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A Proposed Public Health and Safety Standard for Yucca Mountain

Presented to:

Technical Review Board
April 19, 1995

Prepared by:
Rosa Yang
John Kessler

Fuel Reliability, Storage & Disposal

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EPRI Involvement with NAS TYMS Committee

- Designated as industry liaison
- Made technical presentation at each open meeting on:
  - performance assessment, disruptions in repository performance, possible standards, biosphere, probabilistic treatments
- Proposed a public health and safety standard for Yucca Mountain

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Approach

- Use EPRI HLW performance assessment code IMARC to calculate releases and doses using different assumptions and scenarios
  - evaluate the performance of Yucca Mountain
  - analyze sensitivity to input parameters/scenario
  - evaluate/quantify uncertainties

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Criteria

- A high level waste repository standard must
  - assure effective protection of the public into the far future
  - be consistent with scientific and societal realities and uncertainties
  - be licensable

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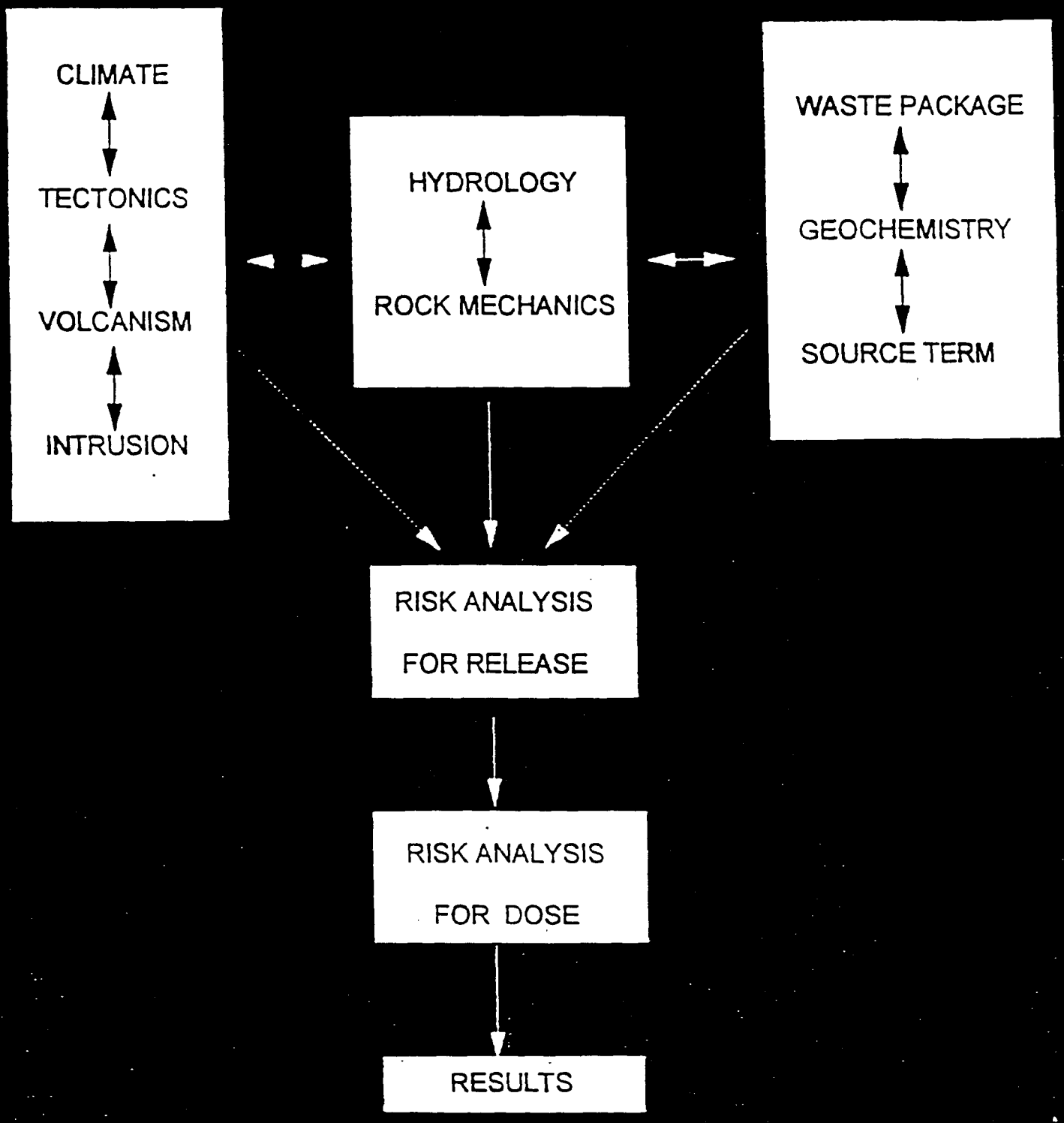
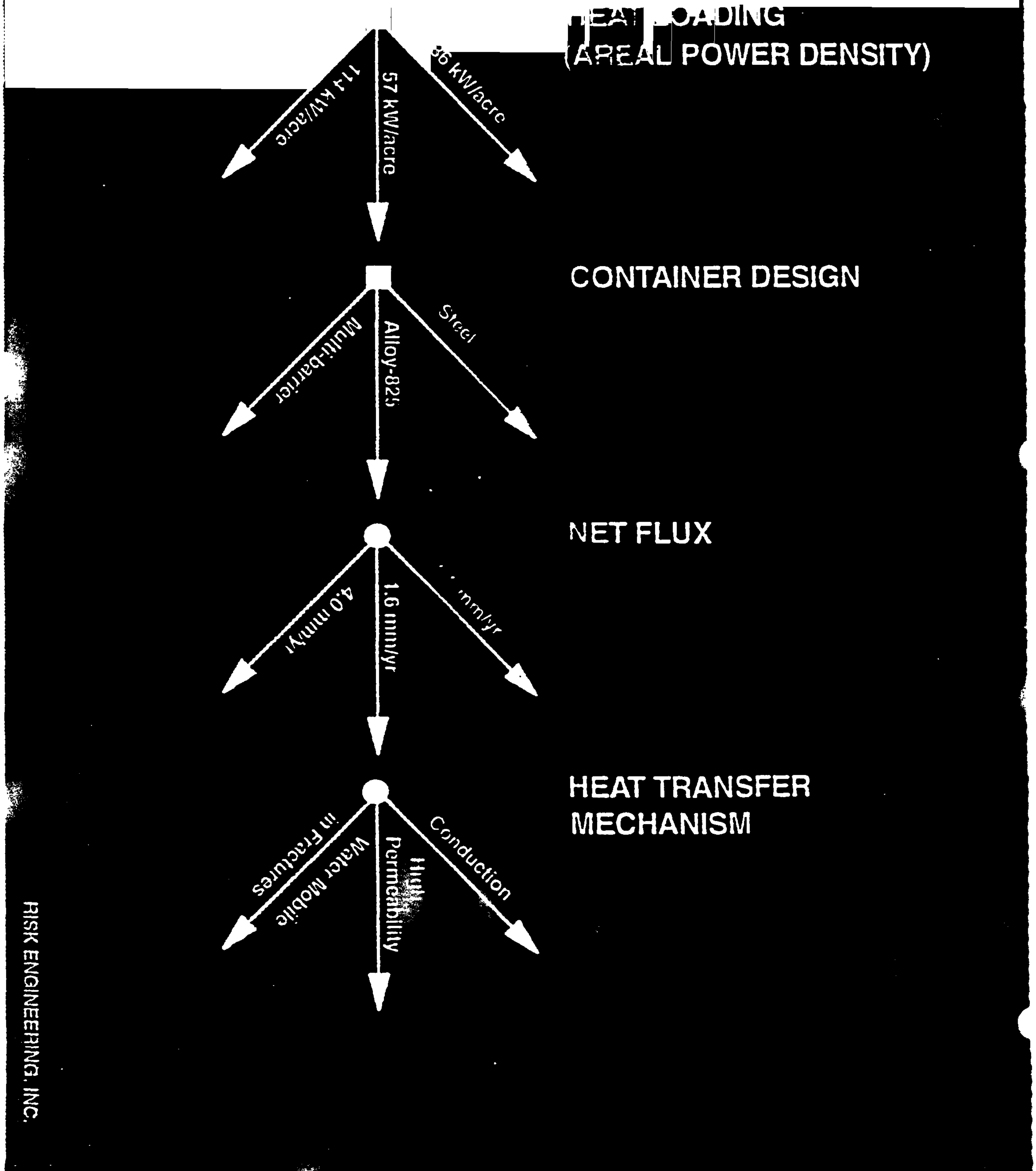
EPRI
HIGH LEVEL WASTE
PERFORMANCE ASSESSMENT EFFORT

