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YUCCA
MOUNTAIN
PROJECT

Studies

VA Results from Importance (DID) Analysis

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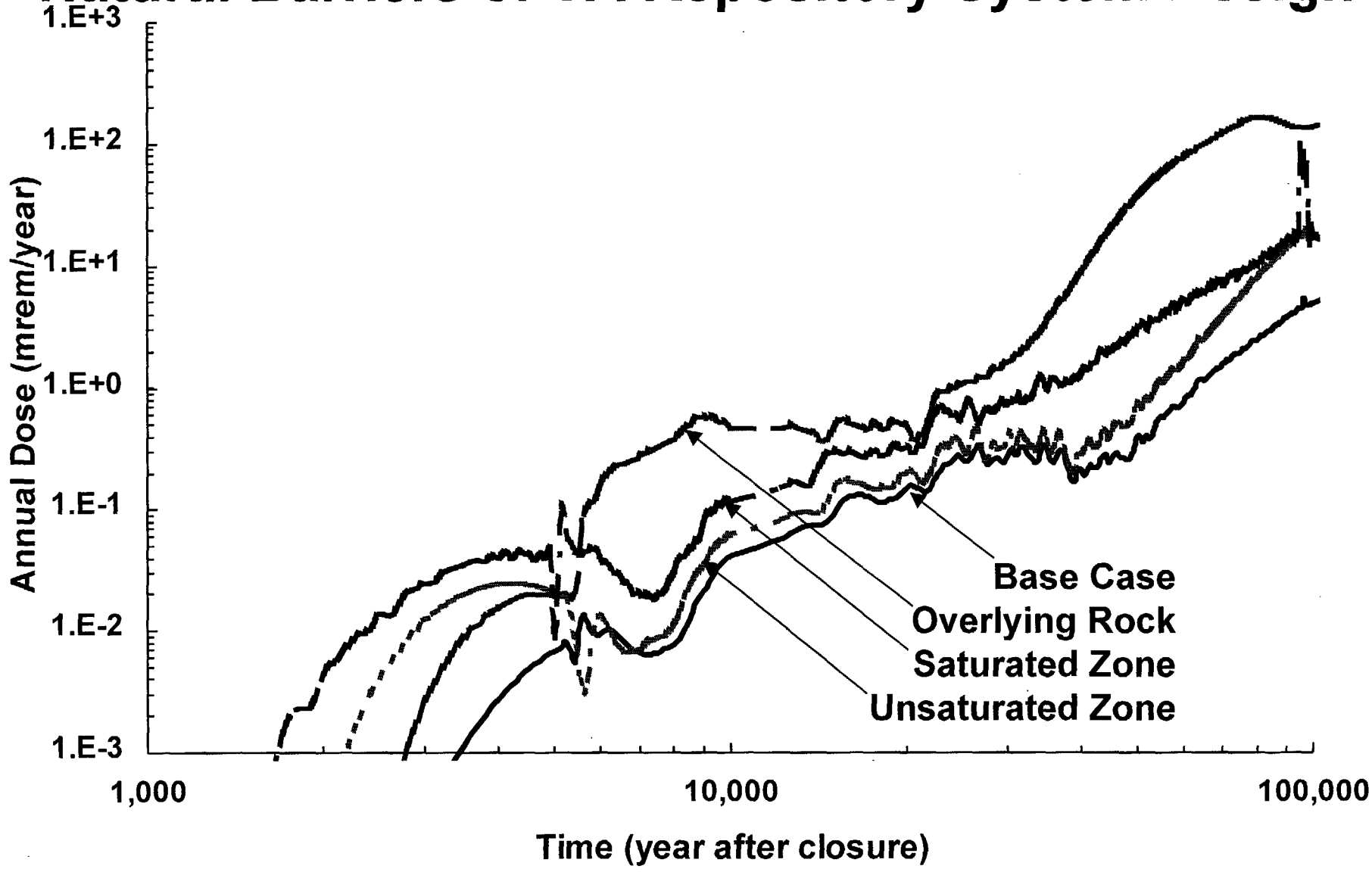
Legacy / Main - Ro

