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

19 November 2002

MEMORANDUM FOR NRC REGION IV (Mrs. Browder)
611 RYAN PLAZA DR STE 400
ARLINGTON TX 76011-8064

FROM: AFMOA/SGZR
110 Luke Avenue Room 405
Bolling AFB, DC 20032-7050

SUBJECT: Review and Approval of the Decommissioning Plan.

Attached is a copy of the document "Decommissioning Plan for Installation Restoration Program Site OT-10, Radiation Training Sites, Kirtland Air Force Base, New Mexico" for your review and approval.

As discussed in our teleconference of 29 July 2002, I am also mailing a copy of this letter along with the attached decommissioning plan to Dr. Boby Abu Eid at the NRC HQ.

If you have any questions or need further input, please contact me at 202-767-4306 or e-mail at ramachandra.bhat@pentagon.af.mil. Our telefax is 202-404-8089.

RAMACHANDRA K.BHAT, Ph.D., CHP
Health Physicist
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Office of the Surgeon General

Attachment: Decommissioning Plan
cc:
AFMC/CEVR (Mr. Sillerud) w/o Atch
377 AMDS/SGPB (Capt Sheely) w/o Atch
HQ AFMC/SG (Maj Hoak) w/Atch
AFIA/SGO (Lt Col Rademacher) w/Atch
AFIERA/SDR (Lt Col Nichelson) w/Atch
NRC HQ (Dr. Boby Abu Eid) w/Atch

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INSTALLATION RESTORATION PROGRAM
KIRTLAND AIR FORCE BASE
NEW MEXICO

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

REVISED AUGUST 2002

Prepared for
HQ AFCEE/ERD
ENVIRONMENTAL RESTORATION DIVISION
BROOKS AFB, TX 78253-5363
USAF CONTRACT NO. F41624-97-D-8013 DELIVERY ORDER NO. 0037

Prepared by
MWH AMERICAS, INC.
ALBUQUERQUE, NEW MEXICO

NOTICE

This Decommissioning Plan has been prepared for the U.S. Air Force by MWH Americas to guide the remediation of radiologically-contaminated soils at Site 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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PREFACE

This Decommissioning Plan specifies the activities that will be performed during calendar years 2002 through 2004 at Installation Restoration Program Site OT-10, Kirtland Air Force Base, New Mexico. This plan addresses the requirements of the U.S. Air Force statement of work dated March 2, 2001, and the rules for license termination and site decommissioning as defined in Title 10 of the *Code of Federal Regulations* (CFR) § 40.42.

This Decommissioning Plan was prepared by MWH Americas in August 2002. Mr. Rodney Arnold of the U.S. Air Force Center for Environmental Excellence served as the Contracting Officer Representative.

Jeffrey W. Johnston
MWH Americas Project Manager

Neil Wrubel
MWH Americas Task Manager

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ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

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
ANL	Argonne National Laboratory
ANSI	American National Standards 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
CAU	corrective action unit
CFR	*Code of Federal Regulations*
Ci/m^3	curies per cubic meter
cm	centimeter
cm/sec	centimeters per second
cpm	counts per minute
DAC	derived air concentration
DCGL	derived concentration guideline level
DNA	Defense Nuclear Agency
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
EMC	elevated measurement comparison
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
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
G-M	Geiger-Müeller
GPS	global positioning system

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE (Continued)

HASP	health and safety plan
HAZWOPER	hazardous waste site operations and emergency response
HP	health physicist
HR1	hydrologic region 1
hrs	hours
IP	industrial package
IRP	Installation Restoration Program
keV	kiloelectron volts
kg	kilogram
kg/cm^2	kilograms per square centimeter
LBGR	lower boundary of gray region
lpm	liters per minute
l.s.	lump sum
LSA	low specific activity
m	meter
m^2	square meter
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
mCi/ml	millicuries per milliliter
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MeV	million electron volts
mg/kg	milligrams per kilogram
ml	milliliter
mm	millimeter
mos	months
mR/hr	milliRoentgens per hour
mrem	millirem
MWHA	MWH Americas
MWHCI	MWH Constructors Incorporated
NAS	National Academy of Sciences
nCi/g	nanocuries per gram
nCi/L	nanocuries per liter
NE	not established
NIST	National Institute of Standards and Technology
NM	New Mexico

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE (Continued)

NMED	New Mexico Environment Department
NRC	U.S. Nuclear Regulatory Commission
NSWC	Naval Surface Warfare Center
NTIS	National Technical Information Service
ODC	other direct cost
OSC	Operations Support Command
OSHA	Occupational Safety and Health Administration
pCi/g	picocuries per gram
PID	photoionization detector
PPE	personal protective equipment
QAPP	quality assurance project plan
r^2	Pearson's Correlation
RCRA	*Resource Conservation and Recovery Act*
RESRAD	residual radiation
RSO	radiation safety officer
SAP	sampling and analysis plan
SDRH	Surveillance Directorate Radiation Surveillance Division/ Health Physics Branch
sec	second
SNL	Sandia National Laboratories
SOP	standard operating procedure
SVOC	semivolatile organic compound
SW	solid waste
TAC	*Texas Administrative Code*
TAL	target analyte list
TCEQ	Texas Commission on Environmental Quality
TCLP	toxicity characteristic leachate procedure
TDH	Texas Department of Health
TEDE	total effective dose equivalent
TLD	thermoluminescent dosimeter
TS1	Training Site 1
TS2	Training Site 2
TS3	Training Site 3
TS4	Training Site 4
TS5	Training Site 5
TS6	Training Site 6
TS7	Training Site 7
TS8	Training Site 8

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE (Concluded)

UAC	*Utah Administrative Code*
$\mu Ci/cm^2$	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
WCS	Waste Control Specialists
WRS	Wilcoxon Rank Sum
yd^3	cubic yards

EXECUTIVE SUMMARY

This plan describes the decommissioning activities planned at four inactive, former Defense Nuclear Weapons School Radiation Training Sites at Kirtland Air Force Base (AFB). The sites, Training Site 5 (TS5), Training Site 6 (TS6), Training Site 7 (TS7), and Training Site 8 (TS8) comprise Kirtland AFB's Installation Restoration Program Site OT-10. The training sites are owned by the U.S. Government and regulated by the U.S. Nuclear Regulatory Commission (NRC) under U. S. Air Force (USAF) Master Materials License No. 42-23539-01AF. 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 thorium oxide sludge were applied and tilled into site soils to simulate dispersed plutonium. Four other sites (Training Sites 1 through 4) remain active.

The nature and extent of radiologically-contaminated soil at the OT-10 sites were characterized during four prior investigations (USAF, 1992 and 1993; 1997a; 1999a; and 2002a). The results of the investigations are summarized as follows:

- Radiological contamination occurs in or on onsite surface and subsurface soils, building surfaces at TS8, vegetation, and standing surface water (when present).
- Land area contamination is primarily limited to thorium-232 and its decay progeny. The thorium-232 decay series is in secular equilibrium. The uranium-238 decay series is not in secular equilibrium because of processing or natural leaching. Uranium-238 and uranium-234 currently comprise about 5 percent of the thorium-232 activity at OT-10. Thorium-230 and radium-226 concentrations account for about 11 and 1.7 percent of the thorium-232 activity, respectively.
- The concentrations of thorium-232 exceed background in 22.1 of the 43.2 OT-10 acres. The contaminated areas are TS5 (5.8 of 13.4 acres), TS6 (13.8 of 19 acres), TS7 (1.4 of 8.4 acres), and TS8 (1.1 of 2.4 acres) (USAF, 2002a).
- The maximum thorium-232 concentrations observed in OT-10 soils are 1,120 picocuries per gram (pCi/g) (TS5), 299.0 pCi/g (TS6), 112.7 pCi/g (TS7), and 188.0 pCi/g (TS8).
- Radionuclide contamination extends at hot spots to an average of 1 foot (ft) below ground surface (bgs) at TS7 and 2 ft bgs at TS5, TS6, and TS8. Radionuclide contamination is limited to about 6 inches bgs in areas of low to moderate surface activity.
- The interior surfaces of the two storage bunkers (Buildings 28005 and 28010) at TS8 are contaminated.

Derived concentration guideline levels (DCGLs), were developed using Residual Radiation (RESRAD) Model Version 6.1 (land areas) and RESRAD-Build Version 3.0 (building surfaces). The DCGLs represent residual levels of surface contamination expected to result in a Total Effective Dose Equivalent of 25 millirem per year above background.

The modified land area DCGL for OT-10 is 5.9 pCi/g thorium-232 for a release to a residential land-use scenario. Modified DCGLs for the remaining long-lived radionuclides at OT-10 are: 5.9 pCi/g radium-228 and thorium-228; 0.33 pCi/g uranium-238 and uranium-234; 0.65 pCi/g thorium-230; 0.29 pCi/g radium-226 and lead-210; 0.014 pCi/g uranium-235; and 0.028 pCi/g actinium-227 and protactinium-231.

Concentrations of thorium-232 exceed the land area modified DCGL in 9.4 of the 43.2 acre site area. Contaminated areas above the DCGL are TS5 (1.7 of 13.4 acres), TS6 (6.7 of 19 acres), TS7 (0.6 of 8.4 acres), and TS8 (0.4 of 2.4 acres) (USAF, 2002a). These land areas pose an increased cancer risk to chronically exposed individuals. The volume of contaminated material above the DCGL is estimated at approximately 26,000 cubic yards.

The DCGL for the total surface activity of thorium-232, including its progeny, on OT-10 building surfaces is 250 disintegrations per minute (dpm) per 100 square centimeters (cm^2). For thorium-232 surface contamination, 68 percent of the particle emissions are expected to be alpha particles and 32 percent of the emissions will be beta particles. This corresponds to particle emission rates of 0.68*250=170 dpm/100 cm^2 alpha and 0.32*250=80 dpm/100 cm^2 beta. Removable contamination is 20 percent of the total, or 34 dpm/100 cm^2 alpha and 16 dpm/100 cm^2 beta.

Decommissioning of the sites is planned for calendar years 2002 through 2004, to address the increased cancer risk posed by the thorium-232 and uranium-238 decay series. Remediation of the sites to the DCGL will support unrestricted release to a residential land use scenario and license termination.

Planned decommissioning activities include excavating and packaging contaminated vegetation, debris, and soil; profiling (sampling and analyzing) excavated soil and debris, manifesting the waste, and transporting the waste by truck and/or rail to an NRC-licensed disposal facility: Envirocare of Utah in Clive, Utah and by truck to Waste Control Specialists in Andrews County, Texas. Decommissioning activities will close with a final status survey. Excavated areas will be graded and replanted with native vegetation after the NRC has approved the final status survey. With the exception of re-vegetation, these activities will be conducted under a radiation safety program.

The cost to decommission OT-10 is estimated at US $12,791,971.13.

1.0 INTRODUCTION

This plan describes the decommissioning activities planned at four inactive, former Defense Nuclear Weapons School (DNWS) Radiation Training Sites at Kirtland Air Force Base (AFB). The sites, Training Site 5 (TS5), Training Site 6 (TS6), Training Site 7 (TS7), and Training Site 8 (TS8) comprise Kirtland AFB's Installation Restoration Program (IRP) Site OT-10. The training sites are owned by the U.S. Government and regulated by the U.S. Nuclear Regulatory Commission (NRC) under U.S. Air Force (USAF) Master Materials License No. 42-23539-01AF. The sites are located in the north-central part of Kirtland AFB and are shown in relation to each other on Figure 1-1.

From 1961 to 1990, the OT-10 sites were used to train radiological response personnel to detect contaminants generated during simulated nuclear weapons accidents. Known quantities of thorium oxide sludge were applied and tilled into site soils to simulate dispersed plutonium.

The nature and extent of radiological contamination at the OT-10 sites were characterized during four prior investigations (USAF, 1992 and 1993; 1997a; 1999a; and 2002a). Elevated thorium concentrations were identified at each training site. These elevated thorium concentrations present an excess cancer risk under both residential and industrial land-use scenarios.

The objectives of this decommissioning plan are to

- develop derived concentration guideline levels (DCGLs) for thorium-232, uranium-238, and uranium-235 and their decay progeny;
- present the planned OT-10 decommissioning activities; and
- provide a framework for license termination.

This plan was prepared in accordance with the U.S. Air Force statement of work dated January 4, 2000, and the rules for license termination and site decommissioning as defined in Title 10 of the *Code of Federal Regulations* (CFR) § 40.42. The decommissioning plan requirements as defined in Title 10 CFR § 40.42 are presented in Appendix F. This plan is a deliverable under Contract Number F41624-97-D-8013, Delivery Order 0037.

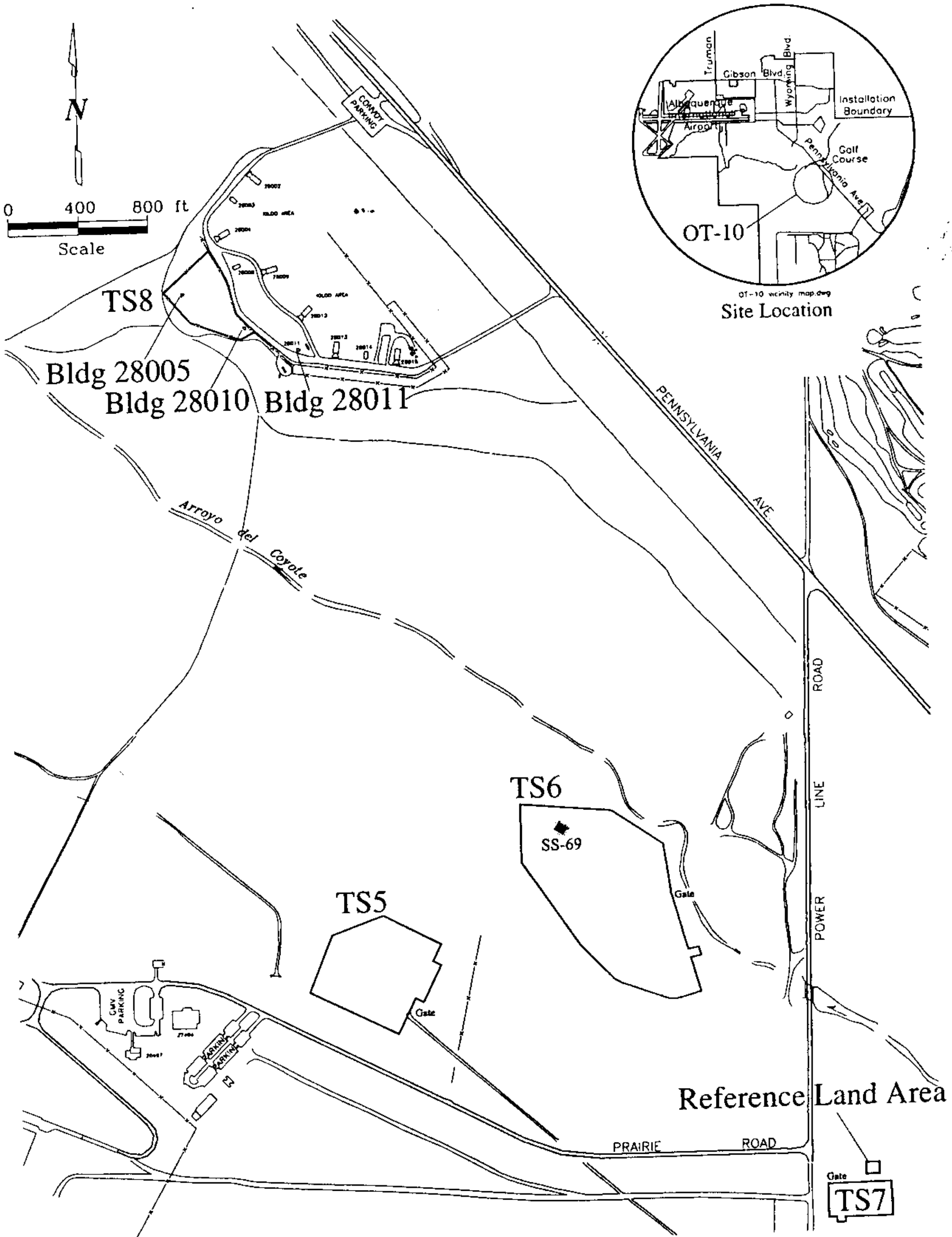


Figure 1-1. Installation Restoration Program Site OT-10 Vicinity Map

The plan is divided into seven text sections. Section 1 provides the introduction and defines the plan objectives. Section 2 presents a historical site assessment, including a description of site conditions and the results of previous investigations. Section 3 develops the DCGLs for the thorium-232, uranium-238, and uranium-235 series in land areas and structures; and describes the decommissioning activities. Section 4 describes the methods planned to protect workers. Section 5 outlines the final status survey methodology, Section 6 presents the cost estimate for decommissioning, and Section 7 presents the schedule for decommissioning activities. Reference citations are presented in the last unnumbered section. Appendixes include Appendix A, Derivation of Cleanup Criteria; Appendix B, Site-Specific Health and Safety Plan; Appendix C, Qualifications of the Site Radiation Safety Officer (RSO); Appendix D, Calculations of Contaminated Soil Volume; Appendix E, Quality Assurance Project Plan (QAPP); Appendix F, Title 10 CFR § 40.42; and Appendix G, 2000/2001 Static and Scanning Gamma Radiation Measurements.

2.0 HISTORICAL SITE ASSESSMENT

2.1 Site History (Operational) ...

Eight radiation training sites were established in November 1961 at Kirtland AFB. The U.S. Government owns the sites, which are regulated by the NRC under USAF Master Materials License No. 42-23539-01AF. The four inactive sites, TS5 through TS8, comprise IRP Site OT-10 and are scheduled for decommissioning. The other sites, Training Sites 1 through 4 (TS1 through TS4), are active.

The four inactive training 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 to detect dispersed contamination resulting from simulated nuclear weapons accidents. Known quantities of 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 inventory of 1,710 kilograms (kg) thorium sludge or approximately 602 kg of thorium-232 was applied at the inactive sites (Defense Nuclear Agency [DNA], 1994). Table 2-1 presents the estimated thorium inventory by training site.

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

Training Site	Approximate Area [acres]	Inventory of Thorium Sludge Applied (kg)	Estimated Thorium-232 Applied [kg][a]
TS5	13.4	611	215
TS6	19	872	307
TS7	8.4	102	36
TS8	2.4	125	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, 1999a, are for thorium sludge.
DNA = Defense Nuclear Agency
kg = kilogram
USAF = U.S. Air Force

Training activities were discontinued at TS5 through TS8 in 1990. Large pieces of military equipment, such as fuselages, vehicles, parts, and other debris present at TS5 through TS8 were removed and redistributed at active sites TS1 through TS4. The debris remaining at TS5 through TS8 consists primarily of small metal fragments and small military equipment parts. TS8 was also used as a storage site and has two storage bunkers (Buildings 28005 and 28010) located within its fenced area. In addition, TS6 contains corrective action unit (CAU) SS-69, a 50-foot (ft) by 50-ft area previously used to store drums of thorium oxide sludge, contaminated soil, and waste fuels (USAF, 1999b). CAU SS-69 is managed as a separate corrective action unit under Kirtland AFB's *Resource Conservation and Recovery Act* (RCRA) Part B Permit.

At least 90 drums were counted at the SS-69 site when it was first cataloged. Approximately 35 drums contained solid materials (such as cardboard, plastic, and soil) and liquids. The contents of 16 drums were analyzed: 4 contained radioactive waste, 4 contained RCRA characteristic waste, and 8 contained diluted diesel and oil sludge with gasoline and/or solvents. An interim corrective measure was conducted at CAU SS-69 in March through June 1998 and January 1999 to remove hydrocarbon- and radiologically-contaminated soil (USAF, 1999b). The wastes were repacked and disposed of properly.

With the exception of TS8, barbed-wire fences delineated the training site property boundaries prior to 1996. Between March and May 1996, chain-link security fences were installed around the contaminated land areas at TS5, TS6, and TS7 and the barbed wire fences were removed (USAF, 1997b). It is assumed that the chain-link security fence at TS8 was installed in the 1960s, when the storage bunkers were constructed.

In May 1998, an erosion control measure was implemented in Arroyo del Coyote, an ephemeral stream that parallels the eastern edge of TS6. The measure was taken to prevent the arroyo from eroding the eastern edge of TS6 and mobilizing radioactively-contaminated soils. Kirtland AFB re-shaped the banks and bed of the arroyo near TS6, and stabilized the western bank with gabion mattresses and spur dikes (USAF, 1998).

2.2 Site Setting

2.2.1 Climate

The climate at Kirtland AFB is typical of a high-desert plateau, with low precipitation, wide temperature extremes and clear, sunny days. It is classified as Arid Continental (USAF, 1995a). 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, and occur as brief but heavy localized 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 (°F); the annual mean minimum temperature is 44 (°F). The highest mean maximum temperature is 91 (°F) in July, and the lowest mean temperature is 24 (°F) in January.

The prevailing wind direction from May through October is south to southeast, and the mean wind speed is about 8 knots. The prevailing wind direction from November through April 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, 1995a). 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. Two major surface water features drain the area: 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.

Figure 1-1 shows the relative positions of the training sites.

2.2.3 Geologic Setting

The western portion of Kirtland AFB lies within the Albuquerque-Belen Basin (USAF, 1995a). 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 is aligned north to south and is bordered on the east and west by up-faulted blocks (Lozinski, 1988).

The deposits within the Albuquerque-Belen Basin consist of interbedded layers of gravel, sand, silt, and clay, the majority of which part of the Santa Fe Group. These sediments were deposited during the Late Tertiary and Quaternary 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 but basin faults cause the thickness to vary considerably.

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 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. Groundwater is thought to be unconfined in the upper portion of the aquifer, but this may not be true in all areas. HR1 contains a shallow saturation zone above the regional aquifer, at approximately 200 to 250 ft below ground surface (bgs). 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 is not defined, but is believed not to exist near OT-10.

The estimated depth-to-groundwater at OT-10 is 500 ft bgs. This estimate is based on the depth-to-groundwater measured in Monitoring Well AVN-2 at Sandia National Laboratories/New Mexico (SNL/NM) Tech Area V, the closest well to OT-10.

2.2.5 Soil and Vegetation Types

Table 2-2 lists the soils and vegetation types at each training site. Figure 2-1 shows the vegetation types at Kirtland AFB, along with the training site locations.

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, 1995a.
[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*).

2.3 Site Characterization

Kirtland AFB identified the DNWS sites during a 1981 Phase I Records Search. The USAF conducted limited radiological surveys at TS5, TS6, and TS7 between 1988 and 1990 to identify contaminated areas, qualitatively assess the magnitude of the contamination, and assess the potential for offsite migration of radiological contamination (USAF, 1992 and 1993). Additional investigations followed between October 1994 to May 1995 (USAF, 1997a), and December 1996 to September 1998 (USAF, 1999a). Kirtland AFB conducted a survey for the pending decommissioning from October 2000 to May 2001 (USAF, 2002a).

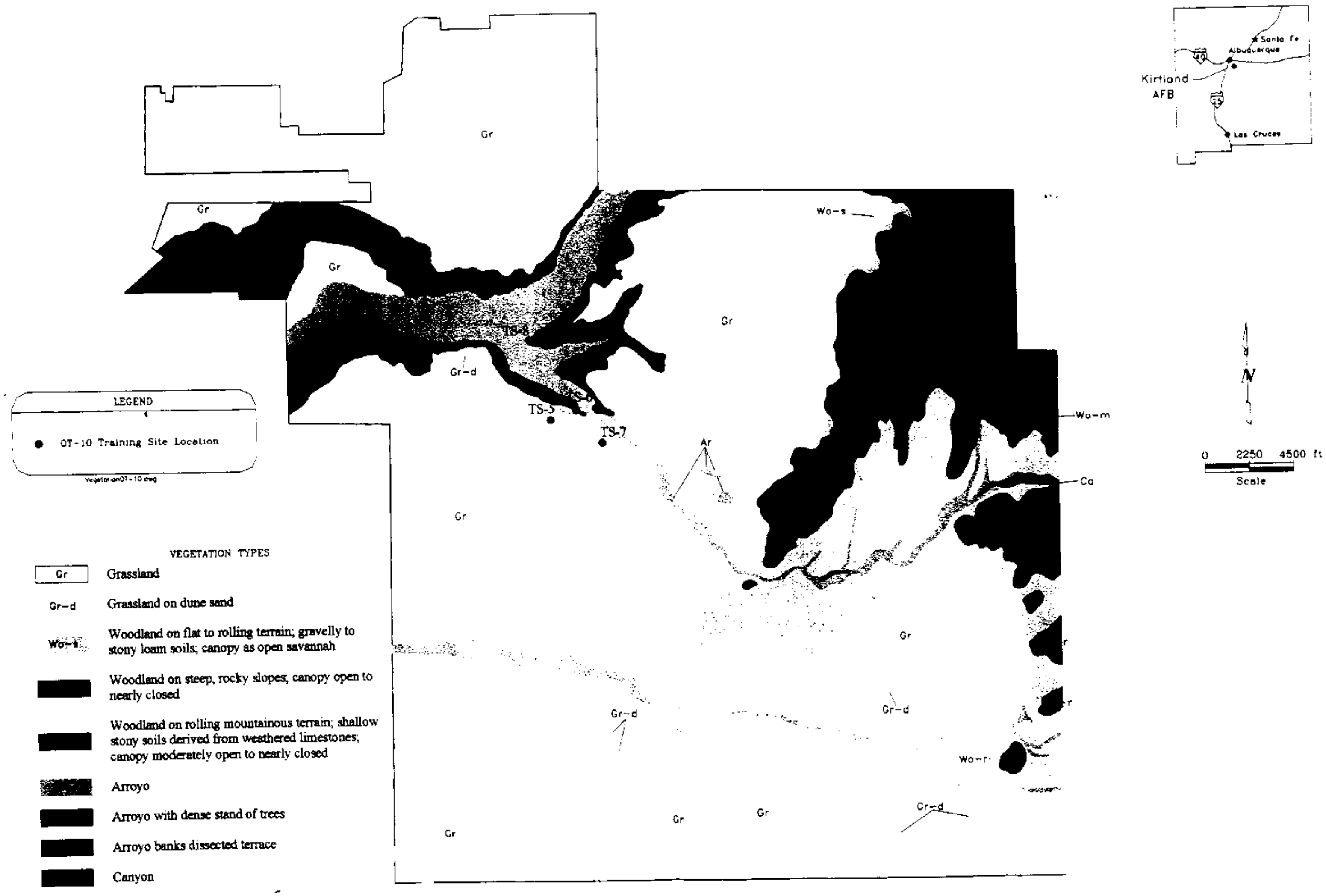


Figure 2-1. Generalized Vegetation Areas at Kirtland Air Force Base, New Mexico

The following sections present relevant portions of these activities. Sections 2.4.1 (TS5), 2.4.2 (TS6), 2.4.3 (TS7), 2.4.4 (TS8) and 2.5 (General Findings) present only those investigation results that are relevant to the OT-10 decommissioning.

2.3.1 1988/1990 Investigation

Between 1988 and 1990, the USAF scanned TS5, TS6, and TS7 land areas using a 5-inch sodium iodide detector coupled to an Eberline ESP-2 electronics package and/or a calcium fluoride detector coupled to a Bicron Analyst count rate meter.

USAF field personnel collected the following data:

- 208 gamma-radiation measurements in the southeast area of the TS6 and 159 gamma-radiation measurements at the perimeter of TS6 along the old barbed-wire fence.
- 80 gamma-radiation measurements in the approximate middle of TS7 and at the site perimeter along the old barbed-wire fence.

USAF field personnel also collected the following samples, which were analyzed for gamma-emitting radionuclides by gamma spectrometry:

- Surface soil samples at three locations within TS6 and two soil samples at its perimeter, where elevated count rates were observed.
- Several surface soil samples from TS6 and TS7.
- Two plant and standing surface water samples from the contaminated area at TS7.
- Soil samples from trenches installed at TS5 and TS6 in areas of elevated readings, and one installed in a background area outside the training sites. Field personnel collected soil samples every 2-inches from the trench sidewalls, from ground surface to 24 inches bgs (USAF, 1992 and 1993).

Kirtland AFB added the sites to its *Management Action Plan* (USAF, 1995b) for future corrective action, based on the results of these surveys.

2.3.2 1994/1995 Investigation

In October 1994 and May 1995, the USAF delineated general areas of contamination at OT-10 by way of gamma-radiation scanning surveys and collection and analysis of surface and subsurface soil samples.

Field personnel performed the following activities:

- Subdivided land areas into 100-ft by 100-ft grid sections and scanned these areas using a sodium iodide gamma scintillation detector coupled to a rate meter.
- Subdivided grid sections containing hot spots into 10-ft by 10-ft grid sections, which were resurveyed.
- Scanned additional 100-ft by 100-ft grid sections established offsite at points along site perimeters where elevated readings were detected.
- Collected samples from at least 10 locations at each training site based on the scanning data. Five locations at each site correlated to areas of high surface contamination; the remaining locations were selected randomly. The samples were collected using a hand auger or hand trowel in 6-inch depth intervals. Each sample was screened in the field, using a Geiger-Müeller (G-M) detector.
- Homogenized the retained samples, which were placed in cylindrical, 900-milliliter (ml) Marinelli beakers
- Sequentially placed each sample in a "cave" constructed of lead bricks and analyzed each sample onsite using a 2-inch by 2-inch sodium iodide scintillation detector, coupled to a rate meter/scaler set in integration mode. Field personnel recorded one-minute integrated counts for each sample.
- Stopped sampling a particular core when the deepest sample exhibited background radioactivity levels. Samples exhibiting radioactivity above about twice background were retained for onsite and/or offsite laboratory analysis.

An offsite laboratory analyzed 20 of the surface and/or subsurface soil samples (including 3 replicates) for isotopic thorium by alpha spectrometry. The offsite laboratory also analyzed five of these samples for gamma-emitting radionuclides by gamma spectrometry (USAF, 1997a).

The onsite gamma radiation counts correlated to the offsite laboratory analytical results as follows, with a Pearson's correlation (r^2) value of 0.74:

$$C_{thorium-232} = 1.8 * {cpm}/{g} + 3.2 \qquad \text{Eq. 2-1}$$

where C is the laboratory analytical concentration of thorium-232 in pCi/g and cpm/g is the onsite counts per minute per gram. Equation 2-1 considers data obtained only from the OT-10 training sites.

The complete results of the 1994/1995 investigation are reported elsewhere (USAF, 1997a). The authors used both onsite counts and actual thorium-232 soil concentrations to determine the vertical extent of contamination.

Only the offsite laboratory analytical results from this investigation are reported in Sections 2.4.1.2 (TS5), 2.4.2.2 (TS6), 2.4.3.2 (TS7), and 2.4.4.2 (TS8).

2.3.3 1996/1998 Investigation

Between December 1996 and September 1998, the USAF expanded work of the previous investigations to include radiological and geophysical surveys, analyses for non-radioactive constituents, soil property tests, and a study to correlate soil grain size and thorium content (USAF, 1999a).

2.3.3.1 Radiological Surveys

Field personnel used a hand-held gamma survey meter (Bicron Surveyor 50) to locate hot spots in land areas and to confirm and/or supplement the extent of previously identified areas of contamination. The USAF collected 88 surface and/or subsurface soil samples from cores advanced at points where surface soils exhibited the highest observed levels of radioactivity. Field personnel also collected 39 surface samples outside of the training sites, in land areas then considered background. An onsite laboratory analyzed the 127 samples for gamma-emitting radionuclides by gamma spectrometry. Section 2.4.5.2 presents cesium-137 concentrations determined in background samples and at Site OT-10 during the 1996/1998 investigation.

2.3.3.2 Geophysical Surveys

Field personnel conducted geophysical surveys using a backpack-mounted magnetometer system and a Portable Surface Towed Ordnance/Object Locator System®. These systems use data from a differential global positioning system (GPS) to acquire data within a relative position of 10 to 20 centimeters (cm) from point to point and a sub-meter (m) accuracy in subsequent targets. Field personnel detected small surface and/or subsurface ferrous materials that were attributed to historical training activities.

2.3.3.3 Non-Radiological Sampling and Analysis

Field personnel collected 22 surface soil samples inside and outside the four inactive training sites. An offsite laboratory analyzed these samples for non-radioactive parameters using the following U.S. Environmental Protection Agency (EPA) solid waste (SW) analytical methods: semivolatile organic compounds (SVOCs; Method SW-846-8270B): total petroleum hydrocarbons (TPH; Method SW-846 8015 modified); target analyte list (TAL) metals (Method SW-846-6010A); and mercury, (Method SW-846-7471) (EPA, 1996). An onsite laboratory analyzed portions of four of these samples for TAL metals, lithium, and molybdenum, using Method SW-846-3000; and SVOCs using Method SW-846-8270B.

Gasoline-range hydrocarbons and SVOCs were not detected. Diesel-range hydrocarbon detections (0.63 to 3.1 milligrams per kilogram [mg/kg]) were two to three orders of magnitude lower than the existing 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, 2000). Arsenic concentrations (1.5 to 10.1 mg/kg) were within the accepted background arsenic levels at Kirtland AFB, published jointly in 1996 by SNL/NM and the NMED (SNL/NMED, 1996). The Kirtland AFB background concentrations for arsenic range from 4.4 to 7 mg/kg (SNL/NMED, 1996).

2.3.3.4 Soil Property Tests

Field personnel collected one surface soil sample from radiological hot spots, selected arbitrarily at each of the training sites, to characterize soil properties. An offsite laboratory tested these samples for pH, conductivity, moisture, unconfined compressive strength, dry density, field density, and permeability.

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®) 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.

