U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING

SUBJECT: SENSITIVITY ANALYSES TO EVALUATE ALTERNATIVE CONCEPTUAL MODELS OF UNSATURATED ZONE FLOW

PRESENTER: Dr. ABE VAN LUIK

PRESENTER'S TITLE AND ORGANIZATION: TECHNICAL SYNTHESIS TEAM LEADER
U.S. DEPARTMENT OF ENERGY
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT OFFICE
LAS VEGAS, NEVADA

TELEPHONE NUMBER: (702) 794-1424

ARLINGTON, VA
OCTOBER 9, 1996

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Objective

To provide a snapshot of the first preliminary evaluations of the system performance implications of one of the conceptualizations of unsaturated zone flow recently completed by the Project.

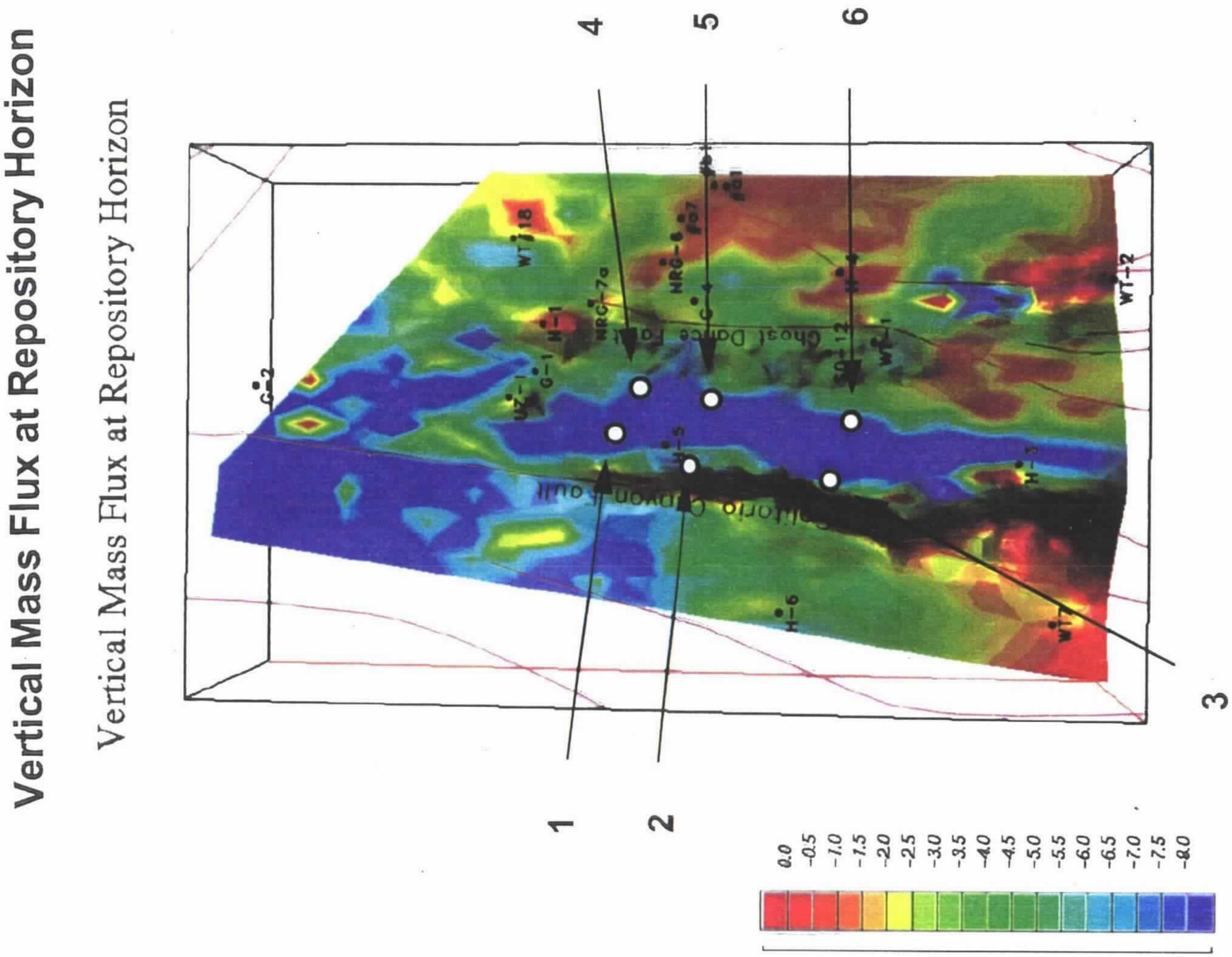
Outline

- 1996 unsaturated zone flow model case evaluated
- Modifications made to TSPA 1995
- The three TSPA cases
- Preliminary results
- Preliminary interpretations

Sensitivity Analyses to Evaluate Alternative Conceptual Models of Unsaturated Zone Flow

