a number of steps that culminate in a quantitative evaluation of the potential adverse human health effects caused by constituents located at the site. The steps to be discussed include:

| | |
|---|---|
| Step 1. | Site data are described that provide information on the potential COCs, as well as the relevant physical characteristics and properties of the site. |
| Step 2. | Potential pathways are identified by which a representative population might be exposed to the COCs are identified. |
| Step 3. | The potential intake of these COCs by the representative population is calculated using a tiered approach. The first component of the tiered approach includes two screening procedures. One screening procedure compares the maximum concentration of the COC to an approved SNL/NM maximum background screening value. COCs that are not eliminated during the first screening procedure are subjected to a second screening procedure that compares the maximum concentration of the COC to the SNL/NM proposed Subpart S action level. |
| Step 4. | Toxicological parameters are identified and referenced for COCs that were not eliminated during the screening steps. |
| Step 5. | Potential toxicity effects (specified as a Hazard Index [HI]) and excess cancer risks are calculated for nonradiological COCs and background. For radiological COCs, the incremental total effective dose equivalent (TEDE) and incremental estimated cancer risk are calculated by subtracting applicable background concentrations directly from maximum on-site contaminant values. This background subtraction only occurs when a radiological COC occurs as contamination and exists as a natural background radionuclide. |
| Step 6. | These values are compared with guidelines established by the U.S. Environmental Protection Agency (EPA) and DOE to determine if further evaluation, and potential site cleanup, is required. Nonradiological COC risk values are also compared to background risk so that an incremental risk may be calculated. |
| Step 7. | Uncertainties in the previous steps are discussed. |

### VI.2 Step 1. Site Data

The description and history for SWMU 108 is provided in Section I. Comparison of results to DQOs is presented in Section II. The determination of the nature, rate, and extent of contamination is described in Section III.

### VI.3 Step 2. Pathway Identification

SWMU 108 has been designated with a future land-use scenario of industrial (DOE and USAF March 1996) (see Appendix 1 for default exposure pathways and parameters). Because of the location and the characteristics of the potential contaminants, the primary pathway for human exposure is considered to be soil ingestion for the nonradiological COCs and direct gamma exposure for the radiological COCs. The inhalation pathway for both nonradiological and radiological COCs is included because of the potential to inhale dust and volatiles. Soil ingestion is also included for the radiological COCs. No contamination at depth was determined, and therefore no water pathways to the groundwater are considered. Depth to groundwater at SWMU 108 is approximately 347 feet below ground surface. Because of the lack of surface water or other significant mechanisms for dermal contact, the dermal exposure pathway is considered not to be significant. No intake routes through plant, meat, or milk ingestion are considered appropriate for the industrial land-use scenario. However, plant uptake is considered for the residential land-use scenario.

**Pathway Identification**

| Nonradiological Constituents | Radiological Constituents |
|---|---|
| Soil ingestion | Soil ingestion |
| Inhalation (dust and volatiles) | Inhalation (dust) |
| Plant Uptake (residential only) | Plant Uptake (residential only) |
| | Direct gamma |

## VI.4 Step 3. COC Screening Procedures

Step 3 is discussed in this section and includes two screening procedures. The first screening procedure is a comparison of the maximum COC concentration to the approved background screening level. The second screening procedure compares maximum COC concentrations to SNL/NM proposed Subpart S action levels. This second procedure is applied only to COCs that are not eliminated during the first screening procedure.

### VI.4.1 Background Screening Procedure

#### *VI.4.1.1 Methodology*

Maximum concentrations of COCs are compared to the approved SNL/NM maximum screening level for this area (Dinwiddie September 24, 1997). The approved SNL/NM maximum background concentration is selected to provide the background screen in Table 3 and used to calculate risk attributable to background in Table 9. Only the COCs that are above their respective SNL/NM maximum background screening level or do not have a quantifiable background screening level are considered in further risk assessment analyses.

For radiological COCs that exceed the SNL/NM background screening levels, background values are subtracted from the individual maximum radionuclide concentrations. Those that do not exceed these background levels are not carried any further in the risk assessment. This approach is consistent with DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (DOE 1993). Radiological COCs that do not have a background value and are detected above the analytical minimum detectable activity are carried through the risk assessment at their maximum levels. The resultant radiological COCs remaining after this step are referred to as background-adjusted radiological COCs.

*VI.4.1.2 Results*

A Comparison of SWMU 108 maximum COC concentrations to approved SNL/NM maximum background values (Dinwiddie September 24, 1997) for human health risk assessment is presented in Table 3. For the nonradiological COCs, four constituents have maximum measured values greater than their respective background screening levels. Two nonradiological COCs do not have a quantifiable background concentration, so it is unknown if those COCs exceed background. One of the COCs is an organic compound and does not have a background screening level.

The maximum concentration value for lead is 362 milligrams per kilogram (mg/kg). The EPA intentionally provides no human health toxicological data on lead, and therefore no risk parameter values can be calculated. However, EPA Region 6 guidance for the screening value for lead for an industrial land-use scenario is 2,000 mg/kg (EPA 1996a); for a residential land-use scenario, the EPA screening guidance value is 400 mg/kg (EPA July 1994). The maximum concentration value for lead at this site is less than both screening values, and therefore lead is eliminated from further consideration in the human health risk assessment.

For the radiological COCs, four constituents had maximum measured activities greater than their respective background (U-234, U-235, U-238, and Th-234). The constituents are representative of the depleted uranium used at the site. The Th-234 is the short-lived daughter of U-238 whose health and safety effects are accounted for in U-238 calculations.

VI.4.2 Subpart S Screening Procedure

*VI.4.2.1 Methodology*

The maximum concentrations of nonradiological COCs not eliminated during the background screening process were compared with action levels calculated using methods and equations promulgated in the proposed Resource Conservation and Recovery Act (RCRA) Subpart S (*Federal Register*, Vol. 55, Title 40 Part 264, 265, 270, and 271 [EPA 1990]) and Risk Assessment Guidance for Superfund (RAGS) (EPA 1989). Accordingly, all calculations were based upon the assumption that receptor doses from both toxic and potentially carcinogenic compounds result most significantly from ingestion of contaminated soil. Because the samples are all taken from the surface, this assumption is considered valid. If there were 10 or fewer COCs and each has a maximum concentration less than one-tenth of the action level, then the site would be judged to pose no significant health hazard to humans. If there were more than 10 COCs, the Subpart S screening procedure was not performed.

*VI.4.2.2 Results*

Table 3 shows the COCs and the associated proposed Subpart S action level. The table compares the maximum concentration values to 1/10 of the proposed Subpart S action level. This methodology was guidance given to SNL/NM from the EPA (EPA 1996b). One COC does not have a proposed Subpart S action level. Because of this COC, the site fails the Subpart S screening criteria and a hazard quotient (HQ) and excess cancer risk value must be calculated for all the COCs.

Radiological COCs have no predetermined action levels analogous to proposed Subpart S levels, and therefore this step in the screening process is not performed for radiological COCs.

## VI.5 Step 4. Identification of Toxicological Parameters

Tables 6 (nonradiological) and 7 (radiological) show the COCs retained in the risk assessment and the values for the available toxicological information. The toxicological values used for nonradiological COCs in Table 6 are from the Integrated Risk Information System (IRIS) (EPA 1998), Health Effects Assessment Summary Tables (HEAST) (EPA 1997a), and EPA Region 9 (EPA 1996c) databases . Dose conversion factors (DCF) used in determining the excess TEDE values for radiological COCs for the individual pathways were the default values provided in the RESRAD computer code (Yu et al. 1993b) as developed in the following documents:

- DCFs for ingestion and inhalation are taken from "Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion" (EPA 1988).

- DCFs for surface contamination (contamination on the surface of the site) were taken from DOE/EH-0070, *External Dose-Rate Conversion Factors for Calculation of Dose to the Public* (DOE 1988).

- DCFs for volume contamination (exposure to contamination deeper than the immediate surface of the site) were calculated using the methods discussed in *Dose-Rate Conversion Factors for External Exposure to Photon Emitters in Soil* (Health Physics 28:193-205 [Kocher 1983]) and ANL/EAIS-8, *Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil* (Yu et al. 1993b).