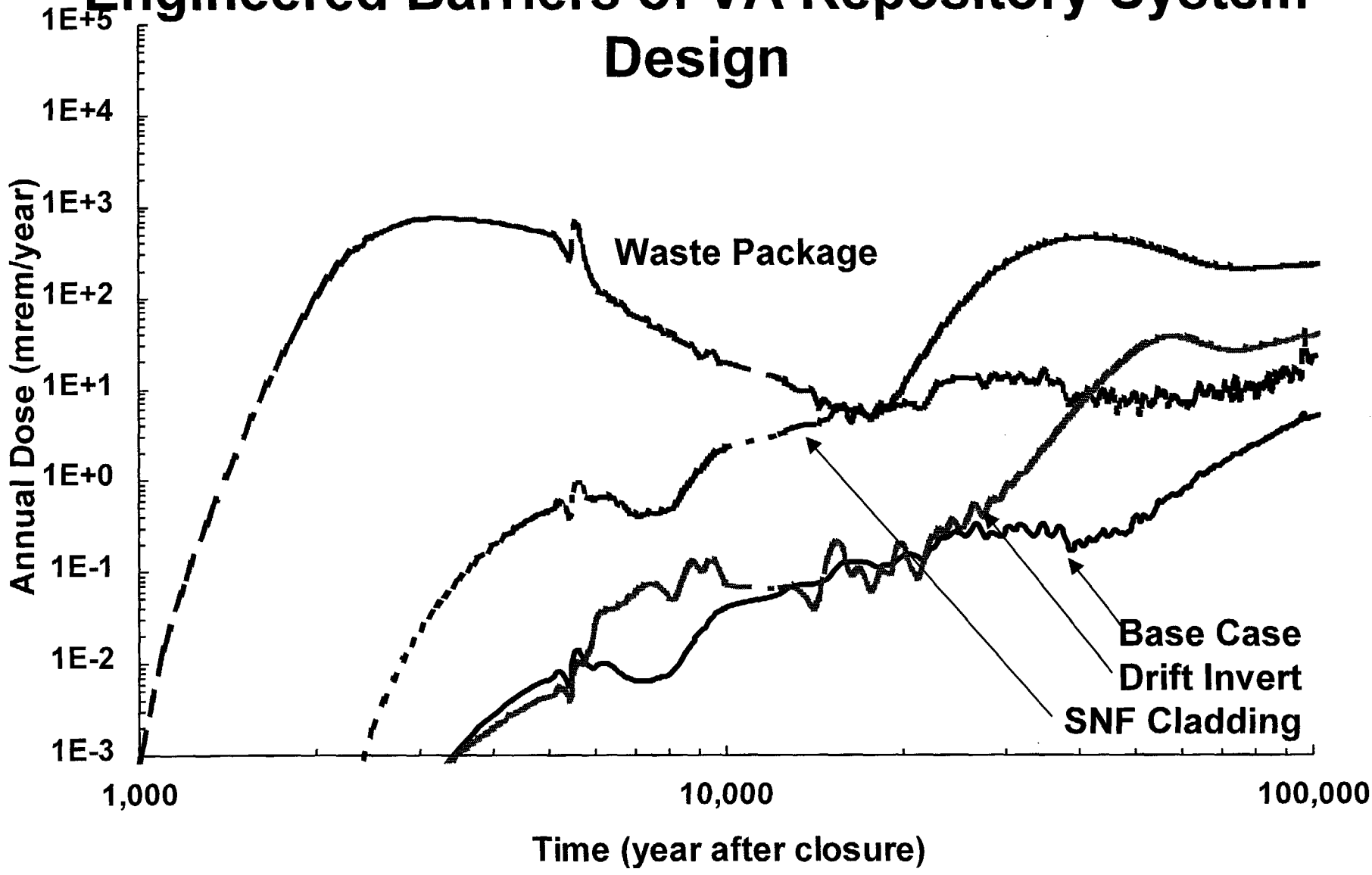
Overview

- Issues identified at the 1/25/99 NWTRB meeting
- NRC letter highlighting potential issues
  - Potential differences in concepts of neutralization and importance analysis
  - Potential differences in how TSPA codes and models are used to represent the system
  - Desirability of resolving issues with importance analysis well in advance of licensing
- Objective here is to address these three issues

