DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC

JUL 17 2000

MEMORANDUM FOR NRC Region IV (Mr. Cain)

14 Jul 2000

FROM: AFMOA/SGOR
110 Luke Ave Room 405
Bolling AFB DC 20332-7050

SUBJECT: Radiological Site Decommissioning Plan for Kirtland AFB OT-10 Sites, submitted under USAF Master Materials License No. 42-23539-01AF, Docket No. 030-28641

Pleased find attached the subject decommissioning plan submitted by Kirtland AFB, as requested in your 11 Jan 2000 letter to our office. The draft plan has been reviewed once by our office, with the permittee's responses provided in front pocket of the plan.

Our point of contact is Maj Wrobel at 202-767-4309 or E-Mail at mark.wrobel@usafsg.bolling.af.mil. Our Telefax is 202-767-5302. Our Beeper for receiving after-duty-hours Incident/Accident Reports is 1-888-425-3861. AFMOA/SGOR's web page is http://sg-www.satx.disa.mil/moasgor/.

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Air Force Medical Operations Agency
Office of the Surgeon General

Attachment:
OT-10 Decommissioning Plan

cc:
HQ AFMC/CEVR (Mr. Moore) w/o Atch
HQ AFMC/SGCR w/o Atch

No: 468060

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INSTALLATION RESTORATION PROGRAM
KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

DECOMMISSIONING PLAN
FOR
INSTALLATION RESTORATION PROGRAM SITE OT-10, RADIATION TRAINING SITES, KIRTLAND AIR FORCE BASE, NEW MEXICO

JULY 2000

Prepared for
U.S. ARMY CORPS OF ENGINEERS, OMAHA DISTRICT
CENWO-ED-E
OMAHA, NEBRASKA 68102
USACE CONTRACT NO. DACW45-94-D-0003 D.O. NO. 23, WAD 27

Prepared by
FOSTER WHEELER AND MONTGOMERY WATSON
ALBUQUERQUE, NEW MEXICO

NOTICE

This Decommissioning Plan has been prepared for the U.S. Army Corps of Engineers by Foster Wheeler and Montgomery Watson to guide the remediation of radiologically-contaminated soils at OT-10 under the Installation Restoration Program (IRP). As the plan relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final decision on remedial action may be in the public's interest. The limited objectives of this plan and the ongoing nature of the IRP, along with the evolving knowledge of site conditions and radiological effects on the environment and health, must be considered when evaluating this plan, because subsequent facts may become known that may make this plan premature or inaccurate.

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ROBERT S. MILLIGAN
Environmental Public Affairs Officer

PREFACE

This Decommissioning Plan specifies the activities that will be performed during calendar years 2000 through 2002 at Installation Restoration Program Site OT-10, Kirtland Air Force Base, New Mexico. This plan addresses the requirements of the U.S. Army Corps of Engineers statement of work, dated September 23, 1999 and the rules for license termination and site decommissioning as defined in 10 Code of Federal Regulations (CFR) § 40.42.

This Decommissioning Plan was prepared by Montgomery Watson in March through July 2000. Mr. Steven M. Rowe of the U.S. Army Corps of Engineers served as the Contracting Officer Representative.

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For
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Foster Wheeler Project Manager

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ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

ABQ	Albuquerque
AFB	Air Force Base
AFIERA	Air Force Institute for Environment, Safety and Occupational Health Risk Analysis
AFRMWO	Air Force Radioactive and Mixed Waste Office
ALARA	as low as reasonably achievable
ANSI	American National Standard Institute
ASTM	American Society for Testing and Materials
bgs	below ground surface
Bq/cm^2	bequerels per square centimeter
Bq/g	bequerels per gram
CADD	computer-aided design and drafting
CFR	*Code of Federal Regulations*
ci/m^3	curies per cubic meter
cm/sec	centimeters per second
cpm/g	counts per minute per gram
CQP	construction quality plan
DAC	derived air concentration
DCGL	derived concentration guideline level
DNWS	Defense Nuclear Weapons School
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
dpm	disintegrations per minute
DQO	data quality objective
DRC	Utah Division of Radiation Control
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
ft	foot or feet
G&A	general and administrative
g/cm^3	grams per cubic centimeter
GIS	geographical information system
GPS	global positioning system
HASP	health and safety plan
HBL_{SA}	health-based specific activity levels
HP	health physicist
HR	hydrologic region
hrs	hours

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE (Continued)

IP	industrial package
IRP	Installation Restoration Program
kg	kilogram
kg/cm^2	kilograms per square centimeter
LLRW	low-level radioactive waste
lpm	liters per minute
l.s.	lump sum
LSA	low specific activity
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
mCi/ml	millicuries per milliliter
MDA	minimum detectable activity
MDC	minimum detectable concentration
m	meter
mm	millimeter
mos	months
mrem	millirem
MWA	Montgomery Watson Americas
MWCI	Montgomery Watson Constructors Incorporated
nCi/L	nanocuries per liter
NM	New Mexico
NMED	New Mexico Environment Department
NRC	U.S. Nuclear Regulatory Commission
NSWC	Naval Surface Warfare Center
NTIS	National Technical Information Service
ODCs	other direct costs
OSHA	Occupational Safety and Health Administration
pCi/g	picocuries per gram
PID	photoionization detector
PPE	personal protective equipment
QAPP	Quality Assurance Project Plan
QTY	quantity
RCRA	*Resource Conservation and Recovery Act*
RESRAD	residual radiation
RIC	Radioisotope Committee
RSO	radiation safety officer

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE (Concluded)

SAP	sampling and analysis plan
SDRH	Surveillance Directorate Radiation Surveillance Division Health Physics Branch
SLC	Salt Lake City
SNL	Sandia National Laboratories
SOP	standard operating procedure
STOLS®	Portable Surface Towed Ordnance/Object Locator System®
SVOC	Semivolatile Organic Compound
SWMU	solid waste management unit
TAL	target analyte list
TCLP	Toxicity Characteristic Leachate Procedure
TI	transport index
TLD	thermoluminescent dosimeter
TS5	Training Site 5
TS6	Training Site 6
TS7	Training Site 7
TS8	Training Site 8
μCi/cm^2	microcuries per square centimeter
μCi/ml	microcuries per milliliter
μm	micrometers
μmhos/cm	micromhos per centimeter
μR/hour	microRoentgens per hour
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
WRS	Wilcoxon Rank Sum

EXECUTIVE SUMMARY

This plan describes the decommissioning activities planned at four, former Defense Nuclear Weapons School (DNWS) Radiation Training Sites at Kirtland Air Force Base (AFB). The inactive sites TS5 (13.4 acres), TS6 (19 acres), TS7 (8.4 acres), and TS8 (2.4 acres) comprise Kirtland AFB's Installation Restoration Program (IRP) Site OT-10. The sites are located in the north-central part of Kirtland AFB.

From 1961 to 1990, the sites were used to train radiological response personnel to detect contaminants generated during simulated nuclear weapons accidents. Known quantities of Brazilian thorium oxide sludge were applied and tilled into site soils to simulate dispersed plutonium. Four other training sites (TS1 through TS4) remain active. The training sites are owned by the U.S. Government and regulated by the Nuclear Regulatory Commission (NRC) under United States Air Force (USAF) Master Materials License No. 42-23539-01AF.

The nature and extent of thorium-contaminated soils at the OT-10 sites were characterized during three prior investigations. From December 1985 to January 1990, limited initial site surveys were conducted at TS5, TS6, TS7, and TS8 to assess radionuclide contamination in surface and subsurface soils, vegetation, and surface water and to assess the potential for contamination to migrate offsite. Each of these media was identified as impacted and limited offsite migration of radionuclide contamination was observed (Rademacher, 1992).

The first extensive scan investigation of OT-10, conducted between October 1994 and May 1995, included surface gamma ray surveying and soil sampling to delineate the general extent of radionuclide contamination. Radiological contamination at OT-10 was shown empirically to be limited to thorium-232 and its decay progeny (USAF, 1997). The maximum observed thorium-232 concentrations during the 1994 to 1995 investigation were 332.3 picocuries per gram (pCi/g) (TS5), 421.6 pCi/g (TS6), 683.4 pCi/g (TS7), and 1047.9 pCi/g (TS8).

The most recent investigation, conducted in 1996 and 1998, included an assessment of radionuclides and chemicals in OT-10 background and contaminated soils, geophysical surveys of the sites, a health physics assessment, and a radionuclide grain size analysis. The horizontal extent of previously identified radiological soil contamination was confirmed, and the vertical extent of the radiological contamination was defined at surface hot spots. Concentrations of radionuclides were observed to decrease with increasing depth. Radionuclide concentrations extended at the hot spots to about 1 foot (ft) below ground surface (bgs) at TS7, 3 ft bgs at TS5, and 5 ft bgs at TS6 and TS8. The maximum observed concentrations of thorium-232 during the 1996 and 1998 investigation were 1,120 pCi/g (TS5), 299.0 pCi/g (TS6), 33.2 pCi/g (TS7), and 188.0 pCi/g (TS8) (USAF, 1999b).

Approximately 9.2 of the 43.2 acres in OT-10 were affected with elevated thorium concentrations at the time of the most recent investigation (USAF, 1999b). The contaminated areas were TS5 (2.7 of 13.4 acres), TS6 (6.1 of 19 acres), TS7 (0.03 of 8.4 acres), and TS8 (0.4 of 2.4 acres) (USAF, 1999b).

Several radioisotopes were evaluated in terms of cancer risk. The health-based specific activities for several radionuclides were uranium-235 and decay progeny (56.4 pCi/g), uranium-238 and decay progeny (280.4 pCi/g), thorium-232 and decay progeny (4.6 pCi/g), and cesium-137 (7.2 pCi/g). With the exception of thorium-232, the concentrations of radionuclides at OT-10 were below their respective health-based specific activities. However, about 66 percent of samples exhibited thorium-232 concentrations greater than its health-based specific activities; therefore, the site poses an increased cancer risk to chronically exposed individuals. Based on the increased cancer risk posed by thorium-232 at the sites, formal decommissioning of the sites is planned for calendar years 2000 through 2002.

Preliminary soil remediation goals, or derived concentration guideline levels (DCGLs), were developed using the Residual Radiation (RESRAD) Model. The NRC dose criterion of 25 millirem per year above background was used to develop the preliminary soil DCGL. The OT-10 DCGLs are 7 pCi/g thorium-232 above background for a release to industrial land-use scenario, 1.94 pCi/g thorium-232 above background for a release to residential land-use scenario at TS5, TS6, and TS8; and 2.4 pCi/g thorium-232 above background for a release to residential land-use scenario at TS7. Remediation of the sites to the residential land-use criterion will support an unrestricted land-use scenario and license termination.

Planned decommissioning activities include gamma-ray scan surveying; excavating and packaging thorium-contaminated vegetation, debris, and soil; profiling (sampling and analyzing) excavated soil and debris, manifesting the waste, performing a final status survey, and transporting contaminated materials by rail to a licensed radioactive waste disposal facility (Envirocare) in Clive, Utah. Excavated areas will be graded and replanted with native vegetation. Decommissioning activities will be conducted under a Radiation Safety Program.

The cost for OT-10 decommission is estimated at US $14,300,000.

1.0 INTRODUCTION

This plan describes the decommissioning activities planned at four, former Defense Nuclear Weapons School (DNWS) radiation training sites at Kirtland Air Force Base (AFB), New Mexico. The inactive sites, Training Site 5 (TS5) with 13.4 acres, Training Site 6 (TS6) with 19 acres, Training Site 7 (TS7) with 8.4 acres, and Training Site 8 (TS8) with 2.4 acres, comprise Kirtland AFB's Installation Restoration Program (IRP) Site OT-10. The sites are located in the north-central part of Kirtland AFB (Figure 1-1).

From 1961 to 1990, the sites were used to train radiological response personnel in the detection of dispersed contamination resulting from simulated nuclear weapons accidents. Known quantities of Brazilian thorium oxide sludge were applied and tilled into site soils to simulate dispersed plutonium contamination. Four other training sites (TS1 through TS4) remain active. The training sites are owned by the U.S. Government and regulated by the Nuclear Regulatory Commission (NRC) under United States Air Force (USAF) Master Materials License No. 42-23539-01AF.

The nature and extent of radiologically-contaminated soil at the OT-10 sites were characterized during three prior investigations (Rademacher, 1992; USAF, 1997, 1999b). Elevated thorium concentrations were identified in portions of each training site. These elevated thorium concentrations present an excess cancer risk under both residential and industrial land-use scenarios.

Based on the excess cancer risk posed by thorium-232 concentrations at the sites, formal decommissioning of OT-10 is planned for calendar years 2000 through 2002. This plan describes the decommissioning activities to be implemented at the four training sites. The objectives of this decommissioning plan are to

- develop a preliminary soil remediation goal or derived-concentration guideline level (DCGL) for thorium-232;
- define the OT-10 decommissioning activities; and
- provide a framework for license termination.

This plan was prepared in accordance with the U.S. Army Corp of Engineers statement of work dated September 23, 1999, and the rules for license termination and site decommissioning as defined in 10 Code of Federal Regulations (CFR) § 40.42. This plan is considered a deliverable under Contract Number DACW45-94-D-0003, Delivery Order 0023.

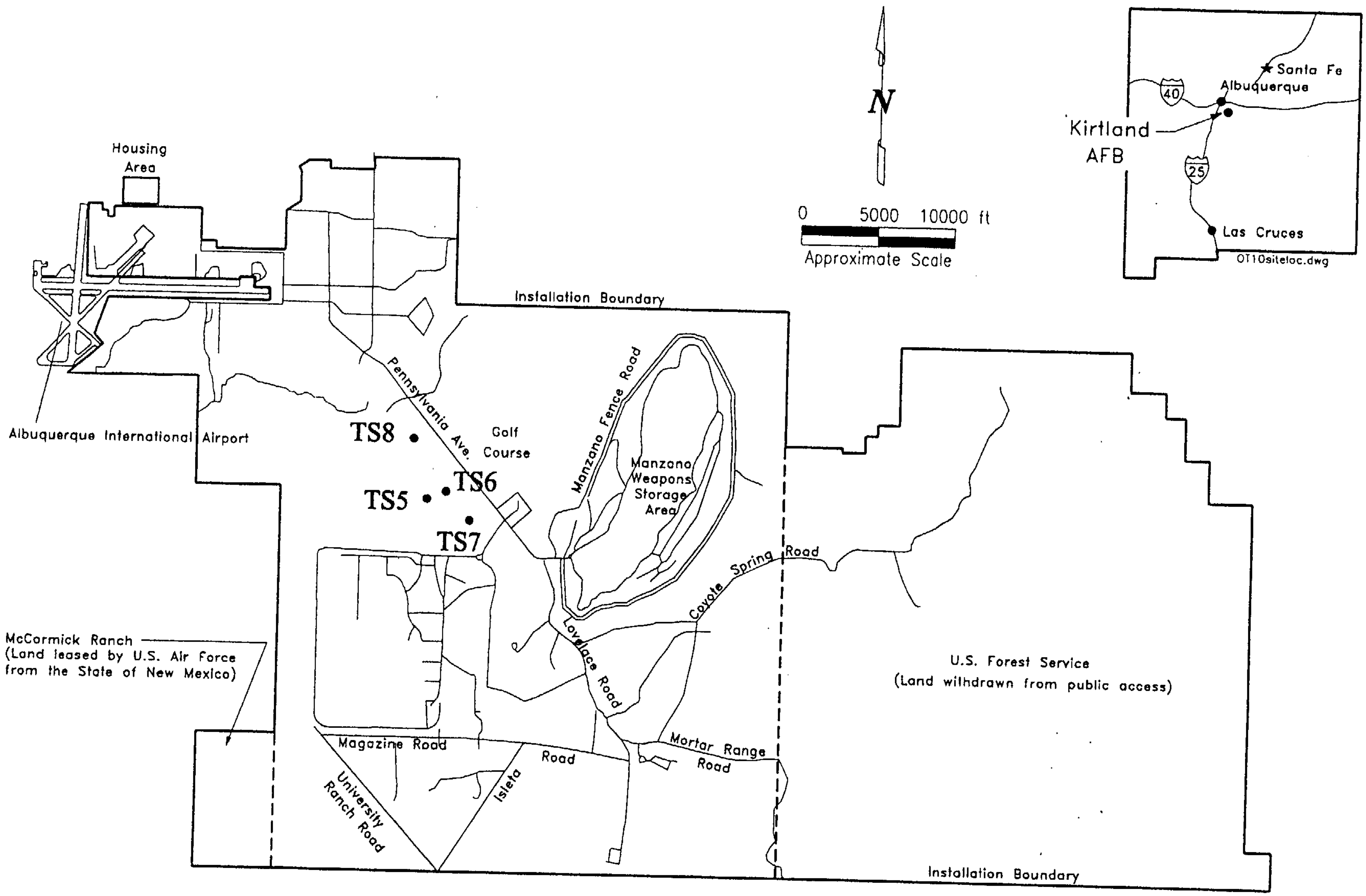

Figure 1-1. Site Location Map for IRP Site OT-10, Radiation Training Sites

The plan is divided into six text sections: Section 1 provides the introduction and defines the plan objectives, Section 2 presents a description of site conditions and the results of previous investigations, Section 3 develops the preliminary soil remediation goal or DCGL for thorium-232 and describes the decommissioning activities, Section 4 describes the methods to be used to ensure worker protection, and Section 5 describes the final radiation survey, and Section 6 presents the cost estimate for decommissioning. The reference citations are presented in the last unnumbered section. Appendixes include Appendix A—Derivation of Cleanup Criteria and Appendix B—Site-Specific Health and Safety Plan.

2.0 DESCRIPTION OF SITE CONDITIONS

2.1 Site History (Operational)

Eight radiation training sites were established in November 1961 at Kirtland AFB. The sites are owned by the U.S. Government and regulated by the NRC under USAF Master Materials License No. 42-23539-01AF. The four inactive sites, TS5 through TS8, are scheduled for decommissioning and are shown on Figure 2-1.

The four sites were used to train U.S. Department of Defense (DOD), U.S. Department of Energy (DOE), Federal Emergency Management Agency (FEMA), and other federal and state personnel in the detection of dispersed contamination resulting from simulated nuclear weapons accidents. Known quantities of Brazilian thorium oxide sludge were applied and tilled into site soils to simulate dispersed radiological contamination. The thorium oxide sludge served as a low hazard analog for plutonium. A total estimated inventory of approximately 602 kilograms (kg) of thorium-232 was applied at the inactive sites. The estimated thorium-232 inventory, by site, is presented in Table 2-1.

Table 2-1. Training Site Acreage and Thorium-232 Inventory

Training Site	Approximate Area [acres]	Estimated thorium-232 Applied [kg][a]
TS5	13	215
TS6	19	307
TS7	8	36
TS8	2	44

Notes:

[a] Thorium-232 inventory from DNA, 1994. The author of this report used the following assumptions to determine the mass of thorium-232: Mass of thorium-232 = 0.88 * Mass thorium oxide and Mass thorium oxide = 0.4 * Mass of thorium sludge. Inventories reported in USAF, 1997, and USAF, 1999b, are for thorium sludge.

Training activities were discontinued at sites TS5 through TS8 in 1990. Large pieces of military equipment, such as fuselages, vehicles, parts, and other debris, present at sites TS5 through TS8, were removed and redistributed at the active sites TS1 through TS4. The debris remaining at TS5 through TS8 consists primarily of small metal fragments and small military equipment parts.

The four inactive sites, TS5 through TS8, are listed as IRP site OT-10. TS8 was also used as a storage site and has a storage bunker located within its fenced area. In addition, TS6 contains solid waste management unit (SWMU) SS-69, a 50-foot (ft) by 50-ft fenced area previously used to store drums of thorium oxide sludge, contaminated soil, and waste fuels. SWMU SS-69 is managed as a separate corrective action unit under Kirtland AFB's *Resource Conservation and Recovery Act* (RCRA) Part B Permit.

2.2 Site Setting

2.2.1 Climate

The climate at Kirtland AFB and its vicinity is typical of a high-desert plateau, with low precipitation, wide temperature extremes and, typically, clear sunny days. It is classified as Arid Continental (USAF, 1995c). The mean annual precipitation is about 8.4 inches and the mean annual snowfall is 1.25 inches. Summer rains typically account for nearly half of the annual moisture, in the form of brief but heavy local thunderstorms.

Potential evapotranspiration (evaporation occurring when no soil-water deficit exists) in the Albuquerque area is 30.9 inches. Actual evapotranspiration is about 95 percent of precipitation in the climatic regime; the remaining 5 percent is split equally between runoff and recharge.

The annual mean maximum temperature at Kirtland AFB is 69 degrees Fahrenheit; the annual mean minimum temperature is 44 degrees Fahrenheit. The highest mean maximum temperature is 91 degrees Fahrenheit in July, and the lowest mean temperature is 24 degrees Fahrenheit in January.

The prevailing wind direction from May through October is south to southeast, and the mean wind speed is about 8 knots. From November through April, the prevailing wind direction is north to northwest, and the mean wind speed is about 7 knots.

2.2.2 Physiographic Setting

Kirtland AFB is located on a high, semiarid piedmont alluvial plain and adjacent foothills, about 5 miles east of the Rio Grande (USAF, 1995c). The alluvial plain is cut by the east-west trending Tijeras Arroyo, which drains into the Rio Grande. TS5 through TS8 are located on the alluvial plain south of Tijeras Arroyo. The area is drained by two major surface water features: Arroyo del Coyote and Tijeras Arroyo. The terrain is relatively flat at TS5 and TS7; however, site topography at TS6 and TS8 is influenced by proximity to arroyos and slopes gently towards these features.

The relative positions of the training sites are shown on Figure 2-1.

