YUCCA MOUNTAIN PROJECT

Studies

NWTRB Repository Panel meeting Postclosure Defense in Depth in the Design Selection Process

Presented to:
Nuclear Waste Technical Review Board
Panel For the Repository

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DEPARTMENT OF ENERGY UNITED STATES OF AMERICA

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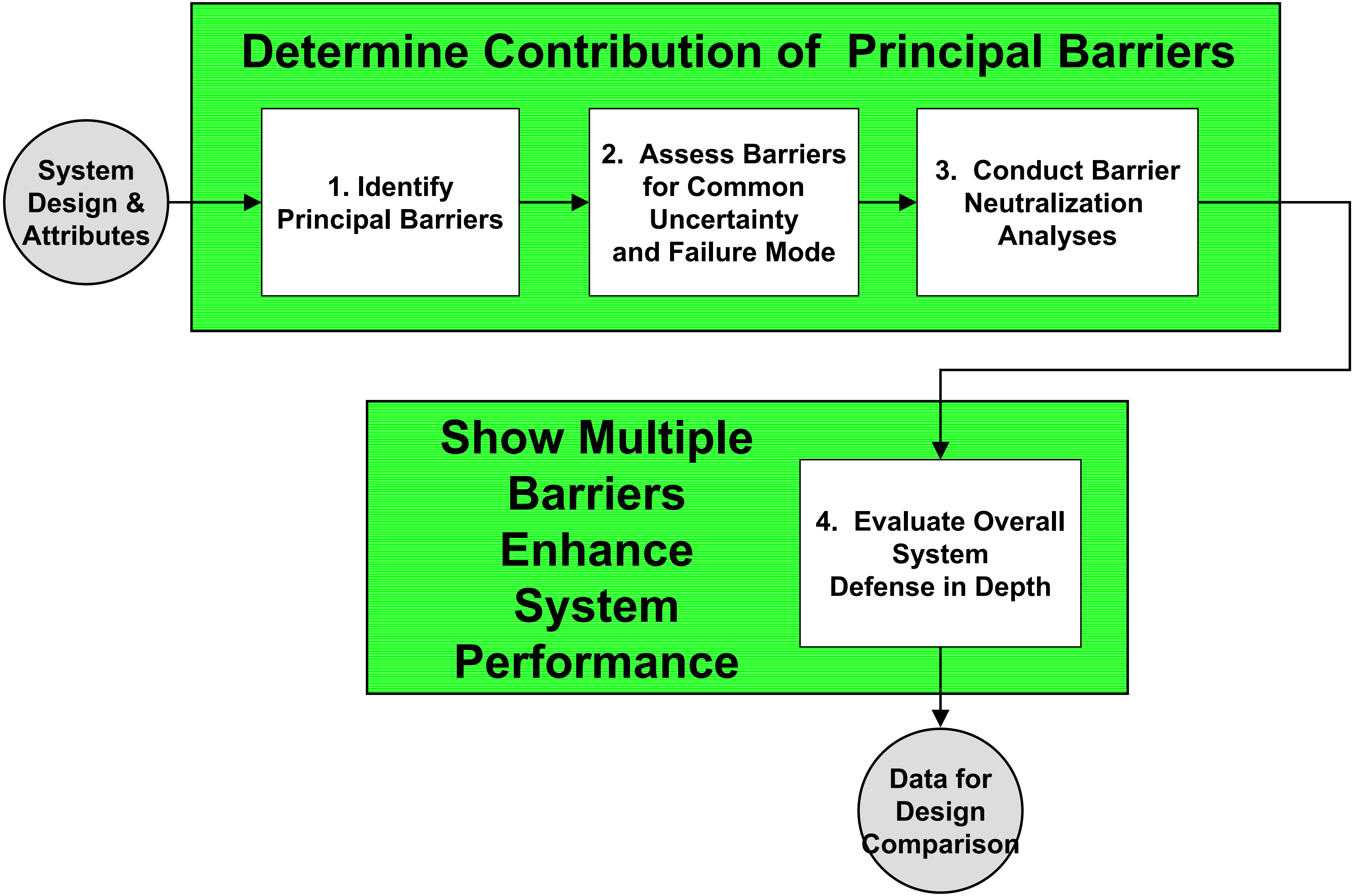
Defense in Depth

- **DID is a safety philosophy that employs multiple barriers to ensure that failure in any one of them does not imply failure of the entire system**
- **For licensing safety case DOE expected to**
  - **Identify the principal barriers of the system**
  - **Provide transparent assessment of contribution of each barrier**
  - **Indicate system performance enhancement provided by multiple diverse barriers**
- **Approach to DID chosen to support development of a robust design and display the contribution of individual engineered and natural barriers for that design**

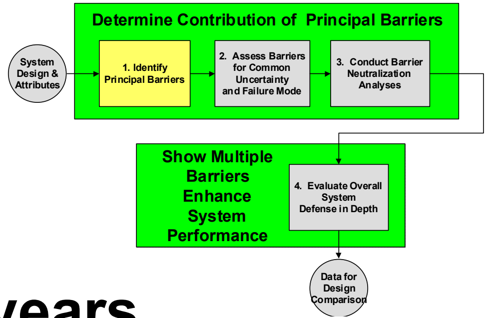
Application to EDA Development

- **Analytic approach developed to provide a measure for comparison of designs regarding DID**
- **Principal use will be in Phase 2 evaluation**
- **Although approach resembles TSPA, its focus is much different--it focuses on redundancy among barriers to mitigate uncertainties--it does not replace TSPA**
- **Focus in the approach is barrier “neutralization”**
  - **Determine contribution of each barrier to TSPA**
  - **Determine if system of barriers is resilient against uncertainties**

