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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

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DISCLAIMER

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Acronyms and Abbreviations

FY	(Federal) fiscal year
LHS	Latin hypercube sample
NNSS	Nevada National Security Site
PA	Performance Assessment
RWMS	Radioactive Waste Management Site
SA	Special Analysis
SLB	Shallow land burial
SNL	Sandia National Laboratory
TED	Total effective dose
UGTA	Underground Test Area
WAC	Waste Acceptance Criteria
yr	year

1.0 Introduction

This special analysis (SA) evaluates whether the Sandia National Laboratory (SNL) Classified Macroencapsulated Mixed Waste stream (ASLA000001007, Revision 4) is suitable for disposal by shallow land burial (SLB) at the Area 5 Radioactive Waste Management Site (RWMS) at the Nevada National Security Site (NNSS). The SNL Classified Macroencapsulated Mixed Waste stream consists of debris from classified nuclear weapons components (SNL 2015). The SNL Classified Macroencapsulated Mixed Waste stream required a special analysis due to tritium (^{3}H) exceeding the NNSS Waste Acceptance Criteria (WAC) Action Levels (U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office [NNSA/NFO] 2015).

2.0 Methods

The SA evaluates the impact of the SNL Classified Macroencapsulated Mixed Waste stream inventory on the long-term performance of the Area 5 RWMS.

2.1 Waste Description

The SNL Classified Macroencapsulated Mixed Waste stream consists of debris from classified nuclear weapons components including but not limited to neutron tubes, ferro-electric neutron generators, tube transformer assemblies, and electronic neutron generators. The waste stream is a mixed waste, regulated under the Resources Conservation and Recovery Act for Toxicity Characteristic Leaching Procedure metals. The waste is macroencapsulated in polyethylene using UltraTech International Incorporated Macro Pack containers.

The waste stream includes 18 reportable radionuclides, but only ^{3}H exceeds the NNSS WAC Action Levels. The SNL Classified Macroencapsulated Mixed Waste stream represents a 2.3% increase in the disposed SLB ^{3}H inventory at closure (Table 1).

Table 1. Comparison of SNL Classified Macroencapsulated Mixed Waste Stream Inventory and the Disposed Inventory of Radionuclides Exceeding Their Action Levels (NSTEC 2015)

Nuclide	FY 2014 Disposed Post 1988 SLB Geometric Mean Inventory (Bq) at Closure (10/1/2028)	ASLA000001007_4 Geometric Mean Inventory (Bq) at Closure (10/1/2028)	% Change
^{3}H	3.5E+16	8.1E+14	+2.3

2.2 Performance Assessment Modeling

The performance assessment (PA) modeling is performed by adding the inventory of the SNL Classified Macroencapsulated Mixed Waste stream to the current baseline PA model (A5 RWMS version [v] 4.119) and determining if there is a reasonable expectation of meeting the U.S. Department of Energy (DOE) Manual DOE M 435.1-1, "Radioactive Waste Management Manual," Chapter IV, Section P performance objectives (DOE 1999).

The SNL Classified Macroencapsulated Mixed Waste stream radionuclide inventory is estimated from the activity concentrations reported in Table D.5 of the waste profile sheet (SNL 2015). The waste stream inventory is estimated as the product of the activity concentration and the total waste stream volume, 386 cubic meters (m^3) (504 cubic yards [yd^3]) (SNL 2015). The waste

stream radionuclide inventory is assumed to be lognormally distributed. The geometric mean of the distribution is assumed to be the activity estimated from the representative activity concentration. The 95th percentile of the distribution is estimated from the high activity concentration reported on the waste profile sheet (Table 2).