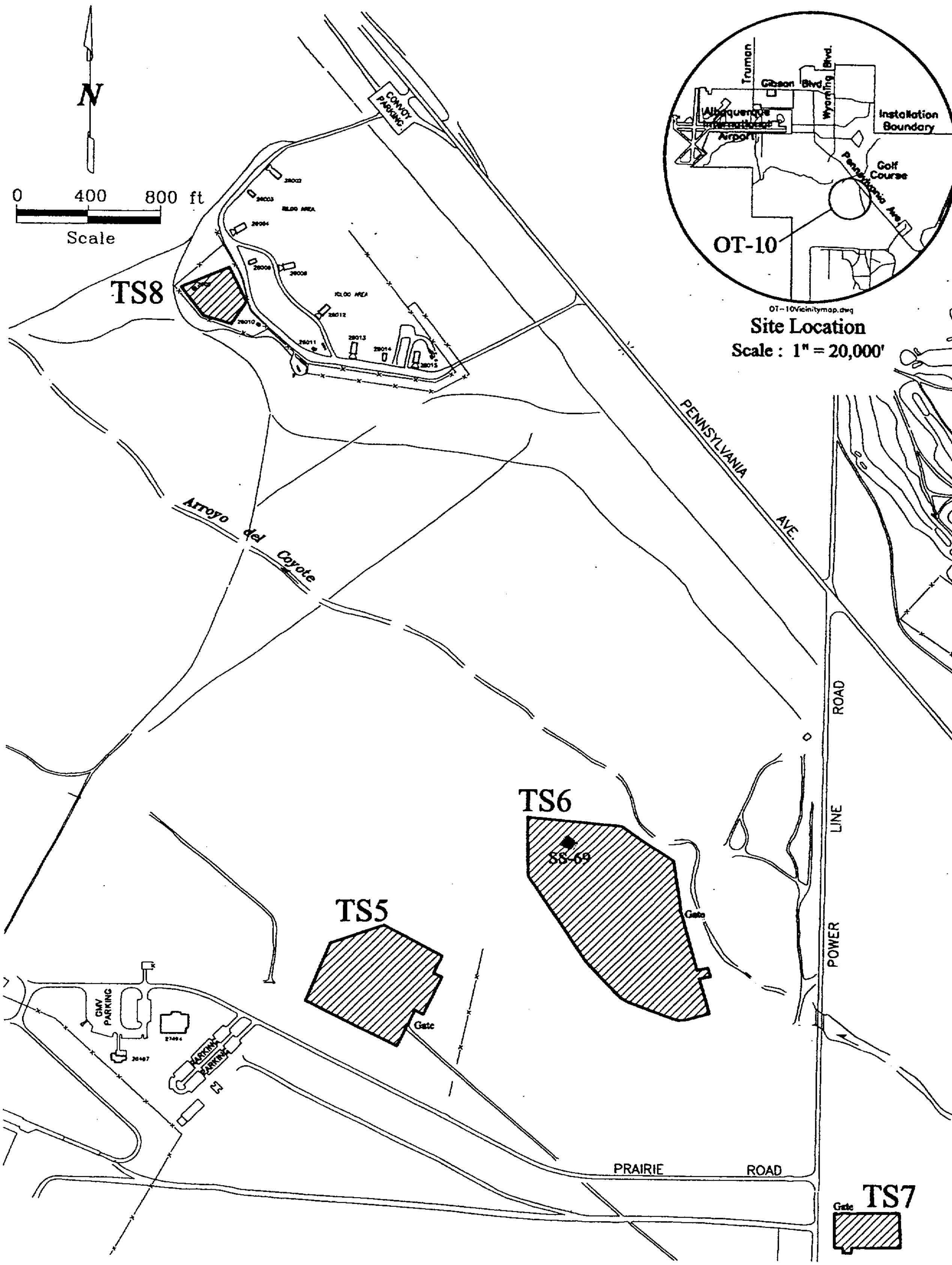

Figure 2-1. IRP Site OT-10 Vicinity Map

2.2.3 Geologic Setting

The western portion of Kirtland AFB lies within the Albuquerque-Belen Basin (USAF, 1995c). The Albuquerque-Belen structural basin contains the through-flowing Rio Grande and lies within a series of grabens and structural basins called the Rio Grande Rift. The basin has a general north-south alignment and is bordered on the east and west by up-faulted blocks (Lozinski, 1988).

The deposits within the Albuquerque-Belen Basin consist of interbedded gravel, sand, silt, and clay, the bulk of which are referred to as the Santa Fe Group. These sediments were deposited during the Late Tertiary and Quanternary as alluvial fan, playa, and fluvial deposits that filled the subsiding basin. The thickness of most basin-fill deposits is greater than 3,000 ft, although the thickness varies considerably because of faulting in the basin.

The Santa Fe Group is comprised of beds of unconsolidated to loosely consolidated sediment and interbedded volcanic rock. The materials range in size from boulders to clay. Well-sorted stream channel deposits to poorly-sorted slopewash deposits are found on Kirtland AFB.

2.2.4 Soil and Vegetation Types

Soils and vegetation types at each training site are listed in Table 2-2. The vegetation types at Kirtland AFB are shown on Figure 2-2, along with the training site locations.

2.2.5 Hydrogeology

OT-10 is located in Hydrogeologic Region 1 (HR1) of Kirtland AFB (USAF, 1996a). The uppermost aquifer in HR1 occurs within the Santa Fe Group. The estimated hydraulic conductivity in this unit ranges from less than 0.3 ft/day to greater than 30 ft/day. The depth to groundwater in HR1 is between 300 and 500 ft. Groundwater is thought to be unconfined in the upper portion of the aquifer, but this may not be true in all areas.

A shallow saturation zone above the regional aquifer, approximately 200 to 250 ft below ground surface (bgs), has been identified in HR1. This zone is located adjacent to and northwest of the Kirtland AFB landfill. It is associated with either a system of multiple perched aquifers or a groundwater mound. The extent of a shallower saturation zone has not been defined and it is unknown if it exists in the vicinity of OT-10.

Table 2-2. Soils and Vegetation Types at IRP Site OT-10

Site	Soil Type[a]	Description of Soil[a]	Native Vegetation[a,b]
TS5	Tome very fine sandy loam	Deep, well-drained soils that formed in alluvial sediments derived from limestone and shale on broad alluvial fans.	Black Grama, Blue Grama, Alkali Sacaton, Bush Muhly, Galleta Grass
TS6	Gila fine sandy loam and Bluepoint-Kokan association	Gila fine sandy loams are deep well-drained soils that formed in recent alluvium on the floodplains along the Rio Grande and Rio Puerco. The Bluepoint series consists of deep, somewhat excessively drained soils that formed in sandy alluvial and eolian sediments on alluvial fans and terraces.	Alkali Sacaton, Inland Saltgrass, Vine-mesquite, Fourwing Saltbush, Mesa Dropseed, Indian Ricegrass, Giant Dropseed, and Black Grama.
TS7	Wink fine sandy loam and Tijeras gravelly fine sandy loam	The Wink series consists of deep, well-drained soils that formed in old unconsolidated alluvian modified by wind on piedmonts. The Tijeras series consists of deep, well-drained soils that formed in decomposed granitic alluvium on old alluvial fans.	Blue Grama, Sand Dropseed, Broom Snakeweed, Blue and Black Grama, and Soapweed Yucca
TS8	Gila fine sandy loam	Described above	Alkali Sacaton, Inland Saltgrass, Vine-mesquite, Fourwing Saltbush

Notes:

a Adapted from USAF, 1995b.

b Common name (scientific name): Alkali Sacaton (*Sporobulus airoides*), Black Grama (*Bouteloua eriopoda*), Blue Grama (*Bouteloua gracilis*), Broom Snakeweed (*Gutierrezia sarothrae*), Bush Muhly (*Muhlenbergia porteri*), Fourwing saltbush (*Atriplex canescens*), Galleta Grass (*Hilaria jamesii*), Giant Dropseed (*Sporobulus wrightii*), Indian Ricegrass, (*Oryzopsis hymenoides*), Inland Saltgrass (*Distichlis spicata*), Mesa Dropseed (*Sporobulus flexuosus*), Sand dropseed (*Sporbolus cryptandrus*), Soapweed Yucca (*Yucca baileyi*), Vine-mesquite (*Panicum obtusum*).

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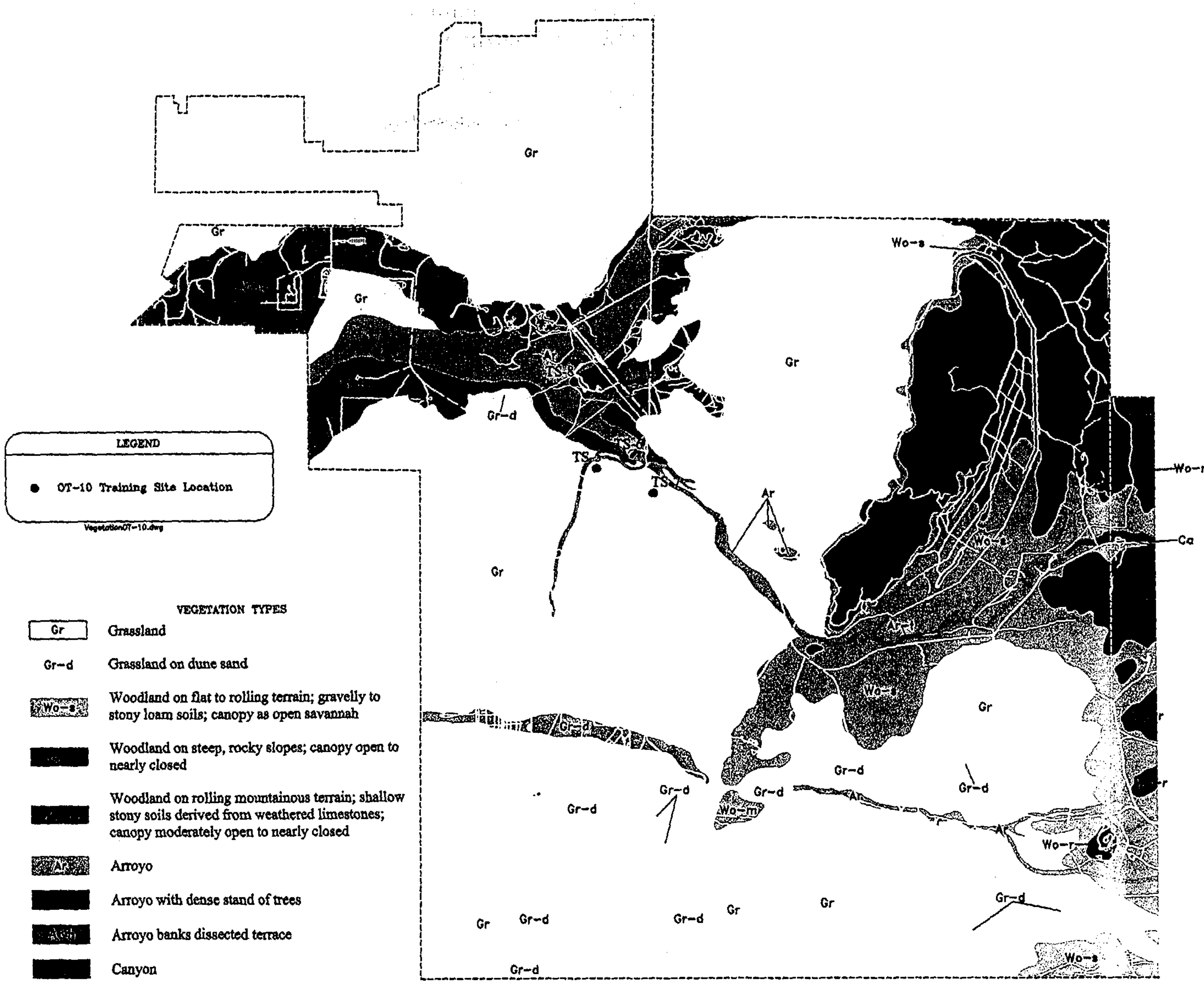

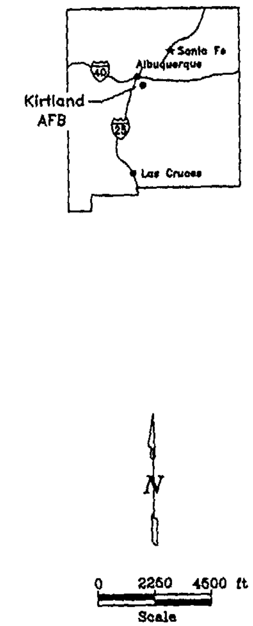

Figure 2-2.
Generalized Vegetation Areas
Kirtland Air Force Base, New M

C01

2.3 Site Characterization and Corrective Measures

In 1981, the DNWS sites were identified during a Phase I Records Search. Limited radiological surveys at TS5, TS6, and TS7 were conducted between 1988 and 1990 to provisionally identify contaminated areas, qualitatively assess the magnitude of the contamination, and assess the potential for offsite migration of radiological contamination (Rademacher, 1992). Additional investigations were conducted at OT-10 during October 1994 to May 1995 and December 1996 to September 1998.

2.3.1 1988 Through 1990 Surveys

Between 1988 and 1990, TS5, TS6, and TS7 were surveyed using a 5-inch sodium iodide detector coupled to an Eberline ESP-2 electronics package and/or a calcium fluoride detector coupled with a Bicron Analyst count rate meter. Soils exhibiting meter readings above background were considered contaminated. In addition, several surface soil samples were collected from TS6 and TS7 and analyzed by gamma-spectroscopy. Limited depth-distribution studies were also performed at TS5 (in 1989) and TS6 (in 1988). One trench was installed at each of these sites, in areas of elevated readings. A third trench was installed in a background area outside both TS5 and TS6. Samples were collected every 2-inches from the sidewalls of the three trenches at depths from ground surface to 24 inches bgs (Rademacher, 1992). Based on the results of these surveys, the sites were added to Kirtland AFB's Management Action Plan for future corrective action (USAF, 1995a).

2.3.2 1994 Through 1995 Investigation

In October 1994 and May 1995, general areas of contamination at OT-10 were delineated quantitatively using gamma-ray scanning surveys, and collection and analysis of surface and subsurface soil samples. Scanning is the process by which an operator uses portable radiation detection instruments to detect the presence of radionuclides on a specific surface (EPA, 1997). A sodium iodide scintillation detector coupled to a rate meter was used to measure field gamma activity in 100-ft by 100-ft grid sections. Grid sections containing hot spots were subdivided into 10-ft by 10-ft grid sections and resurveyed. Additional 100-ft by 100-ft grids sections were established offsite at points along site perimeters where elevated readings were detected. Thirty-nine soil samples were collected and measured by detector in the field and analyzed by alpha spectroscopy in a laboratory. Ten of these samples were also analyzed by gamma-spectroscopy. A correlation was developed between the sample laboratory results for thorium-232 concentration and the field gamma counts. A regression coefficient of 2.52 picocuries per gram (pCi/g) thorium-232 per counts/minute/gram (cpm/g) was calculated using linear regression analysis; with an associated regression coefficient (r^2) of 0.91 (USAF, 1997). This correlation factor was used to calculate thorium-232 concentrations from the gamma field counts.

2.3.3 1996 Through 1998 Investigation

The work of the previous investigations was expanded between December 1996 and September 1998 to include extensive radiological and geophysical surveys, a health physics assessment of radiochemistry data, analyses for non-radioactive constituents, soil property tests, and a study to correlate soil grain size and thorium content (USAF, 1999b).

This latest investigation included collection of a greater number of training site and local background surface and subsurface soil samples and determination of thorium-232 concentrations, its decay progeny, and several other isotopes in these samples in an onsite laboratory. A hand-held gamma survey meter (Bicron Surveyor 50) was also used to locate hot spots and to confirm and/or supplement the extent of previously identified areas of contamination. Subsurface samples were collected from cores advanced at points where surface soils exhibited the levels of highest radioactivity. The general areas and ranges of contamination identified at each site are covered in the site-specific findings.

Thirty-nine samples were collected outside of the training sites, in areas considered as background. The average concentration of thorium-232 in these samples was 1.01 pCi/g. Averaged background values at each of the training sites were similar: TS5 (1.02 pCi/g), TS6 (0.95 pCi/g), TS7 (1.35 pCi/g), and TS8 (0.93 pCi/g).

Health-based specific activities (HBL_{SA}) were determined for several isotopes during the health physics assessment. A target excess individual lifetime cancer risk of 3×10^{-4}, corresponding to the U.S. Environmental Protection Agency's (EPA) 15 millirems (mrem)/year total dose standard for a remediated site, was selected. Other parameters used to calculate the HBL_{SA} were selected from EPA sources and a report on a depleted uranium site at the Naval Surface Warfare Center (NSWC), Dahlgren Laboratory, Virginia (USAF, 1999b, reference therein).

HBL_{SA} for a site worker were calculated using the following equation:

$$HBL_{SA} = \frac{TR}{ED \times \left[(SF_o \times CF_1 \times EF \times IR_s) + (SF_i \times CF_2 \times EF \times IR_a \times \left\{ \frac{1}{PEF} \right\}) + (SF_e \times \{1 - S_e\} \times T_e) \right]} \qquad \text{Eq. 2-1}$$

where:

HBL_{SA} = health based specific activity of isotope and decay progeny in soil [pCi/g],

TR = target excess individual lifetime cancer risk,

ED = exposure duration [years],

SF_o = oral slope factor [risk/pCi],

CF_1 = conversion factor for the ingestion route [g/mg],

EF = exposure frequency [days/year],

IR_s = daily soil ingestion rate [mg/day],

SF_1 = inhalation slope factor [risk/pCi],

CF_2 = conversion factor for the inhalation route [g/mg],

IR_a = 8-hour (hr) workday air inhalation rate [m^3/day],

PEF = particle emission factor [m^3/kg],

SF_e = external slope factor [risk/pCi],

S_e = gamma shielding factor, and

T_e = gamma exposure factor.

Specific EPA slope factors were selected for four radioactive decay series: uranium-235 and decay progeny, uranium-238 and decay progeny, thorium-232 and decay progeny, and cesium-137 and decay progeny.

The HBL_{SA} for these radionuclides were: uranium-235 and decay progeny (56.4 pCi/g), uranium-238 and decay progeny (280.4 pCi/g), thorium-232 and decay progeny (4.6 pCi/g), and cesium-137 (7.2 pCi/g). With the exception of thorium-232, the concentrations of radionuclides at OT-10 were below their respective HBL_{SA}. However, about 66 percent of samples exhibited thorium-232 concentrations, which were greater than its HBL_{SA}, and, therefore, pose an increased cancer risk to chronically-exposed individuals.

Geophysical surveys were conducted using a backpack-mounted magnetometer system and a Portable Surface Towed Ordnance/Object Locator System® (STOLS®). These systems use data from a differential global positioning system to acquire data within a relative position of 10 to 20 centimeters from point to point and a sub-meter accuracy in subsequent targets. Small surface and/or subsurface ferrous materials, related to training activities, were detected at each site. An area of subsurface, unconsolidated rubble was detected at TS5. This area was referred to as a burial pit. It is discussed in Section 2.3.3.1.

Twenty-two surface soil samples were collected inside and outside the four inactive training sites. Portions of four of these samples were analyzed in an onsite laboratory for non-radioactive parameters. The onsite laboratory performed tests for target analyte list (TAL) metals, lithium, and molybdenum, using Method SW846-3000; and semivolatile organic compounds (SVOCs) using Method SW846-8270B. The twenty-two samples were also tested by an offsite laboratory for SVOCs using Method SW846-8270B, total petroleum hydrocarbons by EPA Method 8015M; TAL Metals, using Method SW846-6010A; and mercury, using Method SW846-7471 (EPA, 1996).

Gasoline-range hydrocarbons and SVOCs were not detected by either laboratory. The detections of diesel-range hydrocarbons (0.63 to 3.1 milligrams per kilogram [mg/kg]) were two to three orders of magnitude lower than the New Mexico Environment Department (NMED) Underground Storage Tank screening level (100 mg/kg) (NMED, 1995). With the exception of arsenic, metals concentrations were below current EPA human health risk-based soil screening levels (EPA, 1999). The concentrations of arsenic (1.5 to 10.1 mg/kg) were within the accepted background arsenic levels at Kirtland AFB, published jointly in 1996 by Sandia National Laboratories/New Mexico (SNL/NM) and the NMED (SNL/NMED, 1996). The NMED-approved background concentrations for arsenic range from 4.4 to 7 mg/kg.

Soil tests included pH, conductivity, moisture, unconfined compressive strength, dry density, field density, and permeability. One surface soil sample was collected from radiological hot spots, selected arbitrarily at each of the training sites. Because one surface soil sample may not represent site soil properties, the results of these tests are discussed here collectively and not in the site-specific discussions. Soil pH (determined on a 2:1 water:soil extract) for each site was slightly to moderately alkaline; it ranged from 8.9 to 9.47 (average of 9.15). Soil conductivity (determined on a 2:1 water:soil extract) ranged from 59.1 to 65.6 micromhos per centimeter (μmhos/cm) (average of 63.0 μmhos/cm). Soil moisture (determined using a probe) ranged from 2.8 to 7.5 percent. Unconfined compressive strength (determined using a Pocket Geotester instrument) was between 3.2 and 6.0 kilograms per square centimeter (kg/cm^2) (average of 4.68 kg/cm^2). Dry soil density (determined by volumeter and dry weight of sample) ranged from 1.17 to 1.64 grams per cubic centimeter (g/cm^3) (average 1.39 g/cm^3). Field soil density (determined by volumeter and wet weight of sample) ranged from to 1.18 to 1.70 g/cm^3 (average of 1.51 g/cm^3). Soil permeability (determined by falling head test) ranged from 5.59×10^{-5} to 3.95×10^{-4} centimeters per second (cm/sec) (average of 2.19×10^{-4} cm/sec).

One soil sample from each OT-10 site was dried and sorted mechanically into various grain-size bins. The sorted portions of each sample were analyzed for thorium concentrations, which were compared to soil grain sizes. After sorted portions were normalized for mass percents, thorium masses tended to be highest in grain sizes between 75 and 850 micrometers (μm). This correlation between grain size and thorium concentrations was similar in each sample.

2.3.3.1 Findings at TS5

In the limited survey, radiologically-contaminated soil was qualitatively identified by gamma-ray scanning survey. Measurements along the perimeter of the site were similar to background. However, offsite migration was identified along the northeast boundary of the site. In addition, vertical migration of thorium-232 was limited to approximately 2 inches (Rademacher, 1992).

In the 1994 and 1995 investigation, 30 surface and subsurface soil samples were collected to, at most, 6-ft bgs from 12 hand-augured boreholes (Figure 2-3). According to the correlation between thorium-232 activity and field counts, about 20 percent of the TS5 area was affected to an average depth of 16 inches bgs. Thorium-232 soil concentrations ranged from 2.2 to 421.6 pCi/g (average of 67.9 pCi/g) (USAF, 1997).

The 1997 and 1998 investigation confirmed the general horizontal extent of the contamination delineated in the 1994 and 1995 investigation, characterized the vertical distribution of contamination at hot spots, and defined a background thorium concentration. Twenty-two samples were collected and analyzed from five soil cores advanced at TS5. The thorium-232 concentrations at the surface of each of these cores was 24.2 pCi/g (Core 1), 15.9 pCi/g (Core 2), 49.6 pCi/g (Core 3), 66.6 pCi/g (Core 4), and 158.0 pCi/g (Core 5). The surface soil sample locations and their thorium-232 concentrations are depicted on Figure 2-3. The approximate area of thorium-contaminated soil at TS5 is shown on Figure 2-4.

With the exception of one core, radiological impact extended from ground surface to 18 inches bgs. The average activity to 18 inches bgs in each of these cores was 11.3 pCi/g (Core 1), 7.1 pCi/g (Core 2), 21.2 pCi/g (Core 3), and 26.7 pCi/g (Core 4). The exceptional core (Core 5) was collected from what was referred to as a burial pit that contained unconsolidated rubble such as small pieces of metal. Some of the pieces were covered with an orange paint that was similar to the paint observed on some of the larger aircraft parts at TS5 and other training sites. Samples collected from this core also exhibited the highest levels of thorium-232 at TS5, ranging from 158.0 to 1,120 pCi/g (average 597 pCi/g). The 1997 and 1998 investigation determined the dimensions of the burial pit to be 20-ft long by 20-ft wide by 6-feet deep (2,400 cubic feet) (USAF, 1999b).

2.3.3.2 Findings at TS6

During the 1990 survey, 208 gamma-ray measurements were taken in the southeast area of the site. One hundred fifty-nine gamma-ray measurements were also taken at the perimeter of the site along the barbed-wire fence. Furthermore, three surface soil samples were collected at three survey points within the site boundary and two soil samples were collected at the perimeter, where elevated count rates were observed. Finally, a brief depth-distribution study was conducted at TS6 (Rademacher, 1992).

With the exception of one point, gamma counts in the southeast area of TS6 were at least twice those of background. Counts measured along the old barbed-wire fence ranged from background to three times background. Elevated counts were thought to have represented the migration of radiologically-contaminated soil off the southeast portion of TS6. The concentrations of thorium-232 in the soil samples (68.5 to 277 pCi/g) were one to two orders of magnitude above background, which was typically about 1 pCi/g-dried. The perimeter soil samples exhibited thorium concentrations that were one order of magnitude above background. The depth-distribution study, conducted at a hot spot, indicated that the thorium-232 concentration in the top 2 inches of the soil sample was greater than 200 times background; it decreased to background at 4 inches bgs.