## VI.6 Step 5. Exposure Assessment and Risk Characterization

Section VI.6.1 describes the exposure assessment for this risk assessment. Section VI.6.2 provides the risk characterization, including the HI value and the excess cancer risk for both the potential nonradiological COCs and associated background for industrial and residential land uses. The incremental TEDE and incremental estimated cancer risk are provided for the background-adjusted radiological COCs for both industrial and residential land uses.

## Table 6
## Toxicological Parameter Values for SWMU 108 Nonradiological COCs

| COC Name | $RfD_O$ (mg/kg-d) | Confidence[a] | $RfD_{inh}$ (mg/kg-d) | Confidence[a] | $SF_O$ (mg/kg-day)$^{-1}$ | $Sf_{inh}$ (mg/kg-day)$^{-1}$ | Cancer Class[b] |
|---|---|---|---|---|---|---|---|
| Barium | 7E–2[c] | M | 1.4E–4[d] | -- | -- | -- | -- |
| Cadmium | 5E–4[c] | H | 5.7E–5[d] | -- | -- | 6.3E+0[c] | B1 |
| Mercury | 3E–4[e] | -- | 8.6E–5[c] | M | -- | -- | D |
| Selenium | 5E–3[c] | H | -- | -- | -- | -- | D |
| Silver | 5E–3[c] | L | -- | -- | -- | -- | D |
| HMX | 5E–2[c] | L | 5E–2[d] | -- | -- | -- | D |

[a]Confidence associated with IRIS (EPA 1998) database values (L = low, M = medium, H = high).
[b]EPA weight-of-evidence classification system for carcinogenicity (EPA 1989) taken from IRIS (EPA 1998):

B2 - Probable human carcinogen. Indicates sufficient evidence in animals and inadequate or no evidence in humans.

D - Dot classifiable as to human carcinogenicity.

[c]Toxicological parameter values from IRIS electronic database (EPA 1998).
[d]Toxicological parameter values from EPA Region 9 electronic database (EPA 1996c).
[e]Toxicological parameter values from HEAST database (EPA 1997a).

| | |
|---|---|
| COC | = Constituent of Concern. |
| EPA | = U.S. Environmental Protection Agency. |
| HEAST | = Health Effects Assessment Summary Tables. |
| IRIS | =Integrated Risk Information System. |
| $RfD_o$ | = Oral chronic reference dose. |
| $RfD_{inh}$ | = Inhalation chronic reference dose. |
| $SF_o$ | = Oral slope factor. |
| $SF_{inh}$ | = Inhalation slope factor. |
| -- | = Information not available. |
| mg/kg-day | = Milligram per kilogram day. |
| (mg/kg-day)$^{-1}$ | = Per milligram per kilogram day. |

**Table 7**
**Radiological Toxicological Parameter Values for SWMU 108 COCs Obtained from RESRAD Risk Coefficients[a]**

| COC Name | $SF_o$ (1/pCi) | $Sf_{inh}$ (1/pCi) | $SF_{ev}$ (g/pCi-yr) | Cancer Class[b] |
|---|---|---|---|---|
| U-238[c] | 6.20E−11 | 1.20E−08 | 6.60E−08 | A |
| U-235 | 4.70E−11 | 1.30E−08 | 2.70E−07 | A |
| U-234 | 4.40E−11 | 1.40E−08 | 2.10E−11 | A |

[a]Yu et. al. 1993a.
[b]EPA weight-of-evidence classification system for carcinogenicity (EPA 1989): A - human carcinogen.
[c]U-238 also accounts for Th-234 contribution, since Th-234 is short-lived U-238 progeny.

COC = Constituents of concern.
EPA = U.S. Environmental Protection Agency
$SF_o$ = Oral (ingestion) slope factor.
$SF_{inh}$ = Inhalation slope factor.
$SF_{ev}$ = External volume exposure slope factor.
SWMU = Solid waste management unit.
1/pCi = One per picocurie.
g/pCi-yr = Gram per picocurie-year.

VI.6.1 Exposure Assessment

Appendix 1 shows the equations and parameter input values used in calculating intake values and subsequent HI and excess cancer risk values for the individual exposure pathways. The appendix shows parameters for both industrial and residential land-use scenarios. The equations for nonradiological COCs are based upon RAGS (EPA 1989). Parameters are based upon information from the RAGS (EPA 1989) and other EPA guidance documents and reflect the reasonable maximum exposure (RME) approach advocated by the RAGS (EPA 1989). For radiological COCs, the coded equations provided in RESRAD computer code were used to estimate the incremental TEDE and cancer risk for individual exposure pathways. Further discussion of this process is provided in the Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0 (Yu et al. 1993b).

Although the designated land-use scenario is industrial for this site, risk and TEDE values for a residential land-use scenario are also presented. These residential risk and TEDE values are presented only to provide perspective of potential risk to human health under the more restrictive land-use scenario.

VI.6.2 Risk Characterization

Table 8 shows an HI value of 0.01 for the SWMU 108 nonradiological COCs and an excess cancer risk is $5 \times 10^{-10}$ for the designated industrial land-use scenario. The numbers presented include exposure from soil ingestion and dust and volatile inhalation for nonradiological COCs. Table 9 shows that assuming the maximum background concentrations of the SWMU 108 associated background constituents, the HI is 0.00, and there is no excess cancer risk for the designated industrial land-use scenario.

**Table 8**
**Risk Assessment Values for SWMU 108 Nonradiological COCs**

| COC Name | Maximum Concentration (mg/kg) | Industrial Land-Use Scenario[a] | | Residential Land-Use Scenario[a] | |
|---|---|---|---|---|---|
| | | Hazard Index | Cancer Risk | Hazard Index | Cancer Risk |
| Barium | 384 | 0.01 | -- | 0.06 | -- |
| Cadmium | 1.63 | 0.00 | 5E–10 | 1.33 | 9E–10 |
| Mercury | 0.0574 | 0.00 | -- | 0.10 | -- |
| Selenium | 0.941 | 0.00 | -- | 0.33 | -- |
| Silver | 5.56 | 0.00 | -- | 0.23 | -- |
| HMX | 4.23 | 0.00 | -- | 0.00 | -- |
| | | | | | |
| **Total** | | **0.01** | **5E–10** | **2** | **9E–10** |

[a]EPA (1989).

COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
SWMU = Solid waste management unit.
mg/kg = milligram(s) per kilogram.
-- = Information not available..

**Table 9**
**Risk Assessment Values for SWMU 108 Nonradiological Background Constituents**

| COC Name | Background Concentration[a] (mg/kg) | Industrial Land- Use Scenario[b] | | Residential Land- Use Scenario[b] | |
|---|---|---|---|---|---|
| | | Hazard Index | Cancer Risk | Hazard Index | Cancer Risk |
| Barium | 130 | 0.00 | -- | 0.02 | -- |
| Cadmium | <1 | -- | -- | -- | -- |
| Mercury | <0.1 | -- | -- | -- | -- |
| Selenium | <1 | -- | -- | -- | -- |
| Silver | <1 | -- | -- | -- | -- |
| | | | | | |
| **Total** | | **0.00** | **--** | **0.02** | **--** |

[a]IT (1997), Canyons Area.
[b]EPA (1989).

COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
SWMU = Solid waste management unit.
mg/kg = milligram(s) per kilogram.
-- = Information not available.

For the radiological COCs, contribution from the direct gamma exposure pathway is included. For the industrial land-use scenario, the most limiting case TEDE was calculated for an individual who spends his workday 50/50 indoors/outdoors on the site. This resulted in an incremental TEDE of 1.5 millirem per year (mrem/yr). In accordance with EPA guidance found in OSWER Directive No. 9200.4-18 (EPA 1997c), an incremental TEDE of 15 mrem/yr is used for the probable land-use scenario (industrial in this case); the calculated dose value for SWMU 108 for the industrial land use is well below this guideline. The estimated excess cancer risk is $1.7 \times 10^{-5}$.

For the residential land-use scenario nonradiological COCs, the HI value increases to 2, and the excess cancer risk is $9 \times 10^{-10}$ (Table 8). The numbers presented included exposure from soil ingestion, dust and volatile inhalation, and plant uptake. Although the EPA (1991) generally recommends that inhalation not be included in a residential land-use scenario, this pathway is included because of the potential for soil in Albuquerque, New Mexico, to be eroded and, subsequently, for dust to be present in predominantly residential areas. Because of the nature of the local soil, other exposure pathways are not considered (see Appendix 1). Table 9 shows that for the SWMU 108 associated background constituents, the HI is 0.02, and there is no excess cancer risk.