MAJOR DISCIPLINE INTERACTIONS



RISK ENGINEERING, INC.


HEAT LOADING
(AREAL POWER DENSITY)
114 kW/acre
57 kW/acre
kW/acre
CONTAINER DESIGN
Multi-barrier
Alloy-825
Steel
NET FLUX
4.0 mm/yr
1.6 mm/yr
mm/yr
HEAT TRANSFER
MECHANISM
Water Mobile in Fractures
High Permeability
Conduction
RISK ENGINEERING, INC.

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EPRI Proposal on The Yucca Mountain Performance Standard

Heart of the Proposed Standard:
Reasonable assurance of sustained, low health risk to average individuals in future, local population groups

Two time periods to provide an added margin of safety

Time periods are:

- engineered barrier (0 to ~1000 years after emplacement)
- geologic (~1000 to beyond 10,000 years)

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Fixed or Risk-Based Criteria?

Uncertainty does and always will exist. Types of uncertainty:

- External factors
- Geologic parameters
- Engineered barrier parameters
- Geochemical parameters
- Biosphere parameters
- Human behavior
- Pathways and mechanisms

There will always be a few, low probability scenarios which will result in high doses.

Does it make sense to set criteria which will not be met by a few, low probability scenarios? NO

THEREFORE, CHOOSE RISK-BASED CRITERIA
(Reasonable Assurance)

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Release- Versus Health-Based Standards

- Release-based standards cannot capture true health impacts for all scenarios

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Conclusion:

A Health- (i.e., Dose-) Based Standard

- Won't have to be revised every time parameters/models change
- Directly regulates the ultimate measure of satefy-health effects
  - Models
    - Biosphere model (e.g. enclosed basin rather than discharge to to a river)
    - Thermal/hydrologic models
  - Parameters
    - rock properties
    - solubilities
    - external events
    - dose conversion ratios