Approach


Determine Contribution of Principal Barriers
System Design & Attributes
1. Identify Principal Barriers
2. Assess Barriers for Common Uncertainty and Failure Mode
3. Conduct Barrier Neutralization Analyses
Show Multiple Barriers Enhance System Performance
4. Evaluate Overall System Defense in Depth
Data for Design Comparison

1. Identify Principal Barriers



- **Principal barriers:**

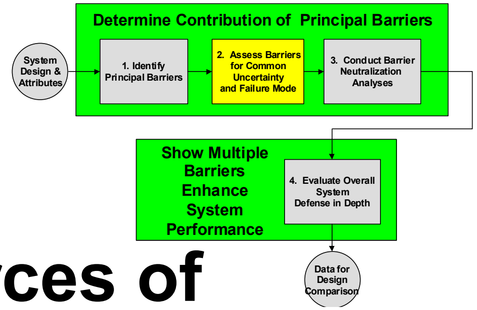
  Delay water or radionuclides at least 1,000 years

  (or)

  Limit fractional rate of release to < 10^{-4} per year

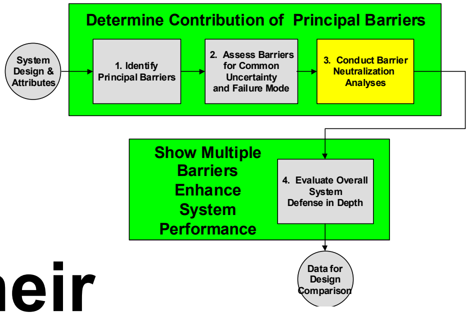
- **Assessment based on barrier properties, e.g.**
  - **Delay: longevity, porosity, permeability**
  - **Fractional rate of release: longevity, diffusivity, dispersivity**

2. Assess Principal Barriers



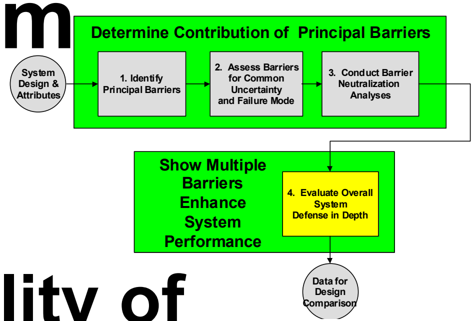
- **Assess common-mode failures and sources of uncertainty to determine barriers that should be neutralized together**
- **Considerations**
  - **Common materials subject to same uncertainties in properties**
  - **Representations derived from common model**
  - **Common-mode failure (e.g., failure of one barrier limits effectiveness of another)**

3. Neutralize Barriers



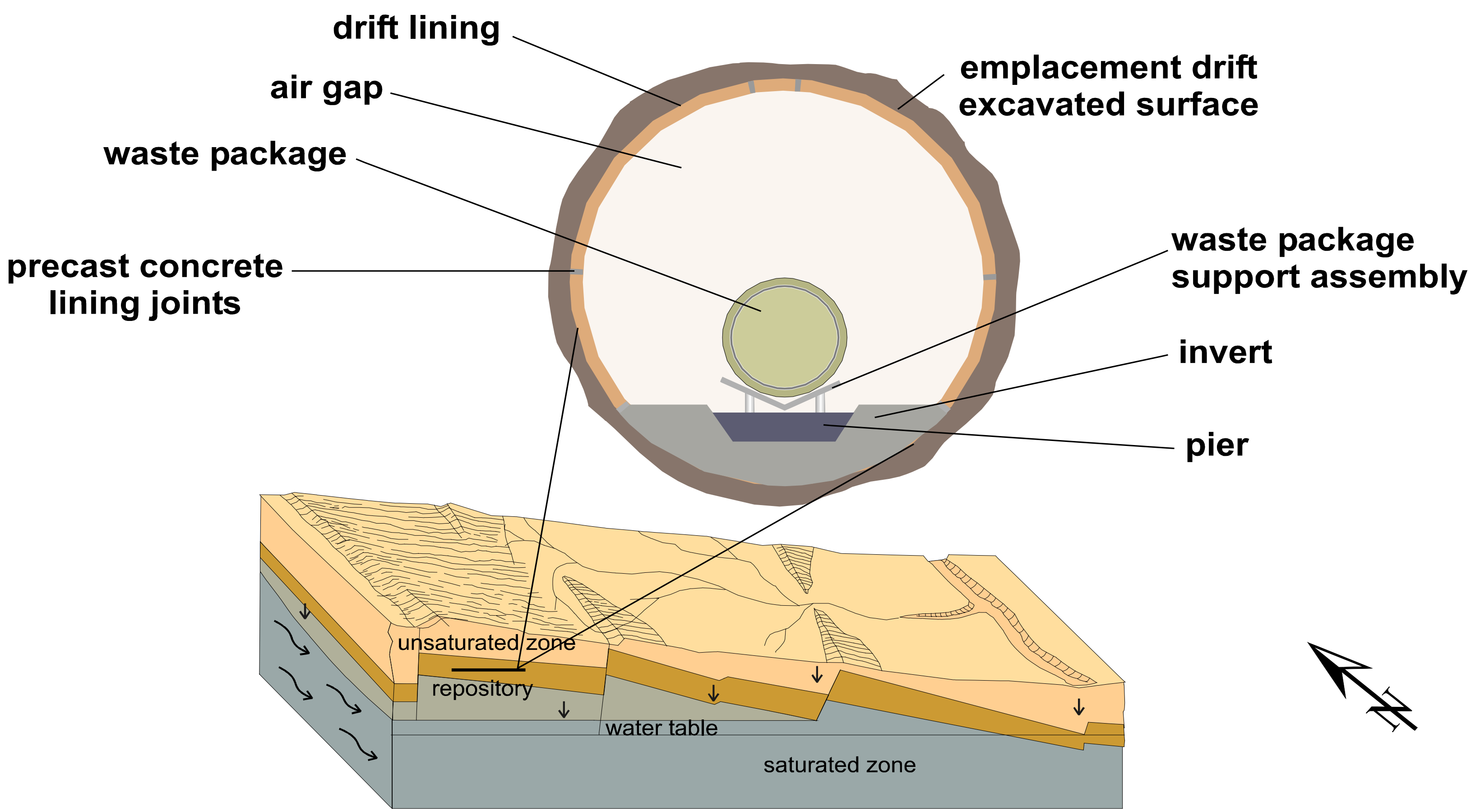
- **Process of stripping off barriers to see their importance to system**
- **"Neutralize" each barrier combination**
  - **Assume ineffective in limiting movement of water/radionuclides**
  - **In all other respects, barriers perform as in base case**
- **Because object is to determine contribution to base case performance, barrier combination <u>completely</u> neutralized**