Table 2. Estimated Geometric Mean, 95th Percentile, and Geometric Standard Deviation of the Concentration and Inventory of the SNL Classified Macroencapsulated Mixed Waste Stream

Nuclide	Geometric Mean Activity Concentration (Bq m^{-3})	95th Percentile Activity Concentration (Bq m^{-3})	Geometric Mean Activity (Bq)	95th Percentile Activity (Bq)	Geometric Standard Deviation
^{241}Am	3.0E+06	3.0E+07	1.1E+09	1.2E+10	4.07
^{60}Co	3.3E+07	3.0E+09	1.3E+10	1.2E+12	15.3
^{137}Cs	6.7E+04	6.8E+05	2.6E+07	2.6E+08	4.07
^{3}H	4.3E+12	6.0E+15	1.7E+15	2.3E+18	80.2
^{40}K	4.6E+04	9.2E+04	1.8E+07	3.6E+07	1.52
^{63}Ni	8.7E+06	8.3E+09	3.3E+09	3.2E+12	64.1
^{210}Pb	1.1E+04	2.3E+04	4.4E+06	8.8E+06	1.52
^{238}Pu	1.1E+06	1.1E+07	4.2E+08	4.2E+09	4.08
^{239}Pu	1.6E+07	1.7E+08	6.3E+09	6.6E+10	4.16
^{240}Pu	5.5E+06	5.5E+07	2.1E+09	2.1E+10	4.05
^{241}Pu	1.6E+07	1.6E+08	6.1E+09	6.2E+10	4.05
^{242}Pu	8.0E+02	8.1E+03	3.1E+05	3.1E+06	4.06
^{226}Ra	1.1E+04	2.3E+04	4.4E+06	8.8E+06	1.52
^{90}Sr	6.7E+04	6.8E+05	2.6E+07	2.6E+08	4.07
^{232}Th	8.0E+06	1.9E+07	3.1E+09	7.2E+09	1.67
^{234}U	1.5E+07	4.3E+08	5.9E+09	1.6E+11	7.52
^{235}U	1.0E+06	2.8E+07	3.9E+08	1.1E+10	7.54
^{238}U	6.3E+07	1.8E+09	2.4E+10	6.8E+11	7.51

The geometric standard deviation of the lognormal distribution is calculated as:

$$GSD = e^{\frac{\ln(UL) - \ln(GM)}{1.65}}$$

where

GSD = geometric standard deviation (dimensionless)
UL = 95th percentile activity, Bq
GM = geometric mean, Bq

The SA is performed by adding the SNL Classified Macroencapsulated Mixed Waste stream radionuclide inventory to the inventory of post-1988 SLB waste disposed through fiscal year (FY) 2014. In addition to the SLB inventory, the SA includes the Pit 6, Pit 13, and post-1988 Greater Confinement Disposal borehole inventories. The model is run with a 2.5-meter (m) (8.2-foot [ft]) closure cover for SLB disposal units.

The mean and median model results are calculated using 5,000 Latin hypercube samples (LHS). A sample size of 5,000 has been previously shown to provide stable estimates of the mean and 95th percentile results for earlier versions of the PA model (Bechtel Nevada [BN] 2006). A reasonable expectation of compliance with the performance objectives is assumed if the mean and median are less than the performance objectives for 1,000 years after closure. In every case, the maximum mean was greater than the maximum median. Only the maximum mean results are reported in the SA for comparison with the performance objectives.

For comparison purposes, baseline results are obtained by running the model with FY 2014 disposed inventory and without the SNL Classified Macroencapsulated Mixed Waste stream.

3.0 Results

3.1 Performance Assessment Results

3.1.1 Air Pathway Results

The air pathway annual total effective dose (TED) is evaluated for the resident exposure scenario using 5,000 LHS realizations. The resident exposure scenario estimates the dose to an adult residing in a home at the 100 m (330 ft) site boundary. A complete description of the exposure scenario can be found in PA documentation (BN 2006). The annual TED is calculated for a period of 1,000 years after closure. The maximum mean and 95th percentile annual TED occur at 1,000 years and are less than the 0.1 millisievert (mSv) limit (Table 3). Addition of the SNL Classified Macroencapsulated Mixed Waste stream has no significant effect on the maximum resident air pathway results.