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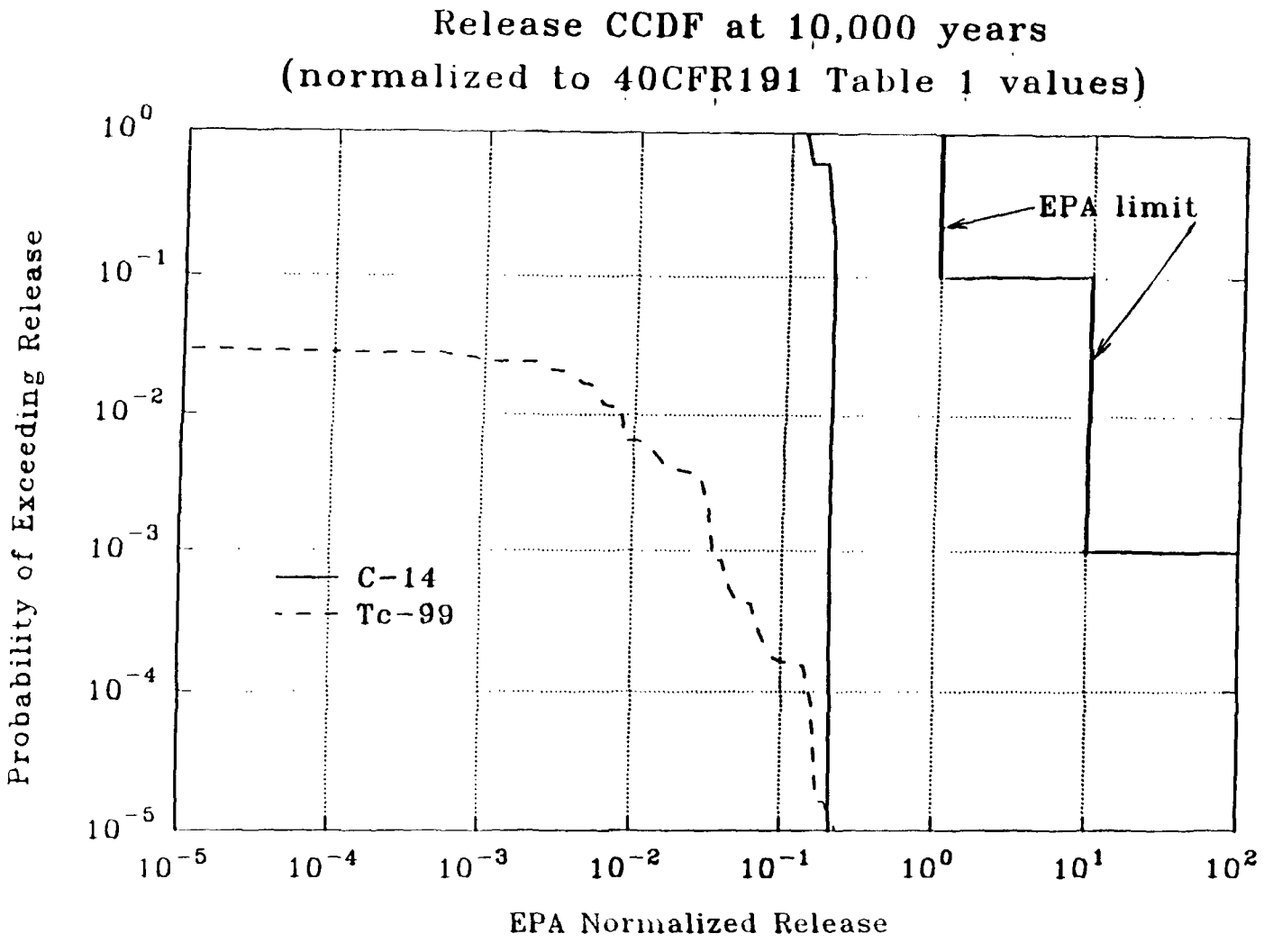
