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2016 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

March 2017

Prepared by

National Security Technologies, LLC
Las Vegas, Nevada

Prepared for

U.S. Department of Energy,
National Nuclear Security Administration
Nevada Field Office
Under Contract Number
DE-AC52-06NA25946

DISCLAIMER

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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 to the 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 Field Office (NNSA/NFO) performed an annual review of the Area 3 and Area 5 RWMS PAs and CAs for federal fiscal year (FY) 2016. This annual summary report presents results and conclusions of the FY 2016 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) 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 2016 include the following:

- Development of a new Area 5 RWMS closure inventory estimate based on disposals through FY 2016
- Evaluation of new or revised waste streams by special analysis
- Development and acceptance of version 4.200 of the Area 5 RWMS GoldSim PA/CA model

The Area 3 RWMS has been in inactive status since July 1, 2006, with the last shipment received in April 2006. The FY 2016 review of operations, facility design, closure plans, monitoring results, and R&D results for the Area 3 RWMS indicates no changes that would impact PA validity. The conclusion of the annual review is that all performance objectives can be met and the Area 3 RWMS PA remains valid. There is no need to revise the Area 3 RWMS PA.

Review of Area 5 RWMS operations, design, closure plans, monitoring results, and R&D activities indicates that no significant changes have occurred. The FY 2016 PA results, generated with the Area 5 RWMS v4.200 GoldSim PA model, indicate that there continues to be a reasonable expectation of meeting all performance objectives. All results remain less than 50% of their performance objectives. The results and conclusions of the Area 5 RWMS PA are judged valid, and there is no need to the revise the PA.

A review of changes potentially impacting the CAs indicates that no significant changes occurred in FY 2016. A new Corrective Action Unit (CAU), CAU 576, with corrective action sites near the Area 3 RWMS and Area 5 RWMS was identified in FY 2016. The sites are currently under investigation and not expected to be important sources for the CA. The continuing adequacy of the CAs was evaluated with the new models, and no significant changes that would alter the CAs' results or conclusions were found. The revision of the Area 3 RWMS CA, which will include the Yucca Flat Underground Test Area (CAU 97) source, is scheduled for FY 2024, following the completion of the Corrective Action Decision Document/Corrective Action Plan. Inclusion of the Frenchman Flat Underground Test Area (CAU 98) source in the Area 5 RWMS CA is planned pending the completion of the CAU 98 Closure Report in FY 2017.

Near-term R&D efforts will focus on continuing development of the PA, CA, and inventory models for the Area 3 and Area 5 RWMSs.

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ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ac	acre(s)
Am	americium
BN	Bechtel Nevada
Bq	becquerel
Bq m^{-2} s^{-1}	becquerel per square meter per second
CA	composite analysis
CADD	Corrective Action Decision Document
CAI	Corrective Action Investigation
CAIP	Corrective Action Investigation Plan
CAP	Corrective Action Plan
CAS	Corrective Action Site
CAU	Corrective Action Unit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Ci	curie
COCs	contaminants of concern
COPCs	contaminants of potential concern
CR	Closure Report
Cs	cesium
CY	calendar year
DAS	Disposal Authorization Statement
DOE	U.S. Department of Energy
ER	Environmental Restoration
ET	evapotranspirative
FEPs	features, events, and processes
FFACO	*Federal Facility Agreement and Consent Order*
ft	foot (feet)
ft^3	cubic foot (cubic feet)
FY	(federal) fiscal year
GCD	Greater Confinement Disposal
GMX	Gadget, Mechanics, and Explosives
GZ	ground zero
^3H	tritium
INL	Idaho National 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, ABBREVIATIONS AND SYMBOLS (continued)

m	meter(s)
m^3	cubic meter(s)
MFP	mixed fission products
mSv	millisievert(s)
NDEP	Nevada Division of Environmental Protection
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NNSS	Nevada National Security Site
NSTec	National Security Technologies, LLC
ORNL	Oak Ridge National Laboratory
PA	performance assessment
Pb	lead
PDCF	pathway dose conversion factor
POA	point of assessment
Pu	plutonium
R&D	research and development
Ra	radium
RaDU	radium disposal unit
RCRA	Resource Conservation and Recovery Act
RIDP	Radionuclide Inventory and Distribution Program
Rn	radon
RTG	radioisotope thermoelectric generator
RWAP	Radioactive Waste Acceptance Program
RWMC	Radioactive Waste Management Complex
RWMS	Radioactive Waste Management Site
SLB	shallow land burial
Sr	strontium
TBq	terabecquerel
Tc	technetium
TED	total effective dose
Th	thorium
TLD	thermoluminescent dosimeter
TRU	transuranic
U	uranium
UDQ	unreviewed disposal question
UGTA	Underground Test Area

UR	use restriction
WAC	waste acceptance criteria

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1.0 INTRODUCTION

This report presents the results and conclusions of the 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 the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) for review and approval.

The annual review evaluates planned and discovered changes in facility operations, facility design, site monitoring, research and development (R&D), PA/CA models, and supporting documents. 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?

This report follows the 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) and 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 federal fiscal year (FY) 2016.
- 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 NNSA/NFO Closure and Monitoring Plans for the Area 3 and Area 5 RWMSs (NSTec 2007b, 2008a).

- 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 summarizes changes that would impact waste disposed at the Area 3 and Area 5 RWMS before September 26, 1988.
- Section 3.2 summarizes R&D results for FY 2016.
- 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 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 2016 inventories and models.
- Section 3.5 answers the key review questions regarding the continuing validity of the CA.

Appendix A is a self-evaluation using the Low-Level Waste Disposal Facility Federal Review Group (LFRG) annual summary checklist. Appendix B lists special analyses published since the latest Area 3 RWMS and Area 5 RWMS PA or CA were approved.

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 DAS was issued on October 20, 1999 (DOE 1999a). The Area 3 RWMS DAS contained one PA condition and two CA conditions (Tables 1 and 2). All DAS conditions were resolved when the final PA/CA document was issued (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 Resource Conservation and Recovery Act/Comprehensive Environmental Response, Compensation, and Liability Act (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) 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 for transuranic (TRU) waste disposed in Greater Confinement Disposal (GCD) boreholes at the Area 5 RWMS (Cochran et al. 2001). The GCD PA was prepared to 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 Area 5 RWMS DAS was issued on December 5, 2000 (DOE 2000). The PA and CA each had two conditions (Tables 3 and 4). All 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). Pit 6 was closed in FY 2011.
"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 SECONDARY ISSUES

The Maintenance Plan (NSTec 2007a) addresses resolution of secondary issues identified in the LFRG review reports for the Area 3 and Area 5 RWMS PAs and CAs. Table 5 lists the secondary issues that were tracked and resolved through the maintenance program. The resolution for each issue is included in the third column of Table 5. All secondary issues are currently resolved.

Table 5. Secondary 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
An engineered barrier will be added, and the assurance requirements of 40 CFR 191 must be met for the GCD boreholes.	GCD PA	The GCD assurance requirements, including installation of an engineered barrier, 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 PA and CA models using the GoldSim software system has systematically eliminated 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 3 and Area 5 RWMSs are ongoing; data are being incorporated into the GoldSim models to increase confidence in the PA results.

Table 5. Secondary Issues Identified in the LFRG Review Reports for the Area 3 and Area 5 RWMS PAs and CAs (continued)

Identified Issue	Source Document for Issue	Resolution
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	All interacting sources are being closed under the *Federal Facility Agreement and Consent Order* (FFACO) process. FFACO documents are reviewed as part of the annual review process. Site characterization data and corrective actions are compared with CA assumptions.
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 are reviewed annually through the maintenance program, and results are 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, 2008a). Monitoring results are evaluated 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 2016 are noted and described below. The effects of these changes on PA results are described 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 2016.

2.1.2 Waste Receipts

The Area 3 and Area 5 RWMS PAs analyze waste inventories that are the sum of past disposals and estimated future disposals. The closure inventory estimate changes over time as records of past disposals are revised, waste received does not match forecasts, or 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 waste generators, acceptance of new waste streams, and disposal of wastes at alternative disposal sites. The FY 2016 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 conformance with WAC and potential impacts on the PA. New or revised waste streams are screened as potential unreviewed disposal questions (UDQs). Potential UDQs are evaluated to identify significant changes that may impact the PA, CA, DAS, or Radioactive Waste Management Basis. The UDQ screening process for new or revised waste streams 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 cause changes to operations or the Radioactive Waste Management Basis are classified as positive UDQs. Positive UDQs are usually resolved by preparation, review, and approval of a special analysis.

Special analyses for inventory changes 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. Special analyses published since the latest approved Area 3 and Area 5 RWMS PAs and CAs are listed in Appendix B.

In FY 2016, 112 changes to new or revised waste streams were screened as potential UDQs. Nine changes involving seven new or revised waste streams were found to be positive UDQs. All of the UDQs were resolved by special analysis (Table 6). All of the seven waste streams had UDQs for disposal of radionuclides that exceeded WAC action levels. The special analyses indicated that all performance objectives could be met with the addition of the waste stream inventories to the site inventory. Four waste streams were accepted with conditions on the total waste stream inventory.

Table 6. Waste Streams Evaluated by Special Analysis in FY 2016

Waste Stream	Description	Issues	Result
ASLA000001007, Rev. 4	Sandia National Laboratory Classified Macroencapsulated Mixed Waste	^{3}H Exceeds WAC Action Level	Accepted
ORNLACTMETAL1, Rev. 4	Oak Ridge National Laboratory Activated Metals	12 Radionuclides Exceed WAC Action Levels, 23 Nuclides without Action Levels	Accepted with Conditions†
INEL04MP4173, Rev. 10	Low-Level Waste Generated at the Idaho Chemical Processing Plant Waste Processing Areas	^{226}Ra Exceeds WAC Action Level, Radionuclides without Action Levels	Accepted with Conditions†
PORTFBP000031, Rev. 0	Enriched Uranium Fluoride Solids	^{99}Tc, ^{234}U, and ^{230}Th Exceed WAC Action Levels	Accepted
NEID0900RALLW, Rev. 3	INL Regulated Asbestos Low-Level Waste	^{3}H Exceeds WAC Action Level	Accepted
INEL163597TR2, Rev. 0	INL Unirradiated Light Water Breeder Reactor UO_2/ThO_2 and UO_2/ZrO_2 Rods and Pellets	^{233}U, ^{232}U, ^{234}U, ^{229}Th, and ^{230}Th Exceed WAC Action Levels	Accepted with Conditions†
NEID11SOURCES, Rev. 2	INL Contact Handled Sealed Sources	^{226}Ra, ^{3}H, and ^{152}Eu Exceed WAC Action Levels	Accepted with Conditions†

† - Condition set for total waste stream activity for specific radionuclides

The Oak Ridge National Laboratory (ORNL) Activated Metal and the Idaho National Laboratory (INL) Chemical Processing Plant waste streams also had positive UDQs for disposal of long-lived radionuclides that are not evaluated in the PA and have no WAC action levels. Special analyses showed the inventory of radionuclides without action levels to have negligible effects on the PA.

All seven waste streams were recommended for acceptance with the conditions noted above.

2.1.2.2 FY 2016 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 does not include future waste.

The FY 2016 inventory is estimated with the Area 3 Inventory model, version 2.016. The model sums past disposals and inventory revisions 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 closure inventories are well fit by a lognormal distribution and described by the geometric mean and standard deviation estimated by the maximum likelihood estimators (Table 7). The estimated inventories are decayed until the assumed date of closure on October 1, 2025.

Table 7. FY 2016 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)

Nuclide	U-3ax/bl		U-3ah/at	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
^{3}H	1.3E+14	3.13	7.7E+11	2.17
^{14}C	1.0E+11	3.13	1.1E+08	2.88
^{26}Al	4.0E+06	3.16	4.3E+03	2.90
^{36}Cl	2.2E+10	3.27	2.4E+07	2.91
^{39}Ar	1.0E+11	3.16	1.1E+08	2.98
^{40}K	6.0E+09	3.07	6.7E+06	2.65
^{41}Ca	1.6E+11	3.07	1.7E+08	3.08
^{60}Co	1.2E+10	3.20	*Negligible*	--
^{59}Ni	4.2E+09	3.13	4.5E+06	2.83
^{63}Ni	3.4E+11	3.19	4.0E+08	2.85
^{85}Kr	6.4E+10	3.10	1.3E+08	2.67
^{90}Sr	5.2E+12	3.08	7.8E+09	2.53
^{93}Zr	5.7E+08	3.08	6.3E+05	2.67
^{93m}Nb	7.4E+10	3.31	1.2E+08	2.91
^{94}Nb	1.4E+11	3.26	1.5E+08	3.01
^{99}Tc	1.4E+10	2.45	1.0E+10	3.81
^{107}Pd	2.5E+07	3.08	2.8E+04	2.68
^{113m}Cd	6.4E+10	3.17	1.1E+08	2.94
^{121m}Sn	1.4E+12	3.18	1.7E+09	2.93
^{126}Sn	2.5E+08	3.08	2.7E+05	2.66
^{129}I	1.3E+07	3.08	1.4E+04	2.66
^{135}Cs	4.4E+08	3.07	4.9E+05	2.66
^{137}Cs	7.2E+12	3.06	1.0E+10	2.61
^{151}Sm	5.5E+11	3.07	6.5E+08	2.66
^{150}Eu	2.0E+11	3.38	2.3E+08	3.59
^{152}Eu	4.9E+11	3.25	8.8E+08	3.02
^{154}Eu	8.8E+10	3.26	2.0E+08	3.17

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

Negligible – Inventory less than 37 becquerel (Bq)

Pre-1988 waste is disposed in U-3ax/bl and U-3ah/at, with 80% of the volume and 99% of the activity disposed in U-3ax/bl. The total pre-1988 inventory as of October 1, 2025, consists of approximately 1.5×10^2 terabecquerel (TBq) (4.1×10^3 curies [Ci]) in 2.4×10^5 cubic meters (m^3) (8.5×10^6 cubic feet [ft^3]) of waste.

