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1998 Annual Site Environmental Report Tonopah Test Range, Nevada

Dianne Duncan and Rebecca Sanchez

Prepared by

Sandia National Laboratories

Albuquerque, New Mexico 87185 and Livermore, California 94550

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1998

Annual Site Environmental Report

Tonopah Test Range, Nevada

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Produced by
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ABSTRACT

Sandia National Laboratories (SNL) operates the Tonopah Test Range (TTR) for the Department of Energy (DOE) Weapons Ordnance Program. This annual report (calendar year 1998) summarizes the compliance status to environmental regulations applicable at the site including those statutes that govern air and water quality, waste management, cleanup of contaminated areas, control of toxic substances, and adherence to requirements as related to the National Environmental Policy Act (NEPA). In compliance with DOE orders, SNL also conducts environmental surveillance for radiological and nonradiological contaminants. SNL's responsibility for environmental surveillance at TTR extends only to those areas where SNL activities are carried out. Annual radiological and nonradiological routine releases and unplanned releases (occurrences) are also summarized. This report has been prepared in accordance with DOE Order 5400.1, *General Environmental Protection Program* (DOE 1990a).

PREFACE

This report presents summary information on the compliance status and monitoring results for the Tonopah Test Range (TTR). Appendix B contains all relevant location maps for sampling activities described in Chapter 4. Ancillary information at the end of the report lists acronyms, units, and other abbreviations.

Radar Tracking Station at the Tonopah Test Range

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<i>Joe Bonaguidi</i>	Surface water discharges
<i>Todd Culp</i>	Radiological and nonradiological surveillance of air and terrestrial media, including National Emission Standards for Hazardous Air Pollutants (NESHAP) compliance, and Clean Slate Site information
<i>Dianne Duncan</i>	Site information, geology, fauna, and climate
<i>Charles Fink</i>	Storm water
<i>William Forston</i>	Environmental monitoring activities and waste management, as well as general input to all areas of this report (Bill is SNL's TTR site lead for most environmental activities.)
<i>Joseph Guerrero</i>	National Environmental Policy Act (NEPA) activities
<i>Heidi Herrera</i>	Radiological and nonradiological terrestrial media statistical data analyses
<i>Adrian Jones</i>	Wastewater discharges
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<i>Jason Moore</i>	Environmental Restoration (ER) Project

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CONTENTS

ABSTRACT

EXECUTIVE SUMMARY

1.0	INTRODUCTION	1-1
1.1	TTR History and Operations	1-1
1.2	Site Description and Demographics	1-3
1.3	Regional Geology, Hydrology, Climate, and Fauna	1-4
1.4	Clean Slate and Double Tracks Sites	1-5
2.0	COMPLIANCE SUMMARY	2-1
2.1	Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)	2-1
2.2	Resource Conservation and Recovery Act (RCRA)	2-2
2.3	Federal Facilities Compliance Act (FFCA)	2-2
2.4	Clean Air Act (CAA) and Clean Air Act Amendments of 1990 (CAAA)	2-3
2.5	Clean Water Act (CWA)	2-3
2.6	Safe Drinking Water Act (SDWA)	2-3
2.7	Toxic Substances Control Act (TSCA)	2-4
2.8	Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	2-4
2.9	National Environmental Policy Act (NEPA)	2-4
2.10	Endangered Species Act (ESA)	2-5
2.11	Cultural Resources Acts	2-5
2.12	Executive Orders (EOs)	2-5
2.13	1998 Audits	2-6
2.14	1998 Issues and Actions for TTR	2-6
2.15	Environmental Permits	2-6
2.16	Occurrence Reporting	2-7
3.0	ENVIRONMENTAL PROGRAM INFORMATION	3-1
3.1	Environmental Restoration (ER) Activities	3-1
3.2	Spill Prevention Control and Countermeasures (SPCC) Plan	3-2
3.3	Waste Management Programs	3-2
3.4	National Environmental Policy Act (NEPA) Program	3-8
3.5	Local Environmental Monitoring Performed by Outside Agencies	3-8
3.6	Summary of Release Reporting	3-12
4.0	TERRESTRIAL SURVEILLANCE AND WATER MONITORING	4-1
4.1	Terrestrial Surveillance Objectives, Sampling Site Selection, and Analysis Method	4-1
4.2	Terrestrial Surveillance Results	4-4
4.2.1	Stable Metal Soil Sampling Results	4-4
4.2.2	Soil Sampling Results - Radiological Analyses	4-5
4.2.3	Trend Analyses (1994 - 1998)	4-6
4.2.4	Results from NEDS Lake and Antelope Lake Sampling Event)	4-7

CONTENTS (Concluded)

4.2.5	Thermoluminescent Dosimeter (TLD) Monitoring Results	4-8
4.3	Perspective on Plutonium Distribution in the Environment	4-9
4.4	Environmental Monitoring Performed by TPG	4-10
4.5	Water Monitoring	4-10
4.5.1	Production Well Monitoring	4-10
4.5.2	Sewage System and Septic Tank Monitoring	4-11
4.5.3	Storm Water Monitoring	4-12
5.0	AIR QUALITY SURVEILLANCE AND EMISSIONS MONITORING	5-1
5.1	Radiological Air Monitoring	5-1
6.0	REFERENCES	6-1
	ANCILLARY INFORMATION	G-1
APPENDIX A	State of Nevada Regulations and Permit Listings	
APPENDIX B	Sampling Location Maps and Radiological Results	

TABLES

1-1	Project Roller Coaster Test Information	1-7
2-1	SNL Reporting Activities for TTR in 1998 with Respect to SARA Title III Compliance.....	2-2
2-2	Summary of Environmental Audits Performed at TTR in 1998	2-7
2-3	Summary of Permit Ownership at TTR	2-7
3-1	DOE/NV Environmental Restoration (ER) Project TTR Corrective Action Units (CAUs) and Corrective Action Sites (CASS)	3-3
3-2	Summary of 1998 Industrial and Soil Sites DOE/NV Environmental Restoration (ER) Activities.	3-7
3-3	RCRA-Regulated Hazardous Waste Shipped Offsite in 1998	3-9
3-4	Non-RCRA-Regulated Hazardous or Toxic Waste Shipped Offsite in 1998	3-10
3-5	Regulated Hazardous or Toxic Waste Shipped Offsite in 1998 for Recycling.	3-10
3-6	Categories of Radioactive Waste Shipped to NTS for Disposal in 1998	3-11
4-1	Sampling Locations at TTR.....	4-3
4-2	Radiological Summary Data for Soil Samples Collected at TTR in 1998	4-6
4-3	Summary of Thermoluminescent Dosimeter (TLD) Measurements for 1998	4-9
5-1	Calculated Dose Assessment Results for Onsite Receptor	5-2

FIGURES

1-1	Location of Tonopah Test Range (TTR) Within the Boundaries of the Nellis Air Force Range (NAFR), Nevada.....	1-2
1-2	Location of Facilities Operated by SNL at TTR	1-7
5-1	TTR Onsite Receptor Locations.....	5-2

B-2A/B61-11 Certification Drop - TTR (Nov. 20, 1996)

Executive Summary

As required by U.S. Department of Energy (DOE) Order 5400.1, *General Environmental Protection Program* (DOE 1990a), this Annual Site Environmental Report (ASER) has been prepared for Sandia National Laboratories, Nevada (SNL/NV) to characterize current environmental conditions in the vicinity of SNL's operations at the Tonopah Test Range (TTR) and to summarize compliance status with Federal, State, and local requirements and permits. This report represents a key component of the DOE's effort to keep the public informed about environmental conditions throughout the DOE complex.

TTR is located within the boundaries of the Nellis Air Force Range (NAFR) in Nevada and is sited on 336,665 acres at the north end of the range. TTR is used to support activities related to the missions of the DOE and the United States Air Force (USAF). SNL operates TTR for research and development and component testing activities related to DOE's weapons ordnance programs. These activities include air drops, gun firings, ground-launched rockets, air-launched rockets, and other explosive tests.

The following paragraphs present the major activities, accomplishments, and results of various environmental programs conducted at TTR under SNL's cognizance during 1998. These environmental program areas and activities include:

- Waste management
- Environmental Restoration (ER)
- Terrestrial surveillance
- Water quality monitoring
- Air quality compliance

- National Environmental Policy Act (NEPA) activities
- Environmental occurrences

WASTE MANAGEMENT

TTR is classified as a "small quantity generator" for hazardous waste under the Resource Conservation and Recovery Act (RCRA). In 1998, SNL shipped out 8,767 kg of RCRA-hazardous waste, of which 7,642 kg was derived from the ER remediation work. A total of 105,971 kg of regulated non-RCRA waste was also shipped, of which 104,188 kg was ER soils. The total amount of ER waste shipped in 1998 (radioactive and chemical waste) was 130,181 kg. This included stored waste as well as waste generated in 1998; most of this was contaminated soils. All waste was shipped to permitted treatment, storage, and disposal facilities (TSDFs). Waste management is conducted by SNL's onsite contractor, The Plus Group (TPG).

An informal waste minimization and recycling program is practiced at TTR. Recycled items include used oil, various battery types, solvents, lead, silver, and fluorescent and sodium light bulbs. A total of 9,673 kg of recyclables were shipped offsite for energy recovery or recycling in 1998.

ENVIRONMENTAL RESTORATION (ER)

ER activities at TTR are managed through the DOE Nevada Office (DOE/NV). The DOE currently has 47 Corrective Action Units

(CAUs) designated at TTR. These have been categorized into four "Soil Sites CAUs" and 43 "Industrial Sites CAUs." Each CAU comprises one or more specific Corrective Action Sites (CASs). ER sites at TTR include areas contaminated from past rocket firing and target tests, abandoned septic systems, solvent contaminated soils at previous underground storage tank (UST) areas, and disposal areas for ordnance, septic sludge, and depleted uranium (DU).

ER activities in 1998 included Corrective Action Investigations (CAIs) for several septic waste systems, landfills, and underground discharge points (UDPs). Closure activities were completed for the Cactus Spring waste trenches and the sewage lagoons at the Roller Coaster Sewage Lagoons and North Disposal Trench.

ER sites related to the Project Roller Coaster Tests are referred to as the Clean Slate Sites and the Double Tracks Site. These sites are contaminated over a large area with transuranics resulting from nuclear weapon destruction tests performed in 1963. Double Tracks is located west of TTR on NAFR, while all three Clean Slate sites are located within TTR boundaries. Remediation was completed for the Double Tracks site in 1996. Clean Slate 1 was remediated in 1997. The remaining two Clean Slate sites (2 and 3) are pending remediation.

TERRESTRIAL SURVEILLANCE

Soil samples were collected from SNL-controlled property areas and vicinity in June 1998. All soil samples were analyzed for total uranium (U_{tot}) and by gamma spectroscopy. Gamma spectroscopy was used primarily to detect the presence of americium. A total of 27 onsite and perimeter locations were sampled and compared to a total of 14 offsite sampling locations.

Results showed some onsite samples slightly elevated in comparison to offsite samples. Radiological analysis indicated slightly elevated results for uranium-235 at one perimeter location. Onsite, in the vicinity of the Clean Slate sites, elevated results were found for plutonium isotopes, americium-241, and uranium. All other locations were statistically indistinguishable from offsite locations.

WATER MONITORING

Water quality sampling at the production well for Area 3, supplying the Main Sandia Compound, was found to contain coliform bacteria above standards. The cause was due to a faulty chlorination system, which had stopped working one week prior to the sampling. Notifications were made to State authorities and onsite workers were alerted to the problem. There were no illnesses reported due to the contaminated water. The system was superchlorinated for several weeks and put back into normal service without further incident.

The USAF is required to submit a quarterly Discharge Monitoring Report (DMR) to the State of Nevada. SNL submits annual data for inclusion into the report. All results of wastewater sampled from the Area 3 compound in 1998 met regulatory standards.

AIR QUALITY COMPLIANCE AND MONITORING

Air emissions in 1998 were in compliance with the existing permits as listed in Table 2-3. Radiological and nonradiological ambient air quality monitoring is not required by SNL/NV at TTR. Chapter 5 of this report discusses the decision to conduct continuous air monitoring for one year at TTR. The monitoring was to determine the dose contributed from the Clean Slate sites due to the re-suspension of radiological contaminants (diffuse source). The

1998 dose assessment result for TTR has been determined to be 0.024 millirem/year (mrem/yr) at the TTR airport for the maximally exposed individual (MEI). This measurement is based on one year of continuous monitoring that was performed during 1996 and 1997.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

At TTR, NEPA compliance is a joint effort between SNL/NV and DOE Kirtland Area Office (DOE/KAO) in Albuquerque, New Mexico. Compliance is also supported by the assistance of the Desert Research Institute (DRI), a branch of the University of Nevada System. A total of seven NEPA Checklists were submitted to DOE/KAO for proposed actions.

The proposal to build an outdoor Fire Experiment Facility required the preparation of an Environmental Assessment (EA). The draft EA was completed on June 16, 1999.

ENVIRONMENTAL OCCURRENCES

One environmental release occurred in 1998. Approximately 32 gal of diesel fuel spilled to the ground in the Area 3 compound due to a broken float valve that controlled diesel flow from a main tank to a day tank. Contaminated soil was removed except for the area directly under the building foundation. A "closure in place" was requested from the State for the remaining contaminated soil.

Main Compound at Tonopah Test Range Showing Control Tower Overlooking the Range Flight Area

Introduction

The Tonopah Test Range (TTR) is located on 336,665 acres within the boundaries of the Nellis Air Force Range (NAFR) withdrawal and is used to support activities related to the missions of the U.S. Department of Energy (DOE) and the United States Air Force (USAF). Sandia National Laboratories, Nevada (SNL/NV) operates the TTR with respect to DOE's Weapons Ordnance Program.

As required in DOE Order 5400.1, *General Environmental Protection Program* (DOE 1990a), this Annual Site Environmental Report (ASER) has been prepared for the TTR to summarize data that characterize site environmental management performance and confirm compliance with Federal, State, and local environmental standards and requirements. This report contains summary information about the radiological and nonradiological environmental conditions of the site. The ASER represents a key component of the DOE's effort to keep the public informed about environmental conditions at DOE facilities.

1.1 TTR HISTORY AND OPERATIONS

In 1940, President Roosevelt established the "Las Vegas Bombing and Gunnery Range" (now referred to as NAFR), which is part of the

Nellis Air Force Base (NAFB) Complex. The Complex includes NAFB, located eight miles north of Las Vegas, Nevada, several auxiliary small arm ranges, and the NAFR—divided into a North Range and a South Range (Figure 1-1). The Nevada Test Site (NTS) is located between these two ranges. The entire NAFB Complex comprises approximately three million acres. TTR is 32 miles southeast of Tonopah, Nevada.

TTR Site Selection

TTR was eventually selected as a bombing range after similar facilities at the Salton Sea Test Base in California, as well as Yucca Flat on the NTS, became inadequate. By the mid-1950s, the atmosphere at the Salton Sea Test Base became permeated with haze, which limited visibility and hampered photography. Nevada's Yucca Flat site also became inadequate due to the increasing emphasis on low-altitude approaches and deliveries that required flat terrain and a long approach corridor. The TTR site was located in the northwest corner of the then Las Vegas Bombing and Gunnery Range. The site, which was approximately seven times the size of the Salton Sea Test Base, was well suited because it had the immense areas of flat terrain needed for the increasing use of rockets and low-altitude, high-speed aircraft operations. The area was withdrawn in 1956 and TTR became operational in 1957 to operate and test new weapon systems. In the years following World War II, facilities

FIGURE 1-1. Location of the Tonopah Test Range (TTR), Within the Boundaries of the Nellis Air Force Range (NAFR), Nevada

that were built at TTR were originally designed and equipped to gather data on aircraft delivered inert test vehicles under Atomic Energy Commission (AEC) cognizance (now DOE). Over the years, the facilities and capabilities at TTR were expanded to accommodate tests related to the DOE's Weapons Ordnance Program.

Operations Control Center

The Main Compound in Area 3 is the heart of the test range activities. The Operations Control Center, located on the top (2nd) floor of the Operations Building, controls and coordinates all test functions and affords a 360 degree view of the site. During test operations, the test director, range safety officer, test project engineer, camera controller, and range communicator, operate the consoles in the Center to control and coordinate all test functions.

Another key location at the range is Area 9, which has weapons storage facilities and is used to conduct ground to air rocket launching tests.

TTR Activities

Principal DOE activities at the TTR include: stockpile reliability testing; research and development testing support of structural development; arming, fusing and firing systems testing; and testing nuclear weapon delivery systems. (However, no nuclear devices are tested at the range.) TTR is instrumented with a wide array of signal tracking equipment including video, high-speed cameras, and radar tracking devices used to characterize ballistics, aerodynamics, and parachute performance on artillery shells, bomb drops, missiles, and rockets.

In recent years, specific test activities at TTR have consisted of the following:

- Air drops (trajectory studies of simulated weapons)
- Gun firings
- Ground-launched rockets (study of aeroballistics and material properties)
- Air-launched rockets (deployed from aircraft)
- Explosive testing (e.g., optimize design of shipping and storage containers)
- Static rocket tests (related to the Trident Submarine Program)
- Ground penetrator tests

These activities require a remote range for both public safety and to maintain national security. The majority of test activities at TTR occur within Cactus Flat, a valley with almost no topographical relief flanked by mountains and hills.

Site Responsibility

On October 1, 1997 a Memorandum of Agreement (MOA) was signed between DOE Albuquerque Operations Office (DOE/AL) and DOE Nevada Operations Office (DOE/NV) related to operational responsibility at TTR. The MOA specified that DOE/AL and DOE Kirtland Area Office (DOE/KAO) are responsible for the oversight of SNL activities at TTR. DOE/NV, however, will continue to be responsible for Environmental Restoration (ER) activities at the site. SNL/NV is overseen by DOE/NV and works in concert with SNL/NM for all environmental operations at TTR.

1.2 SITE DESCRIPTION AND DEMOGRAPHICS

TTR is sited within the NAFR at the northern boundary. The area north of the TTR boundary is sparsely populated public lands administered by both the Bureau of Land Management (BLM) and the U.S. Forest Service. The land is currently used to graze cattle. To the east of TTR, and also within the NAFR, is the Nevada Wild Horse Range. This land is also administered by the BLM.

The nearest residents are located in the town of Goldfield (population 659), approximately 35.4 km (22 mi) west of the site boundary. The town of Tonopah (population 3,616) is the next largest population center, approximately 48.2 km (30 mi) northwest of the site (DOC 1991). Las Vegas is 225.2 km (140 mi) from TTR. The total population within an 80-kilometer (50-mile) radius around TTR is approximately 6,871 (SNL 1999). This number includes the potential population at TTR if all housing units within the base were used.