2.3.4 2000/2001 Surveys

In October 2000 and January, April and May 2001, the USAF conducted radiological surveys of the land areas at the four training sites, a reference land area, the two storage bunkers at TS8, and a reference bunker to address the following data gaps (USAF, 2002a):

- changes in surface conditions since the last radiological surveys conducted in 1997, induced by wind and water erosion;
- areas of contamination in relation to fixed reference points, such as fences;
- the vertical extent of contamination in land areas with low to moderate activity; and
- the nature and extent of contamination on the interior surfaces of storage bunkers at TS8.

The land area surveys comprised scanning surveys, followed by static gamma radiation measurements, and soil sampling and analysis. Field personnel conducted the following activities:

- Scanned the entire site in October 2001, using hand-held unshielded detectors.
- Scanned "hot spots" in January 2001, using hand-held collimated detectors to characterize the effects of gamma "shine."
- Collected co-located static gamma radiation measurements and soil samples from OT-10 and a reference land area in April 2001, at locations selected from the October 2000 survey data.

The May 2001 bunker surveys comprised scanning, static measurements, and sampling. Field personnel surveyed the interior surfaces of two storage bunkers (Buildings 28005 and 28010) at TS8 and an offsite reference bunker (Building 28011). It was known prior to the surveys that thorium oxide sludge was stored in the bunkers at TS8 and that a fire possibly had occurred in Building 28005. No data existed regarding the radiological status of the bunkers.

2.3.4.1 Gamma Radiation Scanning Surveys

The October 2000 gamma radiation scanning surveys covered 100 percent of each training site, using an estimated 5-ft transect spacing. These surveys included areas outside of the security fences. Two Ludlum 44-10 2-inch by 2-inch, sodium iodide gamma scintillation detectors attached 5 ft apart to opposing sides of a push cart at 18 inches above the ground surface measured gross gamma count rates. Each of the detectors was coupled to a Ludlum 2221 ratemeter/scaler set in rate meter (count) mode and a Trimble Pathfinder® ProXR differential GPS. Field personnel opened the detector windows completely and set the rate meter thresholds at 40 kiloelectron volts (keV). A health physics technician pushed the cart and flagged the walking track. The health physics technician collected additional data at hot spots by shortening the transect spacing.

The Trimble Pathfinder® ProXR GPS datalogger tagged gamma radiation counts automatically with location coordinates every 2 seconds (equivalent to about every 5 linear ft paced). The spatial density of points was determined by the speed at which personnel were scanning land areas and the distance between detectors. GPS coordinates were 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, were also included in the survey. The Trimble Pathfinder® ProXR is "mapping grade" survey equipment accurate to within 1 m when moving; approximately 80 percent of the data are accurate to within 1 ft.

Real-time correction provides for the high position accuracy. Real-time surveying involves using a base station that receives differential corrections and transmits the corrections directly to the GPS unit by radio modem. A satellite transmits these corrections; the receivers perform the correction on a real-time basis.

Health physics personnel downloaded the data into an offsite computer equipped with vendor proprietary software. One of the functions of this software is to post-process differential error corrections, if needed, as determined by the base station data. ArcView Geographic Information Systems® (GIS) software mapped the data.

2.3.4.2 *Reference Land Area Scanning, Static Gamma Radiation Measurements, and Soil Sampling*

April 2001 survey activities included scanning a reference area for gamma activity, taking static gamma radiation measurements at the four training sites and reference area, and sampling surface and subsurface soil at the four training sites and reference area.

Kirtland AFB identified a 2,000-square meter (m^2) land area north of TS7 as the provisional OT-10 reference land area (see Figure 1-1). This surface area is equivalent to the *Multi-Agency Radiation Site and Survey Investigation Manual* (MARSSIM) Class 1 survey unit to be adopted for the OT-10 remedial action. Soil types and vegetation at the reference area are similar to those observed at the training sites.

Field personnel scanned the reference area on April 9, 2001, after delineating the corners using the GPS. The scanning methodology was the same as that used in the October 2000 surveys. Appendix G presents the scanning data and location coordinates.

From April 9 to 17, 2001, field personnel recorded static gamma radiation measurements and collected soils samples at 20 co-located static measurement/sampling locations at each training site and the reference land area. Kirtland AFB selected these locations to correlate thorium-232 concentrations in soil to gamma radiation counts. Sample locations were biased; that is, they were selected from land areas exhibiting low to moderate activities in the October 2000 surveys. The goal of this activity was to derive investigation levels, in counts per minute (cpm), correlating to the DCGL for the remedial action.

The 20 soil samples collected from the 2,000-m^2 reference area also were used to determine the background concentrations of thorium-232 and thorium-230. The sampling frequency corresponds to one sample collected from each 100-m^2 area.

Field personnel recorded two static gamma radiation measurements at each location, using a Ludlum 44-10, 2-inch by 2-inch, sodium iodide gamma scintillation detector, coupled to a Ludlum 2221 rate meter/scaler set in scaler (integration) mode. Field personnel held the detector 18 inches above the ground surface and took the first one-minute integrated count. The second count was taken after a lead collimator was placed on the detector, which was held at six inches above ground. This height corresponds to the height normally used for excavation control monitoring in areas where gamma shine exists from nearby sources.

Field personnel collected the surface soil samples immediately after recording each static gamma radiation count, using a five-point composite method. A 3-ft diameter circle was drawn in the soil at each sample location. The diameter was equivalent to the "view" of the bare sodium iodide scintillation detector used to take static gamma measurements. Soil samples were collected at the center of the circle and at four points along the circle, each 9 inches away from the center. Soil samples were collected at each point from zero to 6 inches bgs, using a Macro-Core® sampler.

Subsurface soil samples were collected from the base of each surface sample boring, which were cleared prior to subsurface probing using a stainless steel hand trowel. The Macro-Core® sampler was advanced from 6 to 12 inches bgs at each location.

Two additional surface samples were collected at TS6 for waste profiling purposes. The samples were collected using the Macro-Core® sampler (soil for radiochemical analyses) and a shovel (soil for geotechnical analyses).

All samples were shipped to Severn Trent Laboratories in St. Louis, Missouri, where they were analyzed for isotopic thorium by alpha spectrometry (National Academy of Sciences [NAS]/Department of Energy [DOE] Method 3004/RP-725 modified) (NAS/DOE, 1994) and gamma-emitting radionuclides by gamma spectrometry (EPA Method 901.1 modified) (EPA, 1980). The subsurface samples were analyzed only for gamma-emitting radionuclides.

The waste profile samples were analyzed for isotopic thorium and uranium by alpha spectrometry (NAS/DOE Methods 3004/RP-725 and 3050/RP-725 modified, respectively) (NAS/DOE, 1994) and the following EPA methods (EPA, 1997): pH (Method SW-846 6045A), Toxicity Characteristic Leachate Procedure (TCLP) chlorinated herbicides (Method SW-846 1311 followed by Method SW-846 8151), TCLP RCRA metals and zinc (Method SW-846 1311 followed by Method SW-846 6010B); TCLP mercury (Method SW-846 1311 followed by Method SW-846 7470A), TCLP organochlorine pesticides (Method SW-846 1311 followed by Method SW-846 8081A), TCLP SVOCs (Method SW-846 1311 followed by Method SW-846 8270C), TCLP volatile organic compounds (Method SW-846 1311 followed by Method SW-846 8260B), reactive sulfide (Method SW-846 7.3.4), reactive cyanide (Method SW-846 7.3.3), and paint filter test (Method SW-846 9095).

The waste profile samples also were subject to the following geotechnical analyses: percent moisture (EPA Method 160.3 modified) (EPA, 1983), bulk/dry density (U.S. Army Corps of Engineers [USACE] Method EM-1110-2-1906, Appendix II) (USACE, 1970), particle-size analysis (American Society for Testing and Materials [ASTM] Method D 422) (ASTM, 1998), and Standard Proctor test (ASTM Method D 698) (ASTM, 1996).

Appendix G presents the static measurements and co-located sampling measurement location coordinates. Sections 2.4.1.4 (TS5), 2.4.2.4 (TS6), 2.4.3.4 (TS7), and 2.4.4.4 (TS8) present the laboratory-derived thorium-232 and thorium-230 concentrations. Section 2.4.2.4 (TS6) presents the results of the two waste profile samples.

2.3.4.3 Building Surface Surveys

The interior surfaces of an offsite reference bunker (Building 28012); and Buildings 28005 and 28010 at TS8 and were surveyed in May 2001, to determine compliance with surface contamination limits. Figures 2-2, 2-3, and 2-4 show the reference bunker, Building 28012 (Figure 2-2), Building 28005 (Figure 2-3), and Building 28010 (Figure 2-4).

Figure 2-2. Photograph of Reference Bunker, Building 28012, Installation Restoration Program Site OT-10

Figure 2-3. Photograph of Building 28005, Installation Restoration Program Site OT-10

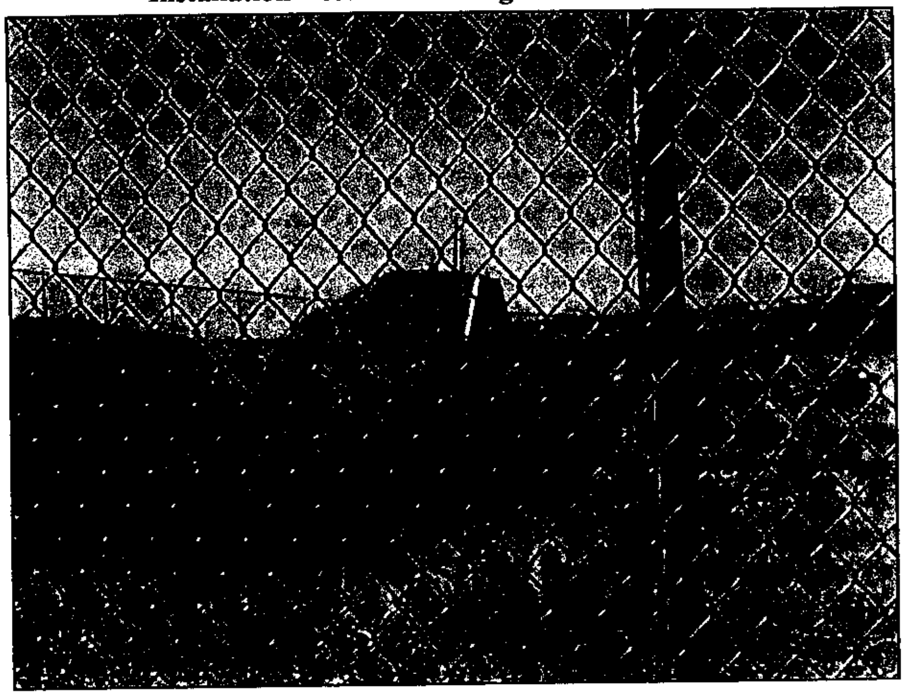


Figure 2-4. Photograph of Building 28010, Installation Restoration Program Site OT-10

Building 28012 was selected as a reference bunker because it is constructed of the same materials and has the same dimensions as Buildings 28005 and 28010. No radiation materials are stored in Building 28012, which is currently being used for tear gas training. Each building is approximately 10 ft by 20 ft with a maximum height of 10 ft, concrete floors, steel doors and front walls, and corrugated steel ceilings and back walls. The ceilings, side walls, and back walls are covered under earth. There are no utilities in the bunkers.

The door to the reference bunker was opened three hours prior to the survey to allow excess radon to exchange with the outside air. This, however, was not long enough for all of the unsupported radon-222 progeny, if present, to have decayed. Although the reference bunker is only 100 m from TS8, it is unlikely that it would have been influenced by the large quantities of radon-220 generated there.

The interior surfaces of the reference bunker were divided into 1-m^2 grid blocks, using blue chalk. Two Ludlum 43-5 zinc sulfide alpha scintillation detectors, each coupled to a Ludlum 2221 ratemeter/scaler were used to scan the grid blocks. The narrow Ludlum 43-5 detectors were selected over others because they best fit into the corrugated ceilings of the bunkers. The scanning technicians conducted 1-minute scans of each grid block with the ratemeter/scaler in the scaler (integration) mode. The data recorded were count rates per 100 square centimeters (cm^2), averaged over each grid block.

Field personnel collected one wipe sample from a random location within each accessible grid block, over approximate areas of 100 cm^2. The samples were sealed in a bag and analyzed 9 days later. The delay was selected to allow radon progeny on the wipe samples to decay. The wipe samples were analyzed for both gross alpha and gross beta contamination using a Ludlum 2929/Ludlum 43-10-1 alpha tray counter. The alpha efficiency of the tray counter was determined using a National Institute of Standards and Technology (NIST) traceable, plated thorium-230 source.

The storage bunkers at TS8, Buildings 28005 and 28010, were surveyed differently because of obstructions and/or high surface activity levels. The two bunkers at TS8 exhibited high levels of surface activity and gamma exposure rates, indicating a need for remedial measures. Considering the additional effort, the difficulties of contamination control, and radiation exposure to survey personnel, radiological surveys designed for demonstrating compliance with cleanup criteria could not be justified and were not performed.

In Building 28010, a Ludlum Model 43-5 zinc sulfide alpha scintillation detector, coupled to a Ludlum Model 2221 ratemeter/scaler was used to briefly evaluate the surface contamination levels. The detector was set in scaler (integration) mode. One-minute integrated counts of total surface contamination were taken at 10 locations. No attempt was made to bias the samples. Wipe samples were collected at each of these locations, from approximate 100-cm^2 areas.

Results from wipe sample analyses were converted to activities per 100 cm^2 and compared to the following site-specific gross alpha contamination limits:

- 170 disintegrations per minute (dpm)/100 cm^2 for total alpha contamination; and,
- 34 dpm/100 cm^2 for removable alpha contamination.

Residual radiation (RESRAD)-Build (version 3.0) (Argonne National Laboratory [ANL], 1994; NRC, 2000) was used to derive these surface contamination limits. The derivation is described in Section 3.1.2 and in greater detail in Appendix A.

A Ludlum Model 44-9 thin window G-M pancake probe, coupled to a Ludlum Model 2221 ratemeter/scaler, was used to measure exposure rates. The ratemeter/scaler was set in scaler (integration) mode and was used to take 1-minute static counts at several locations.

In Building 28005, a Ludlum Model 43-5 zinc sulfide alpha scintillation detector, coupled to a Ludlum Model 2221 ratemeter/scaler, was used to briefly evaluate the surface contamination levels. The detector was set in scaler (integration) mode. One-minute integrated counts of total surface contamination were taken at 9 unbiased locations within the bunker. No wipe samples were collected. Several exposure rate measurements were taken, using the same Ludlum Model 44-9 G-M pancake probe and Ludlum Model 2221 ratemeter/scaler used in Building 28010.

The following sections present the results of previous investigations.

2.4 Results of Previous Investigations

2.4.1 Findings at TS5

The results of previous investigations at TS5 are summarized below and are discussed collectively with results obtained from the other training sites in Section 2.4.5, General Findings.

2.4.1.1 1988 through 1990 Investigation

Gamma radiation measurements taken along the perimeter of TS5 were similar to background. However, offsite migration was identified along the northeast boundary of the site. In addition, vertical migration of thorium-232 was observed to be limited to approximately 2 inches where trenches were installed (USAF, 1992).

2.4.1.2 1994/1995 Investigation

The 1994/1995 investigation reported that about 20 percent of the TS5 area was affected to an average depth of 16 inches bgs. Table 2-3 lists the thorium-230 and thorium-232 soil concentrations observed during this investigation. Thorium-232 concentrations, determined by alpha spectrometry, ranged from 0.93 to 101.8 pCi/g (USAF, 1997b).

Table 2-3. Isotopic Thorium Concentrations in Soil Samples Collected during the 1994/1995 Investigation at Training Site 5, Installation Restoration Program Site OT-10

Sample ID	TS5HAHH05.3		TS5HAHAC05.3		TS5HAGI05.3	
Depth (Inches bgs)	Thorium-232 (pCi/g ± 2σ)[a]	Thorium-230 (pCi/g ± 2σ)[a]	Thorium-232 (pCi/g ± 2σ)[a]	Thorium-230 (pCi/g ± 2σ)[a]	Thorium-232 (pCi/g ± 2σ)[a]	Thorium-230 (pCi/g ± 2σ)[a]
0-6	68.2 ± 6.2[b] (151 ± 12) (replicate)	8.2 ± 1.9[b] (17.5 ± 3.3) (replicate)	NA	NA	NA	NA
6-12	101.8 ± 8.9	12.4 ± 2.7	NA	NA	NA	NA
12-18	NA	NA	NA	NA	NA	NA
18-24	NA	NA	NA	NA	4.21 ± 0.39	0.93 ± 0.16
24-30	NA	NA	79.2 ± 6.9	9.3 ± 2.0	NA	NA
30-36	NA	NA	12.34 ± 0.78	2.16 ± 0.23	NA	NA

Notes:
[a]Results determined using alpha spectrometry
[b]The average thorium-232 and thorium-230 concentrations of the sample and its replicate are 110 and 12.9 pCi/g, respectively. The average thorium-232 concentration (110 pCi/g) is reported on Figure 2-6.
bgs = below ground surface
NA = not analyzed
pCi/g = picocuries per gram
σ = standard deviation

2.4.1.3 1996/1998 Investigation

In the 1996/1998 investigation, the average concentration of thorium-232 in 9 samples collected outside TS5 was 1.02 pCi/g. Table 2-4 presents the thorium-232 concentrations in the soil core samples collected from the high activity areas during this investigation (USAF, 1999a).

Table 2-4. Thorium-232 Concentrations in Soil Samples Collected during the 1996/1998 Investigation at Training Site 5, Installation Restoration Program Site OT-10

Depth (inches bgs)	Thorium-232 Concentration (pCi/g)[a]				
	Core 1 (Rad1)	Core 2 (Rad2)	Core 3 (Rad3)	Core 4 (Rad4)	Core 5 (Rad5)
0-6	24.2 ± 1.05%	15.9 ± 1.05%	49.6 ± 3.50%	66.6 ± 3.72%	158.0 ± 9.63%
6-12	4.64 ± 0.33%	3.94 ± 0.36%	12.0 ± 0.62%	9.24 ± 0.64%	171.0 ± 8.76%
12-18	5.14 ± 0.34%	1.31 ± 0.13%	1.85 ± 0.16%	4.35 ± 0.26%	1,039.0 ± 5.11%
18-24	1.50 ± 0.11%	1.26 ± 0.11%	1.19 ± 0.08%	1.19 ± 0.08%	1,120 ± 3.38%
24-30	NA	NA	NA	NA	802.0 ± 4.81%
30-36	NA	NA	NA	NA	290.0 ± 4.92%

Notes:
[a]Results determined by gamma spectrometry
bgs = below ground surface
NA = not analyzed
pCi/g = picocuries per gram

With the exception of one core, thorium contamination extended from ground surface to 12 or 18 inches bgs. The average concentration to 18 inches bgs in each of these cores was 8.9 pCi/g (Core 1), 5.6 pCi/g (Core 2), 16.2 pCi/g (Core 3), and 20.3 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. The dimensions of the burial pit were reportedly 20-ft long by 20-ft wide by 6-feet deep (2,400 cubic feet) (USAF, 1999a).

2.4.1.4 2000/2001 Surveys

Table 2-5 presents the thorium-232 and thorium-230 concentrations in the surface samples collected at TS5 in April 2001 (USAF, 2002a). The thorium-232 concentrations determined by alpha and gamma spectrometry are equivalent within error ranges. Section 2.4.5 discusses the collective ratio of thorium-230 to thorium-232 at OT-10.

Table 2-6 presents the thorium-232 concentrations in the subsurface samples collected at TS5. Thorium-232 concentrations exceed the land area DCGL (5.9 pCi/g thorium-232) in four of 20 samples.

Table 2-5. Thorium Concentrations in Surface Soil Samples Collected in April 2001 at Training Site 5, Installation Restoration Program Site OT-10

Sample ID	Date Collected	Thorium 232 by Gamma Spectrometry (pCi/g ± 2σ)	Thorium-232 by Alpha Spectrometry (pCi/g ± 2σ)	Thorium-230 by Alpha Spectrometry (pCi/g ± 2σ)
TS5-SS-01A-0000[a]	4/12/01	1.09 ± 0.44	1.37 ± 0.4	0.99 ± 0.32
TS5-SS-01-0000	4/12/01	0.93 ± 0.46	1.34 ± 0.41	1.13 ± 0.36
TS5-SS-02-0000	4/12/01	0.76 ± 0.42	0.9 ± 0.3	0.67 ± 0.24
TS5-SS-03-0000	4/12/01	0.94 ± 0.42	0.84 ± 0.27	0.84 ± 0.27
TS5-SS-04-0000	4/10/01	1.47 ± 0.56	1.22 ± 0.49	1.42 ± 0.55
TS5-SS-05-0000	4/10/01	21.4 ± 5.8	20.3 ± 4.9	3.12 ± 0.87
TS5-SS-06-0000	4/10/01	2.18 ±. 84	1.92 ± 0.59	1.26 ± 0.43
TS5-SS-07-0000	4/10/01	5.8 ± 1.6	4.5 ± 1.2	1.07 ± 0.36
TS5-SS-08-0000	4/10/01	3.2 ± 1.1	3.40 ± 0.95	1.02 ± 0.37
TS5-SS-09-0000	4/10/01	1.25 ± 0.51	1.25 ± 0.41	0.97 ± 0.34
TS5-SS-10-0000	4/10/01	3.6 ± 1.1	3.8 ± 1	1.12 ± 0.38
TS5-SS-10A-0000[b]	4/10/01	3.2 ± 1	4.7 ± 1.2	1.21 ± 0.41
TS5-SS-11-0000	4/10/01	5.7 ± 1.7	6.6 ± 1.6	1.46 ± 0.45
TS5-SS-12-0000	4/10/01	4.7 ± 1.4	5.1 ± 1.4	1.54 ± 0.5
TS5-SS-13-0000	4/10/01	5.9 ± 1.8	5.8 ± 1.5	1.24 ± 0.4
TS5-SS-14-0000	4/10/01	2.58 ± 0.91	3.62 ± 0.94	1.30 ± 0.41
TS5-SS-15-0000	4/10/01	5.6 ± 1.6	7.3 ± 1.8	1.86 ± 0.55
TS5-SS-16-0000	4/10/01	1.17 ± 0.51	0.78 ± 0.31	1.01 ± 0.37
TS5-SS-17-0000	4/10/01	2.18 ± 0.76	1.75 ± 0.48	0.93 ± 0.29
TS5-SS-18-0000	4/10/01	0.99 ± 0.42	1.02 ± 0.34	0.96 ± 0.33
TS5-SS-19-0000	4/10/01	1.00 ± 0.49	0.93 ± 0.32	0.84 ± 0.3
TS5-SS-20-0000	4/10/01	4.1 ± 1.2	3.51 ± 0.92	1.13 ± 0.37
TS5-SS-20A-0000[c]	4/10/01	3.5 ± 1.1	2.49 ± 0.66	1.0 ± 0.32

Notes:
[a]Sample is a replicate of TS5-SS-01-0000
[b]Sample is a replicate of TS5-SS-10-0000
[c]Sample is a replicate of TS5-SS-20-0000

pCi/g = picocuries per gram
σ = standard deviation

Table 2-6. Thorium Concentrations in Subsurface Soil Samples Collected in April 2001 at Training Site 5, Installation Restoration Program Site OT-10

Field Sample ID	Date Collected	Thorium 232 by Gamma Spectrometry (pCi/g ± 2σ)
TS5-SB-01-0612	4/12/01	1.74 ± 0.78
TS5-SB-02-0612	4/12/01	1.39 ± 0.54
TS5-SB-03-0612	4/12/01	<1.1
TS5-SB-04-0612	4/10/01	<1.3
TS5-SB-05-0612	4/10/01	3.3 ± 1.2
TS5-SB-06-0612	4/10/01	2.19 ± 0.79
TS5-SB-07-0612	4/10/01	4.5 ± 1.4
TS5-SB-08-0612	4/10/01	1.58 ± 0.79
TS5-SB-09-0612	4/10/01	1.30 ± 0.62
TS5-SB-10-0612	4/10/01	2.59 ± 0.93
TS5-SB-10A-0612[a]	4/10/01	1.77 ± 0.86
TS5-SB-11-0612	4/10/01	10.1 ± 2.7
TS5-SB-12-0612	4/10/01	23.5 ± 6
TS5-SB-13-0612	4/10/01	11.7 ± 3.2
TS5-SB-14-0612	4/10/01	4.2 ± 1.4
TS5-SB-15-0612	4/10/01	13.2 ± 3.4
TS5-SB-16-0612	4/10/01	<1.2
TS5-SB-17-0612	4/10/01	3.1 ± 1.1
TS5-SB-18-0612	4/10/01	1.43 ± 0.65
TS5-SB-19-0612	4/10/01	1.27 ± 0.72
TS5-SB-20-0612	4/10/01	3.3 ± 1
TS5-SB-20A-0612[b]	4/10/01	3.0 ± 1.1

Notes:
[a]Sample is a replicate of TS5-SB-10-0612
[b]Sample is a replicate of TS5-SB-20-0612
pCi/g = picocuries per gram
σ = standard deviation

2.4.1.5 Graphical Presentations of Results at TS5

A series of three figures present radiological findings at TS5. Figure 2-5 presents the most recent gamma radiation scanning data (October 2000). Figure 2-6 depicts thorium-232 concentrations in surface soil samples from soil cores collected during the 1994/1995 and 1996/1998 investigations, superimposed on isocontours of the October 2000 gamma radiation scanning data. Figure 2-7 shows the April 2001 soil sample results superimposed on the same gamma radiation isocontours. ArcView GIS 8.1® was used to map the spatial distribution of 2000 gamma radiation counts, sample locations, and features such as fences.

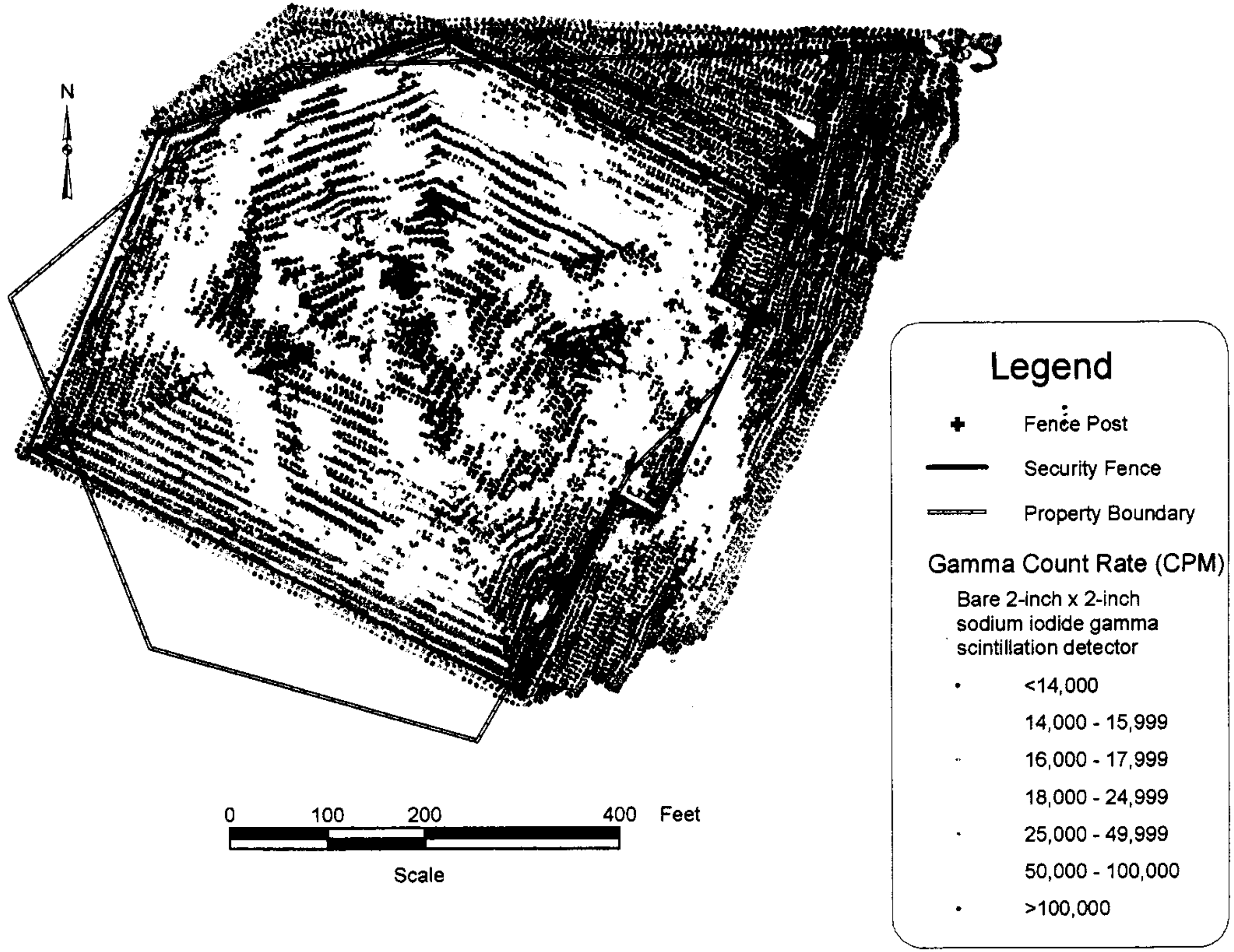


Figure 2-5. October 2000 Gamma Radiation Scanning Results at Training Site 5, Installation Restoration Program Site OT-10

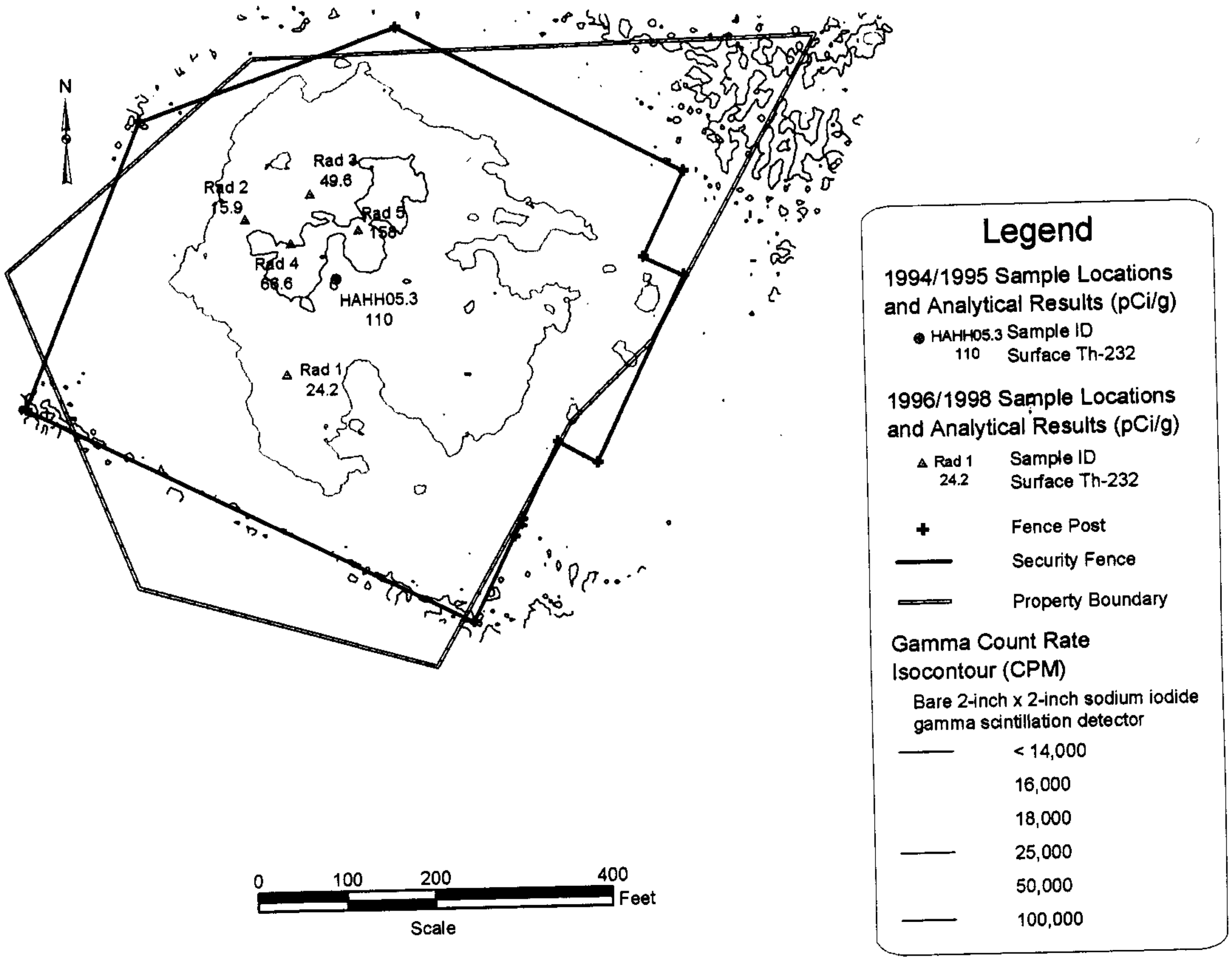


Figure 2-6. Historical Sampling Locations and Results Superimposed on October 2000 Gamma Radiation Scanning Results at Training Site 5, Installation Restoration Program Site OT-10

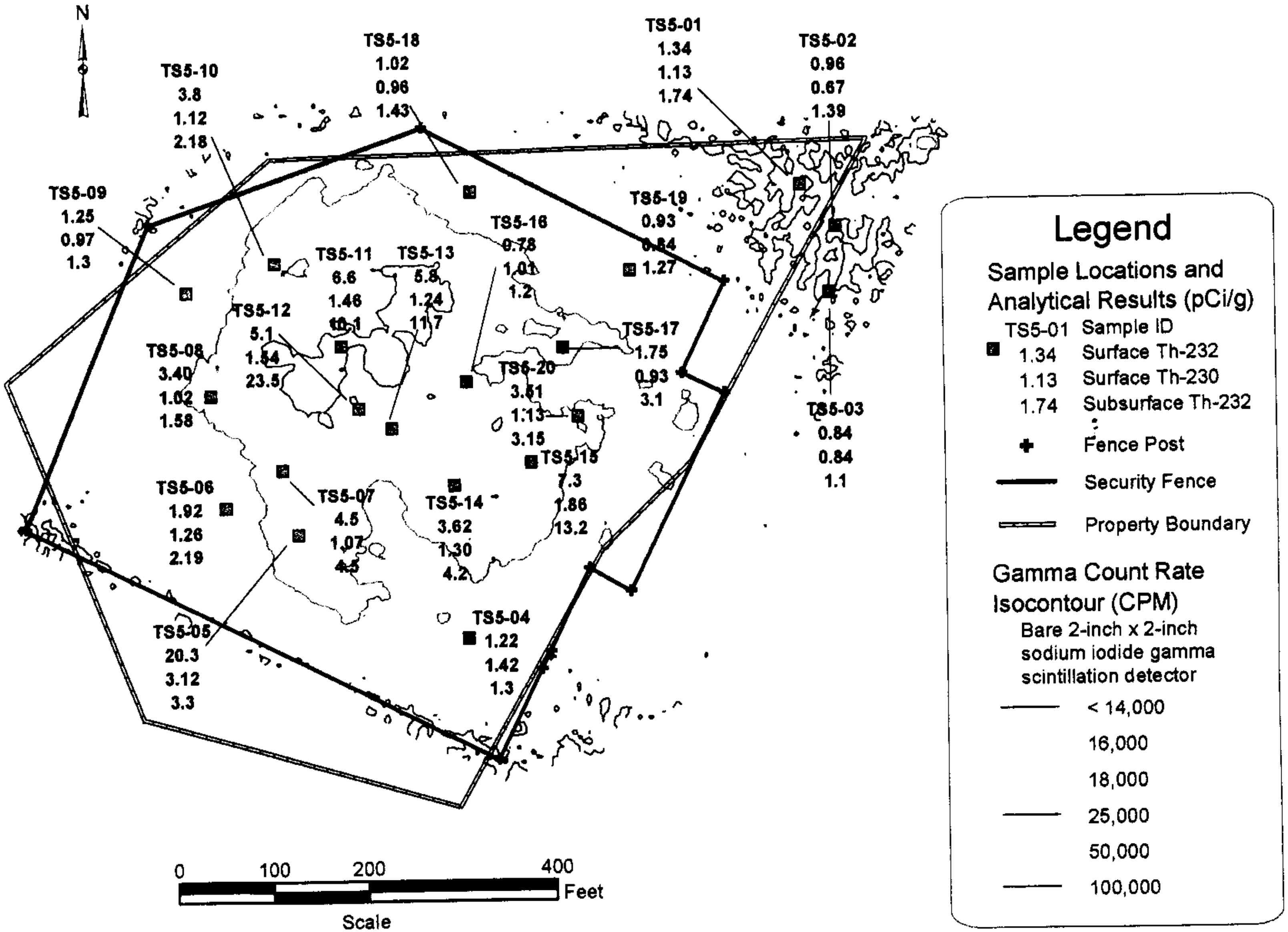


Figure 2-7. April 2001 Sampling Locations and Results Superimposed on October 2000 Gamma Radiation Scanning Results at Training Site 5, Installation Restoration Program Site OT-10

2.4.2 Findings at TS6

The results of previous investigations at TS6 are summarized below and are discussed collectively with results obtained from the other training sites in Section 2.4.5, General Findings.

