National Nuclear Security Administration
Sandia Site Office
P.O. Box 5400
Albuquerque, New Mexico 87185-5400

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NMED Hazardous
Waste Bureau

Mr. James Bearzi
Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Road East
Building 1
Santa Fe, New Mexico 87505

Dear Mr. Bearzi:

On behalf of Sandia Corporation (Sandia) and the Department of Energy (DOE), DOE is submitting the Long-Term Monitoring and Maintenance Plan (LTMMP) for the Mixed Waste Landfill (MWL) at Sandia National Laboratories/New Mexico (SNL/NM) (EPA ID No. NM5890110518). The MWL LTMMP is required by the New Mexico Secretary of the Environment's Final Order No. HWB 04-11(M) and the New Mexico Environment Department (NMED) Class 3 Permit Modification for the MWL, both documenting the final remedy selection and associated requirements for the MWL.

The MWL LTMMP addresses monitoring, sampling, maintenance, and physical and institutional controls at the MWL following the final remedy implementation (installation of the vegetative soil cover with a biointrusion barrier). Although the Class 3 Permit Modification requires that DOE and SNL/NM submit the Long Term Monitoring and Maintenance Plan to NMED within 180 days after the NMED approval of the Corrective Measures Implementation Report, this document has been prepared ahead of schedule at NMED's request.

If you have any questions, please contact me at (505) 845-6036, or Dan Pellegrino of my staff at (505) 845-5398.

Sincerely,

Patty Wagner

Patty Wagner
Manager

Enclosure

cc w/enclosure:
W. Moats, NMED-HWB (Via Certified Mail)
L. King, EPA, Region 6 (Via Certified Mail)
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CERTIFICATION STATEMENT FOR APPROVAL AND FINAL RELEASE OF DOCUMENTS

Document title: **Long-Term Monitoring and Maintenance Plan for the Mixed Waste Landfill, September 2007**

Document author: **Stacy Griffith and Tim Goering, Dept. 6765**

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine or imprisonment for knowing violations.

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Sept 19, 2007
Date

and

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Patty Wagner
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Sandia Site Office
Owner and Co-Operator

9-24-07
Date

Sandia National Laboratories/New Mexico
Environmental Restoration Project

LONG-TERM MONITORING AND MAINTENANCE PLAN FOR THE MIXED WASTE LANDFILL

September 2007

United States Department of Energy
Sandia Site Office

Sandia is a multiprogram laboratory managed and operated by Sandia Corporation, a wholly-owned subsidiary of Lockheed Martin Corporation, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

EXECUTIVE SUMMARY

The Mixed Waste Landfill (MWL) is an inactive landfill, designated as a Solid Waste Management Unit, at Sandia National Laboratories, New Mexico (SNL). The SNL facility is owned by the U.S. Department of Energy (DOE). SNL is managed and operated by Sandia Corporation (Sandia). Both the DOE and Sandia, hereinafter referred to as the DOE/Sandia, are co-permittees of the MWL. The MWL is located in Technical Area III of SNL which is within the boundaries of the federally-owned Kirtland Air Force Base, south of the city of Albuquerque. The MWL is undergoing corrective action in accordance with:

- Resource Conservation and Recovery Act (RCRA) regulations
- Module IV of the RCRA Permit No. NM5890110518
- New Mexico Environment Department (NMED) Class 3 Permit Modification for the MWL (NMED August 2005)
- New Mexico Secretary of the Environment Final Order No. HWB 04-11(M) in the matter of request for a Class 3 Permit Modification for Corrective Measures for the Mixed Waste Landfill No. HWB 04-11(M) (Curry May 2005)
- NMED Compliance Order on Consent (Consent Order) (NMED April 2004)

In the Final Order on the MWL, the NMED selected a vegetative soil cover with a biointrusion barrier as the final remedy and requested the identification of specific monitoring trigger levels, the exceedance of which initiates an evaluation of the need for further corrective action. This Long-Term Monitoring and Maintenance Plan (LTMMP) addresses monitoring, sampling, maintenance, and physical and institutional controls (ICs) at the MWL following the final remedy implementation (installation of the cover). The purpose of long-term monitoring is to ensure that the final remedy for the MWL is protective of human health and the environment. The DOE/Sandia will meet the long-term monitoring requirements for the MWL through various activities identified in this LTMMP. The scope and frequency of these activities along with prescribed actions to be implemented are detailed.

The DOE/Sandia will monitor air, surface soil, vadose zone, groundwater, and biota to determine whether the MWL cover is performing as designed. The DOE/Sandia have identified parameters to monitor based upon the results of the probabilistic performance-assessment modeling conducted for the MWL (Ho et al. January 2007) and input from the NMED and the public. The following parameters will be monitored:

- Radon concentrations in the air
- Tritium, gamma-emitting radionuclides, and metal concentrations in surface soil
- Soil moisture in the vadose zone
- Volatile organic compound (VOC) concentrations in the vadose zone
- VOC, uranium, and radionuclide concentrations in groundwater
- Gamma-emitting radionuclides in biota

The monitoring and sampling activities, frequencies, and analytical methods are presented for each parameter. Sampling and analysis plans are provided in the appendices detailing specific sampling procedures and applicable data quality objectives. Although monitoring is planned for radionuclides in various media at the MWL, the information related to radionuclides is provided voluntarily by the DOE/Sandia.

Monitoring triggers have been established as the criteria against which the monitoring results will be compared. In the event that a trigger level is exceeded, an evaluation process is in place that allows for sufficient data to be collected to assess trends and determine whether corrective action is warranted. Specific triggers include numerical thresholds derived from U.S. Environmental Protection Agency, DOE, and NMED regulatory standards, as well as NMED-approved background concentrations for select radionuclides.

Routine surveillance and maintenance of the cover and associated facilities will also be performed to ensure the integrity of the cover. Surveillance will be conducted on the following:

- Physical condition (vegetation survey, signs of erosion, settlement, water ponding, intrusion by animals, contiguous areas lacking vegetation)

- Surface-water diversion structures

- Groundwater monitoring wells, soil-vapor sampling wells, and neutron access tubes

- Security fence, signs, gates and locks, and survey benchmarks

Maintenance will be performed to prevent deterioration or failure of any feature of the cover or associated facilities and, if needed, corrective action will be taken to restore conditions to the original specifications.

ICs are a key element of the long-term monitoring and maintenance strategy for the MWL. Categories of ICs in place at the MWL include:

- Government ownership
- Entry restrictions
- Warning notices
- Active controls
- Resource-use management
- Site information systems

The application of multiple ICs at the MWL is consistent with a conservative strategy that incorporates multiple, independent layers of safety to protect human health and the environment. In the event of the temporary failure of a control, others are in place to mitigate significant consequences of the failure.

Contingency procedures are addressed through the trigger evaluation process, which will be used to evaluate any monitoring results that exceed the specified triggers. Potential failure scenarios are presented, along with possible corrective action responses. Any such response will be assessed on a situation-specific basis in cooperation with the NMED.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Concluded)

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LIST OF FIGURES

Figure

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LIST OF TABLES

Table

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LIST OF APPENDICES

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ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
CFR	Code of Federal Regulations
Ci	curie(s)
cm	centimeter(s)
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
FLUTe™	Flexible Liner Underground Technologies
g	gram(s)
HSWA	Hazardous and Solid Waste Amendments
HWB	Hazardous Waste Bureau
IC	institutional control
KAFB	Kirtland Air Force Base
L	liter(s)
LTES	Long-Term Environmental Stewardship
LTMMP	Long-Term Monitoring and Maintenance Plan
m^2	square meter
MCL	maximum contaminant level
μg	microgram(s)
mm	millimeter(s)
MP	Monitoring Plan
MWL	Mixed Waste Landfill
NMED	New Mexico Environment Department
NOD	Notice of Disapproval
P&A	plug and abandonment
PCE	tetrachloroethane
pCi	picocurie(s)
ppb	part(s) per billion
ppmv	part(s) per million by volume
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RWP	Radiological Work Permit
s	second
Sandia	Sandia Corporation
SAP	Sampling and Analysis Plan
SNL	Sandia National Laboratories
SNL/NM	Sandia National Laboratories/New Mexico
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit

ACRONYMS AND ABBREVIATIONS (Concluded)

TA	Technical Area
TCE	trichloroethene
UNM	University of New Mexico
VOC	volatile organic compound
yr	year

1.0 INTRODUCTION

The Mixed Waste Landfill (MWL) at Sandia National Laboratories/New Mexico (SNL/NM) is a Solid Waste Management Unit (SWMU) undergoing corrective action in accordance with the Resource Conservation and Recovery Act (RCRA) regulations, the New Mexico Secretary of the Environment's Final Order in the matter of request for a Class 3 Permit Modification for Corrective Measures for the Mixed Waste Landfill No. HWB 04-11(M) (Curry May 2005), the New Mexico Environment Department (NMED) Class 3 Permit Modification for the MWL (NMED August 2005), and the Compliance Order on Consent (Consent Order) (NMED April 2004).

On May 26, 2005, the NMED issued the Final Order on the MWL selecting a vegetative soil cover with biointrusion barrier as the final remedy for the MWL. The NMED Final Order and the Class 3 Permit Modification require the development of this Long-Term Monitoring and Maintenance Plan (LTMMP) to address monitoring, maintenance, and physical and institutional controls (ICs) at the MWL following remedy implementation.

1.1 Purpose

This LTMMP describes how the U.S. Department of Energy (DOE) and Sandia Corporation (Sandia), hereinafter referred to as the DOE/Sandia, will meet the long-term monitoring requirements for the MWL. This plan describes the necessary physical controls and ICs to be implemented, the maintenance and monitoring activities for the cover, and the frequencies at which they will be conducted. These activities will be performed to ensure that the MWL vegetative soil cover and biointrusion barrier will perform as designed and will continue to protect human health and the environment.

1.2 Regulatory Background

On November 3, 2005, the DOE/Sandia submitted a Corrective Measures Implementation (CMI) Plan (SNL/NM November 2005) incorporating the final remedy selected by the NMED. The CMI Plan presented the design for a 3-foot-thick, vegetated soil cover, underlain by a 1-foot-thick biointrusion barrier and a subgrade layer that varies from 2 to 40 inches in thickness. The CMI Plan also included detailed engineering design drawings and construction specifications, a construction quality assurance plan, and the results of a fate and transport model with proposed triggers for corrective action.

In November 2006, the NMED submitted a Notice of Disapproval (NOD) on the MWL CMI Plan (NMED November 2006). The NOD contained two sets of comments, requesting 1) clarification regarding the MWL cover design and fate and transport model, and 2) additional triggers for long-term monitoring. The DOE/Sandia responses to the NOD included clarifications regarding the MWL cover design, the fate and transport model, and a revised list of monitoring triggers for long-term monitoring (Sandia Corporation December 2006 and January 2007). The revised triggers for long-term monitoring are discussed in Chapter 5.0 of this document.

Triggers for long-term monitoring have been developed for both hazardous and radioactive constituents; however, the triggers and monitoring for radionuclides are provided voluntarily by the DOE/Sandia. The voluntary inclusion of such radionuclide information shall not be enforceable and shall not constitute the basis for any enforcement because such information falls wholly outside the requirements of the Consent Order. Additional information on radionuclides and the scope of the Consent Order is available in Section III.A of the Consent Order (NMED April 2004).

Although the Class 3 Permit Modification requires the Permittees (DOE/Sandia) to submit this document to the NMED within 180 days after the NMED's approval of the CMI Report, the schedule for this document has been accelerated at the NMED's request. Therefore, preparation and submission of this LTMMP occurs prior to construction of the MWL cover. The actual cover construction will take place once the NMED approves the cover design submitted in the CMI Plan (SNL/NM November 2005). To minimize requirements for future modifications to this plan once the cover is completed, the document is written in the present tense as if the cover were already completed.

The exception to this convention is the discussion of the groundwater monitoring well network. At the writing of this document, several modifications to the groundwater monitoring well network have been proposed. As important details (construction diagrams and locations) of the proposed wells could not be provided in this plan, the DOE/Sandia fully discuss the existing well network with reference to the proposed changes. Efforts have been made to include all proposed wells in the discussion, as these are critical to the long-term monitoring of the groundwater. Because the proposed wells have not yet been installed, the circumstances of their installation may change.

1.3 Legal and Regulatory Requirements

The MWL is designated as an Underground Radioactive Material Area and a Hazardous and Solid Waste Amendments (HSWA) SWMU, subject to corrective action and remedy selection under state regulations. The NMED Hazardous Waste Bureau (HWB) is the lead regulatory agency and oversees corrective action at the MWL under the corrective action provisions of the HSWA Module of the RCRA Part B Permit, issued to the DOE/Sandia by the U.S. Environmental Protection Agency (EPA) Region 6 on August 26, 1993 (EPA August 1993).

A requirement to develop an LTMMP was presented in the NMED Final Order on the MWL (Curry May 2005) and the Class 3 Permit Modification (NMED August 2005). Although the Consent Order (NMED April 2004) governs the remedy selection process for the MWL, it does not contain any requirements related to long-term monitoring, other than requirements for monitoring well replacement. Rather, the Consent Order defers to the RCRA Part B Permit (as revised by the August 2005 Class 3 Permit Modification for the MWL) for implementation of long-term controls for SWMUs.

The Class 3 Permit Modification provides the framework for the LTMMP and states the following in Section V(6):

> A long-term monitoring and maintenance plan, which includes all necessary physical and institutional controls to be implemented in the future shall be submitted by the Permittees to the Administrative Authority for approval within 180 days after the Administrative Authority's approval of the CMI Report. The Administrative Authority may require monitoring, maintenance, and physical and institutional controls different than those specified in the Corrective Measures Study report referenced in V.1 of this section. The plan shall also include contingency procedures that

must be implemented by the Permittees if the remedy set forth in Section V.2 above fails to be protective of human health and the environment.

As discussed in Section 1.2, the Class 3 Permit Modification requires the Permittees (DOE/Sandia) to submit this document to the NMED within 180 days after the NMED's approval of the CMI Report. However, the schedule for the LTMMP has been accelerated at the NMED's request, and this document is being prepared and submitted prior to the NMED's approval of the cover design provided in the MWL CMI Plan (SNL/NM November 2005).

The Class 3 Permit Modification also requires the Permittees to prepare a report every five years, reevaluating the feasibility of excavation and analyzing the continued effectiveness of the MWL remedy. The Five-Year Reevaluation Report will include a review of all major MWL documents, as well as any data collected during long-term monitoring and maintenance at the site. The report will include an update of the fate and transport model for the MWL with current data and a reevaluation of the likelihood of contaminants reaching groundwater. Finally, the Five-Year Reevaluation Report will detail all efforts to ensure any future releases or migration of contaminants are detected and addressed before there is an impact to groundwater quality or increased risk to human health or the environment. The initial Five-Year Reevaluation Report will be submitted within five years after the completion of the remedy.

1.4 Roles of the DOE and Sandia

SNL/NM is owned by the DOE as well as managed and operated by Sandia, a wholly owned subsidiary of Lockheed Martin Corporation. Sandia has a Management and Operating Contract with the DOE for Sandia National Laboratories (SNL). The DOE/Sandia serve as co-permittees for purposes of hazardous waste management and corrective action, in accordance with SNL/NM's RCRA Permit.

The DOE/Sandia are jointly responsible for preparation, revision, and implementation of the LTMMP. If the LTMMP requires amendment, the DOE/Sandia will notify the NMED in writing and will include a copy of the amended LTMMP for review and approval. Interested members of the public will be allowed to review and comment on changes to the LTMMP.

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2.0 FINAL SITE CONDITIONS

This chapter presents general information on the facility and the MWL and provides the context within which long-term monitoring activities will occur.

2.1 Location, Conditions, and Description of the MWL

This section presents a brief history of the disposal activities at the MWL and summarizes the results of the two RCRA facility investigations (RFIs) conducted at the site. Groundwater flow conditions and the MWL monitoring well network are also discussed, and surface features are summarized. Additional MWL characterization data are available in the following documents:

- Report of the Phase 1 RFI of the Mixed Waste Landfill (SNL/NM September 1990)
- Report of the Mixed Waste Landfill Phase 2 RFI, Sandia National Laboratories, Albuquerque, New Mexico (SNL/NM September 1996)
- Mixed Waste Landfill Groundwater Report, 1990 through 2001 (Goering et al. 2002)

2.1.1 Location and Description

SNL/NM is located within the boundaries of Kirtland Air Force Base (KAFB), immediately south of the City of Albuquerque in Bernalillo County, New Mexico (Figure 2.1.1-1). The MWL is located 4 miles south of SNL/NM's central facilities and 5 miles southeast of Albuquerque International Sunport. The landfill is located in the north-central portion of Technical Area (TA)-III at SNL/NM (Figure 2.1.1-2).

The MWL accepted containerized and uncontainerized low-level radioactive waste and minor amounts of mixed waste from SNL/NM research facilities and off-site DOE and U.S. Department of Defense generators from March 1959 to December 1988. Approximately 100,000 cubic feet of low-level radioactive waste (excluding packaging, containers, demolition and construction debris, and contaminated soil) containing 6,300 curies (Ci) of activity (at the time of disposal) were disposed of at the MWL. Disposal cells at the landfill are unlined and were backfilled and compacted to grade with stockpiled soil.

Two distinct disposal areas are present at the MWL: the classified area (occupying 0.6 acres) and the unclassified area (occupying 2.0 acres) (Figure 2.1.1-3). Wastes in the classified area were disposed of in a series of vertical, cylindrical pits. Historical records indicate that early pits were 3 to 5 feet in diameter and 15 feet deep; later pits were 10 feet in diameter and 25 feet deep. Once pits were filled with waste, they were backfilled with soil and capped with concrete. Wastes in the unclassified area were disposed of in a series of parallel, north-south trenches. Records indicate that trenches were 15 to 25 feet wide, 150 to 180 feet long, and 15 to 20 feet deep. Trenches were backfilled with soil on a quarterly basis and, once filled with waste, were capped with the original soil that had been excavated and locally stockpiled.

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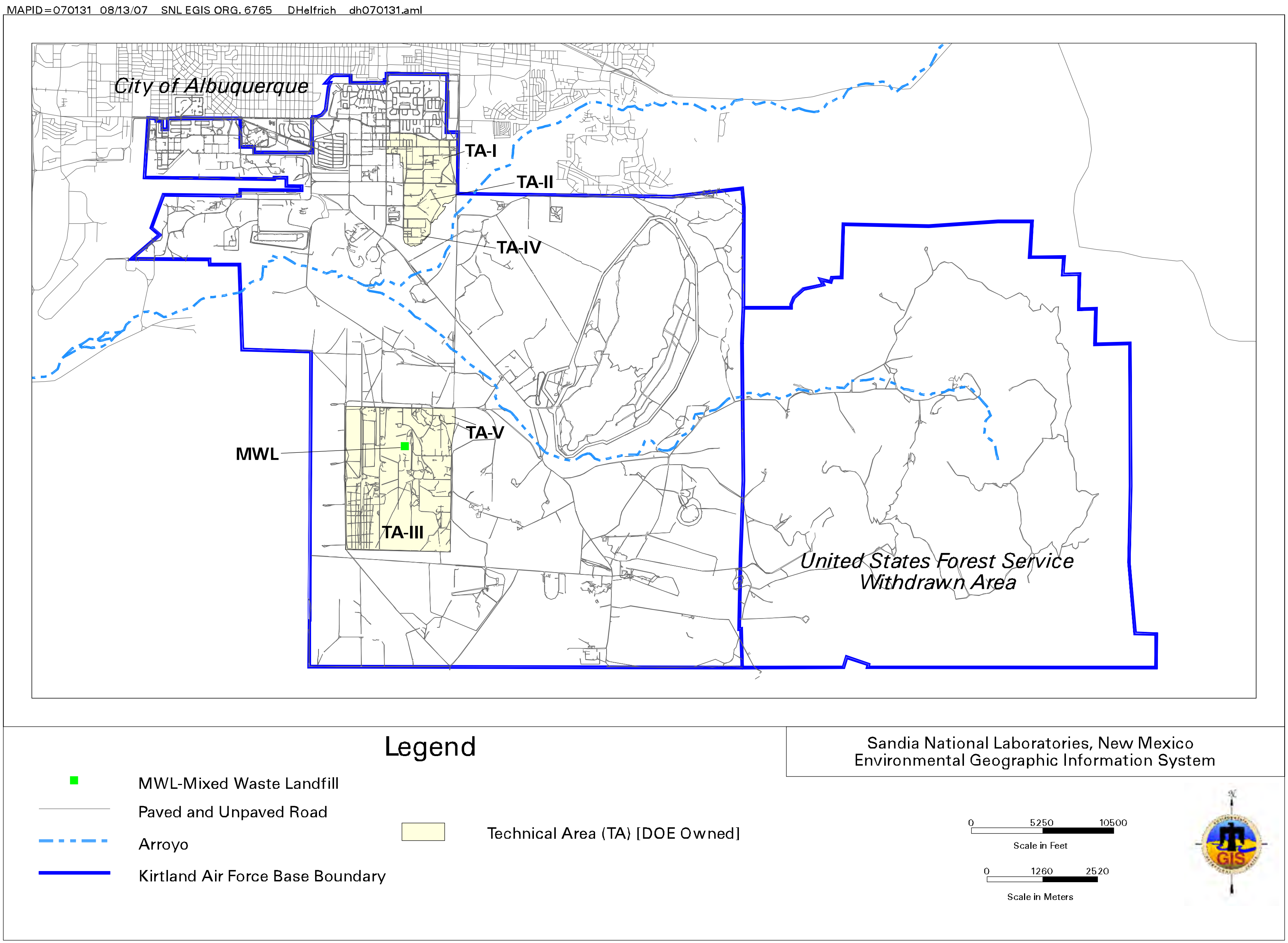

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Figure 2.1.1-1 Location of Sandia National Laboratories and Kirtland Air Force Base

Legend

Road

Technical Area

Mixed Waste Landfill

Figure 2.1.1-2
Location of the Mixed Waste Landfill within Technical Area III

0 1000 2000
Scale in Feet

0 240 480
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

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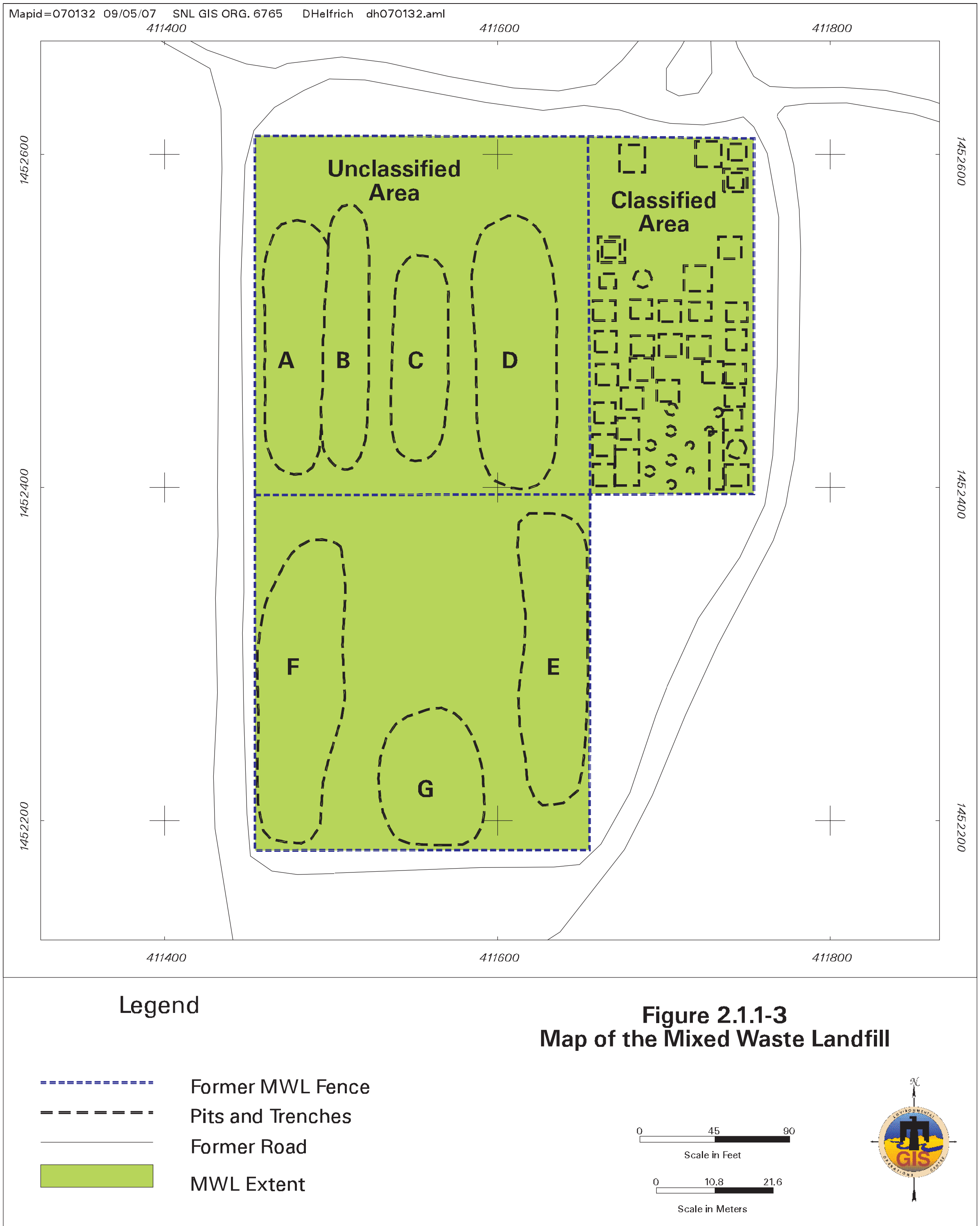

Figure 2.1.1-3
Map of the Mixed Waste Landfill

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

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Containment and disposal of routine waste commonly occurred using tied, double-polyethylene bags, sealed A/N cans (military ordnance metal containers of various sizes), fiberboard drums, wooden crates, cardboard boxes, and 55-gallon steel and polyethylene drums. Larger items, such as glove boxes, spent fuel shipping casks, and contaminated soil, were disposed of in bulk without containment. Disposal of free liquids was not allowed at the MWL. Liquids such as acids, bases, and solvents were solidified with commercially available agents before containerization and disposal. A detailed MWL waste inventory, by pit and trench, is provided in the Environmental Restoration (ER) Project "Responses to NMED Technical Comments on the Report of the Mixed Waste Landfill Phase 2 RCRA Facility Investigation, June 15, 1998" (SNL/NM June 1998).

A Phase 1 RFI was conducted in 1989 and 1990 to determine whether a release of RCRA contaminants had occurred at the MWL (SNL/NM September 1990). A Phase 2 RFI was conducted from 1992 to 1995 to determine the contaminant source, define the nature and extent of contamination, identify potential contaminant transport pathways, evaluate potential risks posed by the levels of contamination identified, and provide remedial action alternatives for the landfill (SNL/NM September 1996).

Both investigations revealed that tritium has migrated from the pits and trenches of the MWL. Tritium was detected during the Phase 2 RFI in surface and near-surface soil in, and around, the classified area of the landfill at levels ranging from 1,100 picocuries (pCi) per gram (g) in surface soil to 206 pCi/g in subsurface soil. The highest tritium levels were found within 30 feet below ground surface (bgs) in soil adjacent to, and directly beneath, classified area disposal pits. At distances greater than 30 feet bgs, tritium levels decrease rapidly to a few pCi/g of soil. Tritium has been detected to a maximum depth of 120 feet bgs beneath the MWL. Tritium also occurs as a diffuse air emission from the landfill. A study conducted in 2003 estimated the annual tritium flux to be 0.09 Ci/year (yr) (URS Corporation February 2004).

2.1.2 Groundwater

Groundwater occurs approximately 500 feet bgs within Santa Fe Group deposits (basin fill), in either fine-grained alluvial fan deposits or coarse-grained Ancestral Rio Grande deposits. Hydraulic conductivities average 1.64×10^{-2} feet/day in the alluvial fan deposits and 1.81 feet/day in the Ancestral Rio Grande deposits. Groundwater flows westward at an average velocity of 0.17 feet/yr in the alluvial fan deposits and 18.5 feet/yr in the Ancestral Rio Grande deposits. Figure 2.1.2-1 shows the regional potentiometric surface of the basin fill aquifer west of the Sandia fault complex. Figure 2.1.2-2 shows the localized potentiometric surface of the basin fill aquifer at TA-III. Groundwater levels beneath the MWL are declining at an average rate of 0.5 feet/yr as a result of pumping from regional production wells.

2.1.3 Surface Features

No permanent aboveground structures are located at the MWL. All disposal pits and trenches were excavated below grade. No perennial streams are present in the immediate area of the MWL. Surface runoff is regionally controlled and generally to the west. The MWL vegetative cover slopes gently and sheds surface runoff to the landfill perimeter. A drainage swale located immediately east of the landfill diverts surface runoff from the landfill. Figure 2.1.3-1 presents the final grading plan for the MWL cover and shows the location of the drainage swale.

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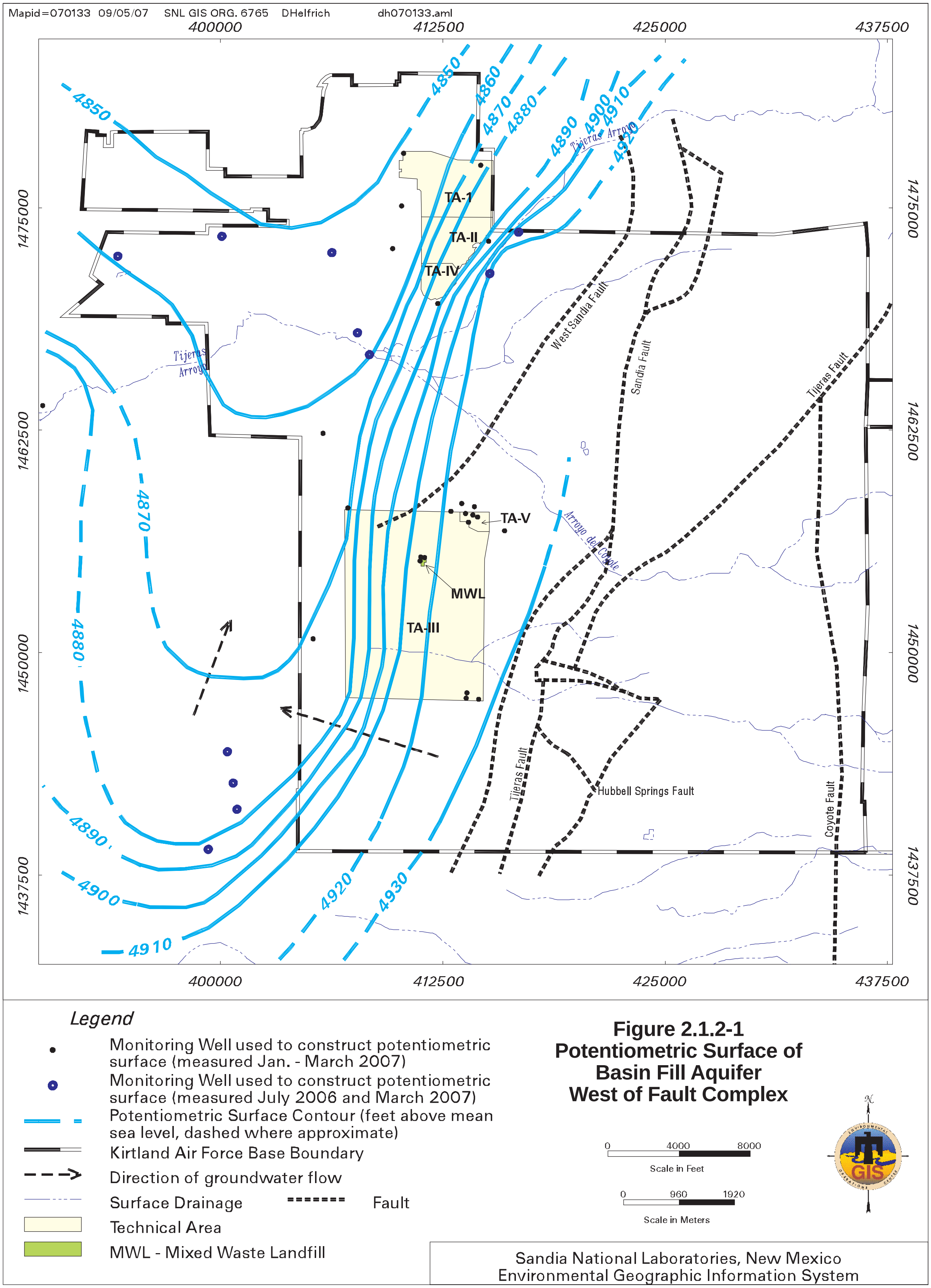

Figure 2.1.2-1
Potentiometric Surface of Basin Fill Aquifer West of Fault Complex

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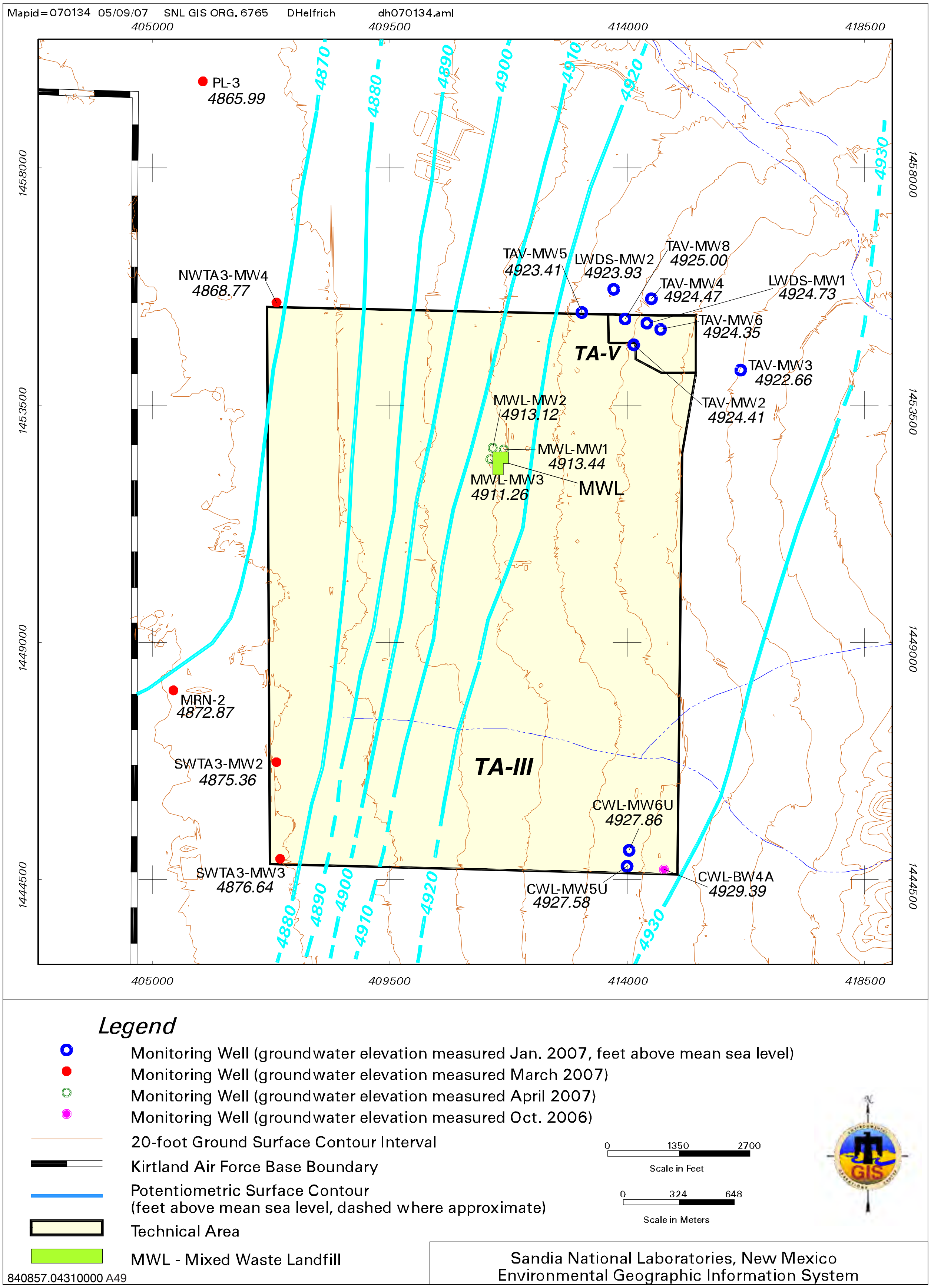

Figure 2.1.2-2 Localized Potentiometric Surface of Basin Fill Aquifer at Technical Area III

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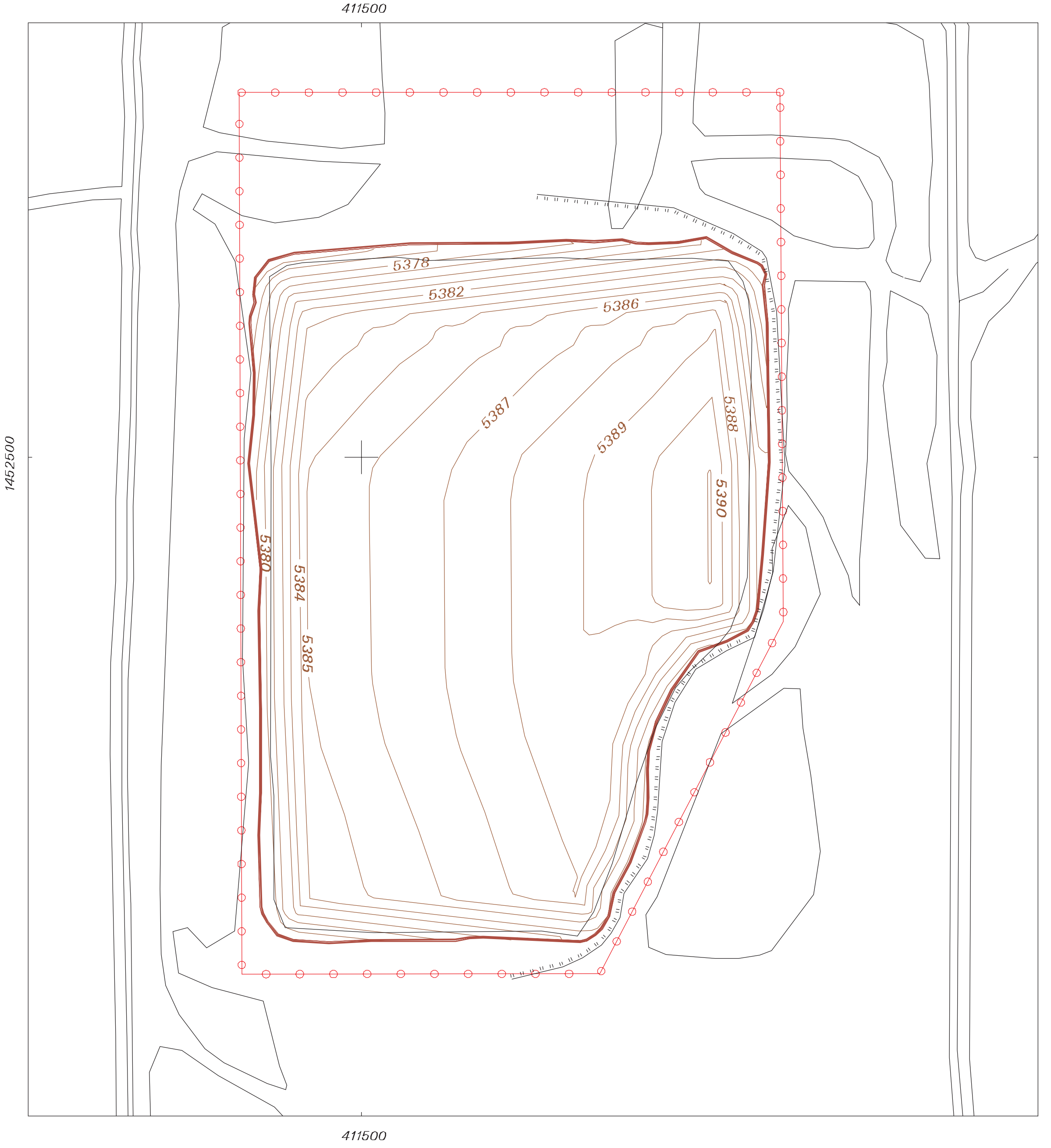

Legend

Drainage Swale
1-ft Landfill Cover Contour Interval
Fence
Toe of Landfill Cover
Road and Berm

Figure 2.1.3-1
Mixed Waste Landfill
Final Cover Grading Plan

0 60 120
Scale in Feet

0 14.4 28.8
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

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2.2 Description of the Engineered Cover

The MWL cover occupies 3.6 acres and consists of a 3-foot-thick native soil layer overlying a 1-foot-thick, crushed rock, biointrusion barrier. The biointrusion barrier overlies the subgrade soil and existing landfill surface. The uppermost layer of the cover consists of an 8-inch-thick, vegetated, topsoil layer admixed with 25 percent 3/8-inch crushed gravel. The cover is centrally crowned with a 2-percent slope. A cross-section of the cover is shown in Figure 2.2-1.

The topsoil layer has been seeded with native grasses to mitigate surface erosion and promote evapotranspiration. The native grass species were selected based upon biological assessments of TA-III (Sullivan and Knight 1992, Peace et al. November 2004), and consist of black grama, spike dropseed, galleta grass, and ring muhly. This plant community was designed to approximate the dominant and subdominant species in TA-III and will gradually develop into a climax community indistinguishable from the natural community.

Additional details on the MWL cover are presented in the MWL CMI Plan (SNL/NM November 2005) and the pending CMI Report. The CMI Plan includes engineering design drawings, construction specifications, and the construction quality assurance plan. The CMI report includes a summary of the MWL cover construction activities, as-built drawings and specifications, and the construction quality assurance report.

2.3 Storm-Water Diversion Structures

Surface drainage features designed to control surface-water run-on and runoff are shown in the MWL Final Grading Plan (Plate 4 in the CMI Plan [SNL/NM November 2005]). The primary storm-water diversion structure incorporated into the MWL remedy is a drainage swale along the eastern perimeter of the landfill, schematically shown in Figure 2.1.3-1. This feature prevents storm-water run-on from eroding the cover. The vegetated, gently sloping topography (approximately 2-percent grade from east to west) and crown of the MWL cover and the 6:1 side slopes of the cover prevent significant run-on by directing the upgradient surface water away from the site. Runoff from the MWL cover is accommodated by the gentle slope of the cover and crown towards the eastern swale or western perimeter of the landfill, away from the MWL.