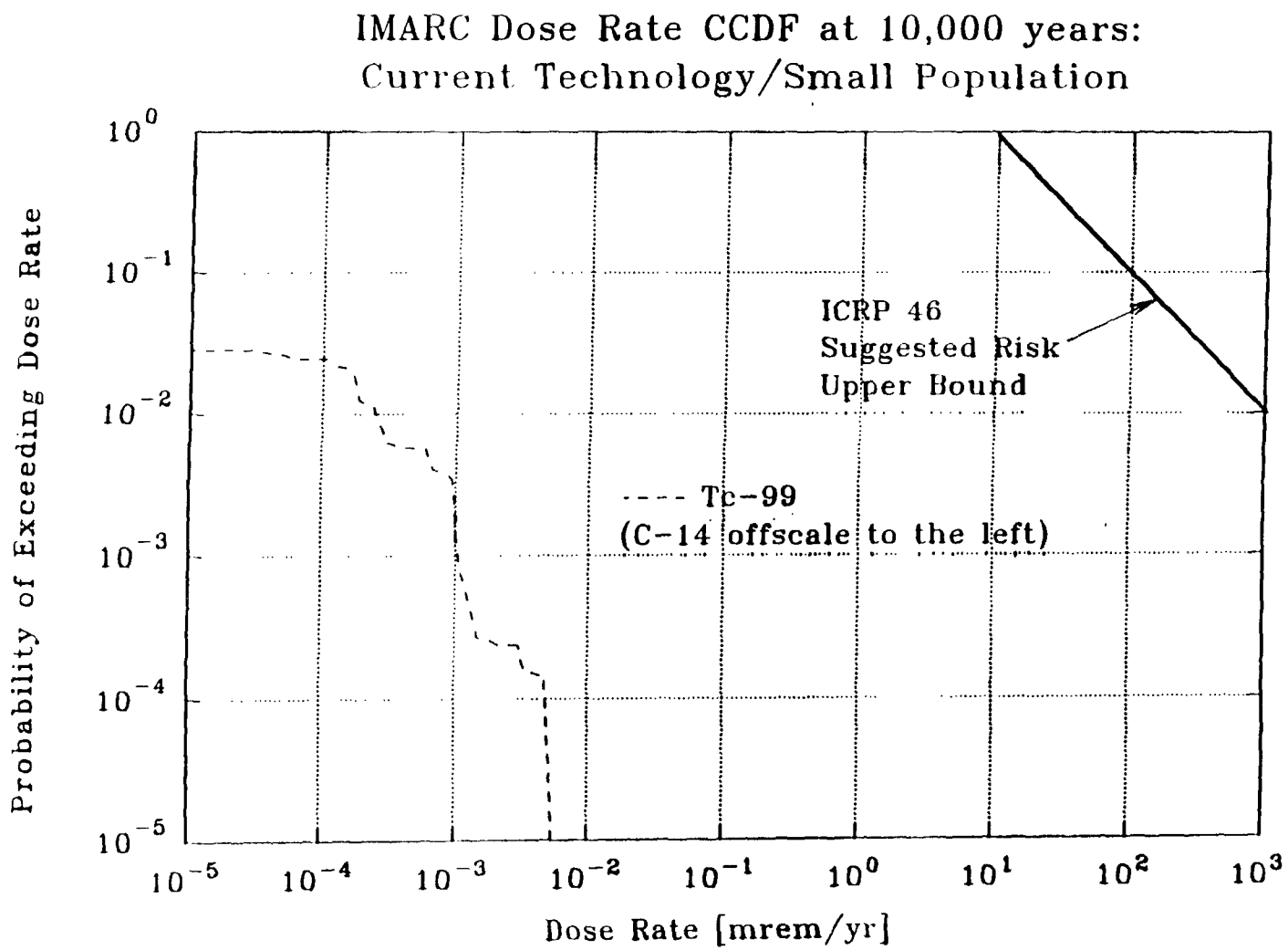
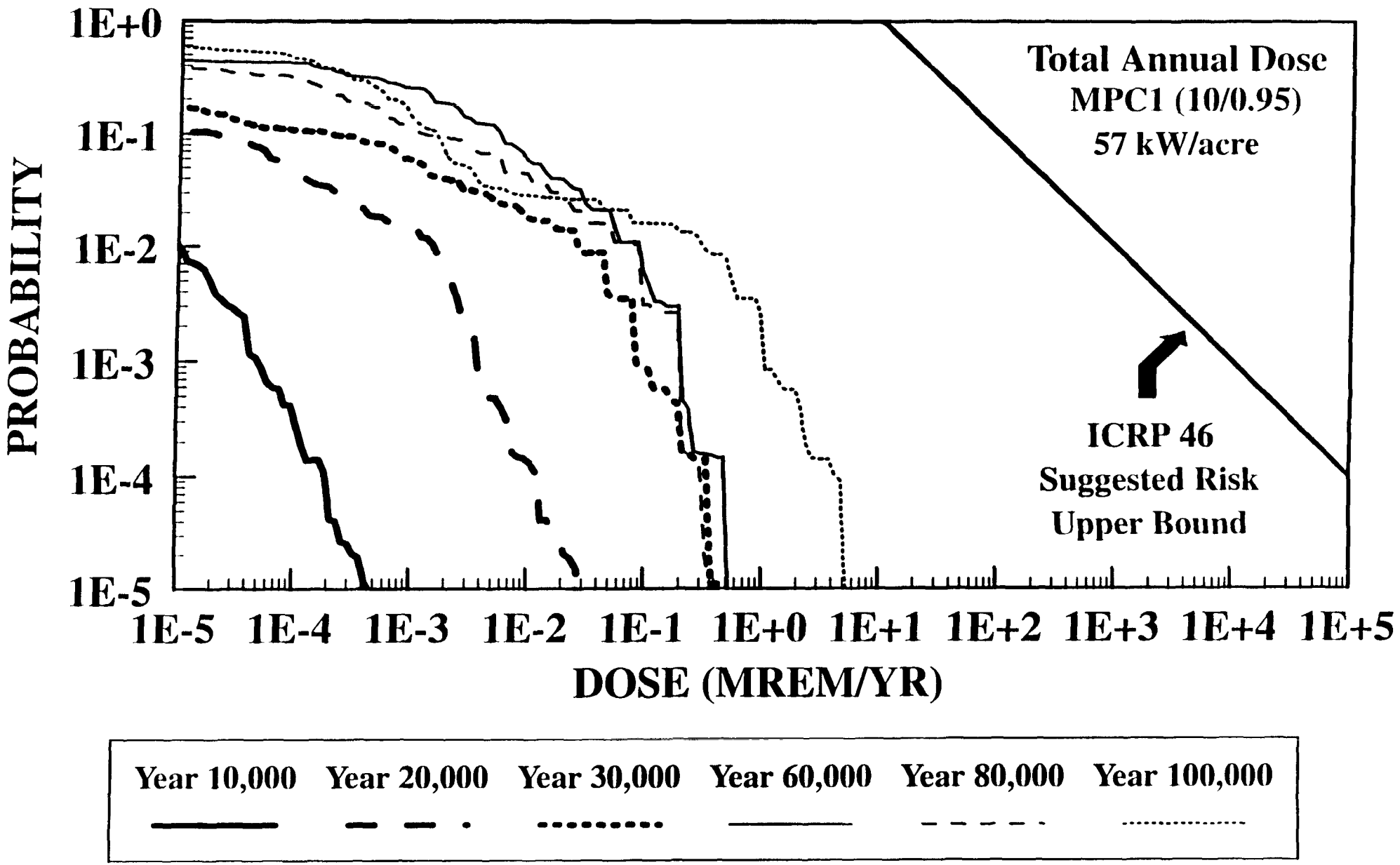