The Area 3 RWMS post-1988 waste is disposed in U-3ah/at and U-3bh. The post-1988 inventory consists of approximately 1.3×10^4 TBq (3.4×10^5 Ci) in 3.3×10^5 m^3 (1.2×10^7 ft^3) of waste. On an activity basis, the inventory is predominantly ^{3}H (Table 8).

Table 8. FY 2016 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
^{3}H	7.5E+15	2.06	4.5E+15	2.15
^{14}C	9.8E+10	1.76	3.0E+07	2.11
^{26}Al	9.5E+04	2.40	*Negligible*	--
^{36}Cl	6.1E+08	2.29	*Negligible*	--
^{39}Ar	2.6E+09	2.50	*Negligible*	--
^{42}Ar	4.4E+08	2.01	2.4E+08	2.49
^{40}K	2.6E+09	1.82	7.1E+08	2.58
^{41}Ca	4.0E+09	2.39	*Negligible*	--
^{44}Ti	1.2E+10	2.04	5.6E+09	2.61
^{60}Co	3.6E+09	1.79	2.4E+09	1.89
^{59}Ni	9.4E+08	2.31	1.7E+08	2.06
^{63}Ni	2.1E+11	1.77	7.5E+09	1.97
^{79}Se	2.5E+07	2.13	*Negligible*	--
^{85}Kr	3.6E+09	2.13	*Negligible*	--
^{90}Sr	3.1E+14	2.75	4.4E+10	1.94
^{93}Zr	1.4E+07	2.28	*Negligible*	--
^{93m}Nb	2.8E+09	2.42	*Negligible*	--
^{94}Nb	3.4E+09	2.56	1.8E+08	2.10
^{99}Tc	2.0E+12	1.90	7.7E+10	1.98
^{107}Pd	6.2E+05	2.28	*Negligible*	--
^{113m}Cd	2.7E+09	2.41	*Negligible*	--
^{121m}Sn	3.7E+10	2.42	*Negligible*	--
^{126}Sn	5.8E+08	2.15	9.1E+05	2.66
^{129}I	4.7E+08	2.03	2.4E+08	2.63
^{135}Cs	1.1E+07	2.29	*Negligible*	--
^{137}Cs	1.7E+14	1.96	4.9E+10	1.75
^{133}Ba	5.0E+09	1.99	1.6E+09	2.73
^{151}Sm	1.5E+10	2.28	1.2E+06	2.23
^{150}Eu	6.1E+09	2.76	*Negligible*	--
^{152}Eu	3.9E+10	1.87	1.3E+09	2.42
^{154}Eu	8.6E+09	1.99	1.6E+08	2.04
^{166m}Ho	1.3E+08	2.38	*Negligible*	--
^{210}Pb	9.6E+10	1.77	4.5E+08	1.86
^{207}Bi	3.8E+05	2.27	1.8E+07	2.19
^{210m}Bi	6.7E+06	1.96	2.1E+08	2.23
^{226}Ra	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
^{228}Ra	1.3E+10	1.69	1.9E+11	2.70
^{227}Ac	2.5E+09	1.85	1.4E+06	2.15
^{228}Th	7.2E+10	1.91	1.8E+11	2.70
^{229}Th	4.0E+07	1.95	4.8E+07	2.53
^{230}Th	4.7E+10	2.00	7.1E+10	2.72
^{232}Th	1.4E+10	1.71	2.0E+11	2.70
^{231}Pa	3.8E+08	1.79	5.0E+06	2.16
^{232}U	5.3E+10	2.20	*Negligible*	--
^{233}U	1.6E+10	1.93	2.2E+10	2.52
^{234}U	7.4E+12	1.98	1.3E+11	2.08
^{235}U	3.4E+11	1.83	1.1E+10	2.18
^{236}U	3.6E+11	2.34	9.6E+07	2.71
^{238}U	1.3E+13	1.74	5.8E+11	2.32
^{237}Np	2.4E+11	2.08	1.5E+08	1.91
^{238}Pu	5.6E+11	1.97	1.8E+11	2.07
^{239}Pu	2.7E+12	1.68	5.1E+11	1.85
^{240}Pu	5.4E+11	1.70	8.6E+10	2.07
^{241}Pu	1.5E+12	1.75	1.6E+11	2.00
^{242}Pu	1.1E+08	1.61	4.0E+07	2.32
^{241}Am	5.3E+11	1.56	8.8E+10	1.84
^{242m}Am	2.3E+08	2.18	3.3E+06	2.84
^{243}Am	5.9E+08	1.80	4.3E+07	2.63
^{243}Cm	3.1E+06	1.74	9.9E+05	2.61
^{244}Cm	8.2E+09	1.60	1.1E+08	2.09
^{245}Cm	5.4E+08	1.90	8.2E+06	2.64
^{246}Cm	8.8E+07	1.86	*Negligible*	--
^{247}Cm	7.0E+05	2.72	*Negligible*	--
^{249}Cf	3.4E+03	2.21	*Negligible*	--
^{250}Cf	1.3E+03	2.81	*Negligible*	--
^{251}Cf	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). A significant fraction of the waste activity was disposed after preparation of the Area 3 RWMS PA/CA in 1996. Waste volume uncertainty is not estimated for the Area 3 RWMS, because the volume records are believed to be complete and no future volume is assumed.

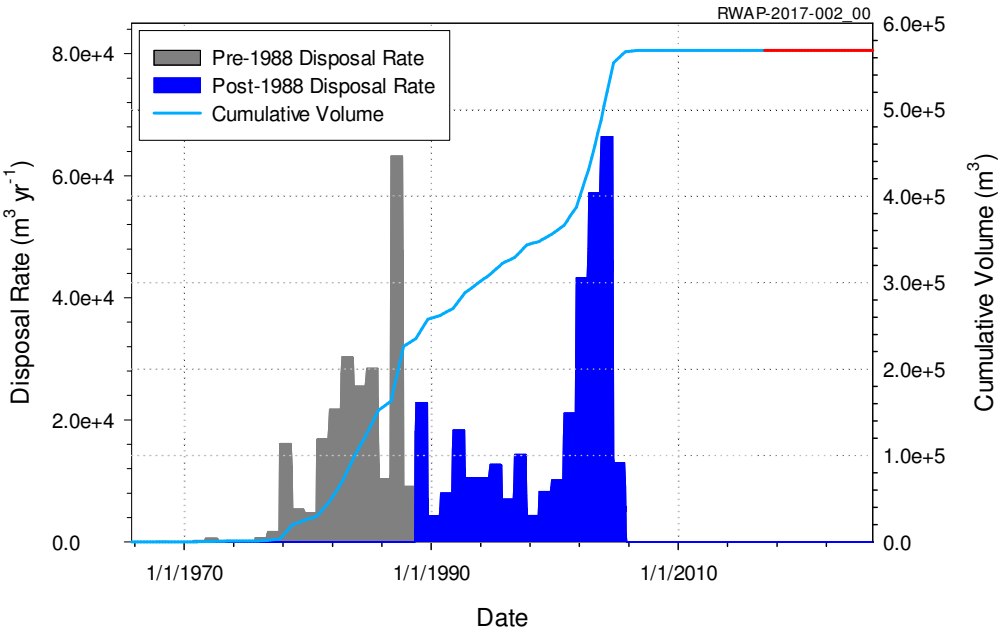

Figure 1. Annual Volume Disposal Rate and Total Volume for the Area 3 RWMS. Future Volume Shown in Red.

Total activity at the Area 3 RWMS was disposed predominantly in the post-1988 period (Figure 2). Significant increases in activity occurred after preparation of the PA in 1996. Activity uncertainty includes characterization uncertainty and uncertainty in the composition of radionuclide mixtures (e.g., mixed fission products, depleted uranium).

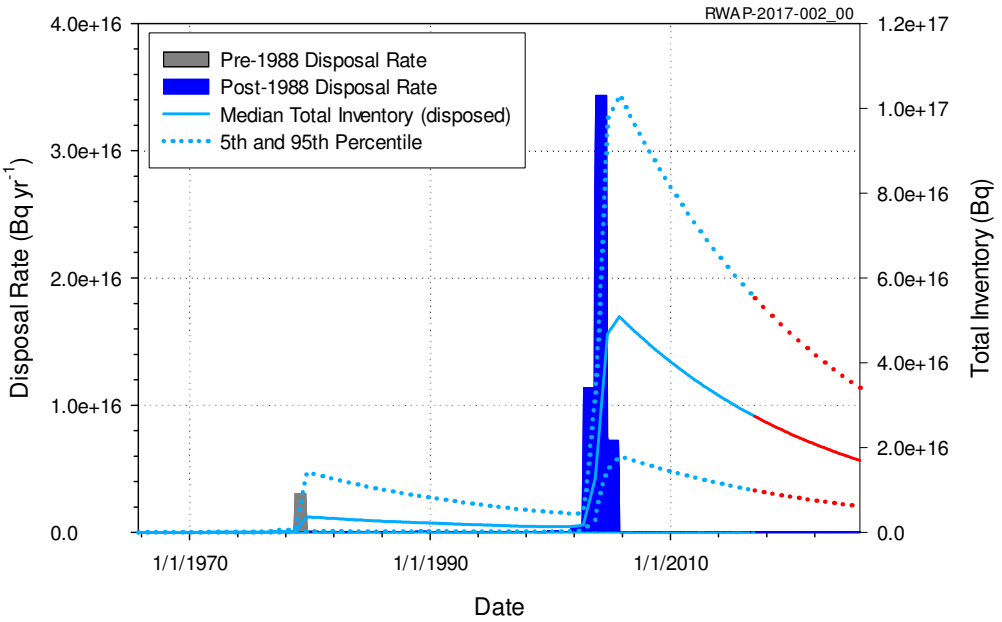

Figure 2. Annual Activity Disposal Rate and Total Inventory for the Area 3 RWMS. Future Inventory Shown in Red.

The FY 2016 pre-1988 waste volume estimate is unchanged relative to the volume assumed in the CA (Table 9). The FY 2016 estimate of the pre-1988 activity is approximately double the inventory analyzed in the CA. The increase is due mostly to an assumption that tritium (^{3}H) is present in waste disposed as mixed fission products and inclusion of the pre-1988 U-3ah/at inventory. The significance of the activity increase was evaluated by special analysis in 2012 using the FY 2011 inventory estimate (NSTec 2012). The special analysis confirms that the CA conclusions are unaffected by the increase in pre-1988 inventory. The FY 2016 volume and activity estimate are unchanged relative to the FY 2011 estimate.

Table 9. Comparison of FY 2016 Total Volume and Activity Estimate with Data Used in the Area 3 RWMS PA/CA and Special Analysis

Parameter	Area 3 RWMS PA/CA (Shott et al. 2001)	Special Analysis (NSTec 2012)	FY 2016
Pre-1988 Volume (m^3)	2.3E5	2.4E5	2.4E5
Post-1988 Volume (m^3)	3.8E5	3.3E5	3.3E5
Total Closure Volume (m^3)	6.1E5	5.7E5	5.7E5
Pre-1988 Activity (TBq)	6.5E1†	1.5E2‡	1.5E2‡
Post-1988 Activity (TBq)	3.2E1†	1.3E4‡	1.3E4‡
Total Closure Activity (TBq)	9.7E1†	1.3E4‡	1.3E4‡

† - Mode of triangular distribution for 2013
‡ - Median of lognormal distribution on 10/1/2025

The FY 2016 post-1988 volume estimate is slightly less than the PA volume due to the current assumption that the U-3ah/at and U-3bh disposal units will be partially full at final closure. The FY 2016 post-1988 activity estimate is orders of magnitude greater than the inventory evaluated in the PA due to disposal of additional waste after completion of the PA. The effects of these changes were evaluated by special analysis (NSTec 2012). The special analysis confirms the PA conclusions that there is a reasonable expectation of compliance and all results are a small fraction of the performance objectives. The FY 2016 post-1988 volume and activity estimate are unchanged relative to the FY 2011 estimate used to prepare the special analysis.

