Disposal of Al-clad, HEU spent fuel in a repository

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

Presented to:
Nuclear Waste Technical Review Board

Presented by:
David Haught
Yucca Mountain Site Characterization Office

YUCCA MOUNTAIN PROJECT

Studies

December 17, 1997

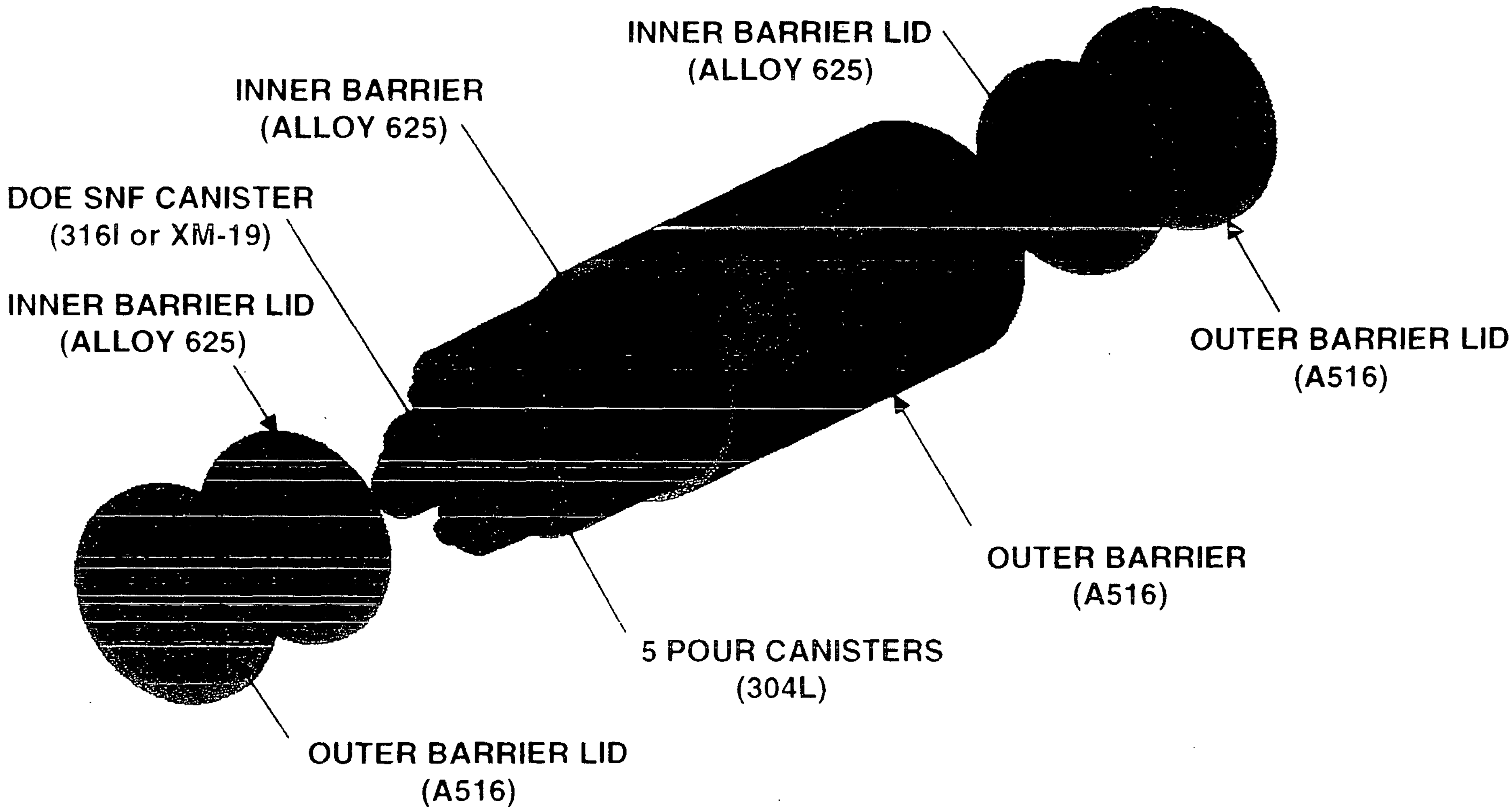
Overview

- Waste package design
- Performance assessment
- Criticality analyses
  - Analysis approach
  - Preliminary findings