1.3 REGIONAL GEOLOGY, HYDROLOGY, CLIMATE, AND FAUNA

Geology

The geology at TTR is characterized by broad, flat, valleys bordered by north/south trending mountain ranges. The regional area is located in the western part of the Basin and Range geophysical province. This area is marked by horst and graben topography, a system of mountains and down-dropped fault valleys formed through regional extension. TTR lies northeast of the Walker Lane, a zone of transcurrent faulting and shear, and the Las Vegas Valley shear zone to the southeast (Sinnock 1982). Cactus Flat, the main working area of TTR, is an alluvial-filled basin bordered by the Cactus Range to the west and the Kawich Range to the east. An area of low hills outcrops in the south. The Cactus Range, situated mostly within the boundaries of TTR, is the remnants of a major volcanic center consisting of relatively young (six million-year-old) folded and faulted tertiary volcanics. These mountains are one of at least five northwest-trending, raised structural blocks that lie along the Las Vegas Valley-Walker Lane lineaments (ERDA 1975). Elevations within TTR range from 1,630 m (5,347 ft) at the valley floor to 2,279 m (7,482 ft) at Cactus Peak. The town of Tonopah is at 6,030 ft.

Surface Water

Drainage patterns within and near TTR are intermittent (ephemeral stream channels) and end in closed basins. Ephemeral streams occasionally carry spring runoff to the center of Cactus Flat where there is a string of north-south trending dry lakes (playas); however, due to the high rate of evaporation, little is recharged to the groundwater (DRI 1991).

There are several small springs within the Cactus and Kawich Ranges. Three springs occur within TTR boundaries: Cactus, Antelope, and Silverbow Springs. Water from these springs does not travel more than several tens of meters dissipating rapidly through evaporation and infiltration with the effect on the landscape, purely local.

Groundwater

TTR derives its water from local wells. The U.S. Geological Survey (USGS) has recorded groundwater depths from 21 ft to 454 ft at the site. Groundwater is encountered at the Antelope Mine well in the Cactus Range at 21 ft and at the EH2 well, near the TTR Airport, at 454 ft. The depth to groundwater at the Area 9 well (north end of the site) is approximately 131 ft. South of that well, groundwater is encountered at 361 ft to 394 ft in Area 3. The static water level at Well 6 (the main water supply well) is approximately 350 ft.

Climate

The climate at TTR is mild and usually dry, but, as is typical of high deserts, is subject to large diurnal and seasonal changes in temperature—from a record high of 38.8 degrees Celsius (°C) (102 degrees Fahrenheit [°F]) to a record low of 24 °F (Schaeffer 1982). The hottest months are July and August with temperatures ranging from the 90s during the day and dropping to the 50s at night. Clear, sunny days with light to moderate winds are usual.

Rainfall is dependent on elevation. The annual average at the desert floor is 10 cm (4 in.) and 30.4 cm (12 in.) in the mountains. The primary rainfall season is in the summer with a lesser rainy season in the winter (DOI/BLM 1979).

Winds are mostly from the northwest from late fall to spring, and are influenced by the Pacific air flow patterns coming over the Sierra Nevada Mountains in California. From summer through early fall, the winds generally shift to a southeasterly direction coming from the Gulf of Mexico. Dust storms are common in the spring and dust devils are common in the summer.

Vegetation

Temperature extremes and arid conditions of the high desert limit vegetational coverage. Sparse vegetation occurring in Cactus Flat is predominantly range grasses and low shrubs typical of the Great Basin Desert flora (ERDA 1975; EG&G 1979a).

Vegetation is divided into two basic types at the site by elevation—salt desert shrub in the low areas and northern desert shrub in the higher elevations (DOI/BLM 1979, DRI 1991). Salt desert shrub is characteristic of poorly drained soils and is common along dry lake beds. Specific plants in this group include saltbrush, shadscale, greasewood, Russian thistle, and sagebrush. Northern desert shrub, found in the Cactus Range, includes sagebrush, rabbitbrush, squirrel tail, wheat grass, juniper, and Nevada bluegrass. Joshua trees and juniper grow in the transition zone at the base of the mountains.

Wildlife

The Nevada Wild Horse Range and other wild horse land-use areas compose a significant portion of the North Range with herds common in Cactus and Gold Flats, the Kawich Valley, Goldfield Hills, and the Stonewall Mountains. Hundreds of wild horses graze freely throughout TTR and the activities onsite have had apparently little effect on the horse population or their grazing habits. When the herd does become too large and overgrazing is a concern,

horses are rounded up for dispersal through BLM's Horse Adoption Program.

Other large mammals common to the area include pronghorn antelope, mule deer, kit fox, bobcat, coyote, and gray fox. To a lesser extent, bighorn sheep, mountain lions, and burros are also located in the area (DOI/BLM 1979, DRI 1991).

Common birds in the area include the American kestrel, hawks, owls, and quail.

In general, the NAFR land withdrawal has provided a positive effect on local plant and animal life. Since much of the withdrawn area is undisturbed by human activity, large habitat areas are protected from the effects of public use. For example, recreational off-road vehicles can cause significant impacts to desert flora and fauna and it can take years for fragile desert ecosystems to recover from disturbances.

1.4 CLEAN SLATE AND DOUBLE TRACKS SITES

Project Roller Coaster, performed in May and June of 1963, included a series of four nuclear weapons destruction tests that resulted in plutonium dispersal in the surrounding soils. Three of these tests were conducted within the boundaries of TTR; the fourth was conducted on the NAFR just west of the TTR. The locations of the three Project Roller Coaster tests at TTR are referred to as Clean Slates 1, 2, and 3. The fourth site at NAFR is referred to as Double Tracks. In 1996, the Double Tracks was closed after being remediated to a soil contamination level of less than or equal to 200 picocuries per gram (pCi/g) of transuranics (Figure 1-2).

Table 1 summarizes test information related to the four Project Roller Coaster sites. As previously noted, DOE/NV has responsibility for these and all other Environmental Restoration (ER) sites at TTR. SNL will continue to be responsible for environmental compliance at these sites.

The initial cleanup of each Clean Slate site was conducted shortly after each test. Test-related debris was bladed into a hole at test ground-zero and backfilled. An initial fence was built around each test area where the soil contamination was set at approximately 1,000 micrograms per square meter ($\mu\text{g}/\text{m}^2$) of plutonium. The soil survey was conducted on 61-meter grids with a hand-held survey meter or FIDLER (field instrument for the detection of low-energy radiation). In 1973, additional outer fences were set at 40 pCi/g of plutonium in soil also using the hand-held meter method. Soil sampling is conducted periodically at these sites and the areas are visually inspected twice a year to determine whether any fence repairs are required. When discovered, horses that may have wandered inside the fenced areas are promptly removed.

An aerial radiological survey was performed by EG&G, Inc. for the Nevada Applied Ecology Group (NAEG) in 1977. The aerial surveys were undertaken to supplement the FIDLER and previous soil sample measurements of transuranics. The objective was to determine the extent of surficial distribution of plutonium and other transuranic elements dispersed during the Project Roller Coaster tests. Radiation isopleths showing soil activity due to americium-241, plutonium-239, and plutonium-240 were drawn for each area. The cumulative area of the diffuse sources, as determined by the aerial survey, is 20 million square meters. The results of the survey found transuranic contamination outside the fenced area in the downwind direction (EG&G 1979b).

Air Monitoring at ER sites

Remediation activities were conducted at Clean Slate 1 in 1997. The Desert Research Institute (DRI) collected air monitoring data from several locations in the vicinity of Clean Slate 1 before, during, and after remediation activities. While these data have been validated, they have as yet only been presented to DOE/NV in draft reports. A final report is pending.

TABLE 1-1. Project Roller Coaster Test Information

Test Name	Date of Test	Location	Status
Clean Slate 1	May 25, 1963	TTR	Remediation completed in 1997
Clean Slate 2	May 31, 1963	TTR	Remediation on hold
Clean Slate 3	June 9, 1963	TTR	Remediation pending
Double Tracks	May 15, 1963	NAFR, North Range (west of TTR)	Remediation completed in 1996

SOURCE: IT 1996 -- Sampling and Analysis Plan for Clean Slate 1, September 1996.

FIGURE 1-2. Location of Facilities Operated by SNL at TTR

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Compliance Summary

SNL/NV is responsible for Environment, Safety and Health (ES&H) compliance for activities at TTR performed under its direction. This chapter discusses the status of ES&H compliance with Federal environmental statutes, regulations, Executive Orders, and DOE orders. Environmental audit summaries, occurrence reporting, and environmental permit status for 1998 are also discussed.

SNL/NV strives to meet 100 percent compliance with environmental laws, regulations, and other requirements established by Federal and State agencies. The State of Nevada implements most environmental regulations applicable to TTR. Specific State regulations are listed in Table A-1 of Appendix A, including regulations governing solid and hazardous waste management, wildlife, sewage systems, and radiation control. Radionuclide air emissions regulations are administered directly by the U.S. Environmental Protection Agency (EPA).

The Plus Group (TPG) contracts for SNL/NV to assist in performing various compliance activities such as air monitoring, water sampling, and waste characterization.

2.1 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)

CERCLA, commonly known as Superfund, defines certain assessment activities and reporting requirements for inactive waste sites at all Federal facilities. The National Priorities List (NPL) is an ordered ranking of top priority CERCLA sites based on a threshold level of contaminants present, as established by the EPA. There are no NPL designations located at the TTR site.

As required under CERCLA Section 120(d), a Preliminary Assessment (PA) was submitted for all facilities listed on the Federal agency hazardous waste compliance docket in 1988. TTR was in compliance with all applicable CERCLA requirements in 1998.

Superfund Amendments and Reauthorization Act (SARA), Title III

TPG assists SNL/NV in meeting two annual requirements: the SARA Title III, Emergency Planning and Community Right-to-Know Act (EPCRA) reporting requirements, and the State of Nevada's extremely hazardous materials reporting requirements. In 1998, neither report was required since SNL was below the reporting threshold for EPCRA and no extremely hazardous substances (EHSs) were used at TTR in 1998. Table 2-1 summarizes SNL's compliance with SARA Title III reporting requirements.

TABLE 2-1. SNL Reporting Activities for TTR in 1998 with Respect to SARA Title III Compliance

SARA, Title III (EPCRA)	Regulation Section Description	SNL Reporting			Explanation
		Yes	No	Not Required	
302 - 303	Planning Notification	✓			This report was submitted to notify State and local emergency response authorities and to carry out other facility notification responsibilities.
304	Emergency Release Notification			✓	There were no reportable quantity releases of EHS as defined under CERCLA. No EHS is used in routine operations at TTR.
311-312	MSDS/Chemical Inventory	✓			MSDS information is made available to local emergency organizations.
313	Toxic Release Inventory (TRI) Reporting			✓	SNL/NV was below the reporting threshold for any listed chemical.

NOTE: MSDS = Material Safety Data Sheet
EHS = Extremely Hazardous Substance

2.2 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

Under the RCRA Hazardous Waste Permit Program (40 CFR 270.61), TTR is permitted as a "small quantity generator." Under this designation, hazardous waste cannot be stored onsite for over 180 days before it must be shipped offsite for treatment and disposal at an EPA-permitted facility. At TTR, hazardous waste shipments are scheduled to occur at least two to three times per year. In 1998, there were eight hazardous waste shipments; two were made through Romic Environmental Technologies and six were shipped through Safety Kleen.

Sanitary solid waste, which is also regulated under RCRA, is disposed of at landfills onsite. There is one Class II sanitary landfill in operation at TTR operated by the USAF Operations and Maintenance (O&M) contractor. The landfill is used cooperatively by all organizations at TTR.

Underground Storage Tanks (USTs) – RCRA, Subtitle I (implemented under 40 CFR 280) sets forth requirements for USTs that contain hazardous materials or petroleum products. SNL/NV currently has no registered USTs in its ownership. The last five USTs were removed in August 1995; two diesel tanks and two gasoline tanks were removed from Area 3 at the site of a former gas station, and one diesel tank was removed from Area 9 that had supplied generator fuel.

2.3 FEDERAL FACILITIES COMPLIANCE ACT (FFCACT)

The FFCACT amendments to RCRA specifically address Land Disposal Restriction (LDR) requirements for the treatment of mixed waste (MW) at Federal facilities. Since the TTR does not generate MW and currently has no MW stored onsite, this statute is not applicable to SNL/NV operations.

2.4 CLEAN AIR ACT (CAA) AND CLEAN AIR ACT AMENDMENTS (CAAA) OF 1990

The requirements of the CAA and CAAA of 1990 are implemented by the State of Nevada air quality regulations. The EPA retains compliance authority for all radionuclide air releases, which are regulated by National Emission Standards for Hazardous Air Pollutants (NESHAP) and implemented under 40 CFR 61, Subpart H.

NESHAP Compliance

The Clean Slate sites, discussed in Chapter 1, have been the only source of radionuclide air emissions at TTR. Continuous air monitoring was completed at these sites in 1997. Air monitoring was performed at the location of the maximally exposed individual (MEI)—determined to be in the TTR Airport area. The result of 0.024 mrem/yr, was below the threshold of 0.1 mrem/yr for which continuous air monitoring would be required. A NESHAP report was prepared detailing the monitoring results (SNL 1999).

2.5 CLEAN WATER ACT (CWA)

Wastewater effluents and potable water supplies are regulated under CWA and State of Nevada water pollution and sanitary waste systems regulations. The State of Nevada, Bureau of Health Protection Services, and the Nevada Department of Environmental Protection (NDEP) administer regulations relevant to wastewater discharges. At TTR, wastewater is discharged to the sewer system connected to the USAF sewage lagoon and to six septic tank systems.

There were no excursions or other permit violations in 1998 with respect to wastewater discharges.

Storm Water

The issuance of a National Pollutant Discharge Elimination System (NPDES) storm water permit is generally based on whether or not storm water runoff is discharged to “waters of the U.S.,” which includes all streams, channels, and arroyos that lead to a river or other significant body of water. The TTR site is primarily a closed basin with runoff evaporating or infiltrating to the ground. However, since the USAF has permitted its airfield and Area 10 for storm water runoff, SNL/NV is re-evaluating NPDES requirements at TTR. Although the current position of DOE and SNL is that a separate NPDES permit is not required, SNL/NV may choose to implement the *TTR Storm Water Pollution Prevention Plan* (CDM 1994).

2.6 SAFE DRINKING WATER ACT (SDWA)

SNL/NV meets standards for drinking water as defined in the SDWA and State of Nevada public water supply and public water systems regulations. Well 6 provides all drinking water for SNL/NV operations at TTR and is operated under a permit issued by the State of Nevada. SNL remained in compliance with all Well 6 permit requirements in 1998.

Bacteriological sampling identified coliform contamination at the well head in 1998. The cause was found to be a faulty chlorination system. All public and State notifications were made upon discovery of the problem. The system was disinfected, super-chlorinated and resampled to ensure the water met standards

before being declared it safe for consumption. Full details are discussed in Chapter 4.

2.7 TOXIC SUBSTANCES CONTROL ACT (TSCA)

Compliance with TSCA at TTR primarily concerns the management of asbestos and polychlorinated biphenyls (PCBs). As defined by TSCA, any material with greater than or equal to 500 parts per million (ppm) is considered "PCB"; materials with greater than or equal to 50 ppm but less than 500 ppm are considered "PCB-contaminated." In 1993, sampling was performed on TTR transformers owned by DOE/KAO to determine if PCBs were present in the oil (IT 1993). None of the samples contained over 50 ppm of PCBs.

2.8 FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)

Chemical pesticide use at TTR may include the use of herbicides, rodenticides, and insecticides, as required. All chemicals used are EPA-approved and applied in accordance with applicable label guidelines and regulations. SNL/NV retains records of the quantities and types of pesticides that are used as well as Material Safety Data Sheets (MSDSs) for each pesticide. There were no violations of FIFRA in 1998.

2.9 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

NEPA law applies to Federal government agencies; and any private entities that are performing Federally-sponsored projects. NEPA requires Federal agencies, such as DOE, to analyze the potential impacts to the environment from their proposed actions. If the proposed action is potentially "significant," the agency would be required to prepare an Environmental Assessment (EA) or an Environmental Impact Statement (EIS) before the project could be started. Although, a major intention of NEPA is to preserve the environment for future generations, the law does not mandate environmental protection per se—it only ensures that Federal agencies make an informed decision and are aware of the environmental impacts of their actions before proceeding. NEPA does mandate that the decision process be open for public review.

The NEPA program is under the direction of DOE/KAO. SNL/NM provides technical guidance for all NEPA issues at TTR.

1998 NEPA Documentation

During 1998, SNL/NM submitted seven NEPA Checklists to DOE/KAO for proposed projects. Further NEPA documentation was only required for the Fire Experiment Facility.

- DOE/EA-1294 – Environmental Assessment (EA) for the Construction and Operation of the Fire Experiment Facility. The proposed project is to build an outdoor fire experiment facility at TTR. The draft EA was completed on June 16, 1999.

Activities at the TTR conducted by SNL/NV were included in the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE 1996).

Air Force NEPA Checklists (Form 813)

In addition to SNL's NEPA Checklists, 13 USAF Form-813 submittals were made in 1998 for projects occurring on USAF land. On the basis of these Checklists, the USAF requested the preparation of three EAs. One EA was finalized in 1998; the other two are still under review by the USAF.

2.10 ENDANGERED SPECIES ACT (ESA)

ESA applies to both private individuals and Federal agencies. Federal agencies must ensure that any action authorized, funded, or carried out by them will not jeopardize the continued existence of a threatened or endangered species, or result in adverse modifications of its habitat. ESA is addressed under the NEPA Program. If potentially significant impacts to sensitive species or habitat are found as a result of the proposed action, an EA or an EIS must be prepared.

The final EIS, which includes activities at TTR, discusses biological resources present at the site (DOE 1996). As of 1996, no Federal threatened, endangered, or candidate plant or animal species were known to occur at TTR. Bald eagles and peregrine falcons, however, may be rare migrants at the site. The western burrowing owl, a State-protected species, is known to occur on TTR.

2.11 CULTURAL RESOURCES ACTS

Federal cultural resources management responsibilities at TTR are applicable but not limited to the following acts:

- National Historic Preservation Act (NHPA)
- Archaeological Resources Protection Act (ARPA)
- American Indian Religious Freedom Act (AIRFA)

Cultural acts are addressed under the NEPA Program. DOE/KAO has responsibility for determining the level of applicability.

2.12 EXECUTIVE ORDERS (EOs)

EO 11988, *Floodplain Management*, and EO 11990, *Protection of Wetlands*, require evaluation of the potential effects of actions taken in these environmentally sensitive areas. However, there are no floodplains or significant wetlands at TTR. There are, however, some very limited wetlands in the vicinity of several springs. These provide an important source of drinking water for wildlife in the area. SNL/NV complies with all applicable mandates stated in the EOs.

2.13 1998 AUDITS

Table 2-2 lists audits and inspections made by agencies external to SNL/NV in 1998. Only minor observations were noted in all cases. There were no State of Nevada audits or inspections conducted in 1998.

