WASTE FORM STUDIES

Presented by
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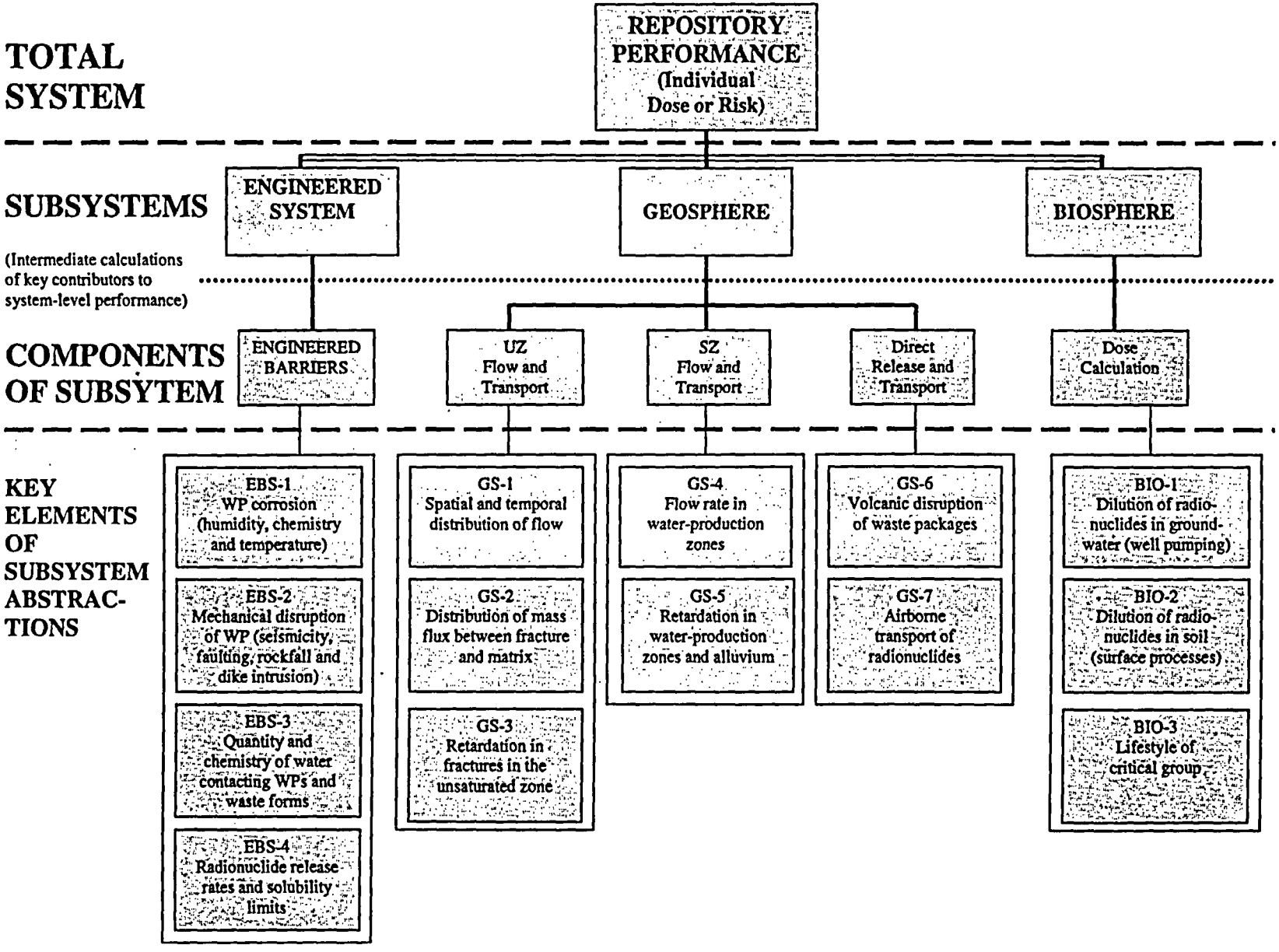
FLOWDOWN DIAGRAM FOR TOTAL SYSTEM PERFORMANCE ASSESSMENT