Waste package Design

- Al-clad, HEU fuel in canisters
  - 16 MIT or 10 ORR assemblies per basket
  - 4 baskets per canister (stacked 4 high)
  - 64 MIT or 40 ORR assemblies per canister
- Canisters contain long term criticality control features
- Canisters co-disposed along with HLW canisters in a waste package

Codisposal Waste Package For DOE-SNF and HLW



LENGTH = 3790 mm
DIAMETER = 1970 mm
TARE WEIGHT = 24,782 kg
LOADED WEIGHT = 35,692 kg

Performance assessment

- Changes from TSPA-1995 bases (Sensitivity analysis for DOE SNF)
  - Percolation flux ranges 4 to 10 mm/yr. (6.2 mm/yr. average over repository footprint)
  - Drips on waste package (10% to 30%)
  - Updated diffusion properties
  - 83 MTHM/acre, centered-in-drift
    - (same as TSPA-1995)
  - Updated near-field thermohydrologic calculations
  - Np solubility decreased by two orders of magnitude

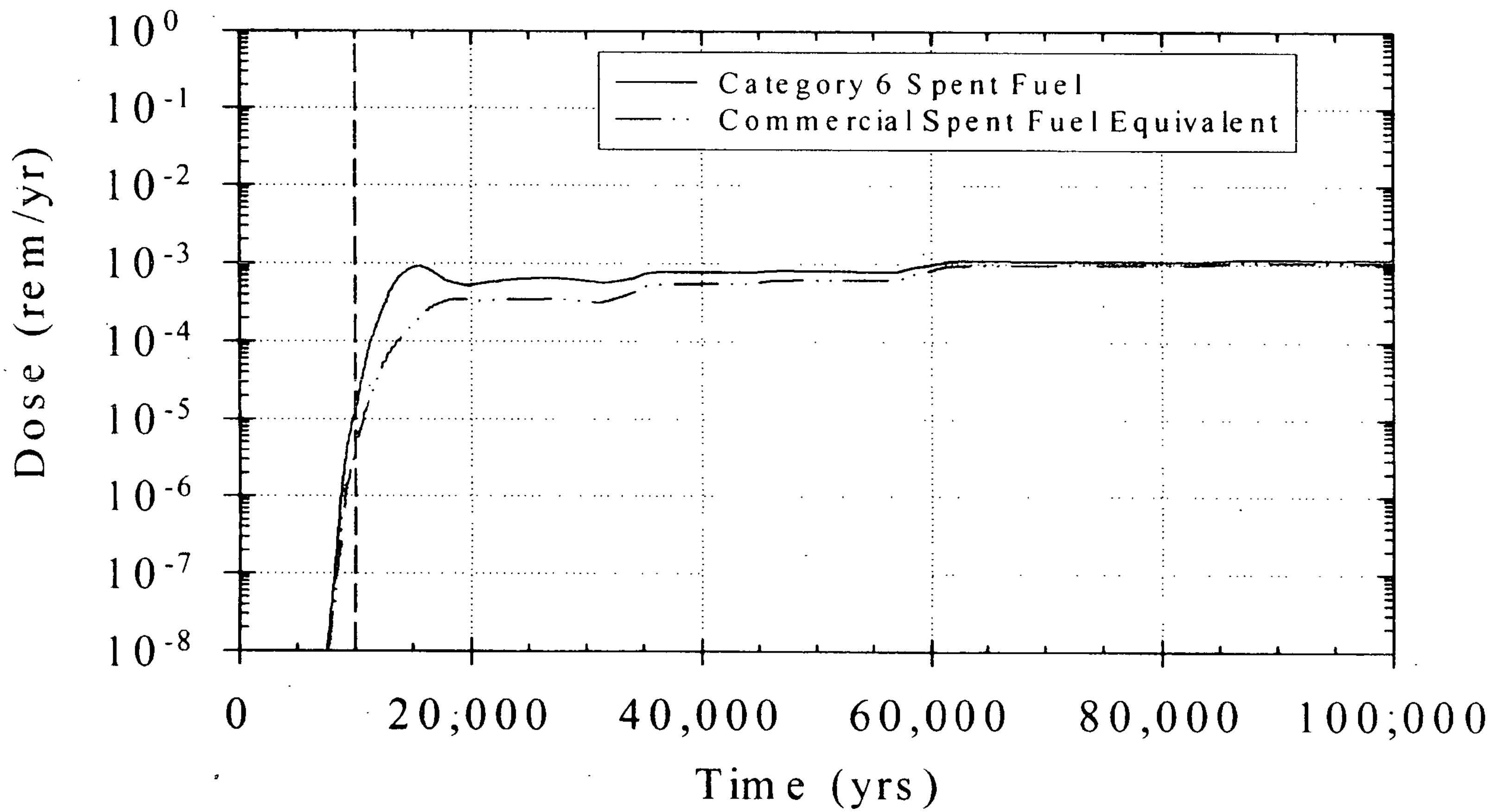
Performance Assessment
(continued)

