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2011 Annual Summary Report for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada National Security Site Nye County, Nevada

Review of the Performance Assessments and Composite Analyses

Prepared for

U.S. Department of Energy,
National Nuclear Security Administration
Nevada Site Office

Prepared by

National Security Technologies, LLC
Las Vegas, Nevada

Under Contract Number
DE-AC52-06NA25946

March 2012

National Security Technologies LLC
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EXECUTIVE SUMMARY

The *Maintenance Plan for the Performance Assessments and Composite Analyses for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site* (National Security Technologies, LLC, 2007a) requires an annual review to assess the adequacy of the Performance Assessments (PAs) and Composite Analyses (CAs), with the results submitted annually to U.S. Department of Energy (DOE) Office of Environmental Management. The Disposal Authorization Statements for the Area 3 and Area 5 Radioactive Waste Management Sites (RWMSs) also require that such reviews be made and that secondary or minor unresolved issues be tracked and addressed as part of the maintenance plan (DOE, 1999a; 2000).

The U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office performed an annual review of the Area 3 and Area 5 RWMS PAs and CAs for fiscal year (FY) 2011. This annual summary report presents data and conclusions from the FY 2011 review, and determines the adequacy of the PAs and CAs. Operational factors (e.g., waste forms and containers, facility design, and waste receipts), closure plans, monitoring results, and research and development (R&D) activities were reviewed to determine the adequacy of the PAs. Likewise, the environmental restoration activities at the Nevada National Security Site (NNSS) (formerly the Nevada Test Site) relevant to the sources of residual radioactive material that are considered in the CAs, the land-use planning, and the results of the environmental monitoring and R&D activities were reviewed to determine the adequacy of the CAs.

Important developments in FY 2011 include the following:

- Operation of a new shallow land disposal unit and a new Resource Conservation and Recovery Act (RCRA)–compliant lined disposal unit at the Area 5 RWMS
- Development of new closure inventory estimates based on disposals through FY 2011
- Evaluation of new or revised waste streams by special analysis
- Development of version 2.102 of the Area 3 RWMS GoldSim PA model
- Development of version 4.113 of the Area 5 RWMS GoldSim PA model

Analysis of the latest available data using the Area 5 RWMS v4.113 GoldSim PA model indicates that all performance objectives can be met. The results and conclusions of the Area 5 RWMS PA are judged valid, and there is no need to the revise the PA.

The Area 3 RWMS has been in inactive status since July 1, 2006, with the last shipment received in April 2006. In FY 2011, there were no operational changes, monitoring results, or R&D results for the Area 3 RWMS that would impact PA validity. Despite the increase in waste volume and inventory at the Area 3 RWMS since 1996 when the PA was approved, the facility performance evaluated with the Area 3 RWMS PA GoldSim model, version 2.0 (with the final closure inventory), remains well below the performance objectives set forth in U.S. Department of Energy Order DOE O 435.1, “Radioactive Waste Management” (DOE, 2001). The conclusions of the Area 3 RWMS PA remain valid. A special analysis was prepared to update

the PA and CA results for the Area 3 RWMS in FY 2011. Release of the special analysis is planned for FY 2012.

The continuing adequacy of the CAs was evaluated with the new models, and no significant changes that would alter CA results or conclusions were found. Inclusion of the Frenchman Flat Underground Test Area (UGTA) results in the Area 5 RWMS CA is scheduled for FY 2016, pending the completion of the closure report for the Frenchman Flat UGTA corrective action unit (CAU) in FY 2015. An industrial site, CAU 547, with corrective action sites near the Area 3 RWMS was found to have a significant plutonium inventory in 2009. CAU 547 will be evaluated for inclusion of future revisions or updates of the Area 3 RWMS CA. The revision of the Area 3 RWMS CA, which will include the UGTA source terms, is expected in FY 2024, following the completion of the Yucca Flat CAU Corrective Action Decision Document, scheduled for FY 2023.

Near-term R&D efforts will focus on continuing development of the Area 3 and Area 5 RWMS GoldSim PA/CA and inventory models.

TABLE OF CONTENTS

List of Figures

List of Tables

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ACRONYMS AND ABBREVIATIONS

ac	acre
^{241}Am	americium-241
BN	Bechtel Nevada
Bq	becquerel
Bq m^{-2} s^{-1}	becquerel per square meter per second
CA	composite analysis
CADD	Corrective Action Decision Document
CAP	Corrective Action Plan
CAS	Corrective Action Site
CAU	Corrective Action Unit
CFR	Code of Federal Regulations
Ci	curie
^{60}Co	cobalt-60
CY	calendar year
DAS	Disposal Authorization Statement
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ET	evapotranspirative
FEPs	features, events, and processes
FFACO	*Federal Facility Agreement and Consent Order*
ft	foot
ft^3	cubic foot
FY	fiscal year
GCD	Greater Confinement Disposal
ha	hectare
hr	hour
INEL	Idaho National Engineering Laboratory
LFRG	Low-Level Waste Disposal Facility Federal Review Group
LHS	Latin hypercube sampling
LLW	low-level waste
LLWMU	Low-Level Waste Management Unit

ACRONYMS AND ABBREVIATIONS (continued)

m	meter
m^3	cubic meter
mSv	millisievert
NDEP	Nevada Division of Environmental Protection
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NNSS	Nevada National Security Site
NSTec	National Security Technologies, LLC
PA	performance assessment
pdf	probability density function
^{193}Pt	platinum-193
R&D	research and development
^{226}Ra	radium-226
RaDU	radium disposal unit
RCRA	Resource Conservation and Recovery Act
^{222}Rn	radon-222
RTG	radioisotope thermoelectric generator
RWAP	Radioactive Waste Acceptance Program
RWMS	Radioactive Waste Management Site
SLB	shallow land burial
^{90}Sr	strontium-90
TBq	terabecquerel
^{99}Tc	technetium-99
TED	total effective dose
^{230}Th	thorium-230
^{232}Th	thorium-232
TLD	thermoluminescent dosimeter
TRU	transuranic
^{234}U	uranium-234
^{238}U	uranium-238
UGTA	Underground Test Area
WAC	waste acceptance criteria
yr	year

1.0 INTRODUCTION

This report summarizes the results and conclusions of an annual review of the Area 3 and Area 5 Radioactive Waste Management Sites (RWMSs) performance assessments (PAs) and composite analyses (CAs). The Area 3 and Area 5 RWMSs were issued Disposal Authorization Statements (DASs) in accordance with U.S. Department of Energy Order DOE O 435.1 "Radioactive Waste Management" (U.S. Department of Energy [DOE], 2001). The Area 3 RWMS and Area 5 RWMS DASs (DOE, 1999a; 2000) require preparation of an annual summary report and a determination of the continuing adequacy of the PAs and CAs. The requirement to prepare an annual summary report is implemented in the Maintenance Plan for the PAs and CAs (National Security Technologies, LLC [NSTec], 2007a). The annual summary report is submitted to DOE Office of Environmental Management for review and approval.

The purpose of the annual review is to summarize changes in site operations, facility design, site monitoring, research and development (R&D), PA/CA models, and planning documents that may impact the validity of the PA and CA. The impact of changes and new information on the adequacy of the PA and CA is evaluated by answering three key questions:

1. Does the annual summary information indicate that changes to the PA or CA are required?
2. Does the annual summary information indicate that the conclusions of the PA and CA remain valid?
3. Does the annual summary information indicate that facility performance will remain within the U.S. Department of Energy Manual DOE M 435.1-1, "Radioactive Waste Management," (DOE, 1999b) PA performance objectives, CA performance goals, and any conditions in the facility DAS?

Following the annual summary format in U.S. Department of Energy Guide DOE G 435.1-4, "Maintenance Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analysis" (DOE, 1999c), this report presents the annual summary for the PAs in Section 2.0 and the CAs in Section 3.0. The annual summary for the PAs includes the following:

- Section 2.1 summarizes changes in waste disposal operations and includes new estimates of the closure inventories derived from the actual disposals through fiscal year (FY) 2011.
- Section 2.2 summarizes changes related to facility design and environmental monitoring.
- Section 2.3 summarizes closure plans and land use plans.
- Section 2.4 summarizes R&D activities conducted under the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) Closure and Monitoring Plans for the Area 3 and Area 5 RWMSs (NSTec, 2007b; 2008).
- Section 2.5 is a summary of changes, including proposed and discovered changes, in facility design, operation, future plans, the monitoring plan, R&D activities, and the maintenance program.

- Section 2.6 answers the key review questions addressing the continuing validity of the PA.

Section 3.0 presents the annual summary for the CAs emphasizing changes not addressed in the PA annual summary. The annual summary for the CAs includes the following:

- Section 3.1 presents an assessment of activities at the Nevada National Security Site (NNSS), formerly the Nevada Test Site, that would impact the sources of residual radioactive material considered in the CAs.
- Section 3.2 summarizes R&D results for FY 2011.
- Section 3.3 updates the status of sources of residual radioactive material interacting with the Area 3 and Area 5 RWMSs.
- Section 3.4 summarizes of changes in monitoring plans, R&D activities, and the maintenance program that occurred since the CAs were prepared.
- Section 3.4.3.1 updates the CA results using the FY 2011 inventories and models.
- Section 3.5 answers the key review questions regarding the continuing validity of the CA.

Appendix A is a self evaluation of the Low-Level Waste Disposal Facility Federal Review Group (LFRG) checklist for review of the annual summary.

1.1 STATUS OF DISPOSAL AUTHORIZATION STATEMENT CONDITIONS

The Area 3 RWMS PA and CA were issued in a single document (Shott et al., 2001). The Area 3 RWMS was issued a DAS on October 20, 1999 (DOE, 1999a). The Area 3 RWMS DAS contained one PA condition and two CA conditions (Tables 1 and 2). The DAS conditions were resolved with the revision of the PA/CA document (Shott et al., 2001).

Table 1. Status of the Area 3 RWMS DAS PA Conditions

Condition	Status
"Provide to LFRG, within eight months of the date of issuance of this disposal authorization statement, a revision to the performance assessment that includes resolution of the following secondary issues: 1) Lack of justification for excluding particular exposure scenarios based on exhumed waste, 2) Inadequate justification for omission of surface water, 3) Lack of sensitivity analysis regarding the assumed 250 years of institutional control, 4) Need for clarification of the RCRA/CERCLA regulatory involvement, if any, in low-level waste disposal at Area 3, 5) Need for clarification of the location of the point of maximum exposure, 6) Need for better explanation of the borehole and field data within the framework of the no-recharge conceptual model."	A revised Area 3 RWMS PA/CA was issued in December 2001 (Shott et al., 2001). The DAS conditions were closed in 2002 (DOE, 2002a).

Table 2. Status of the Area 3 RWMS DAS CA Conditions

Condition	Status
"Provide to LFRG, within eight months of the date of issuance of this disposal authorization statement, a revision to the composite analysis that includes qualitative assessment including an options analysis of the effect of groundwater contamination resulting from underground nuclear testing. Before any portion of the Nevada Test Site is considered for a reduction in institutional control, Nevada Operations Office will have quantified the potential dose from the underground testing residues and taken measures to mitigate the dose, as appropriate."	A revised Area 3 RWMS PA/CA was issued in December 2001 (Shott et al., 2001). The DAS conditions were closed in 2002 (DOE, 2002a).
"Resolution of the following secondary issues identified in the review of the composite analysis: Need for a better explanation of the borehole and field data within the framework of the no-recharge conceptual model."	A revised Area 3 RWMS PA/CA was issued in December 2001 (Shott et al., 2001). The DAS conditions were closed in 2002 (DOE, 2002a).

The Area 5 RWMS PA documentation consists of the original DOE O 435.1 low-level waste (LLW) PA (Shott et al., 1998), referred to as the 1998 Area 5 RWMS PA, and supporting addenda (Bechtel Nevada [BN], 2001a; 2006). The Area 5 RWMS CA was issued as a single document (BN, 2001b) and has a single addendum (BN, 2001c).

In addition to the LLW PA, a PA was prepared and approved to meet the requirements of Title 40 Code of Federal Regulations (CFR) Part 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Waste" (CFR, 1994). The 40 CFR 191 PA was prepared for transuranic (TRU) waste disposed in Greater Confinement Disposal (GCD) boreholes at the Area 5 RWMS (Cochran et al., 2001).

The Area 5 RWMS DAS was issued on December 5, 2000 (DOE, 2000). The PA and CA each had two conditions (Tables 3 and 4). The DAS conditions were closed on May 23, 2002.

Table 3. Status of the Area 5 RWMS DAS PA Conditions

Condition	Status
"The specific radionuclide concentration or inventory limits shall be imposed on Pit 6 to ensure that performance objectives will not be exceeded. A quantitative dose estimate shall be calculated using the reduced inventory to determine compliance with the performance objective."	An addendum to the Area 5 RWMS PA was issued in November 2001 (BN, 2001a). The DAS conditions were closed in 2002 (DOE, 2002b).
"The closure plan shall require a closure cap thickness of at least 4 meters as stated in Section 5.1 of the 1998 PA to ensure that performance objectives for the agricultural scenario will not be exceeded. A quantitative dose estimate shall be calculated using the 4 meter cap to demonstrate compliance with the performance objectives."	An addendum to the Area 5 RWMS PA was issued in November 2001 (BN, 2001a). The DAS conditions were closed in 2002 (DOE, 2002b).

Table 4. Status of the Area 5 RWMS DAS CA Conditions

Condition	Status
"The CA for the RWMS shall either be revised or an addendum issued within one year of the date of the issuance of this DAS to incorporate the Supplemental Information. The revised CA or addendum shall be submitted to the LFRG. Nevada Operations Office shall address all secondary issues and issues identified in Appendix B of the Review Team Report through the maintenance program."	An addendum to the Area 5 RWMS CA was issued in November 2001 (BN, 2001c). The DAS conditions were closed in 2002 (DOE, 2002b).
"Consistent with the site's Land-Use Plan and the conditions identified in the Area 3 DAS before any portion of the Nevada Test Site is considered for a reduction in institutional controls, Nevada Operations Office will have quantified the potential dose from the underground testing residues."	An addendum to the Area 5 RWMS CA was issued in November 2001 (BN, 2001c). The DAS conditions were closed in 2002 (DOE, 2002b).

1.2 TRACKING OF MINOR ISSUES

Tracking and resolution of all minor or secondary issues identified in the LFRG review reports for the Area 3 and Area 5 RWMS PAs and CAs continued in FY 2011. Table 5 lists the minor issues that are being tracked and resolved through the maintenance program. The resolution pathway for each issue is included in the third column of Table 5.

Table 5. Minor Issues Identified in the LFRG Review Reports for the Area 3 and Area 5 RWMS PAs and CAs

Identified Issue	Source Document for Issue	Resolution Pathway
An engineered barrier will be added, and the assurance requirements of 40 CFR 191 must be met for the GCD boreholes.	GCD PA	An engineered barrier will be added, and the assurance requirements will be met at the time of final closure of the Area 5 RWMS in FY 2028.
Inconsistencies exist between conceptual models for the Area 5 RWMS PA and CA, the Area 3 RWMS PA and CA, and the GCD PA.	Area 5 RWMS PA, Area 5 RWMS CA, Area 3 RWMS PA/CA, GCD PA	The continuous development of probabilistic performance assessment models using the GoldSim software system is systematically eliminating inconsistencies; this work will continue to be described in annual summary reports.
Conduct site monitoring and site characterization studies, as required, to increase confidence in the results of the PAs.	Area 3 RWMS PA/CA	Monitoring programs at both Area 5 and Area 3 RWMSs are ongoing; data are being incorporated into the GoldSim models to increase confidence in the PA results.
The maintenance program must include periodic assessment of changes in potentially interacting sources (Underground Test Areas [UGTAs], industrial sites) and impacts on the CAs	Area 5 RWMS CA, Area 3 RWMS PA/CA	Changes in potentially interacting sources will be evaluated through the maintenance program, and results will be presented in the annual summary reports.