2.1.2.3 FY 2016 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 and cover thickness. Most wastes are disposed in shallow land burial (SLB) disposal units. Wastes capable of producing significant radon-222 (^{222}Rn) flux densities are disposed below thicker covers in two radium disposal units (RaDUs), the lower cell of Pit 6 and the northern section of Pit 13. Prior to 1992, high specific activity and TRU wastes were 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 2016 estimate of the Area 5 RWMS closure inventory was prepared using the GoldSim Area 5 Inventory v2.118 model. No significant changes were made to the Area 5 Inventory model, except for routine updating with FY 2016 disposal data.

The model sums past disposals, revisions, and future inventory estimates probabilistically. Probability distributions representing uncertainty in annual activity disposed are assigned for

each radionuclide and each FY. These distributions are sampled for each model realization to obtain a stochastic disposal time history for each radionuclide. Radioactive decay and ingrowth during the operational period are explicitly included in the model. The model's closure inventory estimates are well fit by a lognormal distribution. The geometric mean and standard deviation of the distribution are estimated using the maximum likelihood estimators (Table 10). The estimated inventories are decayed until the assumed date of closure on October 1, 2028.

Table 10. FY 2016 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
^{3}H	3.2E+16	1.84	3.6E+16	1.57	4.9E+16	3.08
^{14}C	2.7E+11	1.94	2.1E+13	2.40	1.2E+12	6.87
^{26}Al	8.9E+06	2.04	1.1E+06	1.88	2.2E+04	55.0
^{36}Cl	4.9E+10	2.00	6.4E+08	1.87	3.3E+07	8.12
^{39}Ar	2.2E+11	2.03	3.1E+10	2.05	3.9E+06	1.37E4
^{42}Ar	*Negligible*	--	1.3E+09	2.02	2.7E+07	106
^{40}K	1.3E+10	1.99	3.7E+10	1.47	7.7E+09	2.49
^{41}Ca	3.6E+11	2.07	1.4E+09	2.52	4.4E+05	609
^{44}Ti	*Negligible*	--	7.3E+10	1.77	3.7E+09	53.2
^{60}Co	2.1E+12	2.76	9.0E+14	1.63	6.2E+14	3.48
^{59}Ni	9.1E+09	2.01	2.8E+12	1.69	3.1E+11	5.20
^{63}Ni	7.0E+11	2.00	3.0E+14	1.68	4.4E+13	3.54
^{79}Se	*Negligible*	--	3.3E+12	2.00	5.0E+10	167
^{85}Kr	3.9E+11	2.69	3.4E+10	1.70	8.2E+09	3.53
^{90}Sr	1.8E+15	4.13	4.4E+16	1.75	5.7E+15	7.17
^{93}Zr	1.2E+09	1.99	1.1E+08	1.85	3.2E+06	40.4
^{93m}Nb	1.2E+11	2.05	1.3E+11	1.98	1.8E+09	64.5
^{94}Nb	3.0E+11	2.06	2.0E+11	2.35	9.7E+09	14.8
^{99}Tc	1.3E+13	2.58	8.7E+14	1.50	1.7E+14	2.49
^{107}Pd	5.4E+07	1.99	8.6E+05	1.85	1.6E+04	38.2
^{108m}Ag	*Negligible*	--	1.2E+12	2.12	4.0E+09	258
^{113m}Cd	9.8E+10	2.02	3.6E+10	2.22	8.1E+08	99.3
^{121m}Sn	2.2E+12	2.00	1.1E+10	2.62	7.7E+03	97.8
^{126}Sn	5.2E+08	1.99	3.7E+10	2.14	3.1E+08	237
^{129}I	3.9E+07	2.01	1.7E+10	1.98	1.8E+09	5.49
^{135}Cs	9.4E+08	1.99	3.1E+07	2.00	2.3E+05	145
^{137}Cs	3.2E+15	3.71	3.5E+15	1.74	5.8E+14	3.92
^{133}Ba	1.5E+08	3.12	7.9E+10	1.73	2.5E+10	3.82

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
^{151}Sm	1.1E+12	1.99	2.4E+12	2.50	6.7E+10	30.6
^{150}Eu	4.0E+11	2.13	3.9E+09	2.14	1.1E+06	4.96E3
^{152}Eu	2.7E+12	2.47	4.7E+13	2.10	3.2E+12	22.1
^{154}Eu	2.8E+11	2.36	6.4E+13	1.89	1.0E+13	25.8
^{148}Gd	*Negligible*	--	4.9E+10	2.08	1.9E+08	345
^{166m}Ho	1.2E+10	2.06	5.8E+08	1.74	5.5E+06	347
^{193}Pt	*Negligible*	--	3.5E+12	1.68	1.5E+11	256
^{210}Pb	1.0E+12	3.20	8.8E+11	1.54	1.6E+11	2.51
^{207}Bi	5.0E+05	3.71	1.9E+07	1.72	2.6E+06	5.02
^{210m}Bi	*Negligible*	--	5.3E+07	2.44	3.6E+03	605
^{226}Ra	1.3E+12	3.21	1.2E+12	1.73	2.3E+11	2.98
^{228}Ra	4.7E+10	2.16	7.1E+11	1.46	2.1E+11	2.77
^{227}Ac	1.2E+10	1.93	9.0E+10	2.22	8.0E+09	7.96
^{228}Th	6.4E+10	1.90	3.0E+12	1.67	5.1E+11	2.43
^{229}Th	1.6E+08	2.22	6.0E+11	1.81	3.6E+10	5.07
^{230}Th	4.4E+10	1.89	3.7E+11	1.49	1.5E+11	3.34
^{232}Th	4.7E+10	2.16	7.5E+11	1.46	3.4E+11	2.85
^{231}Pa	7.6E+09	1.91	1.2E+10	1.38	2.0E+09	2.35
^{232}U	1.2E+10	2.06	2.1E+12	1.90	2.7E+11	3.24
^{233}U	3.4E+10	2.28	1.3E+14	2.15	7.9E+12	6.94
^{234}U	8.8E+13	2.05	1.8E+14	1.35	4.4E+13	1.81
^{235}U	3.6E+12	2.08	8.0E+12	1.35	2.4E+12	1.72
^{236}U	1.1E+12	2.75	7.8E+12	1.51	1.4E+12	2.21
^{238}U	9.8E+13	2.20	4.4E+14	1.48	1.2E+14	1.87
^{237}Np	2.5E+11	2.02	2.2E+11	1.51	3.2E+10	2.53
^{238}Pu	7.0E+12	1.88	7.2E+12	1.51	2.5E+12	2.13
^{239}Pu	1.4E+13	1.97	1.9E+13	1.43	4.9E+12	1.94
^{240}Pu	2.6E+12	2.06	6.9E+12	1.65	1.5E+12	2.56
^{241}Pu	2.9E+12	1.98	4.2E+13	1.76	1.5E+13	3.35
^{242}Pu	6.7E+08	1.85	4.5E+11	2.46	2.4E+10	17.6
^{244}Pu	4.6E+09	3.98	2.9E+06	1.82	2.1E+05	6.19
^{241}Am	3.9E+12	1.87	1.1E+13	1.45	2.1E+12	2.42
^{242m}Am	*Negligible*	--	1.6E+09	1.81	2.1E+08	5.63
^{243}Am	4.4E+08	2.40	5.5E+10	1.72	8.8E+09	3.53
^{243}Cm	5.6E+09	2.74	2.1E+10	1.89	3.1E+09	4.88
^{244}Cm	7.4E+10	2.71	3.7E+12	1.64	8.7E+11	3.02

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
^{245}Cm	1.2E+05	3.80	5.1E+11	2.03	2.7E+10	14.8
^{246}Cm	7.7E+04	2.91	1.1E+11	1.84	1.3E+10	4.63
^{247}Cm	*Negligible*	--	1.6E+08	1.64	1.3E+07	14.2
^{248}Cm	5.8E+04	3.38	2.4E+08	1.68	3.9E+09	4.60
^{249}Cf	*Negligible*	--	2.2E+09	1.60	3.3E+08	2.91
^{250}Cf	2.5E+05	2.68	1.4E+09	2.23	4.6E+07	36.8
^{251}Cf	*Negligible*	--	4.9E+08	1.89	3.2E+07	14.3
Total	3.7E+16		8.7E+16		5.6E+16	

Negligible – Inventory less than 37 Bq

The median SLB closure volume estimate increased to 1.0×10^6 m^3 (3.7×10^7 ft^3) in FY 2016 (Figure 3). The median post-1988 SLB closure volume increased to 8.6×10^5 m^3 (3.0×10^7 ft^3) in FY 2016. The increases are the net effect of waste disposed in FY 2016 and increases in the estimated future waste volume. The future waste volume increase is due to proposed disposal of large volume environmental restoration waste streams. Area 5 RWMS waste volume uncertainty is attributable to incomplete waste database records and uncertainty in future waste forecasts.

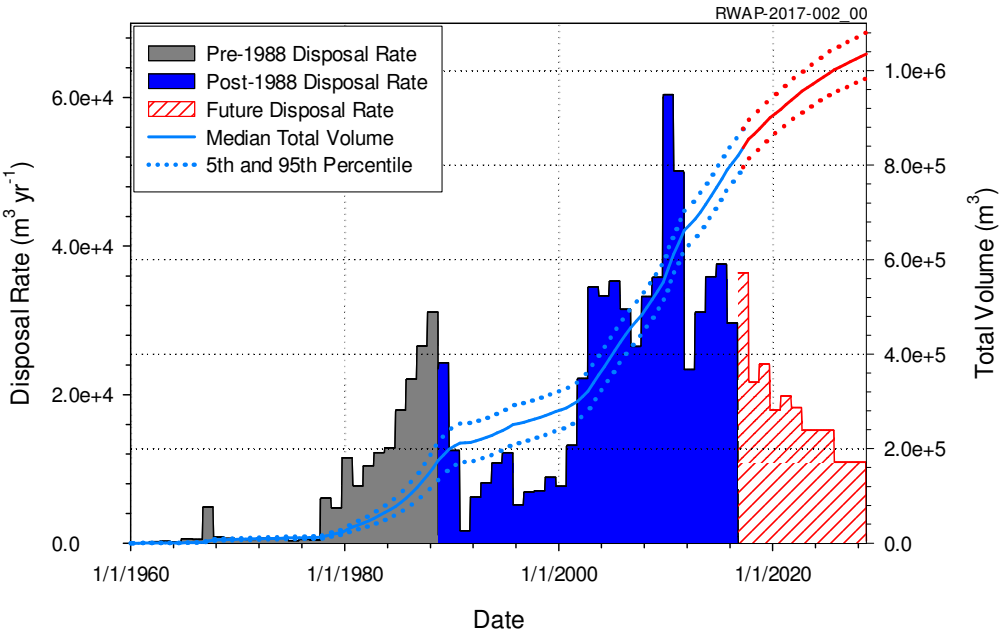

Figure 3. Annual Volume Disposal Rate and Total Volume for the Area 5 RWMS SLB Disposal Units. Future Volume Shown in Red.

The median closure activity estimate increased to 2.2×10^5 TBq (6.1×10^6 Ci) in FY 2016. The median post-1988 closure activity estimate increased to 1.7×10^5 TBq (4.6×10^6 Ci) in FY 2016. The Area 5 RWMS inventory uncertainty includes characterization uncertainty, uncertainty in the composition of radionuclide mixtures (e.g., mixed fission products, depleted uranium), uncertainty in the activity not recorded in waste management databases, and uncertainty in the inventory of future waste. The median activity forecast continues to project gradually declining total activity until closure due to the radioactive decay of the disposed inventory (Figure 4).

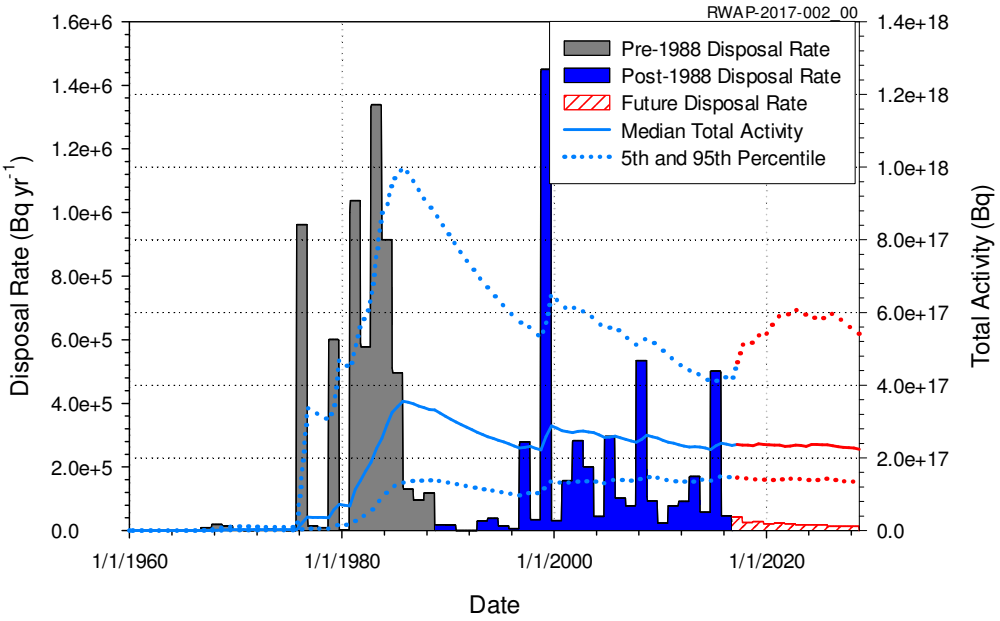

Figure 4. Annual Activity Disposal Rate and Total Inventory for the Area 5 RWMS SLB Disposal Units.

