Hydrology and Nuclear Waste Disposal at Yucca Mountain, Nevada

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Deep Geologic Disposal

- **The goal of deep geologic disposal of high-level nuclear waste is that the waste emplaced in a rock formation beneath the earth's surface will remain isolated at that location for the hazardous lifetime of the waste.**

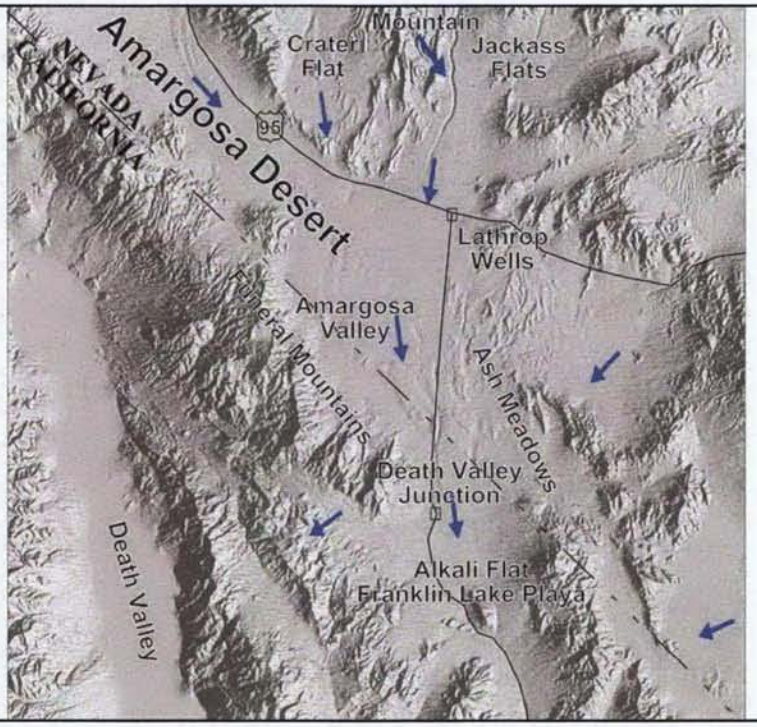
Yucca Mountain Cannot Meet This Goal

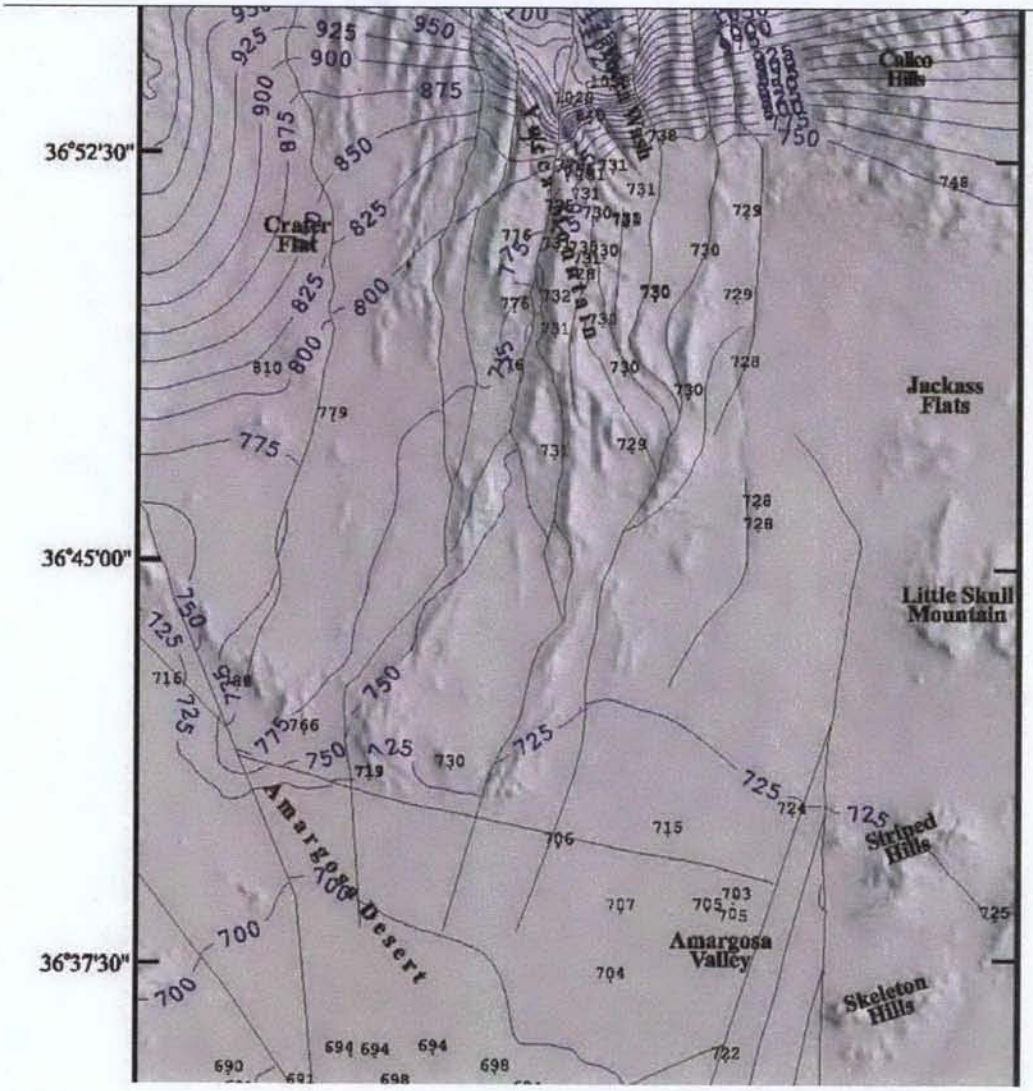
- The waste will surface in Nevada by groundwater withdrawal and at the land surface in California.
- It is not a question of IF
- It is a question of WHEN

