



U.S. Department of Energy
Office of Civilian Radioactive Waste Management



Preliminary Site Suitability Evaluation

Presented to:

Nuclear Waste Technical Review Board

Presented by:

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Department of Energy

Yucca Mountain Site Characterization Office

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Outline

- **Regulatory Basis for a Site Suitability Evaluation**
- **Preliminary Site Suitability Evaluation Summary**
- **Preliminary Site Suitability Evaluation Results**
- **Summary**

Regulatory Basis for a Site Suitability Evaluation

- **The Nuclear Waste Policy Act (NWPA) requires the Environmental Protection Agency (EPA) to promulgate standards for protection of the environment from offsite releases from radioactive material in repositories**
- **In accordance with the NWPA and the Energy Policy Act of 1992, the EPA has issued 40 CFR Part 197 establishing the following environmental radiation protection standards for activities at Yucca Mountain (June 2001):**
 - **Preclosure public protection standard (40 CFR 197.4)**
 - **Postclosure individual protection (40 CFR 197.20)**
 - **Human Intrusion scenario (40 CFR 197.25)**
 - **Groundwater protection (40 CFR 197.30)**

Regulatory Basis for a Site Suitability Evaluation

(Continued)

- **The NWPA requires the Nuclear Regulatory Commission (NRC) to establish requirements and criteria relating to receipt of high-level radioactive waste or spent fuel**
- **The NWPA also requires NRC to adopt and implement EPA standards**
- **These requirements and criteria apply to**
 - **Applications for authorization to construct a repository**
 - **Applications for licenses to receive and possess spent fuel and high-level radioactive waste**
 - **Applications for authorization for closure and decommissioning**

Regulatory Basis for a Site Suitability Evaluation

(Continued)

● Proposed NRC Regulations

- The NRC proposed technical and licensing criteria for the Yucca Mountain site to be codified at 10 CFR Part 63 (February 1999) include
 - ◆ Radiation protection requirements for preclosure operations in proposed 10 CFR 63.111 which references 10 CFR Part 20
 - ◆ An integrated safety analysis to demonstrate compliance with NRC requirements in the Geologic Repository Operations Area through permanent closure (proposed 10 CFR 63.112)
 - ◆ Performance objectives and performance assessment requirements to demonstrate compliance with radiation protection standards after permanent closure (proposed 10 CFR 63.113 and 10 CFR 63.114)
 - ◆ Additional requirements for licensing

Regulatory Basis for a Site Suitability Evaluation

(Continued)

● Proposed DOE Regulations

- DOE proposed site suitability guidelines to be codified at 10 CFR 963 (November 30, 1999)
 - ◆ Final rule contingent on NRC concurrence
- Proposed rule is based on technical requirements in proposed licensing rule (10 CFR Part 63)
- Proposed rule would also include preclosure and postclosure criteria that reflect processes and models important to repository system performance at Yucca Mountain
- Site suitability would be based on applicable radiation protection standards established by the EPA at 10 CRF 197 and implemented by the NRC

Regulatory Basis for a Site Suitability Evaluation

(Continued)

- **Proposed DOE Regulations** (Continued)

- **DOE's proposed preclosure suitability guidelines:**

- ◆ **Include a safety evaluation method that is consistent with the preclosure integrated safety analysis in proposed 10 CFR 63.112**
- ◆ **Emphasize performance requirements, analytical bases and technical justifications, and evaluations to assess the adequacy of the design and safety functions**
- ◆ **Address applicable preclosure radiation standards contained in proposed 10 CFR 63.111 and 40 CFR 197.40**

Regulatory Basis for a Site Suitability Evaluation

(Continued)

- **Proposed DOE Regulations** (Continued)

- **DOE's proposed postclosure suitability guidelines:**

- ◆ **Include a method for conducting a total system performance assessment (TSPA) that is consistent with the method proposed in 10 CFR 63.114 (a) through (j)**
- ◆ **Require the acquisition of field data, accounting for uncertainties, consideration of alternative models, and a structured method for evaluating features, events, and processes that might affect performance**

Regulatory Basis for a Site Suitability Evaluation

(Continued)

● Proposed DOE Regulations (Continued)

- The DOE's proposed postclosure suitability guidelines state that DOE will consider performance of the system in terms of likely compliance with the applicable radiation standards. These include:
 - ◆ Individual protection (40 CFR 197.20 and proposed 10 CFR 63.113 (b))
 - ◆ Groundwater protection (40 CFR 197.30)
 - ◆ Human Intrusion scenario (40 CFR 197.25 and proposed 10 CFR 63.113(d))