Neutralizing Water/Radionuclide Barrier Functions
Natural Barriers of VA Repository System Design



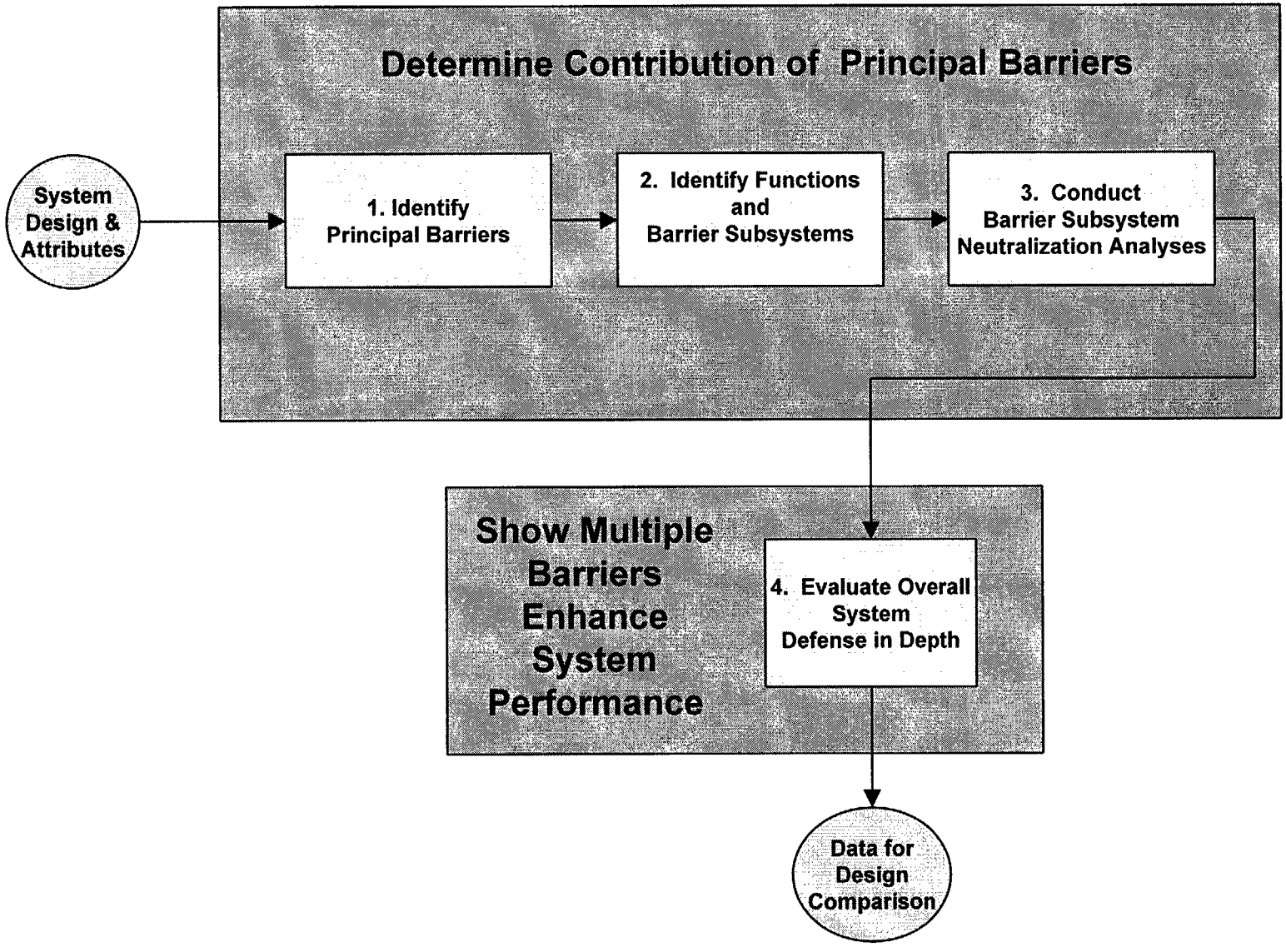
Neutralizing Water/Radionuclide Barrier Functions Engineered Barriers of VA Repository System Design