Identified Issue	Source Document for Issue	Resolution Pathway
The maintenance program must include periodic assessment of changes in land-use restrictions and impacts on the CAs.	Area 5 RWMS CA, Area 3 RWMS PA/CA	Changes in land-use restrictions will be reviewed through the maintenance program, and results will be presented in the annual summary reports.
Monitoring systems need to be deployed and data gathered and evaluated to distinguish between interacting sources at the Area 3 RWMS.	Area 3 RWMS PA/CA	The monitoring systems deployed at the disposal facilities are described in the site closure plans (NSTec, 2007b; 2008); monitoring results will be evaluated and presented in the annual summary reports.

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2.0 PERFORMANCE ASSESSMENT REVIEW

The PA maintenance plan requires an annual review of waste operations including evaluation of waste forms, waste containers, facility design, waste acceptance criteria (WAC), closure design, and waste inventory. Changes in waste inventory, facility design, WAC, environmental monitoring, institutional controls, and closure design occurring during FY 2011 are noted and described below. The impacts of these changes are assessed in Section 2.5.

2.1 WASTE DISPOSAL OPERATIONS

2.1.1 Waste Forms and Containers

The Area 3 and Area 5 RWMS PAs do not explicitly model the effects of waste forms and containers on the near-field release of radionuclides. Radionuclides are assumed to be fully available for release and transport at site closure. These assumptions continue to apply for waste disposed at the Area 3 and Area 5 RWMSs through FY 2011.

2.1.2 Waste Receipts

The Area 3 and Area 5 RWMS PAs analyze waste inventories that are estimated as the sum of known past disposals and estimated future disposals. The closure inventory estimate changes over time as records of past disposals are revised or when future waste forecasts change. Closure inventory uncertainty is dominated by uncertainty in future disposals. Sources of uncertainty that are unique to future disposals include approval of new generators or new waste streams and wastes being sent to alternative disposal sites. The FY 2011 closure inventory estimates for the Area 3 and Area 5 RWMS are summarized below.

2.1.2.1 New or Revised Waste Streams

Each new or revised waste stream is evaluated by the Radioactive Waste Acceptance Program (RWAP) for its potential impacts on the PA and conformance with WAC. Part of this evaluation includes a comparison of waste concentrations with the WAC action levels using a sum of fractions calculation. Waste streams with a sum of fractions greater than one or with a potential to alter PA assumptions or conceptual models require a special analysis.

Special analyses for new or revised waste streams are performed by adding the additional inventory to the Area 5 RWMS PA model and determining if all performance objectives can be met. Occasionally, waste streams may present issues other than inventory changes that require a special analysis. If the special analysis shows that all performance objectives can be met, the waste stream is recommended for approval.

In FY 2011, 12 special analyses were performed for new or revised waste streams (Table 6). Eleven of the 12 special analyses were required due to the waste streams' potential to impact radon-222 (^{222}Rn) flux density. Waste streams impacting the ^{222}Rn flux density had high concentrations of ^{222}Rn parents (e.g., radium-226 [^{226}Ra], thorium-230 [^{230}Th], uranium-234 [^{234}U], and/or uranium-238 [^{238}U]). Two waste streams had other nuclides (technetium-99 [^{99}Tc]

and cobalt-60 [^{60}Co]) that exceed WAC action levels. The results of the special analyses indicated that all performance objectives could be met with the addition of the waste streams to the site inventory. Ten waste streams requiring special analysis in FY 2011 were accepted without conditions. Two sealed source waste streams, DRTK000000034 and ORNLSOURCES01, were accepted with conditions. The DRTK000000034 waste stream was limited to a total ^{226}Ra inventory of 4.4E11 becquerels (Bq). The ORNLSOURCES01 waste stream was limited to sealed sources with a maximum activity of 5.5E10 Bq per source.

Table 6. Waste Streams Evaluated by Special Analysis in FY 2011

Waste Stream	Description	Issue	Result
DRTK000000034, Rev. 0	Lawrence Berkley National Laboratory Sealed Sources	^{222}Rn Flux Density	Accepted with Conditions
INEL11ARPROMC, Rev. 0	Idaho National Engineering Laboratory (INEL) Macroencapsulated Roaster Oxides	^{222}Rn Flux Density	Accepted
INEL11ARPROSB, Rev. 0	INEL Stabilized Roaster Oxides	^{222}Rn Flux Density	Accepted
LANL000000018, Rev. 0	Los Alamos National Laboratory ^{60}Co Source	^{60}Co Inventory	Accepted
LITN000000006, Rev. 14	Navarro Investigation Derived Waste	^{222}Rn Flux Density	Accepted
ORNLSOURCES01, Rev. 0	Oak Ridge National Laboratory Sealed Sources	^{222}Rn Flux Density	Accepted with Conditions
PGDPPAD000011, Rev. 0	Paducah Neptunium Low-Level Waste	^{222}Rn Flux Density	Accepted
PGDPPAD000016, Rev. 0	Paducah Unclassified Debris	^{222}Rn Flux Density, ^{99}Tc Inventory	Accepted
PORTLPP000026, Rev. 1	Portsmouth High Gram Low Enrichment Uranium Metal	^{222}Rn Flux Density	Accepted
WVDP000000012, Rev. 5	West Valley Extraction Cell 2 Waste	^{222}Rn Flux Density	Accepted
WVDP000000013, Rev. 8	West Valley Contaminated Concrete and General Debris	^{222}Rn Flux Density	Accepted
WVDP000000023, Rev. 0	West Valley Asbestos Contaminated Low-Level Waste	^{222}Rn Flux Density	Accepted

2.1.2.2 FY 2011 Closure Inventory Estimate for the Area 3 RWMS

The Area 3 RWMS was placed in inactive status July 1, 2006, by closing active disposal units with operational covers and suspending waste disposal operations. Although the site remains available for future disposal of large volume bulk waste streams, no waste streams are currently designated for the Area 3 RWMS. The current inventory estimate assumes no future waste disposals.

The FY 2011 inventory is estimated with the Area 3 Inventory model, version 2.016. The model sums past disposals and revisions estimates probabilistically. Probability distributions

representing uncertainty in annual activity disposed are sampled each FY during operations. Radioactive decay and ingrowth during the operational period are explicitly included in the model. The estimated inventories are decayed until the assumed date of closure on September 30, 2025. The current estimate is not significantly different from the previous estimate. There are no significant changes to the underlying inventory data and the inventory model.

Pre-1988 waste is disposed in U-3ax/bl and U-3ah/at, with 80 percent of the volume and 99 percent of the activity disposed in U-3ax/bl (Table 7). The total pre-1988 inventory as of October 1, 2025, consists of approximately 1.5×10^2 terabecquerels (TBq) (4.1×10^3 curies [Ci]) in 2.3×10^5 cubic meters (m^3) (8.1×10^6 cubic feet [ft^3]) of waste.

Table 7. FY 2011 Estimate of the Area 3 RWMS Inventory Disposed before September 26, 1988 (Estimates are calculated from 500 Latin hypercube sampling [LHS] realizations and decayed to October 1, 2025)

	U-3ax/bl		U-3ah/at	
Nuclide	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
H-3	1.3E+14	3.13	7.7E+11	2.17
C-14	1.0E+11	3.13	1.1E+08	2.88
Al-26	4.0E+06	3.16	4.3E+03	2.90
Cl-36	2.2E+10	3.27	2.4E+07	2.91
Ar-39	1.0E+11	3.16	1.1E+08	2.98
K-40	6.0E+09	3.07	6.7E+06	2.65
Ca-41	1.6E+11	3.07	1.7E+08	3.08
Co-60	1.2E+10	3.20	*Negligible*	
Ni-59	4.2E+09	3.13	4.5E+06	2.83
Ni-63	3.4E+11	3.19	4.0E+08	2.85
Kr-85	6.4E+10	3.10	1.3E+08	2.67
Sr-90	5.2E+12	3.08	7.8E+09	2.53
Zr-93	5.7E+08	3.08	6.3E+05	2.67
Nb-93m	7.4E+10	3.31	1.2E+08	2.91
Nb-94	1.4E+11	3.26	1.5E+08	3.01
Tc-99	1.4E+10	2.45	1.0E+10	3.81
Pd-107	2.5E+07	3.08	2.8E+04	2.68
Cd-113m	6.4E+10	3.17	1.1E+08	2.94
Sn-121m	1.4E+12	3.18	1.7E+09	2.93
Sn-126	2.5E+08	3.08	2.7E+05	2.66
I-129	1.3E+07	3.08	1.4E+04	2.66
Cs-135	4.4E+08	3.07	4.9E+05	2.66
Cs-137	7.2E+12	3.06	1.0E+10	2.61
Sm-151	5.5E+11	3.07	6.5E+08	2.66
Eu-150	2.0E+11	3.38	2.3E+08	3.59
Eu-152	4.9E+11	3.25	8.8E+08	3.02

Nuclide	U-3ax/bl		U-3ah/at	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
Eu-154	8.8E+10	3.26	2.0E+08	3.17
Ho-166m	5.4E+09	3.17	5.9E+06	2.92
Pb-210	4.0E+11	4.07	1.1E+05	2.19
Ra-226	5.5E+11	4.07	3.6E+05	2.19
Ra-228	1.4E+09	2.71	4.8E+05	2.66
Ac-227	1.3E+06	2.20	1.7E+06	2.22
Th-228	8.3E+09	2.85	7.8E+06	2.87
Th-229	1.5E+07	3.05	1.4E+04	2.62
Th-230	3.6E+07	2.04	4.4E+07	2.19
Th-232	1.5E+09	2.71	4.9E+05	2.66
Pa-231	3.0E+06	2.21	4.2E+06	2.22
U-232	5.9E+09	3.24	7.0E+06	2.91
U-233	3.5E+09	3.07	3.9E+06	2.60
U-234	9.3E+10	2.13	1.3E+11	2.19
U-235	3.6E+09	2.22	5.3E+09	2.22
U-236	2.5E+09	2.82	2.4E+09	2.84
U-238	4.3E+10	2.31	1.1E+11	2.55
Np-237	5.3E+08	2.46	2.3E+08	2.40
Pu-238	2.0E+11	3.08	1.8E+10	2.61
Pu-239	1.2E+12	3.05	2.3E+09	2.17
Pu-240	3.1E+11	3.05	5.8E+08	2.11
Pu-241	4.6E+11	3.09	1.6E+09	2.02
Pu-242	1.2E+08	3.07	1.6E+05	2.31
Am-241	3.8E+11	3.03	7.0E+08	2.07
Am-243	5.2E+07	3.12	5.7E+04	2.69
Cm-244	9.2E+09	3.10	1.5E+07	2.66
Total	**1.5E+14**		**1.1E+12**	

Negligible – Inventory less than 37 becquerels (Bq)

The post-1988 waste is disposed in U-3ah/at and U-3bh (Table 8). The post-1988 inventory is estimated to consist of approximately 1.2×10^3 TBq (3.4×10^4 Ci) in 3.3×10^5 m^3 (1.2×10^7 ft^3) of waste. On an activity basis, the inventory is predominantly tritium (^3H).

Table 8. FY 2011 Estimate of the Area 3 RWMS Inventory Disposed after September 26, 1988 (Estimates are calculated from 500 LHS realizations and decayed to October 1, 2025)

Nuclide	U-3ah/at		U-3bh	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
H-3	7.5E+15	2.06	4.5E+15	2.15
C-14	9.8E+10	1.76	3.0E+07	2.11
Al-26	9.5E+04	2.40	*Negligible*	
Cl-36	6.1E+08	2.29	*Negligible*	
Ar-39	2.6E+09	2.50	*Negligible*	
Ar-42	4.4E+08	2.01	2.4E+08	2.49
K-40	2.6E+09	1.82	7.1E+08	2.58
Ca-41	4.0E+09	2.39	*Negligible*	
Ti-44	1.2E+10	2.04	5.6E+09	2.61
Co-60	3.6E+09	1.79	2.4E+09	1.89
Ni-59	9.4E+08	2.31	1.7E+08	2.06
Ni-63	2.1E+11	1.77	7.5E+09	1.97
Se-79	2.5E+07	2.13	*Negligible*	
Kr-85	3.6E+09	2.13	*Negligible*	
Sr-90	3.1E+14	2.75	4.4E+10	1.94
Zr-93	1.4E+07	2.28	*Negligible*	
Nb-93m	2.8E+09	2.42	*Negligible*	
Nb-94	3.4E+09	2.56	1.8E+08	2.10
Tc-99	2.0E+12	1.90	7.7E+10	1.98
Pd-107	6.2E+05	2.28	*Negligible*	
Cd-113m	2.7E+09	2.41	*Negligible*	
Sn-121m	3.7E+10	2.42	*Negligible*	
Sn-126	5.8E+08	2.15	9.1E+05	2.66
I-129	4.7E+08	2.03	2.4E+08	2.63
Cs-135	1.1E+07	2.29	*Negligible*	
Cs-137	1.7E+14	1.96	4.9E+10	1.75
Ba-133	5.0E+09	1.99	1.6E+09	2.73
Sm-151	1.5E+10	2.28	1.2E+06	2.23
Eu-150	6.1E+09	2.76	*Negligible*	
Eu-152	3.9E+10	1.87	1.3E+09	2.42
Eu-154	8.6E+09	1.99	1.6E+08	2.04
Ho-166m	1.3E+08	2.38	*Negligible*	
Pb-210	9.6E+10	1.77	4.5E+08	1.86
Bi-207	3.8E+05	2.27	1.8E+07	2.19
Bi-210m	6.7E+06	1.96	2.1E+08	2.23
Ra-226	1.0E+11	1.98	9.4E+08	2.25

Nuclide	U-3ah/at		U-3bh	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
Ra-228	1.3E+10	1.69	1.9E+11	2.70
Ac-227	2.5E+09	1.85	1.4E+06	2.15
Th-228	7.2E+10	1.91	1.8E+11	2.70
Th-229	4.0E+07	1.95	4.8E+07	2.53
Th-230	4.7E+10	2.00	7.1E+10	2.72
Th-232	1.4E+10	1.71	2.0E+11	2.70
Pa-231	3.8E+08	1.79	5.0E+06	2.16
U-232	5.3E+10	2.20	*Negligible*	
U-233	1.6E+10	1.93	2.2E+10	2.52
U-234	7.4E+12	1.98	1.3E+11	2.08
U-235	3.4E+11	1.83	1.1E+10	2.18
U-236	3.6E+11	2.34	9.6E+07	2.71
U-238	1.3E+13	1.74	5.8E+11	2.32
Np-237	2.4E+11	2.08	1.5E+08	1.91
Pu-238	5.6E+11	1.97	1.8E+11	2.07
Pu-239	2.7E+12	1.68	5.1E+11	1.85
Pu-240	5.4E+11	1.70	8.6E+10	2.07
Pu-241	1.5E+12	1.75	1.6E+11	2.00
Pu-242	1.1E+08	1.61	4.0E+07	2.32
Am-241	5.3E+11	1.56	8.8E+10	1.84
Am-242m	2.3E+08	2.18	3.3E+06	2.84
Am-243	5.9E+08	1.80	4.3E+07	2.63
Cm-243	3.1E+06	1.74	9.9E+05	2.61
Cm-244	8.2E+09	1.60	1.1E+08	2.09
Cm-245	5.4E+08	1.90	8.2E+06	2.64
Cm-246	8.8E+07	1.86	*Negligible*	
Cm-247	7.0E+05	2.72	*Negligible*	
Cf-249	3.4E+03	2.21	*Negligible*	
Cf-250	1.3E+03	2.81	*Negligible*	
Cf-251	2.2E+08	2.29	*Negligible*	
Total	**8.0E+15**		**4.5E+15**	

Negligible – Inventory less than 37 Bq

The volume of waste disposed at the Area 3 RWMS is divided approximately equally between the pre- and post-1988 period (Figure 1). The total activity has been disposed predominately in the post-1988 period since 2000 (Figure 2).