2.4.2.1 1988 through 1990 Investigation

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 soil samples (68.5 to 277 pCi/g) were two to three orders of magnitude above background, which was reportedly 1 pCi/g-dried. Soil samples collected at the site perimeter 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 (USAF, 1992).

2.4.2.2 1994/1995 Investigation

The 1994/1995 investigation reported that about 32 percent of the TS6 area was affected to an average depth of 19 inches bgs. Table 2-7 lists the thorium-230 and thorium-232 soil concentrations observed during this investigation. Thorium-232 concentrations, determined by alpha spectrometry, ranged from 0.57 to 40.1 pCi/g (USAF, 1997a).

Table 2-7. Isotopic Thorium Concentrations in Soil Samples Collected during the 1994/1995 Investigation at Training Site 6, Installation Restoration Program Site OT-10

Sample ID	TS6HAKK05.8		TS6HAJD05.6		TS6HAJD05.4	
Depth (inches bgs)	Thorium-232 (pCi/g ± 2σ)[a]	Thorium-230 (pCi/g ± 2σ)[a]	Thorium-232 (pCi/g ± 2σ)[a]	Thorium-230 (pCi/g ± 2σ)[a]	Thorium-232 (pCi/g ± 2σ)[a]	Thorium-230 (pCi/g ± 2σ)[a]
0-6	40.1 ± 3.3	1.18 ± 0.45	NA	NA	16.7 ± 1.0	0.84 ± 0.13
6-12	NA	NA	NA	NA	1.24 ± 0.17	0.76 ± 0.13
12-18	NA	NA	NA	NA	0.94 ± 0.15	0.57 ± 0.11
18-24	NA	NA	NA	NA	NA	NA
24-30	NA	NA	4.83 ± 0.38 (4.60 + 0.39) (replicate)	0.89 ± 0.14 (0.74 + 0.12) (replicate)	NA	NA
30-36	NA	NA	NA	NA	NA	NA

Notes:
[a]Results determined by alpha spectrometry
bgs = below ground surface
NA = not analyzed
pCi/g = picocuries per gram
σ = standard deviation

2.4.2.3 1996/1998 Investigation

In the 1996/1998 investigation, the average concentration of thorium-232 in 10 samples collected outside TS6 was 0.95 pCi/g (USAF, 1999a).

Table 2-8 presents the thorium-232 concentrations in the soil core samples from high activity areas. Two affected areas (referred to as "North" and "South") were delineated.

With the exception of one core, thorium contamination extended from ground surface to 12 to 24 inches bgs. The average thorium-232 concentrations to 24 inches bgs in the cores were 33.9 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.

Table 2-8. Thorium-232 Concentrations in Soil Samples Collected during the 1996/1998 Investigation at Training Site 6, Installation Restoration Program Site OT-10

Site	Depth (inches bgs)	Thorium-232 Concentration (pCi/g)[a]			
		Core 1 (Rad 1)	Core 2 (Rad 2)	Core 3 (Rad 3)	Core 4 (Rad 4)
TS6 South	0-6	48.1 ± 5.50%	22.2 ± 6.55%	130.0 ± 3.70%	45.2 ± 5.96%
	6-12	17.6 ± 6.75%	39.5 ± 6.69%	18.1 ± 6.19%	3.51 ± 6.94%
	12-18	68.6 ± 6.57%	3.63 ± 13.5%	4.46 ± 7.77%	1.85 ± 8.73%
	18-24	1.37 ± 8.55%	4.00 ± 4.82%	2.28 ± 5.40%	1.46 ±9.84%
TS6 North	0-6	35.3 ± 6.45%	299.0 ± 5.30%	23.8 ± 7.19%	15.4 ± 7.22%
	6-12	10.3 ± 6.51%	47.7 ± 5.45%	11.0 ± 7.12%	1.33 ± 10.2%
	12-18	7.00 ± 6.77%	15.8 ± 7.39%	1.16 ± 13.3%	1.02 ± 13.1%
	18-24	2.39 ± 7.45%	7.05 ± 6.35%	1.38 ± 8.77%	1.28 ± 6.75%
	24-30	NA	15.1 ± 7.60%	NA	NA
	30-36	NA	7.61 ± 10.4%	NA	NA
	36-42	NA	4.34 ± 9.36%	NA	NA
	42-48	NA	5.14 ± 5.78%	NA	NA
	48-54	NA	7.06 ± 8.42%	NA	NA
	54-60	NA	5.32 ± 10.7%	NA	NA

Notes:
[a]Results determined using gamma spectrometry
bgs = below ground surface
NA = not analyzed
pCi/g = picocuries per gram

2.4.2.4 2000/2001 Surveys

Table 2-9 presents the thorium-232 and thorium-230 concentrations in the surface samples collected at TS6 in April 2001 (USAF, 2002a). With two exceptions (TS6-SS-06-0000 and TS6-SS-10-0000), the thorium-232 concentrations determined by alpha and gamma spectrometry are equivalent within error ranges. Section 2.4.5 discusses the collective ratio of thorium-230 to thorium-232 at OT-10.

Table 2-10 presents the thorium-232 concentrations in the subsurface samples collected at TS6. All thorium-232 concentrations in the 2001 subsurface samples are below the land area DCGL (5.9 pCi/g thorium-232).

Table 2-11 presents the radiological, non-radiological, and geotechnical results for the two waste profile samples collected at TS6.

Table 2-9. Thorium Concentrations in Surface Soil Samples Collected in April 2001 at Training Site 6, Installation Restoration Program Site OT-10

Field Sample ID	Date Collected	Thorium 232 by Gamma Spectrometry (pCi/g ± 2σ)	Thorium-232 by Alpha Spectrometry (pCi/g ± 2σ)	Thorium-230 by Alpha Spectrometry (pCi/g ± 2σ)
TS6-SS-01-0000	4/13/01	10.6 ± 2.7	9.4 ± 2.4	2.49 ± 0.74
TS6-SS-02-0000	4/13/01	1.40 ± 0.62	1.74 ± 0.58	1.27 ± 0.46
TS6-SS-03-0000	4/13/01	1.27 ± 0.64	1.61 ± 0.48	1.09 ± 0.35
TS6-SS-04-0000	4/13/01	13.6 ± 3.5	17.9 ± 4.4	2.63 ± 0.77
TS6-SS-05-0000	4/13/01	6.0 ± 1.7	3.48 ± 0.99	1.43 ± 0.48
TS6-SS-06-0000	4/13/01	6.8 ± 1.9	13.3 ± 3.2	2.53 ± 0.71
TS6-SS-07-0000	4/13/01	1.69 ± 0.61	2.82 ± 0.83	1.35 ± 0.47
TS6-SS-08-0000	4/13/01	3.16 ± 0.997	3.18 ± 0.9	1.54 ± 0.5
TS6-SS-09-0000	4/13/01	2.29 ± 0.81	1.71 ± 0.51	1.14 ± 0.38
TS6-SS-10-0000	4/13/01	4.1 ± 1.2	2.16 ± 0.6	0.88 ± 0.3
TS6-SS-10A-0000[a]	4/13/01	4.9 ± 1.4	3.8 ± 1.1	1.81 ± 0.58
TS6-SS-11-0000	4/13/01	11.8 ± 3.3	10.0 ± 2.5	2.05 ± 0.62
TS6-SS-12-0000	4/13/01	24.9 ± 6.2	24.4 ± 5.8	4.0 ± 1.1
TS6-SS-13-0000	4/13/01	1.54 ± 0.64	2.56 ± 0.71	1.07 ± 0.36
TS6-SS-14-0000	4/13/01	<0.96	0.89 ± 0.34	1.07 ± 0.38
TS6-SS-15-0000	4/13/01	<0.72	0.87 ± 0.32	1.12 ± 0.38
TS6-SS-16-0000	4/13/01	1.46 ± 0.65	1.30 ± 0.46	1.61 ± 0.54
TS6-SS-17-0000	4/13/01	4.0 ± 1.2	5.2 ± 1.4	1.47 ± 0.47
TS6-SS-18-0000	4/13/01	6.4 ± 1.8	7.3 ± 1.9	2.08 ± 0.62
TS6-SS-19-0000	4/13/01	2.17 ± 0.87	2.20 ± 0.66	1.60 ± 0.52
TS6-SS-20-0000	4/13/01	<0.93	1.37 ± 0.49	1.06 ± 0.42
TS6-SS-20A-0000[b]	4/13/01	1.16 ± 0.59	0.97 ± 0.35	1.16 ± 0.4

Notes:
[a]Sample is a replicate of TS6-SS-10-0000
[b]Sample is a replicate of TS6-SS-20-0000
pCi/g = picocuries per gram
σ = standard deviation

Table 2-10. Thorium Concentrations in Subsurface Soil Samples Collected in April 2001 at Training Site 6, Installation Restoration Program Site OT-10

Field Sample ID	Date Collected	Thorium 232 by Gamma Spectrometry (pCi/g ± 2σ)
TS6-SB-01-0612	4/13/01	3.5 ± 1.2
TS6-SB-02-0612	4/13/01	1.45 ± 0.56
TS6-SB-03-0612	4/13/01	1.67 ± 0.71
TS6-SB-04-0612	4/13/01	3.1 ± 1.1
TS6-SB-05-0612	4/13/01	4.3 ± 1.4
TS6-SB-06-0612	4/13/01	2.9 ± 1.1
TS6-SB-07-0612	4/13/01	<1.1
TS6-SB-08-0612	4/13/01	1.50 ± 0.59
TS6-SB-09-0612	4/13/01	<1.4
TS6-SB-10-0612	4/13/01	<1.1
TS6-SB-10A-0612[a]	4/13/01	1.88 ± 0.85
TS6-SB-11-0612	4/13/01	3.3 ± 1.3
TS6-SB-12-0612	4/12/01	5.2 ± 1.7
TS6-SB-13-0612	4/13/01	1.90 ± 0.76
TS6-SB-14-0612	4/13/01	<1.3
TS6-SB-15-0612	4/13/01	<1.1
TS6-SB-16-0612	4/13/01	<1.6
TS6-SB-17-0612	4/13/01	1.69 ± 0.7
TS6-SB-18-0612	4/13/01	3.2 ± 1.2
TS6-SB-19-0612	4/13/01	2.3 ± 1
TS6-SB-20-0612	4/13/01	2.16 ± 0.87
TS6-SB-20A-0612[b]	4/13/01	<1.5

Notes:
[a]Sample is a replicate of TS6-SB-10-0612
[b]Sample is a replicate of TS6-SB-20-0612
pCi/g = picocuries per gram
σ = standard deviation

Table 2-11. Analytical Results for Waste Profile Samples Collected in May 2001 at Training Site 6, Installation Restoration Program Site OT-10

	Location ID	TS6	TS6
	Depth Interval (ft bgs)	0 – 0.5	0 – 0.5
	Sample ID	TS6-SS-21-0000	TS6-SS-22-0000
	Date Collected	5/31/01	5/31/01
Analytical Method/Units			
Gamma Spectrometry (EPA 901.1 modified)/pCi/g ± 2σ	**Value in 40 CFR § 261.24 Table 1**		
Actinium 228	NE	44 ± 11	168 ± 41
Bismuth-212	NE	53.8 ± 8.7	191 ± 26
Bismuth-214	NE	1.38 ± 0.57	2.9 ± 1.4
Cesium-137	NE	0.27 ± 0.23	-0.18 ± 0.38
Cobalt-60	NE	0.11 ± 0.17	0.03 ± 0.29
Lead-212	NE	42.3 ± 6.7	153 ± 24
Lead-214	NE	2.20 ± 0.73	2.0 ± 1.1
Potassium-40	NE	21.9 ± 4.7	31.4 ± 6.9
Radium-226	NE	1.37 ± 0.57	2.9 ± 1.4
Radium-224	NE	46 ± 27	157 ± 92
Thallium-208	NE	15.2 ± 2.7	54.5 ± 9.4
Thorium-234	NE	10.2 ± 6.0	99 ± 18
Uranium-235	NE	0.19 ± 0.96	-0.6 ± 2.0
Isotopic thorium (NAS/DOE 3004/RP-725/pCi/g ± 2σ			
Thorium-228	NE	45 ± 11	176 ± 43
Thorium-230	NE	7.1 ± 1.9	25.3 ± 7.9
Thorium-232	NE	54 ± 13	139 ± 34
Isotopic uranium (NAS/DOE 3050/RP-725/pCi/g ± 2σ			
Uranium-234	NE	4.06 ± 0.98	13.6 ± 3.1
Uranium-235	NE	0.27 ± 0.15	0.81 ± 0.31
Uranium-238	NE	4.5 ± 1.1	13.1 ± 3.0
TCLP Organochlorine Pesticides (EPA SW-846 1311/8081A)/µg/L			
Chlordane	30	<5.0	<5.0
Endrin	20	<0.50	<0.50
Lindane	400	<0.50	<0.50
Heptachlor	8	<0.50	<0.50
Heptachlor epoxide	8	<0.50	<0.50
Methoxychlor	10,000	<1.0	<1.0
Toxaphene		<20	<20
TCLP VOCs (EPA SW-846 1311/8260B)/µg/L			
Vinyl chloride	200	<100	<100
1,1-Dichloroethene	700	<50	<50
2-Butanone (methyl ethyl ketone)	200,000	<200	<200
Chloroform	6,000	<50	<50
Carbon tetrachloride	500	<50	<50
1,2-Dichloroethane	500	<50	<50
Benzene	500	<50	<50
Trichloroethene	500	<50	<50
Tetrachloroethene	700	<50	<50
Chlorobenzene	100,000	<50	<50

Table 2-11. Analytical Results for Waste Profile Samples Collected in May 2001 at Training Site 6, Installation Restoration Program Site OT-10 (concluded)

Location ID		TS6	TS6
Depth Interval (ft bgs)		0 – 0.5	0 – 0.5
Sample ID[a]		TS6-SS-21-0000	TS6-SS-22-0000
Date Collected		5/31/01	5/31/01
Analytical Method/Units			
TCLP Organochlorine Herbicides (EPA SW-846 1311/8151A)/µg/L	**Value in 40 CFR § 261.24 Table 1**		
2,4-Dichlorophenoxyacetic acid	10,000	<40	<40
Silvex	1,000	<10	<10
TCLP VOCs (EPA SW-846 1311/8270C)/µg/L			
Pyridine	100[a]	<100	<100
1.4-Dichlorobenzene		<50	<50
2-Methylphenol (*o*-Cresol)	200,000	<50	<50
4-Methylphenol (*p*-Cresol)	200,000	<50	<50
Hexachloroethane	3,000	<50	<50
Nitrobenzene	2,000	<50	<50
Hexachlorobutadiene	500	<50	<50
2,4,6-Trichlorophenol	2,000	<50	<50
2,4,5-Trichlorophenol	400,000	<50	<50
2,4-Dinitrotoluene	50[a]	<50	<50
Hexachlorobenzene	50[a]	<50	<50
Pentachlorophenol	100,000	<250	<250
TCLP Metals (EPA SW-846 1311/6010B)/µg/L			
Arsenic	5,000	14.0	20.5
Barium	100,000	1,750	1,790
Cadmium	1,000	1.1	4.1
Chromium	5,000	<250	3.2
Lead	5,000	3.7	5.3
Silver	5,000	<250	<250
Selenium	1,000	6.0	4.3
Copper	NE	17.7	22.3
Zinc	NE	103	276
TCLP Mercury (EPA SW-846 1311/7470A)/µg/L	200	<1.0	<1.0
pH (EPA SW 846 9045A)	NE	8.7	8.6
Paint Filter Test (EPA SW-846 9095)	NE	Pass	Pass
Percent Moisture (EPA 160.3 modified)/percent	NE	0.95	0.50
Reactive Cyanide (EPA SW-846 7.3.3)/mg/kg	NE	<0.050	<0.050
Reactive Sulfide (EPA SW-846 7.3.3)/mg/kg	NE	<22.4	<22.3
Bulk/Dry Density (USACE EM-1110-2-1906)/lb/ft^3	NE	80.5/76.6	94.4/91.1
Standard Proctor-Maximum Dry Density (ASTM D 698)/ lb/ft^3	NE	106.4	112.4
Standard Proctor-Optimum Moisture (ASTM D 698)/	NE	15.4	13.2

Notes:
[a]Quantitation limit is the regulatory level according to footnote c of Table 1 in 40 CFR § 261.24.
ASTM = American Society for Testing and Materials
bgs = below ground surface
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
ft = foot/feet
ID = identifier
lb/ft^3 – pounds per cubic foot
mg/kg = milligrams per kilogram
NAS = National Academy of Sciences
NE = not established
pCi/g = picocuries per gram
σ = standard deviation
SW = solid waste
TCLP = Toxicity Characteristic Leachate Procedure
µg/L = micrograms per liter
USACE = U.S. Army Corps of Engineers

2.4.2.5 Graphical Presentations of Results at TS6

A series of three figures present radiological findings at TS6. Figure 2-8 presents the most recent gamma radiation scanning data (October 2000). Figure 2-9 depicts thorium-232 concentrations in surface soil samples in soil cores collected during the 1994/1995 and 1996/1998 investigations, superimposed on isocontours of the October 2000 gamma radiation scanning data. Figure 2-10 shows the April 2001 soil sample results superimposed on the same isocontours. ArcView GIS 8.1® mapped the spatial distribution of 2000 gamma radiation counts, sample locations, and features such as fences.

2.4.3 Findings at TS7

The results of previous investigations at TS7 are summarized below and are discussed collectively with the other training sites in Section 2.4.5, General Findings.

2.4.3.1 1988 through 1990 Investigation

Gamma-radiation counts typically were near or less than two times background. The count rate of only one perimeter measurement was greater than two times background (USAF, 1992).

Thorium-232 concentrations in the two plant 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.

2.4.3.2 1994/1995 Investigation

The 1994/1995 investigation reported that about 0.3 percent of the TS7 area was affected to an average depth of 19 inches bgs. Table 2-12 lists the thorium-230 and thorium -232 soil concentrations observed during this investigation. The range of thorium-232 soil concentrations, determined by alpha spectrometry, was 0.73 to 112.7 pCi/g (USAF, 1997a).

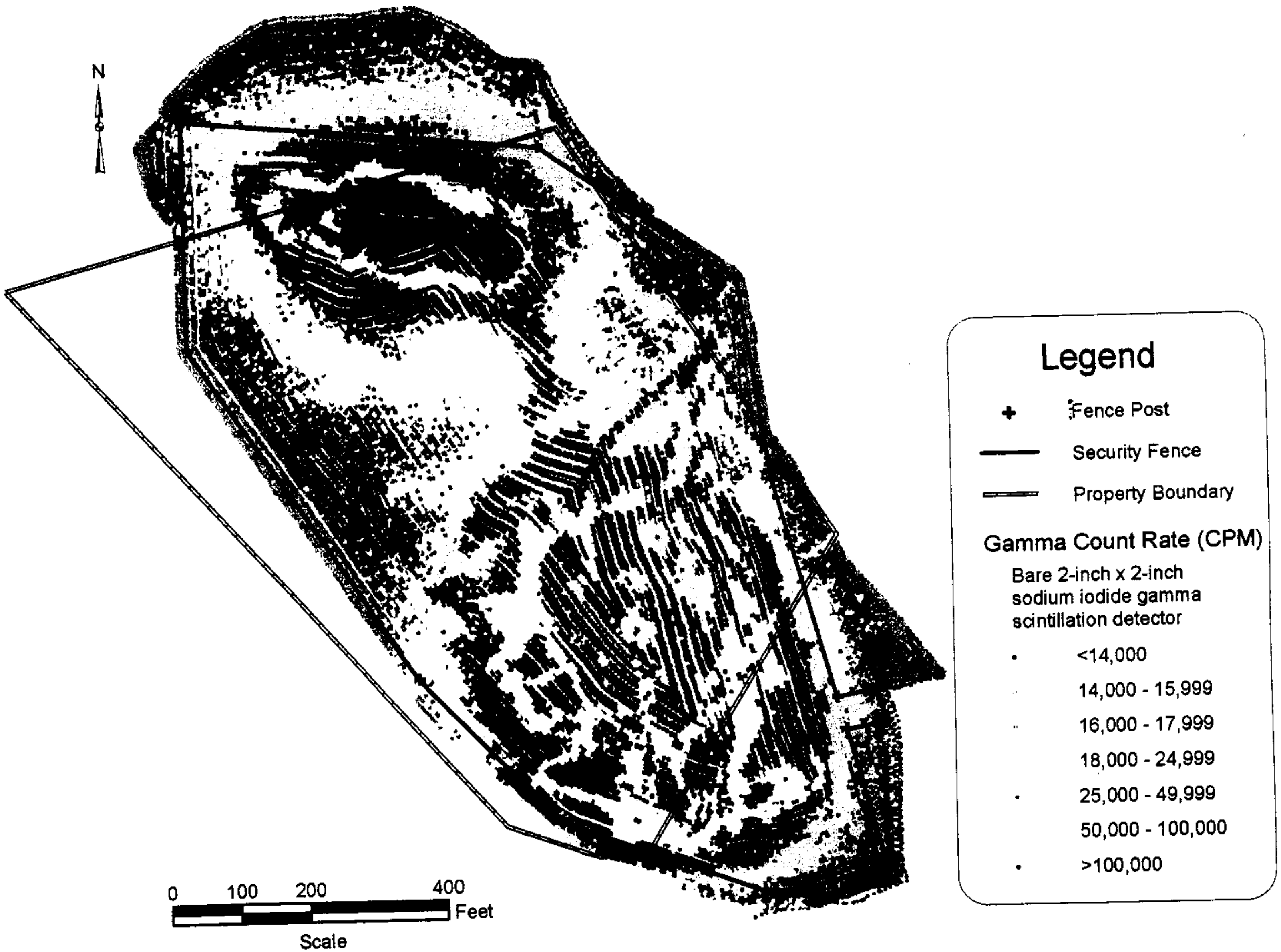


Figure 2-8. October 2000 Gamma Radiation Scanning Results at Training Site 6, Installation Restoration Program Site OT-10

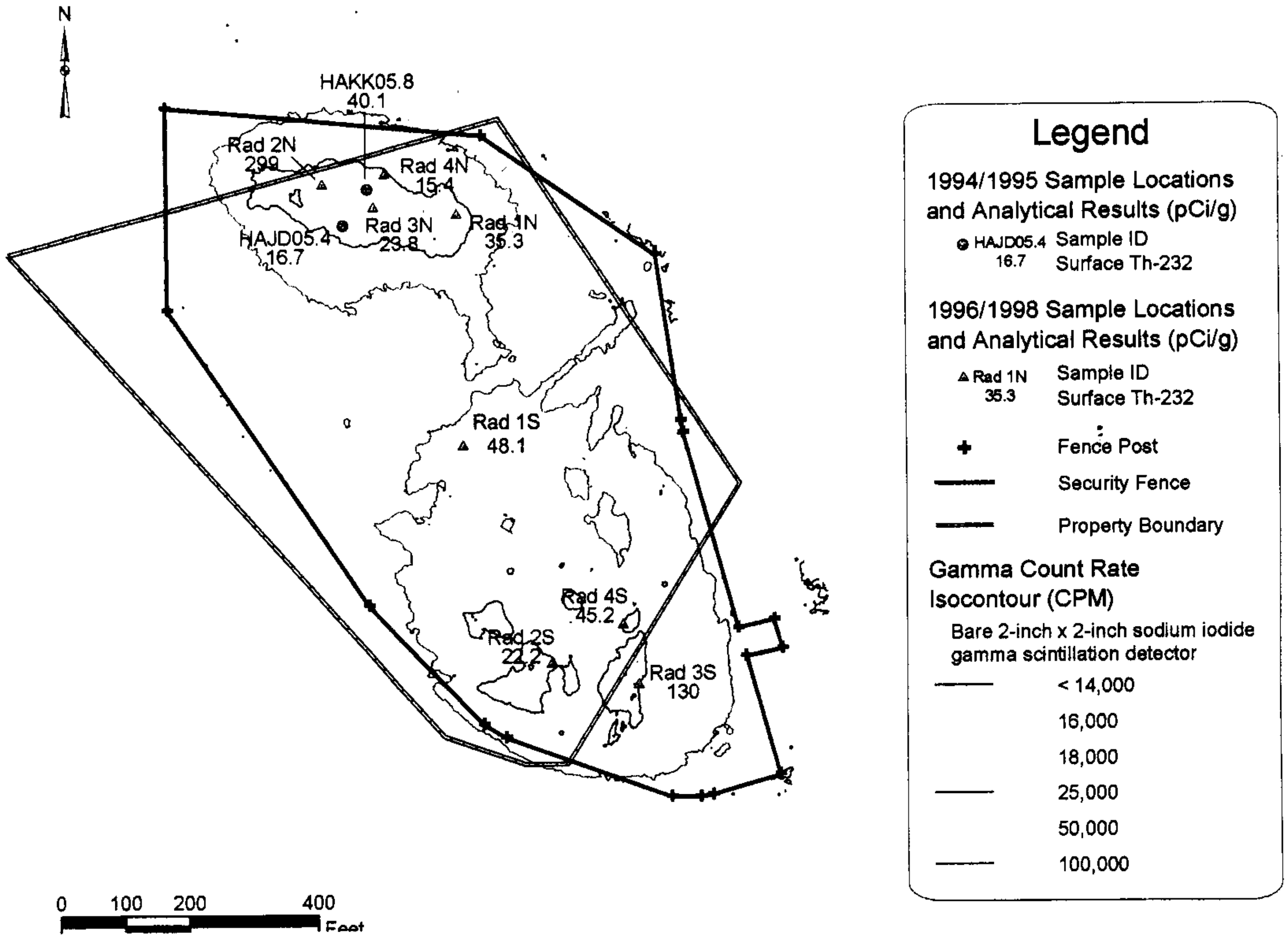


Figure 2-9. Historical Sampling Locations and Results Superimposed on October 2000 Gamma Radiation Scanning Results at Training Site 6, Installation Restoration Program Site OT-10

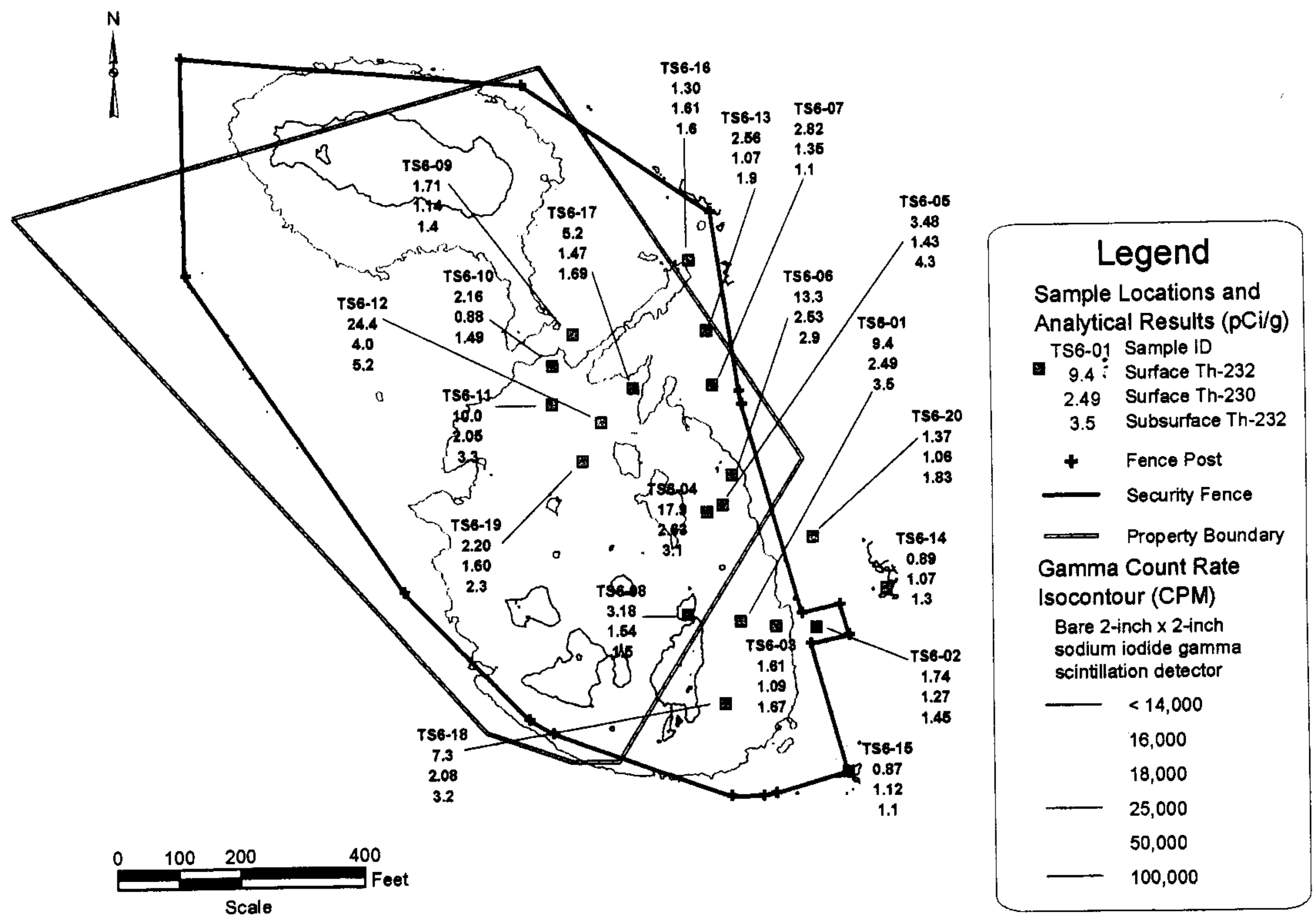


Figure 2-10. April 2001 Sampling Locations and Results Superimposed on October 2000 Gamma Radiation Scanning Results at Training Site 6, Installation Restoration Program Site OT-10

Table 2-12. Isotopic Thorium Concentrations in Soil Core Samples Collected during the 1994/1995 Investigation at Training Site 7, Installation Restoration Program Site OT-10

Sample ID	TS7HACI01.87		TS7HACe02.78		TS7HACe02.8		TS7HACg02.6	
Depth (inches bgs)	Thorium-232 (pCi/g ± 2σ)[a]	Thorium-230 (pCi/g ± 2σ)[a]	Thorium-232 (pCi/g ± 2σ)[a]	Thorium-230 (pCi/g ± 2σ)[a]	Thorium-232 (pCi/g ± 2σ)[a]	Thorium-230 (pCi/g ± 2σ)[a]	Thorium-232 (pCi/g ± 2σ)[a]	Thorium-230 (pCi/g ± 2σ)[a]
0-6	NA	NA	NA	NA	NA	NA	7.92 ± 0.59	1.89 ± 0.24
6-12	NA	NA	NA	NA	84.5 ± 6.4	14.8 ± 2.1	NA	NA
12-18	1.65 ± 0.20	0.73 ± 0.13	112.7 ± 8.6	19.1 ± 2.9	NA	NA	NA	NA
18-24	NA	NA	NA	NA	NA	NA	NA	NA
24-30	NA	NA	NA	NA	52.7 ± 4.9	8.6 ± 1.7	NA	NA
30-36	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
[a]Results determined using alpha spectrometry
bgs = below ground surface
NA = not analyzed
pCi/g = picocuries per gram
σ = standard deviation

2.4.3.3 1996/1998 Investigation

The 1996/1998 investigation confirmed the general extent of contamination defined in the previous investigation (USAF, 1999a). In addition, eight samples were collected from two soil cores advanced in high activity areas at TS7. Table 2-13 presents the thorium-232 concentrations in these samples.