For the radiological COCs, the incremental TEDE for the residential land-use scenario is 4.4 mrem/yr. The guideline being utilized is an excess TEDE of 75 mrem/yr (SNL/NM 1998) for a complete loss of institutional controls (residential land use in this case); the calculated dose value for SWMU 108 for the residential land-use is well below this guideline. Consequently, SWMU 108 is eligible for unrestricted radiological release as the residential land-use scenario resulted in an incremental TEDE to the on-site receptor of less than 75 mrem/yr. The estimated excess cancer risk is $5.5 \times 10^{-5}$. The excess cancer risk from the nonradiological COCs and the radiological COCs is not additive, as noted in RAGS (EPA 1989).

## VI.7 Step 6. Comparison of Risk Values to Numerical Guidelines.

The human health risk assessment analysis evaluated the evaluation of the potential for adverse health effects for both an industrial land-use scenario (the designated land-use scenario for this site) and a residential land-use scenario. For the industrial land-use scenario nonradiological COCs, the HI calculated is 0.01 (much less than the numerical guideline of 1 suggested in RAGS [EPA 1989]). Excess cancer risk is estimated at $5 \times 10^{-10}$. Guidance from the New Mexico Environment Department (NMED) indicates that excess lifetime risk of developing cancer by an individual must be less than $10^{-6}$ for Class A and B carcinogens and less than $10^{-5}$ for Class C carcinogens (NMED 1998). The excess cancer risk is driven by cadmium, which is a Class B1 carcinogen. Thus, the excess cancer risk for this site is below the suggested acceptable risk value ($10^{-6}$).

This risk assessment also determined risks considering background concentrations of the potential nonradiological COCs for both the industrial and residential land-use scenarios. For nonradiological COCs, assuming the industrial land-use scenario, the HI is 0.00. There is no quantifiable excess cancer risk. Incremental risk is determined by subtracting risk associated with background from potential COC risk. These numbers are not rounded before the difference is determined and therefore may appear inconsistent with numbers presented in tables and within the text. The incremental HI is 0.01, and the incremental cancer risk is $5 \times 10^{-10}$ for the industrial land-use scenario. Incremental risk calculations indicate insignificant risk to human health from nonradiological COCs considering an industrial land-use scenario.

For radiological COCs of the industrial land-use scenario, incremental TEDE is 1.5 mrem/yr, which is significantly less than EPA's numerical guideline of 15 mrem/yr. Incremental estimated excess cancer risk is $1.7 \times 10^{-5}$.

The calculated HI for the residential land-use scenario nonradiological COCs, the calculated HI is 2, which is above the numerical guidance. The excess cancer risk is estimated at $9 \times 10^{-10}$. The excess cancer risk is again driven by cadmium, which is a Class B1 carcinogen. Therefore, the excess cancer risk for this site is below the suggested acceptable risk value ($10^{-6}$). The HI for associated background for the residential land-use scenario is 0.02. There is no quantifiable excess cancer risk. The incremental HI is 2.03, and the incremental cancer risk is $9 \times 10^{-10}$ for the residential land-use scenario. These incremental risk calculations indicate potentially significant contribution to human health risk from the COCs considering a residential land-use scenario.

The incremental TEDE for a residential land-use scenario from the radiological components is 4.4 mrem/yr, which is significantly less than the numerical guideline of 75 mrem/yr suggested in the SNL/NM RESRAD Input Parameter Assumptions and Justification (SNL/NM February 1998). The estimated excess cancer risk is $5.5 \times 10^{-5}$.

## VI.8 Step 7. Uncertainty Discussion

The determination of the nature, rate and extent of contamination at SWMU 108 was based upon an initial conceptual model validated with confirmatory sampling at the site. The confirmatory sampling was implemented in accordance with the Sampling and Analysis Plan (SNL/NM July 1997), which was reviewed by NMED OB. The DQOs contained in the Sampling and Analysis Plan (SNL/NM July 1997) are appropriate for use in risk screening assessments. The data collected, based upon sample location, density, and depth, are representative of the site. The analytical requirements and results satisfy the DQOs. Data quality were validated in accordance with SNL/NM procedures (SNL/NM July 1994). Therefore, there is no uncertainty associated with the data quality used to perform the risk screening assessment at SWMU 108.

Because of the location, history of the site, and future land-use (DOE and USAF March 1996), there is low uncertainty in the land-use scenario and the potentially affected populations that were considered in making the risk assessment analysis. Because the COCs are found in surface and near-surface soils and because of the location and physical characteristics of the site, there is little uncertainty in the exposure pathways relevant to the analysis.

An RME approach was used to calculate the risk assessment values. This means that parameter values used in the calculations are conservative and that calculated intakes are probably overestimates. Maximum measured values of the COC concentrations are used to provide conservative results.

Table 6 shows the uncertainties (confidence) in nonradiological toxicological parameter values. There is a mixture of estimated values and values from IRIS (EPA 1998), HEAST (EPA 1997a) and EPA Region 9 (EPA 1996c) databases. Where values are not provided, information is not available from the HEAST (EPA 1997a), IRIS (EPA 1998), or the EPA regions (EPA 1996c, 1997b). Because of the conservative nature of the RME approach, uncertainties in toxicological values are not expected to be sufficiently high to change the conclusion from the risk assessment analysis.

Risk assessment values for nonradiological COCs are within the human health acceptable range for the industrial land-use scenario compared to established numerical guidance.

For radiological COCs, the conclusion of the risk assessment is that potential effects on human health for both industrial and residential land-use scenarios are within guidelines and are a small fraction of the estimated 360 mrem/yr received by the average U.S. population (NCRP 1987).

The overall uncertainty in all of the steps in the risk assessment process is considered not significant with respect to the conclusion reached.

## VI.9 Summary

SWMU 108 has identified COCs consisting of some inorganic, organic, and radiological compounds. Because of the location of the site, the designated industrial land-use scenario, and the nature of contamination, the potential exposure pathways identified for this site included soil ingestion and dust and volatile inhalation for chemical constituents and soil ingestion, dust inhalation, and direct gamma exposure for radiological exposure. Plant uptake was included as an exposure pathway for the residential land-use scenario.

Using conservative assumptions and employing an RME approach to risk assessment, calculations for nonradiological COCs show that for the industrial land-use scenario the HI (0.01) is significantly less than the accepted numerical guidance from the EPA. The excess cancer risk ($5 \times 10^{-10}$) is also below the acceptable risk value provided by the NMED for an industrial land use (NMED March 1998). The incremental HI is 0.01, and the incremental cancer risk is $5 \times 10^{-10}$ for the industrial land-use scenario. Incremental risk calculations indicate insignificant risk to human health for a industrial land-use scenario.

Incremental TEDE and corresponding estimated cancer risk from radiological COCs are much less than EPA guidance values; the estimated TEDE is 1.5 mrem/yr for the industrial land-use scenario. This value is much less than the numerical guidance of 15 mrem/yr in EPA guidance (EPA 1997c). The corresponding incremental estimated cancer risk value is $1.7 \times 10^{-5}$ for the industrial land-use scenario. Furthermore, the incremental TEDE for the residential land-use scenario that results from a complete loss of institutional control, is only 4.4 mrem/yr. The guideline for this scenario is 75 mrem/year (SNL/NM February 1998). Therefore, SWMU 108 is eligible for unrestricted radiological release.

The uncertainties associated with the calculations are considered small relative to the conservativeness of the risk assessment analysis. It is therefore concluded that this site does not have potential to affect human health under an industrial land-use scenario.

## VII. Ecological Risk Screening Assessment

### VII.1 Introduction

This section addresses the ecological risks associated with exposure to constituents of potential ecological concern (COPEC) in soils at SWMU 108 (the Firing Site, Building 9940). A component of the NMED Risk-Based Decision Tree is to conduct an ecological screening assessment that corresponds with that presented in the EPA's Ecological Risk Assessment Guidance for Superfund (EPA 1997d). The current methodology is tiered and contains an initial scoping assessment followed by a more detailed screening assessment. Initial components of NMED's decision tree (a discussion of DQOs, a data assessment, and evaluations of bioaccumulation and fate-and-transport potential) are addressed in the scoping assessment (Section VII.2), with the exception of DQOs, which are reviewed in Section II of this report. Following the completion of the scoping assessment, a determination is made as to whether a more detailed examination of potential ecological risk is necessary. If deemed necessary, the scoping assessment proceeds to a screening assessment whereby a more quantitative estimate of ecological risk is conducted. Although this assessment incorporates conservatisms in the estimation of ecological risks, ecological relevance and professional judgment are also utilized as recommended by the EPA (EPA 1996d) to ensure that predicted exposures of selected ecological receptors reasonably reflect those reasonably expected to occur at the site.