4. Evaluate Overall System Defense in Depth



- **System performance evaluated from totality of neutralizations: e.g., identify barriers whose uncertainty is not compensated by other barriers**
- **Determine if system performance depends strongly on any single barrier**
- **Design should permit repository performance objective to be met even if a barrier fails to perform as anticipated**

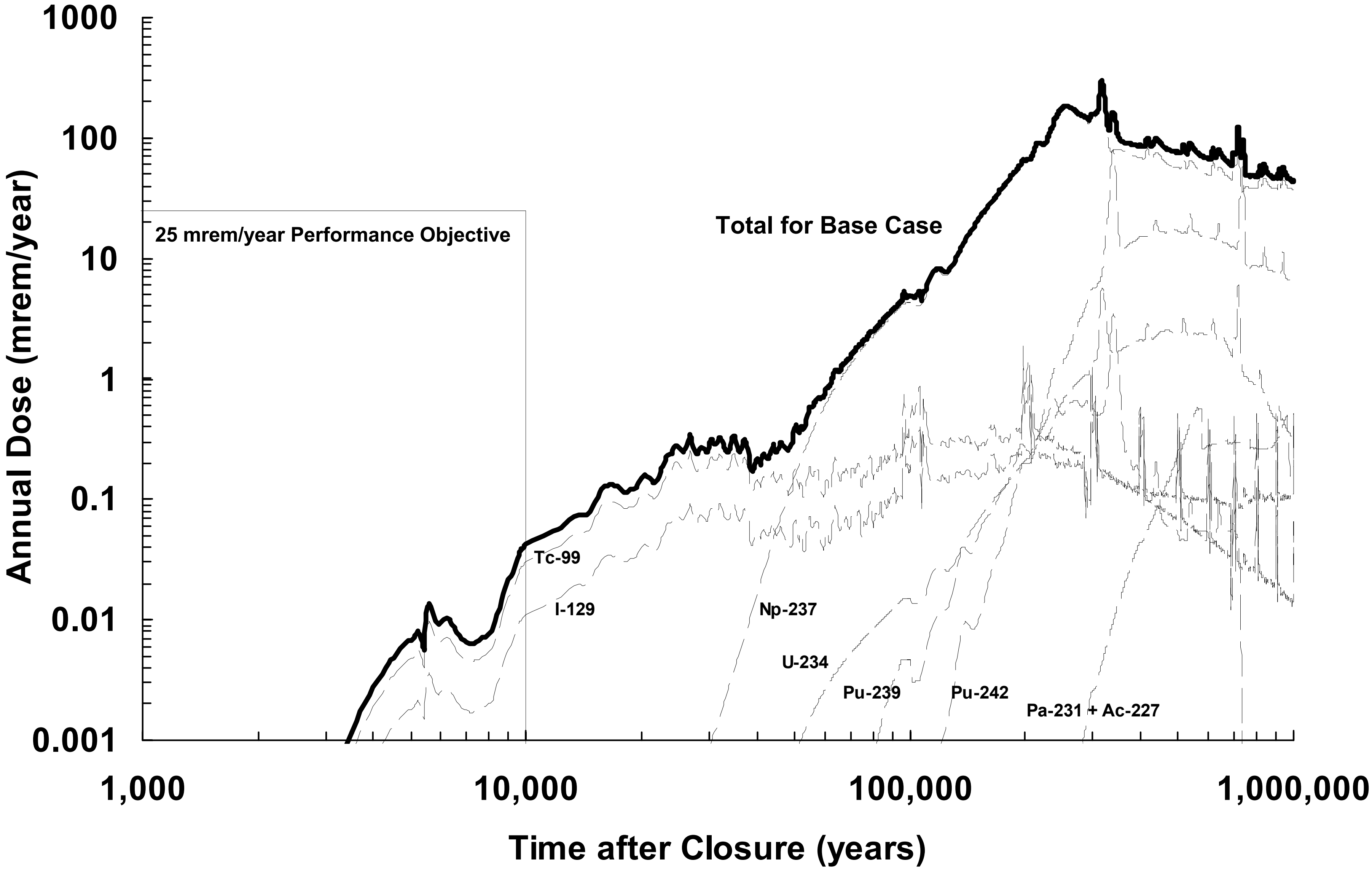
Example-VA Base Case



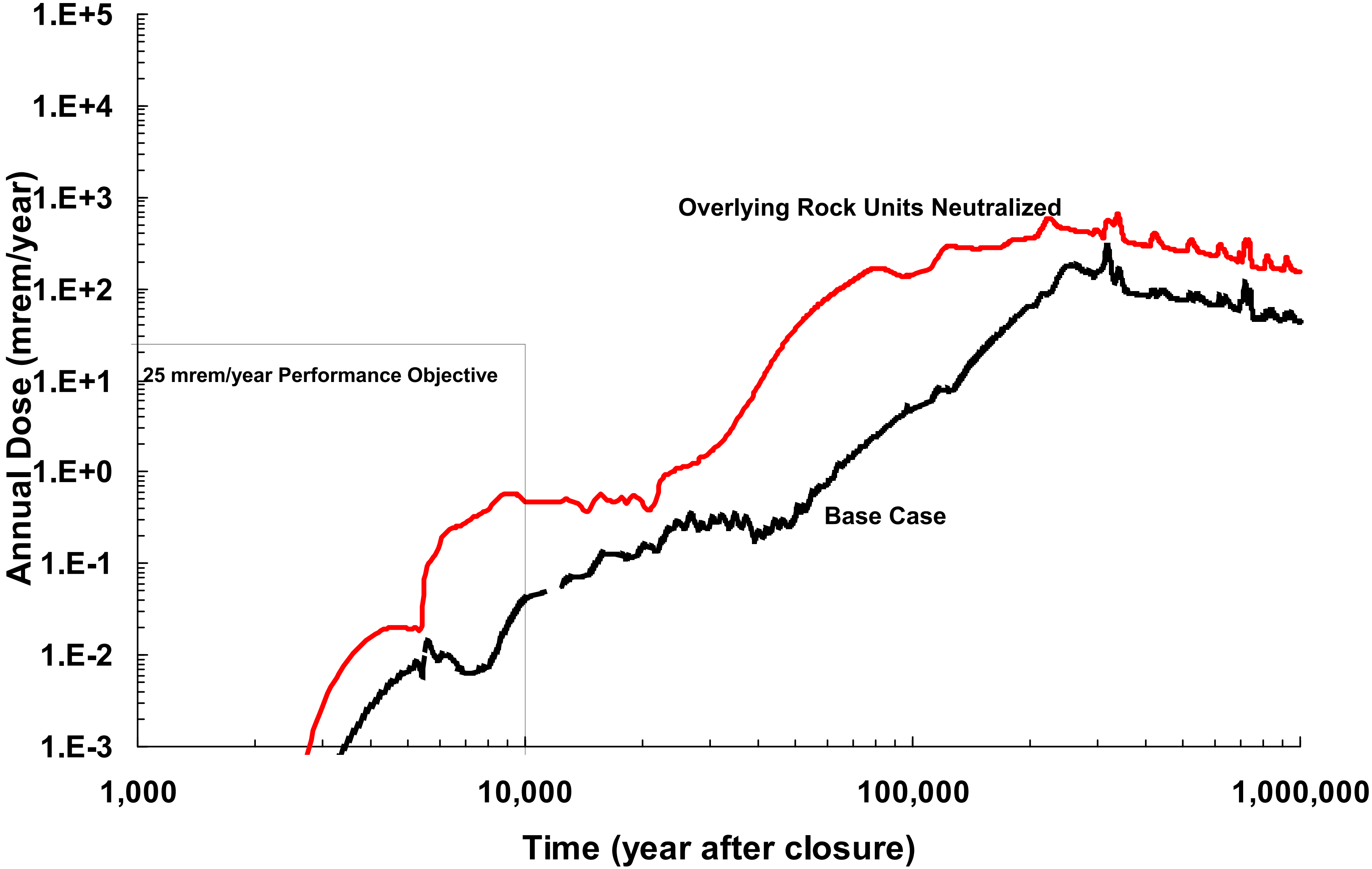
Example-VA Base Case
Barrier Combinations To Be Neutralized

- Overlying flow barriers (common flow model)
- UZ barriers (common flow and transport models)
- SZ barriers (common flow and transport models)
- Waste package (outer barrier protects inner barrier)
- Spent fuel cladding
- Invert