In the 1996/1998 investigation, the average concentration of thorium-232 in 10 samples collected outside TS7 was 1.35 pCi/g.

Table 2-13. Thorium-232 Concentrations in Soil Samples Collected during the 1996/1998 Investigation at Training Site 7, Installation Restoration Program Site OT-10

Site	Depth (inches bgs)	Thorium-232 Concentration (pCi/g)[a]	
		Core 1 (Rad1)	Core 2 (Rad2)
TS7	0-6	33.2 ± 5.46%	25.1 ± 5.95%
	6-12	4.76 ± 6.81%	6.81 ± 6.89%
	12-18	0.741 ± 12.88%	1.53 ± 8.04%
	18-24	0.710 ± 9.16%	1.12 ± 750%

Notes:
[a]Results determined using gamma spectrometrry
bgs = below ground surface
pCi/g = picocuries per gram

Radiological contamination extended from ground surface to 12 to 18 inches bgs. The average concentrations of thorium-232 to 24 inches bgs in the cores were 9.9 pCi/g (Core 1) and 8.6 pCi/g (Core 2).

2.4.3.4 2000/2001 Surveys

Table 2-14 presents the thorium-232 and thorium-230 concentrations in the surface samples collected at TS7. With one exception (TS6-SS-17-0000), the thorium-232 concentrations determined by alpha and gamma spectrometry are equivalent within error ranges. Section 2.4.5 discusses the collective ratio of thorium-230 to thorium-232 at OT-10.

Table 2-15 presents the thorium-232 concentrations in the subsurface samples collected at TS7. All thorium-232 concentrations in the 2001 subsurface samples are below the land area DCGL (5.9 pCi/g thorium-232).

Table 2-14. Thorium Concentrations in Surface Soil Samples Collected in April 2001 at Training Site 7, Installation Restoration Program Site OT-10

Field Sample ID	Date Collected	Thorium 232 by Gamma Spectrometry (pCi/g ± 2σ)	Thorium-232 by Alpha Spectrometry (pCi/g ± 2σ)	Thorium-230 by Alpha Spectrometry (pCi/g ± 2σ)
TS7-SS-01-0000	4/9/01	1.95±0.7	2.46±0.72	1.14±.039
TS7-SS-02-0000	4/9/01	0.88±0.39	1.06±0.43	1.16±0.46
TS7-SS-03-0000	4/9/01	0.82±0.5	0.97±0.33	1.08±0.35
TS7-SS-04-0000	4/9/01	2.01±0.69	2.54±0.78	1.32±0.47
TS7-SS-05-0000	4/9/01	4.3±1.3	3.07±0.88	1.24±.43
TS7-SS-06-0000	4/9/01	1.12±0.43	0.47±0.32	0.68±0.4
TS7-SS-07-0000	4/9/01	1.40±0.62	1.56±0.5	0.88±0.33
TS7-SS-08-0000	4/9/01	0.85±0.49	1.42±0.5	0.96±0.39
TS7-SS-09-0000	4/9/01	4.1±1.2	5.6±1.6	1.49±0.54
TS7-SS-10-0000	4/9/01	5.1±1.4	5.1±1.3	1.41±0.44
TS7-SS-10A-0000[a]	4/9/01	4.9±1.4	5.0±1.2	1.15±0.36
TS7-SS-11-0000	4/9/01	3.9±1.1	4.3±1.1	1.35±0.44
TS7-SS-12-0000	4/9/01	44±11	30.7±7.4	4.0±1.1
TS7-SS-13-0000	4/9/01	3.4±1	3.06±0.86	1.39±0.46
TS7-SS-14-0000	4/9/01	12.6±3.3	17.9±4.3	1.94±0.57
TS7-SS-15-0000	4/9/01	21.2±5.4	21.0±6.3	2.07±0.83
TS7-SS-16-0000	4/9/01	18.5±4.8	12.9±3.1	1.85±0.56
TS7-SS-17-0000	4/9/01	3.5±1.1	6.9±1.8	1.34±0.45
TS7-SS-18-0000	4/9/01	11.1±3.1	11.3±2.9	2.14±0.69
TS7-SS-19-0000	4/9/01	9.6±2.6	10.5±2.6	1.74±0.52
TS7-SS-20A-0000	4/9/01	42±11	40.1±9.6	4.3±1.2

Notes:
[a]Sample is a replicate of TS7-SS-10-0000
pCi/g = picocuries per gram
σ = standard deviation

Table 2-15. Thorium Concentrations in Subsurface Soil Samples Collected in April 2001 at Training Site 7, Installation Restoration Program Site OT-10

Field Sample ID	Date Collected	Thorium-232 by Gamma Spectrometry (pCi/g ± 2σ)
TS7-SB-01-0612	4/9/01	<1.1
TS7-SB-02-0612	4/9/01	<0.94
TS7-SB-03-0612	4/9/01	0.74±0.72
TS7-SB-04-0612	4/9/01	<1.6
TS7-SB-05-0612	4/9/01	1.55±0.66
TS7-SB-06-0612	4/9/01	<1.0
TS7-SB-07-0612	4/9/01	<0.99
TS7-SB-08-0612	4/9/01	<1.1
TS7-SB-09-0612	4/9/01	1.66±0.73
TS7-SB-10-0612	4/9/01	2.07±0.86
TS7-SB-10A-0612[a]	4/9/01	1.95±0.7
TS7-SB-11-0612	4/9/01	2.8±1
TS7-SB-12-0612	4/9/01	2.01±0.75
TS7-SB-13-0612	4/9/01	1.59±0.74
TS7-SB-14-0612	4/9/01	3.2±1.1
TS7-SB-15-0612	4/9/01	<1.3
TS7-SB-16-0612	4/9/01	3.9±1.5
TS7-SB-17-0612	4/9/01	<1.2
TS7-SB-18-0612	4/9/01	1.12±0.63
TS7-SB-19-0612	4/9/01	4.2±1.3
TS7-SB-20-0612	4/9/01	2.17±0.78
TS7-SB-20A-0612[b]	4/9/01	1.68±0.72

Notes:
[a]Sample is a replicate of TS7-SB-10-0612
[b]Sample is a replicate of TS7-SB-20-0612
pCi/g = picocuries per gram
σ = standard deviation

2.4.3.5 Graphical Presentations of Results at TS7

A series of three figures present relevant radiological findings at TS7. Figure 2-11 presents the most recent gamma radiation scanning data (October 2000). Figure 2-12 depicts thorium-232 concentrations in surface soil samples from soil cores collected during the 1994/1995 and 1996/1998 investigations, superimposed on isocontours of the October 2000 gamma radiation scanning data. Figure 2-13 shows the April 2001 soil sample results superimposed on the same gamma radiation isocontours. ArcView GIS 8.1® was used to map the spatial distribution of 2000 gamma radiation counts, sample locations, and features such as fences.

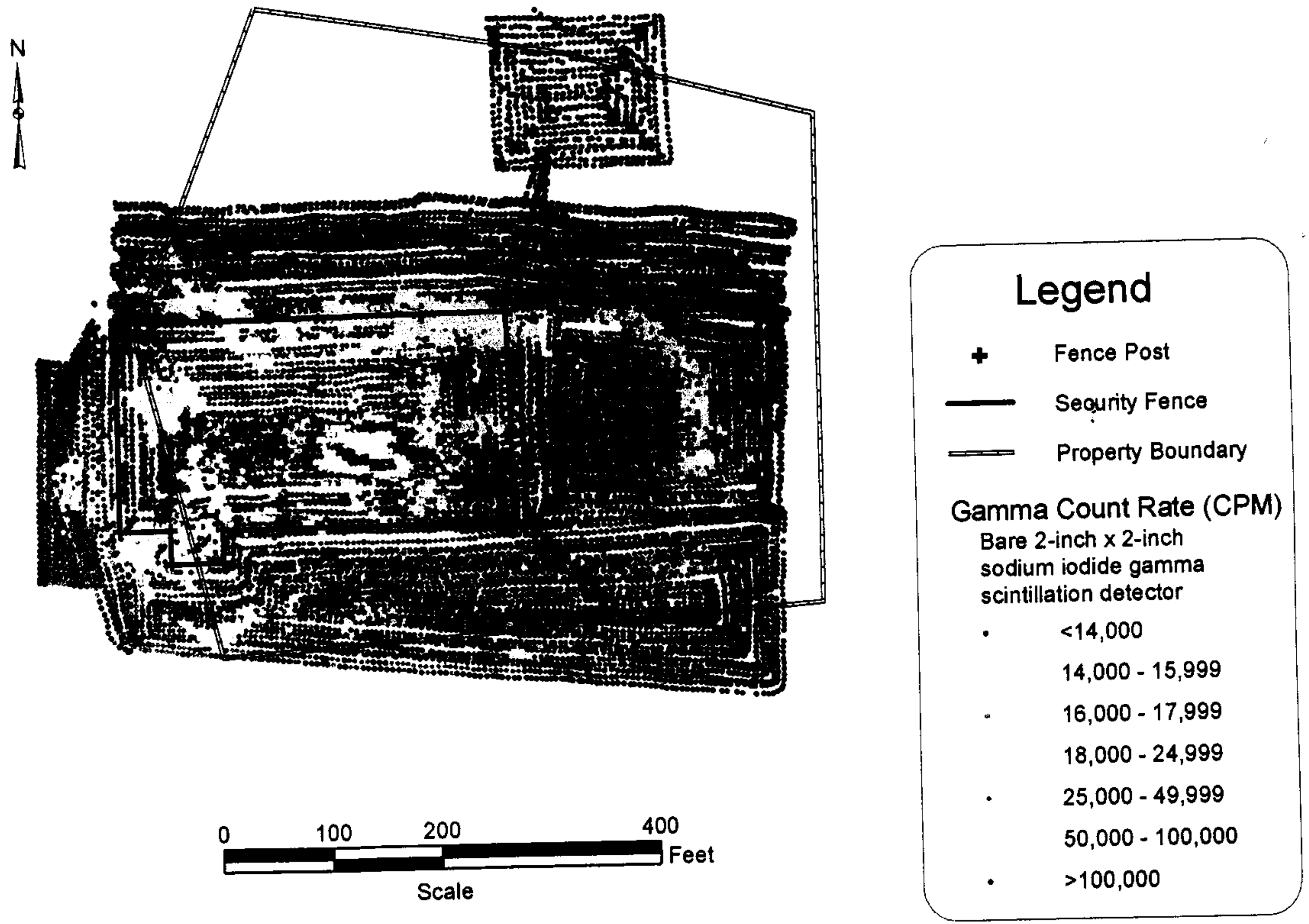


Figure 2-11. October 2000 Gamma Radiation Scanning Results at Training Site 7, Installation Restoration Program Site OT-10

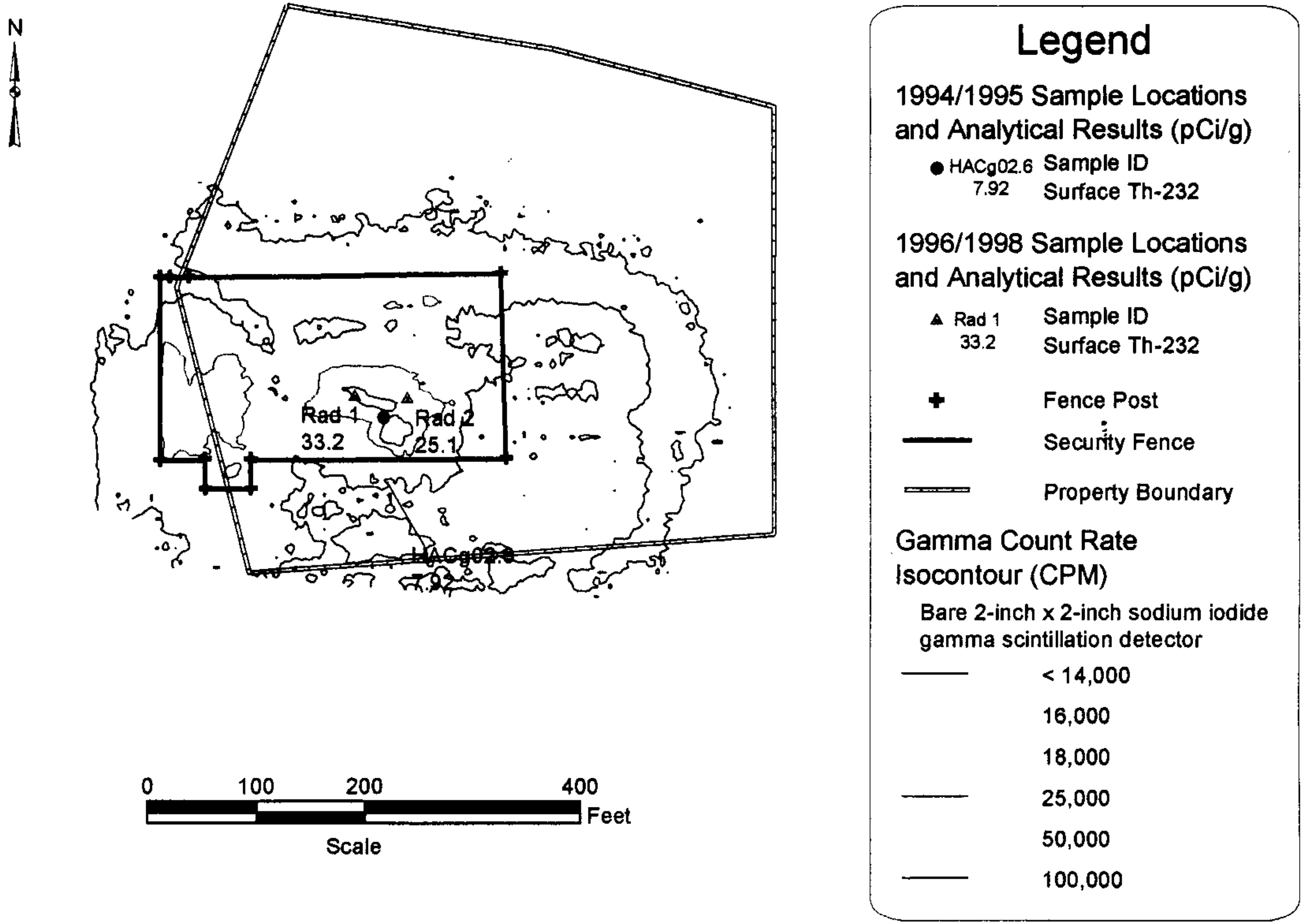


Figure 2-12. Historical Sampling Locations and Results Superimposed on October 2000 Gamma Radiation Scanning Results at Training Site 7, Installation Restoration Program Site OT-10

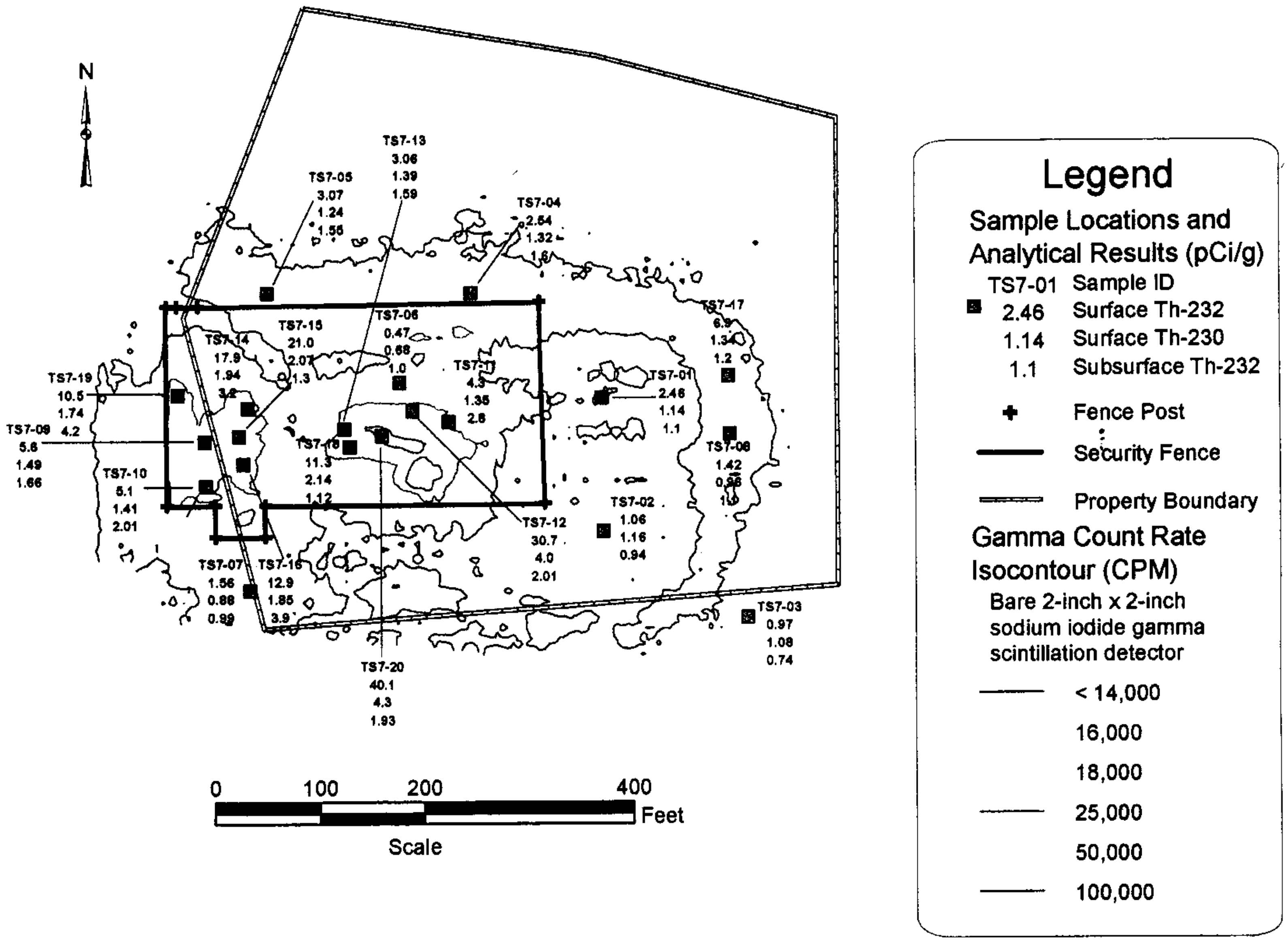


Figure 2-13. April 2001 Sampling Locations and Results Superimposed on October 2000 Gamma Radiation Scanning Results at Training Site 7, Installation Restoration Program Site OT-10

2.4.4 Findings at TS8

The results of previous investigations at TS8 are summarized below and are discussed collectively with results obtained from the other training sites in Section 2.4.5, General Findings.

2.4.4.1 1988 through 1990 Investigation

In 1990, a soil sample was collected outside 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 (USAF, 1992).

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 (USAF, 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 existing USAF removable surface contamination limits, the value of which was not identified in the report (USAF, 1992).

In 1992, air samples were collected quarterly (one each quarter) from the approximate center of Building 28005. 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 (USAF, 1993).

2.4.4.2 1994/1995 Investigation

The 1994/1995 investigation erroneously reported that the entire TS8 area was affected to an average depth of 16 inches bgs. Table 2-16 lists the thorium-230 and thorium-232 soil concentrations observed during this investigation. Thorium-232 concentrations in two samples, determined by alpha spectrometry, were 2.50 and 53.6 pCi/g (USAF, 1997b).

Table 2-16. Isotopic Thorium Concentrations in Soil Core Samples Collected during the 1994/1995 Investigation at Training Site 8, Installation Restoration Program Site OT-10

Sample ID	TS8HACI01.87		TS8HACG01.68	
Depth (inches bgs)	Thorium-232 (pCi/g ± 2σ)[a]	Thorium-230 (pCi/g ± 2σ)[a]	Thorium-232 (pCi/g ± 2σ)[a]	Thorium-230 (pCi/g ± 2σ)[a]
0-6	NA	NA	53.6 ± 2.9	9.17 ± 0.67
6-12	NA	NA	NA	NA
12-18	NA	NA	NA	NA
18-24	2.50 ± 0.27	0.84 ± 0.15	NA	NA
24-30	NA	NA	NA	NA
30-36	NA	NA	NA	NA

Notes:
[a]Results determined using alpha spectrometry
bgs = below ground surface
NA = not analyzed
pCi/g = picocuries per gram
σ = standard deviation

2.4.4.3 *1996/1998 Investigation*

In the 1996/1998 investigation, the average concentration of thorium-232 in 10 samples collected outside TS8 was 0.93 pCi/g.

The 1996/1998 investigation also confirmed the general extent of the contamination defined in the previous investigation. Table 2-17 presents results for the eighteen samples collected from three soil cores advanced at TS8.

Table 2-17. Thorium-232 Concentrations in Soil Samples Collected during the 1996/1998 Investigation at Training Site 8, Installation Restoration Program Site OT-10

Site	Depth (inches bgs)	Thorium-232 Activity (pCi/g)[a]		
		Core 1 (Rad1)	Core 2 (Rad 2)	Core 3 (Rad 3)
TS8	0-6	32.4 + 5.14%	188.0 + 6.45%	3.91 + 9.16%
	6-12	1.92 + 9.47%	7.60 +7.16%	3.18 + 6.58%
	12-18	2.23 + 9.97%	6.85 + 7.06%	1.98 + 8.76%
	18-24	1.22 + 6.95%	9.08 + 4.72%	3.74 + 4.91%
	24-30	NA	12.9 + 6.91%	NA
	30-36	NA	6.53 + 6.41%	NA
	36-42	NA	7.61 + 8/55%	NA
	42-48	NA	3.40 + 9.22%	NA
	48-54	NA	3.95 + 9.55%	NA
	54-60	NA	2.62 ± 16.27%	NA

Notes:
[a]Results determined using gamma spectrometry
bgs = below ground surface
NA = not applicable
pCi/g = picocuries per gram

With the exception of one core (Core 2), radiological impact extended from ground surface to 10-to-24 inches bgs. The average activities to 24 inches bgs in Cores 1 and 2 were 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 (USAF, 1999a).

2.4.4.4 2000/2001 Surveys

Table 2-18 presents the thorium-232 and thorium-230 concentrations in the surface samples collected at TS8 in April 2001 (USAF, 2002a). With three exceptions (TS8-SS-03-0000, TS8-SS-12-0000, and TS8-SS-19-0000), the thorium-232 concentrations determined by alpha and gamma spectrometry are equivalent within error ranges. Section 2.5.1 discusses the collective ratio of thorium-230 to thorium-232 at OT-10.

Table 2-19 presents the thorium-232 concentrations in the subsurface samples collected at TS8. With one exception (TS8-SB-20-0612), all thorium-232 concentrations in the 2001 subsurface samples are below the land area DCGL (5.9 pCi/g thorium-232).

Table 2-18. Thorium Concentrations in Surface Soil Samples Collected in April 2001 at Training Site 8, Installation Restoration Program Site OT-10

Field Sample ID	Date Collected	Thorium 232 by Gamma Spectrometry (pCi/g ± 2σ)	Thorium-232 by Alpha Spectrometry (pCi/g ± 2σ)	Thorium-230 by Alpha Spectrometry (pCi/g ± 2σ)
TS8-SS-01-0000	4/12/01	1.10 ± 0.44	0.74 ± 0.33	0.89 ± 0.37
TS8-SS-02-0000	4/12/01	0.91 ± 0.46	0.80 ± 0.35	0.73 ± 0.33
TS8-SS-03-0000	4/12/01	<0.44	0.99 ± 0.35	0.66 ± 0.26
TS8-SS-04-0000	4/12/01	1.96 ± 0.69	3.31 ± 0.85	0.85 ± 0.29
TS8-SS-05-0000	4/12/01	0.95 ± 0.4	0.69 ± 0.34	0.53 ± 0.29
TS8-SS-06-0000	4/12/01	1.15 ± 0.49	1.78 ± 0.61	1.05 ± 0.42
TS8-SS-07-0000	4/12/01	1.62 ± 0.59	1.24 ± 0.49	1.09 ± 0.45
TS8-SS-08-0000	4/12/01	0.96 ± 0.47	1.61 ± 0.44	1.12 ± 0.33
TS8-SS-09-0000	4/12/01	2.88 ± 0.88	2.84 ± 0.09	0.69 ± 0.32
TS8-SS-10-0000	4/12/01	3.4 ± 1	3.21 ± 0.81	0.80 ± 0.27
TS8-SS-10A-0000[a]	4/12/01	4.1 ± 1.1	3.04 ± 0.83	0.73 ± 0.28
TS8-SS-11-0000	4/12/01	2.53 ± 0.82	3.28 ± 0.77	0.81 ± 0.24
TS8-SS-12-0000	4/12/01	4.8 ± 1.3	21.2 ± 4.6	3.15 ± 0.76
TS8-SS-13-0000	4/12/01	6.5 ± 1.8	10.4 ± 2.4	2.05 ± 0.53
TS8-SS-14-0000	4/12/01	8.4 ± 2.3	7.7 ± 1.8	<0.7
TS8-SS-15-0000	4/12/01	3.4 ± 1	3.1 ± 1.1	1.19 ± 0.55
TS8-SS-16-0000	4/12/01	2.68 ± 0.89	3.1 ± 1	0.95 ± 0.42

Table 2-18. Thorium Concentrations in Surface Soil Samples Collected in April 2001 at Training Site 8, Installation Restoration Program Site OT-10 (concluded)

Field Sample ID	Date Collected	Thorium 232 by Gamma Spectrometry (pCi/g ± 2σ)	Thorium-232 by Alpha Spectrometry (pCi/g ± 2σ)	Thorium-230 by Alpha Spectrometry (pCi/g ± 2σ)
TS8-SS-17-0000	4/12/01	9.6±2.6	10.2±2.4	2.11±0.57
TS8-SS-18-0000	4/12/01	11.2±3	15.4±3.4	2.46±0.63
TS8-SS-19-0000	4/12/01	11.8±3.1	32.5±7.4	6.0±1.4
TS8-SS-20-0000	4/12/01	52±13	47±12	5.4±1.6
TS8-SS-20A-0000[b]	4/12/01	42±11	43±11	4.8±1.3

Notes:
[a]Sample is a replicate of TS8-SS-10-0000
[b]Sample is a replicate of TS8-SS-20-0000
pCi/g = picocuries per gram
σ = standard deviation

Table 2-19. Thorium Concentrations in Subsurface Soil Samples Collected in April 2001 at Training Site 8, Installation Restoration Program Site OT-10

Field Sample ID	Date Collected	Thorium-232 by Gamma Spectrometry (pCi/g)
TS8-SB-01-0612	4/12/01	<1.0
TS8-SB-02-0612	4/12/01	1.31 ± 0.68
TS8-SB-03-0612	4/12/01	1.21 ± 0.5
TS8-SB-04-0612	4/12/01	<1.2
TS8-SB-05-0612	4/12/01	<0.84
TS8-SB-06-0612	4/12/01	<1.1
TS8-SB-07-0612	4/12/01	<1.0
TS8-SB-08-0612	4/12/01	<1.0
TS8-SB-09-0612	4/12/01	2.28 ± 0.87
TS8-SB-10-0612	4/12/01	2.20 ± 0.91
TS8-SB-10A-0612[a]	4/12/01	1.41 ± 0.78
TS8-SB-11-0612	4/12/01	2.88 ± 0.98
TS8-SB-12-0612	4/12/01	2.04 ± 0.78
TS8-SB-13-0612	4/12/01	2.10 ± 0.77
TS8-SB-14-0612	4/12/01	1.97 ± 0.8
TS8-SB-15-0612	4/12/01	<1.2
TS8-SB-16-0612	4/12/01	1.75 ± 0.76
TS8-SB-17-0612	4/12/01	3.7 ± 1.1
TS8-SB-18-0612	4/12/01	5.1 ± 1.4
TS8-SB-19-0612	4/12/01	5.5 ± 1.6
TS8-SB-20-0612	4/12/01	19.8 ± 4.8
TS8-SB-20A-0612[b]	4/12/01	20.6 ± 5.2

Notes:
[a]Sample is a replicate of TS8-SB-10-0612
[b]Sample is a replicate of TS6-SB-20-0612
pCi/g = picocuries per gram
σ = standard deviation

2.4.4.5 *Graphical Presentations of Land Area Results at TS8*

A series of three figures present relevant radiological findings at TS8. Figure 2-14 presents the most recent gamma radiation scanning data (October 2000). Figure 2-15 depicts thorium-232 concentrations in surface soil samples from soil cores collected during the 1994/1995 and 1996/1998 investigations, superimposed on isocontours of the October 2000 gamma radiation scanning data. Figure 2-16 shows the April 2001 soil sample results superimposed on the same isocontours. ArcView GIS 8.1® was used to map the spatial distribution of 2000 gamma radiation counts, sample locations, and features such as fences.

2.4.4.6 *Bunker Survey Results*

The building surface survey showed that the bunker chosen as a reference has very low levels of radioactivity on its surfaces, and exposure rate levels within the bunker represent those encountered outside the bunker. In addition, the total activity measurements agreed well with the removable levels, serving as evidence that the levels of radon progeny also were very low in the reference bunker.

Figure 2-17 is a drawing of the reference bunker. One-m^2 grid blocks were established over the floor, two walls, and ceiling. The total alpha counts for each grid block are shown in Figure 2-18.

No areas of maximum contamination could be observed in any of the grid blocks. The maximum total surface alpha activity was assumed equal to the average for each grid block. The average surface activity was 0.56 cpm with a maximum of 5 cpm.

Equation 2-2 was used to calculate the average surface activity in terms of dpm/100 cm^2:

$$A_d = A_c / (\varepsilon * Area / 100), \qquad \text{Eq. 2-2}$$

where A_d is surface activity in dpm/100 cm^2, A_c is surface activity in cpm, ε is probe efficiency in cpm/dpm, and area is the probe area in cm^2.

With a probe efficiency of 0.13 cpm/dpm and an active probe area of 76 cm^2, 0.56 cpm corresponds to an average surface activity of 6 dpm/100 cm^2 and 5 cpm corresponds to 51 dpm/100 cm^2, averaged over 1 m^2.

The exposure rates within the reference bunker were all within the normal variation of the Ludlum Model 44-9 thin window G-M pancake probe, ranging from 8-13 microRoentgens per hour (μR/hr), which is typical of natural background in the vicinity of OT-10.