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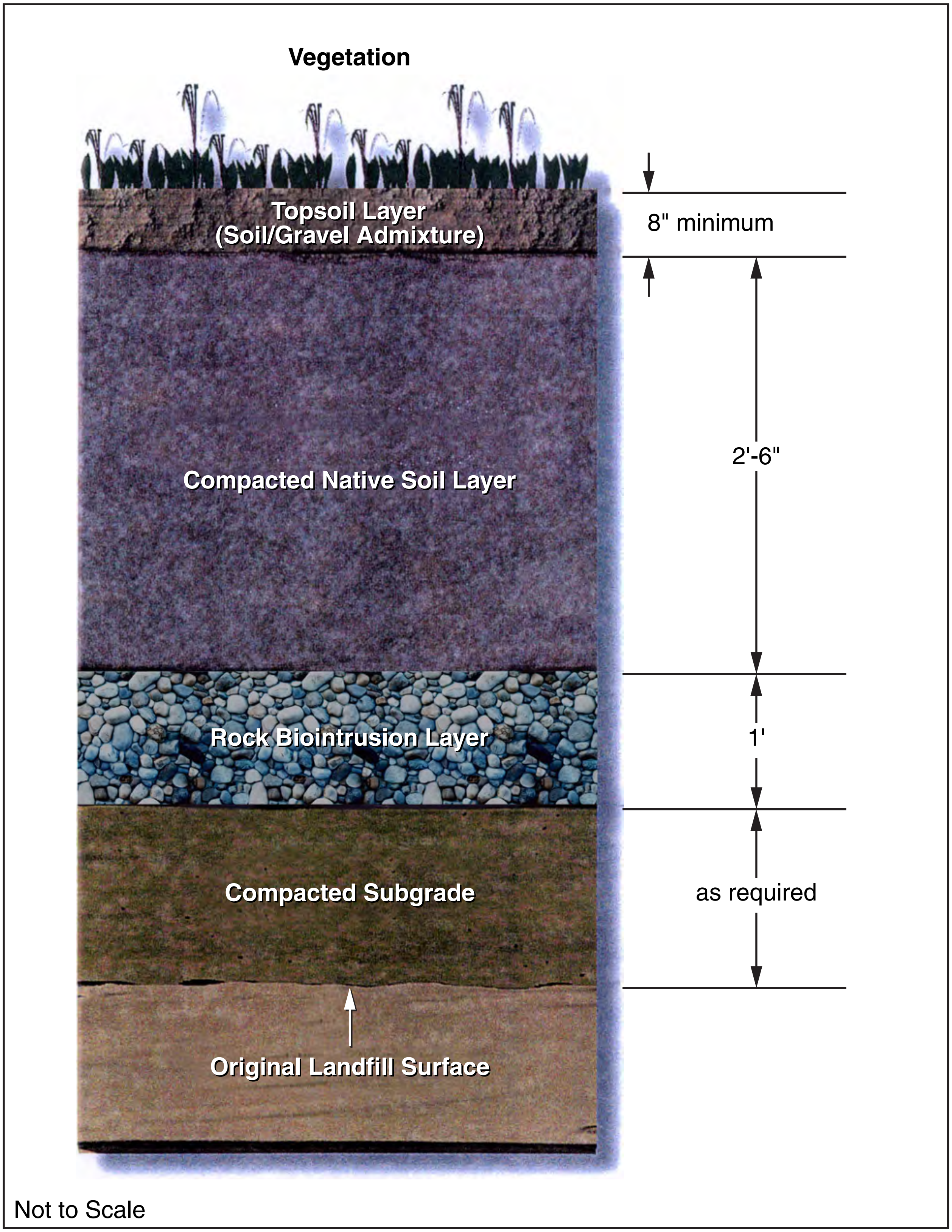

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Figure 2.2-1
Schematic of the Mixed Waste Landfill Vegetative Cover and Biointrusion Barrier

3.0 MONITORING ACTIVITIES AND FREQUENCIES

This section describes all monitoring activities to be conducted at the MWL as part of the LTMMP. The activities include monitoring of air, surface soil, vadose zone, groundwater, and biota. Monitoring frequencies are also provided.

3.1 Introduction

The primary objective of the monitoring activities at the MWL is to ensure that the final remedy is protective of human health and the environment. Long-term monitoring is planned for air, surface soil, the vadose zone, groundwater, and biota at the MWL. Air will be monitored for radon; surface soil will be monitored for tritium; the vadose zone will be monitored for volatile organic compounds (VOCs) and moisture; groundwater will be monitored for tritium, VOCs, and RCRA metals; and soil from animal burrows and ant hills will be monitored for RCRA metals and gamma-emitting radionuclides, and vegetation will be monitored for gamma-emitting radionuclides.

Although monitoring is planned for radionuclides in various media at the MWL, the information related to radionuclides is provided voluntarily by the DOE/Sandia. The voluntary inclusion of such radionuclide information shall not be enforceable and shall not constitute the basis for any enforcement because such information falls wholly outside the requirements imposed by the NMED, as specified in Section III.A of the Consent Order (NMED April 2004).

A summary of the long-term monitoring frequency, parameters, and analytical methods is presented in Table 3.1-1. Monitoring activities and frequencies are discussed in Sections 3.2 through 3.6. Sampling and Analysis Plans (SAPs) and Monitoring Plans (MPs) for each type of monitoring are presented in Appendices A through E.

Changes to sampling parameters and monitoring frequencies may be warranted as trends are established and as additional data needs are identified. If changes to the monitoring program are warranted, the DOE/Sandia will submit a request in writing to the NMED to modify the LTMMP. Once NMED approval has been obtained, portions of the LTMMP, including SAPs and MPs, will be revised and submitted to the NMED for final approval, prior to incorporating any changes in monitoring parameters or frequencies.

3.2 Air Monitoring

Air monitoring for radon shall be conducted at the MWL along the perimeter and at select locations on the engineered cover. This section discusses why air monitoring for radon will be conducted, while air monitoring for tritium and other radionuclides will not be performed. The monitoring method and sampling locations for radon are also discussed.

Table 3.1-1
Summary of Long-Term Monitoring Parameters, Frequencies, and Methods
Mixed Waste Landfill, Sandia National Laboratories/New Mexico

Sampling Media	Monitoring Parameters[a]/ Constituents of Concern	Monitoring Frequency[a]	Number of Samples Per Event	Locations	Monitoring Method	Comments
Air	Radon	Year 1 – Quarterly Year 2 – Quarterly Year 3 – Semiannual Year 4 – Semiannual Year 5 and subsequent years – Annual	17	10 detectors placed at corners and midpoints of perimeter fence 5 detectors placed on completed cover 2 detectors at background locations (TBD)	Track-etch detectors (at breathing level) Sampling and analysis per Appendix A	Samples are time-weighted average, and will be collected over a 3-month period.
Surface Soil	Tritium	Annual	4	One sample collected from each corner of the MWL	Grab samples of soil collected; moisture extracted and tritium analyzed using liquid scintillation	Samples collected by the SNL/NM Terrestrial Monitoring Program. Program to be continued at current level of effort.
Vadose Zone	VOCs in soil vapor	Year 1 – Quarterly Year 2 – Quarterly Year 3 – Semiannual Year 4 – Semiannual Year 5 and subsequent years – Annual	15	Samples collected from 3 FLUTe™ wells at depths of 50, 100, 200, 300, and 400 ft	Sampling and analysis per Appendix B (Compendium Method TO-14 VOCs[b])	VOCs to be collected from 3 FLUTe™ wells installed in vertical boreholes outside landfill perimeter.
Vadose Zone	Moisture content in underlying vadose zone	Year 1 – Quarterly Year 2 – Quarterly Year 3 – Semiannual Year 4 – Semiannual Year 5 and subsequent years – Annual	171	Three soil-moisture monitoring access tubes Measurements made at 1-ft increments from 4 ft to 25 ft, then 5-ft increments to total depth of the access tube (200 linear ft)	Soil-moisture monitoring per Appendix C	Moisture content in vadose zone beneath the cover to be measured using neutron probe.

Refer to footnotes at end of table.

Table 3.1-1 (Concluded)
Summary of Long-Term Monitoring Parameters, Frequencies, and Methods
Mixed Waste Landfill, Sandia National Laboratories/New Mexico

Sampling Media	Monitoring Parameters[a]/ Constituents of Concern	Monitoring Frequency[a]	Number of Samples Per Event	Locations	Monitoring Method	Comments
Groundwater	VOCs by EPA Method 8260[c] and metals by EPA Methods 6020[c] and 7470[c]	Annual	6	MWL monitoring well network (except MWL-MW4, which will not be sampled routinely during long-term monitoring)	Sampling and Analysis per Appendix D	Continuation of MWL current groundwater monitoring program. Sampling recommended using low-flow pumps, with NMED approval.
Biota	Distribution of ant hills and animal burrows RCRA metals and gamma spectroscopy Cover vegetation[d] diversity and growth Gamma-emitting radionuclides in vegetation	Annual surveys for distribution of ant hills and animal burrows. Sampling of soil from ant hills (if they exist) and animal burrows and every two years for RCRA metals and gamma spectroscopy. Cover vegetation[d] diversity and growth monitoring will be conducted quarterly until established, then annually. Sampling of vegetation for gamma-emitting radionuclides every two years.	Up to 6 ant hills (if they exist on the cover) Up to 6 animal burrows (if they exist on the cover)	Ant hills and animal burrows on the MWL vegetated soil cover (if they exist) Vegetation[d] on the cover	GPS surveying of ant hill and animal burrow locations. Grab samples of soil from ant hills and animal burrows, and vegetation.	Biota sampling is planned to address potential for mobilization of contaminants by biota.

[a]Monitoring frequency and parameters will be reevaluated every five years in the Five-Year Reevaluation Reports.
[b]EPA January 1999.
[c]EPA November 1986.
[d]Cover vegetation monitoring is discussed in Section 4.2.1.

EPA = U.S. Environmental Protection Agency.
FLUTe™ = Flexible Liner Underground Technologies.
ft = Foot (feet).
GPS = Global positioning system.
MWL = Mixed Waste Landfill.
NMED = New Mexico Environment Department.
RCRA = Resource Conservation and Recovery Act.
SNL/NM = Sandia National Laboratories/New Mexico.
TBD = To be determined.
TO-14 = EPA Method TO-14.
VOC = Volatile organic compound.

3.2.1 Radon

The MWL fate and transport model predicts no potential for release of radon-222 into the atmosphere in excess of regulatory standards, as long as the sealed sources containing radium-226 within the MWL inventory remain intact (Ho et al. January 2007). This modeling prediction is consistent with the results from a study conducted in 1997 to measure radon surface flux from the MWL (Haaker January 1998). The 1997 study, which involved placement of 89 4-inch-diameter activated charcoal radon canisters across the MWL surface, evaluated radon surface fluxes in the vicinity of the MWL and at background locations. The results showed that the measured radon fluxes above the MWL were not significantly different from the background values (Haaker January 1998). The median radon flux in the vicinity of the MWL was 0.33 pCi/square meter (m^2)/second (s), while the median background flux was 0.35 pCi/m^2/s. The maximum measured fluxes for the MWL and background were 1.02 and 0.664 pCi/m^2/s, respectively.

The MWL fate and transport model also predicts that if the sealed sources containing radium-226 degrade over time, a potential exists for radon to be emitted to the atmosphere in concentrations above regulatory standards. For this reason, radon monitoring at the landfill surface will be conducted to determine whether significant quantities of radon are being emitted from the MWL. Commercially-available track-etch radon detectors (referred to as detectors) will be utilized to measure the radon concentration in air. These detectors provide an integrated average concentration of radon in air over long exposure periods, on the order of three to six months. The alternative monitoring detectors, charcoal canisters, are only useful for short exposure periods, on the order of a few days.

The detectors will be placed on posts at approximately breathing level (5 feet) along the MWL perimeter and at five locations on the surface of the MWL. Radon monitoring locations within the MWL boundary were selected based upon the MWL inventory. Table 3.2.1-1 list pits and trenches containing radium-226, also based upon the MWL inventory (SNL/NM June 1998). Figure 3.2.1-1 shows the relative locations of these pits and trenches within the MWL. As Table 3.2.1-1 indicates, four of the MWL pits contain millicurie quantities of radium-226 (a potential source for radon at the MWL). Because these pits contain the highest concentrations of radium-226, radon emissions from these pits would have the greatest potential to exceed the regulatory standard, should the sealed sources degrade over time. For this reason, these pits will be monitored for radon emissions.

The fifth radon sampling point within the MWL perimeter will be located over Trench D, where a broken radium-226 source was disposed. The exact location of the source in Trench D is unknown, and the detector will be placed above the middle of the trench.

Figure 3.2.1-2 shows the radon sampling locations. The detectors will be placed along the MWL perimeter and at the five locations on the surface of the MWL as discussed.

Radtrak® radon gas track-etch detectors, or equivalent, will be used and are designed to monitor radon exposure over long exposure periods to obtain long-term average concentrations over time. Radtrak® measures the average radon concentration at the location of the detector during the monitoring period. The alpha-track detector has a radiosensitive element that records alpha particle emissions (alpha tracks) from the natural radioactive decay of radon.

Table 3.2.1-1
Pits and Trenches Containing Radium-226 at the Mixed Waste Landfill
Sandia National Laboratories/New Mexico

Location	Ra-226 Quantity (mCi)	MWL Inventory Listing[a]
Trench D	Unknown	Broken Ra-226 source in plastic holder
Pit 33	250	Ten each 25-mCi Ra-226 sources encapsulated in concrete-filled, 55-gallon drums
Pit 31	4.01	One each 10-microCi Ra-226 ionostat; one each 4-mCi Ra-226/Be source
Pit 16	3.12	Two each nonfunctional 1.5-mCi Ra-226 ionization alphatron gauges encapsulated in a concrete-filled A/N can; twenty each 5-microCi Ra-226/Be sources in lead container encapsulated in concrete-filled, A/N can; two each 10-microCi Ra-226/Be sources in lead container encapsulated in a concrete-filled, 5-gallon, A/N can
Pit 24	1.5	Three each 500-microCi Ra-226
Pit 32	<1.0	Ra-226, Na-22, Ba-133, Co-60, Co-57, Mo-54, mixed isotopes (1.0 mCi) in lead pig
Pit 26	0.86	Four each 10-microCi Ra-226/Be sources in a lead container encapsulated in concrete-filled, 55-gallon drum; five each sealed 160-microCi Ra-226 sources; two each sealed 10-microCi Ra-226 check sources; eighteen each 1.8-microCi Ra-226 ionization alphatron gauges encapsulated in concrete-filled, 32-gallon, A/N can
Pit 17	0.5	One each 0.5-mCi Ra-226/Be source
Pit 13	0.1103	One each 98-microCi Ra-226 source, one each 1.3-microCi Ra-226 source, two each 5-microCi Ra-226 sources, and one each 1-microCi Ra-226 source encapsulated in concrete-filled, A/N can.
Pit 15	0.107	One each 102.1-microCi Ra-226/Be source and one each 5.5-microCi source in a encapsulated in concrete-filled, 55-gallon drum; fume hood filters and filter housings
Trench C	0.1	One each 0.1-mCi Ra-226/Be source encapsulated in concrete-filled, A/N can
Pit 18	0.07	Seven each 10-microCi Ra-226/Be sources in a lead container encapsulated in concrete-filled, 55-gallon drum
Pit 25	0.0516	One each 11.6-microCi Ra-226 dew pointer in brass cylinder, four each 10-microCi Ra-226/Be sources in a lead container encapsulated in concrete-filled, 55-gallon drum

[a]SNL/NM June 1998.
Ba = Barium.
Be = Beryllium.
Ci = Curie(s).
Co = Cobalt.
mCi = Millicurie(s)
Mo = Molybdenum.
MWL = Mixed Waste Landfill.
Na = Sodium.
Ra = Radium.

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Legend

Mixed Waste Landfill

Pit without Ra-226

31 4.01 Pit Number (upper left) with Ra-226 Activity (lower right - millicuries)

Trench with Ra-226 Activity (millicuries)

Figure 3.2.1-1
Pits and Trenches Containing Radium-226 at the Mixed Waste Landfill

0 20 40
Scale in Feet

0 4.8 9.6
Scale in Meters

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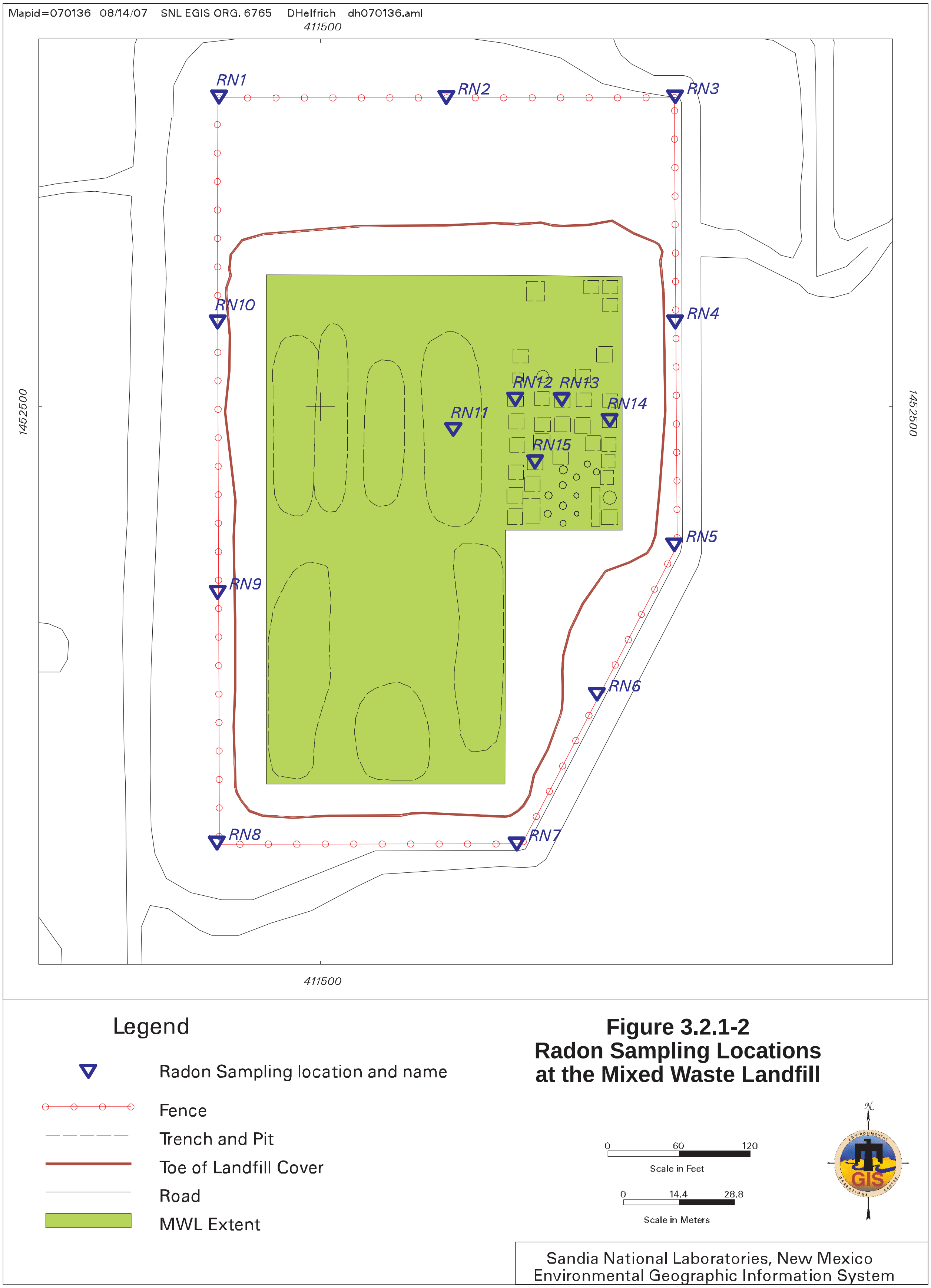

Figure 3.2.1-2
Radon Sampling Locations at the Mixed Waste Landfill

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After exposure, the detectors are returned to the manufacturer for analysis, and the alpha tracks are counted using computer-assisted image analysis equipment. The number of alpha tracks along with the deployment time period provides the basis for calculating the average radon concentration. The resulting data are reported in pCi of radon per liter (L) of air.

Radon monitoring will be conducted on a quarterly basis following cover completion to establish initial concentration data, then on a semiannual basis, and later on an annual basis if no significant trends are observed in radon concentrations over time. Additional details of the radon monitoring to be conducted at the MWL are presented in Appendix A, “Air Sampling and Analysis Plan for the Mixed Waste Landfill.”

3.2.2 Tritium and Other Radionuclides

Air monitoring for tritium and radionuclides other than radon will not be conducted due to the significant decline in tritium emissions from the MWL over the last decade, as well as the lack of a reasonable transport scenario to the atmosphere for other radionuclides. Although the MWL is a diffuse source for tritium to the environment, studies conducted during 1992, 1993, and 2003 revealed that tritium concentrations released to the atmosphere are at low levels and do not pose a threat to human health or the environment (Radian Corporation September 1992, November 1992, and 1994; URS Corporation February 2004). These studies indicate that, as expected, tritium concentrations released from the landfill to the atmosphere declined significantly during the 10-year period from 1993 to 2003. The estimated tritium emitted from the MWL to the atmosphere in 1993 was 0.486 Ci/yr, while the estimated tritium emitted from the MWL in 2003 was 0.090 Ci/yr. This significant reduction reflects the natural radioactive decay of tritium and its relatively short half-life of 12.3 years. Because tritium levels in the MWL inventory will continue to decline due to radioactive decay, concentrations released to the atmosphere will continue to decline as well.

The maximum predicted dose to an exposed site worker and an off-site worker was orders of magnitude below regulatory limits in 1993 (Phase 2 RFI), and even lower in 2003. Because it is highly unlikely that tritium could be released from the MWL to the atmosphere above regulatory limits, long-term monitoring of tritium in air at the MWL will not be conducted.

Similarly, there is no reasonable scenario for the transport of other radionuclides from the MWL to the air pathway. Tritium is the primary radionuclide disposed of at the MWL with the potential to move through vapor transport upward into the atmosphere. Radon has some potential to be released from the landfill contents and could potentially migrate to the atmosphere. For this reason, radon will be monitored (Section 3.2.1). The remaining radionuclides within the MWL inventory are relatively immobile and are buried under 3 or more feet of backfill, 2 to 40 inches of subgrade soil, 1 foot of rock biointrusion barrier, and 3 feet of soil. Because there is no reasonable scenario for transport of radionuclide contaminants upward through the engineered cover and into the atmosphere, there is no rationale for air monitoring of other radionuclides at the MWL.

3.3 Surface Soil Monitoring

The SNL/NM Terrestrial Surveillance Program has monitored concentrations of tritium and gamma-emitting radionuclides in surface soil at the MWL on an annual basis since 1985. Terrestrial surveillance activities are conducted in accordance with SNL/NM Terrestrial

Surveillance Field Operating Procedure (FOP 95-03) (SNL/NM 2006), available at the Sandia National Laboratories Customer-Funded Records Center. As part of the SNL/NM Terrestrial Surveillance Program, soil samples are collected annually at the four corners of the MWL (outside the fence), and analyzed for tritium and gamma-emitting radionuclides. Tritium is routinely detected in soil samples collected at the corners of the landfill, with highest concentrations most often detected at the northeastern corner of the MWL (Section 5.2.2.1). These concentrations have been diminishing with time due to natural radioactive decay of tritium, and although elevated above background levels, they do not pose a threat to human health or the environment.

The DOE/Sandia will continue to sample soil at the four corners of the landfill on an annual basis for long-term monitoring at the site. Figure 3.3-1 shows surface soil sampling locations for tritium at the MWL. Tritium is very mobile and should a significant release of tritium from the landfill contents occur, increased tritium would be detected in soil samples during the annual sampling events.

3.4 Vadose Zone Soil-Vapor and Soil-Moisture Monitoring

The vadose zone beneath the MWL extends nearly 500 feet from ground surface to groundwater. Because VOCs released from the MWL have the potential to migrate via the soil-vapor phase to groundwater (Ho et al. January 2007), a monitoring system is planned for the vadose zone at the MWL to serve as an early warning system for protecting groundwater. This system will provide early evidence of potential threats to groundwater and will allow corrective action to be initiated long before groundwater contamination occurs.

Long-term monitoring of the vadose zone is planned for both soil vapor (VOCs) and moisture content to provide assurance that the MWL remedy remains protective of human health and the environment. The details of the monitoring systems for VOCs and moisture content are presented in the following sections.

3.4.1 Vadose Zone Soil-Vapor Monitoring for VOCs

VOCs are the most mobile of the hazardous constituents detected in the soil beneath the MWL. During the MWL Phase 2 RFI, two passive and three active soil-gas surveys at the MWL showed the presence of low concentrations of VOCs in soil gas (soil vapor) (SNL/NM September 1996). Low concentrations of VOCs were also detected in subsurface soil samples collected from boreholes drilled during the MWL Phase 2 RFI (SNL/NM September 1996).

VOC concentrations with depth shall be monitored using three Flexible Liner Underground Technologies (FLUTe™) soil-vapor monitoring wells (hereinafter referred to as FLUTe™ wells) that provide data regarding VOC concentrations versus depth. The FLUTe™ wells are constructed in vertical boreholes located immediately outside the perimeter of the MWL cover with the locations selected near areas where the highest concentrations of VOCs were detected during earlier studies at the MWL. Figure 3.4.1-1 shows the locations of the three FLUTe™ wells. Soil-vapor sampling ports were installed in each FLUTe™ well at depths of 50, 100, 200, 300, and 400 feet. Soil-vapor data collected from the FLUTe™ wells will be used to assess current VOC distributions with depth and to monitor VOC concentrations over time, allowing early identification of any potential threats to groundwater. The VOC data from the FLUTe™ wells will also be included in the MWL fate and transport model updated every five years, as

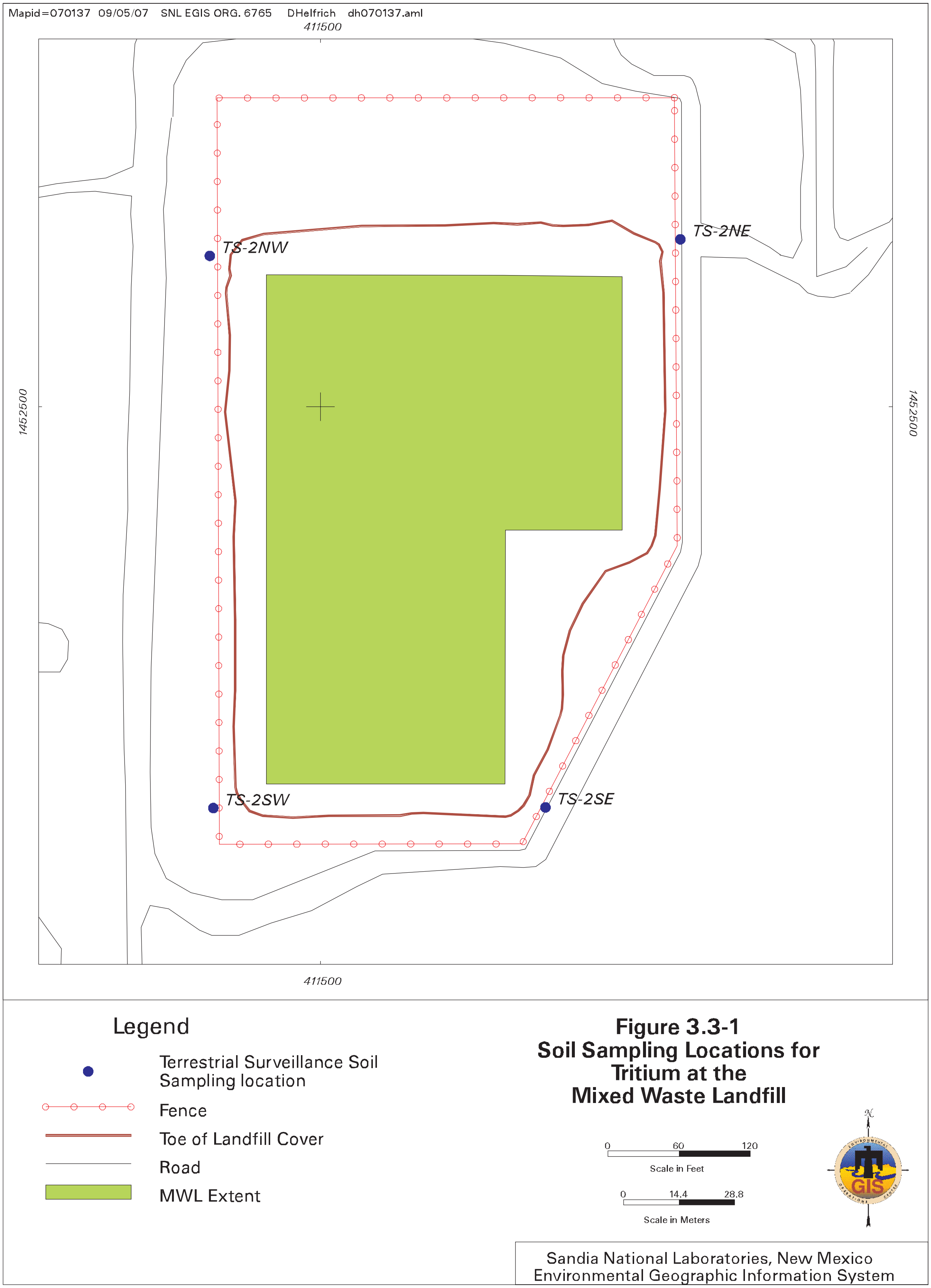

Figure 3.3-1
Soil Sampling Locations for Tritium at the Mixed Waste Landfill

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Legend

- Soil-Moisture Monitoring Access Tube (showing horizontal extent of tube)
- FLUTe™ Well
- Fence
- Toe of Landfill Cover
- Road
- MWL Extent

Figure 3.4.1-1
FLUTe™ Well Locations and Soil-Moisture Monitoring Access Tubes at the Mixed Waste Landfill

0 60 120
Scale in Feet

0 14.4 28.8
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

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required in the NMED Final Order (Curry May 2005). The soil-vapor SAP for the MWL is presented in Appendix B.

3.4.2 Soil-Moisture Monitoring

A soil-moisture monitoring system has been installed beneath the landfill and consists of three soil moisture access tubes drilled at a 30-degree angle (from vertical) directly below waste disposal cells. The monitoring system functions as an early warning system, providing infiltration and cover performance information as well as evidence of potential contaminant migration from the landfill, and establishes background and trend analysis information.

In August 2003, three angled, 4.5-inch-outside-diameter, 3.75-inch-inside-diameter steel access tubes were installed in the shallow vadose zone directly beneath the MWL: two to the west and one to the east of the cover (Figure 3.4.1-1). The access tube locations were selected to provide optimal coverage beneath the MWL. The tubes are spaced at equal increments in a north-south direction, with the east access tube halfway between the two west access tubes. The tubes were installed using the Resonant Sonic drilling technique. Resonant Sonic is the preferred drilling technique for this application because it fluidizes and displaces the surrounding soil as the drill string advances, creating a very tight fit between the drill string and the formation.

Each access tube is collared approximately 10 feet outside the toe of the cover side slopes. Each borehole was drilled 200 linear feet at 30 degrees to a true vertical depth of 173 feet (Figure 3.4.2-1). Each tube remains open to the vadose zone at the bottom, and a protective cover constructed of steel pipe extends 2 feet bgs and 3 feet above grade. Each protective cover is fitted with a locking cap. A 3- by-3-foot concrete pad was constructed around each protective cover to prevent preferential flow down the annulus, and protective stanchions were placed at the outer corners of each concrete pad.

Moisture content with depth shall be monitored using a neutron probe, a technique developed in the 1950s that provides an efficient and reliable method for monitoring soil moisture. The neutron probe consists of a source of fast (energized) neutrons, a detector of slow (thermalized) neutrons, and an electronic gauge to monitor the flux of slow neutrons scattered by the soil. The probe is lowered into the access tube, and the emitted neutrons interact with soil water surrounding the tube and are detected by the instrument. Because energized neutrons can easily travel through steel, the steel access tube is essentially invisible to the neutrons, allowing measurement of moisture in the surrounding soil without interference from the tube itself.

Infiltration through the cover shall be indirectly monitored via the moisture content in the vadose zone beneath the MWL. A significant increase in moisture content beneath the landfill may indicate that the engineered cover may not be performing as originally designed and that infiltration through the cover is greater than originally predicted.

Moisture content shall be measured using neutron logging, and data can be compared to baseline moisture content data collected prior to deployment of the MWL cover. This noninvasive method allows cover performance to be assessed without damaging the integrity of the engineered cover. A significant increase in moisture content within the vadose zone may indicate that corrective action is warranted in order to prevent the downward movement of water through the waste. Moisture content data shall be evaluated to ensure that the performance

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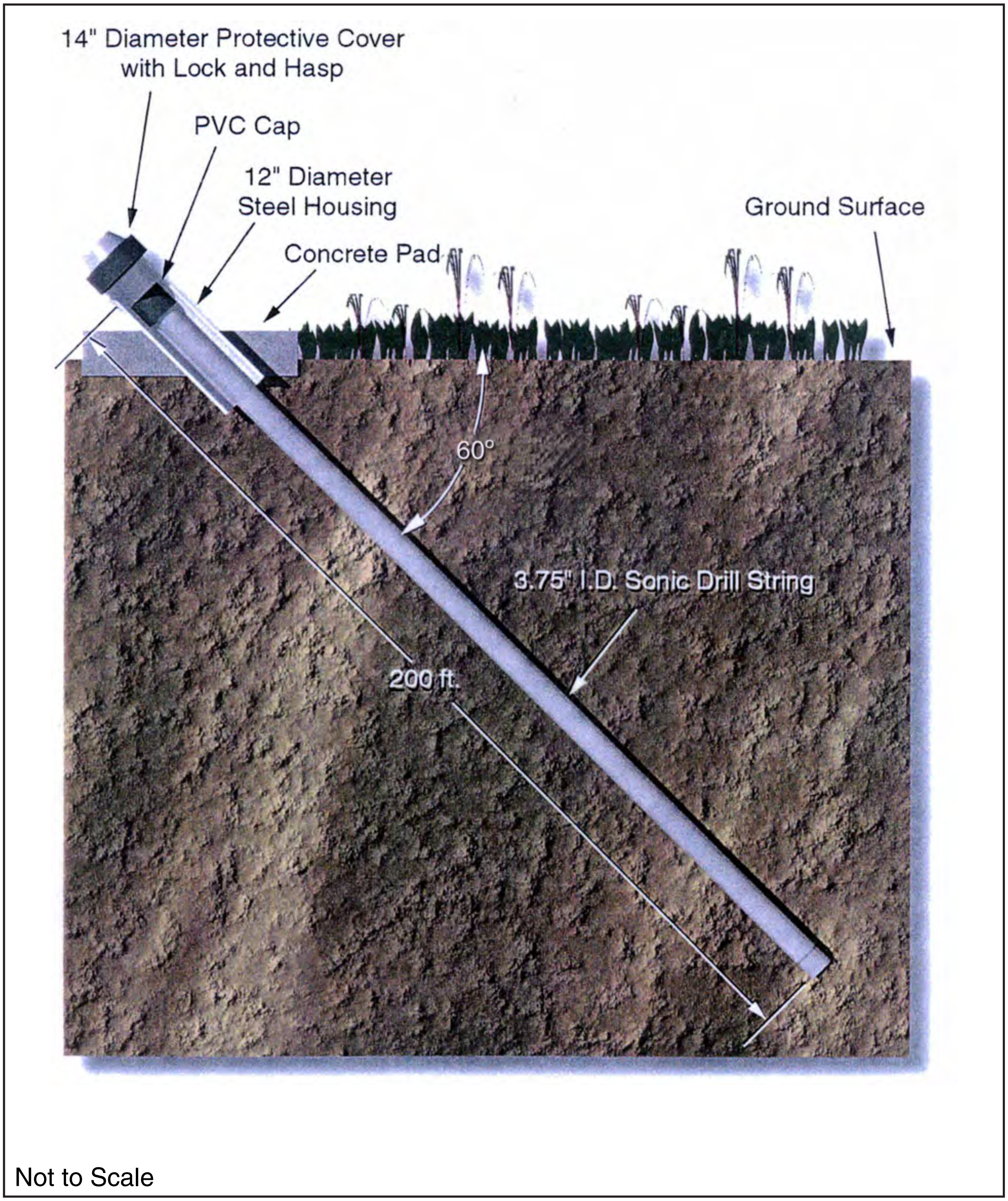

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Figure 3.4.2-1
Soil-Moisture Monitoring Access Tube,
Mixed Waste Landfill

objective of infiltration through the MWL cover is less than the EPA-prescribed technical equivalence criteria of 10^{-7} centimeters (cm)/s (31.5 millimeters [mm]/yr), as detailed below. Appendix C presents the Soil-Moisture MP; Section 5.2.3.2 provides additional information on the trigger for soil moisture beneath the MWL.

3.5 Groundwater Monitoring

Groundwater in the area of the MWL has been extensively characterized since 1990 for major ion chemistry, VOCs, semivolatile organic compounds (SVOCs), nitrate, metals, radionuclides, and perchlorate. Data collected indicate that groundwater has not been contaminated by releases from the MWL (Goering et al. 2002; SNL/NM July 2001, November 2001, January 2002, April 2002, July 2002, October 2002, April 2003, September 2003, April 2004; Lyon and Goering April 2005; SNL/NM April 2006).

3.5.1 MWL Monitoring Well Network

The MWL monitoring well network (Figure 3.5.1-1) currently (as of September 2007) consists of seven wells completed within interfingering, fine-grained alluvial fan deposits and coarse-grained Ancestral Rio Grande deposits (Goering et al. 2002). This network includes one background well (MWL-BW1), one on-site well (MWL-MW4), and five downgradient or cross-gradient wells (MWL-MW1, MWL-MW2, MWL-MW3, MWL-MW5, and MWL-MW6). All seven wells are constructed of 5-inch, Schedule 80 polyvinyl chloride (PVC) casing. Wells MWL-BW1, MWL-MW1, MWL-MW2, and MWL-MW3 have screens composed of slotted Type 304 stainless steel. Wells MWL-MW4, MWL-MW5, and MWL-MW6 have screens composed of slotted Schedule 80 PVC. Table 3.5.1-1 presents well construction information and recent water levels measured in existing monitoring wells. Well database summary sheets showing monitoring well completion diagrams are presented in Appendix F.

Monitoring well MWL-MW4 was installed in 1993 directly beneath a disposal trench in which 204,000 gallons of coolant wastewater from the SNL/NM Engineering Reactor Facility were disposed of in 1967 (Peace et al. September 2002). MWL-MW4 was completed at an angle of 6 degrees from vertical and is screened at two discrete intervals 20 feet apart to evaluate vertical anisotropy, vertical potentiometric gradients, and changes in aquifer parameters with depth. The approximate horizontal extent of MWL-MW4 is shown in Figure 3.5.1-1. An inflatable packer separates the screened intervals, and pressure is maintained in the packer to prevent the mixing of water from the two screened sections of the aquifer.

The monitoring well network is being updated in preparation for long-term monitoring at the MWL. The four oldest wells, MWL-BW1, MWL-MW1, MWL-MW2, and MWL-MW3, were installed in 1988 and 1989, and although they have provided excellent quality data over the years, they are becoming increasingly problematic.

Two of these wells, MWL-BW1 and MWL-MW3, are nearly dry due to declining water levels in the regional aquifer. Groundwater levels beneath the MWL declined an average rate of 0.5 feet/yr between April 2001 and October 2006. As of April 2007, approximately 1 foot of water remained above the well screen in MWL-BW1, and approximately 3 feet of water remained above the well screen in MWL-MW3 (Table 3.5.1-1).

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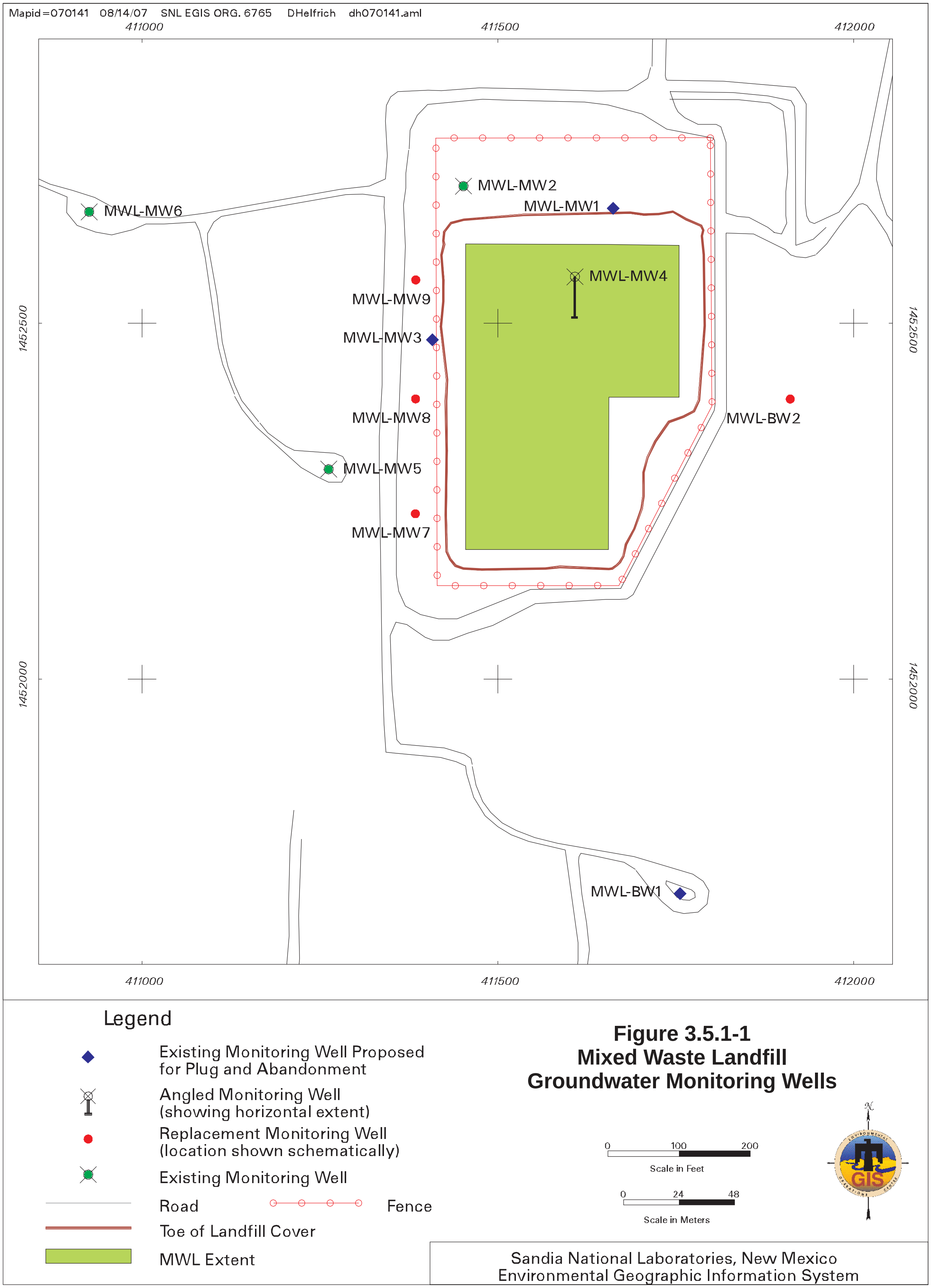

Figure 3.5.1-1
Mixed Waste Landfill
Groundwater Monitoring Wells

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Table 3.5.1-1
Monitoring Well Construction Details and Recent Water Levels
Mixed Waste Landfill, Sandia National Laboratories/New Mexico

Monitoring Well	Top of Inner Casing[a] (FAMSL)	Ground Surface Elevation (FAMSL)	Well Depth (FBGS)	Top of Well Screen (FBGS)	Bottom of Well Screen (FBGS)	Bottom of Well Screen (FAMSL)	April 2007 Measured Depth to Water (FBGS)	April 2007 Water Level (FAMSL)	Screened Lithology	Comments
MWL-BW1	5384.51	5382.70	477.17	452.2	472.2	4910.53	472.94	4911.57	Alluvial Fan	Well to be plugged and abandoned and replaced.
MWL-MW1	5381.54	5379.12	478.00	456.0	476.0	4903.12	468.10	4913.44	Alluvial Fan	Well to be plugged and abandoned and replaced.
MWL-MW2	5377.26	5375.71	477.00	452.0	472.0	4903.71	464.14	4913.12	Alluvial Fan	Well to be plugged and abandoned and replaced.
MWL-MW3	5381.32	5378.97	476.30	451.3	471.3	4907.67	470.06	4911.26	Alluvial Fan	Well to be plugged and abandoned and replaced.
MWL-MW4[b] (upper)	5383.46	5381.61	520.00	482.5	502.5	4881.86	494.19	4889.27	Alluvial Fan	Well contains two screens, hydraulically separated by a pneumatic packer.
MWL-MW4[b] (lower)	5383.46	5381.61	520.00	522.5	542.5	4842.08	NM	NM	Alluvial Fan/ Ancestral Rio Grande	
MWL-MW5	5379.89	5377.65	521.50	496.5	516.5	4861.15	492.31	4887.58	Alluvial Fan/ Ancestral Rio Grande	
MWL-MW6	5372.64	5369.96	530.50	505.5	525.5	4844.46	486.25	4886.39	Ancestral Rio Grande	

[a]Top of inner casing is the measurement point for the well.
[b]Well MWL-MW4 is screened at two intervals and is angled 6 degrees from vertical.
BW = Background well.
FAMSL = Feet above mean sea level.
FBGS = Feet below ground surface.
MW = Monitoring well.
MWL = Mixed Waste Landfill.
NM = Not measured.

The NMED requested that MWL-BW1 be plugged and abandoned and replaced (NMED March 2007). A Monitoring Well Plug and Abandonment (P&A) Plan and Replacement Well Construction Plan for MWL-BW1 was submitted to the NMED on April 17, 2007 (SNL/NM April 2007). However, the NMED submitted a Notice of Disapproval regarding this plan in June 2007 (NMED June 2007), and DOE/Sandia resubmitted a P&A and Replacement Well Construction Plan for MWL-BW1 in July 2007 (SNL/NM July 2007a).