2.14 1998 ISSUES AND ACTIONS FOR TTR

Ongoing self-assessments of SNL's compliance status continue to identify compliance issues. Resolution of these issues is coordinated with regulatory agencies to ensure that they are adequately addressed. The following sections highlight current issues of concern or interest at TTR.

Federal Facility Agreement and Consent Order (FFACO) Compliance for Environmental Restoration (ER) Activities

An ongoing action started in 1996 is the FFACO with the State of Nevada. This agreement was implemented in May 1996 between the State of Nevada, DOE, and the Department of Defense (DoD) (DoD/DOE 1996). All DOE cleanup activities in the State of Nevada must be conducted in conformance with the requirements of this agreement. The FFACO is an enforceable agreement with stipulated penalties for violations. The ER sites for which DOE has assumed responsibility, and which are subject to this agreement, include the Nevada Test Site (NTS), areas within TTR, sections of the Nellis Air Force Range (NAFR), the Central Nevada Test Area, and the Project School Area.

A summary of DOE's ER sites in Nevada can be found in the FFACO report (DoD/DOE 1996).

The list of sites has been modified for consistency with Nevada Department of Environmental Protection (NDEP) requirements and grouped into Corrective Action Units (CAUs) and listed by Corrective Action Site (CAS) numbers. Each CAU is listed in the FFACO under Appendices II (inactive CAUs) and III (active CAUs). Table 3-1 gives a listing of ER sites located at TTR.

2.15 ENVIRONMENTAL PERMITS

Environmental compliance permits for TTR include those for the potable water supply, sewage, and specific air emission units such as generators. The permit application and registration of SNL/NV activities at TTR are issued directly by the State of Nevada to either DOE/NV or DOE/KAO and administered by TPG. SNL/NV and TPG ensure all permit conditions are followed. Permits and registrations in effect in 1998 are listed in Table 2-3. TTR was in full compliance with all permitting requirements for 1998.

The permit for Well 6 (NY-3014-12NC) is renewed annually by the State of Nevada Bureau of Health Protection Services. Permit updates are obtained annually and copies are forwarded to DOE/KAO and SNL/NV.

TABLE 2-2. Summary of Environmental Audits Performed at TTR in 1998

Audit Title	Date	Results Summary
ES&H Self-Assessment of Department 9324, Tonopah Test Range	May 19-21 1998	Several noteworthy comments and numerous minor recommendations were made.
Water System Survey at TTR	Aug 20, 1998	Several recommendations were made.
Annual Spill Prevention Control and Countermeasures (SPCC) Inspection	Aug 20, 1998	There were no violations. Several minor recommendations were made.

2.16 OCCURRENCE REPORTING

There was one environmental occurrence in 1998 as described below:

Diesel fuel Spill – On January 16, 1998, a diesel fuel spill was discovered from a tank in Area 3. The tank was used to supply fuel for the generator in the Un-interruptable Power Supply (UPS) building. Fuel overflowed from the system during continuous pumping from the

1,000-gal main tank to the day tank. This was caused by a faulty float valve in the day tank, which failed to shut off the system. Fuel first spilled over into the 10-gal secondary containment, and then overflowed to the ground. The pump had been running for about 3.5 hours before the problem was discovered. Estimating a pump rate of 12 gal per hour, this released approximately 42 gal of fuel—10 gal to the secondary containment and 32 gallons to the ground. All contaminated soil, except for the soil directly under the building foundation was removed. A request for a “closure in place” was submitted to the State of Nevada for the remaining fuel oil under the foundation.

TABLE 2-3. Summary of Permit Ownership at TTR

Permit Type and Location	Permit Number	Issue Date	Expiration Date	Comments
Air Quality Permits				
Surface Area Disturbance (General Air Operation Permit)	AP9711-0549	Apr 4 1997	Apr 4, 2002	CS-II ER Project
• Site Specific Permit Attachment to above	1574	Jun 30, 1997		Attachment to CS-II ER Project, Permit to operate 15 emission units *
Class II Air Quality Operation Permit	AP9611-0680	Mar 1, 1999	Jun 12, 2001	1 3x5 Screening Plant 1 7x7 Screening Plant Generators (53 emission units) Boilers (7 emission units) Maintenance Activities (5 emission units) Propane Storage Tanks (23 emission units) Surface Area Disturbance >5 acres
RCRA - Hazardous Waste				
SNL/EPA Generator	NV1890011991	Jan 7, 1993	Indefinite	State of Nevada
Production Well (Drinking Water)				
Well 6 Production Well	NY-3014-12NC	Sep 1998	Sep 1999	State of Nevada (renewed annually)

NOTE: * “Emission units” are sources such as generators and boilers.

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Environmental Program Information

Environmental Programs are in place to meet compliance with State and Federal regulations, Executive Orders, and DOE Orders. Programs and activities discussed in this chapter include the Environmental Restoration (ER) Project, the Waste Management Program, National Environmental Policy Act (NEPA) compliance activities, environmental audit results, and environmental occurrences. The Environmental Surveillance Program, water quality programs, and air quality programs are discussed in the remaining chapters of this report.

3.1 ENVIRONMENTAL RESTORATION (ER) ACTIVITIES

The ER Project at TTR began in 1980 to address contamination resulting primarily from nuclear weapons testing and related support activities. In late 1992 and early 1993, an agreement was reached between DOE Headquarters (DOE/HQ), DOE Albuquerque Operations Office (DOE/AL), and DOE Nevada Operations Office (DOE/NV) regarding the management of ER activities at TTR. The decision was to designate responsibility of ER site management to DOE/NV.

Since 1996, cleanup activities for sites located in the State of Nevada have been regulated by the Federal Facility Agreement and Consent Order (FFACO). The FFACO was negotiated between DOE/NV, the Nevada Division of

Environmental Protection (NDEP), and the Department of Defense (DoD). The Compliance Order took effect on May 10, 1996 and accomplished the following:

- Established a framework for identifying Corrective Action Sites (CASs)
- Grouped CASs into Corrective Action Units (CAUs)
- Prioritized CAUs
- Implemented corrective action activities

CAUs located at TTR are addressed by two ER Division Projects:

- *Industrial Sites Project* – Past sites used to support nuclear testing activities
- *Soil Sites Project* – Areas where tests resulted in extensive surface and/or shallow subsurface contamination

ER site contamination includes radiological (e.g., depleted uranium [DU] and plutonium) and nonradiological constituents (artillery, solvents, septic sludges, and heavy metals).

CAS Identification

The initial identification, description, and listing of CASs at TTR were derived from the Preliminary Assessment (PA) and the *Federal Facility Preliminary Assessment Review* (E&E 1989). In 1993, the potential TTR CASs identified in the PA were subdivided into four “Soil Sites CAUs” and 43 “Industrial Sites CAUs.” Twelve additional potential CASs not

included in the PA were also identified. These CASs were identified through:

- ER Sites inventory process
- Ordnance removal activities
- Geophysical surveys
- Former worker interviews
- Archive reviews
- Site visits
- Aerial radiological and multispectral surveys (1993 to 1996)

Table 3-1 summarizes the existing Industrial and Soil Sites CAUs and CASs at the TTR. The ER activities planned for these CASs range from “no activities currently planned” to “NDEP-approved closure.” The CAS information presented in Table 3-1 is contained in Appendices II, III, and IV of the FFACO (DoD/DOE 1996).

Table 3-2 summarizes the 1998 DOE/NV ER activities related to both the Industrial and Soil Sites CAUs/CASs at TTR. A total of 111,830 kg of nonradioactive ER waste was generated in 1998; 130,181 kg of ER waste was shipped offsite. No TTR CAUs were closed in 1998.

The remediation activities at the Clean Slate sites (Project Roller Coaster) are discussed in Chapter 1. These sites are listed as CAU-412, -413, and 414 in Table 3-1.

TPG participates in environmental cleanup and restoration activities.

3.2 SPILL PREVENTION CONTROL AND COUNTER- MEASURES (SPCC) PLAN

The *Oil Spill Prevention Control and Countermeasures (SPCC) Plan* (CDM 1995) was fully implemented in 1995. This plan was prepared in accordance with 40 CFR 112, “Oil Pollution Prevention.”

There are 11 aboveground storage tanks (ASTs) applicable to the SPCC Plan at TTR. Minor maintenance on some of the facilities was recommended and documented in the annual SPCC inspection report dated June 3, 1998.

3.3 WASTE MANAGEMENT PROGRAMS

The Waste Management Program at TTR encompasses the management of active and standby facilities and the treatment, storage, and disposal of radioactive waste, hazardous waste—regulated by the Resource Conservation and Recovery Act (RCRA), other chemical waste, and non-hazardous solid waste. Waste minimization and recycling efforts are a part of the program activities.

Chemical and Hazardous Waste Management

All regulated chemical wastes generated by SNL/NV activities at TTR are managed by TPG, the onsite contractor. TPG has 14 personnel certified with 40-hour Hazardous Waste Operations and Emergency Response training who also perform hazardous waste sampling, as required. Hazardous and chemical waste generated and shipped offsite at TTR in 1998 is as follows:

Waste Type	Weight
RCRA-regulated	8,767 kg
Non-RCRA regulated	105,971 kg
Recyclables (hazardous/toxic)	9,673 kg
ER waste (all categories shipped)	130,181 kg

All regulated waste was disposed of offsite at permitted treatment, storage, and disposal facilities (TSDFs). The ER waste consisted of rinsate, soil, personal protective equipment (PPE), sampling debris and field testing kit waste. Waste shipped offsite include hazardous solid and liquid waste, radioactive waste, and hydrocarbon impacted soil.

TABLE 3-1. DOE/NV Environmental Restoration (ER) Project TTR Corrective Action Units (CAUs) and Corrective Action Sites (CASs)

Industrial Sites CAUs/CASs		
CAS Number	CAS Description	General Location
CAU-400 - Closed Bomblet Pit and Five Points Landfill, TTR		
TA-19-001-05PT	Ordnance Disposal Pit	Five Points Intersection
TA-55-001-TAB2	Ordnance Disposal Pit	Bunker 2 Road
CAU-401 - Closed Area 3 Gas Station UST Site, TTR		
03-02-003-0357	UST, Gas	First Gas Station, Area 3
CAU-402 - Closed Area 3 Bldg. 0353 UST Site, TTR		
03-02-001-0353	UST, Diesel	Bldg. 0353
CAU-403 - Closed Area 3 Second Gas Station UST, TTR		
03-02-004-0360	USTs	Second Gas Station
CAU-404 - Closed Roller Coaster Lagoons and Trench, TTR		
TA-03-001-TARC	Roller Coaster Lagoons	NW of Antelope Lake
TA-21-001-TARC	Roller Coaster North Disposal Trench	NW of Antelope Lake
CAU-405 Area 3 Septic Systems, TTR		
03-05-002-SW03	Septic Waste System	Area 3
03-05-002-SW04	Septic Waste System	Area 3
03-05-002-SW07	Septic Waste System	Area 3
CAU-406 Area 3 Bldg. 03-74 and Bldg. 03-58 UDPs, TTR		
03-51-002-0374	Heavy Duty Shop UDP, Sumps	Bldg. 0374
03-51-003-0358	UPS Building UDP	UPS Building, Area 3
CAU-407 Roller Coaster Rad Safe Area, TTR		
TA-23-001-TARC	Roller Coaster Rad Safe Area	Northwest of Antelope Lake
CAU-408 Bomblet Target Area, TTR		
TA-55-002-TAB2	Bomblet Target Areas	Antelope Lake
CAU-409 Other Waste Sites, TTR		
RG-24-001-RGCR	Battery Dump Site	Cactus Repeater
TA-53-001-TAB2	Septic Sludge Disposal Pit	Bunker 2
TA-53-002-TAB2	Septic Sludge Disposal Pit	Bunker 2

SOURCE: DoD/DOE 1996 and ongoing updates

NOTE: DOE/ERD = Department of Energy/Environmental Restoration Division

CAU = Corrective Action Unit

CAS = Corrective Action Site

UDP = underground discharge point

UST = underground storage tank

TABLE 3-1. DOE/NV Environmental Restoration Project (ER) TTR Corrective Action Units (CAUs) and Corrective Action Sites (CASs) (Continued)

Industrial Sites CAUs/CASs		
CAS Number	CAS Description	General Location
CAU-410		
Area 9 Underground Vault and Disposal Trench, TTR		
09-21-001-09MG	Former Bunker or Underground Vault	East of Area 9 Magazines
09-21-001-TA09	Disposal Trenches	Area 9
CAU-423		
Area 3 UDP, Bldg. 0360, TTR		
03-02-002-0308	UDP	Bldg. 0360
CAU-424		
Area 3 Landfill Complex, TTR		
03-08-001-A301	Landfill Cell A3-1	Area 3 Landfill Complex
03-08-002-A302	Landfill Cell A3-2	Area 3 Landfill Complex
03-08-002-A303	Landfill Cell A3-3	Area 3 Landfill Complex
03-08-002-A304	Landfill Cell A3-4	Area 3 Landfill Complex
03-08-002-A305	Landfill Cell A3-5	Area 3 Landfill Complex
03-08-002-A306	Landfill Cell A3-6	Area 3 Landfill Complex
03-08-002-A307	Landfill Cell A3-7	Area 3 Landfill Complex
03-08-002-A308	Landfill Cell A3-8	Area 3 Landfill Complex
CAU-425		
Area 9 Main Lake Construction Debris Disposal Area, TTR		
09-08-001-TA09	Construction Debris Disposal Area	Area 9/Main Lake
CAU-426		
Cactus Spring Waste Trenches, TTR		
RG-08-001-RGCS	Waste Trenches	Cactus Spring Ranch
CAU-427		
Area 3 Septic Waste Systems 2 and 6, TTR		
03-05-002-SW02	Septic Waste System No. 2	Area 3
03-05-002-SW06	Septic Waste System No. 6	Area 3
CAU-428		
Area 3 Septic Waste Systems 1 and 5, TTR		
03-05-002-SW01	Septic Waste System No. 1	Area 3
03-05-002-SW05	Septic Waste System No. 5	Area 3
CAU-429		
Area 3 Bldg. 03-55 and Area 9 Bldg. 09-52 UDPs, TTR		
03-51-001-0355	Photo Shop UDPs, Drains	Photo Shop Area 3
09-51-001-0952	Mobile Photographic Lab UDPs	Area 9
CAU-430 - Closed		
DU Artillery Round #1, TTR		
TA-55-003-0960	DU Artillery Round	South of Area 9

SOURCE: DoD/DOE 1996 and ongoing updates

NOTE: DOE/ERD = Department of Energy/Environmental Restoration Division

CAU = Corrective Action Unit

CAS = Corrective Action Site

DU = depleted uranium

UDP = underground discharge points

TABLE 3-1. DOE/NV Environmental Restoration Project (ER) TTR Corrective Action Units (CAUs) and Corrective Action Sites (CASs) (Continued)

Industrial Sites CAUs/CASs		
CAS Number	CAS Description	General Location
CAU-453 Area 9 UXO Landfill, TTR		
09-55-001-0952	Area 9 Landfill	Area 9
CAU-461 Test Area JTA Sites, TTR		
TA-52-002-TAML	DU Impact Site	Main Lake
TA-52-003-0960	DU Artillery Round #2	South of Area 9
TTR-001	1987 W-79 JTA	Unknown – South of Area 9
CAU-484 Antelope and NEDS Lakes Waste Sites, TTR		
TA-52-001-TANL	NEDS Detonation Area	NEDS Lake
TA-52-004-TAAL	Metal Particle Dispersion Test	Antelope Lake
TA-52-005-TAAL	JTA DU Sites	Antelope Lake
CAU-485 - Closed Cactus Spring Ranch Pu and DU Site, TTR		
TA-39-001-TAGR	Cactus Spring Ranch, Soil Contamination	West of Target Areas
CAU-486 Double Tracks Rad Safe Area, Nellis Range 71 North		
71-23-001-71DT	Double Tracks Rad Safe Area	Nellis Range 71 North
CAU-487 Thunderwell Site, TTR		
RG-26-001-RGRV	Thunderwell Site	Thunderwell Site
CAU-488 Davis Gun Site, TTR		
RG-52-007-TAML	Davis Gun Site - Mellan	Test Range
CAU-489 WWII UXO Sites, TTR		
RG-55-001-RGMN	WWII Ordnance Site	Mellan Airstrip
RG-55-002-RGHS	WWII Ordnance Site	H-Site Road
RG-55-003-RG36	WWII Ordnance Site	Gate 36E
CAU-490 Station 44 Burn Area, TTR		
RG-56-001-RGBA	Fire Training Area	Station 44
03-56-001-03BA	Fire Training Area	Area 3
03-58-001-03FN	Sandia Service Yard	Area 3
09-54-001-09L2	Solid Propellant Burn Site	Area 9
CAU-491 Bunker 2 Debris Mound and NEDS Trench, TTR		
TA-19-002-TAB2	Debris Mound	Bunker 2
TA-21-003-TANL	Disposal Trench	NEDS Lake

SOURCE: DoD/DOE 1996 and ongoing updates

NOTE: CAU = Corrective Action Unit

CAS = Corrective Action Site

DOE/ERD = Department of Energy/Environmental Restoration Division

JTA = Joint Test Assembly

NEDS = Non-Explosive Destruction Site

UXO = unexploded ordnance

TABLE 3-1. DOE/NV Environmental Restoration Project (ER) TTR Corrective Action Units (CAUs) and Corrective Action Sites (CASs) (Concluded)

Industrial Sites CAUs/CASs		
CAS Number	CAS Description	General Location
CAU-492 South Antelope Lake Disposal Trench, TTR		
TA-21-002-TAAL	Disposal Trench	South Antelope Lake
CAU-493 Colimbo Detonation Site, TTR		
TA-52-006-TAPL	DU Surface Debris	Colimbo Detonation Area, NEDS Lake
CAU-494 Rocket Propellant Burn Area – NEDS Lake, TTR		
TA-54-001-TANL	Rocket Propellant Burn Area	NEDS Lake
CAU-495 Unconfirmed JTA Sites, TTR		
TA-55-006-09SE	Buried Artillery Round	Test Area
TA-55-007-09SE	Buried Artillery Round	Test Area
CAU-496 Buried Rocket Site – Antelope Lake, TTR		
TA-55-008-TAAL	Buried Rocket	Antelope Lake
CAU-499 Hydrocarbon Spill Site, TTR		
RG-25-001-RD24	Hydrocarbon Spill Site	Radar 24 Site
Soil Sites CAUs/CASs:		
CAU-411 Double Tracks Plutonium Dispersion, Nellis		
NAFR-23-01	Pu-contaminated Soil	Double Tracks
CAU-412 Clean Slate I Plutonium Dispersion, TTR		
TA-23-01CS	Pu-Contaminated Soil	Clean Slates I
CAU-413 Clean Slate II Plutonium Dispersion, TTR		
TA-23-02CS	Pu-Contaminated Soil	Clean Slates II
CAU-414 Clean Slate III Plutonium Dispersion, TTR		
TA-23-03CS	Pu-Contaminated Soil	Clean Slates III