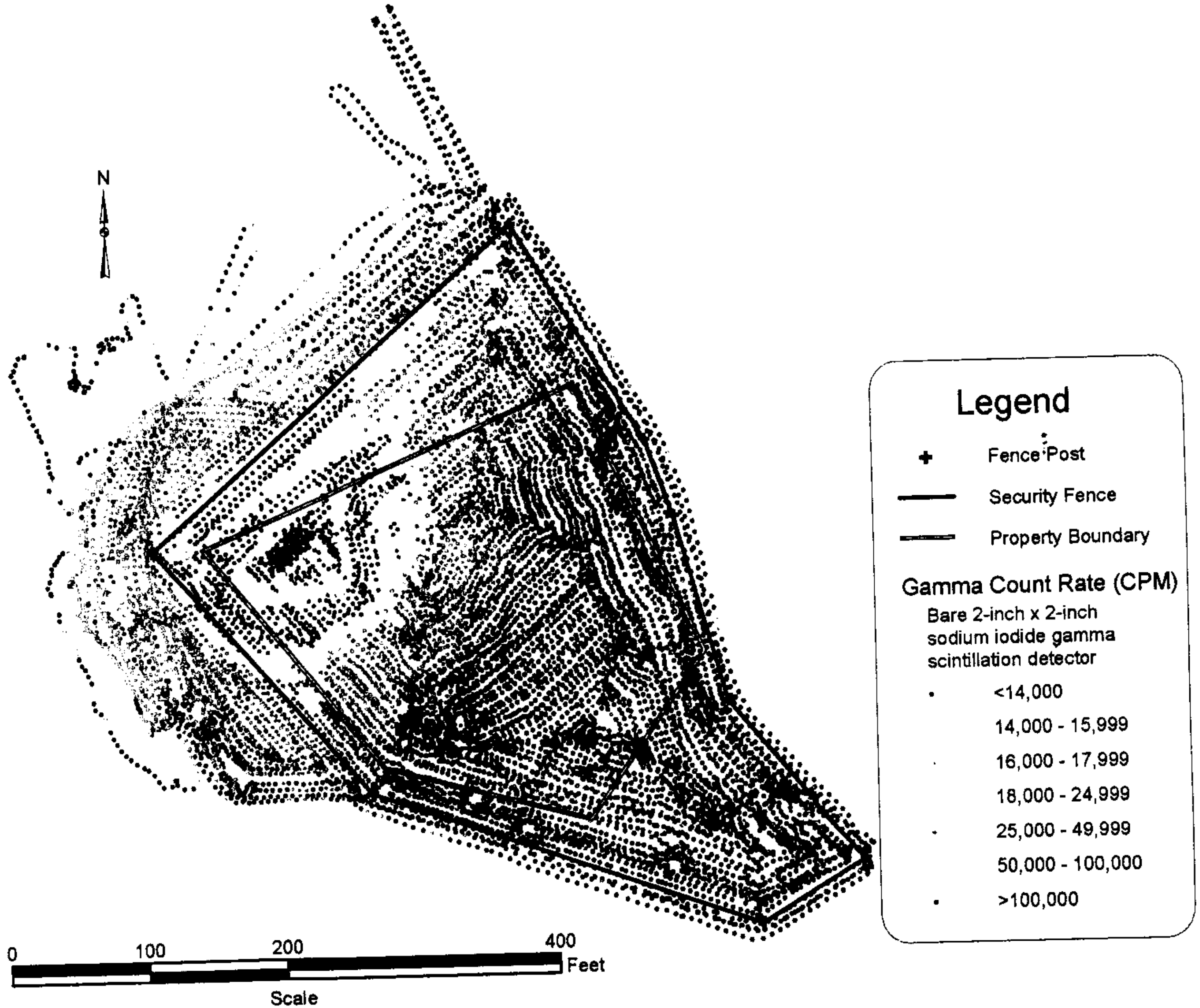


Figure 2-14. October 2000 Gamma Radiation Scanning Results at Training Site 8, Installation Restoration Program Site OT-10

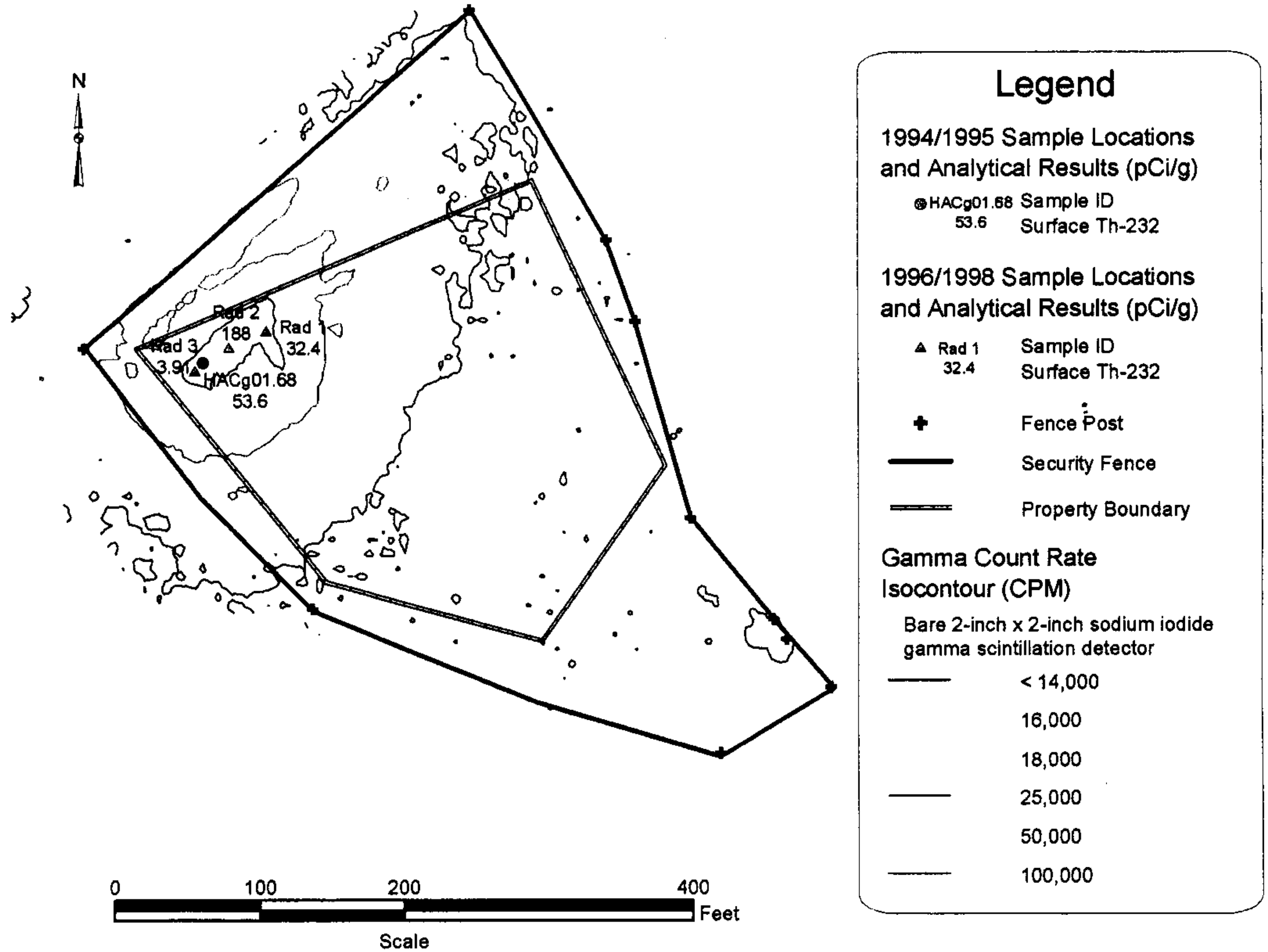


Figure 2-15. Historical Sampling Locations and Results Superimposed on October 2000 Gamma Radiation Scanning Results at Training Site 8, Installation Restoration Program Site OT-10

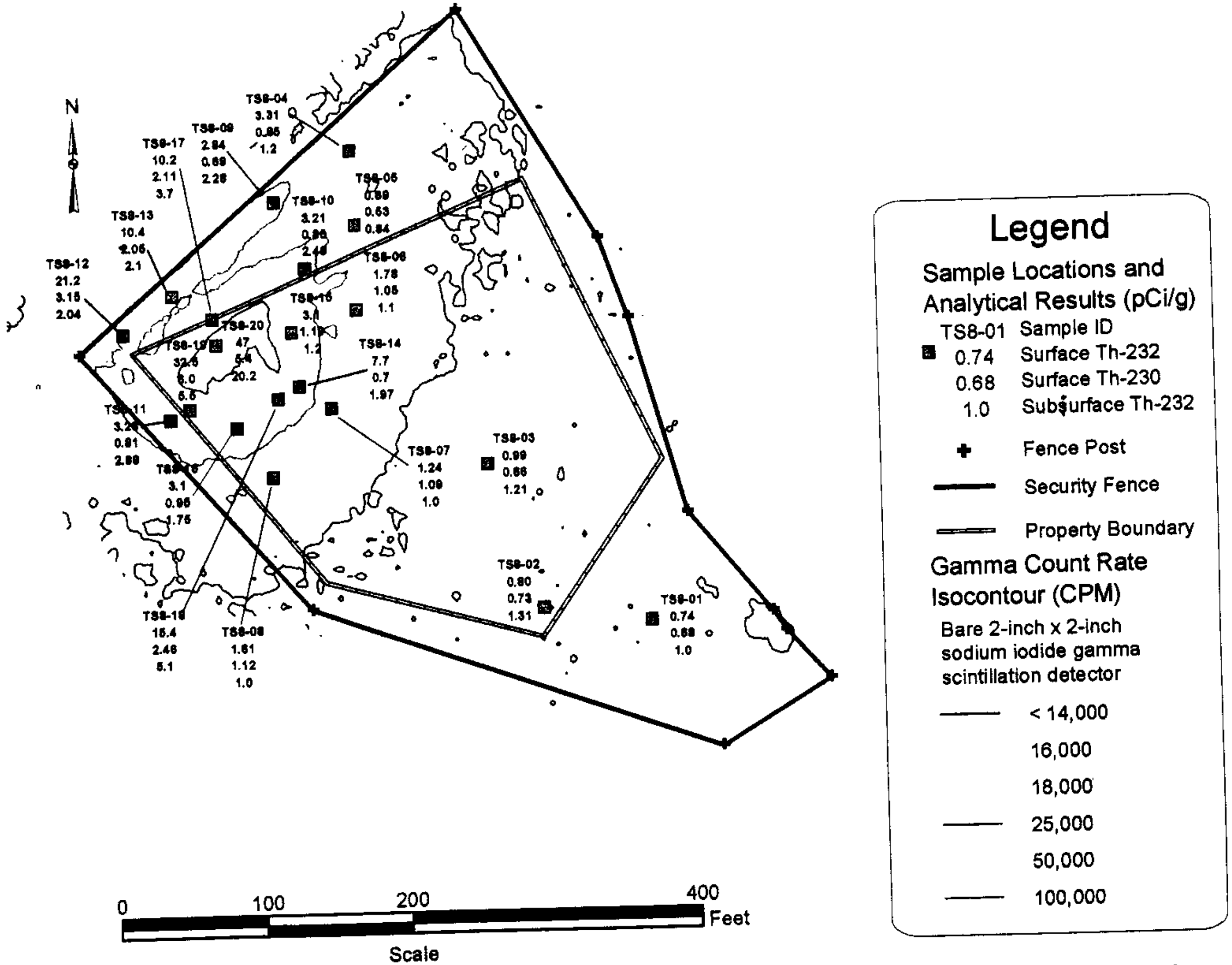


Figure 2-16. April 2001 Sampling Locations and Results Superimposed on October 2000 Gamma Radiation Scanning Results at Training Site 8, Installation Restoration Program Site OT-10

Figure 2-17. Reference Bunker, Building 28012, Installation Restoration Program Site OT-10

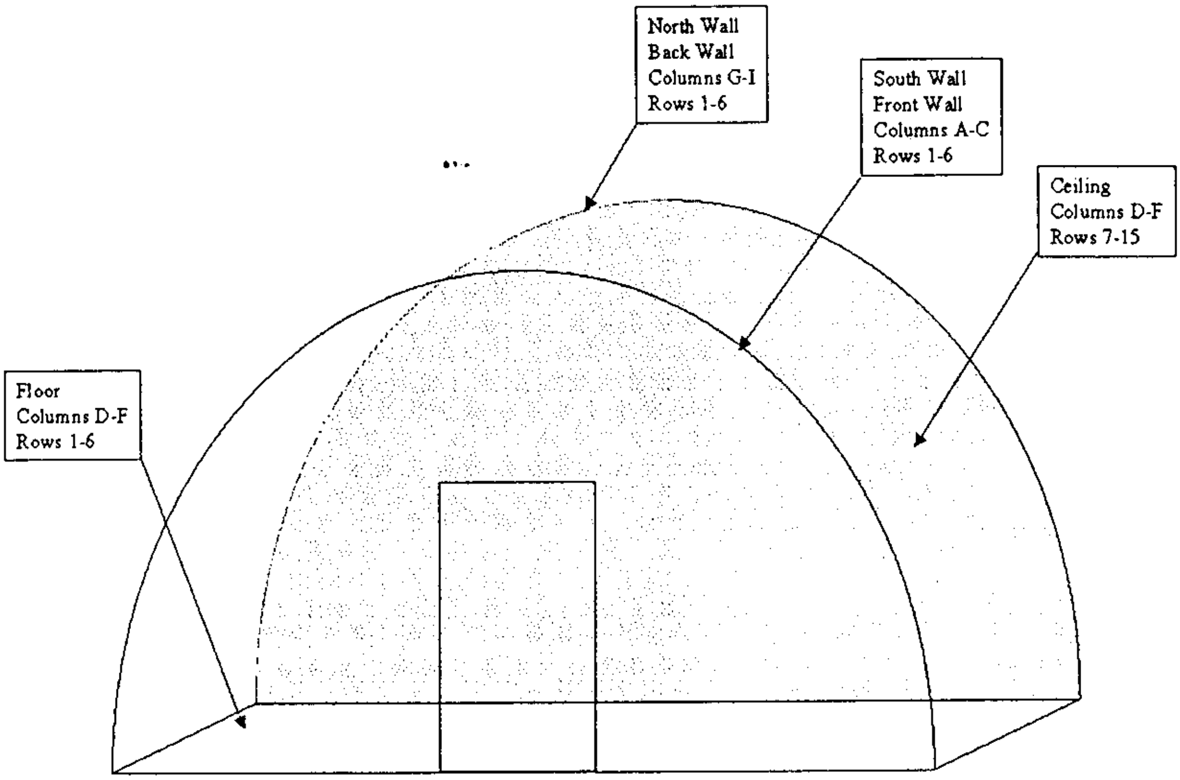


Figure 2-18. Total Surface Contamination in Reference Bunker Grid Blocks on Floor, Walls, and Ceiling, Building 28012, Installation Restoration Program Site OT-10

South Wall

A1 n/a	B1 0 cpm	C1 0 cpm
A2 4 cpm	B2 2 cpm	C2 1 cpm
A3 1 cpm	B3 0 cpm	C3 5 cpm
A4 0 cpm	B4 1 cpm	C4 1 cpm
A5 0 cpm	B5 0 cpm	C5 1 cpm
A6 n/a	B6 0 cpm	C6 1 cpm

South **Floor** **North**

D1 0 cpm	E1 0 cpm	F1 0 cpm
D2 0 cpm	E2 0 cpm	F2 0 cpm
D3 0 cpm	E3 0 cpm	F3 0 cpm
D4 0 cpm	E4 0 cpm	F4 0 cpm
D5 0 cpm	E5 0 cpm	F5 0 cpm
D6 0 cpm	E6 0 cpm	F6 0 cpm

North Wall **Top**

G1 1 cpm	H1 0 cpm	I1 n/a
G2 0 cpm	H2 0 cpm	I2 2 cpm
G3 3 cpm	H3 0 cpm	I3 0 cpm
G4 0 cpm	H4 1 cpm	I4 0 cpm
G5 1 cpm	H5 2 cpm	I5 0 cpm
G6 1 cpm	H6 1 cpm	I6 n/a

West End of Floor										East End of Floor
North	F7 0 cpm	F8 1 cpm	F9 0 cpm	F10 0 cpm	F11 n/a	F12 n/a	F13 1 cpm	F14 0 cpm	F15 0 cpm	
	E7 1 cpm	E8 2 cpm	E9 1 cpm	E10 2 cpm	E11 n/a	E12 n/a	E13 3 cpm	E14 2 cpm	E15 0 cpm	
South	D7 0 cpm	D8 1 cpm	D9 1 cpm	D10 2 cpm	D11 0 cpm	D12 n/a	D13 1 cpm	D14 0 cpm	D15 1 cpm	

Center of Ceiling

Nine, 1-minute integrated exposure rate measurements were taken in the bunker after the gamma exposure rate in the bunker was determined to be uniform. Field personnel used a Ludlum Model 44-9 thin window G-M pancake probe coupled to a Ludlum Model 2221 ratemeter/scaler set in scaler mode. The results were 44, 45, 54, 57, 61, 63, 63, 66, and 68 cpm. The efficiency of the detector is approximately 14 percent for both alpha particles and beta particles and approximately 1 percent for gamma rays. The background measured outside the bunker prior to the survey was 69 cpm.

Removable contamination readings were the calculated differences between gross and background count rates. The average removable levels of contamination were 0.2 dpm/100 cm^2 for alpha and –9 dpm/100 cm^2 for beta (USAF, 2002a).

For the wipe samples, the Ludlum Model 43-10-1 alpha/ beta tray counter had an alpha efficiency of 0.365 cpm/dpm and a beta efficiency of 0.212 cpm/dpm for thorium-230 and technitium-99 sources, respectively. Fifteen, 1-minute background counts were taken with the counter. The alpha background averaged 0.2 cpm with a standard deviation of 0.4. The beta background averaged 83 cpm with a standard deviation of 10.

The background counts were used to calculate minimum detectable activities (MDAs) for alpha (14 dpm/100 cm^2) and beta (214 dpm/100 cm^2), using the following MARSSIM equation:

$$MDA = \frac{100 * \left(3 + 4.65\sqrt{S_b}\right)}{T\varepsilon A} \qquad \text{Eq. 2-3}$$

where MDA is in dpm/100 cm^2, S_b is the standard deviation of background counts in cpm, T is the counting in minutes, ε is probe efficiency in cpm/dpm, and A is the probe area in cm^2 (EPA, 1997).

The average removable levels of alpha (0.2 dpm/100 cm^2) and beta (-9 dpm/100 cm^2) contamination were three orders of magnitude below their associated MDAs. It can be concluded that, on average, no detectable activity was removed from the building surfaces by the wipe samples.

2.4.4.7 Building 28010

Thirty-two 55-gallon steel drums, mostly without bottoms or lids, were stacked on their sides approximately four drums high along the west wall in Building 28010. The drums are remnants of a USAF remediation effort at CAU SS-69. The drums were staged temporarily in Building 28010 prior to potential disposal action (USAF, 2002c). Two lidded drums, one orange and one black, stood in the north central portion of the bunker. Both drums were heavy; that is, not empty. The lid of the orange drum was not banded. Two pallets lay on the southern end of the floor. Figure 2-19 is a photograph of the contents of Building 28010.

The unobstructed area of the floor was covered with blow sand and dirt to a depth of approximately one centimeter. The sand and dirt probably entered through the vents in the doors and/or spaces between the doors and east wall. Figure 2-20 is a drawing of Building 28010 and features therein.

Figure 2-19. Photograph of Contents in Building 28010, Installation Restoration Program Site OT-10

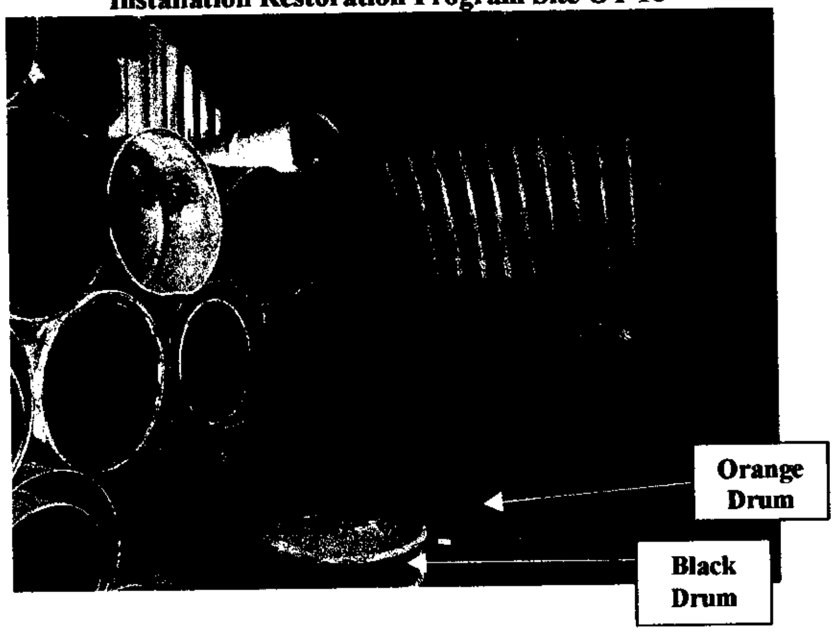
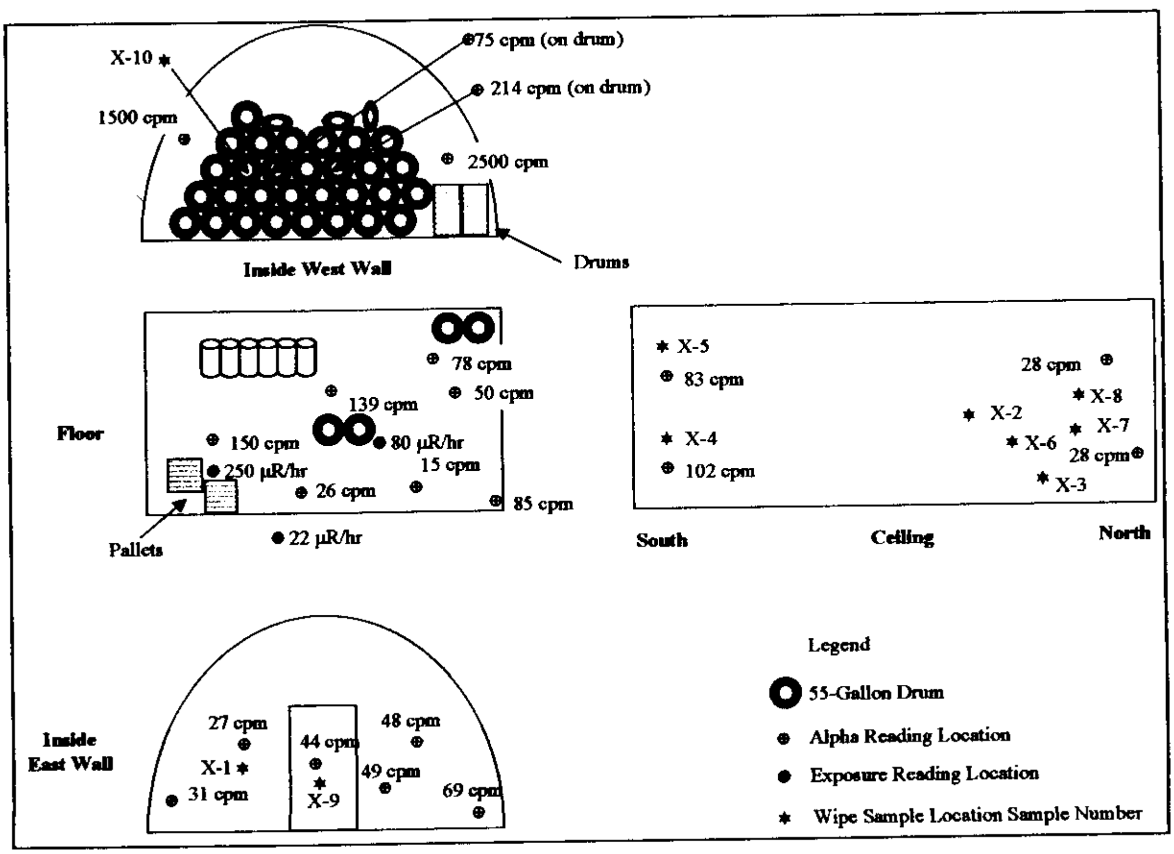


Figure 2-20. Total Surface Contamination in Building 28010, Installation Restoration Program Site OT-10



The gamma exposure rate was 22 µR/hr at the door outside the bunker, whereas the outside background was 10 to12 µR/hr. Upon entry to the building, the exposure rate climbed significantly. A maximum exposure rate of 250 µR/hr was measured at a pile of slag-like material and debris in the southeast corner on the floor. Exposure rates within some of the empty drums located along the west wall of the bunker were significantly elevated, apparently from residual contamination. The exposure rate on the orange drum was 80 µR/hr. The exposure rate on the black drum was similar to local background inside the bunker.

Background alpha levels, determined using a Ludlum 43-5 detector, were approximately zero cpm. A total surface contamination reading of 370 dpm/100 cm^2 (44 cpm) was obtained on the outside of the door near a vent. The surface contamination levels on the floor, walls, and ceiling of the bunker ranged from 100 to 800 dpm/100 cm^2. Contamination on some of the drums exceeded 2,500 dpm/100 cm^2.

Total surface contamination levels were taken and wipe samples were collected at the 10 locations marked X-1 through X-10 on Figure 2-20. Table 2-20 shows the total alpha and beta counts on interior surfaces. The range of total surface contamination measurements (120 to 544 dpm/100 cm^2) for the first count activities enveloped the limit for total surface contamination (170 dpm/100 cm^2) and the average (275 dpm/100 cm^2) exceeded this limit.

Table 2-20. Alpha and Beta Counts on Interior Surfaces and Wipe Samples Collected from Building 28010

	Field Measurement Using Ludlum 43-5	Gross Count Rate Using Alpha/Beta Tray Counter (cpm/100 cm^2)		Background Count Rate (cpm/100 cm^2)		Removable Surface Contamination (using wipe samples)		Total Surface Contamination
Location	Alpha (dpm/76 cm^2) a	Alpha b	Beta b'	Alpha c	Beta c'	Alpha (dpm/100 cm^2) =(b-c)/0.365	Beta (dpm/100 cm^2) =(b'-c')/0.211	Alpha (dpm/100 cm^2) =a(10.88)
X-1	50	36	84	0.2	83	98	5	544
X-2	11	14	80	0.2	83	38	-14	120
X-3	11	8	73	0.2	83	21	-47	120
X-4	23	15	71	0.2	83	41	-57	250
X-5	33	15	82	0.2	83	41	-5	359
X-6	15	7	102	0.2	83	19	90	163
X-7	13	8	86	0.2	83	21	14	141
X-8	18	21	94	0.2	83	57	52	196
X-9	44	34	78	0.2	83	93	-24	478
X-10	35	18	79	0.2	83	49	-19	381

Notes:
cpm = counts per minute
cm^2 = square centimeters
dpm = disintegrations per minute

The limit for removable alpha contamination (34 dpm/100 cm^2) also occurred within the range of observations (19 to 98 dpm/100 cm^2). The average of results (48 dpm/100 cm^2) exceeded the limit.

The wipe samples were collected at approximately 2 p.m. on June 1, 2001. The samples were counted at 4 p.m. on that day and again at 9:30 a.m. on June 9, 2001. Table 2-21 presents the results for the two counting times. The first count activities were elevated whereas the second count activities were near background levels.

Table 2-21. Reduction in Alpha Contamination on Wipe Samples Collected from Building 28010

Location	Total Alpha (dpm/100 cm^2)	Removable Alpha on 6/1/01 4:00 p.m. (dpm/100 cm^2)	Removable Alpha on 6/9/01 9:30 a.m. (dpm/100 cm^2)
X-1	544	98	-1
X-2	120	38	-1
X-3	120	21	2
X-4	250	41	2
X-5	359	41	-1
X-6	163	19	5
X-7	141	21	2
X-8	196	57	-1
X-9	478	93	2
X-10	381	49	10

Notes:
cm^2 = square centimeters
dpm = disintegrations per minute

Activities on most of the wipe samples were less than about 30 percent of the total activity (after approximately 3 hours decay time) and near background levels after 8 days. This indicates that the activity came from radon decay progeny on the walls.

Because the reference bunker did not have high levels of surface activity from natural radon sources, the radon progeny within Building 28010 is probably derived from the thorium ore stored in the bunkers. The exceptional sample is X-10, which was the only sample collected from a drum surface. The residual alpha contamination in this case is probably from slag on the drum surface.

2.4.4.8 Building 28005

Upon entry to Building 28005, contamination levels were immediately considered to be above those allowing decontamination as a viable option. As shown in Figure 2-21, the gamma exposure rate within the bunker ranged from 250 μR/hr to 4.5 milliRoentgens/hour (mR/hr).

The bunker contained three drums: one drum was empty but the other two drums contained radioactive material producing exposure rates at the drum surface of 4 and 4.5 mR/hr. Of the two non-empty drums, one was filled with material, with coveralls visible on the top. The other drum had a lid and was wrapped in clear plastic. The nine total surface contamination measurements made with a Ludlum Model 43-5 detector ranged from 1,000 cpm (10,000 dpm/100 cm^2) to 20,000 cpm (200,000 dpm/100 cm^2). Because of the limited number of measurements (9), there is no reason to believe that this range bounds the surface contamination values. The walls, ceiling, and floor of this bunker were covered with a thick black surface residue, confirming anecdotal information that there had been a fire in the bunker. Figure 2-22 is a photograph of one of the walls, the floor, and the ceiling. Two of the three drums are shown in this figure.

No surface wipe samples were taken from this bunker. The high activity, as predicted from the direct measurements, would have made it difficult to count the samples without creating potential personnel, laboratory, and equipment contamination problems. Without wipe samples, it is not possible to determine the percent of surface activity from radon-220 progeny.

Figure 2-21. Total Surface Contamination and Exposure Measurements in Building 28005, Installation Restoration Program Site OT-10

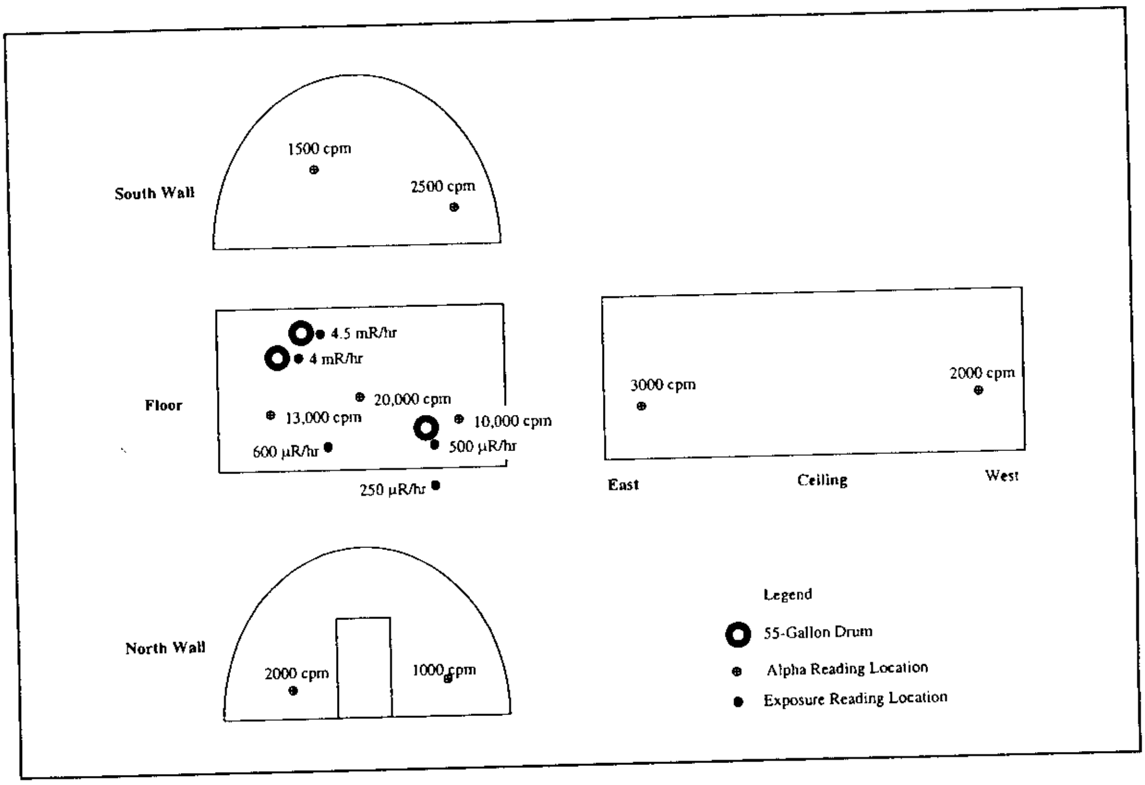
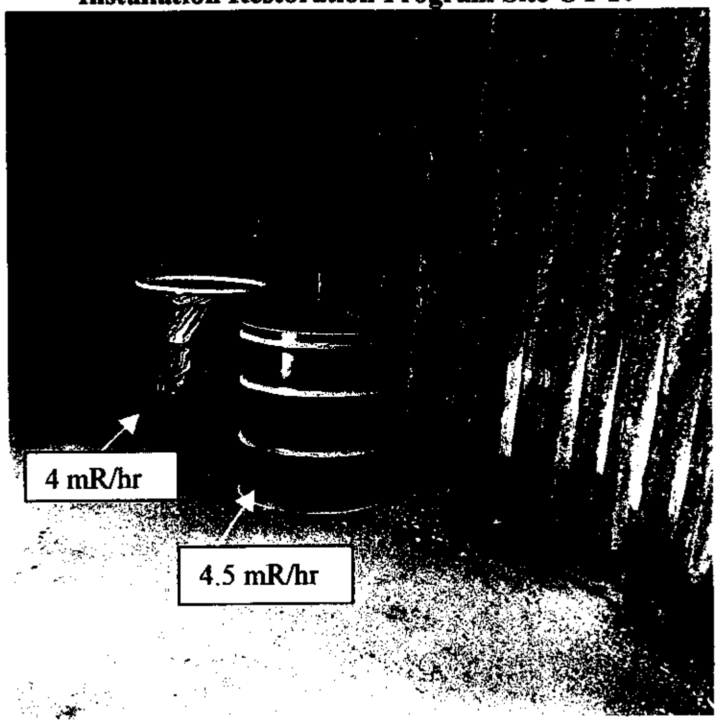


Figure 2-22. Photograph of Contamination in Building 28005, Installation Restoration Program Site OT-10



2.4.5 General Findings at OT-10

2.4.5.1 Reference Area

Figure 2-23 presents the gamma radiation measurements at the reference area and the April 2001 soil sample results. Gamma radiation measurements ranged from 10,427 to 15,379 cpm and averaged 12,407 cpm (USAF, 2002a).

Table 2-22 presents the thorium-232 concentrations detected in the April 2001 reference area surface soil samples. Table 2-22 also lists the static bare and collimated 2-inch by 2-inch sodium iodide detector measurements.