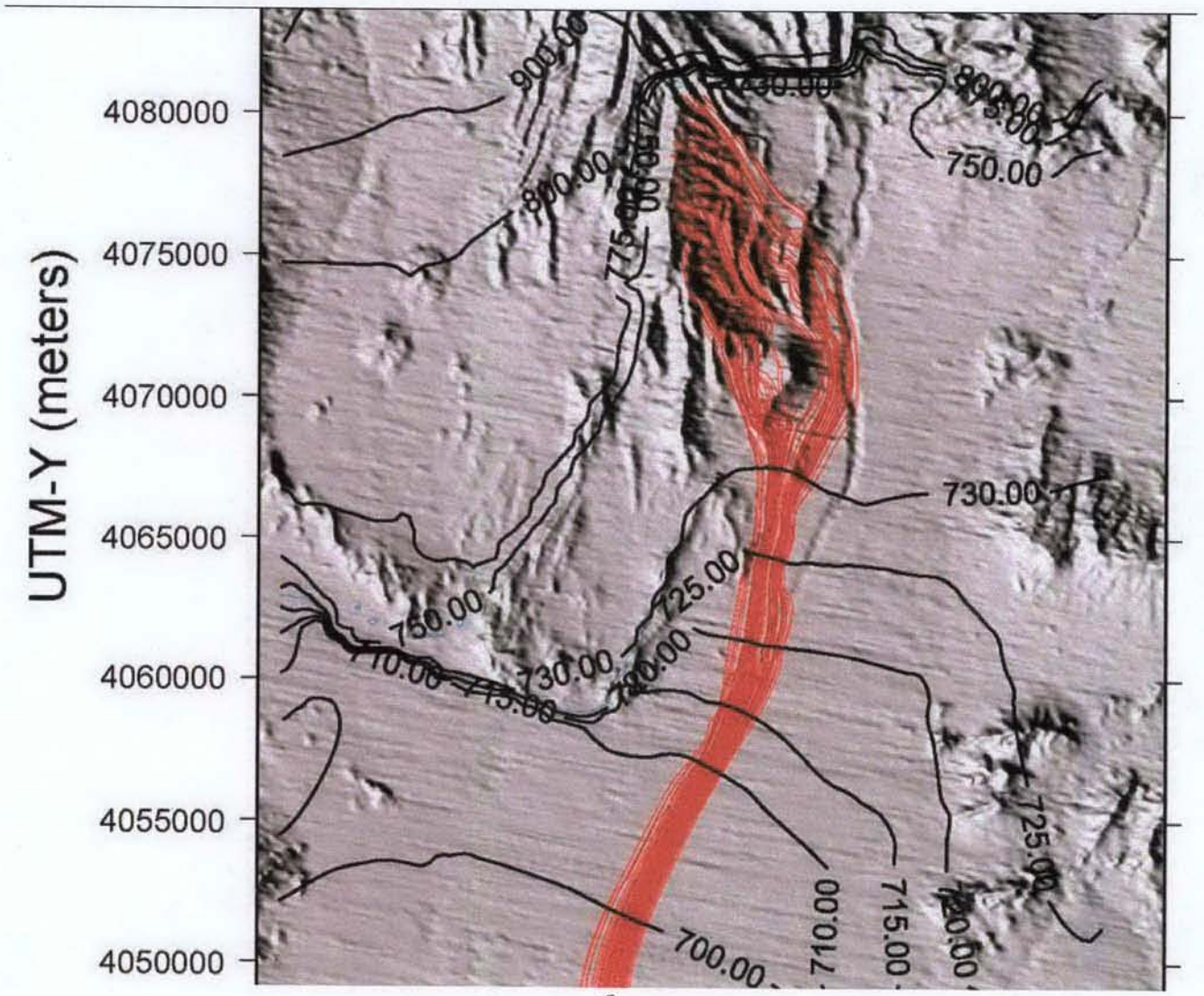
Follow the Water


39 00'
38 00'
37 00'
36 00'
35 00'
119 00'
117 00'
116 00'
115 00'
114 00'
N4000000ft
N4200000ft
N4400000ft
N4600000ft
N4800000ft
N5000000ft
Gabbs
Tonopah
White Pine County
Utah
Nye County
Esmeralda County
Yucca Mountain Site
Nevada Test Site
Nevada
California
Beatty
Death Valley
Amargosa Valley
Pioche
Panaca
Caliente
Alamo
Lincoln County
Mesquite
Moapa
Indian Springs
North Las Vegas
Las Vegas
Pahrump
Clark County
Henderson
Boulder City
Arizona
Inyo County
San Bernardino County
Laughlin
Barstow
95
6
93
15
127
395