- This work is in progress; only a preliminary example is available at this time
- TSPA-1995 was modified to make a reasonably conservative case, an optimistic case, and a pessimistic case
  - representative columns from the 1996 iteration of the unsaturated zone (UZ) flow model were used with spatially variable infiltration
  - "average" percolation flux at depth was increased to 7 mm/yr
  - dual permeability model was used to define fracture-matrix flux and velocity distributions

Fluxes and Locations of Representative Columns Modeled



Assumptions Common to all Three Sensitivity Cases

- Based on TSPA-1995 model (e.g., waste-package degradation, waste-form degradation, solubilities, retardation, etc.)
- 83 MTU/acre thermal loading
- Drinking water doses (2 L/day) at 5 km, 20 km, and 30 km downgradient
- Primary differences from TSPA-1995:
  - Velocities from the most recent UZ conceptual model
  - Cyclic climate change not yet considered (pluvial case assumes continuously wet climate after repository closure)

Pessimistic-Case Assumptions

- 100% of packages see dripping water
- "Drips on waste form" release model: advective flow directly contacts entire waste form after first pit breakthrough
- ^{129}I, ^{36}Cl, and ^{14}C migrate through engineered barrier system as gaseous species
- Very low matrix diffusion
- No backfill

Conservative-Case Assumptions

- 36% of packages see dripping water
- "Drips on waste package" release model: diffusion through corrosion pits before contacting advective flow
- ^{129}I, ^{36}Cl, and ^{14}C migrate through engineered barrier system as aqueous species
- Relatively low matrix diffusion from fractures to matrix
- No backfill