Table 2-22. Thorium-232 Concentrations in April 2001 Reference Area Surface Soil Samples, Installation Restoration Program Site OT-10

Field Sample ID	Date Collected	Thorium 232 by Alpha Spectrometry (pCi/g ± 2σ)	Thorium-232 by Gamma Spectrometry (pCi/g ± 2σ)	Thorium 230 by Alpha Spectrometry (pCi/g ± 2σ)	Bare Detector Reading (cpm)	Collimated Detector Reading (cpm)
RA-SS-01-0000	4/7/01	0.91 ± 0.4	1.04 ± 0.45	1.01 ± 0.43	12,305	3,901
RA-SS-02-0000	4/7/01	0.84 ± 0.35	0.91 ± 0.39	1.02 ± 0.4	12,642	3,842
RA-SS-03-0000	4/7/01	0.75 ± 0.4	<0.79	1.1 ± 0.51	12,508	3,938
RA-SS-04-0000	4/7/01	0.96 ± 0.35	<0.76	0.76 ± 0.3	12,296	3,841
RA-SS-05-0000	4/7/01	0.81 ± 0.37	0.67 ± 0.41	0.78 ± 0.37	12,239	3,865
RA-SS-06-0000	4/7/01	0.79 + 0.33	0.68 ± 0.48	0.88 ± 0.36	12,243	3,951
RA-SS-07-0000	4/7/01	1.07 ± 0.49	1.0 ± 0.47	0.92 ± 0.45	12,448	3,902
RA-SS-08-0000	4/7/01	0.83 ± 0.34	0.72 ± 0.35	0.87 ± 0.36	12,533	3,878
RA-SS-09-0000	4/7/01	0.97 ± 0.39	1.1 ± 0.43	0.87 ± 0.36	12,621	3,952
RA-SS-10-0000	4/7/01	0.67 ± 0.27	0.86 ± 0.36	0.91 ± 0.37	12,102	3,932
RA-SS-10a-0000[a]	4/7/01	0.89 ± 0.33	0.93 ± 0.4	0.89 ± 0.38	12,102	3,932
RA-SS-11-0000	4/7/01	0.89 ± 0.36	1.04 ± 0.46	1.05 ± 0.41	12,924	3,991
RA-SS-12-0000	4/7/01	1.06 ± 0.47	0.86 ± 0.39	1.06 ± 0.47	13,045	3,986
RA-SS-13-0000	4/7/01	0.75 ± 0.29	<0.61	0.75 ± 0.29	12,357	3,964
RA-SS-14-0000	4/7/01	0.85 ± 0.3	1.22 ± 0.48	0.85 ± 0.3	12,491	3,907
RA-SS-15-0000	4/7/01	0.67 ± 0.67	0.87 ± 0.47	0.67 ± 0.28	12,277	3,936
RA-SS-16-0000	4/7/01	1.2 ± 0.43	<0.80	1.08 ± 0.4	12,978	4,016
RA-SS-17-0000	4/7/01	1.06 ± 0.39	0.80 ± 0.47	1.12 ± 0.4	12,398	3,818
RA-SS-18-0000	4/7/01	1.12 ± 0.36	0.74 ± 0.41	0.96 ± 0.32	12,975	4,193
RA-SS-19-0000	4/7/01	0.91 ± 0.34	0.87 ± 0.49	1.08 ± 0.38	12,621	3,958
RA-SS-20-0000	4/7/01	1.04 ± 0.37	<0.66	0.81 ± 0.34	12,911	4,027
RA-SS-20a-0000[a]	4/7/01	1.15 ± 0.43	1.16 ± 0.49	1.15 ± 0.43	12,911	4,027

Notes:
[a]Sample is a replicate of RA-SS-10-0000
[b]Sample is a replicate of RA-SS-20-0000
cpm = counts per minute
ID = identification
pCi/g = picocuries per gram
σ = standard deviation

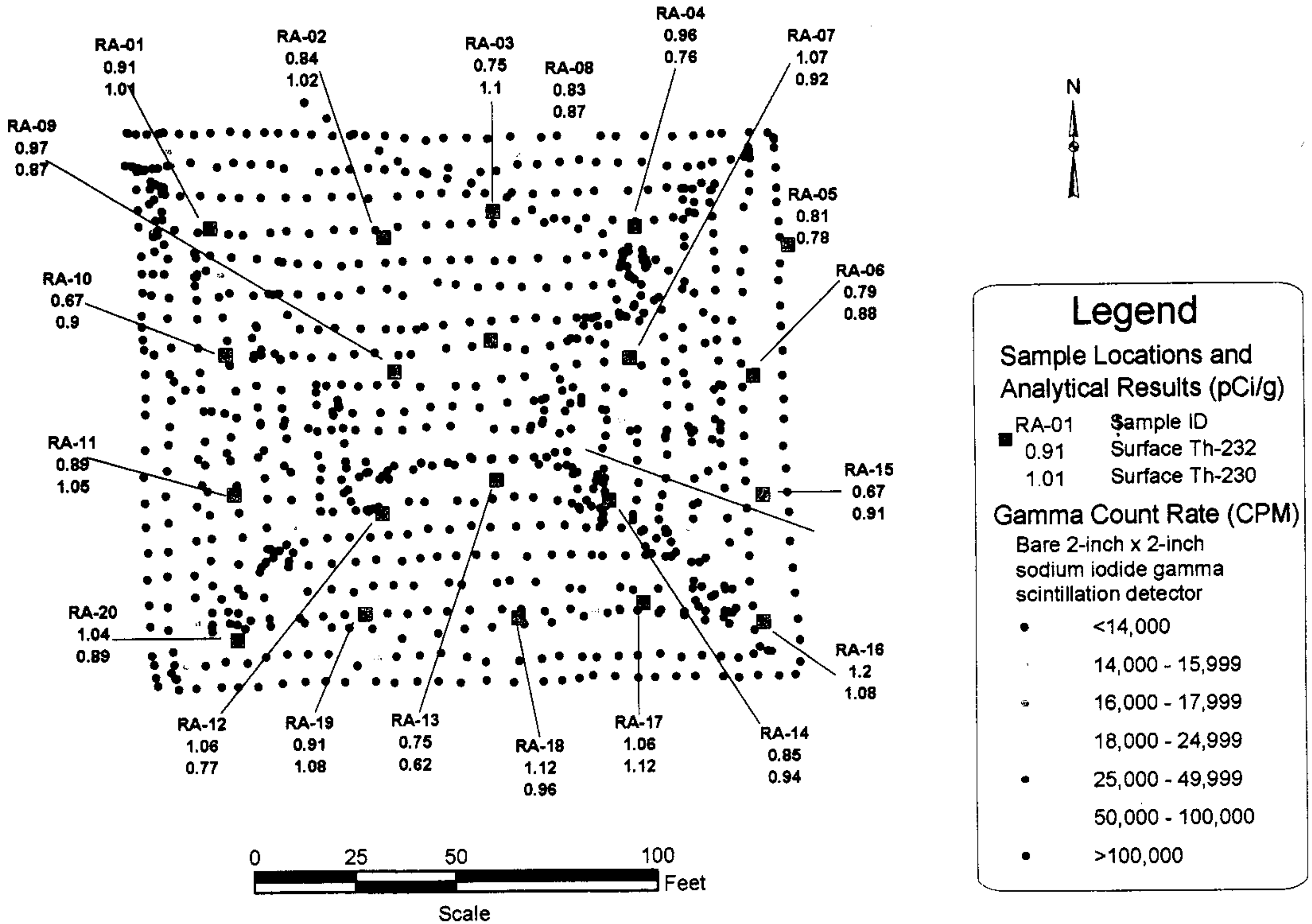


Figure 2-23. April 2001 Soil Sampling Results Superimposed on Gamma Radiation Scanning Results at the Reference Land Area, Installation Restoration Program Site OT-10

Table 2-23 presents the average, standard deviations, and ranges of the population of thorium-232 and thorium-230 concentrations in the reference area.

Table 2-23. Distributions of Thorium-232 and Thorium-230 in the Reference Area Installation Restoration Program Site OT-10

Thorium-232 Concentration (pCi/g)			Thorium-230 Concentration (pCi/g)		
Average	Standard Deviation	Range	Average	Standard Deviation	Range
0.91	0.15	0.67 – 1.2	0.93	0.13	0.62 – 1.12

Notes:
pCi/g = picocuries per gram

The 2000/2001 reference area thorium-232 concentration (0.91 pCi/g) is adopted as the background value for thorium-232 for the OT-10 decommissioning. The standard deviation of thorium-232 concentrations in the reference area will be used to calculate the number of samples to be collected in the final status survey, if it exceeds the standard deviation determined during remedial action support surveys.

The uranium-238 background concentration is assumed to be 0.93 pCi/g. The actual reference area (background) concentration of uranium-238 will be determined during project mobilization. An offsite laboratory will analyze approximately 15 archived reference area samples for isotopic uranium. The archived samples are the same samples collected from the reference land area in 2001; they were returned by Severn Trent Laboratories to Kirtland AFB after being analyzed for isotopic thorium and gamma spectrometry.

2.4.5.2 Analysis of Source Material

In 1993, AFIERA/SDRH analyzed the OT-10 source material for gamma-emitting radionuclides by gamma spectrometry. Table 2-24 presents the analytical results.

Table 2-24. Gamma Spectrometry Analysis of Source Material, Installation Restoration Program Site OT-10

Sample ID	GS920248	
Radionuclide	Concentration (pCi/g)	Error (pCi/g)
Actinium-228	18,000	300
Bismuth-212	<800	
Bismuth-214	1,900	100
Cesium-134	<50	
Cesium-137	<70	
Lead-212	15,000	700
Lead-214	2,000	100
Potassium-40	<600	
Radium-224	<3000	
Radium-226	<1,100	
Thallium-208	6,200	200
Thorium-228	20,000	1,300
Thorium-232	18,000	300
Uranium-235	2,300	20

Notes:
ID = identifier
pCi/g = picocuries per gram

2.4.5.3 Cesium-137 Concentrations

Twenty-four background surface soil samples were analyzed by gamma spectrometry for cesium-137 in the 1996/1998 investigation. The average concentration of cesium-137 in these samples was 0.24 pCi/g. In addition, eight of the surface samples and five of the subsurface samples collected from OT-10 hot spots were analyzed for cesium-137 (USAF, 1999a). The average concentrations of cesium-137 in these samples were 0.21 pCi/g (surface samples) and 0.16 pCi/g (subsurface samples) (USAF, 1999a). Table 2-25 presents cesium-137 concentrations determined in the 1996/1998 investigation.

Cesium-137 concentrations in the 2000/2001 waste profile surface samples were 0.27 and -0.18 pCi/g as reported in Table 2-11.

The SNL/NMED approved background concentration for surface soil near Site OT-10 (0.908 pCi/g [SNL/NMED, 1996]) exceeds the average OT-10 concentrations by approximately a factor of 4. In addition, none of the Site OT-10 cesium-137 concentrations observed to date exceeds this SNL/NMED-approved background concentration.

Table 2-25: Cesium-137 Concentrations Detected in 1996/1998 Investigation, Installation Restoration Program Site OT-10

Location	Field Sample ID	Cesium-137 by Gamma Spectrometry (pCi/g ± Error %)	SNL/NMED Approved Background Cesium-137 Concentration (pCi/g)[a]
Background Samples: TS5	S5-bkgA	0.29 ± 5.76	0.908
	S5-bkgB	0.17 ± 6.32	0.908
	S5-bkg1	0.28 ± 6.16	0.908
	S5-bkg2	0.03 ± 15.76	0.908
	S5-bkg3	0.16 ± 6.64	0.908
	S5-bkg4	0.21 ± 6.64	0.908
	S5-bkg5	0.31 ± 6.09	0.908
	S5-bkg6	0.34 ± 13.25	0.908
	S5-bkg7	0.06 ± 7.34	0.908
Background Samples: TS6	S6-bkgNorth	0.24 ± 5.45	0.908
	S6-bkgSouth	0.28 ± 5.44	0.908
	S6-bkg1	0.22 ± 6.55	0.908
	S6-bkg2	0.30 ± 6.30	0.908
	S6-bkg3	0.12 ± 6.78	0.908
	S6-bkg4	0.74 ± 5.84	0.908
	S6-bkg5	0.44 ± 5.97	0.908
	S6-bkg6	0.44 ± 5.97	0.908
	S6-bkg7	0.26 ± 6.28	0.908
	S6-bkg8	0.01 ± 35.93	0.908
Background Samples: TS7	S5-bkgA	0.29 ± 6.56	0.908
	S7-bkg7	0.13 ± 7.37	0.908
Background Samples: TS8	S8-bkgA	0.02 ± 15.41	0.908
	S7-bkgB	0.01 ± 4.69	0.908
Hot Spot Samples: TS5	Core 1 0-6 inches	0.32 ± 16.08	0.908
	Core 2 0-6 inches	0.11 ± 32.73	0.908
	Core 4 0-6 inches	0.19 ± 39.76	0.908
Hot Spot Samples: TS6	Core 1 South 6-12 inches	0.73 ± 48.33	NE
	Core 2 South 18-24 inches	0.02 ± 44.90	NE
	Core 1 North 0-6 inches	0.21 ± 35.29	0.908
	Core 1 North 12-18 inches	0.02 ± 55.85	NE
	Core 3 North 0-6 inches	0.10 ± 50.51	0.908
	Core 4 North 0-6 inches	0.44 ± 12.75	0.908
	Core 4 North 6-12 inches	0.02 ± 28.37	NE
Hot Spot Samples: TS7	Core 1 0-6 inches	0.22 ± 15.95	0.908
	Core 1 6-12 inches	0.03 ± 52.32	NE
	Core 2 0-6 inches	0.09 ± 43.67	0.908

Notes:
[a]SNL/NMED, 1996.
NE = not established
NMED = New Mexico Environmental Department
pCi/g = picocuries per gram
SNL = Sandia National Laboratories
TS5, 6, 7, 8 = Training Sites 5, 6, 7, and 8

2.4.5.4 *Gamma Radiation Counts*

The ranges and *geometric* averages of gamma radiation counts observed in 2000/2001 at OT-10 were:

- 10,983 to 600,594 cpm, averaging 28,116 cpm at TS5;
- 12,050 to 999,960 cpm, averaging 28,184 cpm at TS6;
- 9,694 to 735,542 cpm, averaging 15,842 cpm at TS7; and
- 9,736 to 681,079 cpm, averaging 15,740 cpm at TS8.

2.4.5.5 *Comparison of Thorium-230 and Thorium-232 Concentrations in OT-10 Soil Samples*

The concentration of thorium-230 is about 11 percent of the thorium-232 concentration in the source material applied at OT-10. The data set contains 29 samples comprised of 1994/1995 and 2000/2001 investigation analytical results and an analysis of the source material. Natural background concentrations are assumed at 0.93 pCi/g thorium-230 and 0.91 pCi/g thorium-232, identical to the respective average concentrations observed in the reference area. Only the samples that clearly showed thorium-230 and thorium-232 above background were considered; that is, only those samples with thorium-230 and thorium-232 values higher than background plus 3 standard deviations (the analytical errors are approximately 0.3 pCi/g). Thus, the minimum concentration considered was 2 pCi/g or higher (equivalent to 0.91 or 0.93 pCi/g plus 3*0.3=1.8 rounded to 2). The background concentrations were subtracted from all of the concentrations prior to calculating current ratios. The median ratio as shown in Table 2-26 is 11 percent.

The current radium-226:thorium-230 ratios were determined as follows. The natural background concentrations of radium-226 and thorium-230 were assumed to be 0.93 pCi/g and the minimum concentrations considered were 2 pCi/g or higher. The background concentration of 0.93 pCi/g was subtracted from all of the concentrations prior to calculating current radium-226 to thorium-230 ratios.

The data set contains 17 samples comprised of 2000/2001 investigation analytical results. The average ratio as shown in Table 2-27 is 0.15. The average ratio would be approximately 1 if radium-226 and thorium-230 were in secular equilibrium. Thus, radium-226 is not in secular equilibrium with thorium-230.

Table 2-26. Ratio of Thorium-230 to Thorium-232 at Installation Restoration Program Site OT-10

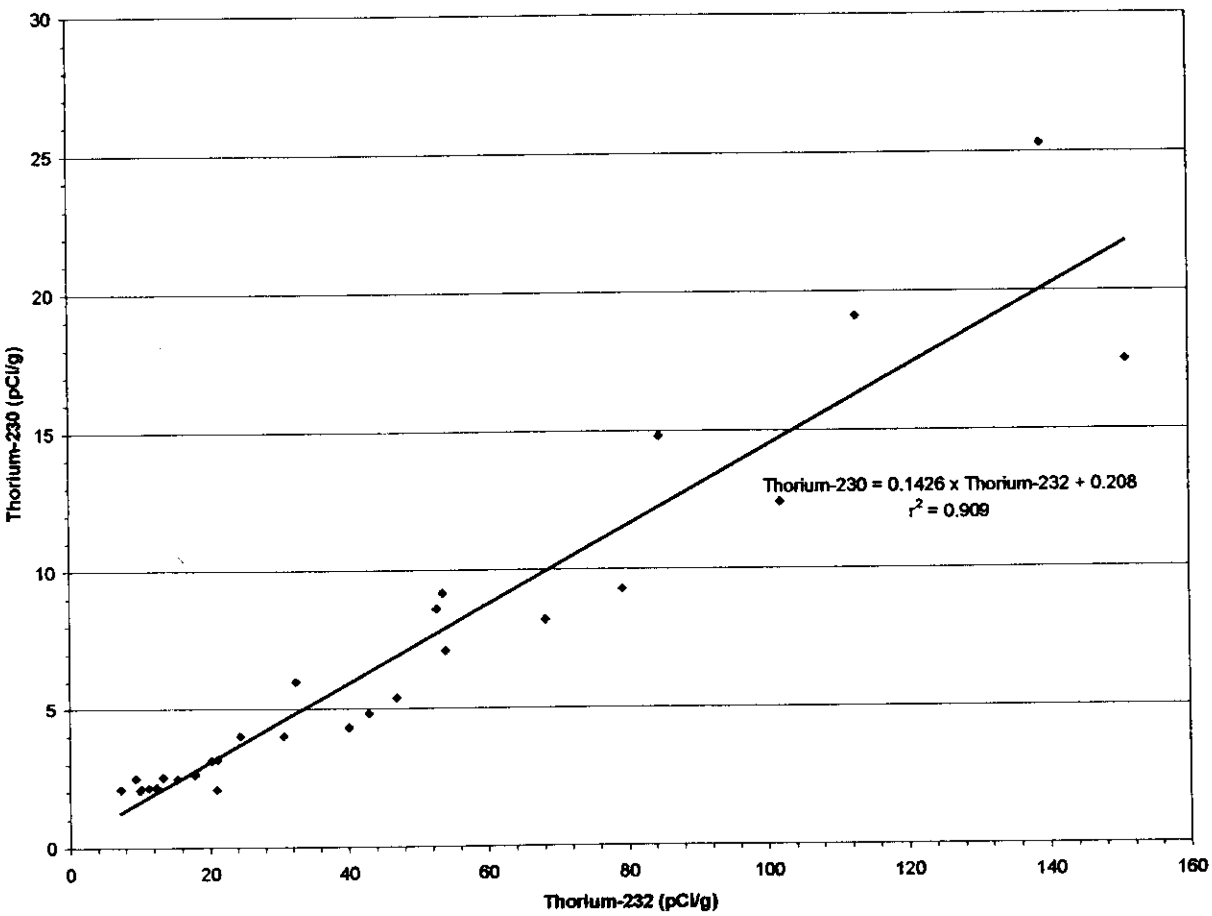
		Concentration (pCi/g)				Excess Thorium Concentrations (pCi/g)		
Investigation	**Sample ID No**	**Thorium-232**	**Thorium-232 Error**	**Thorium-230**	**Thorium-230 Error**	**Thorium-232**	**Thorium-230**	**Thorium-230/Thorium-232**
2000/2001	TS6-SS-11-0000	10	2.5	2.05	0.62	9.09	1.12	0.12
2000/2001	TS7-SS-15-0000	21	6.3	2.07	0.83	20.09	1.14	0.06
2000/2001	TS6-SS-18-0000	7.3	1.9	2.08	0.62	6.39	1.15	0.18
2000/2001	TS8-SS-17-0000	10.2	2.4	2.11	0.57	9.29	1.18	0.13
2000/2001	TS7-SS-18-0000	11.3	2.9	2.14	0.69	10.39	1.21	0.12
2000/2001	TS8-SS-18-0000	15.4	3.4	2.46	0.63	14.49	1.53	0.11
2000/2001	TS6-SS-01-0000	9.4	2.4	2.49	0.74	8.49	1.56	0.18
2000/2001	TS6-SS-06-0000	13.3	3.2	2.53	0.71	12.39	1.60	0.13
2000/2001	TS6-SS-04-0000	17.9	4.4	2.63	0.77	16.99	1.70	0.10
2000/2001	TS5-SS-05-0000	20.3	4.9	3.12	0.87	19.39	2.19	0.11
2000/2001	TS8-SS-12-0000	21.2	4.6	3.15	0.76	20.29	2.22	0.11
2000/2001	TS6-SS-12-0000	24.4	5.8	4	1.1	23.49	3.07	0.13
2000/2001	TS7-SS-12-0000	30.7	7.4	4	1.1	29.79	3.07	0.10
2000/2001	TS7-SS-20A-0000	40.1	9.6	4.3	1.2	39.19	3.37	0.09
2000/2001	TS8-SS-20A-0000	43	11	4.8	1.3	42.09	3.87	0.09
2000/2001	TS8-SS-20-0000	47	12	5.4	1.6	46.09	4.47	0.10
2000/2001	TS8-SS-19-0000	32.5	7.4	6	1.4	31.59	5.07	0.16
2000/2001	TS6-SS-21-0000	54	13	7.1	1.9	53.09	6.17	0.12
2000/2001	TS6-SS-22-0000	139	34	25.3	7.9	138.09	24.37	0.18
1988-1990	GS920248[a]	18000	300	1900	100	17999.09	1899.07	0.11
1994/1995	TS5HAHAC05.3 (K2309)	12.34	0.78	2.16	0.23	11.43	1.23	0.11
1994/1995	TS5HAHH05.3 (K2001)	68.2	6.2	8.2	1.9	67.29	7.27	0.11
1994/1995	TS7HACE02.8 (K2321)	52.7	4.9	8.6	1.7	51.79	7.67	0.15
1994/1995	TS8HACG01.68	53.6	2.9	9.17	0.67	52.69	8.24	0.16
1994/1995	TS5HAHAC05.3 (K2310)	79.2	6.9	9.3	2	78.29	8.37	0.11
1994/1995	TS5HAHH05.3 (K2002)	101.8	8.9	12.4	2.7	100.89	11.47	0.11
1994/1995	TS7HACE02.8 (K2304)	84.5	6.4	14.8	2.1	83.59	13.87	0.17
1994/1995	TS5HAHH05.3 (K2311)	151	12	17.5	3.3	150.09	16.57	0.11
1994/1995	TS7HACE02.78	112.7	8.6	19.1	2.9	111.79	18.17	0.16
					Median Thorium-230:Thorium-232			**0.11**

Notes:
[a]AFIERA analysis of source material
AFIERA = Air Force Institute for Environment, Safety and Occupational Health Risk Analysis
ID = identification
pCi/g = picocuries per gram

A strong linear correlation exists between thorium-230 and thorium-232 concentrations in OT-10 soil samples, with an r^2 of 0.91. The correlation is described by Equation 2-4, with concentrations measured in pCi/g. Figure 2-24 presents the data (backgrounds not subtracted from soil concentrations), along with the linear trend line, linear equation and r^2 value. Sample GS920248 is not included in the regression. Its thorium concentrations are at least 2 orders of magnitude greater than the next highest concentrations. Including GS920248 values would result in a linear regression with an unrealistic r^2 of 1.

$$C_{thorium-230} = 0.14 * C_{thorium-232} + 0.21 \quad \text{Eq. 2-4}$$

Figure 2-24. Correlation of Thorium-230 and Thorium-232 Concentrations, Installation Restoration Program Site OT-10



2.4.5.6 Loss of Equilibrium in the Uranium-238 Series

The uranium-238 series is not in secular equilibrium. There is an apparent lack of correlation between thorium-230 and its decay progeny, particularly radium-226. In addition, uranium-238 and uranium-234 concentrations are not equivalent to thorium-230 concentrations.

Table 2-27. Ratio of Radium-226 to Thorium-230 at Installation Restoration Site OT-10

	Concentrations (pCi/g)				Excess Concentrations (pCi/g)		
Sample ID No	Thorium-230	Thorium-230 Error	Radium-226	Radium-226 error	Radium-226	Thorium-230	Radium-226:Thorium-230
TS5-SB-05-0000	3.12	0.87	0.45	0.45	-0.48	2.19	-0.22
TS6-SS-01-0000	2.49	0.74	1.18	0.37	0.25	1.56	0.16
TS6-SS-04-0000	2.63	0.77	1.16	0.39	0.23	1.70	0.14
TS6-SS-06-0000	2.53	0.71	0.81	0.26	-0.12	1.60	-0.08
TS6-SS-11-0000	2.05	0.62	1.97	0.64	1.04	1.12	0.93
TS6-SS-12-0000	4	1.1	2.54	0.64	1.61	3.07	0.52
TS6-SS-18-0000	2.08	0.62	1.3	0.4	0.37	1.15	0.32
TS7-SS-12-0000	4	1.1	1.35	0.62	0.42	3.07	0.14
TS7-SS-15-0000	2.07	0.83	0.76	0.31	-0.17	1.14	-0.15
TS7-SS-18-0000	2.14	0.69	1.86	0.6	0.93	1.21	0.77
TS7-SS-20A-0000	4.3	1.2	0.97	0.55	0.04	3.37	0.01
TS8-SS-12-0000	3.15	0.76	0.7	0.2	-0.23	2.22	-0.10
TS8-SS-17-0000	2.11	0.57	1.08	0.36	0.15	1.18	0.13
TS8-SS-18-0000	2.46	0.63	0.84	0.38	-0.09	1.53	-0.06
TS8-SS-19-0000	6	1.4	1.03	0.36	0.10	5.07	0.02
TS8-SS-20-0000	5.4	1.6	1.44	0.56	0.51	4.47	0.11
TS8-SS-20A-0000	4.8	1.3	0.95	0.47	0.02	3.87	0.01
				Average Radium-226:Thorium-230			0.15

Notes:
ID = identification
pCi/g = picocuries per gram

It is also important to note that thorium-230 is not in equilibrium with uranium-238. Uranium-234 and uranium-238 activities in the two 2001 waste profile samples are present at about half the activity of thorium-230 ((uranium-238:thorium-230 ratios for the two samples are ((0.6+0.5)/2=0.55)).

In summary, uranium-238, uranium-234, and radium-226 are not in secular equilibrium with thorium-230. The loss of uranium and radium is important because Title 10 CFR Part 20, Subpart E (20.1401(d)), states that "when calculating the TEDE [total effective dose equivalent] to the average member of the critical group the licensee shall determine the peak annual TEDE dose expected within the first 1,000 years after decommissioning." The loss of equilibrium in the uranium-238 implies that the current dose will increase over 1,000 years, primarily because radium-226 concentrations will increase. This assumes conservatively that uranium will not leach naturally.

2.4.5.7 Derivation of Thorium-232 Investigation Levels

Table 2-28 presents training site-specific equations relating 2000/2001 thorium-232 soil concentrations and co-located gamma radiation counts and corresponding investigation levels. The investigation level associated with the entire data set is also provided as a reference. Thorium-232 concentrations are compared to bare detector measurements on Figures 2-25 (entire data set), 2-26 (TS5), 2-27 (TS6), 2-28 (TS7), and 2-29 (TS8).

Table 2-28. Site-Specific Investigation Levels, Installation Restoration Program Site OT-10

	Collimated Detector			Bare Detector		
Data Set	Linear Equation	r^2	IL[a] (cpm)	Linear Equation	r^2	IL[a] (cpm)
All	$Gamma = 977xC_{thorium-232} + 4099$	0.67	11,000	$Gamma = 2596xC_{thorium-232} + 15427$	0.61	33,000
TS5	$Gamma = 1059xC_{thorium-232} + 6172$	0.55	13,000	$Gamma = 3121xC_{thorium-232} + 22835$	0.44	44,000
TS6	$Gamma = 808xC_{thorium-232} + 5583$	0.71	11,000	$Gamma = 2060xC_{thorium-232} + 22081$	0.54	36,000
TS7	$Gamma = 642xC_{thorium-232} + 4526$	0.77	9,000	$Gamma = 1652xC_{thorium-232} + 15024$	0.79	26,000
TS8	$Gamma = 1320xC_{thorium-232} + 1947$	0.75	10,000	$Gamma = 3547xC_{thorium-232} + 8990$	0.75	33,000

Notes:
[a] Residential investigation level is rounded to the nearest thousand.
c = concentration
cpm = counts per minute
DCGL = derived concentration guideline level
IL = investigation level
r^2 = Pearson's correlation

Considering only the r^2 values in Table 2-28, the correlations are similar at TS7 and TS8 for the bare and collimated detectors. The correlation improves at TS5 and TS6 from the bare to collimated detector. Apparently, shielding provided by the collimator reduced the gamma "shine" present at the TS5 and TS6 sampling locations. The removal of hot spots at TS5 and TS6 is expected to render the correlation at these sites more like those at TS7 and TS8. The investigation levels at TS5 and TS6 should ultimately approach those calculated from the TS7 and TS8 data because the extent of gamma "shine" at the latter sites is minimal.

The collimated site-specific investigation levels presented in Table 2-28 will be used to guide the initial stages of remedial action. It is expected that they will be replaced after hot spots are removed and subsequent static measurements and soil samples are collected. Figures 2-25 (entire data set), 2-26 (TS5), 2-27 (TS6), 2-28 (TS7), and 2-29 (TS8) show the 2001 correlations of thorium-232 soil concentrations to collimated static measurements.

Figures 2-30 (entire data set), 2-31 (TS5), 2-32 (TS6), 2-33 (TS7), and 2-34 (TS8) show the 2001 correlations of thorium-2332 concentrations to bare static measurements.

The bare detector residential investigation levels and MARSSIM Class 1 and Class 2 survey units were placed on the gamma radiation scanning survey results of each training site, using ArcView GIS 8.1®. Figures 2-35 (TS5), 2-36 (TS6), 2-37 (TS7), and 2-38 (TS8) show the provisional bare detector investigation levels and MARSSIM Class 1 and Class 2 survey units superimposed on the October 2000 scanning gamma radiation measurements .

2.4.5.8 *Area and Volume Estimates of Impacted Soil*

The areas and volumes of soil requiring removal were estimated using the scanning gamma radiation data from the October 2000 survey, the vertical profiling data from the April 2001 survey, and the hot spot vertical profiling data from the 1994/1995 (USAF, 1997a) and 1996/1998 investigations (USAF, 1999a).

Estimates of the total contaminated land area and volume at OT-10 were calculated using an arbitrary gamma radiation threshold of 18,000 cpm. Estimates also were calculated for the residential remedial action scenario, using the site-specific investigation levels presented in Table 2-28. The estimates assume a soil bulking factor of 30 percent and that soil contamination in areas of low to moderate contamination is limited to 6 inches bgs. Training-site-specific depths of contamination in the "hot" spots (that is, gamma radiation measurements greater than 50,000 cpm) were taken from the 1996/1998 investigation vertical profiling data (USAF, 1999a).