- Changes from TSPA-1995 bases (continued)
  - Updated waste package degradation studies
  - Updated saturated-flux (0.31 m/yr. and a porosity of 20%)
  - No climate cycles
  - 8.96 MTHM of Uranium-Aluminum fuel, 11.40 MTHM of Uranium silicide fuel

Findings: Dose at the accessible environment

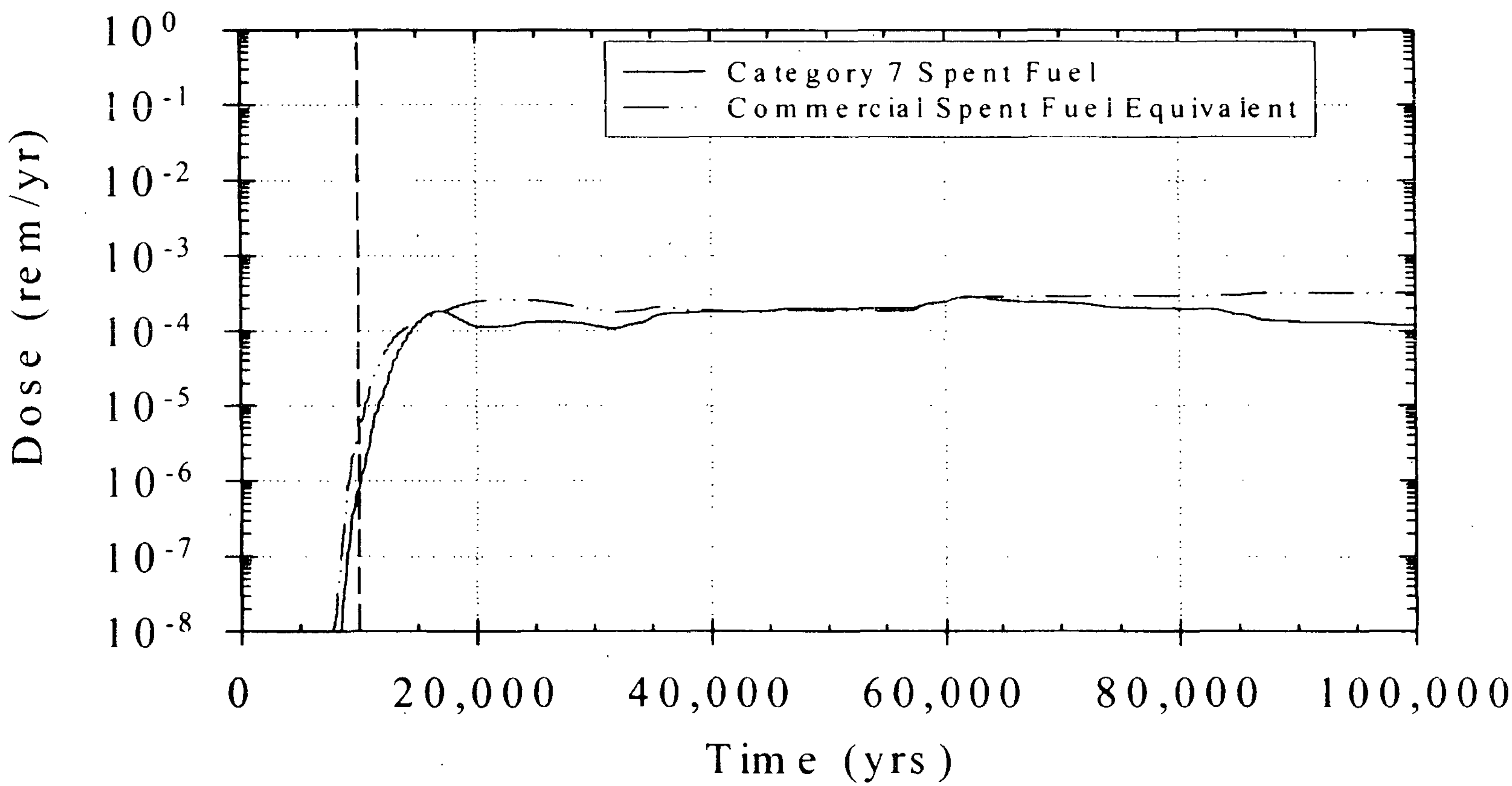
- Peak dose is equivalent to commercial SNF
- Dose from Uranium-Aluminum alloy fuels due to ^{99}Tc & ^{129}I is somewhat higher than for commercial SNF
  - Less than one order of magnitude difference
  - Less than the peak dose

