EPRI

SOURCE TERM
IN THE EPRI
PERFORMANCE ASSESSMENT

Presented by
Robert A. Shaw
EPRI

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EPRI PERFORMANCE ASSESSMENT MODEL

- Calculates radionuclide releases to accessible environment
- Probability-based using logic diagrams to calculate CCDF's
- Uses individual experts to develop nodes on logic tree
- Relies on more detailed models and analyses
  - For controlling mechanisms and parametric values

OVERVIEW OF PRESENTATION

- Source term results from published work

  EPRI Report TR-100384, May 1992
  "Demonstration of Risk-Based Approach to High-Level Waste Repository Evaluation: Phase 2"

- Recent refinement of source term analyses

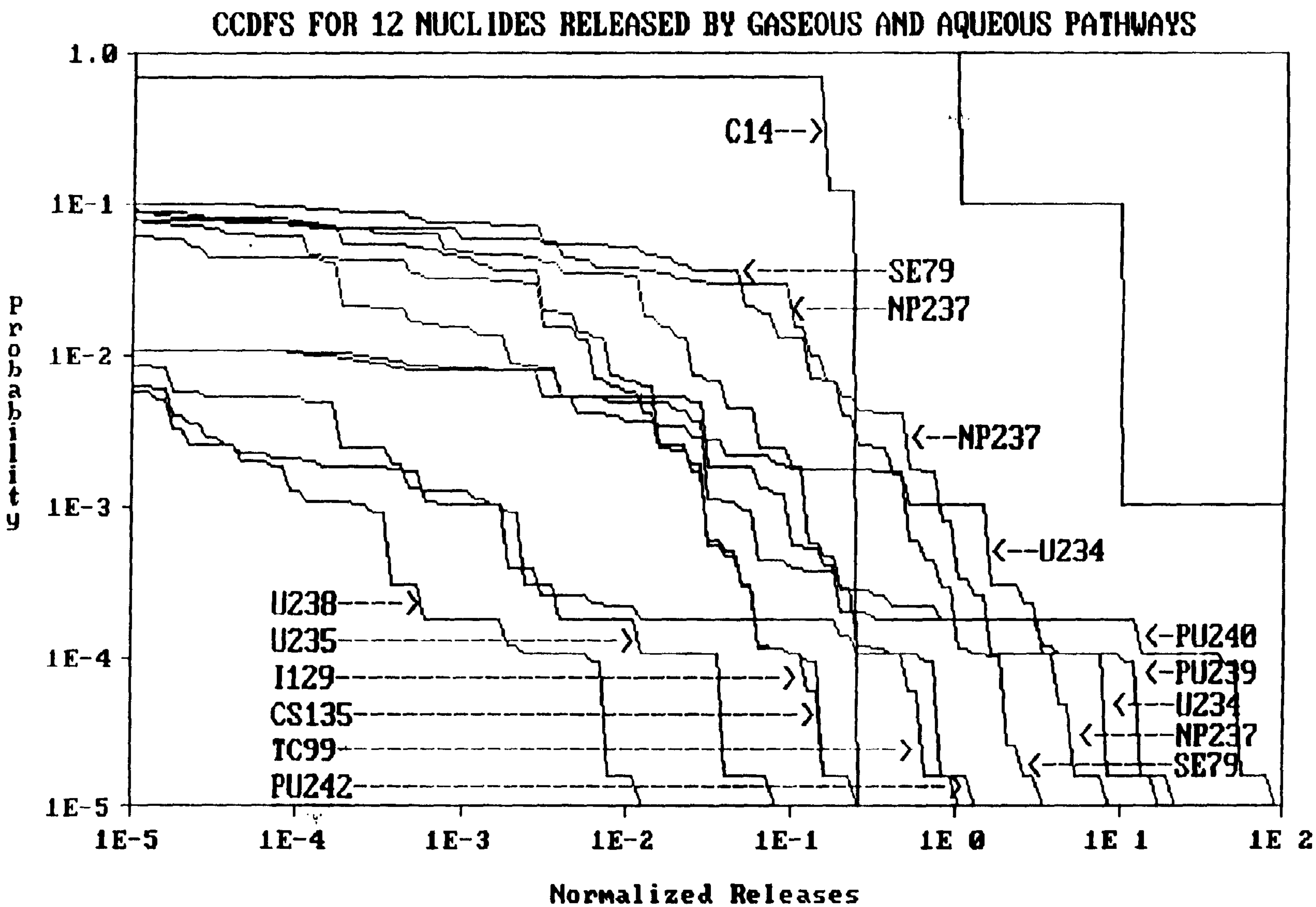


Figure 16-1. CCDFs for 12 nuclides released by gaseous and aqueous pathways.