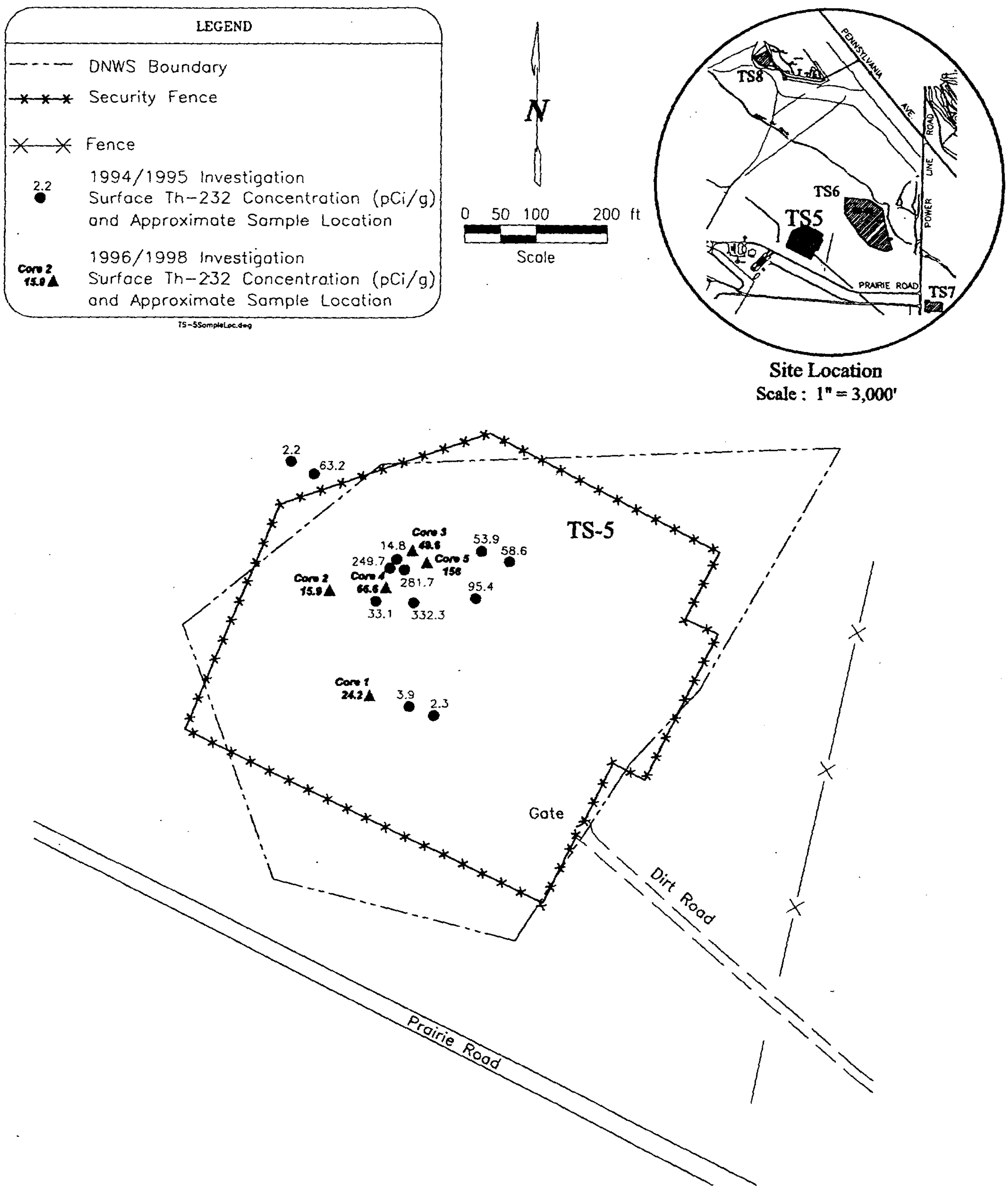

Figure 2-3. Sample Locations at TS5, IRP Site OT-10

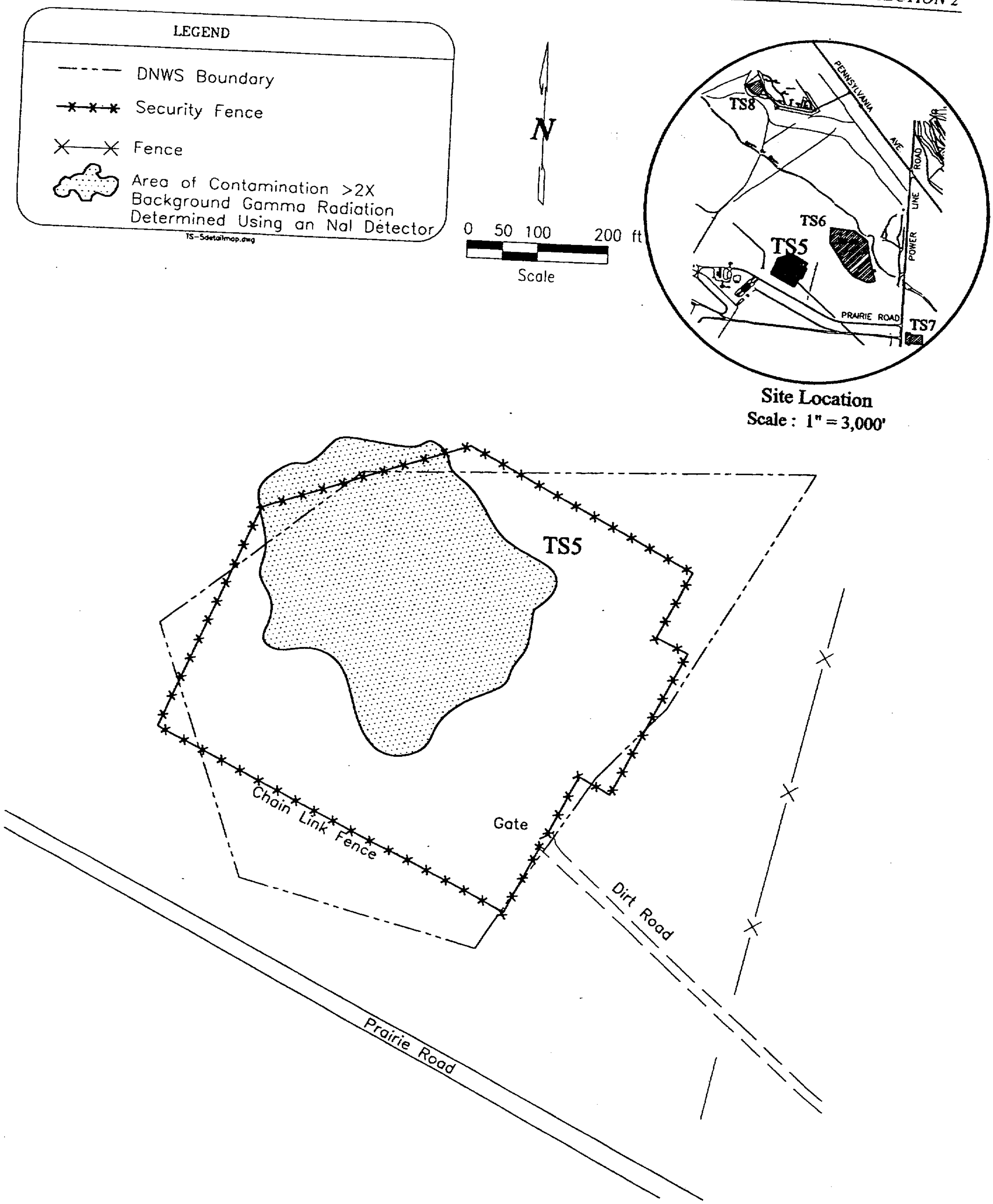

Figure 2-4. TS5 Security Fence and Area of Radiological Contamination

TS6 contains a fenced drum storage area, which has been designated as SWMU SS-69. SWMU SS-69 was used to store drums of thorium oxide sludge and contaminated soil. At least 90 drums were counted at the SS-69 site when it was first cataloged. Approximately 35 of these contained solid materials (such as cardboard, plastic, and soil) and liquids. The contents of 16 drums were analyzed: 4 were found to contain radioactive waste, 4 contained RCRA characteristic waste, and 8 contained diluted diesel and oil sludge with gasoline and/or solvents. The wastes were repacked and disposed of properly. An interim corrective measure was conducted at SWMU SS-69 in March through June 1998 and January 1999 to remove hydrocarbon- and radiologically-contaminated soil (USAF, 1999a).

In the 1994 and 1995 investigation, 26 surface and subsurface soil samples were collected from 10 locations at TS6 (Figure 2-5). According to the linear correlation between thorium-232 concentrations and field counts, about 32 percent of the TS6 area was contaminated to an average depth of 19 inches bgs. The range of thorium-232 soil concentrations was 2.8 to 683.4 pCi/g (average of 100.8 pCi/g) (USAF, 1997).

The 1997 and 1998 investigation confirmed the general extent of the contamination defined in the previous investigation. Thirty-six samples were also collected from eight soil cores advanced at TS6 (Figure 2-5). Two affected areas (labeled as "North" and "South") were delineated. Concentrations of thorium-232 in surface samples were 48.1 pCi/g (Core 1 South), 22.2 pCi/g (Core 2 South), 130 pCi/g (Core 3 South), 45.2 pCi/g (Core 4 South), 35.3 pCi/g (Core 1 North), 23.8 pCi/g (Core 3 North), and 15.4 pCi/g (Core 4 North). With the exception of one core, soils were affected from ground surface to 24 inches bgs. The average thorium-232 concentrations to 24 inches bgs in the cores were 39 pCi/g (Core 1 South), 17.3 pCi/g (Core 2 South), 38.7 pCi/g (Core 3 South), 13.0 pCi/g (Core 4 South), 13.7 pCi/g (Core 1 North), 9.3 pCi/g (Core 3 North), and 4.8 pCi/g (Core 4 North). The exceptional core (Core 2) was affected to at least 5 ft bgs. Samples collected from this core also exhibited the highest levels of thorium-232 activity at TS6; ranging between 4.34 to 299.0 pCi/g (average of 41.4 pCi/g).

The surface soil sample locations and their thorium-232 concentrations are depicted on Figure 2-5. The approximate area of thorium-contaminated soil at TS6 is shown on Figure 2-6.

2.3.3.3 Findings at TS7

In 1990, 80 gamma-ray measurements were taken in the approximate middle of TS7 and at the site perimeter along the barbed-wire fence. Gamma-ray counts were typically near or less than two times background. The count rate of only one perimeter measurement was greater than two times background (Rademacher, 1992).

Two plant samples were collected from the contaminated area at this site. The thorium-232 concentrations in these samples were 9.0 pCi/g-dry and 16 pCi/g-dry. Two standing surface water samples were also collected from the contaminated area. The thorium-232 activity in one sample was 5.93 nanocuries/liter (nCi/L); the activity in the second sample was below the instrument's detection limit.

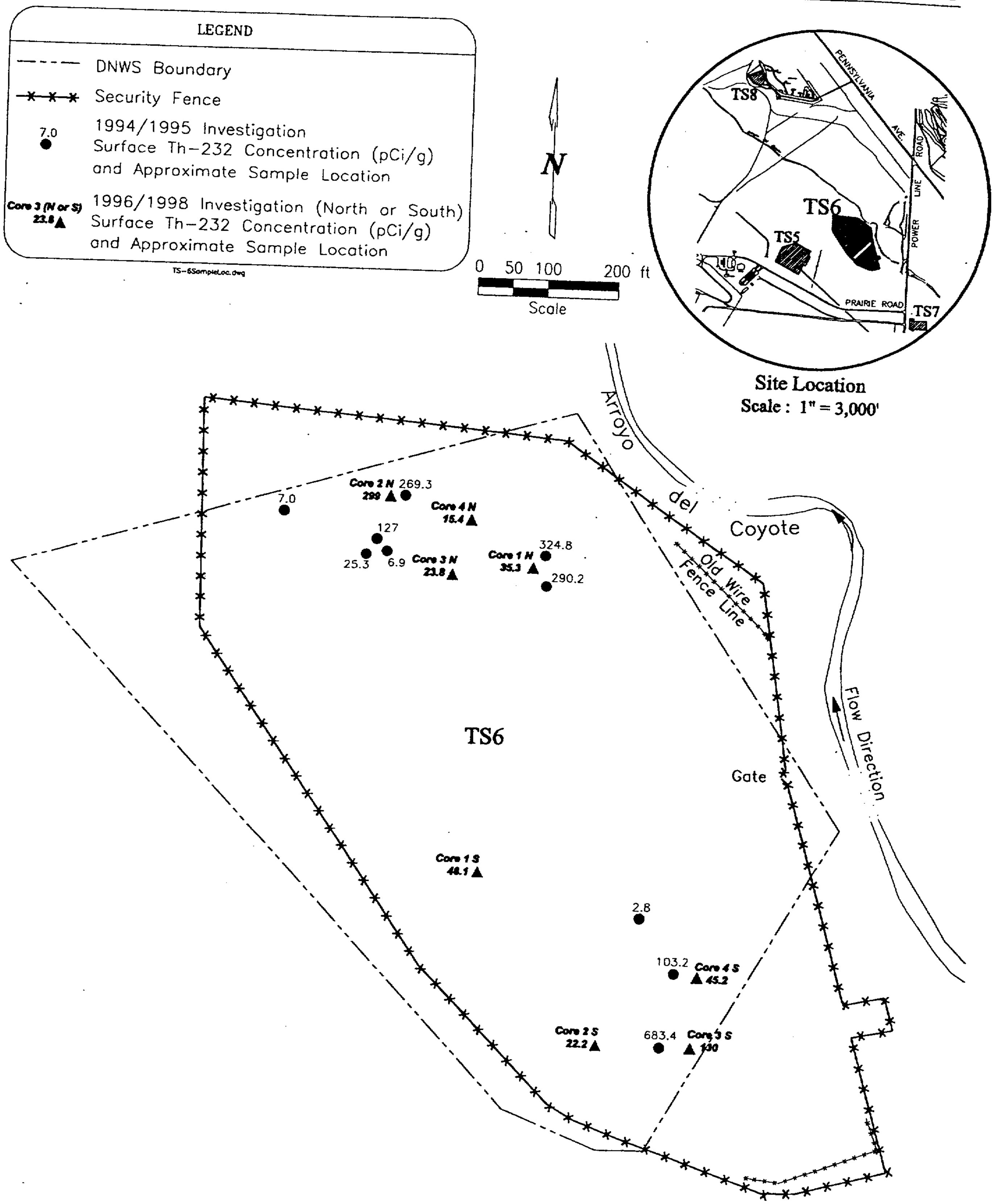

Figure 2-5. Sample Locations at TS6, IRP Site OT-10

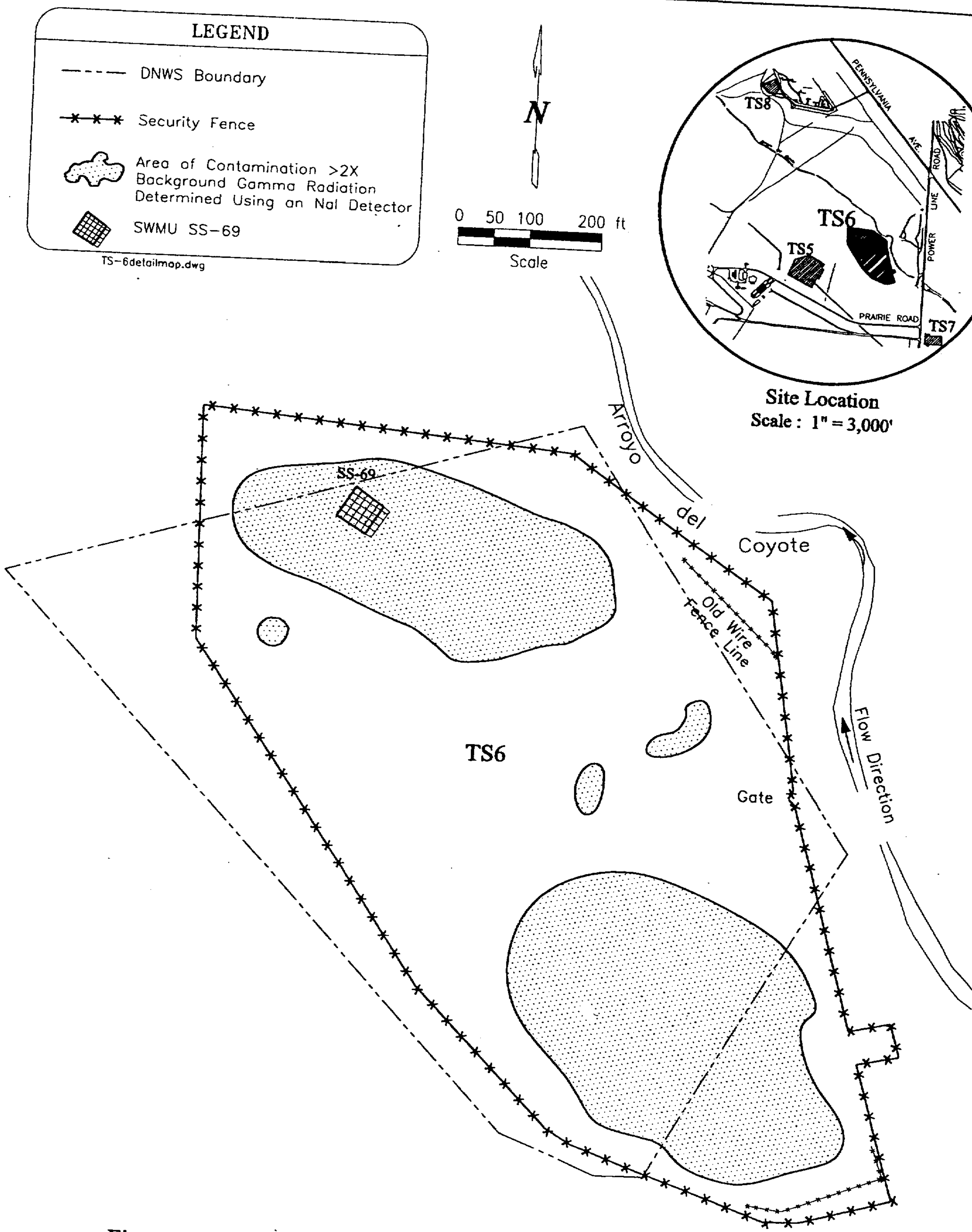

Figure 2-6. TS6 Security Fence and Areas of Radiological Contamination

In the 1994 and 1995 investigation, 29 surface and subsurface soil samples were collected from 9 locations at TS7 (Figure 2-7). According to the linear correlation between thorium-232 concentrations and gamma-ray field counts, about 0.3 percent of the TS7 area was contaminated above TS7 background (determined at the time to be 2.3 pCi/g) to an average depth of 19 inches bgs. The range of thorium-232 soil concentrations was 2.3 to 466.0 pCi/g (average of 55.9 pCi/g) (USAF, 1997).

The 1996 and 1998 investigation confirmed the general extent of contamination defined in the previous investigation. Eight samples were collected from two soil cores advanced at TS7. Radiological contamination extended from ground surface to 24 inches bgs. The average concentration of thorium-232 to 24 inches bgs in the cores was 9.9 pCi/g (Core 1) and 8.6 pCi/g (Core 2).

The surface soil sample locations at TS7 and their associated thorium-232 concentrations are depicted on Figure 2-7. The approximate area of thorium-contaminated soil at TS7 is shown on Figure 2-8.

2.3.3.4 Findings at TS8

In 1990, a soil sample was collected at the DNWS storage igloo, Building 28005 (assumed), where drums containing thorium-232 sludge were stored. Thorium-232 activity was identified in the soil sample, but no value was given.

In 1992, 12 surface soil samples were collected along the site perimeter. The thorium-232 concentrations in four of these samples exceeded those of background (Rademacher, 1992).

From 1990 to 1992, swipe surveys were conducted quarterly at the thorium storage igloo (Building 28010). Thorium activities in the swipe samples were below the acceptable removable surface contamination limits, the value of which was not identified in the report (Rademacher, 1992).

In 1992, air samples were collected quarterly (one each quarter) from the approximate center of the thorium oxide storage igloo. The thorium-232 concentration in one of the four samples exceeded the thorium-232 occupational exposure limit, the value of which was not identified in the report (Rademacher, 1993).

In the 1994 and 1995 investigation, 26 surface and subsurface soil samples were collected from 10 locations at TS8 (Figure 2-8). According to the linear correlation between thorium-232 activity and field counts, the entire TS8 area was contaminated to an average depth of 16 inches bgs. The range of thorium-232 was 2.1 to 1,047.9 pCi/g (average of 76.4 pCi/g) (USAF, 1997).

