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Total System Performance Assessment Model/Analysis for the License Application Addendum 01

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Change History

11. Revision and Addendum No.	12. Description of Change
Rev.00 AD 01	This addendum presents updated analyses for the TSPA-LA Rev 00 and any changes to the parent document necessary to document these updated analyses. The updated analyses include updates to direct inputs of the TSPA-LA. In addition, issues identified in Appendix P of the parent document are addressed here per the review criteria outlined in Sections 2.1.4 and 2.3.5.2.1 of the *Technical Work Plan for: Total System Performance Assessment FY 07-08 Activities* (SNL 2008 [DIRS 184920]).

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EXECUTIVE SUMMARY

This addendum to the Executive Summary in *Total System Performance Assessment Model/Analysis for the License Application* (hereafter referred to as the parent document), contains changes in the form of corrections and insertions for clarity. The addendum to the Executive Summary consists of a combination of supplemental information and revised TSPA-LA Model results for the postclosure performance demonstrations in revisions to plots, tables, and discussions found in the parent document. The organization of the sections and subsections is the same as found in the parent document Section, figure, and table numbers referred to in the text with [a] indicate sections of this addendum with revised information, while those without [a] refer to the unrevised section, figure, and table numbers in the parent document. Each section designated as no change means the reader should refer to the parent document for the content of that section. In some cases, portions of the Executive Summary are restated from the parent document for clarity. This addendum to the Executive Summary is intended to be used in conjunction with the Executive Summary in the parent document.

ES1[a] SCOPE

This addendum provides minor corrections as well as an update of the results of the Total System Performance Assessment for the License Application (TSPA-LA) presented in *Total System Performance Assessment Model/Analysis for the License Application*. The updated TSPA-LA Model results address the issues identified and described in Appendix P of the parent document. The issues were identified during analysis, checking, and review activities. These issues, documented in Appendix P of the parent document, were primarily related to minor inaccuracies in model implementation and identification of undocumented or unintended conservatisms or non-conservatisms. TSPA-LA Model v5.005 incorporates changes to TSPA-LA Model v5.000, the source for results in the parent document, and TSPA-LA Model v5.005 was used to provide the analyses presented in this addendum. Appendix P[a] of this addendum includes tables that summarize the issues that were addressed in the development of TSPA-LA Model v5.005. Tables P-6[a] and P-7[a] discuss the changes to TSPA-LA Model v.5005 in response to the issues identified in Appendix P of the parent document. Table P-6[a] summarizes the TSPA-LA Model implementation issues and Table P-7[a] summarizes the impact assessments as a result of the changes to the TSPA-LA Model. The additional analyses presented in this addendum were developed according to the review criteria outlined in *Technical Work Plan for: Total System Performance Assessment FY 07-08 Activities* (SNL 2008 [DIRS 184920], Sections 2.1.4 and 2.3.5.2.1).

ES1.1[a] Introduction

The performance requirements discussed in Section ES1.1[a] are restated from the parent document in order to provide clarity in the subsequent presentation.

Among the regulatory mandates of U.S. Nuclear Regulatory Commission (NRC) Proposed Rule 10 CFR Part 63 ([DIRS 178394] and [DIRS 180319]) is the requirement to demonstrate, by means of a probabilistic assessment, that there is a reasonable expectation of meeting the requirements of 10 CFR 63 Subpart L (DIRS 180319] regarding waste isolation after closure of the repository (NRC Proposed Rule 10 CFR 63.303, unrevised, [DIRS 180319]) according to the performance measures given in NRC Proposed Rule 10 CFR 63.303(a) and (b) [DIRS 178394]. NRC Proposed Rule 10 CFR Part 63 ([DIRS 178394] and [DIRS 180319]) sets standards for individual protection and for protection of groundwater. The Individual Protection Standard after Permanent Closure applies to the first 10,000 years following repository closure (10 CFR 63.311(a)(1) [DIRS 178394]), and 10 CFR 63.311(a)(2) [DIRS 178394] specifies the individual protection standard from 10,000 years to the period of geologic stability, defined as one million years after disposal (10 CFR 63.302 [DIRS 178394]).

Figure ES-1 shows the Yucca Mountain area and the entrance to the underground facilities, which will become part of the repository after a license to construct the repository is granted. Figure ES-2 shows a timeline of the major legislative and regulatory actions bearing on the Yucca Mountain Project from 1980 to the present.

In particular, the TSPA-LA Model calculates estimates of the:

a. Annual doses to the reasonably maximally exposed individual (RMEI) from releases from the undisturbed Yucca Mountain disposal system (NRC Proposed Rule 10 CFR 63.311 [DIRS 178394], Individual Protection Standard after Permanent Closure), subject to the performance measures in NRC Proposed Rule 10 CFR 63.303 [DIRS 178394]

b. Annual doses to the RMEI from releases from the Yucca Mountain disposal system resulting from human intrusion (NRC Proposed Rule 10 CFR 63.321 [DIRS 178394], Individual Protection Standard for Human Intrusion), excluding very low probability events after 10,000 years per NRC Proposed Rule 10 CFR 63.342(b) [DIRS 178394]

c. Levels of radioactivity (NRC Proposed Rule 10 CFR 63.331 [DIRS 180319], Separate Standards for Protection of Groundwater) in the representative annual volume of groundwater of 3,000 acre-feet (NRC Proposed Rule 10 CFR 63.332(a)(3) [DIRS 180319])

d. Annual doses to the RMEI for early drip shield (DS) and waste package (WP) failures, the two failure modes that meet the low probability of occurrence requirement of NRC Proposed Rule 10 CFR 63.342(a) [DIRS 178394]

e. Mean annual doses to the RMEI for all scenario classes considered for 10,000 years after repository closure (NRC Proposed Rule 10 CFR 63.342(c)(1) [DIRS 178394])

f. Median annual doses to the RMEI for all scenario classes considered (NRC Proposed Rule 10 CFR 63.342(c)(1) [DIRS 178394]) after 10,000 years but within the period of geologic stability.

ES2[a] TOTAL SYSTEM PERFORMANCE ASSESSMENT METHODOLOGY

The general TSPA process adopted by the U.S. Department of Energy (DOE) follows the methodology described by the NRC (Eisenberg et al. 1999 [DIRS 155354], Section 1 and Appendix A). Over time, the methodology has been developed and enhanced by critical reviews conducted by various national and international organizations. In addition, DOE has adopted the methodology developed by Cranwell et al. (1990 [DIRS 101234], Sections 2 and 3) to arrive at scenarios for use in evaluating the Yucca Mountain repository. Figure ES-4 shows the major steps in the Performance Assessment (PA) process. Previous PAs and related supplemental analyses were conducted to meet various DOE milestones that followed the publication of the Nuclear Waste Policy Amendments Act of 1987, Public Law No. 100-203 [DIRS 100016]. The Yucca Mountain PAs have been iterative, with each succeeding PA building on and extending the scope and results of the previous PAs. The successive PAs incorporate both an improved understanding of the processes affecting performance, and additional field observations and measurements, laboratory experiments and analyses, and better identification and quantification of the parameters used in the PA analyses. Figure ES-5 illustrates the evolution of the PA iterations for the Yucca Mountain Project and identifies the corresponding TSPAs. The most recent TSPA documents were *Total System Performance Assessment for the Site Recommendation* (TSPA-SR) (CRWMS M&O 2000 [DIRS 143665]) and the application of the TSPA-SR Model in *Total System Performance Assessment – Analyses for Disposal of Commercial and DOE Waste Inventories at Yucca Mountain – Input to Final Environmental Impact Statement and Site Suitability Evaluation* (Williams 2001 [DIRS 157307]). The TSPA-LA Model is built on the foundation of those earlier PAs and has been enhanced by updated analyses of the processes affecting Yucca Mountain and the design elements of the repository, including a comprehensive consideration of the features, events and processes (FEPs) that are relevant to repository system performance.

ES3[a] TSPA-LA MODEL DEVELOPMENT PROCESS

No change.

ES3.1[a] Features, Events, and Processes Analysis

No change.

ES3.2[a] Development of the Scenario Classes

The TSPA-LA approach focuses on a set of scenario classes that are distinguished by initiating events. The Nominal Scenario Class includes all possible future outcomes except those initiated by early failure of the DSs or WPs, igneous or seismic activity, and inadvertent human intrusion into the repository. The Early Failure Scenario Class addresses FEPs that describe the potential for DS and WP early failure in the absence of igneous or seismic events. The early failure scenarios include DSs and WPs that fail prematurely. The Igneous Scenario Class includes all possible future outcomes initiated by igneous activity. The Seismic Scenario Class includes all possible future outcomes initiated by seismic activity. In addition to the analyses of the scenario classes, the TSPA-LA Model also simulates a Human Intrusion Scenario according to the scenario description and criteria in 10 CFR 63.322 [DIRS 180319].

ES3.3[a] Incorporation of Uncertainty

No change.

ES3.4[a] Natural and Engineered Model Components

No change.

ES3.5[a] Alternative Conceptual Models

No change.

ES3.6[a] Configuration Management for the TSPA-LA Model

No change.

ES4[a] YUCCA MOUNTAIN SITE DESCRIPTION

No change.

ES4.1[a] Physiographic Setting and Topography

There is no change to the text of ES4.1. However, the caption for Figure ES-12 in the parent document has been corrected and is included as Figure ES-12[a] of this addendum.

ES4.2[a] Climate

No change

ES4.3[a] Geology

No change.

ES4.4[a] Regional Tectonic Setting

The overall tectonic setting of the Great Basin physiographic province, including Yucca Mountain, is extensional, and generally consisting of fault-bounded basins and mountain ranges that have been modified by volcanic activity during the past 15 million years. Typically, the faults in the Great Basin include normal and strike-slip faults that reflect the extensional deformation caused by plate tectonic interactions in the western portion of the North American continent. The structural geology of Yucca Mountain and its vicinity is generally characterized by north-trending normal faults with displacement down to the west (Figures ES-14 and ES-15). Some of the faults on Figure ES-14 show evidence of Quaternary activity (i.e., activity within the last 1.8 million years).

ES5[a] THE REPOSITORY SUBSURFACE FACILITY AND ENGINEERED BARRIER SYSTEM

No change.

ES6[a] NATURAL AND ENGINEERED BARRIERS

No change.

ES7[a] GENERAL DESCRIPTION OF THE TSPA-LA MODEL

No change.

ES8[a] VERIFICATION/VALIDATION OF THE TOTAL SYSTEM PERFORMANCE ASSESSMENT MODEL

SCI-PRO-006, *Models*, Section 6.3, was utilized to support verification and validation of the TSPA-LA Model, providing confidence that the TSPA-LA Model adequately represents the physical processes in the repository system and properly transfers outputs between the TSPA-LA Model modules and submodels. In preparing this addendum, each validation activity utilized for TSPA-LA Model v5.000 was reviewed to determine which activities were affected by changes made between TSPA-LA Model v5.000 and v5.005. Where validation activities could potentially be affected by these model changes, the affected validation activities were repeated using v5.005 to verify that model changes did not adversely affect the overall validation of the TSPA-LA Model. Additional verification and validation results beyond those presented in the parent document are also provided to further enhance confidence in the TSPA-LA Model. This section summarizes revised or additional validation activities that were conducted for TSPA-LA Model v5.005 and are documented in this addendum. The following subsections include any changes to the Executive Summary in the parent document.

ES8.1[a] Verification and Validation Strategy

No change.

ES8.2[a] Computer Code and Input Verification

The following model verification activities are described in the parent document and/or were revised and included in this addendum and demonstrate that incorporation of information and submodels from other sources into the TSPA-LA Model has not altered the validity of the information, the submodels, or both:

- The TSPA-LA Model software, GoldSim, was qualified and placed under the control of Software Configuration Management per IM-PRO-003.
- Outputs from DLLs from other sources, including analysis/model reports and data tracking numbers, were correctly replicated in the TSPA-LA Model.
- Analysis of the verification of the range of applicability of submodels and model components was performed.
- Outputs from DLLs calculated within the TSPA-LA Model were found to be within established acceptance criteria.
- Individual submodels were validated in their respective analysis/model reports.
- Results from submodels within the TSPA-LA Model were compared to results contained in analysis/model reports and were found to agree within selected acceptance criteria.

- Feeds from one submodel to another submodel were found to be correctly transferred, and the values used were determined to be appropriate for the intended use of the receiving submodel (Section 7.2.6[a]).

- Inputs from the TSPA Input Database were verified to correspond with source data.

Computer codes and input reverification presented in Section 7.2[a] include: (1) reverification of a revised version of the GoldSim software (GoldSim V9.60.300, STN: 10344-9.60-03 [DIRS 184387]) used in all updated TSPA-LA Model results reported in this addendum; (2) verification testing for the Human Intrusion Submodel, testing that was inadvertently omitted from the parent document (Section 7.2.4.1.12[a]); and (3) a summary of an assessment of the range of validity for all TSPA-LA Model submodels that was inadvertently omitted from the parent document (Section 7.2.6[a]).

The activities in Section 7.2 of the parent document and the additional work presented in Section 7.2[a] of this addendum demonstrate that the system software for TSPA-LA Model v5.005 is appropriate and valid, that input is correct and verified, that the internal transfer of information within TSPA-LA Model v5.005 is correct and within the valid range of successive submodels, and that submodels are valid per their respective source analysis/model reports. Therefore, incorporation of information and submodels from other sources into TSPA-LA Model v5.005 has not altered the validity of the information or the submodels, or both, as demonstrated in the parent document for TSPA-LA Model v5.000.

ES8.3[a] Stability Testing

Section 7.3.1 of the parent document presents analyses that demonstrate the statistical stability of the total mean annual dose (summed over all modeling cases) and the mean annual dose for each modeling case for TSPA-LA Model v5.000. Section 7.3.1[a] compares uncertainty and sensitivity analyses generated by TSPA-LA Model v5.000 and TSPA-LA Model v5.005 and concludes that the results from TSPA-LA Model v5.005 are also statistically stable. An additional illustration of the stability of the estimate of the total mean annual dose for TSPA-LA Model v5.005, using a bootstrap sampling procedure to generate confidence intervals, is presented for results for both the 10,000-year and 1,000,000-year time periods. This addendum confirms the numerical accuracy of the expected annual dose calculations for the Seismic Fault Displacement Modeling Case.

This addendum also includes an update to the evaluation of temporal stability of the TSPA-LA Model for both the Nominal Modeling Case and the Human Intrusion Modeling Case. A reevaluation of the temporal stability of the Human Intrusion Modeling Case was necessary due to the change in the timestepping system used for the Human Intrusion Modeling Case in TSPA-LA Model v5.005. The simulations were conducted by reducing the TSPA-LA Model timestep size to examine sensitivity to timestep duration. The annual dose from the TSPA-LA Model calculations with different timestep durations were compared graphically to determine the effect of changing the timestep durations. The approach and results of this analysis are provided in Section 7.3.3 of the parent document. The results of this analysis show a better resolution using the revised timestep durations than previously documented in the parent document. The test results for the Human Intrusion Modeling Case confirm that its timestep system was adequate.

Section 7.3.3.7[a] presents a revised evaluation of the temporal stability of the TSPA-LA Model Nominal Modeling Case. The temporal discretization used to determine general corrosion rates is influential to the annual dose resulting from nominal corrosion processes. The nominal modeling case simulation was conducted with shorter timesteps for the calculation of the crack growth rate, which removes the jumps in the number of WP failures by stress corrosion cracking (SCC), which in turn is reflected in the expected annual dose curves for the alternative timestepping. However, the similarity in statistics for expected annual dose for the two timestep durations indicates that the Nominal Modeling Case is sufficiently stable with respect to temporal discretization.

Section 7.3.2[a] demonstrates that the calculation of expected annual dose is sufficiently accurate for each TSPA-LA Model modeling case.

ES8.4[a] Uncertainty Characterization Reviews

No change.

ES8.5[a] Surrogate Waste Form Validation

Section 7.5.3[a] presents a reevaluation of the adequacy of using commercial spent nuclear fuel (CSNF) as a surrogate for naval spent nuclear fuel (NSNF) using TSPA-LA Model v5.005. The analyses presented in Section 7.5 of the parent document and Section 7.5[a] of this addendum show that the use of a surrogate to represent NSNF is appropriate. The analyses show that mean annual dose from NSNF is bounded by the mean annual dose calculated for the Zircaloy-clad CSNF surrogate.

ES8.6[a] Corroboration of Abstraction Model Results with Validated Process Models

No change.

ES8.7[a] Auxiliary Analyses

The auxiliary analyses presented in the parent document were updated with a reevaluation of the corroboration of the TSPA-LA Model results documented in the parent document with auxiliary analyses (Section 7.7[a]). These additional verification and validation activities further enhance confidence in the TSPA-LA Model.

Single-Realization Analyses

The single realization analyses presented in the parent document and in Section 7.7.1[a] comprise a comprehensive explanation of how the transport of key radionuclides is affected by coupling various submodel components of the engineered barrier system (EBS), unsaturated zone (UZ), and saturated zone (SZ) domains in the TSPA-LA Model, following WP failure under varying physical-chemical-thermal-mechanical conditions. These results provide confidence that these model components are working as expected and the aggregate TSPA-LA

Model results (in terms of dose) are consistent with the model components. Examination and explanation of key aspects affecting radionuclide releases demonstrate that the TSPA-LA Model is functioning as intended and that the submodels are coupled correctly and provide system-level results. The revised analyses in this addendum provide confidence that TSPA-LA Model v5.005 is functioning as designed and helps confirm the validation of the model.

The parent document includes single realization analyses of four modeling cases: (1) Waste Package EF Modeling Case, (2) Drip Shield EF Modeling Case, (3) Igneous Intrusion Modeling Case, and (4) Seismic Ground Motion (GM) Modeling Case (1,000,000 years). The revised analyses using TSPA-LA Model v5.005 include additional analyses of outlier realizations in Section 7.7.1[a]. Three additional modeling cases: (1) Nominal Modeling Case, (2) Human Intrusion Modeling Case, and (3) Seismic GM Modeling Case (10,000 years), are included in this addendum. The results confirm that the changes from TSPA-LA Model v5.000 to TSPA-LA Model v5.005 support the demonstration of model validation and add to the confidence in the TSPA-LA Model results.

Comparison with Simplified TSPA Analysis

A comparison of the TSPA-LA Model results to a stand-alone Simplified TSPA Analysis was conducted and documented in Section 7.7.2 and Appendix L of the parent document. Section 7.7.2 of the parent document provides the comparative results for the individual modeling cases for the Simplified TSPA Analysis and the TSPA-LA Model, including the minor differences in the prominence of certain radionuclides and in the mean annual doses calculated by the two approaches. Section 7.7.2[a] provides a comparison of the updated results presented in this addendum with the Simplified TSPA Analysis in the parent document.

Section 7.7.2[a] compares the TSPA-LA Model v5.005 results to the Simplified TSPA Analysis and corroborates the conclusions presented in the parent document.

Comparison with Electric Power Research Institute TSPA Analysis

This addendum describes a limited comparison of the Electric Power Research Institute (EPRI) TSPA Analysis results with those of TSPA-LA Model v5.005. The similarities and differences between the EPRI TSPA Analysis and TSPA-LA Model v5.000 are discussed in Section 7.7.3 of the parent document. Appendix M of the parent document provides additional information.

The results documented in Section 7.7.3[a] confirm the general similarities as well as the differences between the results from the EPRI TSPA Analysis and those of the TSPA-LA Model as described in Section 7.7.3 of the parent document.

Performance Margin Analysis

A comparison of TSPA-LA Model v5.005 results with the Performance Margin Analysis (PMA) confirms the quantitative evaluation of the differences in repository performance due to significant explicit and implicit conservatisms embedded in the TSPA-LA Model subcomponents as documented in Section 7.7.4 and Appendix C of the parent document. The conservatisms were evaluated to (1) confirm that they are conservative with respect to the mean annual dose calculated by the TSPA-LA Model; (2) quantify the extent to which TSPA-LA Model v5.005

and the PMA, individually and collectively, overestimate the projected annual dose; and (3) assess whether or not the evaluated conservatisms introduced any inappropriate risk dilution in the TSPA-LA Model results presented in support of the LA. Section 7.7.4 of the parent document describes the approach and results of the PMA, and Appendix C provides additional supporting material. The results show that the margin evaluated in the PMA, as documented in the parent document, is indeed conservative with respect to the total system performance measures (e.g., maximum mean annual dose); the largest doses calculated in the PMA for 10,000 years and 1,000,000 years are lower than the doses used in the compliance demonstration presented in Section 8[a] of this addendum. The additional analyses confirm that the largest calculated PMA mean annual doses are lower by over an order of magnitude and a factor of two over the largest mean annual dose relative to the TSPA-LA Model (Section 8[a]) for the time periods of 10,000 years and 1,000,000 years, respectively. Further, this PMA confirms that the significant conservatisms did not introduce risk dilution in the TSPA-LA results, as demonstrated by the absence of higher maximum mean annual doses in the comparison of the projected total mean annual dose for the PMA relative to TSPA-LA Model v5.005. The differences in the relative contributions to the total mean annual dose from each of the modeling cases evaluated with the PMA and the TSPA-LA Model indicate that having fewer conservative assumptions in the PMA than in these TSPA-LA model components provides a performance margin in the projected annual dose predictions presented in Section 8 of the parent document and Section 8[a] of this addendum.

ES8.8[a] Confidence Building: Natural Analogues

No change.

ES8.9[a] Summary of Technical Reviews

Technical reviews of PA models form an important part of model validation. During the past decade, the Yucca Mountain Project has developed successive TSPA models as well as accompanying input process models, all of which have been subject to technical reviews by external experts as part of their validation. Each milestone PA for the Yucca Mountain repository was subject to external reviews. The Total System Performance Assessment for the Viability Assessment was the subject of a peer review as described in Section 7.9.1. An International Review Team conducted an evaluation of the TSPA-SR, and the accompanying TSPA-SR performance assessment model. Appendix E summarizes the 27 comments provided by the International Review Team review of the TSPA-SR Model. The responses to those comments were addressed and implemented as appropriate into the TSPA-LA Model and its supporting documents. An Independent Validation Review Team (IVRT) reviewed a draft version of the TSPA-LA Model and the accompanying IVRT report provided comments as described in Section 7.9. The comments from the IVRT technical review of the draft TSPA-LA Model were addressed, and the TSPA-LA Model incorporates the material contained in the responses to those comments.

ES9[a] SYSTEM PERFORMANCE ANALYSES

The revisions found in the following subsections of Section ES9[a] contain primarily references to updated figures and revised estimates for the magnitude and timing of estimates of the maximum mean annual dose, radionuclides of importance, revised results of the uncertainty/sensitivity analyses, and other information derived from the revised simulations of modeling cases using TSPA-LA Model v5.005. Except for one correction to a reference to proposed 10 CFR Part 63 and clarification of the language relating to meeting the proposed 10 CFR Part 63 performance standards, the text in this section is largely the same as that in the parent document.

The TSPA-LA Model was used to conduct a PA of the Yucca Mountain repository system. The analyses provide mean and median annual dose to the RMEI for the first 10,000 years after repository closure and for the period of geologic stability (one million years) specified in NRC Proposed Rule 10 CFR 63.302 [DIRS 178394]. The TSPA-LA Model evaluated modeling cases representing nominal conditions, early DS and WP failures, and disruptive events. The TSPA-LA Model analyses also address both the individual and groundwater protection standards of NRC Proposed Rule 10 CFR 63.311 [DIRS 178394] and 10 CFR 63.331 ([DIRS 180319], Table 1), respectively.

The analyses account for uncertainties in the representations of FEPs that could affect the annual dose. The PA analyses address the effect of alternative parameters, submodels, and approaches to FEPs. The calculations are probabilistic in the sense that the results are for multiple realizations, carried out using sampled values from the probability distributions for the values of the uncertain model parameters.

ES9.1[a] Total Mean Annual Dose to the Reasonably Maximally Exposed Individual for the Repository System

Figure ES-40[a] displays the total expected annual dose for the first 10,000 years after repository closure, and the calculated results indicate that the greatest mean annual dose for this period is less than 0.24 millirem. Figure ES-41[a] displays the total expected annual dose for the postclosure period from 10,000 to one million years after repository closure, and the calculated results indicate that the greatest median annual dose for this period is less than 0.96 millirem. These total expected annual dose values represent the sum of the expected dose calculations for the four scenario classes considered for the TSPA-LA Model. Figures ES-40[a] and ES-41[a] show the distribution of the expected annual doses and, thus, display the uncertainty in the total expected annual dose resulting from epistemic uncertainty about the repository system.

Figure ES-42[a] shows the radionuclides that contribute most to the estimate of mean annual dose, and indicates that ^{99}Tc, ^{14}C, ^{129}I, and ^{239}Pu dominate the estimated mean annual dose during the first 10,000 years after repository closure. In a similar manner, Figure ES-43[a] shows that ^{239}Pu, ^{99}Tc, and ^{129}I generally dominate the mean annual dose for the first 100,000 years of the postclosure period, and that ^{242}Pu, ^{237}Np, ^{129}I, and ^{226}Ra generally dominate the mean annual dose for the postclosure period from 100,000 to one million years.

ES9.2[a] Results of the Scenario Class Modeling Case Simulations

Following are descriptions of the results provided by the scenario class modeling cases used to simulate repository performance. Figures ES-44[a] through ES-51[a] and ES-54[a] through ES-57[a] present the expected annual dose calculated for the individual modeling cases. Figures ES-52 and ES-53 for the Volcanic Eruption Modeling Case are unchanged from those in the parent document. The following sections describe, by modeling case, the results of the scenario class modeling case simulations.

ES9.2.1[a] Nominal Scenario Class Modeling Case

The results of this modeling case show no annual dose to the RMEI in the first 10,000 years. The earliest occurrence of dose is around 21,000 years. The projections of WP breaches exhibit a few realizations with a SCC crack penetrating the WP outer barrier well before 100,000 years. In particular, one crack penetration occurred in less than 10,000 years in one WP in one realization because a combination of sampled values for SCC in the closure-lid weld resulted in a large initial crack length and a high crack propagation velocity (Section 8.2.1). Because infiltration rates and temperatures vary across the repository footprint, the time of occurrence of the continuous thin film of adsorbed water required to begin diffusive radionuclide transport also varies, delaying radionuclide releases until after 10,000 years. The bulk of the WP failures (by nominal SCC) would occur after 100,000 years, and the DSs would begin to fail by general corrosion at approximately 260,000 years. Figure ES-44[a] shows the estimated maximum mean and median annual doses for the postclosure period from 10,000 to one million years, and the calculated results indicate that the values would be 0.55 and 0.28 millirem, respectively. Figure ES-45[a] shows the radionuclides that dominate the estimate of mean annual dose for the Nominal Scenario Class Modeling Case. The main contributors to mean annual dose would be the highly soluble and mobile radionuclides ^{129}I and ^{99}Tc.

ES9.2.2[a] Early Failure Scenario Class Modeling Cases

The Early Failure Scenario Class Modeling Cases include FEPs that relate to early WP and DS failure due to manufacturing, material defects, or pre-emplacement operations that would include improper heat treatment. Radionuclide mobilization and transport for the Early Failure Scenario Class is similar to the Nominal Scenario Class, but differs from the Nominal Scenario Class in that the Early Failure Scenario Class considers only WPs affected by early DS and WP failures.

ES9.2.2.1[a] Drip Shield Early Failure Modeling Case

The defective DSs were modeled as being failed at the time of repository closure, and WPs underlying any failed DSs and exposed to seepage are conservatively considered as failed. Figure ES-46[a] shows the expected annual dose histories for the first 10,000 years after closure and the postclosure period from 10,000 to one million years. The expected annual doses account for aleatory uncertainty about the number of early failed DSs, types of WPs under failed DSs, and their locations in the repository. The mean, median, and 5th and 95th percentile curves in this plot show the uncertainty in the expected annual dose due to epistemic uncertainty from incomplete knowledge of the behavior of the repository system. The calculations for the first 10,000 years indicate a projected mean annual dose of approximately 2.8×10^{-4} millirem at 2,000 years after repository closure. The calculated mean annual dose then decreases steadily and is less than 1.5×10^{-4} millirem during the postclosure period from 10,000 to one million years.

Figure ES-47a[a] shows that the radionuclides contributing most to the total mean annual dose during the first 2,000 years after repository closure are soluble and mobile radionuclides, in particular ^{99}Tc, ^{129}I, and ^{14}C. During the postclosure period from 10,000 to one million years, Figure ES-47b[a] shows that ^{239}Pu dominated the mean annual dose for the first 200,000 years, and ^{242}Pu and ^{237}Np dominate the mean annual dose up to one million years.

ES9.2.2.2[a] Waste Package Early Failure Modeling Case

The WPs are assumed to be failed at the time of repository closure. However, intact DSs overlying early failed WPs will degrade by general corrosion after repository closure. Figure ES-48[a] shows the expected annual dose histories for the first 10,000 years after repository closure and for the postclosure period from 10,000 to one million years. The expected annual dose accounts for aleatory uncertainty about the number of early failed WPs, types of early failed WPs, and their locations in the repository. The mean, median, and 5th and 95th percentile curves on Figures ES-48a[a] and ES-48b[a] reflect the epistemic uncertainty in the expected annual dose.

Figure ES-48a[a] shows the estimated mean annual dose. The maximum mean annual dose occurs between 9,000 and 10,000 years and its value is 3.7×10^{-3} millirem. The mean annual dose during the first 10,000 years postclosure results from early failed co-disposed (CDSP) WPs. The relative humidity in the CDSP WP emplacement locations tend to be higher and forms an aqueous layer suitable for radionuclide diffusion earlier than in the CSNF WPs. Because the CDSP WPs contain DOE SNF and the TSPA-LA Model does not take credit for the canister, cladding, or fuel matrix, diffusive transport of radionuclides can start as soon as the humidity in the breached CDSP WPs is greater than 95 percent (Section 8.2.2.2). The increase in mean annual dose at about 9,800 years postclosure, as shown on Figure ES-48a[a], is due to the beginning of diffusive transport from early-failed CSNF WPs. Figure ES-48b[a] shows the estimated mean and median annual doses; the calculated results indicate that the maximum values are 2.1×10^{-2} and 6.1×10^{-3} millirem, respectively, before 15,000 years, and the doses gradually decrease thereafter until about 250,000 years postclosure. At about 250,000 years postclosure, the DSs begin to fail from general corrosion, and the expected annual dose increases during the period from 300,000 to 400,000 years postclosure because of advective transport of radionuclides through failed WPs.

Figure ES-49a[a] shows that in the first 10,000 years after closure, the more soluble and mobile radionuclides, ^{99}Tc, ^{129}I, and ^{14}C, dominate the estimate of mean annual dose. Figure ES-49b[a] shows that during the postclosure period from 10,000 to one million years, ^{239}Pu, ^{242}Pu, ^{237}Np, and ^{226}Ra dominate the expected mean annual dose.

ES9.2.3[a] Igneous Scenario Class Modeling Cases

The Igneous Scenario Class addresses the set of FEPs that describe igneous events that could affect repository performance. The Igneous Scenario Class is represented by: (1) the Igneous Intrusion Modeling Case that represents a magmatic dike that intrudes into the repository causing subsequent release of radionuclides to the groundwater in the UZ, and (2) the Volcanic Eruption Modeling Case that represents a hypothetical volcanic eruption from a volcanic conduit that passes through the repository and emerges at the land surface with the release of radionuclides to the atmosphere.

ES9.2.3.1[a] Igneous Intrusion Modeling Case

After a magmatic dike intersects the repository, radionuclide release and transport away from the repository would be similar to the Nominal Modeling Case. All of the DSs and WPs would be damaged, exposing the waste forms to percolating groundwater with subsequent degradation, radionuclide mobilization, and transport through the UZ to the SZ. The Igneous Intrusion Modeling Case considers that the remnants of the DSs, WPs, or cladding do not divert any water from the waste.

Figure ES-50[a] shows the distribution of calculated expected annual dose histories, one for each sample element, where each dose history accounts for aleatory uncertainty in igneous intrusions, such as the number of future events and the time at which they may occur. The mean, median, and 5th and 95th percentile curves on Figure ES-50[a] indicate epistemic uncertainty in expected annual dose resulting from incomplete knowledge of the behavior of the physical system during and after the disruptive event. The maximum calculated mean annual dose for the first 10,000 years postclosure is 6.6×10^{-2} millirem, occurring at the end of the 10,000-year period. The maximum projected median annual dose during the postclosure period from 10,000 to one million years is estimated to be 0.32 millirem, and the maximum value occurs at the end of the one-million year period.

Figure ES-51a[a] shows that ^{99}Tc and ^{129}I dominate the estimate of the expected mean annual dose for the first 4,000 years, and ^{239}Pu, ^{99}Tc, and ^{240}Pu dominate the estimate of the mean annual dose for the first 10,000 years postclosure. Figure ES-51b[a] shows that ^{239}Pu dominates the estimate of the mean annual dose for the first 100,000 years, and ^{242}Pu, ^{226}Ra, and ^{237}Np dominate the expected mean annual dose for the postclosure period from 10,000 to one million years.

ES9.2.3.2[a] Volcanic Eruption Modeling Case

No change.

ES9.2.4[a] Seismic Scenario Class Modeling Cases

The Seismic Scenario Class represents the direct effects of vibratory ground motion and fault displacement associated with seismic activity affecting repository performance. The Seismic Scenario Class modeling cases include seismic-related changes in seepage, the performance of WPs and DSs, and flow in the EBS. The Seismic Scenario Class is represented by the Seismic GM Modeling Case and the Seismic Fault Displacement (FD) Modeling Case.