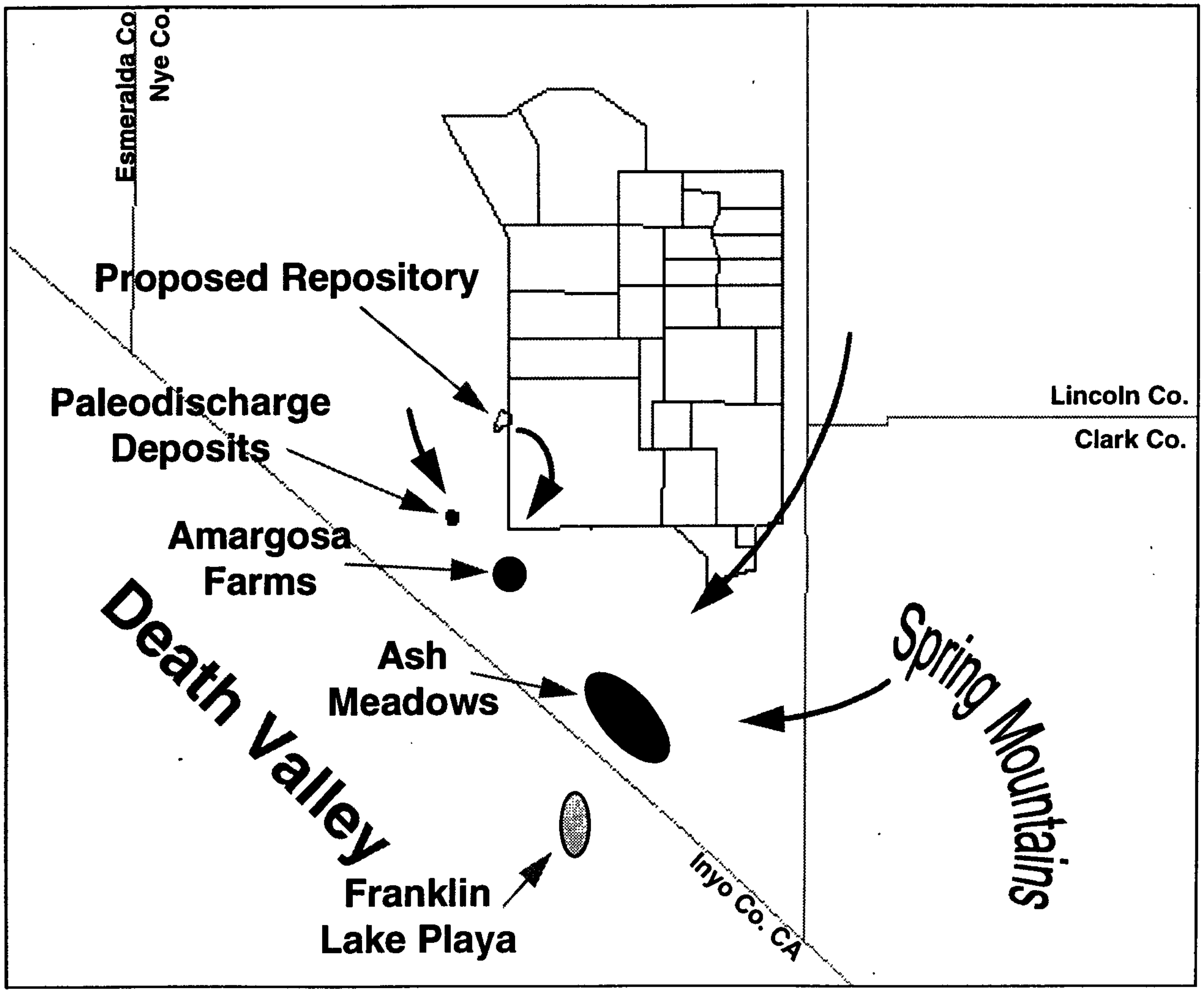
Optimistic-Case Assumptions

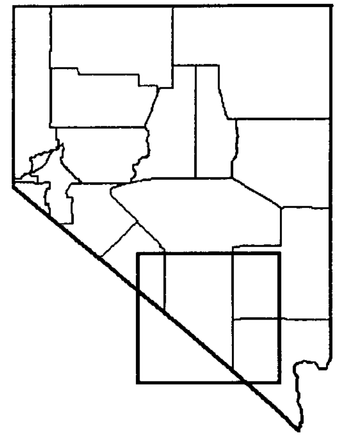
- 4% of packages see dripping water
- 50% galvanic protection of waste packages
- Fuel-rod cladding reduces release rate
- "Drips on waste package" release model: diffusion through corrosion pits before contacting advective flow
- ^{129}I, ^{36}Cl, and ^{14}C migrate through engineered barrier system as aqueous species
- Moderate matrix diffusion from fractures to matrix
- Backfill

Conservative-Case Pluvial-Climate Assumptions

- 53% of packages see dripping water
- Unsaturated-zone matrix/fracture fluxes and pore velocities increased by a factor of 3; saturated-zone flux increased by a factor of 3
- "Drips on waste package" release model: diffusion through corrosion pits before contacting advective flow
- ^{129}I, ^{36}Cl, and ^{14}C migrate through engineered barrier system as aqueous species
- Relatively low matrix diffusion from fractures to matrix
- No backfill

Approximate Direction of Ground Water Flow





5 km = 40 CFR 191 Accessible Environment boundary

20 km - Approximates down-gradient Nevada Test Site boundary

30 km - Approximates distance to Amargosa Farms area

Blue arrows indicate approx. flow direction

10,000-year Peak Drinking Water Doses

Distance from Yucca Mountain	TSPA-1995		
	Optimistic Case (mrem/yr)	Conservative Case (mrem/yr)	Pessimistic Case (mrem/yr)
5 km	0.0	0.8	12
20 km	0.0	0.02	0.3
30 km	0.0	0.004	0.06

Preliminary 10,000-year Peak Drinking Water Doses

Distance from Yucca Mountain	1996 UZ Flow Model Fluxes and Pore Velocities			
	Optimistic Case (mrem/yr)	Conservative Case (mrem/yr)	Pessimistic Case (mrem/yr)	Conservative Case *Pluvial* (mrem/yr)
5 km	0.0	24	170	-
20 km	0.0	0.77	6.6	2.6
30 km	0.0	0.2	1.3	-

