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 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
• $^{129}\text{I}$, $^{36}\text{Cl}$, and $^{14}\text{C}$ 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}\text{I}, \(^{36}\text{Cl},\) and \(^{14}\text{C}\) 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

Blue arrows indicate approx. flow direction

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
10,000-year Peak Drinking Water Doses

<table>
<thead>
<tr>
<th>Distance from Yucca Mountain</th>
<th>TSPA-1995</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Optimistic Case (mrem/yr)</td>
</tr>
<tr>
<td>5 km</td>
<td>0.0</td>
</tr>
<tr>
<td>20 km</td>
<td>0.0</td>
</tr>
<tr>
<td>30 km</td>
<td>0.0</td>
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</tbody>
</table>
## Preliminary 10,000-year Peak Drinking Water Doses

<table>
<thead>
<tr>
<th>Distance from Yucca Mountain</th>
<th>1996 UZ Flow Model Fluxes and Pore Velocities</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Optimistic Case (mrem/yr)</td>
<td>Conservative Case (mrem/yr)</td>
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<tr>
<td>5 km</td>
<td>0.0</td>
<td>24</td>
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<tr>
<td>20 km</td>
<td>0.0</td>
<td>0.77</td>
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<tr>
<td>30 km</td>
<td>0.0</td>
<td>0.2</td>
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</table>
# 100,000-year Peak Drinking Water Doses

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</thead>
<tbody>
<tr>
<td></td>
<td>Optimistic Case (mrem/yr)</td>
</tr>
<tr>
<td>5 km</td>
<td>0.002</td>
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<tr>
<td>20 km</td>
<td>0.0001</td>
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<tr>
<td>30 km</td>
<td>0.00008</td>
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</tbody>
</table>
Preliminary 100,000-year Peak Drinking Water Doses

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<td>Optimistic Case (mrem/yr)</td>
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<tr>
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<td>0.03</td>
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<tr>
<td>20 km</td>
<td>0.002</td>
</tr>
<tr>
<td>30 km</td>
<td>0.001</td>
</tr>
</tbody>
</table>
100,000-yr Total Drinking Water Dose History
TSPA-1995/Pessimistic

(Time (yrs))

(Preliminary Draft)
Preliminary
100,000-yr Total Drinking Water Dose History

Pessimistic

1996 UZ Flow Model

10^4
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}

Dose (mrem/yr)

0 20000 40000 60000 80000 100000

Time (yrs)

5 km
20 km
30 km

(Primary radionuclides: ^{99}Tc, ^{129}I, ^{237}Np)
100,000-yr Total Drinking Water Dose History
TSPA-1995/Conservative

(Drawings of graphs showing dose over time for different distances (5 km, 20 km, 30 km) with primary radionuclides: $^{99}$Tc, $^{129}$I, $^{237}$Np)
100,000-yr Total Drinking Water Dose History

Conservative

1996 UZ Flow Model

(Dose (mrem/yr)

Time (yrs)

(Presy radionuclides: $^{99}$Tc, $^{129}$I, $^{237}$Np)
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

(Dose (mrem/yr))

(Primary radionuclides: $^{99}$Tc, $^{129}$I, $^{237}$Np)
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 breakthrough 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

Dripping

No Dripping