ES9.2.4.1[a] Seismic Ground Motion Modeling Case

The Seismic GM Modeling Case considers the possible failures of DSs and WPs due to mechanical damage associated with seismic vibratory ground motion, including: accumulation of rockfall on DSs, collapse of the DS framework, SCC of WPs, and rupture or puncture of WPs. Figure ES-54[a] presents calculated expected annual dose histories for the Seismic GM Modeling Case for the first 10,000 years after closure and the postclosure period from 10,000 to one million years. The distribution of the expected annual dose takes into account aleatory uncertainty associated with the number of seismic ground motion events, the time and magnitude of each event, and the effects of each event on WPs, DSs, and the emplacement drifts.

The mean, median, and 5th and 95th percentiles of the distribution of the expected annual dose shown on Figure ES-54[a] reflect epistemic uncertainty due to incomplete knowledge of the behavior of the repository system during and after seismic events. Figure ES-54[a] shows the mean annual dose for the first 10,000 years after closure, and the calculated results indicate that the maximum value is 0.17 millirem. The maximum median annual dose for the postclosure period from 10,000 to one million years was calculated to be 0.37 millirem. The plot of the expected annual doses shown on Figure ES-54a[a] was developed using a quadrature method to numerically integrate over the aleatory uncertainty for the first 10,000 years after repository closure. Alternatively, the realizations contributing to Figure ES-54b[a] were calculated using a Monte Carlo method to numerically integrate over aleatory uncertainty for the postclosure period from 10,000 to one million years.

The results on Figure ES-55a[a] show that ^{99}Tc, ^{14}C, ^{129}I, and ^{36}Cl dominate the estimate of the mean for the first 10,000 years after closure. Figure ES-55b[a] shows that radionuclides ^{99}Tc, ^{129}I, ^{242}Pu, and ^{237}Np dominate the calculated expected mean annual dose during most of the postclosure period from 100,000 to one million years, with ^{242}Pu and ^{237}Np increasingly prominent after 800,000 years postclosure. Because of radioactive decay, the expected mean annual dose due to ^{14}C decreases to insignificant levels within the first 100,000 years postclosure. The CDSP WPs would be the primary WPs damaged during the first 10,000 years after closure because the CSNF WPs are more failure resistant. The CSNF WPs will be more robust than CDSP WPs because they include two inner stainless-steel vessels instead of one. Although the CSNF WPs have an inner vessel and lid similar to the CDSP WPs, the CSNF WPs are placed in an outer, tightly fitting stainless-steel transportation, aging, and disposal canister. In contrast, the CDSP WPs contain several smaller waste-containing canisters that do not fit as tightly and could move more freely under the influence of ground motion. The predominant mechanism that would cause damage to both CDSP and CSNF WPs is SCC, which would result in diffusive releases of radionuclides.

ES9.2.4.2[a] Seismic Fault Displacement Modeling Case

The Seismic FD Modeling Case includes disruption of WPs and DSs by the displacement of faults. Figure ES-56[a] shows the expected annual dose histories for the Seismic FD Modeling Case for the first 10,000 years after closure and for the postclosure period from 10,000 to one million years. The expected annual dose accounts for aleatory uncertainty about the number, type, and locations of disrupted DSs and WPs. The mean, median, and 5th and 95th percentile curves on Figure ES-56[a] show uncertainty in the distribution of expected annual dose, due to epistemic uncertainty regarding the behavior of the repository system during and after fault displacement events. These figures show the maximum mean annual dose for the first 10,000 years after closure; the calculated results indicate that the maximum mean annual value is 1.5×10^{-3} millirem. The maximum median projected dose for the postclosure period from 10,000 to one million years is calculated to be 1.1×10^{-2} millirem.

Figure ES-57a[a] shows that ^{99}Tc and ^{129}I dominate the dose for the first 5,000 years after closure, and ^{99}Tc and ^{239}Pu dominate the dose between 5,000 and 10,000 years after closure.

Figure ES-57b[a] shows that ^{239}Pu dominates the mean annual dose up to 200,000 years postclosure, and ^{242}Pu, ^{237}Np, and ^{226}Ra dominate the mean annual dose for the remainder of the postclosure period from 200,000 to one million years.

ES9.2.5[a] Total Mean Annual Dose to the Reasonably Maximally Exposed Individual for the Repository System

Figure ES-58[a] shows the contribution to the total mean annual dose histories for the Drip Shield Early Failure (EF), Waste Package EF, Igneous Intrusion, Volcanic Eruption, Seismic GM, and Seismic FD Modeling Cases. Figure ES-58[a] shows that the Seismic GM and Igneous Intrusion Modeling Cases provide the largest contributions to the total mean annual dose for the postclosure period from 10,000 to one million years. The Seismic GM Modeling Case includes general corrosion processes for the postclosure period from 10,000 to one million years. Figure ES-58[a] shows that the events that most affect the total mean annual dose are seismic ground motion, igneous intrusions, and WP failure due to general corrosion.

ES9.3[a] Comparison of Annual Dose with Postclosure Individual and Groundwater Protection Standards

ES9.3.1[a] Individual Protection Standard

The results provided by the TSPA-LA Model include calculations of the total mean annual dose to the RMEI in any year during the next 10,000 years after repository closure (NRC Proposed Rule 10 CFR 63.303(a) [DIRS 178394]) and the total median annual dose to the RMEI in any year from 10,000 years after repository closure through the period of geologic stability (NRC Proposed Rule 10 CFR 63.303(b) [DIRS 178394]). According to NRC Proposed Rule 10 CFR 63.311 [DIRS 178394], the postclosure individual protection standard is 15 millirem up to 10,000 years postclosure, and 350 millirem after 10,000 years, but within the period of geologic stability (one million years). The TSPA-LA Model results, shown on Figures ES-40[a] and ES-41[a], which refer to distribution of total expected annual dose, show that the maximum projected total mean and total median annual doses to the RMEI are estimated to be about 0.24 millirem (Figure ES-40[a]) and 0.96 millirem (Figure ES-41[a]), respectively. These results demonstrate that the total mean annual dose to the RMEI in any year during the next 10,000 years after repository closure is less than the individual protection standard of 15 millirem per NRC Proposed Rule 10 CFR 63.311(a)(1) [DIRS 178394]. In addition, the highest projected dose values, mean or median, throughout the period of geologic stability are more than two orders of magnitude below the individual protection limit of 350 millirem per 10 CFR 63.311(a)(2) [DIRS 178394].

Uncertainty/Sensitivity Results

For different time frames in the analysis, different epistemic parameters emerge as important to the overall uncertainty in the results. Table ES-1[a] lists summary results of the sensitivity analysis. The important parameters listed on Table ES-1[a] are as follows:

- *IGRATE*. This parameter is the probability of an igneous event expressed as the annual frequency of an intersection of the repository by a volcanic dike. Uncertainty in this parameter arises from epistemic uncertainty about igneous activity that may affect the repository.

- *SCCTHRP*. This parameter is the residual stress threshold for the Alloy 22 WP outer barrier, expressed as a percentage of the yield strength. If the residual stress in the WP outer barrier exceeded this threshold value, stress corrosion cracks could form, which could allow radionuclides to migrate from the WP. The primary causes of residual stresses in the WP outer barrier would be high peak-ground-velocity seismic ground motions, which may cause impacts from WP to WP, from WP to emplacement pallet, and from WP to DS. These impacts could cause dynamic loads that could dent the WP, resulting in structural deformation with residual stresses that could make the material susceptible to SCC.

- *SZGWSPDM*. This SZ flow and transport parameter is the logarithm of the scale factor for the groundwater specific discharge multiplier, which accounts for the epistemic uncertainty in the discharge flow rate used to compute advective radionuclide transport. This uncertainty parameter is applied to all of the climate states. Values for this parameter are sampled from an empirical cumulative distribution function; the technical basis for that distribution is documented in *Saturated Zone Flow and Transport Model Abstraction* (SNL 2008 [DIRS 183750], Section 6.5.2.1).

- *WDGCA22*. This parameter relates to the temperature dependence of the Alloy 22 WP outer barrier general corrosion rate. This uncertainty parameter determines the magnitude of this temperature dependence and directly influences the short-term and long-term general corrosion rates of the Alloy 22. Larger values of *WDGCA22* result in earlier, higher general corrosion rates during the thermal period, and lower long-term corrosion rates when the repository temperatures are near the ambient *in situ* temperature.

The parameters in Table ES-1[a] that most affect the total uncertainty in the TSPA-LA Model are factors that govern degradation of the WPs, the occurrence of damage from seismic events, and the frequency with which igneous intrusions occur.

Table ES-1[a]. Top Ranking Uncertainty Importance Parameters

Time After Closure (years)	**Two Most Important Parameters**	
3,000	SCCTHRP	IGRATE
5,000	SCCTHRP	IGRATE
10,000	SCCTHRP	IGRATE
125,000	IGRATE	*SZGWSPDM*
250,000	IGRATE	*SZGWSPDM*
500,000	IGRATE	WDGCA22
1,000,000	IGRATE	WDGCA22

Sources: Appendix K[a], Figure K8.1-2[a] and Figure K8.2-2[a]; output DTN: MO0801TSPAMVAC.000 [DIRS 185080].

ES9.3.2[a] Groundwater Protection Standard

The separate standards for protection of groundwater in NRC Proposed Rule 10 CFR 63.331 ([DIRS 180319], Table 1) stipulate that the releases of radionuclides in groundwater at the location of the RMEI should not cause the level of radioactivity in the representative water volume of 3,000 acre-feet of water (10 CFR 63.332(a)(3) [DIRS 180319]) to exceed the groundwater protection standards. The regulation does not require that evaluation of the groundwater protection standards include very unlikely events (NRC Proposed Rule 10 CFR 63.342(b) and (c)(1) [DIRS 178394]).

Figures ES-59[a], ES-60[a], and ES-61[a] show the projections for the performance measures of the separate standards for protection of groundwater in the representative volume of 3,000 acre-ft of water. Figure ES-59[a] shows the projections of the combined ^{226}Ra and ^{228}Ra activity concentrations, excluding natural background. Figure ES-60[a] shows the combined activity concentrations of all alpha emitters (including ^{226}Ra but without radon and uranium isotopes), excluding natural background. Figure ES-61[a] shows the dose from beta-and photon-emitting radionuclides in the groundwater at the location of the RMEI, expressed in terms of annual dose to the whole body or any organ of a human receptor resulting from drinking two liters of this water per day. The TSPA-LA Model results show that the projected releases from the repository will meet the NRC separate standards for protection of groundwater in NRC Proposed Rule 10 CFR 63.331 ([DIRS 180319], Table 1).

ES9.4[a] Human Intrusion Scenario

The TSPA-LA Model was used to simulate a Human Intrusion Scenario in order to address the second requirement of the human intrusion standard (10 CFR 63.321(b) [DIRS 178394]). To calculate dose for all environmental pathways per 10 CFR 63.321(c) [DIRS 178394], the TSPA-LA Model used a probabilistic approach analogous to that used to evaluate conformance with the individual protection and groundwater protection standards.

The estimates of WP degradation suggest that, using current technology, a degraded WP could not be penetrated by drilling before about 200,000 years postclosure. Consequently, the analysis considered the effects of a drilling intrusion at 200,000 years. Figure ES-62[a] shows the expected annual dose that could result from a drilling intrusion 200,000 years after repository closure. The expected annual dose accounts for aleatory uncertainty about the type of WP intersected by the drill and location of the intersected WP. The mean, median, and 5th and 95th percentiles of the distribution of expected annual dose reflect epistemic uncertainty due to incomplete knowledge of the behavior of the physical system during and after the drilling intrusion.

The values on Figure ES-62[a] represent the dose from a single WP and are not combinations of releases from other WPs that may fail due to other processes. The mean and median annual doses from human intrusion are estimated to be less than 0.014 millirem. These results indicate that releases from a human intrusion would result in doses well below the human intrusion individual protection standard of 350 millirem annual individual dose to the RMEI during the postclosure period from 200,000 to one million years.

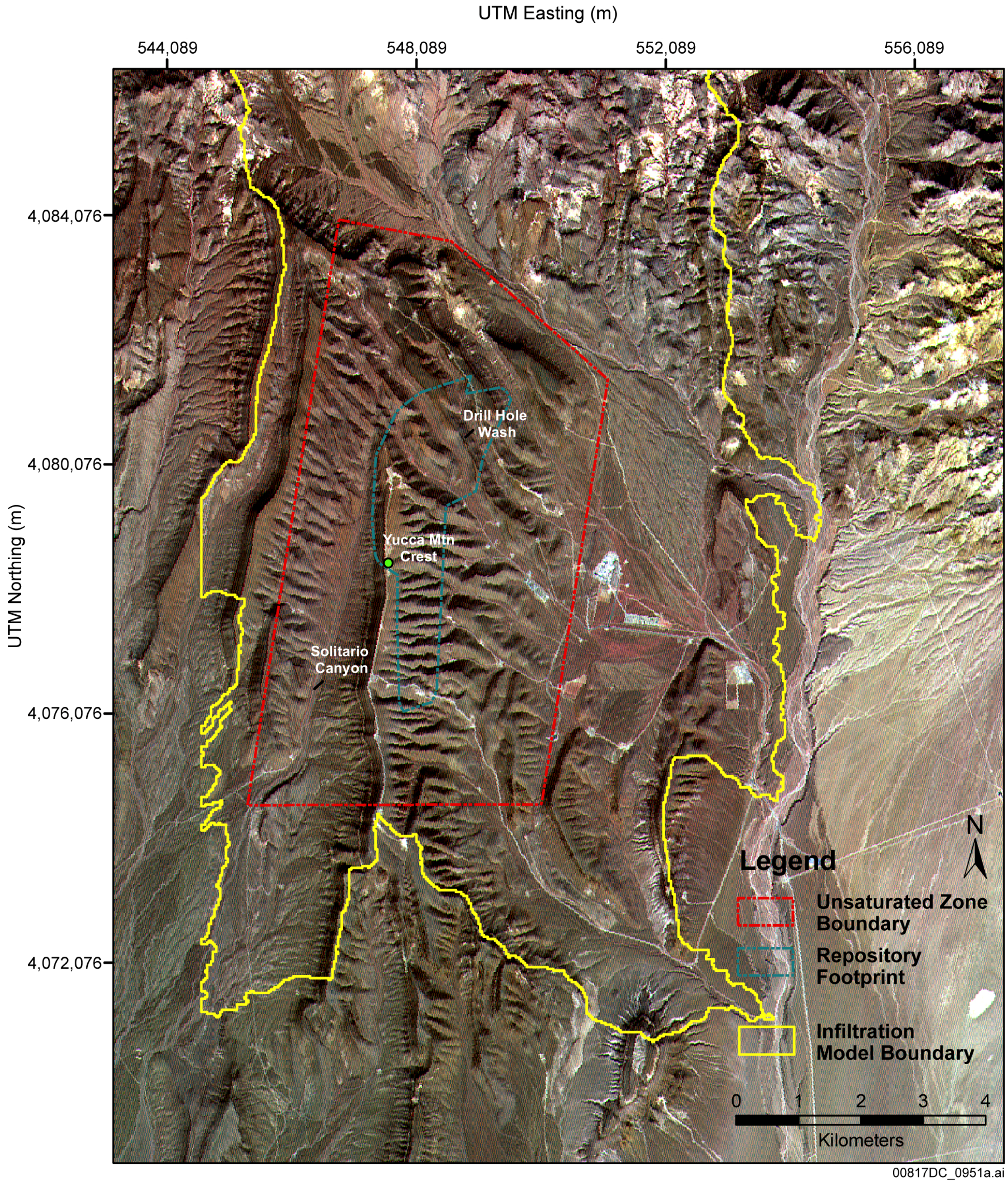
ES10[a] SUMMARY OF THE RESULTS OF THE TSPA-LA MODEL

The TSPA-LA Model was applied to the assessment of total system performance of the Yucca Mountain repository based on FEPs that could affect total system performance. The TSPA-LA analyses incorporate uncertainty in input data and submodel performance and use the validated TSPA-LA Model.

The TSPA-LA Model simulation/analysis periods cover 10,000 years after repository closure and from 10,000 years to the one-million-year period of geologic stability (NRC Proposed Rule 10 CFR 63.302 [DIRS 178394]). The 10,000-year simulations were extended an additional 10,000 years to assess whether or not the trends present at the end of 10,000 years continued beyond that time. The results of the analyses showed that the period between 10,000 years to 20,000 years after repository closure did not display any significant changes to the trends observed from 0 to 10,000 years, providing confidence in the conclusions regarding the 10,000-year period.

The TSPA-LA Model results demonstrate that the projected maximum mean dose to the RMEI in any year during the next 10,000 years after repository closure is less than the individual protection standard after permanent closure in NRC Proposed Rule 10 CFR 63.311(a)(1) [DIRS 178394], which describes the limits on radionuclides in the representative volume. The TSPA-LA Model analyses also indicate the performance of the repository system provides significant protection to groundwater. The results show that concentrations in the groundwater are likely to be well below the separate standards for the protection of groundwater in NRC Proposed Rule 10 CFR 63.331 ([DIRS 180319], Table 1). The results suggest the mean annual drinking water dose to any organ and to the whole body from beta- and photon-emitting radionuclides is likely to be well below the separate standards for the protection of groundwater.

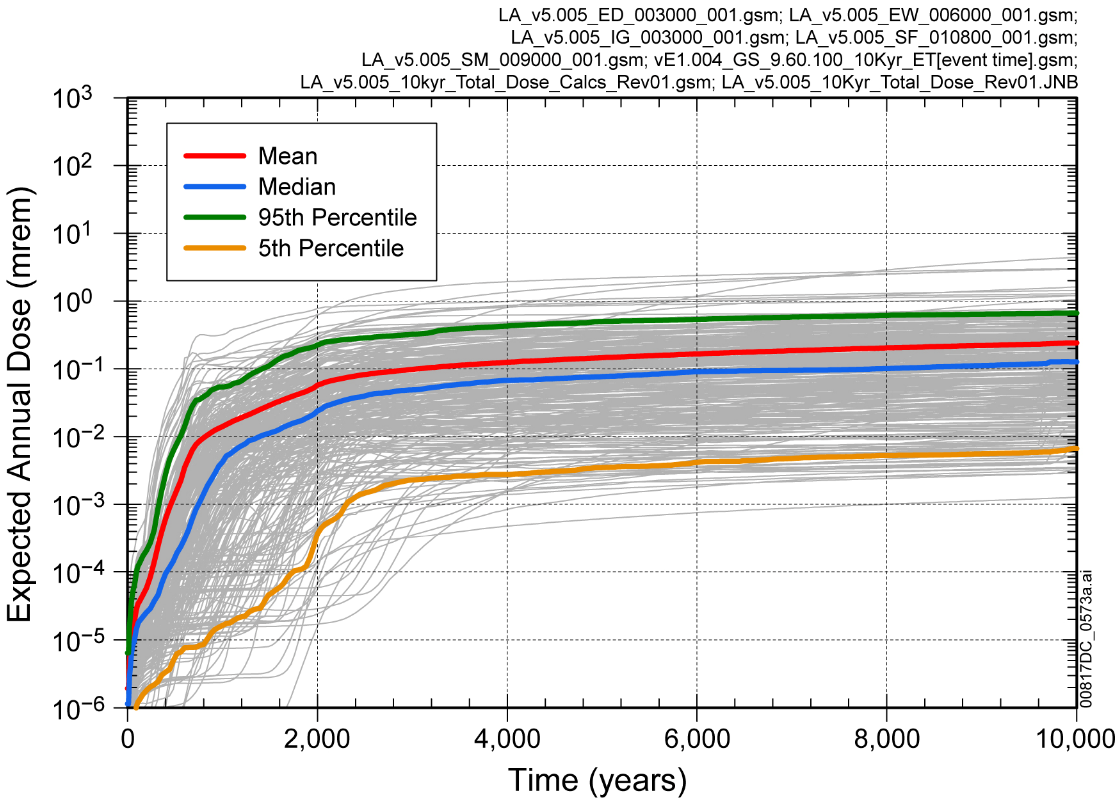
The physiographic setting, topography, climate, area geology, and soil characteristics at the site of the Yucca Mountain repository are favorable for restricting the amount of infiltration of precipitation into the subsurface. The reduced infiltration along with rock characteristics, ambient and perturbed subsurface environmental conditions, and the geometry of emplacement drifts will further limit the amount of liquid water available to enter the drifts. Features of the waste form and other components of the EBS, together with limitations due to the solubility of radionculides and the subsurface geology and hydrology, will limit the release, rate of release, and transport of radionuclides to the SZ beneath the repository. Only a small fraction of the radionuclide inventory is projected to be released from the EBS, move down through the UZ beneath the repository, and enter the SZ. Sorption and diffusion of radionuclides into the UZ will further reduce the concentrations of radionuclides entering the SZ. After the migrating radionuclides enter the SZ, the TSPA-LA Model results indicate that the characteristics of the rock, soil, and the hydrologic and geochemical environmental factors in the SZ will combine to retard radionuclide transport and reduce the rate of radionuclide transport to the accessible environment. Including igneous and seismic phenomena, the TSPA-LA Model analysis indicates that the repository will, with a high degree of confidence, perform in a manner that protects the natural environment and future human populations in the area.



Source: Modified from SNL 2007 [DIRS 182145], Figure 6.5.2.1-1[a].

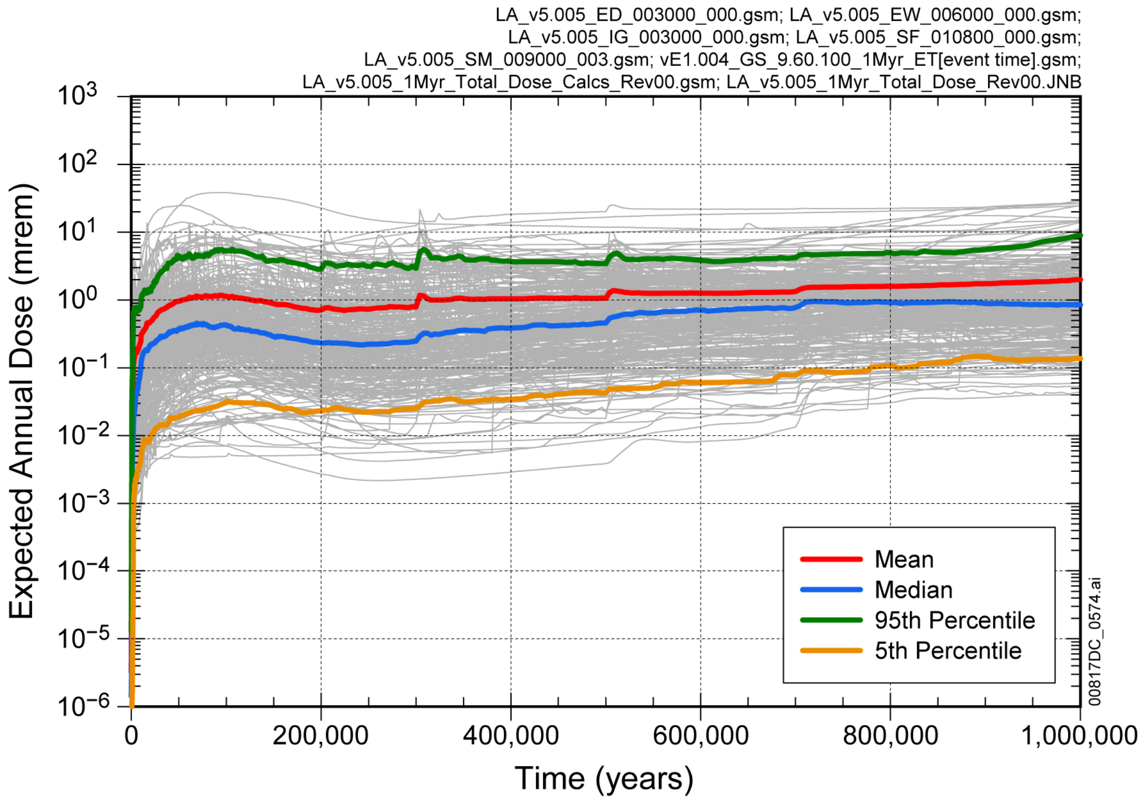
NOTE: The model boundary is the same as the 1999 unsaturated zone flow model domain of the TSPA-SR.

Figure ES-12[a]. Topographic Map of the Yucca Mountain Site Showing Differences in Slope Characteristics North and South of Drill Hole Wash



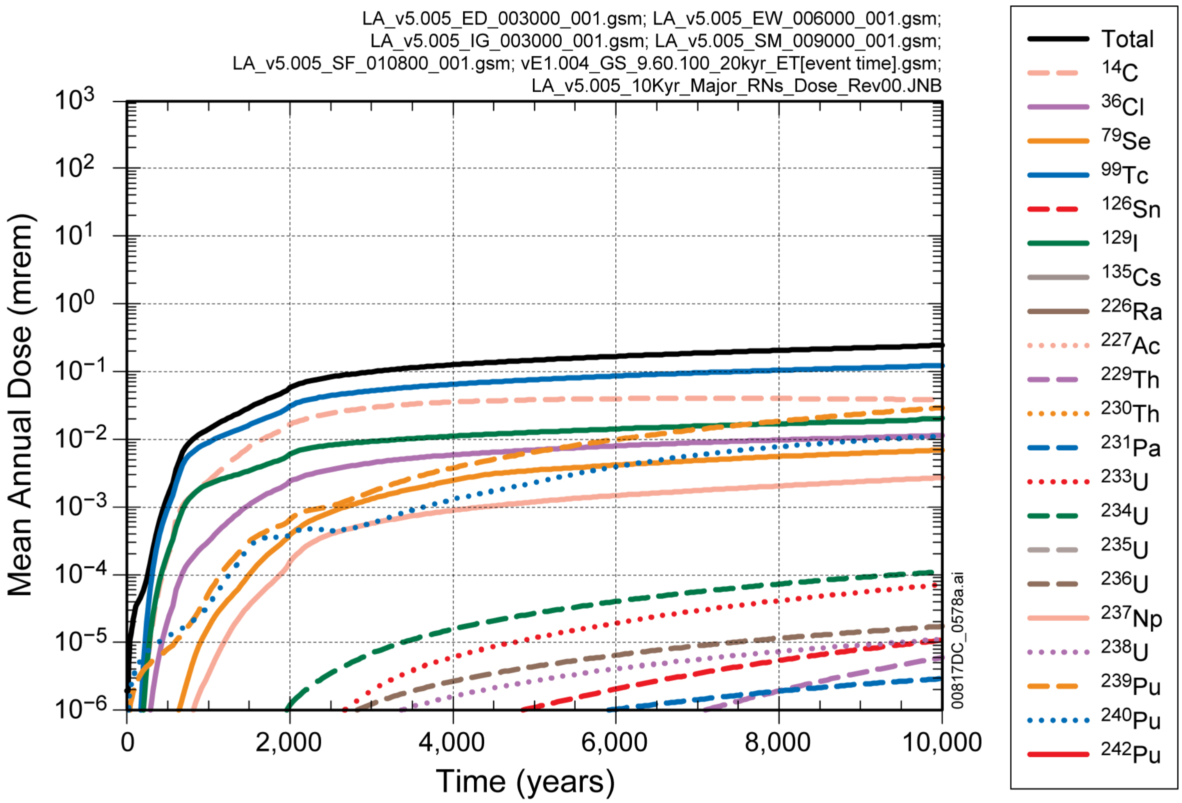
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; MO0710PLOTSFIG.000 [DIRS 185207]; and MO0709TSPAREGS.000 [DIRS 182976].

Figure ES-40[a]. Total Expected Annual Dose for 10,000 Years after Repository Closure



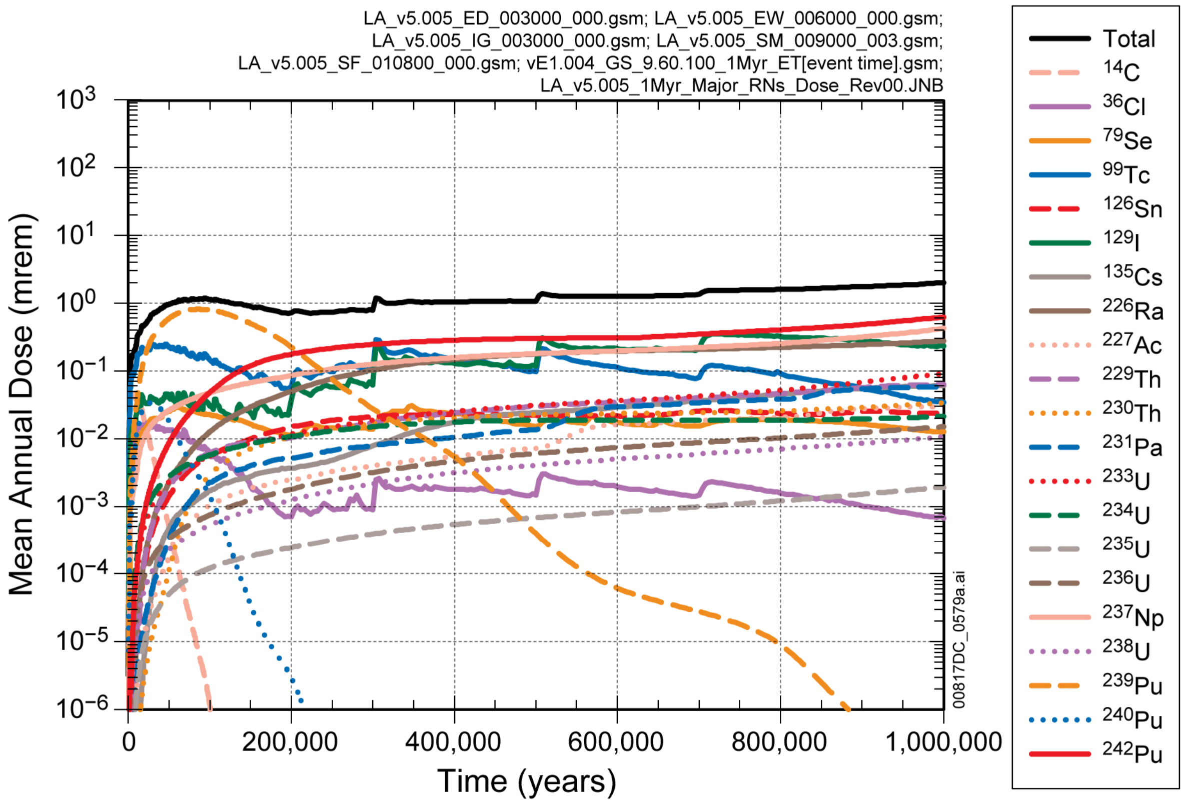
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; MO0710PLOTSFIG.000 [DIRS 185207]; and MO0709TSPAREGS.000 [DIRS 182976].

Figure ES-41[a]. Total Expected Annual Dose for 1,000,000 Years after Repository Closure



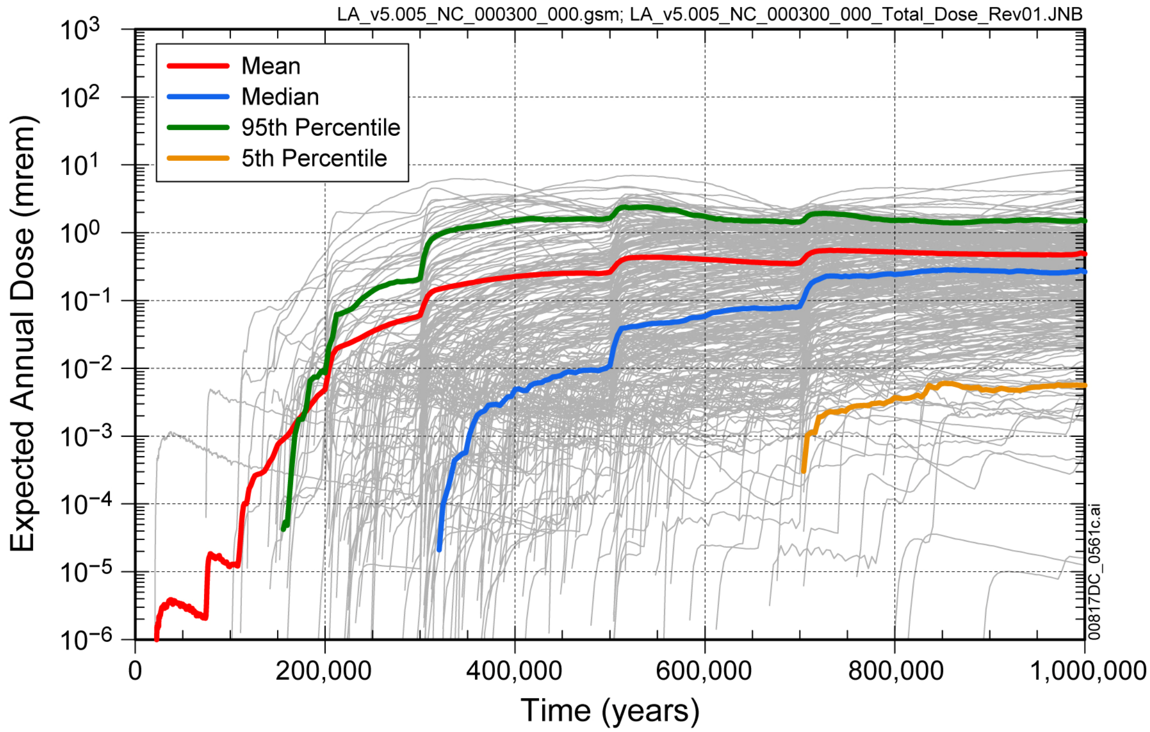
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; MO0710PLOTSFIG.000 [DIRS 185207]; and MO0709TSPAREGS.000 [DIRS 182976].