On July 2, 2007, the NMED requested replacement of monitoring wells MWL-MW1 and MWL-MW3 due to low water levels in MWL-MW3 and to problems with corrosion of the stainless-steel screens in these wells (NMED July 2007). DOE/Sandia submitted a P&A and Replacement Well Construction Plan for both of these wells in July 2007 (SNL/NM July 2007b). In addition, DOE/Sandia plan to replace MWL-MW2 in the near future because of corrosion of its stainless-steel screen.

The proposed replacement wells for MWL-BW1, MWL-MW1, MWL-MW2, and MWL-MW3 are shown in Figure 3.5.1-1 as MWL-BW2, MWL-MW7, MWL-MW8, and MWL-MW9. The well MWL-BW2 will serve as an upgradient background well and MWL-MW7, MWL-MW8, and MWL-MW9 will serve as point-of-compliance wells located at the downgradient toe of the landfill cover.

The DOE/Sandia intend to leave MWL-MW4 in place but not include it in annual sampling because it is not a point-of-compliance well. The packer pressure will be maintained and the well will be available for discretionary sampling.

Therefore, the groundwater monitoring well network proposed to be in place for long-term monitoring includes six wells (existing wells MWL-MW5 and MWL-MW6 and proposed wells MWL-BW2, MWL-MW7, MWL-MW8, and MWL-MW9).

3.5.2 Monitoring Well Plugging and Abandonment Guidance

Requirements for monitoring well replacement are presented in the Consent Order (NMED April 2004). MWL monitoring wells will be plugged and abandoned when they are no longer required in the monitoring network, no longer provide representative groundwater samples because of declining water levels or insufficient productivity, or become damaged beyond repair. The goal of well abandonment is to seal the well in such a manner that it cannot act as a conduit for the migration of contaminants from either the ground surface to the saturated zone or between saturated zones. Well P&A plans will be prepared for any wells that meet these criteria and will be submitted to the NMED for approval. No groundwater monitoring wells at the MWL will be abandoned without prior written approval of the NMED.

3.5.3 Monitoring Well Replacement

At the request of the NMED, additional wells may be necessary to replace wells that require P&A. Additional monitoring wells will be constructed to the specifications provided in Sections VIII.A and VIII.B of the Consent Order (NMED April 2004).

Replacement wells for long-term monitoring at the MWL will have 30-foot PVC screens to maximize the monitoring life of the wells. Replacement wells will comply with the requirements of the Consent Order (NMED April 2004) as well as the guidelines established in EPA guidance, including, but not limited to, the following:

- "RCRA Groundwater Monitoring: Draft Technical Guidance," EPA/530-R-93-001 (EPA November 1992)
- "RCRA Groundwater Monitoring Technical Enforcement Guidance Document," OSWER-9950.1 (EPA September 1986)
- "Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells," EPA 600/4-89/034 (Aller et al. 1991)

3.5.4 Groundwater Monitoring Parameters and Frequency

Groundwater monitoring at the MWL was initiated in September 1990 and continues to occur on an annual basis to meet the requirements of the Consent Order (NMED April 2004). Groundwater has been characterized for major ion chemistry, VOCs, SVOCs, nitrate, metals, radionuclides, and perchlorate. The extensive data collected to date indicate that groundwater beneath the MWL has not been contaminated by wastes disposed at the MWL.

Table 3.5.4-1 summarizes analytical requirements and EPA Test Methods (EPA November 1986) applicable to groundwater monitoring at the MWL. Sampling for parameters for which triggers apply (Section 5.2.4) is considered required. Sampling for the remaining parameters will be conducted on an as-needed basis to characterize major ion chemistry and determine groundwater characteristics.

Perchlorate screening is required by the Consent Order (NMED April 2004) for all newly installed groundwater monitoring wells for four consecutive quarters, unless perchlorate is detected. If detected, a sampling frequency for continued monitoring will be negotiated with the NMED.

The long-term groundwater monitoring network discussed in Section 3.5.1 (or the most current version) will be sampled annually according to the Groundwater SAP for the MWL provided in Appendix D. The groundwater surface elevation, hydraulic gradient, and flow direction will also be determined annually (groundwater flow rate can be calculated from these data). The Groundwater SAP provides guidance, methods, and analytical protocols for collecting and analyzing groundwater samples during the long-term monitoring period.

The groundwater monitoring network will be used to determine whether groundwater beneath the former MWL meets the regulatory standards for the constituents of concern being monitored. Groundwater samples from the MWL monitoring wells will be analyzed for VOCs, total uranium, gamma-emitting radionuclides, tritium, and gross alpha and beta activity. Samples collected from replacement monitoring wells will also be analyzed for perchlorate during the first four quarters of sampling to meet the requirements of the Consent Order (NMED April 2004). Additional samples may be collected on an as-needed basis to assess changes in groundwater major ion chemistry.

Table 3.5.4-1
Groundwater Monitoring Parameters, Test Methods, and Selection Criteria
Mixed Waste Landfill, Sandia National Laboratories/New Mexico

Parameter	Required or Optional?	EPA Method[a]	Selection Criteria
Volatile Organic Compounds	Required	SW846-8260	Screening for VOCs
Total Uranium	Required	SW846-6020	Screening for uranium
Gamma Spectroscopy (short list)	Required	EPA 901.1 or Equivalent	Screening for radionuclides
Gross alpha/beta	Required	EPA 900.0 or Equivalent	Screening for radionuclides
Tritium	Required	EPA 906.0 or Equivalent	Screening for tritium
Perchlorate[b]	Required for the first four quarters for new wells	EPA 314.0	Required by Consent Order
Total TAL[c] Metals	Optional	SW846-6020/7470	Major Ion Chemistry; screening for RCRA metals
Filtered TAL[c] Metals (filtered in the field)	Optional	SW846-6020/7470	Major Ion Chemistry; screening for RCRA metals
Nitrate plus Nitrite	Optional	EPA 353.2	Major ion chemistry
Major Anions	Optional	SW846-9056	Major ion chemistry
Total Alkalinity	Optional	EPA 310.1	Major ion chemistry
Total Dissolved Solids	Optional	EPA 160.1	General groundwater chemistry
Field Alkalinity	Optional	HACH 8203	Major ion chemistry

[a]EPA November 1986.
[b]Perchlorate screening is required by the Consent Order (NMED April 2004) for all newly installed groundwater monitoring wells for four consecutive quarters, unless perchlorate is detected. If detected, a sampling frequency for continued monitoring will be negotiated with the NMED.
[c]TAL metals = Aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, cyanide, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc.

EPA = U.S. Environmental Protection Agency.
HACH = Hach Company.
NMED = New Mexico Environment Department.
RCRA = Resource Conservation and Recovery Act.
SW = Solid waste.
TAL = Target Analyte List.
VOC = Volatile organic compound.

3.5.5 Transition to Low-Flow Purging and Sampling Techniques

In order to obtain the most representative samples possible, the DOE/Sandia will use dedicated low-flow pumps and sampling techniques in MWL wells during long-term monitoring. Low-flow purging and sampling techniques are recommended for all MWL wells because the hydrogeologic environment is well suited for this type of groundwater sampling. In the past, low-flow sampling techniques have been successful at other sites across SNL/NM. However, on October 23, 2003, the NMED requested that all DOE/Sandia low-flow sampling (which the NMED termed "micropurging") be ceased for all RCRA-compliant groundwater monitoring at SNL/NM (NMED October 2003).

The low-flow purging method has been approved by the EPA (Puls and Barcelona 1996) and offers the following advantages over conventional sampling methods currently used at the MWL:

- Low-flow sampling causes less well disturbance, minimizing the disturbance of the fine-grained sediments that have collected in the wells. As a result, samples collected using low-flow purging and sampling methods typically have lower sample turbidity and variability of sampling results.

- Low-flow sampling minimizes the required purge volume by up to 95 percent, reducing the time and labor required for purging and sampling and minimizing waste.

- Low-flow purging reduces problems related to excessive drawdown and pumped volumes.

- Dedicated equipment for low-flow sampling saves field time and eliminates contamination from other wells and equipment handling.

The NMED has issued a position paper, "Use of Low-Flow and Other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring" (NMED October 2001), which allows low-flow purging and sampling techniques to be used if the monitoring wells meet the Low-Flow Well Selection Criteria (described in the position paper).

Low-flow purging and sampling techniques will be performed in accordance with the approach outlined in the NMED Position Paper and presented by the EPA (Puls and Barcelona 1996).

3.6 Biota Monitoring

Baseline soil and vegetation environmental monitoring data, collected from soil samples from animal burrows and ant hills and plant material of deep-rooted vegetation growing on the MWL, indicate that a potential exists for transport of radionuclides by biota (SNL/NM 2007, pending). Samples of soil from on-site animal burrows and ant hills showed elevated concentrations of cesium-137 above established background levels, suggesting that burrowing animals and ants may have the potential to transport contaminants to the ground surface. Plant material (stems and leaves) collected from one four-wing saltbush growing over Trench B showed detectable activities of cobalt-60 and cesium-137.

These data indicate that biotic mobilization of contaminants is a potential contaminant transport mechanism that should be considered during long-term monitoring at the MWL. The construction of the MWL biointrusion barrier considerably reduces this potential. The intent of the rock barrier is to prevent any intrusion by burrowing animals, and it should also restrict plant root growth as long as the underlying materials are relatively dry (Anderson and Forman September 2002). The potential for biotic mobilization of contaminants is also reduced by the addition of 2 to 40 inches of compacted subgrade soil underneath the biointrusion barrier, as well as the addition of 3 feet of compacted soil above the biointrusion barrier.

The potential for mobilization of contaminants by plants will be further reduced by the removal of deep-rooted vegetation growing on the cover during routine maintenance (Section 4.2.1).

Although the potential for biotic mobilization of contaminants by plants is significantly reduced by the engineered cover, rock biointrusion barrier and removal of deep-rooted vegetation, the DOE/Sandia will sample vegetation on the cover every two years to determine whether radionuclides (other than tritium) are being taken up by plants. The vegetation samples will be analyzed for gamma-emitting radionuclides.

Although the potential for biotic mobilization of contaminants by burrowing animals and ants is also low due to the addition of the engineered cover and rock biointrusion barrier, the DOE/Sandia will monitor animal burrows and ant hills to confirm that they do not represent a significant transport mechanism in the future. The locations of animal burrows and ant hills (if they exist) will be surveyed using a global positioning system on an annual basis, and surface soil samples will be collected from up to six animal burrows and ant hills every two years to determine whether contaminants have been mobilized by biota. The soil samples will be analyzed for RCRA metals and gamma-emitting radionuclides. The SAP for monitoring of biota is presented in Appendix E.

4.0 INSPECTION/MAINTENANCE/REPAIR ACTIVITIES AND FREQUENCIES

Surveillance and maintenance will be conducted on the following elements of the MWL final design:

- The MWL cover
- The surface-water diversion structures
- The groundwater and soil-vapor monitoring networks
- The perimeter security fence, security signs, gate locks, and survey benchmarks and/or monuments

Inspection and maintenance of these systems will be conducted on a regularly scheduled basis to ensure the integrity of the cover; surface-water diversion structures; groundwater and vadose zone monitoring network; and perimeter security fence, signs, gate locks, and survey benchmarks. These surveillance and maintenance details are discussed in the following sections.

4.1 Criteria for Successful Revegetation of the Engineered Cover

In addition to routine inspection and maintenance, the cover will be monitored to ensure the revegetation effort is successful, a critical element in the long-term performance of the cover.

The following information summarizes a climax plant community typical of the undisturbed east mesa ecosystem of TA-III (Peace et al. November 2004).

- Total percent foliar coverage equals 22.5 percent (i.e., 22.5 percent of the land surface is covered with living plants versus 77.5 percent bare surface area).
- Of the 22.5 percent of total foliar coverage, 19.2 percent is comprised of native perennial species and 3.3 percent is comprised of annual species, which includes native annual species and nonnative, transitory (or invasive) plant species.
- Considering only the total percentage of foliar coverage, 85.3 percent consists of native perennial species, and 14.7 percent comprises annual species (the majority of the annual species are nonnative, transitory species).

Based upon this information, the operational criteria for achieving successful revegetation for the MWL cover under average annual precipitation conditions are presented as follows:

- Total percent foliar coverage equals 25 percent (i.e., 25 percent of the land surface is covered with living plants versus 75 percent bare surface area).
- Of the 25 percent total foliar coverage, 50 percent or greater comprises native perennial species and less than 50 percent comprises annual species.

- No contiguous bare spots greater than 200 square feet (approximately 14 by 14 feet) are present.

If these criteria are met under average precipitation conditions, it will be concluded that the native community is successfully reestablished. These criteria do not apply under periods of drought conditions.

Successful revegetation is projected to take three to five years. The cover monitoring, inspection, and maintenance/repair activities described in Section 4.2 will allow assessment of the cover revegetation effort and determine whether or not the criteria are met. Local climate trends will have a major impact on plant growth and health and will be documented, evaluated, and summarized along with vegetation survey results in the annual MWL long-term monitoring and maintenance report.

4.2 Final Cover System Inspection/Maintenance/Repair

This section describes the inspection, maintenance, and repair process for the final engineered cover. It includes details for the cover vegetation monitoring, the process for cover inspections, and cover maintenance and repairs.

4.2.1 Vegetation Inspection

Cover vegetation monitoring will be accomplished using a two-phase approach. The first phase will concentrate on establishing the vegetation on the cover from seed to a mature plant community. This phase is anticipated to take from three to ten or more years, depending on the degree of compaction of the soil cover. Normal succession processes should occur and continue once native flora has been established over greater than 50 percent of the foliar coverage. During this period, a staff biologist will inspect and document the inventory of the main flora populating the cover on a quarterly basis, inspect the cover for contiguous areas lacking vegetation in excess of 200 square feet, and recommend soil augmentations, surface scarification, reseeding, or other corrective actions as deemed appropriate to establish a long-term sustainable native plant community. Deep-rooted plants such as fourwing saltbush and other shrubs and trees will be removed if they are present on the cover.

During this monitoring period, the staff biologist will be responsible for noting and interpreting signs of animal intrusion. These inspections will be documented on the Biology Checklist for the MWL Cover inspection form (Appendix G). At the end of the fourth quarter of each year, the staff biologist will compile the results of the quarterly inspections in a summary report that will be included in the annual MWL long-term monitoring and maintenance report submitted to the NMED.

Once native flora are established and self-sustaining, the second phase of monitoring will begin. Cover vegetation will be monitored by the staff biologist on an annual basis to gauge the overall health of the cover vegetation. Based upon these observations, the staff biologist will submit in writing any recommendations for soil augmentation, surface scarification, and reseeding as necessary to maintain established vegetation. The presence of deep-rooted plants growing on the cover will be noted, and the plants will be removed by field technicians (Section 4.2.3). The results of the staff biologist inspections will be reported in the long-term monitoring and maintenance report submitted annually to the NMED.

4.2.2 Cover Inspection

A field technician and a staff biologist will perform cover inspections on a quarterly basis. Settlement of the cover surface in excess of 6 inches, erosion of the cover soil in excess of 6 inches deep, areas of ponding water, animal intrusion burrows in excess of 4 inches in diameter, contiguous areas lacking vegetation in excess of 200 square feet, and any other conditions that may impact the cover integrity will be noted on the Cover Inspection Checklist (Appendix G). Documentation of animal intrusion burrows in excess of 4 inches in diameter and contiguous areas lacking vegetation in excess of 200 square feet will be noted quarterly on the Biology Checklist for the MWL Cover (Appendix G) instead of the Cover Inspection Checklist.

4.2.3 Cover Maintenance/Repair

Field technicians will perform soil augmentations, surface scarification, reseeding, or other vegetation maintenance/repair (such as removal of deep-rooted plants) as necessary. Damage to cover vegetation that exceeds the criteria listed in Section 4.2.2 will be repaired within 60 days of notation on the Cover Inspection Checklist (Appendix G) to a condition that meets or exceeds the original design. Repairs to the cover will be done using materials consistent with the cover installation specifications, according to soil classification and gradation specifications in the MWL CMI Plan (SNL/NM November 2005). Repair specifications include, but are not limited to, the following:

- Soil augmentations, surface scarification, reseeding, or other corrective actions for areas lacking vegetation in excess of 200 square feet and reestablishing the topsoil layer to provide a suitable seedbed

- Backfilling, compacting, and reseeding settlement areas, areas of ponding water, animal intrusion burrows, and areas of erosion in excess of 6 inches deep using either stockpiled clean soil from the cover installation or locally derived clean fill with properties meeting the criteria for the soil used to construct the MWL cover

Supplemental watering should not be necessary to establish the long-term sustainable native plant community on the MWL cover. In the unlikely event that the staff biologist deems supplemental watering to be necessary to establish the native grasses, the NMED will be notified prior to conducting supplemental watering, and care will be taken to minimize the volume of water applied.

4.3 Storm-Water Diversion Structure Inspection/Maintenance/Repair

This section describes the inspection, maintenance, and repair process for the storm-water diversion structures associated with the final engineered cover.

4.3.1 Inspection

The function of storm-water diversion structures associated with the cover is to prevent storm-water run-on and runoff from eroding the cover and to reduce the amount of water that could potentially infiltrate the cover. The storm-water diversion structures will be inspected by a field technician on a quarterly basis to verify structural integrity and ensure adequate performance. These inspections will be documented on the MWL Long-Term Monitoring Checklist form (Appendix G). Inspections will document erosion of the channels or sidewalls in excess of 6 inches deep and accumulations of silt greater than 6 inches deep or debris that blocks more than one-third of the channel width.

4.3.2 Maintenance/Repair

Based upon the results from the storm-water diversion structure inspections, erosion that exceeds the 6-inch inspection limits will be repaired within 60 days of notation on the Cover Inspection Checklist (Appendix G) to a condition that meets or exceeds the original design. Sediment and debris accumulations that exceed these limits will be removed within 60 days of notation on the Cover Inspection Checklist (Appendix G). Reseeding of the surface drainage features may also be performed to facilitate revegetation and erosion resistance, if necessary.

4.4 Groundwater and Vadose Zone Monitoring Network Inspection/Maintenance/Repair

This section describes the inspection, maintenance, and repair process for groundwater and vadose zone monitoring networks. These include groundwater monitoring wells, FLUTe™ wells, and soil-vapor monitoring access tubes.

4.4.1 Inspection

The groundwater monitoring wells, FLUTe™ wells, and soil-moisture monitoring access tubes will be inspected during regularly scheduled groundwater, soil-vapor, and soil-moisture monitoring events. These inspections will be documented on the MWL Long-Term Monitoring Checklist form (Appendix G). The inspection will note the condition of the components including protective casings and stanchions, wellhead covers/caps, soil-vapor sampling ports, and well identification markings. Groundwater pumps and sample tubing will be inspected annually during each sampling event. Pump replacement and maintenance and tubing replacement will be performed on an as-needed basis based upon pump performance and tubing inspections.

4.4.2 Maintenance/Repair

The groundwater monitoring wells, FLUTe™ wells, and soil-moisture monitoring access tubes will be maintained annually, as needed, based upon inspection and analytical results. Maintenance activities will also include ensuring that all system components are protected from the weather.

4.5 Fence Inspection/Maintenance/Repair

This section describes the inspection, maintenance, and repair process for the fence, gates, locks, warning signs, and survey benchmarks and monuments.

4.5.1 Inspection

The fence, gates, locks, warning signs, and survey benchmarks and monuments will be routinely inspected. The inspections will document the condition of the fence, including fence wires, posts, gates, gate locks, and warning signs using the MWL Long-Term Monitoring Inspection Form included in Appendix G. Excessive accumulations of wind-blown plants and debris that would obscure warning signs, block access to the MWL, or interfere with any monitoring and sampling events also will be documented.

4.5.2 Maintenance/Repair

The fence, gates, warning signs, and survey benchmarks and/or monuments will be maintained and/or repaired within 60 days of discovery of a problem by routine inspections. Activities may include, but are not limited to, removing excessive accumulations of wind-blown plants and debris, repairing broken wire sections and posts, repairing and oiling gates, cleaning or replacing locks, repairing or replacing warning signs, and removing excess soil and/or vegetation covering survey monuments. Maintenance records will be maintained with the MWL Long-Term Monitoring Inspection Forms.

4.6 Inspection Schedule, Corrective Actions, and Recorded Results

A schedule for implementing inspections and prescribed maintenance of the MWL cover, surface-water drainage features, monitoring network, and access controls is provided in Table 4.6-1. Inspection results for the MWL monitoring systems will be recorded on the Long-Term Monitoring Inspection Forms included in Appendix G. Inspection results will be summarized in the annual MWL long-term monitoring and maintenance report.

Repairs and maintenance will be undertaken to ensure the integrity of the MWL cover, protect human health and the environment, and mitigate any potential hazards. If an inspection of the MWL reveals that a nonemergency problem has developed, the necessary repairs, maintenance, or replacement will be initiated within three days of notation on the Cover Inspection Checklist (Appendix G), unless circumstances beyond the control of the DOE/Sandia cause further delay. The DOE/Sandia will limit any such delays to as short a time period as reasonably possible. Repairs should not take longer than 60 days to complete. If an unexpected event or issue outside of DOE/Sandia control causes the repairs to take longer than 60 days to complete, then NMED will be consulted to discuss the impacts to the schedule. If a hazard appears imminent or a hazardous situation already exists, remedial action will be initiated immediately. Any remedial action taken pursuant to an inspection will be noted on the MWL Long-Term Monitoring Inspection Form. If any identified hazard meets the definition of an emergency, standard notification procedures will be followed.

Table 4.6-1
Long-Term Monitoring, Inspection, and Maintenance Schedule
Mixed Waste Landfill, Sandia National Laboratories/New Mexico

MWL System to be Inspected	Inspection Parameters	Inspection Frequency	Maintenance Implementation	Maintenance/ Repair Frequency[a]
Final Cover Surface	Vegetation Inventory	Quarterly until vegetation is established, annually thereafter by a staff biologist[b]	Soil augmentations and/or reseeding	Within 60 days of discovery of needed repairs
	Contiguous areas of no vegetation >200 ft^2		Revegetate barren areas that exceed prescribed limits	
	Animal intrusion burrows in excess of 4 inches in diameter		Repair cover system damage that exceeds prescribed limits	
Final Cover Surface	Settlement of cover surface in excess of 6 inches	Quarterly by a field technician	Repair cover system damage that exceeds prescribed limits	Within 60 days of discovery of needed repairs
	Erosion of cover soil in excess of 6 inches deep			Within 60 days of discovery of needed repairs
	Animal intrusion burrows in excess of 4 inches in diameter			Within 60 days of discovery of needed repairs
	Contiguous areas of no vegetation >200 ft^2 [c]		Revegetate barren areas that exceed prescribed limits[c]	Within 60 days of discovery of needed repairs
Surface-Water Drainage Features	Channel or sidewall erosion in excess of 6 inches deep	Quarterly by a field technician	Repair erosion that exceeds prescribed limits	Within 60 days of discovery of needed repairs
	Accumulations of sediment in excess of 6 inches deep or debris that blocks more than 1/3 of the channel width		Remove sediment and debris accumulations that exceed prescribed limits	
FLUTe™ Soil-Vapor Monitoring Wells, Soil-Moisture Monitoring Wells, and Groundwater Monitoring Wells	Concrete pads, stanchions, and protective casings	Groundwater and Vadose Zone Network Components: annually by a field technician during sampling events	Maintain, clean, repair, replace, re-label, as appropriate	Within 60 days of discovery of needed repairs
	Well cover caps and Swagelok® (or equivalent) dust caps			
	Monitoring wells and soil-vapor sampling port labels			
	Locks			
	Sampling pumps and tubing			

Refer to footnotes at end of table.

Table 4.6-1 (Concluded)
Long-Term Monitoring, Inspection, and Maintenance Schedule
Mixed Waste Landfill, Sandia National Laboratories/New Mexico

MWL System to be Inspected	Inspection Parameters	Inspection Frequency	Maintenance Implementation	Maintenance/ Repair Frequency[a]
Fence	Presence of wind-blown plants and debris	Quarterly by a field technician	Remove wind-blown plants and debris	Within 60 days of discovery of needed repairs
	Condition of fence wires, posts, gates, gate locks, warning signs, and survey monuments in the local area		Repair broken wire sections and posts, repair/oil gates, clean/replace locks, repair/replace warning signs, clear dirt/debris from monuments	

[a]Maintenance/repairs will be performed as necessary, based upon the results of inspections.
[b]As explained in Section 4.2.1, the transition from quarterly to annual inspections by a staff biologist is based upon the establishment of native flora in a self-sustaining manner as determined by the staff biologist.
[c]Barren areas exceeding >200 ft^2 will not require corrective action after the native vegetation is established in a self-sustaining manner; however, these areas will be noted and tracked during inspections after the 3- to 5-year time frame is completed and reviewed annually by the staff biologist to determine whether corrective action is required based upon comparison to surrounding vegetation.
ft^2 = Square feet.
MWL = Mixed Waste Landfill.

4.7 Record Keeping and Reporting

The following active records shall be maintained at the SNL/NM Customer-Funded Records Center:

1. Current and complete copy of the MWL LTMMP, including all appendices

2. Current written versions of operating procedures (administrative, standard, and laboratory) and related guidance referenced in the MWL LTMMP

3. A written Operating Record that includes the following:

    a. All completed inspection forms

    b. Long-Term Monitoring and Maintenance Annual Reports

    c. All waste management documentation for the last three years

    d. Emergency or incident response records and reports

4. Site-specific health and safety plan

Additionally, the following MWL records shall be maintained at the SNL/NM Customer-Funded Records Center:

1. All correspondence and other documents from the NMED and any other governmental agencies related to long-term monitoring and maintenance

2. All training records for current employees and training records for any former employee for a minimum of three years from the last date the employee worked at the MWL

3. All completed long-term monitoring and maintenance reports

4. All groundwater monitoring results and records, including full laboratory data packages/reports

5. All soil-vapor monitoring results and records, including full laboratory data packages/reports

6. All vadose zone moisture monitoring results and records, including full laboratory data packages/reports

7. All air monitoring results and records, including full laboratory data packages/reports

8. All biota monitoring results and records, including full laboratory data packages/reports

9. All records of actions taken to prevent or mitigate releases of hazardous waste or hazardous constituents to the environment

The DOE/Sandia will comply with the record-keeping provisions of Title 40, Code of Federal Regulations (CFR), Section 264.74, concerning the availability, retention, and disposition of records.

4.7.1 Annual Long-Term Monitoring and Maintenance Reports

During the long-term monitoring and maintenance period, the DOE/Sandia will submit an MWL long-term monitoring and maintenance report to the NMED on an annual basis. The report will include calendar year data and will:

1. Summarize inspection, maintenance, and repair activities, and indicate whether any implemented repairs were effective and met the original specifications
2. Provide groundwater, vadose zone soil vapor and soil moisture, air, and biota monitoring results
3. Indicate whether trigger levels were exceeded for any constituent
4. Summarize any problems that either endangered or presented significant potential to endanger human health and the environment for the reporting period and what was done to mitigate such problems

The annual reports are due by April 30 of each calendar year and will cover the previous calendar year.

4.7.2 Five-Year Reevaluation Reports

The DOE/Sandia will also submit a report every five years reevaluating the feasibility of excavation and analyzing the continued effectiveness of the selected remedy. The report will include a review of the annual long-term monitoring and maintenance reports and any other pertinent data, as well as additional documentation required by the NMED. In each five-year report, the DOE/Sandia will:

1. Update the fate and transport model for the MWL with current data
2. Reevaluate any likelihood of contaminants reaching groundwater
3. Detail all efforts to ensure that any future releases or mobilization of contaminants are detected and addressed well before any effect on groundwater or increased risk to public health or the environment occurs

4.8 Potential for Exposure

The MWL vegetative soil cover provides a significant barrier between the surface environment and the buried wastes beneath the cover. The following measures have been implemented to reduce the risk of exposure from the wastes buried at the MWL:

- The engineered cover is designed to minimize the potential for the migration of liquid into the MWL.

- Monitoring of the vadose zone will be conducted to determine whether contaminants are being released that pose a threat to groundwater.

- Security and IC measures will be maintained to restrict access to the area.

- Federal ownership and the industrial land-use designation will help prevent inappropriate use of the MWL site.

- Inspections, maintenance, and repairs (as necessary) will be performed on a regularly scheduled basis and in accordance with the LTMMP.

4.9 Potential for Emergency

Due to the current conditions at the MWL, the potential for fire, explosion, or unplanned sudden release of radionuclides or RCRA-regulated hazardous waste or hazardous waste constituents that would significantly threaten human health or the environment is low. In the unlikely event of an emergency, the SNL/NM Emergency Operations Center will provide coordination, resources, and appropriate emergency equipment on an as-needed basis.

5.0 TRIGGERS FOR LONG-TERM MONITORING

The NMED Class 3 Permit Modification (NMED August 2005) required that the MWL CMI Plan (SNL/NM November 2005) include triggers for future action (e.g., increased monitoring, contaminant mitigation, etc.) that identify and detail specific monitoring results that may require additional testing or corrective action. Based upon the results of the probabilistic performance-assessment modeling for the MWL (Ho et al. January 2007), the following parameters were identified as important for long-term monitoring:

- Surface emissions of tritium and radon
- Infiltration through the MWL cover
- Concentrations of uranium in groundwater
- Concentrations of VOCs in the soil vapor and groundwater

Monitoring triggers are established for these parameters to ensure that the MWL performance metrics and corrective action objectives are met. These triggers were derived from EPA, DOE, and NMED regulatory standards, as well as NMED-approved background concentrations. To address concerns regarding potential mobilization of contaminants by biota, additional monitoring triggers are established for metals and radionuclides in surface soil near animal burrows and ant hills.

The trigger evaluation process is described in Section 5.1. This process will be initiated if a trigger is exceeded during long-term monitoring at the MWL. The logic and rationale for specific triggers are presented in Section 5.2. The triggers discussed in Section 5.2 have been revised from the original triggers presented in the MWL CMI Plan (SNL/NM November 2005) to address regulatory and public concerns expressed in the CMI Plan review process.

5.1 Trigger Evaluation Process

A trigger evaluation process will be utilized during long-term monitoring activities at the site (Figure 5.1-1). The process will be a phased approach designed to ensure the protection of human health and the environment, while allowing adequate data collection to evaluate whether corrective action is warranted.

In the event that a trigger level is exceeded, the process shown in Figure 5.1-1 will be used to ensure that adequate data are collected to determine whether additional corrective action is warranted. The increased frequency of data collection (see Step 3 in Figure 5.1-1) and the corresponding explanation will ensure that adequate data are collected to eliminate field sampling error, laboratory error, and to identify short-term exceedances that do not reflect long-term trends. Thus, any recommendations for corrective action because of trigger exceedances will be based upon data trends rather than upon single detection values above the trigger level. If the monitored parameters indicate an established trend above the trigger level, the process requires that a technical letter report be submitted to the NMED identifying the trend and recommending whether or not corrective action should be implemented.

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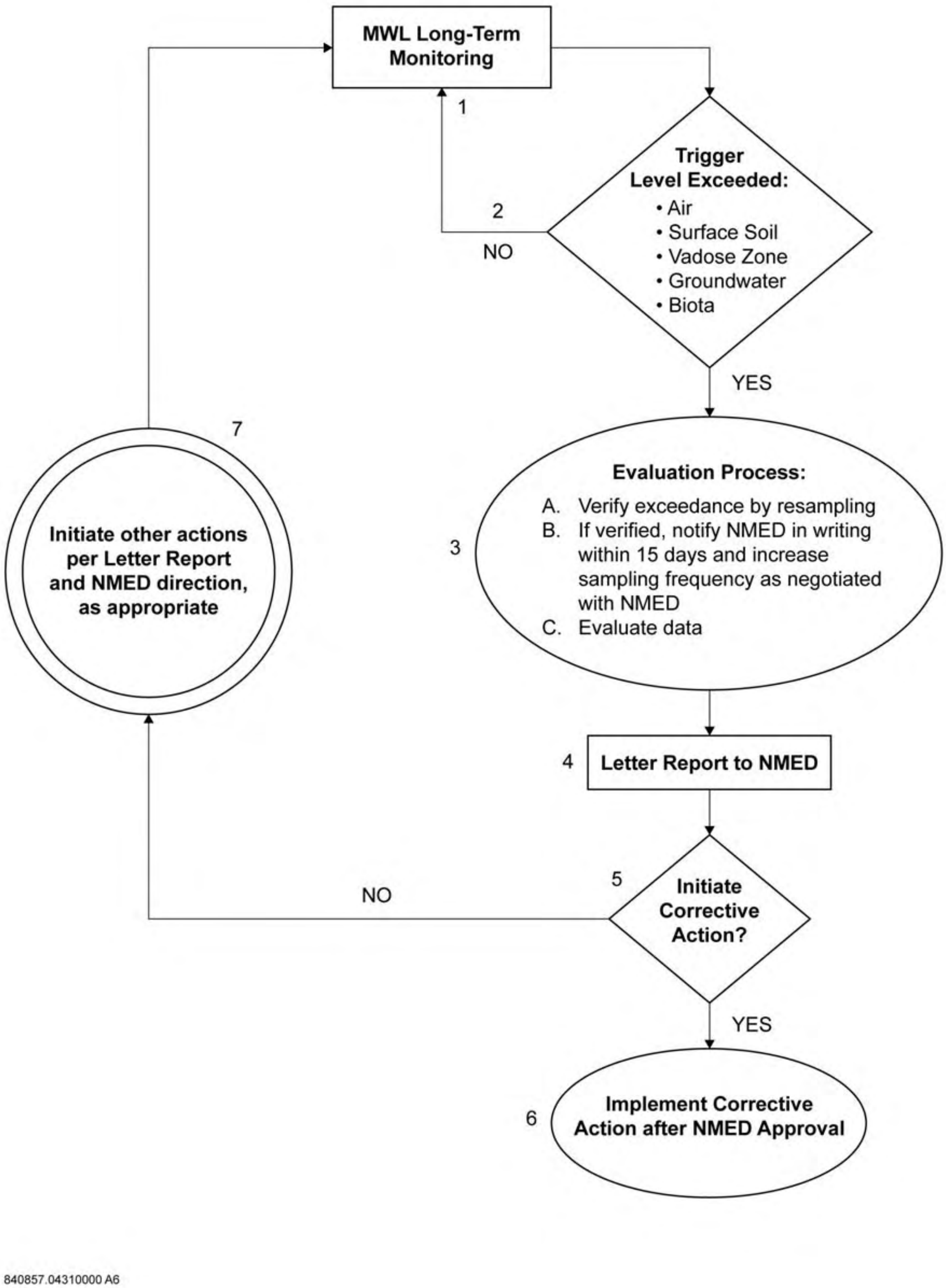

Figure 5.1-1
Trigger Evaluation Process for the Mixed Waste Landfill

The steps outlined in Figure 5.1-1 are explained as follows:

1. Long-term monitoring of the air, surface soil, vadose zone, and groundwater at the MWL.

2. Exceedance of one or more trigger levels initiates the specific actions described in the following steps.

3. Step A of the evaluation process initiates resampling to verify the result(s) that exceeded the trigger level. If the trigger exceedance is verified, the NMED will be notified of the exceedance in writing within 15 days. Step B is based upon the conceptual model for the MWL. Because infiltration through the MWL cover is expected to be very low, and contaminant transport times in the vadose zone and groundwater are anticipated to be relatively slow, a longer period for data collection at an increased sampling frequency is recommended to determine trends. The length of this period and the increased sampling frequency will be negotiated with the NMED. Once the increased sampling data have been collected, the data and any resulting trends will be evaluated to determine the significance of the exceedance (Step C).

4. After the trends have been evaluated, a brief technical letter report will be prepared and submitted to the NMED, presenting the results of the increased monitoring, and providing recommendations regarding corrective action.

5. NMED Decision Point: after the technical letter report is submitted to the NMED, a meeting will be held to discuss the data evaluation and the recommendations regarding corrective action. If the NMED determines that further investigation of the trigger exceedance is needed, the NMED may require corrective action based upon a finding that releases of contaminants have occurred or are occurring.

6. If the data trend is increasing and higher than the trigger value, corrective action may be necessary. The technical letter report will address appropriate options and form the basis for further discussion with the NMED to determine the final corrective action.

7. If the data trend is not clear or is decreasing, corrective action may not be necessary, but other actions may be required as proposed in the technical letter report or requested by the NMED.

5.2 Monitoring Triggers

Based upon both the results of the probabilistic performance-assessment modeling conducted for the MWL (SNL/NM November 2005, Ho et al. January 2007) and subsequent input received from the NMED and the public, monitoring triggers are established for the air, soil, vadose zone, and groundwater at the MWL. These triggers are listed in Table 5.2-1 and are discussed in the following sections.

Although triggers for long-term monitoring have been developed for both hazardous and radioactive constituents, the triggers and monitoring for radionuclides are provided voluntarily by the DOE/Sandia. The voluntary inclusion of such radionuclide information shall not be enforceable and shall not constitute the basis for any enforcement because such information falls wholly outside the requirements of the Consent Order. Additional information on radionuclides and the scope of the Consent Order is available in Section III.A of the Consent Order (NMED April 2004).

5.2.1 Air Monitoring Triggers

The trigger for radon is based upon the results of the probabilistic performance-assessment modeling (Ho et al. January 2007). The modeling indicates that a possibility exists that the radon-222 flux from the MWL to the atmosphere will exceed the design standard of 20 $pCi/m^2/s$ at the landfill surface.

The trigger for radon in air is 4 pCi/L, and the point of compliance is the MWL perimeter. This value is the EPA action threshold for radon in household air (EPA September 2005). This value is significantly lower than the simulated radon-gas concentrations (greater than 10,000 pCi/L) at the surface of the MWL which yielded fluxes that exceeded the design standard of 20 $pCi/m^2/s$ (Ho et al. January 2007). Should the radon trigger of 4 pCi/L be exceeded in air at the MWL point of compliance, then the trigger evaluation process shown in Figure 5.1-1 will be implemented.

5.2.2 Surface Soil and Biota Monitoring Triggers

The surface soil and biota monitoring triggers include a trigger for tritium concentrations in soil collected at select locations along the MWL perimeter. Several additional triggers have been established to address concerns regarding potential mobilization of contaminants by biota. These include triggers for radionuclides and metals in surface soil near animal burrows and ant hills, and triggers for gamma-emitting radionuclides in vegetation growing on the cover.

5.2.2.1 Tritium in Surface Soil

Tritium is the most mobile radionuclide disposed of at the MWL, and the performance-assessment model (Ho et al. January 2007) indicates a low (2 percent) probability that tritium emitted from the MWL may exceed the performance objective of 10 millirem/yr dose to the public via the air pathway. For this reason, a trigger was developed for tritium emitted from the MWL. Based upon the modeling results, the maximum simulated surface

Table 5.2-1
Monitoring Triggers for the Mixed Waste Landfill
Sandia National Laboratories/New Mexico

Environmental Medium	Monitoring Parameter	Main Potential Receptors	Trigger Value[a]	Sampling Points	Performance Objective	Basis for Performance Objective
Air	Radon[a]	Humans	4 pCi/L (measured by track-etch radon detectors)	MWL Perimeter	Average flux of radon-222 gas shall be less than 20 $pCi/m^2/s$ at the landfill surface (design standard)	EPA Action Threshold for radon in air (EPA September 2005)
Surface Soil	Tritium[a]	Humans and ecological receptors	20,000 pCi/L tritium in soil moisture	MWL Perimeter	Dose to the public via the air pathway shall be less than 10 mrem/yr	DOE Order 5400.5 (DOE 1993), 10 CFR 61 Subpart H, 40 CFR 141.66
Surface Soil	Cs-137[a]	Humans and ecological receptors	0.664 pCi/g	Animal burrows and ant hills on the cover	Radionuclide concentrations in soil shall not exceed NMED-approved maximum background concentrations	NMED-Approved Maximum Background Concentrations (Dinwiddie September 1997)
Surface Soil	Ra-226[a]	Humans and ecological receptors	2.30 pCi/g	Animal burrows and ant hills on the cover	Radionuclide concentrations in soil shall not exceed NMED-approved maximum background concentrations	NMED-Approved Maximum Background Concentrations (Dinwiddie September 1997)
Surface Soil	Th-232[a]	Humans and ecological receptors	1.01 pCi/g	Animal burrows and ant hills on the cover	Radionuclide concentrations in soil shall not exceed NMED-approved maximum background concentrations	NMED-Approved Maximum Background Concentrations (Dinwiddie September 1997)
Surface Soil	U-235[a]	Humans and ecological receptors	0.16 pCi/g	Animal burrows and ant hills on the cover	Radionuclide concentrations in soil shall not exceed NMED-approved maximum background concentrations	NMED-Approved Maximum Background Concentrations (Dinwiddie September 1997)
Surface Soil	U-238[a]	Humans and ecological receptors	1.4 pCi/g	Animal burrows and ant hills on the cover	Radionuclide concentrations in soil shall not exceed NMED-approved maximum background concentrations	NMED-Approved Maximum Background Concentrations (Dinwiddie September 1997)
Surface Soil	Arsenic	Humans and ecological receptors	17.7 mg/kg	Animal burrows and ant hills on the cover	RCRA metal concentrations in soil shall not exceed NMED industrial/occupational SSLs	NMED Industrial/Occupational SSLs (NMED June 2006)

Refer to footnotes at end of table.

Table 5.2-1 (Continued)
Monitoring Triggers for the Mixed Waste Landfill
Sandia National Laboratories/New Mexico

Environmental Medium	Monitoring Parameter	Main Potential Receptors	Trigger Value[a]	Sampling Points	Performance Objective	Basis for Performance Objective
Surface Soil	Barium	Humans and ecological receptors	100,000 mg/kg	Animal burrows and ant hills on the cover	RCRA metal concentrations in soil shall not exceed NMED industrial/occupational SSLs	NMED Industrial/Occupational SSLs (NMED June 2006)
Surface Soil	Cadmium	Humans and ecological receptors	564 mg/kg	Animal burrows and ant hills on the cover	RCRA metal concentrations in soil shall not exceed NMED industrial/occupational SSLs	NMED Industrial/Occupational SSLs (NMED June 2006)
Surface Soil	Chromium	Humans and ecological receptors	3,400 mg/kg	Animal burrows and ant hills on the cover	RCRA metal concentrations in soil shall not exceed NMED industrial/occupational SSLs	NMED Industrial/Occupational SSLs (NMED June 2006)
Surface Soil	Lead	Humans and ecological receptors	800 mg/kg	Animal burrows and ant hills on the cover	RCRA metal concentrations in soil shall not exceed NMED industrial/occupational SSLs	NMED Industrial/Occupational SSLs (NMED June 2006)
Surface Soil	Mercury	Humans and ecological receptors	100,000 mg/kg	Animal burrows and ant hills on the cover	RCRA metal concentrations in soil shall not exceed NMED industrial/occupational SSLs	NMED Industrial/Occupational SSLs (NMED June 2006)
Surface Soil	Selenium	Humans and ecological receptors	5,680 mg/kg	Animal burrows and ant hills on the cover	RCRA metal concentrations in soil shall not exceed NMED industrial/occupational SSLs	NMED Industrial/Occupational SSLs (NMED June 2006)
Surface Soil	Silver	Humans and ecological receptors	5,680 mg/kg	Animal burrows and ant hills on the cover	RCRA metal concentrations in soil shall not exceed NMED industrial/occupational SSLs	NMED Industrial/Occupational SSLs (NMED June 2006)
Biota	Gamma Spectroscopy	Ecological receptors	No regulatory standards available	Deep-rooted plants on the cover	Protection of natural resources, including biota	No regulatory guidelines apply

Refer to footnotes at end of table.

Table 5.2-1 (Continued)
Monitoring Triggers for the Mixed Waste Landfill
Sandia National Laboratories/New Mexico

Environmental Medium	Monitoring Parameter	Main Potential Receptors	Trigger Value[a]	Sampling Points	Performance Objective	Basis for Performance Objective
Vadose Zone	Moisture Content	Humans via groundwater	23 percent by volume	Linear depths of 10 to 100 ft along neutron probe access holes beneath the MWL	Infiltration through the cover shall be less than the EPA-prescribed technical equivalence criterion of 31.5 mm/yr [10E-7 cm/s]	RCRA 40 CFR Part 264.301
Vadose Zone	PCE	Humans via groundwater	20 ppmv	Soil Vapor from Deepest Sampling Port in FLUTe™ well	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Vadose Zone	TCE	Humans via groundwater	20 ppmv	Soil Vapor from Deepest Sampling Port in FLUTe™ well	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Vadose Zone	Total VOCs	Humans via groundwater	25 ppmv	Soil Vapor from Deepest Sampling Port in FLUTe™ well	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	Uranium	Humans via groundwater	15 µg/L	Downgradient monitoring well locations	Uranium concentrations in groundwater shall not exceed the EPA MCL of 30 µg/L	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	1,1,1-TCA	Humans via groundwater	100 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	1,1,2-TCA	Humans via groundwater	2.5 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	1,1-Dichloroethene	Humans via groundwater	3.5 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	1,2-Dichloroethane	Humans via groundwater	2.5 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	1,2-Dichloropropane	Humans via groundwater	2.5 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)

Refer to footnotes at end of table.