OUTLINE OF PRESENTATION

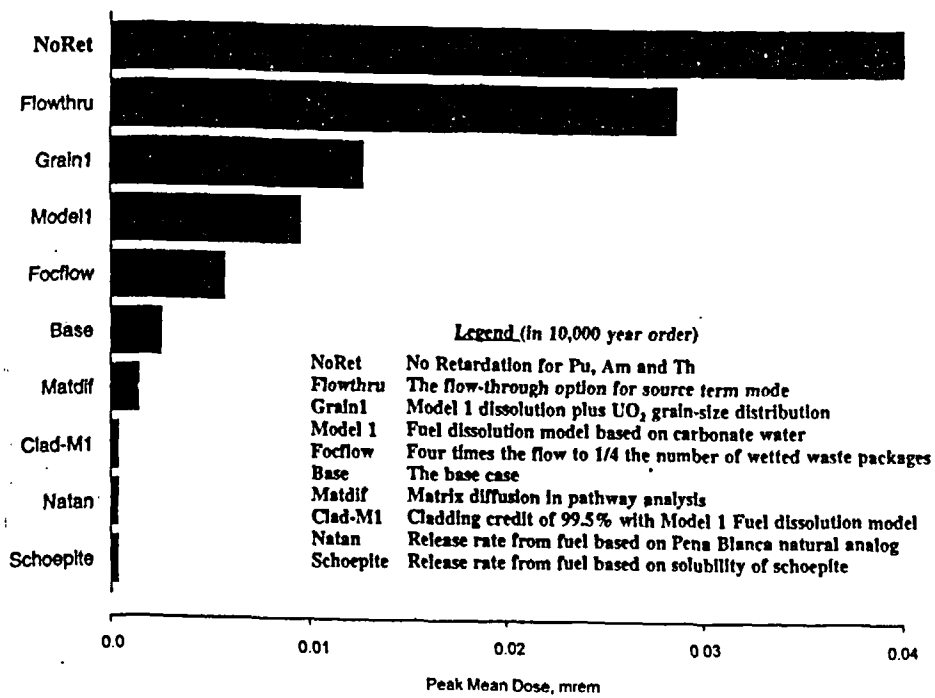
- Spent Nuclear Fuel (SNF)
- Cladding
- High-Level Waste (HLW) Glass