Figure ES-42[a]. Contribution of Individual Radionuclides to Total Mean Annual Dose for 10,000 Years after Repository Closure



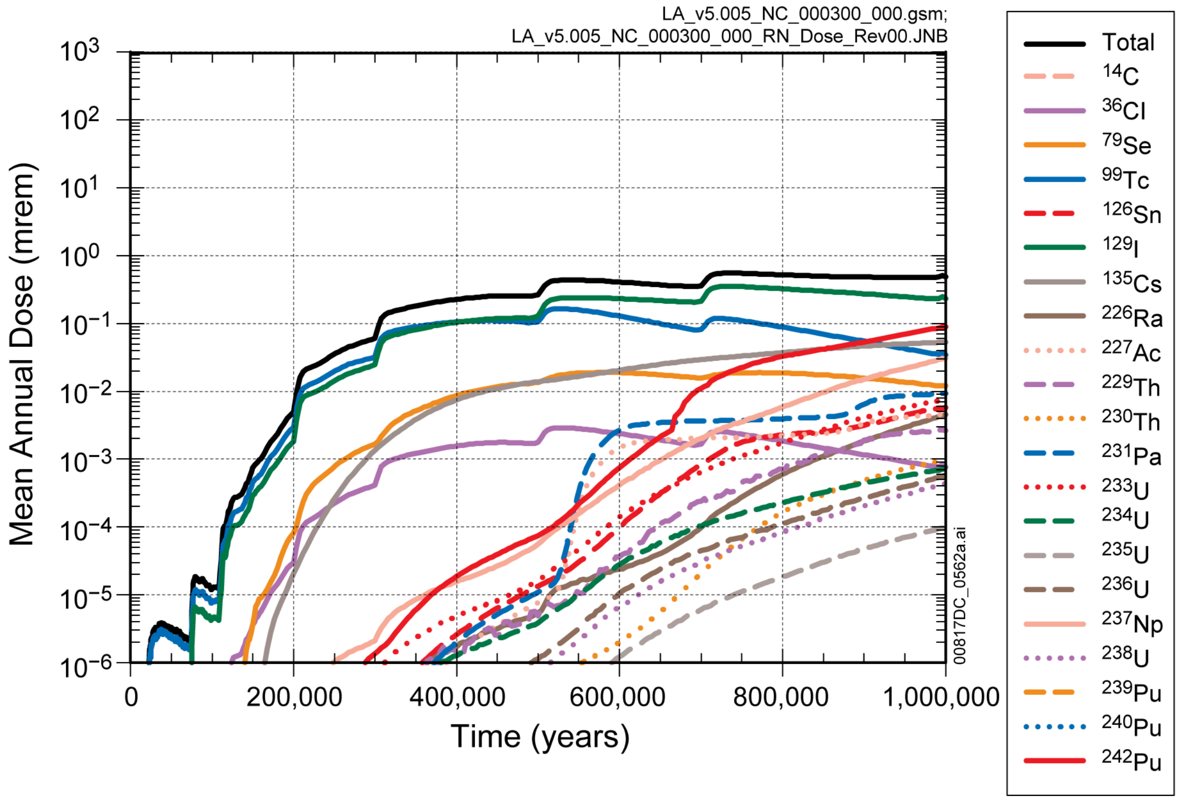
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; MO0710PLOTSFIG.000 [DIRS 185207]; and MO0709TSPAREGS.000 [DIRS 182976].

Figure ES-43[a]. Contribution of Individual Radionuclides to Total Mean Annual Dose for 1,000,000 Years after Repository Closure



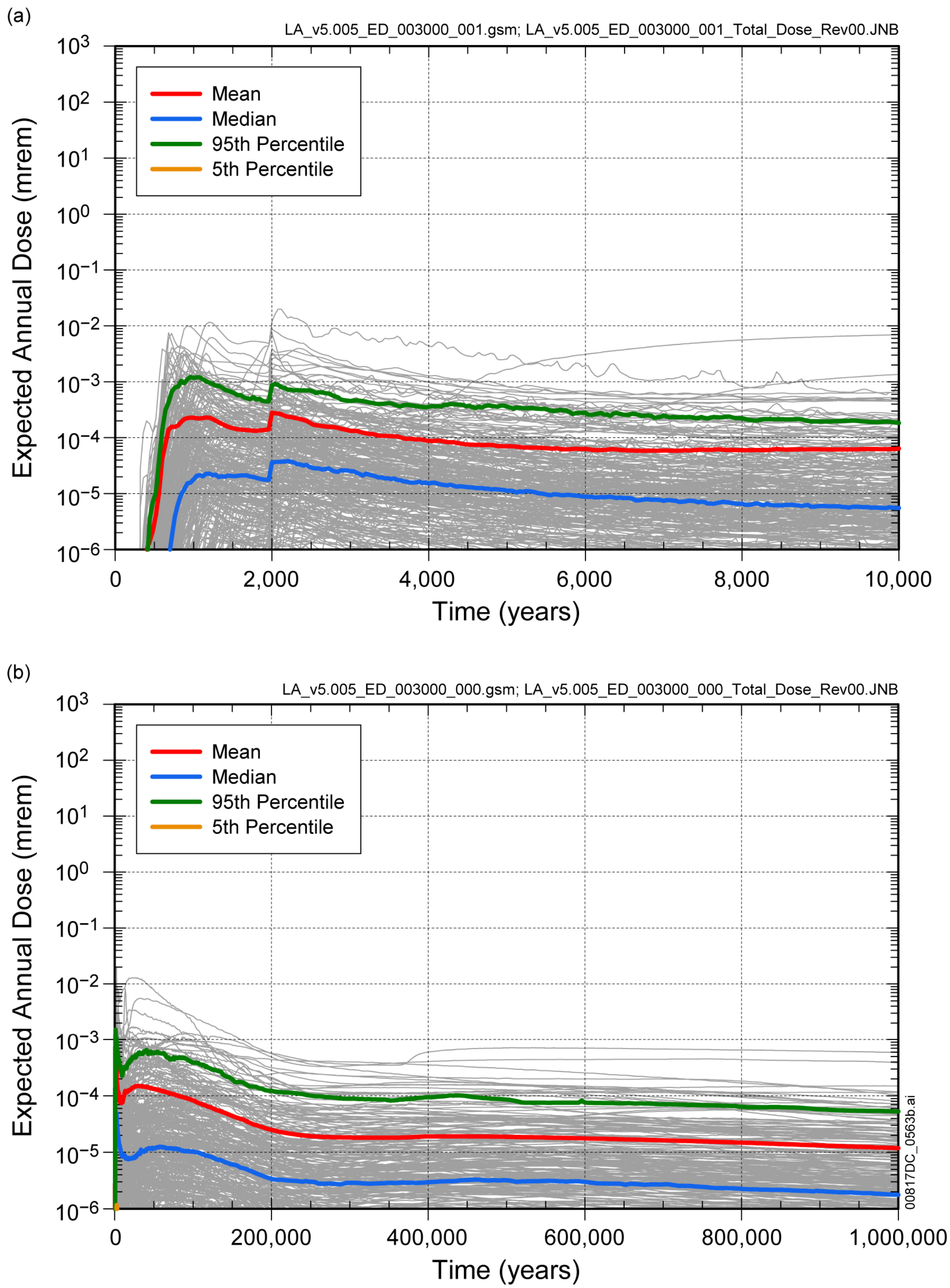
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-44[a]. Annual Dose for the Nominal Scenario Class Modeling Case for the Post-10,000-Year Period



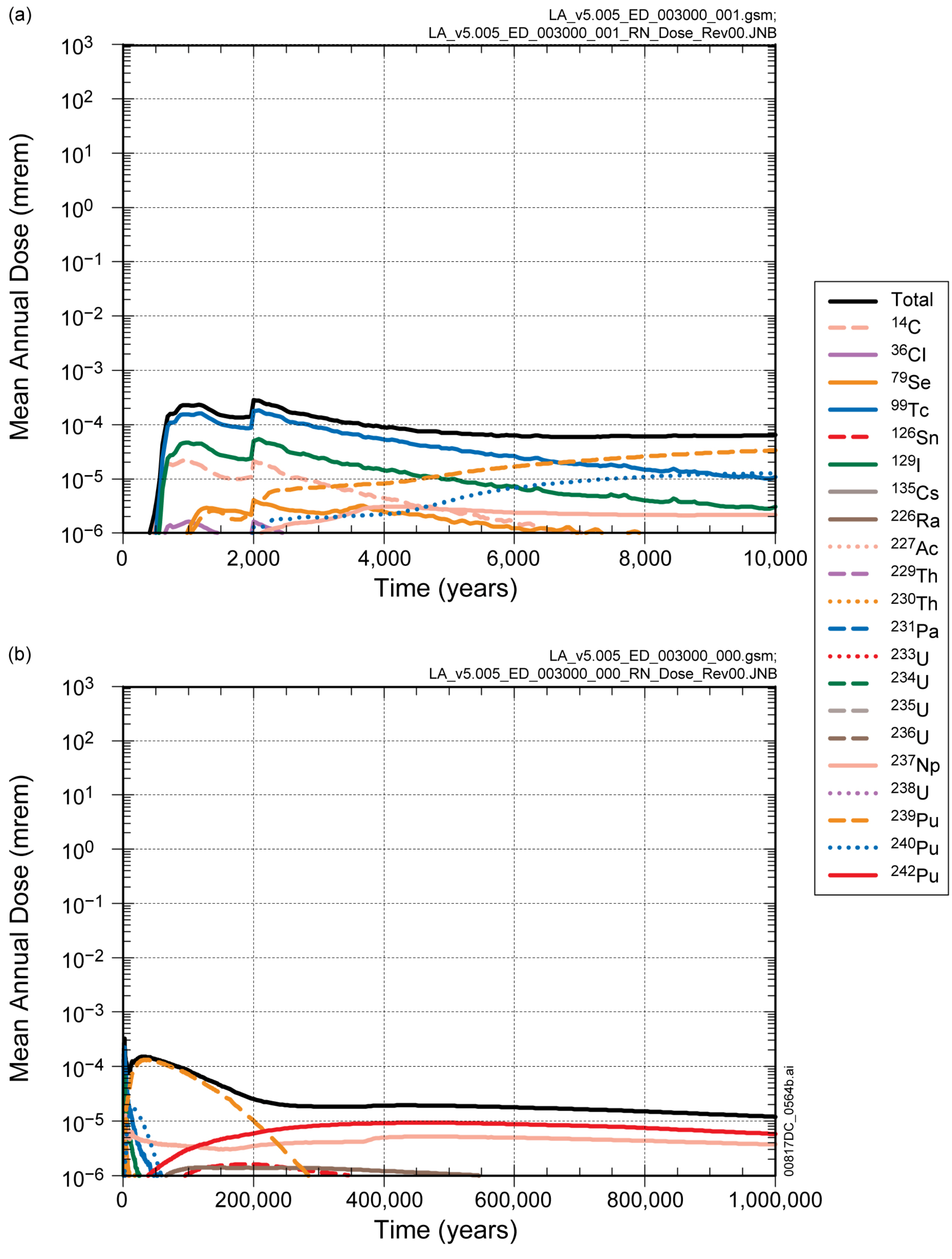
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-45[a]. Mean Annual Dose Contributions from Major Radionuclides for the Nominal Scenario Class Modeling Case for the Post-10,000-Year Period



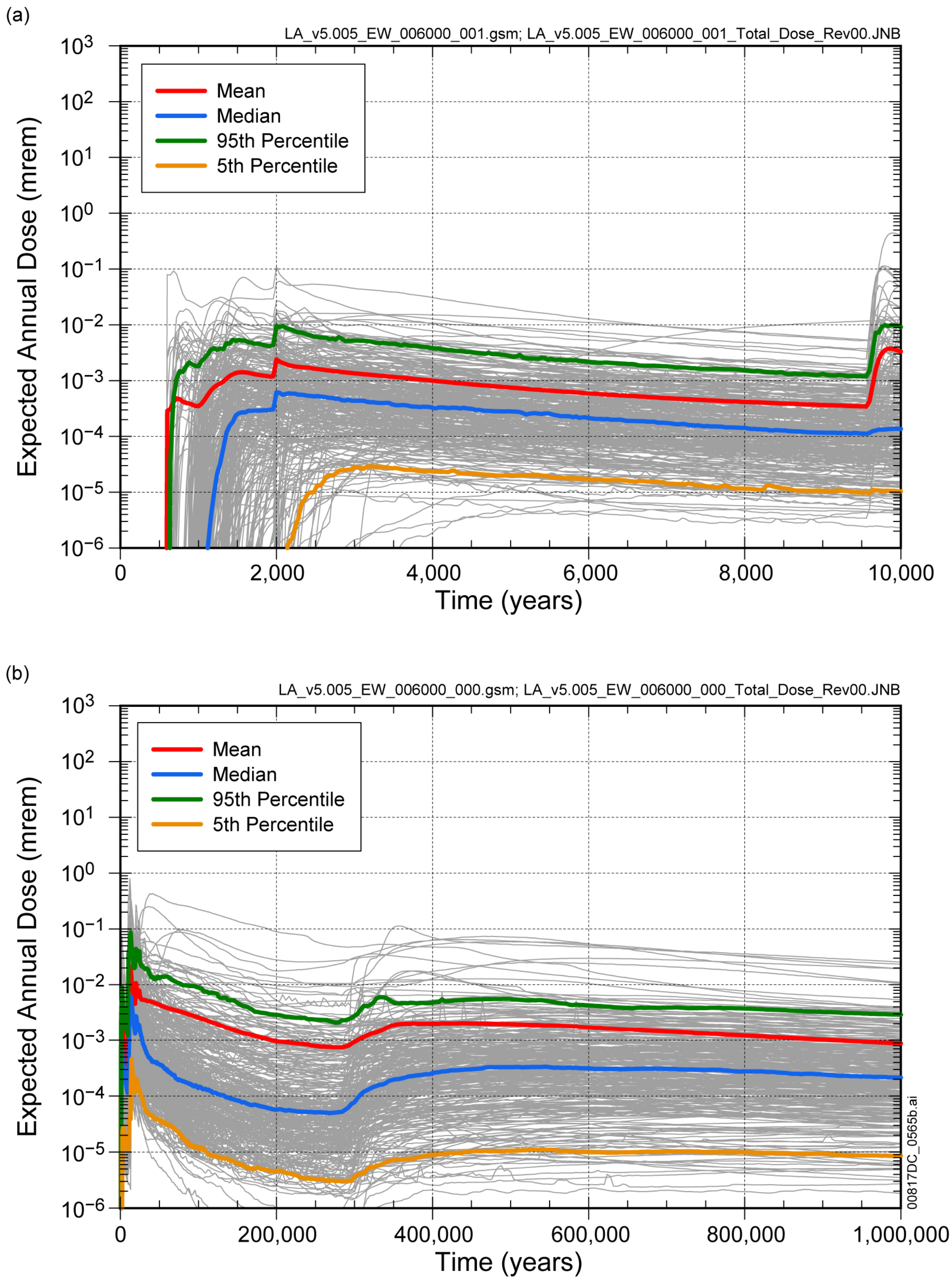
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-46[a]. Expected Annual Dose for the Drip Shield Early Failure Modeling Case for (a) the First 10,000 Years after Repository Closure and (b) Post-10,000-Year Period



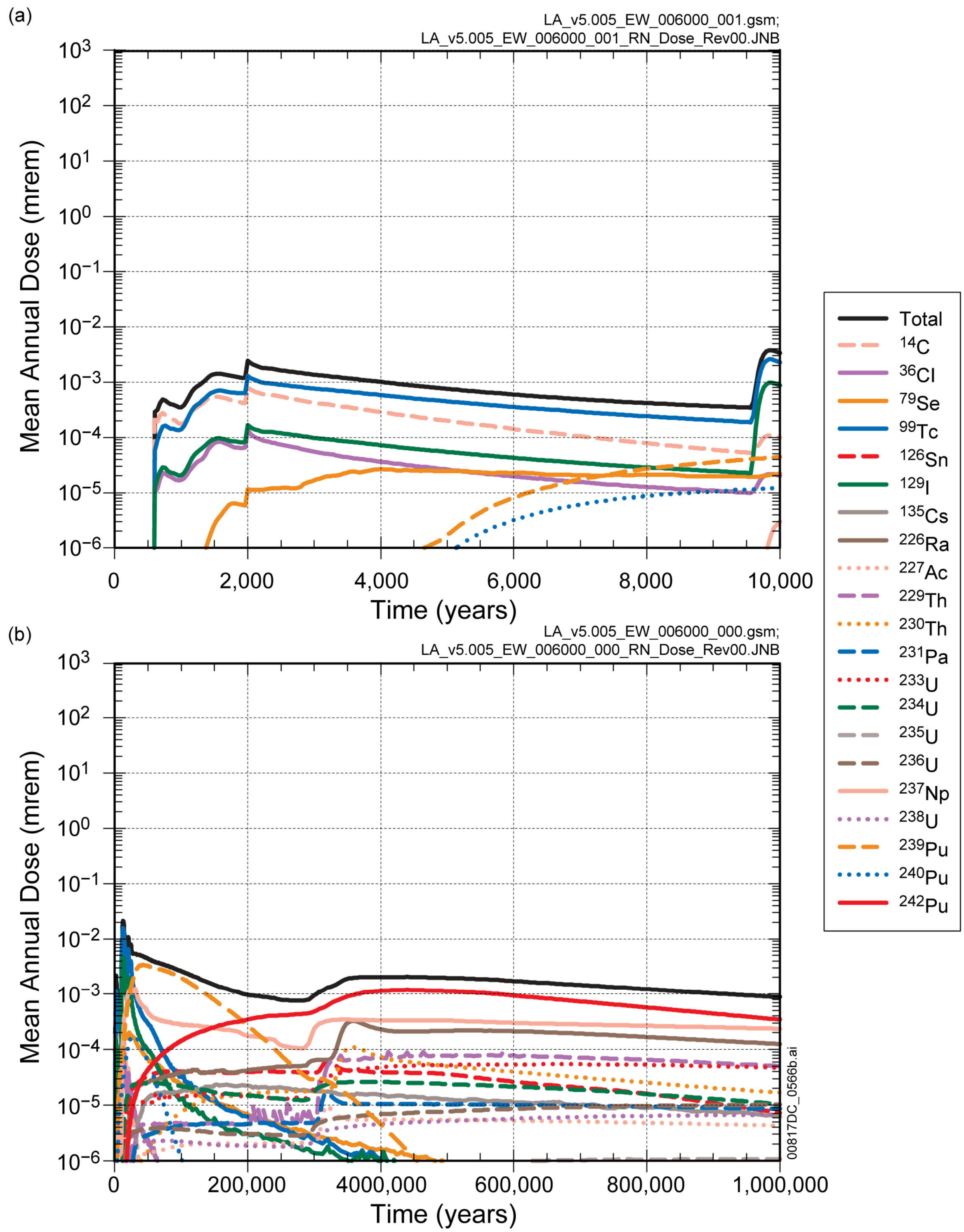
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-47[a]. Mean Annual Dose Contributions from Major Radionuclides for the Drip Shield Early Failure Modeling Case for (a) the First 10,000 Years after Repository Closure and (b) Post-10,000-Year Period



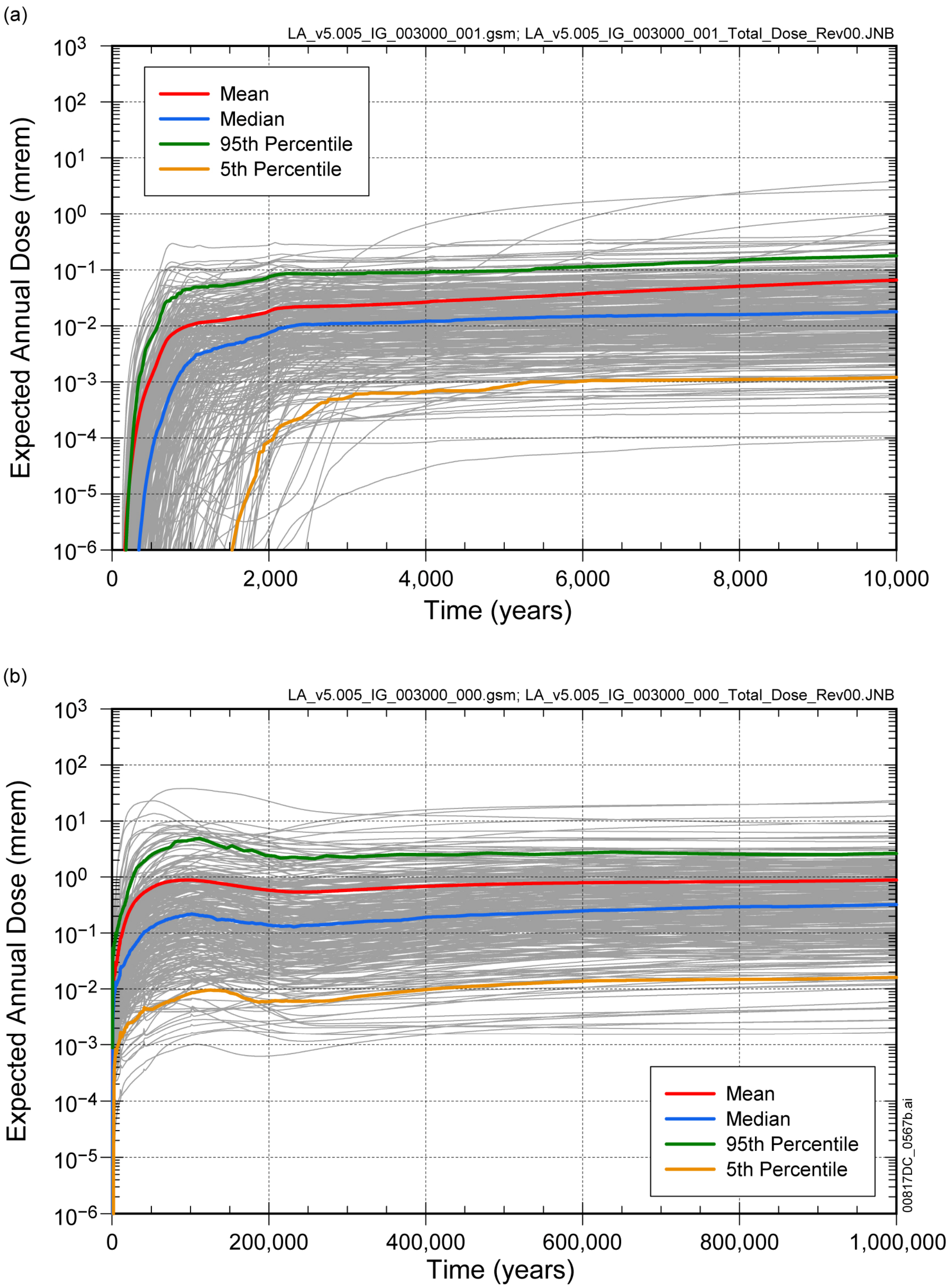
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-48[a]. Expected Annual Dose for the Waste Package Early Failure Modeling Case for (a) the First 10,000 Years after Repository Closure and (b) Post-10,000-Year Period



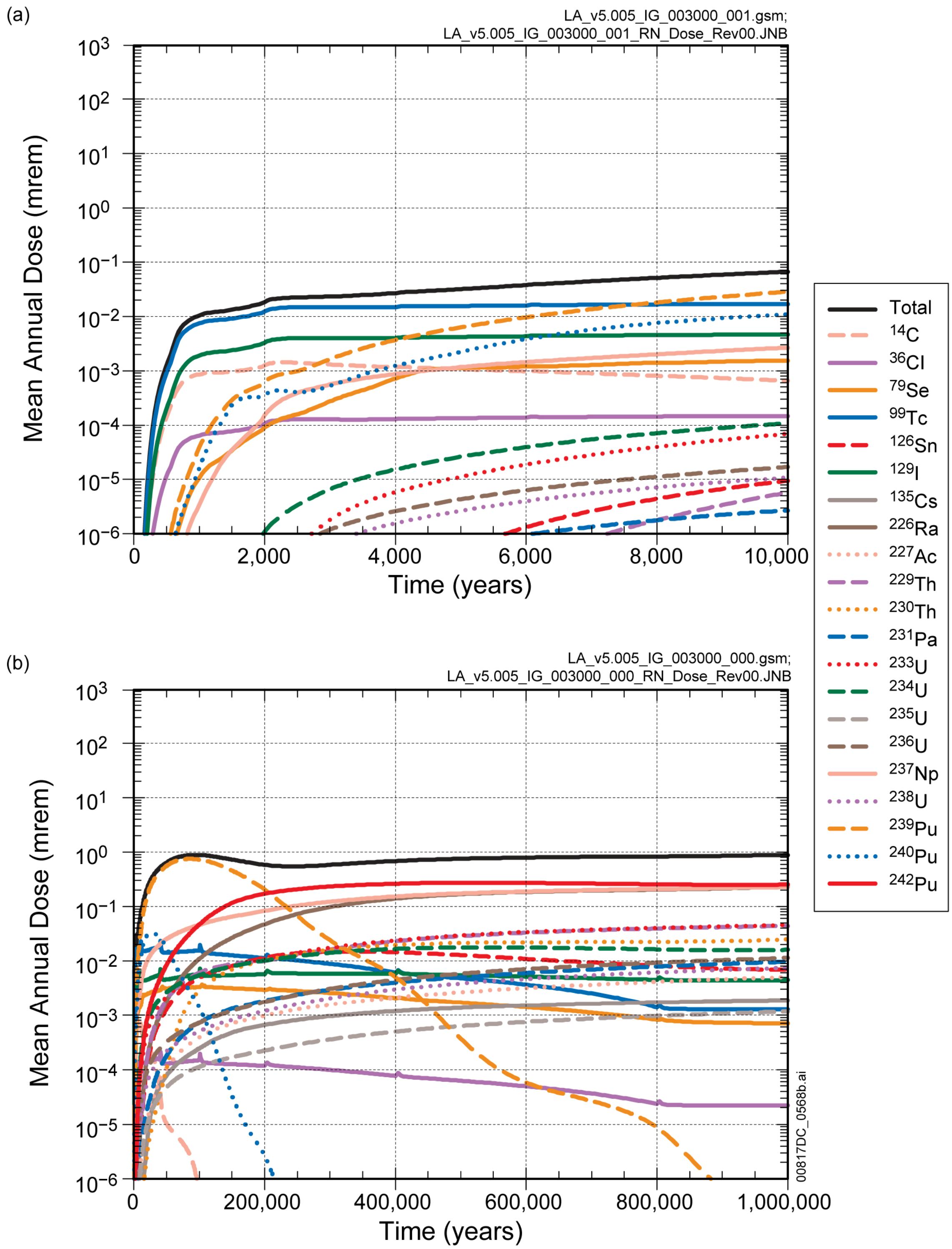
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-49[a]. Mean Annual Dose Contributions from Major Radionuclides for the Waste Package Early Failure Modeling Case for (a) the First 10,000 Years after Repository Closure and (b) Post-10,000-Year Period



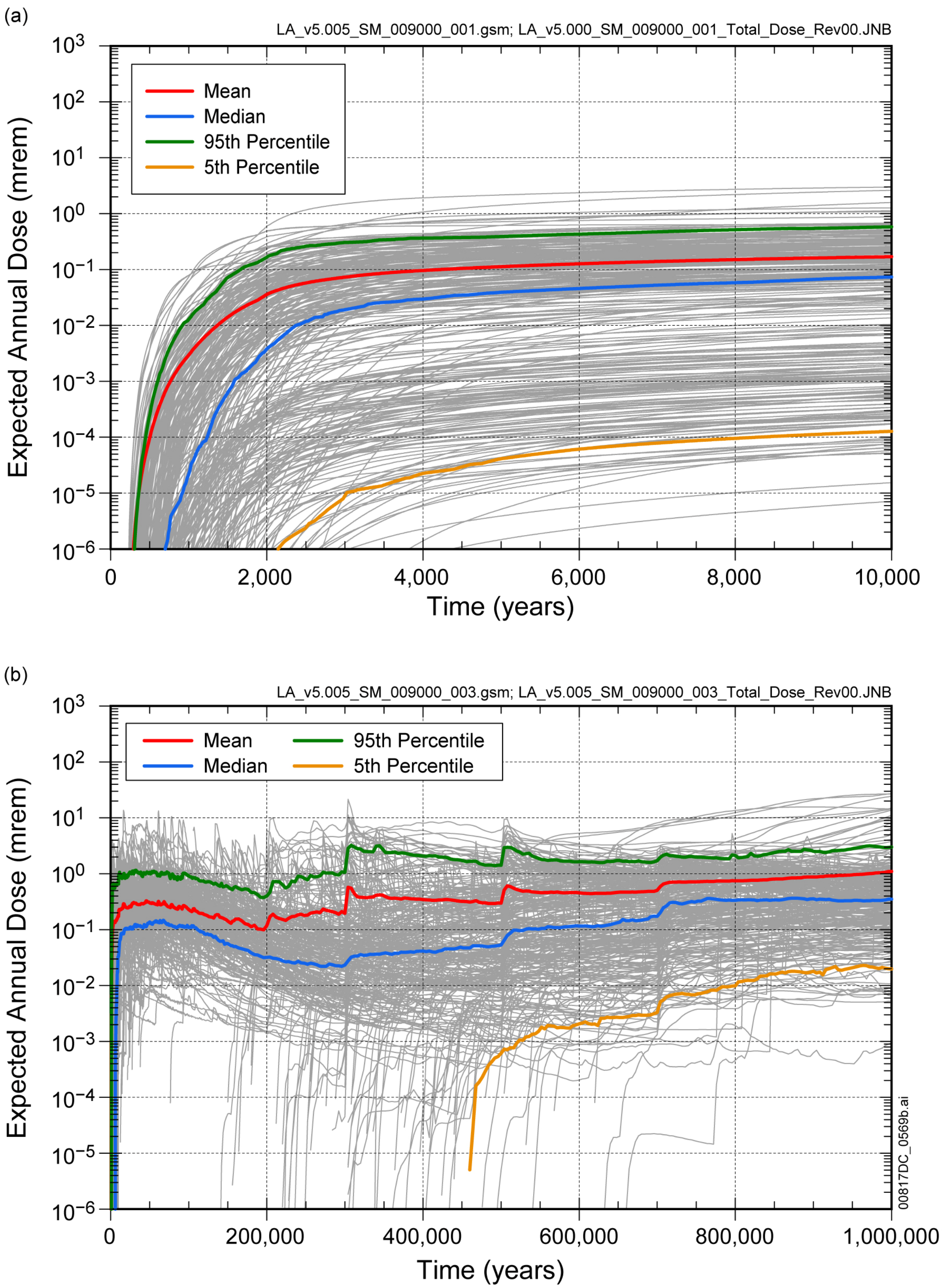
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-50[a]. Expected Annual Dose for the Igneous Intrusion Modeling Case for (a) 10,000 Years after Repository Closure and (b) Post-10,000-Year Period



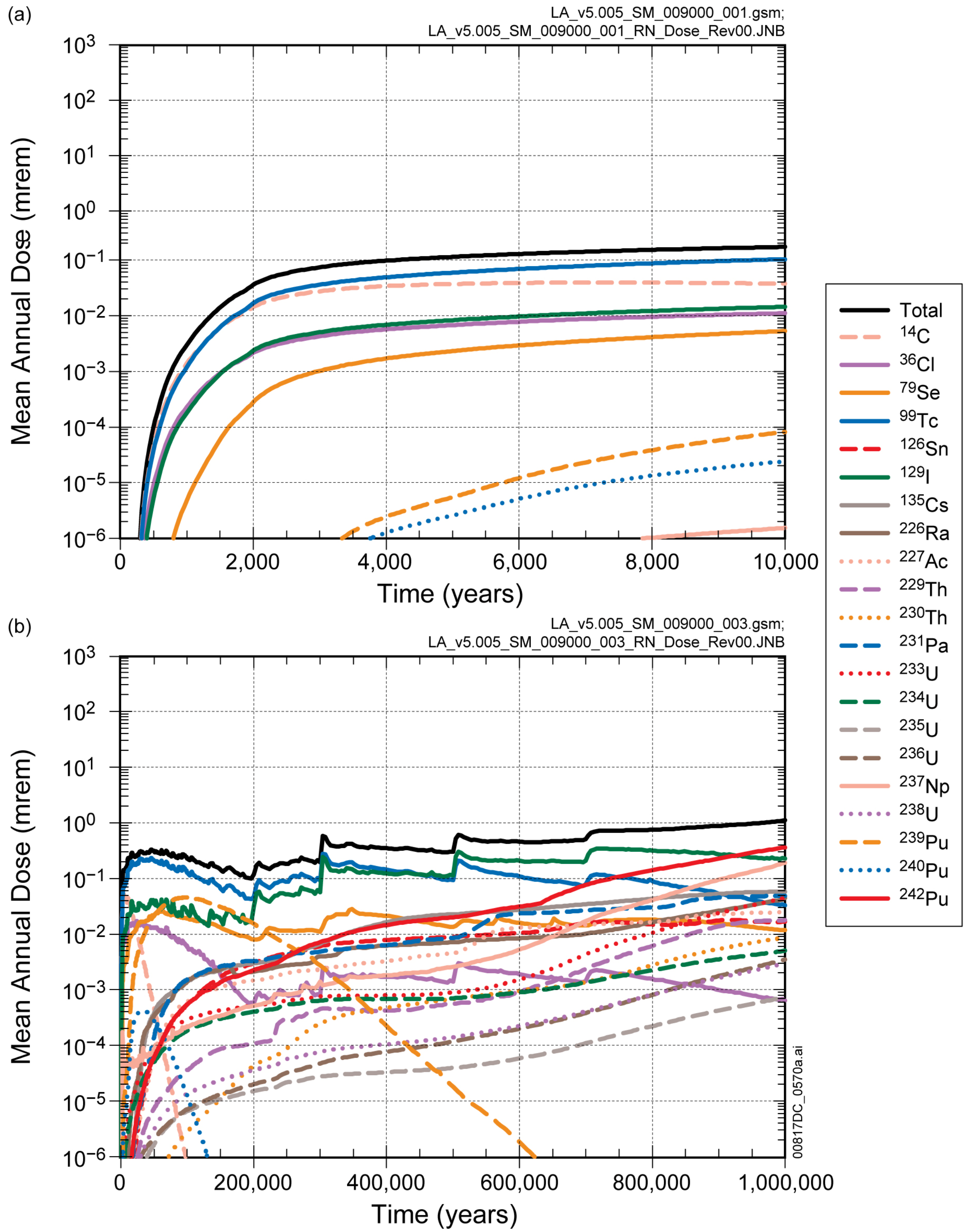
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-51[a]. Mean Annual Dose Contributions from Major Radionuclides for the Igneous Intrusion Modeling Case for (a) the First 10,000 Years after Repository Closure and (b) Post-10,000-Year Period