Question 1: Concepts of Neutralization and Importance Analysis

- Summary of concept
- Limitations of the application to the VA system

Approach for VA Evaluation



1. Identify Principal Barriers

- Candidates identified in TSPA analyses
- Barriers are features that inhibit movement of water or radioactive materials
  - Fractional rate of transmission < 10-4 per year or (1)
  - Travel time delay > 1,000 years (2)
- Principal Barriers for VA Reference System
  - Overlying rock units (barriers to water) (2)
  - Waste package barriers (barriers to water) (2)
  - Cladding (barrier to water) (2)
  - Drift invert (barrier to radionuclide transport) (1)
  - Unsaturated zone (UZ) radionuclide transport barriers (1) & (2)?
  - Saturated zone (SZ) radionuclide transport barriers (1) & (2)

2. Identify Functions and Barrier Subsystems for Neutralization

- Identify function (e.g., barrier function)
- Identify each barrier subsystem contributing to the function
- Also identify combinations of barriers subject to "common-mode" issues
  - Occurrences affecting multiple barriers
  - Failure of one barrier affects another
  - Common source of model uncertainty

3. Neutralize Barriers--Determine Contribution of Each Barrier

- Neutralize each barrier system with respect to the function at issue
- Object is to determine contribution to base case performance: barrier is completely neutralized
- Difference indicates contribution--however, assessment must consider all neutralizations

4. Assess Overall Postclosure Defense in Depth

- Use simple measure
  - Consider difference relative to those of other barriers--indicates degree of defense in depth
  - Consider difference relative to standard--indicates significance of uncertainties in models for barrier
- Measure indicates whether performance depends unduly on any single barrier
- Measure indicates whether uncertainties in any principal barrier are compensated by performance of others

Summary: Concepts of Neutralization and Importance Analysis

- Concepts of the Approach
  - An approach to assessing contribution of principal barriers
  - Provides transparency in evaluating roles of barriers
  - Permits examination of importance of model assumptions
- Issues
  - Neutralization models complex except in limited situations
  - Simple neutralizations limit assessment of coupled effects
  - Functions most profitably neutralized
  - Impact of model uncertainty on the approach itself

Question 2: Use of PA Models and Codes in Representing the System

- Comparison of DOE and NRC models
- Causes for differences in results
- Using the approach to examine the importance of model assumptions and uncertainty

Comparison of DOE and NRC Models--Seepage

- Fraction WP wetted
  - Results directly proportional to fraction.
  - TSPA-VA: 1 to 10 percent under current climate. Up to 25 percent under long-term average climate.
  - TPA 3.2: 0 to 100 percent (uniform)
- Flow Rate
  - Not too important for advectively-dominated release because all exposed technetium and iodine flushed from WP for even very low flow rate.
  - TSPA-VA: Based on percolation flux.
  - TPA 3.2: Based on a reflux model that can significantly delay water contacting the waste.

Comparison of DOE and NRC Models-- Waste Package Degradation

- Corrosion Processes (CRM)
  - Both TPA 3.2 and TSPA-VA consider localized and uniform corrosion of CRM.
  - Both models utilize temperature switch for CRM.
- Timing of Waste Package Failure: Corrosion
  - TSPA-VA: slightly less than 10,000 years to more than 700,000 years.
  - TPA 3.2: slightly greater than 10,000 years to slightly less than 50,000 years.
- Variability in Corrosion Failure
  - TSPA-VA: considerable
  - TPA 3.2: little

Comparison of DOE and NRC Models-- Other Waste Package Failure Modes

half the time = 0

- **Juvenile Failures**
  - **TSPA-VA: ~~1~~-10, coupled with seepage toward smaller number of "true" juvenile failures. Always in same repository location.** 0
  - **TPA 3.2: 10-4 to 10-2 of the waste packages within a subarea.**
- **Disruptive Events**
  - **TSPA-VA: No assessment in nominal case.**
  - **TPA 3.2: Consequence modules result in failures within 10,000 years.**
  - **Need to weight consequences with occurrence probability.**
  - **Detailed evaluation not yet complete.**