One key PA radionuclide, technetium-99 (^{99}Tc), shows a significant increase in FY 2016. No new long-lived radionuclides were disposed in FY 2016. No radionuclides were added to the PA/CA model in FY 2016.

Small increases in SLB volume and activity occurred between FY 2015 and FY 2016 (Table 11). The increases are due in part to soil remediation projects forecast for FY 2017. Cumulative volume and activity changes occurring between the 2006 PA update and FY 2016 are more significant. The post-1988 SLB volume and activity have approximately doubled since the 2006 PA update. The consequences of the increase have been evaluated annually using the PA/CA model and reported in the Annual Summary Report (see Section 2.5.3). The results of the annual evaluation continue to confirm that there is a reasonable expectation of compliance with all performance objectives and that all results are less than 50% of their respective performance objective. No LFRG Notification Criteria have been exceeded.

Table 11. Comparison of FY 2016 Total SLB Volume and Activity Estimate with Data Used in the Area 5 RWMS PA/CA and Prior FY

Parameter	Area 5 RWMS PA Update (BN 2006)	FY 2015	FY 2016
Pre-1988 SLB Volume (m^3)†	1.7E5	1.7E5	1.7E5
Post-1988 SLB Volume (m^3)†	3.9E5	8.0E5	8.6E5
Total Closure SLB Volume (m^3)†	5.3E5	9.7E5	1.0E6
Pre-1988 SLB Activity (TBq)§	3.0E5‡	4.2E4	4.3E4
Post-1988 SLB Activity (TBq)§	6.0E4	1.3E5	1.7E5
Total Closure SLB Activity (TBq)§	3.6E5	2.1E5	2.2E5

† - Median
‡ - Deterministic value for 1988
§ - Median on 10/1/2028 unless otherwise noted

RaDU Inventory

The lower cell of Pit 6 and Pit 13 were excavated to greater depth to dispose thorium wastes that have the potential to generate ^{222}Rn in the future, as radium-226 (^{226}Ra) is produced by the decay of thorium-230 (^{230}Th). The inventory in both disposal units is predominantly ^{232}Th. The lower cell of Pit 6 was operated from FY 1992 to FY 2002. The upper cell of Pit 6 was filled with LLW and closed in FY 2011. The Pit 6 inventories remain unchanged from previous years (Table 12).

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 12. The Pit 13 SLB inventory is included in the post-1988 SLB inventory.

Table 12. FY 2016 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 (Lower Cell)		Pit 6 (Upper Cell)		Pit 13 RaDU	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
^{3}H	*Negligible*	--	2.9E+12	1.81	1.4E+09	2.38
^{14}C	*Negligible*	--	1.1E+09	2.52	*Negligible*	--
^{26}Al	*Negligible*	--	1.2E+03	2.45	*Negligible*	--
^{42}Ar	*Negligible*	--	9.5E+06	2.43	*Negligible*	--
^{40}K	*Negligible*	--	3.5E+08	2.45	4.0E+03	2.44
^{44}Ti	*Negligible*	--	3.7E+08	2.41	*Negligible*	--
^{60}Co	*Negligible*	--	2.0E+10	2.03	6.2E+06	2.53
^{63}Ni	*Negligible*	--	4.9E+10	2.12	4.3E+07	2.46
^{85}Kr	*Negligible*	--	2.2E+07	2.08	*Negligible*	--
^{90}Sr	1.8E+07	2.76	5.2E+10	1.91	5.4E+09	2.48

Nuclide	Pit 6 (Lower Cell)		Pit 6 (Upper Cell)		Pit 13 RaDU	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
^{94}Nb	*Negligible*	--	7.7E+03	2.54	*Negligible*	--
^{99}Tc	9.5E+08	2.63	4.3E+12	2.17	1.1E+11	1.87
^{126}Sn	*Negligible*	--	*Negligible*	--	1.3E+07	2.36
^{129}I	*Negligible*	--	3.8E-02	2.33	1.1E+07	2.71
^{137}Cs	*Negligible*	--	5.3E+10	1.89	7.2E+09	2.47
^{133}Ba	*Negligible*	--	5.0E+04	2.21	*Negligible*	--
^{151}Sm	*Negligible*	--	1.9E+06	2.34	*Negligible*	--
^{150}Eu	*Negligible*	--	8.0E-01	2.55	*Negligible*	--
^{152}Eu	*Negligible*	--	2.2E+06	1.76	1.0E+07	2.52
^{154}Eu	*Negligible*	--	3.1E+07	2.08	1.4E+07	2.46
^{152}Gd	*Negligible*	--	1.3E-07	1.76	8.3E-07	2.51
^{210}Pb	6.8E+09	1.65	1.2E+09	1.99	7.1E+10	1.66
^{226}Ra	1.9E+10	1.67	8.5E+08	2.06	1.4E+11	1.66
^{228}Ra	5.7E+12	1.63	4.7E+09	2.10	5.6E+12	1.06
^{227}Ac	2.2E+06	1.93	5.7E+07	1.97	8.3E+05	1.93
^{228}Th	5.6E+12	1.63	4.6E+09	2.08	5.4E+12	1.06
^{229}Th	4.7E+09	2.15	2.3E+06	2.01	2.1E+02	2.19
^{230}Th	1.5E+12	1.69	2.6E+09	1.69	1.9E+12	2.31
^{232}Th	5.8E+12	1.64	5.2E+09	2.11	5.9E+12	1.06
^{231}Pa	5.9E+06	1.94	1.6E+08	1.89	3.2E+06	1.94
^{232}U	*Negligible*	--	3.2E+07	2.37	1.6E+08	2.57
^{233}U	1.8E+12	2.14	2.9E+08	2.00	1.9E+05	2.17
^{234}U	1.7E+11	1.95	3.7E+12	2.12	1.1E+11	1.95
^{235}U	8.7E+09	1.94	1.0E+11	2.10	7.4E+09	1.95
^{236}U	1.9E+08	2.14	2.7E+11	2.02	1.3E+10	2.06
^{238}U	2.1E+11	1.91	1.6E+13	2.37	4.9E+11	1.88
^{237}Np	7.6E+05	2.50	2.2E+09	2.13	2.0E+09	2.14
^{238}Pu	1.3E+10	2.02	1.3E+10	2.22	4.0E+08	2.40
^{239}Pu	3.3E+06	2.17	1.4E+11	1.75	8.3E+09	2.12
^{240}Pu	*Negligible*	--	2.6E+10	1.68	4.6E+07	2.33
^{241}Pu	1.1E+10	2.19	7.3E+10	1.68	5.6E+09	2.46
^{242}Pu	*Negligible*	--	6.2E+06	1.77	3.0E+03	2.49
^{244}Pu	*Negligible*	--	4.0E+01	2.02	*Negligible*	--
^{241}Am	1.1E+09	2.20	2.7E+10	1.62	1.4E+09	1.96
^{242m}Am	*Negligible*	--	2.3E+05	2.12	*Negligible*	--
^{243}Am	*Negligible*	--	4.8E+07	2.14	*Negligible*	--

Nuclide	Pit 6 (Lower Cell)		Pit 6 (Upper Cell)		Pit 13 RaDU	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
^{243}Cm	*Negligible*	--	7.7E+07	2.41	*Negligible*	--
^{244}Cm	*Negligible*	--	2.7E+08	2.13	*Negligible*	--
^{245}Cm	*Negligible*	--	6.2E+05	2.41	*Negligible*	--
^{246}Cm	*Negligible*	--	3.2E+00	2.45	*Negligible*	--
^{247}Cm	*Negligible*	--	9.6E+05	2.43	*Negligible*	--
^{248}Cm	*Negligible*	--	7.0E+05	2.43	*Negligible*	--
^{249}Cf	*Negligible*	--	5.6E+04	2.23	*Negligible*	--
Total	2.1E+13		2.8E+13		2.0E+13	

Negligible – Inventory less than 37 Bq

The FY 2016 volumes estimates for the Pit 6 and Pit 13 RaDUs are unchanged relative to FY 2015 estimates (Table 13). The FY 2016 volume estimates are unchanged relative to the 2006 PA update, except for the upper cell of Pit 6. The upper cell of Pit 6 volume increase reflects an increase in the actual volume of the disposal unit relative to earlier PA assumptions. The FY 2016 activity estimate is unchanged relative to the FY 2015 estimate. The FY 2016 activity estimate is unchanged relative to the 2006 PA update, except for the upper cell of Pit 6.

Table 13. Comparison of FY 2016 Total Pit 6 and Pit 13 RaDU Volume and Activity Estimate with Data Used in the Area 5 RWMS PA and Prior FY

Parameter	Area 5 RWMS PA Update (BN 2006)	FY 2015	FY 2016
Lower Cell Pit 6 Volume (m^3)	5.0E3	5.0E3	5.0E3
Upper Cell Pit 6 Volume (m^3)	1.2E4	2.2E4	2.2E4
Pit 13 RaDU Volume (m^3)	1.0E4	1.1E4	1.1E4
Lower Cell Pit 6 Activity (TBq)	2.1E1	2.1E1	2.1E1
Upper Cell Pit 6 Activity (TBq)	~1.3E3	2.8E1	2.8E1
Pit 13 RaDU Activity (TBq)	1.7E1	2.0E1	2.0E1

The effects of Pit 6 and Pit 13 RaDU volume and activity changes have been evaluated annually in the Annual Summary Report (see Section 2.5.3). The FY 2016 results confirm a reasonable expectation of compliance with all performance objectives and that all results are less than 50% of their limits.

GCD Inventories

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

1988 period. The current GCD inventory estimates are summarized in Table 14. The GCD inventories are not significantly different from previous estimates.

Table 14. FY 2016 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
^{3}H	2.2E+16	2.30	1.7E+14	2.50
^{14}C	6.6E+04	2.85	*Negligible*	--
^{26}Al	2.5E+00	2.94	*Negligible*	--
^{36}Cl	1.5E+04	2.89	*Negligible*	--
^{39}Ar	6.6E+04	2.92	*Negligible*	--
^{40}K	3.8E+03	2.79	*Negligible*	--
^{41}Ca	1.1E+05	2.88	*Negligible*	--
^{60}Co	9.2E+11	2.70	*Negligible*	--
^{59}Ni	2.7E+03	2.88	*Negligible*	--
^{63}Ni	2.2E+05	2.89	*Negligible*	--
^{85}Kr	5.9E+04	2.81	*Negligible*	--
^{90}Sr	5.4E+15	3.86	1.0E+08	4.38
^{93}Zr	3.6E+02	2.79	*Negligible*	--
^{93m}Nb	6.1E+04	2.96	*Negligible*	--
^{94}Nb	8.5E+04	2.94	*Negligible*	--
^{99}Tc	7.2E+09	3.73	5.9E+09	4.18
^{107}Pd	1.6E+01	2.78	*Negligible*	--
^{113m}Cd	5.6E+04	2.98	*Negligible*	--
^{121m}Sn	8.3E+05	2.96	*Negligible*	--
^{126}Sn	1.6E+02	2.80	*Negligible*	--
^{129}I	8.3E+00	2.81	*Negligible*	--
^{135}Cs	2.8E+02	2.78	*Negligible*	--
^{137}Cs	2.6E+14	3.76	*Negligible*	--
^{151}Sm	3.7E+05	2.80	*Negligible*	--
^{150}Eu	1.4E+05	3.31	*Negligible*	--
^{152}Eu	4.2E+05	2.97	*Negligible*	--
^{154}Eu	9.2E+04	2.92	*Negligible*	--
^{152}Gd	1.1E-07	2.96	*Negligible*	--
^{166m}Ho	3.4E+03	2.95	*Negligible*	--
^{210}Pb	2.7E+12	4.04	3.8E+04	2.45
^{226}Ra	3.6E+12	4.04	1.2E+05	2.45
^{228}Ra	8.7E+08	3.53	6.8E-09	4.50

Nuclide	Pre-1988 GCD		Post-1988 GCD	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
^{227}Ac	7.0E+10	4.23	5.4E+05	2.57
^{228}Th	8.6E+08	3.53	5.8E-09	4.50
^{229}Th	8.1E+01	2.10	4.6E+01	2.35
^{230}Th	5.8E+07	3.07	1.4E+07	2.45
^{232}Th	8.7E+08	3.53	1.0E-08	4.51
^{231}Pa	5.0E+06	3.04	1.2E+06	2.57
^{232}U	4.0E+03	2.93	*Negligible*	--
^{233}U	3.9E+04	2.12	2.5E+04	2.36
^{234}U	1.4E+11	3.06	3.9E+10	2.45
^{235}U	5.4E+09	3.03	1.5E+09	2.57
^{236}U	3.6E+08	3.85	1.0E+01	4.51
^{238}U	3.5E+10	2.98	7.2E+10	2.36
^{237}Np	2.2E+08	2.16	1.4E+08	2.36
^{238}Pu	4.0E+11	3.18	3.7E+06	4.42
^{239}Pu	2.6E+13	2.54	1.6E+08	4.34
^{240}Pu	1.0E+12	3.25	8.9E+06	4.51
^{241}Pu	1.2E+12	3.21	1.4E+07	4.38
^{242}Pu	1.6E+08	3.22	*Negligible*	--
^{244}Pu	0.0E+00	1.01	*Negligible*	--
^{241}Am	3.5E+12	2.66	8.8E+06	4.49
^{243}Am	3.3E+01	2.79	*Negligible*	--
^{244}Cm	7.3E+03	2.82	*Negligible*	--
Total	**2.7E+16**		**1.7E+14**	

Negligible – Inventory less than 37 Bq

The FY 2016 GCD volume and activity estimates are unchanged relative to the FY 2015 values (Table 15). The FY 2016 estimates are similar to the PA/CA values, except for the post-1988 volume estimate, which has decreased significantly.