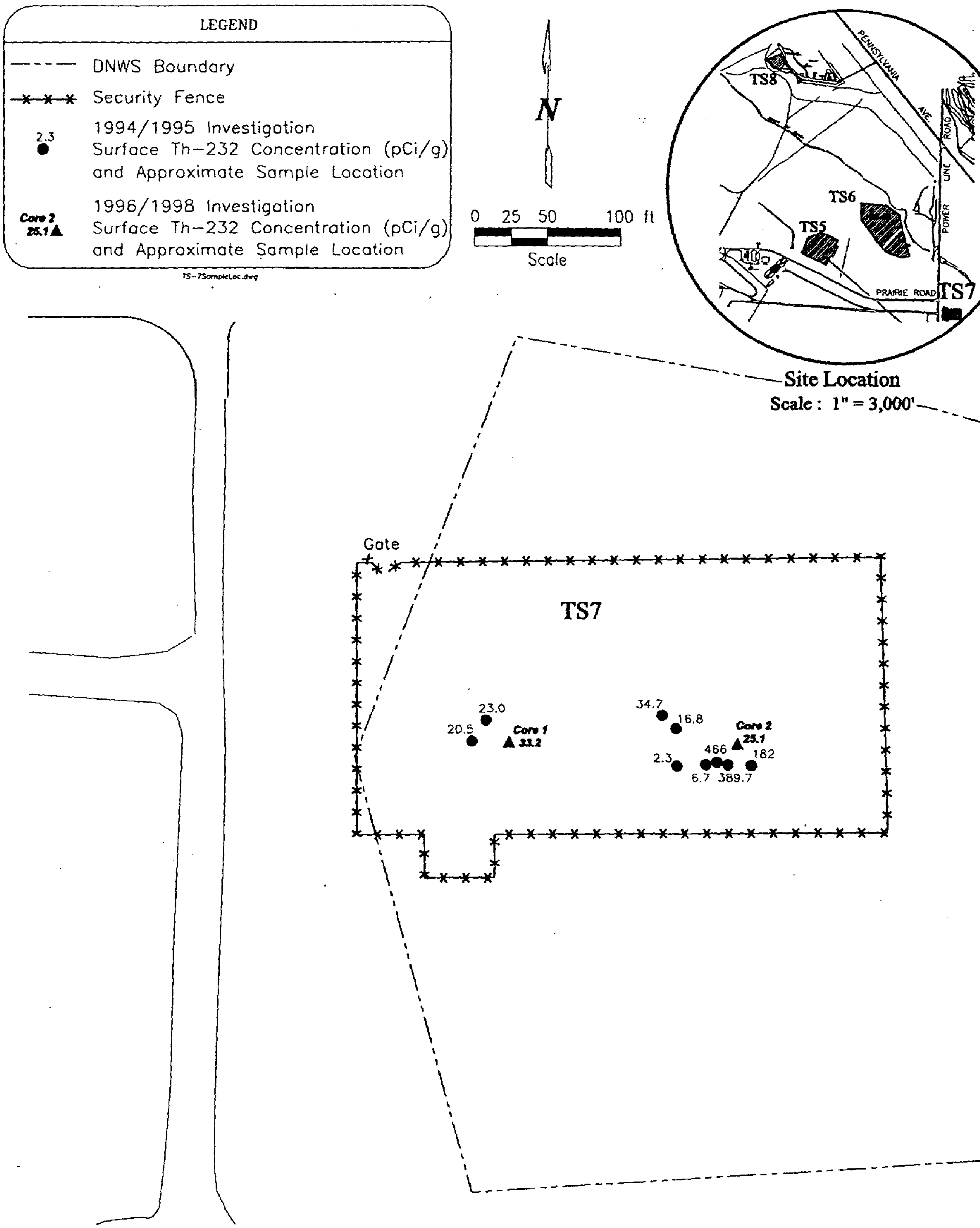

Figure 2-7. Sample Locations at TS7, IRP Site OT-10

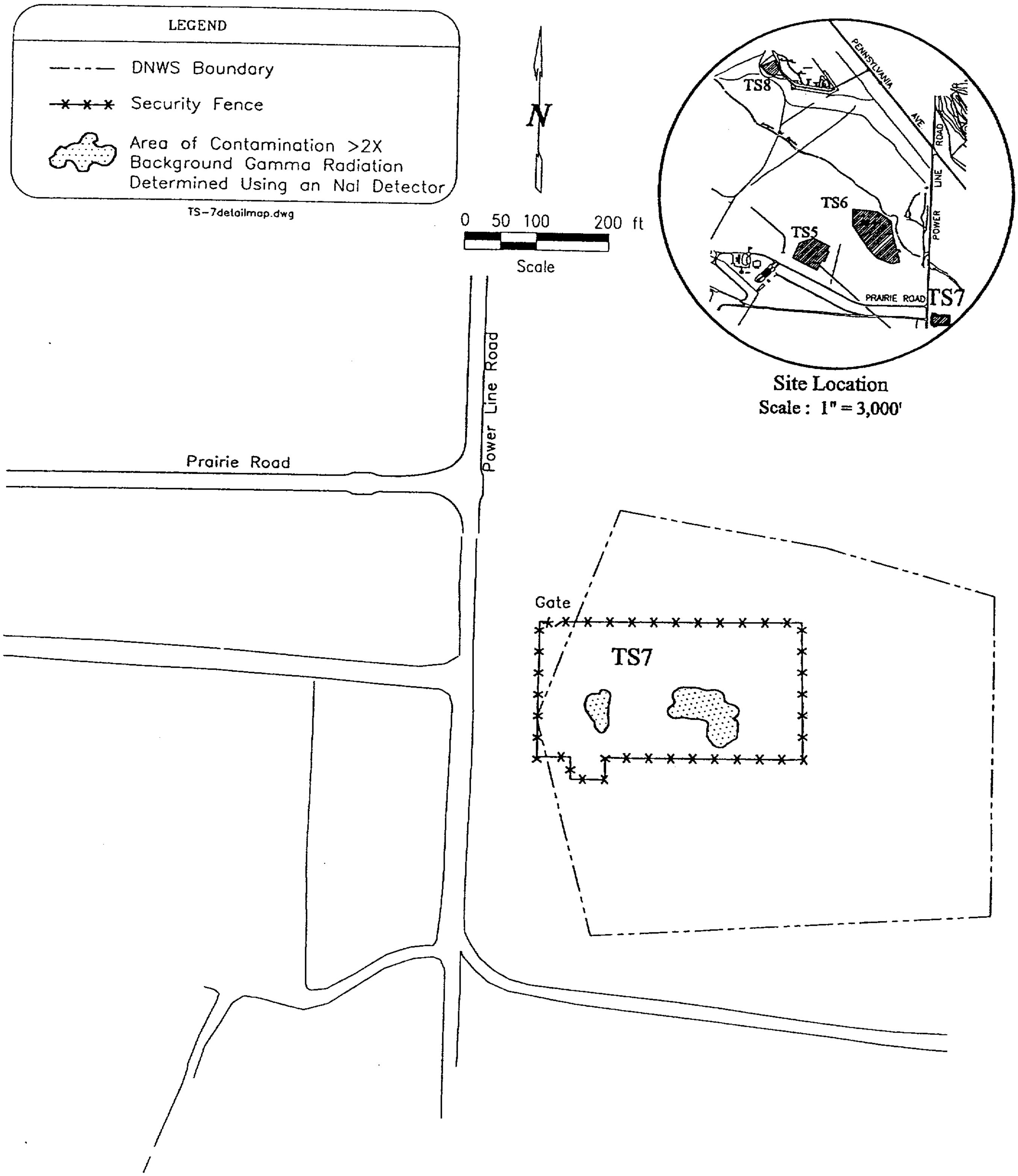

Figure 2-8. TS7 Security Fence and Areas of Radiological Contamination

The 1996 and 1998 investigation confirmed the general extent of the contamination defined in the previous investigation. Eighteen samples were collected from three soil cores advanced at TS8 (Figure 2-8). With the exception of one core (Core 2), radiological impact extended from ground surface to 24 inches bgs. The average activity to 24 inches bgs in each of these cores was 9.4 pCi/g (Core 1) and 3.2 pCi/g (Core 3). Ten samples were collected to 5 ft bgs in Core 2. These samples exhibited the highest concentrations of thorium-232 at TS8; ranging between 2.62 to 188.0 pCi/g (average of 24.9 pCi/g).

The surface soil sample locations at TS8 and their associated thorium-232 concentrations are depicted on Figure 2-9. The approximate area of thorium-contaminated soil at TS8 is shown on Figure 2-10.

2.3.3.5 General Findings

The quantities and concentrations of thorium-232 contaminated soil at OT-10 are summarized Table 2-3. The data have been taken from the results of the 1994 to 1995 investigation (USAF, 1997).

Table 2-3. Estimated Concentrations and Volumes of Thorium-Contaminated Soil at IRP Site OT-10

Training Site	Percent of Area Contaminated Above Background	Volume of Soil Contaminated Above Background (yd^3)	Average Depth of Soil Contaminated Above Background (in)	Average Th-232 Concentration (pCi/g)[a]	Range of Th-232 Concentrations (pCi/g)[a]
TS5	20	5,637	16	67.9	2.2 – 421.6
TS6	32	15,599	16	100.8	2.8 – 683.4
TS7	0.3	60	19	55.4	2.3 – 466
TS8	100	6,223	16	76.4	2.1 – 1,047.9

Notes:

[a] Based on correlation of field gamma-ray counts and laboratory analyses: pCi/g=(cpm/g)/2.52

[b] Adapted from USAF, 1997

2.4 Site Conceptual Model

A preliminary site conceptual model was developed for the OT-10 training sites based upon the results of the previous investigations. The site conceptual model is comprised of the following:

- The four inactive training sites are contaminated with thorium oxide sludge applied to the sites to simulate nuclear weapons accidents.

- Approximately, 9.2 acres of the 43.2 acre site area are impacted with thorium oxide sludge.

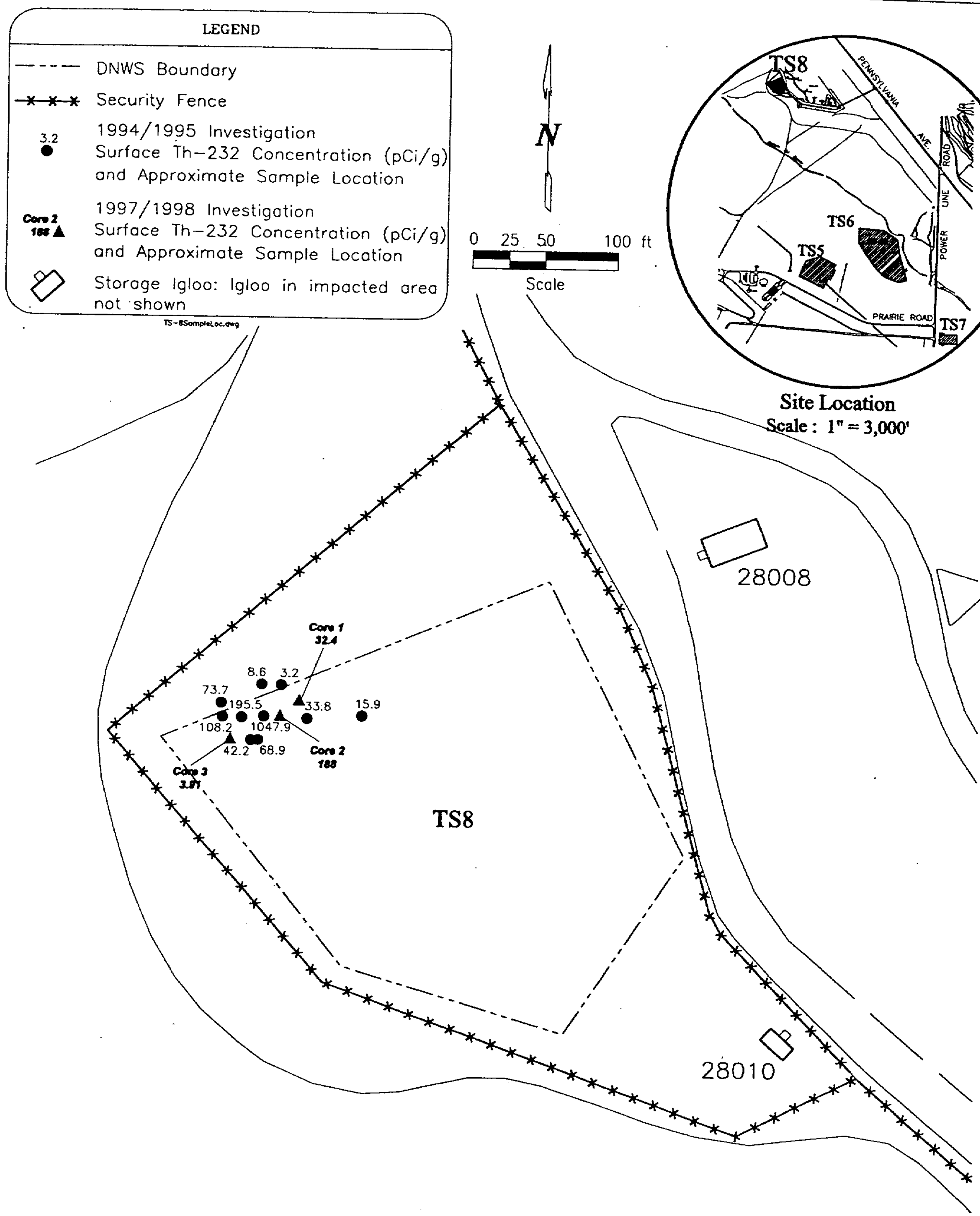

Figure 2-9. Sample Locations at TS8, IRP Site OT-10

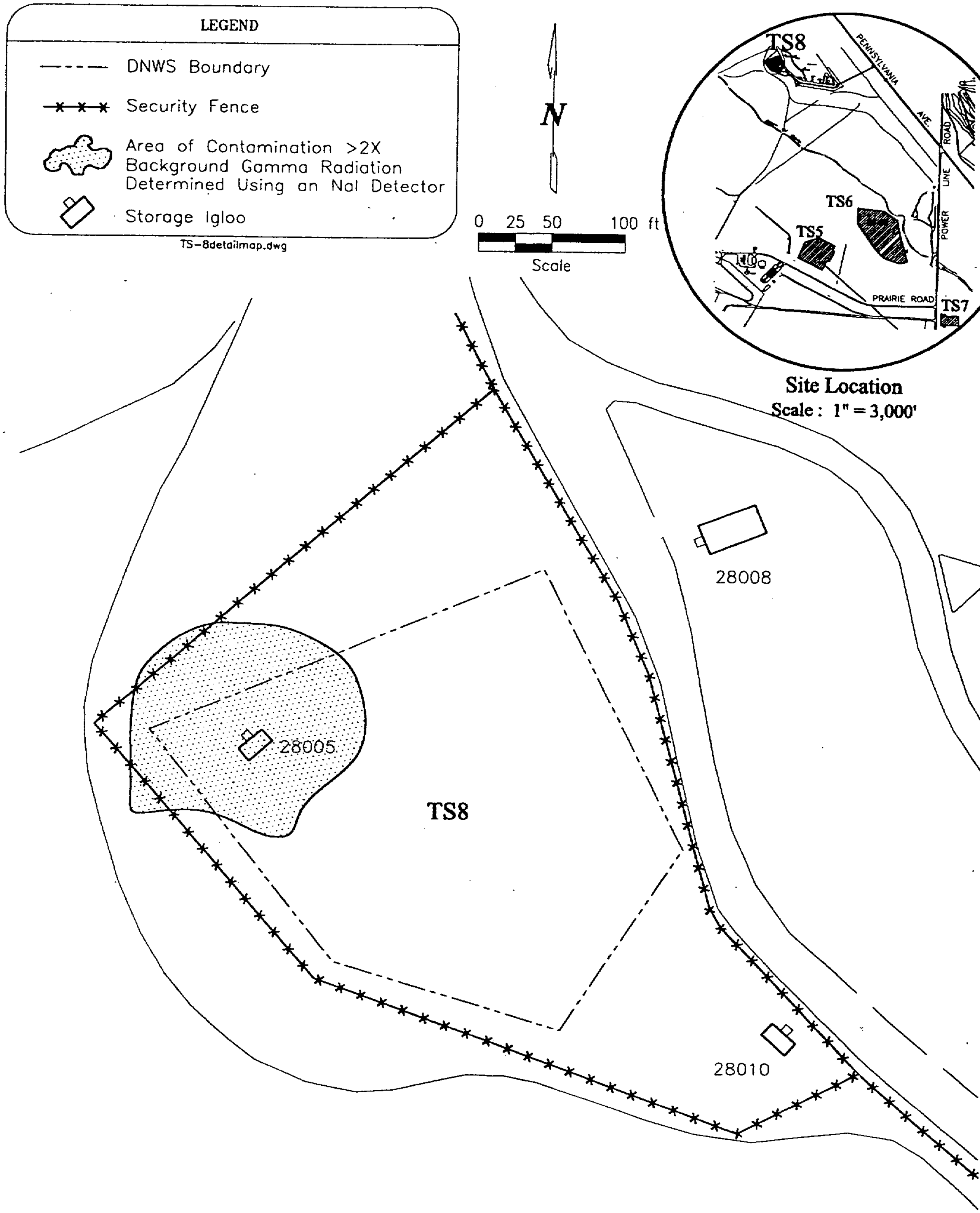

Figure 2-10. TS8 Security Fence and Area of Radiological Contamination

- Contaminants of potential concern associated with the thorium oxide sludge include thorium-232 and its decay progeny and, to a lesser extent, uranium-238 and its decay progeny.

- The extent of contamination is limited to the immediate vicinity of the training sites and to a maximum depth of 5-ft bgs.

- The vertical extent of contamination is typically 1 to 2 ft bgs.

- An estimated 27,500 cubic yards of soil are radiologically contaminated.

There are no indications of contaminant migration into surface water drainages or groundwater. The thorium-232 concentrations at site present an elevated exposure risk under both industrial and residential land-use scenarios. Therefore, the OT-10 sites do not currently meet the compliance criteria for license termination.

3.0 PLANNED DECOMMISSIONING ACTIVITIES

The site characterization data collected from the OT-10 sites indicate that thorium-contaminated soils pose elevated levels of risk to human health. The decommissioning criteria and activities planned to mitigate these risks are presented in this section.

Planned decommissioning activities include conducting radiation scanning surveys, excavating and packaging contaminated vegetation, debris, and soil; sampling and analyzing excavated soil and debris to profile and manifest the waste; conducting final status surveys; and transporting contaminated materials by rail to a licensed radioactive waste disposal facility (Envirocare) in Clive, Utah. Following site remediation activities, excavated areas will be graded and replanted with native vegetation.

3.1 Decommissioning Criteria

The decommissioning process ensures that residual radioactivity will not result in individuals being exposed to unacceptable levels of radiation or radioactive materials (EPA, 1997). Regulatory agencies establish radiation dose standards based on risk considerations and data relating dose to risk. The NRC total effective dose equivalent of 25 mrem/year above background and ALARA was selected for the OT-10 decommissioning criterion. This standard will allow for unrestricted release of the sites and support license termination.

Site exposure was quantified for thorium-232 and its decay progeny using the Residual Radiation (RESRAD) Program, version 5.95. Exposures to uranium-238 and its decay progeny were not evaluated because their concentrations are typically one order of magnitude lower than thorium-232 concentrations in OT-10 soils. Additionally, elevated uranium concentrations are associated with elevated thorium concentrations, and HBL_{SA} activities for uranium-238 and its decay progeny are two orders of magnitude higher than those for thorium-232. Therefore, OT-10 will be remediated to a site exposure scenario based on thorium-232.

RESRAD can calculate site-specific radiation doses and/or excess lifetime cancer risks to exposed individuals. Exposure scenarios were modeled for two variables, receptors and assumed land use, using RESRAD default, site-specific, and EPA parameters. Model runs identified preliminary remediation goals or DCGLs for thorium-232, which will permit the unrestricted use of OT-10. The detailed derivation of the preliminary remediation goals is presented in Appendix A.

The observed subsurface residual radioactivity was addressed as potential surface residual radioactivity; that is, excavation was assumed to expose subsurface radioactivity. The dose modeling and the survey methods were modified to account for the subsurface residual activity.

The OT-10 preliminary remediation goals or DCGL for thorium-232 activity in soil are 1.94 pCi/g above background at TS5, TS6, and TS8, and 2.4 pCi/g above background at TS7 for release to residential land-use. These concentrations are about 2 times greater than the site-specific OT-10 background of 1.06 pCi/g, as determined in the 1996 and 1998 investigation (USAF, 1999b).

The only difference in the modeling for each training site was the contaminated site area. The contaminated site areas were large enough at TS-5, TS-6, and TS-8 such that for the pathways evaluated and the range of site areas that exist, the contaminated site area of a training site did not factor into the dose received from thorium-232 or its decay progeny. The small, contaminated site area of TS7 led to its higher preliminary remediation goal.

3.2 Initial Radiation Survey

Gamma-ray scanning surveys will be conducted at each of the training sites to achieve the following Data Quality Objectives (DQOs): (1) to establish a relationship field gamma-ray counts and actual thorium-232 soil concentrations and (2) to define the aerial extent of radiologically-impacted soil.

These objectives will be used to guide excavation, identify non-impacted areas that may be appropriate for reference areas, and provide input to a Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)-compliant final status survey design (EPA, 1997). Radiological data-mapping of the sites will be performed using a 2-inch by 2-inch sodium iodide scintillation detector coupled to a digital ratemeter/scaler to measure gross gamma radiation. The scanning minimum detectable concentration (MDC) for a 2-inch by 2-inch sodium iodide scintillation detector is estimated at 1.8 pCi/g, based on MARSSIM Table 6-7 (EPA, 1997). Sodium iodide detectors are not effective at dose rates above 1 mrem/hr. Therefore, an alternate detector such as a Ludlum Model 9 ion chamber may be used in areas where such dose rates are observed.

Radiological data will be automatically tagged with location coordinates using a Global Positioning System (GPS) when count rates are recorded. The gamma-ray scanning surveys will cover 100 percent of each training site, using an estimated 5-ft transect spacing that will be demarcated using a Global Positioning System. The detector will be held at 18 inches above ground and swung from side-to-side. The perimeters of hot spots will also be scanned. The surveys will be extended to include affected areas outside of fenced areas.

GPS coordinates will be referenced to the central zone of the New Mexico State Plane Coordinate System. Location coordinates for salient site features, such as fence boundaries and building corners, will be included in the survey.

ArcView Geographic Information System (GIS) software will be used to develop gamma-ray anomaly maps of the training sites. These maps will contain isocontours of gamma-ray counts and spatial features such as fence locations. Isocontour maps of radiation anomalies will be expressed in microRoentgens per hour (μR/hour) exposure rate units and gamma-ray counts per minute. Proposed excavation boundaries will be based on results of initial radiation surveys, marked on the maps, and staked at the sites.

The bunkers within TS8, Buildings 28005 and 28010, will be surveyed for surface contamination for compliance with surface contamination limits according to ANSI Standard ANSI/HPS N13.12=1999, Surface and Volume Radioactivity Standards for Clearance. The bunker surfaces will be divided into grid blocks no larger than 1 m^2. A Ludlum Model 2221 ratemeter/scaler will be coupled to a Ludlum Model 43-5 alpha scintillation detector. The technician will conduct a 1-minute scan of the grid block with the Model 2221 in the integration mode. The data recorded will be the average count rate per 1 m^2 for each grid block. While scanning, the technician will note through audio level or ratemeter readings where the maximum contamination level occurred within the 1 m^2 grid block. At that point, a static 1-minute integrated count will be taken and recorded as the maximum count rate. The alpha efficiency will be determined using a NIST traceable plated Th-230 source. The count rates will then be converted to activity per 100 cm^2 and compared to the surface contamination limit of 600 dpm/100 cm^2. The sensitivity of the Ludlum Model 43-5 is addressed in the Radiation Safety Plan (see Chapter 4).

While wipe samples are not necessarily recommended, the presence of loose dust or dirt-like material will indicate that wipe samples will be taken of those surfaces. They will be analyzed on the Ludlum 2929/Ludlum 43-10-1 alpha tray counter. The limits will be compared to 600 dpm/100 cm^2. A minimum of three samples will be taken from each grid block.

A gamma-ray survey will be done inside the bunker using a Ludlum Model 19 micro-R meter. Contact readings will be recorded at the grid intersection points. These readings will be compared to readings obtained in other bunkers that are known to be uncontaminated. Any readings 20 μR/h above background will be further evaluated to determine the source of above background exposure levels.

3.2.1 Field and Laboratory Analysis Correlation

A relationship between thorium-232 soil concentrations and gamma-ray counts will be established by comparing field gamma-ray counts to laboratory-derived concentrations. Then an investigation level (in counts per minute) that corresponds to the preliminary soil remediation goal, or DCGL, will be determined. Field gamma-ray counts can then be used to guide excavation and improve the efficiencies of the remedial action support and final radiological surveys.

The extent of excavation will be defined by soils exhibiting low thorium-232 concentrations. Low levels of activity will be closer to the soil remediation goal than higher levels. Thus, the samples used to correlate gamma-ray field counts and specific thorium-232 concentrations will be collected from soils exhibiting field gamma-ray counts at approximately one to five times background.

A minimum of 10 composite soil samples will be collected from the training sites during the initial gamma-ray scanning surveys. These samples will be collected from soils that do not contain hot spots. A five-point composite method will be used. A circle will be drawn, the diameter of which will be equivalent to the "view" of the sodium iodide scintillation detector. Its center will be directly below the field measuring point. Soil samples will be collected at the center of the circle and at four points within the circle, each nine inches away from the center. The sample location coordinates will be recorded at the center.

In addition, we will collect one replicate sample for each 10 soil samples, one matrix spike/matrix duplicate sample for each 20 samples, and one equipment blank per day as Quality Assurance/Quality Control samples for the initial survey. Equipment calibration and function checks will be performed prior to each use and at the conclusion of each workday.

These samples will be shipped to an offsite laboratory for thorium and uranium analysis by alpha spectroscopy and gamma spectroscopy after field measurements are taken. Laboratory thorium-232 concentrations in soil samples will be correlated to their respective field gamma-ray counts by linear regression.

The field gamma-ray counts will be recorded using a 2-inch by 2-inch sodium iodide scintillation detector coupled to a ratemeter/scaler. A lead shield will be used with the detector. The detector will be placed at 18 inches above the ground at points where samples are collected. This height corresponds to the height normally used for GPS-based gamma-ray scanning surveys. Digitized radiological count rate data will be recorded every two seconds by transmission to a Trimble ProXR GPS Receiver, which automatically tags the data with the coordinates at the time the data count rate is received.