Figure 2-25. Correlation of 2001 Thorium-232 Concentrations and Collimated Static Gamma Radiation Measurements, Installation Restoration Program Site OT-10

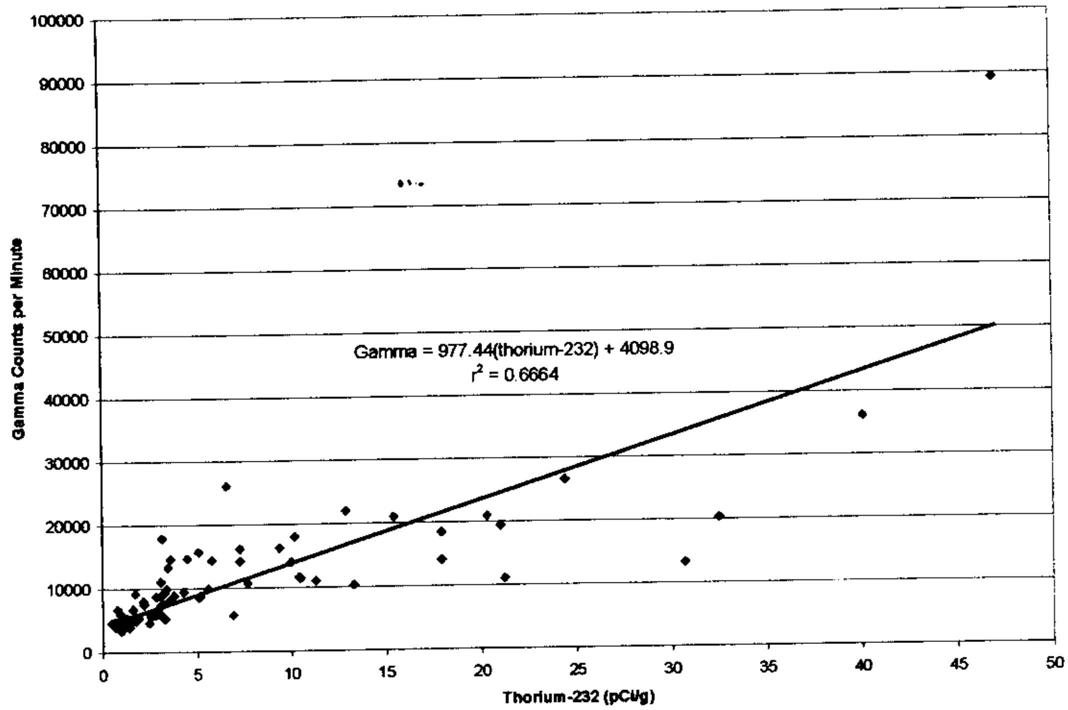


Figure 2-26. Correlation of 2001 Thorium-232 Concentrations and Collimated Static Gamma Radiation Measurements at Training Site 5, Installation Restoration Program Site OT-10

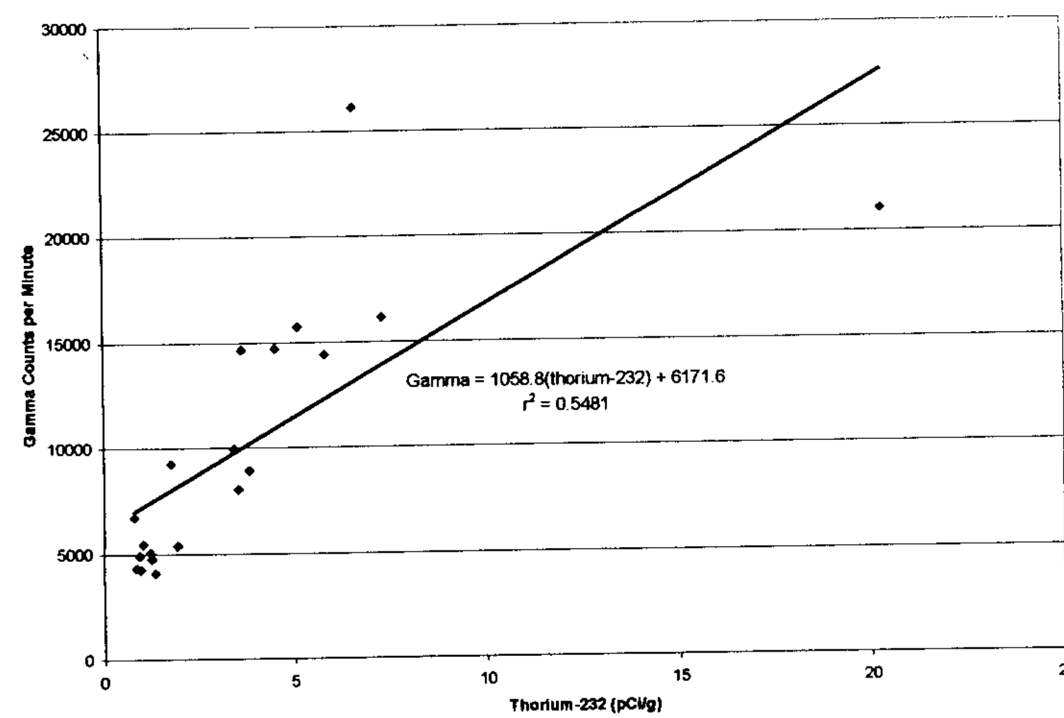


Figure 2-27. Correlation of 2001 Thorium-232 Concentrations and Collimated Static Gamma Radiation Measurements at Training Site 6, Installation Restoration Program Site OT-10

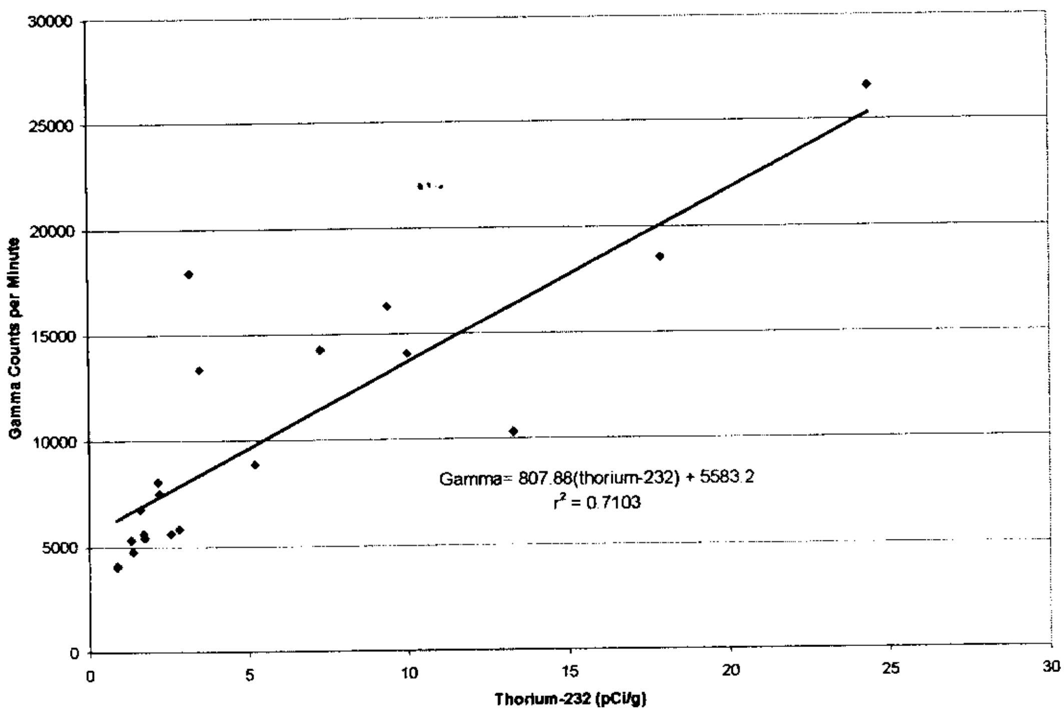


Figure 2-28. Correlation of 2001 Thorium-232 Concentrations and Collimated Static Gamma Radiation Measurements at Training Site 7, Installation Restoration Program Site OT-10

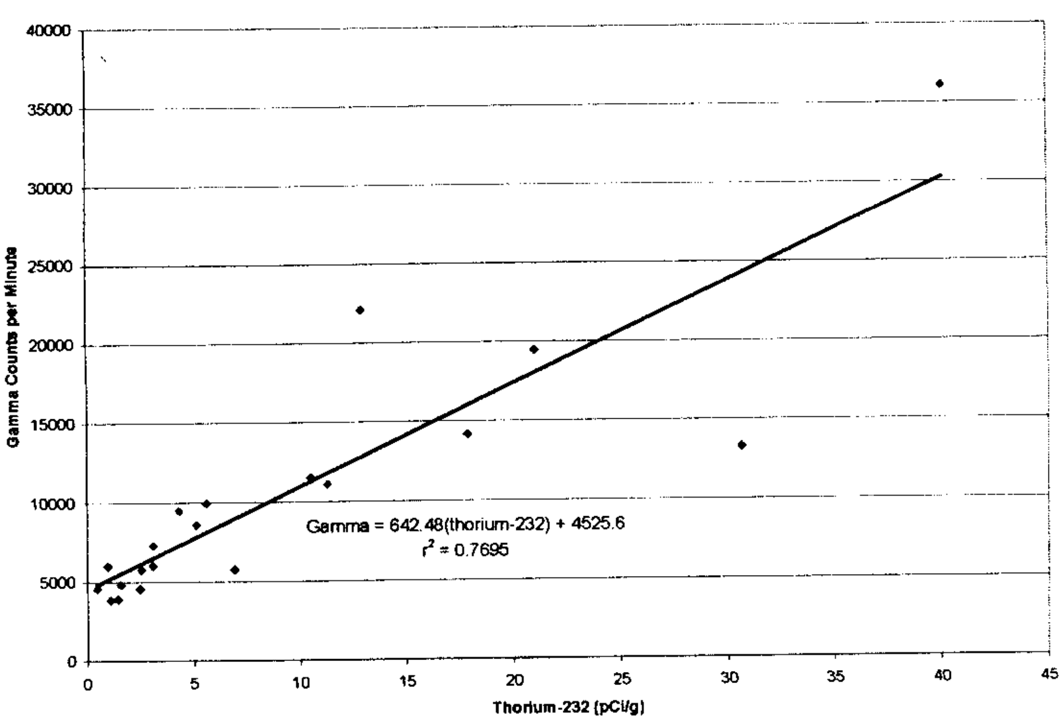


Figure 2-29. Correlation of 2001 Thorium-232 Concentrations and Collimated Static Gamma Radiation Measurements at Training Site 8, Installation Restoration Program Site OT-10

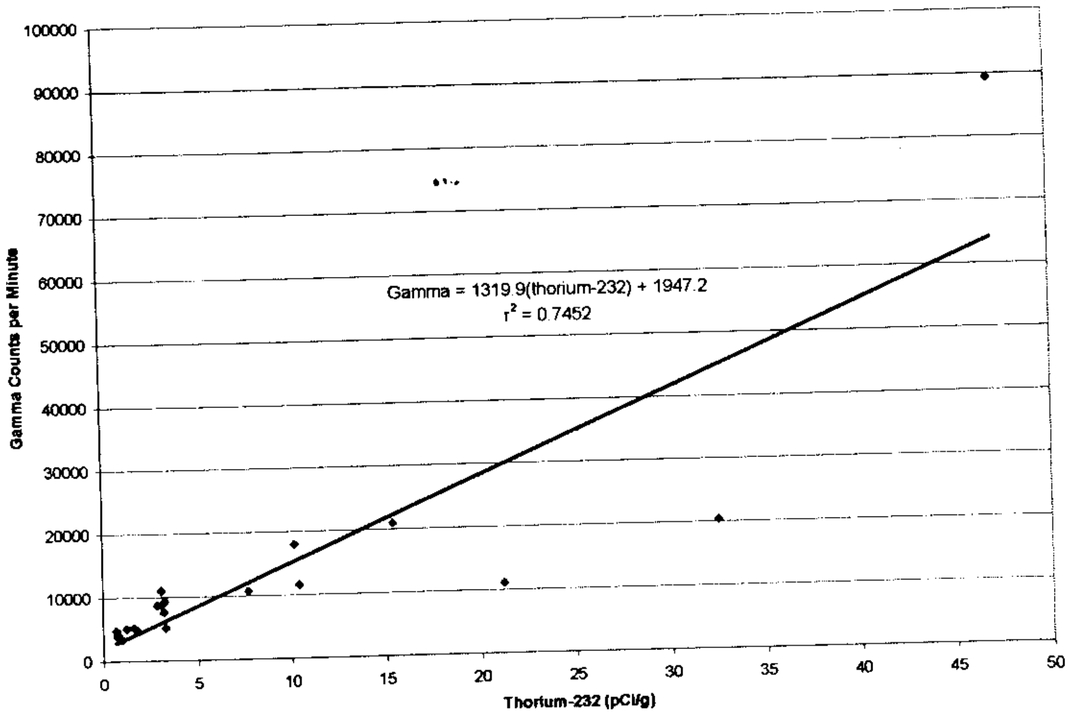


Figure 2-30. Correlation of 2001 Thorium-232 Concentrations and Bare Static Gamma Radiation Measurements, Installation Restoration Program Site OT-10

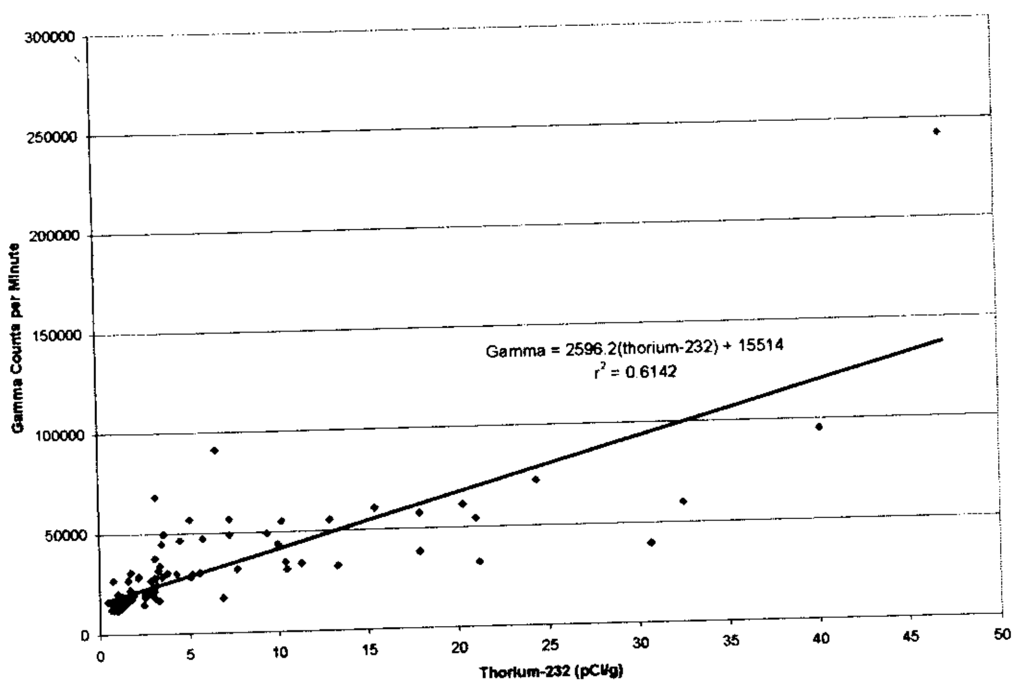


Figure 2-31. Correlation of 2001 Thorium-232 Concentrations and Bare Static Gamma Radiation Measurements at Training Site 5, Installation Restoration Program Site OT-10

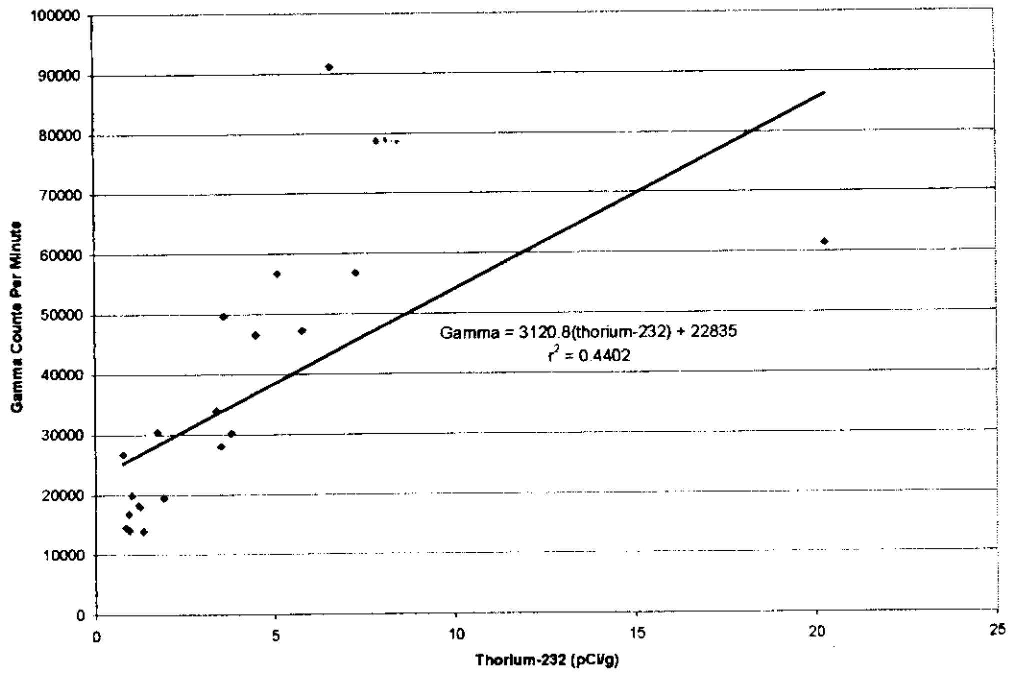


Figure 2-32. Correlation of 2001 Thorium-232 Concentrations and Bare Static Gamma Radiation Measurements at Training Site 6, Installation Restoration Program Site OT-10

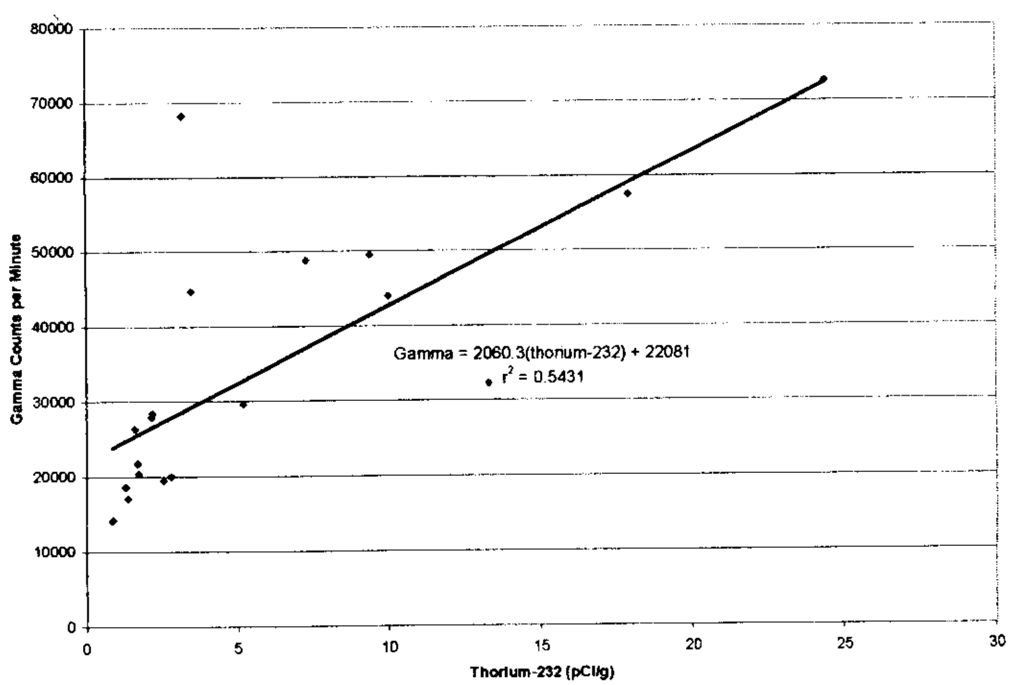


Figure 2-33. Correlation of 2001 Thorium-232 Concentrations and Bare Static Gamma Radiation Measurements at Training Site 7, Installation Restoration Program Site OT-10

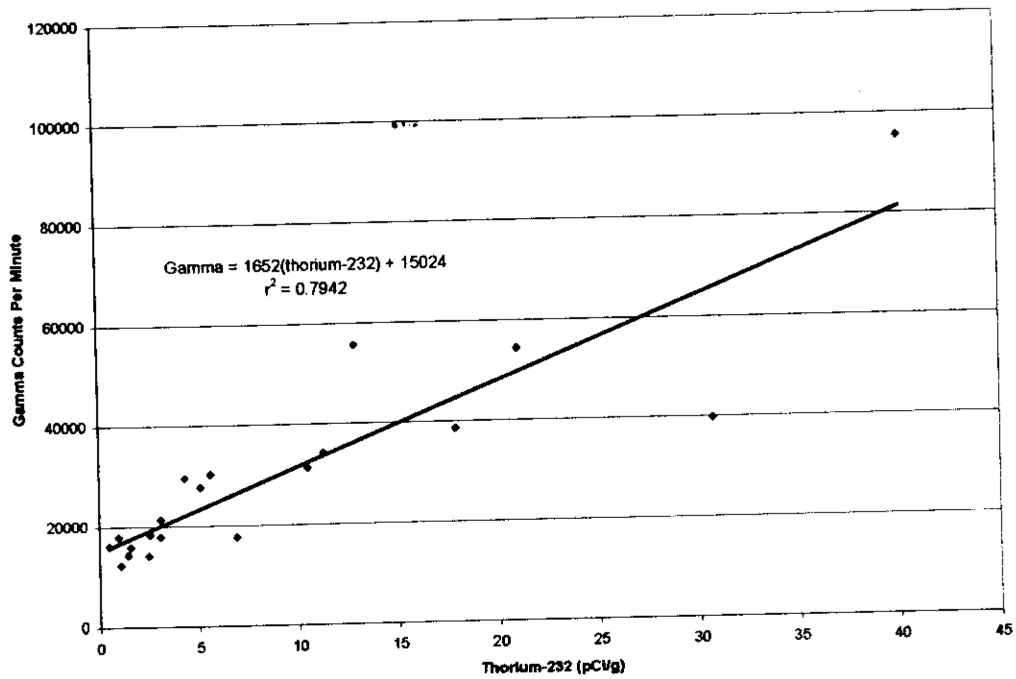
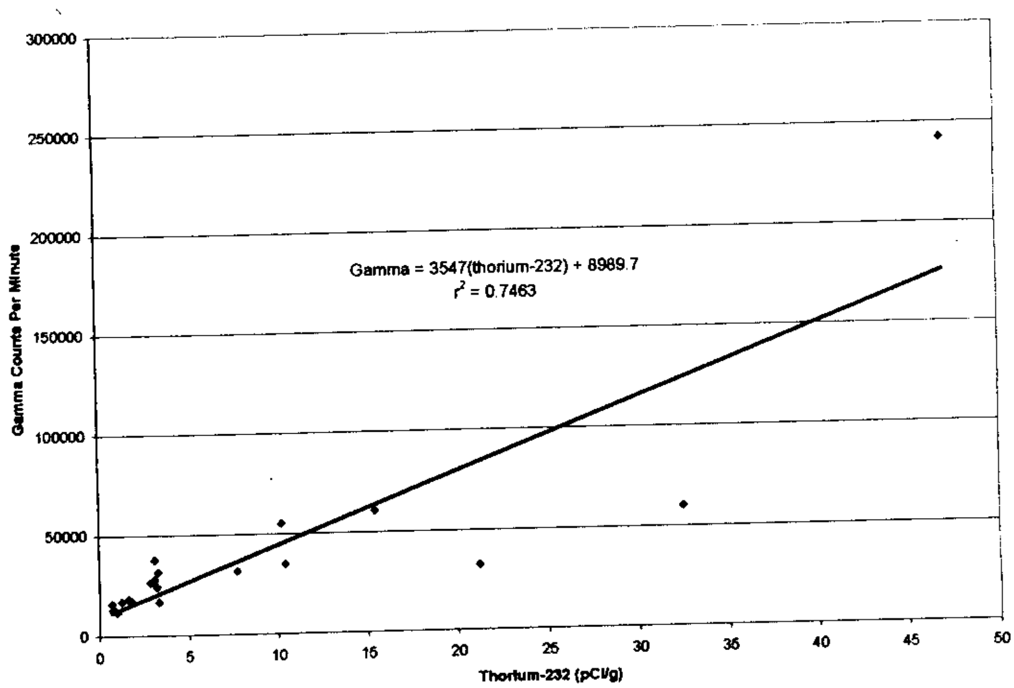


Figure 2-34. Correlation of 2001 Thorium-232 Concentrations and Bare Static Gamma Radiation Measurements at Training Site 8, Installation Restoration Program Site OT-10



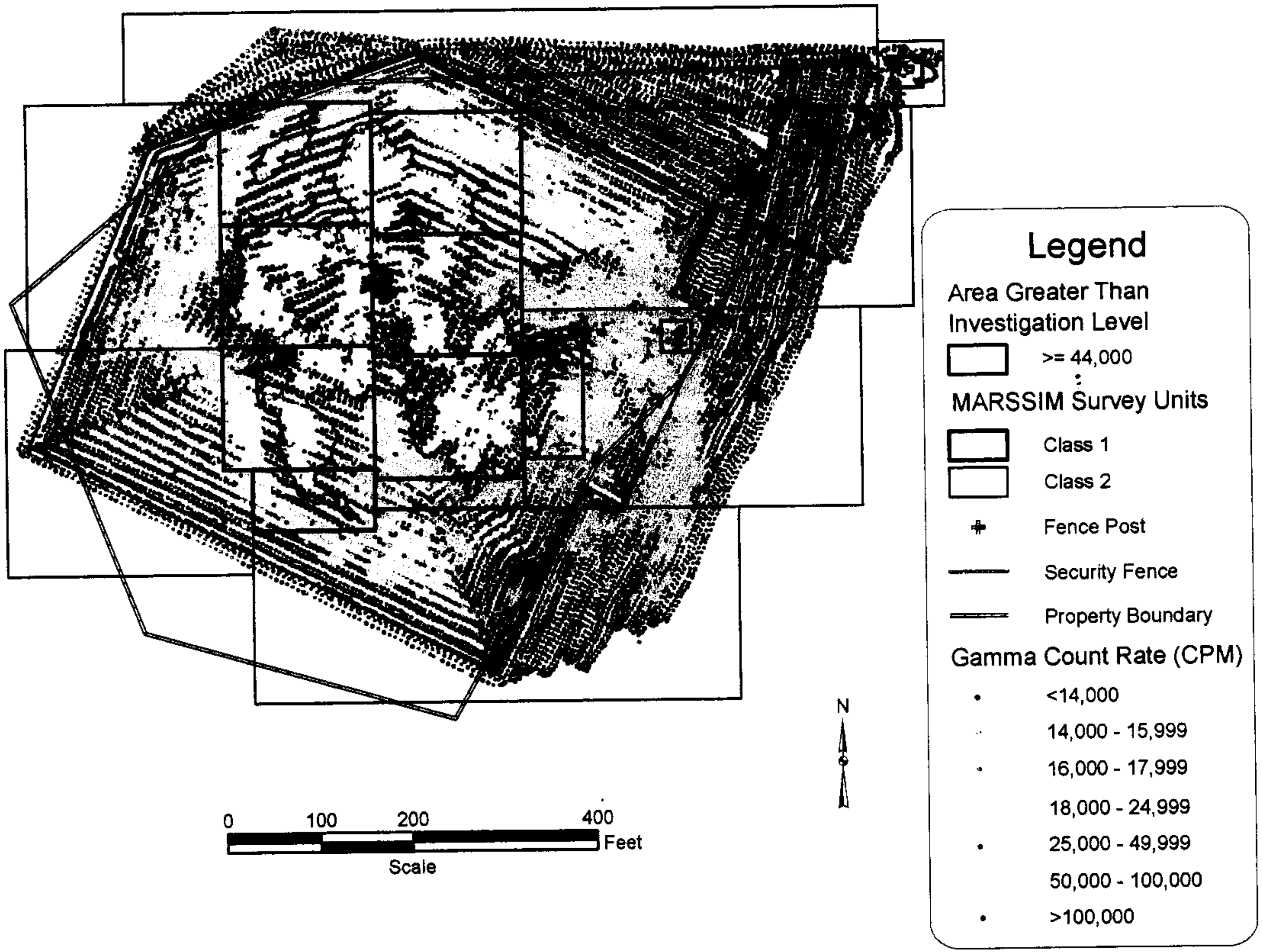


Figure 2-35. October 2000 Gamma Radiation Scanning Data with Investigation Level and MARRSIM Class 1 and Class 2 Survey Units at Training Site 5, Installation Restoration Program Site OT-10

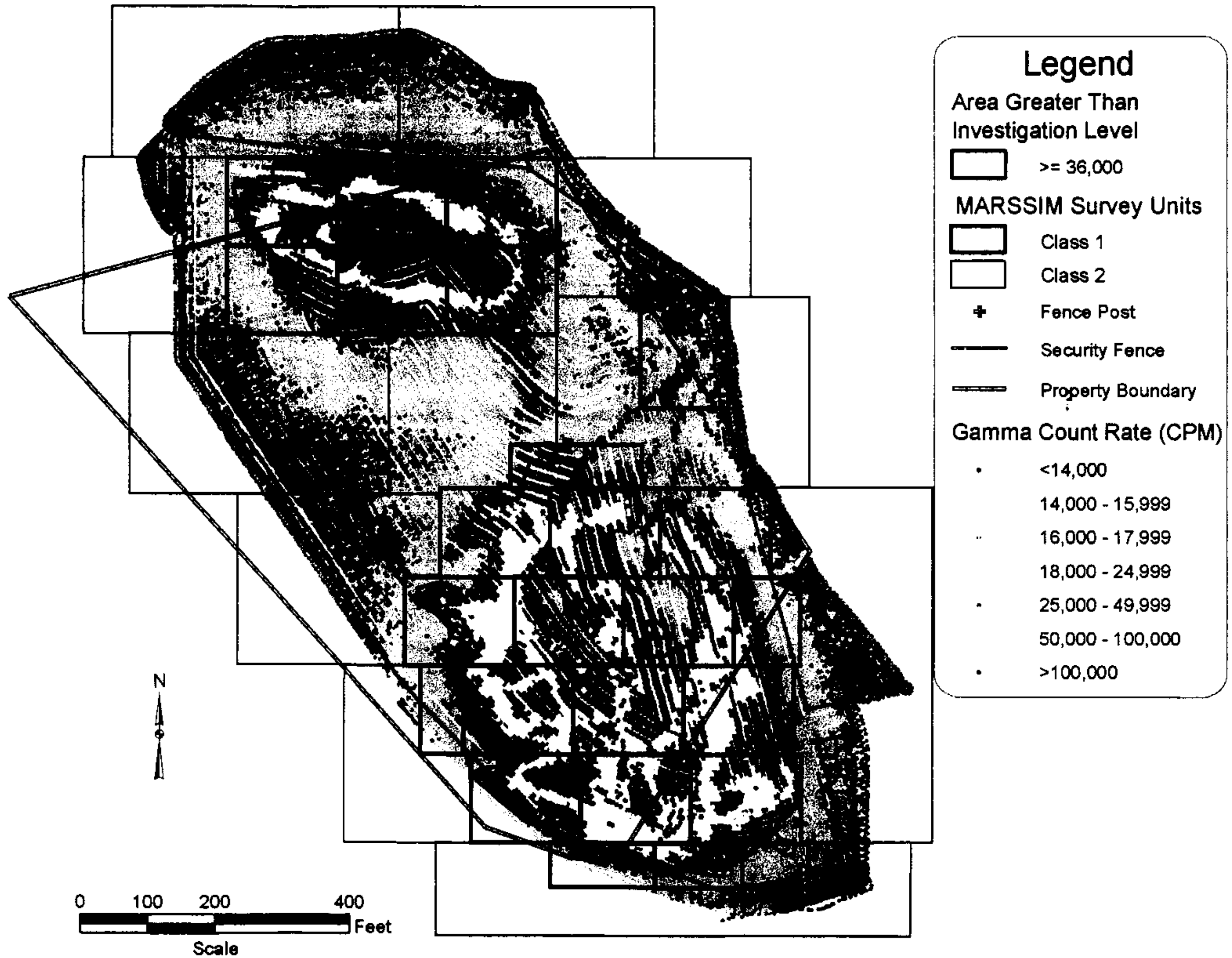


Figure 2-36. October 2000 Gamma Radiation Scanning Data with Investigation Level and MARRSIM Class 1 and Class 2 Survey Units at Training Site 6, Installation Restoration Program Site OT-10

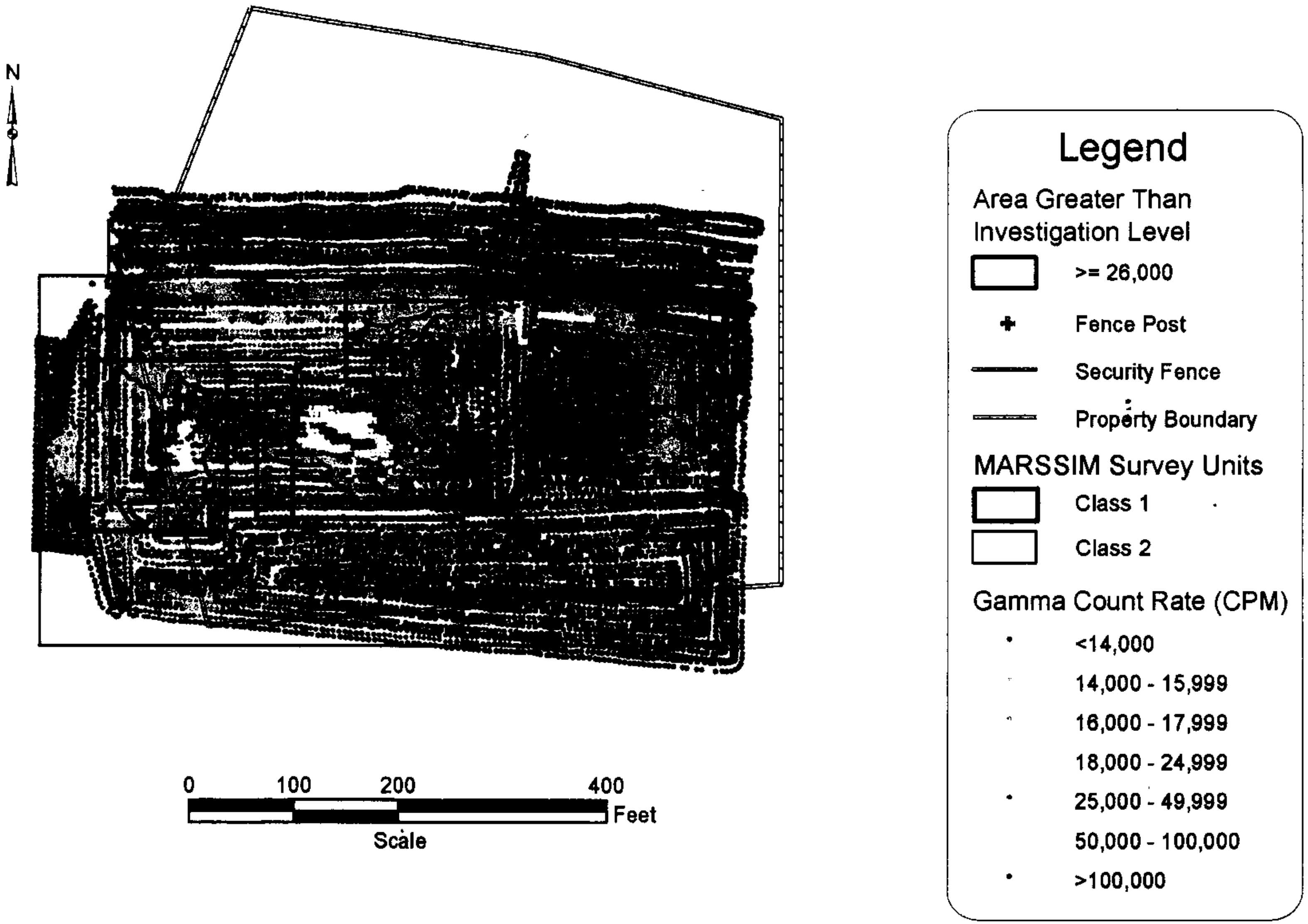


Figure 2-37. October 2000 Gamma Radiation Scanning Data with Investigation Level and MARRSIM Class 1 and Class 2 Survey Units at Training Site 7, Installation Restoration Program Site OT-10

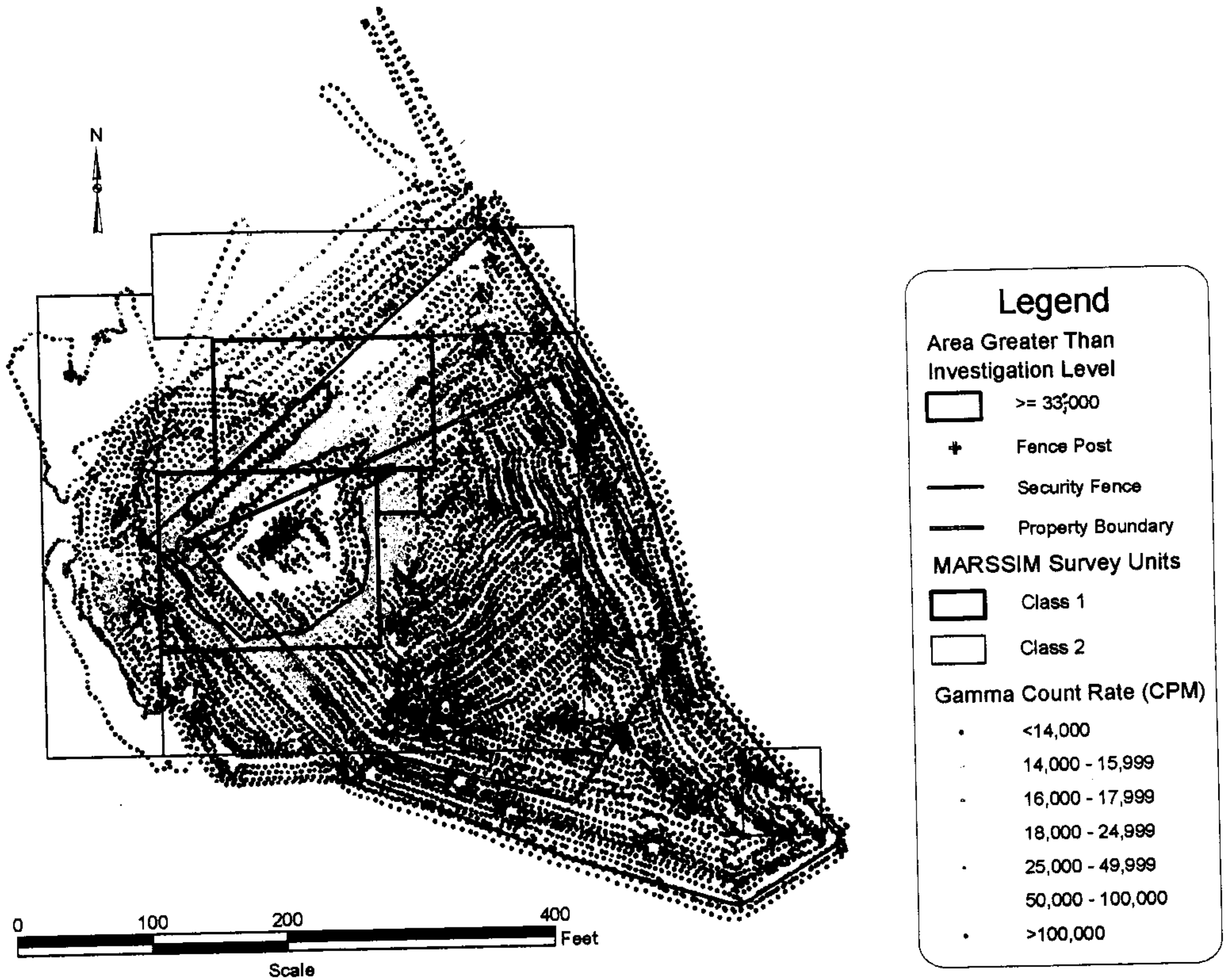


Figure 2-38. October 2000 Gamma Radiation Scanning Data with Investigation Level and MARRSIM Class 1 and Class 2 Survey Units at Training Site 8, Installation Restoration Program Site OT-10

Table 2-29 presents the area and volume estimates; Appendix D presents the area and volume calculations.