Table 3. Maximum Air Pathway Annual TED for a Resident at the Area 5 RWMS 100 m (330 ft) Site Boundary and the Waste Inventory Disposed through FY 2014

Scenario	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Resident (Baseline)	1,000 yr	1.5E-4	5.2E-4
Resident (with Candidate Waste Stream)	1,000 yr	1.5E-4	5.2E-4

Addition of the SNL Classified Macroencapsulated waste stream increases the air pathway mean annual TED from approximately 100 to 200 years after closure (Figure 1). The median and 95th percentile annual TED show little or no change. The ^{3}H geometric standard deviation estimate is large. The mean annual TED is likely biased upwards by a small number of large realizations of the ^{3}H inventory.

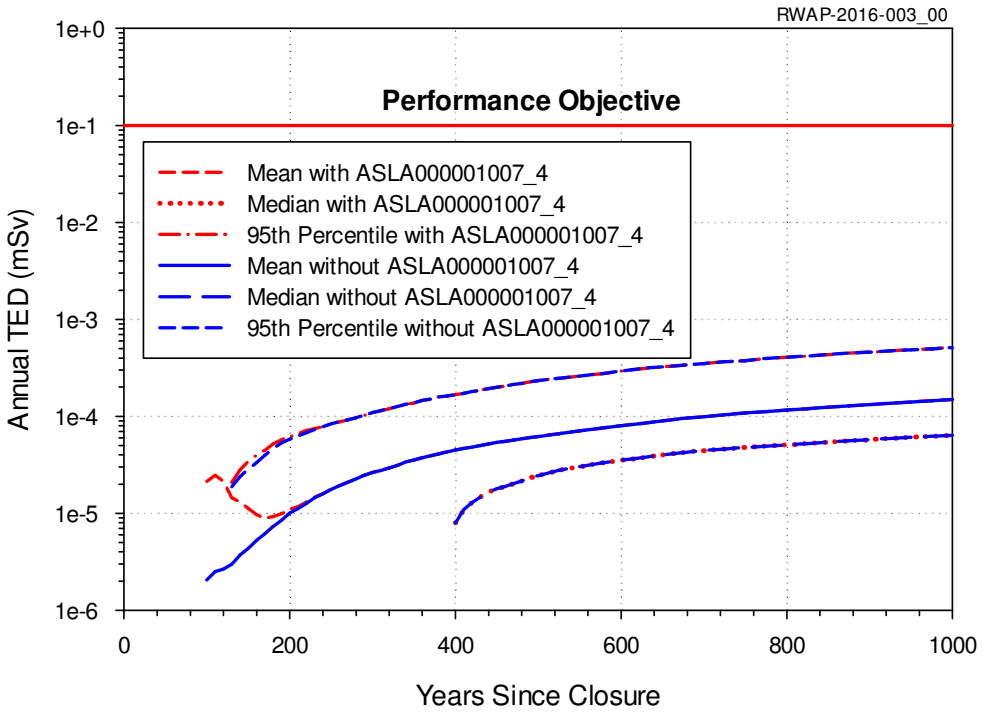

Figure 1 Air Pathway Annual TED Time History for a Resident at the 100-m (330-ft) Boundary with and without the ASLA000001007_4 Waste Stream

3.1.1.1 Alternative Air Pathway Scenarios

The air pathway annual TED for alternative scenarios is calculated to assess the uncertainty contributed by the exposure scenario. The scenarios evaluated are the transient occupancy scenario, the resident with agriculture scenario, and the open rangeland scenario for a ranch at the nearest NNSS boundary and at Cane Spring. The scenarios and their assumptions have been described previously (BN 2006).

The maximum of the mean and 95th percentile are all less than the performance objective for all of the alternative scenarios (Table 4). Although the exposure scenario is a source of uncertainty, there is a high likelihood of compliance for a range of reasonable scenarios. Addition of the SNL Classified Macroencapsulated Mixed Waste stream increases the maximum result and shifts the maximum to 110 years for the transient occupancy and open rangeland scenarios.