Comparison of U-Al alloy fuels vs. commercial SNF
(no galvanic protection)



Comparison of U-Si fuels vs. commercial SNF

(no galvanic protection)



Criticality Analyses

- Based on two fuels
  - ORR SNF: 21% enriched U-Si-Al alloy
  - MIT SNF: 93.5% enriched U-Al alloy
- Analyzed with MCNP4A
- Alternative neutron absorber materials
- Conservative assumptions
  - Fresh fuel assumed
  - Optimum moderation in clay

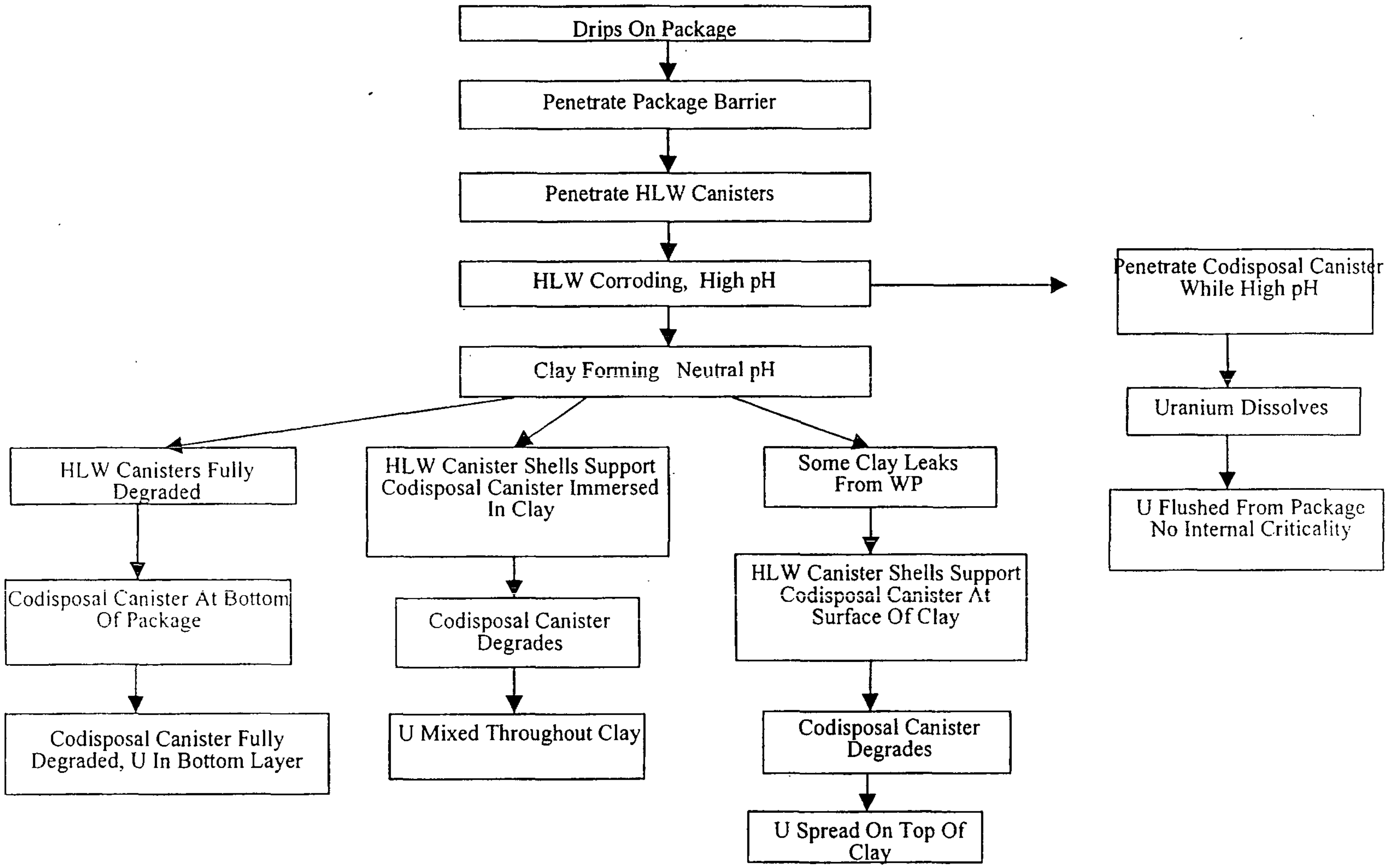
Phased analysis approach

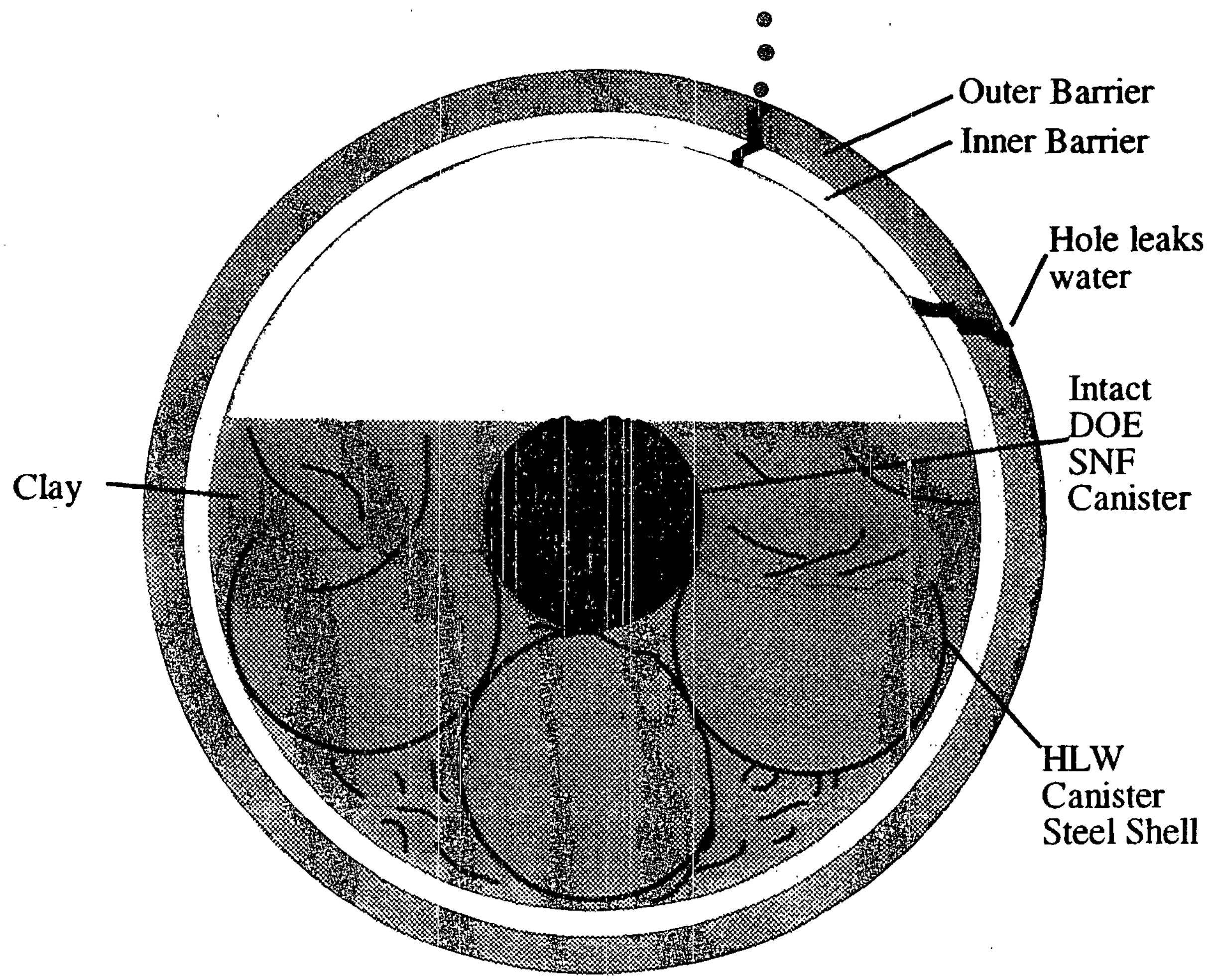
- Phase 1
  - Intact configuration
  - Conceptual waste package identified
- Phase 2
  - Degraded configurations within the waste package
  - EQ 3/6 used to analyze geochemistry
  - Range of parameters investigated
    - Environmental parameters
    - corrosion/degradation rates of waste forms & containers