Preliminary Site Suitability Evaluation Summary

- DOE has issued a *Preliminary Site Suitability Evaluation (PSSE)* to facilitate public review and comment on a possible site recommendation
 - Considers scientific investigations and preliminary design descriptions in the body of technical work completed to date, as summarized in the Yucca Mountain Science and Engineering Report and the SSPA
 - Provides a preliminary evaluation of compliance with DOE proposed site suitability guidelines at 10 CFR 963
 - Addresses the EPA final radiation protection standards

Preliminary Site Suitability Evaluation Summary

(Continued)

- **The PSSE also considers the Supplemental Science and Performance Analyses Report that documents**
 - **The evaluation of the significance of uncertainty and degree of conservatism/optimism that was not quantified in TSPA-SR Rev 00 ICN 01**
 - **The evaluation of the significance of new information available since completion of TSPA-SR Rev 00 ICN 01**
 - **Additional analysis of thermal dependencies to more fully evaluate effects of coupled processes and thermal operating mode on system performance**
 - **Comparative TSPA analyses using the supplemental TSPA model over a range of possible thermal operating modes**

Preliminary Site Suitability Evaluation Summary

(Continued)

- **The SSPA includes**

- **Volume 1 focusing on the technical work within each process model area, encompassing uncertainty quantification, updated scientific bases, and analyses of a range of operating modes**
 - ◆ **Subjects are organized in a manner similar to the organization found in the Yucca Mountain Science and Engineering Report**
- **Volume 2 documenting analyses that provide insight into the effects on Total System Performance Assessment (TSPA) of information in Volume 1**

Preliminary Site Suitability Evaluation Summary

(Continued)

- **PSSE structure**

- **Section 1: Introduction**
- **Section 2: Preliminary Preclosure Suitability Evaluation**
- **Section 3: Preliminary Postclosure Suitability Evaluation**
- **Section 4: Summary of Results**

Structure of Preliminary Preclosure Site Suitability Evaluation (Figure 1-1)

EVALUATION PROCESS

- Evaluate whether site is likely to meet applicable radiation protection standards
- Consider performance of system in terms of criteria

- Evaluate ability to preserve option to retrieve wastes during preclosure period

- Structures, systems, equipment, operator actions to mitigate or prevent accidents
- Design bases & limits on operations
- Adequacy of facilities to perform functions
- Hazards, event sequences, consequences
- Site characteristics, surface & underground facilities

DOCUMENTATION

Preliminary Site Suitability Evaluation

**Retrieval Equipment & Strategy Documents
System Description Documents**

**Preliminary Preclosure Safety Assessment
Design Documents
System Description Documents**



Preliminary Preclosure Evaluation Results

- **Summary of preliminary preclosure suitability evaluation**
 - **Dose to repository workers during the preclosure period would fall below the limits specified in the EPA radiation protection standards and proposed NRC requirements**
 - **Dose to individual members of the public for normal operations and category 1 design basis events (e.g., postulated accident during handling) would fall below the limits specified in the EPA radiation protection standards and proposed NRC requirements**

Summary of Preclosure Dose Limits and Preliminary Results (Table 4-1)

Standard	Limits	Preliminary Results
EPA 40 CFR 197 Subpart A Environmental Standards for Storage		
Public Protection Standard, 40 CFR 197.4	15 mrem ^a	0.06 mrem ^b
NRC Proposed 10 CFR 63 Subpart E Technical Criteria		
Public Exposures		
Preclosure Performance Objective, Proposed 10 CFR 63.111(a)(2) for normal operations and Category 1 design basis events	25 mrem ^b	0.06 mrem ^b
ALARA Implementation for Air Emissions, 10 CFR 20.1101(d)	10 mrem ^b	0.06 mrem ^b
Dose Limits for Individual Members of the Public for normal operations and Category 1 design basis events, 10 CFR 20.1301	100 mrem ^b	0.06 mrem ^b
	2 mrem/hr in any unrestricted area from external sources	<<2 mrem/hr
Preclosure Performance Objective, Proposed 10 CFR 63.111(b)(2) for Category 2 design basis events	5,000 mrem ^b	20 mrem ^b
	50,000 mrem organ or tissue dose (other than the lens of the eye)	100 mrem
	15,000 mrem lens of the eye dose	60 mrem
	50,000 mrem skin dose	40 mrem
Workers' Exposures		
Occupational Dose Limits for Adults from normal operational emissions and Category 1 design basis events, 10 CFR 20.1201	5,000 mrem ^b	10 mrem ^b
	50,000 mrem organ or tissue dose (other than the lens of the eye)	100 mrem
	15,000 mrem lens of the eye dose	100 mrem
	50,000 mrem skin dose	100 mrem
Routine Occupational Dose Limits for Adults, 10 CFR 20.1201	5,000 mrem ^b	150 to 400 mrem ^{b,c}

NOTES:

^aAnnual committed effective dose equivalent.