Table 2-29. Area and Volume Estimates of Impacted Soil at Installation Restoration Program Site OT-10

Scanning Radiation Measurements	Estimate	Training Site 5	Training Site 6	Training Site 7	Training Site 8	Totals
18,000 CPM	Area (acres)	5.8	13.8	1.4	1.1	22.1
	Volume (yd^3)	11,311	26,163	1,637	1,485	40,596
Site-specific investigation levels	Area (acres)	1.7	6.7	0.6	0.4	9.4
	Volume (yd^3)	5,570	18,725	751	732	25,779

Notes:
cpm = counts per minute
yd^3 = cubic yards

2.5 Site Conceptual Model

A 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 9.4 acres of the 43.2 acres at OT-10 are impacted with thorium oxide sludge at concentrations above the DCGL.
- 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. Uranium-235 and its decay progeny provide an insignificant contribution to the total effective dose equivalent (TEDE). The thorium series is in secular equilibrium; the uranium series is not in secular equilibrium.
- The extent of contamination is limited to the immediate vicinity of the training sites and to a maximum observed depth of 5-ft bgs.
- The vertical extent of contamination is typically 1 to 2 ft bgs in high activity areas and is limited to 6-inches bgs in areas of low to moderate activity.
- An estimated 25,779 cubic yards of soil are radiologically contaminated above the DCGL.

The gamma radiation scanning surveys did not identify contaminant migration into surface water drainages. In addition, there is a difference of approximately 495 ft between the maximum depth of soil contamination and groundwater at OT-10 that prevents contaminant migration to groundwater.

The TEDE in 22 percent of the OT-10 land area exceeds 25 mrem/yr above background. Therefore, the OT-10 sites do not currently meet the compliance criteria for license termination.

3.0 PLANNED DECOMMISSIONING ACTIVITIES

Site characterization data collected from the OT-10 sites indicate that thorium-contaminated soils pose elevated levels of risk to human health. This section presents the decommissioning criteria and activities planned to mitigate these risks.

Planned decommissioning activities include excavating and packaging contaminated soil, vegetation, and debris; profiling and manifesting the waste; and transporting the waste by truck and/or rail to an NRC-licensed radioactive waste disposal facility, Envirocare of Utah (Envirocare) in Clive, Utah.

The USAF has petitioned the NRC to allow a portion of the licensed material to be disposed of at an alternate facility, Waste Control Specialists (WCS) facility in Andrews, Texas. If approved, the portion of waste destined for WCS will be strictly limited to soil containing unimportant quantities of source material as defined in 10 CFR § 40.13; that is, less than 0.05 percent by weight .

Decommissioning activities will conclude with final status surveys and closure reporting. Excavated areas will be graded and replanted with native vegetation upon NRC approval of the final status surveys.

The decommissioning activities will be conducted under the Radiation Safety Program described in Section 4.0. In addition, the OT-10 waste will be brokered by an NRC-licensed, DOD-certified waste broker.

3.1 Decommissioning Criteria

The goal of decommissioning is a residual radioactivity that will not result in individuals being exposed to unacceptable levels of radiation (EPA, 1997). The NRC considers such a level of residual radioactivity to occur at a TEDE of 25 mrem/year above background and as low as reasonably achievable (ALARA) contamination levels (10 CFR § 20.1402).

OT-10 land areas and structures (Buildings 28005 and 28010 at TS8) will be remediated to standards that meet these NRC requirements. Decommissioning to such standards will result in unrestricted release of the sites and support license termination.

DCGLs, defined as radionuclide concentrations or activities corresponding to a TEDE of 25 mrem/yr above background, were developed for land areas and building structures using the RESRAD Program, version 6.1 and RESRAD-Build, version 3.0, respectively.

The DCGLs are derived in Appendix A. Background concentrations of 0.91 pCi/g for thorium-232 and 0.93 pCi/g thorium-230 were established during the 2000/2001 survey, as described in Section 2.4.5.1 of this decommissioning plan.

DCGLs for land areas and structures are presented in the next two sections.

3.1.1 Decommissioning Criteria for Land Areas

RESRAD version 6.1 can calculate site-specific radiation doses posed by land areas to exposed individuals. Exposure scenarios were modeled for two variables, receptors and assumed land use, using RESRAD default, site-specific, and EPA parameters. The exposure pathways considered were incidental soil ingestion, external radiation, inhalation of radon, and consumption of contaminated drinking water.

Model runs generated modified DCGLs for thorium-232, uranium-238, and uranium-235, including their decay progeny, in surface soil. Table 3-1 presents the residential modified DCGLs for residual long-lived radionuclides in the top 15 cm of surface soil. The modified DCGLs are based on radionuclide ratios determined during site characterization. Thorium-232 will be measured using actinium-228 as a surrogate by gamma spectrometry. All other radionuclide activities will be calculated using the established ratios.

Table 3-1. Land Area Modified Derived Concentration Guideline Levels, Installation Restoration Program Site OT-10

Radionuclide	Modified DCGLs above background (pCi/g)[a]
Thorium-232 Decay Series	
Thorium-232	5.9
Radium-228	5.9
Thorium-228	5.9
Uranium-238 Decay Series	
Uranium-238	0.33
Uranium-234	0.33
Thorium-230	0.65
Radium-226	0.29
Lead-210	0.29
Uranium-235 Decay Series	
Uranium-235	0.014
Actinium-227	0.028
Protactinium-231	0.028

Notes:
[a]Uranium-235 background concentration assumed as natural abundance of 2.2 percent of uranium-234 plus uranium-238 activity.
DCGL = derived concentration guideline level
pCi/g = picocuries per gram

3.1.2 Decommissioning Criteria for Structures

RESRAD-Build 3.0 (ANL, 1994; NRC, 2000) evaluated the dose to industrial workers occupying the two storage bunkers at TS8 (Buildings 28005 and 28010). The exposure pathways considered were external exposure due to the source, inhalation of airborne radioactive material, and inadvertent ingestion of radioactive material. Parameter analysis was based on guidance provided in NUREG-5512 Volumes 1 and 3 (NRC, 1992a and NRC, 1999) and NUREG/CR-6697 (NRC, 2000).

Conservative surface contamination limits were based only on the presence of thorium-232 and its progeny that would result in a maximum dose to the workers of 25 mrem/yr. A mixture of the uranium-238 series and thorium-232 series would be less hazardous per disintegration than the thorium-232 series, based on a RESRAD-Build sensitivity analysis (Appendix A).

The total surface activity on structures must be limited to 250 dpm /100 cm^2 to limit the dose for workers in the bunkers to a TEDE of 25 mrem/yr. Sixty-eight percent of the particles emitted by thorium-232 contamination are expected to be alpha particles and 32 percent of the emissions will be beta particles. This corresponds to an alpha emission rate of 0.68*250=170 dpm/100 cm^2 and a beta emission rate of 0.32*250=80 dpm/100 cm^2.

Removable activity is defined as the activity that may be removed by taking a wipe sample or other non-chemical or highly abrasive methods. The removable activity corresponds to material that is more readily removed from the surface, and thus may lead to greater exposure. Therefore, it has a separate exposure limit. In RESRAD-Build dose assessment modeling, the model default assumes that 20 percent of the total activity is removable. Therefore, the alpha removable limits will be 0.2*170=34 dpm/100 cm^2 and the beta removable limit will be 0.2*80=16 dpm/100 cm^2.

3.2 Decommissioning Procedures for Land Areas

Field personnel will excavate soils exhibiting gamma radiation measurements greater than the site-specific investigation levels described in Section 2.4.5.4. The thorium-contaminated soil will be transported by truck and/or rail to an appropriate disposal facility.

Shipments will comply with applicable U.S. Department of Transportation (DOT) and state regulations; and applicable disposal facility licenses, permits, and requirements.

3.2.1 Excavating and Loading Contaminated Soil

Field personnel will excavate soils from land areas exhibiting site-specific gamma-radiation field counts greater than the investigation level. Associated vegetation and debris also will be removed.

Soil in hot spots will be excavated from the surface to an estimated depth of 1 to 2 ft bgs. Soil will be excavated in 3- to 6-inch lifts and land areas will be resurveyed after each lift is removed. In situ soils will continue to be excavated in lifts until gamma radiation count rates are below the investigation level. Soils in areas of low to moderate contamination will be excavated in 3-inch lifts. Site soils will also be sampled and analyzed onsite during the excavation process. The combination of gamma radiation counting data and onsite soil analysis should limit excavation to those soils in excess of the DCGL.

The contaminated soil, vegetation, and debris will be transferred to steel intermodal containers, each nominally containing a maximum load of 15 cubic yards (yd^3). Soil will be loaded carefully into the intermodal containers to minimize contaminating their outer surfaces. Loaded intermodal containers will be decontaminated and placed onto trucks for transport offsite.

Light water spraying will control and minimize emissions of dust during excavation activities. Field personnel also will spray heavily-traveled clean areas. Accumulating surface water in affected areas will be dammed and left to evaporate, and/or mixed into contaminated soils. The latter option is preferred because OT-10 soils have low soil moisture contents, well below the optimum level for placement in a disposal cell.

Detailed construction procedures are currently being prepared for OT-10 decommissioning (USAF, 2002b).

3.2.2 Remedial Action Support Surveys

Remedial action support surveys will be conducted to guide excavation, 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. The remedial action support surveys will consist of scanning and static gamma-radiation readings and soil sampling and analysis. A combination of field portable gamma radiation instruments and an onsite laboratory will be used to guide excavation.

Excavation and radiation surveying will proceed iteratively until residual radioactivity in soil is below the site-specific investigation levels or soil analyses are below the DCGL. Static and scanning gamma-radiation readings will be taken in excavated MARSSIM Class 1 areas, using a Ludlum 44-10 2-inch by 2-inch sodium iodide scintillation detector coupled to a Ludlum 2221 ratemeter/scaler. Static scanning and sampling methodologies will be the same as those used in the 2000/2001 characterization survey. The collimated detector will be the preferred survey instrument during excavation. The use of a collimated detector should help minimize the effect of gamma shine and limit excavation to soils in excess of the DCGL. Soils may also be screened in the backhoe bucket or placed on level ground and screened prior to placement in the waste container to minimize the effect of different source-detector geometry.

Soil samples will be collected from residual soils during the excavation process, homogenized, and analyzed onsite for thorium-232 (using actinium-228 as a surrogate), using an Ortec model sodium iodide gamma-spectrometer (model number and minimum detectable concentration (MDC) to be determined).

It is anticipated that approximately 10 surface soil samples will be collected from each Class 1 survey unit during the remedial action support surveys. The distribution and numbers of samples to be collected will be identified in the field.

Each MARSSIM Class 1 survey unit will be considered ready for a final status survey when the average concentration of thorium-232 in soil is below 6.8 pCi/g (DCGL plus background concentration), and when the levels of elevated measurements in smaller areas within survey units are below the DCGLs for thorium-232 and scan MDCs determined for elevated measurement comparisons. Stakes and caution tape will be installed to limit access to these survey units.

MARRSIM Class 2 survey units will be surveyed after all MARSSIM Class 1 survey units at a training site have been remediated.

3.2.2.1 Determining Static and Scan Minimum Detectable Concentrations

Static and scan MDCs were determined using data obtained during the 2000/2001 investigation. Derivation of these MDCs is discussed below.

Static MDC

The one-minute static MDC can be estimated from the background (2000/2001 reference area data) distributions for collimated and bare Ludlum 2221 2-inch by 2-inch sodium iodide (thallium) detectors coupled to a Ludlum 44-10 ratemeter/scaler set in integration mode. The standard deviations for the collimated and bare detectors for the reference area were 83 and 287 cpm, respectively, for one-minute counts at 20 sampling locations. The thorium-232 background concentration in the soil for the reference area was 0.91 pCi/g with a standard deviation of 0.15 pCi/g, based on 20 surface soil samples (0-15cm depth) taken at the 20 sampling locations.

In the 2000/2001 investigation, field personnel collected 20 surface soil samples and 20 gross-gamma measurements at each of the four training sites. The correlation between the thorium-232 concentrations and the gross-count rates for the bare and collimated detectors was used to obtain detector efficiencies of 2,600 cpm/pCi/g and 980 cpm/pCi/g, respectively (see linear equations for the entire bare and collimated data sets in Table 2-28).

The static MDC for the two detector configurations was estimated using the following equation,

$$MDC = \left(\frac{3 + 4.65 * \sigma_b}{\varepsilon} \right) \qquad \text{Eq. 3-1}$$

where σ_b is the standard deviation of the background count rate and ϵ is the detector efficiency. Using the data for the collimated and bare detector, the static MDC for the collimated and bare detectors is calculated to be 0.51 pCi/g and 0.40 pCi/g, respectively.

Scan MDC (Bare Detector)

The scan MDC was estimated using the method recommended in NUREG-1507 (NRC, 1997) and incorporated into the MARSSIM (EPA, 1997).

The mean gamma radiation count rate in the 2000/2001 reference area was 12,407 cpm. The Ludlum 2221/44-10 detector system recorded counts every 2 seconds; 892 counts were recorded. The standard deviation of these counts was 700 cpm. The variation in the soil concentrations of radionuclides contributes to this standard deviation.

A Ludlum 2221/44-10 GPS system was set up in the laboratory to simulate a system exposed to the mean count rate in the reference area. The counts at 2-second intervals were recorded and the standard deviation calculated. The mean and standard deviation were 12,271 cpm and 436 cpm, respectively. The standard deviation of these 2-second interval records is 3.9 times the theoretical standard deviation obtained from a set of one-minute integrated counts (square root of 12,271 cpm). This factor is used in the calculations below.

The method postulates a first stage where a technician scans slowly and stops to investigate further when it is suspected that the DCGL has been exceeded. In this first stage, it is assumed that 95 percent true detections are required while allowing 60 percent false positives. This corresponds to a detectability index, d' = 1.38 (MARSSIM Table 6-5 [EPA, 1997]). Assuming a 2-second collection interval while scanning, then the number of background counts in the observation interval is 12,407 cpm * (2/60) = 413 counts. For an ideal observer, the net counts needed (above background) is obtained by the product of d' and the standard deviation of the net counts (MARSSIM Equation 6-8 [EPA, 1997]). Ideally, the standard deviation of the net counts would be the square root of 413 counts. However, as indicated in the preceding paragraph, the standard deviation should be increased by a factor of 3.9. This results in a net count of 109 (=square root of 413*3.9*1.38) in the 2-second interval, or 3,270 cpm (109*(60/2)) on the LED display. Adding the background (12,407 cpm), then the gross count-rate at which the ideal technician would stop to conduct further investigations would be 15,677 cpm. This is called the minimum detectable count rate (MDCR).

For the second stage, it is postulated that the technician will stop and perform a 6-second integrated count and compare the integrated value to a value calculated to produce a 95 percent true positive rate and only a 20 percent false positive rate. This corresponds to a d' of 2.48 in MARSSIM Table 6-5 (EPA, 1997). The expected number of counts from background in the 6-second interval is (6/60)* 12,407 = 1,241. Therefore, the minimum detectable number of net counts required is estimated by multiplying the square root of 1,241 by 2.48, or 87. This corresponds to a gross count rate of 1,241 + 87 = 1,328 counts in the 6-second interval. The digital LED display of 1,328 counts or greater will indicate that the DCGL has been exceeded, using the associated statistical criteria. This corresponds to a MDCR of 13,735 cpm.

The MDC is calculated by using the highest minimum detectable count rate, which is 15,677 cpm obtained in the first stage. For that situation, the incremental change above the mean background on the LED display was 3,270 cpm. Using the 2,600 cpm/pCi/g efficiency for thorium-232 in surface soils from the correlation studies, the MDC = 3,270/2,600 pCi/g, or 1.3 pCi/g.

The method introduces a surveyor efficiency factor to account for the fact that a technician may not be able to recognize when the minimum detectable count rate has been exceeded through audible responses or a meter response. We contend that the proposed detection system is less dependent on the technician in that the digital updates every two seconds will clearly reveal to the technician that the minimum detectable count rate has been exceeded. In addition, GPS-based surveys are planned to support the cleanup, where the data will be plotted on maps with areas exceeding the MDCR clearly identified. Therefore, we have not adjusted the MDCR to account for surveyor errors.

Scanning MDC (Collimated Detector)

The scanning MDC for the collimated detector was calculated using the same statistical assumptions for the first stage and second stage surveys. No GPS-based survey data are available for the reference area (background area). However, the one-minute integrated counts taken at the unbiased locations within the area provide a reasonable estimate of the background mean count rate. The mean and standard deviation of the count rate are 3,930 cpm and 83 cpm, respectively. The factor of 3.9 increase in standard deviation compared to the square root of the background count rate was assumed to be appropriate for the collimated detector configuration. The efficiency of the 980 cpm/pCi/g thorium-232 concentration in the surface soils was used to convert the MDCR to MDC.

Following the same calculation path as used for the bare detector MDC calculations, the calculations for the first survey stage resulted in a MDCR of 5,790 cpm. The second stage MDCR was calculated to be 4,420. The MDC is obtained by taking the larger of the two MDCR and dividing by 980 cpm/pCi/g, obtaining 1.9 pCi/g as the MDC.

Minimum Contaminated Area

The minimum contaminated area that corresponds to this MDCR is a function of the scanning speed and the response of the detector. For the first stage scanning, the time required to obtain a maximum reading while exposed to a source is less than 6 seconds. With a scanning speed of 1/3 m/sec, the minimum detectable area is approximately 2 meters (m) across. For the stage-2 determination, the minimum detectable area is anticipated to be less than one meter across. For the first stage, the minimum detectable area would be a 2-m by 2-m square; for the second stage, the minimum detectable area would be a 1-m diameter circular area.

Selection of Detector for Radiological Surveys

The static MDC for thorium-232 using the bare and collimated detectors was calculated to be 0.40 pCi/g and 0.51 pCi/g, respectively. The scanning MDC for the bare and collimated detectors was calculated to be 1.3 pCi/g and 1.9 pCi/g, respectively. The difference in the results is primarily due to the efficiency differences in the two detector configurations. The advantage of the collimated detector is that fewer false positives and false negatives result when surveying in areas affected by gamma shine. This assumes that the only influence on the detectors is background and the source to be identified. Experience at other sites and the linear equations on Table 2-28 confirm that the collimated detector will be the preferred instrument during excavation. Once the gamma radiation is eliminated, the bare detector will be the preferred instrument.

While every attempt has been made to use actual data related to the site conditions and the specific radiation survey equipment, refinement of these numbers may be required. Many surface soil samples will be taken to assure that only the desired soil is removed. The samples will be analyzed in the onsite laboratory and the thorium-232 results compared to the MDCR in use at the time. Where appropriate, the MDCR will be adjusted.

Survey 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(s) to confirm constancy in instrument response. The check source(s) will be comprised of diluted OT-10 source material and will emit the same type and magnitude of radiation being measured, to yield a similar response.

3.2.3 Waste Transportation

The OT-10 waste will be transported and disposed of offsite under the supervision of a DOD-certified waste broker. The following sections address site operations; and transportation, transporter, and shipping paper requirements.

3.2.3.1 Site Operations

One composite sample will be collected from each intermodal container. The samples will be analyzed at an onsite laboratory to determine average concentrations of thorium-232 and uranium-238 (inferred through the use of ratios) in the containers, using gamma spectrometry analysis. The gamma spectrometer has not been selected; nominally, it will be an Ortec gamma spectrometer with a sodium iodide detector (model number and MDC to be determined).

The loaded intermodal containers will be transported by truck and/or rail from Kirtland AFB to the appropriate disposal facility.

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.

3.2.3.2 Transportation Requirements

The OT-10 contaminated soils will likely be classified as DOT Radioactive Material Hazard Class 7, Normal Form, exclusive use, low specific activity (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, 1999a).

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 this section.

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 levels of radioactive contamination on external surfaces will be rendered ALARA.
- The external dose rate will not exceed a radiation level of 1,000 millirem per hour (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.
- 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} microcuries per square centimeter ($\mu Ci/cm^2$) (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.

There are no conveyance activity limits for LSA material, according to Table 9 in 49 CFR § 173.427 (f).

Domestically transported LSA-I bulk packages are excepted from DOT marking and labeling requirements. However, the exterior of each container will be labeled with the following information: "Radioactive-LSA-I" (required under 49 CFR § 173.427), its generation date, and a unique identification number. The latter two labels are not DOT requirements, but will assist waste tracking.

Transport vehicles, both trucks and/or 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).

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 DOD-certified waste broker.

Packages will meet 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. 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). The selected intermodal containers will satisfy the DOT requirements for transport of LSA materials as either IP-1 or strong, tight containers.

The intermodal containers will meet the following packaging requirements for the OT-10 soils:

- 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.

3.2.3.3 Waste Transporter Requirements

The waste transporter will be required to

- maintain an approved RCRA Part A waste transporter application and a notarized copy of their EPA waste transport identification number,

- provide notarized statements describing the status and background of any civil or criminal lawsuits filed against them within the last 10 years,

- provide bills of lading to accompany the shipments, and

- 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.

3.2.3.4 Shipping Paper Requirements

Uniform Low-Level Radioactive Waste Manifests, NRC Forms 540, 541, and 542 for each waste shipment will be generated completely and accurately by the DOD-certified waste broker, who also will sign the manifests as shipper.

NRC Form 540 will accompany waste shipments. NRC Forms 541 and 542 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 Envirocare 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 also will 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 per gram [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 the HQ Army Operations Support Command (OSC) Safety Officer.

OT-10 soils with high concentrations of thorium-232 may be classified as Reportable Quantities or Hazardous Class 9 for environmentally hazardous substances (UN3077), based on Table 2 to Appendix A of 49 CFR § 172.101. According to this table, the reportable quantity for thorium-232 in secular equilibrium with its daughters is 0.011 curies. The concentration of thorium-232 at which the quantity held in an intermodal container becomes reportable under the *Comprehensive Environment Response Compensation and Liability Act* is 630 pCi/g.

The calculation follows

$$\frac{0.011Ci}{15\,yd^3 x 95\frac{lb}{ft^3} x 454\frac{g}{lb} x 27\frac{ft^3}{yd^3} x \frac{Ci}{10^{12}\,pCi}} = 630\,pCi/g \qquad \text{Eq. 3-2}$$

with the following assumptions: 15 yd^3 is the volume of soil in an intermodal container and 95 lb/ft^3 is the wet soil bulk density.

Emergency response information will meet the requirements of 49 CFR Part 172 Subpart G. The DOD-certified broker will serve as the 24-hr-a-day point of contact.

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

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

The DOD-certified waste broker will complete a Texas Commission on Environmental Quality (TCEQ) Form 0311, uniform hazardous waste manifest, for all shipment destined for WCS. Electronic transmittal of this form is not available.

3.2.4 Waste Acceptance Procedures

The following sections describe waste acceptance procedures for Envirocare and WCS.

3.2.4.1 Envirocare 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.

A Kirtland AFB point of contact, RCRA Part B Permit information and a description of the waste will be recorded on Envirocare's radioactive waste profile record form for wastes destined for Envirocare. The waste will be described by the date it was generated and its history, volume, general characteristics, radiological and chemical constituents, and physical properties. Similar information will be recorded on WCS' waste profile sheet and an attachment to this sheet for radioactive material.

Envirocare requires third-party certified laboratory results to evaluate incoming wastes. Two waste profile samples were collected prior to excavation activities and sent to an offsite laboratory. The excavated material were analyzed for the following radiological, chemical, and physical parameters:

- radionuclides by gamma spectrometry and isotopic thorium and uranium by alpha spectrometry;
- TCLP RCRA metals listed in Table 1 of 40 CFR § 261.24 and zinc;
- TCLP for the 32 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.

The results of these waste profile analyses are presented in Table 2-11 of this decommissioning plan. The DOD-certified waste broker will identify incoming radionuclides by element, mass number, and concentration limits. These limits will be based on the average concentration per container for each radionuclide.

Envirocare will evaluate the waste profile and classify radionuclides for near-surface disposal. The classification parameters are those defined in 10 CFR § 61.55 and *Utah Administrative Code* (UAC) R313-

15-1008. Three classes have been determined in these rules: Classes A, B, and C. Envirocare accepts only Class A wastes.

The Kirtland AFB packages also are expected to meet the long-lived and short-lived radionuclide activity requirements of Class A wastes listed in Tables 3-1 (long-lived radionuclides) and 3-2 (short-lived radionuclides). 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 R-313-15-1008 provides a sum of fractions method to classify wastes containing a mixture of the short-lived and long-lived radionuclides in Tables 3-2 and 3-3. However, the OT-10 soils are not expected to contain such mixtures. Therefore, this method is not discussed here.

Table 3-2. Long-lived Radionuclides

Radionuclide[a]	Concentration	
	[Ci/m^3]	[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.
CFR = *Code of Federal Regulations*
Ci/m^3 = curies per cubic meter
nCi/g = nanocuries per gram

Table 3-3. Short-lived Radionuclides

Radionuclide[a]	Concentration [Ci/m^3][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.
CFR = *Code of Federal Regulations*
Ci/m^3 = curies per cubic meter
UAC = *Utah Administrative Code*

The Kirtland AFB intermodal containers 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 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.

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.

3.2.4.2 Waste Control Specialists Procedures

WCS' waste acceptance procedures include waste profiling and manifesting, and pre-shipment scheduling.

WCS can accept source material (thorium and uranium) in any physical or chemical form, solution or alloy in which the source material is less than 0.05 percent by weight. This translates to the following concentrations: thorium-232 (54.5 pCi/g), uranium-238 (166.5 pCi/g), natural uranium (355.0 pCi/g total uranium), natural thorium (110.0 pCi/g total thorium), and depleted uranium (250.0 pCi/g total uranium). In the case of OT-10, disposal of such material requires NRC approval because the OT-10 source material is licensed under the Atomic Energy Act.

The DOD-certified waste broker will accomplish the following for wastes destined for WCS:

- Submit a complete waste profile sheet to WCS providing information about the generator, the waste to be shipped (concentrations of long-lived radionuclides and RCRA constituents, and soil properties), and assurances that the WCS shipping/disposal requirements will be satisfied. The waste profile sheet will be submitted to WCS at least 72 hours prior to the arrival of a shipment at the WCS facility.

- Schedule each shipment at least 72 hours prior to its arrival at the WCS site, using a WCS shipment scheduling form.

- Submit a TCEQ Form 0311, uniform hazardous waste manifest, and NRC Forms 540 and 541, with all shipments destined for WCS.

- The DOD-certified waste broker will identify incoming radionuclides by element, mass number, and concentration limits. These limits will be based on the average concentration per container for each radionuclide.

WCS also requires the following:

- Packages destined for WCS meet all applicable provisions described in Section 3.2.3.2 of this Decommissioning Plan and 25 *Texas Administrative Code* (TAC) § 289.101(o).

- The results of one composite sample for each 20 yd^3 volume of waste.

- All packages have lifting devices to allow handling by forklifts, cranes, or similar handling equipment.

- Waste packages loaded as efficiently and as compactly as practicable to maximize use of interior volume.

3.2.5 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. The contents of each intermodal container will be disposed of in the landfill; the containers will be reused.

Envirocare has an Agreement-State Radioactive Material License (License #UT 2300249, as amended) issued by the Utah Division of Radiation Control. The facility can accept low-level radioactive wastes containing source materials.

WCS does not have an Agreement-State license to dispose of radioactive materials at its Andrews County, Texas facility. However, WCS can accept and dispose of exempt source material in which the source material is less than 0.05 percent by weight. The State of Texas permits such disposal in accordance with 25 TAC § 289.101(o), which is a memorandum of understanding (MOU) between the TCEQ and the Texas Department of Health (TDH). The MOU permits disposal of TDH-exempt materials with no further regulation by the TCEQ, as long as doses to workers are ALARA and below TDH limits for unrestricted release.

3.3 Decommissioning Procedures for Structures

3.3.1 Cleaning Buildings 28005 and 28010

Buildings 28005 and 28010 at TS8 are considered MARSSIM Class 1 survey units, because contamination levels on their interior surfaces exceed the surface contamination limits presented in this plan.

Contamination on the interior surfaces of Building 28010 is expected to be limited to radon-220, radon-222, and their progeny. It is expected that this storage bunker can be decommissioned by vacuuming or washing the walls and floors. Contamination on the interior surfaces of Building 28005 could be more substantial and problematic.

The interior surfaces of Buildings 28005 and 28010 will be vacuumed and/or washed at least 7 days after debris, including drums and pallets, is removed. Building doors will be left open after removal of debris to allow enough time for radon-220, radon-222 and their progeny to decay. Cleaning will be conducted top-down, from the ceilings to the walls to the floors. Wash water, if used, will be conveyed to soil outside of the building, where it will be dammed and allowed to evaporate. Soil impacted by wash water will be removed if it is contaminated above the surface contamination limits.

It is anticipated that both buildings will be subject to remedial action support surveys after the initial cleaning. Additional vacuuming and/or washing, or washing using a chelating agent will be considered if the first cleanings are effective but contamination still exceeds surface contamination limits. Demolition and disposal of these buildings will be performed if the contamination on building surfaces is recalcitrant. The storage bunkers will be demolished using a backhoe equipped with shears and/or a jack hammer, or equivalent, assuming demolition and disposal is warranted. If decontamination of the bunkers is successful, final status surveys will be performed.

3.3.2 Waste Transport and Disposal

Debris from building cleaning and/or demolition activities will be shipped to Envirocare. The DOD-certified waste broker will modify inputs to Envirocare's radioactive waste profile to accommodate the contaminated debris.