SNF DEGRADATION

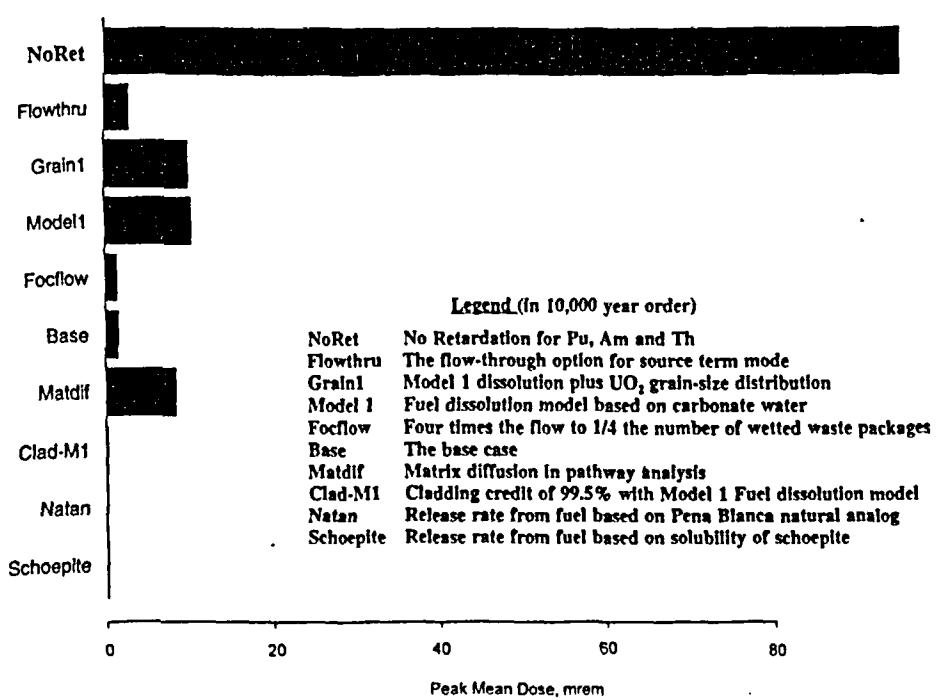
(1) Risk Insights

- The Dose is Sensitive to the Types of SNF Dissolution Processes (Figures)
- The NRC Base Model for SNF Dissolution is More Realistic Compared with the DOE Model; the Dissolution Rate from Tests in J-13 Well Water Is Much Slower; and therefore No Credit was Given to Cladding and More Realistic Juvenile Failure of Container was Allowed.

Peak Mean Dose for 10,000 Years



Peak Mean Dose for 50,000 Years



(2) Technical Basis

- All Categories of SNF: Commercial SNF and DOE-Owned SNF

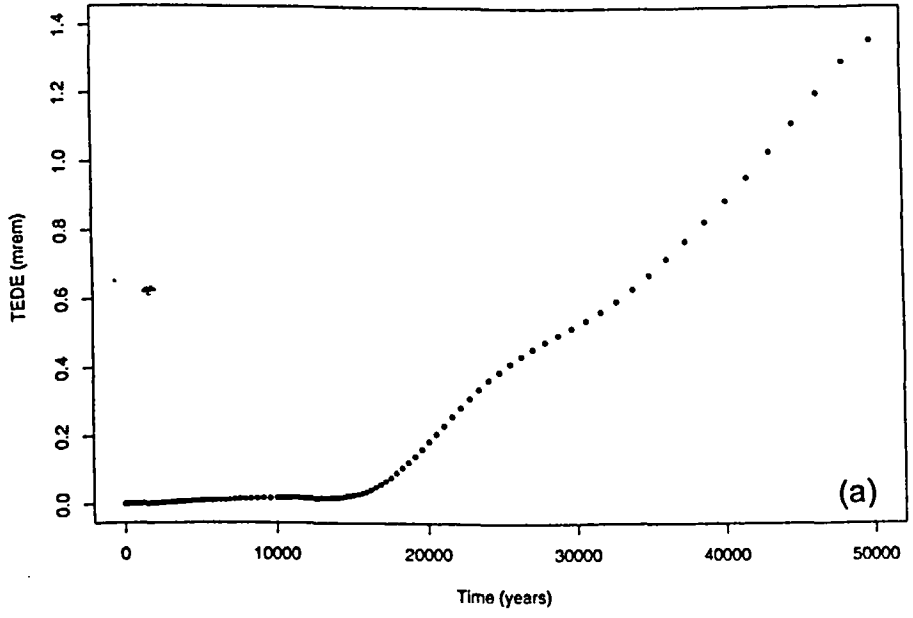
- Likely Processes for SNF Degradation:
  Matrix Dissolution, Colloid Formation, Prompt Radionuclide Release, and Dry Oxidation

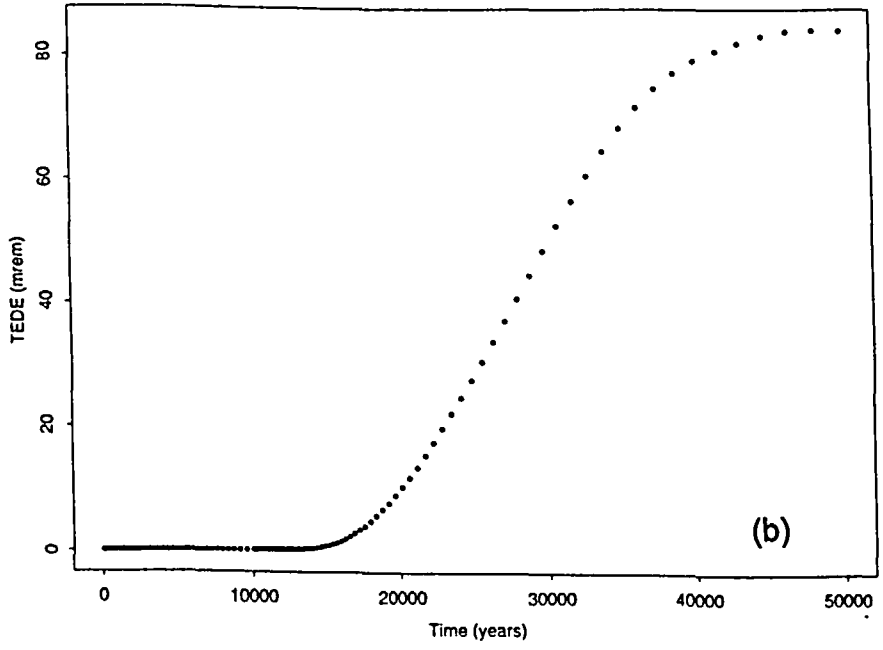
- Models for SNF Dissolution (Table)