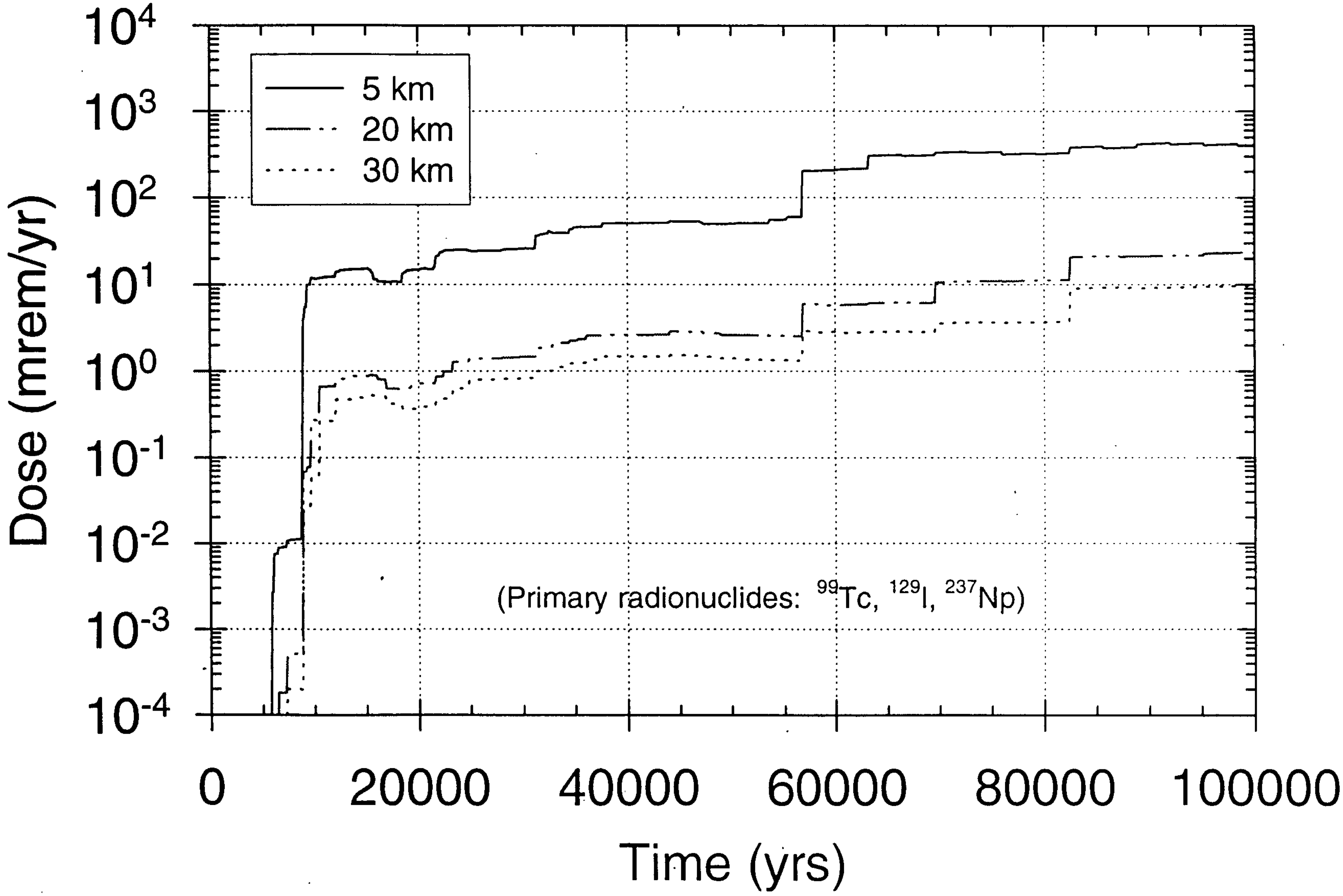
100,000-year Peak Drinking Water Doses

Distance from Yucca Mountain	1996 UZ Flow Model Fluxes and Pore Velocities		
	Optimistic Case (mrem/yr)	Conservative Case (mrem/yr)	Pessimistic Case (mrem/yr)
5 km	0.002	37	400
20 km	0.0001	2.5	24
30 km	0.00008	1.5	10

Preliminary 100,000-year Peak Drinking Water Doses