SOURCE TERM

- Release of radionuclides from near-field
  - Waste package degradation
  - Dissolution of waste
  - Transport of released radionuclides

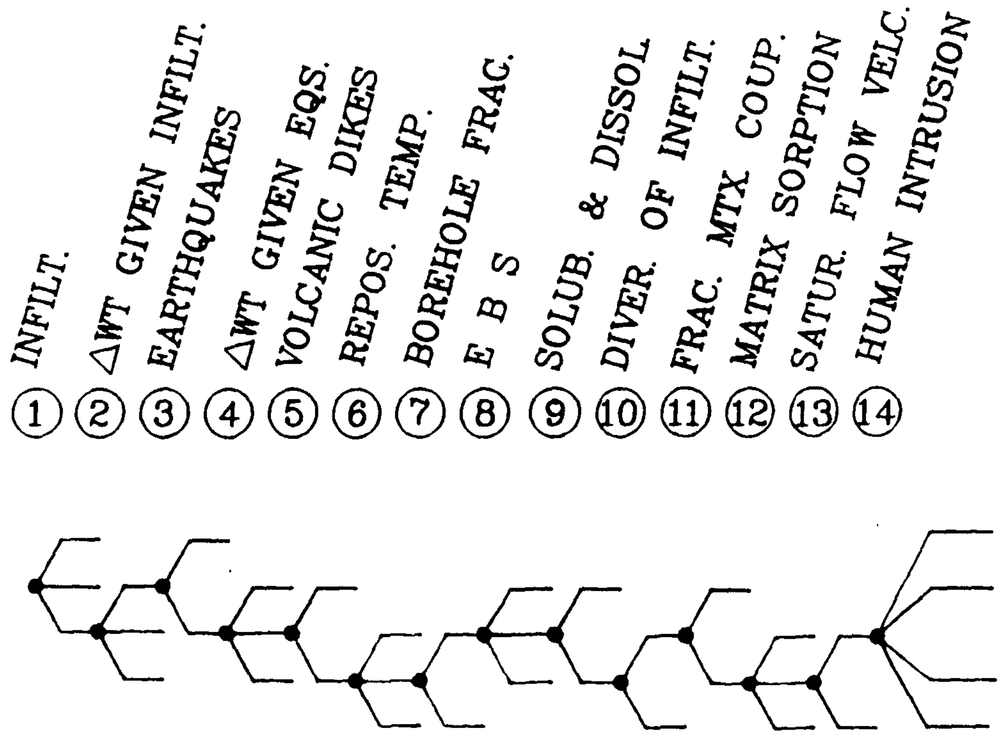


Figure 15-13. Master logic tree.

WASTE PACKAGE DEGRADATION

- Weibull distributions for container & cladding failures
  - Threshold failure times
  - Mean lifetimes
  - Failure rate at mean lifetimes
- Degradation modes & failure mechanisms
  - Environmental, materials, closure, thermo-mechanical history
  - Deterministic models for Weibull parameters
  - Cladding: creep rupture & hydride reorientation