Dissolution Rate (mg m^{-2} d^{-1}) at 25° C

This Base Model (NRC Model 2, Grain, Particle)	$(1 \sim 5)\times10^{-2}$
DOE Model (NRC Model 1, Pure Carbonate Solution, Grain, User Supplied)	~ 3 ($[CO_3]=2\times10^{-3}$M, P_{O_2}=0.2 atm, pH=8.4)
ANL Drip Test Model (NRC Model 3, Particle, User Supplied)	7 ~ 110

- No Retardation of Pu (Potential Colloid Contribution): TPA3.2 Outputs
(a) Nominal Case (McCartin, 1999) (b) No Retardation





- Chemistry Inside Waste Package

- High Concentration of Chloride and Metal Chloride Complexes
  - Sustaining localized corrosion requires presence of metal-chloride complexes at a concentration of about 15 percent of saturation. Hydrolysis of metal cations leads to extremely acidic pH values.
  - Dilution of this solution leads to cessation of pit growth.
  - WP internal environment is packed and hence has many crevices where high concentration electrolytes will prevail.

- Oxidizing Conditions
  - Alpha radiolysis will create highly oxidizing conditions close to the surface of spent fuel
  - The packed regions near the fuel may have other oxidized species such as Fe^{+3}

- Currently there is insufficient understanding of the range of environments that may be present inside the WP: localized concentration and bulk dilution. Modeling and experimental tools exist to investigate the extent of variation of internal environment so that SF dissolution calculations may be more realistic

(3) Progress and Current Studies

- Conducted TPA Sensitivity Analysis
- Evaluate Potential Localized Reducing Environments and Iron Effects
- Evaluate Inter-laboratory Data on SNF Dissolution
- Sample Model Parameters in TPA3.2
- Assess the Chemistry inside Waste Package

(4) Path Forward

- Apply Current Models to New Designs that May Result in Different Temperature and Chemistry of Groundwater
- Elaborate with New DOE Data and Modify the Current Assessment with the Confirmatory Testing Program

CLADDING PERFORMANCE

(1) Risk Insights

- The Dose Is Sensitive to Cladding Protection (Figures).

- Uncertainties Associated with Cladding Performance Need to be Investigated.

(2) Technical Basis

- Likely Processes for Cladding Degradation:
  Localized Corrosion, Stress Corrosion Cracking, Hydride Embrittlement, Creep, Mechanical Failure, and Initial Damage and Conditions (restriction on temperature applies only to retrievability after storage)