### VII.2 Scoping Assessment

The scoping assessment focuses primarily on the likelihood of exposure of biota at/or adjacent to the site to be exposed to constituents associated with site activities. Included in this section are an evaluation of existing data and a comparison of maximum detected concentrations to background concentrations, examination of bioaccumulation potential, and fate and transport potential. A Scoping Risk Management Decision will involve a summary of the scoping results and a determination as to whether further examination of potential ecological impacts is necessary.

### VII.2.1 Data Assessment

As indicated in Section IV (Tables 3 and 4), constituents within the 0- to 5-foot-depth interval that exceeded background concentrations were:

- Barium
- Cadmium
- Lead
- Mercury
- Selenium
- Silver
- Th-234
- U-234
- U-235
- U-238.

In addition, HMX was also detected in soil at the site.

### VII.2.2 Bioaccumualtion

Among the COPECs listed in Section VII.2.1, the following were considered to have bioaccumulation potential in aquatic environments (Section IV, Tables 3 and 4):

- Barium
- Cadmium
- Lead
- Mercury
- Selenium
- U-234
- U-235
- U-238.

It should be noted, however, that as directed by the NMED (NMED 1998), bioaccumulation is exclusively assessed based upon maximum reported bioconcentration factors (BCF) for aquatic species. Because only aquatic BCFs are used to evaluate the bioaccumulation potential for metals, bioaccumulation in terrestrial species is likely to be overpredicted.

### VII.2.3 Fate and Transport Potential

The potential for the COPECs to move from the source of contamination to other media or biota is discussed in Section V. As noted in Table 5 (Section V), moderate fate and transport potential exists due to wind dispersion. Surface-water runoff is expected to be of low significance. Transformation, degradation, and food-chain uptake are also expected to be of low significance. Migration to groundwater is not anticipated.

### VII.2.4 Scoping Risk Management Decision

Based on information gathered through the scoping assessment, it was concluded that complete ecological pathways may be associated with this SWMU and that COPECs also exist at the site. As a consequence, a screening assessment was deemed necessary to predict the potential level of ecological risk associated with the site.

## VII.3 Screening Assessment

As concluded in Section VII.2.4, complete ecological pathways and COPECs are associated with this SWMU. The screening assessment performed for the site involves a quantitative estimate of current ecological risks using exposure models in association with exposure parameters and toxicity information obtained from the literature. The estimation of potential ecological risks is conservative to ensure ecological risks are not under-predicted.

Components within the screening assessment include:

- Problem Formulation—sets the stage for the evaluation of potential exposure and risk
- Exposure Estimation—provides a quantitative estimate of potential exposure
- Ecological Effects Evaluation—presents benchmarks used to gauge the toxicity of COPECs to specific receptors
- Risk Characterization—characterizes the ecological risk associated with exposure of the receptors to environmental media at the site
- Uncertainty Assessment—discusses uncertainties associated with the estimation of exposure and risk
- Risk Interpretation—evaluates ecological risk in terms of HQs and ecological significance
- Screening Assessment Scientific/Management Decision Point—presents the decision to risk managers based on the results of the screening assessment

## VII.3.1 Problem Formulation

Problem formulation is the initial stage of the screening assessment that provides the introduction to the risk evaluation process. Components that are addressed in this section include a discussion of ecological pathways and the ecological setting, identification of COPECs, and selection of ecological receptors. The conceptual model, ecological food webs, and ecological endpoints; other components commonly addressed in a screening assessment; are presented in the "Predictive Ecological Risk Assessment Methodology for SNL/NM ER Program" (IT June 1998) and are not duplicated here.

### *VII.3.1.1 Ecological Pathways and Setting*

SWMU 108 is located approximately 1.1 miles north of Magazine Road and 0.8 mile east of TA-III. The total size of the site is approximately 2.2 acres. The terrain is generally flat with a gentle slope to the west. The primary vegetation within this area is desert grassland. This area was previously surveyed for sensitive species on March 20, 1992 (IT June 1992). No sensitive species were found during this survey, and none are expected to occur due to the lack of suitable habitat. Complete ecological pathways may exist at this site through the exposure of plants and wildlife to COPECs in surface and subsurface soil. Direct uptake of COPECs from soil was assumed to be the major route of exposure for plants, with exposure of plants to wind-blown soil assumed to be minor. Exposure modeling for wildlife receptors was limited to the food and soil ingestion pathways. Because of a lack of surface water at this site, exposure to COPECs through the ingestion of surface water was considered insignificant. Inhalation and dermal contact were also considered insignificant pathways with respect to ingestion (Sample and Suter 1994). Depth to groundwater (at approximately 347 feet below ground surface) is not expected to be affected by COCs at this site.

### *VII.3.1.2 COPECs*

Screening the COPECs at this site include depleted uranium, chromium, and HE. This assessment is based upon the maximum soil concentrations of the COPECs as measured in surface and near-surface soil samples. Both radioactive and nonradioactive COPECs are evaluated (Section IV, Tables 3 and 4). The nonradioactive chemicals include both HE compounds and metals. Inorganic analytes were screened against background concentrations. Those that exceeded the approved SNL/NM background screening levels (Dinwiddie September 24, 1997) for the area were considered COPECs. Most HE constituents were not detected during sampling. The exception to this was HMX, which was detected. In order to provide conservatism in this ecological risk assessment, the exposure models use only the maximum concentration value of each COPEC determined for the entire site. Nonradiological inorganics that are essential nutrients such as iron, magnesium, calcium, potassium, and sodium were not included in this risk assessment per the EPA (1989). Maximum concentrations of the COPECs used in the exposure models are presented in Tables 3 and 4.

### *VII.3.1.3 Ecological Receptors*

As described in detail in IT (June 1998), a nonspecific perennial plant was selected as the receptor to represent plant species at the site. Vascular plants are the principal primary producers at the site and are key to the diversity and productivity of the wildlife community associate with the site. A deer mouse (*Peromyscus maniculatus*) and burrowing owl (*Speotyto cunicularia*) were used to represent wildlife use. Because of its opportunistic food habits, the deer mouse was used to represent a mammalian herbivore, omnivore, and insectivore. The burrowing owl was selected as the top predator. It is present at SNL/NM and is designated as a species of management concern by the U.S. Fish and Wildlife Service in Region 2, which includes the state of New Mexico (USFWS September 1995).

### VII.3.2 Exposure Estimation

Direct uptake of COPECs from the soil was considered the only significant route of exposure for terrestrial plants. Exposure modeling for the wildlife receptors was limited to the food and soil ingestion pathways. Inhalation and dermal contact were considered insignificant pathways with respect to ingestion (Sample and Suter 1994). Drinking water was also considered an insignificant pathway because of the lack of surface water at this site. The deer mouse was modeled under three dietary regimes: as an herbivore (100 percent of its diet as plant material), as an omnivore (50 percent of its diet as plants and 50 percent as soil invertebrates), and as an insectivore (100 percent of its diet as soil invertebrates). The burrowing owl was modeled as a strict predator on small mammals (100 percent of its diet as deer mice). Because the exposure in the burrowing owl from a diet consisting of equal parts of herbivorous, omnivorous, and insectivorous mice would be equivalent to the exposure consisting of only omnivorous mice, the diet of the burrowing owl was modeled with intake of omnivorous mice only. Both species were modeled with soil ingestion comprising 2 percent of the total dietary intake. Table 10 presents the species-specific factors used in modeling exposures in the wildlife receptors. Justification for use of the factors presented in this table is described in the ecological risk assessment methodology document (IT June 1998).

Although home range is also included in this table, exposures for this risk assessment were modeled using an area use factor of 1, implying that all food items and soil ingested are from the site being investigated. The maximum measured COPEC concentrations from surface and near surface soil samples were used to conservatively estimate potential exposures and risks to plants and wildlife at this site.