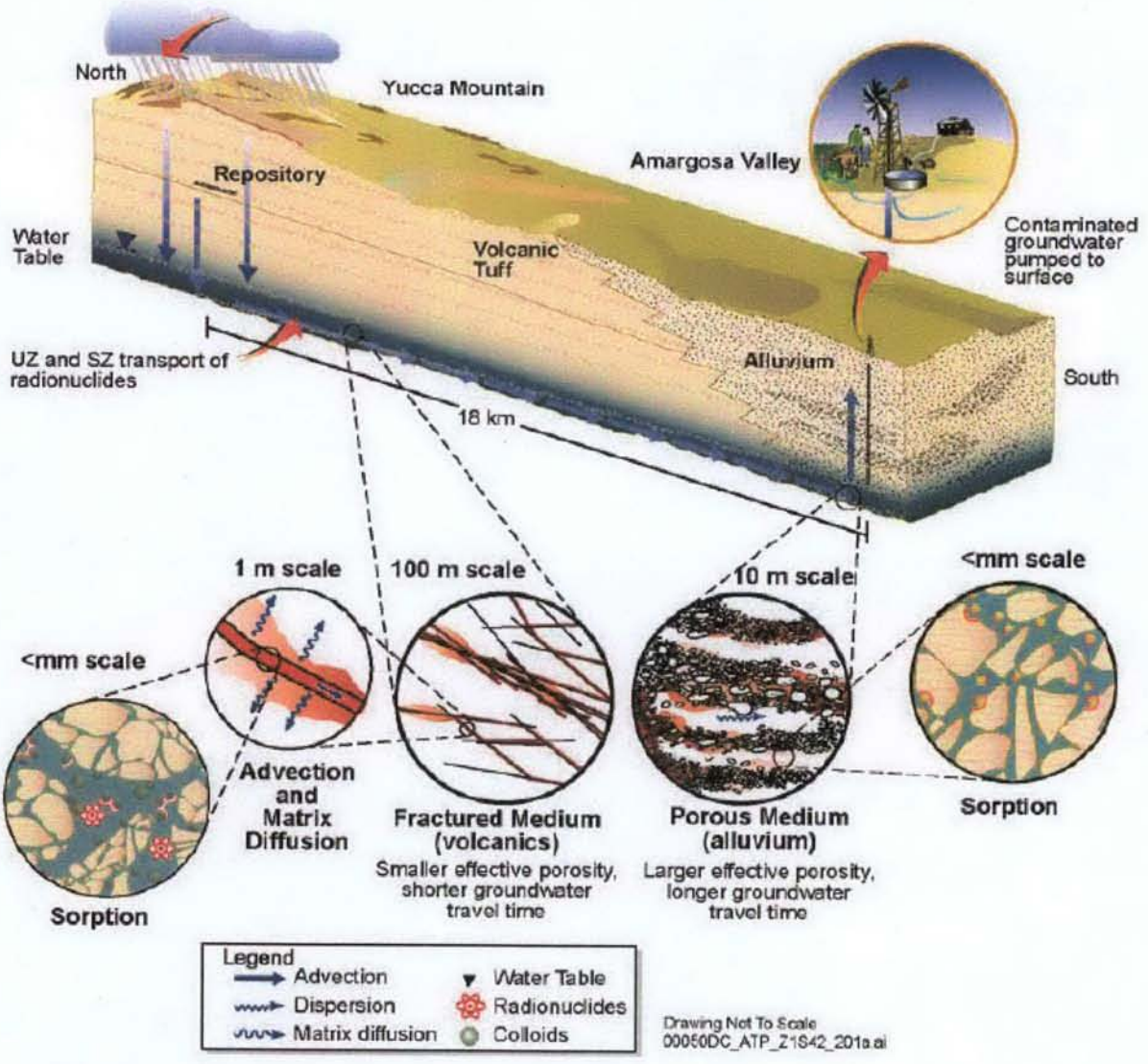
ATP_Z1S1_Fig. 1-1a.ai

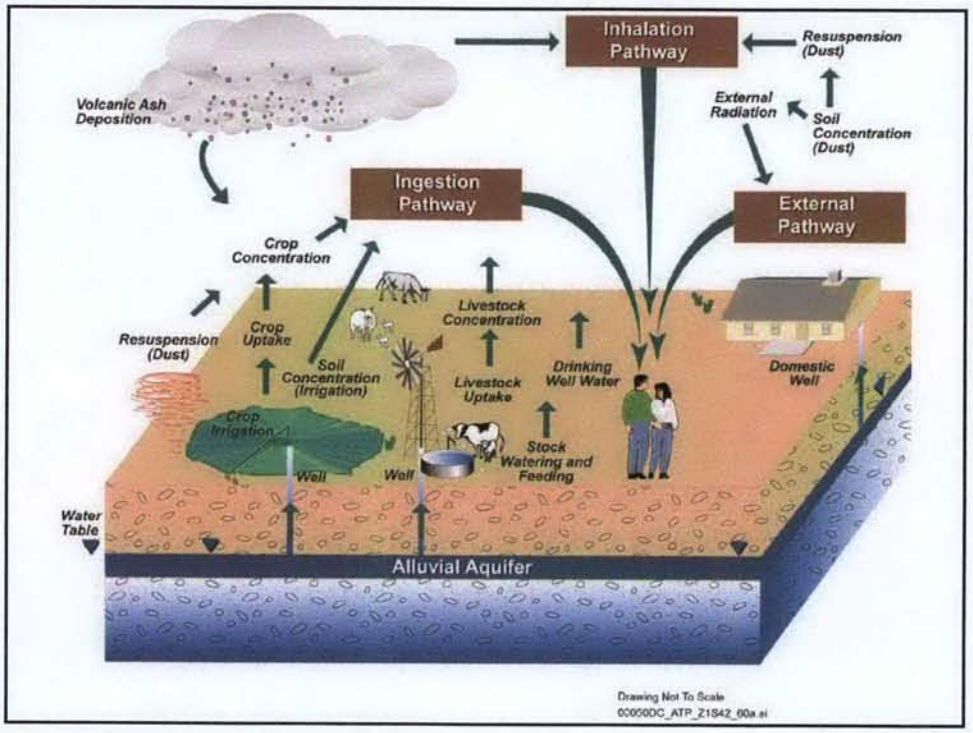


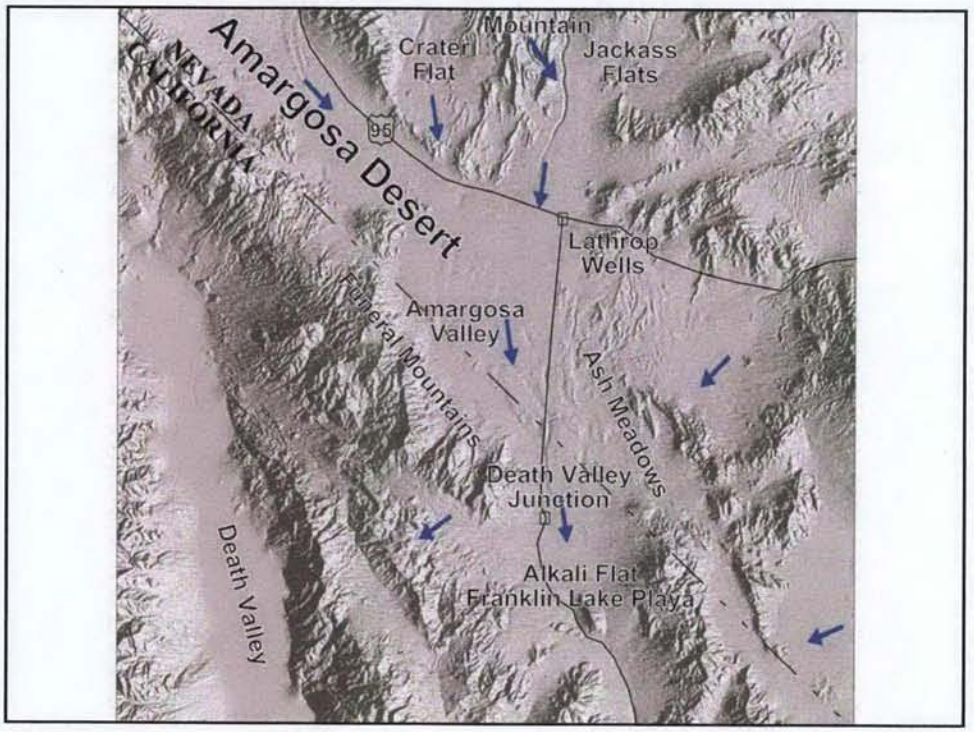

36°52'30"
36°45'00"
36°37'30"
Crater Flat
Calico Hills
Jackass Flats
Little Skull Mountain
Striped Hills
Amargosa Desert
Amargosa Valley
Skeleton Hills
EXPLANATION
Tertiary faults
Potentiometric contour - Shows altitude of potentiometric surface. Contour interval 25 meters. Datum is sea level.
Observation well. Water-level altitude (m).