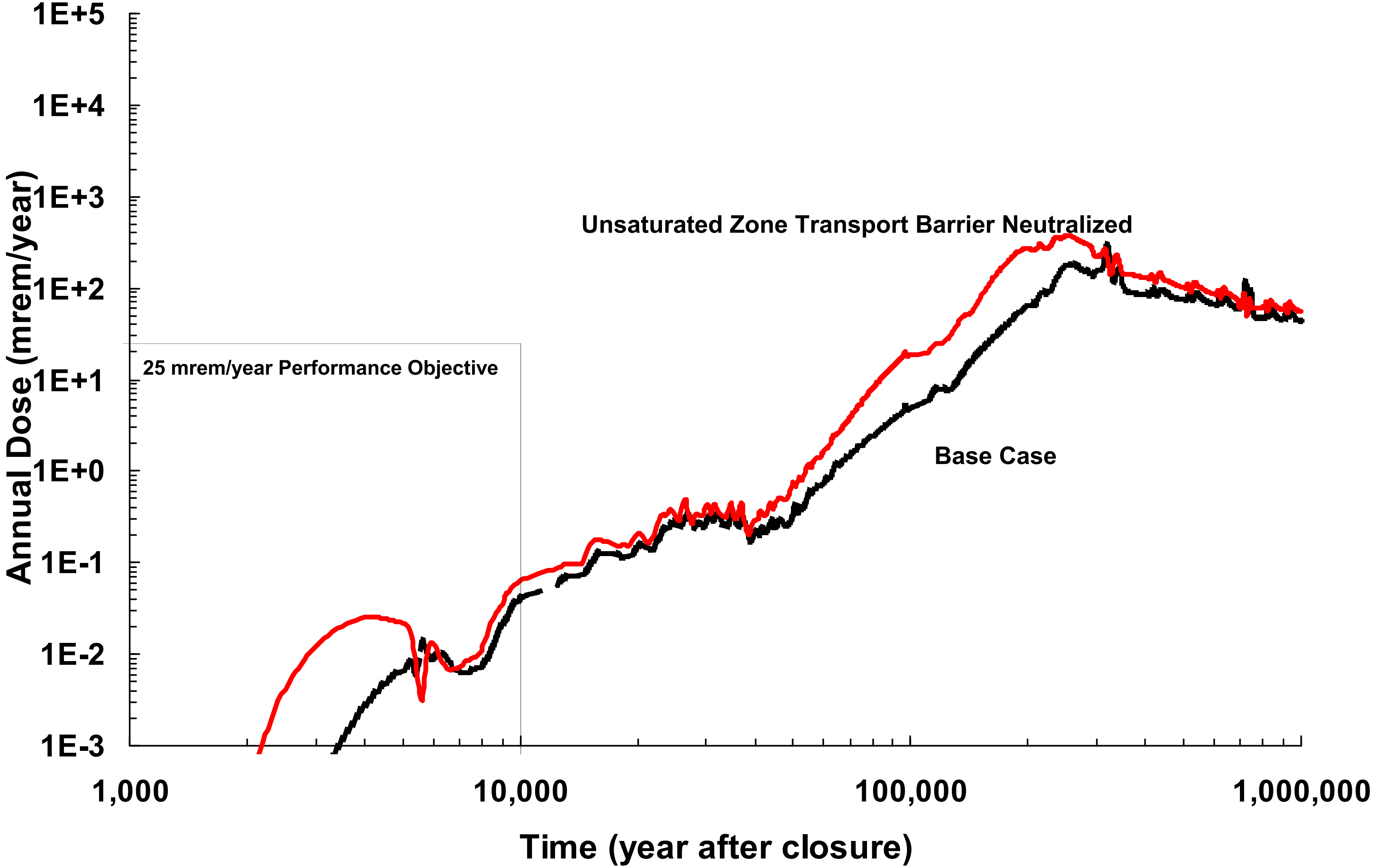
Example--TSPA Including All Barriers



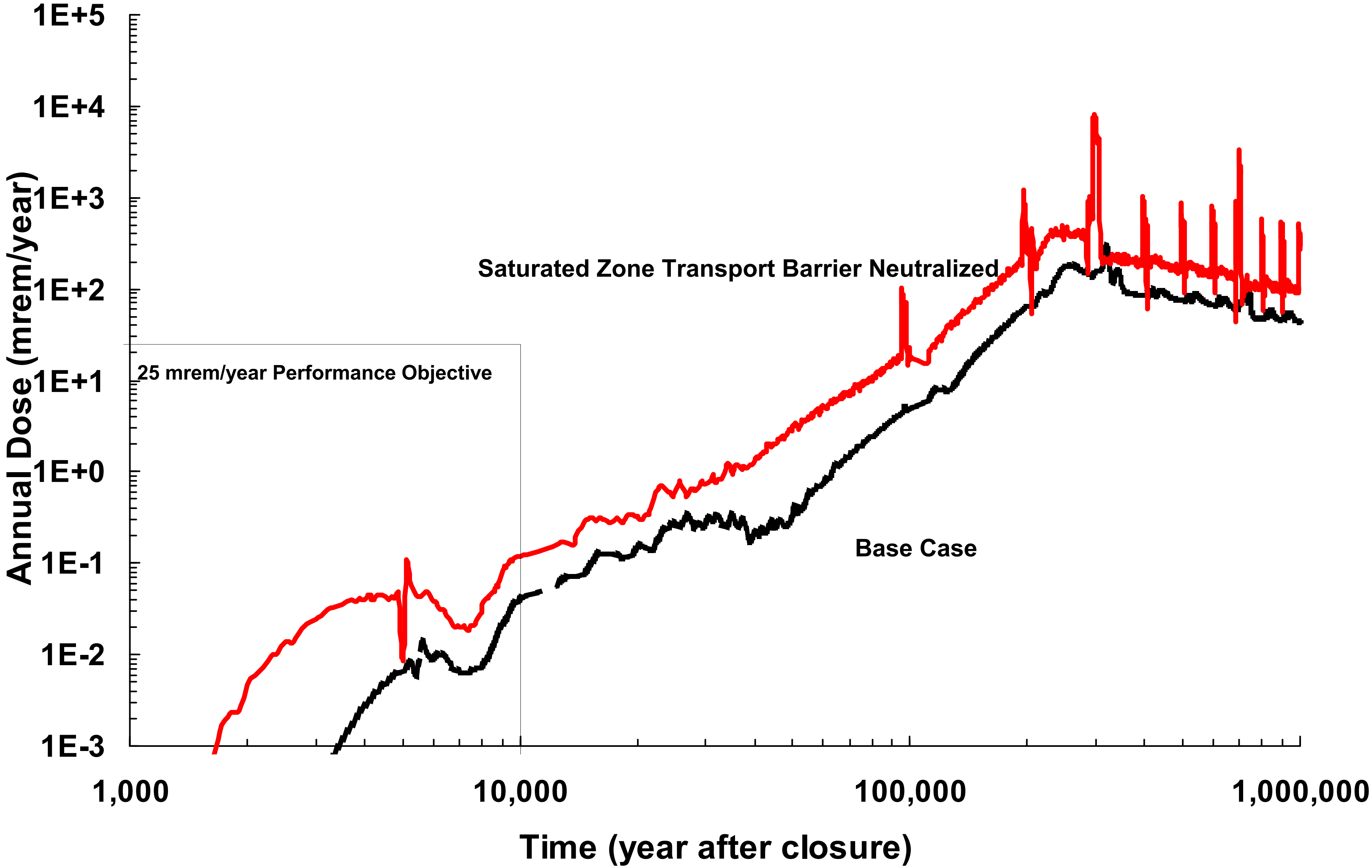