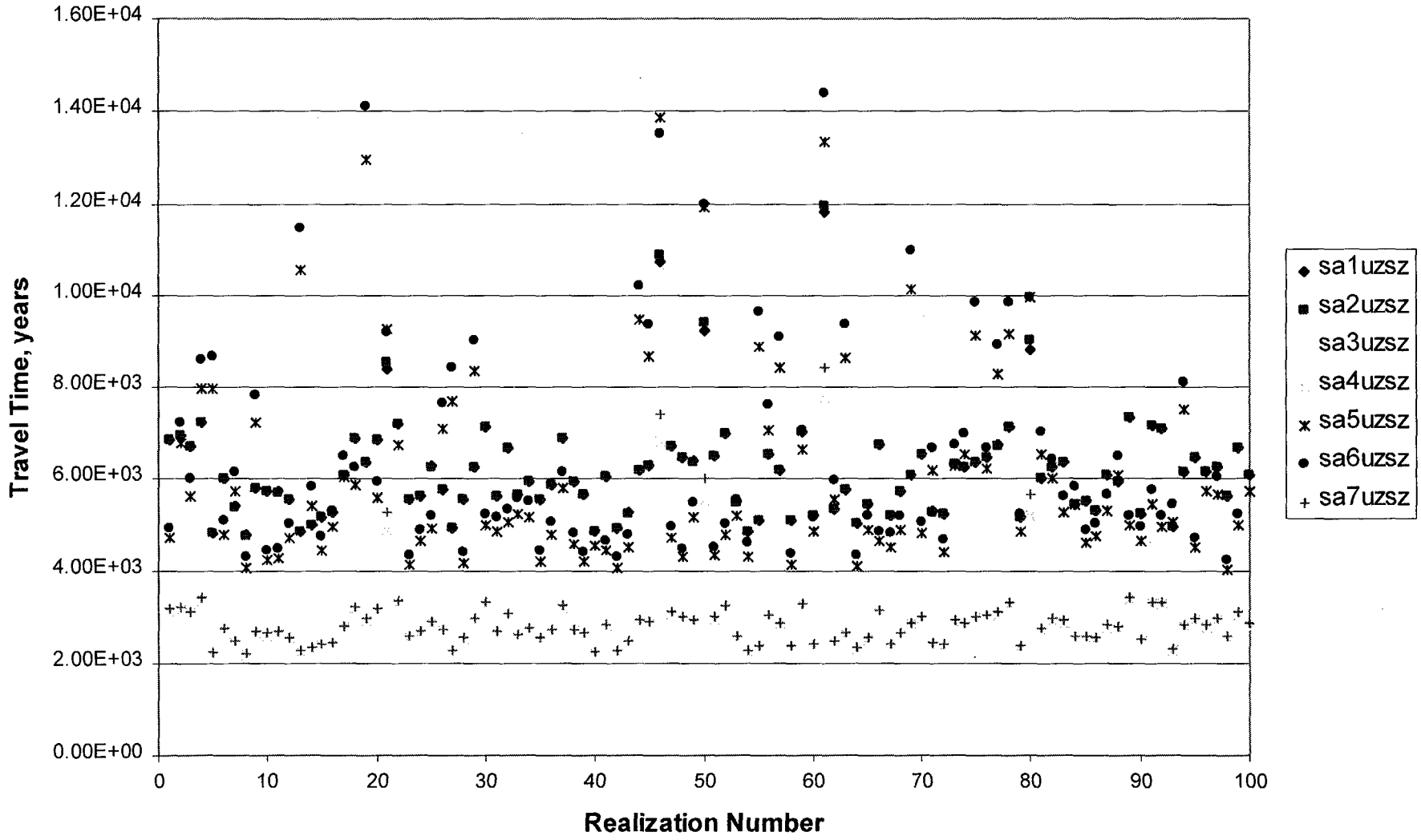
Comparison of DOE and NRC Models-- Waste Form Degradation

- Types
  - For CSNF, both models have similar degradation rates after the thermal pulse (2-3×10-3/yr). At initial times, TPA 3.2 is ~10+ times higher.
  - TSPA-VA: CSNF, HLW, DSNF
  - TPA 3.2: CSNF only
- Fraction wetted in WP
  - TSPA-VA: Entire surface area not covered by cladding is exposed. Changes with time.
  - TPA 3.2: 0 to 100 percent (uniform). Different for each failure mode and subarea, which creates variability. Constant throughout simulation.