For the radiological dose rate calculations, the deer mouse was modeled as an herbivore (100 percent of its diet as plants), and the burrowing owl was modeled as a strict predator on small mammals (100 percent of its diet as deer mice). Both were modeled with soil ingestion comprising 2 percent of the total dietary intake. Receptors are exposed to radiation both internally and externally from U-234, U-235, U-238, and Th-234. Internal and external dose rates to the deer mouse and burrowing owl are approximated using dose rate models from the *Hanford Site Risk Assessment Methodology* (DOE 1995). Radionuclide-dependent data for the dose rate calculations were obtained from Baker and Soldat (1992). The external dose rate model examines the total-body dose rate to a receptor residing in soil exposed to radionuclides. The soil surrounding the receptor is assumed to be an infinite medium uniformly contaminated with gamma-emitting radionuclides. The external dose-rate model is the same for both the deer mouse and the burrowing owl. The internal total-body dose rate model assumes that a fraction of the radionuclide concentration ingested by a receptor is absorbed by the body and concentrated at the center of a spherical body shape. This provides for a conservative estimate for absorbed dose. This concentrated radiation source at the center of the body of the receptor is assumed to be a "point" source.

Radiation emitted from this point source is absorbed by the body tissues to contribute to the absorbed dose. Alpha and beta emitters are assumed to transfer 100 percent of their energy to the receptor as they pass through tissues. Gamma emitting radionuclides only transfer a fraction of their energy to the tissues because gamma rays interact less with matter than beta or alpha emitters. The external and internal dose rate results are summed to calculate a total dose rate due to exposure to the radionuclides in soil.

Table 11 presents the transfer factors used in modeling the concentrations of COPECs through the food chain. Table 12 presents maximum soil concentrations and derived tissue concentrations in various food-chain elements that are used to model dietary exposures for each of the wildlife receptors.

### VII.3.3 Ecological Effects Evaluation

Benchmark toxicity values for the plant and wildlife receptors are presented in Table 13. For plants, the benchmark soil concentrations are based upon the lowest-observed-adverse-effect-level (LOAEL). For wildlife, the toxicity benchmarks are based upon the no-observed-adverse-effect-level (NOAEL) for chronic oral exposure in a taxonomically similar test species.

**Table 10**
**Exposure Factors for Ecological Receptors at SWMU 108**

| Receptor Species | Class/Order | Trophic Level | Body Weight (kg)[a] | Food Intake Rate (kg/day)[b] | Dietary Composition[c] | Home Range (acres) |
|---|---|---|---|---|---|---|
| Deer Mouse (*Peromyscus maniculatus*) | Mammalia/ Rodentia | Herbivore | 2.39E−2[d] | 3.72E−3 | Plants: 100% (+ Soil at 2% of intake) | 2.7E−1[e] |
| Deer Mouse (*Peromyscus maniculatus*) | Mammalia/ Rodentia | Omnivore | 2.39E−2[d] | 3.72E−3 | Plants: 50% Invertebrates: 50% (+ Soil at 2% of intake) | 2.7E−1[e] |
| Deer Mouse (*Peromyscus maniculatus*) | Mammalia/ Rodentia | Insectivore | 2.39E−2[d] | 3.72E−3 | Invertebrates: 100% (+ Soil at 2% of intake) | 2.7E−1[e] |
| Burrowing owl (*Speotyto cunicularia*) | Aves/ Strigiformes | Carnivore | 1.55E−1[f] | 1.73E−2 | Rodents: 100% (+ Soil at 2% of intake) | 3.5E+1[g] |

[a]Body weights are in kilograms wet weight.
[b]Food intake rates are estimated from the allometric equations presented in Nagy (1987). Units are kilograms dry weight per day.
[c]Dietary compositions are generalized for modeling purposes. Default soil intake value of 2% of food intake.
[d]From Silva and Downing (1995).
[e]From EPA (1993), based upon the average home range measured in semiarid shrubland in Idaho.
[f]From Dunning (1993).
[g]From Haug et al. (1993).
kg = Kilogram(s).
dg/da = Kilogram(s) per day.
SWMU = Solid waste management unit.

**Table 11**
**Transfer Factors Used in Exposure Models for Constituents of Potential Ecological Concern at SWMU 108**

| Constituent of Potential Ecological Concern | Soil-to-Plant Transfer Factor | Soil-to-Invertebrate Transfer Factor | Food-to-Muscle Transfer Factor |
|---|---|---|---|
| **Inorganic** | | | |
| Barium | 1.5E–1[a] | 1.0E+0[b] | 2.0E–4[c] |
| Cadmium | 5.5E–1[a] | 6.0E–1[d] | 5.5E–4[a] |
| Lead | 9.0E–2[c] | 4.0E–2[d] | 8.0E–4[c] |
| Mercury | 1.0E+0[c] | 1.0E+0[b] | 2.5E–1[a] |
| Selenium | 5.0E–1[c] | 1.0E+0[b] | 1.0E–1[c] |
| Silver | 1.0E+0[c] | 2.5E–1[d] | 5.0E–3[c] |
| **Organic** | | | |
| HMX | 2.7E+1[e] | 1.4E+1[f] | 3.4E–8[e] |

[a]From Baes et al. (1984).
[b]Default value.
[c]From NCRP (January 1989).
[d]From Stafford et al. (1991).
[e]From equation developed in Travis and Arms (1988).
[f]From equation developed in Connell and Markwell (1990).
SWMU = Solid waste management unit.

**Table 12**
**Media Concentrations[a] for Constituents of Potential Ecological Concern at SWMU 108**

| Constituent of Potential Ecological Concern | Soil (maximum) | Plant Foliage[b] | Soil Invertebrate[b] | Deer Mouse Tissues[c] |
|---|---|---|---|---|
| **Inorganic** | | | | |
| Barium | 3.8E+2 | 5.8E+1 | 3.8E+2 | 1.4E–1 |
| Cadmium | 1.6E+0 | 9.0E-1 | 9.8E-1 | 1.7E-3 |
| Lead | 3.6E+2 | 3.3E+1 | 1.5E+1 | 7.7E–2 |
| Mercury | 5.7E–2 | 5.7E–2 | 5.7E–2 | 4.6E–2 |
| Selenium | 9.4E–1 | 4.7E–1 | 9.4E–1 | 2.3E–1 |
| Silver | 5.6E+0 | 5.6E+0 | 1.4E+0 | 5.6E-2 |
| **Organic** | | | | |
| HMX | 4.2E+0 | 1.2E+2 | 5.7E+1 | 9.3E–6 |

[a]In milligrams per kilogram. All are based upon dry weight of the media.
[b]Product of the soil concentration and the corresponding transfer factor.
[c]Based upon the deer mouse with an omnivorous diet. Product of the average concentration in food times the food-to-muscle transfer factor times the wet weight-dry weight conversion factor of 3.125 (from EPA 1993).
SWMU = Solid Waste Management Unit

Table 13
Toxicity Benchmarks for Ecological Receptors at SWMU 108

| | | Mammalian NOAELs | | | Avian NOAELs | | |
|---|---|---|---|---|---|---|---|
| Constituent of Potential Ecological Concern | Plant Benchmark[a,b] | Mammalian Test Species[c,d] | Test Species NOAEL[d,e] | Deer Mouse NOAEL[e,f] | Avian Test Species[d] | Test Species NOAEL[d,e] | Burrowing Owl NOAEL[e,g] |
| **Inorganic** | | | | | | | |
| Barium | 500 | Rat[h] | 5.1 | 10.5 | Chicks | 20.8 | 20.8 |
| Cadmium | 3 | Rat[i] | 1.0 | 1.89 | Mallard | 1.45 | 1.45 |
| Lead | 50 | Rat | 8.0 | 15.6 | American kestrel | 3.85 | 3.85 |
| Mercury (inorganic) | 0.3 | Mouse | 13.2 | 14.0 | Japanese quail | 0.45 | 0.45 |
| Mercury (organic) | 0.3 | Rat | 0.032 | 0.06 | Mallard | 0.0064 | 0.006 |
| Selenium | 1 | Rat | 0.20 | 0.39 | Screech owl | 0.44 | 0.44 |
| Silver | 2 | Rat | 17.8 | 34.8 | ---[j] | --- | --- |
| **Organic** | | | | | | | |
| HMX | --- | Mouse[k] | 3[k] | 3 | --- | --- | --- |

[a]In milligrams per kilogram soil.
[b]From Will and Suter (1995), except where noted.
[c]Body weights (in kilograms) for the no-observed-adverse-effect level (NOAEL) conversion are as follows: lab mouse, 0.030; lab rat, 0.350 (except where noted).
[d]From Sample et al. (1996), except where noted.
[e]In milligrams per kilogram body weight per day.
[f]Based upon NOAEL conversion methodology presented in Sample et al. (1996), using a deer mouse body weight of 0.0239 kilogram and a mammalian scaling factor of 0.25.
[g]Based upon NOAEL conversion methodology presented in Sample et al. (1996). The avian scaling factor of 0.0 was used, making the NOAEL independent of body weight.
[h]Body weight: 0.435 kilogram.
[i]Body weight: 0.303 kilogram.
[j]--- designates insufficient toxicity data.
[k]From Maxwell and Opresko (1996); body weight 0.023 kg.