Table 4. Maximum Air Pathway Annual TED for Alternative Scenarios with the FY 2014 Inventory

Scenario	Inventory	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Transient Occupancy	Baseline	1,000 yr	7.6E-5	2.8E-4
	With Candidate Waste Stream	100 yr	8.5E-5	NA
Resident With Agriculture	Baseline	1,000 yr	4.1E-4	1.5E-3
	With Candidate Waste Stream	1,000 yr	4.1E-4	1.5E-3
Open Rangeland/Cane Spring	Baseline	1,000 yr	4.9E-9	1.3E-8
	With Candidate Waste Stream	100 yr	4.2E-8	NA
Open Rangeland/NNSS Boundary	Baseline	1,000 yr	8.3E-8	2.3E-7
	With Candidate Waste Stream	100 yr	4.7E-7	NA

NA – Not available, insufficient non-zero realizations to calculate 95th percentile

3.1.2 All-Pathways Results

The all-pathways annual TED is also calculated for the resident exposure scenario. The maximum mean and 95th percentile resident all-pathways annual TEDs are less than the 0.25 mSv limit (Table 5). Addition of the SNL Classified Macroencapsulated Mixed Waste stream has no significant effect on the maximum resident all-pathways annual TED.

Table 5. Maximum All-Pathways Annual TED for a Resident at the Area 5 RWMS 100 m (330 ft) Site Boundary and the Waste Inventory Disposed through FY 2014

Scenario	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Resident (Baseline)	1,000 yr	7.6E-4	2.4E-3
Resident (with Candidate Waste Stream)	1,000 yr	7.6E-4	2.4E-3

Addition of the SNL Classified Macroencapsulated Mixed Waste stream slightly increases the all-pathways annual TED from 100 to 200 years after closure (Figure 2). The median and 95th percentile are only slightly changed.

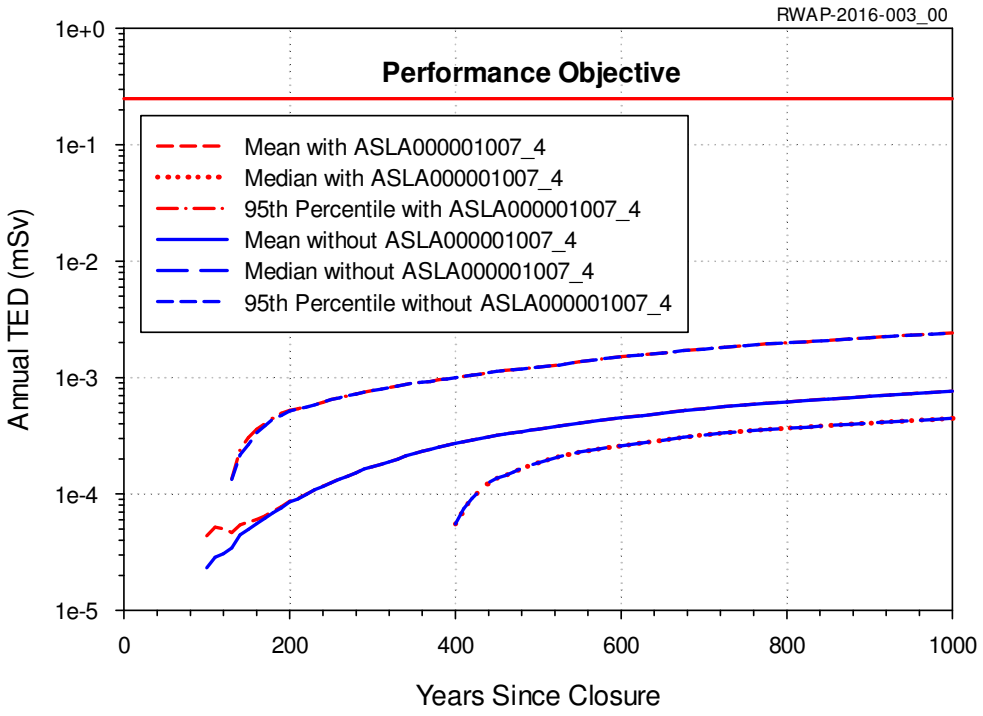

Figure 2 All-Pathways Annual TED Time History for a Resident at the 100-m (330-ft) Boundary with and without the ASLA000001007_4 Waste Stream

3.1.2.1 Alternative All-Pathways Scenarios

Uncertainty contributed by the selected exposure scenario was evaluated by calculating the all-pathway annual TED for alternative scenarios. The scenarios evaluated are the transient occupancy scenario, the resident with agriculture scenario, and the open rangeland scenario for a ranch at the nearest NNSS boundary and at Cane Spring. The scenarios and their assumptions have been described previously (BN 2006).