The 2-inch by 2-inch sodium iodide scintillation detector is expected to be sensitive enough to detect residual contamination that is comparable to the DCGL. Further discussion of the MDC is presented in Section 5.1 of this plan. The gamma-ray count rate for gamma-emitting radionuclides in soil will be directly and linearly proportional to the thorium-232 concentration if the following conditions can be met:

1. the orientation and distance of the sample to the detector is consistent,

2. the contaminant is homogeneously distributed in the soil sample,

3. instrument response parameters are appropriately calibrated, and

4. the types of radionuclides and their relative activity ratios remain the same from sample to sample.

Previous investigations have suggested that radiological contamination at OT-10 is limited to thorium-232 and its decay progeny (USAF, 1999b). However, uranium-238 and its decay progeny were identified in soil samples collected during the RCRA Facility Investigation conducted at SWMU SS-69. The uranium series radioisotopes will contribute to the gamma-ray count rates for the soil. However, the gamma-ray count rate for a soil sample is expected to be proportional to the thorium-232 concentration as long as condition four listed above is met.

Alpha-emitting thorium-232 is the parent of the naturally occurring thorium-232 decay series, which includes radium-228, thorium-228, actinium-228, radium-224, radon-220, and radioactive isotopes of lead, thallium, bismuth, and polonium. The half-life of thorium-232 (14 billion years) is at least ten orders of magnitude greater than the half-lives of the remaining elements in the series. Thus, there is no appreciable change in the time required for its products to attain equilibrium. After equilibrium is reached, equal numbers of atoms of all members of the series disintegrate in unit time. This type of equilibrium is termed secular radioactive equilibrium, and it has been demonstrated empirically in OT-10 contaminated soils (USAF, 1999b).

The activities of the decay progeny can be calculated using the following equation.

$$A_l = A_p (1 - e^{-\lambda t}) \qquad \text{Eq. 3-1}$$

where:

A_l = Activity of progeny,

A_p = Activity of parent,

λ = Progeny Decay Constant = *ln*2/half-life, and

t = time [same unit as half-life].

The progeny of the thorium-232 decay series with the longest half-life (6.7 years) is radium-228. Assuming its A_l is 99 percent of A_p, the activity of radium-228 will be 99 percent of the thorium-232 activity in 45 years. Using a similar assumption, the activity of actinium-228 will be 99 percent of the thorium-232 activity in 40 hrs (1.7 days).

Of the thorium-232 progeny, actinium-228, thorium-228, radium-224, polonium-212, bismuth-212, thallium-208, and polonium-212 are gamma radiation emitters; the gamma spectra of actinium-228 are the most easily resolved. Actinium-228 can be measured using gamma spectroscopy analysis and the activity of thorium-232 can be inferred without the necessity of considering the liberation of radon-220. The presence of gamma-ray-emitting thorium-232 progeny and secular radioactive equilibrium render field gamma surveys a robust tool for guiding excavation activities.

3.3 Excavation of Contaminated Soil

Soils that exhibit gamma-ray field counts greater than the equivalent of the DCGL will be excavated. The DCGL for OT-10 is equivalent to the sum of the site-specific background concentration (1.06 pCi/g) and the derived cleanup criterion for release to residential use (1.94 pCi/g at TS5, TS6, and TS8 or 2.4 pCi/g at TS7). Vegetation and debris associated with this soil has been assumed to be contaminated, because thorium uptake by plants at OT-10 has been observed (Rademacher, 1992). Contaminated soil, vegetation, and debris will be excavated and transferred directly to Lift Liner™ soft-sided disposable containers; each measures approximately 96 inches by 86 inches by 54 inches and can contain a maximum load of 11 tons (10,000 kg or about 1,937 gallons). Soil will be loaded carefully into the bags to prevent breaching them and contaminating their outer surfaces.

The Lift Liner™ waste packaging system includes a 25-mil woven outer polyethylene fabric shell with a 2-mil water resistant coating and a 45-mil double-layer polypropylene inner liner. The outer shell is equipped with 18 lifting straps made of 2-inch polyester seat belt webbing materials. The system also includes a loading frame used to support the shell and inner liner during loading and a lifting/spreader bar. The lifting frame is constructed of steel, meets American Society for Testing and Materials (ASTM) A-500 specifications, and has a design capacity of 40,000 pounds. The lifting weight capacity is 24,000 pounds at 125 percent certified. The lifting/spreader bar attaches to the lifting straps to hoist the container from the loading frame onto a transport vehicle. Photographs of Lift Liners™ are shown in Figure 3-1.

In contaminated areas, soil will be excavated from the surface to an estimated 1 to 2 ft bgs. Excavation will be an iterative process. Soils exhibiting gamma-ray counts that exceed the investigation level will be excavated. Excavated areas will then be resurveyed. Remaining *in situ* soils will be excavated if their count rates exceed the investigation level. These procedures are described in greater detail in Section 3.5 (Remedial Action Support Survey).

Emissions of dust will be controlled and minimized during excavation activities by use of light water spraying. Heavily traveled, clean areas will also be sprayed lightly. Accumulating rainwater in affected areas will be dammed, mixed into contaminated soils, and/or left to evaporate.

Composite soil samples will be collected from the each of the bags and analyzed onsite by gamma spectroscopy for waste profiling and manifesting. The disposal containers will be closed and staged in a loading area to await acceptance by the disposal facility.

Detailed construction procedures are currently being prepared for OT-10 decommissioning (USAF, 2000).

3.4 Packaging Requirements

Packages will meet U.S. Department of Transportation (DOT), NRC, and disposal facility requirements for bulk packaging. In terms of solid materials, bulk packaging contains hazardous materials, with no intermediate form of containment, and has a minimum weight of 882 pounds and a volume greater than 119 gallons.

Low specific activity (LSA)-I, Class 7, materials can be contained in an industrial package (IP-1), a DOT Specification 7A, Type A, package (domestic transport only), or a strong, tight package (domestic transport only). Lift Liner™ soft-sided containers satisfy the DOT requirements for transport of LSA materials as either IP-1 or strong, tight containers. The general design requirements specified in 49 CFR § 173.410 do not normally apply to strong, tight packages containing LSA-1. However, the Lift Liner™ is an exception to this. According to DOT Regulations Conformance Summary EDF Serial Number 036, the Lift Liner™ is an IP-1 or strong, tight package suited to transport LSA materials, but it is also subject to the applicable requirements and limitations specified in 49 CFR § 173.410 (Transport Plastics, 1998).

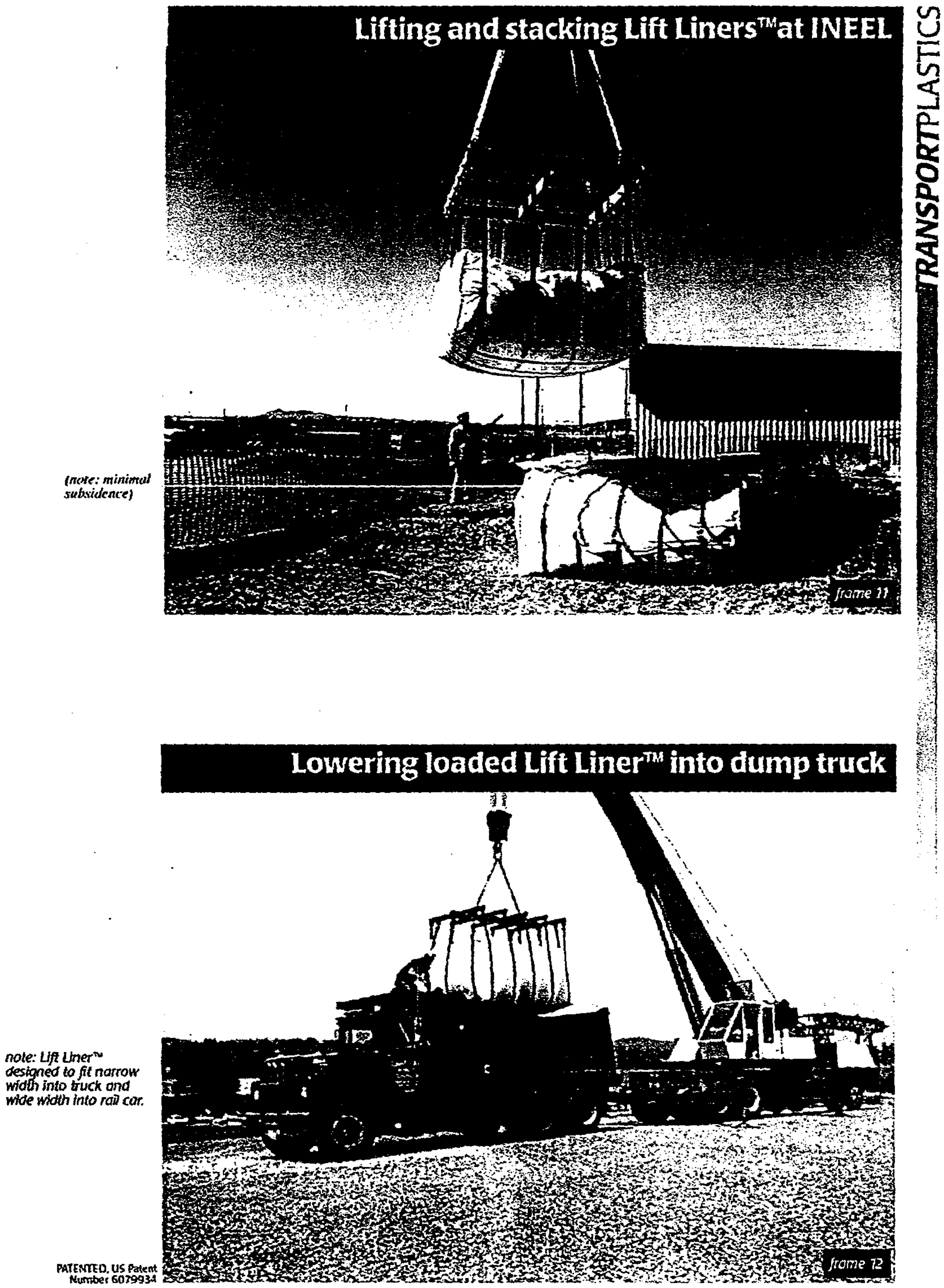

Figure 3-1. Photographs of Lift Liners™ (photographs supplied by Transport Plastics)

The Lift Liner™ disposable containers will meet the following applicable packaging requirements for the OT-10 soils (LSA-I, Class 7, exclusive use materials):

- package integrity will not be reduced by the range of temperatures to which it will be subjected;
- package integrity will not be reduced by way of mixing of internal gases or vapors;
- the package will be compatible with its contents in terms of corrosivity, permeability, softening, premature aging, and embrittlement;
- the package and its contents will not react chemically or galvanically;
- plastics in the package will be compatible with the OT-10 soils and will not be permeable to an extent that a hazardous condition is likely to occur during transportation and handling;
- the closed package will be secure and leak proof, that is, identifiable releases to the environment will not occur;
- the package will be easy to handle and secure on railroad cars during transport;
- each lifting attachment that is a structural part of the package will be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner;
- there will be no other structural parts of the package that could be used to lift the package;
- the external surface will be free of protruding features, pockets, or crevices;
- no features will be added to the packages;
- the package will withstand normal transport ranges of acceleration, vibration, or vibration resonance;
- there will be no valves through which package contents could escape; and
- the packages will be clean.

The first five bullet points address the applicable requirements of 49 CFR § 173.24 (General Requirements for Packagings and Packages); the others address the requirements of 49 CFR § 173.410 (General Design Requirements) and the disposal facility.

3.5 Remedial Action Support Survey

Remedial action support surveys will be conducted to support remediation activities, determine when a survey unit is ready for a final status survey, and provide updated estimates of site-specific parameters to help plan the final status survey.

Near-surface gamma-ray readings will be taken in excavated Class 1 areas, using a 2-inch by 2-inch sodium iodide scintillation detector. These readings will be compared to the investigation level, in cpm, determined as described in Section 3.2.1.

Excavation will proceed interactively until residual radioactivity in soil is at or below the investigation level. Samples will then be collected from the soils, homogenized, and analyzed onsite for thorium-232 (using actinium-228 as a surrogate) by an Ortec Model MicroNomad Gamma-Ray Spectrometer. The distribution and numbers of samples to be collected will be identified in the sampling and analysis plan.

3.6 Waste Acceptance Procedures

Envirocare's waste acceptance procedures include waste profiling; pre-shipment sampling and analysis; waste packaging; transportation and delivery; and waste receipt, sampling, and acceptance.

3.6.1 Waste Profiling

A Kirtland AFB point of contact, RCRA Part B Permit information and a description of the waste will be recorded on a radioactive waste profile record form. The waste will be described by the date it was generated and its history, volume, general characteristics, radiological and chemical constituents, and physical properties.

Envirocare's approval process requires third-party certified laboratory results to evaluate incoming wastes. Two waste profile samples will be collected during excavation and sent to a Utah-certified laboratory. The excavated material will be analyzed for the following radiological, chemical, and physical parameters:

- radionuclides by gamma spectroscopy and isotopic thorium and uranium by alpha spectroscopy;
- total or Toxicity Characteristic Leachate Procedure (TCLP) RCRA metals listed in Table 1 of 40 CFR § 261.24 and zinc;
- TCLP for the 32 organic compounds listed in Table 1 of 40 CFR § 261.24;

- soil pH;
- paint filter liquids test;
- reactive cyanide and sulfide;
- ignitability;
- corrosivity; and
- particle size distribution, dry density, and moisture content.

Envirocare identifies incoming radionuclides by element, mass number, and concentration limits. These limits are based on the average concentration per container for each radionuclide.

Envirocare will evaluate the waste profile and classify the radionuclides for near-surface disposal. The classification parameters are those defined in 10 CFR § 61.55 (Waste Classification) and Utah Administrative Code R313-15-1008 (Classification and General Characteristics of Low-Level radioactive Waste). Three classes have been determined in these rules: Classes A, B, and C. Envirocare accepts only Class A wastes. The Kirtland AFB packagings will meet each of the following requirements for Class A physical form and characteristics:

- the packages will not be cardboard or fiberboard boxes;
- void spaces within the waste and between the waste and its package will be minimized (the Lift Liner™ packages are better suited to this task than wood or steel packages);
- the wastes will be structurally stable;
- there will be no liquid wastes;
- there will be no toxic gases, vapors, or fumes;
- the wastes will not detonate or explode in the presence of water and at normal temperatures and pressures;
- the wastes will not be pyrophoric; and
- the wastes will not contain biological, pathogenic, or infectious material.

The Kirtland AFB packages are also expected to meet the long-lived and short-lived radionuclide activity requirements of Class A wastes. Envirocare may choose to repeat the tests on incoming OT-10 soils; it may reject the waste if its analyses differ.

The long-lived and short-lived radionuclides and their associated activities are listed in Tables 3-1 and 3-2.

Table 3-1. Long-lived Radionuclides

Radionuclide[a]	Concentration	
	[Ci/m³]	[nCi/g]
Carbon-14	8	
Carbon-14 in activated metal	80	
Nickel-59 in activated metal	220	
Niobium-94 in activated metal	0.2	
Technicium-99	3	
Iodine-129	0.08	
Alpha emitting transuranic nuclides with half-life greater than 5 years		100
Plutonium-241		3,500
Curium-242		20,000
Radium-226		100

Notes:

a Radium-226 is listed in UAC R-313-15-1008; not in 10 CFR § 61.55.

Ci/m³ curies per cubic meter

nCi/g nanocuries per gram

Table 3-2. Short-lived Radionuclides

Radionuclide[a]	Concentration [Ci/m³][b]
Total of all radionuclides with less than 5 year half-life	700
Tritium	40
Cobalt-60	700
Nickel-63	3.5
Nickel-63 in activated metal	35
Strontium-90	0.04
Cesium-137	1

Notes:

a With the exception of their footnotes, this table is equivalent in 10 CFR 61.55 and UAC R-313-15-1008.

b Columns 2 and 3 in the CFR and UAC tables have been omitted here because they are needed only to consider whether a waste can be accepted as Classes B or C. As mentioned above, the disposal facility accepts only Class A wastes. Thus, columns 2 and 3 are irrelevant in this case.

Ci/m³ curies per cubic meter

The OT-10 soils will be classified as Class A wastes if

- they contain only the long-lived radionuclides listed in Table 3-1, and the concentrations of these radionuclides are less than 0.1 times those listed in Table 3-1; or
- they contain only the short-lived radionuclides listed in Table 3-2, and the concentrations of these radionuclides are less than those listed in Table 3-2; or
- they contain none of the radionuclides listed in Table 3-1 and Table 3-2.

Both 10 CFR § 61.55 and UAC 313-15-1008 provide a method to classify wastes containing a mixture of short-lived and long-lived radionuclides (sum of fractions method). However, the OT-10 soils are not expected to contain such mixtures. Therefore, this method is not discussed here.

3.6.2 Pre-Shipment Sampling and Analysis

After the waste profile is approved, five pre-shipment samples will be collected from contaminated OT-10 soils and sent to Envirocare. The samples will represent the variety of soils observed at OT-10. Envirocare will subject the samples to the following physical and chemical tests:

- pyrophoricity;
- shock sensitivity;
- air and water reactivity;
- hydrogen sulfide;
- hydrogen cyanide;
- oxidizer/reducer;
- volatile compounds by photoionization detector (PID);
- soil pH; and
- paint filter liquids test.

Envirocare will accept the waste if it passes the first three tests (physical pass/fail tests). It will use the results of the remaining tests to establish the baseline chemical ranges in OT-10 soils. The results for these six parameters in incoming wastes, as listed on their associated waste profiles, should fall within their baseline ranges. Wastes may be rejected if this is not the case.

3.7 Transportation of Radioactive Soil

Offsite transport of NRC-licensed LSA materials is addressed under 10 CFR § 71.5(a), which directs compliance to the DOT regulations published in 49 CFR §§ 170 through 189. The applicable DOT materials classes and shipping, packaging, marking and labeling, placarding, employee training, accident reporting, and transporting requirements are addressed in the following sections.

3.7.1 Soil Sampling for Shipping Manifests

One composite sample will be collected from each group of nine Lift Liners™. Each high-sided gondola railcar is expected to contain a group of nine Lift Liners™. The samples will be analyzed onsite using gamma spectroscopy analysis. The gamma spectrometer will be an Ortec Model MicroNomad with a MDC of 1 pCi/g. The resultant thorium and uranium concentrations will be multiplied by the volume of the containers' contents to determine the total masses of uranium and thorium in the container. This information will be recorded on the shipping manifests to be prepared for each railcar.

3.7.2 Scanning Packages to Determine a Transport Index

Each Lift Liner™ that has been prepared for transport will be scanned at one meter from the external surface. The maximum observed values will be used to calculate transport index (TIs) for each Lift Liner™. The TI is a dimensionless number (rounded up to the nearest tenth) which designates how much control is required of the carrier during transportation. It is the maximum dose rate, in mrem/hr, at 1 m from the surface of the container.

3.7.3 U.S. Department of Transportation Classification of OT-10 Soils

Based on the results of the previous investigations, the OT-10 contaminated soils will likely be classified as DOT Radioactive Material Hazard Class 7, Normal Form, exclusive use, LSA-I materials.

Class 7 materials are defined by a minimum specific activity of 2,000 pCi/g; the aggregate of all observed radionuclides. Cumulative activities in several OT-10 soil samples have been shown to be greater than 2,000 pCi/g (USAF, 1999b).

Normal Form Class 7 materials are those that are not Special Form Class 7 materials. Special Form Class 7 materials are defined as either single solid pieces or materials sealed in a capsule that can only be opened if it is destroyed.

The OT-10 soils will qualify as exclusive-use materials because the rail transport, including the initial, intermediate, and final loading, will be conducted solely by a single consignor (DOD-certified broker) in accordance with the direction of its consignee (Envirocare).

In addition, the OT-10 soils will be also classified as LSA-I materials; that is, ores containing only naturally occurring radionuclides (that is, thorium) and uranium or thorium concentrates of such ores.

3.8 Shipping Paper Requirements

3.8.1 Manifests

Uniform low-level radioactive waste manifests, NRC Forms 540 and 541, for each waste shipment will be generated completely and accurately. NRC Form 540 will accompany the waste shipment. NRC Form 541 will be stored and transmitted in an electronic form or hard copies will be mailed to Envirocare. The information required in the manifests is specified in 10 CFR Part 20, Appendix G and will include for each shipment.

- Kirtland AFB contact and RCRA Part B Permit information;
- carrier contact information (or name and EPA identification number);
- the date of waste shipment;
- the total number of packages/disposal containers;
- the total disposal volume, disposal weight, and radionuclide activity in the shipment;
- the appropriate DOT group notation;
- the activity of each of the radionuclides hydrogen-3 (tritium), carbon-14, technitium-99, and iodine-129 contained in the shipment; and
- the total masses of uranium and thorium in the shipment.

The following information will also be included for each disposal container:

- the unique identification number and a physical description of each disposal container in the shipment;
- the gross weight and volume displaced by the disposal container;
- the approximate volume of waste within the disposal container;
- the maximum radiation level at the surface of each disposal container;
- the maximum radiation level at 1 m from the surface of each disposal container;
- physical and chemical descriptions of the waste;
- the activity of beta, gamma, and low-toxicity alpha emitters in representative 300-cm^2 swipe samples collected from the external surface of the package during loading;
- the identities and activities of individual radionuclides contained in each container (in bequerels (Bq)/g) and the masses of uranium and thorium in the material;
- the total radioactivity; and
- the DOT Hazardous Waste Classification (Class 7).

The Uniform Low-Level Radioactive Waste Manifests will be signed by the disposal facility after the waste is processed and the train has been released. Copies of the signed manifests will be mailed to Kirtland AFB and provided to AFIERA/SDRH (AFRMWO) and HQ Army OSC Safety Officer.

3.8.2 Emergency Response Information

Emergency response information will meet the requirements of 49 CFR Part 172 Subpart G. The Kirtland AFB Radiation Safety Officer (RSO) or DOD-certified broker will serve as the 24-hr a day point of contact.

3.8.3 Exclusive-Use Instructions

Specific instructions for maintenance of exclusive-use shipments will be provided to the carrier along with the shipping papers.

3.8.4 Bills

A Bill of Lading and a Railroad Weigh Bill will also accompany each shipment.

3.9 Transport Requirements

The requirements for LSA-I, Class 7, materials transport, are described in 49 CFR § 173.427. The applicable requirements for a strong, tight container listed below will be met.

- The quantities of particular radionuclides will not exceed their respective A_2 quantities (described in Table 3-3).
- The levels of radioactive contamination on external surfaces will be rendered as low as reasonably achievable (ALARA).
- The external dose rate will not exceed a radiation level of 1,000 mrem/hr at 3 meters from the unshielded material.
- The external dose rate will not exceed a radiation level of 200 mrem/hr at any point on the exterior surface of the package, and the TI will be below 10.
- The activity of beta, gamma, and low-toxicity alpha emitters in representative 300-cm^2 swipe samples collected from the external surface of the package will not exceed 10^{-5} $\mu Ci/cm^2$ (or 22 dpm/300 cm^2) during loading.
- The activity of beta, gamma, and low-toxicity alpha emitters in representative 300-cm^2 swipe samples collected from the external surface of the package will not exceed 10^{-4} $\mu Ci/cm^2$ (or 220 dpm/300 cm^2) during transport.
- Packages will be braced to prevent shifts of lading under normal transport conditions.