Insufficient toxicity information was found to estimate the LOAELs or NOAELs for some COPECs for terrestrial plant life and wildlife receptors, respectively.

The benchmark used for exposure of terrestrial receptors to radiation was 0.1 rad/day. This value has been recommended by the International Atomic Energy Agency (IAEA 1992) for the protection of terrestrial populations. Because plants and insects are less sensitive to radiation than vertebrates (Whicker and Schultz 1982), the dose of 0.1 rad/day should also offer sufficient protection to other components within the terrestrial habitat of SWMU 108.

### VII.3.4 Risk Characterization

Maximum soil concentrations and estimated dietary exposures were compared to plant and wildlife benchmark values, respectively. Results of these comparisons are presented in Table 14. HQs are used to quantify the comparison with benchmarks for plants and wildlife exposure.

Analytes with HQs exceeding unity for plants were lead and silver. Barium and HMX resulted in HQs greater than 1.0 for the omnivorous and insectivorous mouse. Only HMX resulted in an HQ greater than unity for the herbivorous mouse. No analytes resulted in an HQ greater than 1.0 for the burrowing owl, although HQs for the burrowing owl could not be determined for HMX and silver. As directed by the NMED, HIs were calculated for each of the receptors. The HI is the sum of chemical-specific HQs for all pathways for a given receptor. All receptors were found to have HIs greater than one.

Tables 15 and 16 summarize the internal and external dose rate model results for the four radionuclides. The total radiation dose rate to the deer mouse was predicted to be 8.9E-3 rad/day. Total dose rate to the burrowing owl was predicted to be 8.5E–3 rad/day. The external dose rate from exposure to these radionuclides for both receptors is the primary contributor to the total dose rate. The dose rates for the deer mouse and the burrowing owl are considerably less than the benchmark of 0.1 rad/day.

### VII.3.5 Uncertainty Assessment

Many uncertainties are associated with the characterization of ecological risks at SWMU 108. These uncertainties result from assumptions used in calculating risk that may overestimate or underestimate true risk presented at a site. For this risk assessment, assumptions are made that are more likely to overestimate exposures and risk rather than to underestimate them. These conservative assumptions are used to be more protective of the ecological resources potentially affected by the site. Conservatisms incorporated into this risk assessment include the use of the maximum measured soil concentrations to evaluate risk, the use of wildlife toxicity benchmarks based upon NOAEL values, the use of earthworm-based transfer factors for modeling COPECs into soil invertebrates in the absence of insect data, the incorporation of strict herbivorous and strict insectivorous diets for predicting the extreme HQ values for the deer mouse, and the use of 1.0 as the area use factor for wildlife receptors regardless of seasonal use or home range size. Furthermore, the maximum measured soil concentration may have been from depths that are not accessible to ecological receptors.

**Table 14**
**Hazard Quotients for Ecological Receptors at SWMU 108**

| Constituent of Potential Ecological Concern | Plant Hazard Quotient[a] | Deer Mouse Hazard Quotient (Herbivorous)[a] | Deer Mouse Hazard Quotient (Omnivorous)[a] | Deer Mouse Hazard Quotient (Insectivorous)[a] | Burrowing Owl Hazard Quotient |
|---|---|---|---|---|---|
| **Inorganic** | | | | | |
| Barium | 7.7E–1 | 9.6E–1 | **3.4E+0** | **5.8E+0** | 4.2E–2 |
| Cadmium | 5.4E–1 | 7.7E-2 | 8.0E-2 | 8.3E-2 | 2.6E-3 |
| Lead | **7.2E+0** | 4.0E–1 | 3.1E–1 | 2.2E–1 | 2.1E–1 |
| Mercury (inorganic) | 1.9E–1 | 6.5E–4 | 6.5E–4 | 6.5E–4 | 1.2E–2 |
| Mercury (organic) | 1.9E–1 | 1.5E–1 | 1.5E–1 | 1.5E–1 | 8.2E–1 |
| Selenium | 9.4E–1 | 2.0E–1 | 2.9E–1 | 3.8E–1 | 6.2E–2 |
| Silver | **2.8E+0** | 2.6E–2 | 1.6E–2 | 6.8E–3 | ---[b] |
| **Organic** | | | | | |
| HMX | --- | **6.1E+0** | **4.5E+0** | **3.0E+0** | --- |
| | | | | | |
| Hazard Index[c] | **1.2E+1** | **7.9E+0** | **8.7E+0** | **9.6E+0** | **1.1E+0** |

[a]**Bold** text indicates HQ exceeds unity.
[b]--- designates insufficient toxicity data available for risk estimation purposes.
[c]The HI is the sum of individual hazard quotients using the value for organic mercury as a conservative estimate of the HI.
SWMU = Solid waste management unit.
HI = Hazard index.
HQ = Hazard quotient.

**Table 15**
**Internal and External Dose Rates for**
**Deer Mice Exposed to Radionuclides at SWMU 108**

| Radionuclide | Maximum Concentration (pCi/g) | Internal Dose (rad/day) | External Dose (rad/day) | Total Dose (rad/day) |
|---|---|---|---|---|
| U-234 | 6.8E+0 | 7.5E–5 | 7.6E–7 | 7.6E–5 |
| U-235 | 8.4E–1 | 8.8E–6 | 1.4E–5 | 2.3E–5 |
| U-238 | 5.4E+1 | 5.3E–4 | 8.2E–3 | 8.7E–3 |
| Th-234+D[a] | 6.6E+1 | 6.7E–8 | 1.0E–4 | 1.0E–4 |
| Total | | 6.1E–4 | 8.3E–3 | 8.9E–3 |

[a]The dose rate calculation for Th-234 includes its radioactive daughter, protactinium-234m.
pCi/g = Picocurie(s) per gram.
SWMU = Solid waste management unit.

**Table 16**
**Internal and External Dose Rates for**
**Burrowing Owls Exposed to Radionuclides at SWMU 108**

| Radionuclide | Maximum Concentration (pCi/g) | Internal Dose (rad/day) | External Dose (rad/day) | Total Dose (rad/day) |
|---|---|---|---|---|
| U-234 | 6.8E+0 | 2.6E–5 | 7.6E–7 | 2.7E–5 |
| U-235 | 8.4E–1 | 3.1E–6 | 1.4E–5 | 1.7E–5 |
| U-238 | 5.4E+1 | 1.9E–4 | 8.2E–3 | 8.4E–3 |
| Th-234+D[a] | 6.6E+1 | 4.6E–8 | 1.0E–4 | 1.0E–4 |
| Total | | 2.2E–4 | 8.3E–3 | 8.5E–3 |

[a]The dose rate calculation for Th-234 includes its radioactive daughter, protactinium-234m.
pCi/g = Picocurie(s) per gram.

Uncertainties associated with the estimation of risk to ecological receptors following exposure to U-234, U-235, U-238, and Th-234 are primarily related to those inherent in the radionuclide-specific data. Radionuclide-dependent data are measured values that have their associated errors, which are typically negligible. The dose rate models used for these calculations are based upon conservative estimates on receptor shape, radiation absorption by body tissues, and intake parameters. The goal is to provide a realistic, but conservative, estimate of a receptor's exposure to radionuclides in soil, both internally and externally.