^bAnnual total effective dose equivalent.

^cDraft Environmental Impact Statement for a Geologic Repository for the Spent Nuclear Fuel and high Level Waste, Nye County, Nevada.

ALARA = as low as reasonably achievable.



Structure of Preliminary Postclosure Site Suitability Evaluation (Figure 1-2)

EVALUATION PROCESS

DOCUMENTATION

- Evaluate whether site is likely to meet applicable radiation protection standards
- Identify natural and design features important to isolating waste
- Evaluate postclosure suitability, considering suitability criteria

PSSE

- Conduct Total System Performance Assessments
- Account for uncertainty and variability
- Conduct sensitivity studies

TSPA-SR and SSPA

- Provide technical bases for TSPA models
- Provide technical bases for FEPs
- Identify and use data related to criteria

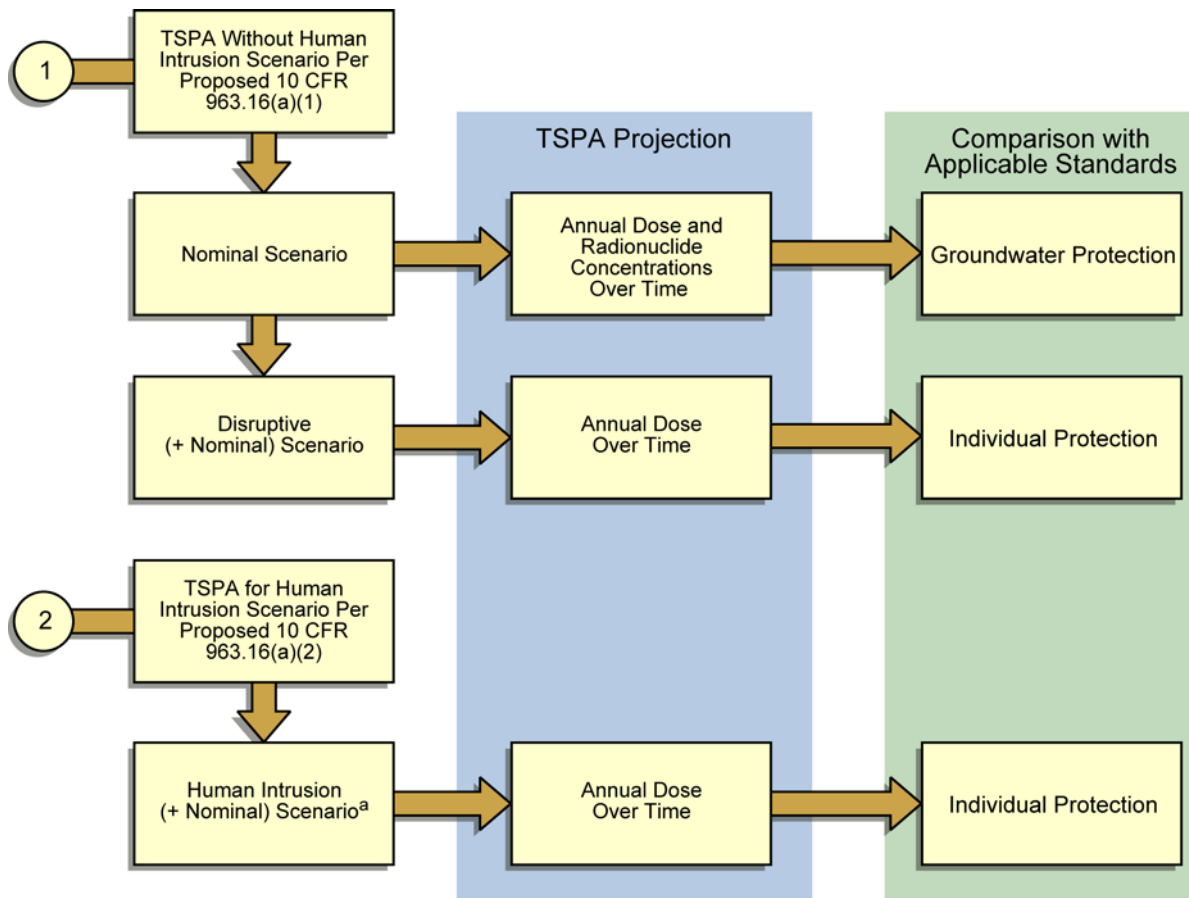
Features, Events, and Processes (FEPs) Screening & Model Abstraction