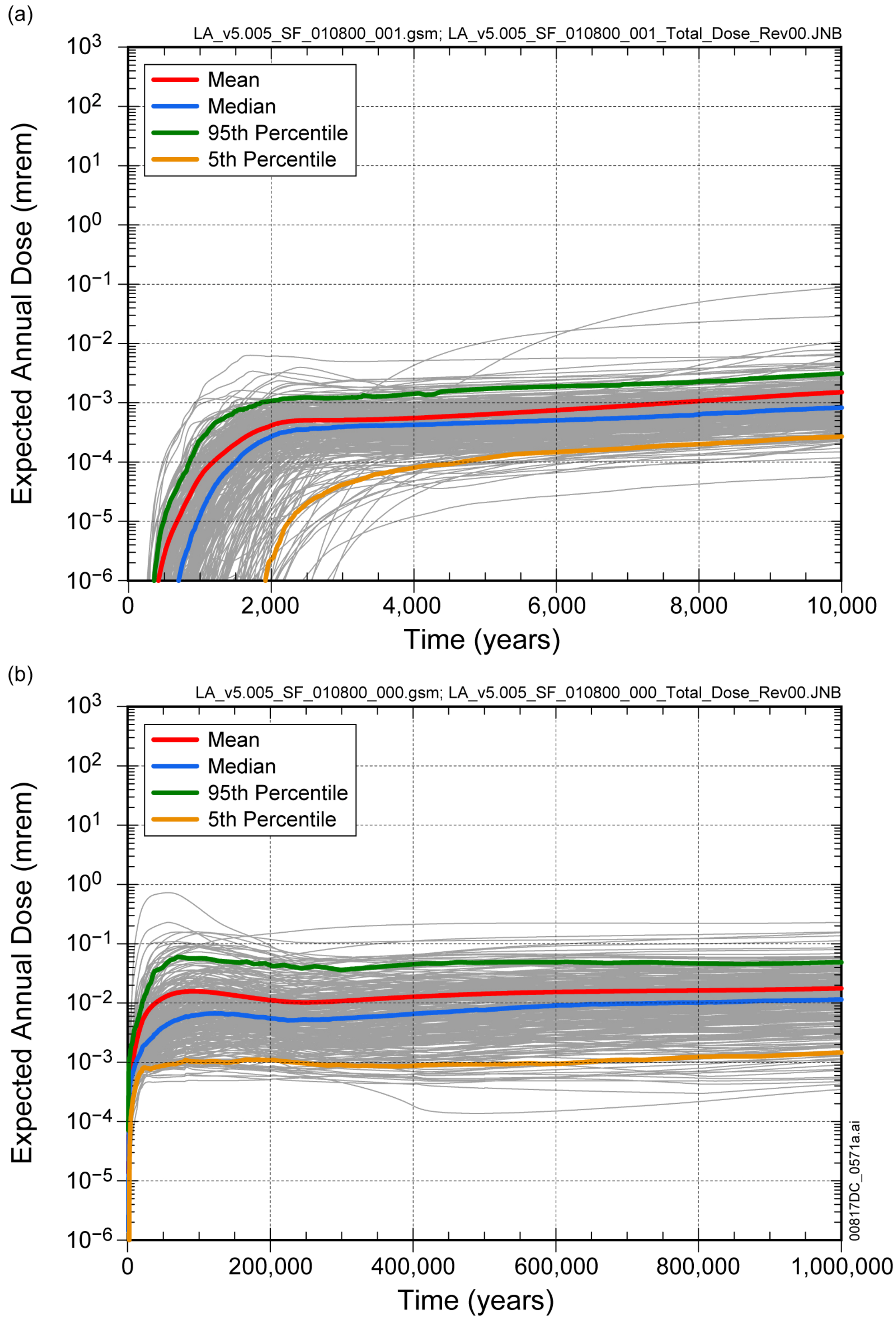
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-54[a]. Expected Annual Dose for the Seismic Ground Motion Modeling Case for (a) 10,000 Years after Repository Closure and (b) Post-10,000-Year Period



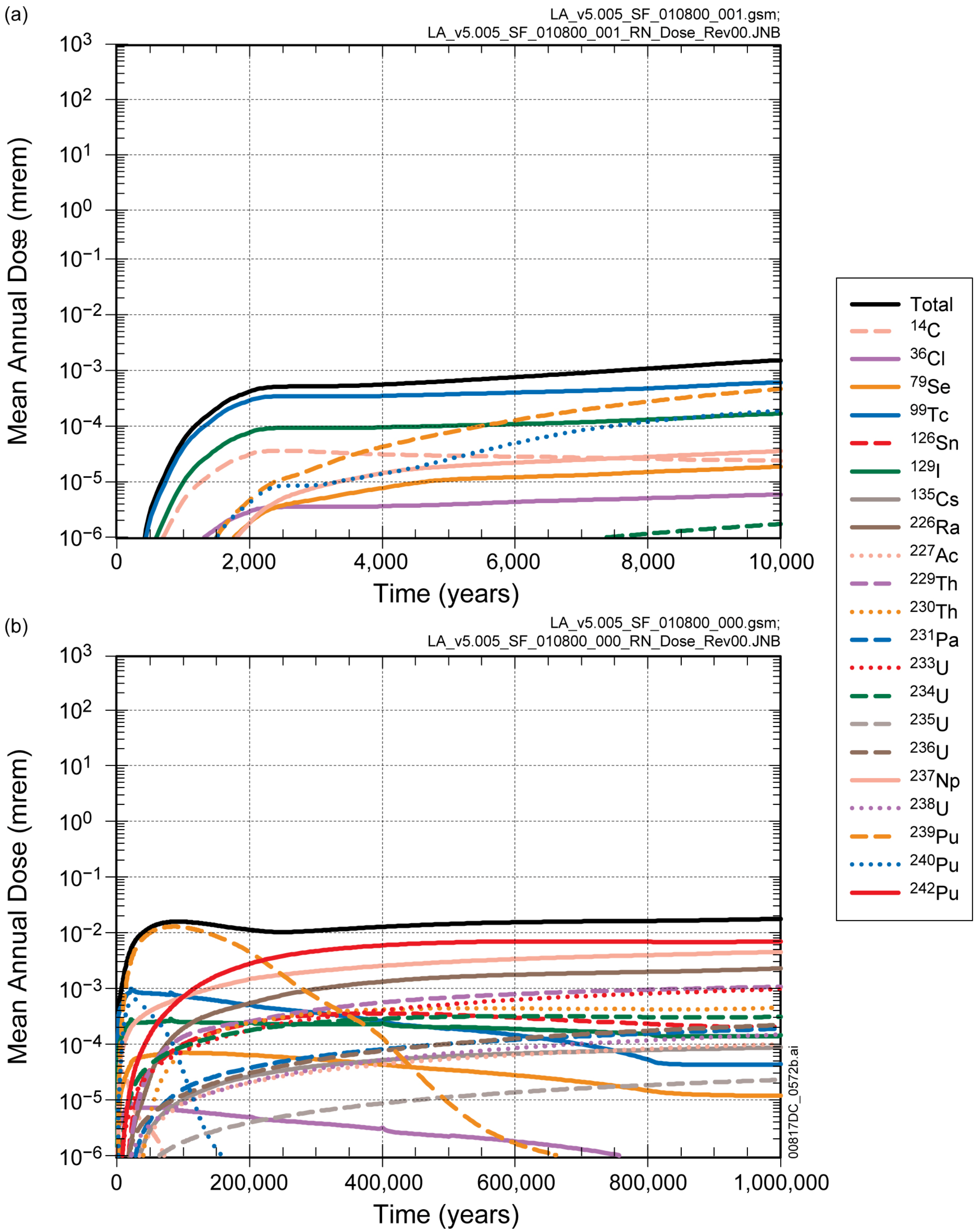
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-55[a]. Mean Annual Dose Contributions from Major Radionuclides for the Seismic Ground Motion Modeling Case for (a) the First 10,000 Years after Repository Closure and (b) Post-10,000-Year Period



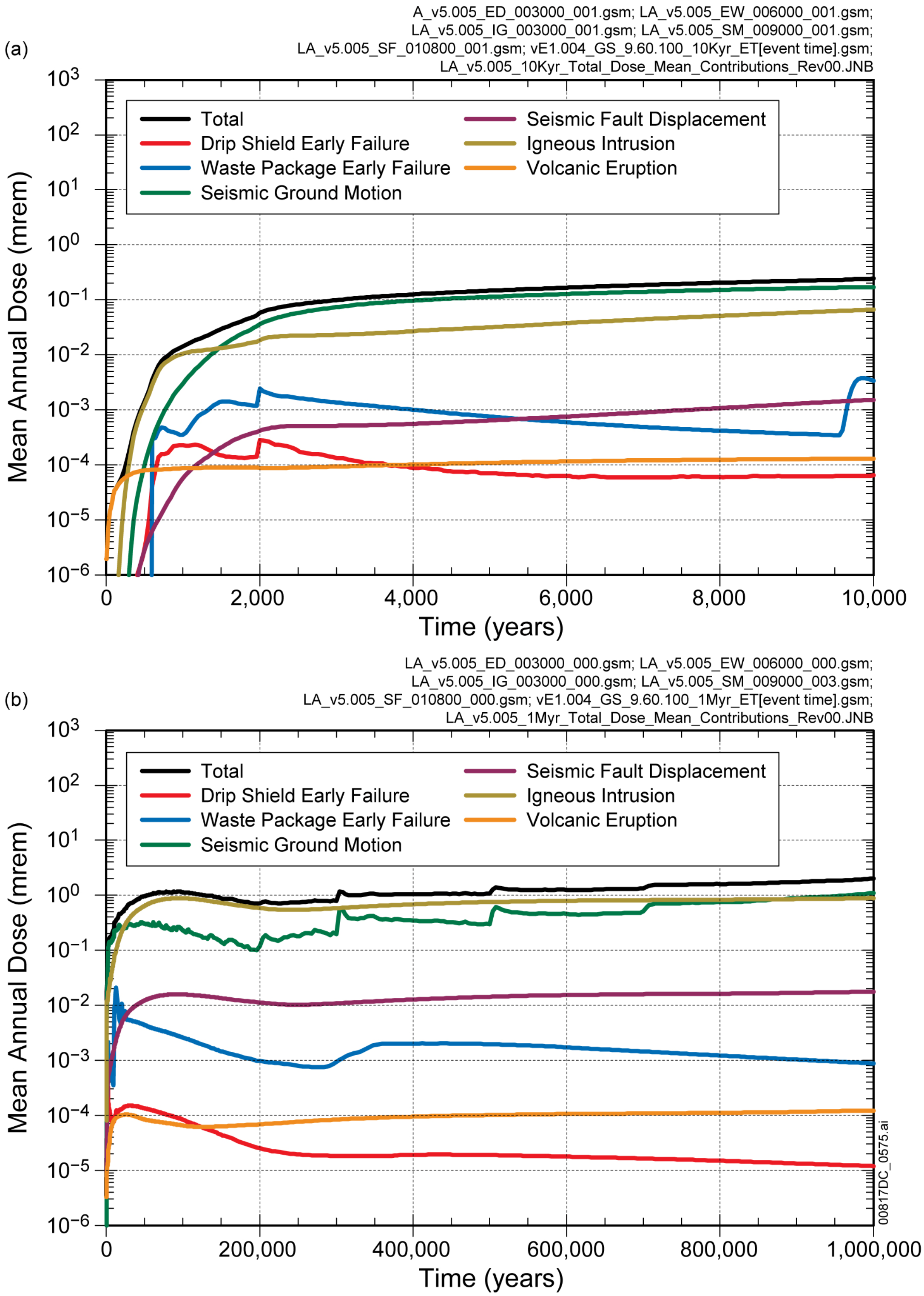
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-56[a]. Expected Annual Dose for the Seismic Fault Displacement Modeling Case for (a) 10,000 Years after Repository Closure and (b) Post-10,000-Year Period



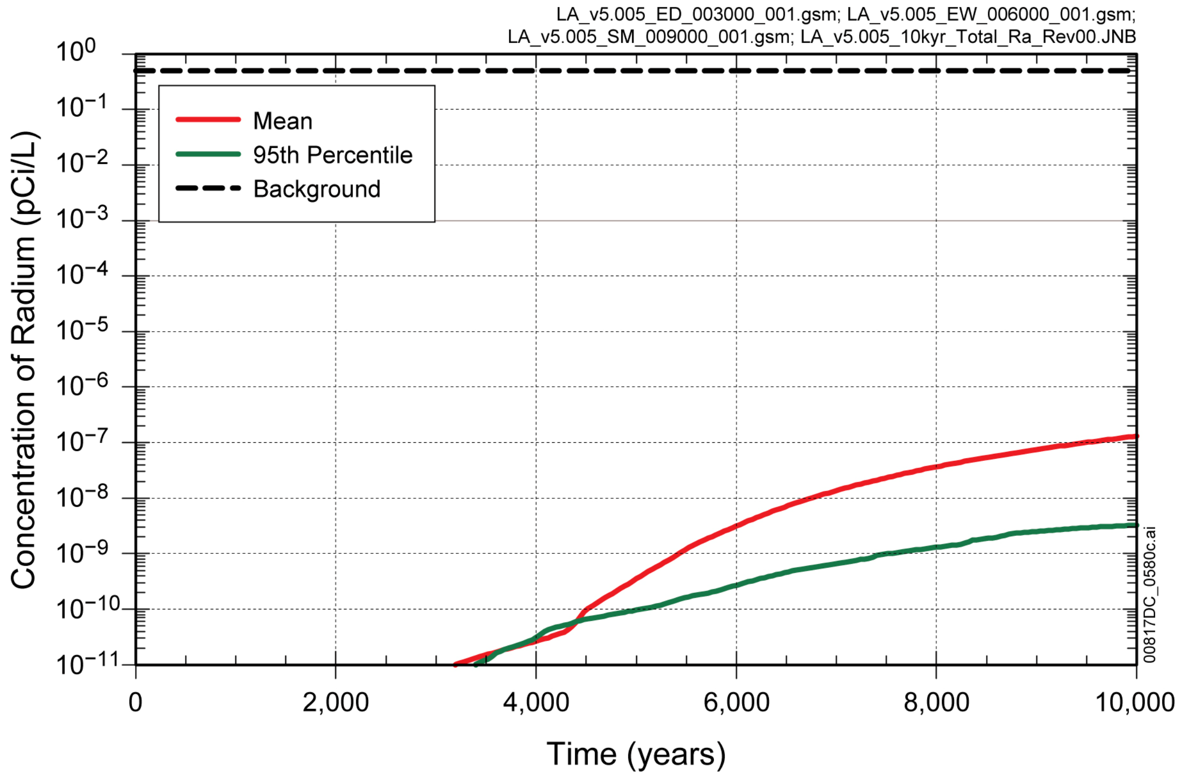
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-57[a]. Mean Annual Dose Contributions from Major Radionuclides for the Seismic Fault Displacement Modeling Case for (a) 10,000 Years after Repository Closure and (b) Post-10,000-Year Period



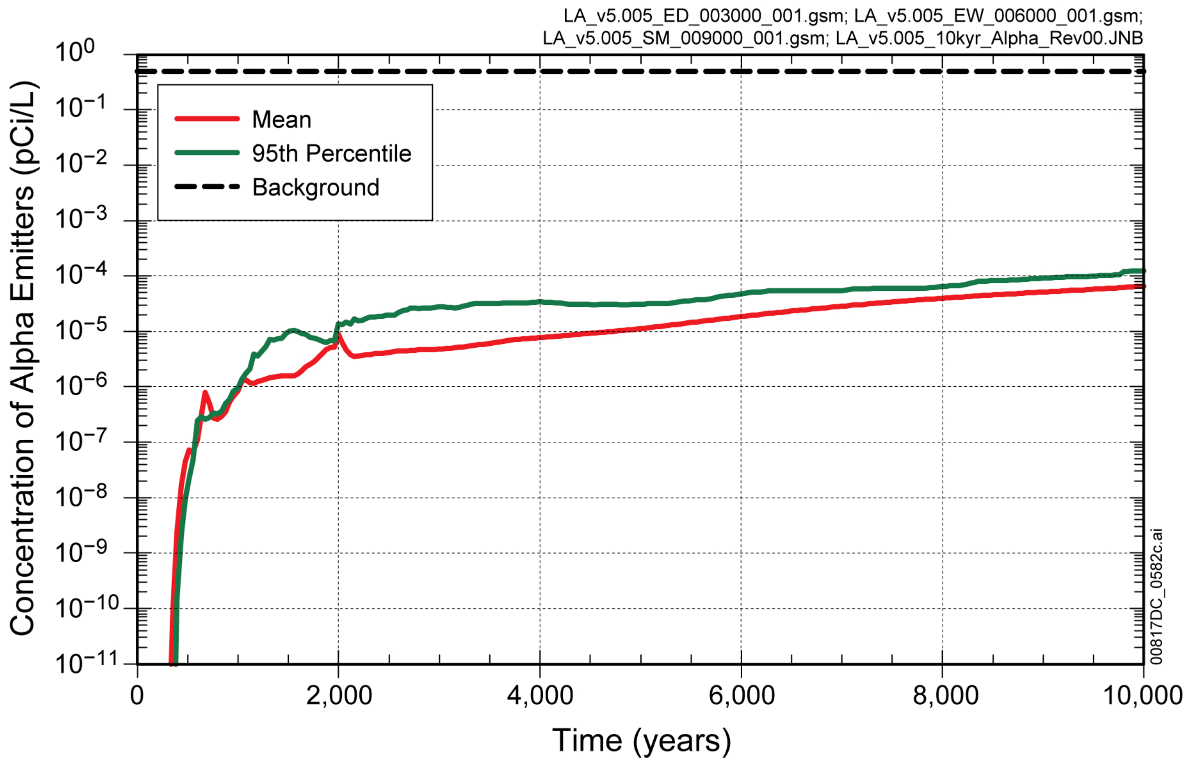
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0709TSPAREGS.000 [DIRS 182976].

Figure ES-58[a]. Total Mean Annual Dose and Median Annual Doses for Each Modeling Case for (a) 10,000 Years after Repository Closure and (b) Post-10,000-Year Period



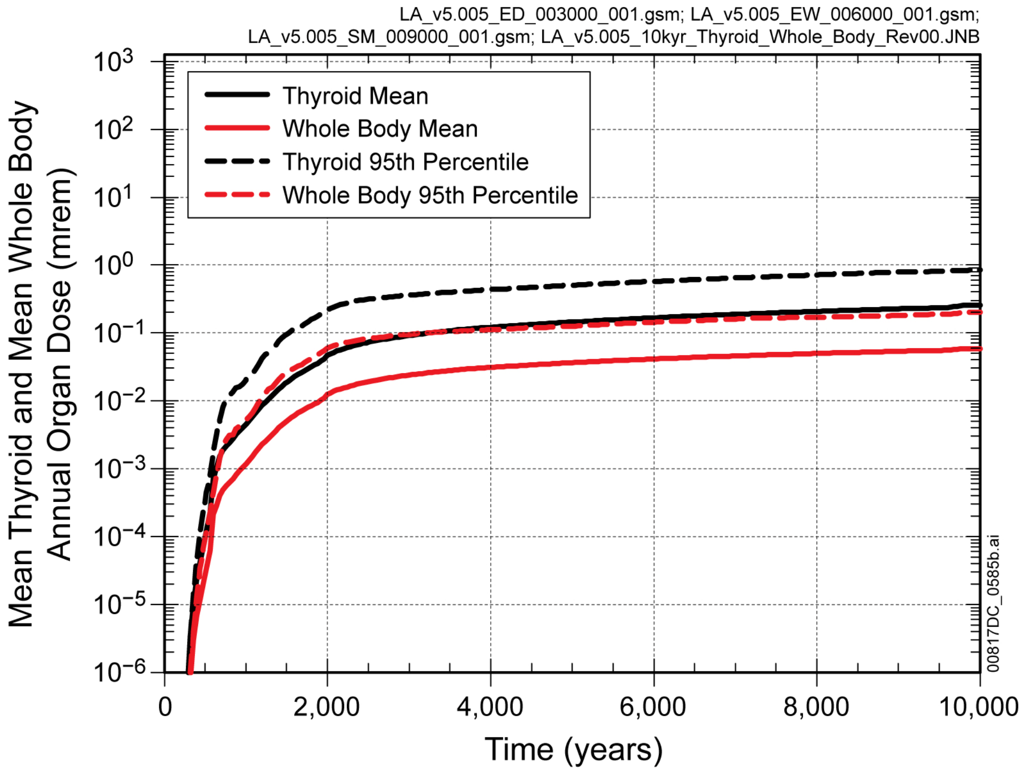
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-59[a]. Combined ^{226}Ra and ^{228}Ra Activity Concentrations, Excluding Natural Background, for Likely Features, Events, and Processes Using Nominal, Early Failure, and Seismic Ground Motion Damage Processes



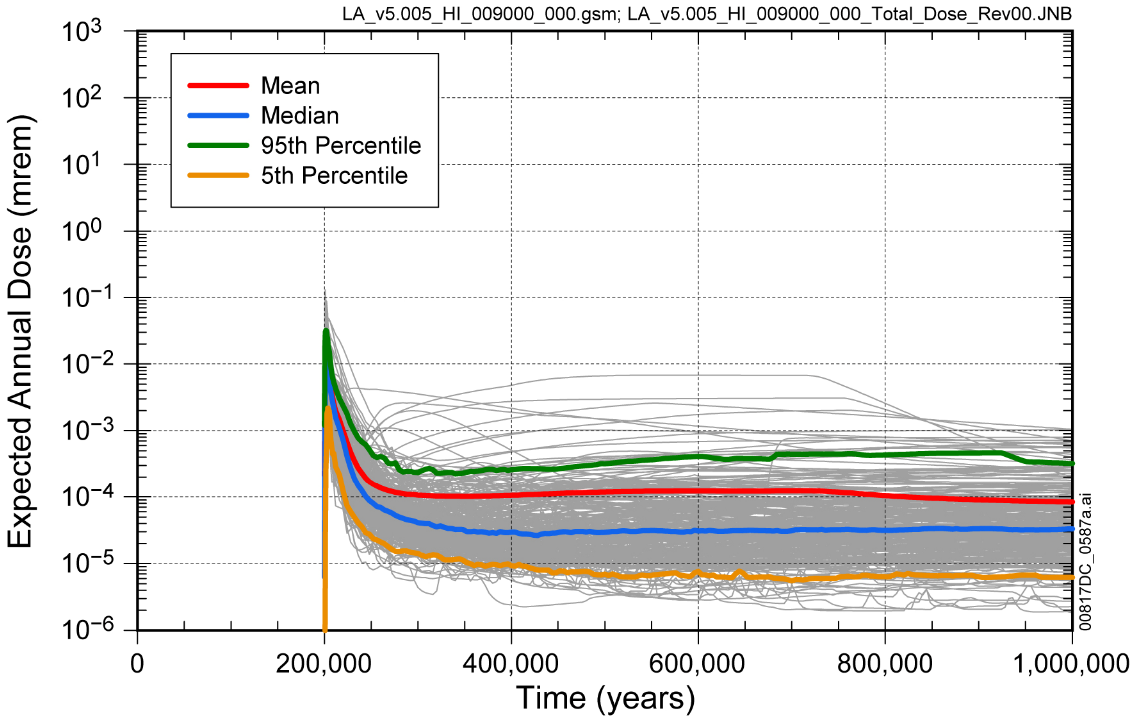
Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-60[a]. Combined Activity Concentrations of All Alpha Emitters (including ^{226}Ra but without radon and uranium isotopes), Excluding Natural Background, for Likely Features, Events, and Processes Using Nominal, Early Failure, and Seismic Ground Motion Damage Processes



Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-61[a]. Mean Annual Drinking Water Dose from Combined Beta and Photon Emitters for Likely Features, Events, and Processes using the Nominal, Early Failure, and Seismic Ground Motion Damage Processes



Source: Output DTNs: MO0710ADTSPAWO.000 [DIRS 183752]; and MO0710PLOTSFIG.000 [DIRS 185207].

Figure ES-62[a]. Expected Annual Individual Dose at the RMEI Location from a Human Intrusion 200,000 Years after Repository Closure

1[a]. PURPOSE

1.1[a] INTRODUCTION

This addendum updates the results of the Total System Performance Assessment for the License Application (TSPA-LA) Model presented in *Total System Performance Assessment Model/Analysis for the License Application* (the parent document). The updated results from TSPA-LA Model v5.005 incorporated changes to a supporting document, *Saturated Zone Flow and Transport Model Abstraction* (SNL 2008 [DIRS 183750]), amended after TSPA-LA Model v5.000 results in the parent document were completed. In addition, this addendum presents TSPA-LA results that address the issues identified and described in Appendix P. The issues were identified during detailed analysis, checking, and review activities. These issues were primarily related to minor inaccuracies in model implementation and identification of undocumented or unintended conservatisms or non-conservatisms. Appendix P[a] of this addendum includes updated tables (Tables P-6[a] and P-7[a]) that summarize the changes made in the TSPA-LA Model to address these issues. These additional analyses are presented in this addendum according to the review criteria outlined in *Technical Work Plan for: Total System Performance Assessment FY 07-08 Activities* (SNL 2008 [DIRS 184920], Sections 2.1.4 and 2.3.5.2.1).

For clarity, the general outline of the parent document is preserved in this addendum. In sections without any changes relative to the parent document, the text from the parent document is not repeated. Instead, the corresponding section in this addendum simply indicates that there are no changes, implicitly referring the reader to the same section of the parent document. Documentation provided in this addendum consists of a combination of supplemental and revised information. Section, figure, or table numbers cited in the text with [a] refer to this addendum, while those without it refer to the section, figure, or table number in the parent document. Section 1.10[a] lists the updates and additions to the parent document by section, which are included in this addendum.

The figures presented in this addendum, primarily reference output data tracking numbers (DTNs) containing data generated by the TSPA-LA Model. These output DTNs are described in Appendix B[a] and Appendix B of the parent document. Figure B-3[a] shows the relationship among the output DTNs referenced in this addendum and the output DTNs described in Appendix B of the parent document. Electronic copies of the figures generated for this addendum from TSPA-LA Model output are found in the output DTN: MO0710PLOTSFIG.000 [DIRS 185207] along with supporting documentation.

1.1.1[a] Governing Regulations

No change.

1.1.2[a] Total System Performance Assessment Methodology

No change.

1.1.3[a] Treatment of Uncertainty

No change.

1.2[a] TSPA-LA MODEL DEVELOPMENT PROCESS

No change.

1.3[a] YUCCA MOUNTAIN SITE DESCRIPTION

No change.

1.4[a] DESIGN OF YUCCA MOUNTAIN REPOSITORY SUBSURFACE FACILITIES

No change.

1.5[a] GENERAL DESCRIPTION OF THE TSPA-LA MODEL

No change.

1.6[a] CONCEPTUAL DESCRIPTION OF PROCESSES RELEVANT TO AN EVALUATION OF POSTCLOSURE PERFORMANCE IN THE ABSENCE OF DISRUPTIVE EVENTS

No change.

1.7[a] CONCEPTUAL DESCRIPTION OF PROCESSES RELEVANT TO AN EVALUATION OF POSTCLOSURE PERFORMANCE AFTER THE OCCURRENCE OF DISRUPTIVE EVENTS

No change.

1.8[a] CONSERVATISMS AND LIMITATIONS RELATED TO THE TSPA-LA MODEL

Section 1.8.2.5[a] addresses condition reports that have changed or are new since the parent document.

1.8.1[a] Conservatisms Incorporated in the TSPA-LA Model

No change.

1.8.2[a] Limitations of the TSPA-LA Model

Section 1.8.2.5[a] addresses condition reports that have changed or are new since the parent document.

1.8.2.1[a] Software Limitations

No change.

1.8.2.2[a] Computational Limitations

No change.

1.8.2.3[a] Data Limitations

No change.

1.8.2.4[a] Process Model Limitations

No change.

1.8.2.5[a] Condition Reports

The *Total System Performance Assessment Model/Analysis for the License Application,* Addendum 01, addresses the issues raised in the following condition reports (CRs) (cutoff date for inclusion: March 07, 2008):

- *Condition Report 11152* (Updates for draft Supplemental Environmental Impact Statement [SEIS]-TSPA)—CR 11152 identifies several issues in the TSPA-LA Model relating to the SEIS. The issues identified in the TSPA-LA Model log as described in the condition report have been addressed as documented in Appendix P[a].

- *Condition Report 11382* (Office of Chief Scientist)—CR 11382 identifies the following expectations of the Office of Chief Scientist: (1) provide an addendum to the *Total System Performance Assessment Model/Analysis for the License Application* to address issues identified in the development of the TSPA-LA Model, and (2) address the proposed changes to the regulations governing the preparation of the TSPA-LA Model in this addendum. The second item is documented in Section 1.1.1, Governing Regulations.

- *Condition Report 11655* (Addenda Planning Documentation)—CR-11655 concerns the issue that the current Technical Work Plan does not address the need for the scope of Addendum 01, and there is no documentation in the records package for the analyses or in the supplemental records package for the Technical Work Plan. However, this condition does not exist for this addendum. The planning for Addendum 01 is found in *Technical Work Plan for: Total System Performance FY 07-08 Activities* (SNL 2008 [DIRS 184920], Section 2.3.5.3). Although the word addendum does not appear, the content of Addendum 01 is planned to document additional analyses and associated changes, based on identified needs, in accordance with the review criteria described in *Technical Work Plan for: Total System Performance FY 07-08 Activities* (SNL 2008 [DIRS 184920], Sections 2.1.4 and 2.3.5.2.1). The additional analyses do not require any changes to the planning document and there is no impact to the TSPA-LA or this addendum.

- *Condition Report 11715* (Inconsistency in the Development of Water Table Temperature)—CR 11715 identifies the water table temperatures that are used in the evaluation of unsaturated zone (UZ) flow uncertainty and the impact on the weighting factors for UZ flow uncertainty cases used in the TSPA-LA Model. Despite the inconsistency in the development of the water table temperature boundary condition, the impact on the weighting factors used in the TSPA-LA Model is expected to be small.

- *Condition Report 11728* (Typographical Error in Table 4-1)—CR 11728 identifies that the DTN SN0701PAWPHIT1.001_R2 [DIRS 182961] addressed on lines 58 and 59 of Table 4-1 of the parent document was incorrectly identified as SN0701PAWPHIT.001_R2 [DIRS 182961]. This issue is corrected in Table 4-1[a].

- *Condition Report 11755* (EBS Radionuclide Transport Abstraction Typographical Error)—This condition report identifies that Table 8.2-4 in the EBS Radionuclide Transport Abstraction contains two parameter values for use in the water adsorption isotherm for corrosion products that are not the same as the output values in DTN: SN0703PAEBSTRA.001_R3 [DIRS 183217] or the values developed in the *EBS Radionuclide Transport Abstraction* (SNL 2007 [DIRS 177407], Section 6.3.4.3.2). The values on Table 8.2-4 are found in the output DTN file: SN0703PAEBSTRA.001-RTA Input Tables.Doc and were used in TSPA-LA Rev. 00 (Parameter Entry Form [PEF] 59). The correct values are found in the same DTN file: Corrosion Products Composite Isotherm 7-19-2007.xls as identified in the DTN readme file. This CR was discovered during the development of the TSPA-LA Rev 00 Addendum 01 and was corrected and verified during checking of the TSPA Input Database (PEF 203). The correct inputs were used to develop the TSPA-LA Addendum outputs.

- *Condition Report 11756* (Draft Data in DTN)—This condition report identifies output DTN: MO0708FREQCALC.000 [DIRS 183006] found in this addendum as containing files with content marked as DRAFT. Specifically, the DTN contains files named FreqDamageTAD.pdf and FreqRupture.pdf with headers on these documents indicating that they are DRAFT. The documentation issues raised in this CR do not involve the quality of the information; therefore, they are judged to have no impact on this addendum.

- *Condition Report 11759* (pdf of TSPA-LA)—The initial pdf file submitted to records for the TSPA-LA Rev00 inadvertently omitted two subsections, included some nonessential text regarding hidden headings, and appeared to have misnumbered pages in Appendix C. The first two items have been corrected and a new pdf has been submitted to records. It has been determined the third item (Appendix C page numbering) is not an issue as all pages were included and, therefore, does not impact the document. The documentation issues raised in this CR do not involve the quality of information and have no impact on this addendum. No further action is required.