The specific concentrations determined from samples collected from each Lift Liner™ will be compared to A_2 quantities prior to transport. For example, assuming a Lift Liner™ package contains 7 yards of OT-10 soils having a loose density of 1,422 kg/yd³, its contents will weigh 10,000 kg (rounded up to the nearest thousand). This assumed mass and the highest activities of thorium-232, uranium-235, uranium-238, and their decay progeny reported in the previous investigations can be used to calculate the most conservative quantities to be expected in a representative package. These and their associated A_2 quantities are listed in Table 3-3. The most conservative packaged quantity of each isotope is lower than its respective A_2 quantity.

Table 3-3. Shipment Radiological Activities

Isotope	Highest Observed Activity [pCi/g]	Total Maximum Quantity in Planned Shipments [pCi]	A2 Quantity[a,b] [pCi]
Actinium-228	1,120	1.1×10^{10}	1.1×10^{13}
Bismuth-212	1,169	1.2×10^{10}	8.11×10^{12}
Lead-212	1,624	1.6×10^{10}	8.11×10^{12}
Thorium-228	181	1.8×10^{9}	1.1×10^{10}
Thorium-230	12.9	1.3×10^{8}	5.4×10^{9}
Thorium-232	1,120	1.1×10^{10}	Unlimited
Thorium-234	18.8	1.9×10^{8}	5.4×10^{12}
Uranium-235	0.39	3.9×10^{6}	Unlimited

Notes:

a Listed in 49 CFR § 173.435. A_2 is the maximum activity permitted in a Type A package. The packaging requirements for LSA differ from those of a Type A package. However, the use of A_2 here is an exception to its definition (see 49 CFR § 173.427 (b) (3) (ii)). The activity of LSA isotopes contained in a strong, tight package cannot exceed their respective A_2 quantities.

b No A_2 quantity reported for thorium-232 decay progeny thallium-208.

LSA low-specific activity

pCi picocuries

pCi/g picocuries per gram

3.9.1 Packaging Markings and Labels

Domestically transported LSA-I bulk packages are excepted from DOT marking and labeling requirements. However, each container will be labeled with the following information to assist decommissioning logistics and communications between Montgomery Watson personnel, the carrier, and Envirocare: "Radioactive-LSA-I", its generation date, and a unique identification number.

3.9.2 Vehicle and Bulk Packaging Placarding

Placards are required by the DOT to be affixed to LSA, exclusive-use shipments. Transport vehicles (trucks and trains) will be placarded in accordance with 40 CFR 172. The placards used will conform to specifications in §172.504 (general placarding requirements), §172.506 (providing and affixing placards: highway), §172.507 (special placarding provisions: highway), §172.508 (placarding and affixing placards: rail), §172.510 (special placarding provisions: rail), §172.514 (bulk packagings), §172.516

(visibility and display of placards), §172.519 (general specifications for placards), §172.527 (background requirements for certain placards), and §172.556 (radioactive placards).

3.10 Transportation of Waste Containers

The disposal containers will be transferred by truck from Kirtland AFB to the Albuquerque rail site after Envirocare has accepted the waste for delivery. A crane—parked and operating in clean areas of OT-10—will transfer the staged disposal containers to trucks (also waiting in clean areas). Trucks leaving OT-10 will be monitored and cleaned, if warranted, to prevent the offsite migration of contaminated soil. Trucks will be weighed at Kirtland AFB before and after loading.

The disposal containers will be transported to the Burlington Northern Santa Fe South Valley rail car loading station, located near 2nd Street and Cesar Chavez Avenue, Albuquerque, New Mexico. A crane will transfer the disposal containers to gondola railcars. Each gondola railcar is expected to hold nine

Lift Liner ™ disposal containers. The disposal containers will be transported by rail to the Envirocare disposal facility, in accordance with 49 CFR Part 172 and applicable local, state, and federal transportation regulations. The route from OT-10 to the rail site is shown in Figure 3-2.

The waste carrier will maintain an approved RCRA Part A waste transporter application and a notarized copy of their EPA waste transport identification number. In addition, the waste transporter will provide notarized statements describing the status and background of any civil or criminal lawsuits filed against them within the last 10 years. Furthermore, the waste transporter will provide bills of lading to accompany the shipments. Finally, the waste transporter will provide evidence that all transport vehicle operators have complied with the minimum health and safety training requirements specified by the EPA, the DOT, and the Occupational Safety and Health Administration (OSHA) for hazardous waste vehicle operators.

Shipments will comply with DOT, state of New Mexico, and state of Utah regulations, and applicable disposal facility licenses, permits, and requirements, including the waste profile.

Rejection of a shipment may imply that it is not compliant with transport regulations; that is, it could potentially endanger public health and safety. Thus, the disposal facility will correct non-compliant shipments prior to their return to Kirtland AFB. Costs incurred in such cases will be borne by the organization signing the waste manifests.

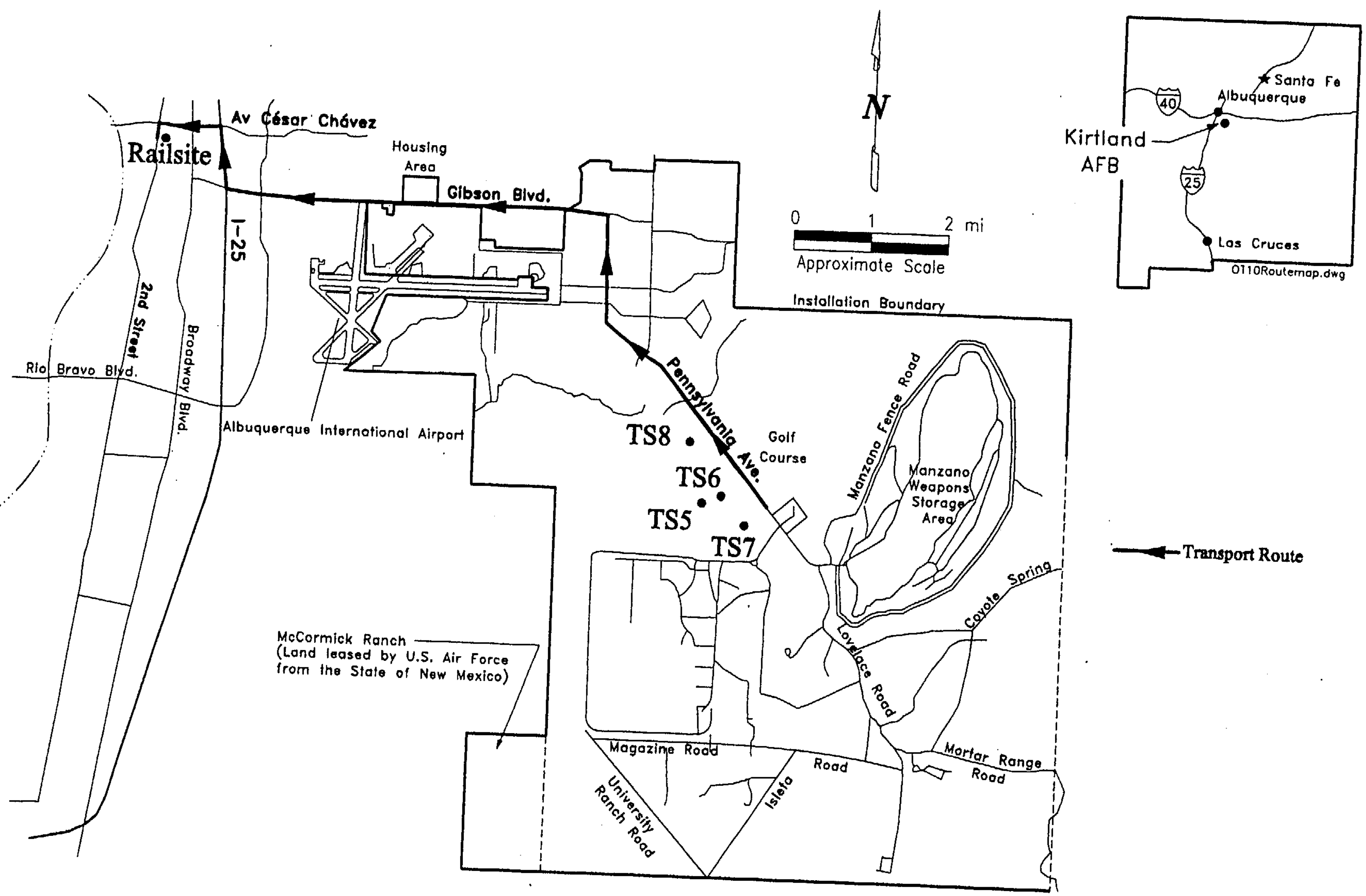

Figure 3-2. Transport Map

3.11 Waste Disposal

According to Envirocare, the low-level radioactive wastes will be disposed of in their low-activity radioactive waste/naturally occurring radioactive materials cell in Clive, Utah. Each Lift Liner™ and its contents will be disposed of in the landfill; the containers will not be reused.

The disposal facility has an Agreement-State Radioactive Material License (License #UT 2300249, as amended) issued by the Utah Division of Radiation Control (DRC). The facility can accept the following wastes: low-level radioactive wastes containing source, byproduct, and/or special nuclear material, naturally occurring radioactive materials, and naturally occurring or accelerator-produced radioactive materials.

4.0 RADIATION SAFETY PROGRAM

4.1 Management and Work Controls

OT-10 consists of four individual radiation training sites, TS5, TS6, TS7, and TS8 located on Kirtland AFB. The sites are owned by the U.S. Government and managed by the USAF in accord with the USAF Master Materials License No. 42-23539-01AF issued by the NRC. This radiation safety program is designed to meet all license requirements as well as the requirements in 10 CFR Parts 19 and 20 and Kirtland AFB Instruction 40-201, Kirtland AFB Ionizing Radiation Safety Program (USAF, 1996b). A site-specific health and safety plan, which covers both radiation safety and industrial hygiene issues, is presented in Appendix B.

4.1.1 Site Management

Figure 1-1 shows the locations of the four training sites within Kirtland AFB. Figures 2-3 through 2-10 show details of each site, including the boundary, the fence location, the area(s) of contamination, and other site features. While the contaminated area extends beyond the chain-link security fence in some locations, the radionuclide concentrations have been determined to be only slightly above background.

All contractor-performed activities will be monitored by the USAF to assure compliance with the decommissioning and health and safety plans. Because the sites are licensed by the NRC, radiation safety and other activities may be audited by the NRC. The NRC will also make a determination as to the final site status following decommissioning.

Montgomery Watson is the contractor responsible for conducting the remediation of the training sites with Mr. Jeff Johnston serving as the Project Manager and Mr. Reid Olson serving as the Site Manager. Dr. Kenneth R. Baker is the site RSO. The Kirtland AFB RSO is Captain Clinton Abell. Mr. Jerroll Sillerud is the Kirtland AFB Environmental Restoration Project Manager. The Site RSO will be responsible for ensuring that this plan is implemented. He, or his representative, will be onsite to manage the radiation safety activities. Both the Site and Kirtland AFB RSOs and their designees have the authority to stop work should radiation safety concerns arise.

4.1.2 Site Control

Site control is necessary to prevent unauthorized, untrained, or unprotected personnel from entering the site. The security fence for each of the training sites will be used to control access. Rope barriers with "Caution Radioactive Material" signs and "No Entry" signs will be used to prevent workers, visitors, and equipment from entering the slightly contaminated areas that extend beyond the fences. While the soil concentrations in these areas are not considered high enough to require radiological monitoring of occupants, these measures will be taken to limit the spread of contamination and to reduce the radiation exposures to ALARA levels.

Each training site will be divided into work zones as defined below.

4.1.2.1 Project Support Zone

This work area is maintained free of contamination and is used for project administration functions, an onsite gamma spectroscopy laboratory, personnel and equipment staging, rest breaks and other personal needs, personal protective equipment (PPE) donning, and access control.

4.1.2.2 Contamination Reduction Zone

This initially clean area serves as a transition area to reduce contamination levels on personnel and equipment before entering the project support zone. The area is initially clean and will be maintained to prevent gross levels of contamination. The contamination monitoring station is placed at the boundary between this zone and the project support zone. Prior to monitoring, personnel will remove PPE and decontaminate when necessary. Personnel and equipment will then be monitored prior to entering the project support zone. Drums for potentially contaminated PPE will be placed in this area.

4.1.2.3 Radiological Exclusion Zone

This work area initially contains all contaminated materials identified for removal from the site. Removal equipment and waste containers will be brought into this area. Prior to exiting this area, all equipment and full container exteriors will be decontaminated, if necessary, and monitored for compliance with unconditional release criteria. All equipment having the potential for being contaminated at other sites will be monitored prior to entering the site to ensure that the equipment is free of contamination.

Signs, barriers, and instructions will be posted in appropriate areas to assist personnel in identifying work zones and performing such tasks as donning and doffing PPE. No smoking, eating, drinking, or chewing will be allowed in this area.

4.1.3 Radiological Exclusion Zone Access

Personnel entering the exclusion zone must have prior authorization. Upon entry, they must sign the access log providing the date, time, and job-related information. Upon exiting, all personnel will enter the time and respirator use information. Regular personnel will be trained to frisk themselves and to don and doff PPE. These activities will be monitored closely by the site RSO.

Visitors or short-term workers may be given abbreviated radiation safety training by the RSO or his designee and escorted into areas not requiring respiratory protection. The escort will be responsible for ensuring that all radiation safety practices are followed and that the escorted individuals are frisked prior to leaving the site. Prior approval by the Site Manager and RSO must be obtained.

4.1.4 ALARA Policy

Montgomery Watson is committed to keeping individual and collective radiation doses to ALARA levels and supports an administrative organization for radiation safety. Montgomery Watson has developed the project health and safety plan and instructions to foster the ALARA concept within the organization.

A monthly assessment of the radiation safety program will be conducted by the RSO. Changes to operating and maintenance procedures and to equipment and facilities will be made if they will reduce exposures unless the cost, in our judgment, is considered unjustified. In addition to maintaining doses to individuals as far below the limits as is reasonably achievable, the sum of the doses received by all exposed individuals will also be maintained at the lowest practicable level.

4.1.5 Standard Operating Procedures

Written standard operating procedures (SOPs) will be required for performing all major tasks associated with this plan. Major tasks include how to conduct radiation measurements, how to don and doff personnel protective equipment, and how to administer the respiratory protection program. These SOPs will be developed and approved by the RSO prior to beginning the soil removal activities.

4.2 Worker Training

All workers in potentially contaminated areas are required to attend a formal radiological safety training program that conforms to 10 CFR §19.12. Emphasis will be placed on site-specific operations and radiological safety practices, including personal decontamination. The training session will last from 4 to 8 hrs. Documentation of the training, in the form of a written examination for each employee, will be retained. Additional weekly safety meetings of brief duration will be held to discuss any safety issues that may concern onsite workers or the RSO. The content of the radiation safety training is as follows:

- General History and Site Overview
- Regulatory Overview
- Fundamentals of Radiological Protection
- Biological Effects
- Radiation Limits
- ALARA
- Personnel Monitoring Programs
- Radioactive Contamination Control
- Radiological Postings and Site Control
- Emergency Procedures

4.3 Radiological Monitoring

General work area monitoring will be conducted to assess potential radiation exposures to workers and for planning purposes to ensure that radiation exposures are ALARA. The two principal radiation exposure pathways are direct gamma radiation from the contaminated soil and inhalation of long-lived airborne particulate radionuclides. Because of the small size of the thorium-contaminated areas, and because rapid atmospheric dilution is anticipated, airborne radon and the short-lived particulate radon progeny should not present a significant hazard. Sources will be leak tested every six months and will be stored in a locked drawer or cabinet when not in use.

4.3.1 Monitoring Equipment Calibration and Maintenance

A large inventory of radiological monitoring equipment is available to support this project. A listing of equipment and associated information is provided in Table 4-1. Radiation monitoring instruments such as alpha scintillometers, gamma scintillometers, and Geiger-Müeller detectors will be function-checked prior to use each day using appropriate radioactive sources. Radiation monitoring equipment will be calibrated semiannually unless damaged, in which case it will be sent for repair and replaced with another calibrated meter. All monitoring equipment will be recalibrated after repair. Sealed radioactive sources are used in instrument calibration and efficiency testing. All sources have been chosen such that they are small quantity sources exempted from licensing by the NRC. These sources will be registered with the Bioenvironmental Engineering Group at Kirtland AFB prior to their use onsite.

Table 4-1. Radiological Monitoring Equipment to Support Decommissioning Activities at IRP Site OT-10

Quantity	Manufacturer	Model	Instrument	Use
1	ORTEC	MicroNomad	Gamma-Ray Spectrometer	Radionuclide Concentrations in Soil
3	Eberline	RAS-1	Air Sampling Pumps 0-80 liters/min	Perimeter and Work Area Air Sampling
2	MSA	Escort Elf	Lapel Air Sampler (0-3 liters/min)	Breathing Air Samples
1	Ludlum	19	Micro-R meter Range (0-5mR/h)	Measure gamma exposure rate
1	Ludlum	2929	Duel Scaler	Use with Model 43-10-1
1	Ludlum	43-10-1	Alpha/Beta Tray Counter	Gross Alpha/Beta smear/air filter counter
1	Ludlum	12	Ratemeter Range (0-500k cpm)	Used with Model 44-9 and 43-5
1	Ludlum	43-5	Alpha Scintillation Detector	Personnel frisking and surface contamination monitoring
1	Ludlum	44-9	G-M detector	Personnel frisking and Surface Contamination
1	Ludlum	2221	Ratemeter/scaler	Gamma scanning surveys
1	Ludlum	44-10	2"x2" Sodium Iodide Scintillation Detector	Gamma scanning surveys

Air sampling equipment will be calibrated at a frequency of three months or less.

4.3.2 Personnel Contamination Monitoring and Decontamination

Personnel leaving the radiological exclusion zone or coming into contact with potentially contaminated material will be monitored with a portable alpha detector. Contaminated clothing such as gloves, boot covers, and Tyvek suits will be removed and placed in a designated radioactive waste container for disposal as radioactive waste. The Tyvek suits will include attached Tyvek booties that will serve as the primary contamination barrier. Rubber overshoes will be worn and reused by workers. These will be removed prior to entry into the contamination reduction zone for later reuse.

For skin contamination reading above background, personnel will be required to wash the affected area and have the area re-surveyed until background levels are achieved or approved by the Site RSO. Based on previous experience, skin contamination is easily removed by washing with soap and water.

4.3.3 External Gamma Exposure

Exposure rate measurements in the work area will be made each week with a Ludlum Model 19 microR-meter or equivalent. A site exposure-rate map will be produced for use in planning work to minimize radiation exposure.

Onsite workers will be issued individual thermoluminescent dosimeters (TLDs) to monitor their external exposure. The TLDs will be worn under protective clothing to prevent possible contamination of the TLD from dirt or airborne dust. All TLDs, as well as controls, will be placed in the support zone when not in use. TLDs will be provided and read quarterly by a third-party vendor certified by the National Voluntary Laboratory Accreditation Program.

4.3.4 Airborne Particulate Sampling in the Workplace

Exposure to airborne particulate radionuclides is a primary concern in limiting radiation exposure to workers. For this project, the work area will be small with only a few personnel involved in most tasks. Therefore, one work-area air sampler will be sufficient to obtain an estimate of the exposure of personnel to airborne particulates. The sampler will be located to obtain a realistic estimate of the personnel exposure and the location will be determined on a task specific basis. The work area monitoring data will be supplemented with data from lapel samplers that will be worn by various workers.

Initial entries into work areas will be done using respiratory protection. Once data are available to project the daily DAC levels, consideration for downgrading the respiratory protection requirements may be done. If justified, the RSO will recommend to the Site Management that work may proceed without respiratory protection. Projected work-area particulate levels of less than 10 percent of the DAC, averaged over a daily work period, will be used as a minimum requirement for not using respiratory protection.

Airborne areas will be posted according to the requirements in 10 CFR Part 20.

4.3.4.1 Work-Area Monitoring Using Lapel Air Samplers

Selected personnel will be required to wear lapel samplers each day that waste material is being handled or when their work activity isolates them from the general work-area monitoring. A lapel sampler (MSA Escort Elf Air Sampler or equivalent) with a flow rate of approximately 2 lpm and a 37-mm filter cassette with a Type A/E glass fiber filter will be used.

In order to analyze the effectiveness of the lapel samplers, they are assumed to be operating for an 8-hour day, resulting in 960 liters of air being pulled through the filter. The sample is then removed and counted 12 or more hours later after the radon-222 progeny have decayed. A final count will be made after one week when most of the radon-220 (thoron) progeny will have decayed. The Ludlum Model 2929/Ludlum Model 43-10-1 tray counters will be used to count gross alpha emissions. These counters have an alpha background count rate of approximately 4 counts per hour and an efficiency of approximately 0.4 counts per minute per disintegrations per minute (dpm) for thorium-230. This corresponds to a minimum detectable activity (MDA) of 0.5 dpm or a MDC of $2.4x10^{-13}$ microCurie per milliliter (μCi/ml) for the lapel sampler under the assumed conditions. This MDC is 24 percent of the DAC for thorium-232.

Assuming a gross alpha air particulate concentration corresponding to the derived air concentration (DAC) for thorium-232 ($1x10^{-12}$ microCuries (μCi)/ml) and a sampling period of eight hours, the filter would have 1 dpm activity deposited on. A 60-min count of the filter would result in 24 counts. An additional 4 counts would be expected from the counter background. This clearly demonstrates that the lapel samplers may be used to assess exposures of 1 DAC or less even if all counts are considered attributable to thorium-232.

The following paragraph shows that the assumption that all measured activity is thorium-232 leads to an over prediction of the percent of the radionuclide-weighted DAC by a factor of three. The discussion of lapel samplers above and the following analysis assume that the background radon-220 and radon-222 progeny have been allowed to decay so that they do not contribute to the analyses.

This analysis evaluates the error resulting in assuming that thorium-232 is the only radionuclide on the filter. An average thorium-232 to thorium-230 concentration ratio of 7.9 has been assumed for the site, based on isotopic thorium analyses of 41 samples. The unsupported short-lived alpha emitting radionuclides have not been addressed in this analysis since the DAC for them is very high and would not change the results of the analysis. Considering the thorium-232 decay series, for every dpm of activity arising from the decay of thorium-232, there will be 1 dpm alpha activity from the decay of thorium-228 and one dpm alpha activity from the decay of radium-224. If the thorium-230 is assumed to be in equilibrium with the uranium-238 series, then for every dpm of thorium-230 activity there will also be an additional dpm from uranium-238, uranium-234, and radium-226, or a total of 4 dpm from the uranium-238 decay series. See Table 4.2 for the DACs for radionuclides of concern at OT-10.

The DACs from 10 CFR 20, Appendix B, Table 1 for the following radionuclides were chosen:

Table 4-2. DACs for Specific Radionuclides

Radionuclide	DAC (µCi/ml)
Thorium-232	$1x10^{-12}$
Thorium-228	$7x10^{-12}$
Radium-224	$7x10^{-10}$
Uranium-238	$3x10^{-10}$
Uranium-234	$3x10^{-10}$
Radium-226	$3x10^{-10}$

Source:10 CFR Part 20, Appendix B, Table 1
DAC derived-air concentration
mCi/ml millicuries per milliliter

For a mixture of radionuclides, 10 CFR Part 20 §20.1202 requires that the sum of the fractions of the concentrations divided by the respective DACs be equal to or less than unity. Using the fact that the activity of thorium-232 equals the activity of thorium-228 and radium-224, the activity of thorium-230 equals that of uranium-238, uranium-234, and radium-226, and the activity ratio of thorium-232 to thorium-230 equals 7.9, the sum of the fractions equation may be written:

$$C_{thorium}{}^{232}\left(\frac{1}{1x10^{-12}}+\frac{1}{7x10^{-12}}+\frac{1}{7x10^{-10}}\right)+\left(\frac{C_{thorium}{}^{232}}{7.9}\right)\left(\frac{3}{3x10^{-10}}+\frac{1}{6x10^{-12}}\right)=1 \quad \text{Eq. 4-1}$$

where:

C = concentration

Solving for $C_{thorium\text{-}232}$, the concentration of thorium-232 at the maximum allowable limit for this radionuclide mixture is $8.57x10^{-13}$ µCi/ml, or approximately 86% of the DAC for thorium-232.