Table 5.2-1 (Continued)
Monitoring Triggers for the Mixed Waste Landfill
Sandia National Laboratories/New Mexico

Environmental Medium	Monitoring Parameter	Main Potential Receptors	Trigger Value[a]	Sampling Points	Performance Objective	Basis for Performance Objective
Groundwater	Benzene	Humans via groundwater	2.5 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	Carbon tetrachloride	Humans via groundwater	2.5 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	Chlorobenzene	Humans via groundwater	50 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	Ethyl benzene	Humans via groundwater	350 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	Methylene chloride	Humans via groundwater	2.5 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	Styrene	Humans via groundwater	50 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	PCE	Humans via groundwater	2.5 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	Toluene	Humans via groundwater	500 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	TCE	Humans via groundwater	2.5 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	Vinyl Chloride	Humans via groundwater	1.0 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	Xylenes (Total)	Humans via groundwater	5,000 µg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)

Refer to footnotes at end of table.

Table 5.2-1 (Concluded)
Monitoring Triggers for the Mixed Waste Landfill
Sandia National Laboratories/New Mexico

Environmental Medium	Monitoring Parameter	Main Potential Receptors	Trigger Value[a]	Sampling Points	Performance Objective	Basis for Performance Objective
Groundwater	cis-1,2-Dichloroethene	Humans via groundwater	35 μg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	Trans-1,2-Dichloroethene	Humans via groundwater	50 μg/L	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA MCLs	EPA National Primary Drinking Water Regulations (40 CFR 141)
Groundwater	EPA Method 8260 VOCs with no MCLs	Humans via groundwater	EPA Region 6 Human Health Medium-Specific Screening Levels	Downgradient monitoring well locations	VOC concentrations in groundwater shall not exceed EPA Region 6 Human Health Medium-Specific Screening Levels	EPA Region 6 Human Health Medium-Specific Screening Levels (EPA December 2006)

[a]Although triggers for long-term monitoring have been developed for both hazardous and radioactive constituents, the triggers and monitoring for radionuclides are provided voluntarily by DOE/Sandia. The voluntary inclusion of such radionuclide information shall not be enforceable and shall not constitute the basis for any enforcement because such information falls wholly outside the requirements of the Consent Order. Additional information on radionuclides and the scope of the Consent Order is available in Section III.A of the Consent Order.

CFR = Code of Federal Regulations.
cm = Centimeter(s).
DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.
FLUTe™ = Flexible Liner Underground Technologies.
ft = Foot (feet).
g = Gram(s).
kg = Kilogram(s).
L = Liter(s).
m^2 = Square meter(s).
MCL = Maximum contaminant level.
μg = Microgram(s).
mg = Milligram(s).
mm = Millimeter(s).
mrem = Millirem.
MWL = Mixed Waste Landfill.
NMED = New Mexico Environment Department.
PCE = Tetrachloroethane.
pCi = Picocurie(s).
ppmv = Parts per million by volume.
RCRA = Resource Conservation and Recovery Act.
s = Second(s).
SSL = Soil screening level.
TCA = Trichloroethane.
TCE = Trichloroethene.
VOC = Volatile organic compound.
yr = Year.

concentration of tritium for the realizations that yielded the peak doses via air are on the order of 10^9 to 10^{10} pCi/L. Therefore, a conservative trigger value of 20,000 pCi/L in surface soil at the MWL perimeter will be used.

The tritium trigger applies to surface soil samples collected annually at select locations outside the MWL perimeter fence by the SNL/NM Terrestrial Surveillance Program. Soil samples have been collected from these locations and analyzed for tritium on an annual basis since 1985. Soil moisture is extracted from these samples, and tritium concentrations in the soil moisture are determined using liquid scintillation. Any increase in tritium emissions from the MWL will be indicated by elevated tritium concentrations in these soil samples.

Figure 5.2.2-1 shows a comparison between historical tritium concentrations measured in samples from the four perimeter locations and the trigger value of 20,000 pCi/L. All exceedances of the trigger value occurred prior to 1998, and exceedances are not anticipated in the future due to radioactive decay and the relatively short (12.3-year) half-life of tritium. These concentrations have been diminishing with time due to natural radioactive decay of tritium, and although elevated above the background value, they do not pose a threat to human health or the environment. If measured concentrations of tritium at the surface exceed 20,000 pCi/L, this would indicate a significant increase relative to present-day values, and the trigger evaluation process (Figure 5.1-1) would be followed. Because the trigger value is four to five orders of magnitude less than simulated concentrations that yielded exceedances in the dose via air, the trigger value serves as a conservative early-warning indicator for potential exceedances of tritium dose via air.

5.2.2.2 Biota Monitoring Triggers

Surface soil from animal burrows and ant hills will be monitored for radionuclides and heavy metals, with samples collected every two years. Triggers for gamma-emitting radionuclides are the NMED-approved background values (Dinwiddie September 1997). Triggers for RCRA metals concentrations in surface soil are the NMED industrial/occupational soil screening levels (NMED June 2006). These triggers are shown in Table 5.2-1.

Vegetation growing on the cover will be sampled every two years for gamma-emitting radionuclides. However, no triggers are established for gamma-emitting radionuclides because no regulatory standards are available.

5.2.3 Vadose Zone Monitoring Triggers

Long-term monitoring of the vadose zone is planned for both soil vapor and moisture content to ensure that the MWL remedy remains protective of human health and the environment. The trigger values for vadose zone soil vapor and moisture content are discussed in the following sections. Additional details regarding the frequency and extent of long-term monitoring activities are included in the Soil-Vapor SAP (Appendix B) and the Soil-Moisture MP for the MWL (Appendix C).

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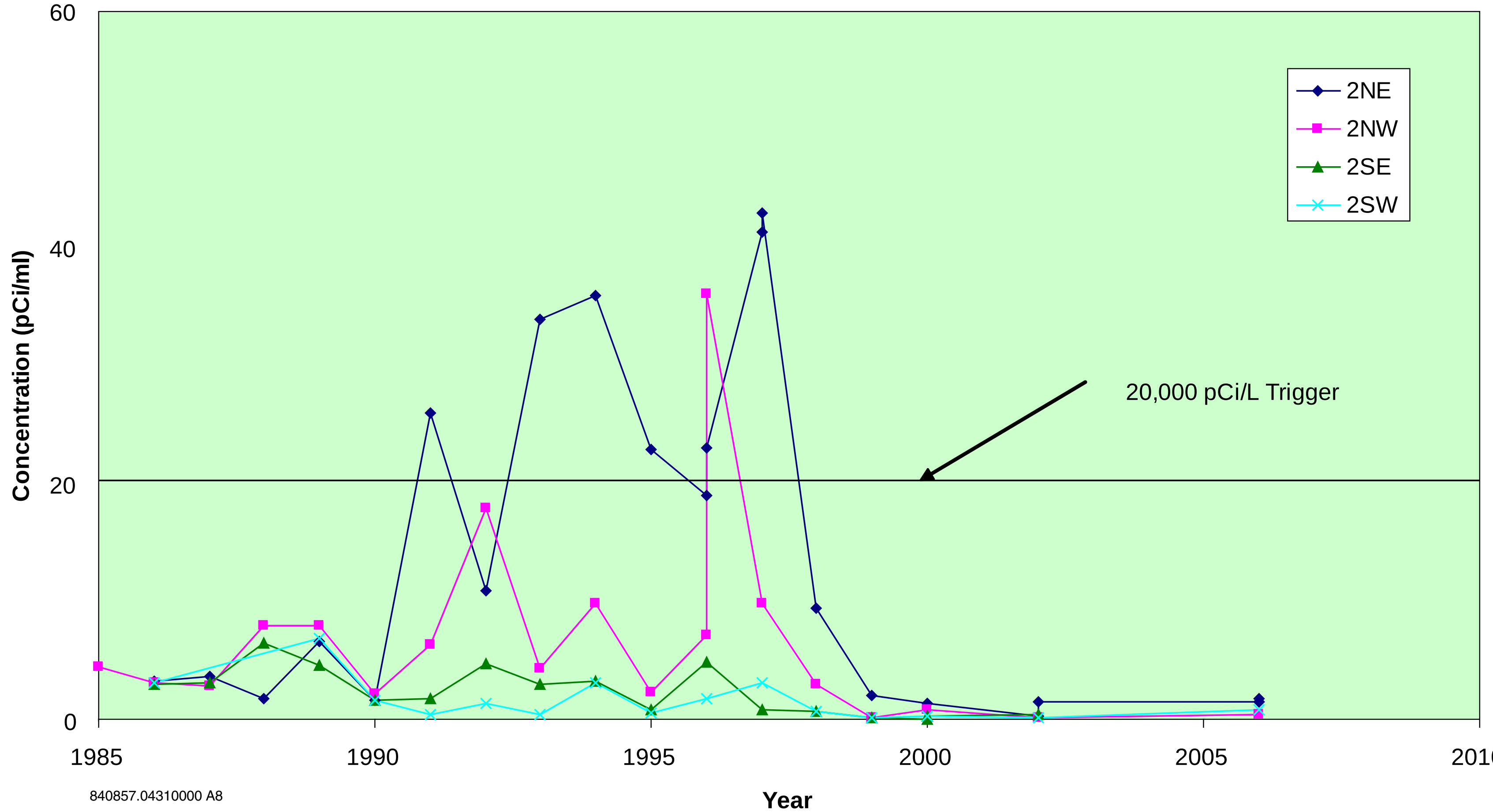

Figure 5.2.2-1
Comparison Between Historical Tritium Concentrations Measured in Samples from the Four Perimeter Locations and the Trigger Value of 20,000 pCi/L, Mixed Waste Landfill

5.2.3.1 Volatile Organic Compounds in Soil Vapor

Triggers for tetrachloroethane (PCE), trichloroethene (TCE), and total VOCs in soil vapor at the MWL are 20 parts per million by volume (ppmv) for PCE and TCE, and 25 ppmv for total VOCs. All triggers apply to samples collected from the deepest sampling port (i.e., 400 feet bgs) in each FLUTe™ well. Should the triggers for PCE, TCE, or total VOCs in soil vapor be exceeded in samples from the deepest sampling port, then the trigger evaluation process (Figure 5.1-1) will be implemented.

5.2.3.2 Moisture Content

Moisture content with depth will be monitored using a neutron moisture probe in three soil-moisture monitoring access tubes that were installed to a linear depth of 200 feet at a 30-degree angle directly beneath the waste disposal cells. The moisture content data will be used to evaluate infiltration through the MWL disposal cell cover. Infiltration is an important parameter for determining whether or not MWL performance objectives are met.

Infiltration through the cover will be indirectly monitored by monitoring the moisture content in the vadose zone beneath the MWL. A significant increase in moisture content beneath the landfill may indicate that the disposal cell cover may not be performing as originally designed, and that infiltration through the cover is greater than originally predicted.

Moisture content will be measured using neutron logging, and data will be compared to baseline moisture content data collected prior to deployment of the MWL cover. This noninvasive method allows cover performance to be assessed without damaging the integrity of the engineered cover. A significant increase in moisture content within the vadose zone may indicate that corrective action is warranted in order to prevent the downward movement of water through the waste. Moisture content data will be evaluated to ensure that the performance objective of infiltration through the MWL cover is less than the EPA-prescribed technical equivalence criteria of 10^{-7} cm/s (31.5 mm/yr), as detailed below.

Infiltration may be estimated indirectly using Darcy's Law (Darcy 1856). The method is based upon soil-physics and the relationship between unsaturated hydraulic conductivity and volumetric moisture content of subsurface soils. The method is described in detail in the MWL Phase 2 RFI SAND Report (Peace et al. September 2002). Assumptions required for this method include one-dimensional, steady-state flow and a vertical hydraulic gradient of unity.

Applying these assumptions, the downward flux at a particular depth is equivalent to the unsaturated hydraulic conductivity as a function of the moisture content at that depth. Thus, by monitoring the moisture content of the vadose zone beneath the MWL, the downward flux through the vadose zone can also be indirectly monitored. If infiltration through the cover increases significantly, then the downward flux through the vadose zone would increase as well, resulting in higher moisture content in the vadose zone beneath the landfill. Hence, by monitoring moisture content in the vadose zone, the performance of the MWL cover can be indirectly monitored. A significant increase in moisture content beneath the MWL may indicate that the cover is not performing as designed.

Figure 5.2.3-1 shows the calculated unsaturated hydraulic conductivity curves for 18 subsurface soil samples collected from near-surface soil approximately 500 feet west of the MWL (Peace and Goering February 2005). Based upon the data presented in this figure and assuming a unit gradient in the vadose zone, if infiltration through the MWL cover exceeds the EPA-prescribed technical equivalence criteria of 10^{-7} cm/s (31.5 mm/yr), then volumetric moisture content in the underlying soil will exceed approximately 23 percent.

The established trigger level is the moisture content that corresponds to an unsaturated hydraulic conductivity equal to the EPA-prescribed technical equivalence criteria of 10^{-7} cm/s (31.5 mm/yr). The moisture content at which this occurs is 23 percent by volume, and the trigger level for moisture content in the vadose zone is, therefore, 23 percent by volume. This value is based on the EPA-prescribed technical equivalence criteria and does not necessarily indicate that hazardous constituents or radionuclides are migrating from the landfill.

The 23-percent trigger applies to linear depths of 10 and 100 feet (vertical depths of 8.7 to 86.6 feet) along the neutron probe access tubes in the vadose zone beneath the MWL. This interval is the "regulated interval" because it lies beneath the root zone, yet is shallow enough that a response would be detected fairly rapidly if infiltration through the cover significantly increases. Should this 23-percent trigger level be exceeded in the regulated interval, then the trigger evaluation process (Figure 5.1-1) will be implemented. Additional details regarding long-term monitoring of the vadose zone for moisture content is presented in the Soil-Moisture MP (Appendix C).

5.2.4 Groundwater Monitoring Triggers

Monitoring triggers for uranium and VOCs in groundwater at the MWL are discussed in the following sections.

5.2.4.1 Uranium

Uranium occurs naturally in MWL groundwater at concentrations ranging from 1.34 to 9.23 micrograms (μg)/L and averaging 5.97 μg/L. Total uranium concentrations in groundwater beneath the MWL are well within the total uranium ranges (0.1 to 86 μg/L) established by the U.S. Geological Survey for the Middle Rio Grande Basin (USGS 2002). Isotopic analyses of uranium have demonstrated that it is of natural origin (Goering et al. 2002).

The probabilistic performance-assessment modeling for the MWL (Ho et al. January 2007) indicates the possibility that uranium will reach the groundwater (although none of the simulations showed the uranium concentrations exceeding the EPA Primary Drinking Water Standard of 30 μg/L). For this reason, a monitoring trigger of 15 μg/L (one-half of the EPA maximum contaminant level [MCL]) is established for uranium in MWL groundwater at the point of compliance. The point of compliance is at each downgradient monitoring well. Should the uranium trigger value be exceeded in MWL groundwater at the point of compliance, then the trigger evaluation process (Figure 5.1-1) will be implemented.

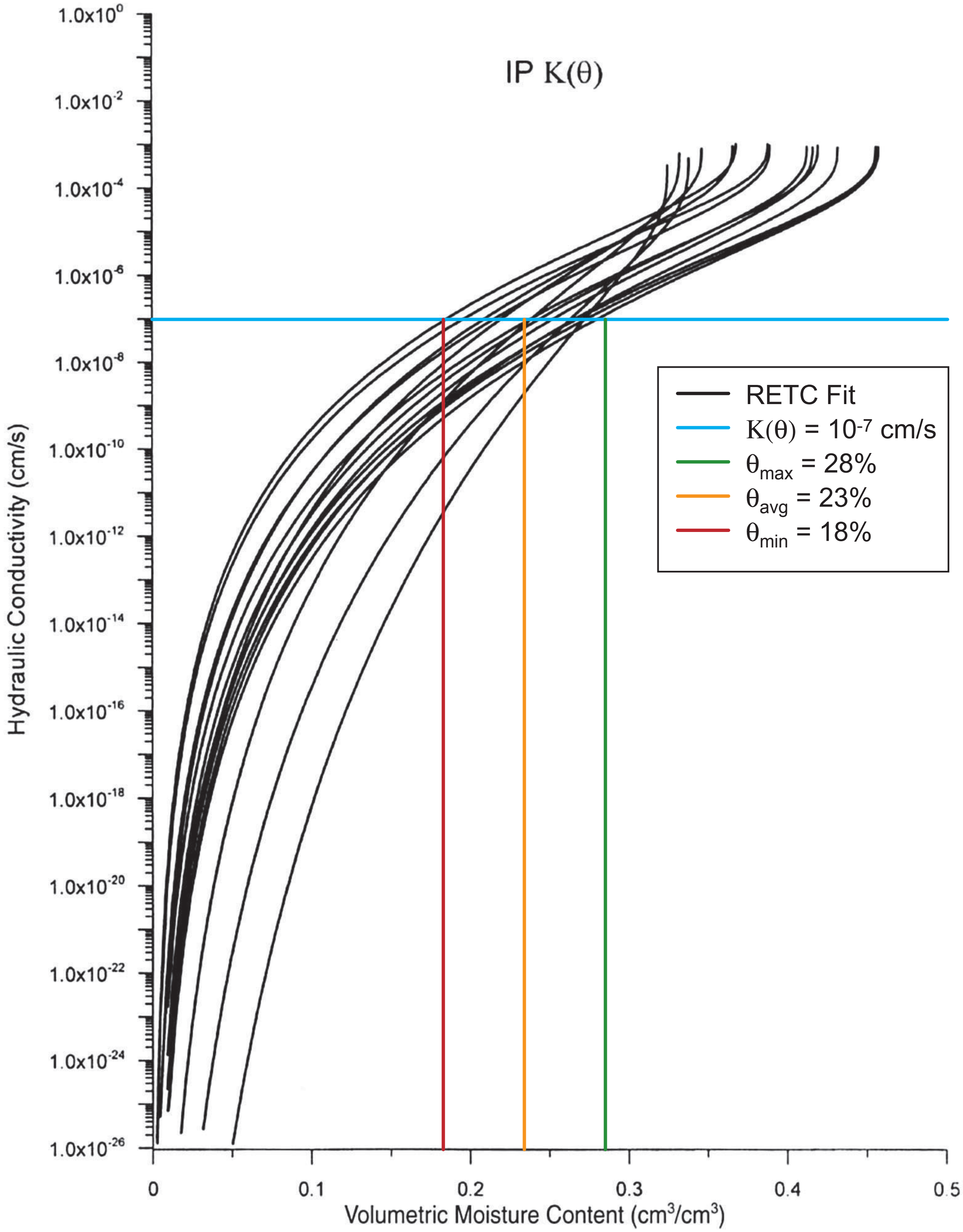

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Figure 5.2.3-1
Hydraulic Conductivity as a Function of Volumetric Moisture Content for Different Soil Samples at the IP Site Mixed Waste Landfill

5.2.4.2 Volatile Organic Compounds

Groundwater monitoring for VOCs at the MWL has been conducted since September 1990 and there is no evidence that the MWL has contaminated groundwater. However, earlier studies (Johnson et al. 1995 and Klavetter August 1995), as well as the current probabilistic performance-assessment modeling (Ho et al. January 2007), have shown that a potential exists for VOCs to contaminate groundwater at the MWL.

The potential downward vertical transport of six organic compounds to groundwater by both aqueous-phase transport and vapor-phase transport was evaluated in 1995 (Klavetter August 1995). The study showed that PCE could eventually migrate to groundwater through vapor-phase transport. Although the modeling predicted that the most likely PCE concentrations in groundwater would be considerably lower than the detection limit of 0.5 parts per billion (ppb), sensitivity analyses suggest that PCE concentrations could potentially reach 1 to 5 ppb within 50 years (Klavetter August 1995).

The current probabilistic performance-assessment modeling (Ho et al. January 2007) also simulated the migration of PCE to groundwater and arrived at similar conclusions regarding the potential contamination of groundwater by PCE through vapor-phase transport. Because PCE is modeled in this study as a proxy (due to its mobility) for other VOCs detected in both soil vapor and soil beneath the MWL, a potential exists for other VOCs from the MWL to also migrate to groundwater in the future. For this reason, groundwater will continue to be monitored for VOCs.

Groundwater trigger levels have been developed for all Target Compound List VOCs for which there are primary EPA MCLs or EPA Region 6 Human Health Medium-Specific Screening Levels (EPA December 2006). The groundwater trigger levels for VOCs with MCLs are equal to one-half of the EPA MCLs; the trigger levels for concentrations of VOCs with no corresponding MCLs are the EPA Region 6 Human Health Medium-Specific Screening Levels.

The point of compliance is at each downgradient monitoring well within the MWL groundwater monitoring well network. Should any VOC trigger values be exceeded in MWL groundwater at the point of compliance, the trigger evaluation process (Figure 5.1-1) will be implemented. Additional details regarding long-term groundwater monitoring at the MWL are presented in the Groundwater SAP for the MWL (Appendix D).

5.3 Summary of Triggers

Based upon the results of the probabilistic performance-assessment modeling conducted for the MWL (Ho et al. January 2007) and input from the NMED and public, monitoring triggers have been developed for the air, surface soil, vadose zone, and groundwater at the MWL. Specific triggers include numerical thresholds for the following:

- Radon concentrations in the air
- Tritium, gamma-emitting radionuclides, and metals in surface soil
- Soil moisture in the vadose zone

- VOCs in the vadose zone
- Uranium, VOCs, metals, water-quality indicators, and radionuclide concentrations in groundwater
- Gamma-emitting radionuclides in biota

The triggers were derived from EPA, DOE, and NMED regulatory standards, as well as NMED-approved background concentrations for select radionuclides. If a trigger is exceeded, then the DOE/Sandia will initiate a trigger evaluation process (Figure 5.1-1) that will allow for sufficient data to be collected to assess trends and recommend corrective action, if necessary.

By utilizing these triggers during long-term monitoring at the MWL, the DOE/Sandia will ensure that the MWL remedy continues to protect human health and the environment, while meeting the performance objectives for the cover and the corrective action objectives established in the MWL Corrective Measures Study (CMS) Final Report (SNL/NM May 2003).

6.0 INSTITUTIONAL CONTROLS

6.1 Introduction

This chapter describes the ICs to be implemented and maintained at the MWL during long-term monitoring at the site. Upon completion of environmental remediation activities, measures to restrict the use of contaminated land and other resources are sometimes required. ICs are mechanisms used to restrict inappropriate uses of land, facilities, and environmental media by limiting exposure to residual contaminants left behind following remedy implementation. ICs can take the form of administrative controls, legal controls, physical barriers or markers, and methods to preserve information and data and inform current and future generations of hazards and risks.

ICs may be appropriate to use when complete remediation is neither technically nor economically feasible, remediation risks to worker health and safety are too great, or collateral ecological damage associated with remediation would be too extensive. ICs are generally used to supplement active remediation measures (EPA September 2000) by instituting post-remediation administrative or physical controls.

ICs typically used at DOE sites include the following:

- Government ownership (e.g., federal or state)
- Warning notices (e.g., no trespassing signs, notification signs for hazardous and sensitive areas)
- Entry restrictions (e.g., requirements for security badges, fencing, training for persons entering hazardous or sensitive areas)
- Resource-use management (e.g., land use and real property controls, excavation permits, groundwater use restrictions)
- Site information systems (e.g., information tracking systems on the location and nature of waste sites or geographic based-information archives)

6.2 Institutional Controls at the Mixed Waste Landfill

ICs are a key element of the long-term monitoring and maintenance strategy for the MWL. Various ICs were already in place for the landfill, and others have been implemented since the remedy was fully implemented. The application of multiple ICs at the MWL is consistent with a conservative strategy that uses multiple, independent layers of safety to protect human health and the environment. Thus, if one control temporarily fails, other controls will be in place to mitigate significant consequences of the failure.

The ICs applicable to the MWL are discussed in depth in the following sections.

6.2.1 Government Ownership

Government ownership is a key IC that restricts or prevents unauthorized access to sites with hazardous or radioactive materials. The MWL is located on KAFB in TA-III, one of five TAs at SNL/NM. TA-III is a test area owned by the DOE and includes two rocket-sled tracks, two centrifuges, and a radiant heat facility. Because of the nature of these facilities, TA-III will likely remain under DOE control (and on land owned by the federal government) indefinitely. Figure 6.2.1-1 shows the location of SNL/NM TAs and land uses within KAFB. Future land-use designations are based upon the Kirtland Area Office input for the DOE Future Use Report (DOE et al. September 1995).

In case of the unlikely scenario that the DOE relinquishes ownership of TA-III and the property is transferred to state or local authorities or to private ownership, the site would have to be reevaluated to determine what, if any, measures would be required to make the site acceptable for its expected land use after ownership transfer.

6.2.2 Entry Restrictions

Entry restrictions are another category of ICs imposed at the MWL. Entry restrictions include security requirements and fencing. Access to the MWL is strictly controlled because of its location on both KAFB and in TA-III. Access to KAFB is strictly limited to members of the workforce, construction/maintenance contractors, visitors with badges, and to families of military personnel who live on base. Access is restricted by armed guards at the gates to KAFB. Access to TA-III is restricted to an even higher level of security than access to KAFB and is controlled using an automated vehicle access gate system at the northeastern corner of the TA. DOE-approved badges are required for access to TA-III.

Three tiers of fences limit access to the MWL. Both KAFB and TA-III are fenced along their perimeters, providing physical controls and deterrents against illegal access. A 44-inch-high, barbed-wire fence surrounds the MWL perimeter. The fence incorporates three strands of barbed-wire with tee-posts set into the ground, and steel corner posts set in concrete.

The MWL fence has one 16-foot-long, 42-inch-high gate comprised of tubular steel with galvanized chain links, located near the northeastern corner of the landfill. This gate is locked at all times except as necessary to provide access for surveillance, maintenance, and monitoring activities. Additional details on the MWL fences and gates are presented in Section 02445 of Appendix A (Construction Specifications) in the MWL CMI Plan (SNL/NM November 2005).

6.2.3 Warning Notices

A third category of ICs at the MWL are warning notices, including “no trespassing” signs and radiological postings for the site. To ensure visual notification, the fence line is posted with signs having as a minimum, a legend reading “Caution—Unauthorized Personnel Keep Out” (Title 20, New Mexico Administrative Code, Section 4.1.500, incorporating 40 CFR 264.14[c]) and warning against entering the area without specific permission of the Owner. The signs are

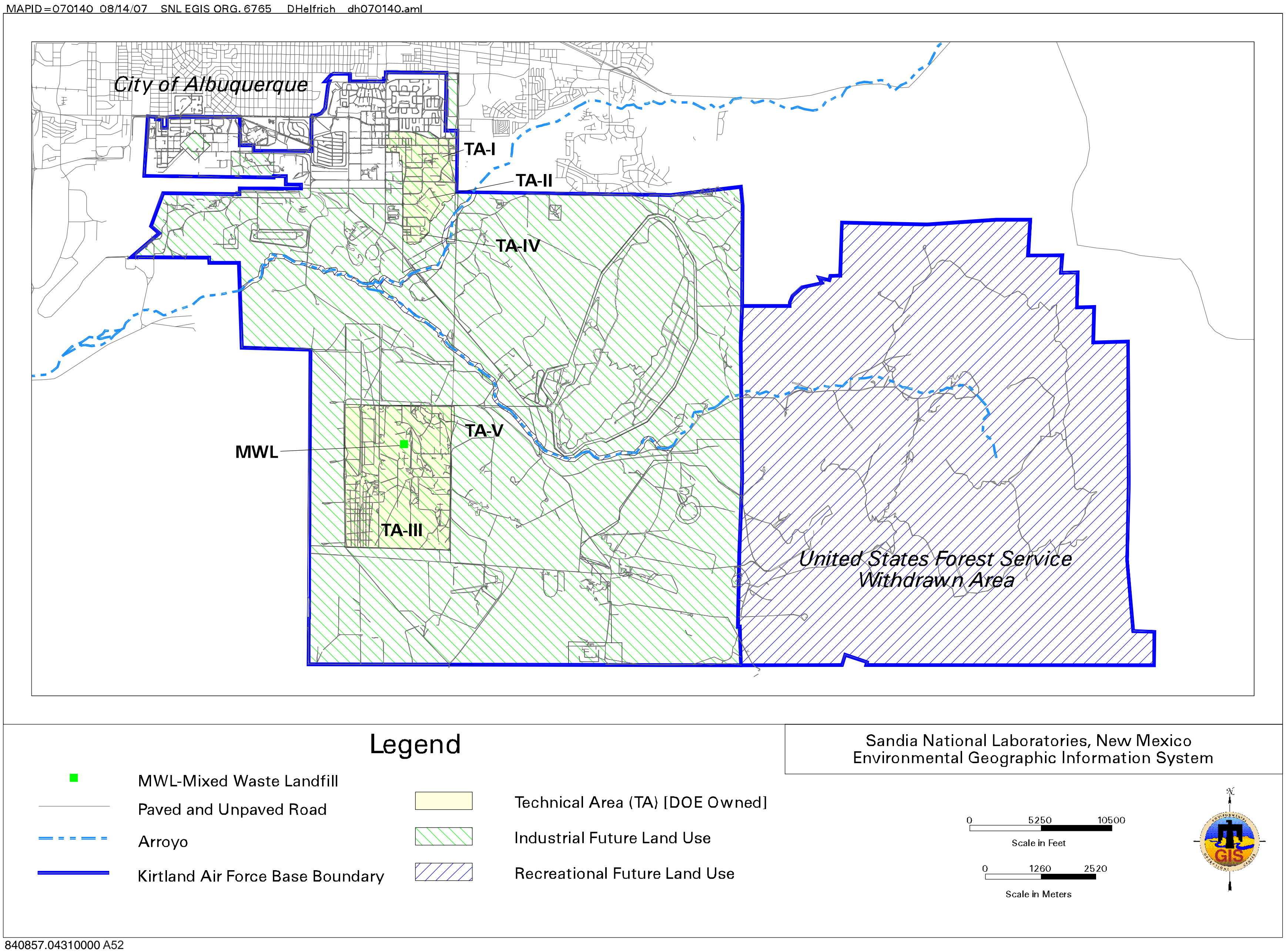

Figure 6.2.1-1 Future Land-Use Designations on Kirtland Air Force Base

legible from a distance of at least 25 feet and will be spaced at intervals of 50 feet. The size of the visual warning and the spacing of the warning signs are large enough and close enough to ensure that one or more of the signs can be seen from any approach prior to an individual actually making contact with the fenceline.

Radiological warning signs are also on the fence. The signs read, "Caution: Underground Radioactive Material, Controlled Area, Authorized Personnel Only." The radiological signs are spaced at intervals of 50 feet along the fence and are legible from a distance of at least 25 feet. Warning notices and radiological postings in Spanish are also installed on the fence.

6.2.4 Active Controls

Another category of ICs are active controls that rely on the presence of humans to fulfill safeguard and maintenance responsibilities. These include the use of security guards to monitor and control site access, monitoring to ensure that contaminant migration is not occurring and the containment design is functioning appropriately, and conducting routine inspections and maintenance at the site. Monitoring activities are discussed in depth in Chapter 3.0 of this document and will include monitoring of air, soil, the vadose zone soil vapor and soil moisture, and groundwater. Inspections and maintenance activities are discussed in Chapter 4.0.

SNL/NM's Protective Force conducts routine, periodic patrols and surveillance of the MWL. Patrols and surveillance consist of drive-by patrolling around the fenced perimeter of the landfill according to a randomly generated schedule. The patrols and surveillance by the Protective Force serve as a deterrent to unauthorized entry into the landfills and as a means of detection should the buried wastes be disturbed. During these patrols, the integrity of the perimeter fence is assessed, and the locked condition of the entrance gate is checked to ensure that gate integrity is maintained and that there is no evidence of tampering. Surveillance also includes visual observations of the entire enclosed area for any signs of human activity. Additionally, surveillance patrols will be conducted around the site perimeter for signs of unauthorized human activities. This surveillance routine will continue as long as waste considered classified remains at the MWL. Mitigating actions will be taken to address any unusual conditions identified during periodic inspection and surveillance by security personnel.

6.2.5 Resource-Use Management

ICs addressing land use and excavation are also in place at SNL/NM and hence, the MWL. Land use within TA-III is managed through the SNL/NM Facilities group, in accordance with all applicable requirements. Land-use controls are mechanisms intended to ensure that land use follows the appropriate planning process and are intended to minimize the potential for unplanned disturbances of sites containing hazardous or radioactive material. Construction activities must be evaluated through a formal National Environmental Policy Act process prior to approval.

Excavation permits are another type of resource-use IC in place at the MWL. Excavation permits are internal work procedures specific to SNL/NM and are required for any excavation activities deeper than 6 inches in depth. Permits are required for digging, saw-cutting, drilling, coring, or trenching into soil, concrete sidewalks, or asphalt to a depth greater than 6 inches. Permits are also required for scraping, blading, or excavating any area previously undisturbed or that appears to be undisturbed, such as areas covered with native vegetation, and blading or improvements to previously unimproved roads or paths. The use of excavation permits reduces the potential for unplanned disturbances and informs and protects workers regarding potential exposure to hazardous or radioactive waste. Excavation permits also reduce the likelihood of mobilizing contaminants from contaminated areas due to human intrusion.

Radiological Work Permits (RWPs) are another resource-use IC affecting potential work within the MWL perimeter. RWPs are required for conducting work in areas involving potential exposure to radiation or radioactive materials. The permit authorizes work that involves exposure to radiation or radioactive materials and identifies radiological conditions, establishes worker protection and monitoring requirements, and contains specific approvals. RWPs are used to establish radiological controls for 1) work in any radiological area; 2) intrusive work in soil contamination areas, underground radioactive material areas, or fixed contamination areas; and 3) work involving direct contact with radioactive material that could result in contamination to the worker or property.

In 1995, the Future Use Logistics and Support Working Group, which included members of the public, conducted a study recommending future land use for the various TAs at SNL/NM. Based upon the nature of test facilities in TA-III, as well as the limited transportation, emergency access, and utility service, the study recommended an "industrial" classification for future use of TA-III (DOE et al. September 1995). It is expected that an industrial land-use designation will be the long-term land use for TA-III.

Although not required by any permit or regulation, the DOE/Sandia will document land use restrictions for the MWL by:

- Submitting, to the Bernalillo County Clerk, a post-remediation notice including a survey plat with the legal description of the MWL, a description of wastes remaining in place, and a statement prohibiting any future disturbance of the MWL surface or subsurface.

- Submitting, to the Bernalillo County Zoning, Building, and Planning Commission, a survey plat containing the legal description of the MWL and a statement prohibiting any future disturbance of the MWL surface or subsurface.

These submittals may address only the MWL or possibly multiple SWMUs.

6.2.6 Site Information Systems

SNL/NM has a number of information systems in place that help to manage its activities. These include the following:

- SNL/NM Customer-Funded Records Center

- SNL/NM Geographic Information System (GIS) Program

- SNL/NM Facilities databases

- Long-Term Environmental Stewardship (LTES) Website

- Geographical Environmental Management System (GEMS)
- Community Resources Information Office (CRIO)
- The Government Information Department Public Reading Room at the University of New Mexico (UNM) Zimmerman Library
- SNL/NM IC Tracking Database

The Administrative Record is the body of documents and information that was considered, or relied upon, to arrive at a final decision for remedial action or hazardous waste management at the MWL. The documents related to the MWL in the Administrative Record include, but are not limited to, RFI Work Plans, Phase 1 and Phase 2 RFI Reports, Responses to Notices of Deficiencies, the MWL CMS Final Report, the MWL CMI Plan, and other relevant correspondence and documents. The Administrative Record may be reviewed at the Government Information Department at the UNM Zimmerman Library and at the NMED in Santa Fe, New Mexico.

Additional information on the MWL is contained in the SNL/NM Customer-Funded Records Center. The Records Center maintains all records on the MWL and other SWMUs at SNL/NM, including location, waste type, and current status. The Records Center is maintained by Sandia in accordance with DOE Orders on records maintenance. The long-term preservation of waste site information is one of the key responsibilities of the Records Center.

6.3 Application of Institutional Controls

As described above, various systems are in place at SNL/NM to implement and maintain ICs. The SNL/NM LTES Program (SNL/NM September 2006) is responsible for ensuring that ICs are properly implemented at active sites and former ER sites.

The LTES Program will ensure that the MWL is inspected on a regular basis to verify that ICs continue to be implemented at the site. IC inspections at the MWL will be conducted in conjunction with IC inspections at the other sites subject to long-term controls, including the Chemical Waste Landfill and the Corrective Action Management Unit. An internal checklist will be used to assess the ICs, and the results will be summarized in the annual long-term monitoring and maintenance report.

It is anticipated that the SNL/NM IC inspection and site walkover will be conducted annually for the first five years, then biannually for four years, and then progress to once every five years. This frequency will be subject to adjustment as needed.

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7.0 CONTINGENCY PROCEDURES

This section details contingency procedures to be implemented if the MWL vegetative soil cover fails to be protective of human health and the environment. Actual contingency responses will be addressed on a situation-specific basis in cooperation with the NMED.

The MWL Class 3 Permit Modification for the MWL states:

> The [long-term monitoring and maintenance] plan shall also include contingency procedures that must be implemented by the Permittees if the remedy set forth in Section V.2 above [the vegetative soil cover with biointrusion barrier] fails to be protective of human health and the environment.

The MWL LTMMP is designed to collect data far enough in advance to allow for contingency measures to be taken. Contingency measures are designed to accommodate any unanticipated events, should the remedy not be protective of human health and the environment.

Possible MWL failure scenarios and contingencies are listed in Table 7-1. The contingencies identified depend heavily upon the implementation of the Trigger Evaluation Process (Section 5.1). Triggers for long-term monitoring at the MWL are discussed in Chapter 5.0. If the monitoring triggers are exceeded, then the Trigger Evaluation Process (Figure 5.1-1) will be initiated, as described in Section 5.1.

All contingencies are addressed through the Trigger Evaluation Process. Should a specific trigger be exceeded, then the process shown in Figure 5.1-1 will be used to ensure that adequate data are collected to determine whether additional corrective action is warranted. The increased frequency of data collection in the trigger evaluation process (Step 3 in Figure 5.1-1) will ensure that adequate data are collected to eliminate field sampling error, laboratory error, or short-term exceedances that do not reflect long-term trends. Thus, any recommendations for corrective action because of trigger exceedances will be based upon data trends rather than upon single detection values above the trigger level. If data trends in the monitored parameters indicate an established trend above the trigger value, the process requires that a technical letter report be submitted to the NMED recommending whether or not corrective action should be implemented.

The Trigger Evaluation Process discussed in Chapter 5.0 allows specific contingencies to be addressed on a situation-specific basis in full coordination with the NMED. An exceedance of a trigger listed in Table 5.2-1 does not necessarily constitute failure of the remedy but does indicate that additional data evaluation is necessary to determine whether corrective action is required (Figure 5.1-1).

Table 7-1
Possible Failure Scenarios and Contingencies
Mixed Waste Landfill, Sandia National Laboratories/New Mexico

Failure Scenario	Notes	Procedure	Possible Corrective Action
Radon concentrations in air exceed trigger level of 4 pCi/L	Scenario unlikely based upon historical measurements of radon emissions from MWL without cover (Haaker January 1998).	1. Verify exceedance of trigger level. 2. If verified, notify NMED in writing within 15 days. 3. Negotiate sampling frequency with NMED. 4. Increase sampling frequency. 5. Reevaluate data. 6. If data indicate persistent and increasing concentrations of radon, consider corrective action.	1. Assess compliance with NESHAP and DOE Orders. If all regulatory standards are met, no further action is necessary. 2. Consider augmenting cover soil to reduce radon concentrations emitted to atmosphere.
Tritium in surface soil exceeds trigger value of 20,000 pCi/L in soil moisture	Scenario possible.	1. Verify exceedance of trigger level. 2. If verified, notify NMED in writing within 15 days. 3. Negotiate sampling frequency with NMED. 4. Increase sampling frequency. 5. Reevaluate data. 6. If data indicate persistent and increasing concentrations of tritium, consider corrective action.	1. Assess compliance with NESHAP and DOE Orders. If all regulatory standards are met, no further action is necessary. 2. Evaluate risk to human health and the environment. If risk is negligible, no further action is required. 3. If risk is significant, implement appropriate engineering and/or administrative controls to reduce risk.
Radionuclides in surface soil at animal burrows and ant hills exceed NMED-approved maximum background concentrations	See Table 5.2-1 for list of radionuclides and NMED maximum background concentrations.	1. Verify exceedance of trigger level. 2. If verified, notify NMED in writing within 15 days. 3. Negotiate sampling frequency with NMED. 4. Increase sampling frequency. 5. Reevaluate data. 6. If data indicate persistent and increasing concentrations of radionuclides, consider corrective action.	1. Assess compliance with DOE Orders. If all regulatory standards are met, no further action is necessary. 2. Evaluate risk to human health and the environment. If risk is negligible, no further action is required. 3. If risk is significant, consider eliminating ant hills and removing animals creating the burrows. 4. If biotic mobilization of contaminants continues to be a major concern, consider adding additional thickness to MWL cover.

Refer to footnotes at end of table.

Table 7-1 (Continued)
Possible Failure Scenarios and Contingencies
Mixed Waste Landfill, Sandia National Laboratories/New Mexico

Failure Scenario	Notes	Procedure	Possible Corrective Action
RCRA metal concentrations in surface soil near animal burrows and ant hills exceed trigger values (NMED industrial SSLs)	See Table 5.2-1 for list of RCRA metals and corresponding trigger values (NMED industrial SSLs).	1. Verify exceedance of trigger level. 2. If verified, notify NMED in writing within 15 days. 3. Negotiate sampling frequency with NMED. 4. Increase sampling frequency. 5. Reevaluate data. 6. If data indicate persistent and increasing concentrations of RCRA metals, consider corrective action.	1. Assess compliance with SSLs and DOE Orders. If all regulatory standards are met, no further action is necessary. 2. Evaluate risk to human health and the environment. If risk is negligible, no further action is required. 3. Consider eliminating ant hills and removing animals creating the burrows. 4. If biotic mobilization of contaminants continues to be a major concern, consider adding additional thickness to MWL cover.
Gamma-emitting radionuclides detected in vegetation growing on landfill surface	Scenario unlikely due to biointrusion barrier.	1. Verify exceedance of trigger level. 2. If verified, notify NMED in writing within 15 days. 3. Negotiate sampling frequency with NMED. 4. Increase sampling frequency. 5. Reevaluate data. 6. If data indicate persistent and increasing concentrations of radionuclides, consider corrective action.	1. Assess compliance with DOE Orders (including 450.1 and 5400.5). If all regulatory standards are met, no further action is necessary. 2. Evaluate risk to human health and the environment. If risk is negligible, no further action is necessary. 3. If risk is significant, consider design changes to the cover. 4. If biotic mobilization of contaminants continues to be a major concern, consider adding additional thickness to MWL cover.

Refer to footnotes at end of table.

Table 7-1 (Continued)
Possible Failure Scenarios and Contingencies
Mixed Waste Landfill, Sandia National Laboratories/New Mexico

Failure Scenario	Notes	Procedure	Possible Corrective Action
Moisture in vadose zone at linear depths of between 10 to 100 ft exceed trigger levels	Scenario unlikely due to anticipated performance of the cover.	1. Verify exceedance of trigger level. 2. If verified, notify NMED in writing within 15 days. 3. Negotiate sampling frequency with NMED. 4. Increase sampling frequency. 5. Reevaluate data. 6. If data indicate persistent and increasing moisture in vadose zone, consider corrective action.	1. Determine if ponding and preferential flow down the boreholes is responsible for the elevated moisture content. If preferential flow is occurring, regrade surface adjacent to soil-moisture monitoring access tubes to divert surface runoff. 2. Evaluate infiltration through the cover using alternative methods such as double-ring infiltrometers or air-entry permeameters. 3. Assess performance of cover; if cover is not reducing infiltration sufficiently to meet the RCRA-prescribed equivalence criteria of 10^{-7} cm/s, determine reasons for poor performance of the cover. 4. Consider remedial measures to improve cover performance, such as discing native soil layer to increase porosity and vegetation growth characteristics. Replant native vegetation to enhance evapotranspiration.
VOCs in vadose zone exceed trigger levels	Scenario possible, based upon MWL fate and transport model results. See Table 5.2-1 for trigger levels for VOCs.	1. Verify exceedance of trigger level. 2. If verified, notify NMED in writing within 15 days. 3. Negotiate sampling frequency with NMED. 4. Increase sampling frequency. 5. Reevaluate data. 6. If data indicate persistent and increasing concentrations of VOCs in vadose zone, consider corrective action.	1. Refine conceptual site model of contaminant distributions and transport through additional soil-vapor samples. 2. Update fate and transport model with additional data to predict potential impacts. 3. If groundwater contamination appears likely, consider corrective action before contaminants reach groundwater. 4. Corrective action may include soil-vapor extraction to reduce the contaminant source term.