- Process models
- Empirical observations

Process Model Reports and Analysis and Model Reports



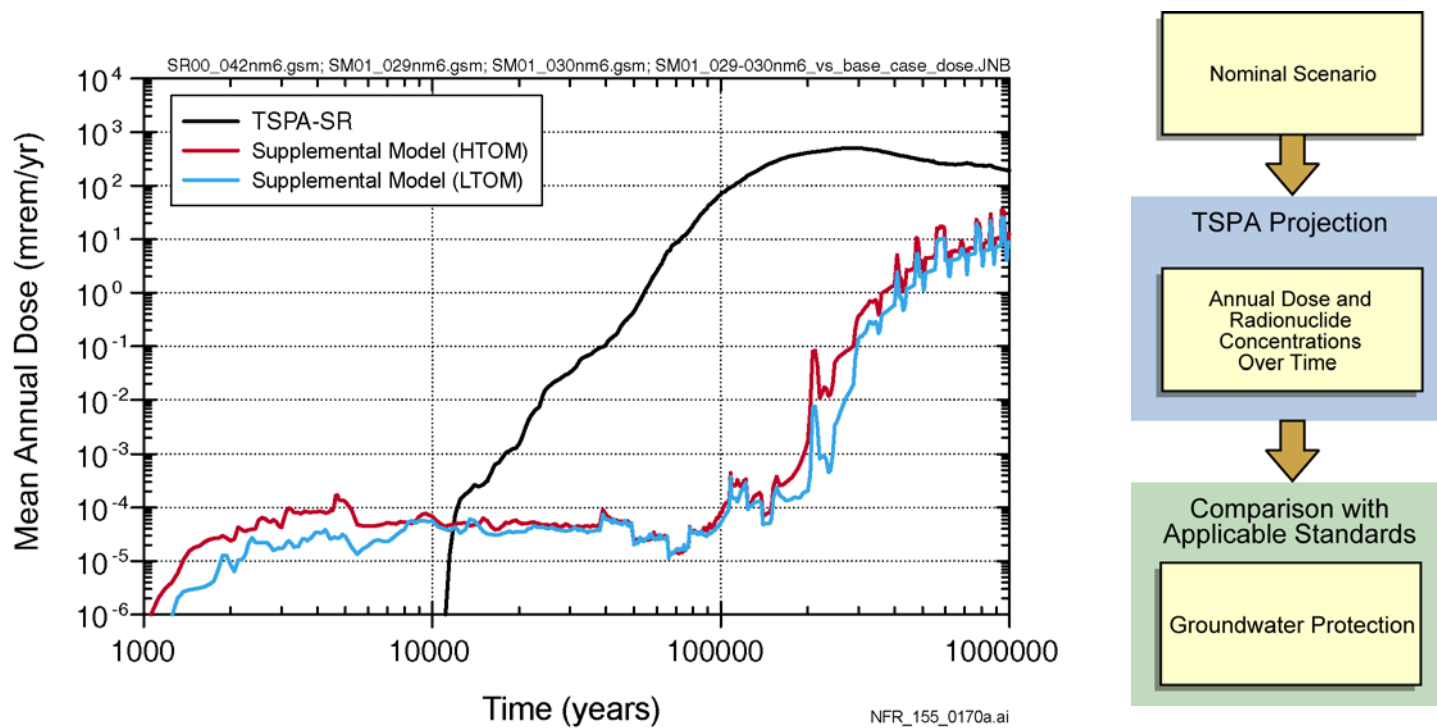
TSPA Analyses for Site Suitability Evaluations (Figure 3-2)