Comparison of DOE and NRC Models--Saturated Zone

- SZ is main natural barrier in TPA 3.2
  - Following figure shows total groundwater travel time from repository to 20 km in TPA 3.2. Most of the travel time is SZ.
- Alluvium
  - TSPA-VA: 0 to 6 km.
  - TPA 3.2: 10 km.
- Retardation in Alluvium (Rd)
  - Particularly important for 10,000 year period.
  - TSPA-VA: 1 for Tc and I; ~50 for Np.
  - TPA 3.2 (includes retardation of Tc and I in alluvium):
    - » Tc: 1 to 30, loguniform (8.5)
    - » I: 1 to 4, loguniform (2.2)
    - » Np: 1 to 3900, lognormal (170)

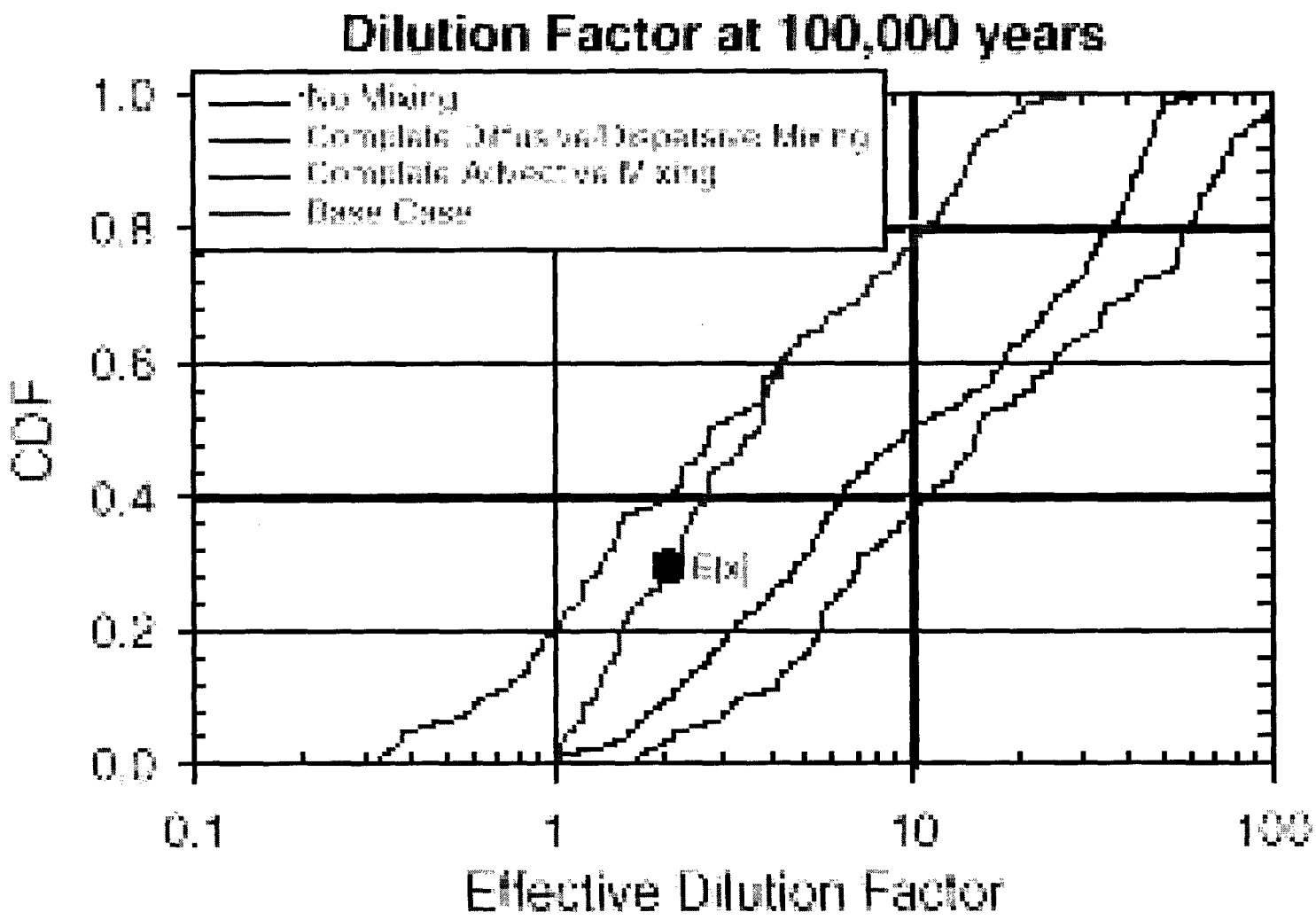
UZ + SZ Groundwater Travel Times in TPA 3.2 Analyses