One large uncertainty associated with the prediction of ecological risks at this site is the use of maximum measured soil concentrations to evaluate risk. This "worse-case scenario" does not necessarily reflect actual conditions and likely results in an over-prediction of risk. Analytical data were examined more closely to assess variability within the data. With regard to the maximum HMX concentration of 4.23 mg/kg, this concentration is based upon a total of 32 surface soil samples. Of the 32 samples analyzed for HMX, only 4 were found to have detectable concentrations of the compound. Detected concentrations ranged from 7.2E–2 to 4.23 mg/kg, with an average detected concentration of 1.23 mg/kg. Inclusion of all detected and nondetected HMX data into the estimation of an average exposure concentration would result in a finding of no ecological risk. The average barium concentration measured in surface soil at the site was 1.1E+2 mg/kg, with a range of 4.1E+1 to 3.6E+2 mg/kg. This concentration is less than the background concentration used for barium. Consequently, risks to plant communities on-site are not expected to be significant. Lead concentrations measured in surface soils from SWMU 108 ranged from 3.5E+0 to 3.6E+2 mg/kg, with an average concentration of 1.94E+1 mg/kg. Exposure of plants at the site to this average concentration would not result in an HQ greater than unity. Silver was detected in 15 of the 32 surface soil samples. Detected concentrations ranged from 8.3E–2 to 5.6E+0 mg/kg, with an average detected concentration of 5.6E–1 mg/kg. This average detected concentration would not result in risk to on-site vegetation.

Background concentrations are included as components of maximum on-site concentrations. Table 17 illustrates risk estimates associated with exposure of each receptor to background concentrations of metal COPECs. An assumption that mercury in soil and prey is exclusively in an organic form resulted in HQs in excess of unity for the plant, deer mouse, and burrowing owl. Another confounding factor associated with the background concentration for mercury is that it is based upon a detection limit where one-half of the detection limit was used to estimate risk. Background barium concentrations were also predicted to be hazardous to the omnivorous and insectivorous mouse. Background constitutes approximately 34 percent of the maximum barium concentration used in the estimation of risk. No other background concentrations contributed significantly to predicted ecological risks associated with SWMU 108.

As illustrated above, consideration of site-specific exposure conditions results in a more realistic estimation of risk. Based upon the home range size of 35 acres for the burrowing owl and the size of SWMU 108 (approximately 2.2 acres, an area use factor of approximately 6.3E–2 could be applied to the HQ for this species. This would result in an even less potential for adverse risk to the owl from exposure to COPECs at SWMU 108.

Based upon this uncertainty analysis, ecological risks at SWMU 108 are expected to be low. No HQ was found to exceed a value of 7.2. Over-estimations of risks predicted through the

## Table 17
## Hazard Quotients for Ecological Receptors Exposed to Background Concentrations for SWMU 108

| Constituent of Potential Ecological Concern | Plant HQ[a] | Deer Mouse HQ (Herbivorous)[a] | Deer Mouse HQ (Omnivorous)[a] | Deer Mouse HQ (Insectivorous)[a] | Burrowing Owl HQ |
|---|---|---|---|---|---|
| **Inorganic** | | | | | |
| Barium | 2.6E–1 | 3.3E–1 | **1.1E+0** | **2.0E+0** | 1.4E–2 |
| Cadmium | 1.7E–1 | 2.4E–2 | 2.5E–2 | 2.6E–2 | 8.1E–4 |
| Lead | 2.4E–1 | 1.3E–2 | 1.0E–2 | 7.0E–3 | 6.9E–3 |
| Mercury (inorganic) | **1.7E+0** | 5.7E–3 | 5.7E–3 | 5.7E–3 | 1.0E–1 |
| Mercury (organic) | **1.7E+0** | **1.3E+0** | **1.3E+0** | **1.3E+0** | **7.1E+0** |
| Selenium | 3.0E–1 | 1.0E–1 | 1.5E–1 | 2.0E–1 | 3.3E–2 |
| Silver | 2.5E–1 | 2.3E–3 | 1.4E–3 | 6.0E–4 | ---[b] |
| | | | | | |
| Hazard Index[c] | **2.9E+0** | **1.8E+0** | **2.6E+0** | **3.5E+0** | **7.2E+0** |

[a]**Bold** text indicates HQ exceeds unity.
[b]--- designates insufficient toxicity data available for risk estimation purposes.
[c]The HI is the sum of individual HQs using the value for organic mercury as a conservative estimate of the HI.
HI = Hazard index.
HQ = Hazard quotient.
SWMU = Solid waste management unit.

calculation of HQ were attributed to use of maximum exposure concentrations, contributions from background, conservative toxicity characteristics, and maximum area use factors.

### VII.3.6 Risk Interpretation

Ecological risks associated with SWMU 108 were estimated through a screening assessment that incorporated site-specific information when available. Ecological risks were predicted for plants exposed to lead and silver; and to deer mice exposed to barium and HMX. No risk was predicted for burrowing owl. Closer examination of the uncertainties associated with the estimation of risk indicated that over-estimations of predicted risks were attributed to use of maximum exposure concentrations, contributions from background, and conservative toxicity characteristics. Use of average exposure concentrations result in a more realistic exposure pattern for the plants and mice with a substantial reduction in predicted risk. Based upon this final analysis, ecological risks associated with SWMU 108 are expected to be low.

### VII.3.7 Screening Assessment Scientific/Management Decision Point

Once potential ecological risks associated with the site have been assessed, a decision is made as whether the site should be recommended for NFA or additional data collected to more thoroughly assess actual ecological risk at the site. With respect to this site, ecological risks were predicted to be low. The scientific/management decision is to recommend this site for NFA.

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# Appendix 1
# EXPOSURE PATHWAY DISCUSSION FOR CHEMICAL AND RADIONUCLIDE CONTAMINATION

## Background

Sandia National Laboratories (SNL) proposes that a default set of exposure routes and associated default parameter values be developed for each future land-use designation being considered for SNL/NM Environmental Restoration (ER) project sites. This default set of exposure scenarios and parameter values would be invoked for risk assessments unless site-specific information suggested other parameter values. Because many SNL/NM SWMUs have similar types of contamination and physical settings, SNL believes that the risk assessment analyses at these sites can be similar. A default set of exposure scenarios and parameter values will facilitate the risk assessments and subsequent review.

The default exposure routes and parameter values suggested are those that SNL views as resulting in a Reasonable Maximum Exposure (RME) value. Subject to comments and recommendations by the USEPA Region VI and NMED, SNL proposes that these default exposure routes and parameter values be used in future risk assessments.

At SNL/NM, all Environmental Restoration sites exist within the boundaries of the Kirtland AFB. Approximately 157 potential waste and release sites have been identified where hazardous, radiological, or mixed materials may have been released to the environment. Evaluation and characterization activities have occurred at all of these sites to varying degrees. Among other documents, the SNL/ER draft Environmental Assessment (DOE 1996) presents a summary of the hydrogeology of the sites, the biological resources present and proposed land use scenarios for the SNL/NM SWMUs. At this time, all SNL/NM SWMUs have been tentatively designated for either industrial or recreational future land use. The NMED has also requested that risk calculations be performed based upon a residential land use scenario. All three land use scenarios will be addressed in this document.

The SNL/NM ER project has screened the potential exposure routes and identified default parameter values to be used for calculating potential intake and subsequent hazard index, risk and dose values. EPA (EPA 1989a) provides a summary of exposure routes that could potentially be of significance at a specific waste site. These potential exposure routes consist of:

- Ingestion of contaminated drinking water;
- Ingestion of contaminated soil;
- Ingestion of contaminated fish and shell fish;
- Ingestion of contaminated fruits and vegetables;
- Ingestion of contaminated meat, eggs, and dairy products;
- Ingestion of contaminated surface water while swimming;
- Dermal contact with chemicals in water;
- Dermal contact with chemicals in soil;
- Inhalation of airborne compounds (vapor phase or particulate), and;

- External exposure to penetrating radiation (immersion in contaminated air; immersion in contaminated water and exposure from ground surfaces with photon-emitting radionuclides).

Based upon the location of the SNL SWMUs and the characteristics of the surface and subsurface at the sites, we have evaluated these potential exposure routes for different land use scenarios to determine which should be considered in risk assessment analyses (the last exposure route is pertinent to radionuclides only). At SNL/NM SWMUs, there does not presently occur any consumption of fish, shellfish, fruits, vegetables, meat, eggs, or dairy products that originate on-site. Additionally, no potential for swimming in surface water is present due to the high-desert environmental conditions. As documented in the RESRAD computer code manual (ANL 1993), risks resulting from immersion in contaminated air or water are not significant compared to risks from other radiation exposure routes.