Neutralize Overlying Flow Barriers



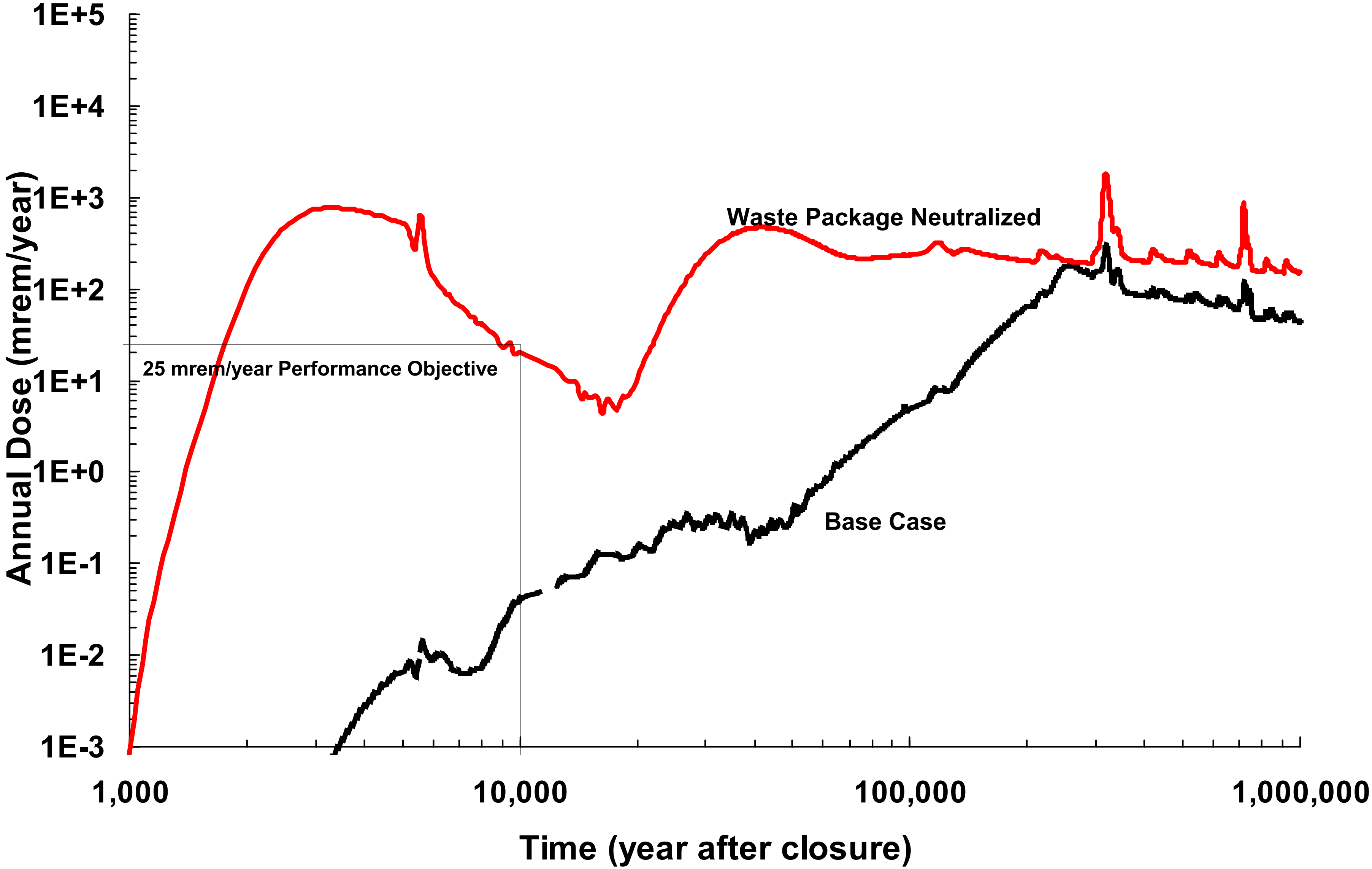
Neutralize Unsaturated