- *Condition Report 11816* (Invert Thickness Change not in EBS RTA)—The range used for the TSPA parameter Diff_Path_Length_Invert_Top_a is based on an earlier outdated invert configuration. The diffusive path length from the WP outer barrier to the mid-point of the invert is treated as an epistemic uncertain parameter

(Diff_Path_Length_Invert_Top_a in Table 6.3.8-4 of the parent document) in the TSPA-LA Model. The updated average invert thickness would cause the diffusive path length used in the TSPA-LA Model to range from 0.47m to 1.41m. Because the diffusive path length parameter used in the TSPA-LA Model is based on a smaller value, the TSPA-LA Model conservatively overestimates diffusive releases from a breached WP to the invert relative to releases that would be obtained sampling an updated diffusive path length range. Therefore, not using the updated range is likely to have a negligible effect on the overall releases from the EBS calculated by the TSPA-LA Model. The issue raised in this CR has been determined to have no impact on this addendum.

1.9[a] DESCRIPTION OF THE TOTAL SYSTEM PERFORMANCE ASSESSMENT MODEL/ANALYSIS FOR THE LICENSE APPLICATION

No change.

1.10[a] DOCUMENT ORGANIZATION

The TSPA-LA parent document is organized in three volumes. This addendum follows the same organizational structure as the parent document. Only sections wherein additional information or results are presented are provided in this addendum. The information found in Volumes I[a], II[a], and III[a] of this addendum, along with the parent document, provides cross referencing that allows investigation of the structure and operation of the TSPA-LA Model files used to perform performance assessment calculations documented herein.

1.10.1[a] Volume I[a]

Volume I[a] of this addendum provides a description of the additional information required to document the TSPA-LA Model that was used for the analyses documented in this addendum. This includes information regarding direct inputs, parameters, and submodel descriptions as required to describe the TSPA-LA Model calculations and trace the sources of the TSPA-LA Model's direct inputs. Volume I[a] also contains appropriate references to source information. Volume I of the parent document should be used in conjunction with the information provided in this addendum.

Section 1[a]: **Purpose**—Section 1[a] provides no additional information with respect to the features, events, and processes that led to the development of the scenario classes used in analyzing the performance of the repository system; the regulatory framework for the TSPA-LA Model; the overview of the natural and engineered barriers in the repository system, including site-description information, descriptions of the elements of the engineered barrier system (EBS), processes affecting water movement through the UZ and saturated zone (SZ), and descriptions of the model components; and a general description of the architecture of the TSPA-LA Model. All of these topics are discussed in the parent document and apply to the analyses presented in this addendum.

Section 2[a]: **Quality Assurance**—Section 2 of the parent document describes the applicable quality assurance procedures of *Quality Assurance Requirements and Description* (DOE 2007

[DIRS 182051]), along with descriptions and references to the methods used for the electronic management of information. There is no additional information provided in this addendum.

Section 3[a]: **Use of Software**—Section 3 of the parent document lists and describes the software used in the development of the TSPA-LA Model. For the analyses presented in this addendum, only additional software or changes in the software used for the model results presented in the parent document are listed in Section 3[a].

Section 4[a]: **Inputs**—Section 4[a] identifies the additional direct inputs used in the TSPA-LA Model results presented in this addendum, either by direct tabulations included in this document or through linkage to the appropriate sections of the GoldSim model file or TSPA-LA Model database. Section 4 of the parent document should be used in conjunction with the data provided in Section 4[a] of this addendum.

Section 5[a]: **Assumptions**—Section 5 of the parent document lists the assumptions directly used to perform the TSPA-LA Model analyses along with their basis. Section 5[a] includes no additional assumptions for the TSPA-LA Model results documented in this addendum.

Section 6[a]: **Model Description**—Section 6 of the parent document describes the TSPA-LA Model representation of the repository system, presents the scenario classes being analyzed, describes the modeling cases used to analyze the scenario classes, and provides references to the applicable sections of the TSPA-LA Model, the GoldSim model file, and supporting analyses. Section 6 of the parent document also includes detailed descriptions of the conceptual models, mathematical formulations, implementations of the submodels in the TSPA-LA Model, conservatisms, and alternate conceptual models. Section 6[a] provides additional information consisting of typographical corrections, omissions, or descriptions of changes or additions to the conceptual models, mathematical formulations, implementations of the submodels for the TSPA-LA Model, conservatisms, and alternate conceptual models necessary to document the additional analyses presented in this addendum. Section 6 of the parent document should be used in conjunction with the data provided in Section 6[a] of this addendum.

1.10.2[a] Volume II[a]

Volume II[a] contains the supplemental information supporting the TSPA-LA Model validation.

Section 7[a]: **Validation**—Section 7 of the parent document describes the validation of the TSPA-LA Model as required by Section 6.3 of SCI-PRO-006, *Models*. The model validation of the TSPA-LA Model is consistent with the intended use of the TSPA-LA Model and the required level of confidence. In addition, the TSPA-LA Model validation results presented in this addendum are consistent with the intended use of the TSPA-LA Model. Additional model validation results documented in Volume II of this addendum are presented to confirm that the TSPA-LA Model validation has been maintained for v5.005 as well as to enhance the overall level of confidence in the TSPA-LA Model.

- Computer code and input re-verification (Section 7.2[a]) including:
  - Verification testing for the Human Intrusion Submodel inadvertently omitted from the parent document (Section 7.2.4.1.12[a])
  - Summary of an assessment of the range of validity for all TSPA-LA Model submodels inadvertently omitted from the parent document (Section 7.2.6[a])
- Demonstration of Model Stability (Section 7.3[a])
  - Comparison between TSPA-LA Model v5.000 and v5.005 expected dose results (Section 7.3.1[a])
  - Reevaluation of the statistical stability of TSPA-LA Model v5.005 results (Section 7.3.1[a])
  - Confirmation of numerical accuracy of expected dose results for the Seismic Fault Displacement (FD) Modeling Case (Section 7.3.2.7[a])
  - Reevaluation of the temporal stability testing for the Human Intrusion Modeling Case as the result of a change to the time step size for this modeling case (Section 7.3.3.6[a])
  - Evaluation of the temporal stability of the Nominal Modeling Case (Section 7.3.3.7[a])
- Surrogate Waste Form Validation (Section 7.5[a])
  - Reevaluation of the adequacy of using commercial spent nuclear fuel (CSNF) as a surrogate for naval spent nuclear fuel (NSNF) using TSPA-LA Model v5.005 (Section 7.5.3[a])
- Reevaluation of the corroboration of the TSPA-LA Model results documented in the parent document with auxiliary analyses (Section 7.7[a]), including:
  - Updated analyses of single realizations for the Early Failure Scenario Class, the Igneous Intrusion Modeling Case, and the Seismic Ground Motion (GM) Modeling Case for 1,000,000 years, including additional analyses of outlier realizations (Section 7.7.1[a])
  - Additional analyses of single realizations including: (1) the Nominal Scenario Class (Section 7.7.1.5[a]), (2) a Seismic GM Modeling Case for 10,000 years (Section 7.7.1.7[a]), and (3) the Human Intrusion Scenario (Section 7.7.1.6[a])
  - Updated evaluation with a Simplified TSPA Analysis (Section 7.7.2[a])
  - Updated evaluation with the Electric Power Research Institute (EPRI) Analysis (Section 7.7.3[a])

– Reevaluation of a comparison of results from the Performance Margin Analysis (Section 7.7.4[a]).

1.10.3[a] Volume III[a]

This volume contains the updated results for the TSPA-LA Model. These are detailed below.

Section 8[a]: **Analyses**—Section 8 of the parent document includes conclusions of the analyses as required by SCI-PRO-006. Section 8[a] of this addendum contains the updated results for the TSPA-LA Model performance analyses evaluating the postclosure performance of the repository and its compliance with U.S. Nuclear Regulatory Commission (NRC) Proposed Rule 10 CFR 63.113 [DIRS 180319] and the performance measures defined in proposed 10 CFR 63.303 [DIRS 178394] for the individual protection standard after permanent closure in proposed 10 CFR 63.311(a)(1) and (2) [DIRS 178394], the individual protection standard for human intrusion in 10 CFR 63.321(a)(1) and (2) [DIRS 178394], and the separate standards for protection of groundwater in 10 CFR 63.331, Table 1 [DIRS 180319]. The probabilistic analyses account for uncertainty and address features, events, and processes that could affect total system performance. Volume III[a] presents the updated results of analyses and calculations in the following areas:

- Comparison of TSPA-LA Model analyses with the performance measures defined in proposed 10 CFR 63.303 [DIRS 178394] for the individual protection standard after permanent closure in proposed 10 CFR 63.311(a)(1) and (2) [DIRS 178394], the individual protection standard for human intrusion in 10 CFR 63.321(a)(1) and (2) [DIRS 178394], and the separate standards for protection of groundwater in 10 CFR 63.331, Table 1 [DIRS 180319]

- System and subsystem performance analyses for the Nominal Scenario Class, including the Nominal Modeling Case; the Early Failure Scenario Class, including the Drip Shield Early Failure (EF) and Waste Package EF Modeling Cases; the Igneous Scenario Class, including both Igneous Intrusion and Volcanic Eruption Modeling Cases; and the Seismic Scenario Class, including the Seismic GM and FD Modeling Cases

- Analyses of the capabilities and importance of the upper and lower natural barriers and the EBS that have been identified as contributing to repository performance.

The results presented in this addendum represent an iterative process that reflects a rigorous model verification and implementation cycle.

Section 9[a]: **Inputs and References**—Section 9[a] provides additional sources of inputs, software, DTNs, and cited references.

Appendices

A. Acronyms and Abbreviations—No changes from the parent document.

B[a]. Data Tracking Numbers for the TSPA-LA Model—Appendix B[a] describes the contents of the output DTNs for the analyses presented in this addendum.

C[a]. Performance Margin Analysis—Appendix C[a] includes an update to Table C9-1 presented in the parent document; issue and impact assessments were not previously documented for the Performance Margin Analysis.

D[a]. Parameter Listing—Appendix D[a] refers to the TSPA Input Database, which contains a listing of all the additional parameters used to conduct the analyses presented in this addendum and the source(s) for each parameter. It also directs the reader to the appropriate sections in this document (Section 4[a] and Appendix K[a]) for further information on the addendum parameters.

E. Response to Review Comments from the International Review Team—No changes from the parent document.

F. Dynamically Linked Libraries Description and Feeds—No changes from the parent document.

G. Wiring Diagrams for Model Information Feeds—No changes from the parent document.

H[a]. Yucca Mountain Review Plan Acceptance Criteria—Appendix H[a] includes minor changes from the parent document to reference the proposed rule.

I[a]. Features, Events, and Processes Mapped to TSPA-LA Model—Appendix I[a] updates selected descriptions in Table I-2 from the parent document.

J[a]. Conceptual Structure of TSPA-LA—This addendum presents additional supplemental material in Appendix J[a], Section J3[a], which provides an overview of the underlying concepts used in the TSPA-LA Model that are described in Appendix J of the parent document.

K[a]. Uncertainty and Sensitivity Analysis Results—Appendix K[a] presents the distributions of results for each modeling case (uncertainty analyses) and identifies the uncertain parameters that predominantly contribute to the uncertainty in each modeling cases' results (sensitivity analyses) for the analyses presented in this addendum.

L. Simplified TSPA—No changes from the parent document.

M[a]. Comparison with Electric Power Research Institute Analysis—Minor changes from the parent document are incorporated to rectify a mistaken reference to supporting documentation.

N. Derivation of Implementing Equations for Waste Package Parsing and Average Damage Area—No changes from the parent document.

O. Localized Corrosion Initiation Uncertainty Analysis—No changes from the parent document.

P[a]. Impact Assessments—Appendix P[a] includes updates to Tables P-6 and P-7 in the parent document indicating the issues that have been addressed in the updated results. In addition, Appendix P[a] includes a modification to the issue description and analysis of the expected impact documented in Section P13 of the parent document.

2[a]. QUALITY ASSURANCE

2.1[a] CONFIGURATION MANAGEMENT

No change.

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3[a]. USE OF SOFTWARE

3.1[a] INTRODUCTION

Section 3 of the parent document describes the software used in the development of the TSPA-LA Model. For the analyses presented in this addendum, only additional software or changes in the software used for the model results presented in the parent document are listed in Section 3[a]. In addition, Table 3-1 has been revised with the additional software and is included as Table 3-1[a] of this addendum. In addition, Figure 3-2 of the parent document incorrectly identified the surface infiltration external process model. Therefore, the figure has been updated and is included as Figure 3-2[a] of this addendum.

3.2[a] ASHPLUME_DLL_LA

No change.

3.3[a] CWD

No change.

3.4[a] EXDOC_LA

No change.

3.5[a] FAR

No change.

3.6[a] FEHM

No change.

3.7[a] GETTHK_LA

No change.

3.8[a] GOLDSIM

A software problem report (SPR013420071203 [DIRS 184391]) was submitted for GoldSim version 9.60.100 (STN: 10344-9.60-01 [DIRS 181903]) as a result of errors in radionuclide ingrowth calculations for the source term elements (Appendix P[a], Table P-7[a], Item P20). A new service pack, GoldSim version 9.60.300 (STN: 10344-9.60-03 [DIRS 184387]) was issued to address the problem. The GoldSim service pack problem report is included in the software problem report (SPR013420071203 [DIRS 184391]). An impact assessment was conducted by comparing results obtained using GoldSim version 9.60.300 with results from GoldSim version 9.60.100. The software errors resulted in an insignificant impact to the TSPA-LA results documented in the parent document (Appendix P, Section P20). Analyses presented in this addendum use the updated software (GoldSim version 9.60.300).

3.8.1[a] Description of Software

No change.

3.8.2[a] Relationship to the TSPA-LA Model

GoldSim version 9.60.100 [DIRS 181903] was used for the TSPA-LA Model development and validation and analysis cases (v5.000) as documented in Section 3.8 of the parent document. GoldSim version 9.60.300 [DIRS 184387] was used for the TSPA-LA Model development and validation and analysis cases (v5.005) documented in this addendum.

A controlled version of GoldSim version 9.60.300 was used prior to a qualified version as allowed by SCI-PRO-006. After qualification, GoldSim version 9.60.300 was obtained from Software Configuration Management in accordance with the governing procedure, IM-PRO-003, *Software Management,* and installed. The GoldSim version 9.60.300 installation package documents the confirmation that the controlled version of GoldSim version 9.60.300 is identical to the qualified version of GoldSim version 9.60.300 obtained from Software Configuration Management.

3.8.3[a] Software Documentation

Table 3-8[a] is modified to list the additional software documents pertaining to GoldSim version 9.60.300 [DIRS 184387].

3.8.4[a] Range of Validation

The range of validation for the versions of GoldSim listed in Section 3.8.2[a] is defined by the documented functionality (i.e., requirements) and range(s) of acceptable inputs. The requirements are located in the respective requirements documents listed in Table 3-8[a]. The range(s) of acceptable inputs is discussed in the respective design and user documents listed in Table 3-8[a].

3.9[a] INTERPZDLL_LA

No change.

3.10[a] MFCP_LA

No change.

3.11[a] MKTABLE AND MKTABLE_LA

No change.

3.12[a] MVIEW

No change.

3.13[a] PASSTABLE1D_LA

No change.

3.14[a] PASSTABLE3D_LA

No change.

3.15[a] PREWAP_LA

No change.

3.16[a] SCCD

No change.

3.17[a] SEEPAGEDLL_LA

No change.

3.18[a] SOILEXP_LA

No change.

3.19[a] SZ_CONVOLUTE

No change.

3.20[a] TSPA_INPUT_DB

No change.

3.21[a] WAPDEG

No change.

3.22[a] CORROBORATIVE SOFTWARE USED

No change.

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Table 3-1[a]. TSPA-LA Model Software Codes

Code	Version	Software Tracking Number	Operating System	DIRS Number
ASHPLUME_DLL_LA[a1]	2.0	STN: 11117-2.0-00	Windows 2000	DIRS 181034
ASHPLUME_DLL_LA[a2 a3]	2.1	STN: 11117-2.1-00	Windows 2000	DIRS 181035
ASHPLUME_DLL_LA[a2 a3]	2.1	STN: 11117-2.1-01	Windows 2003	DIRS 180147
CWD[a2 a3]	2.0	STN: 10363-2.0-00	Windows 2000	DIRS 162809
CWD[a2 a3]	2.0	STN: 10363-2.0-01	Windows 2003	DIRS 181037
EXDOC_LA[b1]	2.0	STN: 11193-2.0-00	Windows 2000 Windows 2003 Windows XP	DIRS 182102
FAR [a1]	1.1	STN: 11190-1.1-00	Windows 2000 Windows 2003	DIRS 180002
FAR [a2]	1.2	STN: 11190-1.2-00	Windows 2000 Windows 2003	DIRS 182225
FEHM[a1]	2.23	STN: 10086-2.23-00	Windows 2000	DIRS 173139
FEHM[a2 a3]	2.24-01	STN: 10086-2.24-01-00	Windows 2000 Windows 2003 Windows XP	DIRS 179419
GetThk_LA [a2 a3]	1.0	STN: 11229-1.0-00	Windows 2000 Windows 2003	DIRS 181040
GoldSim[a1]	9.60	STN: 10344-9.60-00	Windows 2000 Windows 2003 Windows XP	DIRS 180224
GoldSim[a2]	9.60.100	STN: 10344-9.60-01	Windows 2000 Windows 2003 Windows XP	DIRS 181903
GoldSim[a3]	9.60.300	STN: 10344-9.60-03	Windows 2000 Windows 2003 Windows XP	DIRS 184387
InterpZdll_LA [a2 a3]	1.0	STN: 11107-1.0-00	Windows 2000	DIRS 167885
InterpZdll_LA [a2 a3]	1.0	STN: 11107-1.0-01	Windows 2003	DIRS 181043
MFCP_LA[a2 a3]	1.0	STN: 11071-1.0-00	Windows 2000	DIRS 167884
MFCP_LA[a2 a3]	1.0	STN: 11071-1.0-01	Windows 2003	DIRS 181045
MkTable[a1]	1.00	STN: 10505-1.00-00	Windows 2000	DIRS 174528
MkTable_LA[a2 a3]	1.0	STN: 11217-1.0-00	Windows 2000	DIRS 181047
MkTable_LA[a2 a3]	1.0	STN: 11217-1.0-01	Windows 2003	DIRS 181048
MView[b1]	4.0	STN: 10072-4.0-01	Windows XP	DIRS 181049
PassTable1D_LA[a1]	1.0	STN: 11142-1.0-00	Windows 2000	DIRS 169130
PassTable1D_LA[a1]	1.0	STN: 11142-1.0-01	Windows 2003	DIRS 181050
PassTable1D_LA[a2 a3]	2.0	STN: 11142-2.0-00	Windows 2000 Windows 2003	DIRS 181051
PassTable3D_LA[a1]	1.0	STN: 11143-1.0-00	Windows 2000	DIRS 168980

Table 3-1[a]. TSPA-LA Model Software Codes (Continued)

Code	Version	Software Tracking Number	Operating System	DIRS Number
PassTable3D_LA[a1]	1.0	STN: 11143-1.0-01	Windows 2003	DIRS 181052
PassTable3D_LA [a2 a3]	2.0	STN: 11143-2.0-00	Windows 2000 Windows 2003	DIRS 182556
PREWAP_LA[b1]	1.1	STN: 10939-1.1-00	Windows 2000	DIRS 181053
SCCD[a2 a3]	2.01	STN: 10343-2.01-00	Windows 2000	DIRS 181157
SCCD[a2 a3]	2.01	STN: 10343-2.01-01	Windows 2003	DIRS 181054
SEEPAGEDLL_LA[a1]	1.2	STN: 11076-1.2-00	Windows 2000	DIRS 173435
SEEPAGEDLL_LA[a2 a3]	1.3	STN: 11076-1.3-00	Windows 2000	DIRS 180318
SEEPAGEDLL_LA[a2 a3]	1.3	STN: 11076-1.3-01	Windows 2003	DIRS 181058
SoilExp_LA [a1]	1.0	STN: 10933-1.0-00	Windows 2000	DIRS 167883
SZ_Convolute[a1]	3.0	STN: 10207-3.0-00	Windows 2000	DIRS 164180
SZ_Convolute[a2 a3]	3.10.01	STN: 10207-3.10.01-00	Windows 2000/ Windows 2003	DIRS 181060
TSPA_Input_DB[a2 a3]	2.2	STN: 10931-2.2-00	Windows 2000	DIRS 181061
TSPA_Input_DB[a2 a3]	2.2	STN: 10931-2.2-01	Windows 2003	DIRS 181062
WAPDEG[a2 a3]	4.07	STN: 10000-4.07-00	Windows 2000	DIRS 181774
WAPDEG[a2 a3]	4.07	STN: 10000-4.07-01	Windows 2003	DIRS 181064

[a1] Codes are used only for the TSPA-LA Model development (See note below).

[a2] Codes used in the TSPA-LA Model that are used for the TSPA-LA Model development (See note below) and to develop results and conclusions in Section 8 of the parent document.

[a3] Codes used in the TSPA-LA Model that are used for the TSPA-LA Model development (See note below) and to develop results and conclusions in Section 8[a] of this addendum.

[b1] Code is a pre- or post-processor that does not require GoldSim to run codes that are used for the TSPA-LA Model development (See NOTE below) and to develop results and conclusions in Section 8.

NOTE: TSPA-LA Model development should not be confused with model development as described in SCI-PRO-006. TSPA-LA Model development is merely a phrase to represent the draft model versions (i.e., v4.001 to v4.047) that were created before finalizing the model (e.g., v5.000) presented in the parent document and v5.001 to v5.004 that were created before finalizing the model v5.005 presented in this addendum. The draft model versions, v4.001 to v4.047, were submitted as part of the records package for the parent document. The draft model versions, v5.001 to v5.004, are to be submitted as part of the records package for this addendum. All software codes used for the results presented in this document are on the software baseline.

Table 3-8[a]. GoldSim Software Documents for Version 9.60.300 (STN: 10344-9.60-30)

Version 9.60.300, Windows 2000, Windows 2003, and Windows XP (STN: 10344-9.60-03)			
Description	**Document ID**	**DIRS Number**	**Tracking Number**
Requirements Document (RD)	10344-RD-9.60-00	181106	MOL.20070416.0330
Design Document (DD)	10344-DD-9.60-01	181107	MOL.20070416.0338
User Information Document (UID)	10344-UID-9.60-00	181108	MOL.20070416.0339
User's Guide, GoldSim Probabilistic Simulation Environment, v9.60	NA	181727	TIC: 259221
Software Validation Report (SVR)	10344-SVR-9.60-03-WIN2000	185016	MOL.20080125.0059
Software Validation Report (SVR)	10344-SVR-9.60-03-WIN2003	185017	MOL.20080125.0061
Software Validation Report (SVR)	10344-SVR-9.60-03-WINXP	185018	MOL.20080125.0057

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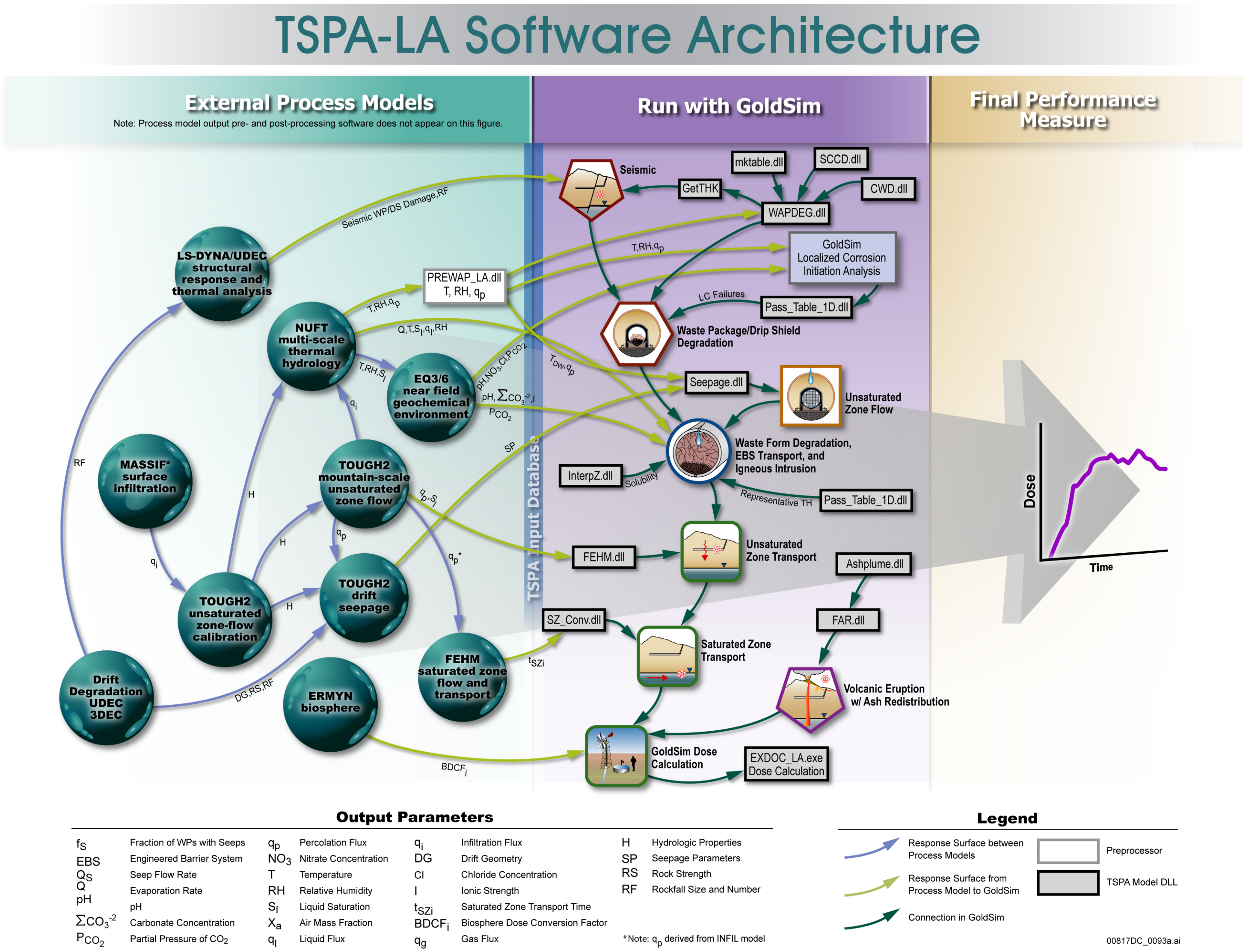

Figure 3-2[a]. TSPA-LA Software Architecture

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4[a]. INPUTS

4.1[a] DIRECT INPUTS

Direct inputs are those parameters whose values are used by the TSPA-LA Model to compute the results presented in this document. This information is stored in the TSPA Input Database and is described in Section 4.7 of the parent document. Table 4-1 lists the direct input required for the analyses in the parent document. Table 4-1[a] of this addendum lists the additional direct input required for the analyses documented in this addendum and associates it with a reference source and a PEF number (see Section 4.3 of the parent document for an overview of PEFs).

The direct inputs listed in Table 4-1[a], except where noted, reflect parameter values that were corrected in TSPA-LA Model v5.005, rather than new direct inputs to the TSPA-LA Model, and are therefore cited in Section 6 of the parent document. The discussions presented in Section 6 of the parent document for these parameters remain unchanged. Line items starting with #129 represent new direct input and are cited in Section 6[a] of this addendum. All other references in Table 4-1 of the parent document remain unchanged.

4.2[a] TSPA-LA MODEL-GENERATED PARAMETERS

The TSPA-LA Model requires the generation of many parameters (often incorporated into large data files) that are created by preprocessing methods (i.e., created prior to running the TSPA-LA Model). These parameters are captured in output DTNs along with explanations for how they were generated. The use of output DTNs in the TSPA-LA Model is described at various locations in the parent document. PEFs that reference new output DTNs generated to support the analyses documented in this addendum are listed in Table 4-2[a].

4.3[a] PARAMETER ENTRY FORMS

No change.

4.4[a] TRACEABILITY OF INPUTS

No change.

4.5[a] CRITERIA

No change.

4.6[a] CODES AND STANDARDS

No change.

4.7[a] TSPA INPUT DATABASE

No change.

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Table 4-1[a]. Direct Inputs

Line #	Document _ID	Reference _Document	Document DIRS	DTN	DTN DIRS	PEF
14 [a]	ANL-EBS-MD-000033 Rev 06	*Engineered Barrier System: Physical and Chemical Environment*	NA	SN0701PAEBSPCE.001_R1	180523	214
58 [a] 59 [a]	ANL-MGR-GS-000003	*Number of Waste Packages Hit by Igneous Events*	NA	SN0701PAWPHIT1.001_R2	182961	30, 61
66 [a]	ANL-WIS-MD-000010 Rev 06	*Dissolved Concentration Limits of Elements with Radioactive Isotopes*	NA	MO0702PAFLUORI.000_R1	181219	215
70 [a]	ANL-WIS-MD-000020 Rev 01 AD01	*Initial Radionuclide Inventories*	NA	SN0310T0505503.004_R0	168761	202
73[a]	ANL-WIS-PA-000001 Rev 03	*EBS Radionuclide Transport Abstraction*	NA	SN0703PAEBSRTA.001_R3	183217	203
79 [a]	MDL-EBS-PA-000004 Rev 03	*Waste Form and In-Drift Colloids-Associated Radionuclide Concentrations: Abstraction and Summary*	NA	MO0701PACSNFCP.000_R1	180439	213
82 [a]	MDL-EBS-PA-000004 Rev 03	*Waste Form and In-Drift Colloids-Associated Radionuclide Concentrations: Abstraction and Summary*	NA	MO0701PAIRONCO.000_R1	180440	219
101 [a]	MDL-NBS-HS-000008 Rev 02 AD01	*Radionuclide Transport Models Under Ambient Conditions*	NA	LA0408AM831341.001_R0	171584	217, 218
103 [a]	MDL-NBS-HS-000008 Rev 02 AD01	*Radionuclide Transport Models Under Ambient Conditions*	NA	LB0701PAKDSESN.001_R0	179299	216, 218
105 [a]	MDL-NBS-HS-000019 Rev 01 AD01	*Abstraction of Drift Seepage*	NA	LB0702PASEEP02.001_R1	181635	201
108 [a] 109 [a]	MDL-NBS-HS-000020 Rev 02 AD02	*Particle Tracking Model and Abstraction of Transport Processes*	NA	LA0701PANS02BR.003_R2	180497	218
110 [a] 111 [a]	MDL-NBS-HS-000020 Rev 02 AD02	*Particle Tracking Model and Abstraction of Transport Processes*	NA	LA0702PANS02BR.001_R1	180322	207
113 [a]	MDL-NBS-HS-000008 Rev 02 AD01	*Radionuclide Transport Models Under Ambient Conditions*	NA	LB0702PAUZMTDF.001_R1	180776	218
115 [a]	MDL-NBS-HS-000020 Rev 02 AD02	*Particle Tracking Model and Abstraction of Transport Processes*	NA	MO0704PAFEHMBR.001_R3	184647	202

Table 4-1[a]. Direct Inputs (Continued)

Line #	Document _ID	Reference _Document	Document DIRS	DTN	DTN DIRS	PEF
129 [b]	MDL-NBS-HS-000021 Rev 03 AD02	*Saturated Zone Flow and Transport Model Abstraction*	NA	SN0710PASZFTMA.003_R0	183485	205, 209
130 [b]	ANL-WIS-MD-000020 Rev 01 AD01	*Initial Radionuclide Inventories*	NA	MO0702PASTREAM.001_R0	179925	202
131 [b]	ANL-WIS-MD-000006 Rev 02	*Radionuclide Screening*	177424	NA	NA	210
132 [c]	ANL-EBS-MD-000003 Rev 03	*General Corrosion and Localized Corrosion of Waste Package Outer Barrier*	178519	NA	NA	212

NOTES: [a] The direct inputs indicated reflect parameter values that were corrected in TSPA-LA Model v5.005, rather than new direct inputs to the TSPA-LA Model and are therefore cited in Section 6 of the parent document. Line item numbers from Table 4-1 of the parent report are listed for these items.

New direct inputs are numbered starting with line 129 to 131 and are cited in Section 6[a] of this addendum.

Line item 132 is a new line item that captures direct input inadvertently omitted from Table 4-1 of the parent document and cited in Section 6.3.5.1.2, Equation 6.3.5-4, in the parent document.

[b] NA–Not applicable. Either the reference document or the DTN listed is the origin for the direct input as indicated.

[c]

Table 4-2[a]. Additional TSPA-LA Model Generated Data Tracking Numbers Referenced by Parameter Entry Forms

Line #	Document ID	Document Title	Document DIRS	OUTPUT DTN	DTN DIRS	PEF
1	MDL-WIS-PA-000005 REV00 AD01	*Total System Performance Assessment Model/Analysis for the License Application*	NA	MO0711GENERINP.000	183937	200, 202, 204, 206, 208, 210, 211, 214, 216, 218
2	MDL-WIS-PA-000005 REV00 AD01	*Total System Performance Assessment Model/Analysis for the License Application*	NA	MO0707UZKDCORR.000	183003	218
3	MDL-WIS-PA-000005 REV00 AD01	*Total System Performance Assessment Model/Analysis for the License Application*	NA	MO0708TSPAGENT.000	183000	202
4	MDL-WIS-PA-000005 REV00 AD01	*Total System Performance Assessment Model/Analysis for the License Application*	NA	MO0707EMPDECAY.000	182995	202

NOTE: See Appendix B in the parent document and Appendix B[a] of this addendum for a complete listing of all DTNs that support the TSPA-LA Model.

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5[a]. ASSUMPTIONS

5.1[a] NOMINAL SCENARIO CLASS

No change.

5.2[a] EARLY FAILURE SCENARIO CLASS

No change.

5.3[a] IGNEOUS SCENARIO CLASS

No change.

5.4[a] SEISMIC SCENARIO CLASS

No change.