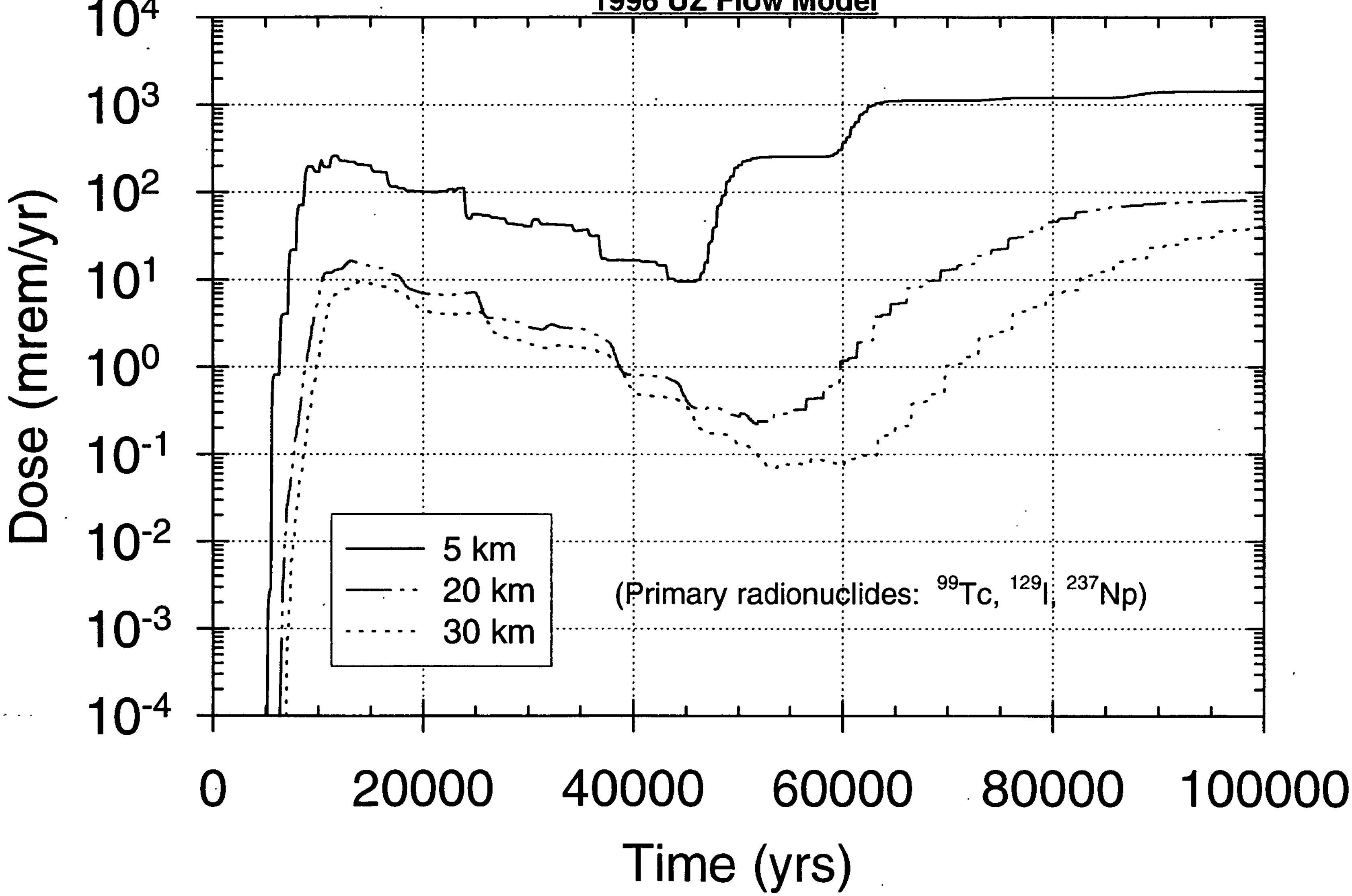
Distance from Yucca Mountain	1996 UZ Flow Model Fluxes and Pore Velocities			
	Optimistic Case (mrem/yr)	Conservative Case (mrem/yr)	Pessimistic Case (mrem/yr)	Conservative Case *Pluvial* (mrem/yr)
5 km	0.03	160	1400	-
20 km	0.002	9.5	82	14
30 km	0.001	4.6	41	-

