Total System Performance Assessment Analyses Evaluating the Final Environmental Protection Agency and Nuclear Regulatory Commission Rules

Presented to:
Nuclear Waste Technical Review Board

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Overview

• Total System Performance Assessment-Site Recommendation (TSPA-SR) Documentation

• Contents of TSPA Letter Report on Final Environmental Protection Agency (EPA) Rule (40 CFR Part 197)
  – To evaluate differences between proposed and final rule

• Contents of TSPA Letter Report on Final Nuclear Regulatory Commission (NRC) Rule (10 CFR Part 63)
  – To evaluate minor differences between proposed and final rule

• Summary
TSPA-SR Documentation

September 2000

TSPA SR
Rev 00

Documents base case TSPA-SR model

December 2000

TSPA SR
Rev 00, ICN 01

Updates base case model to include long term climate model, and secondary phase effects

July 2001

SSPA
Volume 2

Provides additional supplemental TSPA analyses based on TSPA-SR model, including UU analysis, updates in scientific information, and analysis of higher- and lower-temperature operating modes

September 2001

Input to FEIS and SSE

Additional TSPA analyses to respond to final 40 CFR Part 197 EPA rule, including distance to RMEI and calculation of RN concentrations in groundwater at ~18km from the repository and using 3,000 acre-ft as the annual representative volume of water for assessing groundwater protection.

November 2001

TSPA Sensitivity Analyses for Final Regulation

Additional TSPA evaluations to address final 10 CFR Part 63 provisions, including the possible handling of unlikely events (igneous intrusion) in assessing groundwater protection and human intrusion, and the effects of a change to 3,000 acre-ft/hr water demand for evaluation against the individual protection standard.

- Conducted TSPA analyses for updated Supplemental Science and Performance Analyses (SSPA) model
- Analyses considered various waste inventories
  - 70,000 MTHM inventory High Temperature Operating Mode (HTOM) and Low Temperature Operating Mode (LTOM)
  - Expanded inventory (Module 1 and Module 2) (HTOM)
- Analyses for Igneous Activity Scenarios (HTOM/LTOM)
- Analyses for Human Intrusion (HI) Scenarios (HTOM)
  - 30,000 years post closure
  - 100 years post closure
Details of Changes in SSPA TSPA Model

- Groundwater protection assessment modified as specified in 40 CFR Part 197
  - Reasonably Maximally Exposed Individual (RMEI) Biosphere Dose Conversion Factors (BDCFs)
  - 18 km saturated zone (both for groundwater release and ash deposition)
  - 3000 ac-ft/yr average water demand used in individual protection analyses

- Waste inventory calculations removed U.S. Navy spent nuclear fuel from DSNF inventory. Represented Navy fuel as CSNF

- Waste-package corrosion calculations assumed general corrosion independent of temperature
Details of Changes in SSPA TSPA Model

(Continued)

- Process-level LTOM thermal-hydrologic results were corrected to include radiation connections in the thermo-hydrologic model
- Some minor errata corrected in human intrusion scenario, including addition of colloidal transport to UZ borehole
- New version of WAPDEG (includes microbiologically influenced corrosion (MIC) and aging multipliers for inside-out corrosion)
High Temperature Operating Mode Compared to Low Temperature Operating Mode (Nominal case)

- No significant difference between the 2 operating modes in terms of total system performance
- Long waste package lifetime diminishes the effect of early thermal period
Analyses Considered Various Waste Inventories (HTOM only)

- **70,000 MTHM inventory**

- **Module 1: all waste**
  - Commercial Spent Nuclear Fuel (CSNF), DOE Spent Nuclear Fuel (DSNF), High-Level Waste (HLW)

- **Module 2 only:**
  - Greater Than Class C (GTCC) and Special Performance Assessment Required (SPAR)

![Graph showing Mean Annual Dose (mrem/yr) over time (years) with different waste inventories and dose rates.]

Higher C-14 inventory in GTCC.
Analyses for Igneous Activity Scenarios (HTOM/LTOM)

- Updated for 40 CFR 197
  - 18 km RMEI location
  - BDCFs updated
  - Other Features
- Early dose greater than TSPA-SR, but dose decreases at later time
Analyses for Human Intrusion Scenarios

- Waste package has degraded enough so that driller would not recognize it
- Release from 1 waste package through borehole to saturated zone
- HI at 30,000 years
- Proposed NRC rule of HI at 100 years
Contents of TSPA Letter Report on Final NRC Rule (10 CFR Part 63)

• Groundwater (GW) protection standard evaluation utilizing an unlikely igneous-intrusion scenario
  – For both HTOM and LTOM
  – For total radium concentration, gross alpha concentration, and dose to critical organs

• Individual protection standard for HI considering an unlikely igneous intrusion
  – HI assumed to occur immediately after the igneous intrusion

• Use of 3,000 Acre-ft per year water demand for individual protection standard calculation
  – For dose calculation to the RMEI
Unlikely Events

- “Unlikely Features, Events & Processes (FEPs)” not defined in 10 CFR Part 63
- Definition of unlikely was expected to be between $10^{-8}$ and $10^{-4}$ per year at time of these analyses
- Mean annual probability of igneous intrusion at potential repository is $1.6 \times 10^{-8}$ per year ($\Delta$)
- HI considered to be very unlikely
GW Protection Standard Evaluation With an Unlikely Igneous-Intrusion Scenario

- Igneous intrusion disrupts waste packages leading to release to unsaturated zone and then to groundwater
- Calculated total radium concentrations are orders of magnitude lower than background (1.04 pCi/l)
- Calculated gross alpha concentrations are \(~10\) percent of background (0.4 pCi/l) for first 10,000 years
Scenario Logic for Human Intrusion after Igneous Event

- Base case expects HI wouldn’t occur until 30,000 years after closure
  - Waste package could be degraded by corrosion processes sufficiently so that driller wouldn’t recognize it (a hole is opened in the waste package)
- Assumes an igneous event occurs that compromises some waste packages
- Assumes driller would not recognize the waste package after igneous disruption
- Consequence determined by multiplying the conditional dose, the probability of the initiating igneous intrusion event time, and the probability of the driller not detecting the waste package (assumed to be 1 in this case)
Individual Protection Standard for Human Intrusion with an Unlikely Igneous Intrusion

- Assume igneous intrusion probability sometime prior to 30,000 years is $4.8 \times 10^{-4}$ ($30,000 \text{ years} \times 1.6 \times 10^{-8} \text{ per year}$)
- Assume HI at 100 years post-closure (max mean dose $4.8 \times 10^{-3} \text{ mrem/yr}$)
- Approximate maximum mean dose for this case is $2.3 \times 10^{-6} \text{ mrem/year}$
- Potential maximum mean dose due to HI preceded by igneous intrusion is concluded to be much lower than the maximum mean dose due to the igneous intrusion alone
Use of 3,000 Acre-ft per year Water Demand on Individual Protection

- Prior to final NRC rule, water demand was approximately 2,000 acre-ft per year (range of 887 to 3367 acre ft per year)
- Final rule required use of 3,000 acre-ft per year
- Result was to scale the dose to the RMEI by approximately 2/3
- Peak mean annual dose for HTOM was reduced from $1.7 \times 10^{-5}$ mrem/year to $1.1 \times 10^{-5}$ mrem/year
Summary

- Additional analyses conducted to evaluate effect of finalized Environmental Protection Agency (EPA) and Nuclear Regulatory Commission (NRC) rules
- Analyses documented in letter reports (included in statewide Supplemental Hearings in December, 2001)
- Analyses supplemented other TSPA analyses conducted for SR