Zone Transport Barrier



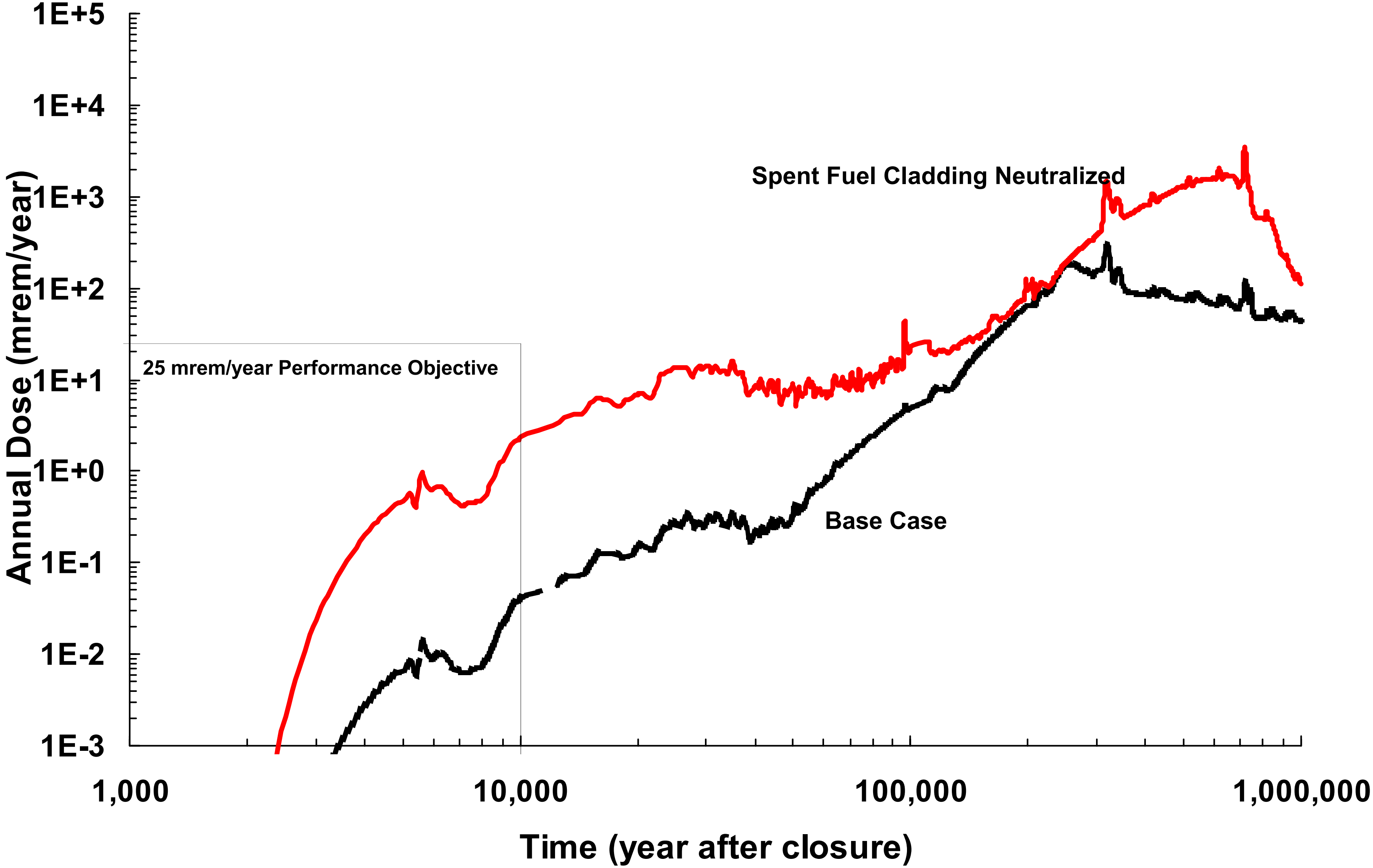
Neutralize Saturated Zone Transport Barrier