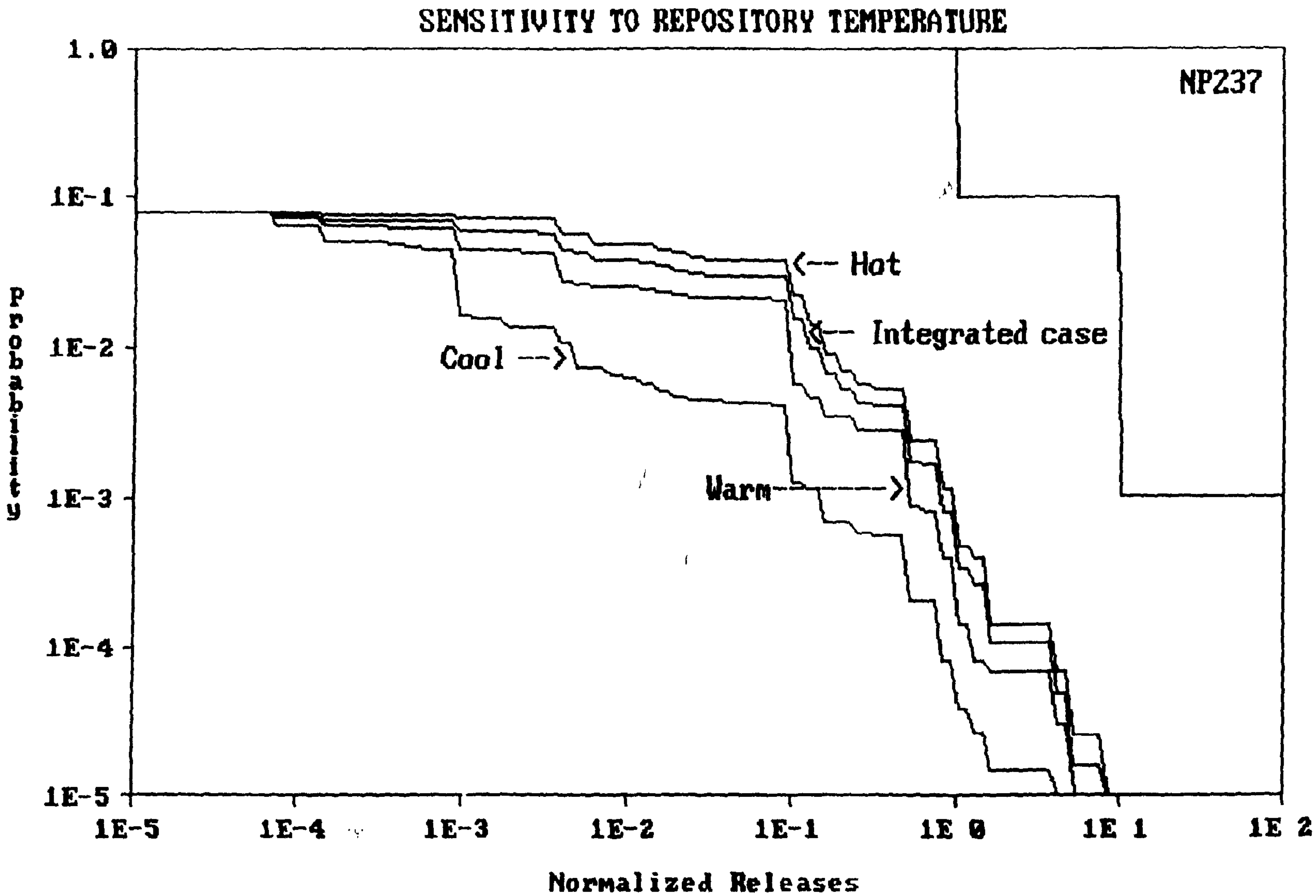


Figure 16-6. Sensitivity of CCDF for ^{237}Np to repository temperature.

DISSOLUTION & TRANSPORT OF WASTES

- Release modes
  - Dry: no release pathway
  - Wet drip: container fills to penetration
  - Moist: diffusive & advective pathways
- Chemical constraints on release
  - Dissolution (alteration, reaction) rates
  - Radioelement solubility limits