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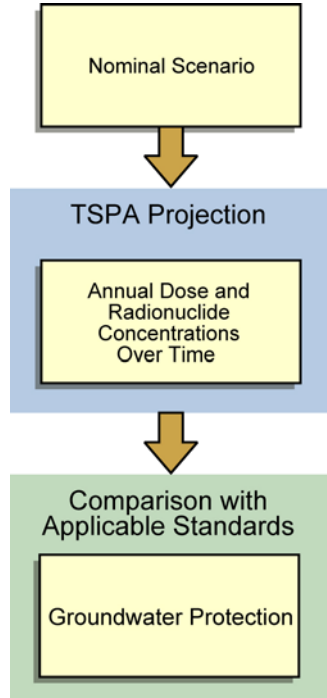
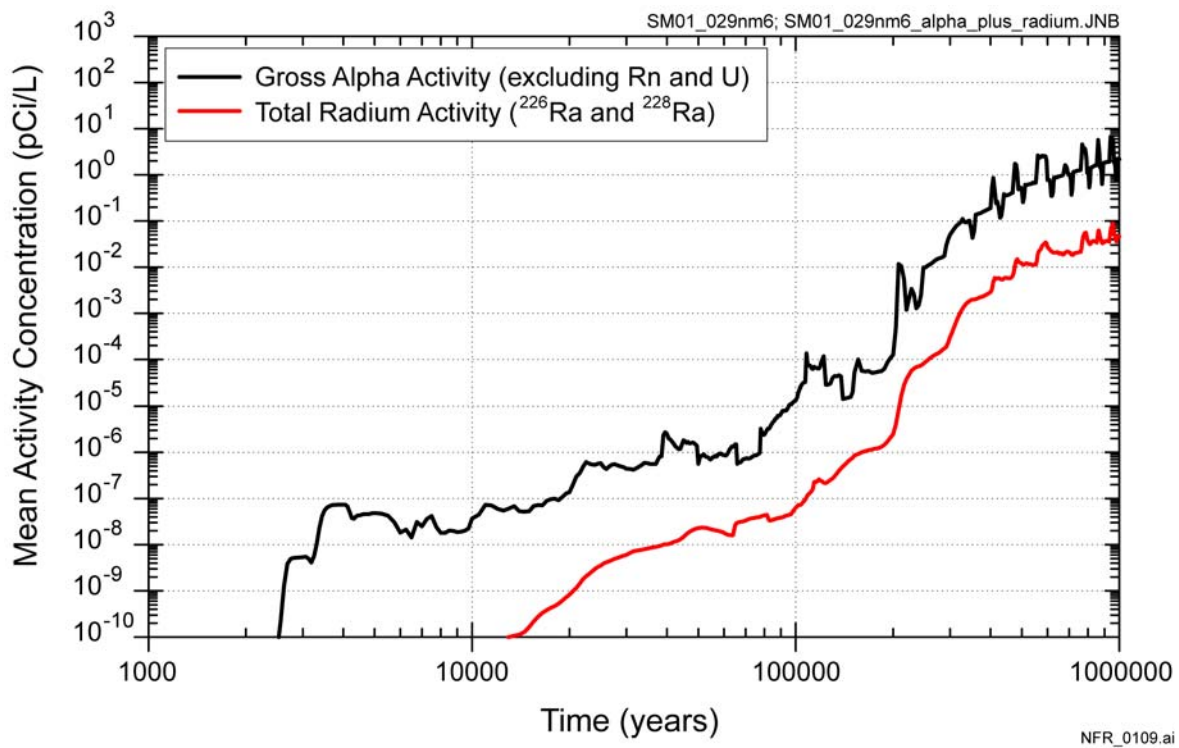
^A The disruptive scenario was not considered for the human intrusion scenario in TSPA

TSPA-SR Model and Supplemental TSPA Model Results: Million-Year Annual Dose Histories for Nominal Performance (Figure 3-3)



Note: Mean annual dose histories are shown for the nominal scenario for TSPA-SR and the higher- temperature operating mode (HTOM) and the lower-temperature operating mode (LTOM) for the supplemental TSPA model in the SSPA.