Table 15. Comparison of FY 2016 GCD Volume and Activity Estimate with Data Used in the Area 5 RWMS PA/CA and Prior FY

Parameter	Area 5 RWMS PA Update and CA (BN 2006, BN 2001b)	FY 2015	FY 2016
Pre-1988 GCD Volume (m^3)	2.9E2	2.7E2	2.7E2
Post-1988 GCD Volume (m^3)	1.1E2	14	14
Pre-1988 GCD Activity (TBq)†	1.1E5‡	2.7E4	2.7E4
Post-1988 GCD Activity (TBq)†	1.6E2	1.7E2	1.7E2

† - Median on 10/1/2028 unless otherwise noted
‡ - Deterministic value for 1991

The effects of GCD volume and inventory changes have been evaluated annually in the Annual Summary Report (see Section 2.5.3). The FY 2016 results confirm a reasonable expectation of compliance with all performance objectives and that all results are a small fraction of the limits.

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*, Revision 10a (NNSA/NFO 2015a). Revision 10a was in effect throughout FY 2016. No WAC changes occurred in FY 2016.

WAC action levels are PA-derived waste concentrations used to screen waste streams for their potential to impact PA results. The Revision 10a action levels are derived in the 2006 PA update. WAC action levels are unchanged and continue to be based on PA results.

Compliance with the NNSS WAC is ensured by the RWAP, an NNSA/NFO program that reviews and approves all new or revised waste streams and generator waste certification programs. No significant changes occurred to the RWAP in FY 2016.

2.2 FACILITY DESIGN

Key facility design features are specifications impacting PA conceptual models, assumptions, or input parameters. Key design features for the Area 3 and Area 5 RWMSs include the following:

- Disposal unit volume, area, thickness, 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 operationally closed. No wastes were disposed at the Area 3 RWMS, and no new disposal units were opened in FY 2016. Area 3 RWMS disposal unit design continues to be consistent with the PA model.

Radioactive waste is disposed at the Area 5 RWMS in shallow unlined pits and trenches. Mixed waste is disposed in a RCRA-compliant, double-lined cell with a leachate collection system. 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.

One new disposal unit, Cell 28, went in to operation at the Area 5 RWMS northern expansion area in FY 2016. Cell 28's design is consistent with other SLB disposal units. Area 5 RWMS disposal unit design continues to be consistent with the PA model.

2.2.2 Engineered Barriers

Engineered barriers at the Area 3 and Area 5 RWMSs include flood protection systems, the closure covers, and the liner and leachate collection system for the Cell 18 mixed waste disposal cell at the Area 5 RWMS. The Area 3 and Area 5 RWMS flood protection systems and closure covers are described in the PAs and closure plans. The Area 3 and Area 5 RWMS flood protection systems and closure cover designs were unchanged in FY 2016. The Area 5 RWMS Cell 18 liner and leachate collection system was described in the FY 2010 Annual Summary Report (NSTec 2011). The Cell 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. The monitoring plan is in final form. Closure plans for the Area 3 RWMS and Area 5 RWMS (NSTec 2007b, 2008a) describe the specific monitoring programs for the waste disposal facilities. No significant changes occurred in the environmental monitoring plan in FY 2016 (Table 16).

Table 16. 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 at four locations in U-3ax/bl disposal unit cover • Eight drainage lysimeters for water balance since 2001	• Measurements of soil water content and water potential in four waste disposal unit covers • Measurements of soil water content in four waste disposal unit floors • 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)

Monitoring Element	Area 3 RWMS	Area 5 RWMS
Meteorology Monitoring	• Air temperature at 3 and 9.5 m (10 and 31 ft) • Relative humidity at two heights • Wind speed and direction at two heights • Barometric pressure • Solar radiation • Precipitation	• Air temperature at 3 and 9.5 m (10 and 31 ft) • Relative humidity at two heights • Wind speed and direction at two heights • Barometric pressure • Solar radiation • Precipitation
Direct Radiation Monitoring	• Nine thermoluminescent dosimeters (TLDs)	• TLDs at 12 locations
Biota Monitoring	• Sampling vegetation, small mammals, and animal burrow spoils for tritium, gamma-emitting radionuclides, ^{90}Sr, americium-241 (^{241}Am), and plutonium • Plant density of U-3ax/bl closure cover	• Sampling vegetation, small mammals, and animal burrow spoils for tritium, gamma-emitting radionuclides, ^{90}Sr, ^{241}Am, and plutonium • Plant density on 92-acre (ac) closure cover
Subsidence Monitoring	• Quarterly inspection of operational covers • U-3ax/bl closure cover surveyed at eight locations on a 2-year interval	• Quarterly inspection of operational covers • 92-ac Low-Level Waste Management Unit (LLWMU) closure cover surveyed annually at 52 locations
Air Monitoring	• Atmospheric moisture sampling for tritium and air particulates sampled at three locations	• Air particulates sampled at two locations; atmospheric moisture sampling for tritium at two locations
Soil Temperature Monitoring around Radioisotope Thermoelectric Generators (RTGs)	• None	• Vertical and horizontal sensor arrays around four RTGs in Pit 5
Lined Mixed Waste Disposal Unit Leachate Monitoring	• None	• Cell 18 leachate monitored for toxicity characteristic contaminants, polychlorinated biphenyls, specific conductance, and pH

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 2015 or the most recent year data are available:

- *Nevada National Security Site Environmental Report* (NSTec 2016a)
- *National Emission Standards for Hazardous Air Pollutants Report* (NSTec 2016b)
- *Waste Management Monitoring Report* (NSTec 2016c)
- *Area 5 Groundwater Monitoring Report* (NSTec 2017*)*

Results of the environmental monitoring programs were consistent with PA input parameters and model results (NSTec 2016c). CY 2015 monitoring results are consistent with trends observed in previous years.

2.2.4 Stability Control

Subsidence is minimized and controlled by the 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. Cover elevation is surveyed biannually at U-3ax/bl and annually on Area 5 RWMS units that have undergone final closure. No changes to these procedures occurred in FY 2016.

2.3 CLOSURE DESIGN

2.3.1 Closure Plan

Final closure cover thickness is a key PA/CA assumption specified in the closure plan. Actual final closure thickness varies with location depending on the disposal unit depth, height of waste stack, and waste compressibility at each location and waste compressibility. Final closure cover thicknesses specified in closure plans and PA/CA models are considered minimum thicknesses.

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 a minimum of 3 m (10 ft) thick after subsidence. The cover design in the *Closure Plan for the Area 3 Radioactive Waste Management Site at the Nevada Test Site* is for a 3-m (10-ft) monolithic ET cover (NSTec 2007b). The Area 3 RWMS PA and CA assumptions continue to be consistent with completed closures and 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 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 92-ac 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 v4.200 GoldSim model assumes a 2.5-m (8.2-ft) cover.

The *Closure Plan for the Area 5 Radioactive Waste Management Site at the Nevada Test Site* describes a two-phase process (NSTec 2008a). The first phase is closure of the 92-ac LLWMU under the FFACO closure process. A Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) for the 92-ac LLWMU (Corrective Action Unit [CAU] 111) was approved by the Nevada Division of Environmental Protection (NDEP) in FY 2009 (NNSA/NSO 2009). The preferred Corrective Action Alternative, a minimum 2.5-m (8.2-ft) thick engineered monolithic ET cover, was constructed in FY 2011. The Closure Report for the 92-ac LLWMU was issued in FY 2012 (NNSA/NSO 2012a). Re-vegetation of the closure cover was initiated in FY 2012 and is ongoing.

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/NFO institutional control policy is to implement, maintain, and enforce restricted access to, and use of, the NNSS and ensure the continuity of appropriate institutional controls in the future (NNSA/NFO 2015b). Based on the institutional control policy, PA/CA analyses assume land-use restrictions will be implemented and maintained indefinitely (NNSA/NSO 2007). The planned land-use restrictions are assumed to prohibit public access for 1,000 years within the use restriction (UR) boundaries negotiated with the State of Nevada.

The Area 3 RWMS and the Area 5 RWMS are expected to be within UR boundaries. The Area 3 RWMS is expected to be within the CAU 97 (Yucca Flat UGTA) UR boundary. The NNSA/NFO Assistant Manager of Environmental Management previously agreed to administratively include the Area 5 RWMS within the CAU 98 (Frenchman Flat UGTA) UR boundaries (NNSA/NSO 2012b). However, results of the CAU investigation indicate that the Area 5 RWMS is not within the CAU 98 area exceeding the groundwater action level. Therefore, the Area 5 RWMS will not be included in the FFACO CAU 98 UR boundary.

In 2009, permanent custody and accountability of the 740-acre Area 5 Radioactive Waste Management Complex (RWMC) was transferred from the Bureau of Land Management to DOE. The land was determined to be unsuitable for return to the public domain and will therefore remain under DOE control in perpetuity (NNSA/NFO 2016a). NNSA/NFO will establish UR boundaries, consistent with the RWMC boundaries, for the Area 5 RWMS. Public access to groundwater contaminated by underground testing near the Area 5 RWMS is still assumed to be prohibited by the CAU 98 UR boundary.

The institutional control policy supports the following PA/CA assumptions:

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 a member of the public and short-term exposure of intruders is assumed possible after institutional controls end. The period of institutional control is randomly sampled from a probability density function derived from expert elicitation. The member of the public will be excluded from within the UR boundaries when the final boundaries are negotiated with the state of Nevada.
4) The institutional control policy and the probabilistic period of institutional controls are 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 assumptions are implemented in the current Area 3 RWMS PA/CA and Area 5 RWMS PA/CA GoldSim models except for revising the points of assessment (POA) to reflect the UR boundaries, which are not finalized.

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/NFO 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/NFO 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 multiple 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 FY 2016 R&D Activities

The major R&D effort undertaken in FY 2016 was the further 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

A new FY 2016 baseline Area 5 RWMS model, version 4.200, has been accepted for all model applications, including waste stream evaluations and compliance determinations (NNSA/NFO

2016b). The FY 2016 PA update was performed with the Area 5 RWMS v4.200 PA model. Major developments since the previous baseline model version include the following:

- Migration from GoldSim version 11.1.3 to 11.1.6.
- All waste volumes, inventories, and disposal unit dimensions are updated with FY 2016 data.
- Member of public dose calculation methods were revised to calculate age- and gender-weighted doses, referred to as reference person dose.

The software changes have no significant effects on PA results as shown in Section 2.5.3.2.

Area 3 RWMS PA GoldSim Model Development

The current baseline version of the Area 3 RWMS model, version 2.102, was accepted for all model applications in FY 2011 (NNSA/NSO 2011a). A special analysis using the Area 3 RWMS v2.102 model was prepared in FY 2012 (NSTec 2012).

Although no new baseline versions were released in FY 2016, model maintenance and development continues. To maintain model consistency, Area 5 RWMS PA model changes and parameter updates that are applicable to Area 3 are also applied to the Area 3 RWMS PA model.

Area 5 RWMS Inventory GoldSim Model Development

The Area 5 RWMS FY 2016 inventory estimate was prepared with the Area 5 Inventory v2.118 model. The only major changes from the previous version are migration to GoldSim version 11.1.6 and the addition of FY 2016 waste disposal data.

Area 3 RWMS Inventory GoldSim Model Development

The Area 3 RWMS FY 2016 inventory estimate was prepared with the Area 3 Inventory v2.016 model. No changes were made to the Area 3 Inventory v2.016 in FY 2016.