Phased analysis approach
(continued)

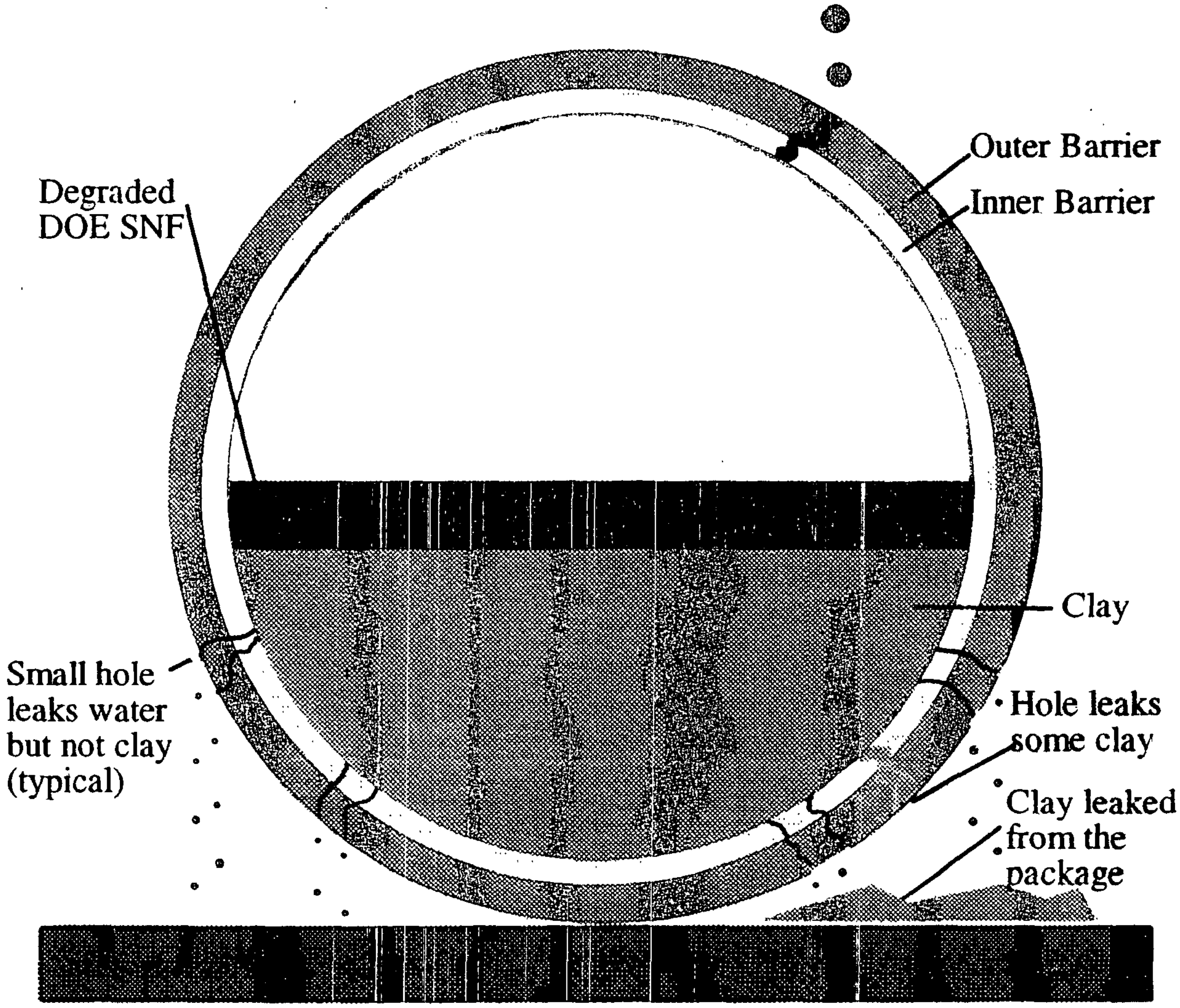
- Phase 3
  - Cumulative analysis
  - Configurations external to waste package
  - Model fissile material mobilization and transport
  - Estimate probability of critical events
  - Calculate consequences of critical events
  - Deposition mechanisms
    - Adsorption on clays of zeolites
    - Reducing zone (organic or hydrothermal upwelling of H_2S)
    - General chemical reaction with host rock