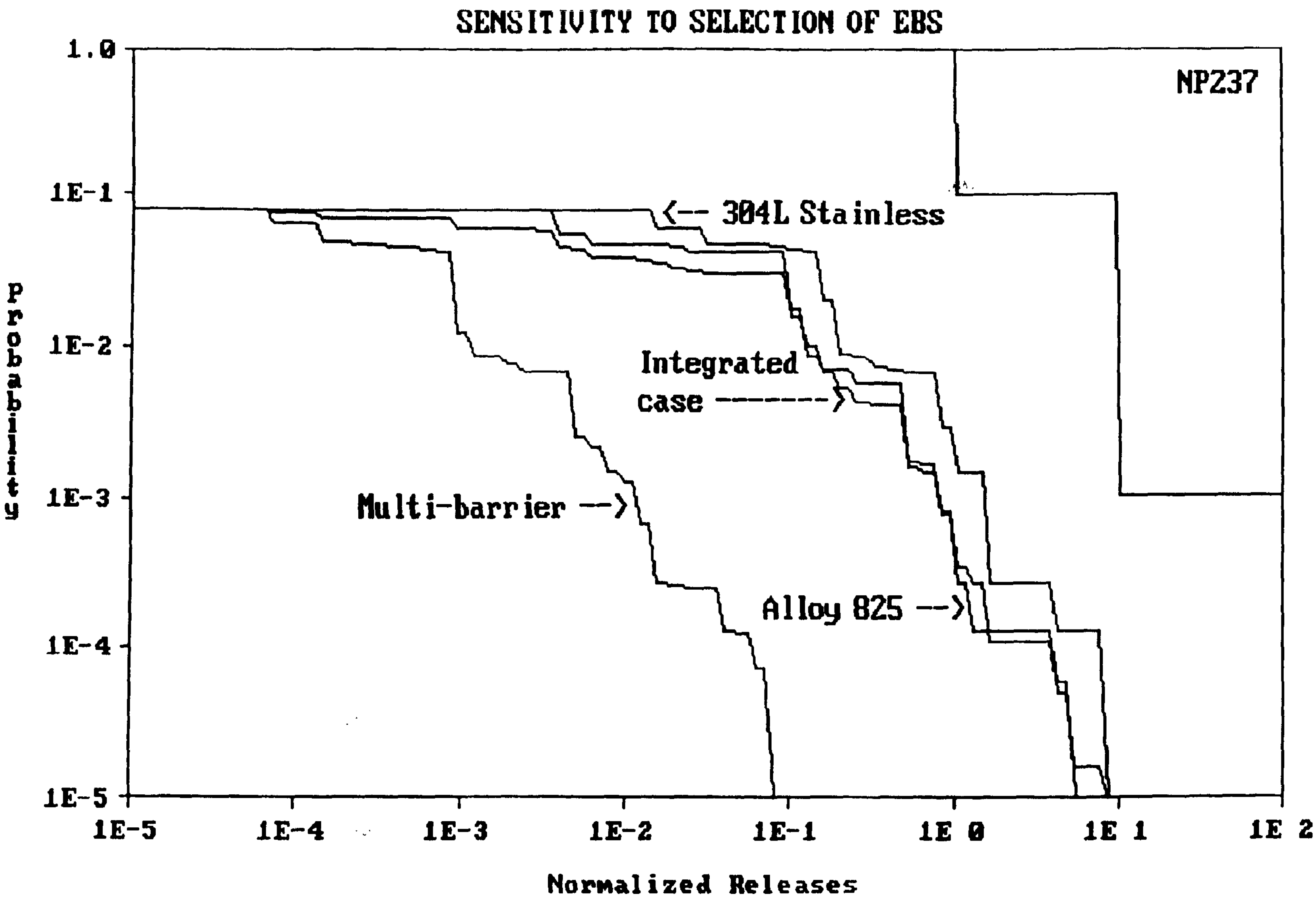


Figure 16-8. Sensitivity of CCDF for ^{237}Np to selection of EBS.

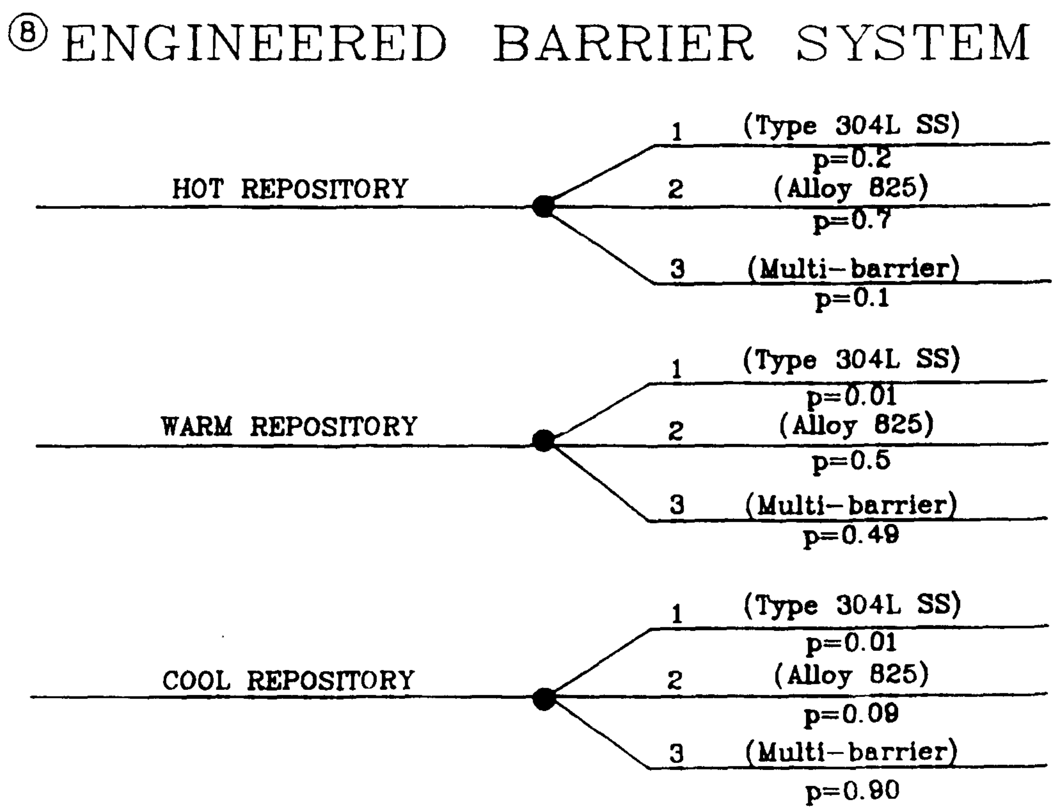


Figure 15-8. Logic tree node for engineered barrier system.