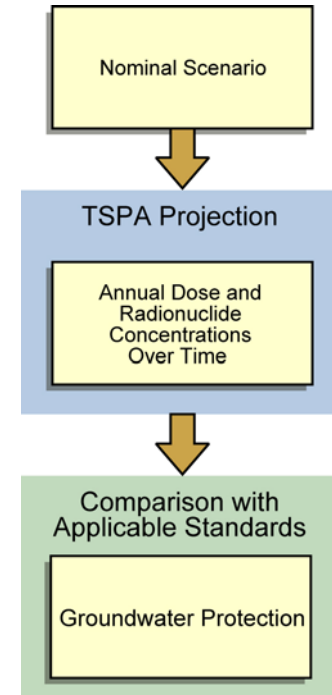
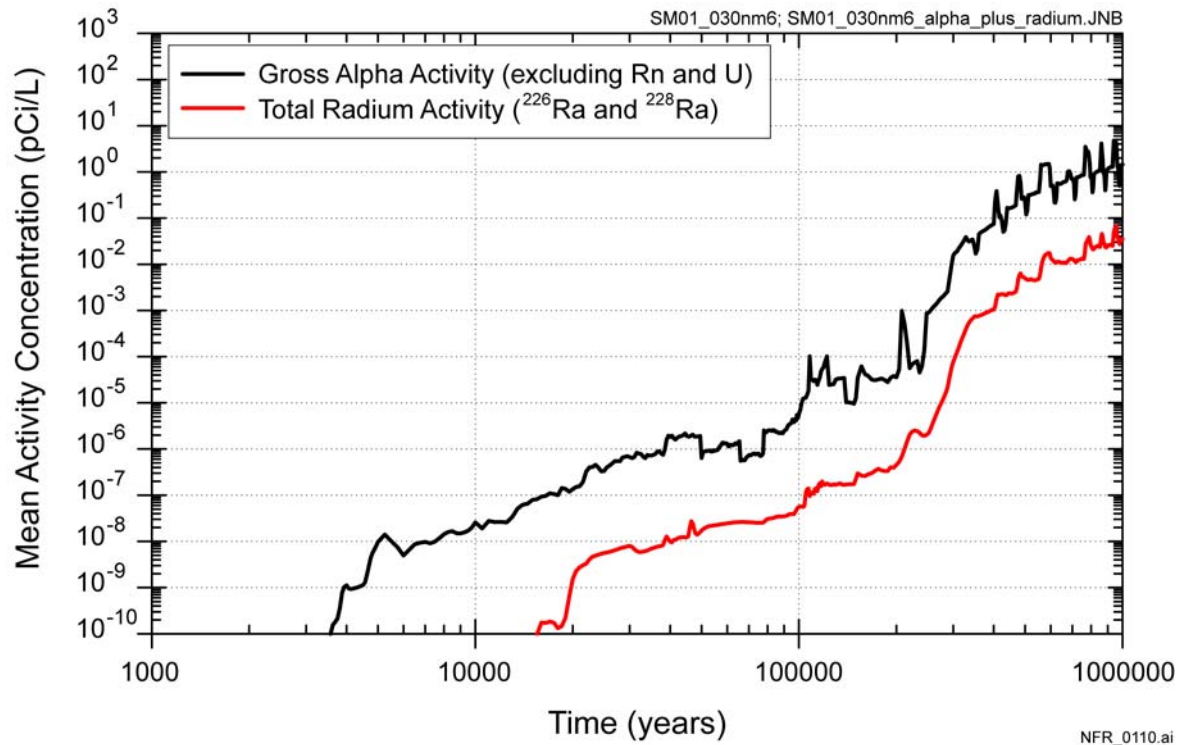
Mean Concentrations of Gross Alpha Activity and Total Radium in Groundwater, Higher Temperature Operating Mode (Figure 3-4)



Note: Concentrations calculated for a representative volume of water of 1,285 acre-ft, 20 km from the potential repository location. Naturally occurring background radionuclide concentrations are not included.