SOURCE: DoD/DOE 1996 and ongoing updates

NOTE: CAU = Corrective Action Unit

CAS = Corrective Action Site

DOE/ERD = Department of Energy/Environmental Restoration Division

DU = depleted uranium

TABLE 3-2. Summary of 1998 Industrial and Soil Sites DOE/NV Environmental Restoration (ER) Activities *All activities are related to TTR CAUs.*

1998 Activities at Industrial and Soil Sites	Type	CAU Number (if applicable)
Industrial Sites Activities:		
• CAIP* for Cactus Spring Ranch Pu and DU Site investigation approved by NDEP	CAIP*	485
• CAIP for Roller Coaster Rad Safe Area approved by NDEP	CAIP	407
• CR for Cactus Spring Waste Trenches submitted to NDEP	CR	426
• CADD for Area 9 UXO Landfill approved by NDEP	CADD	453
• SAFER Plan for Test Area JTA Sites approved by NDEP	SAFER Plan	461
• SAFER Plan for Unconfirmed JTA Sites approved by NDEP	SAFER Plan	495
• CR for Area 3 Second Gas Station UST submitted to NDEP	CR	403
• CR for Roller Coaster Lagoons and Trench submitted to NDEP	CR	404
• CADD for Area 3 Landfill Complexes approved by NDEP	CADD	424
• CAP for Area 3 Landfill Complexes approved by NDEP	CAP	424
• CADD/CR for Cactus Spring Ranch Pu and DU Site approved by NDEP	CADD/CR	485
• CAIP for Double Tracks Rad Safe Area approved by NDEP	CAIP	486
• CADD for Area 3 UDP, Bldg. 0360 approved by NDEP	CADD	423
• CAP for Area 3 Septic Waste Systems 2 and 6 submitted to NDEP	CAP	427
• CAP for Area 3 UDP, Bldg. 03-60 approved by NDEP	CAP	423
• CADD for Area 3 Septic Waste Systems 2 and 6 approved by NDEP	CADD	427
• CAP for Area 9 UXO Landfill approved by NDEP	CAP	453
Soil Sites Activities:		
• Activities at Double Tracks and Clean Slates I, II, and III delayed to develop soil cleanup levels acceptable to all affected organizations. These CAUs were moved from FFACO Appendix III (Active Sites) to FFACO Appendix II (Inactive Sites) in 1997.	No Action	411
		412
		413
		414

NOTE: *Preliminary Assessment accepted as CAIP
 DU = depleted uranium
 NDEP = Nevada Department of Environmental Protection
 CAIP = Corrective Action Investigation Plan
 CR = Closure Report
 CADD = Corrective Action Decision Document
 UXO = unexploded ordnance
 SAFER = Streamlined Approach For Environmental Restoration
 CAP = Corrective Action Plan
 JTA = Joint Test Assembly
 UST = underground storage tank
 UDP = underground discharge point

Table 3-3 shows a detailed breakdown of the RCRA waste categories and quantities. Table 3-4 lists regulated non-RCRA waste categories and quantities. Table 3-5 lists waste categories transported offsite for recycling or alternative fuel use. A *Biannual Hazardous Waste Generation Report* is prepared by TPG and submitted to the EPA through DOE/NV (DOE 1998).

Waste Minimization Program

TTR is committed to achieving significant reductions in the amount of chemical and hazardous wastes generated onsite. To implement this goal, an informal waste minimization program is practiced at TTR. A formal program will be implemented after upcoming changes to the existing waste disposal contract are made. Waste minimization includes recycling and recovery of the following materials:

- Solvents
- Fuels
- Oil
- Antifreeze (onsite recycling unit)
- Lead acid batteries
- Freon (onsite recovery unit)
- Fluorescent and sodium bulbs
- Mercury-containing equipment

Radioactive Waste Management

Although SNL/NV did not generate any new radioactive waste in 1998, radioactive waste was generated by remediation of ER sites. The waste was shipped offsite in 1998. Table 3-6 describes waste types and containers previously stored onsite at SNL's Radioactive Waste Connex located in Area 9 that were shipped to NTS for disposal in 1998. (The total mass was approximately 18,350 kg.)

3.4 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) PROGRAM

NEPA Activities at TTR

At TTR, NEPA compliance is a joint effort by SNL/NV and DOE/KAO. Additionally, under the direction of SNL/NV, compliance is supported by the Water Resources Center at the Desert Research Institute (DRI) through the University of Nevada System. DRI prepares archaeological and biological surveys and reports. Final reports are submitted to SNL/NV for transmittal to DOE/KAO for review and decision making and consultation with State and Federal agencies.

An Environmental Impact Statement (EIS) that included the TTR site was completed in 1996; the DOE Record of Decision (ROD) was December 9, 1996 (DOE 1996).

3.5 LOCAL ENVIRONMENTAL MONITORING PERFORMED BY OUTSIDE AGENCIES

In addition to SNL, other agencies perform environmental monitoring activities at TTR as described below.

Environmental Protection Agency (EPA)

The EPA Environmental Monitoring Systems Laboratory in Las Vegas, Nevada, under an interagency agreement with DOE, monitors background radiation in the vicinities of TTR as part of its Offsite Radiation Monitoring Reports Program. Reports are available through the EPA upon request. Two major EPA reports are as follows:

- *Offsite Monitoring Report: Nevada Test Site and Other Test Areas, Quarterly Report* – EPA, Dose Assessment Branch, Nuclear Radiation Assessment Division.

TABLE 3-3. RCRA-Regulated Hazardous Waste Shipped Offsite in 1998

Waste Description	Waste Codes	Generated (kg)
ER RCRA WASTE		
NOS, Toxic liquid, (rinsate from ER work)	F002, F004, D008, D009, D027	617
NOS, Toxic liquid, (rinsate from ER work)	F002, F004, D008	1,270
NOS, Toxic liquid, (rinsate and spent solvent from field testing kit)	F001, F002, F004, D008, D009, D019, D027	73
NOS, Toxic liquid, (field testing kit waste)	F001, D019, U211	73
NOS, Hazardous solid, (soil, PPE, sampling debris from ER work)	F002, F004, D008, D009, D027	2,132
NOS, (soil, PPE, sampling debris from ER work)	F002, F004, D008	3,402
NOS, (soil, PPE, sampling debris from field test kit)	F001, F002, F004, D008, D009, D019, D027	34
NOS, (soil, PPE sampling debris from field test kit)	F001, D019	34
Isopropanol	D001	7
	Total ER-RCRA Waste	7,642
OTHER RCRA WASTE		
NOS, Wastewater reactive solid, (lithium battery)	D001, D003	0.90
NOS, Explosive waste articles, (ammonium perchlorate)	D003	0.06
NOS, Toxic liquid, organic, (ethylene glycol with benzene, lead)	D008, D018	53
NOS, (rags with methylene chloride)	F002, F003, F005, D035	344
Aerosols flammable (petroleum distillates)	D001	203
Paint-related material	D001, D035, F003, F005, D008	95
Paint-related material	D001	92
Paint-related material	D001, D008	171
Gasoline-contaminated soil	D001, D018	48
NOS, Flammable liquid, (methylene chloride, methanol)	D001	20
Ammonia solution	D002	17
NOS, Corrosive liquid, acidic, inorganic, (hydrofluoric acid)	D002	16
Sulfuric acid with more than 51% acid	D002	47
	Total Other RCRA Waste	1,125
	Total RCRA Waste	8,767

NOTE: NOS = not otherwise specified
PPE = personal protective equipment

TABLE 3-4. Non-RCRA-Regulated Hazardous or Toxic Waste Shipped Offsite in 1998

Non-RCRA Waste	Generated (kg)
ER Waste - Hydrocarbon Impacted soil and debris	104,188
Asbestos contained in manufactured materials	30
Glass sampling equipment	47
Incandescent light bulbs	36
Diisocyanate resin sprayer	36
Empty containers	351
Corrosive, solid, basic, inorganic, NOS	7
Chlorodifluoromethane	8
Oil contaminated rags	163
Tar and asphalt	200
Oil filters	504
Sodium chloride, urea	46
Compressors with oil	90
Developer with hydroquinone	21
Calcium sulfate	53
Metal halide light bulbs	33
Scrap metal steel	158
TOTAL	105,971

NOTE: NOS = not otherwise specified
 PCB = polychlorinated biphenyls
 TSCA = Toxic Substance Control Act

TABLE 3-5. Regulated Hazardous or Toxic Waste Shipped Offsite in 1998 for Recycling

Recycled Material	Generated (kg)
ER Waste	0
Used oil	4,092
Used oil and water mixture	599
Fluorescent light bulbs	163
Nickel-cadmium batteries	242
Waste batteries with acid	189
Waste diesel fuel	383
Waste mercury contained in manufactured materials	6
Sodium vapor bulbs, barium	35
Solid hazardous waste, NOS, lead	551
Solid hazardous waste, NOS, silver	97
Waste combustible liquid, NOS, petroleum naptha	170.55
Waste combustible liquid, NOS, petroleum naptha (Safety Kleen)	170.45
Automotive/equipment lead acid batteries	2,977
TOTAL	9,673

NOTE: NOS = not otherwise specified

TABLE 3-6. Categories of Radioactive Waste Shipped to NTS for Disposal in 1998

Container	Isotope	Contents	Comments
5 - Steel drum 55 gal	Pu-239/240	PPE, plastic, debris	ER work at CAU 407
1 - Steel drum 55 gal	Pu-239/240	Concrete	ER work at CAU 407
13 - Steel drum 55 gal	Pu-239/240	Contaminated soil	ER work at CAU 407
9 - B25 boxes	U-238	Contaminated soil	ER work at CAU 461 (DU round 32)
"Sealand" Trailer Items *			
9 - Steel drum 55 gal	U-238	Contaminated soil	ER work at CAU 461 (TAML site)
1 - Steel drum 20 gal	H-3 (tritium)		Sandia trailer disposal
1 - Steel drum 20 gal	U-238	Contaminated soil	Soil and DU from Lakebed
1 - Steel drum 30 gal	Ra-226	Misc. Equipment	Sandia trailer disposal
Thorium lenses	Th	Thorium lenses	Sandia trailer disposal
Microwave tubes	H-3 (tritium)	Microwave tubes	Sandia trailer disposal
Wind radar pedestal	Ra-226	Wind radar pedestal	Sandia trailer disposal
2 pieces of trailer	Ra-226	2 pieces of trailer	Sandia trailer disposal

NOTE: *All items listed under the "Sealand" container were shipped to NTS by BN.
PPE = personal protective equipment

- **Offsite Environmental Monitoring Report: Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1998** – This report is also published as part of the Nevada Test Site (NTS) Annual Site Environmental Report (ASER).

The EPA also prepares reports relative to NAFR activities that may include information on TTR. These reports, described in Volumes 1 through 4 of the *1992 Environmental Monitoring Report, Tonopah Test Range, Tonopah, Nevada* (SNL 1993) are available from the EPA upon request.

DRI, University of Nevada System

The DRI trains and provides monitoring station managers (generally they are local science teachers) to run the EPA monitoring equipment set up at locations within the local community including the towns of Tonopah and Goldfield. The EPA laboratory in Las Vegas, Nevada

provides the equipment and performs the analysis and reporting.

DRI also provides external quality assurance (QA) on field measurements taken by the EPA at these community-monitoring stations. DRI monitors selected locations concurrently using a portable monitoring station (PMS) and thermoluminescent dosimeters (TLDs). DRI prepares an annual report comparing its data with EPA's results:

- **Community Radiation Monitoring Program Annual Report (DRI 1998)**

DRI also performs other monitoring—primarily hydrological—for the DOE as requested. This may include evaluating environmental impacts due to range construction projects.

The Plus Group (TPG)

As part of its TTR support activities, TPG personnel perform environmental monitoring activities for DOE and/or SNL when needed as follows:

- Drinking water and wastewater sampling
- National Emission Standards for Hazardous Air Pollutants (NESHAP) 40 CFR 61, Subpart H (radionuclides) air quality monitoring
- Soil sampling and site characterization of spill sites
- Waste sampling and characterization

3.6 SUMMARY OF RELEASE REPORTING

The following three release reporting documents are required to be submitted to external organizations agencies.

- *NESHAP Report for Radionuclides Other than Radon from Department of Energy Facilities (Subpart H) Annual Report* – NESHAP, 40 CFR 61, Subpart H, requires that an annual report be submitted from each

DOE site where facility sources contribute a public dose of over 0.1 mrem/yr. The NESHAP report must be submitted to the EPA by June 30th each year, following the reporting year. The report includes the calculated effective dose equivalent (EDE) in mrem/yr for the maximally exposed individual (MEI). Chapter 5 of this report summarizes results of the NESHAP dose assessment results for TTR presented in the annual NESHAP report for TTR (SNL 1999).

- *State of Nevada Reports* – The State of Nevada requires copies of each hazardous waste manifest that accompanies each waste shipment.
- *State of Nevada Extremely Hazardous Material Reporting Requirements* – This is not currently required since SNL/NV does not use any extremely hazardous materials during its routine operations.

Terrestrial Surveillance and Water Monitoring

Environmental surveillance and water monitoring activities are conducted routinely for all SNL work areas at TTR. Samples are taken to determine the level of radiological and nonradiological contaminants in the ambient terrestrial environment, in wastewater effluent, and in water supply wells. All sampling is conducted under the direction of SNL/NM's Environmental Surveillance Program within the Environmental and Emergency Management Department. The onsite contractor, TPG, conducts water sampling throughout the year. The Terrestrial Surveillance Team from SNL/NM conducts soil sampling once a year.

4.1 TERRESTRIAL SURVEILLANCE OBJECTIVES, SAMPLING SITE SELECTION, AND ANALYSIS METHOD

Program Objectives

The overall objective of the Environmental Surveillance Program is to detect the presence and migration of contaminants related to onsite operations at TTR and to determine the potential impact (if any) of SNL site-related activities to the population and the surrounding environment. Data collected is used to determine long-term environmental conditions and trends at the site.

DOE Order 5400.1, *General Environmental Protection Program* (DOE 1990a) mandates environmental surveillance monitoring to detect

any potential contaminant residues that may accumulate in the terrestrial environment. Pollutants are most commonly transported to the ambient environment through the action of wind and water (air deposition, precipitation, and storm water runoff).

Sample Media

Terrestrial materials commonly sampled include soils, water-deposited sediments, surface waters, and vegetation. Because TTR is located in a desert environment where there are no naturally-occurring bodies of water (lakes, rivers, and creeks) and, vegetation is scarce, only soil samples are taken to assess the presence of potential contaminants. Any storm water that does runoff, is quickly infiltrated to the sandy soils in the area or is lost to evaporation. Very little surface runoff recharges to the groundwater (DRI 1991). There are, however, three remote springs in the surrounding hills west of TTR operations. These springs are not used for terrestrial sampling since they are upgradient and far removed from operational areas.

In addition to soil sampling, external gamma radiation measurements are made using thermoluminescent dosimeters (TLDs). These instruments measure the ambient level of gamma radiation (from both man-made and natural background sources). Typical natural sources include cosmic radiation and emissions from naturally-occurring isotopes found in rocks and minerals. Man-made sources contributing to gamma levels at TTR come from the radioactive residues in soils at previous test sites, such as the Clean Slate Sites, where

plutonium and americium isotopes are still present.

Routine Sampling Locations

SNL began environmental monitoring at TTR in 1992. In addition to routine sampling, a large-scale baseline sampling was performed in 1994 in areas where SNL has had a long-term or continued presence.

Routine environmental surveillance locations remain essentially the same from year to year. Additional locations may be added as necessary to monitor new operations or to supplement data from existing locations. The sampling locations, number of samples, and analyses performed are prioritized based on the following criteria:

- Contaminants believed to be present;
- Contamination considered readily dispersible by environmental factors (e.g., wind or rain); and
- Areas with the greatest potential for impact to the public, workers, and the environment.

Soil samples are collected from various locations within three general areas: offsite, onsite, and the site perimeter. The design criteria used in choosing these sites is explained below:

- **Offsite locations** are used to provide a measurement of environmental conditions unaffected by SNL activities at TTR. Data collected from offsite locations serve as a reference point to compare data collected at perimeter and onsite locations. Multiple years of sampling data are compiled to determine statistical averages for offsite concentrations. Offsite locations are chosen both in remote, natural settings as well as in areas near local population centers and along highways. Figure B-1 of Appendix B shows the 14 offsite locations sampled.
- **Perimeter locations** are used to provide a measurement of the site boundary to ascertain if potential contamination is

migrating either on to or off of TTR property. Figure B-2 shows the five perimeter locations sampled. All perimeter locations are in areas of uncontrolled access within TTR.

- **Onsite locations** are located near areas of known contamination, potential sources of contamination, or in areas where contamination, if present, would be expected to accumulate, such as downgradient or downwind from Environmental Restoration (ER) areas. Onsite sampling locations are shown in Figures B-3 to B-8 of Appendix B. A total of 22 locations were sampled onsite. Additionally, Figure B-9 and B-10 show the NEDS and Antelope (dry) Lake sites. Ten samples were collected from each dry lake site in 1998 in a one-time sampling, as discussed below. Similar to perimeter sampling locations, all onsite locations are in areas of uncontrolled access within TTR.

NEDS and Antelope Sampling Task, 1998

In 1998, a special one-time sampling project was performed at two sites proposed for an outdoor fire test facility (see Section 2.9). The purpose of this one-time sampling was to establish a baseline of existing concentrations of metals and radionuclides at each proposed site. The sampling was done to support the site selection process and to satisfy National Environmental Policy Act (NEPA) requirements. The two dry lake bed sites considered were Antelope Lake and NEDS Lake.

1998 Sample Collection and Analysis

SNL/NM's Environmental Surveillance Team collected routine terrestrial samples at TTR in May 1998 for both radiological and nonradiological (stable metal) analysis at offsite, perimeter, and onsite locations as shown in Table 4-1. Sampling at Antelope and NEDS Lake were conducted in May and August.

Metals

Stable metal analysis of soils is performed every other year at TTR. In 1998, all samples were analyzed for 20 stable metals using Inductively Coupled Plasma (ICP-20) plus analysis for mercury. The samples were analyzed for the following metals:

Aluminum	Antimony	Arsenic
Barium	Beryllium	Cadmium
Chromium	Cobalt	Copper
Iron	Lead	Magnesium
Manganese	<i>Mercury</i>	Nickel
Potassium	Selenium	Silver
Thallium	Vanadium	Zinc

Radioisotopes

Radiological analysis included gamma spectroscopy and total uranium (U_{tot}). Additionally, isotopic plutonium analysis was performed on any sample for which gamma spectroscopy identified americium-241 in concentrations greater than its minimum detectable activity (MDA).