For the industrial and recreational land use scenarios, SNL/NM ER has therefore excluded the following four potential exposure routes from further risk assessment evaluations at any SNL/NM SWMU:

- Ingestion of contaminated fish and shell fish;
- Ingestion of contaminated fruits and vegetables;
- Ingestion of contaminated meat, eggs, and dairy products; and
- Ingestion of contaminated surface water while swimming.

That part of the exposure pathway for radionuclides related to immersion in contaminated air or water is also eliminated.

For the residential land-use scenario, we will include ingestion of contaminated fruits and vegetables because of the potential for residential gardening.

Based upon this evaluation, for future risk assessments, the exposure routes that will be considered are shown in Table 1. Dermal contact is included as a potential exposure pathway in all land use scenarios. However, the potential for dermal exposure to inorganics is not considered significant and will not be included. In general, the dermal exposure pathway is generally considered to not be significant relative to water ingestion and soil ingestion pathways but will be considered for organic components. Because of the lack of toxicological parameter values for this pathway, the inclusion of this exposure pathway into risk assessment calculations may not be possible and may be part of the uncertainty analysis for a site where dermal contact is potentially applicable.

**Table 1**
**Exposure Pathways Considered for Various Land Use Scenarios**

| Industrial | Recreational | Residential |
|---|---|---|
| | | |
| Ingestion of contaminated drinking water | Ingestion of contaminated drinking water | Ingestion of contaminated drinking water |
| Ingestion of contaminated soil | Ingestion of contaminated soil | Ingestion of contaminated soil |
| Inhalation of airborne compounds (vapor phase or particulate) | Inhalation of airborne compounds (vapor phase or particulate) | Inhalation of airborne compounds (vapor phase or particulate) |
| Dermal contact | Dermal contact | Dermal contact |
| External exposure to penetrating radiation from ground surfaces | External exposure to penetrating radiation from ground surfaces | Ingestion of fruits and vegetables |
| | | External exposure to penetrating radiation from ground surfaces |

Equations and Default Parameter Values for Identified Exposure Routes

In general, SNL/NM expects that ingestion of compounds in drinking water and soil will be the more significant exposure routes for chemicals; external exposure to radiation may also be significant for radionuclides. All of the above routes will, however, be considered for their appropriate land use scenarios. The general equations for calculating potential intakes via these routes are shown below. The equations are from the Risk Assessment Guidance for Superfund (RAGS): Volume 1 (EPA 1989a and 1991). These general equations also apply to calculating potential intakes for radionuclides. A more in-depth discussion of the equations used in performing radiological pathway analyses with the RESRAD code may be found in the RESRAD Manual (ANL 1993). Also shown are the default values SNL/NM ER suggests for use in Reasonable Maximum Exposure (RME) risk assessment calculations for industrial, recreational, and residential scenarios, based upon EPA and other governmental agency guidance. The pathways and values for chemical contaminants are discussed first, followed by those for radionuclide contaminants. RESRAD input parameters that are left as the default values provided with the code are not discussed. Further information relating to these parameters may be found in the RESRAD Manual (ANL 1993).

Generic Equation for Calculation of Risk Parameter Values

The equation used to calculate the risk parameter values (i.e., Hazard Quotient/Index, excess cancer risk, or radiation total effective dose equivalent [dose]) is similar for all exposure pathways and is given by:

Risk (or Dose) = Intake x Toxicity Effect (either carcinogenic, noncarcinogenic, or radiological)

$$= C \times (CR \times EFD/BW/AT) \times \text{Toxicity Effect} \quad (1)$$

where

C = contaminant concentration (site specific);
CR = contact rate for the exposure pathway;
EFD= exposure frequency and duration;
BW = body weight of average exposure individual;
AT = time over which exposure is averaged.

The total risk/dose (either cancer risk or hazard index) is the sum of the risks/doses for all of the site-specific exposure pathways and contaminants.

The evaluation of the carcinogenic health hazard produces a quantitative estimate for excess cancer risk resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of the quantitative estimate with the potentially acceptable risk range of $10^{-4}$ to $10^{-6}$. The evaluation of the noncarcinogenic health hazard produces a quantitative estimate (i.e., the Hazard Index) for the toxicity resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of this quantitative estimate with the EPA standard Hazard Index of unity (1). The evaluation of the health hazard due to radioactive compounds produces a quantitative estimate of doses resulting from the COCs present at the site.

The specific equations used for the individual exposure pathways can be found in RAGS (EPA 1989a) and the RESRAD Manual (ANL 1993). Table 2 shows the default parameter values suggested for used by SNL at SWMUs, based upon the selected land use scenario. References are given at the end of the table indicating the source for the chosen parameter values. The intention of SNL is to use default values that are consistent with regulatory guidance and consistent with the RME approach. Therefore, the values chosen will, in general, provide a conservative estimate of the actual risk parameter. These parameter values are suggested for use for the various exposure pathways based upon the assumption that a particular site has no unusual characteristics that contradict the default assumptions. For sites for which the assumptions are not valid, the parameter values will be modified and documented.

Summary

SNL proposes the described default exposure routes and parameter values for use in risk assessments at sites that have an industrial, recreational or residential future land-use scenario. There are no current residential land-use designations at SNL SWMUs, but this scenario has been requested to be considered by the NMED. For sites designated as industrial or recreational land-use, SNL will provide risk parameter values based upon a residential land-use scenario to indicate the effects of data uncertainty on risk value calculations or in order to potentially mitigate the need for institutional controls or restrictions on Sandia SWMUs. The parameter values are based upon EPA guidance and supplemented by information from other government sources. The values are generally consistent with those proposed by Los Alamos National Laboratory, with a few minor variations. If these exposure routes and parameters are acceptable, SNL will use them in risk assessments for all sites where the assumptions are consistent with site-specific conditions. All deviations will be documented.

**Table 2**
**Default Parameter Values for Various Land Use Scenarios**

| Parameter | Industrial | Recreational | Residential |
|---|---|---|---|
| **General Exposure Parameters** | | | |
| Exposure frequency (d/y) | *** | *** | *** |
| Exposure duration (y) | 30[a,b] | 30[a,b] | 30[a,b] |
| Body weight (kg) | 70[a,b] | 56[a,b] | 70 adult[a,b]<br>15 child |
| Averaging Time (days)<br>for carcinogenic compounds<br>(=70 y x 365 d/y)<br>for noncarcinogenic compounds<br>(=ED x 365 d/y) | <br>25550[a]<br><br>10950 | <br>25550[a]<br><br>10950 | <br>25550[a]<br><br>10950 |
| | | | |
| **Soil Ingestion Pathway** | | | |
| Ingestion rate | 100 mg/d[c] | 6.24 g/y[d] | 114 mg-y/kg-d[a] |
| | | | |
| **Inhalation Pathway** | | | |
| Inhalation rate ($m^3$/yr) | 5000[a,b] | 146[d] | 5475[a,b,d] |
| Volatilization factor ($m^3$/kg) | chemical specific | chemical specific | chemical specific |
| Particulate emission factor ($m^3$/kg) | 1.32E9[f] | 1.32E9[f] | 1.32E9[f] |
| | | | |
| **Water Ingestion Pathway** | | | |
| Ingestion rate (L/d) | 2[a,b] | 2[a,b] | 2[a,b] |
| | | | |
| **Food Ingestion Pathway** | | | |
| Ingestion rate (kg/yr) | NA | NA | 138[b,d] |
| Fraction ingested | NA | NA | 0.25[b,d] |
| | | | |
| **Dermal Pathway** | | | |
| Surface area in water ($m^2$) | 2[b,e] | 2[b,e] | 2[b,e] |
| Surface area in soil ($m^2$) | 0.53[b,e] | 0.53[b,e] | 0.53[b,e] |
| Permeability coefficient | chemical specific | chemical specific | chemical specific |

*** The exposure frequencies for the land use scenarios are often integrated into the overall contact rate for specific exposure pathways. When not included, the exposure frequency for the industrial land use scenario is 8 h/d for 250 d/y; for the recreational land use, a value of 2 hr/wk for 52 wk/y is used (EPA 1989b); for a residential land use, all contact rates are given per day for 350 d/y.

[a]RAGS, Vol. 1, Part B (EPA 1991).

[b]Exposure Factors Handbook (EPA 1989b)

[c]EPA Region VI guidance.

[d]For radionuclides, RESRAD (ANL 1993) is used for human health risk calculations; default parameters are consistent with RESRAD guidance.

[e]Dermal Exposure Assessment (EPA 1992).

[f]EPA 1996.

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October 13, 2003

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