Comparison of DOE and NRC Models-- Biosphere

- **Dilution Volume**
  - **TSPA-VA: 27,000 m^3/yr in current climate. 146,000 m^3/yr in long-term-average climate. Multiplied by dilution factor (see following figure).**
  - **TPA 3.2: 6 to 18 million m^3/yr**
- **Dose Conversion Factors**

	Tc99		I129		Np237	
Pathway	Current	Pluvial	Current	Pluvial	Current	Pluvial
Direct Exposure	6.8×10^{-1}	4.3×10^{-1}	5.3×10^{2}	3.6×10^{2}	6.3×10^{3}	4.6×10^{3}
Inhalation	5.8×10^{-3}	3.7×10^{-3}	2.4×10^{-1}	1.7×10^{-1}	1.5×10^{3}	1.0×10^{3}
Animal Ingestion	1.4×10^{2}	8.7×10^{1}	8.5×10^{5}	4.9×10^{5}	2.0×10^{5}	1.2×10^{5}
Crop Ingestion	3.0×10^{3}	1.6×10^{3}	2.4×10^{5}	1.2×10^{5}	5.0×10^{6}	2.5×10^{6}
Drinking Water	1.6×10^{3}	1.6×10^{3}	1.8×10^{5}	1.8×10^{5}	3.8×10^{6}	3.8×10^{6}
Total TPA 3.2	4.7×10^{3}	3.3×10^{3}	1.3×10^{6}	7.9×10^{5}	9.0×10^{6}	6.4×10^{6}
TSPA-VA (LTA)	3.1×10^{3}		4.7×10^{5}		6.5×10^{6}	


Dilution Factor at 100,000 years
No Mixing
Complete Diffusive/Dispersive Mixing
Complete Advective Mixing
Base Case
E[x]
CDF
1.0
0.8
0.6
0.4
0.2
0.0
0.1
1
10
100
Effective Dilution Factor