The data summarized in this report do not include all the radionuclides that were identified by gamma spectroscopy. The majority of the radionuclides identified by gamma spectrometry were members of the uranium-238, uranium-235, and thorium-232 natural decay series. Radionuclides that are included are those which are likely related to past or current activities. Past testing has produced plutonium and americium dispersal. Current testing uses only depleted uranium (DU) as an isotope surrogate for conducting test activities. Analysis for commonly occurring isotopes in the environment, such as cesium-137 and potassium-40, are used to provide a general indication of data quality.

TABLE 4-1. Sampling Locations at TTR

Number of Samples	Sampling Area
14	Offsite
5	Site perimeter
22	Onsite <ul style="list-style-type: none"> ▪ South Plume Area (5) ▪ Range Operations Center (5) <ul style="list-style-type: none"> - Storage Yard (2) - Compound (1) ▪ Various Onsite Areas (5) <ul style="list-style-type: none"> - Hard Target (2) - Mellan Hill (2)

Analysis Method

In 1998, statistical analysis for several years of sampling data was performed for the first time. Past annual data collected from 1994 to 1998—with the exception of 1997 for which there were no metal analysis conducted—was used in the trend analysis.

Individual sample results from onsite and site perimeter locations were compared to the upper 95 percent confidence limit of the offsite value. The 95 percent limit is based on the mean offsite value plus two standard deviations of all offsite samples collected. Individual onsite or perimeter samples with values greater than the upper 95 percent confidence interval and greater than the range of observed offsite values, were considered potentially contaminated. However, samples that had any americium-241 or isotopic plutonium detected (e.g., greater than the isotopic detection limit) were automatically considered potentially contaminated, since these radionuclides do not occur naturally in the environment.

4.2 TERRESTRIAL SURVEILLANCE RESULTS

4.2.1 Stable Metal Soil Sampling Results

Offsite Metal Results

The 1998 stable metal (nonradiological) results from the 14 offsite sampling locations (Figure B-1) were found to be reasonably consistent with previous offsite sampling results and are believed to represent the normal, expected range of values for the analyzed metals. Minor differences can be expected due to different analytical equipment and methods used at the several different laboratories that have conducted the analysis over the years. Stable metal results are presented in Table B-1a.

Onsite and perimeter samples are compared to statistically averaged offsite values. However, it should be noted that since the offsite sample size is limited in number, results give only a general indication of specific contaminant concentrations, which may be different within TTR operational areas. Some onsite locations that appear to be marginally elevated above offsite concentrations may not be contaminated at all, but rather show the normal, expected, variation in sample concentration. (Confidence will increase with increasing data points.)

Perimeter Metal Results

Five samples were collected from the TTR site boundary as shown in Figure B-2 and Table B-2a. Location T-11 contained elevated concentrations of beryllium, cobalt, copper, iron, manganese, and zinc as compared to offsite values. Location T-11 is located in the foothills at the west perimeter gate that separates NAFR from TTR. All other locations were statistically indistinguishable from offsite values.

Onsite Metal Results

- **South Plume Area** – Five samples were collected from the South Plume Area of Clean Slate 1 as shown in Figure B-3 and

Table B-3a. Locations T-14, T-16, and T-18 showed slightly elevated concentrations of potassium (5,500, 5,700 and 5,600 mg/kg, respectively) as compared to the offsite average value of 3,200 mg/kg. All other analyses performed on samples collected from the South Plume Area were statistically indistinguishable from offsite concentrations.

- **Range Operations Center** – Eight samples were collected from around the Range Operations Center as shown in Figures B-4 and B-5, and Table B-4a. Location OC-04 contained elevated chromium, cobalt, and zinc. Location OC-13 contained elevated zinc. OC-04 and OC-13 are located outside of the Range Operation Center perimeter fence, in areas used for equipment storage. All other analyses performed on samples collected from the Range Operations Center were statistically indistinguishable from offsite concentrations.
- **Various Onsite Locations** – Nine samples were collected from various locations onsite as shown in Figures B-6, B-7, and B-8, and Table B-5a. The sample collected from the former Project Roller Coaster decontamination site, D-01 (Figure B-6), was elevated in aluminum, cobalt, and iron. Location T-10 (Figure B-6), located at the north end of Clean Slate 1, was elevated in aluminum, chromium, potassium, and thallium. Location MH-04 (Figure B-7), located at Mellan Hill, contained elevated manganese. Location T-21 (Figure B-8), located adjacent to the fenced depleted uranium (DU) area near the Hard Target, was elevated in aluminum, beryllium, cobalt, copper, iron, and potassium. All other analyses performed on samples collected from various locations onsite were statistically indistinguishable from offsite concentrations.

Replicate Sampling

As an added measure of data quality, replicate (triplicate) sampling was performed for two samples (D-01 and T-03) for stable metals. Three samples were taken from each location to assess the reproducibility of the sampling technique and the variation of results of a given location. In locations where replicate sampling was done, only the first sample collected (sample -01) was used in summary calculations for all statistical analysis. The extra two samples were not counted in these summaries since they would skew the data toward replicate sample data. Results of replicate sampling for metals are summarized in Table B-14.

4.2.2 Soil Sampling Results – Radiological Analyses

Offsite Radiological Results

Radionuclide results from the 14 offsite sampling locations (Figure B-1) were found to be consistent with previous years' sampling results. Slight differences are believed to be the normal expected variation for analyzed radionuclides. Radionuclide results are presented in Table B-1b of Appendix B.

The offsite distribution of sample concentrations (averaged from 1994 to 1998) serves as a reference to compare onsite samples. As discussed earlier, the comparison with offsite samples should not be considered as exact in the identification of potential contamination due to the limited sample size. This is believed to be the case for those onsite samples found to be slightly elevated in cesium-137 and total uranium (U_{tot}).

Perimeter Radiological Results

Five samples were collected from the TTR site perimeter (Figure B-2 and Table B-2b). The sample collected at location T-13 contained elevated uranium-235. Location T-13 is located in the foothills at the west perimeter gate that separates NAFB from TTR. All other analyses

performed on samples collected from the site perimeter were statistically indistinguishable from offsite concentrations.

Onsite Radiological Results

- **South Plume Area** – Five samples were collected from the South Plume Area of Clean Slate 1 (Figures B-3 and Table B-3b). The sample collected from location T-14 contained elevated concentrations of americium-241, plutonium-239,240, cesium-137, and uranium-235. Location T-19 was found to be elevated in americium-241, plutonium-238, and plutonium-239,240. All other analyses performed on samples collected from the South Plume Area were statistically indistinguishable from offsite concentrations.
- **Range Operations Center** – Eight samples were collected from around the Range Operations Center (Figures B-4 and B-5, and Table B-4b). All analyses performed on samples collected from the Range Operations Center were statistically indistinguishable from offsite concentrations.
- **Various Onsite Locations** – Nine samples were collected from various locations onsite (Figures B-6, B-7 and B-8, and Table B-5b). The sample collected from the former Project Roller Coaster site, D-01, was found to contain elevated concentrations of americium-241, plutonium-238, and plutonium-239,240. All other analyses performed on samples collected from various locations onsite were statistically indistinguishable from offsite concentrations.

Table 4-2 summarized the radiological results for all sampling areas.

TABLE 4-2. Radiological Summary Data for Soil Samples Collected at TTR in 1998

Location	Number of Samples	Number of Samples with Measurable Transuranics †			U _{tot} (µg/g)	Cs-137 (pCi/g)	Am-241 (pCi/g)	Pu-238 (pCi/g)	Pu-239/240 (pCi/g)
		Am-241	Pu-238	Pu-239, Pu-240					
Offsite Average	14	0	0	0	2.78	0.26	ND	ND	ND
Site Perimeter	5	5	5	5	2.36	0.26	ND	ND	ND
Range Operations Center	8	0	0	0	2.4 – 3.1	-0.85 – 0.46	ND	ND	ND
South Plume Area	5	2	2	2	2.5 – 3.2	0.54 – 1.0	0.16 – 0.23	0.02 – 0.04	0.21 – 2.2
Various Onsite Locations	9	1	1	1	2.2 – 3.3	0.14 – 0.76	0.72	0.02	6.30

NOTE: µg/g = micrograms per gram.

pCi/g = picocurie per gram.

ND = not detected or below the detection limit.

†Samples with measurable americium-241 (greater than detection limit) are considered potentially contaminated.

If americium-241 was detected in any sample, follow-up isotopic plutonium analysis was performed.

Replicate Samples

As discussed under metal results, triplicate samples were taken as an added measure of data quality (locations D-01, T-03, and T-14). Results of replicate soil sampling for radioisotopic analysis are summarized in Table B-15.

4.2.3 Trend Analyses (1994 – 1998)

Statistical analysis was performed on the past five years of TTR surveillance data (1994 to 1998) for both stable metals and radionuclides (with the exception of 1997 for which only radiological analysis was done). The analysis was done to detect any trends that might indicate a general decreasing or increasing level of contaminants being measured in the environment.

Interpreting Trend Analysis Results

While a slight decreasing trend in concentration values was observed for some of the data, it is believed that the differences are a result of using several different laboratories over the years and from errors introduced by the relatively small sample size. The data variation introduced by these variables produces a wider margin of error in the statistical results. Therefore, the apparent decrease in contamination level at TTR is believed to be a false negative trend and not a trend reflecting real-world conditions. This is especially true for the stable metal data since this analysis had even less data points.

Conversely, any positive trends (increasing contamination) noted are looked at with the understanding that the chance of false positives will decrease as the data set increases. If a positive trend for a particular contaminant is detected in conjunction with the contaminant being found in lower average concentrations offsite, this will serve as an indication that SNL/NV operations may be contributing to the onsite levels. If a trend of significantly elevated

values for any particular contaminant is found onsite, SNL/NM will investigate further to determine the source and extent of the contamination.

Several locations showed increasing trends but did not have concentrations in excess of offsite values. One location, however, may be a potential concern. The sample site OC-13 on the east side of the Range Operations Center (Figure B-4) showed an increasing trend for zinc and a concentration greater than the long-term offsite average for zinc. Therefore, SNL will investigate this area to determine if the increasing trend in zinc is real, and if so, a possible source of the zinc.

Trends Noted at the Clean Slate Sites

Of special interest, is the increasing trend for americium-241 found at location D-01 along the Main Road South and down-gradient (northeast) of Clean Slate 1 (Figure B-6). The three Clean Slate Sites are the locations for the former Project Roller Coaster tests performed in 1963 and are known to be contaminated with americium-241 (see Section 1.4). D-01 was specifically located to detect any surface runoff from the Clean Slate 1 site. While americium-241 is shown to be increasing at this site over time, (0.35, 0.42, 0.51, and 0.72 pCi/g), no additional investigation is planned since this is a known contamination source and is being addressed by the Environmental Restoration (ER) Project.

4.2.4 Results from NEDS Lake and Antelope Lake Sampling Event

This section discusses both stable metals and radionuclide analysis results for the Antelope and NEDS Lake one-time sampling event.

Limited soil sampling was conducted at the north end of the two dry lake beds being considered in the site selection process for a proposed fire experiment. Sample locations are

shown in Figures B-9 and B-10. Ten samples from each site were analyzed for 20 stable metals (plus mercury) and radionuclides (U_{tot} and gamma emitting isotopes).

Replicate Samples

Replicate (triplicate) sampling was performed at both NEDS Lake and Antelope Lake to assess the reproducibility of the sampling technique and the variation of results of a given location. In the case of replicate sampling, only the first sample collected (sample-01) was used in the presentation of individual values to avoid any potential skewing of the data toward the replicate sample data. Triplicate results are shown in Tables B-10 and B-12 for stable metals and B-11 and B-13 for radioisotopes. The results demonstrate the high reproducibility in individual sampling.

The data summaries for replicate samples include the mean, the standard deviation, minimum and maximum observed value, the coefficient of variation (measure of relative error), and the number of samples. Of special interest are the small coefficients of variations. The relatively small coefficient of variation for both the stable metal and radiological measurements show the narrow range of observed values and is an indication of the uniform distribution of these common metals and radionuclides in the surface soils at both lake sites.

Stable Metals

Stable metal results for NEDS Lake and Antelope Lake are given in Table B-6 and B-8. Results from NEDS Lake and Antelope Lake samples were unique. It was found that the majority of the metals compared between the two sites (with the exception of those at the detection limit) were statistically different ($\alpha=0.05$). While both locations showed high sample reproducibility and low sample variability, each site is distinct from the other.

Radionuclides

Radionuclide results for NEDS Lake and Antelope Lake are given in Table B-7 and B-9. The radionuclide displaying the largest relative error in sampling and the least reproducibility is americium-241. Americium-241, which does not occur naturally in the environment, was found in very low concentrations, but greater than the analytical detection limit in three of ten samples collected at NEDS. The large sample variability is related to the uncertainty associated with low level measurements and the non-uniform distribution of americium-241 over the sampled area.

NEDS is believed to have limited depleted uranium (DU) contamination related to earlier, unrelated, tests at the site. The earlier contamination is believed to be in the form of DU shards rather than a uniform distribution of uranium in the environment. However, the limited soil sampling did not identify this contamination. Conversely, at Antelope Lake, no unusual radiological results were observed.

Results Summary

The reproducibility and low sample variability of both the radionuclides and stable metals are related processes responsible for their presence in the environment and the playa lake itself. When compared to soil samples collected in other areas of TTR and to background sampling locations offsite, metals that occur naturally within rocks and soils tended to be higher in concentration at both NEDS and Antelope Lakes. The reason for this is thought to be due to the soil itself. Routine soil sampling locations are generally in sandy areas, whereas the lake sites are made up of a high percentage of clay, as is typical of lacustrine deposits where finer particles are the last to settle out of the water column. Also, the long term physical and chemical processes associated with playa lakes tend to provide for a very uniform distribution of chemical constituents.

4.2.5 Thermoluminescent Dosimeter (TLD) Monitoring Results

In January 1994, SNL began an ambient gamma radiation monitoring program as part of the long-term, routine, Environmental Surveillance Program at TTR. TLDs measure external gamma exposure from both background (e.g., cosmic rays) and man-made sources (e.g., fall-out and diffuse sources). Factors such as elevation and local geological deposits can effect TLD measurements. The nationwide average from all sources is 360 millirem per year (mrem/yr).

The TTR TLD network consists of five community (offsite), four perimeter, and 13 onsite locations. Table 4-3 summarizes the TLD measurements of annual radiation exposure.

TLD data was analyzed using the same criteria to identify potential locations of concern as was done with metals and radionuclides (95 percent confidence interval). Last year the results identified high values at onsite TLD location T-13, located at the northeast corner of the Operations Center perimeter fence. The 1997 annual value was 218 ± 52 mrem/yr compared to an annual average offsite exposure of 135 ± 21 mrem/year. However, in 1998, the anomalous high was not observed. The 1998 result was 157 ± 6.6 mrem/yr compared to the offsite average of 144 ± 4 mrem/yr. Therefore T-13 is no longer a site of concern. However, reviews of the historic TLD data for T-13 does show that the elevated results tend to occur on a cyclic or intermittent basis.

TABLE 4-3. Summary of Thermoluminescent Dosimeter (TLD) Measurements for 1998

Location Class	Sample Size	Units	Mean	Error	Minimum	Maximum
TTR (Onsite)	13	mrem/yr	149.58	4.25	114.0	176.0
Perimeter	4	mrem/yr	141.88	3.98	93.9	146.6
Offsite	5	mrem/yr	144.32	4.00	132.4	151.8

NOTE: mR/yr = milliroentgen per year

4.3 PERSPECTIVE ON PLUTONIUM DISTRIBUTION IN THE ENVIRONMENT

It is generally accepted that once plutonium comes in contact with soil in the environment, it becomes firmly attached to a host particle. Previous studies (Tamura 1974, 1975, 1976) of soil samples from safety-shot areas at the Nevada Test Site (NTS) showed plutonium particle-size association was primarily with coarse silts (50 to 20 microns [μm]) and fine sands (125 to 50 μm). The inhalation of finer sizes ($<7 \mu\text{m}$ diameter at a density of 1 gram per cubic centimeter [g/cm^3]) is considered most hazardous (Tamura 1976). However, the coarser soil particles should not be ignored with regard to environmental transport, as these particle sizes are readily subjected to movement by wind (Leavitt 1980). Leavitt (1976) studied five safety-shot areas in Nevada and reported that the wind had a dominant influence on the surface texture of the desert soil by depositing soil fines around the base of brush or vegetation.

A later study by Tamura (1977) discussed the occurrence of sandy mounds formed under desert shrubbery. These mounds are formed by the filtering action of the desert vegetation in intercepting saltating particles (movement of particles by bouncing along the ground surface). This study, and additional studies, found that in plutonium-contaminated areas, the plutonium activity levels were higher in the desert mounds

than in the contiguous desert pavement (soil areas with sparse vegetation and underlain by a hard-pan surface). This demonstrates the effect of wind erosion in dispersal of contaminated material. The Tamura (1977) study also discussed evidence of plutonium migration downward into the soil profile.

Evidence of water erosion has been observed within the outer control fence at Clean Slate 2. The erosive effects of water may pose another mechanism for transport of the contaminated material. Essington and Fowler (1976) observed the ability of plutonium to migrate to deeper layers of soil with time. Vertical transport of contaminants into the soil column may allow greater exposure of roots and a potential for root uptake of contaminants by the plants. Soil profiles from the safety-shot areas at TTR indicate a decrease in the plutonium-to-amerium ratio with depth (Romney et al. 1975), suggesting greater vertical movement of americium-241 relative to plutonium-239 and plutonium-240. This same report also stated that there is evidence showing that americium is much more readily available to plants through roots than is plutonium. Gilbert et al. (1975) stated that erosive processes and penetration into the soil would eventually flatten out peak contaminant concentrations, and that there was a need for long-term hazard evaluation to determine the change in contaminant concentrations over time at the safety-shot areas.

4.4 ENVIRONMENTAL MONITORING PERFORMED BY TPG

TPG performed or assisted in most environmental monitoring activities at the site in 1998. These included the following routine environmental monitoring duties:

- Sampling drinking water sources (Production Well 6)
- Sampling wastewater outfalls
- Ambient air monitoring
- Soil sampling soils at spill sites or in areas requiring characterization
- Managing the TLD network
- Hazardous waste characterization

4.5 WATER MONITORING

Results for potable water and wastewater effluent sampling are presented below. The issue of storm water monitoring is also discussed.

The *Water Conservation Plan for the Tonopah Test Range* complies with State Water Resources Division regulations requiring a water conservation plan for permitted water systems and major water users in Nevada (DOE 1992).