The mean and 95th percentile annual TEDs are all less than the performance objective for all alternative scenarios (Table 6). Although the exposure scenario is a source of uncertainty, there is a high likelihood of compliance for a range of reasonable scenarios. Addition of the SNL Classified Macroencapsulated Mixed Waste stream increases the maximum annual TED and shifts the maximum to 100 years for the resident with agriculture and open rangeland scenarios.

Table 6. Maximum All-Pathway Annual TED for Alternative Scenarios

Scenario	Inventory	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Transient Occupancy	Baseline	1,000 yr	5.9E-3	1.4E-2
	With Candidate Waste Stream	1,000 yr	5.9E-3	1.4E-2
Resident With Agriculture	Baseline	1,000 yr	2.2E-2	7.3E-2
	With Candidate Waste Stream	100 yr	8.7E-2	NA
Open Rangeland/Cane Spring	Baseline	1,000 yr	2.4E-3	8.8E-3
	With Candidate Waste Stream	100 yr	4.3E-2	NA
Open Rangeland/NNSS Boundary	Baseline	1,000 yr	2.6E-3	9.6E-3
	With Candidate Waste Stream	100 yr	5.3E-2	NA

NA – Not available, insufficient non-zero realizations to calculate 95th percentile

3.1.3 Intruder Results

Intruder results are evaluated for acute intruder scenarios only. NNSA/NFO institutional control policy is to maintain and enforce use restrictions consistent with the Underground Test Area (UGTA) Federal Facilities Agreement and Consent Order closure strategies (U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office 2014). The Area 5 RWMS is within the Frenchman Flat UGTA (Corrective Action Unit 98) groundwater use restriction area. The proposed land-use restrictions are assumed to eliminate the possibility of chronic intrusion for 1,000 years.

The acute drilling scenario estimates the TED to a drill crew drilling a water well through a disposal unit. Exposure to contaminated drill cuttings occurs while augering a surface casing for the well. The acute construction scenario estimates the dose to construction workers building a residence on a disposal unit. Construction workers are exposed to waste exhumed from the construction excavation.

The maximum mean and 95th percentile acute intruder TEDs occur at 1,000 years and are less than the 5 mSv limit for both the drilling and construction acute intrusion scenarios (Table 7). Addition of the SNL Classified Macroencapsulated Mixed Waste stream has no significant effect on the maximum acute intruder scenario results.

Table 7. Maximum TED for Acute Intrusion Scenarios at the Area 5 RWMS and the Waste Inventory Disposed through FY 2014

Scenario	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Drilling Intruder (Baseline)	1,000 yr	1.5E-3	2.7E-3
Drilling Intruder (with Candidate Waste Stream)	1,000 yr	1.5E-3	2.7E-3
Construction Intruder (Baseline)	1,000 yr	1.2	2.1
Construction Intruder (with Candidate Waste Stream)	1,000 yr	1.2	2.1

The SNL Classified Macroencapsulated Mixed Waste stream has no significant effect on the acute construction mean, median, or 95th percentile TED (Figure 3).