5.5[a] HUMAN INTRUSION SCENARIO

No change.

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6[a]. TSPA-LA MODEL DESCRIPTION

The primary goals of Section 6 of the parent document are to describe how model components and the associated submodels (illustrated on Figure 6-1 of the parent document) are integrated in the TSPA-LA Model and how the TSPA-LA Model is implemented in order to estimate the dose incurred by a reasonably maximally exposed individual due to radionuclide releases in the Nominal, Early Failure, Igneous, and Seismic Scenario Classes, and the Human Intrusion Scenario. The contents of Section 6 in large part remain unchanged from the parent document. The focus of Section 6.3 of the parent document is on the TSPA-LA Model components and submodels and includes a discussion of their implementation. Section 6.3[a] documents the changes to conceptual models and implementation required for the addendum analyses.

In addition, it should be noted that in the parent document the terms "dripping environment" and "non-dripping environment" were used interchangeably with "seeping environment" and "non-seeping environment." The waste package (WP) groups are determined by the fraction of WP locations that are exposed to drift seepage (Section 6.1.5.3 of parent document), not drift seepage and/or drift-wall condensation. WP locations in a non-seeping environment may be exposed to dripping as a result of drift-wall condensation. When reading the parent document the term "dripping environment" should be replaced with the term "seeping environment" and the term "non-dripping environment" should be replaced with the term "non-seeping environment."

6.1[a] CONCEPTUAL DESIGN

No change.

6.1.1[a] Features, Events, and Processes Screening and Scenario Development

No change.

6.1.2[a] Calculation of Dose for the TSPA-LA Model

This section of the parent document outlines the calculation of total mean annual dose and total median annual dose using the scenario classes defined in Section 6.1.1 of the parent document. Specifically, Section 6.1.2.4 of the parent document describes calculations for each of the individual modeling cases used in the TSPA-LA Model. Section 6.1.2.4.2 has been updated to include additional information inadvertently omitted from the parent document which is relevant to the calculations for the expected annual dose for the Early Failure Modeling Cases. Section 6.1.2.4.2[a] in this addendum contains the additional information which should be used in conjunction with the documentation provided in the parent document. Appendix J of the parent document presents formal derivations for calculation of total mean annual dose and total median annual dose and the calculations performed for each modeling case. Appendix J[a] includes additional supplemental background discussion about the conceptual structure of the TSPA-LA Model calculations.

6.1.2.1[a] Description of Uncertainty

No change.

6.1.2.2[a] Calculation of Total Mean Annual Dose

No change.

6.1.2.3[a] Screening of Scenario Classes

No change.

6.1.2.4[a] Calculation of Expected Annual Dose for the Modeling Cases

Section 6.1.2.4.2[a] includes additional information inadvertently omitted from the parent document which is relevant to the calculations for the expected annual dose for the Early Failure Modeling Cases.

6.1.2.4.1[a] Nominal Scenario Class

No change.

6.1.2.4.2[a] Early Failure Scenario Class

The calculation of expected annual dose for the Waste Package and Drip Shield EF Modeling Case is defined in Equation 6.1.2-13 and Equation 6.1.2-14 of the parent document. In both the Waste Package EF and Drip Shield EF Modeling Cases, aleatory uncertainty in the location of the early failed WP within its assigned percolation bin is implicitly considered by assigning the mass released from the WP uniformly across the bin. The uniform mass release is implemented by distributing the mass released by the WP equally to all the UZ particle tracking model's repository release nodes (Section 6.3.9.3) associated with the specific percolation bin. The definitions of $D_{EW}\left(\tau \| [1, r, s, t], \mathbf{e}_i\right)$ and $D_{ED}\left(\tau \| [1, r, s, t], \mathbf{e}_i\right)$ are modified accordingly:

$D_{EW}\left(\tau \| [1, r, s, t], \mathbf{e}_i\right)$ is the dose at time τ that results from early failure of one WP of type r in percolation bin s with seeping ($t = 1$) or non-seeping conditions ($t = 0$), where release from the WP is distributed uniformly over the UZ repository release nodes for percolation bins. This quantity is calculated using the GoldSim component of the TSPA-LA Model.

and,

$D_{ED}\left(\tau \| [1, r, s, t], \mathbf{e}_i\right)$ is the dose at time τ that results from early failure of one drip shield (DS) over a WP of type r in percolation bin s with seeping ($t = 1$) or non-seeping conditions ($t = 0$), where release from the WP is distributed uniformly over the UZ repository release nodes for percolation bin s. This quantity is calculated using the GoldSim component of the TSPA-LA Model.

6.1.2.4.3[a] Igneous Scenario Class

No change.

6.1.2.4.4[a] Seismic Scenario Class

No change.

6.1.2.5[a] Calculation of Expected Annual Dose for the Human Intrusion Modeling Case

No change.

6.1.3[a] Treatment of Uncertainty in the TSPA-LA Model

No change.

6.1.4[a] TSPA-LA Model Structure and Design

This section in the parent document provides an overview of how model components and submodels are connected within the TSPA-LA Model and how information flows between them. The primary focus of this section is on the description of the TSPA-LA Model for the Nominal Scenario Class. This addendum contains an update that incorporates additional information about the TSPA-LA Model structure and information flow documented in Section 6.1.4.2 of the parent document. In addition, Figure 6.1.4-5 from the parent document has been revised to correct an error in the original figure and is included as Figure 6.1.4-5[a].

6.1.4.1[a] Mountain-Scale Unsaturated Zone Flow

No change.

6.1.4.2[a] Engineered Barrier System Thermal-Hydrologic Environment

In the parent document, the fourth bullet of Output 3, Information Transfer from the EBS TH Environment Submodel to the Drift Seepage and Drift Wall Condensation Submodels, omitted the transfer of information pertaining to drift-wall condensation Stage 2 and Stage 3 start times. This addendum includes the correction for this omission.

Output 3—The following outputs are passed from the EBS TH Environment Submodel (Section 6.3.2) to the Drift Seepage and Drift Wall Condensation Submodel (Section 6.3.3):

- For each of the five percolation subregions (Section 6.3.2):
  - The percolation flux at the base of the PTn for each infiltration scenario and climate at each multiscale thermohydrologic model subdomain location (Drift Seepage Submodel)
  - The average percolation flux at the base of the PTn for each infiltration scenario and climate (Drift Wall Condensation Submodel)
  - The drift-wall temperature surrounding each of the eight WPs (two co-disposed [CDSP] WPs and six CSNF WPs) at each subdomain location (Drift Seepage Submodel)

- Time-dependent temperature for the drift wall and WP for the representative CDSP WP and the representative CSNF WP, including the time that these temperatures drop to 96°C (Drift Wall Condensation Submodel)
- The fraction of lithophysal unit at each location.

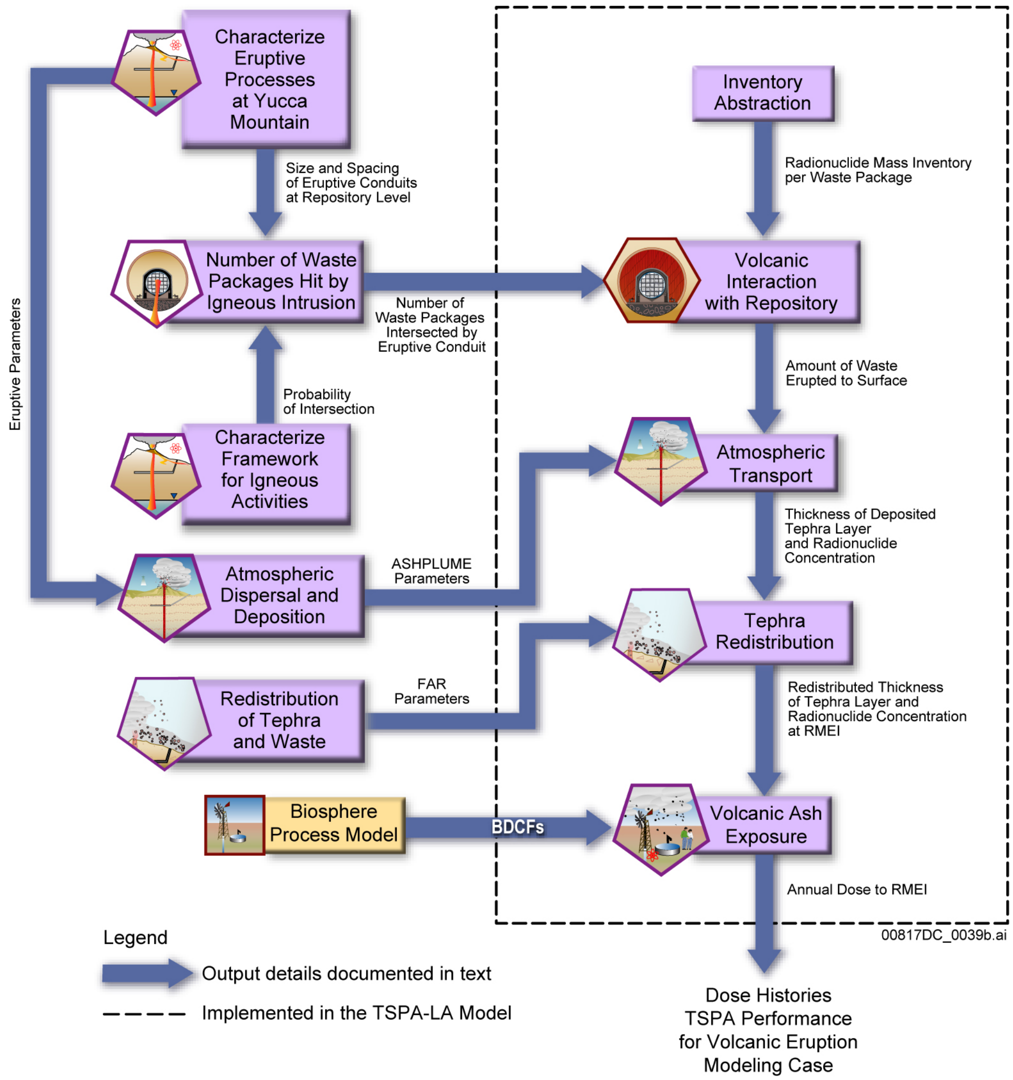

Figure 6.1.4-5[a]. Information Transfer between the Submodels of the TSPA-LA Volcanic Eruption Modeling Case

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6.1.5[a] TSPA-LA Model File Architecture

In addition to the issues that have been addressed in the updated TSPA-LA Model v5.005 model file for this addendum, an additional cosmetic change was made to TSPA-LA Model v5.005. This change was the reorganization of the elements within the model, primarily adding clarity and traceability. As a result, some model pathways identified in Table 6.1.5-1 have changed. Table 6.1.5-1[a] provides an updated summary of the locations of submodel documentation within the GoldSim model file.

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Table 6.1.5-1[a]. Location of Implementation Description in the GoldSim TSPA-LA Model File

Submodel	Documentation Location(s)
Epistemic Parameters GoldSim Submodel	\Epistemic_Uncertainty\Epistemic_Params
Aleatory Parameters and Dynamic Calculations GoldSim Submodel	\Time_Zero\Aleatory_Params
EBS GoldSim Submodel	\Time_Zero\EBS_PS_Loop\EBS_PSE_Loop\EBS_Submodel
Natural System below the Repository	\TSPA_Model
Climate	Epistemic: NA Aleatory: NA EBS: \Global_Inputs_and_Calcs\Global_UZ_Flow\Climate Other: \TSPA_Model\UZ_Flow\Climate
Infiltration	Epistemic: \Input_Params_Epistemic\Epistemic_Params_UZ_Flow\Uncertain_Params_Infiltration Aleatory: NA EBS: \Time_Zero\EBS_PS_Loop\Static_Calcs_PS_Loop\Static_Calcs_UZ_Flow\Infiltration \Global_Inputs_and_Calcs\Global_UZ_Flow\Infiltration
Drift Seepage	Epistemic: \Input_Params_Epistemic\Epistemic_Params_UZ_Flow\Input_Params_Seepage_Uncert \Input_Params_Epistemic\Epistemic_Params_UZ_Flow\Uncertain_Params_Seepage Aleatory: NA EBS: \Time_Zero\EBS_PS_Loop\Static_Calcs_PS_Loop\Static_Calcs_UZ_Flow\Drift_Seepage \Global_Inputs_and_Calcs\Global_UZ_Flow\Drift_Seepage
Drift Wall Condensation	Epistemic: \Input_Params_Epistemic\Epistemic_Params_UZ_Flow\Uncertain_Params_DWC Aleatory: NA EBS: \Global_Inputs_and_Calcs\Global_UZ_Flow\Drift_Wall_Condensation
EBS TH Environment	Epistemic: \Input_Params_Epistemic\Epistemic_Params_EBS_Environ\Uncertain_Params_TH Aleatory: NA EBS: \Global_Inputs_and_Calcs\Global_EBS_Environ\ThermoHydrology
WP and DS Degradation	Epistemic: \Input_Params_Epistemic\Epistemic_Params_WP_DS_Deg Aleatory: \Model_Calcs_Aleatory\Aleatory_Calcs_WP_DS_Deg EBS: \Time_Zero\EBS_PS_Loop\Static_Calcs_PS_Loop\Static_Calcs_WP_DS_Deg \Global_Inputs_and_Calcs\Global_WP_DS_Deg\Global_IWPD
Localized Corrosion	Epistemic: \Input_Params_Epistemic\Epistemic_Params_WP_DS_Deg Aleatory: NA EBS: \Time_Zero\EBS_PS_Loop\Static_Calcs_PS_Loop\Static_Calcs_WP_DS_Deg \Global_Inputs_and_Calcs\Global_WP_DS_Deg\Global_LC

Table 6.1.5-1[a]. Location of Implementation Description in the GoldSim TSPA Model File (Continued)

Submodel	Documentation Location(s)
Radionuclide Inventory	Epistemic: \Input_Params_Epistemic\Epistemic_Params_WF_Deg_Mob\Uncertain_Params_RN_Inventory Aleatory: NA EBS: \Global_Inputs_and_Calcs\Global_WF_Deg_Mob\RN_Inventory
In-Package Chemistry	Epistemic: \Input_Params_Epistemic\Epistemic_Params_WF_Deg_Mob\Uncertain_Params_InPkg_Chem Aleatory: NA EBS: \Global_Inputs_and_Calcs\Global_WF_Deg_Mob\In_Package_Chemistry
Waste Form Degradation	Epistemic: \Input_Params_Epistemic\Epistemic_Params_WF_Deg_Mob\Uncertain_Params_CSNF_WF Aleatory: NA EBS: \Global_Inputs_and_Calcs\Global_WF_Deg_Mob\WF_Degradation\CSNF_WF_Dissolution
	Epistemic: \Input_Params_Epistemic\Epistemic_Params_WF_Deg_Mob\Uncertain_Params_HLW_WF Aleatory: NA EBS: \Global_Inputs_and_Calcs\Global_WF_Deg_Mob\WF_Degradation\Input_Params_HLW_WF
	Epistemic: NA Aleatory: NA EBS: \Global_Inputs_and_Calcs\Global_WF_Deg_Mob\WF_Degradation\Input_Params_DSNF_WF
EBS Chemical Environment	Epistemic: \Input_Params_Epistemic\Epistemic_Params_EBS_Environ\Uncertain_Params_EBS_CE Aleatory: \Input_Params_Aleatory\Input_Params_EBS_Environ\Input_Params_EBS_CE EBS: \Global_Inputs_and_Calcs\Global_EBS_Environ\EBS_Chemical_Environment
Dissolved Concentration Limits	Epistemic: \Input_Params_Epistemic\Epistemic_Params_WF_Deg_Mob\Uncertain_Params_Solubility Aleatory: NA EBS: \Global_Inputs_and_Calcs\Global_WF_Deg_Mob\Global_Solubility
EBS Colloids	Epistemic: \Input_Params_Epistemic\Epistemic_Params_EBS_F_and_T\Uncertain_Params_Colloids Aleatory: NA EBS: \Global_Inputs_and_Calcs\Global_EBS_F_and_T\Model_Input_EBS_Transport\Input_Params_Colloids

Table 6.1.5-1[a]. Location of Implementation Description in the GoldSim TSPA Model File (Continued)

Submodel	Documentation Location(s)
EBS Flow	Epistemic: \Input_Params_Epistemic\Epistemic_Params_EBS_F_and_T\Uncertain_Params_Flux_Split Aleatory: NA EBS: \Global_Inputs_and_Calcs\Global_EBS_F_and_T\Model_Feeds_EBS_Flow
EBS Transport	Epistemic: \Input_Params_Epistemic\Epistemic_Params_EBS_F_and_T Aleatory: NA EBS: \Global_Inputs_and_Calcs\Global_EBS_F_and_T\Model_Input_EBS_Transport
EBS-UZ Interface	Epistemic: \Input_Params_Epistemic\Epistemic_Params_EBS_F_and_T\Uncertain_Params_EBS_UZ_Trans Aleatory: NA EBS: \Global_Inputs_and_Calcs\Global_EBS_F_and_T\EBS_UZ_Transport_Inputs
UZ Transport	Epistemic: \Input_Params_Epistemic\Epistemic_Params_UZ_Transport Aleatory: NA Other: \TSPA_Model\UZ_Transport
SZ Flow and Transport	Epistemic: \Input_Params_Epistemic\Epistemic_Params_SZ_Transport Aleatory: NA Other: \TSPA_Model\SZ_Transport
Biosphere	Epistemic: \Input_Params_Epistemic\Epistemic_Params_Biosphere Aleatory: NA Other: \TSPA_Model\Biosphere
Early Failure Scenario Class	Epistemic: \Input_Params_Epistemic\Epistemic_Params_Events\Epistemic_Parameters_EF Aleatory: \Input_Params_Aleatory\Aleatory_Params_Events\Aleatory_Params_EF EBS: \Time_Zero\EBS_PS_Loop\Static_Calcs_PS_Loop\Static_Calcs_Events\Static_Calcs_EF \Global_Inputs_and_Calcs\Global_Events\Global_EF
Igneous Scenario Class	Epistemic: \Input_Params_Epistemic\Epistemic_Params_Events\Epistemic_Params_Igneous_Intr Aleatory: \Input_Params_Aleatory\Aleatory_Params_Events\Aleatory_Params_Igneous_Intr EBS: \Time_Zero\EBS_PS_Loop\Static_Calcs_PS_Loop\Static_Calcs_Events\Igneous_Intrusion \Global_Inputs_and_Calcs\Global_Events\Igneous_Scenario
	Epistemic: \Model_Uncertainties\EU Aleatory: \Model_Uncertainties\AU EBS: \Eruptive_Model

Table 6.1.5-1[a]. Location of Implementation Description in the GoldSim TSPA Model File (Continued)

Submodel	Documentation Location(s)
Seismic Scenario Class	Epistemic: \Input_Params_Epistemic\Epistemic_Params_Events\Epistemic_Params_Seismic Aleatory: \Input_Params_Aleatory\Aleatory_Params_Events\Input_Params_Seismic_Uncert \Input_Params_Aleatory\Aleatory_Params_Events\Input_Params_Seismic_FD_Uncert EBS: \Time_Zero\EBS_PS_Loop\Static_Calcs_PS_Loop\Static_Calcs_Events\Seismic_Scenario_Class \Time_Zero\EBS_PS_Loop\Static_Calcs_PS_Loop\Static_Calcs_Events\Seismic_Fault_Displacement \Global_Inputs_and_Calcs\Global_Events\Seismic_Scenario
Human Intrusion Scenario	Epistemic: NA Aleatory: \Input_Params_Aleatory\Aleatory_Params_Events\Aleatory_Params_HI EBS: \Time_Zero\EBS_PS_Loop\Static_Calcs_PS_Loop\Static_Calcs_Events\Human_Intrusion_Events \Global_Inputs_and_Calcs\Global_Events\Human_Intrusion Other: \TSPA_Model\UZ_Transport\UZ_Transport_Calculations\HI_Borehole_Transport

6.2[a] ALTERNATIVE CONCEPTUAL MODELS

No change.

6.3[a] TSPA-LA MODEL FOR THE NOMINAL SCENARIO CLASS

This section presents an updated description of the Nominal Scenario Class in support of the analyses of the TSPA-LA Model presented in this addendum (output DTN: MO0710ADTSPAWI.000 [DIRS 183751]). This addendum describes only additions or changes to the conceptual models, model abstractions, and implementation of these abstractions in the TSPA-LA Model that were necessary to support the analyses presented in this addendum. It also provides a description of amendments to the following subsections of the parent document:

- Section 6.3.2, Engineered Barrier System Thermal-Hydrologic Environment
- Section 6.3.3, Drift-Scale Unsaturated Zone Flow
- Section 6.3.7, Waste Form Degradation and Mobilization
- Section 6.3.8, Engineered Barrier System Transport
- Section 6.3.9, Unsaturated Zone Transport
- Section 6.3.10, Saturated Zone Flow and Transport Model Component.

The focus of this section is on the updated TSPA-LA Model components and submodels and their implementation for the Nominal Scenario Class.

6.3.1[a] Mountain-Scale Unsaturated Zone Flow

No change.

6.3.2[a] Engineered Barrier System Thermal-Hydrologic Environment

Section 6.3.2.3[a] includes supplemental material to be used in conjunction with the discussion documented in Section 6.3.2.3 of the parent document. The material was inadvertently omitted from Section 6.3.2.3 of the parent document and does not reflect a change in the EBS Thermal-Hydrologic (TH) Environment conceptual model, abstraction, or implementation in the TSPA-LA Model. In addition, the caption for Figure 6.3.2-7 in the parent document has been corrected and is included as Figure 6.3.2-7[a] of this addendum.

6.3.2.1[a] Conceptual Model

No change.

6.3.2.2[a] Model Abstraction

No change.

6.3.2.3[a] TSPA-LA Model Implementation

Section 6.3.2.3[a] has been modified to include an additional sentence that clarifies the details of the EBS TH Environment Submodel implementation in the TSPA-LA Model.

The following text should be added to the third paragraph of Section 6.3.2.3 of the parent document:

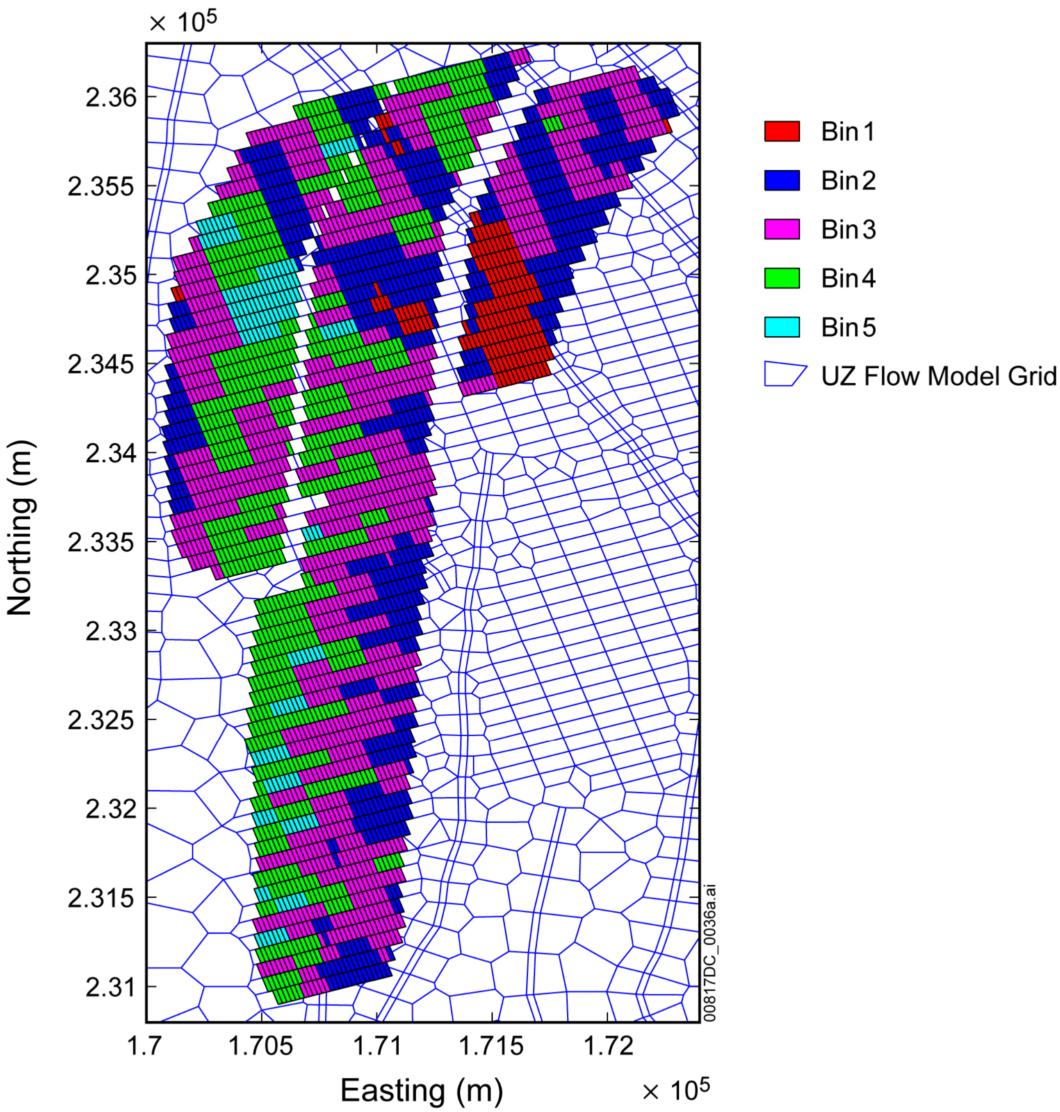
The ten representative TH histories applied to the WP groups in the TSPA-LA Model closely matched the median history of a large group of waste packages that, as modeled, included the effects of percolation, dry out, and rewetting of the host rock above the repository. As such, the history is expected to be representative of a WP whether it is exposed to seepage or not.

6.3.2.4[a] Model Component Consistency and Conservatism in Assumptions and Parameters

No change.

6.3.2.5[a] Alternative Conceptual Model(s) for the Engineered Barrier System Thermal-Hydrologic Environment

No change.



Source: SNL 2007 [DIRS 181383], Figure VIII-1[a].

Figure 6.3.2-7[a]. Repository Percolation Subregions Used in the TSPA-LA Model (based upon the 10th percentile infiltration scenario, glacial-transition period)

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6.3.3[a] Drift-Scale Unsaturated Zone Flow

The analyses documented in this addendum include an update of the seepage fraction for the 10,000-year regulatory time period from that used in the analyses documented in the parent document (Appendix P, Section P2, of the parent document). The following text details the amendments to the Drift-Scale Unsaturated Zone Flow Submodel implementation in support of the analyses documented in this addendum.

6.3.3.1.1[a] Conceptual Model

No change.

6.3.3.1.2[a] TSPA-LA Model Abstraction

No change.

6.3.3.1.3[a] TSPA-LA Model Implementation

The TSPA-LA Model implementation of drift seepage is primarily accomplished through the use of an external dynamically linked library. Drift-seepage submodel calculations in the TSPA-LA Model are conducted by the SEEPAGEDLL_LA (STN: 11076-1.3-01 [DIRS 181058]). Section 6.3.3.1.3 of the parent document describes the drift-seepage implementation in detail. The calculation of the seepage rates is comprised of two main steps: (1) evaluate ambient seepage rate from seepage look-up tables, and (2) adjust ambient seepage rate for thermal and drift degradation effects. This approach remains unchanged in the analyses documented in this addendum. The calculation of the seepage fraction for the addendum is determined as outlined in Step 3 below and differs slightly from that of the parent document.

Step 3: Determination of Seepage Fraction for the TSPA-LA Addendum Analyses

For the analyses documented in this addendum, the seepage fractions for the 10,000-year simulations are based on the glacial-transition climate. The seepage fraction is the fraction of WPs, by type, in a percolation subregion that experiences seepage in a given realization. Although the projections of the expected annual dose to the reasonably maximally exposed individual that are compared to the 10,000-year Individual Protection Standard (NRC Proposed Rule 10 CFR 63.311 [DIRS 178394]) in Section 8.2[a] are extracted from the 20,000-year simulations, the seepage fraction is determined as the fraction of WPs that experiences seepage at any time during the first 10,000 years, instead of over the entire 20,000-year period as calculated in the parent document. The seepage fraction is calculated, as described in Section 6.3.3.1.3 of the parent document, by using a threshold seepage rate of 0.1 kg/yr per WP. WPs with seepage at any time are in a seep environment, and those without seepage are in a non-seep environment as evaluated during the 10,000-year regulatory period. The seepage fractions used for the additional analyses documented in this addendum for the 1,000,000-year simulations are identical to those described in the parent document.

6.3.4[a] Engineered Barrier System Chemical Environment

No change.

6.3.5[a] Waste Package and Drip Shield Degradation

Section 6.3.5.1.3[a] includes supplemental material that should be used in conjunction with the discussion documented in Section 6.3.5.1.3 of the parent document. The material was inadvertently omitted from Section 6.3.5.1.3 of the parent document and does not reflect a change in the WP and DS degradation conceptual model, abstraction, or implementation in the TSPA-LA Model.

6.3.5.1[a] Waste Package and Drip Shield Degradation

Section 6.3.5.1.3[a] has been modified to include an additional paragraph that details the implementation for both incipient and weld flaw crack penetration in a closure-lid patch for WPs in the TSPA-LA Model.

6.3.5.1.1[a] Conceptual Model

No change.

6.3.5.1.2[a] Abstraction of Waste Package and Drip Shield Degradation

No Change.

6.3.5.1.3[a] Implementation in the TSPA-LA Model

The following paragraph should follow the last paragraph in this section of the parent document and be used to supplement the material presented in parent document Section 6.3.5.1.3, under the subheading WP and DS Degradation Submodel Output.

WP and DS Degradation Submodel Output

Stress corrosion cracking can be initiated on an outer barrier closure-lid patch as the result of incipient cracks and weld flaws (Section 6.3.5.1.2 of the parent document). The incipient cracks are present on all lid patches (six cracks per patch with an initial length of 0.05 mm) (Section 6.3.5.1.2 of the parent document). Weld flaws are far less frequent (Equation 6.3.5-12 of the parent document). For a given patch, all incipient cracks grow at the same rate so they penetrate at the same time. The WAPDEG V4.07 (STN: 10000-4.07-00 [DIRS 181774] and STN: 10000-4.07-01 [DIRS 181064]) software tracks only one crack per patch so that the output for the crack area is scaled up by a factor of six to account for the true density of incipient cracks. If the first crack penetration on a closure-lid patch is due to a weld flaw then the scale up is conservative because the probability of 2 or more weld flaws per patch is very small (Equation 6.3.5-12 of the parent document).

6.3.5.2[a] Localized Corrosion on the Waste Package Outer Surface

No change.

6.3.5.3[a] Model Component Consistency and Conservatism in Assumptions and Parameters

No change.

6.3.5.4[a] Alternative Conceptual Model(s) for Waste Package and Drip Shield Degradation

No change.

6.3.6[a] Engineered Barrier System Flow

Figure 6.3.6-3[a] has been revised from the parent document to illustrate a representation of a typical emplacement drift according to the current design.

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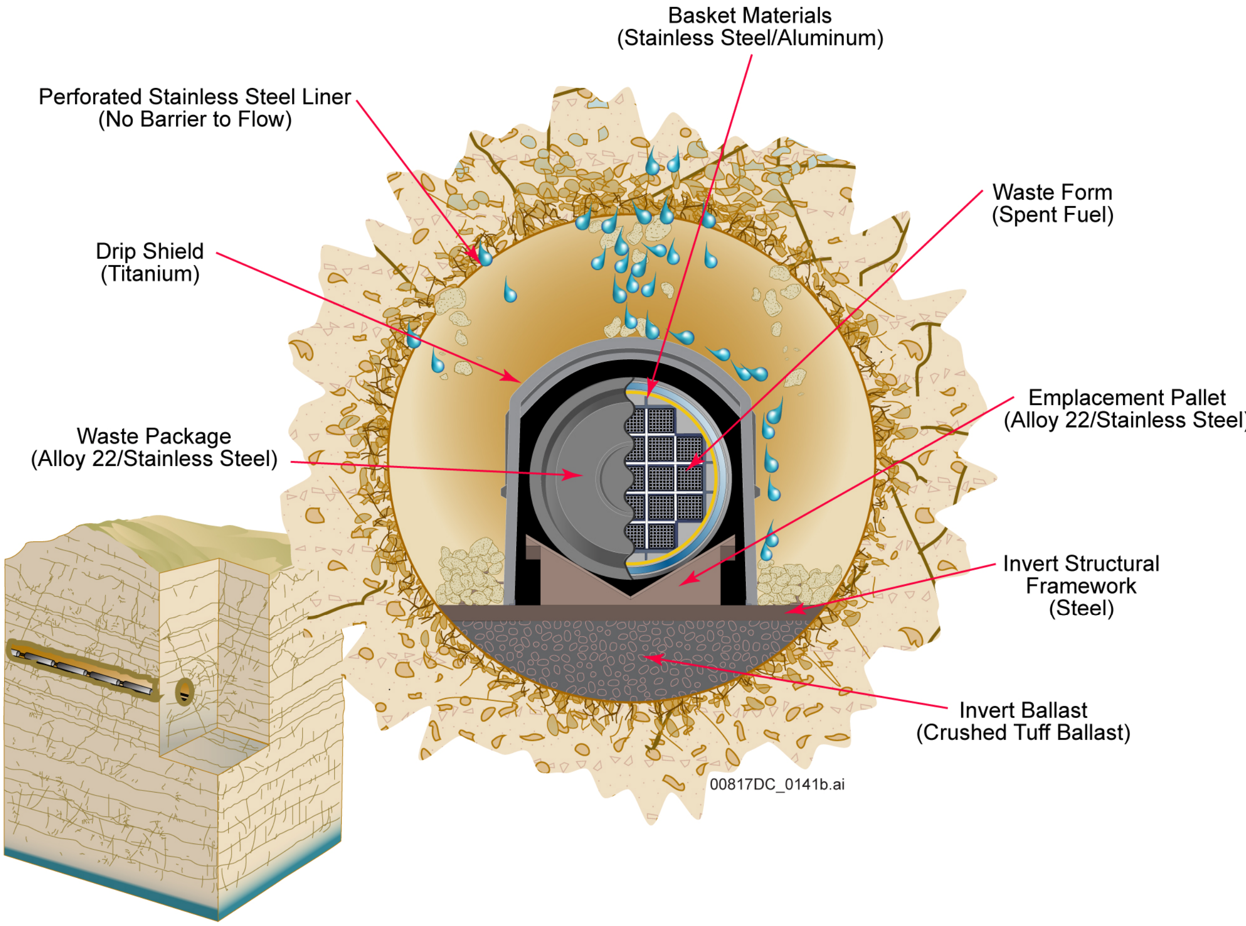

Figure 6.3.6-3[a]. Illustrative Cross Section of a Typical Emplacement Drift

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6.3.7[a] Waste Form Degradation and Mobilization

Table 6.3.7-6[a] contains an update to the summary of the treatment of each radionuclide within the SZ Transport Submodel (Section 6.3.10[a]) and the Biosphere Submodel (Section 6.3.11) for the groundwater release modeling cases. In addition, Table 6.3.7-64[a] contains an update to correct the distribution coefficient for reversible sorption of neptunium onto uranophane colloids, incorrectly implemented as 1 to 5×10^2 (Appendix P[a], Table P-6[a], Item 8).