Refer to footnotes at end of table.

Table 7-1 (Concluded)
Possible Failure Scenarios and Contingencies
Mixed Waste Landfill, Sandia National Laboratories/New Mexico

Failure Scenario	Notes	Procedure	Possible Corrective Action
VOC concentrations in groundwater exceed trigger levels	See Table 5.2-1 for trigger levels. Scenario possible based upon MWL Fate and Transport Model (Ho et al. January 2007)	1. Verify exceedance of trigger level. 2. If verified, notify NMED in writing within 15 days. 3. Negotiate sampling frequency with NMED. 4. Increase sampling frequency. 5. Reevaluate data. 6. If data indicate persistent and increasing concentrations of VOCs, consider corrective action.	1. Update fate and transport model with additional data to predict potential impacts. 2. Conduct risk assessment with contaminant data. 3. Consider additional corrective action measures based upon fate and transport model results and risk assessment results. 4. Possible remedial measures include monitored natural attenuation or active pump and treat. 5. Consider installation of “baro-balls” to control VOCs in the vadose zone above the aquifer. 6. Consider controlling VOC migration through the vadose zone using soil-vapor extraction.
Uranium concentrations in groundwater exceed trigger level	Scenario highly unlikely without significant increase in infiltration through the MWL cover	1. Verify exceedance of trigger level. 2. If verified, notify NMED in writing within 15 days. 3. Negotiate revised groundwater sampling frequency with NMED. 4. Resample per the negotiated frequency. 5. Reevaluate groundwater data for uranium. 6. If data indicate persistent and increasing uranium contamination of groundwater, recommend corrective action.	1. Update fate and transport model with additional data to predict potential impacts. 2. Conduct risk assessment with contaminant data. 3. Consider additional corrective action measures based upon fate and transport model results and risk assessment results. 4. Reduce uranium concentrations through monitored natural attenuation. 5. Install pump and treat system to remediate uranium in groundwater to less than the EPA MCL (30 μg/L).

cm/s = Centimeter(s) per second.
DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.
ft = Foot (feet).
L = Liter(s).
MCL = Maximum contaminant level.
μg = Microgram(s).
MWL = Mixed Waste Landfill.
NESHAP = National Emissions Standards for Hazardous Air Pollutants.
NMED = New Mexico Environment Department.
pCi = Picocurie(s).
RCRA = Resource Conservation and Recovery Act.
SSL = Soil screening level.
VOC = Volatile organic compound.

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APPENDIX A
Air Sampling and Analysis Plan for the Mixed Waste Landfill

TABLE OF CONTENTS

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LIST OF FIGURES

Figure

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LIST OF TABLES

Table

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LIST OF ATTACHMENTS

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1.0 INTRODUCTION

Requirements for monitoring at the Mixed Waste Landfill (MWL) are defined in the Long-Term Monitoring and Maintenance Plan (LTMMP) provided by the U.S. Department of Energy (DOE) and Sandia Corporation (Sandia). This Air Sampling and Analysis Plan (SAP) was developed in response to a request by the New Mexico Environment Department (NMED) to monitor for potential radon emissions at the MWL, Technical Area III (TA-III), Sandia National Laboratories, New Mexico (SNL/NM) (Figure A-1-1). Previously, radon emissions have not been monitored using the track-etch method proposed in this SAP. However, a study of radon flux from the MWL was conducted in 1997 to measure radon surface flux from the MWL (Haaker 1998). The study, which involved placement of 89 four-inch-diameter activated charcoal radon canisters across the MWL surface, evaluated radon surface fluxes in the vicinity of the MWL and at background locations. Results showed that the measured radon fluxes above the MWL were not significantly different than the background values (Haaker 1998).

1.1 Monitoring Objective

The LTMMP, including this SAP, is designed to ensure the monitoring of specified parameters over a period of time. The monitoring objective of this SAP is to provide radon emission data in order to characterize radon emissions at the MWL. In addition to establishing monitoring and data quality objectives (DQOs), this SAP presents specifications for the use of radon detectors, laboratory analysis, data evaluation, records management, and reporting. This document provides sampling personnel with the necessary information to perform radon sampling in air. The results will be compared to the proposed trigger level of 4 picocuries per liter (pCi/L), as presented in the LTMMP and in the "Probabilistic Fate and Transport Modeling of the Mixed Waste Landfill at Sandia National Laboratories" (Ho et al. January 2007).

1.2 Scope

Monitoring (sampling) of radon emissions at the MWL will be conducted on a routine basis throughout the long-term monitoring and maintenance period for the MWL. Monitoring will be conducted quarterly for 2 years to establish baseline conditions, then semiannually for the next 2 years, followed by annually. Each sampling event requires the placement of a radon detector at designated locations for each exposure period. Radon detectors will be collected at the end of the sampling period and analyzed based upon the frequency schedule described below. The locations of the proposed radon sampling sites are shown in Figure A-1.2-1.

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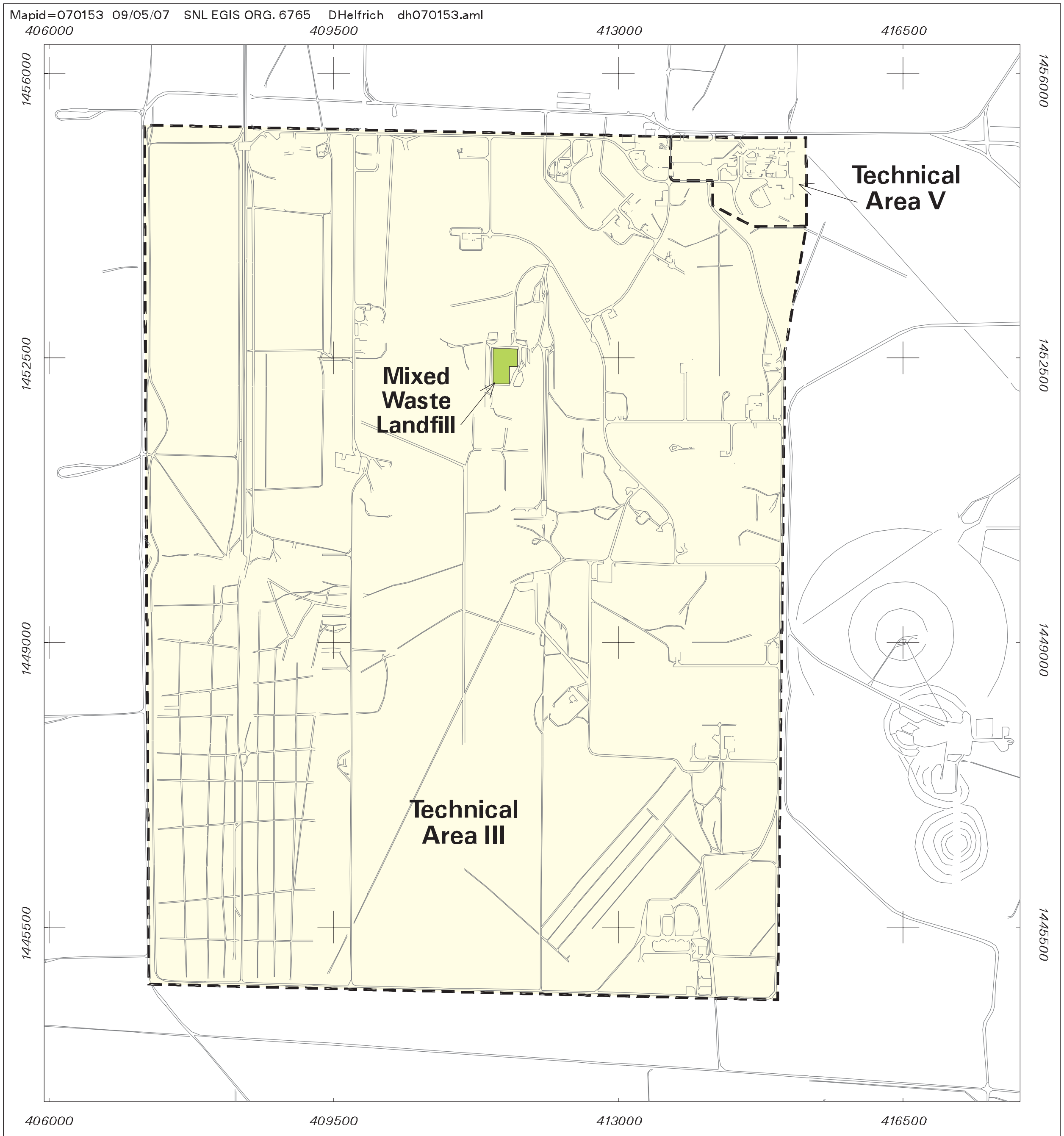

Legend

Road

Technical Area

Mixed Waste Landfill

Figure A-1-1
Location of the
Mixed Waste Landfill
within Technical Area III

0 1000 2000
Scale in Feet

0 240 480
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

840857.04310000 A45.ai

Legend

- Radon Sampling location and name
- Fence
- Trench and Pit
- Toe of Landfill Cover
- Road
- MWL Extent

Figure A-1.2-1
Radon Sampling Locations at the Mixed Waste Landfill

0 60 120
Scale in Feet

0 14.4 28.8
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

840857.04310000 A40

2.0 BACKGROUND INFORMATION

The MWL fate and transport model predicts no potential for release of radon-222 into the atmosphere in excess of regulatory standards, as long as the sealed sources containing radium-226 within the MWL inventory remain intact (Ho et al. 2007). However, the MWL fate and transport model also predicts that if the sealed sources containing radium-226 degrade over time, there is some potential for radon to be emitted to the atmosphere in concentrations above regulatory standards.

Because there is a potential for radon to be emitted from the MWL wastes in excess of regulatory standards, DOE and Sandia will conduct radon monitoring at the landfill surface to verify that the sealed sources remain intact, and that the disposal cell continues to be protective of human health and the environment.

As described in the “Responses to the NMED Notice of Disapproval” (SNL/NM January 2007), radon will be monitored above ground surface along the MWL perimeter using track-etch radon detectors. Additional radon sampling locations are planned at locations overlying select pits and trenches in which radium-226 was disposed, and which have a potential for generating radon in the future. The track-etch technique is superior for analysis of radon flux (unit concentration per unit area per unit time), and will provide more useful information than time-discrete samples collected from soil-vapor samples. Radon has not been detected above background (natural environmental) levels in soils at the MWL. Any significant releases of radon in the near future are unlikely due to the nature of the sealed sources containing radium-226, from which the radon would emanate.

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3.0 DATA QUALITY OBJECTIVES

The primary DQO is to produce representative, accurate, and defensible analytical results to support the monitoring objective (i.e., provide radon emission data). This SAP is designed to ensure that radon measurement procedures are consistent and can be used to establish radon emission trends. This DQO will be accomplished through the implementation of standard operating procedures and analytical procedures/methods through the use of quality assurance (QA) measures, quality control (QC) samples, and data evaluation protocols. Guidance on sampling protocols was also taken from the U.S. Environmental Protection Agency (EPA) (EPA July 1992).

3.1 Measurement of Radon in Air

Radon concentrations will be measured by Radtrak® radon detectors manufactured by Landauer® Incorporated (Attachment A-1). Radtrak® is an alpha-track radon gas detector designed to monitor radon exposure for three months to one year to obtain a long-term average concentration over time. Services provided by Landauer® include the detector, comprehensive analysis (calibration, laboratory background determination, and laboratory QA/QC tests), reporting of exposure results, and long-term storage of the processed detector for a period of at least 25 years. The detectors can be packaged for indoor or outdoor area monitoring or personnel monitoring.

Landauer® has been involved with the development of radiation monitoring services for nuclear research centers and laboratories, hospitals, medical and dental offices, universities, and other industries where radiation might be present. The highly accurate Radtrak® radon detector uses the exclusive Track-Etch® process. Radtrak® radon detectors are used by the EPA, the National Institutes of Health, the American Lung Association, and many other government and professional organizations.

3.2 Detector Locations and Sampling Frequency

Radon levels around the perimeter of the MWL will be measured using Radtrak® radon detectors (referred to as the detectors). A total of 10 detectors will be placed at corners and midpoints of the perimeter fence. Five detectors will be placed within the boundaries of the completed cover at locations overlying pits and trenches containing the highest activities of radium-226 in their disposal inventory (Figure A-1.2-1). Two detectors will be placed in areas determined to represent background conditions. A field control sample (serving as a QC sample) will be prepared during each sampling event.

Table A-3.2-1 gives the sampling (detector exchange) frequency for the 5 years following the completion of the MWL cover. Detector exchange will consist of removing the exposed detector and replacing it at the same location with an unexposed detector. The exposed detector will be sent to the Landauer® laboratory (referred to as the laboratory) for analyses.

Table A-3.2-1
Sampling Frequency

Time Period	Sample Frequency[a]	Sample Locations	Quality Control Samples	Number Samples Per Year
Year 1	4 events (quarterly basis)	10 perimeter	4 trip blanks (1 per event)	72
		2 background		
		5 on site		
Year 2	4 events (quarterly basis)	10 perimeter	4 trip blanks (1 per event)	72
		2 background		
		5 on site		
Year 3	2 events (semi-annual basis)	10 perimeter	2 trip blanks (1 per event)	36
		2 background		
		5 on site		
Year 4	2 events (semi-annual basis)	10 perimeter	2 trip blanks (1 per event)	36
		2 background		
		5 on site		
Year 5 and subsequent years	1 event (annual basis thereafter)	10 perimeter	1 trip blank	18
		2 background		
		5 on site		

[a]Refers to the frequency in which the detectors are exchanged.

3.3 Data Accuracy

Proper sampling procedures and use of QC samples will help reduce random and systematic sampling error or bias. Accurate estimates of radon concentration can be made reliably through the use of a qualified laboratory, appropriate methodologies, and effective QA/QC procedures. These measures along with consistent implementation of the LTMMP and this SAP will satisfy the DQO for accuracy.

3.4 Data Consistency and Comparability

Data consistency and comparability will be achieved through implementation of this SAP, which defines field and laboratory procedures designed for this purpose. Consistency in methods and procedures will be maintained in the following areas to ensure radon emission data are consistent and that the data sets are comparable.

- Field sample collection and management
- Use of an off-site contract laboratory (manufacturer laboratory)

After radon emission results are received from the laboratory, the SNL/NM will review the laboratory report for completeness and conformance to the monitoring and DQOs. If problems are noted that require corrective action during these reviews, the laboratory will be contacted for further information.

Each set of time period (quarter, semi-annual, annual) results of data will be compared to the previous set, as well as the field background. This evaluation process will aid in characterization and allow analysis of trends, but will also help identify outliers or other potential indicators of error and inconsistency.

3.5 Quality Control

The QC measures ensure that data are scientifically sound and of known precision and accuracy. QC samples will be collected to help reduce random and systematic sampling error or bias. Section 3.5.3 presents the samples needed to meet the QC requirements for radon emission monitoring at the MWL.

3.5.1 Calibration Measures

Calibration measurements are the responsibility of the laboratory supplying the detectors. Calibration measurements determine the response or reading of an instrument relative to a series of known values; results are used to develop correction or calibration factors. These factors are determined for a range of concentrations and exposure times, and for a range of other exposure and/or analysis conditions pertinent to the detector.

3.5.2 Laboratory Background Measures

Laboratory background measurements are made in the laboratory by analyzing unexposed detectors (laboratory blanks). The results are subtracted from the actual field measurements before calculating the reported concentration. Laboratory background levels may be due to electronic noise of the analysis system, leakage of radon into the detector, detector response to gamma radiation, or other causes. The laboratory is responsible for routinely measuring the background of a statistically significant number of unexposed detectors from each batch or lot to establish the laboratory background for the batch and the entire measurement system.

3.5.3 Field Control Measures

Two types of field control measures will be employed for quality control; a field control sample (field/trip blank) and a field background sample (natural environmental). These samples are specified in Table A-3.2-1.

A field control sample (field/trip blank) will be prepared during each sampling event. An unexposed detector will be set aside from each detector shipment, kept sealed and in a low radon environment, labeled in the same manner as the field samples to preclude special processing, and returned to the analysis laboratory along with each shipment. These trip blanks measure the background exposure that may accumulate during shipment and storage.

A field (natural environmental) background sample will be collected during each sampling event at areas outside of the MWL, but within TA-III. This will allow the measurement of background radiation that is always present due to cosmic rays and natural radiation. This field background value will be compared to (subtracted from) the sample detectors that are placed on and around the MWL.

4.0 SAMPLING ACTIVITIES

This section describes the field and laboratory measures to be taken in providing radon measurements in air.

4.1 Field Activities

Field activities include the preparation, deployment, collection, and shipping of the detectors and the methods and procedures governing these activities. Adherence to this protocol will help ensure uniformity among measurements, and allow comparison of the results. Activities that will be conducted in preparation for or during radon emission monitoring include the following:

- Health and Safety
- Pre-Field Preparations
- Detector Deployment and Collection
- Sample Labeling
- Sample Custody Documentation
- Sample Handling and Shipment
- Waste Management

The SNL/NM Administrative Operating Procedure (AOPs) and Field Operating Procedure (FOPs) for these activities are listed in Table A-4.1-1 as well as Sample Management Office (SMO) Laboratory Operating Procedures (LOPs) and guidance. All personnel directly involved in radon emission monitoring field activities will review and abide by these procedures.

Table A-4.1-1
Reference Documentation
MWL Radon Monitoring

Document[a]	Title
FOP 94-01 (SNL/NM December 2006)	Safety Meetings, Inspections, and Pre-Entry Briefings
FOP 94-25 (SNL/NM November 2004)	Documentation of Field Activities
FOP 94-34 (SNL/NM May 1995)	Field Sample Management and Custody
AOP 95-16 (SNL/NM February 2007a)	Sample Management and Custody
LOP 94-03 (SNL/NM February 2007b)	Sample Handling, Packaging, and Shipping, SMO

[a]The most current version will be used.
AOP = Administrative operating procedure.
FOP = Field operating procedure.
LOP = Laboratory operating procedure.
MWL = Mixed Waste Landfill.
SMO = Sample Management Office.

4.1.1 Health and Safety

Field operations will be conducted in an approach that prioritizes the health and safety of field personnel above all other objectives. Every team member has the authority and responsibility to stop operations if an unsafe condition develops or is observed. All sampling personnel will perform field activities in accordance with the applicable Health and Safety Plan.

4.1.2 Pre-Field Preparations

Sampling locations will be identified, marked, and numbered. Only the number of detectors needed for each sampling event should be ordered as close as possible to the deployment time in order to minimize chances of background exposure. All information regarding detectors, dates, and locations will be maintained in a log book.

4.1.3 Detector Deployment and Collection

The detector and the radon-proof container will be inspected to make sure that they are intact and have not been physically damaged in shipment or handling. The sampling period begins when the protective cover or bag is removed and will be noted in the log book along with the detector number and sample location. The edge of the bag must be cut carefully, or the cover removed, so that it can be reused to reseal the detector at the end of the exposure period.

At the end of the sampling period (Table A-3.2-1), each detector will be inspected for damage or deviation from the conditions noted at the time of deployment. The time and date of removal and any observable changes to the detector will be noted in the log book. The detector should then be resealed following the instructions provided by the supplier. After retrieval, the detectors should be stored in a low radon environment and returned as soon as possible to the laboratory for processing.

4.1.4 Sample Labeling

Each detector is identified by a unique serial number laser engraved on the inside of the detector (by the manufacturer), printed and bar coded on the outside of the detector, and on the film-foil bag. A unique SNL/NM SMO issued sample identification number will be assigned to each detector. The sample numbers are preprinted on self-adhesive labels in numerical order and are obtained from SMO. After recovery from the field, the sample number will be affixed to or noted on the sample label and/or the analysis request/chain of custody (AR/COC) form.

A SNL/NM sample label will be completed with indelible ink and affixed to each sample container. Each completed sample label should include the following information:

- SNL/NM SMO sample number
- Sample matrix type
- Sample location
- Analysis required
- Date and time of sample collection

- Types of preservatives used, if any
- Name of the sampling personnel

A field log will be maintained documenting the collection of all samples.

4.1.5 Sample Custody Documentation

To ensure the integrity of samples from the time of collection through the reporting of analytical results, sample collection, handling, and custody will be documented. The continuous record of documented sample possession is referred to as the chain-of-custody. Primary elements in the documentation of samples are: sample identification number, sample labels, custody tape, and the AR/COC form. Standardized forms will be used to document sample information. Sample custody and documentation procedures for sampling activities are outlined in AOP 95-16 (SNL/NM February 2007a) and LOP 94-03 (SNL/NM February 2007b).

4.1.6 Sample Handling and Shipment

The exposed detectors will be packaged in either the original bag or in new bags to prevent further exposure. No preservation is needed. Detector numbers will be recorded on an AR/COC form that will accompany the detectors to the laboratory.

Samples will be shipped to the analytical laboratory in accordance with SMO procedures detailed in LOP 94-03. Prior to shipment, the sample collection documentation will be verified. Any error will be noted and corrected as required by SNL/NM SMO protocols.

4.1.7 Waste Management

There will not be any waste generated during these activities.

4.2 Technical Specifications and Concerns

Technical specifications of the detectors include the following:

- The radiosensitive element is a CR-39 (allyl diglycol carbonate) based, passive alpha-track detector.

- The CR-39 is enclosed in a plastic housing composed of electrically conducting material with filtered openings to permit diffusion of radon gas only.

- Minimum level of detection is 30 pCi/L days (0.33 pCi/L based upon 90 days).

- Detectors should not be in locations that exceed a temperature of 160 degrees Fahrenheit (70 degrees Celsius).

- The detectors are packaged in film-foil bags that meet Military Specification MIL-B-131, Class 1 to prevent exposure prior to and following use.
- A metallic label is provided for each detector to seal the filtered openings following the exposure period to minimize subsequent exposure to radon during the return shipment to the laboratory.
- Each detector is identified by a unique serial number laser engraved on the CR-39, printed and bar coded on the outside of the detector, and on the film-foil bag.
- For outdoor monitoring, the detector is fastened to the bottom of a clear plastic cup. The cup is then installed in a protective canister will be attached to a post at approximately 5 feet above ground level.

4.3 Analytical Methods

The detectors measure the average radon concentration at the location of the detector during the sampling period. The alpha-track detector consists of a plastic housing and a radiosensitive element that records submicroscopic damage tracks as the alpha particle emissions (alpha track) from the natural decay of radon strike the detector. At the end of the sampling period, the detectors are returned the laboratory. The detectors are placed in a caustic solution that accentuates the damage tracks so they can be counted using an automated counting system. The number of tracks per unit area is correlated to the radon concentration in air, using a conversion factor derived from data generated at the calibration facility. The number of tracks per unit of analyzed detector area produced per unit of time is proportional to the radon concentration. The detectors function as true integrators and measure the average concentration over the exposure period.

4.4 Records Management and Reporting

Records associated with the radon emission sampling activities include the MWL LTMMP, this SAP, applicable AOPs, FOPs, and LOPs, AR/COC forms, personnel training, field documentation, laboratory analytical results, and technical data evaluations. These records will be maintained at the SNL/NM Customer Funded Records and comply with the record-keeping provisions of 20.4.1.500 New Mexico Administrative Code, incorporating Title 40 Code of Federal Regulations Section 264.74, concerning the availability, retention, and disposition of records.

Reports will be prepared and submitted to the NMED according to the schedule defined in the LTMMP.

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ATTACHMENT A-1
Radtrak® Long-Term Radon Monitoring

LANDAUER®

Radtrak® Long-Term Radon Monitoring

Radtrak is an alpha-track radon gas detector designed to monitor radon exposure for three months to one year to obtain a long-term average concentration over time. Landauer service includes the Radtrak detector, comprehensive analysis, and a confidential report of the findings. Radtrak can be packaged for indoor or outdoor area monitoring or personnel monitoring.

Landauer is the leader and pioneer in radon gas detection and monitoring service. Since 1954, our scientists have been involved with the development of radiation monitoring services for nuclear research centers and laboratories, hospitals, medical and dental offices, universities, and other industries where radiation might be present. This experience and technology have been incorporated into Landauer's highly accurate Radtrak radon detector using our exclusive Track-Etch® process. Radtrak radon detectors are used by the Environmental Protection Agency, the National Institutes of Health, the American Lung Association, and many other government and professional organizations.

Radtrak measures the average radon concentration at the location of the detector during the monitoring period. The alpha-track detector has, inside the plastic housing, a radiosensitive element that records alpha particle emissions (alpha tracks) from the natural radioactive decay of radon.

When the detector is returned to Landauer's laboratory, the alpha tracks are counted using computer-assisted image analysis equipment. The number of alpha tracks along with the deployment time period provides the basis for calculating the average radon concentration. The report with the radon gas measurement, reported in picocuries per liter of air (pCi/l), is mailed within seven to ten days after receipt of detector.

Thoron Proof Filter

Upon request, a detector can be fitted with a thoron proof filter that provides measurement of Rn 222 only.

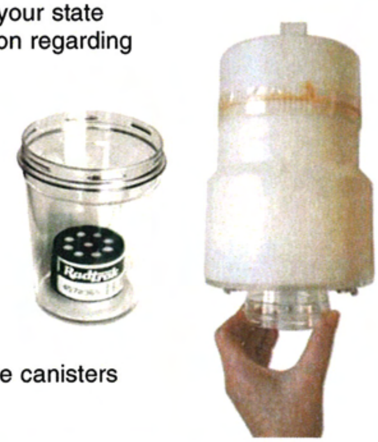
Technical Specifications

- The radiosensitive element is a CR-39 (allyl diglycol carbonate) based, passive alpha-track detector.
- The CR-39 is enclosed in a plastic housing composed of electrically conducting material with filtered openings to permit diffusion of radon gas only.
- Minimum level of detection is 30 pCi/l days i.e., 0.33 pCi/l based on 90 days.
- Detectors, before, during or after exposure, should not be in locations that exceed a temperature of 160°F (70°C).
- Radtrak detectors are packaged in film-foil bags that meet Military specification MIL-B-131, Class 1 to prevent exposure prior to use.
- A metallic label is provided for each detector to seal the filtered openings following the exposure period to minimize subsequent exposure to radon during the return shipment to Landauer's laboratory.
- Each detector is identified by a unique serial number laser engraved on the CR-39, printed and bar coded on the outside of Radtrak, and the film-foil bag.

Indoor Use

Monitoring indoors requires placing the detector in an upright position on a flat surface, or it may be hung from a joist or ceiling with the detector's hanger strip included with the shipment. The U.S. Environmental Protection Agency recommends the detector be placed in the lowest lived-in level of the home. It should be placed in a room that is used regularly but not a kitchen or bathroom. States or other organizations may have differing recommendations. Contact your state agency if you have a question regarding placement.

Outdoor Use



For monitoring outdoors, the detector is fastened to the bottom of a clear plastic cup. The cup is then installed inside a protective canister that has been attached to a post or other location. The protective canisters are sold separately.

Personnel Monitoring

The personnel monitor comes with a clip that easily attaches to the detector and securely fastens to clothing.

For more information on radon, refer to the U.S. Environmental Protection Agency's publication "A Citizen's Guide to Radon" at http://www.epa.gov/iaq/radon/pubs/citguide.html or contact your state department of health.

APPENDIX B
Soil-Vapor Sampling and Analysis Plan for the Mixed Waste Landfill

TABLE OF CONTENTS

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LIST OF FIGURES

Figure

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LIST OF TABLES

Table

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LIST OF ATTACHMENTS

Attachment

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1.0 INTRODUCTION

Requirements for monitoring at the Mixed Waste Landfill (MWL) are defined in the Long-Term Monitoring and Maintenance Plan (LTMMP) provided by the U.S. Department of Energy (DOE) and Sandia Corporation (Sandia). This Soil-Vapor Sampling and Analysis Plan (SAP) was developed in response to a request by the New Mexico Environment Department (NMED) to monitor the vadose zone for volatile organic compounds (VOCs) at the MWL, Technical Area III, Sandia National Laboratories, New Mexico (SNL/NM) (Figure B-1-1) (NMED November 2006).

1.1 Sampling Objective

The LTMMP, including this SAP, is designed to ensure the monitoring of specified parameters over a period of time. The monitoring objective of this SAP is to provide for VOC soil-vapor sampling in the vadose zone at the MWL. In addition to establishing monitoring and data quality objectives (DQOs), this SAP presents specifications for the monitoring systems, analytical laboratory analysis, data validation and evaluation, records management, and reporting. This document provides sampling personnel with the necessary information to perform vadose zone sampling. The results will be compared to the proposed trigger level presented in Chapter 5.0 of the LTMMP and in the “Probabilistic Fate and Transport Modeling of the Mixed Waste Landfill at Sandia National Laboratories” (Ho et al. January 2007).

1.2 Scope

Sampling of soil vapor in the vadose zone at the MWL will be conducted on a routine basis throughout the long-term monitoring and maintenance period for the MWL. Sampling will be conducted quarterly for 2 years to establish baseline conditions, then semiannually for the next 2 years, and annually thereafter.

Each sampling event will require the collection of soil-vapor samples from the soil-vapor monitoring wells and off-site laboratory analysis for VOCs.

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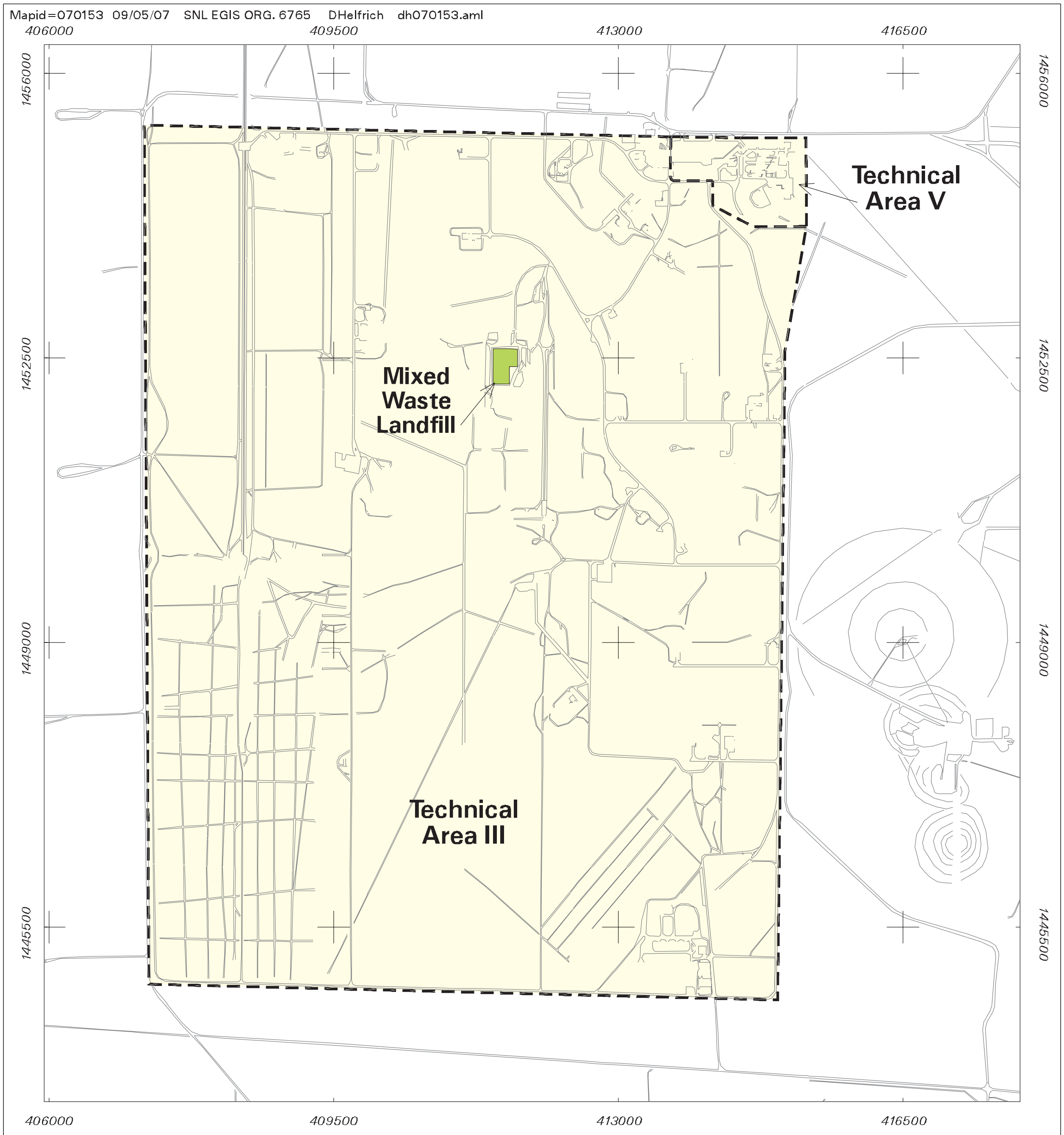

Legend

- Road
- Technical Area
- Mixed Waste Landfill

Figure B-1-1
Location of the Mixed Waste Landfill within Technical Area III

0 1000 2000
Scale in Feet

0 240 480
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

840857.04310000 A21.ai

2.0 BACKGROUND INFORMATION AND HISTORICAL INVESTIGATIONS

2.1 Background Information

The MWL Corrective Measures Implementation Work Plan was written and submitted to the NMED in November 2005 (SNL/NM November 2005). NMED reviewed the document, and responded with a “Notice of Disapproval” (NOD) letter dated November 20, 2006 (NMED November 2006). This letter described a number of deficiencies related to the MWL cover, construction plans, performance and fate and transport modeling, and monitoring triggers. The letter also included a requirement for soil-vapor sampling in the vadose zone, as follows:

> “The NMED expects the vadose zone to be monitored for volatile organic compounds, tritium, and radon, in addition to soil moisture. The NMED may also require soil-gas monitoring to be conducted at depths other than at 173 feet, as implied by the Permittees in the second paragraph of Section 7.1. Monitoring details will need to be included in the long-term monitoring and maintenance plan, due within 180 days following approval of the CMI Report.” (NMED November 2006).

In the “Responses to the NMED Notice of Disapproval” (SNL/NM December 2006), DOE/Sandia proposed a robust soil-vapor monitoring system for long-term monitoring at the MWL. The soil-vapor monitoring wells will serve as an early-warning system to protect groundwater from potential migration of contaminants. Additional information regarding the proposed monitoring, including the parameters and depths to be monitored, were included in the DOE/Sandia responses to the second set of comments within this NOD (Part 2).

In the “Responses to the NMED Notice of Disapproval, Comment Set 2” (SNL/NM January 2007), DOE/Sandia responded to the following statement from the NOD (NMED November 2006):

> “Develop triggers for tritium, radon, PCE and total VOCs as soil vapor. The NMED expects soil-gas in the vadose zone to be monitored for these constituents.”

In order to monitor soil vapor for contaminants, DOE/Sandia proposed installation of a monitoring system for sampling soil vapor within the vadose zone at the MWL. The proposed vadose zone monitoring system would allow early detection of contaminants migrating through the vadose zone, before they impact groundwater quality. Soil-vapor samples would be analyzed for VOCs. Sampling for tritium and radon would be conducted on the ground surface, rather than in the vadose zone, as described in Section 3.2 and 3.3 of the LTMMP.

2.2 Historical Soil-Vapor Investigations

During the Phase 2 Resource Conservation and Recovery Act (RCRA) Facility Investigation in the mid 1990s, extensive soil-vapor data were collected to determine the nature and extent of VOC contamination in near-surface soils at the site (SNL/NM September 1996) with most of the samples collected from depths of 10 feet and 30 feet below ground surface (bgs). Although low concentrations of VOCs have been detected in the vadose zone at the MWL, they have not impacted groundwater quality based upon sixteen years of groundwater monitoring data collected since 1990.

Analytical results for the 1994 soil-vapor samples are presented and discussed in the "Report of the Mixed Waste Landfill Phase 2 RCRA Facility Investigation, Sandia National Laboratories, New Mexico" (SNL/NM September 1996). Eight individual VOCs were detected in the 10 and 30-foot samples, with total VOC concentrations ranging from 0.03 to 30.7 parts per million (ppm) in the 10-feet bgs samples, and from 0.107 to 27.7 ppm in the 30-feet bgs samples. These VOCs included dichloro-difluoromethane, trichloro-fluoromethane, 1,1,2-trichloro-1,2,2-trifluoroethane, trichloroethene, 111-trichloroethane, tetrachloroethane, methylene chloride, and chloroform.

3.0 DATA QUALITY OBJECTIVES

The main DQO is to produce representative, accurate, and defensible analytical results to support the sampling objective (i.e., provide VOC soil-vapor data from the vadose zone). This SAP is designed to ensure that sampling procedures are consistent and can be used to establish VOC concentration trends. This DQO will be accomplished through the implementation of standard operating procedures and analytical procedures/methods through the use of quality assurance (QA) measures, quality control (QC) samples, and data evaluation protocols.

3.1 Monitoring System

The vadose zone monitoring system will provide updated data regarding VOC profiles with depth, and will consist of three Flexible Liner Underground Technologies (FLUTe™) soil-vapor monitoring wells (hereinafter referred to as FLUTe™ wells). The FLUTe™ wells are constructed in vertical boreholes located immediately outside the perimeter of the MWL cover with the locations near areas where the highest concentrations of VOCs were detected during earlier studies at the MWL (Figure B-3.1-1). Soil-vapor sampling ports are installed in each FLUTe™ well at targeted depths of 50 feet, 100 feet, 200 feet, 300 feet, and 400 feet bgs. (Attachment B-1 presents a schematic of a typical FLUTe™ well installation beneath the MWL.)

Soil-vapor data collected from the FLUTe™ wells will be used to assess current VOC distributions with depth, and to monitor VOC concentrations over time, allowing early identification of any potential threats to groundwater. The VOC data from the FLUTe™ wells will also be used to update the MWL fate and transport model every five years, as required in the NMED Final Order (NMED August 2005).

Selection of sampling location and depth, total number of samples per sampling event, and sampling frequency help ensure that the data are representative of conditions in the vadose zone.

Table B-3.1-1 gives the sampling frequency for the 5 years following the completion of the MWL cover.

3.2 Data Accuracy

Proper sampling procedures and use of QC samples such as environmental sample duplicates (Section 3.5) will help reduce random and systematic sampling error or bias. Accurate estimates of VOC concentration can be made reliably through the use of a qualified laboratory, appropriate methodologies, and effective QA/QC procedures. These measures, along with consistent implementation of the LTMMP and this SAP, will satisfy the DQO for accuracy.

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Mapid=070138 09/05/07 SNL EGIS ORG. 6765 DHelfrich dh070138.aml

Legend

Soil-Moisture Monitoring Access Tube (showing horizontal extent of tube)

FLUTe™ Well

Fence

Toe of Landfill Cover

Road

MWL Extent

Figure B-3.1-1
FLUTe™ Well Locations and Soil-Moisture Monitoring Access Tubes at the Mixed Waste Landfill

0 60 120
Scale in Feet

0 14.4 28.8
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

840857.04310000 A41

Table B-3.1-1
Soil-Vapor Sampling Frequency

Time Period	Sample Frequency	Boreholes	Sample Depths (bgs)	Number Samples Per Year
Year 1 Year 2	Quarterly (4 events)	3	50	60
			100	
			200	
			300	
			400	
Year 3 Year 4	Semi-annually (2 events)	3	50	30
			100	
			200	
			300	
			400	
Year 5 and Subsequent Years	Annually	3	50	15
			100	
			200	
			300	
			400	

bgs = Below ground surface.

Accuracy is the agreement between a measured value and an accepted reference value. When applied to a set of observed values, accuracy is a combination of a random component and a systematic bias. Accuracy will be maintained and evaluated through referenced calibration standards, laboratory control samples, matrix spike samples, and surrogate spike samples. The bias component will be evaluated and expressed as a percent recovery (%R). Acceptance criteria are defined in the SNL/NM Statement of Work (SOW) for Analytical Laboratories (SNL/NM March 2003), and verified as part of the data validation process.

$$\%R = \frac{(measure\ sample\ concentration)}{true\ concentration} x100\%$$

3.3 Precision

Precision is the agreement among a set of replicate measurements. Precision data will be derived from environmental and laboratory duplicate samples. Precision will be reported as the relative percent difference (RPD) which is calculated as follows:

$$RPD = \frac{|R_1 - R_2|}{[(R_1 + R_2)/2]} \times 100$$

RPD = Relative percent difference is calculated with the following equation and rounded to nearest whole number where:

R_1 = analysis result

R_2 = duplicate analysis result

The acceptable range for RPD is less than or equal to 20 percent.

3.4 Data Consistency and Comparability

Data consistency and comparability will be achieved through implementation of this SAP, which defines field and laboratory procedures designed for this purpose. Consistency in methods and procedures will be maintained in the following areas to ensure VOC data are consistent and that the data sets are comparable.

- Field sample collection and management
- Use of an off-site contract laboratory
- Use of an identified VOC soil-vapor analytical method
- VOC soil-vapor analytical data review and validation

After VOC soil-vapor analytical results are received from the laboratory, the SNL/NM Sample Management Office (SMO) will review the laboratory report for completeness and conformance to the performance criteria, and arrange for data validation. If problems are noted that require corrective action during these verification and validation reviews, corrective action will be implemented as defined in the SOW (SNL/NM March 2003). The scope of the data verification and validation process addresses field sample management and custody requirements, as well as adherence to QA/QC requirements by the off-site laboratory performing the analyses.

Each new set of VOC soil-vapor data will be compared to historical soil-vapor data collected. This evaluation process can identify term plume trends, but will also help identify outliers or other potential indicators of error and inconsistency.

3.5 Quality Control

Quality control measures ensure that data are scientifically sound and of known precision and accuracy. QC samples will be collected to help reduce random and systematic sampling error or bias. Table B-3.5-1 presents the samples needed to meet the QC requirements for soil-vapor sampling at the MWL.

Table B-3.5-1
Quality Control Samples

Sample Type	Frequency	Acceptance Criteria	Matrix
Duplicate Environmental Soil-Vapor Samples	1 with each sample batch sent to the laboratory or 1 per 20 samples.	RPD less than or equal to 20 percent (guidance only, RPDs for low concentrations of constituents may exceed 20 percent).	Vapor

RPD = Relative percent difference.

4.0 SAMPLING ACTIVITIES

This section describes the field and laboratory measures to be taken in providing VOC soil-vapor data from the vadose zone.

4.1 Field Activities

Field activities include the preparation, purging and VOC monitoring, sample collection, sample shipping, and the methods and procedures governing these activities. Adherence to this protocol will help ensure uniformity among measurements, and allow comparison of the results. Activities that will be conducted in preparation for or during soil-vapor sampling include the following:

- Health and Safety
- Pre-Field Preparations
- Purging and Field Estimation of Total Concentration of VOCs
- Sample Acquisition
- Sample Documentation and Custody
- Handling, Labeling, and Shipment
- Waste Management

The SNL/NM Administrative Operating Procedure (AOPs) and Field Operating Procedure (FOPs) for these activities are listed in Table B-4.1-1 as well as SMO procedures and guidance. All personnel directly involved in VOC soil-vapor sampling activities will review and abide by these procedures. The most current versions of these documents will be used.

4.1.1 Health and Safety

Field operations will be conducted in an approach that prioritizes the health and safety of field personnel above all other objectives. Every team member has the authority and responsibility to stop operations if an unsafe condition develops or is observed. All sampling personnel will perform field activities in accordance with the applicable Health and Safety Plan.

4.1.2 Pre-Field Preparations

Pre-field preparations include a vacuum check of the Summa canister as described in Activity Specific Standard Operating Procedure (ASSOP) pending (SNL/NM 2007a, pending) and calibration of the PID according to FOP 94-28 (SNL/NM March 1997).