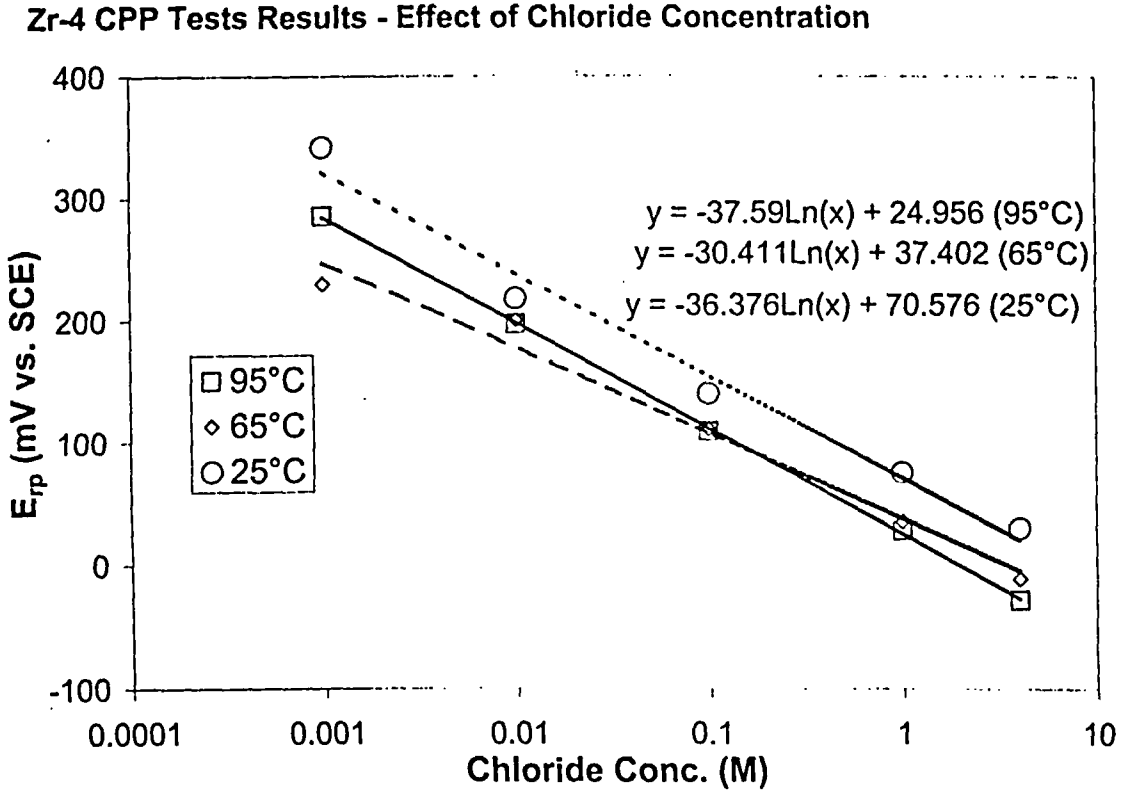
(3) Progress and Current Studies

- Conducted TPA Sensitivity Analysis
- Evaluate Localized Corrosion (Figure)
- Evaluate Mechanical Failure

(4) Path Forward

- Apply Current Models to New Designs that May Result in Different Temperature and Chemistry of Groundwater

- Extend to Evaluate Other Failure Modes



HLW GLASS DEGRADATION

(1) Risk Insights

- Current DOE Models Do not Result in Dose Contribution in the TPA3.2 Exercise.

(2) Technical Basis

- The Degradation Process Includes Three Stage Leaching, Colloid Formation, Hydration, Iron Effects, and Microbial Action.

(3) Progress and Current Studies

- Initiated Scoping Tests: Effects of Corrosion Species in Solution Chemistry Representative of Conditions near Waste Packages; and Long-Term Product Consistency Test (PCT) and Pressurized Unsaturated Flow Tests

- Evaluate Uncertainties Associated with Various Degradation Modes

- Evaluate the TPA3.2 Sensitivity of Hydration, Colloids, and Stage 3 Leaching

(4) Path Forward

- Apply Current Models to New Designs that May Result in Different Temperature and Chemistry of Groundwater

SUMMARY

(1) The System-level Performance of Waste Form Was Studied.

(2) The Dose is Sensitive to Modes of SNF Dissolution and Cladding Performance. A More Realistic Model for SNF Dissolution Was Used in Performance Assessment.

(3) The Technical Bases for Waste Form Degradation are Established.

(4) Uncertainties Associated with SNF, Cladding Performance and HLW Glass Are Being Investigated. Modeling Continues.

(5) Tests of Simulated HLW Glass and Cladding Have Been Initiated.