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Table 6.3.7-6[a]. Disposition of Radionuclides for Groundwater Release Modeling Cases: Nominal, Igneous Intrusion, and Seismic

Radionuclide (Table 6.3.7-2)	Disposition in Waste Form, EBS, and UZ TSPA-LA Model Components (Section 6.3.7)	Disposition in 3-D UZ FEHM Submodel[a] (Section 6.3.9)	Disposition in SZ Submodels (3-D SZ_Convolute and 1-D Pipe)[b] (Section 6.3.10 and 6.3.10[a])	Disposition in Biosphere (Section 6.3.11)
^{227}Ac	Not transported	Not transported	Not transported	Dose from 3-D and 1-D[c], assuming secular equilibrium with ^{231}Pa
^{241}Am	Transport embedded colloid $^{241}Am_{emb}$ (decay to ^{237}Np) Transport irreversible FeO colloid $^{241}Am_{FeO}$ (decay to ^{237}Np) Transport reversible colloid and solute (decay to ^{237}Np)	Transport slow irreversible colloid $^{241}Am_{irs}$ (decay to ^{237}Np) Transport fast irreversible colloid $^{241}Am_{irf}$ (decay to ^{237}Np) Transport reversible colloid and solute (decay to ^{237}Np)	3-D transport of americium/plutonium slow irreversible colloid [SZ BTC 6] 3-D transport of americium/plutonium fast irreversible colloid [SZ BTC 10] 3-D transport of americium /thorium/protactinium reversible colloid and solute [SZ BTC 2]	Dose from 3-D[g]
^{243}Am	Transport embedded colloid $^{243}Am_{emb}$ (decay to $^{239}Pu_{emb}$) Transport irreversible FeO colloid $^{243}Am_{FeO}$ (decay to $^{239}Pu_{FeO}$) Transport reversible colloid and solute (decay to ^{239}Pu)	Transport slow irreversible colloid $^{243}Am_{irs}$ (decay to $^{239}Pu_{irs}$) Transport fast irreversible colloid $^{243}Am_{irf}$ (decay to $^{239}Pu_{irf}$) Transport reversible colloid and solute (decay to ^{239}Pu)	3-D transport of americium/plutonium slow irreversible colloid [SZ BTC 6] 3-D transport of americium/plutonium fast irreversible colloid [SZ BTC 10] 3-D transport of americium/ thorium/protactinium reversible colloid and solute [SZ BTC 2]	Dose from 3-D
^{14}C	Transport solute	Transport solute	3-D transport of nonsorbing solute [SZ BTC 1]	Dose from 3-D
^{36}Cl	Transport solute	Transport solute	3-D transport of nonsorbing solute [SZ BTC 1]	Dose from 3-D
^{245}Cm[d]	Not transported (decay to ^{241}Pu)	Not transported	Not transported	Dose not computed
^{135}Cs	Transport reversible colloid and solute	Transport reversible colloid and solute	3-D transport of cesium reversible colloid and solute [SZ BTC3]	Dose from 3-D
^{137}Cs	Transport reversible colloid and solute	Transport reversible colloid and solute	3-D transport of cesium reversible colloid and solute [SZ BTC 3]	Dose from 3-D[e]
^{129}I	Transport solute	Transport solute	3-D transport of nonsorbing solute [SZ BTC 1]	Dose from 3-D
^{237}Np	Transport reversible colloid and solute (decay to ^{233}U)	Transport solute (decay to ^{233}U)	3-D transport of neptunium solute [SZ BTC 5], boosted[f] by $^{241}Am_{irs}$, $^{241}Am_{irf}$, and $^{241}Am_{rev/sol}$	Dose from 3-D

Table 6.3.7-6[a]. Disposition of Radionuclides for Groundwater Release Modeling Cases: Nominal, Igneous Intrusion, and Seismic (Continued)

Radionuclide (Table 6.3.7-2)	Disposition in Waste Form, EBS, and UZ TSPA-LA Model Components (Section 6.3.7)	Disposition in 3-D UZ FEHM Submodel[a] (Section 6.3.9)	Disposition in SZ Submodels (3-D SZ_Convolute and 1-D Pipe)[b] (Section 6.3.10 and 6.3.10[a])	Disposition in Biosphere (Section 6.3.11)
^{231}Pa	Transport reversible colloid and solute (decay to ^{227}Ac)	Transport reversible colloid and solute (simple decay)	3-D transport of reversible colloid and solute (decay to ^{227}Ac) [SZ BTC 2] 1-D transport only the mass created by ingrowth from ^{235}U decay	Dose from 3-D and 1-D
^{210}Pb[g]	Not explicitly included	Not explicitly included	Not explicitly included	Dose included with ^{226}Ra BDCF[e]
^{238}Pu	Transport embedded colloid $^{238}Pu_{emb}$ (decay to ^{234}U) Transport irreversible FeO colloid $^{238}Pu_{FeO}$ (decay to ^{234}U) Transport reversible colloid and solute (decay to ^{234}U)	Transport slow irreversible colloid $^{238}Pu_{irs}$ (decay to ^{234}U) Transport fast irreversible colloid $^{238}Pu_{irf}$ (decay to ^{234}U) Transport reversible colloid and solute (decay to ^{234}U)	3-D transport of americium/plutonium slow irreversible colloid [SZ BTC 6] 3-D transport of americium/plutonium fast irreversible colloid [SZ BTC 10] 3-D transport of plutonium reversible colloid [SZ-BTC 4]	Dose from 3-D[g]
^{239}Pu	Transport embedded colloid $^{239}Pu_{emb}$ (decay to ^{235}U) Transport irreversible FeO colloid $^{239}Pu_{FeO}$ (decay to ^{235}U) Transport reversible colloid and solute (decay to ^{235}U)	Transport slow irreversible colloid $^{239}Pu_{irs}$ (decay to ^{235}U) Transport fast irreversible colloid $^{239}Pu_{irf}$ (decay to ^{235}U) Transport reversible colloid and solute (decay to ^{235}U)	3-D transport of americium/plutonium slow irreversible colloid [SZ BTC 6], boosted[c] by $^{243}Am_{irs}$ 3-D transport of americium/plutonium fast irreversible colloid [SZ BTC 10], boosted[c] by $^{243}Am_{irf}$ 3-D transport of plutonium reversible colloid [SZ BTC 4], boosted[c] by $^{243}Am_{rev/sol}$	Dose from 3-D
^{240}Pu	Transport embedded colloid Pu_{emb} (decay to ^{236}U) Transport irreversible FeO colloid $^{240}Pu_{FeO}$ (decay to ^{236}U) Transport reversible colloid and solute (decay to ^{236}U)	Transport slow irreversible colloid $^{240}Pu_{irs}$ (decay to ^{236}U) Transport fast irreversible colloid $^{240}Pu_{irf}$ (decay to ^{236}U) Transport reversible colloid and solute (decay to ^{236}U)	3-D transport of americium/plutonium slow irreversible colloid [SZ BTC 6] 3-D transport of americium/plutonium fast irreversible colloid [SZ BTC 10] 3-D transport of plutonium reversible colloid [SZ BTC 4]	Dose from 3-D
^{241}Pu[d]	Not transported (decay to ^{241}Am)	Not transported	Not transported	Dose not computed

Table 6.3.7-6[a]. Disposition of Radionuclides for Groundwater Release Modeling Cases: Nominal, Igneous Intrusion, and Seismic (Continued)

Radionuclide (Table 6.3.7-2)	Disposition in Waste Form, EBS, and UZ TSPA-LA Model Components (Section 6.3.7)	Disposition in 3-D UZ FEHM Submodel[a] (Section 6.3.9)	Disposition in SZ Submodels (3-D SZ_Convolute and 1-D Pipe)[b] (Section 6.3.10 and 6.3.10[a])	Disposition in Biosphere (Section 6.3.11)
^{242}Pu	Transport embedded colloid $^{242}Pu_{emb}$ (decay to ^{238}U) Transport irreversible FeO colloid $^{242}Pu_{FeO}$ (decay to ^{238}U) Transport reversible colloid and solute (decay to ^{238}U)	Transport slow irreversible colloid $^{242}Pu_{irs}$ (decay to ^{238}U) Transport fast irreversible colloid $^{242}Pu_{irf}$ (decay to ^{238}U) Transport reversible colloid and solute (decay to ^{238}U)	3-D transport of americium/plutonium slow irreversible colloid [SZ BTC 6] 3-D transport of americium/plutonium fast irreversible colloid [SZ BTC 10] 3-D transport of plutonium reversible colloid and solute [SZ BTC 4]	Dose from 3-D[f]
^{226}Ra	Transport reversible colloid and solute (simple decay)	Transport solute (simple decay)	3-D transport of solute (simple decay) [SZ BTC 7] 1-D transport only the mass created by ingrowth from ^{230}Th decay	Dose from 3-D and 1-D[f]
^{228}Ra	Not transported	Not transported	Not transported	Dose from3-D and 1-D[f]; assuming secular equilibrium with ^{232}Th
^{79}Se	Transport solute	Transport solute	3-D transport of nonsorbing solute [SZ BTC 11]	Dose from 3-D
^{126}Sn	Transport reversible colloid and solute	Transport reversible colloid and solute	3-D transport of tin reversible colloid and solute [SZ BTC 12]	Dose from 3-D
^{90}Sr	Transport solute	Transport solute	3-D transport of strontium solute [SZ BTC 8]	Dose from 3-D[g]
^{99}Tc	Transport solute	Transport solute	3-D transport of nonsorbing solute [SZ BTC 1]	Dose from 3-D
^{229}Th	Transport reversible colloid and solute (simple decay)	Transport reversible colloid and solute (simple decay)	3-D transport of reversible colloid and solute (simple decay) [SZ BTC 2] 1-D transport only the mass created by ingrowth from ^{233}U decay	Dose from 3-D and 1-D
^{230}Th	Transport reversible colloid and solute (decay to ^{226}Ra)	Transport reversible colloid and solute (decay to ^{226}Ra)	1-D transport of reversible colloid and solute (decay to ^{226}Ra) [SZ BTC 2]	Dose from 1-D[f]
^{232}Th	Transport reversible colloid and solute (decay to ^{228}Ra)	Transport reversible colloid and solute (simple decay)	3-D transport of reversible colloid and solute (decay to ^{228}Ra) [SZ BTC 2] 1-D transport only the mass created by ingrowth from ^{236}U decay	Dose from 3-D and 1-D[f]
^{232}U	Transport reversible colloid and solute	Transport solute	3-D transport of ^{232}U solute [SZ BTC 9]	Dose from 3-D

Table 6.3.7-6[a]. Disposition of Radionuclides for Groundwater Release Modeling Cases: Nominal, Igneous Intrusion, and Seismic (Continued)

Radionuclide (Table 6.3.7-2)	Disposition in Waste Form, EBS, and UZ TSPA-LA Model Components (Section 6.3.7)	Disposition in 3-D UZ FEHM Submodel[a] (Section 6.3.9)	Disposition in SZ Submodels (3-D SZ_Convolute and 1-D Pipe)[b] (Section 6.3.10 and 6.3.10[a])	Disposition in Biosphere (Section 6.3.11)
^{233}U	Transport reversible colloid and solute (decay to ^{229}Th)	Transport solute (decay to ^{229}Th)	1-D transport of solute (decay to thorium) [SZ BTC 9]	Dose from 1-D
^{234}U	Transport reversible colloid and solute (decay to ^{230}Th)	Transport solute (decay to ^{230}Th)	3-D transport of ^{234}U solute, [SZ BTC 9], boosted[c] by ^{238}U, $^{238}Pu_{irs}$, $^{238}Pu_{irf}$, and $^{238}Pu_{rev/sol}$	Dose from 3-D
^{235}U	Transport reversible colloid and solute (decay to ^{231}Pa)	Transport solute (decay to ^{231}Pa)	1-D transport of solute (decay to ^{231}Pa) [SZ BTC 9]	Dose from 1-D[f]
^{236}U	Transport reversible colloid and solute (decay to ^{232}Th)	Transport solute (decay to ^{232}Th)	3-D transport of ^{236}U solute [SZ BTC 9], boosted[c] by $^{240}Pu_{irs}$, $^{240}Pu_{irf}$, and $^{240}Pu_{rev/sol}$	Dose from 3-D
^{238}U	Transport reversible colloid and solute (decay to ^{234}U)	Transport solute (decay to ^{234}U)	3-D transport of ^{238}U solute [SZ BTC 9], boosted[c] by $^{242}Pu_{irs}$, $^{242}Pu_{irf}$, and $^{242}Pu_{rev/sol}$	Dose from 3-D

NOTE: [a] Plutonium and americium isotopes are transported irreversibly on two different colloid types in the EBS: iron oxyhydroxide colloids (e.g., see $^{239}Pu_{FeO}$ in the above table) and waste form colloids (e.g., see $^{239}Pu_{emb}$ in the above table). However, at the EBS-UZ interface, the plutonium or americium mass associated with these two types of colloids is combined (effectively losing or ignoring the mineral specificity) and then resplit into slow-transport and fast-transport irreversible colloids in the natural system (e.g., see $^{239}Pu_{irs}$ and $^{239}Pu_{irf}$ in the above table). Thus, the specific radionuclides in GoldSim, designated “Ic” and “If”, are used differently in the EBS versus the natural system—in the EBS “Ic” stands for plutonium and americium mass transported in “embedded” colloids (i.e., the plutonium and americium mass is embedded in the mineral matrix of these colloid particles), and “If” stands for plutonium and americium mass sorbed irreversibly onto iron oxyhydroxide colloids, whereas in the UZ (Section 6.3.9) and SZ (Section 6.3.10), “Ic” stands for plutonium and americium mass transported irreversibly on slow colloids, and “If” stands for plutonium or americium mass transported irreversibly on fast colloids.

[b] Saturated Zone Breakthrough Curve and the associated number refers to the “Radionuclide Group Number” listed in the first column of Table 6.3.10-1 (Section 6.3.10).

[c] Boosting of a daughter (e.g., ^{239}Pu) means that the injected mass of the daughter over any timestep at the UZ-SZ interface is increased by the maximum decay (over the remaining simulation time) of the designated parent (e.g., ^{243}Am).

[d] ^{245}Cm and ^{241}Pu were recommended for inclusion in the TSPA-LA in *Radionuclide Screening* (SNL 2007 [DIRS 177424], Section 6.6.2 and Table 6-9) only to ensure that the effect of their decay on the inventories of ^{241}Am and ^{237}Np are included in the model. They are not recommended for transport or dose consequences.

[e] Though ^{210}Pb is not tracked, it is assumed to be in secular equilibrium with ^{226}Ra; that is, the biosphere dose conversion (BDCF) used for ^{226}Ra is the summation of the BDCFs provided for ^{226}Ra and ^{210}Pb.

[f] Doses only calculated for 1,000,000-year simulations (SNL 2007 [DIRS 177424], Table 6-9).

[g] Doses only calculated for 10,000-year simulations (SNL 2007 [DIRS 177424], Table 6-9).

SZ BTC = Saturated Zone Breakthrough Curve.

Table 6.3.7-64[a]. Parameters for TSPA-LA Spent Nuclear Fuel Waste Form Reversible Colloid Abstraction

TSPA-LA Parameter Name	Model Abstraction Symbol	Description	Units	Distribution Type	Distribution Specification	
Conc_Col_U_Sampled_a	$m_{coll,Uranophane,sampled}$	Expected mass of uranophane colloids per unit volume or mass of water.	mg/L	Cumulative Distribution Function	Prob Level	Value
					0	1×10^{-3}
					0.5	1×10^{-1}
					0.75	1×10^{0}
					0.90	1×10^{1}
					0.98	5×10^{1}
					1	2×10^{2}
Conc_Col_U_Min	$m_{coll,Uranophane,min}$	Lowest observed or expected mass of uranophane colloids per unit volume or mass of water.	mg/L	Single Value	1×10^{-6}	
U_pH_lo	None	Lower limit of pH range for U colloid stability data.	None	Single Value	4	
U_pH_hi	None	Upper limit of pH range for U colloid stability data.	None	Single Value	9	
Coeff_pH_Sq_U	None	Coefficient of pH squared term for fit of ionic strength threshold for U colloid stability.	None	Single Value	−0.008	
Coeff_pH_U	None	Coefficient of pH term for fit of ionic strength threshold for U colloid stability.	None	Single Value	0.14	
Coeff_inter_U	None	Coefficient of intercept term for fit of ionic strength threshold for U colloid stability.	None	Single Value	0.4	
Kd_Pu_Rev_U_Col_a	$K_{d,Pucoll,uranophane}$	Distribution coefficient for reversible sorption of plutonium onto uranophane colloids.	mL/g	Log Uniform	5×10^{0} to 1×10^{4}	
Kd_Am_Rev_U_Col_a	$K_{d,Amcoll,uranophane}$	Distribution coefficient for reversible sorption of americium onto uranophane colloids.	mL/g	Log Uniform	5×10^{0} to 1×10^{4}	
Kd_Th_Rev_U_Col_a	$K_{d,Thcoll,uranophane}$	Distribution coefficient for reversible sorption of thorium onto uranophane colloids.	mL/g	Log Uniform	5×10^{0} to 1×10^{4}	

Table 6.3.7-64[a]. Parameters for TSPA-LA SNF Waste Form Reversible Colloid Abstraction (Continued)

TSPA-LA Parameter Name	Model Abstraction Symbol	Description	Units	Distribution Type	Distribution Specification
Kd_Pa_Rev_U_Col_a	$K_{d,Pacoll,uranophane}$	Distribution coefficient for reversible sorption of Pa onto uranophane colloids.	mL/g	Log Uniform	5×10^0 to 1×10^4
Kd_Cs_Rev_U_Col_a	$K_{d,Cscoll,uranophane}$	Distribution coefficient for reversible sorption of cesium onto uranophane colloids.	mL/g	Log Uniform	1×10^1 to 1×10^3
Kd_Np_Rev_U_Col_a	$K_{d,Npcoll,uranophane}$	Distribution coefficient for reversible sorption of neptunium onto uranophane colloids.	mL/g	Log Uniform	1×10^1 to 5×10^2
Kd_Ra_Rev_U_Col_a	$K_{d,Racoll,uranophane}$	Distribution coefficient for reversible sorption of radium onto uranophane colloids.	mL/g	Log Uniform	1×10^1 to 1×10^3
Kd_Sn_Rev_U_Col_a	$K_{d,Sncoll,uranophane}$	Distribution coefficient for reversible sorption of tin onto uranophane colloids.	mL/g	Log Uniform	1×10^0 to 1×10^2
Specific_SA_U_Col	$S_{A,\ uranophane,\ coll}$	Specific surface area for uranophane.	m^2/g	Single Value	30
U_Site_Density	$N_{S,uranophane,\ coll}$	Site density for uranophane particle colloid.	Sites/ nm^2	Single Value	2

Source: DTN: MO0701PACSNFCP.000_R1 [DIRS 180439], File: DTN_SNF_REV03.doc.

NOTE: Condition report 11424 describes the errata in the source documents.

6.3.8[a] Engineered Barrier System Transport

Table 6.3.8-4 of the parent document was updated (Table 6.3.8-4[a]) to reflect the update to the TSPA-LA Model for the adsorption isotherm parameter *k* and parameter *s* for corrosion products incorrectly implemented (Appendix P[a], Table P-6[a], Item 7).

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Table 6.3.8-4[a]. Sampled Model Inputs Used in the EBS Radionuclide Transport Abstraction

Input Name	Input Description	Range	Distribution
Invert_Diff_Coeff_Uncert_a	Invert diffusion coefficient uncertainty	Range: $10^{\mu \pm 3\sigma}$ (dimensionless) Mean: μ = 0.033 Std. Dev. σ = 0.218	Truncated Normal
SS_Corrosion_Rate_a	Stainless steel corrosion rate	0.01 – 0.51 μm/yr Mean = 0.267 μm/yr Std. Dev. = 0.209 μm/yr	Truncated Lognormal
CS_Corrosion_Rate_a	Carbon steel corrosion rate	25 – 135 μm/yr Mean = 78.5 μm/yr Std. Dev. = 25.0 μm/yr	Truncated Lognormal
DS_Flux_Uncertainty_a	Drip shield flux-splitting uncertainty factor	0 – 0.85 (dimensionless)	Uniform
WP_Flux_Uncertainty_a	Waste package flux-splitting uncertainty factor	0 – 2.41 (dimensionless)	Uniform
Diameter_Colloid_a	Diameter of colloid particle	50 – 300 nm	Uniform
Goethite_SA_a	Specific surface area of goethite (FeOOH)	14.7 – 110 m^2/g Mean = 51.42 m^2/g Std. Dev. = 30.09 m^2/g	Lognormal (Truncated)
HFO_SA_a	Specific surface area of HFO	68 – 600 m^2/g Mean = 275.6 m^2/g Std. Dev. = 113.4 m^2/g	Lognormal (Truncated)
NiO_SA_a	Specific surface area of NiO	1 – 30 m^2/g	Uniform
Cr2O3_SA_a	Specific surface area of Cr_2O_3	1 – 20 m^2/g	Uniform
Relative_Abundance_Goethite_a	Mass fraction of iron oxides (goethite and HFO) that is goethite	0.45 – 0.80 (fraction)	Uniform
FHH_Isotherm_k_CP_a_5003[a]	FHH adsorption isotherm parameter *k* for corrosion products	1.030 – 1.326 (dimensionless)	Uniform
FHH_Isotherm_s_CP_a_5003[a]	FHH adsorption isotherm parameter *s* for corrosion products	1.493 – 1.799 (dimensionless)	Uniform
CSNF_Rind_SA_a	Specific surface area of CSNF rind	0.5 – 60 m^2/g	Uniform
Density_CSNF_Rind_a	Density of CSNF rind	5,600 – 11,500 kg m^{-3}	Uniform
Porosity_Rind_CSNF_a	Porosity of CSNF rind	0.05 – 0.3 (fraction)	Uniform
FHH_Isotherm_k_CSNF_Rind_a	FHH adsorption isotherm parameter *k* for CSNF rind	1.606 – 8.215 (dimensionless)	Uniform
FHH_Isotherm_s_CSNF_Rind_a	FHH adsorption isotherm parameter *s* for CSNF rind	1.656 – 3.038 (dimensionless)	Uniform
HLWG_Rind_SA_a	Specific surface area of high-level radioactive water glass (HLWG) rind	10 – 38 m^2/g	Uniform
Diameter_Colloid_a	Colloid particle diameter	50 – 300 nm	Uniform
Gamma_AFM_a	Active fracture model gamma parameter DTN: LA0701PANS02BR.003_R2 [DIRS 180497], Readme File	0.2 – 0.6	Uniform

Table 6.3.8-4[a]. Sampled Model Inputs Used in the EBS Radionuclide Transport Abstraction (Continued)

Input Name	Input Description	Range	Distribution
EBS_UZ_Flux_Sat_PS1 EBS_UZ_Flux_Sat_PS2 EBS_UZ_Flux_Sat_PS3 EBS_UZ_Flux_Sat_PS4 EBS_UZ_Flux_Sat_PS5	Unsaturated zone fracture saturation DTN: LA0701PANS02BR.003_R2 [DIRS 180497]. This includes the average fracture and matrix percolation fluxes and saturations for both glacial transition and post-10,000-year periods. There are a total of five percolation subregions.	Average values for the five percolation subregions based on the average of repository nodes in each percolation subregion.	2-D Table; see Table 6.3.8-5
pH_Cell2_Regression_Error_a	Error term added to the surface complexation based pH calculation in the corrosion products domain.	Mean: $\mu = 0$; Std. Dev. $\sigma = 0.32$ Truncated at ± 2 Std. Dev.	Truncated Normal
Diff_Path_Length_Invert_Top_a	Diffusive path length from waste package outer corrosion barrier (OCB) to mid-point of invert.	0.30 – 1.24 m	Uniform

Sources: Modified from DTN: SN0703PAEBSRTA.001_R3 [DIRS 183217], Files: SN0703PAEBSRTA.001_RTA Input Tables.doc and Corrosion Products Composite Isotherm 7-19-2007.xls.

NOTES: [a] Condition Report 11755 documents this error which is being addressed in this Addendum.

6.3.9[a] Unsaturated Zone Transport

The analyses documented in this addendum include a change to Table 6.3.9-1[a] that reflects the radionuclide half-lives documented in the parent document (Appendix P[a], Table P-6[a], Item 2). In addition input errors discovered during the checking of the TSPA Input Database have been corrected and are documented in Table P-6[a], Item 10 and Item 11. Section 6.3.9.4[a] contains an expanded discussion of the consistency of assumptions for UZ Transport Properties. The following text details the amendments to the UZ Transport Submodel implementation in support of the analyses documented in this addendum.

6.3.9.1[a] Conceptual Model

No change.

6.3.9.2[a] TSPA-LA Model Abstraction

To ensure consistency among the EBS Transport Submodel, UZ Transport Submodel, and SZ Transport Submodel, the radionuclide half-lives used in the UZ Transport Submodel were changed to the values listed in Table 6.3.9-1[a] (DTN: MO0702PASTREAM.001_R0 [DIRS 179925]) for the analyses presented in this addendum.

6.3.9.3[a] TSPA LA Model Implementation

No change.

6.3.9.4[a] Model Component Consistency and Conservatism in Assumptions and Parameters

An expanded discussion of the UZ Transport Properties consistency of assumptions is included in Section 6.3.9.4.1[a]. This discussion is a more detailed documentation of the consistency in UZ Transport Properties and is provided as a replacement to the material included in Section 6.3.9.4.1 of the parent document. The remainder of Section 6.3.9.4 included in the parent document remains unchanged.

6.3.9.4.1[a] Consistency of Assumptions

UZ Transport Properties—In the Unsaturated Zone Transport Submodel, the calibrated values of parameters used to develop the pre-generated flow fields do not explicitly match the values used to generate the matrix-diffusion parameters. In general, the parameters used to describe flow and transport are the same (SNL 2008 [DIRS 184748], Sections 6.5.5.4[a], 6.5.7, and A.4[a]; SNL 2007 [DIRS 184614], Section 6.1.5; and SNL 2007 [DIRS 179545]). An exception is the range of values of the active fracture model parameter γ as discussed in *Particle Tracking Model and Abstraction of Transport Processes* (SNL 2008 [DIRS 184748], Section 6.5.6 [a]).

The matrix-diffusion process implemented in the Unsaturated Zone Transport Submodel is sensitive to various physical parameters that are also used to define the UZ flow fields. Because the matrix-diffusion process may be very sensitive to these parameters, it is important to propagate the uncertainties in parameter values into the Unsaturated Zone Transport Submodel.

There are several UZ flow-related parameters used by the radionuclide transport model. Parameters used directly are: matrix porosity, fracture porosity, fracture spacing (the inverse of fracture frequency), and the active fracture model parameter γ. These parameters are deterministic in the UZ Flow Model.

Several matrix hydrologic parameters are also used indirectly to develop mean values of tortuosity (SNL 2008 [DIRS 184748], Section A.2[a]) using a correlation between matrix effective permeability and water content for tortuosity (matrix diffusion) (Equation 6.3.9-1). The matrix parameters used to determine tortuosity are: porosity, residual saturation, capillary strength (van Genuchten α), pore size distribution index (van Genuchten m), and permeability (SNL 2008 [DIRS 184748], Section A.2[a]). Deterministic values are used to compute mean tortuosity values for each of three rock categories; tortuosity is then sampled based on the uncertainty in the tortuosity correlation associated with differences between diffusion coefficient values predicted by Equation 6.3.9-1 and measured values (SNL 2008 [DIRS 184748], Section A.4[a]).

Effect on the TSPA Model—A study presented in *UZ Flow Models and Submodels* (BSC 2004 [DIRS 169861], Section 6.8.1) indicates that the Site-Scale UZ Flow Model is relatively insensitive to changes in the value of the active fracture model parameter γ. In the steady-state site-scale UZ Flow Model, the active fracture model parameter γ influences the partitioning of water flow between the fractures and rock matrix. The conclusion of the study noted that for the flow model, changing the values of active fracture model parameter γ will have only a small effect on matrix liquid saturations, water potentials, and average percolation fluxes. This may also indicate that γ values, estimated based on flow calibrations, may not be well constrained, and the application of a greater uncertainty for transport calculations is valid. Note, the *UZ Flow Models and Submodels* referenced above is a historical document that was revised to incorporate new infiltration data (SNL 2007 [DIRS 184614). Several sensitivity analyses presented in the historical version, which are still valid despite changes in the infiltration data, were not repeated or discussed in the current version but are needed for this discussion.

The aperture values used in the UZ Transport Model are generated from fracture porosity and fracture frequency (the inverse of fracture spacing) values. In general, the large permeability contrast between the fractures and rock matrix (SNL 2007 [DIRS 184614], Appendix B) indicates that the rock matrix will not contribute significantly to the flow process (minimizing the influence of fracture spacing), and matrix diffusion will be the dominant process controlling mass retardation in the rock matrix. In addition, fracture porosities are important in defining the transient matrix-diffusion process in the UZ Transport Model. However, as storage terms in the site-scale UZ Flow Model, they do not influence results of the steady-state model. It should also be noted that fracture permeabilities and van Genuchten α parameters are related to fracture apertures (BSC 2004 [DIRS 170038], Section 6.1.2). A sensitivity study on flow model parameters showed relatively small differences between base-case flow fields and flow fields generated by changing fracture permeabilities and van Genuchten α parameters (BSC 2005 [DIRS 174116], Section 6.3). Studies presented in *Particle Tracking Model and Abstraction of Transport Processes* (SNL 2008 [DIRS 184748], Sections 6.6.3 and 6.6.4) also showed that transport in the UZ is generally less sensitive to changes in flow parameters than to changes in the transport properties. The analyses showed that the transport results were insensitive to the van Genuchten α parameter. Transport results showed greater sensitivity to changes in fracture permeability compared to that of the van Genuchten α parameter, but as noted, the changes were relatively small.

The mean values for tortuosity used in the UZ Transport Submodel are based on the deterministic values of porosity, residual saturation, capillary strength (van Genuchten α), pore size distribution index (van Genuchten m), and permeability used in the 10th percentile infiltration scenario for the UZ Site-Scale Flow Model present-day, monsoon, glacial-transition, and post-10,000-year simulations. The 10th percentile infiltration scenario is the most commonly sampled infiltration scenario (62 percent of the time). Additionally, it can be shown that tortuosity values generated using deterministic parameters from the other infiltration scenarios differ only slightly from the values used in the TSPA-LA Model. The uncertainty in tortuosity values considered in the transport calculations is the uncertainty in the correlation between the tortuosity and fracture permeability and porosity and, therefore, is only pertinent to the transport calculations.

6.3.9.5[a] Alternative Conceptual Model(s) for Unsaturated Zone Transport

No change.