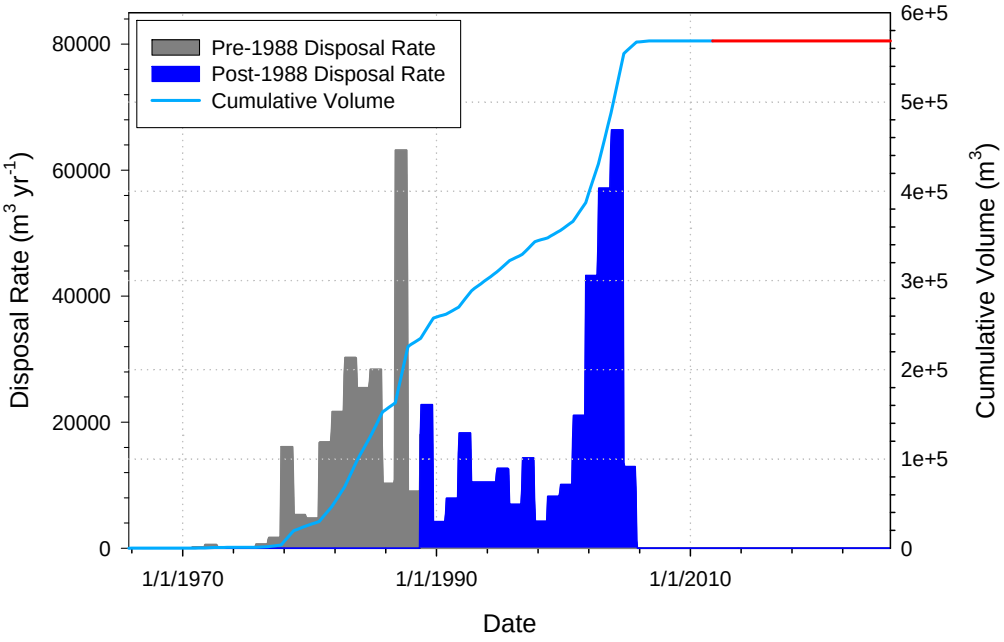

Figure 1. Annual Volume Disposal Rate and Median Cumulative Volume for the Area 3 RWMS

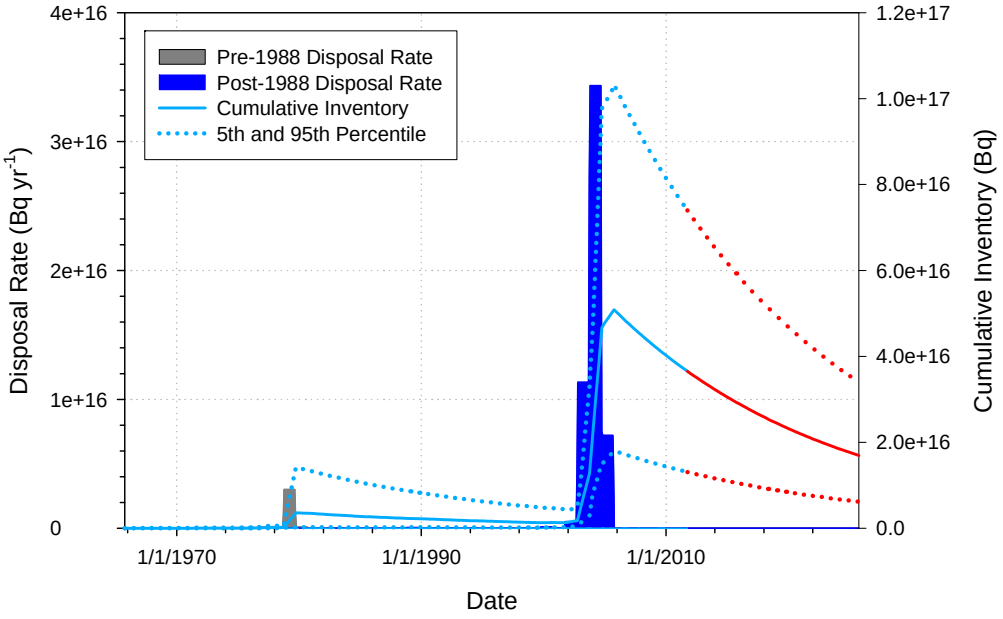

Figure 2. Activity Annual Disposal Rate and Median Inventory for the Area 3 RWMS

2.1.2.3 FY 2011 Closure Inventory Estimate for the Area 5 RWMS

The Area 5 RWMS PA GoldSim model divides the site inventory into three virtual disposal units based on the depth of burial. Most wastes are disposed in shallow land burial (SLB) disposal

units. Wastes capable of producing significant ^{222}Rn flux densities are disposed below thicker covers in two radium disposal units (RaDUs), the lower cell of Pit 6 and Pit 13. High specific activity wastes have been disposed in GCD boreholes. The inventory of the three virtual disposal units is further divided into pre-1988, post-1988 disposed, and future portions.

The FY 2011 estimate of the Area 5 RWMS closure inventory was prepared using the GoldSim Area 5 Inventory v2.108 model. The model sums past disposals, revisions, and future inventory estimates probabilistically. Probability distributions representing uncertainty in annual activity disposed are sampled each FY during operations. Radioactive decay and ingrowth during the operational period are explicitly included in the model. The estimated inventories are decayed until the assumed date of closure on September 30, 2028.

No significant changes were made to the Area 5 inventory model in FY 2011. Significant increases in the ^{226}Ra and ^{238}U inventory are reported for FY 2011, consistent with the large number of special analyses conducted for these nuclides (Table 9). No new radionuclides were disposed in FY 2011. A single radionuclide, platinum-193 (^{193}Pt), exceeded the PA screening threshold and was added to the PA models.

Table 9. FY 2011 Estimate of the Area 5 RWMS SLB Inventory (Estimates are calculated from 500 LHS realizations and decayed to October 1, 2028)

Nuclide	Pre-1988 SLB		Post-1988 SLB		Future SLB	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
H-3	3.6E+16	1.89	3.5E+16	1.54	5.7E+16	2.89
C-14	2.8E+11	1.86	2.6E+13	2.09	1.3E+12	5.30
Al-26	9.1E+06	1.92	2.5E+05	1.93	1.1E+03	33.00
Cl-36	5.2E+10	1.92	2.4E+08	2.26	2.2E+06	8.39
Ar-39	2.3E+11	1.93	9.9E+08	2.35	*Negligible*	
Ar-42	*Negligible*		6.7E+08	2.11	2.1E+06	425.29
K-40	1.3E+10	1.88	2.7E+10	1.53	5.8E+09	3.11
Ca-41	3.7E+11	1.90	1.5E+09	2.33	8.0E+03	1572.41
Ti-44	*Negligible*		2.1E+10	2.11	2.1E+08	198.48
Co-60	2.5E+12	2.31	2.7E+14	1.82	1.2E+14	4.74
Ni-59	9.6E+09	1.91	2.8E+12	1.70	3.2E+11	4.78
Ni-63	7.3E+11	1.90	2.5E+14	1.70	3.0E+13	4.87
Se-79	*Negligible*		3.7E+12	1.98	9.7E+10	110.99
Kr-85	4.8E+11	2.52	7.3E+09	1.68	1.6E+09	4.21
Sr-90	1.7E+15	4.16	1.7E+16	2.14	1.4E+15	10.82
Zr-93	1.2E+09	1.89	8.1E+07	1.95	2.8E+06	25.26
Nb-93m	1.2E+11	1.94	1.0E+09	2.23	6.1E+06	7.60
Nb-94	3.0E+11	1.94	2.1E+11	2.23	4.1E+09	27.87
Tc-99	1.2E+13	2.67	4.3E+14	1.66	6.5E+13	3.60

Nuclide	Pre-1988 SLB		Post-1988 SLB		Future SLB	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
Pd-107	5.6E+07	1.89	9.0E+05	1.79	4.2E+04	7.89
Ag-108m	*Negligible*		2.5E+11	2.78	3.7E+08	295.28
Cd-113m	1.0E+11	1.94	3.3E+10	2.36	9.1E+08	67.28
Sn-121m	2.8E+12	1.90	1.4E+10	2.36	2.9E+04	44.56
Sn-126	5.4E+08	1.89	4.0E+10	1.89	1.5E+09	26.93
I-129	4.1E+07	1.82	1.8E+10	1.92	1.7E+09	5.19
Cs-135	9.8E+08	1.88	3.4E+07	1.81	7.0E+05	46.78
Cs-137	3.4E+15	3.03	1.0E+15	1.99	1.4E+14	4.37
Ba-133	1.8E+08	2.95	9.5E+09	1.69	3.4E+09	5.00
Pm-145	*Negligible*		8.6E+04	2.24	6.5E+03	40.65
Pm-146	*Negligible*		1.5E+05	1.87	5.7E+04	11.51
Sm-151	1.1E+12	1.89	2.1E+10	1.74	1.5E+09	6.55
Eu-150	4.2E+11	2.09	2.0E+09	2.73	*Negligible*	
Eu-152	2.7E+12	2.17	4.9E+13	2.08	4.2E+12	15.31
Eu-154	3.0E+11	2.11	6.8E+13	1.76	1.3E+13	10.30
Gd-148	*Negligible*		1.5E+04	1.68	2.7E+03	7.07
Ho-166m	1.2E+10	1.92	2.8E+08	1.88	1.3E+04	2289.10
Pt-193	*Negligible*		2.2E+11	1.97	1.1E+08	6870.79
Pb-210	1.2E+12	2.79	3.4E+11	1.49	7.3E+10	2.28
Bi-207	5.9E+05	3.00	1.5E+07	1.75	1.7E+06	5.61
Bi-210m	*Negligible*		6.0E+07	2.15	2.7E+04	610.02
Ra-226	1.6E+12	2.80	5.5E+11	1.65	1.1E+11	2.71
Ra-228	4.7E+10	2.39	6.8E+11	1.46	2.8E+11	2.58
Ac-227	1.2E+10	1.79	1.0E+11	2.07	9.6E+09	5.96
Th-228	6.6E+10	2.07	2.6E+12	1.68	6.5E+11	2.53
Th-229	1.7E+08	2.03	6.0E+11	1.86	4.4E+10	4.74
Th-230	4.3E+10	1.80	3.0E+11	1.50	1.4E+11	3.30
Th-232	4.8E+10	2.39	7.2E+11	1.46	3.5E+11	2.62
Pa-231	7.5E+09	1.79	1.2E+10	1.38	2.4E+09	2.08
U-232	1.3E+10	1.97	1.7E+12	1.98	2.3E+11	4.23
U-233	3.7E+10	2.09	1.3E+14	2.23	6.6E+12	7.90
U-234	8.2E+13	1.94	1.6E+14	1.37	4.5E+13	1.97
U-235	3.3E+12	1.96	6.9E+12	1.37	2.3E+12	1.82
U-236	1.1E+12	2.66	7.2E+12	1.53	1.3E+12	2.46
U-238	9.0E+13	2.08	4.1E+14	1.46	1.2E+14	1.87
Np-237	2.3E+11	1.91	2.1E+11	1.52	3.3E+10	2.77
Pu-238	6.4E+12	1.79	6.9E+12	1.56	2.4E+12	2.31

Nuclide	Pre-1988 SLB		Post-1988 SLB		Future SLB	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
Pu-239	1.5E+13	1.84	1.5E+13	1.44	4.0E+12	2.07
Pu-240	3.5E+12	1.88	6.3E+12	1.66	1.2E+12	2.71
Pu-241	3.8E+12	1.75	3.9E+13	1.71	1.1E+13	3.25
Pu-242	7.5E+08	1.75	4.8E+11	2.18	4.5E+10	13.72
Pu-244	4.8E+09	4.05	1.5E+06	1.93	5.4E+04	10.00
Am-241	4.5E+12	1.65	9.7E+12	1.50	1.9E+12	2.55
Am-242m	*Negligible*		1.6E+09	1.75	2.6E+08	4.36
Am-243	5.3E+08	2.29	4.8E+10	1.79	5.6E+09	5.15
Cm-243	5.3E+09	2.32	6.2E+09	1.79	7.2E+08	4.45
Cm-244	8.2E+10	2.93	2.6E+12	1.80	4.2E+11	4.34
Cm-245	1.5E+05	2.84	5.3E+11	1.93	3.5E+10	11.60
Cm-246	8.4E+04	2.82	1.0E+11	1.77	8.2E+09	7.00
Cm-247	*Negligible*		5.4E+07	1.90	9.2E+05	50.71
Cm-248	7.1E+04	3.07	3.8E+07	1.82	9.0E+08	4.46
Cf-249	*Negligible*		8.5E+08	1.77	8.8E+07	3.67
Cf-250	2.8E+05	2.40	9.0E+05	1.86	4.2E+04	19.07
Cf-251	*Negligible*		9.4E+07	1.86	5.5E+06	15.37
Total	**4.1E+16**		**5.5E+16**		**5.9E+16**	

Negligible – Inventory less than 37 Bq

The arithmetic mean SLB volume estimate has increased slightly from 8.4×10^5 to 8.6×10^5 m^3 (2.97×10^7 to 3.04×10^7 ft^3) between FY 2010 and FY 2011 (Figure 3). The arithmetic mean post-1988 SLB volume has increased from 6.6×10^5 to 6.8×10^5 m^3 (2.3×10^7 to 2.4×10^7 ft^3).

The FY 2011 geometric mean closure inventory estimate increased slightly from 1.7×10^5 to 2.0×10^5 TBq (4.7×10^6 to 5.4×10^6 Ci) (Figure 4). The geometric mean post-1988 closure inventory estimate increased from 1.0×10^5 to 1.1×10^5 TBq (2.8×10^6 to 3.1×10^6 Ci).