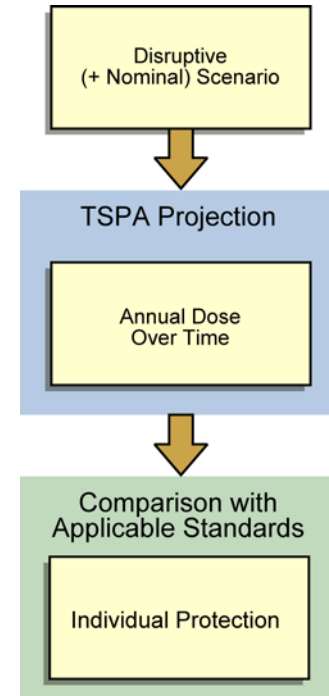
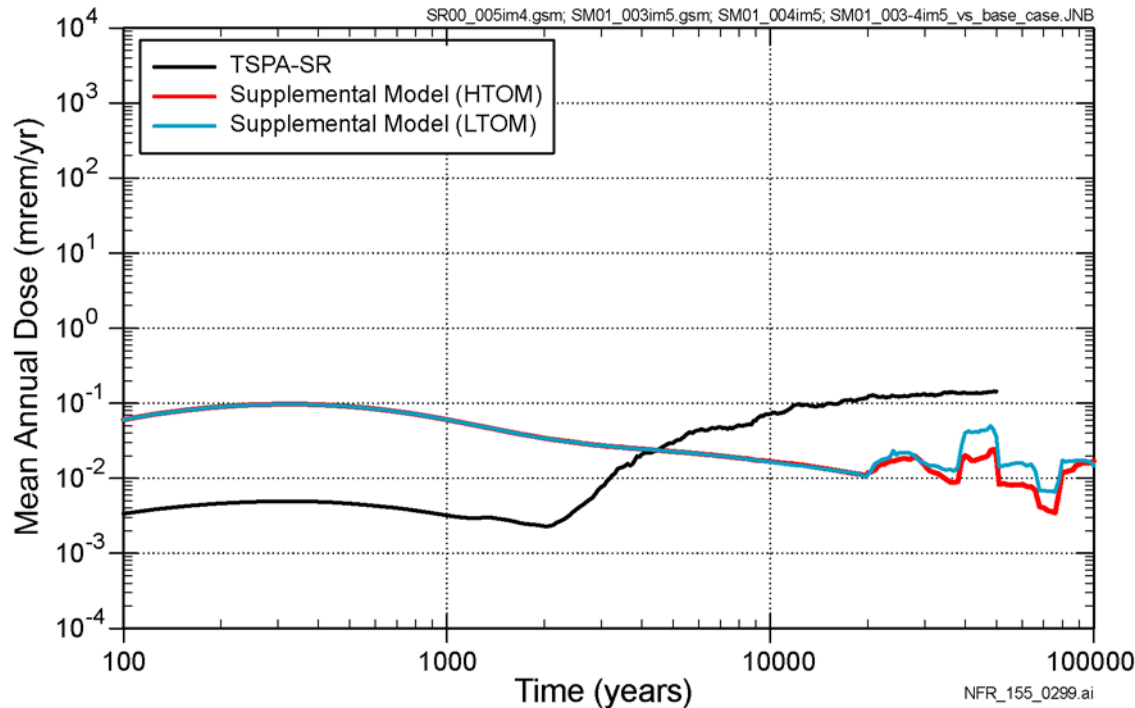


Mean Concentrations of Gross Alpha Activity and Total Radium in Groundwater, Lower Temperature Operating Mode (Figure 3-5)



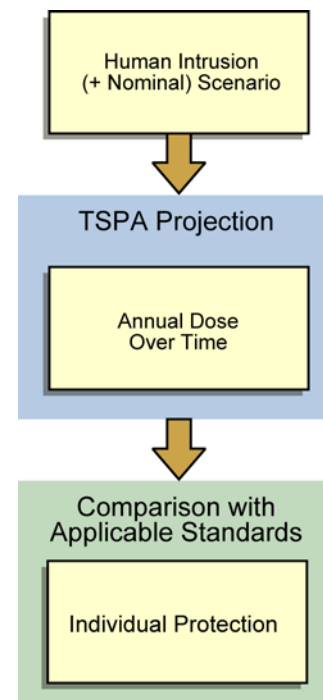
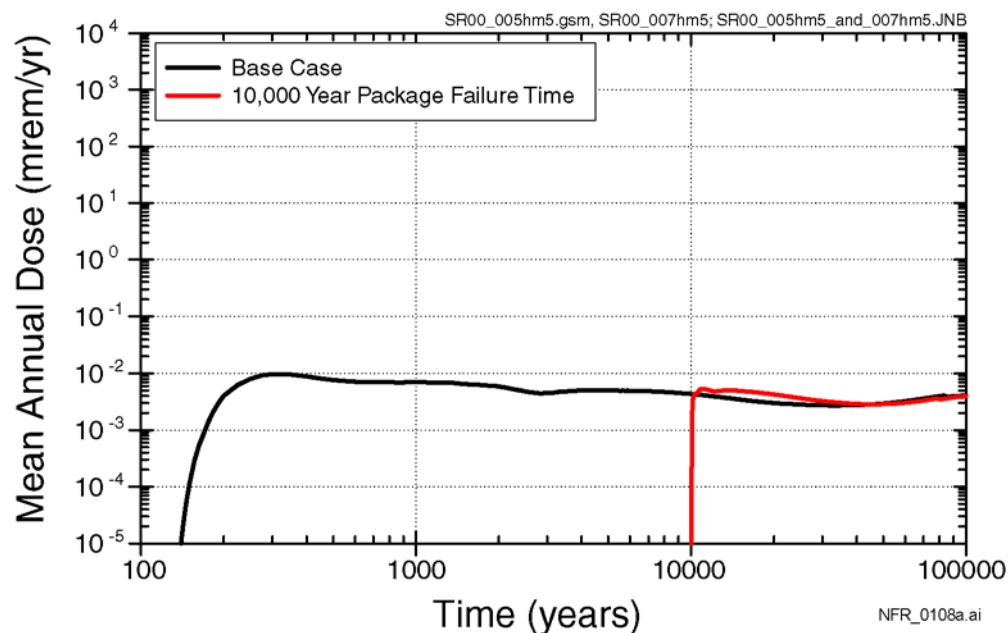
Note: Concentrations calculated for a representative volume of water of 1,285 acre-ft, 20 km from the potential repository location. Naturally occurring background radionuclide concentrations are not included.