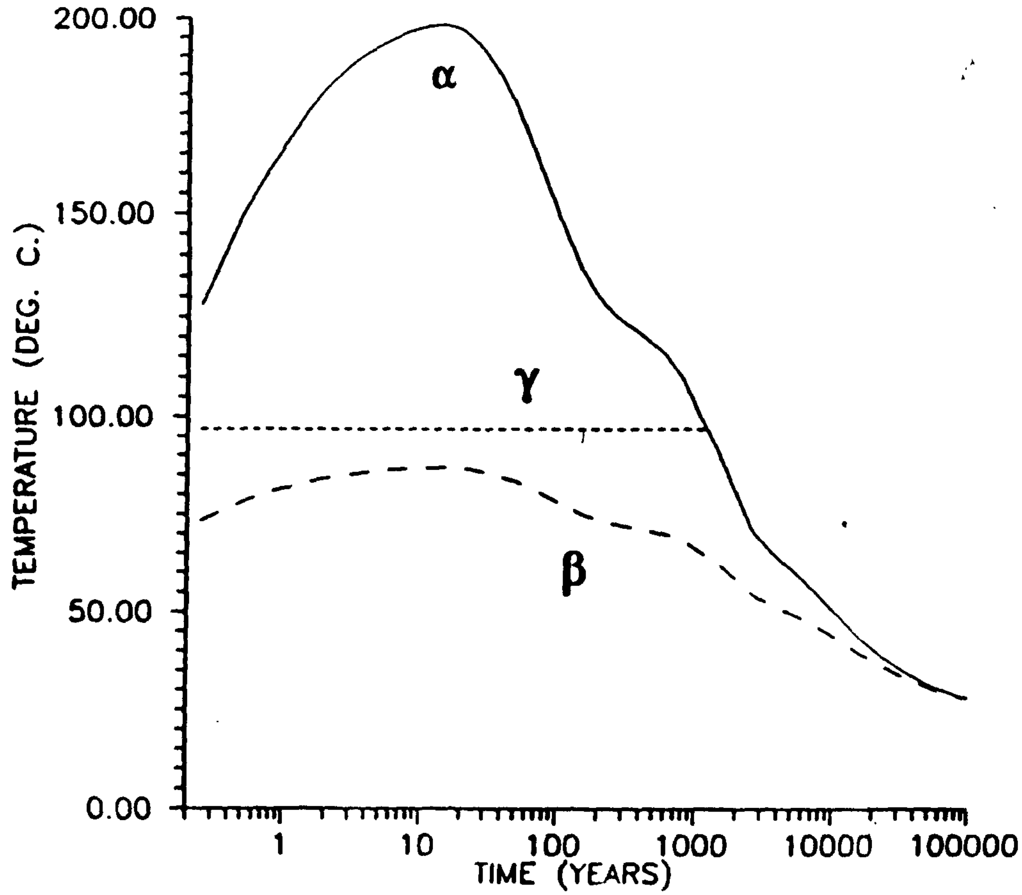


Figure 8-2. Three alternative curves showing temperatures at the outer surface of a waste emplacement hole as functions of time.

Table 8-2

SUMMARY OF TEMPERATURE SCENARIOS AND FRACTIONS OF REPOSITORY AREA FOLLOWING EACH TEMPERATURE CURVE

Scenario	Probability	Curve α	Curve β	Curve γ
1	0.6	0.9	0	0.1
2	0.3	0.1	0	0.9
3	0.1	0	1.0	0