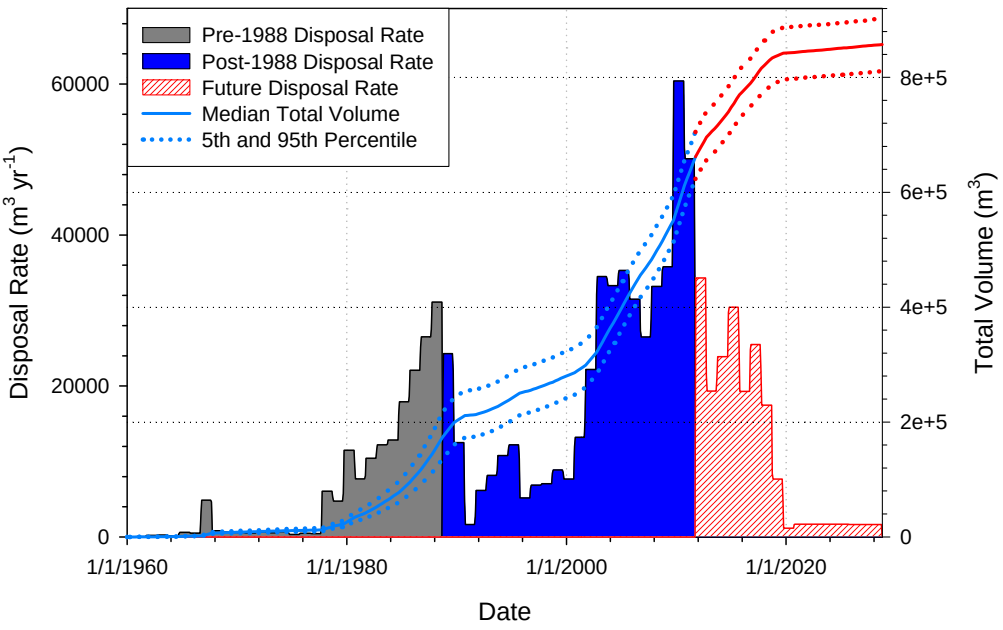

Figure 3. Annual Volume Disposal Rate and Median Cumulative Volume for the Area 5 RWMS Shallow Land Burial Disposal Units

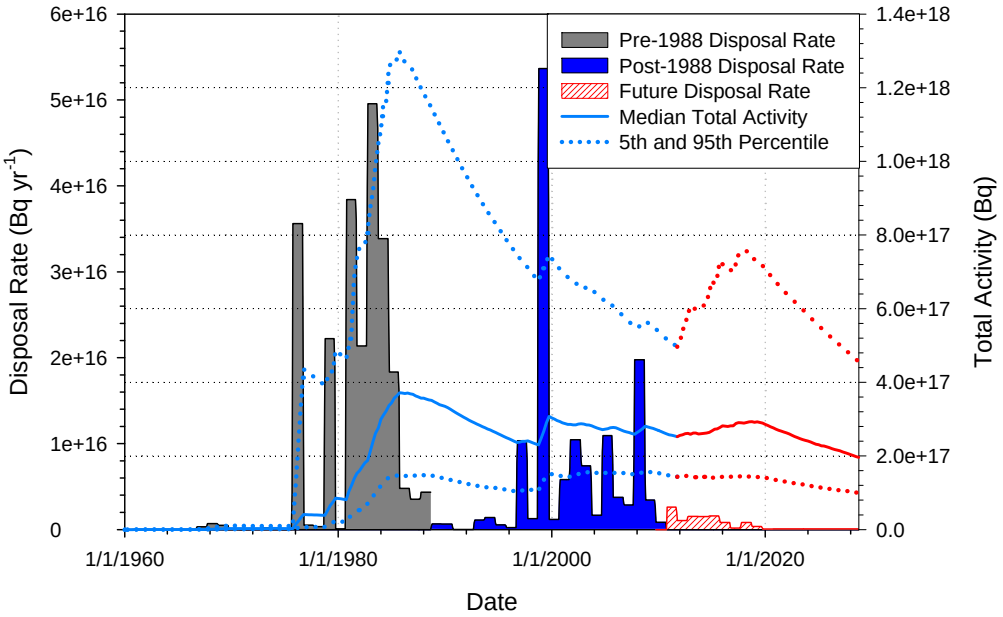

Figure 4. Annual Activity Disposal Rate and Median Inventory for the Area 5 RWMS Shallow Land Burial Disposal Units

RaDU Inventory

The lower cell of Pit 6 and Pit 13 were excavated to greater depth to contain thorium wastes that have the potential to generate ^{222}Rn in the future, as ^{226}Ra is produced by the decay of ^{230}Th. The inventory of both disposal units is predominately thorium-232 (^{232}Th). The lower cell of Pit 6 was operated from FY 1992 to FY 2002. The Pit 6 lower cell inventory remains unchanged from previous years. The upper cell of Pit 6 was filled and closed in FY 2011, and a final inventory for the upper cell is reported (Table 10).

Pit 13 began operations in FY 2004 with disposal of the Defense National Stockpile Center thorium nitrate waste stream. The entire thorium nitrate waste stream was disposed in FY 2004 and 2005 in a single layer, with the top of the waste 6.4 meters (m) (21 feet [ft]) below grade. In FY 2008 for PA modeling purposes, Pit 13 was divided into a northern RaDU portion containing the thorium nitrate waste below a thicker cover and a southern SLB portion with LLW below a thinner cover. The Pit 13 RaDU inventory is summarized in Table 10. The Pit 13 SLB inventory is included in the post-1988 SLB inventory.

Table 10. FY 2011 Estimate of the Area 5 RWMS RaDU Inventory Disposed (Estimates are calculated from 500 LHS realizations and decayed to October 1, 2028)

Nuclide	Pit 6 (Upper Cell)		Pit 6 (Lower Cell) RaDU		Pit 13 RaDU	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
H-3	3.1E+12	1.67	*Negligible*		1.5E+09	2.16
C-14	1.3E+09	2.25	*Negligible*		*Negligible*	
Al-26	1.3E+03	2.22	*Negligible*		*Negligible*	
Ar-42	1.1E+07	2.19	*Negligible*		*Negligible*	
K-40	4.1E+08	2.16	*Negligible*		4.4E+03	2.19
Ti-44	3.9E+08	2.13	*Negligible*		*Negligible*	
Co-60	2.1E+10	1.94	*Negligible*		6.9E+06	2.19
Ni-63	5.1E+10	2.11	*Negligible*		5.2E+07	2.18
Kr-85	2.2E+07	1.96	*Negligible*		*Negligible*	
Sr-90	5.2E+10	1.88	1.8E+07	2.75	6.0E+09	2.18
Nb-94	9.3E+03	2.22	*Negligible*		*Negligible*	
Tc-99	4.9E+12	2.03	9.6E+08	2.64	6.4E+10	1.83
Sn-126	*Negligible*		*Negligible*		1.4E+07	2.22
Cs-137	5.0E+10	1.83	*Negligible*		8.0E+09	2.12
Ba-133	5.8E+04	2.23	*Negligible*		*Negligible*	
Sm-151	2.3E+06	2.18	*Negligible*		*Negligible*	
Eu-152	2.3E+06	1.71	*Negligible*		1.2E+07	2.20
Eu-154	3.3E+07	1.96	*Negligible*		1.6E+07	2.22
Pb-210	1.3E+09	1.84	6.8E+09	1.60	7.1E+10	1.46
Ra-226	8.4E+08	1.93	1.9E+10	1.61	1.4E+11	1.47

Nuclide	Pit 6 (Upper Cell)		Pit 6 (Lower Cell) RaDU		Pit 13 RaDU	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
Ra-228	4.7E+09	1.91	5.9E+12	1.60	5.5E+12	1.05
Ac-227	6.0E+07	1.91	2.3E+06	1.95	6.0E+05	1.80
Th-228	4.5E+09	1.89	5.8E+12	1.60	5.4E+12	1.05
Th-229	2.7E+06	1.95	4.7E+09	2.24	2.3E+02	1.95
Th-230	2.7E+09	1.61	1.5E+12	1.62	1.9E+12	1.99
Th-232	5.2E+09	1.92	6.0E+12	1.61	5.9E+12	1.05
Pa-231	1.6E+08	1.84	6.1E+06	1.95	2.3E+06	1.81
U-232	3.7E+07	2.09	*Negligible*		2.0E+08	2.30
U-233	2.9E+08	1.99	1.8E+12	2.24	2.1E+05	1.93
U-234	3.7E+12	1.99	1.7E+11	1.84	9.1E+10	2.07
U-235	1.0E+11	1.91	9.1E+09	1.95	5.4E+09	1.84
U-236	2.6E+11	2.05	1.9E+08	2.23	9.4E+09	1.99
U-238	1.8E+13	2.08	2.2E+11	1.89	2.2E+11	1.79
Np-237	2.5E+09	1.90	8.0E+05	2.70	2.1E+09	1.91
Pu-238	1.3E+10	1.96	1.3E+10	1.98	3.9E+08	2.01
Pu-239	1.4E+11	1.68	3.2E+06	2.16	8.8E+09	1.95
Pu-240	2.6E+10	1.64	*Negligible*		4.8E+07	2.21
Pu-241	8.0E+10	1.74	1.2E+10	2.19	6.4E+09	2.00
Pu-242	6.0E+06	1.69	*Negligible*		*Negligible*	
Pu-244	4.3E+01	1.97	*Negligible*		*Negligible*	
Am-241	2.7E+10	1.52	1.1E+09	2.19	1.5E+09	1.78
Am-242m	2.6E+05	2.02	*Negligible*		*Negligible*	
Am-243	4.7E+07	1.95	*Negligible*		*Negligible*	
Cm-243	8.5E+07	2.26	*Negligible*		*Negligible*	
Cm-244	2.9E+08	2.01	*Negligible*		*Negligible*	
Cm-245	7.4E+05	2.14	*Negligible*		*Negligible*	
Cm-247	1.1E+06	2.10	*Negligible*		*Negligible*	
Cm-248	7.1E+05	2.16	*Negligible*		*Negligible*	
Cf-249	5.6E+04	1.98	*Negligible*		*Negligible*	
Total	**3.0E+13**		**2.1E+13**		**1.9E+13**	

Negligible – Inventory less than 37 Bq

GCD Inventories

The GCD boreholes have received high specific activity wastes, including TRU waste regulated under 40 CFR 191. The GCD boreholes were active from FY 1984 through FY 1990. The PA divides the GCD inventory into pre- and post-1988 portions. The majority of the waste on an activity and volume basis was disposed in the pre-1988 period. The current GCD inventory

estimates are summarized Table 11. The GCD inventories are not significantly different from previous estimates.

Table 11. FY 2011 Estimate of the Area 5 RWMS GCD Borehole Inventory (Estimates are calculated from 500 LHS realizations and decayed to October 1, 2028)

Nuclide	Pre-1988 GCD		Post-1988 GCD	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
H-3	2.2E+16	2.33	1.9E+14	2.20
C-14	7.2E+04	2.68	*Negligible*	
Cl-36	1.6E+04	2.67	*Negligible*	
Ar-39	7.4E+04	2.65	*Negligible*	
K-40	4.1E+03	2.57	*Negligible*	
Ca-41	1.1E+05	2.66	*Negligible*	
Co-60	1.1E+12	2.56	*Negligible*	
Ni-59	3.0E+03	2.67	*Negligible*	
Ni-63	2.5E+05	2.73	*Negligible*	
Kr-85	6.5E+04	2.59	*Negligible*	
Sr-90	5.4E+15	3.86	1.4E+08	3.78
Zr-93	3.9E+02	2.57	*Negligible*	
Nb-93m	6.6E+04	2.63	*Negligible*	
Nb-94	9.3E+04	2.77	*Negligible*	
Tc-99	7.7E+09	3.10	8.0E+09	3.79
Cd-113m	6.2E+04	2.67	*Negligible*	
Sn-121m	1.0E+06	2.69	*Negligible*	
Sn-126	1.7E+02	2.58	*Negligible*	
I-129	8.9E+00	2.57	*Negligible*	
Cs-135	3.0E+02	2.58	*Negligible*	
Cs-137	2.9E+14	3.81	*Negligible*	
Sm-151	3.9E+05	2.57	*Negligible*	
Eu-150	1.5E+05	3.04	*Negligible*	
Eu-152	4.7E+05	2.76	*Negligible*	
Eu-154	9.7E+04	2.73	*Negligible*	
Ho-166m	3.6E+03	2.70	*Negligible*	
Pb-210	2.6E+12	4.12	4.5E+04	2.14
Ra-226	3.4E+12	4.12	1.5E+05	2.14
Ra-228	1.0E+09	3.06	*Negligible*	
Ac-227	7.7E+10	3.95	6.4E+05	2.20
Th-228	1.0E+09	3.06	*Negligible*	
Th-229	8.5E+01	1.88	5.5E+01	2.12
Th-230	5.4E+07	2.85	1.7E+07	2.14

Nuclide	Pre-1988 GCD		Post-1988 GCD	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
Th-232	1.0E+09	3.06	*Negligible*	
Pa-231	4.6E+06	2.83	1.5E+06	2.20
U-232	4.3E+03	2.70	*Negligible*	
U-233	4.2E+04	1.90	2.9E+04	2.12
U-234	1.3E+11	2.83	4.7E+10	2.15
U-235	5.0E+09	2.82	1.8E+09	2.21
U-236	3.4E+08	3.71	5.2E+01	3.77
U-238	3.9E+10	2.52	8.5E+10	2.12
Np-237	2.5E+08	1.96	1.7E+08	2.12
Pu-238	2.9E+11	3.21	3.8E+06	3.77
Pu-239	1.7E+13	2.98	2.1E+08	3.76
Pu-240	3.7E+12	3.27	4.4E+07	3.77
Pu-241	4.1E+12	3.48	6.5E+07	4.09
Pu-242	3.5E+08	3.20	*Negligible*	
Am-241	6.0E+12	2.54	3.9E+07	3.76
Cm-244	8.0E+03	2.61	*Negligible*	
Total	**2.7E+16**		**1.9E+14**	

Negligible – Inventory less than 37 Bq

2.1.3 Waste Acceptance Criteria

WAC for the Area 3 and Area 5 RWMSs are described in *Nevada National Security Site Waste Acceptance Criteria* (NNSA/NSO, 2011a). No significant changes in the NNSS WAC occurred in FY 2011. Waste action levels continue to be based on PA results. Compliance with the NNSS WAC is ensured by the RWAP, an NNSA/NSO program (NNSA/NSO, 2006a). No changes occurred in RWAP in FY 2011.

2.2 FACILITY DESIGN

Key facility design features are specifications impacting PA conceptual models, assumptions, or input parameters. Key facility design features include the following:

- Disposal unit volume, area, and depth below grade
- Disposal unit engineered barrier design and condition
- Controls that impact and compensate for subsidence

2.2.1 Disposal Unit Design

The Area 3 RWMS uses nuclear subsidence craters as waste disposal units. The Area 3 RWMS was placed in inactive status in July 2006, with the last waste disposed in April 2006. The two post-1988 disposal units, U-3ah/at and U-3bh, are currently operationally closed. No wastes were disposed at the Area 3 RWMS and no new disposal units were opened in FY 2011.

Radioactive waste is currently disposed at the Area 5 RWMS in shallow unlined pits and trenches and a RCRA-compliant mixed waste disposal cell with a double liner. In the past, ^{222}Rn-generating waste was disposed in deeper disposal units with thicker covers known as RaDUs, and high specific activity waste was disposed in intermediate depth GCD boreholes.

Two new SLB disposal units, Pit 19 and Pit 20, were put into operation in FY 2011. The design and waste stacking procedures for these disposal units are consistent with the conceptual model of SLB disposal units used in the PA. Pit 18, a mixed waste disposal unit, was constructed in FY 2010 and began disposing waste in FY 2011. Pit 18 differs from all other SLB disposal units at the Area 5 RWMS because it has a double liner and a leachate collection system. A review of the disposal unit design and the conceptual model has concluded that the presence of the liner below the near-surface hydrodynamically active zone has no effect on the hydrologic conceptual model.

2.2.2 Engineered Barriers

Engineered barriers at the Area 3 and Area 5 RWMSs include the closure cover and the liner and leachate collection system for the Pit 18 mixed waste disposal unit at the Area 5 RWMS. The Area 3 and Area 5 RWMS closure covers are described in the PAs and closure plans. The Area 3 and Area 5 RWMS closure cover designs were unchanged in FY 2011. The Area 5 RWMS Pit 18 liner and leachate collection system was described in the FY 2010 Annual Summary Report (NSTec, 2011a). The Pit 18 liner and leachate collection system design is unchanged.