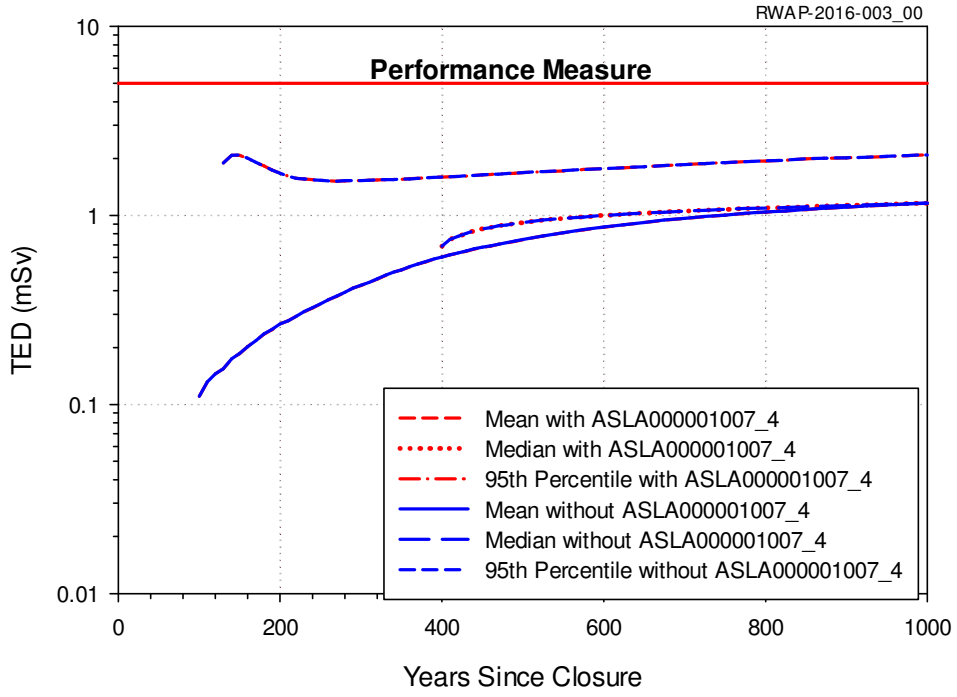

Figure 3 Acute Construction Intruder TED Time History with and without the ASLA000001007_4 Waste Stream

3.1.4 ^{222}Rn Flux Density Results

The radon-222 (^{222}Rn) flux density is averaged over the area of all post-1988 disposal units. The maximum mean and 95th percentile ^{222}Rn flux density occur at 1,000 years and are less than the 0.74 becquerel per square meter per second (Bq m^{-2} s^{-1}) performance objective (Table 8). Addition of the SNL Classified Macroencapsulated Mixed Waste stream has no significant effect on the maximum ^{222}Rn flux density. This waste stream does not require an increased depth of burial to attenuate ^{222}Rn flux.

Table 8. Maximum ^{222}Rn Flux Density at the Area 5 RWMS and the Waste Inventory Disposed through FY 2014

Inventory	Time of Maximum	Mean (Bq m^{-2} s^{-1})	95th Percentile (Bq m^{-2} s^{-1})
Baseline	1,000 yr	0.20	0.45
Baseline with Candidate Waste Stream	1,000 yr	0.20	0.45

4.0 Conclusions

The effect of adding the SNL Classified Macroencapsulated Mixed Waste stream inventory to the waste disposed through the end of FY 2014 was evaluated with the A5 RWMS v 4.119 PA model. The results indicate that all performance objectives can be met with disposal of the SNL Classified Macroencapsulated Mixed Waste stream in a SLB trench.

The SNL Classified Macroencapsulated Mixed Waste stream had no significant effect on the maximum mean and 95th percentile results for the resident air pathway and all-pathways annual TED. The SNL Classified Macroencapsulated Mixed Waste stream increases the mean air pathway and all-pathways annual TED from approximately 100 to 200 years after closure. Addition of the SNL Classified Macroencapsulated Mixed Waste stream inventory shifts the maximum TED to approximately 100 years after closure and increases the TED for several alternative exposure scenarios. The maximum mean and 95th percentile ^{222}Rn flux density remain less than the performance objective throughout the compliance period. The SNL Classified Macroencapsulated Mixed Waste stream is suitable for disposal by SLB at the Area 5 RWMS. The waste stream is recommended for approval without conditions.

5.0 References

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