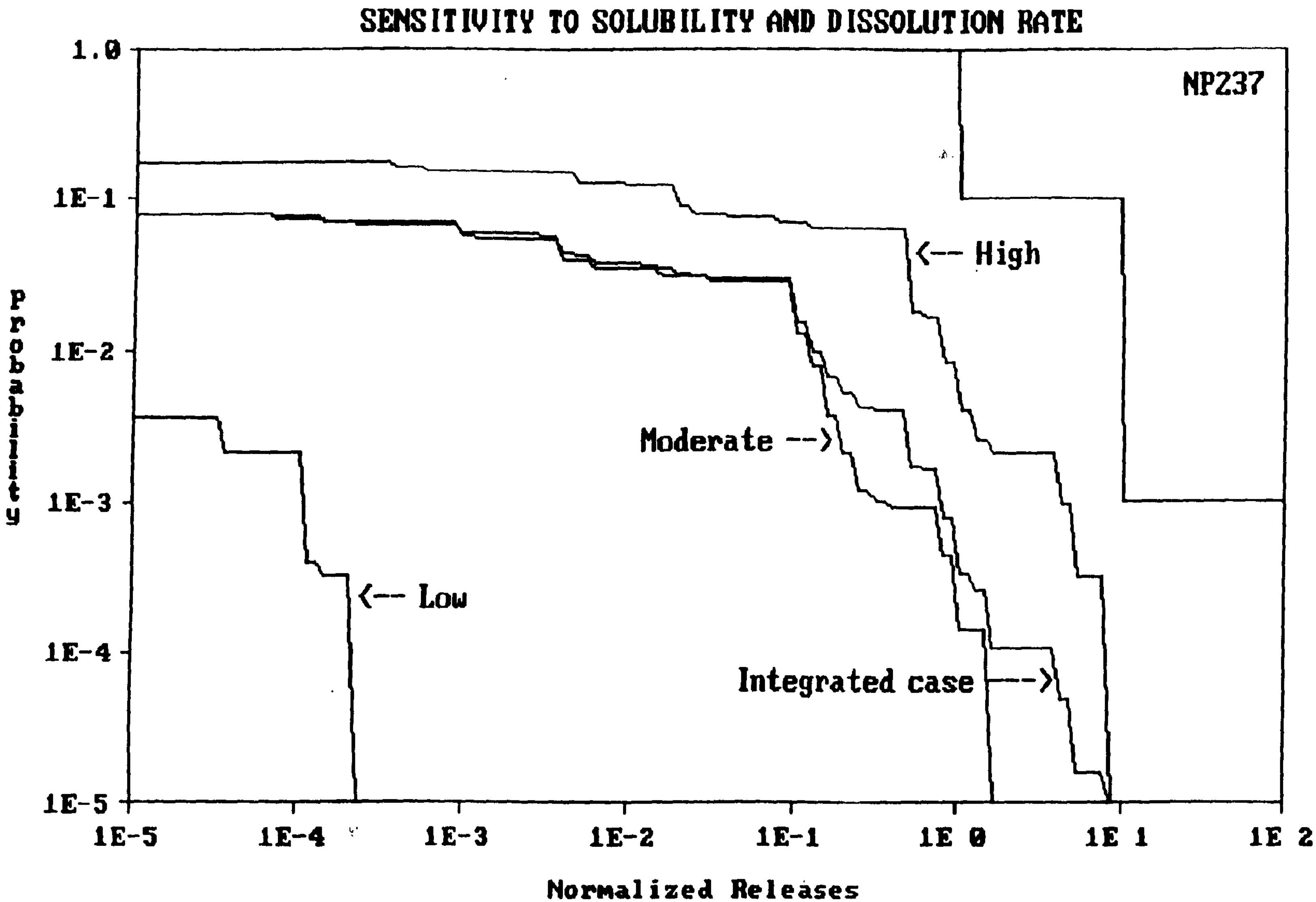


Figure 16-9. Sensitivity of CCDF for ^{237}Np to solubility and dissolution rate.

RECENT REFINEMENTS

- Meetings with LBL, UCB, LLNL & SNL
- 3 Alternative Thermal Loadings (Design Parameter)
- 3 Alternative Waste Containers (Design Parameter)
- 3 Heat-Transfer Mechanisms
  Conduction, Convection & Heat-Pipe
- 4 Time-Temperature Curves

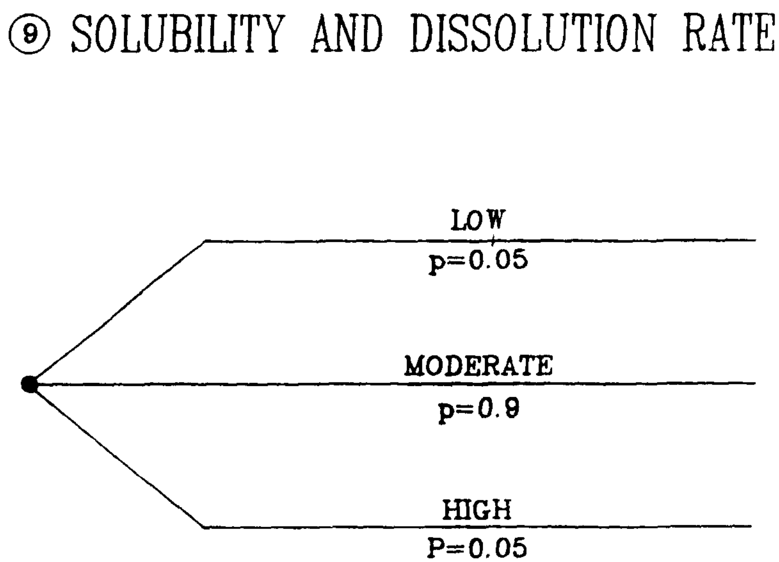


Figure 15-9. Logic tree node for solubility and dissolution rate.

Table 11-4

SOLUBILITIES OF RADIOELEMENTS, IN gm/m^3

Element	Low	Moderate	High
C	1.0	1.4	1.4×10^{2}
Se	7.9×10^{2}	7.9×10^{3}	5.5×10^{5}
Tc	3.5×10^{-2}	1.0×10^{2}	9.9×10^{5}
Sn	1.3×10^{-4}	3.2×10^{-3}	2.2×10^{-2}
I	1.0	3.9×10^{2}	1.0×10^{5}
Cs	1.2	3.9×10^{2}	2.1×10^{3}
Ra	1.0×10^{-5}	4.0×10^{-4}	0.1
U	0.5	2.4	5.0×10^{1}
Np	4.0×10^{-4}	3.6×10^{2}	7.2×10^{2}
Pu	6.0×10^{-5}	9.6×10^{-4}	4.3×10^{-1}
Am	1.5×10^{-7}	9.6×10^{-2}	9.6×10^{-1}
Cm	2.4×10^{-9}	9.6×10^{-2}	9.6×10^{-1}

TABLE 11-2

ESTIMATED PERCENT OF TOTAL RADIONUCLIDE INVENTORIES WITHIN THE SEPARATE REGIONS OF SPENT FUEL (1)