2.2.3 Environmental Monitoring

Monitoring activities at the Area 3 and 5 RWMSs and at the NNSS provide the data necessary to support PA and CA maintenance. The *Nevada Test Site Routine Radiological Environmental Monitoring Plan* (BN, 2003) is the basis for all NNSS-wide environmental surveillance, site-specific effluent monitoring, and operational monitoring conducted by various missions, programs, and projects. Closure plans for the Area 3 RWMS and Area 5 RWMS (NSTec, 2007b; 2008) describe the specific monitoring programs for the waste disposal facilities at the NNSS. No significant changes occurred in the environmental monitoring plan in FY 2011.

Current monitoring activities at the Area 3 and Area 5 RWMS are summarized in Table 12.

Table 12. Summary of Area 3 and Area 5 RWMS Monitoring Programs

Monitoring Element	Area 3 RWMS	Area 5 RWMS
Vadose Zone Monitoring	• Measurements of soil water content in waste disposal unit cover • 8 drainage lysimeters for water balance since 2001	• Measurements of soil water content and water potential in waste disposal unit covers • Measurements of soil water content in waste disposal unit floor • Two weighing lysimeters (vegetated and bare) for water balance in operation since 1994
Groundwater Monitoring	• None	• RCRA detection monitoring at three wells
Radon Monitoring	• Radon flux measurements from waste covers (various locations)	• Radon flux measurements from waste covers (various locations)
Meteorology Monitoring	• Air temperature at 3 and 10 m (10 and 33 ft) • Relative humidity at two heights • Wind speed at two heights • Wind direction at two heights • Barometric pressure • Solar radiation • Precipitation	• Air temperature at 3 and 10 m (10 and 33 ft) • Relative humidity at two heights • Wind speed at two heights • Wind direction at two heights • Barometric pressure • Solar radiation • Precipitation
Direct Radiation Monitoring	• Nine thermoluminescent dosimeters (TLDs)	• Ten TLDs
Biota Monitoring	• Sampling vegetation, small mammals, and animal burrow spoils for tritium, gamma-emitting radionuclides, strontium-90 (^{90}Sr), americium-241 (^{241}Am), and plutonium	• Sampling vegetation, small mammals, and animal burrow spoils for tritium, gamma-emitting radionuclides, ^{90}Sr, ^{241}Am, and plutonium
Subsidence Monitoring	• Routine inspection of operational covers	• Routine inspection of operational covers
Air Monitoring	• Air particulates sampled at four locations; atmospheric moisture sampling for tritium at two locations	• Air particulates sampled at two locations; atmospheric moisture sampling for tritium at two locations
Soil Temperature Monitoring around radioisotope thermoelectric generator (RTGs)	• None	• Vertical and horizontal sensor arrays around four RTGs in Pit 5

Environmental monitoring data are reported on a calendar year (CY) basis. The following four reports, published annually, contain details regarding the monitoring program and results for CY 2010:

- *Nevada National Security Site Environmental Report* (NSTec, 2011b)
- *National Emission Standards for Hazardous Air Pollutants Report* (NSTec, 2011c)
- *Waste Management Monitoring Report* (NSTec, 2011d)
- *Area 5 Groundwater Monitoring Report* (NSTec, 2012*)*

Results of the environmental monitoring programs were consistent with PA input parameters and model results (NSTec, 2011b). CY 2010 monitoring results are consistent with trends observed in previous years.

2.2.4 Stability Control

Subsidence is minimized and controlled by WAC and site operations. The NNSS WAC requires that waste packages be loaded to ensure that the interior space is loaded as compactly and as efficiently as practicable. Site operations minimize subsidence by carefully planning waste placement and by monitoring and repairing subsidence detected on closed disposal units. No changes to these procedures occurred in FY 2011.

2.3 CLOSURE DESIGN

2.3.1 Closure Plan

The approved Area 3 RWMS PA/CA assumes that the site will be closed with a vegetated monolithic evapotranspirative (ET) cover of native alluvium. The cover is assumed to be 3 m (10 ft) thick after subsidence. This was a limiting assumption consistent with closure plans for U-3ax/bl. The current cover design is for a 3 m (10 ft) monolithic ET cover (NSTec, 2007b), consistent with the Area 3 RWMS PA/CA. The Area 3 RWMS PA and CA assumptions continue to be consistent with the current closure plans.

Closure plans for the Area 5 RWMS have evolved over time based on the documented results of PA modeling. The most recently approved PA version, the 2006 Area 5 RWMS PA update (BN, 2006), assumes a 4 m (13 ft) thick closure cover. In FY 2009, an optimization of closure cover thickness was performed for the 37-hectare (ha) (92-acre [ac]) Low-Level Waste Management Unit (LLWMU), the northern expansion area, and the entire Area 5 RWMS (Shott and Yucel, 2009). The optimization used cost-benefit analysis to select the optimum cover thickness, ranging from 2.5 to 4.5 m (8.2 to 15 ft). Each cover option was constrained to meet all performance objectives and CA requirements in DOE M 435.1-1 (DOE, 1999b). The cost of collective dose averted was found to be small relative to cover construction costs. The optimum cover that meets all PA and CA requirements was found to be the 2.5 m (8.2 ft) cover. The current Area 5 RWMS v4.113 GoldSim model assumes a 2.5 m (8.2 ft) cover.

Under the *Closure Plan for the Area 5 Radioactive Waste Management Site at the Nevada Test Site* (NSTec, 2008), closure is planned in two phases. The first phase is closure of the 92-ac

LLWMU under the *Federal Facility Agreement and Consent Order* (FFACO) closure process. A Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) for the 92-ac LLWMU was approved by the Nevada Division of Environmental Protection (NDEP) in FY 2009 (NNSA/NSO, 2009). The preferred Corrective Action Alternative, a 2.5 m (8.2 ft) thick engineered monolithic ET cover, was constructed in FY 2011. Re-vegetation of the closure cover is planned for FY 2012.

The second phase, closure of the northern expansion area, is scheduled for FY 2028. The current Area 5 RWMS closure plan is to close the northern expansion area with a monolithic ET cover. The final cover thickness will be determined by future PA modeling when the final closure inventory is known. Area 5 RWMS closure plans continue to be consistent with PA modeling results.

2.3.2 Institutional Control Policy

The NNSA/NSO institutional control policy states that institutional controls will be implemented to maintain and enforce restricted access to, and use of, the NNSS and ensure the continuity of appropriate institutional controls in the future (NNSA/NSO, 2008). Based on the institutional control policy, PA/CA analyses assume implementation of land-use restrictions consistent with the UGTA FFACO closure strategies for the NNSS (NNSA/NSO, 2007). The planned land-use restrictions will prohibit public access to groundwater for 1,000 years within the UGTA regulatory boundary negotiated with the State of Nevada.

Although the final regulatory boundaries have not been negotiated, the Area 3 RWMS and Area 5 RWMS are expected to be within the boundaries of the Yucca Flat Corrective Action Unit (CAU) and the Frenchman Flat CAU, respectively. The NNSA/NSO Assistant Manager of Environmental Management has administratively agreed to include the Area 5 RWMS with the UGTA groundwater use restriction area (NNSA/NSO, 2008). The Area 5 RWMS is currently within the preliminary Frenchman Flat UGTA CAU contaminant boundary.

The institutional control policy has changed PA analyses in the following areas:

1) Long-term (i.e., chronic) exposure of intruders is assumed to be impossible based on NNSS land-use restrictions and planned UGTA groundwater-use restrictions.
2) Short-term or acute intruder exposure may occur.
3) Exposure of the member of public and short-term exposure of intruders is assumed possible after institutional controls end. The period of institutional control will be randomly sampled from a probability density function. The member of public will be located at the UGTA groundwater regulatory boundary.
4) The institutional control policy and the probabilistic period of institutional controls is not applied to the 40 CFR 191.13 containment requirements, which do not allow PAs to assume institutional control is effective beyond 100 years.

These changes are implemented in the current Area 3 RWMS PA and Area 5 RWMS PA GoldSim models except for changing the point of compliance to the UGTA groundwater regulatory boundary.

2.4 RESEARCH AND DEVELOPMENT

The PA/CA Maintenance Plan calls for annual reviews of R&D activities relevant to the PA. Onsite and offsite R&D activities (e.g., those performed at other DOE sites, the national laboratories, the Desert Research Institute, and academic institutions) provide the data used to evaluate uncertainty in conceptual models, mathematical models, and model parameters and to ensure continuing adequacy of the PA.

The DASs require NNSA/NSO to address all secondary issues (e.g., consistency of models and parameters between the Area 3 and Area 5 RWMSs) noted during the PA/CA reviews as part of the maintenance program. R&D is the mechanism for NNSA/NSO to address these issues and manage uncertainty.

No confirmatory testing is conducted under the R&D program. The environmental monitoring program includes measurement and monitoring of numerous parameters (e.g., vadose zone moisture contents, radionuclide concentrations in air and groundwater) that confirm the performance of the RWMSs and continuing adequacy of the PA.

2.4.1 Fiscal Year 2011 R&D Activities

The major R&D efforts undertaken in FY 2011 were the continuation of the development of the GoldSim models supporting the Area 3 RWMS and Area 5 RWMS PAs and CAs. Model development activities are performed to maintain consistency with known site conditions (e.g., site inventory, monitoring results), improve consistency between the Area 3 and Area 5 RWMS PA/CA models, and reduce model uncertainty.

Area 5 RWMS PA GoldSim Model Development

The FY 2011 PA update was performed with the Area 5 RWMS v4.113 PA model. Version 4.113 was approved by NNSA/NSO for all model applications, including waste stream evaluations and compliance determinations (NNSA/NSO, 2012). Major developments since version 4.110 of the model include the following:

- All inventories are updated to FY 2011 estimates.
- All model inputs were reviewed to confirm that adequate documentation existed of the original data source and any data manipulation performed to develop the input. Several inputs were identified where documentation was weak or lacking. These inputs were revised. The review identified several inputs based on very limited data where significant new data sources were known to be available. These inputs were updated with the new data (Table 13). Changed model parameters include:
    - The mean annual wind speed was updated using 15 years of data from the Area 5 RWMS Meteorology Station.

- The soil resuspension factor probability density function (pdf) was revised using the original data sources (Anspaugh et al., 1975; Shinn et al., 1986; 1997).
- The deterministic deposition velocity was revised to a pdf using the original data sources (Peterson, 1983; National Commission on Radiological Protection and Measurements, 1984).
- Ventilation (breathing) rate pdfs for four activity levels were updated using extensive new data available in the U.S. Environmental Protection Agency (EPA) Exposure Factors Handbook (EPA, 1997).
- Distributions for time spent in various activities were updated using extensive new data available in the EPA Exposure Factors Handbook (EPA, 1997).
- Distance from the Area 5 RWMS to Cane Spring and the closest site boundary was revised. The previous distances are not significantly different from the revised values, but the original source was not documented.
- Updated radionuclide half-lives with data from National Nuclear Data Center.
- Updated soil mass loading pdfs associated with various activities with pdfs developed by the Yucca Mountain Project for the Amargosa Valley (Bechtel SAIC, 2006). Development of previous distributions was not well documented and based on very limited data.
- Updated the probability of inadvertent intrusion, *p(IHI)*, by drilling and construction intrusion using the FY 2011 disposal unit areas. These values increase as disposal unit area increases.

Table 13. Summary of Parameter Changes in the A5 RWMS v 4.113 model.

Parameter		Previous Distribution or Value	New Distribution
Mean Wind Speed		*N(2.6, 0.09 m s^{-1})*	*N(2.63, 0.05 m s^{-1})*
Soil Resuspension Factor		*U(3E-13, 3E-11 s^{-1})*	*LU(8E-14, 5E-11 s^{-1})*
Deposition Velocity		0.2 cm s^{-1}	*LU(0.001, 2.3 cm s^{-1})*
Ventilation Rate	Resting (Sleeping)	*U(0.43, 0.47 m^3 hr^{-1})*	*U(0.4, 0.5 m^3 hr^{-1})*
	Sedentary Activity	*U(0.47, 0.66 m^3 hr^{-1})*	*U(0.4, 0.6 m^3 hr^{-1})*
	Light Activity	*U(0.66, 1.26 m^3 hr^{-1})*	*U(0.6, 1.4 m^3 hr^{-1})*
	Gardening	*U(1.7, 4.2 m^3 hr^{-1})*	*U(1.4, 2.4 m^3 hr^{-1})*
Time in Various Activities	Resting	2922 hr yr^{-1}	*TN(2950.5, 9.4, 178, 8431 hr yr^{-1})*
	Sedentary (No Agriculture)	*U(1138, 3506 hr yr^{-1})*	*TN(5687.6, 20.9, 48, 8550 hr yr^{-1}) – Resting*
	Sedentary (Agriculture)	*U(1038, 3406 hr yr^{-1})*	*TN(5687.6, 20.9, 48, 8550 hr yr^{-1}) – Resting*
	Outdoor (No Agriculture	Time Remaining	*TN(856.4, 21.7, 6, 6412 hr yr^{-1})* – Gardening
	Outdoor (Agriculture)	Time Remaining	*TN(856.4, 21.7, 6, 6412 hr yr^{-1})* – Gardening
	Gardening	100 hr yr^{-1}	*TN(50.4, 4.1, 0, 1E20 hr yr^{-1})*

Parameter	Previous Distribution or Value	New Distribution
Indoor Mass Loading (Resting)	*T(7E-6, 2E-5, 4E-5 g m^{-3})*	*T(1E-5, 3E-5, 5E-5 g m^{-3})*
Indoor Mass Loading (Sedentary)	*T(7E-6, 2E-5, 4E-5 g m^{-3})*	*T(6E-5, 1E-4, 1.75E-4 g m^{-3})*
Outdoor Mass Loading	*N(4.6E-5, 7E-6 g m^{-3})*	*T(2.5E-5, 6E-5, 1E-4 g m^{-3})*
Outdoor Mass Loading (Gardening)	*U(1E-4, 5E-4 g m^{-3})*	*T(1E-3, 3E-3, 1E-2 g m^{-3})*
Drilling *p(IHI)* (SLB)	*B(0.16, 0.052, 0, 1)*	*B(0.24, 0.085, 0, 1)*
Drilling *p(IHI)* (Pit 6)	*B(0.0039, 0.0012, 0, 1)*	*B(0.0080, 0.0033, 0, 1)*
Drilling *p(IHI)* (Pit 13)	*B(0.0064, 0.0021, 0, 1)*	*B(0.0062, 0.0027, 0, 1)*
Drilling *p(IHI)* (GCD)	*B(2.1E-5, 1.0E-5, 0, 1)*	*B(2.1E-5, 1.0E-5, 0, 1)*
Construction *p(IHI)* (SLB)	*B(0.12, 0.038, 0, 1)*	*B(0.17, 0.048, 0, 1)*
Construction *p(IHI)* (Pit 6)	*B(0.0047, 0.0014, 0, 1)*	*B(0.0055, 0.0018, 0, 1)*
Construction *p(IHI)* (Pit 13)	*B(0.0065, 0.0020, 0, 1)*	*B(0.0042, 0.0014, 0, 1)*
Construction *p(IHI)* (GCD)	*B(3.7E-5, 1.1E-5, 0, 1)*	*B(3.7E-5, 1.1E-5, 0, 1)*

U(•,•) – uniform distribution(minimum, maximum)
LU(•,•) – log uniform distribution(minimum, maximum)
N(•, •) – normal distribution(mean, standard deviation)
TN(•, •, •, •) – truncated normal distribution(mean, standard deviation, minimum, maximum)
T(•,•,•) – triangular distribution(minimum, mode, maximum)
B(•, •, •, •) – beta distribution(mean, standard deviation, minimum, maximum)

The most significant effect of the parameter changes is an increase in the dose from inhalation of resuspended soil particulates. Increases in the mean and uncertainty of soil mass loading are partially responsible for the increased doses. The previous mass-loading distributions were based on a single year of data for stations throughout southern Nevada. Additional data collected at the same stations since preparation of the PA indicates large year-to-year variability and a strong decreasing temporal trend in the data. The new distribution is based on data collected from a wider geographic area and over a longer time period. The new distributions have a higher mode and greater variability.