4.5.1 Production Well Monitoring

The production well that supplies drinking water to the Sandia Compound in Area 3 is routinely

sampled for contaminants. All sampling is conducted in accordance with the *Tonopah Test Range Site Sampling Plan* (DOE 1990b). Analytes are sampled at different intervals as follows:

Total Coliform – monthly

Nitrates and nitrites – annually

Dioxins – quarterly

VOCs and semi-VOCs – annually

Copper and lead – annually (but going to 3 yr interval)

A complete chemical and radiological analysis of the site's drinking water is required by the State every three years; this was last performed on March 21, 1996.

1998 Bacteriologic Sampling Results

In 1998, samples that were sent to a State-certified laboratory in Las Vegas, Nevada, were found to be above the established standards for coliform bacteria. (All other results were below maximum established standards.) Total coliform bacteria measurement is an indicator that pathogenic bacteria may be present in the water. Notifications were immediately made to the State of Nevada and a public warning was issued to site users. There were no illnesses reported as a result of the short-term contamination.

The cause of the bacterial contamination stemmed from a faulty chlorination system. The system had gone out of service one week prior to the high bacteria count being noted. A subsequent investigation of the well head found two unsealed openings, which had allowed debris to fall into the water.

The system was super-chlorinated for several weeks to remove all bacteria in accordance with State disinfection and resampling protocols. The openings were sealed and the well head. Normal chlorine treatment levels were resumed when negative coliform results were achieved.

Parallel Sampling by the EPA

The EPA also performs sampling on Well 6 for nitrate and nitrites every three years. In addition, the EPA provides a radiological analysis survey for the Long-Term Hydrologic Monitoring Program. Sampling sites are based on the *Tonopah Test Range Site Sampling Plan* (DOE 1990b) and are in accordance with the Safe Drinking Water Act (SDWA).

4.5.2 Sewage System and Septic Tank Monitoring

SNL conducts wastewater monitoring at the USAF sewage lagoon and septic tanks.

Sewage System

Sewage from SNL facilities in the Main Compound at Area 3 goes to the USAF facultative sewage lagoon. TPG takes annual wastewater samples from Area 3 at the point wastewater leaves SNL property and enters the USAF system.

Septic system sampling is performed on an as-needed basis. There are six septic systems onsite owned by SNL.

The USAF holds the National Pollutant Discharge Elimination System (NPDES) permit for its wastewater discharges. The Air Force takes quarterly samples from the headwater end of the lagoon. SNL used to provide quarterly sampling results to the Air Force for inclusion into their USAF Discharge Monitoring Report (DMR). However, the NPDES permit was modified in 1997 and no longer stipulates the requirement of quarterly data from SNL. Therefore, SNL will now submit annual sample results to the Air Force.

TPG collects 48-hour composite wastewater samples on an annual basis and has the following parameters analyzed:

- Total cyanide (SNL does not use cyanide containing compounds)

- pH and non-filtered residue
- Phenolics (SNL does not use phenol-containing compounds)
- Chemical oxygen demand
- Volatile organic compounds (VOCs)
- Semi-VOCs (SVOCs)
- Metals (cadmium, chromium, copper, nickel, silver, zinc, lead, selenium, and mercury)
- Total recoverable petroleum hydrocarbons (TRPH)
- Oil and grease
- Tritium, gamma spectroscopy, and gross alpha and gross beta

All analytical results of SNL's wastewater sampled from the Area 3 compound were within regulatory limits in 1998. Results can be obtained from TPG.

Septic Tank Systems

TTR's six active septic tanks, used in remote locations, are maintained by the TTR facilities group. The sewage from these locations flows into septic tanks and associated drain fields. None of these systems required maintenance, sampling, or pumping in 1998. All other remaining septic systems have been closed or are undergoing closure and are being addressed by the ER Project.

4.5.3 Storm Water Monitoirng

Currently, SNL/NV has no requirement to perform storm water monitoring at TTR. However, at a meeting held to discuss the upcoming proposed outdoor fire test facility to be constructed at TTR, the Nevada regulator expressed a concern that TTR did not have an NPDES storm water discharge permit. Given the lack of significant runoff, high evaporation rates, and the nature of the closed basin, SNL and DOE contend that storm water monitoring is not needed. A letter will be drafted in 1999 and

submitted to Nevada's Storm Water regulator, stating SNL's and DOE's position that a permit is not required.

Air Quality Surveillance and Emissions Monitoring

Air quality compliance at TTR is met by adherence to specific permit conditions as shown in Table 2-3, and compliance with local, State, and Federal air regulations. Ambient air quality monitoring or emission monitoring is not currently required at TTR. The last ambient air monitoring was conducted in 1996 to ascertain the level of radiological constituents in the air; this is discussed below. The events leading up to the decision to monitor and the results are discussed below.

5. 1 RADIOLOGICAL AIR MONITORING

Operations at TTR conducted by SNL/NV do not involve activities that release radioactive emissions from either point sources (stacks and vents) or current outdoor testing. However, diffuse radiological emissions are produced from the re-suspension of americium and plutonium present at the Clean Slate Environmental Restoration (ER) sites (Figure 5-1). Other ER sites with minor radiological contamination, such as depleted uranium (DU), do not produce air emission sources from re-suspension.

NESHAP

The National Emission Standard for Hazardous Air Pollutants (NESHAP), 40 CFR 61, Subpart H, has set a maximum limit of 10 mrem/yr for all combined sources from any DOE facility. Although the dose calculated

from the Clean Slate sites is many times less than this standard, there was an issue of whether the site would require continuous radiological air monitoring or not.

The 1995 NESHAP report for TTR reported a calculated effective dose equivalent (EDE) to the maximally exposed individual (MEI) of 1.1 mrem/year as a result of diffuse emissions from the Clean Slate sites (SNL 1996). Because the EPA requires continuous air monitoring for any radionuclide source that contributes a dose in excess of 0.1 mrem/yr to the MEI, SNL instituted continuous air monitoring at the site for one year beginning on February 22, 1996 and ending on February 25, 1997. The monitoring site was chosen at the TTR Airport where the highest calculated dose was determined for the onsite MEI, as discussed in the 1996 NESHAP report (SNL 1997). The dose assessment result from the continuous monitoring was 0.024 mrem/yr. This was about five times less than the 0.1 mrem/yr threshold cutoff for which continuous monitoring would be required. The average air concentration, in curies/cubic meter (Ci/m³) were measured as follows:

Americium-241	4.1×10^{-18} Ci/m ³
Plutonium-238	1.6×10^{-18} Ci/m ³
Plutonium-239/240	9.5×10^{-19} Ci/m ³

Although an annual calculated dose assessment is not required for the site, SNL continues to produce an annual NESHAP report for TTR (SNL 1999). The results from the 1996-1997 monitoring will continue to be used for as long as there is no change in the status of the Clean

Slate sites. Table 5-1 summarizes the dose assessment results for 1998. As a comparison, the average nationwide dose a person receives from all radioactive sources (natural and man-made) is approximately 360 mrem/yr—the bulk of which comes from natural sources such as

radon. Future NESHAP activities at TTR are expected to be minimal.

TABLE 5-1. Calculated Dose Assessment Results for Onsite Receptor

Dose to Receptor	Location	1997 Measured Dose*	NESHAP Standard	Natural Background
Onsite Receptor (EDE to the MEI)	Airport TTR Area	0.024 mrem/yr (0.00024 msievert/yr)	10 mrem/yr 0.1 msievert/yr	360 ¹

NOTE: * Dose calculated from continuous monitoring Feb 1996 – Feb 1997.

EDE = effective dose equivalent

MEI = maximally exposed individual

¹ Natural background is estimated at 360 mrem/year nationwide.

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ANCILLARY INFORMATION

Units of Measure

°C	Celsius degree
cm	centimeter
cm ³	cubic centimeter
°F	Fahrenheit degree
ft	foot
g	gram
gal	gallon
in.	inch
kg	kilogram
km	kilometer
L	liter
m	meter
m ²	square meter
m ³	cubic meter
mg/L	milligrams per liter
mi	mile
mi ²	square mile
m/s	meters per second
ppm	parts per million
μm	micron
yr	year
yd ³	cubic yard

Units of Radiological Measure

Ci	curie (unit of radioactivity)
mrem	millirem (unit of radiation dose)
mrem/yr	millirem per year
mR/yr	milliroentgen per year
pCi	picocurie
pCi/g	picocurie per gram
rem	roentgen equivalent man (unit of dose equivalent)
μg/g	microgram per gram
μg/m ²	microgram per square meter
μg/m ³	microgram per cubic meter

Elements

Al	aluminum	Ar	arsenic
Ba	barium	Be	beryllium
Cu	copper	Cd	cadmium
Co	cobalt	Cr	chromium
Fe	iron	Pb	lead
Mg	magnesium	Hg	mercury
Mn	manganese	Ni	nickel
K	potassium	Tl	thallium
Se	selenium	Ag	silver
V	vanadium	Zn	zinc

Isotopes

Am-241	americium-241
Pu-238	plutonium-238
Pu-239	plutonium-239
Pu-240	plutonium-240
Pu-241	plutonium-241
Pu-242	plutonium-242
Ra-226	radium-226
Th-232	thorium-232
H-3	tritium
Cs-137	cesium-137
U	uranium
U-238	uranium-238
U _{tot}	uranium, total

Abbreviations and Acronyms

AEC	U.S. Atomic Energy Commission
AIRFA	American Indian Religious Freedom Act
ARPA	Archaeological Resources Protection Act
ASER	Annual Site Environmental Report
AST	above-ground storage tank
BLM	Bureau of Land Management
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CADD	Corrective Action Decision Document
CAP	Corrective Action Plan
CAI	Corrective Action Investigation
CAIP	Corrective Action Investigation Plan
CAU	Corrective Action Unit
CAS	Corrective Action Site
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
CY	calendar year
DMR	Discharge Monitoring Report
DOC	U.S. Department of Commerce
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE/AL	U.S. Department of Energy/Albuquerque Operations Office
DOE/ERD	U.S. Department of Energy/Environmental Restoration Department
DOE/HQ	U.S. Department of Energy/Headquarters
DOE/KAO	U.S. Department of Energy/Kirtland Area Office
DOE/NV	U.S. Department of Energy/Nevada Operations Office
DOI	U.D. Department of Interior
DRI	Desert Research Institute, Water Resources Center, University of Nevada System
DU	depleted uranium
EA	Environmental Assessment
ECL/ADM	Environmental Checklist/Action Description Memorandum
EDE	effective dose equivalent
EO	Executive Orders
EHS	Extremely Hazardous Substances
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ER	Environmental Restoration
ERDA	U.S. Energy Research and Development Administration
ES&H	Environment, Safety and Health
ESA	Endangered Species Act
FFCAct	Federal Facilities Compliance Act
FFACO	Federal Facilities Agreement and Consent Order
FIDLER	field instrument for the detection of low-energy radiation
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FY	fiscal year

JTA	Joint Test Assembly
KMI	Kirk-Mayer, Inc. (KMI Services)
LDR	Land Disposal Restriction
MOA	Memorandum of Agreement
MDC	minimum detectable concentrations
MEI	maximally exposed individual
MSDS	Material Safety Data Sheet
MW	mixed waste
NA	not applicable, not available
NAEG	Nevada Applied Ecology Group
NAFB	Nellis Air Force Base (Range Complex)
NAFR	Nellis Air Force Range
NEDS	Non-Explosive Destruction Site
ND	Not Detected (or below the detection limit)
NDEP	Nevada Department of Environmental Protection
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NF	None found
NHPA	National Historic Preservation Act
NOS	not otherwise specified
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	National Response Center
NTS	Nevada Test Site
NV	Nevada
ODIS	Onsite Discharge Information System
O&M	Operations and Maintenance
PA	Preliminary Assessment
PCB	polychlorinated biphenyl
PIC	Pressurized Ionization Chamber
PMS	portable monitoring station
QA	quality assurance
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
ROD	Record of Decision
RQ	Reportable Quantity
RWAP	Radioactive Waste Acceptance Package
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SHPO	State Historic Preservation Office
SNL	Sandia National Laboratories
SNL/NM	Sandia National Laboratories/New Mexico
SNL/NV	Sandia National Laboratories/Nevada
SPCC	Spill Prevention, Control, and Countermeasures
SVOC	semi-volatile organic compound

TLD	thermoluminescent dosimeter
TPH	total petroleum hydrocarbon
TRPH	total recoverable petroleum hydrocarbon
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, and disposal facility
TSP	total suspended particulates
TTR	Tonopah Test Range
UDP	underground discharge point
USAF	U.S. Air Force
USGS	U.S. Geological Survey
UST	underground storage tank
UXO	unexploded ordnance
VOC	volatile organic compound

Approximate Conversion Factors for Selected Si (Metric) Units

Multiply Si (metric) unit	by	To obtain U.S. customary unit
cubic meter (m ³)	35	cubic feet (ft ³)
centimeter (cm)	0.39	inch (in.)
meter (m)	3.3	feet (ft)
kilometer (km)	0.62	mile (mi)
square kilometer (km ²)	0.39	square mile (mi ²)
hectare (ha)	2.5	acre
liter (L)	0.26	gallon (gal)
gram (g)	0.035	ounce (oz)
kilogram (kg)	2.2	pound (lb)
microgram per gram (µg/g)	1	parts per million (ppm)
milligram per liter (mg/L)	1	Parts per million (ppm)
Temperature	Equation	Temperature
Celsius (°C)	°F = 9/5 °C + 32	Fahrenheit (°F)

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APPENDIX A

**STATE OF NEVADA REGULATIONS AND
PERMIT LISTINGS**

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CONTENTS

TABLE

A-1	State of Nevada Regulations Applicable to the Tonopah Test Range (TTR).....	A-4
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TABLE A-1. State of Nevada Regulations Applicable to the Tonopah Test Range (TTR)

<i>Nevada Wildlife Regulations</i>	
Nevada Revised Statute, Title 45, Chapter 501. NRS 501.010-501.243	<ul style="list-style-type: none"> • Diversion of surface drainage channels • Clearing, leveling, and grading of site • Road construction • Highway improvement • Installation of water lines
Wildlife Regulations, NAC 504.510-504.550	<ul style="list-style-type: none"> • Installation of water reservoirs • Installation of fuel storage tanks • Construction of sanitary landfill • Construction of explosives bunkers
<i>Nevada Air Quality Regulations</i>	
Nevada Revised Statutes, Title 40, Public Health and Safety, Chapter 445. NRS 445.401-445.601	<ul style="list-style-type: none"> • Diversion of surface drainage channels • Clearing, leveling, and grading of site • Road construction • Highway improvement • Installation of water lines • Installation of water reservoirs • Installation of fuel storage tanks • Construction of sanitary landfill • Construction of explosives bunkers • Construction of support buildings • Incinerator • Diesel-powered emergency generator
NAC 445.430-445.995	
<i>Nevada Water Pollution</i>	
Nevada Revised Statutes, Title 40, Public Health and Safety, Chapter 445. NRS 445.131-445.354	<ul style="list-style-type: none"> • Construction of operation of sewage treatment plant • Disposal of drilling fluids • Water supply treatment plant
NAC 445.070-445.194	
<i>Nevada Regulations Solid Waste Management</i>	
Nevada Revised Statutes, Title 40, Public Health and Safety, Chapter 444. NRS 444.510-444.610	<ul style="list-style-type: none"> • Clearing, leveling, and grading of site • Construction of support buildings • Construction and operation of sanitary landfill • Daily sanitary wastes • Disposal of sewage sludge
Regulations Governing Solid Waste Management	

TABLE A-1. State of Nevada Regulations Applicable to the TTR (Concluded)

<i>Nevada Regulations for Individual Sewer Systems</i>	
Nevada Revised Statutes, Title 40, Public Health and Safety, Chapter 444. NRS 444.650	<ul style="list-style-type: none"> • Construction of sewage collection systems
NAC 444.750-444.840	
<i>Nevada Public Water Supply and Public Water Systems Regulations</i>	
Nevada Revised Statutes, Title 40, Public Health and Safety, Chapter 445. NRS 445.030	<ul style="list-style-type: none"> • Installation of water lines • Installation of water reservoirs
NAC 445.370-445.420	
<i>Nevada Water Resources</i>	
Nevada Revised Statutes, Underground Water and Wells, Chapters 533 and 534. NRS 534.010-534.190	<ul style="list-style-type: none"> • Installation of water lines • Installation of water reservoirs
Regulations for Drilling Wells	
<i>Radiation Control</i>	
Nevada Revised Statutes, Title 40, Public Health and Safety, Chapter 459. NRS 459.010-459.290	<ul style="list-style-type: none"> • Use of radioactive sources
Nevada Regulations for Radiation Control	

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APPENDIX B

**SAMPLING LOCATION MAPS
AND RADIOLOGICAL RESULTS**

Target Lake at Tonopah Test Range (1960s)

CONTENTS

FIGURES

B-1	Offsite Soil Sampling Locations	B-5
B-2	Perimeter Soil Sampling Locations	B-8
B-3	Soil Sampling Locations in the South Plume Area	B-11
B-4	Soil Sampling Locations in the Range Operations Center and Compound	B-14
B-5	Soil Sampling Locations Around the Range Operations Center Storage Yard	B-15
B-6	Various Onsite Soil Sampling Locations	B-18
B-7	Soil Sampling Locations at the Various Locations - Mellan Hill Area	B-19
B-8	Soil Sampling at Various Locations - Near the Hard Target/Depleted Uranium Area	B-20
B-9	Soil Sampling Locations at NEDS Lake	B-23
B-10	Soil Sampling Locations at Antelope Lake	B-26

TABLES

B-1a	Stable Metal Results for Offsite Soil Sampling, 1998	B-6
B-1b	Radiological Results for Offsite Soil Sampling, 1998	B-7
B-2a	Stable Metal Results for Perimeter Soil Sampling, 1998	B-9
B-2b	Radiological Results for Perimeter Soil Sampling, 1998	B-10
B-3a	Stable Metal Results for South Plume Area Soil Sampling, 1998	B-12
B-3b	Radiological Results for South Plume Area Soil Sampling, 1998	B-13
B-4a	Stable Metal Results for Range Operations Center Soil Sampling, 1998	B-16
B-4b	Radiological Results for Range Operations Center Soil Sampling, 1998	B-17
B-5a	Stable Metal Results for Various Onsite Soil Sampling, 1998	B-21
B-5b	Radiological Results for Various Onsite Soil Sampling, 1998	B-22
B-6	Stable Metal Results for NEDS Lake	B-24
B-7	Radiological Results for NEDS Lake	B-25
B-8	Stable Metal Results for Antelope Lake	B-27
B-9	Radiological Results for Antelope Lake	B-28
B-10	Summary of Stable Metals Results for Triplicate Sampling at NEDS Lake	B-29
B-11	Summary of Radionuclide Results for Triplicate Sampling at NEDS Lake	B-30
B-12	Summary of Stable Metals Results for Triplicate Sampling at Antelope Lake	B-31
B-13	Summary of Radionuclide Results for Triplicate Sampling at Antelope Lake	B-32
B-14	Summary of Stable Metals Results for Triplicate Sampling, 1998	B-33
B-15	Summary of Radionuclide Results for Triplicate Sampling, 1998	B-34