The total alpha decays are made up from alpha decays from all alpha emitters in the mixture and can be shown using the above ratios and assumptions to be equal to 3.5 times the count rate from Th-232. Since the allowable limit for the concentration of Th-232 in this mixture is 86% of the DAC fo Th-232, then when the air is at the maximum allowable limit (sum of the fractions =1), the gross alpha decay rate would be equal to 3.5 * 0.86, or 3 times the alpha count rate from Th-232. Therefore by assuming that all of the gross alpha is Th-232, there is a factor of 3 conservatism in the method.

Considering the factor of 3 conservatism discussed above and the calculated MDC assuming all of the activity is Th-232, the actual MDC for the lapel samplers with an 8-hour sample is 8 percent of the DAC for thorium-232.

4.3.4.2 Work-Area Monitoring Using RAS-1 Air Samplers

Work-area airborne particulate sampling will be done using an Eberline RAS-1 intermediate volume air sampler (or equivalent), with a flow rate of approximately 60 liters per minute (lpm). Forty-seven-millimeter (mm) glass fiber filters will be used to collect the sample. The sampling station will be located at a point as near to the workers as practical and will be changed as the work and other factors change. Considerations for locating the sampler include wind rose data, the prevailing wind direction observed on site, site activities, and source term strengths. Air samples will be collected at a height of 1 to 1.5 meters (m) above ground level in locations free from unusual micrometeorological or other conditions that could result in artificially high or low concentrations. General work-area air monitoring will be performed when invasive work is being done or when site activities have the potential for releasing airborne radioactivity.

Since the flow rate of these samplers is approximately 60 lpm, it can be shown that a very short sampling period would be required to measure radionuclides in air at DAC-level concentrations, using the same calculational techniques as presented in Section 4.3.4.1. However, because the samples will be stored for several days to allow for the decay of the unsupported radon-220 and radon-222 progeny, a sampling time of less than a work shift is not anticipated.

After the filters have been aged sufficiently for radon progeny decay, the filters will be counted for gross alpha using the on-site alpha tray counter. Should any personnel be exposed to an average gross alpha air concentration exceeding 10 percent of the DAC (assuming all radionuclides are thorium-232 but considering the reduction factor based upon the assigned protection factor in 10 CFR Part 20 for respirator use), the archived air samples will be composited and sent to a vendor laboratory for analysis for uranium-nat, radium-226, and isotopic thorium. The final committed effective dose equivalent will be based on the laboratory results.

4.3.5 Work Area Radon Monitoring

It is not anticipated that the radon or radon progeny concentrations will be significant because the contaminated areas are small and the work is being conducted outside. The winds should disperse the radon and progeny to levels much below concern for worker protection.

Grab sample measurements of radon-222 and radon-220 (thoron) progeny working levels will be performed prior to beginning work and periodically thereafter to ensure that exposure to radon progeny is not a concern. If levels exceed 10 percent of the 10 CFR Part 20, Appendix B, Table 1, values, long-term radon or working level measurements will be implemented.

4.3.6 Environmental Monitoring

Eberline RAS-1 air samplers with 47-mm Type A/E glass fiber filters will be established on the up-wind and down-wind perimeters of the site to confirm compliance with 10 CFR Part 20, Appendix B, Table 2, air concentration limits. The onsite counting of air filters will be done for gross alpha activity and compared to the limit for the most restrictive isotope of thorium, or thorium-232 ($6x10^{-15}$ µCi/ml). Samplers will be operated for approximately 12 hours per workday. For a 12-hour sampling period at 60 lpm, $4.32x10^{4}$ liters of air will be drawn through the filter. If thorium-232 is the only radionuclide present and the gross alpha air concentration is at 100 percent of the DAC, then the total activity on the filter will be 0.57 dpm. This corresponds to a total count of 14 counts in an hour using the onsite alpha tray counter. In addition, there will be approximately 4 counts arising from the counter background count rate or an MDA of 0.5 dpm ($5.3x10^{-15}$ µCi/ml). This shows that a 12-hour sample time is barely sufficient to detect airborne particulate activity at the thorium-232 limits. For normal operations, a weekly change-out of the filter is anticipated (five 12-hour days). Considering the longer sampling time and the factor of three conservatism built into the method from assuming all alpha activity is thorium-232 decay, the use of gross alpha counting to demonstrate compliance with the regulations is adequate. These factors will bring the MDA calculated above to approximately 6 percent of the DAC for thorium-232.

The RAS-1 air filters will be inspected for mass loading at the end of each workday. During extremely dusty conditions (dust generated primarily off-site), should the air filters indicate mass loading or the sampler flow rate change, the filters will be changed.

Should gross alpha air concentrations approach/exceed the 10 CFR Part 20, Appendix B, Table 2 limits, the base Environmental Management (377 ABW/EMR) and base RSO shall be immediately notified (1 hr). Both 377 ABW/EMR and base RSO must approve engineering controls employed by the contractor to attain acceptable off-site limits prior to resuming operations.

Should the average gross alpha air concentrations approach or exceed the offsite limits, the archived air sample filters will be composited and sent to a vendor laboratory for analysis for natural uranium, radium-226, and isotopic thorium. The laboratory results will then be used to calculate the offsite concentrations. The administrative and engineering controls (discussed in Section 4.4) to limit the work-area airborne particulate concentrations are expected to limit the probability of high measured concentrations at the site boundary.

It is not anticipated that measurable radon or radon progeny concentrations will be detected at the site perimeter. The grab radon progeny measurements in the work area will be used to guide whether to implement a perimeter radon or radon-progeny monitoring program. If work-area measurements indicate that it is necessary to protect the workers from exposure to radon progeny, a site perimeter-monitoring program for radon will be instituted.

4.3.7 Monitoring Equipment for Unconditional Release

Monitoring equipment for unconditional release will be done in accord with the new American National Standard Institute (ANSI) consensus standard, ANSI/HPS N13.12-1999. The NRC and DOD were voting members of the ANSI at the time the standard was adopted. Surface screening limits for Radionuclide Group 1 will be used. Group 1 includes thorium-232 and thorium-230 and their progeny. The limit for surface contamination for Group 1 radionuclides is 0.1 Bq/cm^2 (600 dpm/100 cm^2), averaged over an area no larger than 1 m^2. Individual measurements within this area may not exceed 10 times the average limit, or 6,000 dpm/100 cm^2. There is also a requirement to reduce the levels to ALARA below the limits. Items that cannot be decontaminated to levels below these limits will be considered radioactive waste and disposed of accordingly.

A Ludlum Model 43-5 alpha scintillation detector coupled to a Model 12 ratemeter will be used to scan potentially contaminated areas. The alpha detector has an active area of 76 cm^2 and an alpha efficiency of approximately 0.15 cpm/dpm. The background count rate is normally 1 cpm or less. All guidance documents recommend that the scanning sensitivity should be done empirically although there are no calculation methods. For scanning, the technician listens for an audible increase in the count rate and then stops the scanning and evaluates the level either by waiting for the rate meter to register the full count rate (time depending on the time constant of the ratemeter) or performs an integrated count with a scaler. Since the background for this detector is normally very low, most technicians are trained to pause after hearing a single event.

The surface activity minimum detectable activity (MDA) using a rate meter under static conditions can be approximated by the formula (Knoll, 1979):

$$MDA = 4.65\ (B_R / 2t_c)^{0.5} / (E^* A/100) \qquad \text{Eq. 4-2}$$

where :

B_R = background rate in counts/minute

T_c = meter time constant in minutes (0.161 min)

E = detector efficiency (approximately 0.15 cpm/dpm)

A = detector area 76 cm^2

Substituting the values discussed above into the equation results in an MDA of 168 dpm/100cm^2.

For scanning, attempts have been made to calculate the MDA although empirical determinations are suggested. In order to estimate the MDA, the following information is used. The width of the Model 43-5 is approximately 2 inches. It is reasonable to assume that 0.5 audible counts per second will be adequate to distinguish the count rate of a contaminated surface from background (approximately 0.02 counts/min). This is referred to as the audible discernable increase in count rate. NRC,1992 (p.5.8) indicates that a rough estimate of the scanning MDA may be calculated by dividing the audible discernable rate by the detector efficiency and detector area. For the Ludlum 43-5 detector, that would correspond to an MDA of approximately 260 dpm/100 cm^2. This shows that this detector and method should be adequate to detect 600 dpm/100 cm^2, averaged over an area of 1 m^2 or less.

An empirical determination of the MDA cannot be done at this time since the material is not available. However, a depleted uranium plated source (47mm diameter) having an activity of 453 dpm was used to check whether a Ludlum Model 43-5 detector would detect its presence at a scanning speed of approximately 5 inches per second. During each of several passes, there was an audible indication that the detector was measuring above background levels. The detection efficiency for depleted uranium was approximately 10 percent. Since the average alpha energy from the mixture of radionuclides at OT-10 sites should be significantly higher than that of depleted uranium (and thus a much higher detector efficiency), this test provides a high degree of certainty that the instrumentation is adequate to detect levels below 600 dpm/100 cm^2, averaged over an area of no larger than 1 m^2.

Monitoring for removable contamination is not recommended unless it can be justified. Therefore, unless there are areas that cannot be accessed by direct measurements, no wipe samples will be taken. Direct readings will be made using a Ludlum Model 2221 ratemeter/scaler and a Ludlum Model 43-5 alpha scintillometer, or equivalent. Should wipe samples be taken for analysis of removable contamination, the wipe samples will be counted for gross alpha using the Ludlum Model 2929/Ludlum Model 43-10-1 alpha-beta tray counter.

4.3.8 Clean Area Monitoring

Facilities within the support zone will be monitored for surface contamination at a frequency of not less than once per week to ensure that control of contamination has been maintained. Wipe samples will be taken from administrative offices, the break room, the onsite gamma spectroscopy laboratory, and other appropriate areas and analyzed for surface contamination levels. Areas above the natural background variation levels will be decontaminated, and a review of contamination control procedures made.

4.3.9 Monitoring Waste Packages and Conveyances for U.S. Department of Transportation Compliance

Transport requirements for LSA Class 7 material are given in 49 CFR §173.427. Waste containers will be surveyed for contamination limits prior to release from the site to ensure compliance with the DOT limits presented in 49 CFR §173.443. The TI will be determined for each container by measuring the exposure rate in mrem/hour at a distance of 1 m from the surface and round upward (that is, 0.2 mrem/hour is rounded up for a TI = 1).

The containers will be placed on trucks for shipment to the railcar transfer station. Once the waste containers are placed on a truck, the truck will be monitored to ensure compliance with the dose rate criteria of 10 CFR §173.441. After transfer to the railcar, the exterior of the gondola car will be monitored to assure compliance with 10 CFR §173.441. Since the trucks and the railcars will not come into contact with the waste , they will not be monitored for compliance with the surface contamination criteria in §173.443. All dose-rate measurements will be made using a Ludlum Model 19 microR-meter (or equivalent).

The surface contamination limits for shipment of LSA material apply only to removable contamination, 2.2 dpm/cm^2, based on a 300 cm^2 area (660 dpm/300 cm^2). There are no limits for fixed contamination. The gamma-ray exposure rate limit is 10 mrem/hour, measured at 2 m from any exterior lateral surface of the vehicle (excluding the top and bottom), and 200 mrem/hour, measured on contact with any exterior surface. The limit for any occupied space in a vehicle is 2 mrem/hour.

A minimum of two surface wipe samples will be taken from the waste bags at locations considered to have the greatest potential for contamination. Additional samples will be taken from areas exhibiting the presence of soil or soil-like material. Samples will be analyzed for gross alpha using the Ludlum Model 1000 Scaler coupled to a Ludlum Model 43-10 Alpha Tray Counter (or equivalent).

4.4 Respiratory Protection

Administrative and engineering controls will be used to limit airborne particulate to ALARA levels. Some of the measures that may be used when needed include

- applying of water to areas to be excavated,
- applying of water spray during excavation and material handling operations,
- modifying or stopping work during windy conditions (presence of visible dust),
- controlling locations of work stations relative to wind direction, and
- planning dust generation work during low wind conditions (normally in the morning).

If airborne concentrations of radioactivity in the work area exceed that defined as an "airborne radioactivity area" (10 CFR §20.1003), personnel in the vicinity of the activity will be required to don air-purifying respirators in accordance with Subpart H of 10 CFR 20. The program will comply with Subpart H and the OSHA standard, 29 CFR §1910.134. Other acceptable methods meeting the requirements in Subpart H include limiting exposure times and control of access.

4.5 Personal Protective Equipment

Prior to the decommissioning activity, a preliminary gamma radiation scanning survey and other non-invasive activities will be conducted for the purpose of planning the site decommissioning. Invasive activities are defined as disturbing soils with mechanized equipment where the potential for significant concentrations of airborne particulates exists. For non-invasive activities, a modified EPA-defined Level D PPE will be worn, including steel-toe safety shoes, tyvek coveralls, shoe covers, and inner surgical (latex or nitrile) and outer cloth gloves.

Once the decommissioning activities begin, all personnel entering the exclusion zone will be in Level C protection (Modified Level D, as defined above, and a respirator as directed by the RSO). Work will continue in Level C until it can be demonstrated that the airborne particulate levels are less than 10 percent of the airborne DAC for the mixture of radionuclides and will likely remain at or below these levels.

4.6 Bioassay

Personnel working in an area of potential airborne thorium activity may, at the discretion of the RSO, be required to provide baseline and exit whole-body counts at a nuclear facility (such as, SNL/NM). This program is designed to quantify the radionuclides within each worker prior to beginning work at the site and at the end of the project. Special whole-body counts may be done if there is a reason to believe that a worker has had a significant intake of radionuclides.

4.7 Incidents

All incidents will be carefully documented, including incidents of skin contamination, potential inhalation or ingestion of radionuclide materials, or whole-body exposure. Incidents will be reported as required by 10 CFR Part 20, Subpart M.

Prior to beginning the project, Mr. Jeff Johnston, Project Manager, will coordinate with the USAF response organizations to ensure that potentially contaminated victims of a construction accident will be properly treated. Lovelace Hospital is fully prepared to accept radiologically contaminated victims and will be the designated hospital for medical treatment. Industrial accident victims will be monitored and decontaminated, if necessary, prior to leaving the site only if their injuries are not life threatening and decontamination will not affect the injury. Otherwise, the victims will be handled in the traditional manner as described in Appendix B, Health and Safety Plan. A radiation safety technician, RSO, or the Project Manager will accompany the victim for treatment to aid in proper communication with medical response personnel. Accidental spills of radioactive material during loading or transport will be handled according to the Spill and Discharge Control Plan, which is a section of the OT-10 Technical Plans documentation.

4.8 Records

All surveys, radiation monitoring, and disposal will be documented, and the records will be maintained in accord with 10 CFR Part 20, Subpart L. In addition, all workers will be required to provide documentation of previous exposure history prior to beginning work at the site.

5.0 PLANNED FINAL RADIATION SURVEY

A post-excavation radiological survey will be conducted to support site closure. The release protocols described in general terms below incorporate MARSSIM guidance (EPA, 1997) and NRC guidance (NRC, 1992). Certain statistical parameters, which are required to evaluate license termination, cannot be determined prior to decommissioning activities, because the site conditions will change.

5.1 Selection of Instruments

A 2-inch by 2-inch sodium iodide scintillation detector, coupled to a rate meter/scaler, will be used to scan OT-10 survey units. The detection sensitivity of the detector will be as far below the DCGL as possible. The MARSSIM recommends MDCs less than 10 percent of the DGCL; however, less than 50 percent is considered acceptable. The MDC is defined as the concentration that a specific instrument and technique can be expected to detect 95 percent of the time.

The scanning MDC for a 2-inch by 2-inch sodium iodide scintillation detector is assumed at this stage to be 1.8 pCi/g, based on Table 6-7 of the MARSSIM (EPA, 1997). This value was based on a background count rate of 10,000 cpm (Equation 5-1). This value is below the DCGL for TS5, TS6, and TS8 (1.94 pCi/g); and TS7 (2.4 pCi/g). This estimated MDC exceeds the MARSSIM-recommended threshold of 50 percent of the DCGL. However, site-specific MDCs will be determined as part of the initial gamma-ray scanning survey.

In brief, the scan MDC will depend on the intrinsic characteristics of the detector, the nature and relative distribution of the potential contamination, scan rate, and characteristics of the surveyor. The MARSSIM equation used to determine the MDC is:

$$MDC = C \times L_D = 3 + 4.65\sqrt{B} \qquad \text{Eq. 5-1}$$

where:

C	=	a factor used to convert counts to a concentration
L_D	=	detection limit (counts)
B	=	number of background counts expected to occur during an actual measurement

Equation 5-1 includes the assumptions of 0.05 percent α and β error rates, an integrated measurement over a preset time; and similar sample and background count times.

A critical level, L_C, is the lower bound on the 95% detection interval defined for L_D and the level of counts at which there is a 5 percent chance of calling a background value "greater than background". This value will be used when actually counting samples or making direct radiation measurements. Any response above this level will be considered background. This will ensure a 95% detection capability for L_D. L_C is determined as follows (its variables have been defined above):

$$L_C = 2.33\sqrt{B} \qquad \text{Eq. 5-2}$$

Any count exceeding the difference between B and L_C during the preset integrated measurement period would be regarded as greater than background.

The instruments will be calibrated and checked prior to each site survey for proper response. The response of survey instruments will be compared periodically to a check source to confirm constancy in instrument response. The check source will emit the same type and magnitude of radiation being measured, to yield a similar response.

5.2 Establishing *Multi-Agency Radiation Survey and Site Investigation Manual* Survey Units

All four training sites will initially be assumed Class 1 areas under the MARSSIM classification. The different area classifications are defined as follows:

- A Class 1 area is an impacted area with potential for delivering a dose above the release criterion and potential for small areas of elevated activity.
- A Class 2 area is an impacted area with low potential for delivering a dose above the release criterion and little or no potential for small areas of elevated activity.
- A Class 3 area is an impacted area with little or no potential for delivering a dose above the release criterion and no potential for small areas of elevated activity.

Areas may also be classified as non-impacted.

Areas will be reclassified as impacted and non-impacted from the results of the initial gamma-ray scanning survey. Impacted areas will be subdivided into one of two MARSSIM Classes, Class 1 or Class 2.

Class 1 areas will be divided into 2,000 m^2 survey units. Class 2 areas will be divided into survey units that are between 2,000 and 10,000 m^2. Survey units will be subdivided into 100 m^2 grid sections to assist surveying. The corners of survey units and grid sections will be established using GPS and staked.

5.3 Final Survey

It is expected that excavation will only be conducted in Class 1 areas. After excavation has been completed, Class 1 survey units will be resurveyed in the same manner as the initial survey. Data obtained from the final survey will be evaluated in accordance with a DQO process.

The DQOs will be addressed under a Quality Assurance Project Plan (QAPP), which will be documented in a separate cover (USAF, 2000). The QAPP will describe the tasks needed to plan, implement, and assess the effectiveness of quality assurance/quality control activities.

The release of a survey unit will be determined using the Wilcoxon Rank Sum (WRS) test, a non-parametric statistical method. The number of soil samples to collect from each survey unit and the background area(s) will be selected from the MARSSIM Table 5-3 (EPA, 1997). The following variables are required to choose the number of samples from the Table 5-3 matrix:

- α: probability of incorrectly releasing a survey unit,
- β: probability of incorrectly failing to release a survey unit, and
- Δ/σ: relative shift where Δ is the region between α and β on a frequency distribution and σ is the higher of the standard deviations for the measurements in background and the survey unit.

Five percent decision error rates α and β, representing the level of confidence at which a release decision is made, will be included as part of the DQOs (USAF, 2000). The MARSSIM recommends using an estimated σ from either an initial survey or historical site assessment (EPA, 1997). We will provisionally include a σ, selected from the 1996 and 1998 investigation data, as part of the DQOs (USAF, 1999b). According to the MARSSIM, Δ can be selected as one-half the DCGL as an arbitrary starting point for developing an acceptable final status survey design. In this case, one-half the DCGL is 0.97 pCi/g thorium-232 for TS5, TS6, and TS8, and 1.2 pCi/g thorium-232 for TS7.

The σ and Δ values will be redefined over the course of remediation. In terms of final status, the most relevant estimates of σ and Δ will be obtained during remedial action support surveys, during which soil samples will be collected and analyzed onsite by gamma spectroscopy. It is anticipated that these estimates of σ and Δ will be used in the final status surveys.

Five-point composite soil samples will be collected systematically—starting at a random point—from each of the square grid sections, which will be established from the following MARSSIM equation:

$$L = \sqrt{\frac{A}{0.866n}} \qquad \text{Eq. 5-3}$$

where:

L = Length of grid section,

A = Area of survey unit, and

n = number of samples from MARSSIM Table 5.3.

The soil samples will be analyzed offsite for thorium by alpha spectroscopy. Results will be tabulated and evaluated using the WRS test. We will use the WRS test to compare the distributions of thorium-232 concentrations in background to each survey unit. The DCGL will be added to each background measurement. The combined set of measurements will be ranked in increasing numerical order. If the sum of the ranks of the adjusted background measurements is greater than that of the survey units, the survey unit can be released.

5.4 Addressing Elevated Areas After Excavation

The WRS test applies only to uniform distributions of residual activity in a survey unit. Radioactive hot spots in *in situ* soils will be addressed using the MARSSIM Elevated Measurement Comparison method.

An area factor, the magnitude by which a potential elevated area can exceed the DCGL, will be determined using RESRAD. The training site area will be replaced by the grid section area (L^2) in the model. No other parameters will be changed. The area factor will be calculated by dividing the resulting dose rate for the area into 25 mrem/year.

Each of the grid sections in a survey unit will already have been scanned and the results will be compared to the product of the DCGL and area factor. No further measurements will be required if the scan MDC is lower than this elevated DCGL.

We will collect additional soil samples if the scan MDC exceeds the elevated DCGL. In addition, we will reevaluate survey units in which the final survey gamma-ray counts exceed the *elevated* DCGL. In this case, biased soil sampling will be conducted to demonstrate that the verification procedure identifies areas contaminated at the DCGL limit with a probability of 95 percent. The approach in this plan is to show that the mean of a subset of biased samples is less than the DCGL, at the 95 percent confidence level. If this is shown, then the error rate (contaminated material left *in situ* in a survey unit) for the set of all samples that could have been collected should be much less that the error rate for the subset.

6.0 COST ESTIMATE FOR DECOMMISSIONING

A cost estimate was prepared for decommissioning OT-10 to a residential unrestricted release scenario. The cost estimate is comprised of the following tasks:

- Planning and Preparation of Plans
  - Health and Safety Plan
  - Sampling and Analysis Plan
  - Construction Quality Plan
  - Environmental Cleanup Plan
- Mobilization and Site Preparation
  - Mobilization
  - Pre-construction Conference
  - Utility Clearance
  - Clear and Grub Vegetation
- Monitoring, Sampling, and Testing
  - Radiological Surveys
  - Air Monitoring
  - Correlative Soil Sampling
  - Laboratory Analysis
  - Data Validation

- Solids Collection and Containment
    - Excavation and Consolidation
    - Waste Packaging
    - Manifesting
- Transport and Disposal of Radioactive Waste
- Contract Administration
- Program and Project Management
- Construction Oversight
- Site Restoration
- Demobilization
- Reporting

The costs associated with these tasks are listed in Table 6-1. The following assumptions were used to derive the costs:

- Initial gamma-ray scanning surveys will cover 100 percent of fenced training site areas. Surveys will extend outside of fences where offsite impact has been identified.
- An NMED document review fee of $6,500 will be applied to the environmental cleanup plan.
- Based on the results of the 1994 and 1995 investigation, 27,500 cubic yards will be excavated, packaged, transported to, and disposed of at Envirocare of Utah.