Area 3 RWMS GoldSim Model Development

A new baseline version of the Area 3 RWMS model, 2.102, was approved for all model applications, including waste stream evaluations and compliance determinations in FY 2011 (NNSA/NSO, 2011b). Major developments since version 2.000 of the model include:

- All inventories are updated through July 2006 when the site was placed in standby.
- A resident exposure scenario was added to the model. The resident scenario is equivalent to the community without agriculture scenario in the approved PA.
- Acute intruder scenarios are added to the model.
- A revised subsidence model is included for the U-3ah/at and U-3bh disposal units. The new model, based on additional review of waste form data, is probabilistic and dynamic.

- Internal and external radiological dose conversion factors were updated with adult dose conversion factors from the Federal Guidance Report 13 Supplemental CD (EPA, 1999).
- Revised estimates of disposal unit volume, area, and depth are used.

Preparation of a special analysis using the Area 3 RWMS v2.102 model was initiated in FY 2011. Release of the final special analysis is expected in FY 2012.

Area 5 RWMS Inventory GoldSim Model Development

The Area 5 RWMS FY 2011 inventory estimate was prepared with the Area 5 Inventory v2.108 model. The only major change from the previous version is the addition of FY 2011 disposal data.

Area 3 RWMS Inventory GoldSim Model Development

The Area 3 RWMS FY 2011 inventory estimate was prepared with the Area 3 Inventory v2.016 model. The only major change from the previous version is the revision of the estimated disposal unit volumes.

2.4.2 Future R&D Activities

The Area 3 RWMS v2.102 model will be used to perform a special analysis for the Area 3 RWMS. The purpose of the special analysis is to update performance assessment results and evaluate the continuing adequacy of the PA. The special analysis results, which will include sensitivity analysis, will be used to identify future work for the Area 3 RWMS.

The long-term goal of the maintenance program is to reduce uncertainty in exposure scenarios (member of public and inadvertent human intrusion), conceptual models, mathematical models, and model parameters. Reduction of uncertainty and associated improvement of the PA model will be accomplished through special studies. In addition, future R&D activities include the development of new waste concentration limits, evaluation of waste forms and containers (both engineering and geochemical properties) for disposal, the refinement of closure cover designs, and evaluation of institutional control and land-use options for optimizing disposal operations.

2.5 SUMMARY OF CHANGES

Waste operations, facility design, monitoring results, and R&D results for the Area 3 and Area 5 RWMSs have been reviewed to identify changes potentially impacting the PAs and the DASs. Discovered and proposed changes are summarized below.

2.5.1 Discovered Changes

There are no discovered changes for the Area 3 RWMS and Area 5 RWMS PAs in FY 2011.

2.5.2 Proposed Changes

2.5.2.1 Area 3 RWMS

The Area 3 RWMS was inactive in FY 2011. No significant changes related to operations, facility design, or inventory occurred in FY 2011. Review of the maintenance plan, closure plan, and monitoring plan indicate that no changes or revisions are necessary.

2.5.2.2 Area 5 RWMS

Facility changes occurred at the Area 5 RWMS in FY 2011. Two new SLB disposal units began disposal operations. The 92-ac LLWMU was closed with a 2.5 m (8.2 ft) cover. Additional inventory was disposed in FY 2011, including inventory from 12 new or revised waste streams that required a special analysis for acceptance. Review of the maintenance plan, closure plan, and monitoring plan indicate that no changes or revisions are necessary.

2.5.3 R&D Changes

2.5.3.1 Area 3 RWMS

A new baseline version of the Area 3 RWMS PA model, version 2.102, was released in FY 2011. A special analysis was prepared for the Area 3 RWMS PA using the new baseline version. The special analysis is under internal review and expected to be released in FY 2012. The FY 2006 Annual Summary Report results are still considered valid (NSTec, 2007c). The FY 2006 results showed increases over the PA results, but all results remained a small fraction of their respective limits.

2.5.3.2 Area 5 RWMS

A new baseline version of the Area 5 RWMS PA model, version 4.113, was released in FY 2011. The performance of the Area 5 RWMS was analyzed using the Area 5 RWMS v4.113 GoldSim model to assess the continuing validity of PA conclusions. The geometric mean inventory and standard deviation data listed in Tables 9 through 11 were entered into the inventory elements for the SLB units, Pit 6, Pit 13, and GCD, respectively. The disposal unit area, disposal unit volume, and waste volumes were updated with FY 2011 data. All SLB disposal units were assumed to be closed with a 2.5 m (8.2 ft) thick cover. The model was run assuming a median period of active institutional control of 245 years, a 100-year period of passive institutional control, and a 1,000-year compliance period. The model was run in GoldSim version 10.5(SP2) with 5,000 LHS realizations.

The results for the Area 5 RWMS v4.113 model indicate that there is reasonable assurance of compliance with the member of public performance objectives. The atmospheric pathway mean and 95th percentile annual total effective dose (TED) for all scenarios are less than the limit of 0.1 millisieverts (mSv) (Table 14). The air pathways results show an increase for the transient visitor and resident farmer scenario, while other scenarios are largely unchanged. The increases reflect the increase in inventory and changes in parameters related to the soil inhalation pathway. Although the increases are as much as a factor of two, the maximum air pathway TED is less than 1 percent of the performance objective. The peak annual TED occurs at 1,000 years for all

scenarios except the open rangeland scenario at Cane Spring. The predominant source of atmospheric pathway dose in FY 2011 was ^{238}U and ^{229}Th for all scenarios with peak TED at 1,000 years. Tritium is the primary source of dose for the open rangeland scenario 100-year peak TED.

Table 14. Area 5 RWMS v4.113 GoldSim Model Member of Public Total Annual TED through the Air Pathway

Exposure Scenario	Mean (mSv)	95th Percentile (mSv)	Time of Maximum
Transient Visitor	8.3E-5	3.1E-4	1,000 years
Resident	1.6E-4	5.8E-4	1,000 years
Resident Farmer	4.5E-4	1.6E-3	1,000 years
Open Rangeland (Cane Spring)	6.9E-9	NA	100 years
Open Rangeland (NNSS Boundary)	1.0E-7	2.7E-7	1,000 years

NA – not available, insufficient realizations to calculate 95th percentile

The mean and 95th percentile annual TEDs for the all-pathways scenarios are less than the 0.25 mSv performance objective (Table 15). The all-pathway TEDs show moderate increases for all scenarios. After the increases, the maximum all-pathway TED is approximately 7 percent of the performance objective.

Table 15. Area 5 RWMS v4.113 GoldSim Model Member of Public Annual TED through All Pathways

Exposure Scenario	Mean (mSv)	95th Percentile (mSv)	Time of Maximum
Transient Visitor	4.7E-3	1.0E-2	1,000 years
Resident	7.8E-4	2.7E-3	1,000 years
Resident Farmer	1.9E-2	6.4E-2	1,000 years
Open Rangeland (Cane Spring)	3.7E-3	NA	100 years
Open Rangeland (NNSS Boundary)	4.0E-3	NA	100 years

NA – not available, insufficient realizations to calculate 95th percentile

The transient visitor scenario all-pathways TED is dominated by external exposure to ^{222}Rn progeny in cover soil. The resident scenario TED is due predominantly to ^{238}U, ^{210}Pb, and ^{229}Th. The other scenarios all include agriculture and are dominated by ingestion of ^{99}Tc at 1,000 years or tritium at 100 years.

The mean and 95th percentile ^{222}Rn flux density is less than the 0.74 Becquerel per square meter per second (Bq m^{-2} s^{-1}) performance objective averaged over the entire site (Table 16). The same is true for all virtual disposal units, except for the Pit 13 RaDU, where the 95th percentile ^{222}Rn flux density exceeds the performance objective. The flux density result for the Pit 13 RaDU is not considered significant, because the limit is compared with the flux averaged over the site, not the flux from a portion of an individual disposal unit. The ^{222}Rn flux density increases for all

disposal units, except the Pit 13 RaDU and GCD, which are essentially unchanged. The increases are due to increases in inventory.

Table 16. Area 5 RWMS v4.113 GoldSim Model Rn-222 Flux Density Results

Disposal Unit	Mean (Bq m^{-2} s^{-1})	95th Percentile (Bq m^{-2} s^{-1})	Time of Maximum
All	0.16	0.32	1,000 years
SLB	0.16	0.32	1,000 years
Pit 6 RaDU	0.083	0.17	1,000 years
Pit 13 RaDU	0.56	1.6	1,000 years
GCD	1.1E-8	2.9E-8	1,000 years

Based on the institutional control policy adopted in FY 2008, chronic intrusion is assumed to be an unlikely event. Chronic intrusion results are replaced with drilling and construction acute exposure scenario results. The mean and 95th percentile acute intruder doses are less than the 5 mSv dose limit for both scenarios at all virtual disposal units (Tables 17 and 18). The acute drilling scenario TED increases for the Pit 6 RaDU and decreases or is unchanged for all other scenarios. The Pit 6 RaDU increase is due to disposals occurring in the upper cell prior to final closure. The acute drilling intrusion TEDs remain a small fraction of the dose limit.

Table 17. Area 5 RWMS v4.113 GoldSim Model Acute Drilling Intruder TED

Disposal Unit	Mean (mSv)	95th Percentile (mSv)	Time of Maximum
SLB	1.6E-3	2.7E-3	1,000 years
Pit 6 RaDU	0.034	0.062	1,000 years
Pit 13 RaDU	0.026	0.033	1,000 years
GCD	0.017	0.045	1,000 years

The SLB disposal unit acute construction TEDs are largely unchanged in FY 2011, except for the Pit 6 RaDU, which increases due to an increased inventory in the upper cell. The mean and 95th percentile are less than the performance objective for all scenarios. The mean SLB acute construction scenario TED is 26 percent of the dose limit.

Table 18. Area 5 RWMS v4.113 GoldSim Model Acute Construction Intruder TED

Disposal Unit	Mean (mSv)	95th Percentile (mSv)	Time of Maximum
SLB	1.3	2.4	1,000 years
Pit 6 RaDU	0.85	2.1	1,000 years
Pit 13 RaDU	0.050	0.15	1,000 years
GCD	3.6E-6	NA	100 years

NA – not available, insufficient realizations to calculate 95th percentile

The FY 2011 PA results show increases due to increased inventory and changes to parameters affecting inhalation doses. All results indicate that there is still reasonable assurance of meeting all performance objectives. Therefore, the Area 5 RWMS PA results are still considered valid, and no need to revise the PA is identified.

Comparison of the FY 2011 results with the 2006 PA update indicates that significant changes have occurred in the maximum TEDs and their time of occurrence. The air pathway member of public results have increased for all scenarios, except the open rangeland scenario, and the time of the maximum TED shifted to 1,000 years. Although changes have occurred, the maximum air pathway TED is less than 1 percent of the limit. The all-pathways member of public results have increased for the transient visitor but decrease for the other scenarios. The ^{222}Rn flux density has increased for all disposal units. The intruder scenarios analyzed have changed from chronic scenarios to acute scenarios. The changes occurring since the 2006 PA update reflect the cumulative effects of inventory changes, updated parameters, a new passive institutional control period, a new institutional control policy, a thinner closure cover, and new dose conversion factors.

2.6 CONCLUSIONS

2.6.1 Area 3 RWMS

The most significant change at the Area 3 RWMS is the increased inventory since the approved PA in 1996 and its placement in inactive status. The site's conceptual model; important features, events, processes (FEPs); site characteristics; and compliance points remain unchanged. Environmental monitoring results continue to indicate that the only releases from the site are low levels of tritiated water that remain consistent with PA model results. Monitoring and R&D results continue to confirm and support the hydrologic conceptual model.

The three key questions can be answered as follows:

1. Does the annual summary information indicate that changes to the PA are required? A special analysis of the Area 3 RWMS PA is in preparation to determine the impacts of changes occurring since preparation of the last PA. A full PA revision is not necessary at this time.
2. Does the annual summary information indicate that the conclusions of the PA remain valid? The Area 3 RWMS PA's conclusions regarding compliance and important parameters and processes remain valid.
3. Does the annual summary information indicate that facility performance will remain within the DOE M 435.1-1 PA performance objectives and any conditions in the facility DAS? The FY 2006 Area 3 RWMS v2.0 GoldSim model results indicate that there is still a reasonable assurance of compliance with the performance objectives.

2.6.2 Area 5 RWMS

The most significant changes for the Area 5 RWMS since preparation of the 2006 PA update include increased inventory, updated parameters, revised periods of institutional control, and a thinner closure cover. The conceptual model, important FEPs, site characterization data, and compliance points remain unchanged. Therefore, no new revision to the Area 5 RWMS PA is necessary.

The three key questions can be answered as follows:

1. Does the annual summary information indicate that changes to the PA or CA are required? A revision of the Area 5 RWMS PA is not necessary at this time.
2. Does the annual summary information indicate that the conclusions of the PA and CA remain valid? Although a number of changes have occurred since preparation of the 2006 PA update, the PA's conclusions continue to remain valid.
3. Does the annual summary information indicate that facility performance will remain with the DOE M 435.1-1 PA performance objectives, CA performance goals, and any conditions in the facility DAS? Analysis of the changes with the Area 5 RWMS v4.113 GoldSim model indicates that there is a reasonable assurance of compliance with all performance objectives.

3.0 COMPOSITE ANALYSIS REVIEW

The CA evaluates the impacts of releases from LLW disposal facilities and releases from all other interacting sources of radioactive materials. The PA review above summarizes changes relevant to wastes disposed after September 26, 1988. The CA review emphasizes changes and new results not addressed in the PA review. These include changes relevant to the pre-1988 RWMS waste inventory and sources of residual radioactive materials from Environmental Restoration (ER) sites that interact with the RWMSs.

3.1 WASTE OPERATIONS AND ENVIRONMENTAL REMEDIATION

3.1.1 Radioactive Waste Management Sites

3.1.1.1 Waste Characteristics and Facility Design

There were no discovered or proposed changes related to the Area 3 and Area 5 RWMS pre-1988 disposal units in FY 2011. No new information is available concerning pre-1988 waste forms, containers, facility design, and operations at the Area 3 and Area 5 RWMSs. No remediation involving pre-1988 wastes was performed. A special analysis for the Area 3 RWMS pre-1988 waste was performed in FY 2011 and is currently in review. No special analyses relevant to the Area 5 RWMS pre-1988 wastes were performed in FY 2011.

There were no significant changes to the pre-1988 waste inventories for the Area 3 and Area 5 RWMSs. The Area 3 RWMS CA inventory was estimated with the Area 3 Inventory v2.016 model in FY 2011. The Area 5 RWMS CA inventory was estimated with the Area 5 Inventory v2.108 model.

3.1.1.2 Monitoring

The monitoring activities discussed in Section 2.2.3 also pertain to the CAs. As discussed in Section 2.2.3, the results of environmental monitoring across the NNSS are reported annually in the Annual Site Environmental Report and the National Emission Standards for Hazardous Air Pollutants report (NSTec, 2011b; 2011c). CY 2010 monitoring results are consistent with previous results and the CA resuspension and atmospheric dispersion model results. No significant subsidence events were observed at pre-1988 disposal units at the Area 3 and Area 5 RWMS in CY 2010.