2.4.2 Future R&D Activities

The long-term goal of the maintenance program is to reduce uncertainty in exposure scenarios (member of the 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 PA CHANGES

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

2.5.1 Discovered Changes

No changes were discovered in FY 2016.

2.5.2 Proposed Changes

2.5.2.1 Area 3 RWMS

The Area 3 RWMS was inactive in FY 2016. No significant changes related to operations, facility design, or inventory occurred. The results of special analysis conducted with the most recent baseline model version are summarized in Section 2.5.3.1. 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

A new SLB disposal unit went into operation at the Area 5 RWMS in FY 2016. Additional inventory was disposed, including inventory from new or revised waste streams that required a special analysis for acceptance. A new baseline PA/CA model was released with updated inventories. 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

In FY 2012, a special analysis was prepared for the Area 3 RWMS using a new baseline PA/CA model, version 2.102 (NSTec 2012). The special analysis concluded that there continues to be a reasonable expectation of compliance with all performance objectives and all results are a small fraction of the limits. No significant changes have occurred since preparation of the special analysis.

2.5.3.2 Area 5 RWMS

A new baseline version of the Area 5 RWMS PA model, version 4.200, was released in FY 2016 and used to assess the continuing validity of PA conclusions. The geometric mean and standard deviation inventory data listed in Tables 10, 12, and 14 were entered into the inventory elements for the SLB, Pit 6, Pit 13 disposal units, and GCD boreholes, respectively. The disposal unit area, disposal unit volume, and waste volumes were updated with FY 2016 data. All SLB disposal units were assumed to be closed with a minimum 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 11.1.6 with 5,000 LHS realizations.

The Area 5 RWMS v4.200 model results indicate that there is a reasonable expectation of compliance with the member of the public performance objectives. The mean and 95th percentile air pathway annual total effective dose (TED) for all scenarios are less than the 0.1 millisievert (mSv) limit (Table 17). The maximum air pathway annual TED is less than 1% 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 resident air pathway TED at 1,000 years is contributed predominantly

by uranium-238+P (^{238}U+P) (22%), thorium-229+P (^{229}Th+P) (21%), lead-210+P (^{210}Pb+P) (15%), plutonium-239 (^{239}Pu) (13%), ^{234}U (10%), and ^{233}U (9%), where "+P" indicates that the dose from short-lived progeny assumed to be in secular equilibrium is included. Pb-210 present at 1,000 years is produced predominantly by radioactive decay of ^{234}U present at the time of disposal. At closure, ^{3}H is the predominant source of air pathway TED.

Table 17. Area 5 RWMS v4.200 GoldSim Model Reference Person Annual TED through the Air Pathway

Exposure Scenario	Mean (mSv)	95th Percentile (mSv)	Time of Maximum
Transient Visitor	6.5E-5	2.3E-4	1,000 years
Resident	1.6E-4	5.6E-4	1,000 years
Resident with Agriculture	3.5E-4	1.2E-3	1,000 years
Open Rangeland (Cane Spring)	7.1E-9	NA	100 years
Open Rangeland (NNSS Boundary)	1.2E-7	3.0E-7	1,000 years

NA – insufficient non-zero realizations to calculate quantile

The air pathways results did not significantly change in FY 2016 relative to FY 2015. The air pathway TED for the transient visitor and resident with agriculture scenarios increases relative to the 2006 PA update result, but still remain a small fraction of the performance objective. The times of the maximum result have shifted from 63 years to 1,000 years for most scenarios.

The mean and 95th percentile all-pathways annual TED for the scenarios are less than the 0.25 mSv performance objective (Table 18). The maximum all-pathways TED is approximately 10% of the performance objective. The resident all-pathways TED at 1,000 years is predominantly due to ^{210}Pb+P (43%), ^{238}U+P (24%), and ^{229}Th+P (11%).

Table 18. Area 5 RWMS v4.200 GoldSim Model Reference Person Annual TED through All Pathways

Exposure Scenario	Mean (mSv)	95th Percentile (mSv)	Time of Maximum
Transient Visitor	5.3E-3	1.2E-2	1,000 years
Resident	9.2E-4	2.6E-3	1,000 years
Resident with Agriculture	2.5E-2	8.0E-2	1,000 years
Open Rangeland (Cane Spring)	5.6E-3	1.9E-2	1,000 years
Open Rangeland (NNSS Boundary)	5.8E-3	1.9E-2	1,000 years

The FY 2016 all-pathway TEDs increase for the resident and open rangeland scenarios relative to FY 2015 results. The current all-pathways TED results are less than the 2006 PA update except for the transient visitor scenario. All results remain less than 50% of the performance objective.

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 19). 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 performance objective 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 averaged over all disposal units is 24% of the performance objective.

Table 19. Area 5 RWMS v4.200 GoldSim Model ^{222}Rn Flux Density Results

Disposal Unit	Mean (Bq m^{-2} s^{-1})	95th Percentile (Bq m^{-2} s^{-1})	Time of Maximum
All	0.18	0.40	1,000 y
SLB	0.18	0.40	1,000 y
Pit 6 RaDU	0.086	0.18	1,000 y
Pit 13 RaDU	0.60	1.9	1,000 y
GCD	1.1E-8	2.9E-8	1,000 y

The FY 2016 ^{222}Rn flux density results are not significantly changed relative to FY 2015 results. The FY 2015 ^{222}Rn flux density results have increased significantly relative to the 2006 PA update results as a consequence of increased inventory and a reduced cover thickness. Nevertheless, the mean and median, which are used for compliance evaluation, are less than 50% of the performance objective. The changes do not meet any of the LFRG notification criteria.

Chronic intrusion is assumed to be an unlikely event based on the institutional control policy adopted in FY 2008. Therefore, chronic intrusion results are replaced with drilling and construction acute intruder scenario results. The FY 2016 mean and 95th percentile acute intruder doses are less than the 5 mSv performance measure for both scenarios at all virtual disposal units (Table 20). The acute drilling intrusion TEDs remain a small fraction of the performance measure.

Table 20. Area 5 RWMS v4.200 GoldSim Model Acute Drilling Intruder TED

Disposal Unit	Mean (mSv)	95th Percentile (mSv)	Time of Maximum
SLB	1.3E-3	2.2E-3	1,000 years
Pit 6 RaDU	0.037	0.070	1,000 years
Pit 13 RaDU	0.026	0.034	1,000 years
GCD	0.016	0.043	1,000 years

The FY 2016 acute drilling scenario TEDs are not significantly different from the FY 2015 results. The 2006 PA update did not evaluate acute intrusion scenarios.

The FY 2016 mean and 95th percentile acute construction scenario TEDs are less than the performance measure for all virtual disposal units (Table 21). The mean SLB acute construction scenario TED is 24% of the performance measure. The acute construction intruder TED for the SLB disposal units is predominantly due to ^{238}U+P (37%), ^{229}Th+P (22%), ^{239}Pu (9%), ^{234}U (7%), and ^{233}U (6%).

Table 21. Area 5 RWMS v4.200 GoldSim Model Acute Construction Intruder TED

Disposal Unit	Mean (mSv)	95th Percentile (mSv)	Time of Maximum
SLB	0.99	1.7	1,000 years
Pit 6 RaDU	0.84	2.2	1,000 years
Pit 13 RaDU	0.053	0.18	1,000 years
GCD	2.7E-6	NA	100 years

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

The FY 2016 acute construction TEDs are not significantly changed relative to the FY 2015 results. The 2006 PA update did not evaluate acute intrusion scenarios.

The FY 2016 PA results show little or no change relative to the FY 2015 results. Comparison of the FY 2016 results with the 2006 PA update indicates that changes have occurred in the maximum TEDs and their time of occurrence. The air pathway results have increased for two scenarios. The current maximum air pathway TED is less than 1% of the performance objective. The all-pathways results have increased for the transient visitor but have decreased for all other scenarios. The mean ^{222}Rn flux density averaged over all disposal units has increased to 24% of the performance objective. The 95th percentile remains less than the performance objective. 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 model parameters, a new passive institutional control period, a new institutional control policy, a thinner closure cover, and new dose conversion factors. Although some PA results have increased, all results remain less than 50% of performance objectives. None of the changes meets the LFRG notification requirements (DOE 2015). All results indicate that there is still a reasonable expectation of meeting all performance objectives. Therefore, the Area 5 RWMS PA results are still valid, and no need to revise the PA is identified.

2.6 PA CONCLUSIONS

2.6.1 Area 3 RWMS

The most significant change for the Area 3 RWMS is additional inventory disposed between 1996, when the approved PA inventory was prepared, and 2006, when the area was placed in inactive status. The site's conceptual model, important features, events, and processes (FEPs), site characteristics, and POAs remain unchanged. Environmental monitoring results continue to indicate that the only releases from the site are low levels of tritiated water vapor 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? The Area 3 RWMS has been inactive since 2006. No changes occurred in FY 2015. A special analysis of the Area 3 RWMS (NSTec 2012) demonstrates that PA conclusions are unchanged and that there continues to be a reasonable expectation of compliance with all

performance objectives. No changes requiring LFRG notification have occurred. A PA revision is not necessary.

2. Does the annual summary information indicate that the conclusions of the PA remain valid? The special analysis prepared in FY 2012 confirms that important PA conclusions remain unchanged. No groundwater pathway is expected at the site. No changes have occurred since FY 2012. The Area 3 RWMS PA 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 and any conditions in the facility DAS? The FY 2012 special analysis results (NSTec 2012) indicate that there is still a reasonable expectation of compliance with all performance objectives. All PA results continue to be a small fraction of their performance objectives.

2.6.2 Area 5 RWMS

Since preparation of the 2006 Area 5 RWMS PA update, multiple changes have occurred, including increased inventory, updated parameters, revised periods of institutional control, a thinner closure cover, and updated dose coefficients. The site conceptual model, important FEPs, site characterization data, and POAs remain unchanged. Environmental monitoring results continue to indicate that the only releases from the site are low levels of tritiated water vapor 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 or CA are required? No significant changes occurred in FY 2016 that would require revision of the Area 5 RWMS PA. Although more significant changes have occurred since the 2006 PA update, the mean and median of all PA results remain less than 50% of their respective performance objectives. No LFRG notification criteria have been met. A PA revision is not necessary.
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, PA results updated through FY 2016 in Section 2.5.3.2 confirm that the PA's conclusions continue to be valid. The Area 5 RWMS PA 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 and any conditions in the facility DAS? Updated FY 2015 PA results in Section 2.5.3.2 indicate that there continues to be a reasonable expectation of compliance with all performance objectives.

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3.0 COMPOSITE ANALYSIS REVIEW

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

3.1 WASTE DISPOSAL OPERATIONS

3.1.1 Radioactive Waste Management Sites

3.1.1.1 Waste Characteristics and Facility Design

There were no discovered or proposed changes in the operation, design, and waste characteristics of the pre-1988 disposal units at the Area 3 and Area 5 RWMSs. All pre-1988 disposal units at the Area 3 RWMS and Area 5 RWMS are now closed, except for the U-3ah/at disposal unit at the Area 3 RWMS, which is operationally closed. No operational changes occurred at either site. The CA models remain consistent with the facility designs and waste characteristics.

No new or additional data were acquired about pre-1988 waste forms, containers, and operations at the Area 3 RWMS in FY 2016. No remediation of pre-1988 wastes or disposal units was performed. No special analyses were prepared for the Area 3 RWMS pre-1988 waste in FY 2016.

The Area 5 RWMS pre-1988 waste forms, containers, facility design, and operations were unchanged in FY 2016. No remediation of pre-1988 wastes or disposal units was performed. No special analyses were prepared for the Area 5 RWMS pre-1988 waste in FY 2016. Special analyses described in Section 2.1.2.1 for new or revised waste streams will also affect the CA.

3.1.1.2 Pre-1988 Waste Inventories

The current Area 3 RWMS CA inventory was estimated with the Area 3 Inventory v2.016 model and is reported in Table 7. There are no changes to the pre-1988 waste inventories. The pre-1988 inventory is the same as assumed for the FY 2012 Area 3 RWMS special analysis (NSTec 2012).

The current Area 5 RWMS CA inventory was estimated with the Area 5 Inventory v2.118 model. The pre-1988 SLB and GCD inventories are reported in Tables 10 and 14, respectively. There were no significant changes to the pre-1988 waste inventories for the Area 5 RWMS in FY 2016. The pre-1988 inventory remains consistent with the inventories analyzed in the CA. The CA results using the FY 2016 inventories are updated in Section 3.4.2.

3.1.1.3 Monitoring

Pre-1988 waste and disposal units are covered by the same monitoring activities 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 2016a, 2016b). CY 2015 monitoring results are consistent with previous trends and the CA resuspension and atmospheric dispersion model results.