100,000-yr Total Drinking Water Dose History
TSPA-1995/Pessimistic

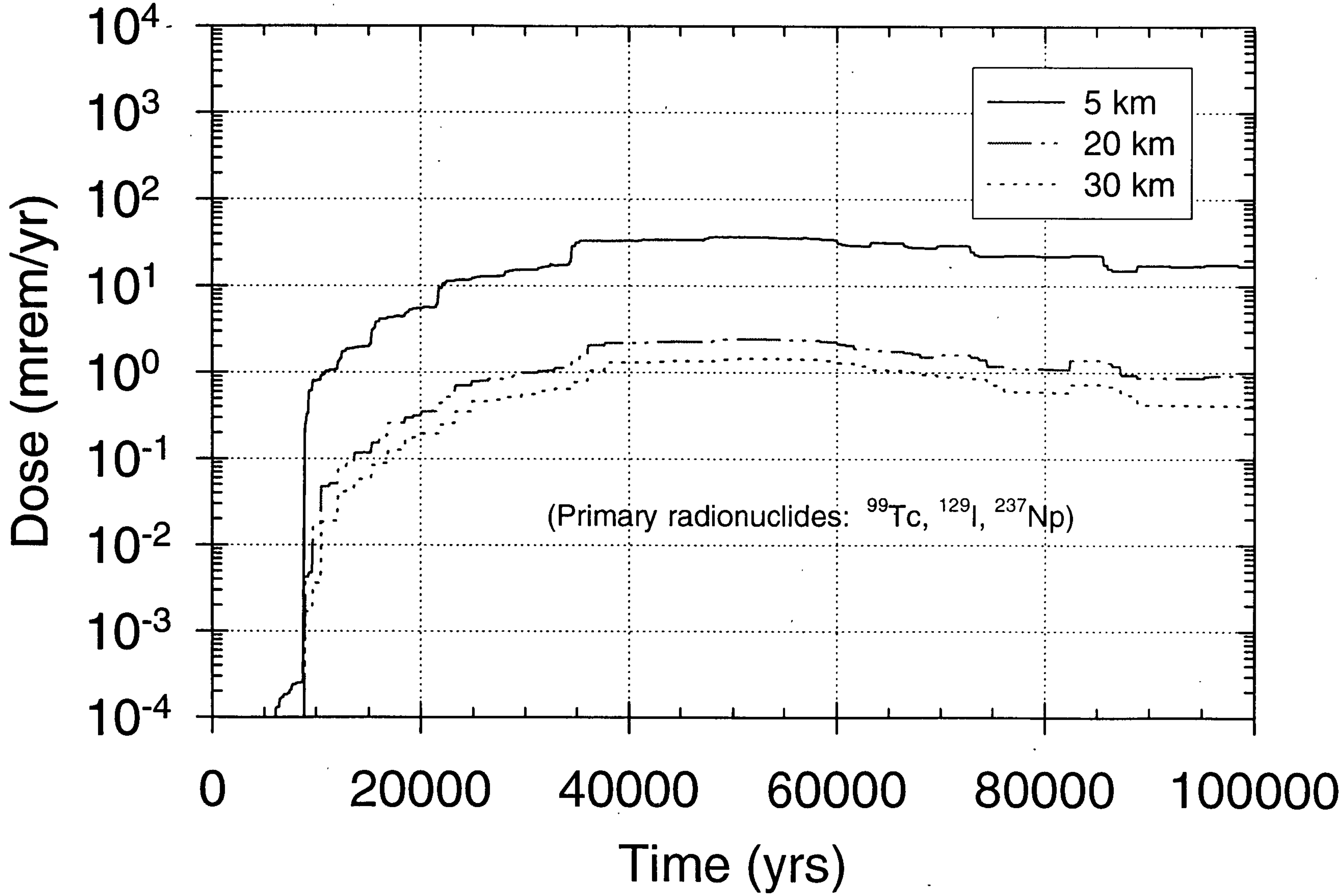


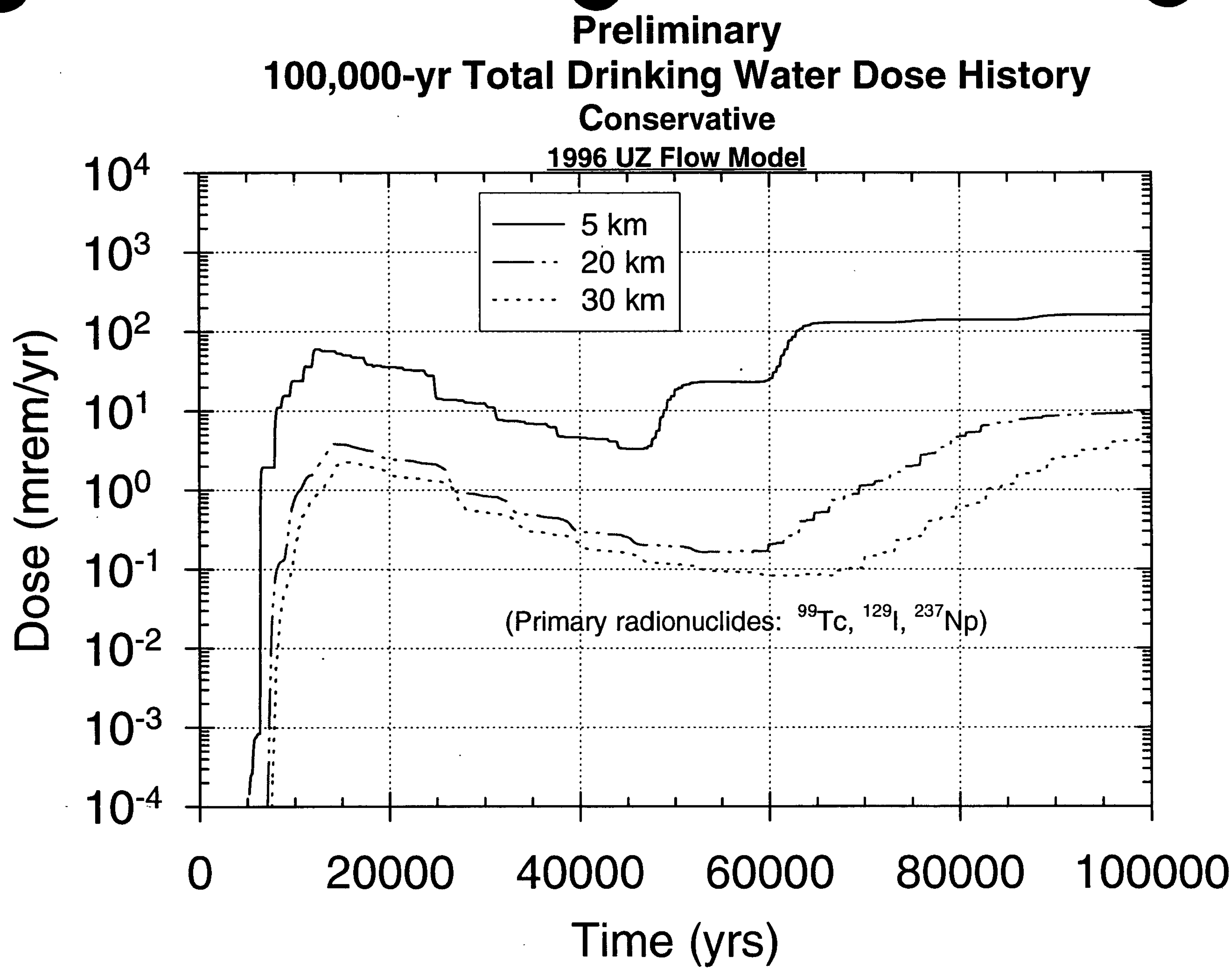
Preliminary Draft

Preliminary
100,000-yr Total Drinking Water Dose History
Pessimistic
1996 UZ Flow Model