3.1.1.3 Closure

The Area 3 RWMS PA/CA assumes that the site will be closed with a vegetated monolithic ET cover of native alluvium (Shott et al., 2001). The cover is assumed to be 3 m (10 ft) thick after subsidence. The U-3ax/bl disposal unit was closed in FY 2001 with the installation of a monolithic alluvium cover. The existing 2.7 m (8.9 ft) operational cover was supplemented with an additional 0.3 m (1 ft) of soil and sloped to promote drainage off the cover. The installed cover is generally consistent with the CA assumption of a 3 m (10 ft) monolithic cover. Current plans are to close U-3ah/at and U-3bh with a 3 m (10 ft) monolithic ET cover. The Area 3 and closure plan (NSTec, 2007b) remains consistent with the CA assumptions.

The Area 5 RWMS CA makes similar but slightly less conservative assumptions (BN, 2001b). The CA assumes that the cover is maintained for 100 years and public access is restricted for 250 years. The cover is assumed to be a monolithic ET cover, measuring 2 to 6 m (6 to 20 ft) thick. In FY 2011, the 92-ac LLWMU at the Area 5 RWMS was closed with a 2.5 m (8 ft) monolithic ET cover. A 2.5 m (8 ft) monolithic ET cover is planned for the northern expansion area. The Area 5 closure plan (NSTec, 2008) remains consistent with the CA assumptions.

3.2 RESEARCH AND DEVELOPMENT

No R&D activities specific to pre-1988 waste or residual radioactive contamination had results that might impact the CA results and conclusions in FY 2011. The discussions of the R&D activities in Section 2.4 for PAs are also pertinent for CAs.

3.3 INTERACTING SOURCE TERMS

3.3.1 Underground Test Areas

The goal of UGTA closure under the FFACO process is to establish groundwater regulatory boundaries with corresponding land-use restrictions. Negotiation of UGTA regulatory boundaries will proceed through a CADD/CAP stage and a Closure Report stage. Details of the FFACO agreement for the UGTA Sub-Project were revised in FY 2011. An initial use restriction boundary and regulatory boundary objectives will now be identified at the start of the CADD/CAP stage. The use restriction boundary will be finalized and the regulatory boundary will be established at the start of the Closure Report stage of the UGTA strategy. The use restriction boundary is established through combined assessments of contaminant boundary forecasts, requirements for protection of worker health and safety, and administrative polices designed to restrict access to contaminated groundwater. A regulatory boundary is chosen to provide protection for the public and the environment from the effects of migration of radioactive contaminants. When radionuclides reach this boundary, NNSA/NSO must submit a plan to NDEP, for approval, to meet the Regulatory Boundary Objectives established at the start of the CADD/CAP stage.

The Area 3 RWMS and Area 5 RWMS CA assume that the sites are within the UGTA use restriction boundaries and that the use restrictions can control exposure of the public to groundwater contamination. In FY 2008, NNSA/NSO implemented a formal policy to implement and maintain the UGTA use restrictions.

The Yucca Flat UGTA, CAU 97, is still in the preliminary stages of the FFACO process. The preliminary groundwater flow and radionuclide transport document for CAU 97 was completed in FY 2011 and processed through internal review (pre-emptive review). The results of the flow and transport studies and the review recommendations were used to identify priority supplemental analysis (modeling and characterization studies) that will be completed before submission of the document to NDEP. The results of the supplemental analysis will be incorporated into a revised version of the flow and radionuclide transport document. This document is scheduled for submittal to and review by NDEP in September 2012. The Area 3 RMWS is still expected to be within the initial use restriction boundary for CAU 97. The results of the flow and transport model that will simulate alternative forecasts of the 1,000-year

groundwater contaminant boundaries for Yucca Flat are not expected until FY 2023. The Area 3 RWMS CA assumptions are still consistent with current plans for the Yucca Flat CAU 97.

The Frenchman Flat UGTA, CAU 98, is in a more advanced stage of the FFACO process. The UGTA Sub-Project for NNSA/NSO completed the CADD/CAP for CAU 98 in July 2011. The CADD portion describes the results of the CAU 98 data collection and modeling activities; the CAP portion describes the correction action implementation plan. The CAP also identifies negotiated CAU regulatory boundary objectives and the initial use restriction boundaries (negotiated by NNSA/NSO and NDEP). The CADD/CAP was reviewed and accepted by NDEP during FY 2011. Exploratory drilling activities identified under model evaluation studies in the CADD/CAP will be initiated in FY 2012. If the evaluations and any model refinements are accepted by NDEP, the final use restriction boundaries for Frenchman Flat will be negotiated at the start of the Closure Report stage in 2015.

Consistent with the CA assumptions, the Area 5 RWMS is currently within the CAU 98 use restriction boundary. The Area 5 RWMS CA will require revision after final closure of the Frenchman Flat UGTA scheduled for FY 2015.

3.3.2 Soil Sites

The CAs assume that the NNSS Soil Sites will not be remediated. No Soil Sites considered in the CAs have been characterized or remediated since completion of the CAs. The closure of Soil Sites is currently awaiting a regulatory determination of appropriate cleanup levels. Therefore, the results of the CAs remain valid and provide bounding estimates of site performance.

3.3.3 Industrial Sites

The CAs assume that the impact of the Industrial Sites is insignificant compared with the Soil Sites. No Industrial Sites are included in the CAs.

From FY 2007 to FY 2009 several Industrial Sites within CAU 547, Miscellaneous Contaminated Waste Sites, were discovered to have significant transuranic inventories. A corrective action site (CAS) within CAU 547, CAS 3-99-19 a gas sampling assembly associated with the TEJON safety test, is located in Area 3 approximately 350 m (1,150 ft) west-northwest of the RWMS boundary. The CAS 3-99-19 $^{239+240}$Pu inventory, 1.4E11 Bq, is contained in steel pipes, much of it below earthen berms.

The CAS 3-99-19 $^{239+240}$Pu inventory is of the same order of magnitude as the HORNET ground zero contaminated soil site at the Area 3 RWMS boundary. The HORNET ground zero contaminated soil site was characterized by soil sampling and in situ gamma spectrometry. Consequently, the HORNET ground zero contaminated soil site inventory most likely does not include the CAS 3-99-19 $^{239+240}$Pu inventory. Therefore, the CAS 3-99-19 $^{239+240}$Pu inventory is potentially a discovered inventory not included in the Area 3 RWMS inventory.

In 2011, the CADD/CAP for CAU 547, Miscellaneous Contaminated Waste Sites was approved by NDEP (NNSA/NSO, 2011c). The selected CAS 3-99-19 closure plan is closure in place below an earthen cover. Contamination at the TEJON site is unlikely to significantly increase the

dose of a future resident at the RWMS boundary due to its containment in steel pipes below a cover and the large uncontained $^{239+240}$Pu inventory already present in surface soils. The CAS 3-99-19 source will be evaluated for inclusion in the CA in the Area 3 RWMS special analysis to be released in FY 2012.

No Industrial Sites have been characterized or remediated that impact interacting sources in Frenchman Flat since preparation of the Area 5 RWMS CA. The Area 5 RWMS CA assumptions remain unchanged.

3.4 SUMMARY OF CHANGES

3.4.1 Discovered Changes

An industrial site, CAU 547, with a CAS located near the Area 3 RWMS was discovered to have a large plutonium inventory. The source, which is contained in a steel pipe and will be closed with a soil cover, should be evaluated for inclusion in the next Area 3 RWMS CA update or revision.

3.4.2 Proposed Changes

The Area 3 RWMS has been inactive since FY 2006. Therefore, no significant operational changes occurred for the Area 3 RWMS in FY 2011. The Area 5 RWMS 92-ac LLWMU, which includes all pre-1988 waste disposal units, was closed with a 2.5 m (8.2 ft) monolithic ET cover in FY 2011. Multiple Area 5 RWMS PA/CA model parameters were updated in FY 2011.

The maintenance plan, closure plan, monitoring plan, and R&D plan are unchanged from previous years. Results from monitoring and R&D are consistent with previous results and continue to support CA conceptual models. No revision of the maintenance plan, closure plan, monitoring plan, or R&D plan are required.

3.4.3 R&D Changes

3.4.3.1 CA Results for the Area 5 RWMS

The Area 5 RWMS CA results were updated with the Area 5 RWMS v4.113 GoldSim model. The model was run as described for the PA, except that the model was placed in CA mode. A slight increase is observed for the dose at the Area 5 RWMS boundary (Table 19). The mean and 95th percentile doses are significantly less than the 0.3 mSv annual dose constraint. Therefore, the Area 5 RWMS CA results are still considered valid.

Table 19. Area 5 RWMS v4.113 GoldSim Model CA All-Pathways Annual TED for a Resident at the Area 5 RWMS

Disposal Unit	Mean (mSv)	95th Percentile (mSv)	Time of Maximum
All	1.0E-3	3.2E-3	1,000 years

3.5 CONCLUSIONS

3.5.1 Area 3 RWMS

The review of the Area 3 RWMS inventories, the results of the monitoring and R&D activities, and land-use planning show that the assumptions in the CAs have not changed. An ER source near the Area 3 RWMS, CAU 547, was found to have a greater inventory than previously thought. Although the source is not expected to have any impact on CA results, CAU 547 should be evaluated in the next Area 3 RWMS CA update or revision.

The three key questions can be answered as follows:

1. Does the annual summary information indicate that changes to the PA or CA are required? A special analysis of the Area 3 RWMS CA is in preparation to determine the impacts of changes occurring since preparation of the last CA. A full CA revision is not necessary at this time.
2. Does the annual summary information indicate that the conclusions of the PA and CA remain valid? The Area 3 RWMS CA's conclusions regarding a high likelihood of meeting the dose constraint and important parameters and processes remain valid.
3. Does the annual summary information indicate that facility performance will remain within the DOE M 435.1-1 PA performance objectives, CA performance goals, and any conditions in the facility DAS? The FY 2006 Area 3 RWMS v2.0 GoldSim model results indicate that there is still a high likelihood of meeting of the dose constraint.

3.5.2 Area 5 RWMS

There have been no changes in FY 2011 that affect the conclusions of the CA, as indicated by reviews of the disposal unit closure inventories, estimated inventories of the ER sources of residual radionuclides, the progress of the ER cleanup projects, land-use planning, closure planning, and the results of the monitoring and R&D activities. No new sources of contamination have been identified, and there is no new information that would reduce the uncertainty of the current sources.

The only changes affecting the CA are the updated inventory and parameter values. The consequences of these changes were evaluated with the Area 5 RWMS v4.113 GoldSim model and found not to affect the CA conclusions.

The three key questions can be answered as follows:

1. Does the annual summary information indicate that changes to the PA or CA are required? A revision of the Area 5 RWMS CA is not necessary at this time.
2. Does the annual summary information indicate that the conclusions of the PA and CA remain valid? Review of the Area 5 RWMS CA indicates that the CA conclusions remain valid.
3. Does the annual summary information indicate that facility performance will remain within the DOE M 435.1-1 PA performance objectives, CA performance goals, and any

conditions in the facility DAS? The Area 5 RWMS v4.113 GoldSim model results indicate that there is a high likelihood of meeting the dose constraint.

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APPENDIX A

Checklist for Review of Annual Summary

This appendix summarizes the results of a review conducted to confirm that the annual summary contains all the information as required by the Low-Level Waste Disposal Facility Federal Review Group (LFRG) Program Management Plan.

Table A.1. Checklist for Review of Annual Summary

Requirement	Result
1.0 Key Questions *The annual summary for each disposal facility must provide information sufficient to evaluate three key questions about the PA for the facility:* *a. Does the annual summary information indicate that changes to the PA are required?*	Section 2.6 concludes that the Area 3 RWMS PA and the Area 5 RWMS PA do not require revision. Preparation of a special analysis for the Area 3 RWMS PA was ongoing in FY 2011.
b. Does the annual summary information indicate that the conclusions of the PA remain valid?	Section 2.6 concludes that the conclusions of the Area 3 and Area 5 RWMS PAs remain valid.
c. Does the annual summary information indicate that facility performance will remain within the PA limits imposed by the U.S. Department of Energy Manual DOE M 435.1-1 performance objectives and any conditions in the facility DAS?	Section 2.6 concludes that the Area 3 and Area 5 RWMSs continue to meet all performance objectives based on PA model results using PA models updated with FY 2011 data.
2.0 Necessary Information *The information provided in the annual summary for each low-level waste disposal facility should include the following:* *a. Description of any changes affecting the PA. Does the annual summary indicate whether any changes affecting the PA have occurred? If so, are their effects on the PA adequately described?*	Changes occurring are described in Sections 2.1 through 2.4 and summarized in Section 2.5. The effects of changes on PA results are described in Section 2.5.3.
b. Description of any PA ramifications of special analyses and reviews performed or proposed for the facility. Does the annual summary indicate whether any special analyses or reviews were performed? If so, are the ramifications for the PA adequately described?	Special analyses and their impacts are described in Section 2.1.2.
c. Description of any proposed changes in facility design or operations. Does the annual summary indicate whether any changes are proposed in facility design or operations? If so, are the effects of the proposed change on the PA adequately described?	Changes to facility designs and operations are discussed in Section 2.1 and 2.2.
d. Description of any corresponding changes required in the PA maintenance plan, the closure plan, and the monitoring plan. Does the annual summary indicate whether any corresponding changes are required in the plans? If so, are they adequately described?	Section 2.5.2 concludes that no changes are required for the maintenance plan, closure plan, or monitoring plan.
e. Description of any proposed changes in the PA. Does the annual summary indicate whether any changes to the PA are required? If so, are they adequately described?	Section 2.5.3 describes proposed changes to the PA model. Section 2.6 concludes that no changes to the PA are required.

Requirement	Result
2.1 Factors to be Addressed *The basic factors to be addressed in the annual summary and evaluated by the LFRG in reviewing the annual summary are operations, facility design, closure design, and research and development. More detailed descriptions of the information relevant to these basic factors are provided below. (For additional detail on the scope and level of detail expected for the topics, see Section 2.2 of the "Maintenance Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses," November 10, 1999.)* *2.1.1 Operations Considerations* *Disposal unit consistency with the PA models (e.g., size and configuration of trenches, shafts, and pits; waste placement and configuration; thickness of operational backfill/cover). Does the annual summary adequately describe disposal unit consistency with the PA models?* *a. Waste receipts including description of form and packaging (especially special waste forms) and their consistency with PA analyses and projections. Does the annual summary adequately describe waste receipts and their consistency with PA analyses and projections?*	Waste receipts are described in Section 2.1.1. The impacts of waste receipts on PA results are described in Section 2.5.2.
b. Waste acceptance criteria including radionuclides significant to and evaluated in the PA, radionuclide concentration and quantity limits established, waste form and packaging requirements, and consistency with PA results. Does the annual summary adequately describe the WAC and their consistency with the PA results?	Section 2.1.3 describes the WAC.
c. Procedures and systems (e.g., verification of waste characteristics, inventory limit controls, generator certification) intended to prevent disposal of inappropriate wastes. Does the annual summary adequately describe procedures and systems?	The Radioactive Waste Acceptance Program is described in Section 2.1.3.
2.1.2 Facility Design Considerations *a. Disposal technology and facility configuration consistency with the PA analyses. Is the consistency adequately described?*	Consistency of facility configuration with PA analyses is described in Section 2.2.
b. Engineered barrier consistency with the PA. Is the consistency adequately described?	Consistency of engineered barriers with PA analyses is described in Section 2.2.2.
c. Monitoring provisions appropriate for evaluation of facility performance. Are monitoring provisions adequately described?	The Monitoring Program is described in Section 2.2.3.
d. Operational controls to promote stability and to compensate for potential subsidence. Are operational controls adequately described?	Controls and monitoring of subsidence is described in Section 2.2.4.