Release CCDF at 10,000 years
(normalized to 40CFR191 Table 1 values)
Probability of Exceeding Release
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
EPA limit
C-14
Tc-99
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
EPA Normalized Release


IMARC Dose Rate CCDF at 10,000 years:
Current Technology/Small Population
Probability of Exceeding Dose Rate
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
ICRP 46
Suggested Risk
Upper Bound
---- Tc-99
(C-14 offscale to the left)
10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}
Dose Rate [mrem/yr]


1E+0
1E-1
1E-2
1E-3
1E-4
1E-5
PROBABILITY
Total Annual Dose
MPC1 (10/0.95)
57 kW/acre
ICRP 46
Suggested Risk
Upper Bound
1E-5 1E-4 1E-3 1E-2 1E-1 1E+0 1E+1 1E+2 1E+3 1E+4 1E+5
DOSE (MREM/YR)
Year 10,000
Year 20,000
Year 30,000
Year 60,000
Year 80,000
Year 100,000

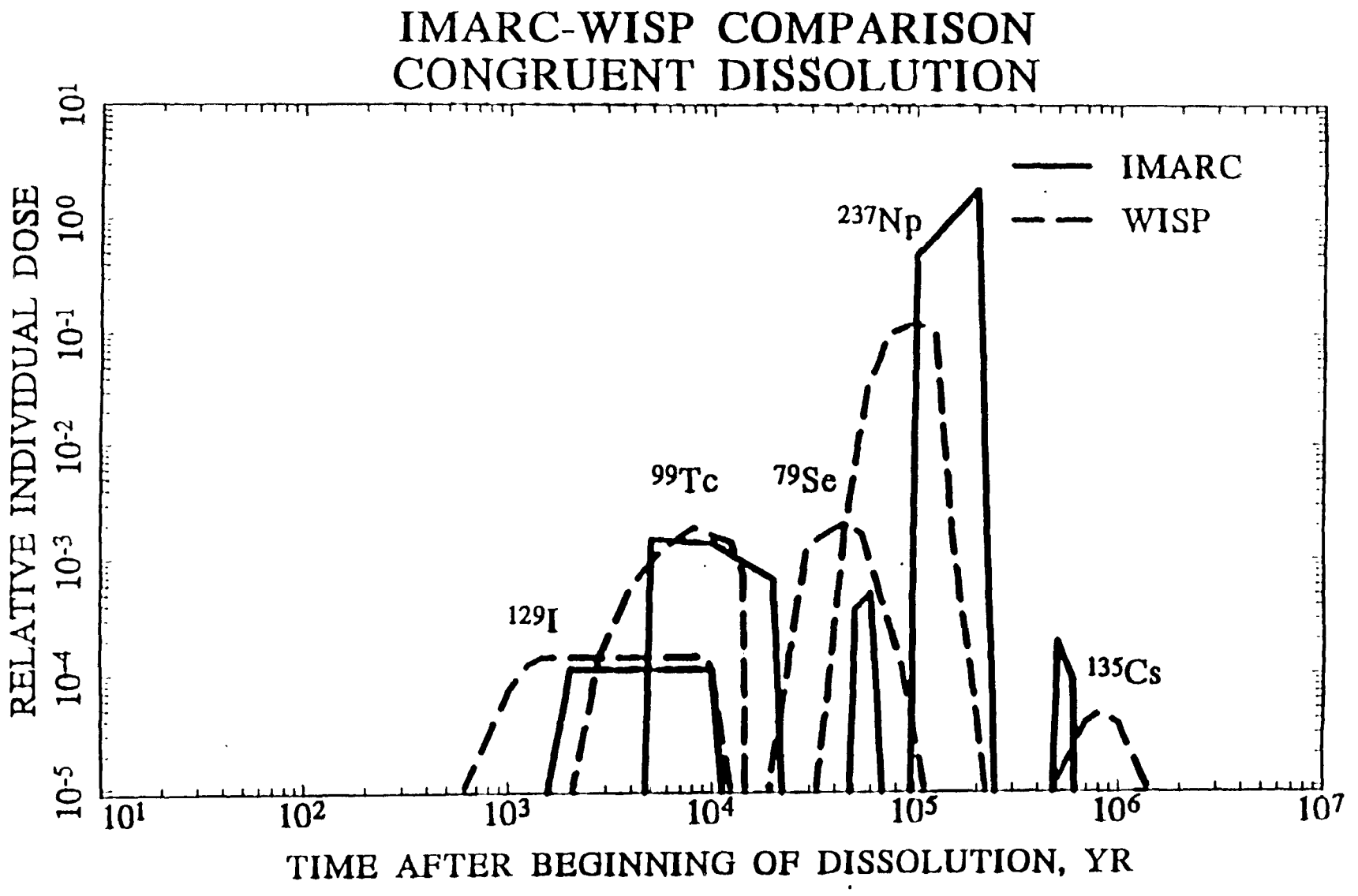


Figure 3-3 Comparison of IMARC and WISP dose calculations for congruent dissolution.

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How Far into the Future Can We Remain Quantitative in a Regulatory Environment?

- Depends on the subsystem AND expert judgement
- NRC will need general scientific consensus (both within and outside of DOE)
- Conclusion: 1000 years may be all the general scientific community will agree on:
  - although some subsystems remain "predictable" for longer, *general* consensus dictates using the subsystem with the shortest time period of predictability
  - 1000 years will significantly reduce the total radionuclide inventory, so a good container is required for that period

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A *Release*-Based Standard *is* Appropriate for this First 1000-Year Period

- Health consequences are essentially nil for the first ~1000 years
  - container design not important in meeting a dose-based standard for the first ~1000 years
  - therefore, a dose standard alone would not provide any additional protection
- A standard regulating release from the EBS for these early years would provide additional protection (defense-in-depth)
  - by requiring development of a reasonably robust waste container