Nuclides	UO_2 Matrix	Gap (+ Grain Boundary)	Cladding	Surface Layer
C-14	35	1	63	1
Se-79	98	2	---	---
Tc-99	98	2	---	---
Sn-126	100	---	---	---
I-129	98	2	---	---
Cs-135	98	2	---	---
U-234	100	---	---	---
U-238	100	---	---	---
Np-237	100	---	---	---
Pu-239	100	---	---	---
Pu-240	100	---	---	---
Pu-242	100	---	---	---
Am-241	100	---	---	---
Am-243	100	---	---	---
Cm-245	100	---	---	---

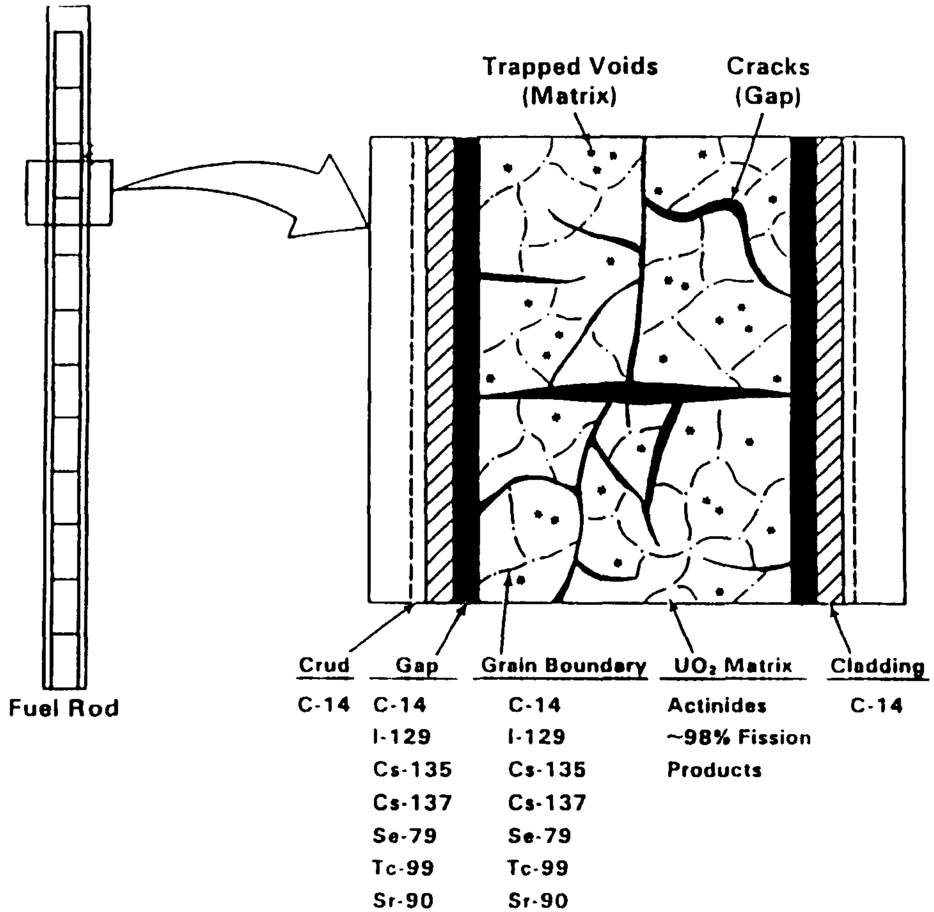
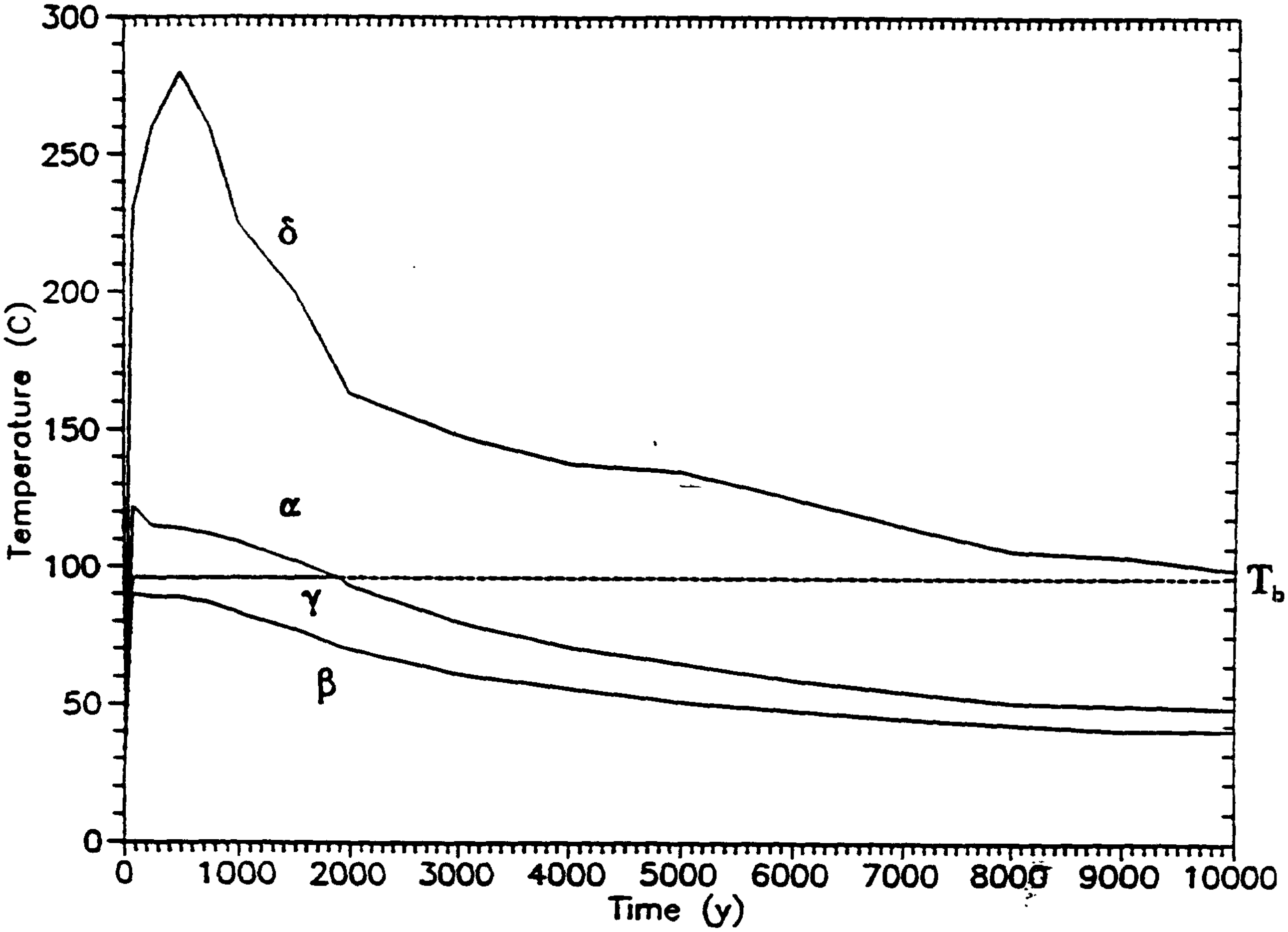