Requirement	Result
2.1.3 Closure Design Considerations *a. Engineered barrier description including consistency of the closure cover design with PA analysis and threats to cover integrity and viability. Are engineered barriers adequately described?*	Consistency of the closure cover with PA analyses is described in Section 2.3.
b. Future land-use plan consistency with PA assumptions. Is consistency of the land-use plan with the PA assumptions adequately described?	Land-use plan consistency with PA assumptions is described in Section 2.3.
2.1.4 Research and Development Considerations *a. R&D efforts required by the facility disposal authorization statement. Are these efforts adequately described?*	R&D efforts required by the DAS are summarized in Section 1.1.
b. R&D efforts pursued for improving and refining the performance assessment. Are these efforts adequately described?	R&D efforts are described in Section 2.4.
c. Results of any confirmatory testing performed. Was any confirmatory testing performed? If so, are the results adequately described?	Confirmatory monitoring of site performance is described under monitoring in Section 2.2.3.
2.2 Changes *The changes that could cause divergence from the conditions used for the PA analysis should be categorized as discovered changes, proposed changes, or R&D changes and should be listed and described in the annual summary.* *[Note: This section of the review should focus on description of the changes (discovered, proposed, and R&D) and any effects of the changes not described in Section 2.2.]* *2.2.1 Discovered Changes* *The annual summary should report divergences from expected or planned conditions that have been <u>discovered</u> in facility operations, construction, site characteristics, and other conditions significant to facility performance. Specific information should address the baseline from which the divergence was identified, comparison of expected conditions to any available monitoring results, significance of the divergence as indicated by comparison to the four LFRG review thresholds (listed below), and incorporation of the changes in the performance assessment, if appropriate.* *The four LFRG review thresholds that trigger the review by the LFRG are* *a. an increase of 25 percent or more in the forecasted doses reported in the current, approved facility documentation or any violation of the performance objectives imposed by DOE M 435.1-1,*	Section 2.5.3 summarizes the FY 2011 PA results for the Area 3 and Area 5 RWMSs. Current PA results for the Area 3 RWMS, which have not been revised since FY 2006, indicate that model and inventory changes have caused increases in projected results. All results continue to meet all performance objectives. Comparison of the FY 2011 Area 5 RWMS PA results with the approved PAs indicates that all results continue to meet all performance objectives. Some results have increased relative to the 1996 PA update results.
b. any change in the point of compliance as reported in the current approved facility documentation,	Changes to PA models are described in Section 2.4. No change in the point of compliance occurred in FY 2011.
c. any fundamental change in the analysis methodology or model used for the facility documentation, and	Changes to PA models are described in Section 2.4.
d. any fundamental change in the hydrologic or geologic parameters used in the facility analysis methodology or model.	Changes to PA models are described in Section 2.4. There are no changes in hydrologic or geologic models.

Requirement	Result
2.2.2 Proposed Changes *a. The annual summary should identify divergences from expected or planned conditions that have been or will be voluntarily made by the facility operators to facility operations, facility construction, or other conditions significant to facility performance. Specific information should address the baseline from which the divergence is planned, comparison of current performance to performance expected after the change is made, significance of the divergence as indicated by comparison to the four LFRG review thresholds (listed in Section 2.4.1 above), and incorporation of the changes in the performance assessment, if appropriate. Does the annual summary report any proposed changes? If so, are they adequately described?*	Proposed changes are described in Section 2.5.2.
2.2.3 Research and Development Changes *a. The annual summary should include descriptions of research and development (both generic and site-specific) relevant to the PA analysis models and input data for them that are to be used to improve the conclusions of the PA. The annual summary should include a description of the significance of the improvements, when and how the anticipated improvements will be incorporated in PA modeling and analyses, and whether the improvements are expected to change the conclusions of the PA. Does the annual summary report any R&D changes? If so, are they adequately described?*	R&D changes are described in Section 2.4. The effects of changes to the PA models are described in Section 2.5.3.
3.0 Composite Analysis Summary *The annual summary for each disposal facility should provide the information required by the LFRG members and staff to evaluate whether the facility CA continues to satisfy the requirements of DOE M 435.1-1 and any additional conditions specified in the facility disposal authorization statement. The focus of the CA review will be on the interacting source terms relative to the performance goals established in DOE M 435.1-1 because the review of the facility PA is focused on the facility itself.* *a. Does the annual summary state that the conclusions of the CA remain valid? If so, does the annual summary state whether confidence in the conclusions has changed?*	Section 3.5 concludes that the Area 3 and Area 5 RWMS CAs remain valid and that there is a high likelihood of compliance with the 0.3 mSv dose constraint.
3.1 Key Questions *The annual summary for each disposal facility must provide information sufficient to evaluate three key questions about the composite analysis for the facility:* *a. Does the annual summary information indicate that changes to the CA are required?*	Section 3.5 concludes that no changes or revisions to the CAs are required.
b. Does the annual summary information indicate that the conclusions of the CA remain valid?	Section 3.5 concludes that the conclusions of the CAs remain valid.
c. Does the annual summary information indicate that the facility performance will remain within the CA performance goals provided in the DOE M 435.1-1 performance goals and any conditions in the facility DAS?	Section 3.5 concludes that there is a reasonable expectation that the Area 3 and Area 5 RWMSs meet the 0.3 mSv dose constraint.

Requirement	Result
3.2 Necessary Information *[This section of the review should focus on the effects of the changes on the CA. Section 3.4 should focus on description of the changes and any effects not described in this section.]* *The information provided in the annual summary for each low-level waste disposal facility should include the following:* *a. Description of any changes affecting the CA including changes in the design or operations of facilities with releases potentially interacting with the disposal facility releases. Does the annual summary indicate whether any changes affecting the CA have occurred? If so, are their effects on the CA adequately described?*	Facility design and operations changes affecting the CAs are described in Section 3.1.
b. Description of any CA ramifications of special analyses and reviews performed or proposed for the facility. Does the annual summary indicate whether any special analyses or reviews were performed? If so, are the ramifications for the CA adequately described?	Section 3.4 summarizes the review performed for the CA in FY 2011. Section 3.4.3 describes CA results using the current CA model.
c. A description of any proposed changes in the low-level waste disposal facility design or operations. Does the annual summary indicate whether any changes are proposed in facility design or operations? If so, are the effects of the proposed changes on the CA adequately described?	Section 3.1 describes facility changes occurring in FY 2011. Section 3.4.3 describes CA results using the current CA model.
d. A description of proposed changes (including remediation activities) in design or operations of facilities with releases potentially interacting with the disposal facility releases. Does the annual summary indicate whether any changes are proposed in the design or operations of facilities with releases potentially interacting with the disposal facility? If so, are the effects of the proposed changes on the CA adequately described?	Proposed changes are summarized in Section 3.4.2.
e. A description of any corresponding changes required in the CA maintenance plan, the closure plan, and the monitoring plan. Does the annual summary indicate whether any corresponding changes are required in the plans? If so, are they adequately described?	Section 3.4.2 summarizes recommended changes to the maintenance plan, monitoring plan, and closure plan.
f. A description of any proposed changes in the CA. Does the annual summary indicate whether any changes to the CA are required? If so, are they adequately described?	Proposed changes are summarized in Section 3.4.2. Section 3.5 concludes that no changes to the CAs are required.
3.3 Factors to be Addressed *The basic factors to be addressed in the annual summary and evaluated by the LFRG in reviewing the annual summary are operations, facility design, closure design, research and development, and interacting source terms. (For additional detail on the scope and level of detail expected for the topics, see Section 2.2 of the "Maintenance Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses," November 10, 1999.)*	

Requirement	Result
3.3.1 Operations Considerations *a. Significant changes in the operations (including remediation activities) and configurations of facilities with releases that could potentially interact with releases from the low-level waste disposal facility. Does the annual summary describe any significant changes in potentially interacting facilities?*	Section 3.3 describes changes to interacting sources affecting the CAs.
b. Disposal unit consistency with the CA models (e.g., size and configuration of trenches, shafts, and pits; waste placement and configuration; thickness of operational backfill/cover). Does the annual summary adequately describe disposal unit consistency with the CA models?	Section 3.1.1 describes RWMSs disposal unit changes affecting the CAs.
c. Waste receipts including description of form and packaging (especially special waste forms) and their consistency with CA analyses and projections. Does the annual summary adequately describe waste receipts and their consistency with CA analyses and projections?	Section 3.1.1.1 describes changes to the pre-1988 waste inventories. Changes to post-1988 inventories are described in Section 2.1.2.
d. Waste acceptance criteria including radionuclides significant to and evaluated in the CA, radionuclide concentration and quantity limits (established in the PA), and waste form and packaging requirements. Does the annual summary adequately describe the WAC and their consistency with the CA results?	The WAC are described in Section 2.1.3.
e. Procedures and systems (e.g., verification of waste characteristics, inventory limit controls, generator certification) intended to prevent disposal of inappropriate wastes. Does the annual summary adequately describe procedures and systems?	The Radioactive Waste Acceptance Program is described in Section 2.1.3.
3.3.2 Facility Design Considerations *a. Consistency with the CA analyses of operations technology and configuration at facilities with releases potentially interacting with releases from the low-level waste disposal facility. Is the consistency adequately described?*	Consistency of facility design with CA analyses is described in Section 3.1.1.
b. Engineered barrier consistency the CA. Is the consistency adequately described?	Consistency of cover design with CA analyses is described in Section 3.1.1.3.
c. Monitoring provisions appropriate for evaluation of facility performance and interacting source terms. Are monitoring provisions adequately described?	The CA monitoring program is described in Section 3.1.1.2.
d. Operational controls to promote stability and to compensate for potential subsidence. Are operational controls adequately described?	Controls and monitoring of subsidence are described in Section 2.2.4.
3.3.3 Closure Design Considerations *a. Engineered barrier description (including those for facilities with releases that interact with the low-level waste disposal facility) including consistency of the closure cover design with CA analysis and threats to cover integrity and viability. Are engineered barriers adequately described?*	Consistency of cover design with CA analyses is described in Section 3.1.1.3.
b. Future land-use plan consistency with CA assumptions. Is consistency of the land-use plan with the CA assumptions adequately described?	The consistency of land-use plans with CA assumptions is discussed in Section 3.3.

Requirement	**Result**
3.3.4 Research and Development Considerations *a. R&D efforts required by the DAS. Are these efforts adequately described?*	R&D efforts relevant to the CAs are described in Section 3.2. DAS-required R&D efforts to characterize UGTA source terms are described in Section 3.3.1.
b. R&D efforts pursued for improving and refining the composite analysis. Are these efforts adequately described?	R&D efforts relevant to the CAs are described in Section 3.2.
c. Results of any confirmatory testing performed. Was any confirmatory testing performed? If so, are the results adequately described?	Confirmatory monitoring is described in Section 3.1.1.2.
3.3.5 Interacting Source Term Considerations *a. Evaluation of significant interacting source terms. Does the annual summary indicate that there is a need to re-evaluate significant interacting source terms? If so, are they adequately re-evaluated?*	Section 3.3 reviews the status of interacting source terms and concludes that no significant changes have occurred for the Area 5 RWMS and identifies an additional Industrial Site for evaluation at the Area 3 RWMS.
b. Alteration of existing source terms. Does the annual summary report any changes in existing source terms including new source terms?	Section 3.3 reviews the status of interacting source terms and concludes that no significant changes have occurred for the Area 5 RWMS and identifies an additional Industrial Site for evaluation at the Area 3 RWMS.
c. Alteration of uncertainty in characteristics of existing sources. Does the annual summary report any changes in uncertainty in characteristics of existing source terms?	Section 3.3 reviews the status of interacting source terms.
3.4 Changes *The changes that could cause divergence from the conditions used for the CA analysis should be categorized as discovered changes, proposed changes, or R&D changes and should be listed and described in the annual summary.* *[This section of the review should focus on description of the changes (discovered, proposed, and R&D) and any effects of the changes not described in Section 3.2.]* *3.4.1 Discovered Changes* *The annual summary should report divergences from expected or planned conditions that have been <u>discovered</u> in facility operations, construction, site characteristics, and other conditions significant to determination of cumulative doses from the disposal facility and potentially interacting source terms. Specific information should address the baseline from which the divergence was identified, comparison of expected conditions to any available monitoring results, significance of the divergence as indicated by comparison to the four LFRG review thresholds (listed in Section 2.4.1 above), and incorporation of the changes in the performance assessment, if appropriate.* *a. Does the annual summary report any discovered changes? If so, are they adequately described?*	Section 3.4.1 describes discovered changes.

Requirement	Result
3.4.2 Proposed Changes *a. The annual summary should identify divergences (for both the low-level waste disposal facility and for facilities with potentially interacting source terms) from expected or planned conditions that have been or will be voluntarily made by the facility operators to facility operations, facility construction, interacting source terms, or other conditions significant to combined facility and interacting source behavior. Specific information should address the baseline from which the divergence is planned, comparison of current performance to performance expected after the change is made, significance of the divergence as indicated by comparison to the four LFRG review thresholds (listed in Section 2.4.1 above), and incorporation of the changes in the performance assessment, if appropriate. Does the annual summary report any proposed changes? If so, are they adequately described?*	Proposed changes to the CA are described in Section 3.4.2.
3.4.3 Research and Development Changes *a. The annual summary should include descriptions of research and development (both generic and site-specific) relevant to the CA analysis models and input data for them that are to be used to improve the conclusions of the CA. The annual summary should include description of the significance of the improvements, when and how the anticipated improvements will be incorporated in CA modeling and analyses, and whether the improvements are expected to change the conclusions of the CA. Does the annual summary report any R&D changes? If so, are they adequately described?*	The CA R&D efforts are described in Section 3.2. Proposed changes are summarized in Section 3.4.2.
4.0 Disposal Authorization Statements *a. The facility annual summary should describe the conditions stated in the current DAS for the facility. For conditions that specify actions to be taken (such as resolution of data uncertainties), the annual summary should describe the required action, any deadlines specified in the DAS, and the current status of efforts to satisfy the requirement. For conditions that place limits on the operations of a facility (such as the maximum allowable inventory of a specified radionuclide), the annual summary should describe the limit, actions taken to ensure compliance with the limit, and either a statement of compliance with the limit or a description and explanation of any divergence. Does the annual summary state whether any DAS conditions are in effect? If so, are they adequately described including satisfaction of any continuing limitations and description of actions to resolve temporary conditions?*	The DAS and closure of DAS conditions are discussed in Section 1.1.

Requirement	Result
5.0 Status of Other Required Documents *The annual summary should describe the status of the facility PA/CA maintenance plan, the monitoring plan, and the closure plan. The description should state whether the documents are currently in draft or final form and should describe any planned revisions. For documents that are in draft form, a description of the key milestones and schedule for completion should be provided. Complete citations should be provided for the current version (or draft) of each document. Is the status of the documents adequately described including milestones and schedules for completion of any that are in draft form, and are full citations provided for the required documents?*	The Maintenance Plan, Closure Plans, and Monitoring Plans are identified in Sections 1.0, 2.3.1, and 2.2.3, respectively. Complete citations are found in Section 4.0.

DAS	Disposal Authorization Statement
DOE	U.S. Department of Energy
CA	Composite Analysis
FY	Fiscal Year
LFRG	Low-Level Waste Disposal Facility Federal Review Group
mSv	millisievert(s)
PA	Performance Assessment
R&D	Research and Development
RWMS	Radioactive Waste Management Site
UGTA	Underground Test Area
WAC	Waste Acceptance Criteria

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