A subsidence area and several cracks were repaired on the Area 3 RWMS U-3ax/bl closure cover in CY 2015. Cumulative U-3ax/bl cover subsidence since CY 2000 ranges from 1.5 to 4.3 cm (0.05 to 0.14 ft) (NSTec 2016c). The next U-3ax/bl subsidence markers survey will occur in CY 2016.

Multiple subsidence areas and erosion rills on cover slopes were repaired on the Area 5 RWMS 92-ac LLWMU closure cover in CY 2015. Cumulative subsidence at 52 locations on the 92-ac LLWMU closure cover averages 1.2 cm (0.04 ft) (NSTec 2016c).

3.1.1.4 RWMS 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, which contains most of the pre-1988 waste at the Area 3 RWMS, was closed in FY 2001 with the installation of a monolithic alluvium cover. The existing U-3ax/bl 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 U-3ax/bl closure cover is 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 (NSTec 2007b). The Area 3 RWMS covers and closure plan remain consistent with CA model assumptions.

The Area 5 RWMS CA cover assumptions are consistent with closure plans (BN 2001b; NSTec 2008a). 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. The current Area 5 RWMS CA model assumes the site is closed with a 2.5 m (8 ft) monolithic ET cover. In FY 2011, the 92-ac LLWMU at the Area 5 RWMS, which includes all pre-1988 disposal units except the GCD Test borehole, was closed with a 2.5-m (8-ft) monolithic ET cover. Closure of the GCD boreholes and GCD Test borehole will occur at final site closure in 2028. Closure of the pre-1988 Area 5 RWMS disposal units and the closure plan are consistent with the CA assumptions (NSTec 2008a).

3.2 RESEARCH AND DEVELOPMENT

No R&D activities occurred in FY 2016 specific to pre-1988 waste or residual radioactive contamination. The model development R&D activities described in Section 2.4 are also relevant for the CAs.

3.3 INTERACTING SOURCE TERMS

Sources that may interact with the Area 3 and Area 5 RWMSs include operating facilities and residual contamination in soil and groundwater from nuclear weapon testing. Sites with residual contamination are remediated and closed under the FFACO process. The FFACO categorizes contaminated sites into UGTAs, Soil Sites, and Industrial Sites

3.3.1 Underground Test Areas

The UGTAs include vadose zone and groundwater units contaminated by belowground testing. The goal of the FFACO UGTA CAU closure process is to define UR boundaries that enclose groundwater potentially exceeding the maximum contaminant levels of the Safe Drinking Water Act within 1,000-years. The Corrective Action Strategy is to use characterization and modeling studies, monitoring, and institutional controls to manage potential risks from contaminated groundwater. The strategy is implemented through a four-stage approach that includes (1) Corrective Action Investigation Plan (CAIP), (2) Corrective Action Investigation (CAI), (3) CADD/CAP, and (4) Closure Report (CR) stages. Initial UR boundary and regulatory boundary objectives are identified at the start of the CADD/CAP stage. The CR stage finalizes the UR boundary and establishes the regulatory boundary. The UR boundary is established through combined assessments of contaminant boundary forecasts, requirements for protection of worker health and safety, and administrative policies 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.

The Area 3 RWMS and Area 5 RWMS CAs assume that the disposal sites are within UGTA UR boundaries and that the URs can control exposure of the public to contaminated groundwater from belowground tests for 1,000 years. NNSA/NFO has a formal policy to implement and maintain institutional controls, including the UGTA URs, as long as necessary (NNSA/NFO 2015b).

CAU 97, the Yucca Flat UGTA, is in the CAI stage of the FFACO process. A formal external peer review of the groundwater flow and radionuclide transport model occurred in FY 2014. Responses to the review were in preparation during FY 2016. The Area 3 RMWS is expected to be within the initial CAU 97 UR boundary. The Area 3 RWMS CA assumptions are still consistent with current plans for CAU 97.

CAU 98, the Frenchman Flat UGTA, is in a more advanced stage of the FFACO process. The CAU 98 CADD/CAP was completed and accepted by NDEP in 2011 (NNSA/NSO 2011b). The initial UR boundaries described in the CADD/CAP enclose three areas in Frenchman Flat: the North Testing Area, the Central Testing Area, and the Area 5 Area-Relinquishment boundary corresponding with the RWMC boundary. The model evaluation report was prepared in FY 2014 (Novarro-Intera 2014). The closure of CAU 98 is expected to be completed in FY 2017.

The most recent CAU 98 modeling and monitoring results indicate that the Area 5 RWMS is not within the area where groundwater may exceed maximum contaminant levels. The Area 5 RWMC boundary is approximately 735 m (2,400 ft) southwest of the closest North Testing Area UR boundary. This approximates the closest projected approach of UGTA groundwater contaminant plumes to the Area 5 RWMS boundary within 1,000 years. The CAU 98 Northern Testing and Central Testing Areas are still expected to be enclosed by UGTA UR boundaries as assumed in the CA.

In FY 2016, NNSA/NFO proposed removing the Area 5 RWMS from the CAU 98 UR boundaries. Permanent custody and accountability for the Area 5 RWMC was transferred from the Bureau of Land Management to DOE in 2009. Access to the Area 5 RWMC will be

controlled by NNSA/NFO institutional controls, which will include URs (NNSA/NFO 2015b, 2016a). Although the expected location and extent of CAU 98 UR boundaries has changed over time as new data have become available, the Area 5 RWMS CA assumption that exposure to contaminated groundwater from underground testing will be controlled by institutional controls remains valid.

3.3.2 Soil Sites and Industrial Sites

Soil Sites and Industrial Sites are FFACO sites with residual chemical or radiological contamination from NNSS nuclear testing operations. The CAs included multiple contaminated soil units characterized by the Radionuclide Inventory and Distribution Program (RIDP) (McArthur 1991) as source terms for atmospheric resuspension and dispersion modeling. The contaminated soil units characterized by the RIDP are composed of multiple FFACO Soil Sites and Industrial Sites. The CAs assume that the RIDP contaminated soil units will be closed in place and any corrective actions will have minimal impact on resuspension and atmospheric dispersion of radionuclides from the sources to the RWMSs. FFACO CAIs and Closures provide information that can be used to evaluate CA assumptions about the extent, level, and composition of contamination characterized by the RIDP.

The Area 3 RWMS CA included 28 RIDP soil units contaminated by aboveground and belowground nuclear testing. No FFACO CAIs or Closures Reports for Soil Sites or Industrial Sites within the Area 3 RWMS contaminated soil units occurred in FY 2016. A new CAU, Miscellaneous Radiological Sites and Debris (CAU 576), was identified that includes a CAS a few hundred meters northwest of the Area 3 RWMS. CAS 03-99-20, Area 3 Subsurface Rad-Chem Piping, is believed to consist of contaminated sub-surface piping. The site is in the early stages of investigation. Past FFACO site characterization and closure activities continue to be consistent with the Area 3 RWMS CA assumptions. Completed or planned closure actions have had no significant impact on radionuclide inventories or radionuclide resuspension rates. Completed and planned corrective actions are not expected to alter CA model assumptions.

The Area 5 RWMS CA considered eight sites with residual soil contamination. Four of the sites are Industrial Sites with small contamination areas. The Industrial Sites, consisting of the 306 Ground Zero (GZ) Rad Contaminated Area (CAS 05-45-04), the 307 GZ Rad Contaminated Area (CAS 05-45-05), the Kay Blockhouse (CAS 05-33-01), and the Gravel Gertie (CAS 05-23-01), were excluded from the CA based on their small radionuclide inventories, limited area, and distance from the RWMS relative to other potential sources.

The remaining four sites are Soil Sites contaminated by weapons tests which have much more extensive contamination areas. The Pu Valley Soil Site (CAU 366) was excluded based on the assumption that the intervening mountain ranges restrict atmospheric dispersion. The other three Soil Sites—the Gadget, Mechanics, and Explosives (GMX) site (CAS 05-23-15), PINSTRIPE (CAS 11-23-05), and the Frenchman Flat Atmospheric Test Site (ABLE CAS 05-23-05, HAMILTON CAU 573, and SMALL BOY CAU 541)—were included in CA modeling.

Since preparation of the CA, most of the excluded sources, except the Pu Valley Soil Site have been closed. Completed closure actions have had no significant impact on radionuclide

inventories or radionuclide resuspension rates. Although CAIs have developed additional site characterization data, the RIDP characterization data are still the preferred source for contaminated Soil Site inventories (NSTec 2008b). CA assumptions remain consistent with the status of the Industrial Sites and Soil Sites. Completed and planned corrective actions are not expected to have any impact on CA model assumptions.

Additional FFACO activities occurred in FY 2016 at Soil Sites included in the Area 5 RWMS CA (Table 22). The CADD/CAP for the Alpha Contaminated Sites (CAU 573) was issued in FY 2016. CAU 573 includes the GMX Alpha Contaminated Area (CAS 05-23-02) and the Hamilton Atmospheric Test Site (CAS 05-45-01) included in the Area 5 RWMS CA. The Hamilton Atmospheric Test Site was included in the RIDP Frenchman Flat playa soil unit. Lead brick, lead plates, and lead-shielded cables were removed from CAU 573 during the CAI phase.

Table 22. FY 2016 Developments for ER Soil Sites Considered in the Area 5 RWMS CA

CAU	Site	Radiological COPCs or COCs	FFACO Status	Corrective Action
573	Alpha Contaminated Sites	Actinides, MFP	CADD/CAP Issued (NNSA/NFO 2016c)	CAS 05-23-02: Closure in Place CAS 05-45-01: Clean Closure

COC – contaminant of concern
COPC – contaminant of potential concern

The recently constituted CAU 576 also includes a CAS near the Area 5 RWMS. CAS 05-19-04, Frenchman Flat Rad Waste Dump, is a 9 x 9 m (30 x 30 ft) site on the northwest edge of Frenchman Flat playa, approximately 4 km (2.4 mi) from the Area 5 RWMS where buried radioactive debris may be present. The site is in the early stages of investigation and the presence of buried contamination has not yet been confirmed. Surface contamination has been identified, but would likely have been included in the RIDP Frenchman Flat playa soil unit source included in the CA. The potential impact of CAU 576 on the CA will continue to be assessed as it moves through the FFACO closure process.

3.3.3 Operational Facilities

Operational facilities near the Area 3 and Area 5 RWMSs may contribute to the CA TED through atmospheric emissions or residual contamination remaining after decommissioning. Operating facilities near the Area 3 and Area 5 RWMSs have no or minimal long-lived particulate air emissions under normal operating conditions (NSTec 2016b). Operating facilities near the Area 3 and Area 5 RWMS are unlikely to leave residual contamination in the accessible environment after decommissioning with the exception of pre-1988 disposal units at the RWMS.

3.4 SUMMARY OF CA CHANGES

3.4.1 Discovered Changes

A new Industrial Site, CAU 576, was identified in FY 2016 that includes two new CASs near the Area 3 and Area 5 RWMSs. CAS 03-99-20, Area 3 Subsurface Rad-Chem Piping, and CAS 05-

19-04, Frenchman Flat Rad Waste Dump, are still under investigation. Both sites involve belowground contamination and are not expected to be important CA sources. There were no other discovered changes affecting the CAs in FY 2016.

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. Closure of ER sources included in the CA is progressing, but closure activities have had no impact on the CA model assumptions.

The Area 5 RWMS 92-ac LLWMU, which includes all pre-1988 waste disposal units except the GCD Test Borehole, was closed with a minimum 2.5-m (8.2-ft) monolithic ET cover in FY 2011. Revegetation of the 92-ac LLWMU cover began in FY 2012 and is continuing. These changes are consistent with the CA model.

Closure of ER sources included in the Area 5 RWMS CA is progressing, but closure activities have had no impact on CA assumptions or models. Corrective action investigations at several ER sources excluded from the CA confirm assumptions that the sources have minimal potential to interact with the Area 5 RWMS. An updated Area 5 RWMS CA baseline model was released in FY 2016. There were no significant changes to the CA model.

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

3.4.3 R&D Changes

3.4.3.1 CA Results for the Area 3 RWMS

The Area 3 RWMS v2.102 GoldSim model was used to update the CA results in FY 2012 (NSTec 2012). The model was run as described for the PA, except that the model was run in CA mode, which includes the pre-1988 waste inventory and Soil Site inventories. The special analysis concluded that there continues to be a high likelihood that the annual TED is a small fraction of the 0.3 mSv dose constraint. Therefore, the Area 3 RWMS CA results are still valid.

3.4.3.2 CA Results for the Area 5 RWMS

The Area 5 RWMS CA results were updated with the Area 5 RWMS v4.200 GoldSim model. The model was run as described for the PA, except that the model was run in CA mode, which includes the pre-1988 waste inventory. The FY 2016 CA TED estimate increases relative to the FY 2015 result (Table 23). The increase is due to an increase in the ^{210}Pb reference person soil ingestion pathway dose conversion factor (PDCF) relative to the adult soil ingestion PDCF used previously. The soil ingestion PDCFs increase for the reference person because of the higher inadvertent soil ingestion rates of children. The composite analysis TED is contributed predominantly by ^{210}Pb+P (55 %), ^{238}U+P (18 %), ^{229}Th+P (7 %), and ^{226}Ra+P (6 %) released from the Area 5 RWMS. The FY 2016 result is significantly less than the CA result (BN 2001b).