Figure 11-5. Schematic diagram of spent fuel showing different source regions with characteristic radionuclides (13).



300
250
200
150
100
50
0
Temperature (C)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Time (y)
δ
α
γ
β
T_b

Fractions of Repository in Different Environments
for APD=57 kW/acre

Conduction-dominated
p=0.5

	α	β	γ	δ	Total
Dry	.7	.09	.06	0	.850
Moist.-Contin.	.01	.002	.03	0	.042
Wet-Drip	.02	.004	.02	0	.044
Episodic	.02	.004	.04	0	.064
Total	.75	.10	.15	0	1.0

High Permeability
p=0.2

	α	β	γ	δ	Total
Dry	.32	.36	.07	0	.750
Moist- Contin.	.01	.01	.04	0	.060
Wet-Drip	.01	.015	.03	0	.055
Episodic	.06	.015	.06	0	.135
Total	.400	.400	.200	0	1.0

Water Mobile in Fractures
p=0.3

	α	β	γ	δ	Total
Dry	.25	.04	.1	0	.390
Moist-Contin.	0	.025	.15	0	.175
Wet-Drip	.005	.03	.15	0	.185
Episodic	.045	.005	.2	0	.250
Total	.300	.100	.600	0	1.0

SOME KEY ISSUES

- EPA HLW Criteria
  - Regulatory & Licensing Implication
- EBS Design
  - Borehole or Drift Emplacement
  - Thermal Load
  - Waste Container (UCS?)
  - Backfill Materials

SOME KEY SOURCE TERM ISSUES

- Solubility Data
- Spent Fuel Inventories
  (ESP. C-14)
- Alteration Rates
- Retardation
- Repository Water Chemistry

SITE UNCERTAINTIES

- Infiltration
  - What is it at repository elevation?
- Degree of fracturing
  - Spacing, sizes, ...
- Coupling between fracture & matrix flow
- Permeability of fractures (connectedness)
- Lateral flow distribution
  - Impermeable layers

PERFORMANCE ASSESSMENT MODELING ISSUES

- How can PA models be validated?
  - subsections with submodels
  - integrated system
- Bounding or conservative calculations vs. realistic or best measure calculations
- Self-consistency: heat, water, mass transport, and coupling
- Cell vs. homogeneous modeling of EBS
- Use of expert judgment

PERFORMANCE ASSESSMENT MODELING ISSUES (continued)

- Detailed model to overview PA model
  - transfer function
- Levels of detail in overview models
- Incorporating probabilistic and deterministic aspects
- Cost and schedule implications