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**FIGURE B-1. Offsite Soil Sampling Locations
(14 Locations)**

TABLE B-1a. Stable Metal Results for Offsite Soil Sampling, 1998

Analyte	B-01 (mg/kg)	B-02 (mg/kg)	B-03 (mg/kg)	B-04 (mg/kg)	B-05 (mg/kg)	B-06 (mg/kg)	B-07 (mg/kg)	B-08 (mg/kg)	B-09 (mg/kg)	B-10 (mg/kg)	B-11 (mg/kg)	B-12 (mg/kg)	B-13 (mg/kg)	B-14 (mg/kg)	Average Offsite Value 1 (mg/kg)	Highest Offsite Value 2 (mg/kg)
Aluminum	11,000	11,000	12,000	7,600	12,000	7,400	7,300	7,900	12,000	8,000	12,000	9,400	6,000	6,000	7,541	12,700
Antimony	5	5	5	5	5	5	5	5	5	6	5	5	5	5	5	6
Arsenic	11	25	11	10	11	9	9	7	14	43	8	9	6	8	12	43
Barium	160	150	140	120	160	170	150	170	170	810	210	160	140	130	160	810
Beryllium	0.5	0.7	0.7	0.5	0.6	0.5	0.5	0.5	0.5	1	0.5	0.6	0.5	0.5	0.5	1
Cadmium	1.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5	0.5	0.5	1.4
Chromium	32	28	16	21	24	48	32	36	26	31	30	21	20	27	15	48
Cobalt	4.2	5.4	4.6	2.3	4.2	3.2	3.8	3.3	4.4	3.9	4.9	3.5	2	2.6	3.3	5.4
Copper	8.4	14	8.3	8.8	13	6.5	8.8	6.5	8.5	14	7.1	6.4	4.5	4.4	8.2	18
Iron	12,000	11,000	12,000	8,700	12,000	10,000	9,500	9,700	13,000	12,000	12,000	8,900	6,900	8,100	8,640	16,800
Lead	15	20	15	14	7	8	37	15	15	15	8	12	6	9	14	37
Magnesium	3,300	4,000	4,400	3,400	4,600	2,400	2,900	2,100	3,600	18,000	4,700	3100	1,800	1,900	3,627	18,000
Manganese	420	490	450	280	300	260	370	360	290	300	440	440	170	220	315	551
Mercury	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Nickel	4	5	4	4	6	5	6	5	6	22	5	6	3	4	5.5	22
Potassium	3,800	3,800	4,100	2,800	4,100	2,600	3,800	3,300	3,800	3,000	5,300	4,400	3,300	2,600	3,053	5,300
Selenium	7	5	5	6	7	5	7	5	6	7	6	5	5	5	6	7
Silver	0.5	1	0.6	1.2	0.5	0.5	0.6	0.5	0.7	0.5	0.5	0.5	0.5	0.5	0.8	3
Thallium	27	NR	NR	NR	NR	NR	10	15	10	15	27	18	10	10	14	27
Vanadium	23	24	27	18	25	20	12	17	24	47	33	13	11	16	16	47
Zinc	42	40	46	43	36	33	50	38	40	87	32	32	23	26	35	87

NOTE: ¹The "average offsite value" is the sum of all measurements taken over the last 5 years (1994 – 1998) divided by the total sample size (excluding 1997, for which no measurements were taken).

²The "highest offsite value" is the highest offsite result taken in the last 5 years (1994 – 1998) (excluding 1997, for which no measurements were taken).

TABLE B-1b. Radionuclide Results for Offsite Soil Sampling, 1998

Analyte	B-01	B-02	B-03	B-04	B-05	B-06	B-07	B-08	B-09	B-10	B-11	B-12	B-13	B-14	Average Offsite Value
Utot (µg/g)	2.5	2.9	3.4	2.8	4.8	2.4	2.5	2.7	2.3	3.4	2	2.6	2.3	2.3	3.08
K-40 (pCi/g)	32	41	35	38	36	36	38	37	36	22	37	41	45	40	0
K-40 Error	2.2	2.9	2.8	2.6	2.7	2.6	2.6	2.4	2.5	1.8	2.6	2.6	3.2	2.6	--
Cs-137 (pCi/g)	0.10	0.81	0.32	0.27	0.22	0.06	0.51	0.33	0.09	0.10	0.36	0.35	0.09	0.01	0.31
Cs-137 Error	0.07	0.14	0.10	0.10	0.17	0.11	0.13	0.07	0.12	0.11	0.10	0.10	0.18	0.12	--
Am-241 (pCi/g)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01

NOTE: ND = not detected
 minimal detectable activity (MDA) = 0.20 pCi/g for americium-241.

FIGURE B-2. Perimeter Soil Sampling Locations (Five Locations)

TABLE B-2a. Stable Metal Results for Perimeter Soil Sampling, 1998

Analyte	Units	T-06	T-08	T-11	T-12	T-13	Average Offsite Value (mg/kg)	Highest Offsite Value (mg/kg)
Aluminum	mg/kg	9,100	4,400	9,600	9,400	6,300	7,541	12,700
Antimony	mg/kg	5	5	5	5	5	5	6
Arsenic	mg/kg	7	6	12	19	20	12	43
Barium	mg/kg	110	100	97	140	160	160	810
Beryllium	mg/kg	0.5	0.5	1.2	0.6	0.7	0.5	1
Cadmium	mg/kg	0.5	0.5	0.5	0.5	0.5	0.5	1.4
Chromium	mg/kg	41	42	39	23	26	15	48
Cobalt	mg/kg	3.2	1	5.9	4.4	3.9	3.3	5.4
Copper	mg/kg	5.7	3.9	18	8.2	6.2	8.2	18
Iron	mg/kg	8,200	5,600	15,000	12,000	12,000	8,640	16,800
Lead	mg/kg	9	5	20	15	17	14	37
Magnesium	mg/kg	2,300	1,300	2,800	3,800	1,400	3,627	18,000
Manganese	mg/kg	380	130	800	520	430	315	551
Mercury	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Nickel	mg/kg	4	2	8	6	2	5.5	22
Potassium	mg/kg	3,400	2,100	2,900	3,600	3,200	3,053	5,300
Selenium	mg/kg	5	5	5	6	5	6	7
Silver	mg/kg	0.5	0.5	0.5	0.5	0.5	0.8	3
Thallium	mg/kg	16	10	17	18	10	14	27
Vanadium	mg/kg	14	8.8	30	21	12	16	47
Zinc	mg/kg	34	20	93	45	43	35	87

NOTE: Values shown in bold were elevated over the highest offsite value.

TABLE B-2b. Radiological Results of Perimeter Soil Sampling, 1998

Analyte	Units	T-06	T-08	T-11	T-12	T-13	Average Offsite Value
U _{tot} (μg/g)	μg/g	2.5	2.4	2.2	2.5	2.2*	3.08
K-40	pCi/g	45	38	38	40	38	0
K-40 - Error	pCi/g	3.1	2.6	2.8	2.7	2.5	--
Cs-137	pCi/g	0.35	0.1	0.22	0.46	0.18	0.31
Cs-137 - Error	pCi/g	0.11	0.07	0.07	0.08	0.12	--
Am-241	pCi/g	ND	ND	ND	ND	ND	0.01

NOTE: * Location T-13 was evaluated for uranium-235.

ND = not detected

Minimal Detectable Activity (MDA) = 0.20 pCi/g for americium-241

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FIGURE B-3. Soil Sampling Locations in the South Plume Area (Five Locations)

TABLE B-3a. Stable Metal Results for South Plume Area Soil Sampling, 1998

Analyte	T-14 (mg/kg)	T-16 (mg/kg)	T-17 (mg/kg)	T-18 (mg/kg)	T-19 (mg/kg)	Average Offsite Value (mg/kg)	Highest Offsite Value (mg/kg)
Aluminum	11,000	11,000	9,000	13,000	9,100	7,541	12,700
Antimony	5	5	5	5	5	5	6
Arsenic	9	7	13	11	8	12	43
Barium	280	250	210	190	120	160	810
Beryllium	0.5	0.5	0.5	0.7	0.5	0.5	1
Cadmium	0.5	0.5	0.5	0.5	0.5	0.5	1.4
Chromium	12	18	16	26	37	15	48
Cobalt	4.6	4.1	4.2	4.6	3	3.3	5.4
Copper	14	7.2	6.8	11	6.9	8.2	18
Iron	12,000	11,000	12,000	13,000	8,900	8,640	16,800
Lead	12	10	13	11	11	14	37
Magnesium	4,000	4,000	3,600	5,600	2,600	3,627	18,000
Manganese	470	490	410	520	380	315	551
Mercury	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Nickel	5	7	7	9	4	5.5	22
Potassium	5,500	5,700	4,800	5,600	3,500	3,053	5,300
Selenium	5	8	5	5	5	6	7
Silver	0.5	0.5	0.5	0.5	0.5	0.8	3
Thallium	28	23	17	24	24	14	27
Vanadium	24	20	24	21	14	16	47
Zinc	37	37	41	41	28	35	87

NOTE: Values shown in bold were elevated above the highest offsite value.

1The "average offsite value" is the sum of all measurements taken over the last 5 years (1994 – 1998) divided by the total sample size (excluding 1997, for which no measurements were taken).

2The "highest offsite value" is the highest offsite result taken in the last 5 years (1994 – 1998) (excluding 1997, for which no measurements were taken).

TABLE B-3b. Radiological Results for South Plume Area Soil Sampling, 1998

Analyte	T-14*	T-16	T-17	T-18	T-19	Average Offsite Value
U_{tot} (μg/g)	2.5*	2.7	2.7	2.6	3.2	3.08
K-40 (pCi/g)	41	40	44	36	41	0
<i>K-40 Error</i>	<i>2.7</i>	<i>2.6</i>	<i>3.1</i>	<i>2.5</i>	<i>3</i>	--
Cs-137 (pCi/g)	1	0.74	0.57	0.94	0.54	0.31
<i>Cs-137 Error</i>	<i>0.13</i>	<i>0.12</i>	<i>0.1</i>	<i>0.11</i>	<i>0.11</i>	--
Am-241 (pCi/g)	0.16	ND	ND	ND	0.23	0.01
<i>Am-241 Error</i>	<i>0.09</i>	-	-	-	<i>0.07</i>	--
Pu-238 (pCi/g)	0.02	NA	NA	NA	0.04	--
<i>Pu-238 Error</i>	<i>0.02</i>	-	-	-	<i>0.03</i>	--
Pu-239, 240 (pCi/g)	0.21	NA	NA	NA	2.2	--
<i>Pu-239, 240 Error</i>	<i>0.08</i>	-	-	-	<i>0.37</i>	--

NOTE: * Location T-14 was elevated for uranium-235.

Values shown in bold were elevated over the highest offsite value.

ND = not detected

minimal detectable activity (MDA) = 0.20 pCi/g for americium-241

NA = not applicable

Isotopic plutonium analysis only performed if Am-241 > MDA.

FIGURE B-4. Soil Sampling Locations in the Range Operations Center and Compound (Six Locations)

FIGURE B-5. Soil Sampling Locations Around the Range Operations Center Storage Yard (2 locations)

TABLE B-4a. Stable Metal Results for Range Operations Center Soil Sampling, 1998

Analyte	OC-02 (mg/kg)	OC-03 (mg/kg)	OC-04 (mg/kg)	OC-10 (mg/kg)	OC-13 (mg/kg)	OC-19 (mg/kg)	OC-22 (mg/kg)	OC-23 (mg/kg)	Average Offsite Value (mg/kg)	Highest Offsite Value (mg/kg)
Aluminum	13,000	6,400	8,900	7,500	8,100	9,500	5,200	7,300	7,541	12,700
Antimony	5	5	5	5	5	5	5	5	5	6
Arsenic	7	11	8	7	16	10	12	6	12	43
Barium	150	100	170	110	150	140	100	120	160	810
Beryllium	0.7	0.5	0.5	0.6	0.5	0.7	0.5	0.5	0.5	1
Cadmium	0.5	0.5	0.5	0.5	0.5	0.9	0.5	0.5	0.5	1.4
Chromium	24	28	28	20	21	72	49	36	15	48
Cobalt	5.7	3.3	4.9	3.5	4	6.5	3.2	4.2	3.3	5.4
Copper	13	6.8	10	6.5	7.6	9	7.3	8	8.2	18
Iron	14000	9,400	12,000	10,000	11,000	12,000	11,000	10,000	8,640	16,800
Lead	15	10	10	13	18	13	16	12	14	37
Magnesium	5400	2,300	3,400	2,700	2,800	6,300	2,100	3,100	3,627	18,000
Manganese	380	250	310	240	280	280	230	330	315	551
Mercury	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Nickel	10	6	6	4	5	15	6	8	5.5	22
Potassium	4800	3,200	3,100	2,800	2,700	4,500	2,400	3,800	3,053	5,300
Selenium	5	5	5	5	5	5	8	7	6	7
Silver	0.6	0.5	0.7	0.5	0.5	0.5	0.5	0.5	0.8	3
Thallium	28	21	33	22	23	21	20	27	14	27
Vanadium	26	18	27	22	27	23	18	21	16	47
Zinc	54	27	31	40	130	150	39	58	35	87

NOTE: Values shown in bold were elevated above the average offsite value.

1 The "average offsite value" is the sum of all measurements taken over the last 5 years (1994 – 1998) divided by the total sample size (excluding 1997, for which no measurements were taken).

2 The "highest offsite value" is the highest offsite result taken in the last 5 years (1994 – 1998) (excluding 1997, for which no measurements were taken).

TABLE B-4b. Radiological Results for Range Operations Center Soil Sampling, 1998

Analyte	OC-02	OC-03	OC-04	OC-10	OC-13	OC-19	OC-22	OC-23	Average Offsite Value
U_{tot} ($\mu\text{g/g}$)	2.8	3.0	2.8	3.0	3.1	2.9	2.7	2.4	3.08
K-40 (pCi/g)	41	42	39	38	37	39	42	42	0
K-40 Error	3	2.7	2.7	2.5	2.6	2.6	3	2.9	--
Cs-137 (pCi/g)	0.25	0.09	0.46	0.02	0.24	-0.85	0.06	0.18	0.31
Cs-137 Error	0.08	0.12	0.10	0.13	0.08	0.13	0.19	0.06	--
Am-241 (pCi/g)	ND	ND	ND	ND	ND	ND	ND	ND	0.01

NOTE: ND = not detected
 minimal detectable activity (MDA) = 0.20 pCi/g for americium-241.

FIGURE B-6. Various Onsite Soil Sampling Locations
(Five Locations)

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FIGURE B-7. Soil Sampling Locations at the Various Locations
- Mellan Hill Area (Two Locations)

FIGURE B-8. Soil Sampling at Various Locations - Near the Hard Target/Depleted Uranium Area (Two Locations)

TABLE B-5A. Stable Metal Results for Various Onsite Soil Sampling, 1998

Analyte	Units	D-01	MH-03	MH-04	T-02	T-03	T-04	T-10	T-20	T-21
Aluminum	mg/kg	14,000	10,000	11,000	13,000	7700	8,200	16,000	12,000	20,000
Antimony	mg/kg	5	5	5	5	5	5	5	5	5
Arsenic	mg/kg	18	13	10	10	9	12	14	8	7
Barium	mg/kg	190	110	160	120	110	120	160	150	170
Beryllium	mg/kg	0.7	0.5	0.5	0.5	0.5	0.5	0.7	0.7	1.3
Cadmium	mg/kg	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6
Chromium	mg/kg	31	28	31	35	37	32	47	22	26
Cobalt	mg/kg	6.5	3.1	4.4	3.1	3.2	3.3	4.5	3.9	6.4
Copper	mg/kg	8.2	12	9.8	6.9	5.2	5.8	9.3	9.4	15
Iron	mg/kg	20,000	9600	11,000	10,000	8,600	9,000	13,000	11,000	17,000
Lead	mg/kg	12	10	9	8	8	9	8	12	12
Magnesium	mg/kg	4,900	3,700	3,700	2,900	2,200	2,700	5,000	4,900	8k600
Manganese	mg/kg	420	280	590	310	350	460	510	310	470
Mercury	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Nickel	mg/kg	6	4	5	4	4	4	7	6	10
Potassium	mg/kg	4,600	3,800	3,700	4,200	2,500	2,900	5,800	5,100	7,800
Selenium	mg/kg	5	5	5	5	5	5	8	7	8
Silver	mg/kg	0.8	0.6	0.7	0.6	0.5	0.6	0.5	0.7	0.7
Thallium	mg/kg	NR	25	29	20	18	14	31	23	17
Vanadium	mg/kg	36	18	21	18	16	15	24	18	22
Zinc	mg/kg	45	33	38	36	28	31	46	36	60

TABLE B-5b. Radiological Results for Various Onsite Soil Sampling, 1998

Analyte	D-01	MH-03	MH-04	T-02	T-03	T-04	T-10	T-20	T-21	Average Offsite Value
U_{tot} (μg/g)	2.2	2.2	3.0	3.0	3.0	3.0	2.2	3.3	2.6	3.08
K-40 (pCi/g)	31	42	43	42	39	42	41	38	35	0
K-40 Error	2.2	2.8	2.6	3	2.6	2.7	2.9	2.6	2.6	--
Cs-137 (pCi/g)	0.14	0.59	0.62	0.38	0.68	0.67	0.28	0.76	0.36	0.31
Cs-137 Error	0.12	0.12	0.10	0.10	0.11	0.10	0.12	0.12	0.08	--
Am-241 (pCi/g)	0.72	ND	ND	ND	ND	ND	ND	ND	ND	0.01
Am-241 Error	0.14	-	-	-	-	-	-	-	-	--
Pu-238 (pCi/g)	0.02	NA	NA	NA	NA	NA	NA	NA	NA	--
Pu-238 Error	0.06	-	-	-	-	-	-	-	-	--
Pu-239, 240 (pCi/g)	6.30	NA	NA	NA	NA	NA	NA	NA	NA	--
Pu-239, 240 Error	0.9	-	-	-	-	-	-	-	-	--

NOTE: Values shown in bold were elevated above the average offsite value.

ND = not detected

minimal detectable activity (MDA) = 0.20 pCi/g for americium-241.