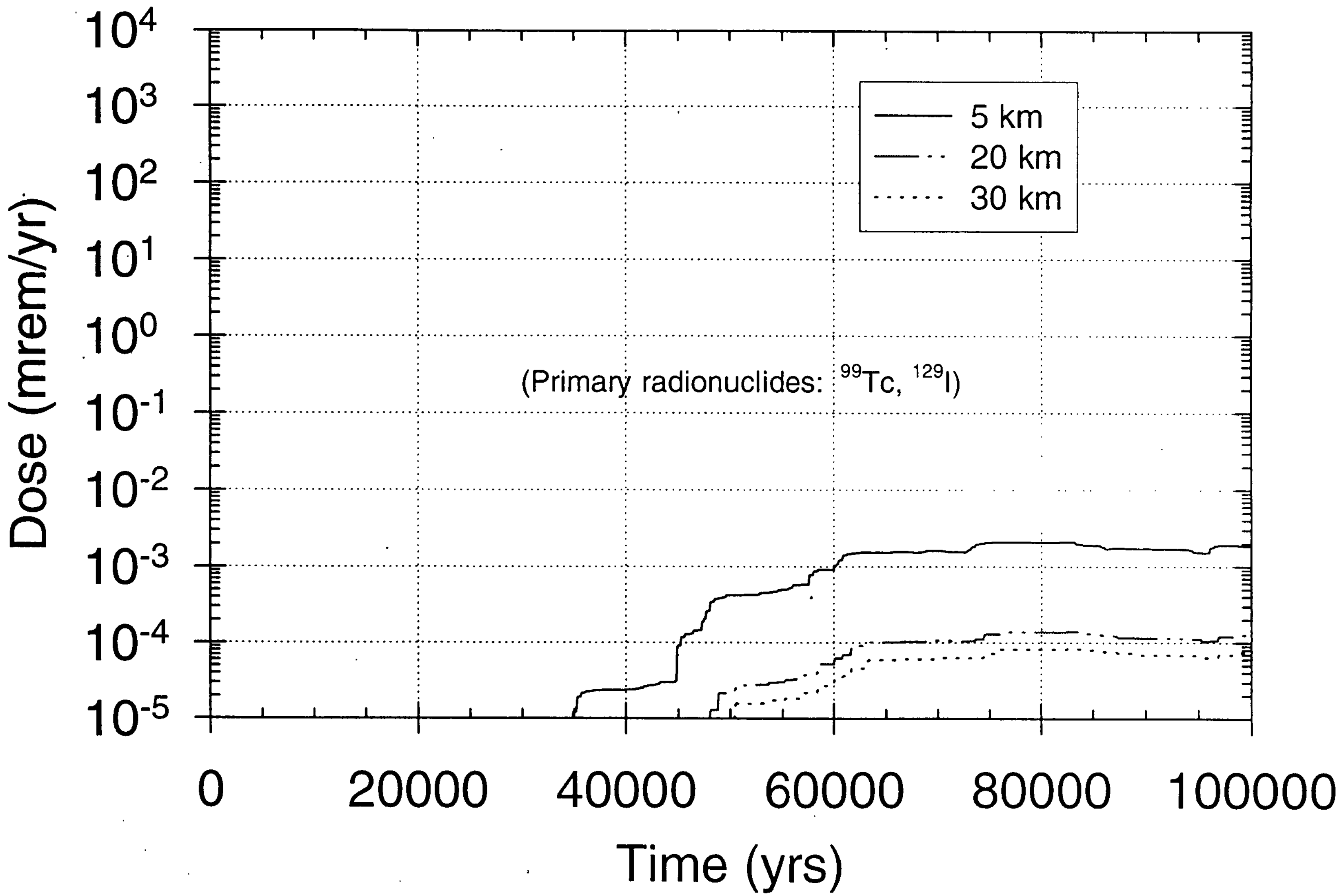


100,000-yr Total Drinking Water Dose History
TSPA-1995/Conservative



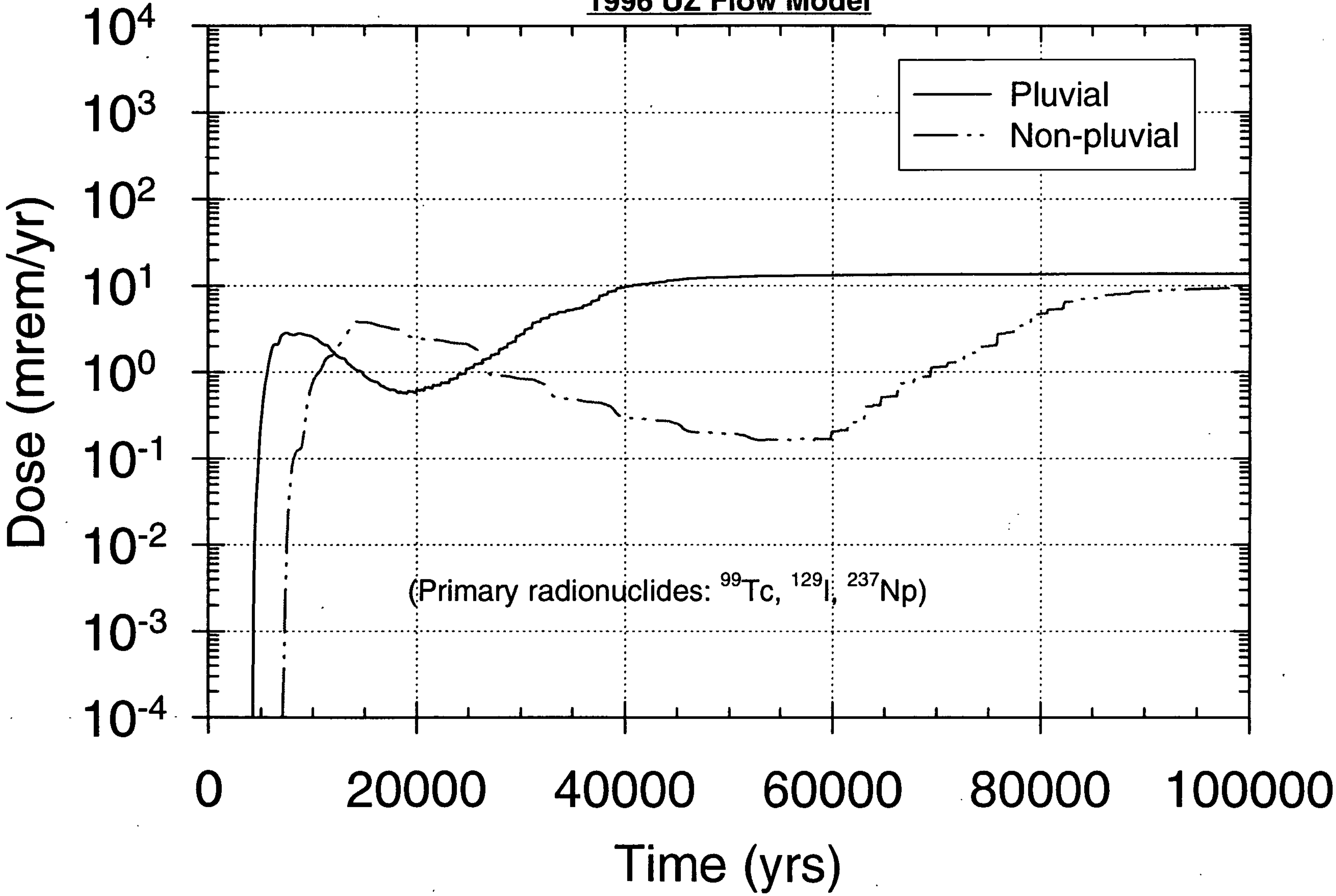

Preliminary
100,000-yr Total Drinking Water Dose History
Conservative
1996 UZ Flow Model
5 km
20 km
30 km
(Primary radionuclides: 99Tc, 129I, 237Np)
Dose (mrem/yr)
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
10^-4
0
20000
40000
60000
80000
100000
Time (yrs)

100,000-yr Total Drinking Water Dose History
TSPA-1995/Optimistic



Preliminary Draft

Preliminary
100,000-yr Total Drinking Water Dose History
Conservative/at 20 km
1996 UZ Flow Model

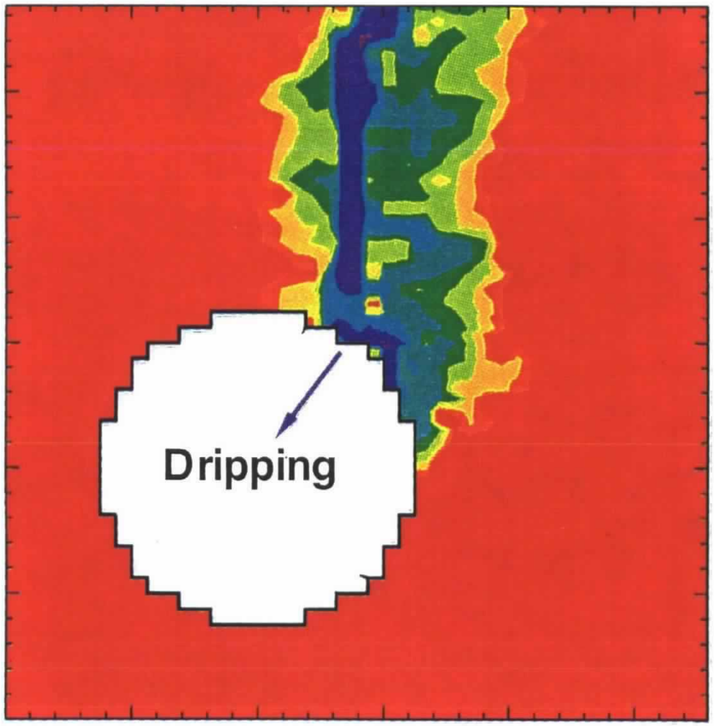


Significance of Modified Unsaturated Zone Flow and Transport Model

- Increased percolation flux and increased bulk average "matrix" permeability
  - Increased percolation flux decreases mean unsaturated zone advective travel time
  - Higher flux may increase percent of packages likely to encounter seepage; high permeability may decrease percent of packages likely to encounter seepage (high flux likely to stay in matrix)
  - Higher flux may decrease time of reduced humidities (thermal hydrology effects)
  - Higher permeability may increase time to initial break-through of radionuclides depending on percent of flux in fractures
  - This evaluation is "work in progress"

Example Analysis of Water Pulse in a Fracture Encountering a Drift

280 mm/yr Pulse
Immediately after Dripping Begins



28 mm/yr Pulse
10,000 Days