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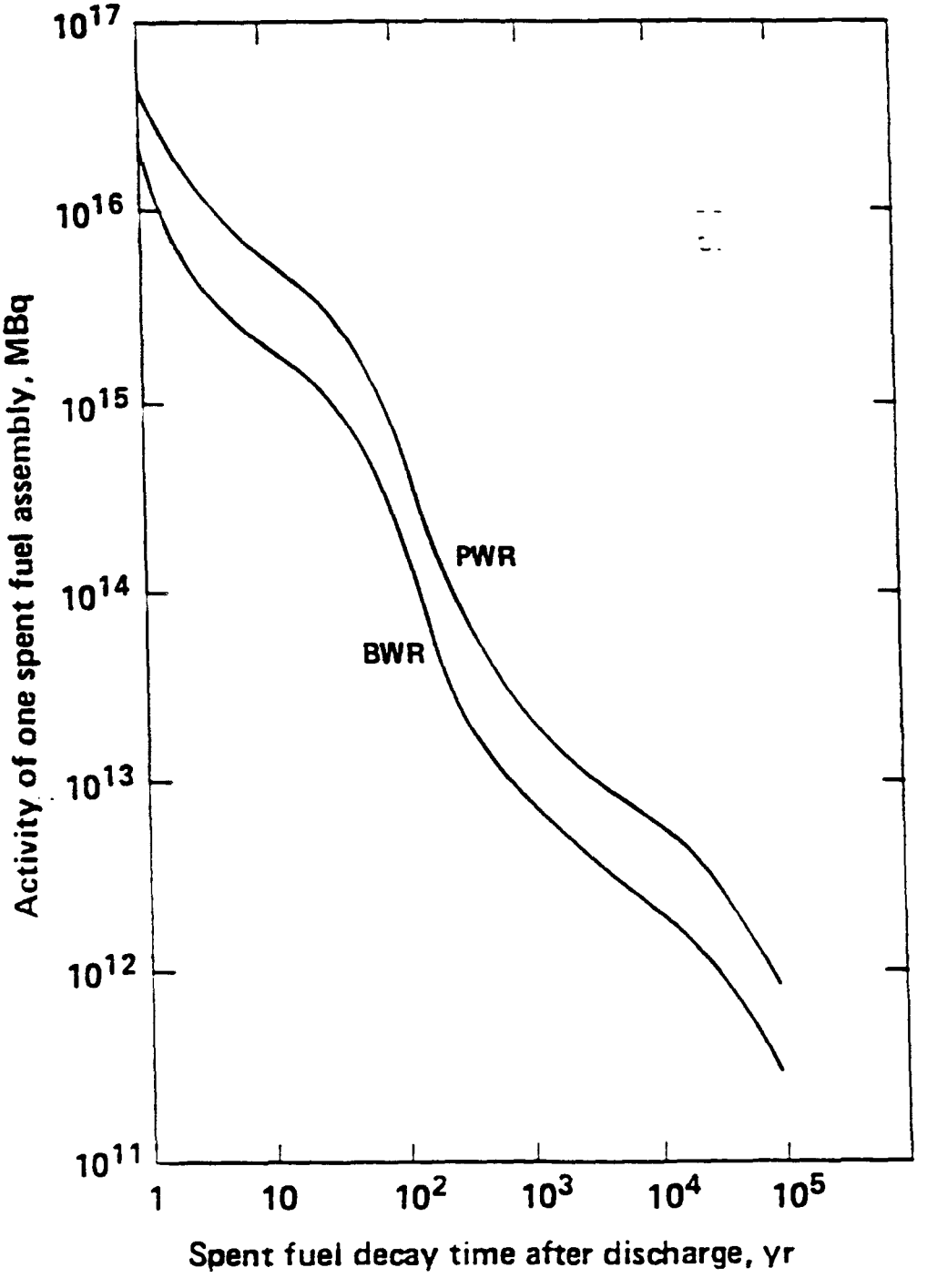
TRB -10-



Activities of spent BWR and PWR fuel assemblies.

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EPRI Position on "To Whom?"
(subjective)

Standard Should be for an Average Individual in a Location Population Group

- **NOT** for a maximally-exposed individual
- Average individual in a local population group
  - *local population* ≡ population in the immediate Yucca Mountain vicinity
  - *average individual* ≡ average age, health, diet, and behavior of local population
  - most representative of entire local population

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Seven Different Local Population Groups (Societies) Were Considered

- Maximally-exposed individual (subsistence farmer)
  - all drinking water from the undiluted, contaminated plume
  - all food grown with water from the undiluted, contaminated plume
  - entire life over plume
- Six other population groups (societies) representing combinations of:
  - two technology levels
    - » current
    - » advanced
  - three population sizes
    - » single farm family
    - » "small" (multiple farm familes)
    - » "large" (urban population)