The FY 2016 mean and 95th percentile doses remain significantly less than the 0.3 mSv annual dose constraint. Therefore, the Area 5 RWMS CA results are still valid.

Table 23. Area 5 RWMS v4.200 GoldSim Model CA All-Pathways Annual TED for a Resident at the 100 m (330 ft) RWMS Boundary

Source	Mean (mSv)	95th Percentile (mSv)	Time of Maximum
Area 5 RWMS	1.2E-3	3.6E-3	1,000 years

3.5 CA CONCLUSIONS

3.5.1 Area 3 RWMS

There have been no changes in FY 2016 that affect the conclusions of the CA, as indicated by reviews of facility operations, waste inventories, ER sources of residual soil contamination, the progress of the ER closure projects, land-use planning, closure planning, and the results of the monitoring and R&D activities. A new CAS was identified near the Area 3 RWMS, but this source is not expected to significantly impact the CA. There is no new information that would reduce the uncertainty of the current sources. A special analysis of the Area 3 RWMS was issued in FY 2012, which includes updated CA results.

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 was prepared in FY 2012 to determine the impacts of changes occurring since preparation of the CA. The special analysis supports the CA conclusions. The special analysis concludes that a CA revision is not necessary. No significant changes have occurred since preparation of the special analysis.
2. Does the annual summary information indicate that the conclusions of the PA and CA remain valid? The FY 2012 special analysis indicates that the annual TED to a resident from the Area 3 RWMS all interacting sources is a small fraction of the 0.3 mSv CA dose constraint and that the HORNET GZ Soil Site is the predominant source. The Area 3 RWMS special analysis results are consistent with the CA results, supporting a conclusion that the CA continues to be 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 3 RWMS v2.102 GoldSim model results indicate that there is still a high likelihood of meeting the 0.3 mSv CA dose constraint.

3.5.2 Area 5 RWMS

There have been no changes in FY 2016 that affect the conclusions of the CA, as indicated by reviews of facility operations, disposed inventories, estimated inventories of the ER sources of residual radionuclides, the progress of the ER corrective actions, land-use planning, closure planning, and the results of the monitoring and R&D activities. A new CAS was identified near the Area 5 RWMS, but is not expected to significantly affect the CA results. No other new

sources of contamination were identified. Corrective action investigations at contaminated soil sites has confirmed and supported CA assumptions.

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? The only change affecting the CA is the updated RWMS inventory. The consequences of the changes were evaluated with the Area 5 RWMS v4.200 GoldSim model and found not to affect the CA conclusions. No CA changes are required.
2. Does the annual summary information indicate that the conclusions of the PA and CA remain valid? The CA results updated with the Area 5 RWMS v4.200 GoldSim model indicate that the CA dose is a small fraction of the dose constraint. The conclusions of the Area 5 RWMS CA 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 v4.200 GoldSim model results indicate that there is a high likelihood of meeting the 0.3 mSv CA 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. Although changes have occurred in the closure plans, inventory, and PA model, updated PA results continue to provide a reasonable expectation of compliance. No LFRG notification criteria have been met.
b. Does the annual summary information indicate that the conclusions of the PA remain valid?	Section 2.6 concludes that updated results for the Area 3 and Area 5 RWMS PAs continue to support the PA's conclusions that the mean or median of all performance objectives are less than 50% of the limit.
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 2016 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 for new or revised waste streams 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.

Requirement	Result
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.
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?*	Disposal unit design is discussed in Section 2.2.1. Disposal unit designs continue to be consistent with PA models. Waste receipts are described in Section 2.1.2. The impacts of waste receipts on PA results are described in Section 2.5.3.
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 and confirms that the WAC action levels are derived from PA results.
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.

Requirement	**Result**
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?*	Subsidence controls and monitoring methods are described in Section 2.2.4.
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?*	Closure cover design and consistency with PA analyses are 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.
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 Area 3 RWMS and Area 5 RWMS DASs are summarized in Section 1.1, Tables 1 and 3, respectively. The tables' status column indicates that all conditions were closed in 2002.
b. *R&D efforts pursued for improving and refining the performance assessment. Are these efforts adequately described?*	R&D efforts required by PA/CA reviews and their resolution are summarized in Section 1.2, Table 5. Ongoing 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?*	No confirmatory monitoring is performed. Monitoring of site performance is described under Section 2.2.3. Monitoring results are published elsewhere as cited in the text.

Requirement	Result
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 discovered 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 most recent PA results for the Area 3 and Area 5 RWMSs. No significant changes occurred in FY 2016 relative to FY 2015. More significant changes are noted relative to the most recent PAs. FY 2016 results continue to meet all performance objectives. The Area 3 RWMS all-pathways dose and ^{222}Rn flux density have increased relative to the PA but remain a small fraction of the performance objectives. The Area 5 RWMS air pathway dose has increased relative to the 2006 PA update, but remains less than 1% of the performance objective. The all-pathways dose has decreased for most scenarios. The ^{222}Rn flux density has increased significantly due to inventory increases and a decreased cover thickness. The 95th percentile flux is less than the performance objective. The mean remains less than 50% of the performance objective.
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 2016.
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. The effects of changes are described in Section 2.5.3. Changes do not trigger any LFRG notification criteria.
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. Current CA results continue to support CA conclusions. There continues to be 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?*	The annual review confirms that no significant changes have occurred. 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?	The current results continue to support the original CA conclusions. Section 3.5 concludes that the conclusions of the CAs remain valid.

Requirement	Result
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.
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?*	The pre-1988 RWMS disposal units are the only facilities interacting with the RWMSs. RWMS design and operations changes affecting the CAs are described in Section 3.1. The effects of all changes on the CA results are described in Section 3.4.3.
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 2.1.2 describes special analysis for new or revised waste streams. No special analyses were performed pre-1988 waste or interacting sources. The effects of changes on CA results are assessed using the current CA models. Current CA results are included in Section 3.4.3.
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 RWMS facility changes occurring in FY 2016. No significant changes to pre-1988 disposal units occurred at the Area 3 RWMS and Area 5 RWMS in FY 2016.
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?*	Changes in facilities (the RWMSs) are summarized in Section 3.1.1. Changes in interacting Environmental Restoration sites are summarized in Section 3.3. Changes in Environmental Restoration sites due to completed and planned corrective actions are not expected to affect CA results.
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 states that there are no 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?*	Changes occurring since preparation of the CA are summarized in Section 3.4.2. Section 3.5 concludes that updating of the CAs is not

Requirement	Result
	required, based on CA results from current models.
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.)*	
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 3.1 describes changes to the RWMSs operations and configuration. Section 3.3 describes changes to interacting Environmental Restoration 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 and their consistency with model assumptions.
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 characteristics. Changes to post-1988 inventories are described in Section 3.1.1.2. No significant changes occurred for pre-1988 inventories.
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. The WAC remain consistent with waste properties assumed in the PA and CA.
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 (RWMS) design with CA analyses is described in Section 3.1.1.

Requirement	Result
b. *Engineered barrier consistency with the CA. Is the consistency adequately described?*	Consistency of facility design with CA analyses is described in Section 3.1.1.1. Consistency of cover design with CA analyses is described in Section 3.1.1.4.
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 3.1.1.3.
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 disposal unit cover design with CA analyses is described in Section 3.1.1.4. Consistency of Environmental Restoration closures with CA analyses is described in Section 3.3.
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.
3.3.4 Research and Development Considerations a. *R&D efforts required by the DAS. Are these efforts adequately described?*	R&D efforts required by the Area 3 RWMS and Area 5 RWMS DASs are summarized in Section 1.1, Tables 1 and 3, respectively. The tables' status column indicates that all conditions were closed in 2002. 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?*	No confirmatory testing is performed. Monitoring is described in Section 3.1.1.3.
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 3 RWMS and Area 5 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 corrective action investigations and corrective actions affecting interacting source terms and concludes that no significant changes have occurred for the Area 3 RWMS and Area 5 RWMS.

Requirement	Result
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. The preferred data source for source inventory is unchanged. There is no significant change in existing source term uncertainty.
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 discovered 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 affecting the CA. A new CAU was identified in FY 2016 that include a CASs near the Area 3 and Area 5 RWMSs.
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 CAs are described in Section 3.4.2. The effects of changes on CA results are presented and discussed in Section 3.4.3.

Requirement	Result
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. The significance and effect of R&D changes on CA results are described in Section 3.4.3.
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 all DAS conditions in 2002 are discussed in Section 1.1. Minor issues being addressed by the PA/CA maintenance process are described in Section 1.2.
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 final Maintenance Plan, Closure Plans, and Monitoring Plans are identified in Sections 1.2, 2.3.1, and 2.2.3, respectively. Complete citations are found in Section 4.0.

CA Composite Analysis
CAU Corrective Action Unit
CAS Corrective Action Site
DAS Disposal Authorization Statement
DOE U.S. Department of Energy
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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APPENDIX B

List of Published Special Analyses

Special analyses published since preparation of the latest Area 3 Radioactive Waste Management Site (RWMS) and Area 5 RWMS Performance Assessments or Composite Analyses are listed below.

National Security Technologies, LLC. 2012. *Special Analysis of the Area 3 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--1617. National Security Technologies, LLC, Las Vegas, NV. September 2012.

National Security Technologies, LLC. 2013. *Special Analysis for the Disposal of the Consolidated Edison Uranium Solidification Project Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--1678. National Security Technologies, LLC, Las Vegas, NV. January 2013.

National Security Technologies, LLC. 2014. *Special Analysis for the Disposal of the Idaho National Laboratory Unirradiated Light Water Breeder Reactor Rods and Pellets Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2186. National Security Technologies, LLC, Las Vegas, NV. August 2014.

National Security Technologies, LLC. 2014. *Special Analysis for the Disposal of the Neutron Products Incorporated Sealed Source Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2187. National Security Technologies, LLC, Las Vegas, NV. August 2014.

National Security Technologies, LLC. 2015. *Special Analysis for the Disposal of the Sandia National Laboratories Radioisotope Thermoelectric Generators Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2374. National Security Technologies, LLC, Las Vegas, NV. March 2015.

National Security Technologies, LLC. 2015. *Special Analysis for the Disposal of the Lawrence Livermore National Laboratory Husman Irradiators Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2389. National Security Technologies, LLC, Las Vegas, NV. March 2015.

National Security Technologies, LLC. 2015. *Special Analysis for the Disposal of the West Valley Demonstration Project Extraction Cell 2 Low Density Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2461. National Security Technologies, LLC, Las Vegas, NV. May 2015.

National Security Technologies, LLC. 2015. *Special Analysis for the Disposal of the Oak Ridge National Laboratory General Radioactive Sources Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2482. National Security Technologies, LLC, Las Vegas, NV. May 2015.

National Security Technologies, LLC. 2015. *Special Analysis for the Disposal of the Lawrence Livermore National Laboratory Low Activity Beta/Gamma Sources Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2501. National Security Technologies, LLC, Las Vegas, NV. June 2015.

National Security Technologies, LLC. 2015. *Special Analysis for the Disposal of the Lawrence Livermore National Laboratory Energy X Macroencapsulated Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2511. National Security Technologies, LLC, Las Vegas, NV. July 2015.

National Security Technologies, LLC. 2015. *Special Analysis for the Disposal of the Sandia National Laboratory Classified Macroencapsulated Mixed Waste at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2698. National Security Technologies, LLC, Las Vegas, NV. December 2015.

National Security Technologies, LLC. 2016. *Special Analysis for the Disposal of the Oak Ridge National Laboratory Activated Metal Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2738. National Security Technologies, LLC, Las Vegas, NV. February 2016.

National Security Technologies, LLC. 2016. *Special Analysis for the Disposal of the Portsmouth Uranium Fluoride Solids Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2768. National Security Technologies, LLC, Las Vegas, NV. April 2016.

National Security Technologies, LLC. 2016. *Special Analysis for the Disposal of the Idaho National Laboratory Idaho Chemical Processing Plant Low-Level Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2769. National Security Technologies, LLC, Las Vegas, NV. April 2016.

National Security Technologies, LLC. 2016. *Special Analysis for the Disposal of the Idaho National Laboratory Unirradiated Light Water Breeder Reactor UO_2/ThO_2 and UO_2/ZrO_2 Rods and Pellets Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2901. National Security Technologies, LLC, Las Vegas, NV. July 2016.

National Security Technologies, LLC. 2016. *Special Analysis for the Disposal of the Idaho National Laboratory Regulated Asbestos Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2902. National Security Technologies, LLC, Las Vegas, NV. July 2016.

National Security Technologies, LLC. 2016. *Special Analysis for the Disposal of the Idaho National Laboratory Contact Handled Sealed Sources Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*. DOE/NV/25946--2965. National Security Technologies, LLC, Las Vegas, NV. August 2016.

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