Table B-4.1-1
Reference Documentation
MWL Soil-Vapor Monitoring

Document[a]	Title
FOP 94-01 (SNL/NM December 2006b)	Safety Meetings, Inspections, and Pre-Entry Briefings
FOP 94-22 (SNL/NM March 1994)	Deep Soil Sampling (modified for the FLUTe™ well sampling system)
FOP 94-25 (SNL/NM November 2004)	Documentation of Field Activities
FOP 94-28 (SNL/NM March 1997)	Health and Safety Monitoring of Organic Vapors (FID and PID)
AOP 95-16 (SNL/NM February 2007a)	Sample Management and Custody
AOP 00-03 (SNL/NM December 1999)	Data Validation Procedure for Chemical and Radiochemical Data
LOP 94-03 (SNL/NM February 2007b)	Sample Handling, Packaging, and Shipping, SMO
ASSOP pending (SNL/NM 2007a, pending)	Activity Specific Standard Operating Procedure for Soil-Vapor Sampling at the Mixed Waste Landfill
SMO 05-03 (SNL/NM 2007b, pending)	Procedure for Completing the Contract Verification Review
NA (SNL/NM March 2003)	SNL/NM Statement of Work for Analytical Laboratories
NA (SNL/NM December 2003)	Quality Assurance Project Plan for the Sample Management Office

[a]The most current version will be used.
AOP = Administrative operating procedure.
ASSOP = Activity-specific standard operating procedure.
FID = Flame Ionization Detector.
FOP = Field operating procedure.
LOP = Laboratory operation procedure.
MWL = Mixed Waste Landfill.
NA = Not applicable.
PID = Photoionization Detector.
SMO = Sample Management Office.
SNL/NM = Sandia National Laboratories/New Mexico.

4.1.3 Purging and Field Estimation of Total Concentration of VOCs

At the FLUTe™ wellhead, a vacuum pump connected to the sample tubing via a Swagelok® or equivalent fitting will be used to purge stagnant and/or pre-existing soil vapor from the monitoring ports and sample tubing. The stream of soil vapor extracted from the sampling port will be screened with the calibrated PID and readings will be monitored during purging and recorded in the field logbook.

Purging requirements for the individual sample depths are defined in the ASSOP pending (SNL/NM 2007a, pending). Table B-4.1-2 provides estimated purging volumes and the purging times. Equations for the calculations are provided in Appendix A of the ASSOP.

4.1.4 Sample Acquisition

Samples are to be collected using the sampling manifold provided by the FLUTe™ well manufacturer and specified in ASSOP 01-07. The manifold allows access to each sampling depth through a sampling port.

Table B-4.1-2
Estimated Purge Volumes and Time

Sample ports at each Flute™ Well (ft bgs)	Total of 3 Purge Volumes (ft^3)	Purge Time (seconds)
50	0.051	5
100	0.102	8
200	0.205	12
300	0.307	17
400	0.409	22

bgs = Below ground surface.
FLUTe™ = Flexible Liner Underground Technologies.
ft = Foot (feet).
ft^3 = Cubic feet.

4.1.5 Sample Documentation and Custody

To ensure the integrity of samples from the time of collection through the reporting of analytical results, sample collection, handling, and custody will be documented. The continuous record of documented sample possession is referred to as the chain-of-custody. Primary elements in the documentation of samples are: sample identification number, sample labels, custody tape, and the analysis request/chain of custody (AR/COC) form. Standardized forms will be used to document sample information. Sample custody and documentation procedures for sampling activities are outlined in AOP 95-16 (SNL/NM February 2007a) and LOP 94-03 (SNL/NM February 2007b). These procedures will be followed throughout each soil-vapor sampling event.

4.1.6 Handling, Labeling, and Shipment

The Summa® canisters are provided with a permanent number identifying each canister. The number is to be recorded in the logbook as well as on the AR/COC form. Do not attach the SNL/NM sample identification labels to the canisters (as requested by the laboratory); place labels on the cardboard box provided for shipping.

A SNL/NM sample label should be completed with indelible ink and affixed to each sample shipping container prior to or during sampling. Each completed sample label should include the following information:

- SNLNM SMO sample number (with sample fraction designation)
- Sample matrix type
- Sample location
- Analysis required
- Date and time of sample collection
- Types of preservatives used, if any
- Name of the sampling personnel

Canisters in the shipping boxes are returned to the SMO office for shipment to the laboratory.

4.1.7 Waste Management

There are no hazardous wastes generated from these soil-vapor sampling activities.

4.2 Analytical Methods

VOCs will be analyzed by U.S. Environmental Protection Agency (EPA) Compendium for Methods for the Determination of Toxic Organic (TO) Compounds in Ambient Air (EPA January 1999) compendium method TO-14A. The off-site laboratory is responsible for implementing the requirements of the method, including analytical methodology, target analytes for quantification, and internal QA/QC procedures. The target analytes are listed in Table B-4.2-1.

Table B-4.2-1
EPA Compendium Method TO-14 Analyte List[a]

Compound	Compound
Acetone	1,2-Dichloropropane
Benzene	cis-1,3-Dichloropropene
Benzyl chloride	trans-1,3-Dichloropropene
Bromodichloromethane	Ethylbenzene
Bromoform	4-Ethyltoluene
Bromomethane	Hexachlorobutadiene
2-Butanone	2-Hexanone
Carbon disulfide	Methylene chloride
Carbon tetrachloride	4-Methyl-2-pentanone
Chlorobenzene	Styrene
Chloroethane	1,1,2,2-Tetrachloroethane
Chloroform	Tetrachloroethene
Chloromethane	Toluene
Dibromochloromethane	1,1,2-Trichloro-1,2,2-trifluoroethane
1,2-Dibromoethane	1,2,4-Trichlorobenzene
1,2-Dichloro-1,1,2,2-tetrafluoroethane	1,1,1-Trichloroethane
1,2-Dichlorobenzene	1,1,2-Trichloroethane
1,3-Dichlorobenzene	Trichloroethene
1,4-Dichlorobenzene	Trichlorofluoromethane
Dichlorodifluoromethane	1,2,4-Trimethylbenzene
1,1-Dichloroethane	1,3,5-Trimethylbenzene
1,2-Dichloroethane	Vinyl acetate
1,1-Dichloroethene	Vinyl chloride
cis-1,2-Dichloroethene	m-, p-Xylene
trans-1,2-Dichloroethene	o-Xylene

[a]EPA January 1999.
EPA = U.S. Environmental Protection Agency.
TO = Toxic Organic.

5.0 DATA VALIDATION, REVIEW, AND REPORTING

Data validation and review of analytical and field documentation will be performed for completeness and conformance to the procedures established for the various activities. Field and analytical QC data will be reviewed for conformance to QC acceptance criteria. The entire data package will be reviewed for representativeness of quality and comparability to determine whether the specified DQOs have been met.

5.1 Field Measurement Data and Documentation Review

Completed field documentation will be reviewed and verified for accuracy, completeness, and conformance with established procedures. The review will occur at the end of each day in the field to allow verification, correction, and retrieval of missing information as appropriate.

5.2 Laboratory Data Verification and Validation

The SNL/NM SMO will review the laboratory report. The data package shall be reviewed for completeness and conformance to the performance criteria of the contract with the laboratory according to SMO 05-03 (SNL/NM December 2003).

Upon receipt of the analytical results from the Analytical Laboratory, the SNL/NM SMO will arrange for the validation of the data. The purpose of the validation is to determine the usability and establish the defensibility of the numerical results in support of the environmental and waste management activities at SNL/NM. Data validation is based upon review of laboratory-supplied QC data, the specific QC criteria identified in the procedures for the EPA-approved analytical methods, and the DQOs identified in this SAP. Data validation will be conducted according to the requirements of AOP 00-03 (SNL/NM December 2003). All associated data validation reports will be provided along with the results for each monitoring event.

5.3 Reporting

A Periodic Monitoring Report shall be prepared as defined in the Compliance Order on Consent (NMED April 2004). All monitoring data will be compiled into an annual report. This report shall include the following (as a minimum):

- Title page and signature block
- Executive summary
- Table of contents
- Introduction
- Scope of activities
- Regulatory criteria
- Monitoring results
- Conclusions
- Tables

- Figures
- Appendices

The report will also include a description of sampling activities, a summary of field measurement data, a summary of laboratory analytical and measurement data, a discussion of QC analyses and data reviews, a description of project variances, and data validation summaries. Copies and monitoring records will be maintained in the SNL/NM Customer Funded Records Center. In addition, any changes to the LTMMP monitoring program or this SAP that would require notification of the NMED and regulatory approval (such as a change in the monitoring well network, sampling frequency, or analyte list) will be presented in the annual report.

5.4 Records Management

Records associated with the soil-vapor sampling effort including field documentation, laboratory analytical results, data validation reports, and LTMMP reports/technical data evaluations will be maintained at the SNL/NM Customer Funded Records Center and comply with the record-keeping provisions of 20.4.1.500 New Mexico Administrative Code, incorporating Title 40, Code of Federal Regulations, Section 264.74, concerning the availability, retention, and disposition of records.

6.0 REFERENCES

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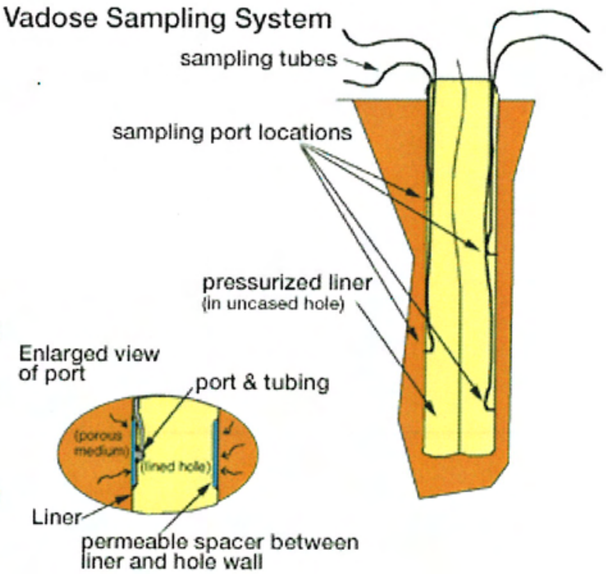
ATTACHMENT B-1
Schematic of a Typical FLUTe^{TM} Well Installation Beneath the MWL

VADOSE FLUTe™

This is the oldest of the FLUTe systems. It has been in use since 1990. The Vadose FLUTe system has the following characteristics:

- Easily installed
- Seals the entire hole with a pressurized liner
- Draws the pore gas directly from the formation
- Easily removed
- Installed in holes drilled in many different ways.

The Vadose FLUTe liner is made of a rugged Nylon fabric with an impermeable polyurethane coating. The tubing in the liner is gathered in sleeves welded to the inside surface of the liner. Exterior permeable spacers over each port are welded to the liner to allow sampling from an area, rather than from a spot on the hole wall.



The Vadose FLUTe liner is normally installed by eversion (everting liner mechanism) from a pressure canister like that shown in the photo. However, many of these systems have been installed in unstable media through driven casing and filled with sand as the casing is withdrawn. A special procedure allows the sand fill to be matched inch by inch with the casing withdrawal. The sand filled liner can not be removed except by drilling out the hole. These liners are easily installed in any direction, even vertically upward.

The interval to be sampled is defined by the spacer length on the outside of the sealing liner (see drawing above). The pore gas is drawn into the port, through the interior tube (on the inside of the liner), to the surface. Five to fifteen ports per liner are typical. The wellhead is usually built to the needs of the particular site.

In those situations where the liner is pressurized with air, a small solar panel and pump are provided to maintain the air pressure indefinitely. The air filled system is easily removed by the reverse of the installation procedure.

Vadose FLUTe liner sizes have ranged from 2-18" diameter and up to 800 feet in length. Some vadose liners have been in use for 10 years for tritium monitoring.

Prices are available at Vadose Prices. Ancillary equipment needs range from renting an air pressure canister to a "Slider", depending upon the installation procedure to be used. Installation procedures are available at Vadose Procedures. Landfill monitoring is an especially useful application of this system.

APPENDIX C
Soil-Moisture Monitoring Plan for the Mixed Waste Landfill

TABLE OF CONTENTS

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LIST OF FIGURES

Figure

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LIST OF TABLES

Table

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1.0 INTRODUCTION

Requirements for monitoring at the Mixed Waste Landfill (MWL) are defined in the Long-Term Monitoring and Maintenance Plan (LTMMP) provided by the U.S. Department of Energy (DOE) and Sandia Corporation (Sandia). This Soil-Moisture Monitoring Plan (MP) was developed for use during long-term monitoring of the vadose zone for soil moisture at the MWL, Technical Area III, Sandia National Laboratories, New Mexico (SNL/NM) (Figure C-1-1).

1.1 Objective

The LTMMP, including this MP, is designed to ensure the integrity and performance of the final landfill cover. The objective of this MP is to provide for soil-moisture monitoring of the vadose zone at the MWL over a period of time. In addition to establishing monitoring and data quality objectives (DQOs), this MP presents specifications for the use and handling of the CPN503 DR Hydroprobe® Moisture Depth Gauge (neutron probe), data evaluation, records management, and reporting. This document provides monitoring personnel with the necessary information to perform vadose zone soil moisture monitoring. The results will be compared to the proposed trigger level presented in Chapter 5.0 of the LTMMP and in the "Probabilistic Fate and Transport Modeling of the Mixed Waste Landfill at Sandia National Laboratories" (Ho et al. January 2007).

1.2 Scope

Monitoring for soil moisture in the vadose zone will be conducted following the installation of the final landfill cover to assess the hydrologic performance of the MWL cover. Quarterly monitoring is planned for the first two years after completion of the cover, followed by semiannual monitoring for two more years, and then annual monitoring thereafter. Each monitoring event requires the deployment of the neutron probe in the current monitoring system consisting of three angled access tubes. The locations of the access tubes are shown in Figure C-1.2-1. A schematic of the MWL soil-moisture monitoring access tubes is shown in Figure C-1.2-2.

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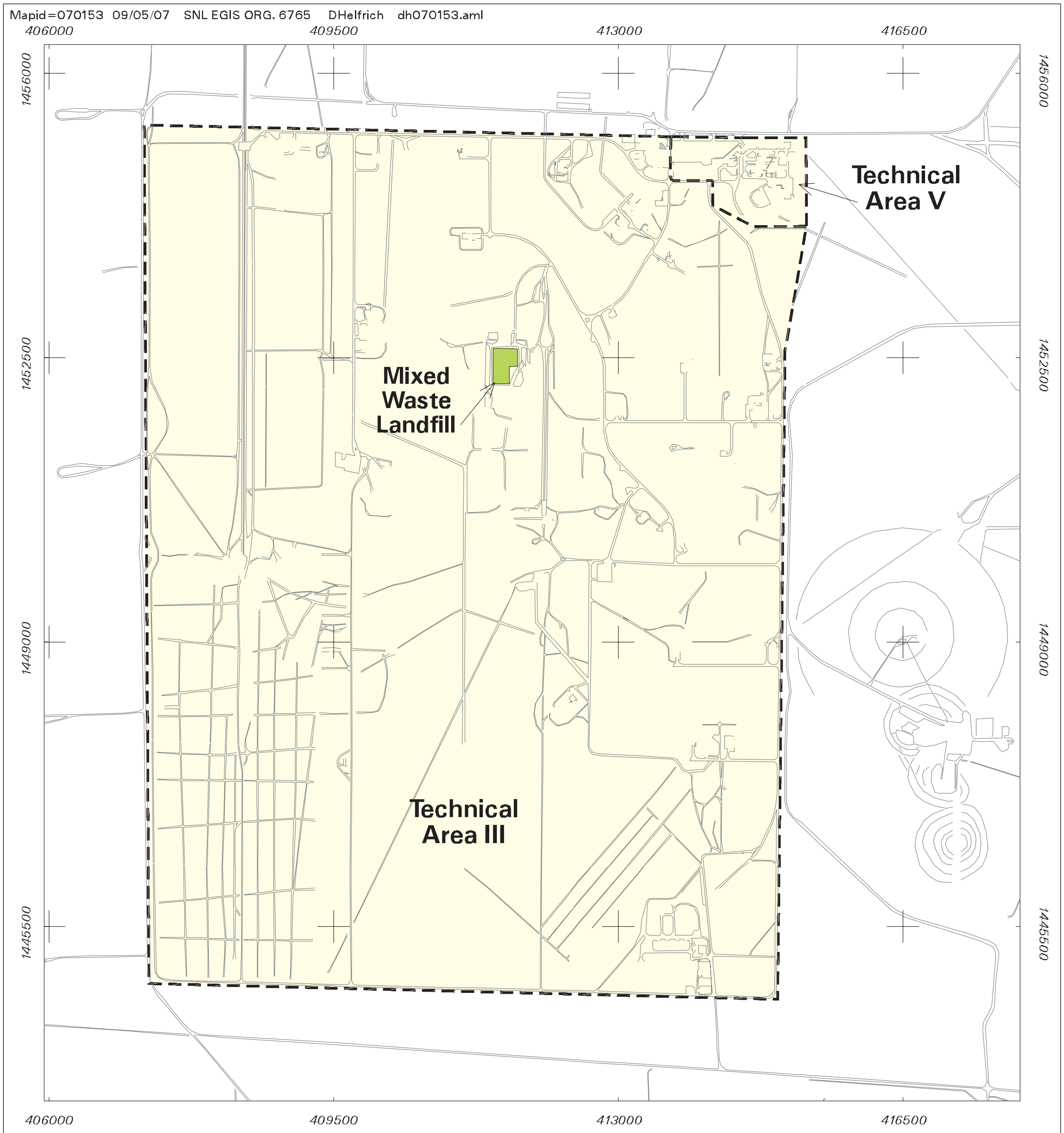

Legend

Road

Technical Area

Mixed Waste Landfill

Figure C-1-1
Location of the
Mixed Waste Landfill
within Technical Area III

0 1000 2000
Scale in Feet

0 240 480
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

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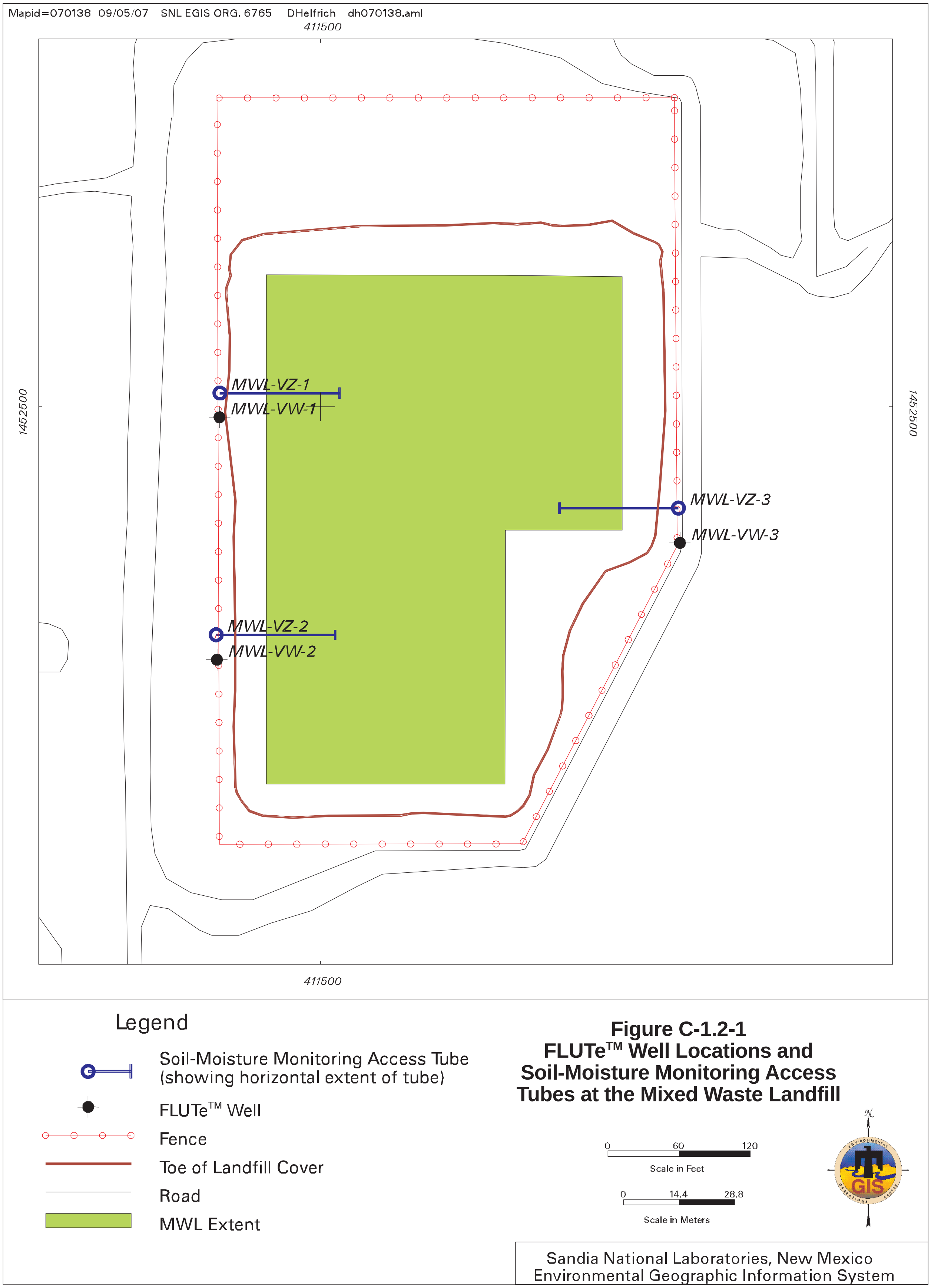

Figure C-1.2-1
FLUTe™ Well Locations and Soil-Moisture Monitoring Access Tubes at the Mixed Waste Landfill

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Environmental Geographic Information System

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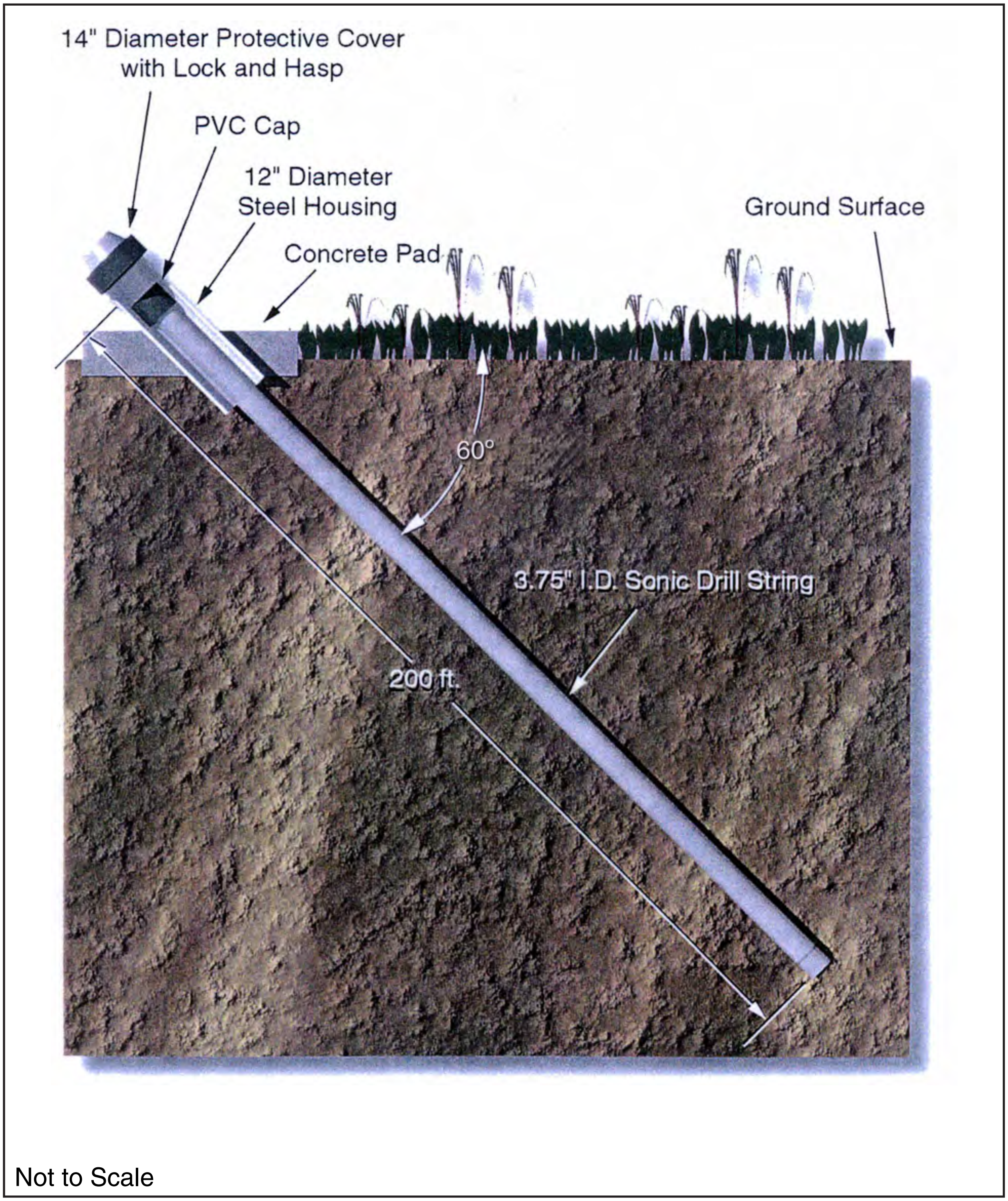

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Figure C-1.2-2
Schematic of Soil-Moisture Monitoring Access Tube,
Mixed Waste Landfill

2.0 BACKGROUND INFORMATION

The MWL Corrective Measures Implementation Work Plan was written and submitted to the New Mexico Environment Department (NMED) in November 2005 (SNL/NM November 2005). NMED reviewed the document, and responded with a "Notice of Disapproval" (NOD) letter dated November 20, 2006 (NMED November 2006). This letter described a number of deficiencies related to the MWL cover, construction plans, performance and fate and transport modeling, and monitoring triggers. The letter also included a requirement for soil-moisture monitoring in the vadose zone, as follows:

> "The NMED expects the vadose zone to be monitored for volatile organic compounds, tritium, and radon, in addition to soil moisture." (NMED November 2006).

In the "Responses to the NMED Notice of Disapproval" (SNL/NM December 2006), DOE/Sandia proposed soil-moisture monitoring via the current monitoring system. The soil-moisture monitoring will serve as an early-warning system for the potential migration of contaminants. Additional information regarding the proposed monitoring, including the trigger levels and depths to be monitored, were included in the DOE/Sandia responses to the second set of comments within the NOD (Part 2) (SNL/NM January 2007).

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3.0 DATA QUALITY OBJECTIVES

The primary DQO is to produce representative, accurate, and defensible results to support the monitoring objective (i.e., provide soil-moisture data from the vadose zone). This MP is designed to ensure that procedures are consistent and can be used to detect soil moisture beneath the landfill cover. This DQO will be accomplished through the implementation of standard operating procedures and the use of quality assurance and quality control (QA/QC) measures and data evaluation protocols.

3.1 Monitoring System

The soil-moisture monitoring system was installed in 2003, and is comprised of three boreholes drilled on a 30-degree angle from vertical to a depth of 200 linear feet and a vertical depth of 173 feet below ground surface. Each borehole was cased with drill string used to advance the borehole. The drill string is approximately 4.5 inches in diameter and is made of steel. The borehole is open to the soil in the bottom (no end cap). These are referred to as the access tubes.

During long term monitoring at the MWL, moisture readings will be taken within each access tube at intervals given in Table C-3.1-1.

Table C-3.1-1
Soil-Moisture Monitoring Frequency

Time Period	Monitoring Frequency	Access Tubes	Depths (ft bgs)
Year 1 Year 2	Quarterly (4 events)	3	4-25, at 1 ft intervals
			25-200, 5 ft intervals
Year 3 Year 4	Semi-annually (2 events)	3	4-25, at 1 ft intervals
			25-200, 5 ft intervals
Year 5 and subsequent years	Annually	3	4-25, at 1 ft intervals
			25-200, 5 ft intervals

bgs = Below ground surface.
ft = Foot (feet).

3.2 Neutron Probe

The primary moisture sensor will be a CPN 503DR neutron moisture probe, or an equivalent soil moisture probe. The CPN 503DR is a geophysical means of measuring soil moisture content. The probe uses a 50.0 millicurie americium-241:beryllium neutron source for moisture content measurements. The probe is self-contained and includes the radioactive sources, and detectors. Briefly, a neutron probe uses the absorption of emitted neutrons to calculate soil moisture content. The assumption is made that the hydrogen in soil moisture is the dominant absorber of the emitted neutrons. In the MWL soil, the calibration and QA/QC procedures to be used for the neutron probe associated with this monitoring system have not been confirmed; therefore, the following calibration and QA/QC checks are required.

3.2.1 Calibration

Calibration of the CPN 503DR neutron probe is performed in a controlled environment that duplicates as close as possible the in situ characteristics of the field monitoring location.

The probe is inserted into the access tube and count readings are taken as the soil moisture content in the repacked native soil is varied. The resulting count/soil moisture content relationship is used to develop a correlation curve for the instrument, which associates a neutron count to a known soil moisture content. Technically, this process is a correlation, not a calibration, because the probe electronics are not actually being adjusted or tuned to a known moisture content. Rather a mathematical formula is developed that correlates a neutron count to a known moisture content.

The CPN 503DR neutron probe was field-calibrated in August 2001 at the Infiltration Pilot Test Site, located approximately 500 feet west of the MWL (SNL/NM September 2001). A calibration study was conducted during which the relationship between neutron count readings measured with the CPN 503DR neutron probe and volumetric water content was determined. The results of this study determined that the relationship between volumetric water content and the neutron count ration can be expressed as follows:

$$\theta = 17.784\ R - 2.0801$$

Where

θ = the volumetric water content, and
R = count ratio (neutron probe counts divided by the standard count)

3.2.2 Quality Assurance and Quality Control

The CPN 503DR neutron probe is operated in accordance with the Activity Specific Standard Operating Procedure (ASSOP) (SNL/NM 2007, pending). A standard count will be taken once daily (during the monitoring event) prior to the moisture logging to ensure the highest measurement of accuracy. The standard count measures the proper function of the gauge electronics and also compensates for the source decay. This measurement shall be performed daily when used as described in ASSOP (SNL/NM 2007, pending).

Each new set of soil-moisture data will be compared to historical data collected. This evaluation process can aid in identifying trends, but will also help identify outliers or other potential indicators of error and inconsistency.

4.0 MONITORING ACTIVITIES

Monitoring activities include preparation for monitoring and monitoring methods and procedures governing these activities. Adherence to this protocol will help ensure uniformity among measurements, and allow comparison of the results. Activities that will be conducted in preparation for or during monitoring include the following:

- Health and safety plan review
- Pre-monitoring activities
- Correlation of the neutron probe
- Visual inspection of access tube entry point

The SNL/NM managing documents and Field Operating Procedure (FOPs) for these activities are listed in Table C-4-1. All personnel directly involved in field activities will review and abide by these procedures.

Table C-4-1
Reference Documentation
MWL Vadose Zone Soil-Moisture Monitoring

Document[a]	Title
FOP 94-01 (SNL/NM December 2006b)	Safety Meetings, Inspections, and Pre-Entry Briefings
FOP 94-25 (SNL/NM November 2004)	Documentation of Field Activities
ASSOP pending (SNL/NM 2007, pending)	Activity Specific Standard Operating Procedure for Use of the CPN 503DR Hydroprobe® Moisture Depth Gauge and Neutron Logging Activities at the Mixed Waste Landfill
HASP PLA 06-05, Revision 00 (SNL/NM May 2006)	Site Health and Safety Plan Environmental Restoration Project Vadose Zone Monitoring at the MWL
PHS SNL06A00497-002 (SNL/NM June 2007)	Primary Hazard Screening Vadose Zone Monitoring at the Mixed Waste Landfill

[a]The most current version will be used.
ASSOP = Activity-specific standard operating procedure.
FOP = Field operating procedure.
HASP = Health and Safety Plan.
MWL = Mixed Waste Landfill.
PHS = Primary Hazard Screening

4.1 Health and Safety

Field operations will be conducted in an approach that prioritizes the health and safety of field personnel above all other objectives. Every team member has the authority and responsibility to stop operations if an unsafe condition develops or is observed. All personnel will perform field activities in accordance with the applicable Health and Safety Plan.

4.2 Data Acquisition

A standard count will be taken and the results recorded in the field logbook. After assembly of the probe and necessary cables, the probe will be lowered to each predetermined location (Table C-3.1-1) in the access tube. At each monitoring location, the neutron counts will be logged and recorded in the field logbook.

The data will be downloaded from the probe (control box) and saved onto a laptop computer. The data files can be accessed in Microsoft Excel.

4.3 Waste Management

There are no hazardous wastes generated from these monitoring activities.

5.0 DATA REVIEW AND REPORTING

Review of data and field documentation will be performed for completeness and conformance to the procedures established for this activity. The data will be reviewed for representativeness of quality and comparability to determine whether the specified DQOs have been met.

5.1 Data Review

Completed field documentation will be reviewed and verified for accuracy, completeness, and conformance with established procedures. The review will occur at the end of each day in the field to allow verification, correction, and retrieval of missing information as appropriate.

5.2 Reporting

Reports will be prepared and submitted to the NMED according to the schedule defined in the LTMMP.

5.3 Records Management

Records associated with the soil-moisture monitoring including field documentation, logging results, reports, and LTMMP reports/technical data evaluations will be maintained at the SNL/NM Customer Funded Records Center and comply with the record-keeping provisions of 20.4.1.500 New Mexico Administrative Code, incorporating Title 40 Code of Federal Regulations Section 264.74, concerning the availability, retention, and disposition of records.

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6.0 REFERENCES

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Sandia National Laboratories/New Mexico (SNL/NM), June 2007. "Primary Hazard Screening (PHS) Vadose Zone Monitoring at the Mixed Waste Landfill," PHS Number: SNL06A00497-002, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), 2007 (pending). "Activity-Specific Standard Operating Procedure for Use of the CPN 503DR Hydroprobe® Moisture Depth Gauge and Neutron Logging activities at the Mixed Waste Landfill," ASSOP pending, Sandia National Laboratories, Albuquerque, New Mexico.

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APPENDIX D
Groundwater Sampling and Analysis Plan for the Mixed Waste Landfill

TABLE OF CONTENTS

TABLE OF CONTENTS (Concluded)

LIST OF FIGURES

Figure

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LIST OF TABLES

Table

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1.0 INTRODUCTION

Requirements for monitoring and sampling at the Mixed Waste Landfill (MWL) are defined in the Long-Term Monitoring and Maintenance Plan (LTMMP) provided by the U.S. Department of Energy (DOE) and Sandia Corporation (Sandia). The MWL is located in Technical Area III of Sandia National Laboratories/New Mexico (SNL/NM) (Figure D-1-1).

This Groundwater Sampling and Analysis Plan (SAP) was developed in response to the New Mexico Environment Department (NMED) Compliance Order on Consent (Consent Order) (NMED April 2004). The Consent Order states that groundwater beneath the MWL is to be monitored via annual sampling.

At the writing of this document, several modifications to the groundwater monitoring well network have been proposed. As important details (construction diagrams and locations) of the proposed wells could not be provided in the LTMMP, the DOE/Sandia fully discuss the existing well network with reference to the proposed changes. Efforts have been made to include all proposed wells in the discussion, as these are critical to the long-term monitoring of the groundwater. Because the proposed wells have not yet been installed, the circumstances of their installation may change.

1.1 Sampling Objective

The LTMMP, including this SAP, is designed to ensure the monitoring of specified parameters over a period of time. The sampling objective of this SAP is to provide defensible data for groundwater monitoring (via the collection of groundwater samples) at the MWL. In addition to establishing sampling and data quality objectives (DQOs), this SAP presents specifications for the purging methods, analytical laboratory analysis, data validation and evaluation, records management, and reporting. This document provides sampling personnel with the necessary information to perform groundwater sampling. The results will be compared with the proposed trigger levels presented in Chapter 5.0 of the LTMMP and in the “Probabilistic Fate and Transport Modeling of the Mixed Waste Landfill at Sandia National Laboratories” (Ho et al. January 2007).

1.2 Regulatory Criteria

Historically, the NMED Hazardous Waste Bureau has provided regulatory oversight of the MWL as Solid Waste Management Unit (SWMU) 76 under the Hazardous and Solid Waste Amendments (HSWA) module of the facility Resource Conservation and Recovery Act permit. The NMED confirmed that the MWL is properly designated as a SWMU (Dinwiddie June 1998), and as such, must comply with the corrective action program defined in Title 20, New Mexico Administrative Code (NMAC), Section 4.1.500, incorporating Title 40, Code of Federal Regulations (CFR), Section 264.101. Requirements for corrective action at the MWL, including groundwater monitoring requirements, are established through the corrective measures process.

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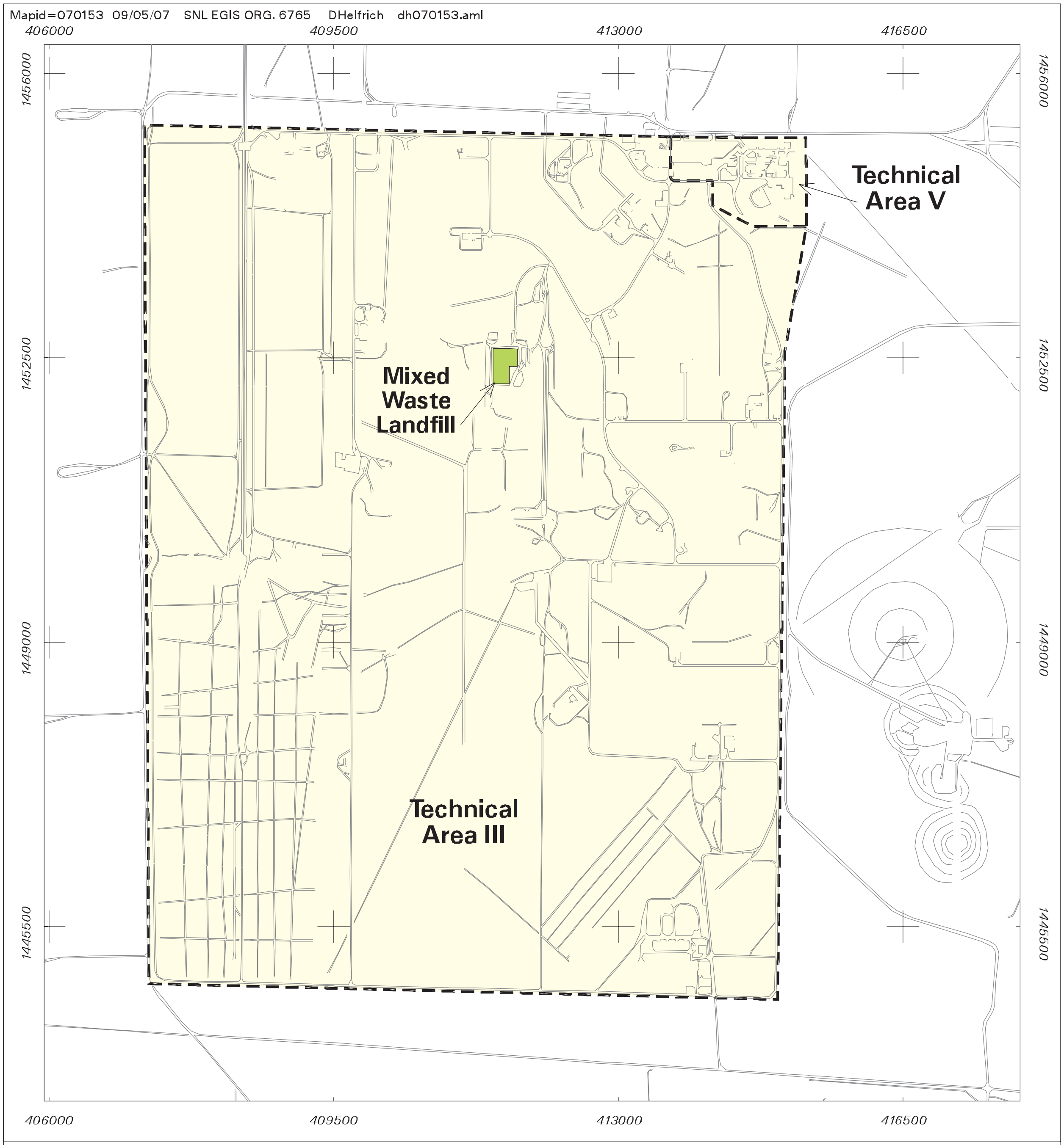

Legend

Road

Technical Area

Mixed Waste Landfill

Figure D-1-1
Location of the
Mixed Waste Landfill
within Technical Area III

0 1000 2000
Scale in Feet

0 240 480
Scale in Meters

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Environmental Geographic Information System

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The issuance of the Consent Order (NMED April 2004) transferred regulatory authority for groundwater sampling at the MWL from the HSWA module to the Consent Order. The Consent Order specifies that a SAP for groundwater monitoring shall, at a minimum, include the elements of discussion listed in Table D-1.2-1. The sections in this SAP where these elements are discussed are also provided in Table D-1.2-1.

Table D-1.2-1
MWL Groundwater SAP Crosswalk Reference

Required Elements as listed in the Consent Order (NMED April 2004)	Sections in this SAP
Water level measurements	4.2
Sampling equipment / pump type	4.5
Purge requirements	4.5
Filtration	4.7
Preservation and holding time	5.0 (Table D-5-1)
Containers	5.0 (Table D-5-1)
Sequence of sample fractions	4.7
Field QC samples	5.2.1
Laboratory QC samples	5.2.2
Labeling containers	4.4
Analytical requests	4.10
Chain of custody	4.10
Handling/shipping	4.10/4.11
Field parameters (pH, temperature, specific conductance, turbidity, dissolved oxygen)	4.6
Decontamination procedures	4.8
Report format	6.3
Schedules and frequency of sampling	3.6
Report due date	6.3
Instrument calibration methods	4.3
Health and safety	4.1

NMED = New Mexico Environment Department.
QC = Quality control.
SAP = Sampling and Analysis Plan.

1.3 Scope

Groundwater will be sampled annually from monitoring wells designated for long-term monitoring at the MWL. Each sampling event requires the collection of groundwater from each well and the off-site laboratory analysis for selected chemical parameters. The locations of the current and proposed groundwater monitoring wells are shown in Figure D-1.3-1.

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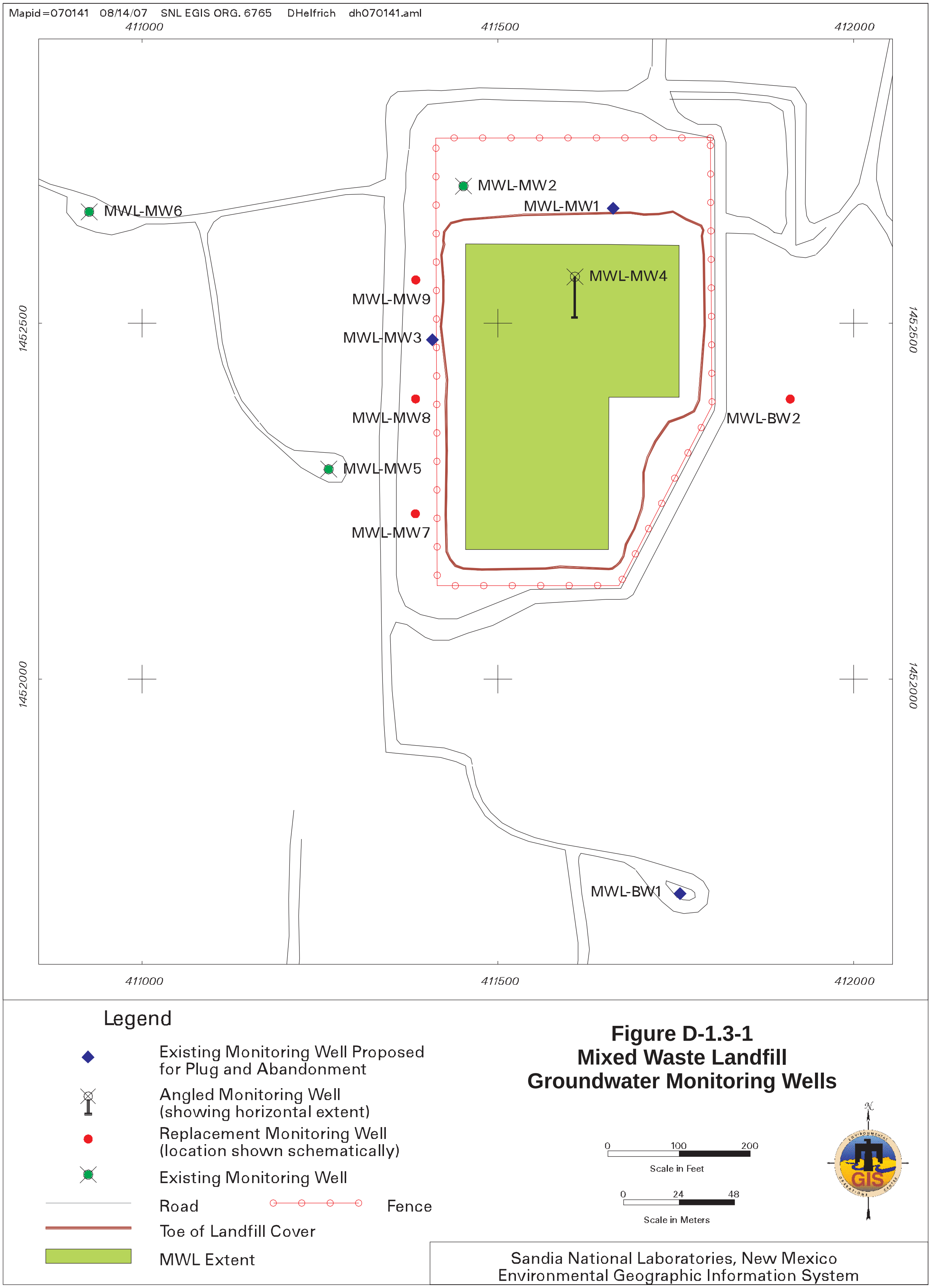

Figure D-1.3-1
Mixed Waste Landfill
Groundwater Monitoring Wells

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

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2.0 BACKGROUND INFORMATION

The MWL monitoring well network (Figure D-1.3-1) currently (as of September 2007) consists of seven wells completed within interfingering, fine-grained, alluvial fan deposits and coarse-grained Ancestral Rio Grande deposits (Goering et al. 2002). This network includes one background well (MWL-BW1), one on-site well (MWL-MW4), and five downgradient or cross-gradient wells (MWL-MW1, MWL-MW2, MWL-MW3, MWL-MW5, and MWL-MW6). All seven wells are constructed of 5-inch, Schedule 80 polyvinyl chloride (PVC) casing. Wells MWL-BW1, MWL-MW1, MWL-MW2, and MWL-MW3 have screens composed of slotted Type 304 stainless steel. Wells MWL-MW4, MWL-MW5, and MWL-MW6 have screens composed of slotted Schedule 80 PVC.