Projected Annual Doses for the Igneous Activity Disruptive Scenario (Figure 3-6)



Note: Probability-weighted mean annual dose histories are shown for the nominal scenario for TSPA-SR and the higher- temperature operating mode (HTOM) and the lower-temperature operating mode (LTOM) for the supplemental TSPA model in the SSPA. Largest Contributor to the increase in projected dose for the HTOM and the LTOM: changes to the dose conversion factors. Other factors include a change in wind speed, an increase in the conditional probability of an eruption at the repository location, and an increase in the total number of eruptive conduits possible within the repository.

Comparison of Total Mean Dose Histories for Human Intrusion Scenarios with Intrusions Occurring at 100 Years and 10,000 Years After Closure (Figure 3-9)



Note: Mean curves based on probabilistic TSPA-SR simulations with 100 realizations (sufficient to see the relative effects of an intrusion 10,000 years after closure in comparison to the base-case intrusion, 100 years after closure).

Preliminary Postclosure Evaluation Results

- **Summary of preliminary postclosure suitability evaluation**
 - **For individual protection, the dose estimates from combined nominal scenario and disruptive scenario would fall below the limits specified in the EPA radiation protection standards of 15 mrem/yr and NRC proposed postclosure performance objective of 25 mrem/yr**
 - **Groundwater concentrations calculated would fall below the EPA groundwater protection standards**
 - **Human intrusion scenario related releases calculated would fall below the EPA radiation protection standards**

Summary of Postclosure Dose Limits and Preliminary Results (PSSE Table 4-2)

Standard	Limits	Range of Peak Mean Annual Doses for 10,000 Years ^a
EPA 40 CFR Part 197 Subpart B Environmental Standards for Disposal		
Individual protection standard: 40 CFR 197.20	15 mrem ^b	0.08 mrem to 0.1 mrem ^c
Human intrusion standard: 40 CFR 197.25	15 mrem ^b	0.01 mrem ^d
Groundwater protection standard: 40 CFR 197.30	5 pCi/L combined radium-226 and radium-228, including natural background	1.04 pCi/L ^e
	15 pCi/L gross alpha activity (including radium-226 but excluding radon and uranium), including natural background	1.1 pCi/L ^e
	4 mrem/yr whole body or any organ combined beta- and photon-emitting radionuclides	0.0 to 0.00005 mrem
NRC Proposed 10 CFR Part 63 Subpart E Technical Criteria		
Postclosure performance objective: proposed 10 CFR 63.113(c)	25 mrem ^f	0.08 mrem to 0.1 mrem ^c
Human intrusion performance objective: proposed 10 CFR 63.113(d)	25 mrem ^f	0.01 mrem ^d

NOTES: ^aThe ranges presented in the table represent results calculated by the TSPA-SR model and the supplemental TSPA model. The numbers were calculated for a compliance point 20 km (12 mi) from the repository. Qualitative evaluations of the difference in consequence due to the changes in the final EPA rule are described in this report.

^bAnnual committed effective dose equivalent.

^cProbability-weighted peak mean annual dose equivalent for the nominal and disruptive scenario, which includes volcanism.

^dPeak mean annual dose equivalent.

^eThese values represent measured natural background radiation concentrations. Calculated numbers are well below minimum detection levels and regulatory requirements.

^fAnnual total effective dose equivalent.



Summary

- **The PSSE documents a preliminary evaluation of the Yucca Mountain site against the criteria proposed at 10 CFR Part 963**
- **It reflects consideration of analytical requirements consistent with the technical approach embodied in NRC's proposed regulation, 10 CFR Part 63**
- **It presents the results of preliminary preclosure and postclosure evaluations of suitability over a range of thermal operating modes, and shows that the calculated doses would fall below the EPA radiation standards and the proposed NRC performance objective**