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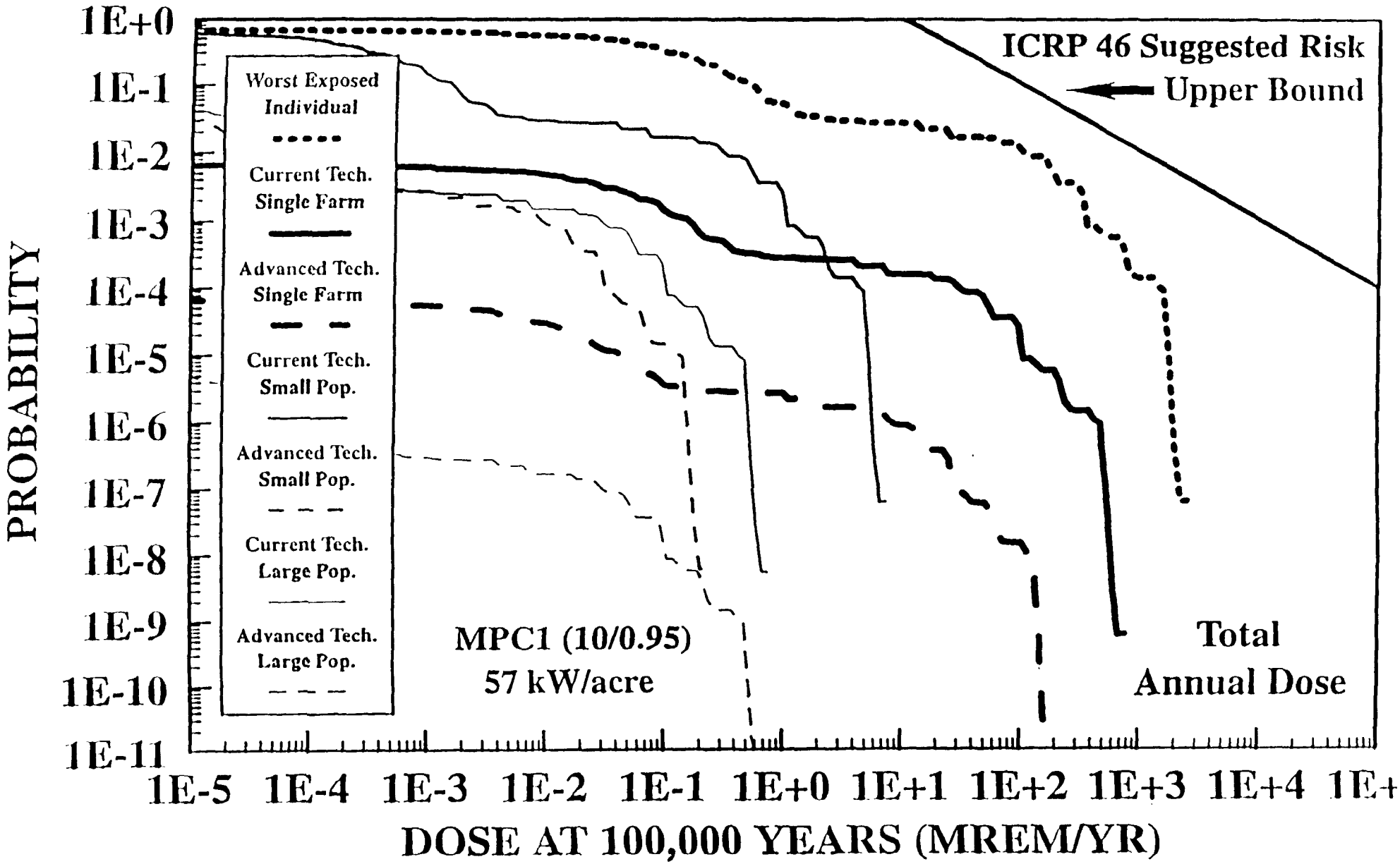
PROBABILITY
1E+0
1E-1
1E-2
1E-3
1E-4
1E-5
1E-6
1E-7
1E-8
1E-9
1E-10
1E-11
Worst Exposed Individual
Current Tech. Single Farm
Advanced Tech. Single Farm
Current Tech. Small Pop.
Advanced Tech. Small Pop.
Current Tech. Large Pop.
Advanced Tech. Large Pop.
ICRP 46 Suggested Risk
Upper Bound
MPC1 (10/0.95)
57 kW/acre
Total Annual Dose
1E-5 1E-4 1E-3 1E-2 1E-1 1E+0 1E+1 1E+2 1E+3 1E+4 1E+
DOSE AT 100,000 YEARS (MREM/YR)

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Engineered Barrier Period
(0 to ~1000 Years After Emplacement)

- Reasonable assurance of substantially complete containment
  - at engineering barrier system
- Repository remains open for the first 100 to 300 years
  - for confirmatory testing
  - for retrievability, if necessary
  - institutional control required
- Provides added margin of safety
  - low release assures essentially no health effects
  - release standard *for the engineered barrier period* is stricter than a health risk standard

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Geologic Period
(Beyond ~1000 Years)

- A single, qualitative standard to ensure sustained low health risk to an average individual in a local population group
- Probabilistic analyses similar to NRC's policy on reactor safety goals
- Calculate dose risk
  - to an average individual in a local population group
  - compare to modified ICRP 46 *as a design objective*, or *figure of merit*, not as a quantitative licensing basis
- Calculations for the geologic period provide regulatory insights, but are NOT part of formal licensing
- Human intrusion is treated qualitatively
- No specious subsystem criteria

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Conclusion

Overall Goal: Sustained, Low Health Risk to an Average Individual in the Local Population

- Two time period approach:
  - 0 to ~1000 years
    - » reasonable assurance of substantially complete containment
  - beyond 1,000 years
    - » EBS and geologic barriers provide sustained, low health risk
- Consistent with scientific realities and uncertainties
- Enhances public acceptance and licensing feasibility
  - strict quantitative standard coupled with bounding calculations to provide very high assurance for 1000 years (licensing basis)
  - probabilistic analysis compared to a qualitative standard to avoid endless, 'unwinnable' litigation (regulatory insight)
  - no other subsystem criteria are necessary