Monitoring well MWL-MW4 was installed in 1993 directly beneath a disposal trench in which 204,000 gallons of coolant wastewater from the SNL/NM Engineering Reactor Facility were disposed of in 1967 (Peace et al. September 2002). MWL-MW4 was completed at an angle of 6 degrees from vertical and is screened at two discrete intervals 20 feet apart to evaluate vertical anisotropy, vertical potentiometric gradients, and changes in aquifer parameters with depth. The approximate horizontal extent of MWL-MW4 is shown in Figure D-1.3-1. An inflatable packer separates the screened intervals and pressure is maintained in the packer to prevent the mixing of water from the two screened sections of the aquifer.

The monitoring well network is being updated in preparation for long-term monitoring at the MWL. The four oldest wells, MWL-BW1, MWL-MW1, MWL-MW2, and MWL-MW3, were installed in 1988 and 1989, and although they have provided excellent quality data over the years, they are becoming increasingly problematic.

Two of these wells, MWL-BW1 and MWL-MW3, are dry or nearly dry due to declining water levels in the regional aquifer. Groundwater levels beneath the MWL declined at an average rate of 0.5 feet/year (yr) between April 2001 and October 2006. As of April 2007, approximately 1 foot of water remained above the well screen in MWL-BW1, and approximately 3 feet of water remained above the well screen in MWL-MW3 (Table D-1.3-1). The NMED has requested that these wells be plugged and abandoned and replaced (NMED March 2007 and July 2007). A Monitoring Well Plug and Abandonment (P&A) Plan and Replacement Well Construction Plan for MWL-BW1 was submitted to the NMED on April 17, 2007 (SNL/NM April 2007). However, the NMED submitted a Notice of Disapproval regarding this plan in June 2007 (NMED June 2007), and the DOE/Sandia submitted a revised P&A and Replacement Well Construction Plan for MWL-BW1 in July 2007 (SNL/NM July 2007a).

On July 2, 2007, the NMED requested replacement of monitoring wells MWL-MW1 and MWL-MW3 due to low water levels in MWL-MW3 and to problems with corrosion of the stainless-steel screens in these wells (NMED July 2007). The DOE/Sandia submitted a P&A and Replacement Well Construction Plan for both of these wells in July 2007 (SNL/NM July 2007b). In addition, the DOE/Sandia plan to replace MWL-MW2 in the near future because of corrosion of its stainless-steel screen.

The proposed replacement wells for MWL-BW1, MWL-MW1, MWL-MW2, and MWL-MW3 are shown in Figure D-1.3-1 as MWL-BW2, MWL-MW7, MWL-MW8, and MWL-MW9. The well MWL-BW2 will serve as an upgradient background well, and MWL-MW7, MWL-MW8, and

MWL-MW9 will serve as point-of-compliance wells located at the downgradient toe of the landfill cover (Table D-2-1).

Table D-2-1
MWL Long-Term Groundwater Monitoring Well Network

Monitoring Well	Location	Installation Year
MWL-BW2	Background	2007 (planned)
MWL-MW5	Downgradient	2001
MWL-MW6	Downgradient	2001
MWL-MW7	Downgradient	2007 (planned)
MWL-MW8	Downgradient	2007 (planned)
MWL-MW9	Downgradient	2007 (planned)

MWL = Mixed Waste Landfill.

The DOE/Sandia intends to leave MWL-MW4 in place but not include it in annual sampling because it is not a point-of-compliance well. The packer pressure will be maintained and the well will be available for discretionary sampling.

Therefore, the groundwater monitoring well network proposed to be in place for long-term monitoring includes six wells (existing wells MWL-MW5 and MWL-MW6 and proposed wells MWL-BW2, MWL-MW7, MWL-MW8, and MWL-MW9).

Sampling has been conducted on a regular basis since 1990 for a variety of analytes. These have included volatile organic compounds (VOCs), semivolatile organic compounds, target analyte list (TAL) metals, total uranium, nitrate plus nitrite, bromide, fluoride, chloride, and sulfate. Radionuclides analyzed include gross alpha/beta radioactivity, tritium, isotopic uranium, and gamma-emitting radionuclides.

3.0 DATA QUALITY OBJECTIVES AND QUALITY CONTROL

The primary DQO is to produce representative, accurate, and defensible analytical results to support the monitoring objective (i.e., provide groundwater data). This SAP is designed to ensure that sampling procedures are consistent and can be used to characterize the groundwater and to ensure that SNL/NM is complying with DOE Orders and guidance, federal, state, and local regulations pertaining to groundwater quality, and that triggers for groundwater quality (listed in Chapter 5.0 of the LTMMP) are not exceeded. This DQO will be accomplished through the implementation of standard operating procedures and analytical procedures/methods through the use of quality assurance measures, quality control (QC) samples, and data evaluation protocols.

DQOs specified as accuracy, precision, data representativeness, completeness, and comparability are imposed on the sample collection and analysis process to verify data quality. DQO measurement data are defined in the following sections.

3.1 Accuracy

Accuracy is the agreement between a measured value and an accepted reference value. When applied to a set of observed values, accuracy is a combination of a random component and a systematic bias. Accuracy will be maintained and evaluated through referenced calibration standards, laboratory control samples (LCS), matrix spike (MS) samples, and surrogate spike samples. The bias component will be evaluated and expressed as a percent recovery (% R). Acceptance criteria are defined in the SNL/NM Statement of Work (SOW) for Analytical Laboratories (SNL/NM March 2003) and verified as part of the data validation process.

$$\%R = \frac{(measure\ sample\ concentration)}{true\ concentration}\, x100\%$$

3.2 Precision

Precision is the agreement among a set of replicate measurements. Precision data will be derived from environmental and laboratory duplicate samples. Precision will be reported as the relative percent difference (RPD) which is calculated as follows:

$$RPD = \frac{|\,R_1 - R_2\,|}{[(R_1 + R_2)\,/\,2]} \times 100$$

RPD = Relative percent difference is calculated with the following equation and rounded to the nearest whole number where:

R_1 = analysis result

R_2 = duplicate analysis result

The acceptable range for RPD is less than or equal to 20 percent.

3.3 Completeness

Completeness is defined as a measure of the amount of usable data resulting from a data collection activity given the sample design and analysis. Examples of events that reduce the amount of usable data include improperly collected and preserved samples, missed holding times, sample container breakage, and operating outside prescribed QC limits. The completeness objective is 100 percent for compliance data. If the completeness objective is not met and sufficient sample material remains for reanalysis, then the laboratory will repeat the analysis.

$$\%Completeness = \frac{number\ of\ accepted\ data\ points}{total\ number\ of\ samples\ collected} x100\%$$

3.4 Data Representativeness

Data representativeness is the degree to which sample analyses accurately and precisely represent the media they are intended to represent. Data representativeness will be achieved by implementing appropriate sample collection procedures and the use of standard analytical methods. Groundwater sampling procedures will ensure that samples are representative of formation water. The analytical methods selected will accurately and precisely represent the true concentration value of the analytes of interest.

3.5 Comparability

Comparability is the extent to which one data set or value can be related to another or to specific regulatory criteria. Comparability between data sets is achieved through the collection and analysis of samples using consistent methods and QC criteria. Aqueous samples will be reported in units of milligrams (mg)/liter (L) or micrograms (μg)/L, whichever unit is most appropriate to the analytical method.

3.6 Sampling Frequency

Table D-3.6-1 gives the sampling frequency for the five years following the completion of the MWL cover.

Table D-3.6-1
MWL Groundwater Monitoring Wells Sampling Frequency

Well Number	Sampling Frequency	Screened Lithology
MWL-BW2	Quarterly for 2 years, then annually	Alluvial fan deposits
MWL-MW5	Annually	Alluvial fan/Ancestral Rio Grande deposits
MWL-MW6	Annually	Ancestral Rio Grande deposits
MWL-MW7	Quarterly for 2 years, then annually	Alluvial fan deposits
MWL-MW8	Quarterly for 2 years, then annually	Alluvial fan deposits
MWL-MW9	Quarterly for 2 years, then annually	Alluvial fan deposits

MWL = Mixed Waste Landfill.

3.7 Quality Control

QC measures ensure that data are scientifically sound and of known precision and accuracy. QC samples will be collected to help reduce random and systematic sampling error or bias. Section 5.2 presents the samples necessary to meet the QC requirements for groundwater sampling at the MWL.

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4.0 FIELD ACTIVITIES

Groundwater sampling and associated field activities will be conducted in accordance with this SAP and SNL/NM Administrative Operating Procedure (AOPs) and Field Operating Procedure (FOPs) listed in Table D-4-1 as well as Sample Management Office (SMO) procedures and guidance. All personnel directly involved in groundwater sampling field activities will review and abide by these procedures. The most current versions of these documents will be used. Adherence to the methods and procedures governing these activities will help ensure uniformity and allow comparison of the results. Activities that will be conducted in preparation for, or during, groundwater sampling include the following:

- Health and Safety
- Water Level Measurements
- Monitoring Equipment Calibration
- Sample Container Labeling
- Well Purging
- Water Quality Measurements
- Sample Acquisition
- Equipment Decontamination
- Waste Management
- Sample Documentation and Custody
- Sample Shipment

Table D-4-1 summarizes documents that are associated with this SAP, which can be obtained from the SNL/NM Customer-Funded Records Center.

4.1 Health and Safety

Field operations will be conducted in a manner that prioritizes the health and safety of field personnel above all other objectives. Every team member has the authority and responsibility to stop operations if an unsafe condition develops or is observed. All groundwater personnel will perform field activities in accordance with the applicable Groundwater Sampling Health and Safety Plan.

4.2 Water Level Measurements

Water level information is used to determine the volume of water in each well and to update the potentiometric surface map. Measurements are referenced to a surveyed mark of known elevation at the top of the well casing. The static water level is measured in each well prior to purging or obtaining a sample, and measurements are taken to the nearest 0.01 foot using a water level indicator. Instructions for water level measurements are provided in FOP 05-01 (SNL/NM August 2005a).

Table D-4-1
MWL LTMMP Groundwater Sampling Reference Documentation

Document[a]	Document Title
AOP 00-03 (SNL/NM July 2007c)	Data Validation Procedure for Chemical and Radiochemical Data
AOP 95-16 (SNL/NM February 2007a)	Administrative Operating Procedure for Sample Management and Custody
FOP 94-01 (SNL/NM December 2006)	Safety Meetings, Inspections, and Pre-Entry Briefings
FOP 94-25 (SNL/NM November 2004)	Documentation of Field Activities
FOP 05-01 (SNL/NM August 2005a)	LTES Groundwater Monitoring Well Sampling and Field Analytical Measurements
FOP 05-02 (SNL/NM August 2005b)	LTES Groundwater Monitoring Equipment Field Check For Water Quality Measurements
FOP 05-03 (SNL/NM August 2005c)	LTES Groundwater Sampling Equipment Decontamination
FOP 05-04 (SNL/NM August 2005d)	LTES Groundwater Monitoring Well Waste Management
LOP 94-03 (SNL/NM February 2007b)	Sample Handling, Packaging, and Shipping
SMO 05-03 (SNL/NM 2007, pending)	Procedure for Completing the Contract Verification Review
NA (SNL/NM March 2003)	SNL/NM Statement of Work for Analytical Laboratories
NA (SNL/NM February 2007c)	Quality Assurance Project Plan (QAPP) for the Sample Management Office

[a]The most current version will be used.
AOP = Administrative Operating Procedure.
MWL = Mixed Waste Landfill.
FOP = Field Operating Procedure.
LOP = Laboratory Operating Procedure.
LTES = Long-Term Environmental Stewardship.
LTMMP = Long-Term Monitoring and Maintenance Plan.
NA = Not applicable.
SMO = Sample Management Office.
SNL/NM = Sandia National Laboratories/New Mexico.

4.3 Monitoring Equipment Calibration

Monitoring instruments used to measure groundwater field parameters shall be calibrated or function-checked prior to sampling activities. Calibration and field-check instructions are presented in FOP 05-02 (SNL/NM August 2005b).

4.4 Sample Container Labeling

A unique SNL/NM SMO-issued sample identification number is assigned to each sample. The sample numbers are preprinted on self-adhesive labels in numerical order and are obtained from the SMO. The sample number should be affixed to, or noted on, the sample label and/or the analysis request/chain of custody (AR/COC) form.

An SNL/NM sample label should be completed with indelible ink and affixed to each sample container prior to, or during, sampling. Each completed sample label should include the following information:

- SNL/NM SMO sample number (with sample fraction designation)
- Sample matrix type
- Sample location
- Analysis required
- Date and time of sample collection
- Types of preservatives used, if any
- Name of the sample collector

4.5 Well Purging

MWL LTMMP groundwater monitoring will be performed using low-flow sampling methods with an appropriate submersible pump system. The DOE/Sandia will purge monitoring wells using low-flow techniques as outlined in the position paper, "Use of Low-Flow and Other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring" (NMED October 2001).

It is assumed in this SAP that low-flow sampling methods will have been approved by the NMED on a well-by-well basis. Each monitoring well in the MWL groundwater monitoring system proposed for low-flow sampling methods will have the following information available that documents proper well construction:

- Well installation details (construction diagrams including the length of the screened interval, lithologic logs, and geophysical logs)

- Well construction diagrams depicting details of the sealed intervals to demonstrate adherence to NMED and U.S. Environmental Protection Agency (EPA) guidance that prohibits surface water infiltration into the screened intervals and communication between saturated zones and/or surface infiltration

Drawdown will be measured and recorded during purging. The purging rate will not exceed the recharge rate.

4.6 Water Quality Measurements

Water quality measurements will be collected during monitoring well purging in accordance with FOP 05-01 (SNL/NM August 2005a). Measurements include groundwater potential of hydrogen (pH), specific conductivity (SC), temperature, and turbidity. Additional field measurements may include dissolved oxygen (DO), oxidation-reduction potential (ORP), and an alkalinity titration. Water quality parameters are defined as follows:

DO Content—The amount of oxygen dissolved in water in percent saturation or in mg/L.

SC—The ability of a cubic centimeter of water to conduct electricity. It varies directly with the amount of ionized minerals in the water and is measured in micro-mhos per centimeter at 25 degrees Celsius (ºC).

pH—A measure of the acidity or alkalinity of a solution. Numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity.

ORP—Potential for an oxidation (loss of electrons to another atom or molecule) or reduction (gain of electrons from another atom or molecule) reaction in millivolts.

Temperature—The temperature of the water in °C.

Turbidity (nephelometric)—The cloudiness in water due to suspended and colloidal organic and inorganic material. Water turbidity is measured in nephelometric turbidity units (NTUs).

Alkalinity—The buffering system or titratable base in water, expressed as calcium carbonate ($CaCO_3$) in mg/L.

Measurements will be made every 5 minutes during purging until stabilization is achieved. The well is considered to be stable when the indicator parameters have stabilized over three consecutive readings spaced a minimum of 5 minutes apart and when the indicator parameters SC, temperature, DO, and turbidity are ± 10 percent, and pH is ± 0.5 units. Alkalinity will only be measured once following stabilization of the other parameters.

4.7 Sample Acquisition

Sample acquisition procedures will take into consideration specific monitoring well characteristics and conditions. Detailed instructions are provided in FOP 05-01 (SNL/NM August 2005a).

MWL LTMMP groundwater monitoring will be performed using low-flow sampling methods as defined in Section 4.5 and until stability is achieved as defined in Section 4.6.

Samples will be collected in laboratory-supplied sample containers. Groundwater samples will be collected from each well in the order of VOCs, metals, nitrate plus nitrite, major anions, gamma spectroscopy, and tritium. All samples collected requiring filtration will be filtered in the field using in-line filters of 0.45-micron or less. To ensure the integrity of samples from the time of collection through analysis results reporting, sample collection, handling, and custody will be documented. Sample container types, preservatives, and holding times are detailed in Section 5.0.

4.8 Equipment Decontamination

All equipment that comes into contact with the sample, the interior of the well, or groundwater will be decontaminated prior to entering the well to prevent cross-contamination. Equipment and materials (including chemicals and protective clothing), decontamination procedures, and waste management are defined in the FOP 05-03 (SNL/NM August 2005c).

4.9 Waste Management

All waste generated during groundwater sampling activities will be managed in accordance with federal, state, and city regulations, and applicable SNL/NM requirements. All purge and decontamination water will be managed as nonregulated waste based upon historical sampling results. Analytical data collected from annual sampling events will be compared to discharge/disposal criteria. Based upon past experience, the anticipated disposal path for purge water and decontamination water will be discharge to the sanitary sewer. If the City of Albuquerque discharge standards are not met, purge and decontamination water will be managed through the SNL/NM Hazardous Waste Management Facility. Personal protective equipment that comes into contact with groundwater will be managed as nonregulated waste disposed of through the SNL/NM Solid Waste Transfer Facility. Waste management activities associated with groundwater monitoring will be performed in accordance with FOP 05-04 (SNL/NM August 2005d).

4.10 Sample Documentation and Custody

To ensure the integrity of samples from the time of collection through the reporting of analytical results, sample collection, handling, and custody will be documented. The continuous record of documented sample possession is referred to as the chain-of-custody. The primary elements in the documentation of samples consist of sample identification number, sample labels, custody tape, and the AR/COC form. Standardized forms will be used to document sample information. Sample custody and documentation procedures for sampling activities are outlined in AOP 95-16 (SNL/NM February 2007a) and Laboratory Operating Procedure (LOP) 94-03 (SNL/NM February 2007b). These procedures will be followed throughout each groundwater sampling event.

4.11 Sample Shipment

Samples will be shipped to the analytical laboratory in accordance with SMO procedures detailed in LOP 94-03 (SNL/NM February 2007b). Prior to shipment, the sample collection documentation will be verified. Any error will be noted and corrected as required by SNL/NM SMO protocols.

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5.0 ANALYTICAL PROCEDURES

The analytical laboratory will analyze samples using EPA-approved analytical methods and specified performance criteria in accordance with the SNL/NM SOW for Analytical Laboratories (SNL/NM March 2003). The analytical laboratory will provide appropriate sample containers prepared with the required sample preservative. The analytical laboratory will prepare and submit to the SNL/NM SMO an analysis data report as described in the SOW for Analytical Laboratories. Table D-5-1 summarizes typical analytical requirements and EPA Methods (EPA November 1986) applicable to groundwater monitoring at the MWL. Sampling for parameters for which triggers have been approved (Chapter 5.0 of the LTMMP) is considered mandatory; sampling for the remaining parameters is optional, and may be conducted for characterization of major ion chemistry and groundwater characteristics.

5.1 Analytical Laboratory

The analytical laboratory is responsible for performing analyses in accordance with this SAP, the SNL/NM SOW for Analytical Laboratories, and regulatory requirements. The laboratory will maintain documentation of sample handling and custody, analytical data, and internal QC data. The laboratory will analyze QC samples in accordance with this SAP, the SNL/NM SOW for Analytical Laboratories, and its own internal QC program for indicators of analytical accuracy and precision. The SNL/NM SMO will direct the laboratory activity, including investigation and corrective action, if necessary, for data generated outside laboratory acceptance limits.

In addition, two types of analytical laboratory audits may be performed as part of the sampling program and are defined as system audits and performance audits. A system audit determines whether appropriate project systems (i.e., equipment, procedures) are in place. Performance audits indicate whether the project systems are functioning properly and are capable of meeting project DQOs. These audits will be completed as required by SNL/NM SMO procedures and protocols.

5.2 Quality Control Samples

QC samples will be analyzed in conjunction with the groundwater samples to ensure that the data generated meet the DQOs of this SAP. QC for the entire activity will be achieved through adherence to requirements and procedures listed and described in Section 3.0 of this SAP. Mandatory QC samples are identified in the following sections.

5.2.1 Field Quality Control Samples

Control of field operations requires the collection and analysis of field QC samples, in addition to conformance to standardized sampling procedures as defined in SNL/NM FOPs. Field QC samples are used to document data quality and identify sampling inconsistencies resulting from variability in sample collection, storage, transportation, and equipment decontamination. Field

Table D-5-1
MWL Groundwater Monitoring Parameters, Test Methods, and Selection Criteria

Parameter	Required or Optional?	EPA Method[a]	Container/Preservative/ Holding Time	Selection Criteria
Volatile Organic Compounds	Required	SW846-8260	40-mL glass vial/ HCL/14 days	Screening for VOCs
Total Uranium	Required	SW846-6020	500-mL HDPE/ HNO_3/6 months	Screening for uranium
Gamma Spectroscopy (short list)	Required	EPA 901.1 or Equivalent	1-L HDPE/HNO_3/6 months	Screening for radionuclides
Gross Alpha/Beta	Required	EPA 900.0 or Equivalent	1-L HDPE/HNO_3/6 months	Screening for radionuclides
Tritium	Required	EPA 906.0 or Equivalent	250-mL amber glass/ 4ºC/6 months	Screening for tritium
Perchlorate[b]	Required for the first 4 quarters for new wells	EPA 314.0	250-mL HDPE/4ºC/28 days	Required by Compliance Order on Consent
Total TAL[c] Metals	Optional	SW846-6020/7470	500-mL HDPE/ HNO_3/6 months[d]	Major Ion Chemistry; screening for RCRA metals
Filtered TAL[c] Metals (filtered in the field)	Optional	SW846-6020/7470	500-mL HDPE/ HNO_3/6 months[d]	Major Ion Chemistry; screening for RCRA metals
Nitrate plus Nitrite	Optional	EPA 353.2	250-mL HDPE/ H_2SO_4/28 days	Major ion chemistry
Major Anions	Optional	SW846-9056	250-mL HDPE/4ºC/28 days	Major ion chemistry
Total Alkalinity	Optional	EPA 310.1	250-mL HDPE/4ºC/14 days	Major ion chemistry
Total Dissolved Solids	Optional	EPA 160.1	1-L HDPE/4ºC/7 days	General groundwater chemistry
Field Alkalinity	Optional	HACH 8203	NA	Major ion chemistry

[a]U.S. Environmental Protection Agency, 1986 (and updates), "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, 3rd Edition, U.S. Environmental Protection Agency, Washington, D.C.

[b]Perchlorate screening is required by the Consent Order (NMED April 2004) for all newly-installed groundwater monitoring wells for four consecutive quarters, unless perchlorate is detected. If detected, a sampling frequency will be negotiated with the NMED.

[c]TAL metals = Aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, cyanide, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium and zinc.

[d]Mercury has a holding time of 28 days.

EPA = U.S. Environmental Protection Agency.
HACH = Hach Company.
HCL = Hydrochloric acid.
HDPE = High-density polyethylene.
HNO_3 = Nitric acid.
H_2SO_4 = Sulfuric acid.
L = Liter(s).
mL = Milliliter(s).
MWL = Mixed Waste Landfill.
NA = Not applicable
NMED = New Mexico Environment Department.
ºC = Degrees Celsius
RCRA = Resource Conservation and Recovery Act.
SW = Solid waste.
TAL = Target Analyte List.
VOC = Volatile organic compound.

QC samples submitted to the analytical laboratory will be handled and analyzed in the identical manner as environmental samples. Field QC samples to be collected include duplicate environmental samples and trip blanks (TBs). Table D-5.2-1 provides a description of the field QC samples.

Table D-5.2-1
MWL Groundwater Monitoring Field Quality Control Samples

Sample Type	Purpose of Sample	Frequency	Acceptance Criteria	Matrix
Duplicate Samples	To evaluate the overall precision of the sampling and analysis system.	1 with each sample batch sent to the laboratory or 1 per 20 samples.	RPD less than or equal to 20 percent (guidance only, RPDs for low concentrations constituents may exceed 20 percent).	Aqueous
Trip Blanks	To evaluate VOC contamination originating from sample, transport, shipping, and site conditions.	1 per cooler containing VOC samples.	If contaminants are detected, the data should be evaluated in order to determine probable source and impact on sample results.	Aqueous

RPD = Relative percent difference.
VOC = Volatile organic compound.

Duplicate environmental samples are collected in the field and analyzed to establish and document the precision of the sampling and analysis process. The duplicate samples will be collected immediately after the original environmental sample in order to reduce variability caused by time and/or sampling mechanics and are typically collected at a frequency of 5 percent (minimum of one per MWL sampling event).

TB samples are used to assess the potential for VOC contamination originating from sample, transport, shipping, and site conditions. The TBs are analyzed for VOCs only. Each batch of VOC groundwater samples, identified with a specific AR/COC, will be accompanied by a TB during shipping. The laboratory prepares the TB by filling a VOC vial with deionized water and using the same sample preservation method designated for VOC environmental samples. Each vial is sealed with custody tape and dated when it is prepared. The TBs accompany the empty sample containers when they are shipped to the field supervisor prior to the start of sample collection. The TBs are taken into the field during sample collection and are included in the shipment of environmental samples to the laboratory. The TBs must remain sealed during this entire cycle and may be opened only for analysis upon return to the analytical laboratory.

5.2.2 Laboratory Quality Control Samples

The analytical laboratory must have established procedures that demonstrate the analytical process is always controlled during each sample analysis step. The procedures include LCSs, method blank samples, and MS samples. Laboratories must operate in conformance with SNL/NM FOPs, SNL/NM AOPs, and the SNL/NM SOW for Analytical Laboratories.

An LCS consists of a control matrix (e.g., deionized water) spiked with analytes representative of the target analytes. LCSs are prepared and analyzed for each analytical procedure performed. LCSs are analyzed with each analytical batch containing environmental samples to verify the precision and bias of the analytical process. The results of the LCS analyses are compared to the control limits established to assess the usability of the data.

Method blank samples are used to check for contamination in the laboratory during sample preparation and analysis. Method blank samples are concurrently prepared and analyzed with each analytical batch. Method blanks are reported in the same units as corresponding environmental samples, and the results are included with each analytical report.

Surrogate spike analysis will be performed for all samples analyzed by Gas Chromatography/ Mass Spectroscopy. The surrogate compounds added to the sample will be those specified in the applicable EPA analytical method procedure (EPA November 1986). Recovery values for surrogate compounds that are outside specified control limits require corrective action, which is detailed in the SNL/NM SOW for Analytical Laboratories.

The analytical process shall be systematically evaluated for the effects of indigenous constituents present in the environmental sample matrix. MS/matrix spike duplicate (MSD) analyses shall be performed in accordance with the specified analytical procedures. An MSD will be prepared for organic sample fractions to evaluate the precision of the analytical process. For inorganic analytes, the precision of the analytical process shall be evaluated by preparing a laboratory replicate analyzed in accordance with the specified analytical procedures.

6.0 DATA VALIDATION, REVIEW, AND REPORTING

Data validation and review of analytical and field documentation will be performed for completeness and conformance to the procedures established for the various activities. Field and analytical QC data will be reviewed for conformance to QC acceptance criteria. The entire data package will be reviewed for representativeness of quality and comparability to determine whether the specified DQOs have been met.

6.1 Field Measurement Data and Documentation Review

Completed field documentation will be reviewed and verified for accuracy, completeness, and conformance with established procedures. The review will occur at the end of each day in the field to allow verification, correction, and retrieval of missing information as appropriate. Field documentation found to be incomplete or questionable will be remeasured and/or corrected prior to finalizing the field reports.

6.2 Laboratory Data Verification and Validation

The SNL/NM SMO will review the laboratory report. The data package shall be reviewed for completeness and conformance to the performance criteria of the contract with the laboratory according to the procedure SMO 05-03 (SNL/NM 2007, pending).

Upon receipt of the analytical results from the Analytical Laboratory, the SNL/NM SMO will arrange for the validation of the data. The purpose of the validation is to determine the usability and establish the defensibility of the numerical results in support of the environmental and waste management activities at SNL/NM. Data qualification is based upon review of laboratory-supplied QC data, the specific QC criteria identified in the procedures for the EPA-approved analytical methods, and the DQOs identified in this SAP. Data validation will be conducted according to the requirements of AOP 00-03 (SNL/NM July 2007c). All associated data validation reports will be provided along with the results for each monitoring event.

6.3 Reporting

A Periodic Monitoring Report shall be prepared as defined in the Consent Order (NMED April 2004). All groundwater monitoring data will be compiled into an annual report. This report shall include the following (as a minimum):

- Title page and signature block
- Executive summary
- Table of contents
- Introduction
- Scope of activities
- Regulatory criteria
- Monitoring results
- Conclusions

- Tables
- Figures
- Appendices

The report may also include a description of sampling activities, a summary of field measurement data, a summary of laboratory analytical and measurement data, a discussion of QC analyses and data reviews, a description of project variances, and data validation summaries. Reports and copies of groundwater monitoring records will be maintained in the SNL/NM Customer-Funded Records Center. In addition, any changes to the LTMMP groundwater monitoring program or this SAP that would require regulatory approval (such as a change in the monitoring well network, sampling frequency, or analyte list) will be presented in the annual report.

6.4 Records Management

Records associated with the groundwater sampling effort, including field documentation, laboratory analytical results, data validation reports, and LTMMP reports/technical data evaluations, will be maintained at the SNL/NM Customer-Funded Records Center and comply with the record-keeping provisions of 20.4.1.500 NMAC, incorporating 40 CFR 264.74, concerning the availability, retention, and disposition of records.

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APPENDIX E
Biota Sampling and Analysis Plan for the Mixed Waste Landfill

TABLE OF CONTENTS

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LIST OF FIGURES

Figure

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LIST OF TABLES

Table

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1.0 INTRODUCTION

Requirements for monitoring at the Mixed Waste Landfill (MWL) are defined in the Long-Term Monitoring and Maintenance Plan (LTMMP). This Biota Sampling and Analysis Plan (SAP) was developed in response to a request by the New Mexico Environment Department (NMED) to monitor for potential biotic mobilization of contaminants at the MWL, Technical Area III, Sandia National Laboratories, New Mexico (SNL/NM) (Figure E-1-1) (NMED November 2006).

Biotic mobilization of contaminants can be defined as the migration of contaminants by burrowing insects and animals (ants and rodents), and uptake by vegetation. The collection of soil samples from ant hills and/or animal burrows, and vegetation samples can determine if contaminant mobilization has occurred via these mechanisms.

1.1 Monitoring Objective

The LTMMP, including this SAP, is designed to ensure the monitoring of specified parameters over a period of time. The monitoring objective of this SAP is to provide analytical data in order to characterize biotic mobilization of contaminants at the MWL. In addition to establishing monitoring and data quality objectives (DQOs), this SAP presents specifications for the locations of sample collection points, sample collection procedures, laboratory analysis, data evaluation, records management, and reporting. This document provides sampling personnel with the necessary information to perform sampling of soil from burrows or nests, and vegetation. The results will be compared to the proposed trigger levels presented in the LTMMP and in the "Probabilistic Fate and Transport Modeling of the Mixed Waste Landfill at Sandia National Laboratories" (Ho et al. January 2007).

1.2 Scope

Following the installation of the final landfill cover, a visual survey will be conducted quarterly to determine the presence of burrowing insects and/or animals and the types of vegetation present on the landfill cover. The locations will be recorded in the geographic information system (GIS) database. Sampling of soil from burrows or nests and vegetation will be conducted in the fifth year following the installation of the final landfill cover (and following years as deemed necessary). Each sampling event requires the identification of burrows and/or nests and the species of vegetation located on the landfill cover. Soil and vegetation samples will be collected from the identified locations and submitted for laboratory analysis of metals and radionuclides by gamma spectroscopy. Vegetation samples will be submitted for laboratory analysis of radionuclides by gamma spectroscopy.

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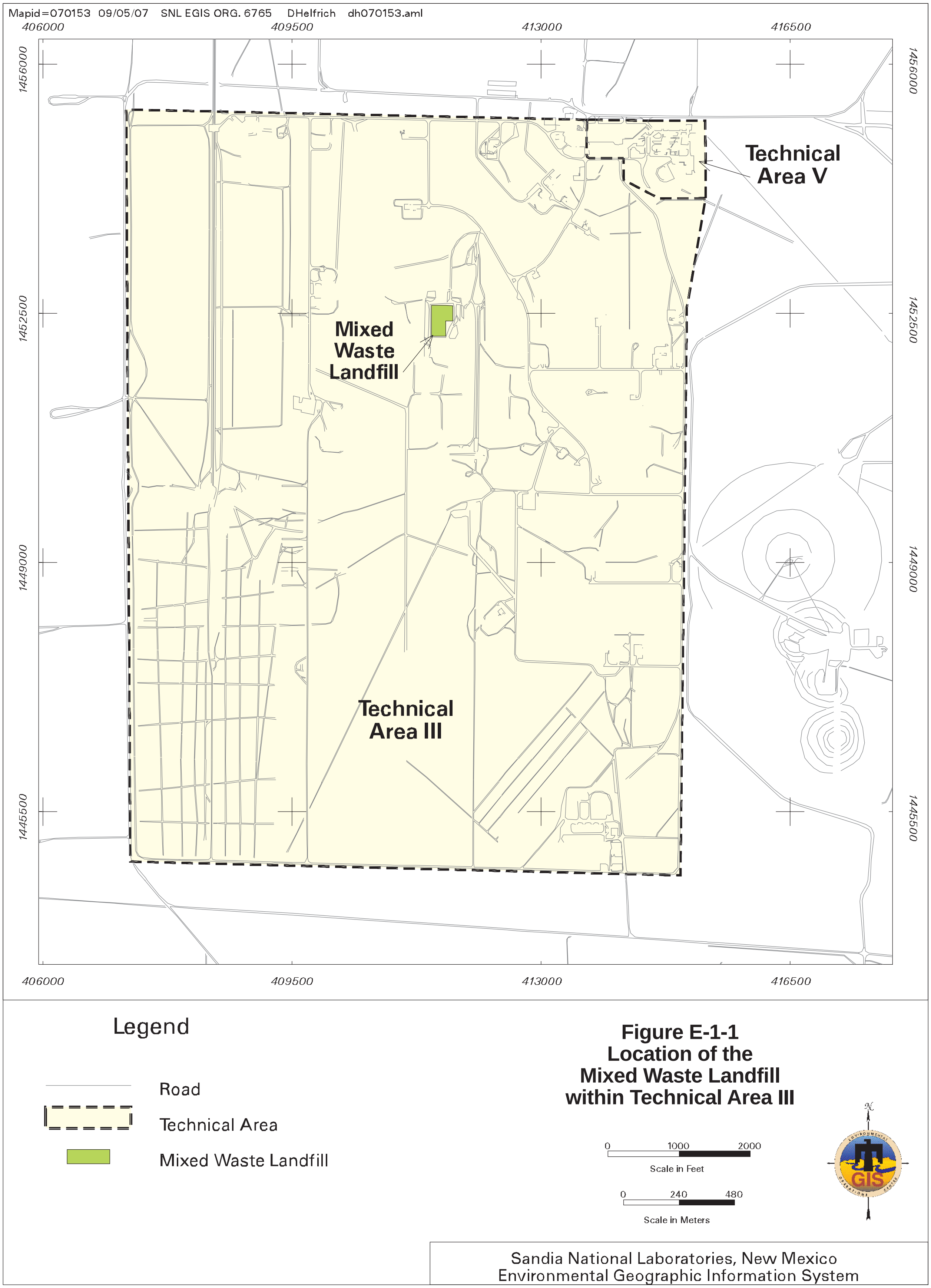

Figure E-1-1
Location of the
Mixed Waste Landfill
within Technical Area III

840857.04310000 A24.ai

2.0 BACKGROUND INFORMATION

The MWL Corrective Measures Implementation Work Plan was written and submitted to the NMED in November 2005 (SNL/NM November 2005). NMED reviewed the document, and responded with a "Notice of Disapproval" letter dated November 20, 2006 (NMED November 2006). This letter described a number of deficiencies related to the MWL cover, construction plans, performance and fate and transport modeling, and monitoring triggers. The letter also included a requirement for additional sampling at the landfill, as follows:

> "The NMED expects surface soil surrounding animal burrows (including ant nests) to be monitored for radionuclides and metals. Develop triggers that are protective of both human health and the environment for radionuclides and metals in soil" (NMED November 2006).

In the "Responses to the NMED Notice of Disapproval" (SNL/NM January 2007) the U.S. Department of Energy (DOE) and Sandia Corporation (Sandia) stated the following:

> "During long-term monitoring at the MWL, DOE/Sandia will monitor animal burrows and ant nests (ant hills).
>
> Current plans are to survey locations of animal burrows and ant hills by GPS [global positioning system] on an annual basis, and to collect surface soil samples from animal burrows and ant hills every five years to ensure that contaminants have not been mobilized by biota. The soil samples will be analyzed for Resource Conservation and Recovery Act (RCRA) metals, gamma-emitting radionuclides, and gross alpha and gross beta activity.
>
> Triggers proposed for RCRA metals concentrations in the surface soil samples are the NMED Industrial/Occupational Soil Screening Levels (NMED 2006). Triggers proposed for gamma-emitting radionuclides are the NMED Hazardous Waste Bureau (HWB) Approved Background Values (Dinwiddie 1997)."
>
> Please note that the Consent Order (NMED April 2004) includes the corrective action requirements for the MWL but contains no requirements for radionuclides or the radioactive portion of mixed waste. Thus, any triggers proposed for radionuclides are provided voluntarily, pursuant to the Consent Order. The voluntary inclusion of such radionuclide information shall not be enforceable and shall not constitute the basis for any enforcement because such information falls wholly outside the requirements of the Consent Order. Additional information on radionuclides and the scope of the Consent Order is available in Section III.A of the Consent Order (NMED April 2004).

Although measurement of gross alpha and beta activity in soil samples from animal burrows and ant hills was originally proposed by DOE/SNL in the "Responses to the NMED Notice of Disapproval" (SNL/NM January 2007), it is not proposed in this document. The analysis of gross alpha and beta activity of soils is neither a typical, nor useful assay for soils, as naturally-occurring radioactive decay chains such as uranium-238 and thorium-232 both have alpha and beta decay radionuclides in their series, which greatly limit any ability to make meaningful interpretation of the results. For this reason, soils from ant nests and animal burrows will not be analyzed for gross alpha and beta activity. However, the soils will still be analyzed for gamma-emitting radionuclides to verify that radionuclides are not being mobilized by ants or burrowing animals. This is consistent with the routine analysis of soils conducted in the Sandia Terrestrial Surveillance Program.

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3.0 DATA QUALITY OBJECTIVES

The main DQO is to produce representative, accurate, and defensible analytical results to support the monitoring objective (i.e., provide analytical data for biotic mobilization of contaminants). This SAP is designed to ensure that procedures are consistent and can be used to establish any contaminant mobilization trends. This DQO will be accomplished through the implementation of standard operating procedures and analytical procedures/methods through the use of quality assurance measures, quality control (QC) samples, and data evaluation protocols.

3.1 Sample Locations and Sampling Frequency

The sampling locations will be identified by visually examining the surface of the landfill cover. The number of available sampling locations is variable, depending on the presence and distribution of the insects, animals, and vegetation. Up to six animal burrows, six ant hills, and six similar plants will be sampled.

The visual survey for burrows and nests, and vegetation will take place quarterly and will be recorded in the GIS database. Soil and vegetation samples will be collected on the second year following the completion of the final landfill cover. Soil and vegetation samples will be collected every two years thereafter. Animal burrows and/or ant hills will be sampled if they have developed on the MWL cover.

3.2 Data Accuracy

Proper sampling procedures and use of QC samples such as environmental sample duplicates will help reduce random and systematic sampling error or bias. Contaminant measurements can be made reliably through the use of a qualified laboratory, appropriate methodologies, and effective QA/QC procedures. These measures along with consistent implementation of the LTMMP and this SAP will satisfy the DQO for accuracy.

Accuracy is the agreement between a measured value and an accepted reference value. When applied to a set of observed values, accuracy is a combination of a random component and a systematic bias. Accuracy will be maintained and evaluated through referenced calibration standards, laboratory control samples (LCS), matrix spike (MS) samples, and surrogate spike samples. The bias component will be evaluated and expressed as a percent recovery (% R). Acceptance criteria are defined in the SNL/NM Statement of Work (SOW) for Analytical Laboratories (SNL/NM March 2003) and verified as part of the data validation process.

$$\%R = \frac{(measure\ sample\ concentration)}{true\ concentration} x 100\%$$

3.3 Precision

Precision is the agreement among a set of replicate measurements. Precision data will be derived from environmental and laboratory duplicate samples. Precision will be reported as the relative percent difference (RPD) which is calculated as follows:

$$RPD = \frac{|R_1 - R_2|}{[(R_1 + R_2)/2]} \times 100$$

RPD = Relative percent difference is calculated with the following equation and rounded to nearest whole number where:

R_1 = analysis result

R_2 = duplicate analysis result

The acceptable range for RPD is less than or equal to 20 percent.

3.4 Data Consistency and Comparability

Data consistency and comparability will be achieved through implementation of this SAP, which defines field and laboratory procedures designed for this purpose. Consistency in methods and procedures will be maintained in the following areas to ensure biotic mobilization data are consistent and that the data sets are comparable.

- Field sample collection and management
- Use of an off-site contract laboratory

After analytical results are received from the laboratory, DOE/Sandia will review the laboratory report for completeness and conformance to the sampling and data quality objectives. If problems are noted that require corrective action during these reviews, the laboratory will be contacted for further information.

Results will be compared to the trigger levels and to established soil background levels. This evaluation process will aid in characterization and allow analysis of trends, but will also help identify outliers or other potential indicators of error and inconsistency.

3.5 Quality Control

Quality control measures ensure that data are scientifically sound and of known precision and accuracy. QC samples will be collected to help reduce random and systematic sampling error or bias. Section 5.2 presents the samples needed to meet the QC requirements for biotic mobilization sampling at the MWL.

4.0 SAMPLING ACTIVITIES

This section describes the field and laboratory measures to be taken in providing biotic mobilization data.

4.1 Field Activities

Field activities include the preparation, identification, collection, and shipping of the samples and the methods and procedures governing these activities. Adherence to this protocol will help ensure uniformity, and allow comparison of the results. Activities that will be conducted in preparation for or during sampling include the following:

- Pre-field work planning
- Health and safety considerations
- Visual inspection of landfill surface for the presence of burrows and/or nests and vegetation
- Enter locations into GIS database
- Sample acquisition
- Sample documentation, handling, and shipping
- Waste management

The SNL/NM Administrative Operating Procedure (AOPs) and Field Operating Procedure (FOPs) for these activities are listed in Table E-4.1-1 as well as Sample Management Office (SMO) procedures and guidance. All personnel directly involved in survey and sampling field activities will review and abide by these procedures. The most current versions of these documents will be used.