Table 6-1. OT-10 Decommissioning Cost Estimate

Task	Itemized	QTY	Unit	Unit Rate	Cost	Subtotal Cost[a]
Preparation of Plans						
HASP/SAP/CQP	**NM Labor 2000**					
	Administrative Assistant II	20	hrs	$53.93	$1,079	
	CADD Use	32	hrs	$19.55	$626	
	Environmental Scientist	200	hrs	$63.36	$12,672	
	Principal Engineer	8	hrs	$122.49	$980	
	Program Manager	50	hrs	$124.16	$6,208	
	Senior Designer I	50	hrs	$68.44	$3,422	
	Senior Engineer	140	hrs	$78.61	$11,006	
	Supervising Engineer	20	hrs	$95.46	$1,909	
	Supervising Environmental Scientist	30	hrs	$92.38	$2,771	
	Word Processor	40	hrs	$48.08	$1,923	$42,596
	Health Physics Subcontractor - HASP	1	l.s.	$6,440.00	$6,440	$6,440
	MWA G&A 2000 on HASP				$821	$821
Environmental Cleanup Plan	**MWCI Construction Plan**	1	l.s.	14850.89	$14,851	*$14,851*
	NM Labor 2000					
	Administrative Assistant I	18	hrs	$45.40	$817	
	Administrative Assistant II	40	hrs	$53.93	$2,157	
	CADD Use	80	hrs	$19.55	$1,564	
	Environmental Scientist	180	hrs	$63.36	$11,405	
	Principal Engineer	36	hrs	$122.49	$4,410	
	Program Manager	100	hrs	$124.16	$12,416	
	Senior Designer I	80	hrs	$68.44	$5,476	
	Senior Engineer	320	hrs	$78.61	$25,156	
	Supervising Engineer	90	hrs	$95.46	$8,591	
	Supervising Environmental Scientist	90	hrs	$92.38	$8,314	
	Supervising Hydrogeologist	90	hrs	$95.65	$8,609	
	Word Processor	100	hrs	$48.08	$4,808	$93,723
	NMED Document Review Fee	1	l.s.	$6,500.00	$6,500	$6,500
	MWA G&A 2000 on Review Fee				$829	$829
	MWA Labor 2000					
	Administrative Assistant I	26	hrs	$45.40	$1,158	
	Administrative Assistant II	38	hrs	$53.93	$2,022	
	Buyer	50	hrs	$52.39	$2,594	
	Contracts Administrator IV	14	hrs	$78.81	$1,103	
	Contracts Administrator	2	hrs	$111.21	$222	
	HW Program Director II	2	hrs	$164.04	$328	
	Librarian II	2	hrs	$56.91	$114	
	Project Administrator	2	hrs	$42.77	$64	
	Senior Engineer	18	hrs	$78.61	$1,415	
	Senior Graphics Artist	1	hrs	$66.48	$66	
	Supervising Environmental Scientist	18	hrs	$92.38	$1,663	
	Supervising Hydrogeologist	12	hrs	$95.65	$1,148	*$11,898*
Mobilization/Site Preparation						
Mobilization	**MWCI: mobilize and set up facilities**	1	l.s.	6772.2	$6,772	$6,772
	NM Labor 2000					
	Administrative Assistant II	10	hrs	$53.93	$539	
	Senior Engineer	50	hrs	$78.61	$3,931	
	Program Manager	10	hrs	$124.16	$1,242	$5,712

Table 6.1. OT-10 Decommissioning Cost Estimate (continued)

Task	Itemized	QTY	Unit	Unit Rate	Cost	Subtotal Cost[a]
Pre-construction Conference	**NM Labor 2000**					
	Administrative Assistant II	32	hrs	$53.93	$1,726	
	Senior Designer	8	hrs	$77.47	$620	
	Senior Engineer	32	hrs	$78.61	$2,516	
	Program Manager	32	hrs	$124.16	$3,973	
	CADD Use	4	hrs	$19.55	$78	$8,912
Utility Clearance	**NM Labor 2000**					
	Administrative Assistant II	8	hrs	$53.93	$431	
	Senior Designer	4	hrs	$77.47	$310	
	Senior Engineer	80	hrs	$78.61	$6,289	
	Program Manager	8	hrs	$124.16	$993	
	CADD Use	8	hrs	$19.55	$156	$8,180
Clear & Grub Vegetation	**Keers Clear & Grub Vegetation**	50	acre	$611.52	$30,576	$30,576
	MWCI G&A 2000 on clearing				$1,676	$1,676
Monitoring, Sampling, Testing						
Soil Sampling	**NM Labor 2000**					
	Administrative Assistant I	40	hrs	$53.93	$2,157	
	Senior Engineer	400	hrs	$78.61	$31,446	
	Program Manager	40	hrs	$124.16	$4,966	$38,569
	Truck - Soil Sampling	2	mo	$1,200.00	$2,400	$2,400
	Field Supplies - Soil sampling	4	l.s.	$275.75	$1,103	$1,103
	MWA G&A 2000 on supplies				$447	$447
Laboratory Analysis	**MWA Labor 2001**					
	Administrative Assistant I	32	hrs	$56.85	$1,819	
	Senior Engineer	160	hrs	$66.83	$10,694	
	Program Manager	32	hrs	$83.01	$2,656	*$15,169*
	Laboratory Services					
	Rail Car Samples	437	each	$334.00	$145,958	
	Correlation Samples	20	each	$334.00	$6,680	
	Confirmation Samples	80	each	$334.00	$26,720	
	Waste Profile Samples	2	each	$1,793.00	$3,586	*$182,944*
	MWA G&A 2001 on lab				$26,984	*$26,984*
Radiological Surveys	**NM Labor 2000**					
	Administrative Assistant I	30	hrs	$53.93	$1,618	
	Senior Engineer	300	hrs	$78.61	$23,584	
	Hydrogeologist	200	hrs	$65.17	$13,034	
	Program Manager	30	hrs	$124.16	$3,725	$41,961
	Truck-Radiological Surveys	2	mo	$1,200.00	$2,400	$2,400
	Field Supplies - Radiological Surveys	1	l.s.	$172.00	$172	$172
	Radiological Surveys	1	l.s.	$48,074.00	$48,074	$48,074
	MWA G&A 2000 on rad survey				$6,457	$6,457

Table 6.1. OT-10 Decommissioning Cost Estimate (continued)

Task	Itemized	QTY	Unit	Unit Rate	Cost	Subtotal Cost[a]
Data Validation	**MWA Labor 2001**					
	Administrative Assistant I	16	hrs	$56.85	$910	
	Environmental Scientist	160	hrs	$66.83	$10,694	
	Supervising Environmental Scientist	32	hrs	$97.60	$3,123	
	Program Manager	8	hrs	$131.30	$1,050	*$15,777*
	Data validation subcontractor	1	l.s.	$27,270.00	$27,270	*$27,270*
	MWA G&A 2001 on validation				$4,022	*$4,022*
Air Monitoring	**NM Labor 2001**					
	Administrative Assistant I	160	hrs	$55.30	$8,848	
	Senior Engineer	4,000	hrs	$80.64	$322,555	
	Environmental Scientist	800	hrs	$66.83	$53,468	
	Program Manager	320	hrs	$127.40	$40,768	$425,637
	Truck-Air monitoring	16	l.s.	$1,200.00	$19,200	$19,200
	Field Supplies - Air monitoring	4	l.s.	$1,690.00	$6,760	$6,760
	MWA G&A 2001 on supplies				$3,829	$3,829
	Health Physics Subcontractor					
	Develop SOPs	1	l.s.	$1,660.00	$1,660	
	Mob/Demob	1	l.s.	$600.00	$600	
	Site Setup/Background Measurements	1	l.s.	$7,300.00	$7,300	
	Training	1	l.s.	$920.00	$920	
	HP/RSO Support - Senior Health Physicist	800	hrs	$115.00	$92,000	
	HP/RSO Support - Health Physicist Technician	4,000	hrs	$75.00	$300,000	
	Report	4	l.s.	$4,600.00	$18,400	
	Equipment	55	wks	$523.25	$28,779	
	Expendables	4	l.s.	$1,130.00	$4,520	$454,179
	MWA G&A 2001 on HP				$66,991	$66,991
Solids Collection and Containment						
Excavation and Consolidation	Keers excavation and consolidation of soil	27,500	cy	$6.76	$185,900	$185,900
	MWCI G&A 2001 on excavation				$10,187	$10,187
Waste Packaging for Disposal	Bag frame for loading lift liners	4	each	$3,100.00	$12,400	*$12,400*
	Lift Liners for Waste Transport	3,929	each	$380.00	$1,493,020	*$1,493,020*
	Keers Waste Packaging for disposal	27,500	cy	$10.64	$292,600	$292,600
	MWCI G&A 2001 on packaging				$98,531	*$98,531*
Manifesting	**NM Labor 2001**					
	Administrative Assistant I	88	hrs	$56.85	$5,003	
	Environmental Scientist	440	hrs	$66.83	$29,407	
	Senior Engineer	880	hrs	$83.01	$73,046	
	Program Manager	220	hrs	$131.30	$28,885	$136,342

Table 6.1. OT-10 Decommissioning Cost Estimate (continued)

Task	Itemized	QTY	Unit	Unit Rate	Cost	Subtotal Cost[a]
Solids Collection (continued)						
Transport Bags to Railsite	Lifting frame for Lift Liners	4	each	$5,100.00	$20,400	*$20,400*
	Keer Transportation to Railroad	3,929	bag	$195.84	$769,455	$769,455
	MWCI G&A 2001 on trucking				$43,284	$43,284
	NM Labor 2001					
	Administrative Assistant I	110	hrs	$56.85	$6,254	
	Senior Engineer	1,090	hrs	$83.01	$90,478	
	Program Manager	218	hrs	$131.30	$28,623	$125,354
Rail Transport and LLRW Disposal						
Transportation of Waste	Rail transport of waste	3,929	bag	$694.00	$2,726,726	
	Mobilization for rail transport	1	l.s.	$15,000.00	$15,000	$2,741,726
	MWCI G&A 2001 rail shipping				$150,247	$150,247
	NM Labor 2001					
	Administrative Assistant I	25	hrs	$56.85	$1,421	
	Environmental Scientist	63	hrs	$66.83	$4,211	
	Senior Engineer	126	hrs	$83.01	$10,459	
	Program Manager	25	hrs	$131.30	$3,282	$19,373
Disposal of Waste	***NM Labor 2001***					
	Rocky Mountain Compact Transfer Fee	1	l.s.	$100,000.00	$100,000	*$100,000*
	MWA Labor 2001					
	Administrative Assistant II	34	hrs	$56.85	$1,933	
	Senior Engineer	168	hrs	$83.01	$13,945	
	Principal Hydrogeologist	34	hrs	$129.59	$4,406	*$20,284*
	MWA Travel & Per Diem					
	Air Fare	3	each	$331.00	$993	
	Car Rental	9	each	$50.00	$450	
	Mileage	150	each	$0.32	$48	
	Airport Parking	9	days	$15.00	$135	
	Per Diem	9	days	$85.00	$765	*$2,391*
	MWA G&A 2001: travel				$353	*$353*
	Envirocare - Disposal of Waste	27,500	cy	$149.50	$4,111,250	*$4,111,250*
	MWCI G&A 2001 on waste disposal				$225,297	*$225,297*
Contract Administration						
Year 3	**MWA Labor 2000**					
	Administrative Assistant I	9	hrs	$53.93	$485	
	Contracts Administrator IV	40	hrs	$78.81	$3,152	
	Senior Engineer	45	hrs	$78.61	$3,538	
	Contracts Administrator	40	hrs	$111.21	$4,448	
	Program Manager	20	hrs	$124.16	$2,483	*$14,107*
Year 4	**MWA Labor 2001**					
	Administrative Assistant I	7	hrs	$56.85	$398	
	Contracts Administrator IV	40	hrs	$83.21	$3,328	
	Senior Engineer	35	hrs	$83.01	$2,905	
	Contracts Administrator	40	hrs	$117.57	$4,703	
	Program Manager	20	hrs	$131.30	$2,626	*$13,960*

Table 6.1. OT-10 Decommissioning Cost Estimate (continued)

Task	Itemized	QTY	Unit	Unit Rate	Cost	Subtotal Cost[a]
Program Management						
Year 3	**MWA Labor 2000**					
	Secretary I	39	hrs	$40.27	$1,570	
	Administrative Assistant I	57	hrs	$45.40	$2,588	
	Accountant I	241	hrs	$53.16	$12,812	
	Project Accountant	101	hrs	$63.28	$6,392	
	Senior Project Accountant	56	hrs	$63.26	$3,543	
	Senior Engineer	216	hrs	$78.61	$16,981	
	Senior Environmental Scientist	64	hrs	$83.15	$5,322	
	Supervising Hydrogeologist	112	hrs	$95.65	$10,713	
	Attorney II	1	hrs	$117.09	$117	
	HW Program Director	84	hrs	$164.04	$13,780	*$73,817*
Year 4	**MWA Labor 2001**					
	Secretary I	71	hrs	$42.33	$3,006	
	Administrative Assistant I	107	hrs	$47.78	$5,113	
	Accountant I	450	hrs	$56.01	$25,205	
	Project Accountant	185	hrs	$66.76	$12,350	
	Senior Project Accountant	108	hrs	$66.73	$7,207	
	Senior Engineer	413	hrs	$83.01	$34,282	
	Senior Environmental Scientist	147	hrs	$87.82	$12,910	
	Supervising Hydrogeologist	88	hrs	$101.06	$8,894	
	HW Program Director	66	hrs	$173.63	$11,459	*$120,425*
Project Management						
Year 3	**NM Labor 2000**					
	Administrative Assistant I	100	hrs	$53.93	$5,393	
	Word Processor	14	hrs	$48.08	$673	
	Program Manager	100	hrs	$124.16	$12,416	$18,482
Year 4	**NM Labor 2001**					
	Administrative Assistant I	204	hrs	$56.85	$11,598	
	Word Processor	14	hrs	$51.76	$725	
	Program Manager	224	hrs	$131.30	$29,410	$41,732
Construction Oversight	**MWCI Labor**					
	Principal Construction Manager	640	hrs	$72.34	$46,299	
	Senior Professional	4,000	hrs	$48.51	$194,032	
	Administrator	600	hrs	$27.10	$16,260	
	MWCI Safety Coordinator	320	hrs	$46.30	$14,817	$271,408
	MWCI Other Direct Costs					
	Cellular Phone	18	mos	$91.31	$1,644	
	Generator Rental	18	mos	$825.00	$14,850	
	Toilet Rental	18	mos	$75.00	$1,350	
	Utility Vehicle	18	mos	$1,200.00	$21,600	$39,444
	MWCI G&A on ODCs				$2,162	$2,162
	MWCI - Subcontractors					
	Field Trailer 10' x 40'	18	mos	$760.00	$13,680	
	Temporary Utilities & Hookups	18	mos	$350.00	$6,300	
	Office Supplies	18	mos	$500.00	$9,000	$28,980

Table 6.1. OT-10 Decommissioning Cost Estimate (continued)

Task	Itemized	QTY	Unit	Unit Rate	Cost	Subtotal Cost[a]
	MWCI G&A on subcontractors				$1,588	$1,588
	MWCI - Travel & Per Diem					
	Air Fare SLC-ABQ	26	each	$331.00	$8,606	
	Per Diem	600	days	$104.00	$62,400	
	Rental Car	60	days	$50.00	$3,000	$74,006
	MWCI G&A on travel				$4,056	$4,056
Site Restoration	**Revegetation**					
	Keers Site Restoration	50	acre	$752.80	$37,640	$37,640
	MWCI G&A on subcontractors				$2,063	$2,063
	NM Labor 2001					
	Administrative Assistant I	20	hrs	$56.85	$1,137	
	Senior Engineer	200	hrs	$83.01	$16,601	
	Program Manager	40	hrs	$131.30	$5,252	$22,990
Demobilization	**Demobilization**					
	MWCI - Demobilization	1	l.s.	$2,042.71	$2,043	$2,043
	NM Labor 2001					
	Administrative Assistant I	8	hrs	$56.85	$455	
	Senior Engineer	50	hrs	$83.01	$4,150	
	Program Manager	8	hrs	$131.30	$1,050	$5,656
Reporting						
Draft Report	**NM Labor 2001**					
	Administrative Assistant I	120	hrs	$56.85	$6,822	
	Senior Designer	80	hrs	$72.23	$5,779	
	Environmental Scientist	240	hrs	$66.83	$16,040	
	Word Processor	80	hrs	$51.76	$4,141	
	Senior Engineer	240	hrs	$83.01	$19,922	
	Supervising Engineer	80	hrs	$100.89	$8,071	
	Supervising Environmental Scientist	80	hrs	$97.60	$7,808	
	Principal Engineer	40	hrs	$129.56	$5,183	
	Program Manager	80	hrs	$131.30	$10,504	
	CADD Use	120	hrs	$19.90	$2,388	$86,656
Draft Final Report	**NM Labor 2001**					
	Administrative Assistant II	24	hrs	$56.85	$1,364	
	Senior Designer	24	hrs	$72.23	$1,734	
	Environmental Scientist	80	hrs	$66.83	$5,347	
	Senior Engineer	80	hrs	$83.01	$6,641	
	Supervising Engineer	40	hrs	$100.89	$4,035	
	Supervising Environmental Scientist	24	hrs	$97.60	$2,342	
	Principal Engineer	12	hrs	$129.56	$1,555	
	Program Manager	40	hrs	$131.30	$5,252	
	CADD Use	40	hrs	$19.90	$796	$29,066
	NMED Document Fee -Draft Final Report	1	l.s.	$9,300.00	$9,300	$9,300
	MWA G&A on document fee				$1,372	$1,372

Table 6.1. OT-10 Decommissioning Cost Estimate (concluded)

Task	Itemized	QTY	Unit	Unit Rate	Cost	Subtotal Cost[a]
Reporting (continued)						
Final Report	**NM Labor 2001**					
	Administrative Assistant II	24	hrs	$56.85	$1,364	
	Senior Designer	24	hrs	$72.23	$1,734	
	Environmental Scientist	80	hrs	$66.83	$5,347	
	Word Processor	24	hrs	$51.76	$1,242	
	Senior Engineer	80	hrs	$83.01	$6,641	
	Supervising Engineer	40	hrs	$100.89	$4,035	
	Supervising Environmental Scientist	24	hrs	$97.60	$2,342	
	Principal Engineer	12	hrs	$129.56	$1,555	
	Program Manager	40	hrs	$131.30	$5,252	
	CADD Use	24	hrs	$19.90	$478	$29,990
				Subtotal		$13,119,166
				MWA Fee		$813,388
				NM Gross Receipts Tax		$378,627
				Project Total		$14,311,181

Notes:
[a] Italicized costs are not subject to New Mexico Gross Receipts Tax

ABQ Albuquerque
CADD computer-aided design and drafting
CQP construction quality plan
G&A General and Administrative
HASP health and safety plan
HP/RSO health physicist/radiation safety officer
hrs hours
HW hazardous waste
LLRW low-level radioactive waste
l.s. lump sum
mos months
MWA Montgomery Watson Americas
MWCI Montgomery Watson Contructors Incorporated
NM New Mexico
NMED New Mexico Environment Department
ODCs other direct costs
QTY quantity
SAP sampling and analysis plan
SLC Salt Lake City
SOPs standard operating procedures

- Work can be conducted throughout the project; that is, there will be no disruptions to the project schedule caused by Kirtland AFB operations or calamities. Working hours are 5 days per week, 10 hours per day.

- Eighty cubic yards per day can be excavated and packaged.

- Two trains, each having a round-rip of 30 days, including loading and unloading, will operate at a lag of 2 weeks. Each train will have 21 high-sided gondola cars. Each car can carry nine Lift Liners™. Each Lift Liner™ can contain up to 7 cubic yards of waste (as limited by weight capacity).

- Forty-two cars carrying nine Lift Liners™ with 7 cubic yards in each will result in a rail transport rate of about 2,650 cubic yards per month or 1,325 cubic yards per train per month. Each train will be loaded in five days (equivalent in unloading time).

- 1,325 cubic yards represent about 190 full Lift Liners™, or 38 Lift Liners™ per day to be loaded. Seven trucks will be needed; twice per month for 5 days. Each truck carries 2 Lift Liners™ and can make 3 trips in each 10-hr day.

- Montgomery Watson Constructors site personnel will include a senior professional to provide full-time construction oversight, a principal construction manager (35 labor-hrs per month), a project administrator (33 labor-hrs per month), and a safety coordinator (18 labor-hrs per month).

- Montgomery Watson Americas site personnel will include a senior engineer to provide construction oversight and assist with health physics monitoring, and an environmental scientist (35 labor-hrs per month).

- Costs are based on quotations from the following subcontractors: Environmental Restoration Group, Inc., for health physics support; Barringer Laboratories, Inc., for analytical services; Laboratory Data Consultants for data validation services; Keers Environmental for clearing/grubbing, excavation, waste packaging, and transport to the rail site; MHF Logistical Solutions, Inc., for rail transport; and Envirocare for waste disposal. These costs and subcontractors may be subject to change.

- Nine labor-hrs to track each railcar shipment.

- Fifty man-hrs at the Albuquerque rail site for each 5-day railcar-loading event.

- Twelve Montgomery Watson Salt Lake City man-hrs to coordinate analytical laboratory, rail transporter, and Envirocare services for each rail shipment.

- Disposal of wastes to Envirocare's low-level radioactive waste cell in their landfill at Clive, Utah.

- Two additional lifting frames purchased as spares.

- One manifest per railcar. Two hours to complete a manifest; 437 manifests implies 874 labor-hrs.

- One month mobilization and one month demobilization.

- Analytical methods are: Isotopic Uranium (EPA 908.0M; soil and water), Isotopic Thorium (USACE RMO 3008; soil and water), Gamma Spectroscopy (EPA 901.1), TCLP Volatile Organic Compounds (SW-846 1311, 8260B), TCLP SVOC (SW-846 1311, 8270C), TCLP Pesticides (SW-846 1311, 8081A), TCLP Herbicides (SW-846 1311, 8151A), TCLP Metals (SW-846 1311, 6010B, 7471A), soil pH (SW-846 9045B), Paint Filter Liquids Test (SW-846 9095A), Reactive Sulfide (SW-846 Section 7.3.3), Reactive Cyanide (SW-846 Section 7.3.4), Total Moisture (ASTM D2216), Particle Size Distribution (ASTM D422 with Hydrometer), Proctor Test (ASTM D698), Soil Bulk Density (ASTM D2937).

- All underground utilities can be identified and mapped prior to excavation activities.

- Rocky Mountain Low-Level Radioactive Waste Board maximum fee of $100, 000 for interstate transfer of low-level radioactive waste.

- Draft, draft final, and final reports will be produced. An NMED document review fee of $9,300 will be applied to the final report.

- Fifty acres will be revegetated.

- New Mexico Gross Receipts Tax of 5.8125 percent on goods and services provided in New Mexico.

- Montgomery Watson pre-tax fixed fee on all project goods and services.

The decommissioning cost for the OT-10 Training Sites is estimated at $14,311,181.

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