NA = not applicable

Plutonium analysis only performed if Am-241 > MDA

99_B-9.ai

FIGURE B-9. Soil Sampling Locations at NEDS Lake (10 Locations)

TABLE B-6. Stable Metal Results for NEDS Lake

Analyte	Units	MDA	NED-01	NED-02	NED-03	NED-04	NED-05	NED-06	NED-07	NED-08	NED-09	NED-10	Average Offsite Value
Aluminum	mg/kg	10	25,000	27,000	26,000	26,000	26,000	24,000	24,000	26,000	23,000	26,000	7,638.10
Antimony	mg/kg	5	5	5	5	5	5	5	5	5	5	5	5.07
Arsenic	mg/kg	5	44	27	28	25	32	28	24	31	22	36	12.93
Barium	mg/kg	5	310	320	300	310	290	300	300	310	290	310	172.36
Beryllium	mg/kg	0.5	1.4	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	0.55
Cadmium	mg/kg	0.5	0.5	0.5	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.54
Chromium	mg/kg	0.5	16	16	16	15	15	15	14	15	15	17	17.88
Cobalt	mg/kg	0.5	8.7	8.9	8.6	9	8.4	8.4	8.4	8.9	8.1	8.4	3.28
Copper	mg/kg	0.5	27	31	22	19	17	17	17	18	20	19	8.17
Iron	mg/kg	1	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	20,000	22,000	8,592.86
Lead	mg/kg	5	23	20	20	21	20	21	21	21	19	22	13.26
Magnesium	mg/kg	5	8,900	9,800	9,400	9,200	9,100	9,100	9,000	9,400	9,500	10,000	3,750
Manganese	mg/kg	0.5	570	580	570	570	560	560	570	580	560	570	329.05
Mercury	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Nickel	mg/kg	1	11	12	12	11	12	12	11	11	12	14	5.62
Potassium	mg/kg	50	8,200	8,700	8,400	8,200	8,200	8,000	7,800	8,400	7,900	8,600	3,200
Selenium	mg/kg	5	8	11	6	7	10	12	5	11	11	12	5.79
Silver	mg/kg	0.5	0.7	1	1	0.9	0.9	0.9	1	1	0.8	0.8	0.55
Thallium	mg/kg	10	18	19	18	21	25	31	22	14	18	23	15.78
Vanadium	mg/kg	0.5	30	32	30	30	30	29	27	30	26	30	16.86
Zinc	mg/kg	0.5	79	74	73	74	73	72	72	74	70	76	35.50

TABLE B-7. Radionuclide Results for NEDS Lake

Analyte	Units	NED-01	NED-02	NED-03	NED-04	NED-05	NED-06	NED-07	NED-08	NED-09	NED-10
Americium-241	pCi/g	0.02	0.22	0.17	0.11	0.05	0.02	-0.02	-0.06	0.05	0.04
Cesium-137	pCi/g	0.75	0.36	0.58	0.48	0.66	0.47	0.64	0.68	0.65	0.46
Plutonium-238	pCi/g	NR	0.01	0.04	0	NR	NR	NR	NR	NR	NR
Plutonium-239+240	pCi/g	NR	0.03	0.06	0.04	NR	NR	NR	NR	NR	NR
Potassium-40	pCi/g	30	29	33	29	34	29	29	34	29	28
Uranium-235	pCi/g	0.25	0.38	0.9	0.62	0.52	0.37	0.3	0.39	0.37	0.2
Uranium, Total	ug/g	2.7	1.4	1.3	1.2	1.1	1.2	1.2	1.2	1.1	1.2

NOTE: NR = not reported.

99_B-10.ai

FIGURE B-10. Soil Sampling Locations at Antelope Lake (10 Locations)

TABLE B-8. Stable Metal Results from Antelope Lake

Analyte	MDA (mg/kg)	ANT-01 (mg/kg)	ANT-02 (mg/kg)	ANT-03 (mg/kg)	ANT-04 (mg/kg)	ANT-05 (mg/kg)	ANT-06 (mg/kg)	ANT-07 (mg/kg)	ANT-08 (mg/kg)	ANT-09 (mg/kg)	ANT-10 (mg/kg)	Average Offsite Value
Aluminum	10	39,000	43,000	41,000	44,000	40,000	44,000	38,000	41,000	46,000	46,000	7,638.10
Antimony	5	5	5	5	5	5	5	5	5	5	5	5.07
Arsenic	5	9	14	14	20	12	21	16	7	11	11	12.93
Barium	5	230	250	240	260	230	240	230	230	250	240	172.36
Beryllium	0.5	1.8	1.7	1.8	1.8	1.8	1.9	1.8	1.7	1.9	1.8	0.55
Cadmium	0.5	0.5	0.5	0.5	0.7	0.5	0.5	0.5	0.5	0.5	0.5	0.54
Chromium	0.5	17	19	18	20	18	19	18	18	19	18	17.88
Cobalt	0.5	8.1	8.7	8.6	9.1	8	8.2	8.2	7.6	8.4	7.9	3.28
Copper	0.5	32	23	25	26	24	25	22	21	25	24	8.17
Iron	1	26,000	27,000	27,000	27,000	26,000	27,000	25,000	26,000	27,000	26,000	8,592.86
Lead	5	15	18	16	19	16	17	16	13	15	12	13.26
Magnesium	5	14,000	14,000	14,000	14,000	14,000	14,000	13,000	13,000	14,000	14,000	3,750
Manganese	0.5	650	710	710	730	640	660	650	630	700	670	329.05
Mercury	0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.1
Nickel	2	15	13	14	14	13	15	14	12	14	13	5.62
Potassium	50	15,000	16,000	15,000	16,000	15,000	16,000	14,000	15,000	17,000	17,000	3,200
Selenium	5	7	10	6	10	12	15	14	11	11	11	5.79
Silver	0.5	0.9	0.8	0.8	0.9	0.9	0.9	1	0.7	1	0.8	0.55
Thallium	10	29	56	36	42	38	48	44	46	27	35	15.78
Vanadium	0.5	36	43	40	43	38	41	36	39	42	42	16.86
Zinc	0.5	92	95	96	97	92	97	91	92	99	96	35.50

TABLE B-9. Radionuclide Results for Antelope Lake

Analyte	Units	ANT-01	ANT-02	ANT-03	ANT-04	ANT-05	ANT-06	ANT-07	ANT-08	ANT-09	ANT-10
Cesium-137	pCi/g	0.3	0.3	0.4	0.31	0.24	0.38	0.26	0.29	0.33	0.21
Potassium-40	pCi/g	35	35	39	35	34	37	32	31	34	31
Uranium-235	pCi/g	0.24	0.53	-0.04	0.06	0.28	-0.19	0.47	0.65	0.86	0.37
Uranium, Total	µg/g	1.8	2.3	2.3	2.3	1.9	2.3	2.3	2.2	2.4	2.3

NOTE: No americium-241 was reported; therefore plutonium is not reported.

TABLE B-10. Summary of Stable Metal Results for Triplicate Sampling at NEDS Lake

ANALYTE	NED-04							NED-10					
	Units	Count	Mean	Std Dev	Minimum	Maximum	CV (%)	Count	Mean	Std Dev	Minimum	Maximum	CV (%)
Aluminum	mg/kg	3	26,000	1,528	24,000	27,000	5.9	3	24,000	2,887	21,000	26,000	11.9
Antimony	mg/kg	3	5	0	5	5	0	3	5	0	5	5	0
Arsenic	mg/kg	3	28	3	25	31	10.7	3	29	6.3	25	36	22.1
Barium	mg/kg	3	313	15.3	300	330	4.9	3	310	0	310	310	0
Beryllium	mg/kg	3	1.2	0	1.2	1.2	0	3	1.2	0.1	1.2	1.3	4.7
Cadmium	mg/kg	3	0.5	0	0.5	0.5	0	3	0.5	0	0.5	0.5	0
Chromium	mg/kg	3	15	1	14	16	6.7	3	16	1.7	14	17	10.8
Cobalt	mg/kg	3	8.8	0.2	8.6	9	2.3	3	8.3	0.3	8	8.5	3.2
Copper	mg/kg	3	21	5.9	17	28	27.5	3	18	1	17	19	5.6
Iron	mg/kg	3	22,000	1,000	21,000	23,000	4.5	3	21,000	1155	20,000	22,000	5.4
Lead	mg/kg	3	21	0.6	20	21	2.8	3	21	1	20	22	4.8
Magnesium	mg/kg	3	9,200	252	8,900	9,400	2.7	3	9,900	173	9,700	10,000	1.7
Manganese	mg/kg	3	567	5.8	560	570	1.0	3	563	5.8	560	570	1.0
Mercury	mg/kg	3	0.1	0	0.1	0.1	0	3	0.1	0	0.1	0.1	0
Nickel	mg/kg	3	11.7	0.6	11	12	4.9	3	13	1	12	14	7.7
Potassium	mg/kg	3	8,167	451	7,700	8,600	5.5	3	8,233	635	7,500	8,600	7.7
Selenium	mg/kg	3	9.3	2.1	7	11	22.3	3	10	2	8	12	20
Silver	mg/kg	3	0.9	0.1	0.8	1	11.1	3	0.8	0.1	0.8	0.9	6.9
Thallium	mg/kg	3	24.7	3.2	21	27	13.0	3	23.3	7.5	16	31	32.2
Vanadium	mg/kg	3	29.3	3.1	26	32	10.4	3	27.3	4.6	22	30	16.9
Zinc	mg/kg	3	73.7	1.5	72	75	2.1	3	73.3	3.8	69	76	5.2

NOTE: Italicized and bolded values are reported at MDA value.

CV = coefficient of variation

TABLE B-11. Summary of Radionuclide Results for Triplicate Sampling at NEDS Lake

ANALYTE	NED-04							NED-10					
	Units	Count	Mean	Std Dev	Minimum	Maximum	CV (%)	Count	Mean	Std Dev	Minimum	Maximum	CV (%)
Americium-241	pCi/g	3	0.06	0.06	0	0.11	92.8	3	0.12	0.14	0.03	0.28	121.3
Cesium-137	pCi/g	3	0.48	0.07	0.42	0.55	13.5	3	0.57	0.11	0.46	0.68	19.4
Potassium-40	pCi/g	3	29.3	1.5	28	31	5.2	3	30	2	28	32	6.7
Uranium-235	pCi/g	3	0.38	0.22	0.18	0.62	58.6	3	0.6	0.5	0.2	1.2	85.1
Uranium, Total	µg/g	3	1.2	0.1	1.1	1.2	4.9	3	1.2	0.1	1.1	1.2	4.9
Plutonium-238	pCi/g	1	0.00		0	0	NC	1	0.02		0.02	0.02	NC
Plutonium-239+240	pCi/g	1	0.04		0.04	0.04	NC	1	0.06		0.06	0.06	NC

NOTE: NC = not calculated
 CV = coefficient of variation

TABLE B-12. Summary of Stable Metal Results for Triplicate Sampling at Antelope Lake

Analyte	Units	ANT-04						ANT-10					
		Count	Mean	Std Dev	Minimum	Maximum	CV (%)	Count	Mean	Std Dev	Minimum	Maximum	CV (%)
Aluminum	mg/kg	3	42,000	2,000	40,000	44,000	4.8	3	44,000	3,464	40,000	46,000	7.9
Antimony	mg/kg	3	5	0	5	5	0	3	5	0	5	5	0
Arsenic	mg/kg	3	19	3.1	16	22	15.8	3	11	3	8	14	27.3
Barium	mg/kg	3	257	5.8	250	260	2.2	3	233.3	11.5	220	240	4.9
Beryllium	mg/kg	3	1.8	0	1.8	1.8	0	3	1.8	0	1.8	1.8	0
Cadmium	mg/kg	3	0.6	0.1	0.5	0.7	20.4	3	0.5	0	0.5	0.5	0
Chromium	mg/kg	3	19	1	18	20	5.3	3	18	1	17	19	5.6
Cobalt	mg/kg	3	9	0.2	8.8	9.1	1.9	3	8	0.1	7.9	8.1	1.3
Copper	mg/kg	3	25	1.1	24	26	4.7	3	24.3	1.5	23	26	6.3
Iron	mg/kg	3	27,000	577	26,000	27,000	2.2	3	26,000	0	26,000	26,000	0
Lead	mg/kg	3	18.7	0.6	18	19	3.1	3	14.3	2.1	12	16	14.5
Magnesium	mg/kg	3	14,000	0	14,000	14,000	0	3	14,000	0	14,000	14,000	0
Manganese	mg/kg	3	727	5.77	720	730	7.9	3	673.3	5.8	670	680	0.9
Mercury	mg/kg	3	0.1	0	0.1	0.1	0	3	0.10	0	0.1	0.1	0
Nickel	mg/kg	3	14.3	0.6	14	15	4.0	3	13.7	0.6	13	14	4.2
Potassium	mg/kg	3	15,333	577.3	15,000	16,000	3.8	3	16,666	577.3	16,000	17,000	3.5
Selenium	mg/kg	3	12	2	10	14	16.7	3	12	2.6	10	15	22.0
Silver	mg/kg	3	0.87	0.06	0.8	0.9	6.7	3	0.9	0.2	0.8	1.1	19.2
Thallium	mg/kg	3	37.3	4.04	35	42	10.8	3	34.3	6.0	28	40	17.6
Vanadium	mg/kg	3	41.3	1.5	40	43	3.7	3	39.7	3.2	36	42	8.1
Zinc	mg/kg	3	96	1.0	95	97	1.0	3	96	2	94	98	2.1

NOTE: Italicized and bolded values are reported at MDA value.

CV = coefficient of variation

TABLE B-13. Summary of Radionuclide Results for Triplicate Sampling at Antelope Lake

ANT-04														ANT-10					
Analyte	Units	Count	Average	Std Dev	Minimum	Maximum	CV (%)		Count	Average	Std Dev	Minimum	Maximum	CV (%)					
Cesium-137	pCi/g	3	0.27	0.05	0.21	0.31	19.2		3	0.27	0.06	0.21	0.32	20.8					
Potassium-40	pCi/g	3	33.7	3.2	30	36	9.5		3	35.3	3.8	31	38	10.7					
Uranium, total	µg/g	3	2.5	0.3	2.3	2.8	11.7		3	2.2	0.1	2.2	2.3	2.6					
Uranium-235	pCi/g	3	0.08	0.09	0.01	0.18	104.8		3	0.56	0.17	0.37	0.68	29.9					

NOTE: No americium-241 was reported; therefore no plutonium was reported.

CV = coefficient of variation

TABLE B-14. Summary of Stable Metal Results from Triplicate Sampling, 1998

Analyte	Units	D-01						T-03					
		Count	Average	Std Dev	Minimum	Maximum	CV	Count	Average	Std Dev	Minimum	Maximum	CV
Aluminum	mg/kg	3	12,000	2,000	10,000	14,000	16.67%	3	7,767	602.77	7,200	8,400	7.76%
Antimony	mg/kg	3	5.00	0	5	5	0.00%	3	5	0	5	5	0.00%
Arsenic	mg/kg	3	14	4	10	18	28.57%	3	8	1.00	7	9	12.50%
Barium	mg/kg	3	193.33	25.17	170	220	13.02%	3	106.67	5.77	100	110	5.41%
Beryllium	mg/kg	3	0.63	0.06	0.6	0.7	9.12%	3	0.5	0	0.5	0.5	0.00%
Cadmium	mg/kg	3	0.5	0	0.5	0.5	0.00%	3	0.5	0	0.5	0.5	0.00%
Chromium	mg/kg	3	27.67	7.57	19	33	27.37%	3	29	8.54	20	37	29.46%
Cobalt	mg/kg	3	6.23	0.31	5.9	6.5	4.90%	3	3.03	0.29	2.7	3.2	9.52%
Copper	mg/kg	3	7.53	0.61	7	8.2	8.11%	3	4.77	0.45	4.3	5.2	9.46%
Iron	mg/kg	3	17,666	2,081	16,000	20,000	11.78%	3	8,300	435.89	7,800	8,600	5.25%
Lead	mg/kg	3	11.67	0.58	11	12	4.95%	3	8.33	0.58	8	9	6.93%
Magnesium	mg/kg	3	4,700	200	4,500	4,900	4.26%	3	2,167	57.74	2,100	2,200	2.66%
Manganese	mg/kg	3	410	10	400	420	2.44%	3	357	11.55	350	370	3.24%
Mercury	mg/kg	3	0.1	0	0.1	0.1	0.00%	3	0.1	0	0.1	0.1	0.00%
Nickel	mg/kg	3	4.67	1.15	4	6	24.74%	3	3.33	0.58	3	4	17.32%
Potassium	mg/kg	3	4,133	642.91	3,400	4,600	15.55%	3	2,667	152.75	2,500	2,800	5.73%
Selenium	mg/kg	3	5	0	5	5	0.00%	3	5	0	5	5	0.00%
Silver	mg/kg	3	0.73	0.06	0.7	0.8	7.87%	3	0.5	0	0.5	0.5	0.00%
Thallium	mg/kg	2	30.50	6.36	26	35	20.87%	3	16.00	1.73	15	18	10.83%
Vanadium	mg/kg	3	30.33	6.03	24	36	19.87%	3	14.67	1.53	13	16	10.41%
Zinc	mg/kg	3	42.33	2.52	40	45	5.94%	3	27.67	0.58	27	28	2.09%

TABLE B-15. Summary of Radionuclide Results from Triplicate Soil Sampling, 1998

Location	Analyte	Units	Number of Samples	Mean	Standard Deviation	Minimum	Maximum	CV (%)
D-01	Americium-241	pCi/g	3	0.68	0.17	0.49	0.82	25.01%
	Cesium-137	pCi/g	3	0.17	0.04	0.14	0.21	22.72%
	Potassium-40	pCi/g	3	32.00	1.00	31	33	3.13%
	Plutonium-238	pCi/g	3	0.01	0.02	-0.01	0.02	229.13%
	Plutonium-239+240	pCi/g	3	5.37	0.83	4.7	6.3	15.52%
	Uranium-235	pCi/g	3	0.24	0.41	-0.12	0.68	166.44%
	Uranium, Total	µg/g	3	2.20	0.00	2.2	2.2	0.00%
T-03	Americium-241	pCi/g	1	0.19	NC	0.19	0.19	NC
	Cesium-137	pCi/g	3	0.72	0.08	0.67	0.81	10.85%
	Potassium-40	pCi/g	3	40.00	1.00	39	41	2.50%
	Plutonium-238	pCi/g	1	0.02	NC	0.02	0.02	NC
	Plutonium-239+240	pCi/g	1	1.60	NC	1.6	1.6	NC
	Uranium-235	pCi/g	3	0.11	0.02	0.09	0.13	18.18%
	Uranium, Total	µg/g	3	3.00	0.00	3	3	0.00%
T-14	Americium-241	pCi/g	1	0.16	NC	0.16	0.16	NC
	Cesium-137	pCi/g	3	0.90	0.10	0.8	1	11.11%
	Potassium-40	pCi/g	3	38.33	2.52	36	41	6.57%
	Plutonium-238	pCi/g	1	0.02	NC	0.02	0.02	NC
	Plutonium-239+240	pCi/g	1	0.21	NC	0.21	0.21	NC
	Uranium-235	pCi/g	3	0.41	0.48	0.05	0.96	118.01%
	Uranium, Total	µg/g	3	2.53	0.15	2.4	2.7	6.03%

NOTE: NC = not calculable

CV = coefficient of variation

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