4.2 Health and Safety

Field operations will be conducted in an approach that prioritizes the health and safety of field personnel above all other objectives. Every team member has the authority and responsibility to stop operations if an unsafe condition develops or is observed. All sampling personnel will perform field activities in accordance with the applicable Health and Safety Plan.

4.3 Surface Survey

The annual visual inspection of the surface of the landfill will be performed in order to identify the presence of burrowing animals and/or ant hills, and vegetation. All information regarding dates, locations, and species type (if available) will be maintained in a log book. Locations will be recorded in the GIS database.

Table E-4.1-1
Reference Documentation
MWL Biotic Mobilization Sampling

Document[a]	Document Title
AOP 00-03 (SNL/NM July 2007)	Data Validation Procedure for Chemical and Radiochemical Data
AOP 95-16 (SNL/NM February 2007)	Sample Management and Custody
FOP 94-01 (SNL/NM December 2006b)	Safety Meetings, Inspections and Pre-Entry Briefings
FOP 94-25 (SNL/NM November 2004)	Documentation of Field Activities
FOP 95-03 (SNL/NM March 2006)	Terrestrial Surveillance Program
NA (SNL/NM December 2003)	Quality Assurance Project Plan for the Sample Management Office

[a]The most current version will be used.
AOP = Administrative Operating Procedure.
MWL = Mixed Waste Landfill.
FOP = Field Operating Procedure.
NA = Not applicable.
SNL/NM = Sandia National Laboratories/New Mexico.

4.4 Sample Acquisition and Labeling

Samples will be collected from the designated locations using FOP 95-03 (SNL/NM March 2006). Soil will be placed in appropriate containers obtained from the laboratory and labeled with sample identification information.

A unique SNL/NM SMO issued sample identification number is assigned to each sample. The sample numbers are preprinted on self-adhesive labels in numerical order and are obtained from SMO. The sample number should be affixed to or noted on the sample label and/or the analysis request/chain of custody (AR/COC) form.

A SNL/NM sample label should be completed with indelible ink and affixed to each sample container prior to or during sampling. Each completed sample label should include the following information:

- SNLNM SMO sample number (with sample fraction designation)
- Sample matrix type
- Sample location
- Analysis required
- Date and time of sample collection
- Types of preservatives used, if any
- Name of the sampling personnel

A field log will be maintained documenting the collection of all samples.

An aliquot of soil will be collected for analysis of RCRA metals and radionuclides by gamma spectroscopy. See Section 5.0 below for sample container information.

4.5 Equipment Decontamination

All equipment that comes into contact with the sample will be decontaminated prior to and following the collection of the sample to prevent cross-contamination. Equipment and materials (including chemicals and protective clothing), decontamination procedures, and waste management are defined in the FOP 95-03 (SNL/NM March 2006).

4.6 Sample Custody Documentation

To ensure the integrity of samples from the time of collection through the reporting of analytical results, sample collection, handling, and custody will be documented. The continuous record of documented sample possession is referred to as the chain-of-custody. Primary elements in the documentation of samples are: sample identification number, sample labels, custody tape, and the AR/COC form. Standardized forms will be used to document sample information. Sample custody and documentation procedures for sampling activities are outlined in AOP 95-16 (SNL/NM February 2007).

4.7 Sample Shipment

Samples will be shipped to the analytical laboratory in accordance with FOP 95-03. Prior to shipment, the sample collection documentation will be verified. Any error will be noted and corrected as required by SNL/NM SMO protocols.

4.8 Waste Management

Waste generated during sampling activities may include used personal protective equipment and decontamination water. All waste generated will be managed in accordance with federal, state, and city regulations, and applicable SNL/NM requirements. Analytical data collected from the sampling event will be used to characterize any waste generated. Waste management activities associated with the sampling event will be performed in accordance with the requirements of the Waste Management specialist at the time.

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5.0 ANALYTICAL METHODS

The analytical laboratory will analyze samples using U.S. Environmental Protection Agency (EPA)-approved analytical methods and specified performance criteria in accordance with the SNL/NM SOW for Analytical Laboratories (SNL/NM March 2003). The analytical laboratory will provide appropriate sample containers prepared with the required sample preservative (if applicable). The analytical laboratory will prepare and submit to SNL/NM SMO an analysis data report as described in the SOW for Analytical Laboratories. Table E-5-1 summarizes analytical requirements and EPA Methods (EPA November 1986) applicable to biota monitoring at the MWL.

Table E-5-1
Laboratory Analytical Methods
MWL Biotic Mobilization Sampling

Parameter	EPA Method[a]	Container Type/Size x Number/Preservative
RCRA[b] Metals	SW846-6020/7470	1-gallon Ziplock bag
Gamma Spectroscopy (short list)	EPA 901.1 or Equivalent	1-gallon Ziplock bag

[a]U.S. Environmental Protection Agency, 1986 (and updates), "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, 3rd Edition, U.S. Environmental Protection Agency, Washington, D.C.
[b]RCRA metals = arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver.
EPA = U.S. Environmental Protection Agency.
MWL = Mixed Waste Landfill.
RCRA = Resource Conservation and Recovery Act.
SW = Solid waste.

5.1 Analytical Laboratory

The analytical laboratory is responsible for performing analyses in accordance with this SAP, SNL/NM SOW for Analytical Laboratories, and regulatory requirements. The laboratory will maintain documentation of sample handling and custody, analytical data, and internal QC data. The laboratory will analyze QC samples in accordance with this SAP, the SNL/NM SOW for Analytical Laboratories, and its own internal QC program for indicators of analytical accuracy and precision. The SNL/NM SMO will direct the laboratory activity, including investigation and corrective action, if necessary, for data generated outside laboratory acceptance limits.

In addition, two types of analytical laboratory audits may be performed as part of the sampling program and are defined as system audits and performance audits. A system audit determines whether appropriate project systems (i.e., equipment, procedures) are in place. Performance audits indicate whether the projects systems are functioning properly and are capable of meeting project DQOs. These audits will be completed as required by SNL/NM SMO procedures and protocols.

5.2 Quality Control Samples

QC samples will be analyzed in conjunction with the soil samples to ensure that the data generated meet the DQOs of this SAP. QC for the entire activity will be achieved through adherence to requirements and procedures listed and described in Section 2.0 of this SAP. Mandatory QC samples are identified in the following sections.

5.2.1 Field Quality Control Samples

Control of field operations requires the collection and analysis of field QC samples, in addition to conformance to standardized sampling procedures as defined in SNL/NM FOPs. Field QC samples are used to document data quality and identify sampling inconsistencies resulting from variability in sample collection, storage, transportation, and equipment decontamination. Field QC samples submitted to the analytical laboratory will be handled and analyzed in the identical manner as environmental samples. Field QC samples to be collected include equipment blanks and duplicate environmental samples. Table E-5.2-1 provides a description of the field QC samples.

Table E-5.2-1
Field Quality Control Samples

Sample Type	Purpose of Sample	Frequency	Acceptance Criteria	Matrix
Duplicate Samples	To evaluate the overall precision of the sampling and analysis system.	1 with each sample batch sent to the laboratory or 1 per 20 samples.	RPD less than or equal to 20 percent (guidance only, RPDs for low concentrations constituents may exceed 20 percent).	Soil
Equipment Blanks	To evaluate decontamination procedures and cross sample contamination by sampling equipment.	1 with each sample batch sent to the laboratory or 1 per 20 samples.	If contaminants are detected, the data should be evaluated in order to determine probable source and impact on sample results.	Aqueous

RPD = Relative percent difference.

Equipment blank (EB) samples demonstrate the effectiveness of equipment decontamination and monitor the cleanliness of the sampling system. After sampling equipment decontamination has been completed, an EB sample is collected prior to the collection of an environmental sample. EB samples will be collected at a frequency of 5 percent (minimum of one per MWL sampling event) and analyzed for the specified analytical parameters.

Duplicate environmental samples are collected in the field and analyzed to establish and document the precision of the sampling and analysis process. The duplicate samples will be collected immediately after the original environmental sample in order to reduce variability caused by time and/or sampling mechanics and are typically collected at a frequency of 5 percent (minimum of one per MWL sampling event).

5.2.2 Laboratory Quality Control Samples

The analytical laboratory must have established procedures that demonstrate the analytical process is always in control during each sample analysis step. The procedures include LCSs, method blank samples, and MS samples. Laboratories must operate in conformance with SNL/NM FOPs, SNL/NM AOPs, and the SNL/NM SOW for Analytical Laboratories.

An LCS consists of a control matrix (e.g., deionized water) spiked with analytes representative of the target analytes. LCSs are prepared and analyzed for each analytical procedure performed. LCSs are analyzed with each analytical batch containing environmental samples to verify the precision and bias of the analytical process. The results of the LCS analyses are compared to the control limits established to assess the usability of the data.

Method blank samples are used to check for contamination in the laboratory during sample preparation and analysis. Method blank samples are concurrently prepared and analyzed with each analytical batch. Method blanks are reported in the same units as corresponding environmental samples, and the results are included with each analytical report.

Surrogate spike analysis will be performed for all samples analyzed by Gas Chromatography/ Mass Spectroscopy. The surrogate compounds added to the sample will be those specified in the applicable EPA analytical method procedure (EPA November 1986). Recovery values for surrogate compounds that are outside specified control limits require corrective action, which is detailed in the SNL/NM SOW for Analytical Laboratories.

The analytical process shall be systematically evaluated for the effects of indigenous constituents present in the environmental sample matrix. For inorganic analytes, the precision of the analytical process shall be evaluated by preparing a laboratory replicate analyzed in accordance with the specified analytical procedures.

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6.0 DATA VALIDATION, REVIEW, AND REPORTING

Data validation and review of analytical and field documentation will be performed for completeness and conformance to the procedures established for the various activities. Field and analytical QC data will be reviewed for conformance to QC acceptance criteria. The entire data package will be reviewed for representativeness of quality and comparability to determine whether the specified DQOs have been met.

6.1 Field Measurement Data and Documentation Review

Completed field documentation will be reviewed and verified for accuracy, completeness, and conformance with established procedures. The review will occur at the end of each day in the field to allow verification, correction, and retrieval of missing information as appropriate.

6.2 Laboratory Data Verification and Validation

The SNL/NM SMO will review the laboratory report. The data package shall be reviewed for completeness and conformance to the performance criteria of the contract with the laboratory according to the SMO 05-03 (SNL/NM 2007, pending).

Upon receipt of the analytical results from the laboratory, the SNL/NM SMO will arrange for the validation of the data. The purpose of the validation is to determine the usability and establish the defensibility of the numerical results in support of the environmental and waste management activities at SNL/NM. Data qualification is based upon review of laboratory-supplied QC data, the specific QC criteria identified in the procedures for the EPA-approved analytical methods, and the DQOs identified in this SAP. Data validation will be conducted according to the requirements of AOP 00-03 (SNL/NM July 2007). All associated data validation reports will be provided along with the results for each monitoring event.

6.3 Reporting

A report of the biotic mobilization results will be submitted based upon the schedule presented in the LTMMP. The report may include a description of sampling locations and activities, a summary of laboratory analytical and measurement data, a discussion of QC analyses and data reviews, a description of project variances, and data validation summaries.

6.4 Records Management

Records associated with the biotic mobilization sampling effort including field documentation, laboratory analytical results, data validation reports, and LTMMP reports/technical data evaluations will be maintained at the SNL/NM Customer Funded Records Center and comply with the record-keeping provisions of 20.4.1.500 New Mexico Administrative Code, incorporating Title 40 Code of Federal Regulations Section 264.74, concerning the availability, retention, and disposition of records.

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U.S. Environmental Protection Agency (EPA), November 1986. "Test Methods for Evaluating Solid Waste," 3rd ed., and all updates, SW-846, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

APPENDIX F
Mixed Waste Landfill Well Database Summary Sheets

WELL DATABASE SUMMARY SHEET

Project Name:	MIXED WASTE LANDFILL	**Geo Location:**	TA III
ER ADS #:	1289	**Well Completion Date:**	01-JUL-1989
Well Name:	MWL-BW1	**Completion Zone:**	SAND AND GRAVEL
Owner Name:	SNL/NM	**Formation of Completion:**	SANTA FE
Date Drilling Started:	24-JUN-1989	**Well Comment:**	WATER LEVEL MEASURED ON 5/14/90
Drilling Contractor:	STEWART BROTHERS		
Drilling Method:	MUD ROTARY		
Borehole Depth:	519		
Casing Depth:	477.17		

Survey Data

Survey Date: 12-APR-1990

Surveyed By: SANTIAGO ROMERO AND ASSOCIATES

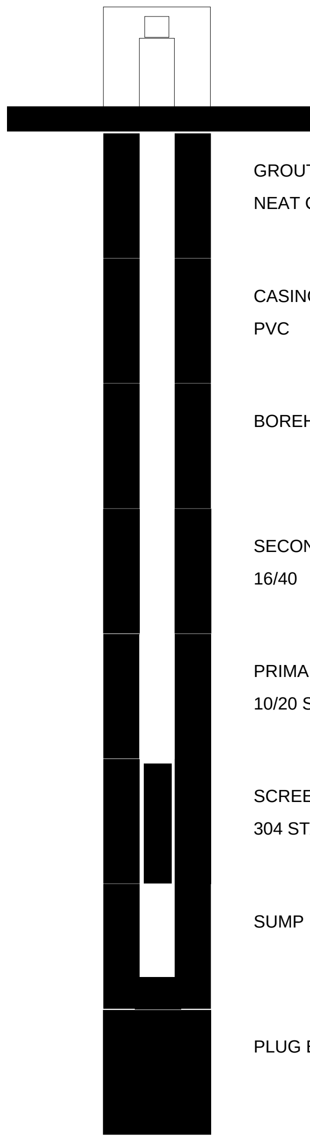
State Plane Coordinates

(X) Easting: 411756.001

(Y) Northing: 1451698.73

Surveyed Elevations (FAMSL)

Protective Casing:	5385.05
Top of Inner Well Casing:	5384.51
Concrete Pad:	5383.35
Ground Surface:	5382.7



Completion Data Measured Depths (FBGS)

Casing Stickup: 1.16

Interval		Start	Stop
GROUT/BACKFILL NEAT CEMENT		0'	433'
CASING PVC	I.D. 5"	0'	477.17'
BOREHOLE	O.D. 12.25"	0'	519'
SECONDARY PACK 16/40		441'	443'
PRIMARY PACK 10/20 SAND		443'	478'
SCREEN 304 STAINLESS STEEL	Slot Size .01"	452.17'	472.17'
SUMP		472.17'	477.17'
PLUG BACK		477.17'	519'

Calculated Depths and Elevations

Initial Water Elevation: (FAMSL) 4923.3

Initial Depth To Water: (FBGS) 461.21

Last measured water level was 4918.54 **FASL**
measured on 06-AUG-1996

Date Updated: 14-MAR-00

Date Printed: 20-JUN-2006

WELL DATABASE SUMMARY SHEET

Project Name:	MIXED WASTE LANDFILL	**Geo Location:**	TA III
ER ADS #:	1289	**Well Completion Date:**	01-JUL-1989
Well Name:	MWL-BW1	**Completion Zone:**	SAND AND GRAVEL
Owner Name:	SNL/NM	**Formation of Completion:**	SANTA FE
Date Drilling Started:	24-JUN-1989	**Well Comment:**	WATER LEVEL MEASURED ON 5/14/90
Drilling Contractor:	STEWART BROTHERS		
Drilling Method:	MUD ROTARY		
Borehole Depth:	519		
Casing Depth:	477.17		

WELL DATABASE SUMMARY SHEET

Project Name:	MIXED WASTE LANDFILL	**Geo Location:**	MIXED WASTE LANDFILL
ER ADS #:	1289	**Well Completion Date:**	01-OCT-1988
Well Name:	MWL-MW1	**Completion Zone:**	SILTY SAND
Owner Name:	SNL	**Formation of Completion:**	SANTA FE GROUP
Date Drilling Started:	28-SEP-1988	**Well Comment:**	BOREHOLE DIAM IS 14" TO 200' - 10" TO 478.67 - WATER LEV ELEV 8/16/90
Drilling Contractor:	WATER DEVELOPMENT		
Drilling Method:	AIR ROTARY		
Borehole Depth:	478.67		
Casing Depth:	478		

Survey Data

Survey Date: 01-JAN-1990

Surveyed By: SANTIAGO ROMERO AND ASSOCIATES

State Plane Coordinates

(X) Easting: 411661.747

(Y) Northing: 1452661.099

Surveyed Elevations (FAMSL)

Protective Casing:	5382.2
Top of Inner Well Casing:	5381.54
Concrete Pad:	5379.56
Ground Surface:	5379.12

Calculated Depths and Elevations

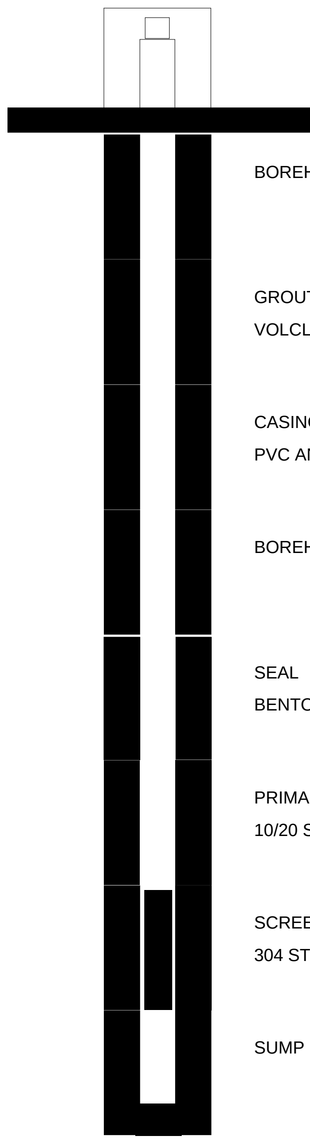
Initial Water Elevation: (FAMSL) 4923.36

Initial Depth To Water: (FBGS) 458.18

Last measured water level was 4918.82 **FASL**
measured on 06-AUG-1996

Date Updated: 14-MAR-00

Date Printed: 20-JUN-2006



Completion Data Measured Depths (FBGS)

Casing Stickup: 1.98

Interval		Start	Stop
BOREHOLE		0'	200'
	O.D.		14"
GROUT/BACKFILL		0'	434.9'
VOLCLAY			
CASING		0'	478'
PVC AND STEEL	**I.D.** 5"		
BOREHOLE		200'	478.67'
	O.D.		10"
SEAL		434.9'	445.5'
BENTONITE PELLETS			
PRIMARY PACK		445.5'	478.67'
10/20 SILICA SAND			
SCREEN		456'	476'
304 STAINLESS STEEL			
	Slot Size		.01"
SUMP		476'	478'

WELL DATABASE SUMMARY SHEET

Project Name:	MIXED WASTE LANDFILL	**Geo Location:**	MIXED WASTE LANDFILL
ER ADS #:	1289	**Well Completion Date:**	01-OCT-1988
Well Name:	MWL-MW1	**Completion Zone:**	SILTY SAND
Owner Name:	SNL	**Formation of Completion:**	SANTA FE GROUP
Date Drilling Started:	28-SEP-1988	**Well Comment:**	BOREHOLE DIAM IS 14" TO 200' - 10" TO 478.67 - WATER LEV ELEV 8/16/90
Drilling Contractor:	WATER DEVELOPMENT		
Drilling Method:	AIR ROTARY		
Borehole Depth:	478.67		
Casing Depth:	478		

WELL DATABASE SUMMARY SHEET

Project Name:	MIXED WASTE LANDFILL	**Geo Location:**	TA III
ER ADS #:	1289	**Well Completion Date:**	01-AUG-1989
Well Name:	MWL-MW2	**Completion Zone:**	SAND
Owner Name:	SNL	**Formation of Completion:**	SANTA FE
Date Drilling Started:	21-JUL-1989	**Well Comment:**	WATER LEVEL MEASURED ON 5/14/90
Drilling Contractor:	STEWART BROTHERS		
Drilling Method:	MUD ROTARY		
Borehole Depth:	521		
Casing Depth:	477		

Survey Data

Survey Date: 12-APR-1990

Surveyed By: SANTIAGO ROMERO AND ASSOCIATES

State Plane Coordinates

(X) Easting: 411451.366

(Y) Northing: 1452692.592

Surveyed Elevations (FAMSL)

Protective Casing:	5378.18
Top of Inner Well Casing:	5377.26
Concrete Pad:	5376.49
Ground Surface:	5375.71

Calculated Depths and Elevations

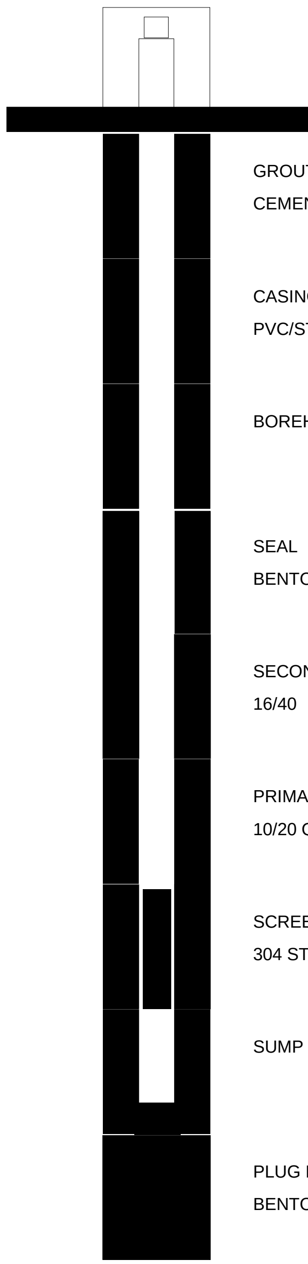
Initial Water Elevation: (FAMSL) 4923.27

Initial Depth To Water: (FBGS) 453.99

Last measured water level was 4918.78 **FASL** **measured on** 06-AUG-1996

Date Updated: 14-MAR-00

Date Printed: 20-JUN-2006



Completion Data Measured Depths (FBGS)

Casing Stickup: .77

Interval	Start	Stop
GROUT/BACKFILL CEMENT/BENTONITE	0'	430'
CASING PVC/STAINLESS STEEL — **I.D.** 5"	0'	477'
BOREHOLE — **O.D.** 12.25"	0'	521'
SEAL BENTONITE	430'	442'
SECONDARY PACK 16/40	442'	444'
PRIMARY PACK 10/20 QUARTZ SAND	444'	477'
SCREEN 304 STAINLESS STEEL — **Slot Size** .01"	452'	472'
SUMP	472'	477'
PLUG BACK BENTONITE	477'	521'

WELL DATABASE SUMMARY SHEET

Project Name:	MIXED WASTE LANDFILL	**Geo Location:**	TA III
ER ADS #:	1289	**Well Completion Date:**	01-AUG-1989
Well Name:	MWL-MW2	**Completion Zone:**	SAND
Owner Name:	SNL	**Formation of Completion:**	SANTA FE
Date Drilling Started:	21-JUL-1989	**Well Comment:**	WATER LEVEL MEASURED ON 5/14/90
Drilling Contractor:	STEWART BROTHERS		
Drilling Method:	MUD ROTARY		
Borehole Depth:	521		
Casing Depth:	477		

WELL DATABASE SUMMARY SHEET

Project Name:	MIXED WASTE LANDFILL	**Geo Location:**	TA-III
ER ADS #:	1289	**Well Completion Date:**	22-AUG-1989
Well Name:	MWL-MW3	**Completion Zone:**	SAND
Owner Name:	SNL	**Formation of Completion:**	SANTA FE
Date Drilling Started:	20-AUG-1989	**Well Comment:**	BOREHOLE TD AT 501', BACKFILL WITH .4 BENTONITE/CEMENT PLUG TO 478' ABOUT 1' OF 16/40 FN SIL SAND AT TOP OF FILTER PACK
Drilling Contractor:	STEWART BROTHERS		
Drilling Method:	MUD ROTARY		
Borehole Depth:	501		
Casing Depth:	476.3		

Survey Data

Survey Date: 16-AUG-1990

Surveyed By: SANTIAGO ROMERO AND ASSOCIATES

State Plane Coordinates

(X) Easting: 411407.995

(Y) Northing: 1452476.617

Surveyed Elevations (FAMSL)

Protective Casing:	5381.78
Top of Inner Well Casing:	5381.32
Concrete Pad:	5379.41
Ground Surface:	5378.97

Calculated Depths and Elevations

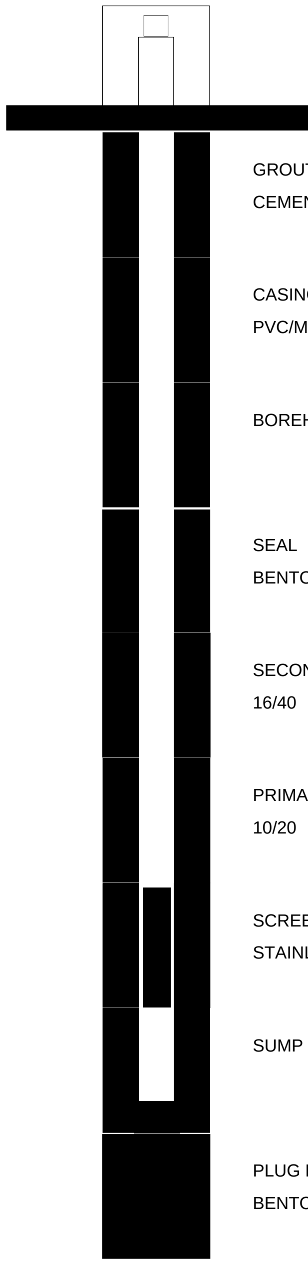
Initial Water Elevation: (FAMSL) 4921.1

Initial Depth To Water: (FBGS) 460.22

Last measured water level was 4917.35 **FASL**
measured on 06-AUG-1996

Date Updated: 14-MAR-00

Date Printed: 20-JUN-2006



Completion Data Measured Depths (FBGS)

Casing Stickup: 1.91

Interval	Start	Stop
GROUT/BACKFILL CEMENT/BENTONITE	0'	429'
CASING PVC/METAL	0'	478.8'
	O.D.	5"
BOREHOLE	0'	501'
	O.D.	12.25"
SEAL BENTONITE	429'	444'
SECONDARY PACK 16/40	444'	446'
PRIMARY PACK 10/20	446'	476'
SCREEN STAINLESS STEEL	451.3'	471.3'
	Slot Size	.01"
SUMP	471.3'	476.3'
PLUG BACK BENTONITE	476.3'	501'

WELL DATABASE SUMMARY SHEET

Project Name:	MIXED WASTE LANDFILL
ER ADS #:	1289
Well Name:	MWL-MW3
Owner Name:	SNL
Date Drilling Started:	20-AUG-1989
Drilling Contractor:	STEWART BROTHERS
Drilling Method:	MUD ROTARY
Borehole Depth:	501
Casing Depth:	476.3
Geo Location:	TA-III
Well Completion Date:	22-AUG-1989
Completion Zone:	SAND
Formation of Completion:	SANTA FE
Well Comment:	BOREHOLE TD AT 501', BACKFILL WITH .4 BENTONITE/CEMENT PLUG TO 478' ABOUT 1' OF 16/40 FN SIL SAND AT TOP OF FILTER PACK

WELL DATABASE SUMMARY SHEET

Project Name: MIXED WASTE LANDFILL
ER ADS #: 1289
Well Name: MWL-MW4
Owner Name: SNL/NM
Date Drilling Started: 16-DEC-1992
Drilling Contractor: WATER DEVELOPMENT CORPOF
Drilling Method: SONIC/DRY
Borehole Depth: 552.5
Casing Depth: 548

Geo Location: TA III
Well Completion Date: 10-FEB-1993
Completion Zone: FINE MEDIUM SAND/GRAVELLY SAND
Formation of Completion: SANTA FE GROUP
Well Comment: 2 SCREENED INTERVALS

Survey Data

Survey Date: 15-MAY-1994
Surveyed By: GREINER,INC.

State Plane Coordinates

(X) Easting: 411608.044
(Y) Northing: 1452565.255

Surveyed Elevations (FAMSL)

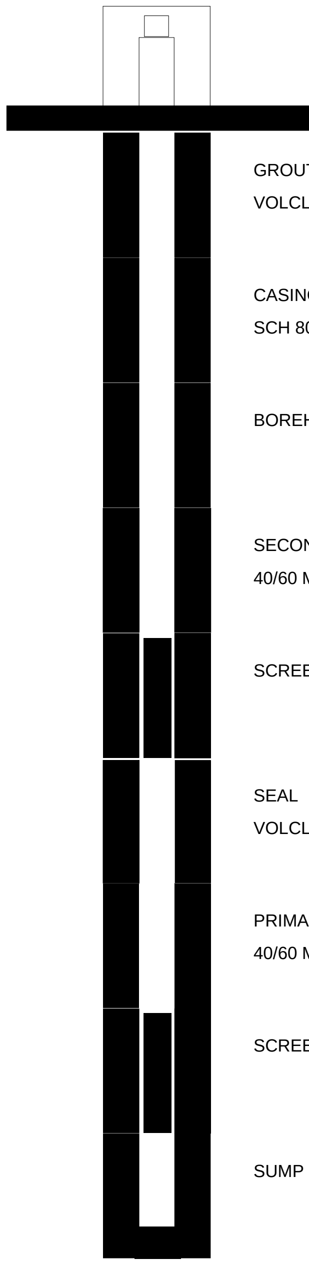
Protective Casing: 5384.05
Top of Inner Well Casing: 5383.46
Concrete Pad: 5381.35
Ground Surface: 5381.61

Calculated Depths and Elevations

Initial Water Elevation: (FAMSL) 4896.46
Initial Depth To Water: (FBGS) 487

Last measured water level was measured on **FASL**

Date Updated: 14-MAR-00
Date Printed: 20-JUN-2006



Completion Data Measured Depths (FBGS)

Casing Stickup: 2.11

Interval	Start	Stop
GROUT/BACKFILL VOLCLAY	0'	473'
CASING SCH 80 PVC	0'	548'
I.D. 4.768"		O.D. 5.563"
BOREHOLE	0'	552.5'
		O.D. 11"
SECONDARY PACK 40/60 MESH	473'	508'
SCREEN	482.5'	502.5'
Slot Size .01"		
SEAL VOLCLAY/BENTONITE	503'	520'
PRIMARY PACK 40/60 MESH	520'	552.5'
SCREEN	522.5'	542.5'
Slot Size .01"		
SUMP	542.5'	548'

WELL DATABASE SUMMARY SHEET

Project Name:	MIXED WASTE LANDFILL	**Geo Location:**	TA III
ER ADS #:	1289	**Well Completion Date:**	10-FEB-1993
Well Name:	MWL-MW4	**Completion Zone:**	FINE MEDIUM SAND/GRAVELLY SAND
Owner Name:	SNL/NM	**Formation of Completion:**	SANTA FE GROUP
Date Drilling Started:	16-DEC-1992	**Well Comment:**	2 SCREENED INTERVALS
Drilling Contractor:	WATER DEVELOPMENT CORPOF		
Drilling Method:	SONIC/DRY		
Borehole Depth:	552.5		
Casing Depth:	548		

WELL DATABASE SUMMARY SHEET

Project Name:	MIXED WASTE LANDFILL	**Geo Location:**	TAIII
ER ADS #:	1289	**Well Completion Date:**	19-NOV-2000
Well Name:	MWL-MW5	**Completion Zone:**	SILTY SAND
Owner Name:	SNL/NM	**Formation of Completion:**	SANTA FE GROUP
Date Drilling Started:	03-OCT-2000	**Well Comment:**	
Drilling Contractor:	STEWART BROTHERS		
Drilling Method:	ARCH		
Borehole Depth:	550		
Casing Depth:	521.5		

Survey Data

Survey Date: 26-JAN-2001

Surveyed By: ALBUQUERQUE SURVEYING CO.

State Plane Coordinates

(X) Easting: 411261.94

(Y) Northing: 1452294.82

Surveyed Elevations (FAMSL)

Protective Casing:	5380.53
Top of Inner Well Casing:	5379.89
Concrete Pad:	5377.97
Ground Surface:	5377.65

Calculated Depths and Elevations

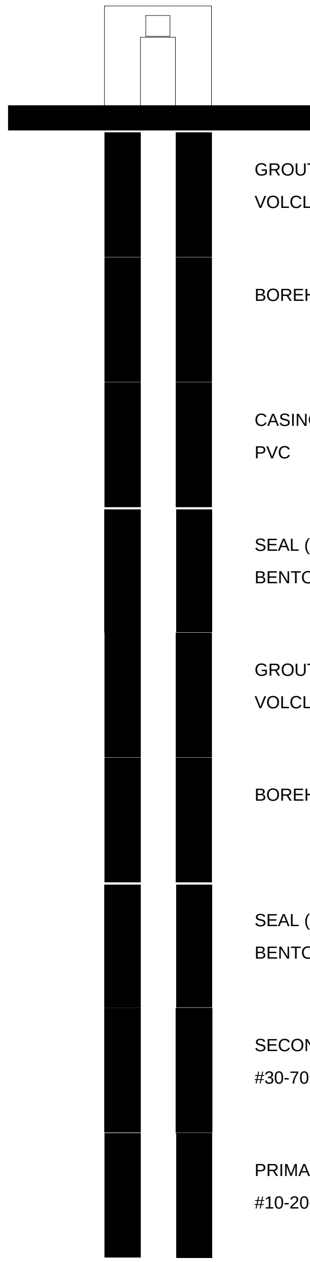
Initial Water Elevation: (FAMSL) 4893.3

Initial Depth To Water: (FBGS) 486.59

Last measured water level was measured on **FASL**

Date Updated: 18-APR-01

Date Printed: 20-JUN-2006



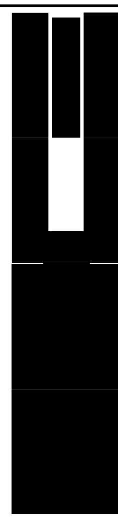
Completion Data Measured Depths (FBGS)

Casing Stickup: 2.24

Interval	Start	Stop
GROUT/BACKFILL (1) VOLCLAY	0'	171'
BOREHOLE (1)	0'	300' **O.D.** 11.75"
CASING PVC	0'	521.5'
SEAL (1) BENTONITE PELLETS	171'	192'
GROUT/BACKFILL (2) VOLCLAY	192'	465'
BOREHOLE (2)	300'	550' **O.D.** 9.625"
SEAL (2) BENTONITE PELLETS	465'	487'
SECONDARY PACK #30-70 SAND	487'	489'
PRIMARY PACK #10-20 SAND	489'	521'

WELL DATABASE SUMMARY SHEET

Project Name:	MIXED WASTE LANDFILL	**Geo Location:**	TAIII
ER ADS #:	1289	**Well Completion Date:**	19-NOV-2000
Well Name:	MWL-MW5	**Completion Zone:**	SILTY SAND
Owner Name:	SNL/NM	**Formation of Completion:**	SANTA FE GROUP
Date Drilling Started:	03-OCT-2000	**Well Comment:**	
Drilling Contractor:	STEWART BROTHERS		
Drilling Method:	ARCH		
Borehole Depth:	550		
Casing Depth:	521.5		



Interval	**Start**	**Stop**
SCREEN	496.5'	516.5'
5" PVC		
	Slot Size	.02"

Interval	**Start**	**Stop**
SUMP	516.5'	521.5'

Interval	**Start**	**Stop**
PLUG BACK (1)	521.5'	527'
BENTONITE PELLETS		

Interval	**Start**	**Stop**
PLUG BACK (2)	527'	546'
#10-20 SAND		

WELL DATABASE SUMMARY SHEET

Project Name: MIXED WASTE LANDFILL
ER ADS #: 1289
Well Name: MWL-MW6
Owner Name: SNL/NM
Date Drilling Started: 07-SEP-2000
Drilling Contractor: STEWART BROTHERS
Drilling Method: ARCH
Borehole Depth: 550
Casing Depth: 505.5

Geo Location: TA III
Well Completion Date: 19-OCT-2000
Completion Zone: SAND
Formation of Completion: SANTA FE GROUP
Well Comment:

Survey Data

Survey Date: 26-JAN-2001
Surveyed By: ALBUQUERQUE SURVEYING CO.

State Plane Coordinates

(X) Easting: 410925.5
(Y) Northing: 1452656.51

Surveyed Elevations (FAMSL)

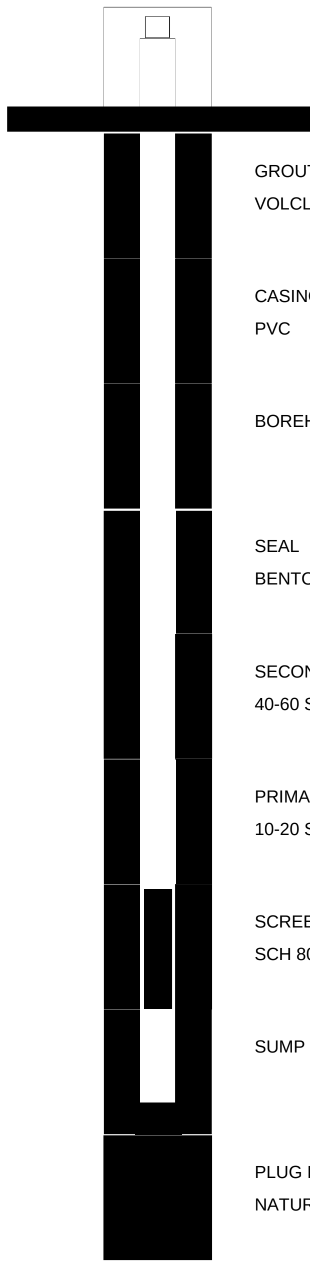
Protective Casing: 5372.87
Top of Inner Well Casing: 5372.64
Concrete Pad: 5370.21
Ground Surface: 5369.96

Calculated Depths and Elevations

Initial Water Elevation: (FAMSL) 4888.8
Initial Depth To Water: (FBGS) 483.84

Last measured water level was measured on **FASL**

Date Updated: 18-APR-01
Date Printed: 20-JUN-2006



Completion Data Measured Depths (FBGS)

Casing Stickup: 2.68

Interval	Start	Stop
GROUT/BACKFILL VOLCLAY	0'	478'
CASING PVC	0'	505.5' **O.D.** 5"
BOREHOLE	0'	550' **O.D.** 9.625"
SEAL BENTONITE PELLETS	478'	493'
SECONDARY PACK 40-60 SAND	493'	499'
PRIMARY PACK 10-20 SAND	499'	537'
SCREEN SCH 80 PVC	505.5'	525.5' **Slot Size** .02"
SUMP	525.5'	530.5'
PLUG BACK NATURAL BACKFILL	537'	550'

WELL DATABASE SUMMARY SHEET

Project Name:	MIXED WASTE LANDFILL	**Geo Location:**	TA III
ER ADS #:	1289	**Well Completion Date:**	19-OCT-2000
Well Name:	MWL-MW6	**Completion Zone:**	SAND
Owner Name:	SNL/NM	**Formation of Completion:**	SANTA FE GROUP
Date Drilling Started:	07-SEP-2000	**Well Comment:**	
Drilling Contractor:	STEWART BROTHERS		
Drilling Method:	ARCH		
Borehole Depth:	550		
Casing Depth:	505.5		

APPENDIX G
Mixed Waste Landfill Long-Term Monitoring Inspection Forms

Biology Checklist for MWL Cover

Mixed Waste Landfill
Post-Closure Inspection Form
Biology Inspection Checklist for the MWL Cover

Mandatory requirement:

The inspector has read the MWL Long-Term Monitoring Plan and activity-related procedures in the last 12 months, and completed all required training: (*Inspector must initial box before proceeding with the inspection.)*

Date read ______________________

Approximate vegetative coverage (actively photosynthesizing): ______%

Approximate percent native vegetation of the total vegetative cover: ______%

Listed below are the main plant species identified growing on the MWL cover and the approximate percent cover for each species.

Scientific Name	Common Name (optional)	% [a]

[a]Total cover photosynthesizing

Mixed Waste Landfill
Biology Inspection Checklist for the MWL Cover (Continued)

Are there any contiguous areas of no vegetation greater than 200 square feet? (approximately 14 x14 ft.): _______

If "Yes," mark such areas on a map and attach to this checklist, and provide the MWL project lead with recommendations to improve such area(s) with native vegetation via soil augmentation, scarification, and/or reseeding.

Are there any very deeply rooted (roots greater than 8 feet deep at maturity) plant species present on the cover? ________

If "Yes," mark such areas on a map and attach to this checklist, and remove plant(s) from the cover.

Notes: ____

____

____

____

Inspection for animal burrow intrusion into MWL cover

Are any burrows present on the cover? ______

Does any burrow(s) appear to be active? ______

Does any active burrow(s) appear to be that of a species that is able to burrow 6 feet deep or greater? ______

If any of the active burrows appear to be that of a species that is able to burrow 6 feet or greater, mark such burrow(s) on a map and attach at the end of this checklist, and provide the MWL project lead with recommendations to take actions as necessary to prevent damage to the cover.

Notes: ____

____

Biological Aspects Map – [note: sketch map to locate specific features will be attached]

Survey Biologist Name: ______________________________ Date: _____________

Original to: Sandia National Laboratories Customer-Funded Records Center

Mixed Waste Landfill
Inspection Checklist

Mixed Waste Landfill
Long-Term Monitoring
Inspection Checklist

1. Date of Inspection ________________________
2. Time of Inspection ________________________
3. Name of Inspector ________________________

Mandatory requirement:

The inspector has read the MWL Long-Term Monitoring Plan and activity-related procedures in the last 12 months, and completed all required training: (*Inspector must initial box before proceeding with the inspection.)* ☐

Date read _______________________

Provide explanatory notes for each parameter not inspected or each action required. Include any remedial steps required.

I. COVER SYSTEM [Quarterly]			
Inspection Parameters	***Parameter Inspected (Yes or No)***	***Action Required (Yes or No)***	***Note Number***
A. Visible settlement of the soil cover in excess of 6 inches.			
B. Erosion of the soil cover in excess of 6 inches deep.			
C. Evidence of water ponding.			
D. Animal intrusion burrows in excess of 4 inches in diameter.			
E. Evidence of growth of very deeply rooted (rooted greater than 8 feet deep at maturity) plant species.			
F. Contiguous areas of no vegetation greater than 200 ft^2.			
II. SURFACE-WATER (STORM-WATER) DIVERSION STRUCTURES [Quarterly]			
Inspection Parameters	***Parameter Inspected (Yes or No)***	***Action Required (Yes or No)***	***Note Number***
A. Channel or sidewall erosion in excess of 6 inches deep.			
B. Channel sediment accumulation in excess of 6 inches deep.			
C. Debris that blocks more than 1/3 of the channel width.			

Mixed Waste Landfill
Inspection Checklist (Continued)

III. FENCE [Quarterly]			
Inspection Parameters	***Parameter Inspected (Yes or No)***	***Action Required (Yes or No)***	***Note Number***
A. Accumulation of wind-blown plants and debris.			
B. Fence wires and posts in need of repair/maintenance.			
C. Gates in need of oiling/repair/maintenance.			
D. Locks in need of cleaning or replacement.			
E. Warning signs in need of repair or replacement.			
F. Survey monuments in vicinity of MWL visible.			

IV. SOIL-VAPOR AND GROUNDWATER MONITORING WELLS [Semi-Annually]			
Inspection Parameter	***Parameter Inspected (Yes or No)***	***Action Required (Yes or No)***	***Note Number***
A. Concrete pads, bollards, and protective casings in need of repair/maintenance.			
B. Well cover caps and Swagelok® dust caps in need of repair/maintenance.			
C. Soil-vapor monitoring ports, pumps and tubing in need of repair/maintenance.			
D. Monitoring wells and soil-vapor sample port locations properly labeled.			
E. Locks in need of cleaning or replacement.			
V. PREVIOUS DEFICIENCIES [Quarterly]			
Inspection Parameter	***Parameter Inspected (Yes or No)***	***Action Required (Yes or No)***	***Note Number***
A. Uncorrected/undocumented previous deficiencies.			

Mixed Waste Landfill
Inspection Checklist (Continued)

NOTES

Note Number	Description

Mixed Waste Landfill
Inspection Checklist (Continued)

Action (Note Number) _____ assigned to _________________Date action completed_________

Action (Note Number) _____ assigned to _________________Date action completed_________

Action (Note Number) _____ assigned to _________________Date action completed_________

Action (Note Number) _____ assigned to _________________Date action completed_________

Action (Note Number) _____ assigned to _________________Date action completed_________

Additional Comments:

Inspector's Signature ___________________________

Original to: Mixed Waste Landfill Operating Record

Copy to: Sandia National Laboratories Customer-Funded Records Center