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Table 6.3.9-1[a]. Radionuclide Half-Life and Daughter Products Used in the TSPA-LA Addendum

No.	Species	Half Life (years)	Daughter Index
1	^{14}C	5.72×10^{3}	NA
2	^{135}Cs (rev)	2.30×10^{6}	NA
3	^{137}Cs (rev)	3.01×10^{1}	NA
4	^{129}I	1.57×10^{7}	NA
5	^{90}Sr	2.88×10^{1}	NA
6	^{99}Tc	2.13×10^{5}	NA
7	^{243}Am (rev)	7.37×10^{3}	10
8	$^{243}Am^{Ic}$	7.37×10^{3}	11
9	$^{243}Am^{If}$	7.37×10^{3}	12
10	^{239}Pu (rev)	2.41×10^{4}	13
11	$^{239}Pu^{Ic}$	2.41×10^{4}	13
12	$^{239}Pu^{If}$	2.41×10^{4}	13
13	^{235}U	7.04×10^{8}	14
14	^{231}Pa (rev)	3.28×10^{4}	NA
15	^{241}Am (rev)	4.33×10^{2}	18
16	$^{241}Am^{Ic}$	4.33×10^{2}	18
17	$^{241}Am^{If}$	4.33×10^{2}	18
18	^{237}Np	2.14×10^{6}	19
19	^{233}U	1.59×10^{5}	20
20	^{229}Th (rev)	7.30×10^{3}	NA
21	^{240}Pu (rev)	6.56×10^{3}	24
22	$^{240}Pu^{Ic}$	6.56×10^{3}	24
23	$^{240}Pu^{If}$	6.56×10^{3}	24
24	^{236}U	2.34×10^{7}	25
25	^{232}Th (rev)	1.40×10^{10}	NA
26	^{232}U	6.98×10^{1}	NA
27	^{242}Pu (rev)	3.75×10^{5}	33
28	$^{242}Pu^{Ic}$	3.75×10^{5}	33
29	$^{242}Pu^{If}$	3.75×10^{5}	33
30	^{238}Pu (rev)	8.77×10^{1}	34
31	$^{238}Pu^{Ic}$	8.77×10^{1}	34
32	$^{238}Pu^{If}$	8.77×10^{1}	34
33	^{238}U	4.47×10^{9}	34
34	^{234}U	2.46×10^{5}	35
35	^{230}Th (rev)	7.54×10^{4}	36
36	^{226}Ra	1.60×10^{3}	NA
37	^{36}Cl	3.01×10^{5}	NA
38	^{79}Se	2.90×10^{5} (2.95×10^{5})[a]	NA
39	^{126}Sn (rev)	2.30×10^{5} (2.50×10^{5})[a]	NA

Source: DTN: MO0702PASTREAM.001_R0 [DIRS 179925], File: DTN-Inventory-Rev00.xls.

NOTES: rev = reversible colloids.

Daughter Index lists the radionuclide species number of the daughters produced for decay-chain species.

[a] Denotes the half-life value used in the analyses documented in the parent document.

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6.3.10[a] Saturated Zone Flow and Transport Model Component

The analyses documented in this addendum include changes necessary to reflect the most recent addendum to *Saturated Zone Flow and Transport Model Abstraction* (SNL 2008 [DIRS 183750]). The discussions below supplement the material presented in Section 6.3.10 of the parent document, noting differences between the 3-D and 1-D SZ Flow and Transport Abstractions used in the analyses documented in this addendum.

6.3.10.1[a] Conceptual Model

No change.

6.3.10.2[a] TSPA-LA Model Abstraction

As documented in the parent document, two abstractions of the SZ Flow and Transport Model Component were implemented in the TSPA-LA Model: (1) the 3-D SZ Flow and Transport Abstraction Model, which uses a convolution integral technique to combine radionuclide breakthrough curves with time-varying radionuclide sources from the UZ to quantify radionuclide transport to the accessible environment, and (2) the 1-D SZ Flow and Transport Abstraction implemented directly in the TSPA-LA Model to calculate radioactive decay, ingrowth, and transport for specified radionuclide chains. These analyses incorporate amendments to both the 3-D and 1-D SZ Transport Model Abstractions, as documented in *Saturated Zone Flow and Transport Model Abstraction* (SNL 2008 [DIRS 183750] and DTN: SN0710PASZFTMA.003_R0 [DIRS 183485]). The following sections detail the amendments to the SZ Transport Submodel abstraction and implementation in support of the analyses documented in this addendum.

3-D SZ Flow and Transport Abstraction—The three-dimensional SZ flow and transport process modeling, described in *Saturated Zone Site-Scale Flow Model* (SNL 2007 [DIRS 177391]) and *Site-Scale Saturated Zone Transport* (SNL 2008 [DIRS 184806]), forms the technical basis for the 3-D SZ Flow and Transport Abstraction, as documented in the parent document for the TSPA-LA Model. The analyses documented within this addendum utilize the same abstraction documented in the parent document (SNL 2008 [DIRS 183750], Section 6.3.1[a]). The 3-D SZ Flow and Transport Abstraction used for the analyses presented in this addendum differs from the parent document (DTNs: SN0702PASZFTMA.002_R1 [DIRS 183471], File: Test_SZ_Sampled_Vectors_Latest.txt, and SN0702PASZFTMA.001 [DIRS 179504], File: output_to_TSPA-dir.zip) only in the updated half-life values for ^{79}Se and ^{126}Sn, reflecting a revision to the source data for the radionuclide half-lives (DTN: MO0702PASTREAM.001_R0 [DIRS 179925], File: DTN-Inventory-Rev00.xls).

1-D SZ Flow and Transport Abstraction—Because the ingrowth of radionuclides is not explicitly included in the 3-D SZ Flow and Transport Abstraction, a 1-D SZ Flow and Transport Abstraction is used to account for the decay and ingrowth of radionuclide daughter products for the four decay chains shown on Figure 6.3.10-8[a]. The updated 1-D SZ Flow and Transport Abstraction (DTN: SN0710PASZFTMA.003_R0 [DIRS 183485], File: Compliance_Sampling_with_LDISP_Changes_Truncated.txt) includes the same uncertain input parameters as the 3-D SZ Flow and Transport Abstraction. With one exception, these input parameters are identical to those documented in Table 6.3.10-2 of the parent document. However, the longitudinal dispersivity that is used in the 1-D SZ Flow and Transport Model for the analyses documented in the parent document has an unbounded lognormal distribution that defines the epistemic uncertainty in longitudinal dispersivity (Table 6.3.10-2). The sampled value is further adjusted by increasing it by one order of magnitude (SNL 2008 [DIRS 183750], Section 6.5.1.2[a]). As documented in Section P15 of the parent document, the values calculated for the longitudinal dispersivity could become larger than are physically possible. The analyses documented in this addendum include an amended distribution for longitudinal dispersivity values used in the 1-D SZ Flow and Transport Abstraction (DTN: SN0710PASZFTMA.003_R0 [DIRS 183485], File: Compliance_Sampling_with_LDISP_Changes_Truncated.txt). The normal distribution for the logarithm of the longitudinal dispersivity (α_L), implemented in the 1-D SZ Flow and Transport Model for the analyses documented in this addendum, was truncated at the upper end at two standard deviations from the mean, and the sampled value was used directly without further adjustment (DTN: SN0710PASZFTMA.003_R0 [DIRS 183485], File: Readme.txt).

6.3.10.3[a] TSPA-LA Model Implementation

For the analyses documented in this addendum, the 1-D SZ Flow and Transport Abstraction is used to account for the ingrowth of the second-, third-, or fourth-generation daughters: ^{235}U, ^{231}Pa, ^{227}Ac, ^{233}U, ^{229}Th, ^{232}Th, ^{228}Ra, ^{230}Th, and ^{226}Ra. The exception is ^{234}U, which is second generation in one chain and first generation in another chain. The radionuclide mass input to the 1-D SZ Flow and Transport Abstraction comes from the UZ Transport Submodel. As documented in the parent document, this mass is fed to both the 1-D and 3-D SZ Flow and Transport Abstractions. The radionuclide mass for all species is tracked in both the 1-D and 3-D SZ Flow and Transport Abstractions. As a response to the issue identified in Section P15 of the parent document and for the analyses documented in this addendum, no mass is passed from the UZ Transport Submodel to the 1-D SZ Flow and Transport Abstraction for the following radionuclides: ^{231}Pa, ^{229}Th, ^{232}Th, and ^{226}Ra. The radionuclide mass exiting each submodel (3-D and 1-D) is then screened such that, for the biosphere calculation, only the mass from the 1-D SZ Flow and Transport Abstraction is used for the second-generation daughter species ^{235}U, ^{233}U, and ^{230}Th. In addition, for the biosphere calculations, the mass of the daughter products ^{231}Pa, ^{229}Th, ^{232}Th, and ^{226}Ra created along the transport pathway due to decay of their parent species from the 1-D SZ Flow and Transport Submodel is summed with the mass from the 3-D SZ Flow and Transport Submodel. The 3-D SZ Flow and Transport Submodel is used to transport the radionuclide mass that is passed from the UZ Transport Submodel. For these four species, no mass is passed from the UZ Transport Submodel to the 1-D SZ Flow and Transport Submodel, so the output from the 1-D SZ Flow and Transport Submodel contains only the mass of the daughter products. All the other radionuclide biosphere calculations utilize the output from the 3-D SZ Flow and Transport Abstraction. The disposition of SZ submodel mass is shown in Table 6.3.10-8[a].

Even though they are accounted for in the 3-D SZ Flow and Transport Abstraction, the parents of the second-generation daughters are also transported in the 1-D SZ Flow and Transport Abstraction. The parents are included in the 1-D SZ Flow and Transport Abstraction to account for the in growth of the second-generation daughters.

6.3.10.4[a] Model Component Consistency and Conservatism in Assumptions and Parameters

No change.

6.3.10.5[a] Alternative Conceptual Model(s) for Saturated Zone Flow and Transport

No change.

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Table 6.3.10-8[a]. Radionuclide Species Mass Passed to the Biosphere Submodel

Radionuclide Group		3-D SZ Flow and Transport Submodel	1-D SZ Flow and Transport Submodel
Fission Products		^{14}C, ^{36}Cl, ^{79}Se, ^{90}Sr, ^{99}Tc, ^{126}Sn, ^{129}I, ^{135}Cs, ^{137}Cs, ^{232}U	None
Actinide Decay Chains	Actinium Series	^{243}Am, ^{239}Pu, ^{231}Pa	^{235}U, ^{231}Pa[a]
	Neptunium Series	^{241}Am, ^{237}Np, ^{229}Th	^{233}U, ^{229}Th[a]
	Thorium Series	^{240}Pu, ^{236}U, ^{232}Th	^{232}Th[a]
	Uranium Series	^{242}Pu, ^{238}U, ^{238}Pu, ^{234}U, ^{226}Ra	^{230}Th, ^{226}Ra[a]

[a] Denotes only the radionuclide mass produced as a result of ingrowth (e.g., only the daughter product mass is counted for these species).

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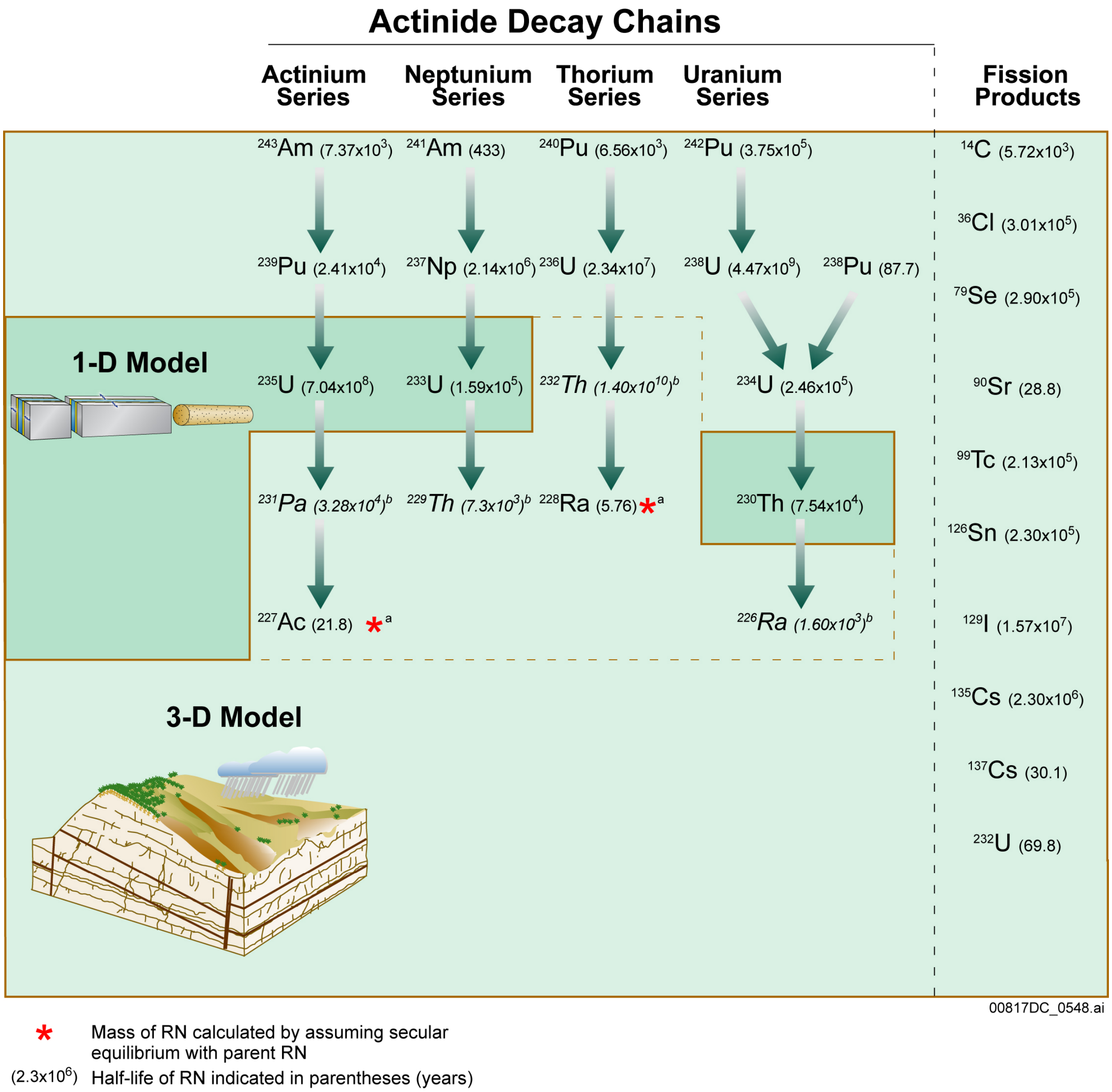

Sources: DTNs: MO0702PASTREAM.001_R0 [DIRS 179925], File: DTN-Inventory-Rev00.xls; and SN0710PASZFTMA.003_R0 [DIRS 183485], File: Radionuclides_1D_3D.doc.

NOTES: The (a) denotes half-life values used in the 1-D Transport Model taken from DTN: MO0702PASTREAM.001_R0 [DIRS 179925]; (b) denotes the mass created by ingrowth from actinide decay in the 1-D SZ Flow and Transport Abstraction for ^{231}Pa, ^{229}Th, ^{232}Th, and ^{226}Ra are added to the radionuclide mass for these species from the 3-D SZ Transport model, the combined mass is used as the input to the Biosphere Submodel calculations (Section 6.3.10.3[a]).

The Biosphere Submodel calculations use the mass released from the SZ 1-D Transport Model for radionuclides ^{235}U, ^{233}U, and ^{230}Th as indicated by the shaded areas. The Biosphere Submodel calculations use the mass released from the 3-D SZ Flow and Transport Abstraction for all other radionuclides (see Section 6.3.10[a] for details).

Figure 6.3.10-8[a]. Radionuclide Decay Chains Considered in Saturated Zone Transport Calculations

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6.3.11[a] Biosphere

No change.

6.4[a] TSPA-LA MODEL FOR THE EARLY FAILURE SCENARIO CLASS

No change.

6.5[a] TSPA-LA MODEL FOR THE IGNEOUS SCENARIO CLASS

No change.

6.6[a] TSPA-LA MODEL FOR THE SEISMIC SCENARIO CLASS

The analyses documented in this addendum include changes necessary to reflect the removal of a non-physical and conservative treatment of WP damage from seismic events following the first breach due to nominal corrosion processes as documented in Appendix P of the parent document, specifically Section P3. In addition, issues identified on Table P-6 of the parent document, Items 3, 4, and 14, have been addressed in TSPA-LA Model v5.005 (see Appendix P[a] for a list of the issues addressed in this addendum). Sections 6.6.1.3.7[a] and 6.6.1.3.8[a] outline the modifications necessary for the revised treatment of WP damage from seismic events used in TSPA-LA Model v5.005. In addition, the caption for Figure 6.6-13 in the parent document has been revised and is included as Figure 6.6-13[a]. Section 6.6.2.4[a] contains an update to two paragraphs that incorrectly documented the implementation of the Localized Corrosion Submodel for the Seismic Scenario Class.

6.6.1[a] TSPA-LA Model Components and Submodels for the Seismic Scenario Class

The subsections included in this addendum outline only the model implementation descriptions that have changed from those presented in the parent document.

6.6.1.1[a] Conceptual Model for Seismic Response of the Engineered Barrier System

No change.

6.6.1.2[a] Abstraction Model for Seismic Response of the Engineered Barrier System

No change.

6.6.1.3[a] Implementation in the TSPA-LA Model

Sections 6.6.1.3.1, 6.6.1.3.7, and 6.6.1.3.8 of the parent document have been updated to provide corrected descriptions and to reflect model changes for TSPA-LA Model v5.005.

6.6.1.3.1[a] TSPA-LA Modeling Cases

The aleatory parameter set used to calculate mean annual dose in the Seismic GM Modeling Case for 10,000 years was not reported correctly in the parent document. Table 6.6-3[a] shows the correct values for this modeling case. These corrections are described in the following paragraph.

Seismic GM Modeling Case

For each element in the Latin hypercube sample, the expected annual dose history is calculated by Equation 6.1.2-22 of the parent document, using the annual dose histories computed for each element of the Latin hypercube sample. The integral in Equation 6.1.2-22 of the parent document accounts for the uncertainty in the number of seismic events, the time of each event, and the damaged area. Table 6.6-3[a] summarizes these parameters for the Seismic GM Modeling Case (10,000 years), including the correct time for the first seismic event (200 years) and one additional CDSP damage fraction of 0.0001, which was inadvertently omitted from the parent document.

6.6.1.3.2[a] Seismic Event Time and Magnitude Calculations for the 1,000,000-Year Ground Motion Case

No change.

6.6.1.3.3[a] Methodology for Damage Abstraction Implementation

No change.

6.6.1.3.4[a] Implementation of Rockfall for the 1,000,000-Year Ground Motion Case

No change.

6.6.1.3.5[a] Implementation of Drip Shield Plate and Framework Damage from Ground Motion

No change.

6.6.1.3.6[a] Implementation of Waste Package Rupture and Puncture from Ground Motion

No change.

6.6.1.3.7[a] Implementation of Waste Package Stress Corrosion Cracking Damage from Ground Motion

The probability of seismic damage is provided for two end-member states of the WP—one with intact internals and one with fully degraded internals. In TSPA-LA Model v5.000, once any WP is breached by a nominal process in a given percolation subregion (e.g., from first occurrence of stress corrosion cracks located on the outer lids), the probability of seismic damage is switched from the intact internals abstraction to the fully degraded internals abstraction for all WPs in a given percolation subregion. This implementation selection increases the chance of seismic damage occurring while the DS is intact, which is conservative, as most of the WPs have not yet failed by the nominal processes and should be using the intact internals damage probability (as documented in Appendix P, Section P3, of the parent document). In TSPA-LA Model v5.005, documented in this addendum, the implementation has been modified as outlined below to track the fraction of packages with degraded internals (e.g., WPs that have been breached) and apply the seismic WP damage proportionally over each repository percolation subregion. The description of the implementation for the probability of WP damage for both end-member states and the calculation of WP damage area, as presented in Section 6.6.1.3.7 of the parent document, remains unchanged.

The abstractions for the probability of WP damage and for the conditional damaged area are functions of whether or not the WP internals are degraded. The internals are considered non-degraded until an intact package is breached by a seismic event or nominal corrosion process. If WP failure, due to nominal corrosion processes, occurs before the first seismic damage event, the calculation of probability of seismic damage is switched from the intact internals abstraction to the fully degraded internals abstraction, which increases the chance of seismic damage occurring. Damage from seismic events is accumulated and applied only to those WPs that are failed. When either a seismic event occurs that is large enough to damage all the WPs (including those that have not failed) or all of the WPs have been breached by nominal corrosion processes, the accumulated seismic damage area is applied to all WPs in the percolation subregion.

6.6.1.3.8[a] Waste Package Thickness Calculations

In Section 6.6.1.3.8 of the parent document, the abstraction for the probability of damage for CSNF WPs surrounded by rubble used results for a 17-mm WP outer corrosion barrier (OCB) thickness to obtain a conservative estimate of the probability of first failure time of a CSNF WP surrounded by rubble. The same approximation is used for CDSP WPs if the WP damage does not occur before DS failure. The 17-mm abstraction was applied to determine the time of first failure for a WP surrounded by rubble regardless of the time-dependent thickness of the WPs in TSPA-LA Model v5.000. In TSPA-LA Model v5.005, this conservatism is no longer applied. The first damage time to WPs surrounded by rubble is calculated using both the 17-mm and 23-mm thickness abstractions. In addition, in TSPA-LA Model v5.000, WP puncture was omitted as a mechanism contributing to the time of first WP failure because of the low probability of puncture occurring (Appendix P of the parent document, Table P-6, Item 14). In TSPA-LA Model v5.005, this omission has been corrected as outlined in the paragraphs below.

WPs and overlying DSs are partitioned among the five percolation subregions according to the partitioning described in Section 6.3.2.2.1. In the Seismic GM Modeling Case, the calculations for the probability of damage and damaged area are a function of WP OCB thickness, which depends on the general corrosion rate of Alloy 22. The general corrosion calculation depends on temperature, and other parameters that vary at the percolation subregion level and with fuel type (Section 6.3.5.1.2). Therefore, the time-dependent WP OCB thickness will be different for each of the five percolation subregions and for each of the two fuel types.

The general corrosion rate of the Titanium Grade 7 DSs is given by a distribution that is independent of percolation subregion parameters and will be the same for all DSs (Section 6.3.5.1.2).

The abstractions for WP degradation used in the Seismic GM Modeling Case require the spatially-averaged thickness of the WP OCB as a function of time. This calculation is done as part of the WP and DS Degradation Submodel calculations. The WAPDEG V4.07 software is run 10 times, once for each percolation subregion and fuel type, to produce a time history of WP thickness. This calculation is done separately from the calculation of WP breach used to feed the EBS Flow and Transport Model Component (Sections 6.3.6 and 6.3.8) for nominal corrosion processes. The general corrosion rate used for the feed to the Seismic GM Modeling Cases is done with an average rate rather than an extreme patch approximation to the general corrosion rate discussed in Section 6.3.5.1.2. The method discussed in Section 6.3.5.1.2 used the highest of four sampled corrosion rates (from the two-parameter Weibull distribution) to analyze general corrosion of the WP patch. For the purposes of the seismic abstractions, the average of the four sampled corrosion rates was used to generate the general corrosion rate fed to the WAPDEG V4.07 software (output DTN: MO0707WPDRIPSD.000 [DIRS 183005]). The GetThk_LA V1.0 (STN: 11229-1.0-00 [DIRS 181040]) software was used to post-process the thickness file output by the WAPDEG V4.07 software and generate a one-dimensional table of mean WP OCB thickness versus time. This mean thickness is a spatially-averaged WP OCB thickness over all the WPs in a particular percolation subregion for each fuel type.

Since the nominal corrosion processes calculated by the WAPDEG V4.07 software calculations are included in the Seismic GM Modeling Case, the calculations must account for inside-out corrosion that occurs after a seismic event has damaged a WP. The mean time of the first seismic event that causes WP damage is an input to the WAPDEG V4.07 calculations. However, the WAPDEG V4.07 calculations are done at the beginning of the simulation, before any seismic calculations are done. Therefore, a separate *a priori* calculation of the time that WPs are first damaged by a seismic event is carried out.

The calculation of the first damage time is performed *a priori* in the Aleatory Parameters and Dynamic Calculations GoldSim Submodel. The calculation generates a history of seismic events and evaluates whether or not each event causes WPs to fail. The time of the event that causes the first failure for each fuel type and percolation subregion is recorded as an output of the calculation. The calculation considers whether the WPs are under an intact DS or are surrounded by rubble. If the WPs are surrounded by rubble, the calculations evaluate whether or not stress corrosion crack damage or punctures occur.

CSNF and CDSP WPs are considered to have intact internals before the first seismic damage event and the probability of damage for WPs with intact internals under intact DSs is not a function of WP thickness (Figures 6.6-10 and 6.6-11; and DTN: MO0703PASEISDA.002_R4 [DIRS 183156], Tables 1-4 and 1-6). However, for CSNF WPs, damage is not likely to occur before DS failure. Therefore, for CSNF WPs, the abstraction for the probability of damage for WPs surrounded by rubble is dependent on the thickness of the WPs (Figure 6.6-15; and DTN: MO0703PASEISDA.002_R4 [DIRS 183156], Table 1-8). For each percolation subregion and fuel type, time histories for the average WP thickness under nominal conditions are generated when the Nominal Scenario Class is performed. These histories are used to determine the time of first WP damage in the Seismic Scenario Class when the DS plates have failed and the WP is surrounded by rubble.

6.6.2[a] Interaction of Seismic Scenario Class Submodels with other TSPA-LA Submodels

In the parent document, Section 6.6.2.4, Waste Package Localized Corrosion Initiation Submodel for Seismic Disruption, the title of this subsection was misleading and the first and second paragraphs contained incorrect information concerning the environmental conditions that can support initiation of localized corrosion. In addition, Section 6.6.2.4 of the parent document omitted a cross-reference to the supporting localized corrosion initiation analyses documented in Appendix O of the parent document. Section 6.6.2.4[a] of this addendum, now titled Waste Package Localized Corrosion Initiation Submodel Implementation for Seismic Disruption, includes the corrected version of only the first two paragraphs of Section 6.6.2.4. These paragraphs should be used in replacement of the first two paragraphs included in Section 6.6.2.4 of the parent document. These changes are strictly due to the documentation and do not represent any model changes from TSPA-LA Model v5.000. The conclusions and analyses presented in the parent document remain unchanged.

6.6.2.1[a] Drift Seepage Submodel and Drift Wall Condensation Submodel Modification for Seismic Disruption

No change.

6.6.2.2[a] Engineered Barrier System Thermal-Hydrologic Environment Submodel Modification for Seismic Disruption

No change.

6.6.2.3[a] Waste Package and Drip Shield Degradation Submodel Modifications for Seismic Disruption

No change.

6.6.2.4[a] Waste Package Localized Corrosion Initiation Submodel Implementation for Seismic Disruption

The Seismic Scenario Class does not include the potential effect of crown-seepage initiated localized corrosion on the WP outer surface. Although crown-seepage induced localized corrosion is possible for both the Seismic GM and FD Modeling Cases, a stand-alone localized corrosion initiation analysis has been carried out to determine if the environmental conditions required for localized corrosion initiation are present only for approximately 12,000 years after repository closure (Figure O-2 of the parent document). Beyond this time, the chemistry of the seepage water is benign, and localized corrosion no longer occurs (Section O3 of the parent document). This stand-alone analysis is documented in Section 6.3.5.2. The temperature, pH, chloride-ion concentration, and nitrate-ion concentration in aqueous solutions on the WP outer surface are the primary factors that determine the potential for initiating localized corrosion. In addition, localized corrosion can only occur if crown seepage water contacts the WP outer surface (i.e., if the DS is failed).

In the Seismic GM Modeling Case simulations, there is a low probability (Figure 7.3.2-16 of the parent document) of DS plate failure occurring before 12,000 years. Section 7.3.2.6.1.3.2 of the parent document discusses the justification for not considering localized corrosion due to these early DS failures. In the Seismic FD Modeling Case simulations, DSs can be failed at early times where environmental conditions are suitable for localized corrosion initiation. However, it is assumed that the added damage due to the fault displacement is sufficient to account for the effects of localized corrosion. This assumption has been verified by simulation runs showing that the dose is insensitive to increasing the fraction of the damaged area beyond 1/3 of the WP cross-sectional area (Section 7.3.2.7 and Figure 7.3.2-25 of the parent document).

6.6.3[a] Model Component Consistency and Conservatisms in Assumptions and Parameters

No change.

6.6.4[a] Alternative Conceptual Model(s) for Seismic Scenario Modeling Cases

No change.

Table 6.6-3[a]. Seismic Ground Motion and Fault Displacement Modeling Cases Using Pre-Specified Parameters

Modeling Case	Seismic Event Time (yr)	CSNF WP Damage Fraction (fraction of WP surface area)	CDSP WP Damage Fraction (fraction of WP surface area)	Number of Failed CSNF WPs	Number of Failed CDSP WPs	Rubble Volume Accumulated (m^3/m)	Rubble Fill Time (yr)	DS Damage Fraction (fraction of WP surface area)
Seismic 1M year FD Case[a]	1,000 20,000 80,000 200,000 400,000 800,000	0.028 0.056 0.084	0.0335 0.067 0.101	0 100	100 0	120	Seismic Event Time	1.0
Seismic 10k year FD Case[b]	200 800 2,000 4,000 8,000 18,000	0.028 0.056 0.084	0.0335 0.067 0.101	0 100	100 0	120	Seismic Event Time	1.0
Seismic 10k year GM Case[c]	200 1,000 3,000 6,000 12,000 18,000	0	1.00×10^{-7} 1.00×10^{-6} 0.00001 0.0001 0.001	0	3416	0	2,000,000	0.0
Seismic 1M yr GM Case	Section 6.6.1.3.1	Section 6.6.1.3.4	Section 6.6.1.3.4	Section 6.6.1.3.4	Section 6.6.1.3.4	Section 6.6.1.3.2	Section 6.6.1.3.2	Section 6.6.1.3.3

Source: [a] Output DTN: MO0708TSPAGENT.000 [DIRS 183000], folder: PL-TSPA-DTN-9 (PEF 126)
[b] Output DTN: MO0708TSPAGENT.000 [DIRS 183000], folder: PL-TSPA-DTN-8 (PEF 125)
[c] Output DTN: MO0708TSPAGENT.000 [DIRS 183000], folder: PL-TSPA-DTN-7 (PEF 124)

NOTE: For each modeling case run defined above, the model cycles through all possible combinations of the aleatory parameters one realization at a time, holding the epistemic sample number constant. For the Seismic FD Case (1,000,000 years) and the Seismic FD Case (10,000 years), there are 108 possible combinations of aleatory parameters. For the Seismic GM Case (10,000 years) there are 30 possible combinations of aleatory parameters.

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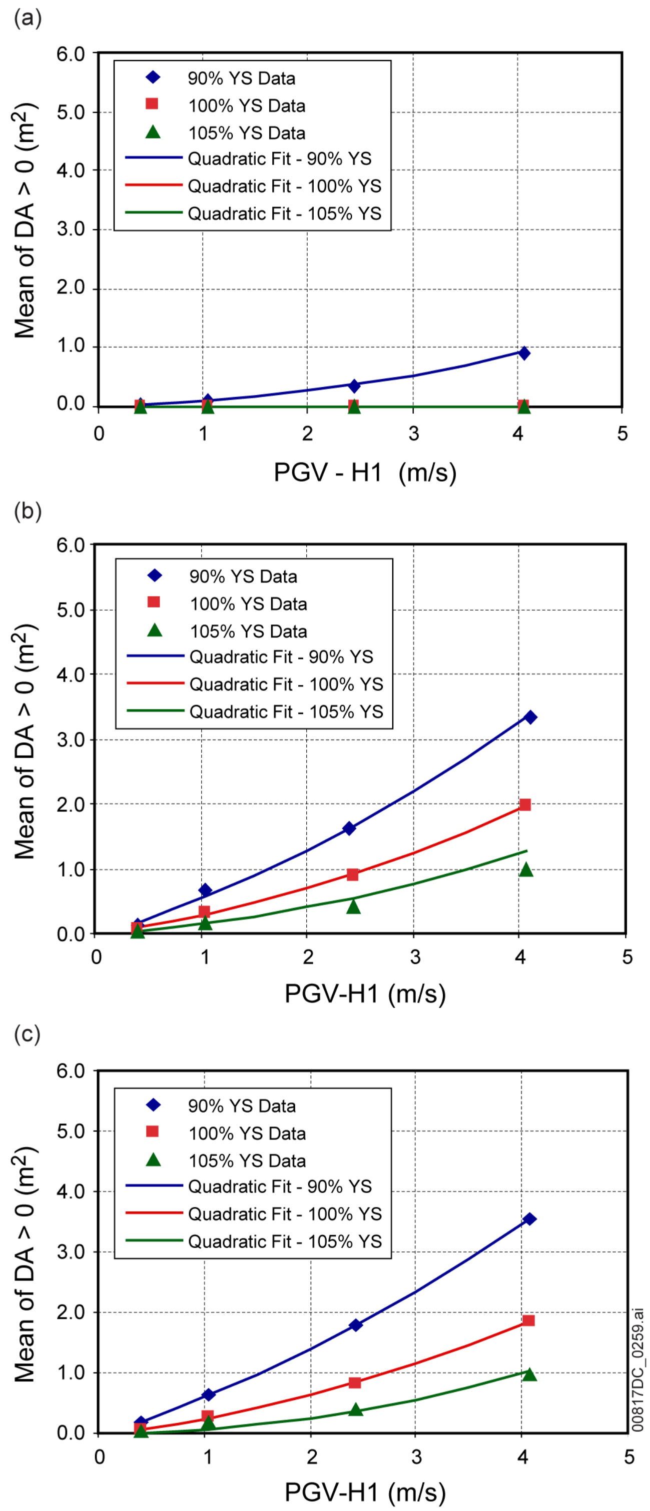

Source: DTN: MO0703PASDSTAT.001_R3 [DIRS 183148], CDSP *Kinematic Damage Abstraction 23-mm Intact.xls, Dependence on RST, CDSP Kinematic Damage Abstraction 23-mm Degraded.xls, Dependence on RST*, and *CDSP Kinematic Damage Abstraction 17-mm Degraded.xls, Dependence on RST*.

Figure 6.6-13[a]. Quadratic Fit for Mean Damaged Area on a CDSP WP under an Intact Drip Shield: (a) 23-mm WP Outer Barrier with Intact Internals, (b) 23-mm WP Outer Barrier with Degraded Internals, and (c) 17-mm WP Outer Barrier with Degraded Internals

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6.7[a] TSPA-LA MODEL FOR THE HUMAN INTRUSION SCENARIO

No change.

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