Internal Degradation Scenarios for Al Clad SNF

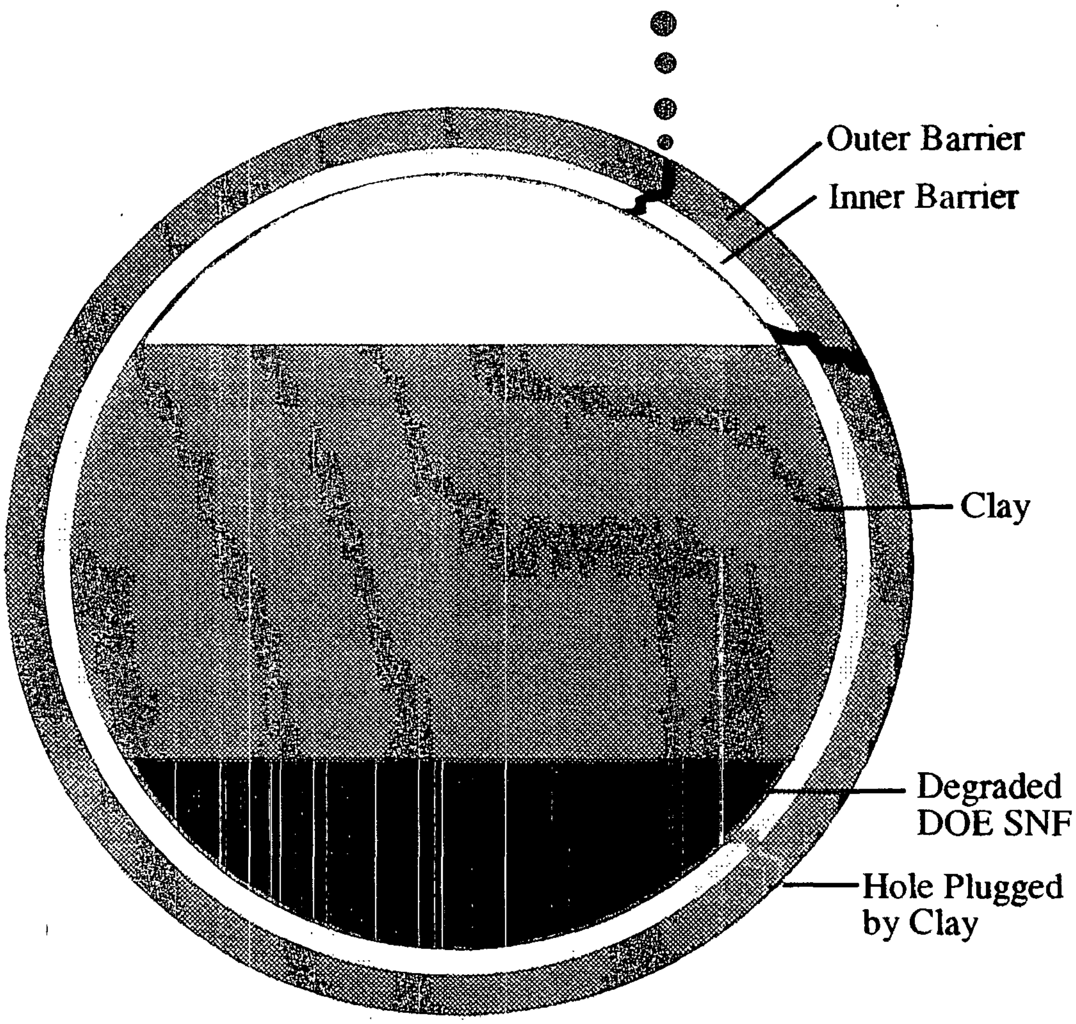




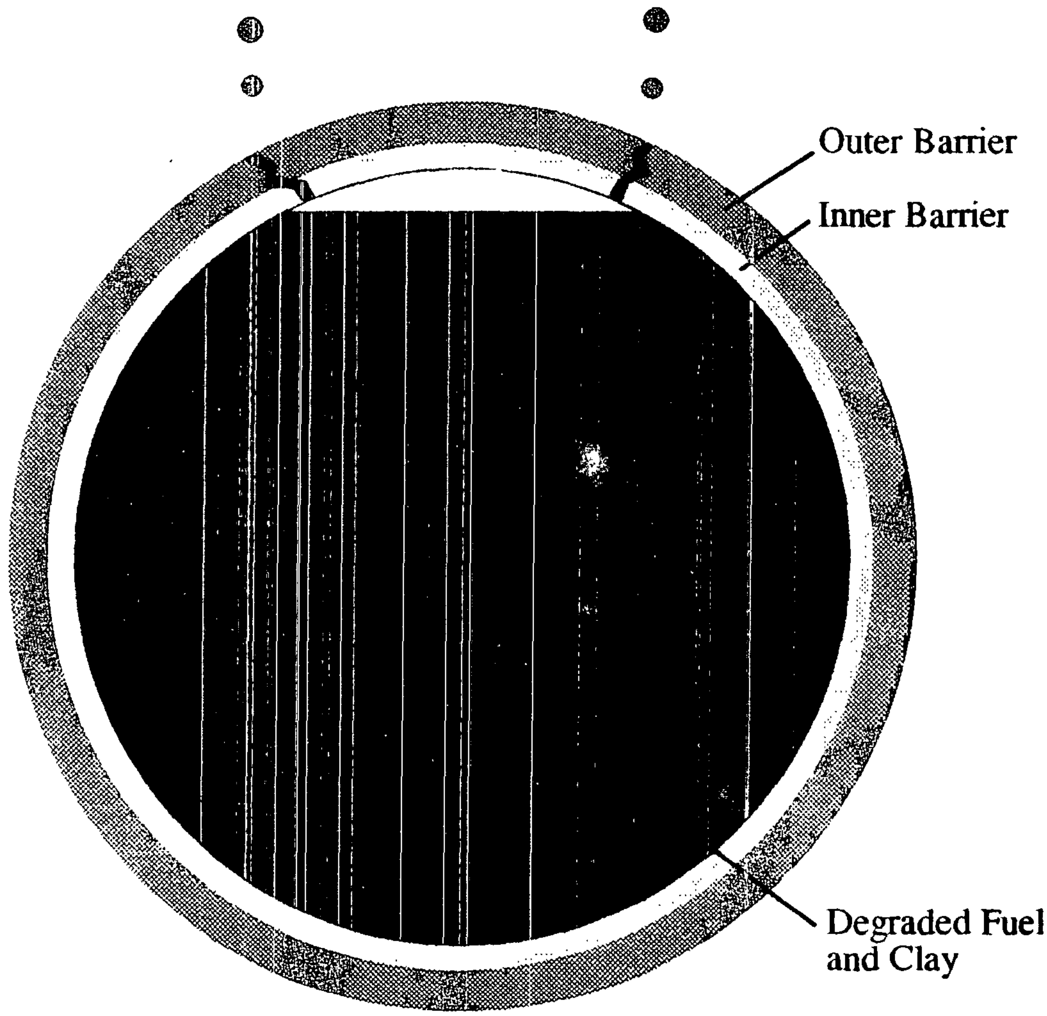
Extreme Stratification within the DOE SNF Canister: 78% of 235U in Lower Layer and 22% in Upper Layer



Possible Final Configuration with Significant Loss of Material



Possible Final WP Configuration with Little Loss of Material



Possible Configuration with no Loss of Material

Findings

- ORR SNF in carbon steel basket having borated stainless steel between-layer separator plates is subcritical in all configurations

Findings (continued)

- MIT SNF in intact basket requires ~1kg of B or Gd distributed in absorber plates
- Degraded MIT SNF and degraded basket (within canister)
  - Requires 0.25 kg of Gd homogeneously distributed if a stainless steel basket is used
  - Requires 0.12 kg of Gd homogeneously distributed if a carbon steel basket is used

Findings (continued)

- Degraded MIT SNF configurations (external to canister, internal to waste package)
  - U on top requires 0.20 kg of Gd homogeneously distributed with SNF (no Fe credit)
  - U on bottom requires 0.10 kg Gd homogeneously distributed with SNF (no Fe credit)
  - U homogeneously mixed with clay remains subcritical (no Fe or Gd credit)

Current Status

- Phase 1 : Complete
- Phase 2 : In review
- Phase 3 : Planned for FY99

Summary

- Co-disposal concept appears workable
- Small impact to repository performance
- Internal configurations can be maintained at subcritical levels
- Analysis of external configurations planned for FY99
- Probability & consequence evaluations planned for FY99