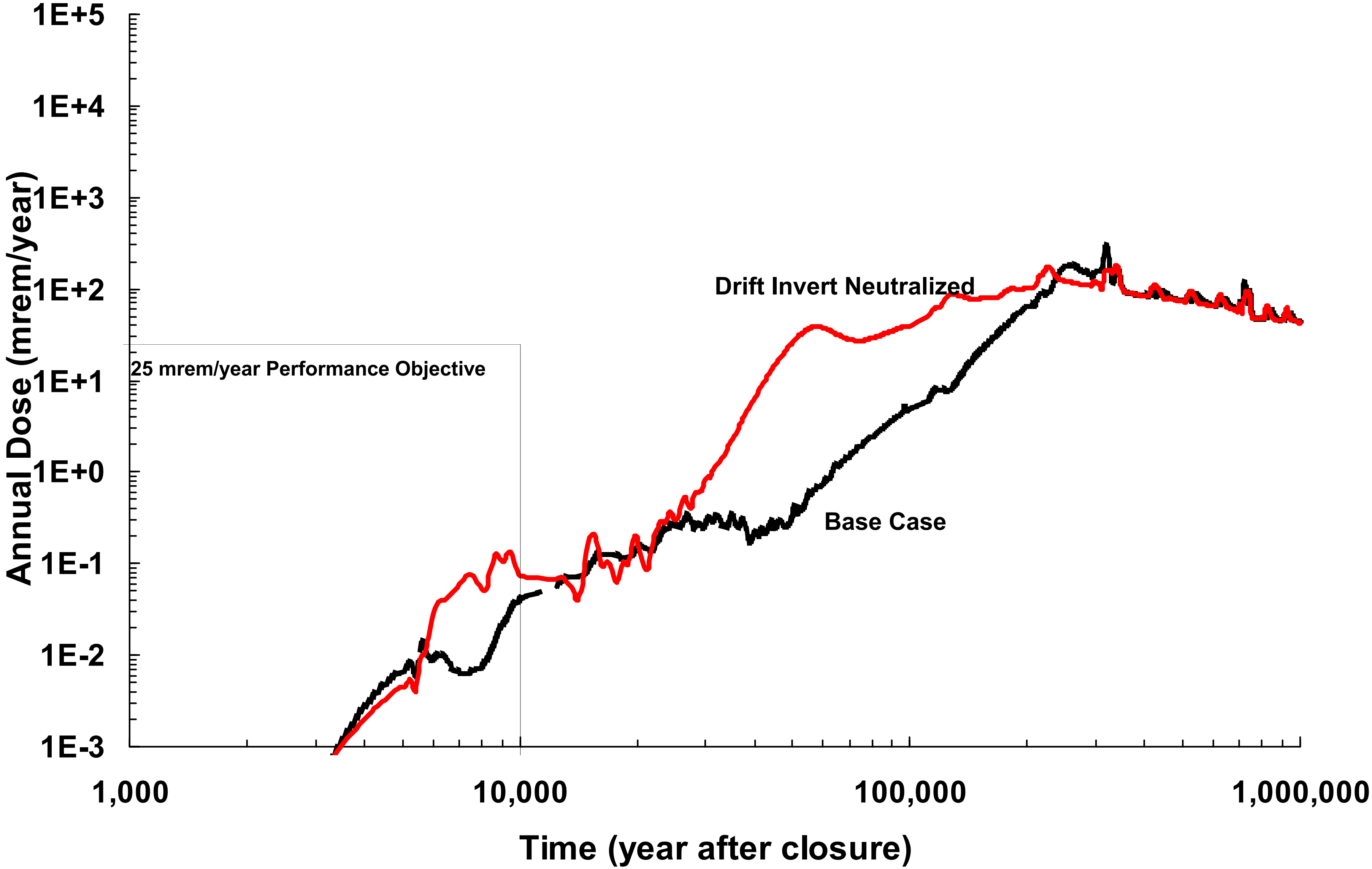
Neutralize Waste Package



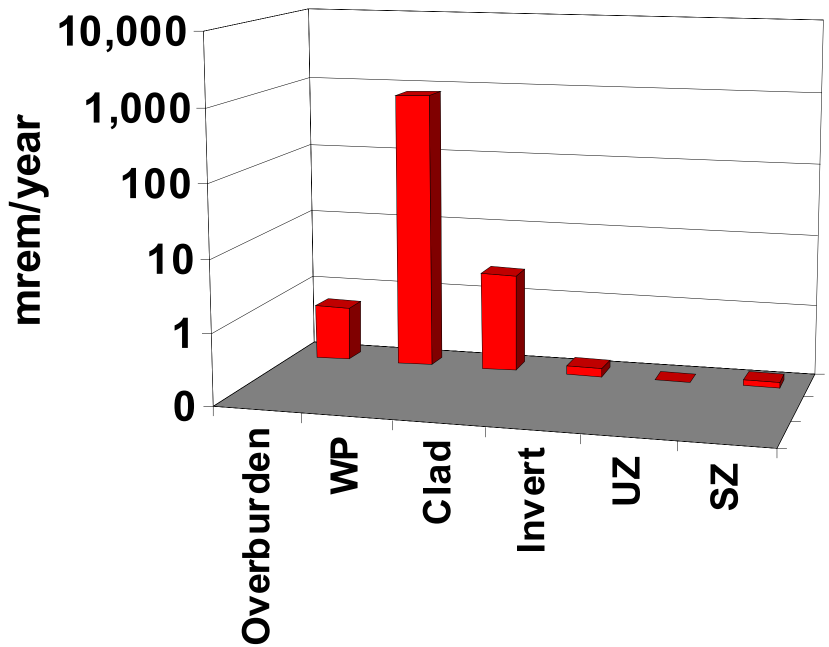
Neutralize Spent Fuel Cladding



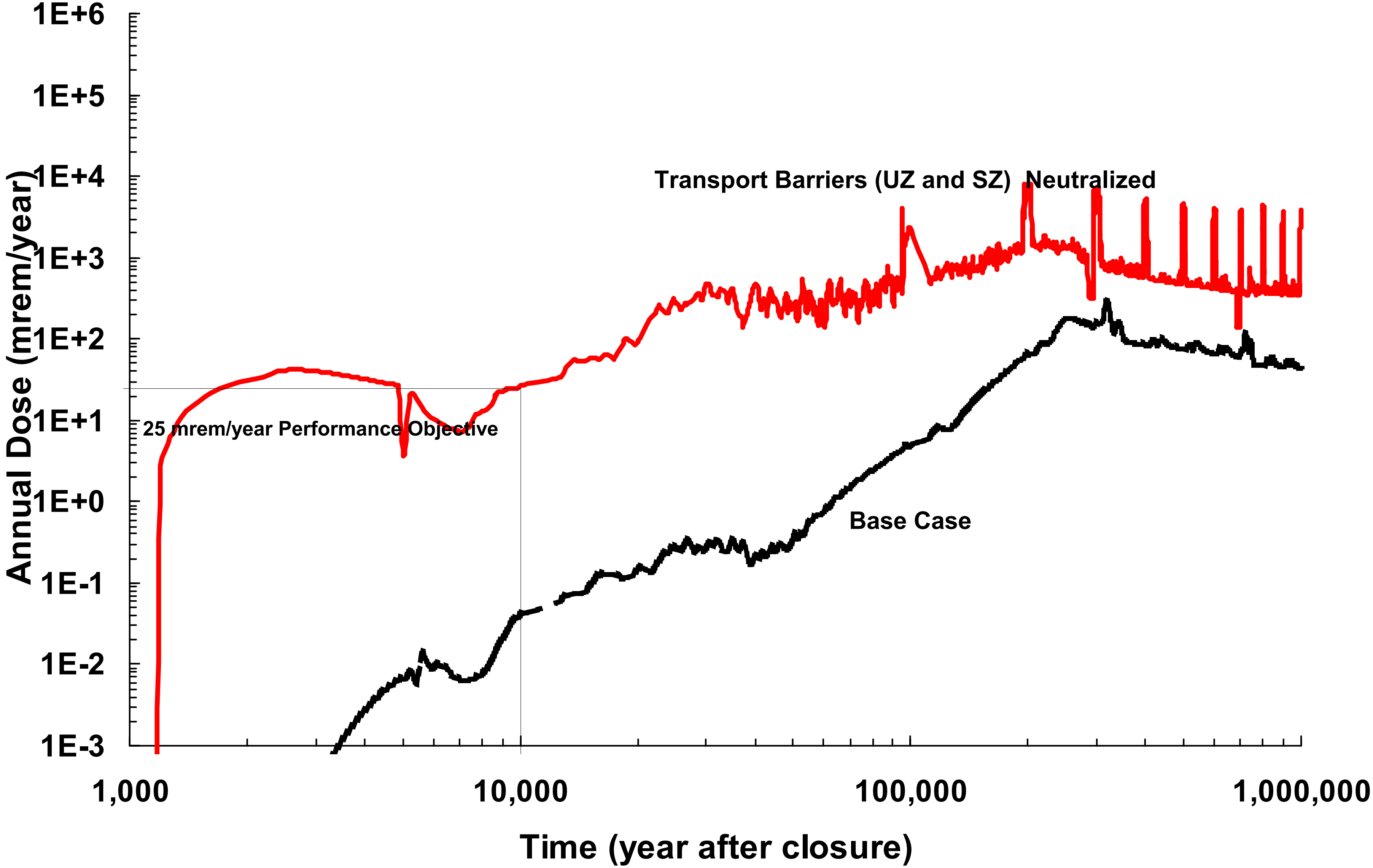
Neutralize Invert Transport Barrier



Relative Contribution of Barriers - VA Design (10,000 Years)



Neutralize Both UZ and SZ Transport Barriers



Notes on Postclosure Defense in Depth

- Analysis of VA illustrative only--Results for other designs will depend on barriers of those designs
- Analytic approach is tailored to indicate roles of barriers that might be obscured and to indicate where multiple barriers could enhance confidence
- Approach does not diminish need for sound scientific and engineering basis for system design and licensing case
- Approach is part of overall effort to address engineering uncertainties and those of the natural system