Comparison of NRC and DOE Calculations

- Comparison

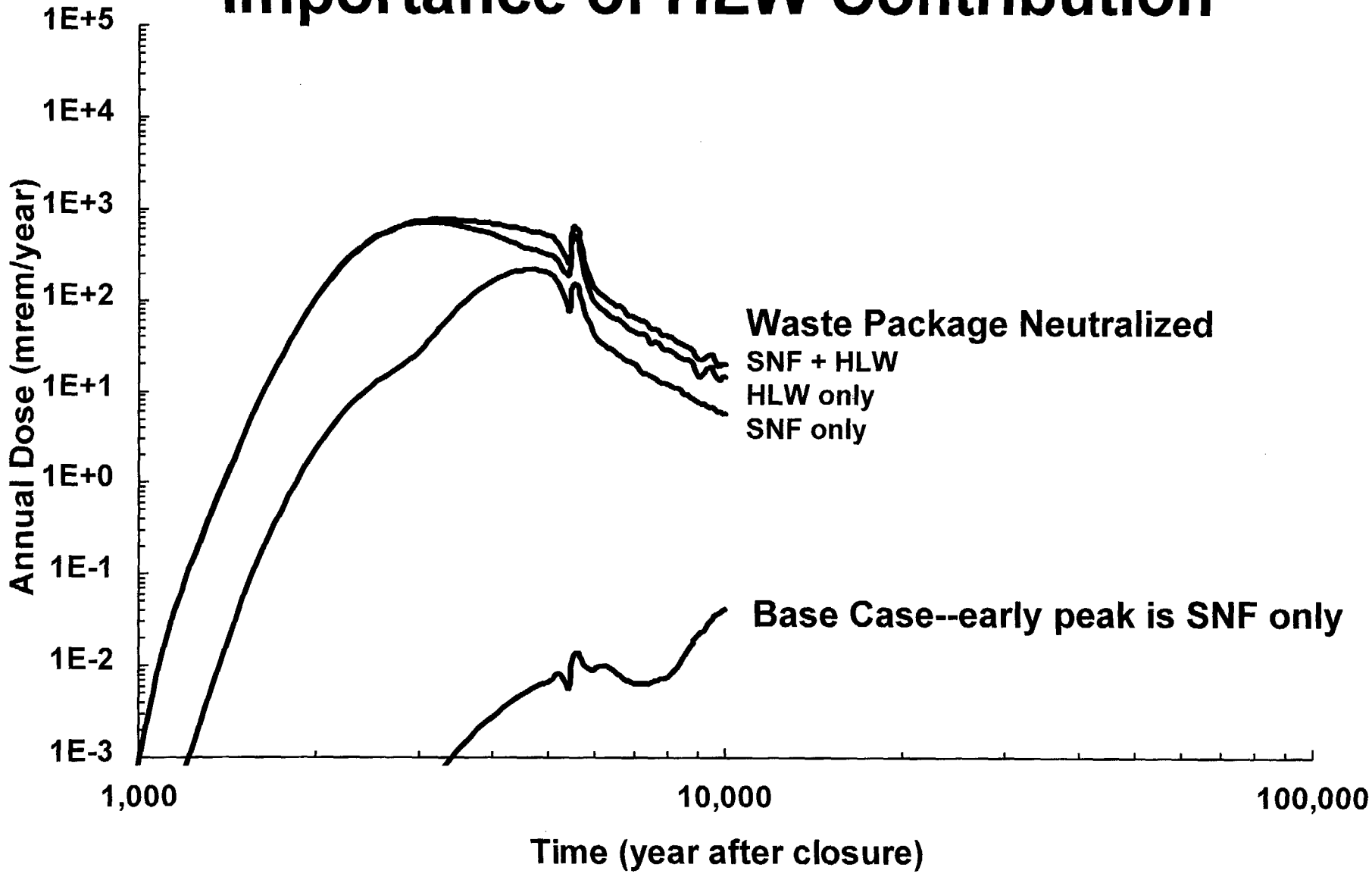
- Important differences in the models
  - Waste package juvenile failure and degradation
  - Cladding
  - Retardation in saturated zone
  - Dilution

Comparison of NRC and DOE Neutralizations

- NRC neutralization scales according to number of SNF waste packages:

- DOE neutralization scales according to SNF packages and dilution factor
- Another key effect however is contribution of HLW:

Waste Package Neutralization Indicates Importance of HLW Contribution



Barriers Importance (DID) Assessment for Recommended Design

- Enhanced design includes drip shield, providing redundancy with waste package--neutralization of waste package shows smaller effect
- Neutralizations address specific functions of natural barriers (retardation, solubility limits) making individual effects more transparent

Barriers Importance Approach for LA

- Application to VA design suggested value of design enhancement and improvement of certain models
- That application provided some value in increasing the transparency of the TSPA-VA calculation
- However evaluation of approach not yet complete:
  - Effect of combinations of uncertainties not yet evaluated--considering utility of probabilistic approach
  - Need to consider contributions/detriments of other functions (e.g., thermal effects)
- DOE continuing to evaluate and will adopt an approach that both provides transparency and demonstrates multiple barriers enhance system performance