Follows fractures

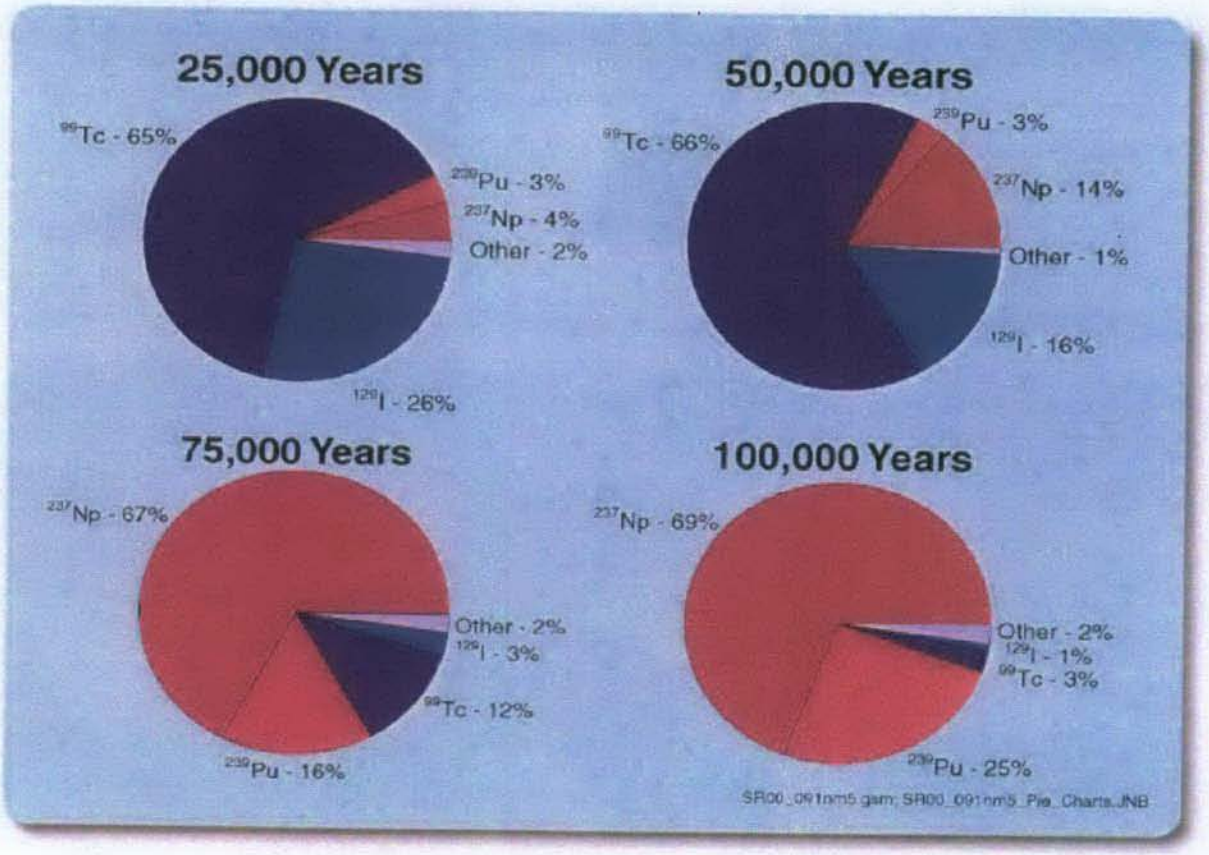

North
Yucca Mountain
Amargosa Valley
Repository
Water Table
Volcanic Tuff
Contaminated groundwater pumped to surface
UZ and SZ transport of radionuclides
Alluvium
South
18 km
1 m scale
100 m scale
10 m scale
<mm scale
<mm scale
Advection and Matrix Diffusion
Fractured Medium (volcanics)
Smaller effective porosity, shorter groundwater travel time
Porous Medium (alluvium)
Larger effective porosity, longer groundwater travel time
Sorption
Sorption
Legend
Advection
Dispersion
Matrix diffusion
Water Table
Radionuclides
Colloids
Drawing Not To Scale
00050DC_ATP_Z1S42_201a.ai


Inhalation Pathway
Resuspension (Dust)
Volcanic Ash Deposition
External Radiation
Soil Concentration (Dust)
Ingestion Pathway
External Pathway
Crop Concentration
Livestock Concentration
Resuspension (Dust)
Crop Uptake
Soil Concentration (Irrigation)
Livestock Uptake
Drinking Well Water
Domestic Well
Crop Irrigation
Stock Watering and Feeding
Well
Well
Water Table
Alluvial Aquifer
Drawing Not To Scale
000000C_ATP_Z1S42_60a.ai


Amargosa Desert
NEVADA
CALIFORNIA
Crater Flat
Mountain
Jackass Flats
95
Lathrop Wells
Amargosa Valley
Funeral Mountains
Ash Meadows
Death Valley Junction
Death Valley
Alkali Flat
Franklin Lake Playa

Dose is a Factor of Radionuclide Release

- Calculate dose vs. time using a Total System Performance Assessment
  - Probabilistic risk calculation with over 1,000 variable parameters – many bounded
- The two most sensitive parameters
  - Infiltration rate
  - Waste package failure time



155_0003

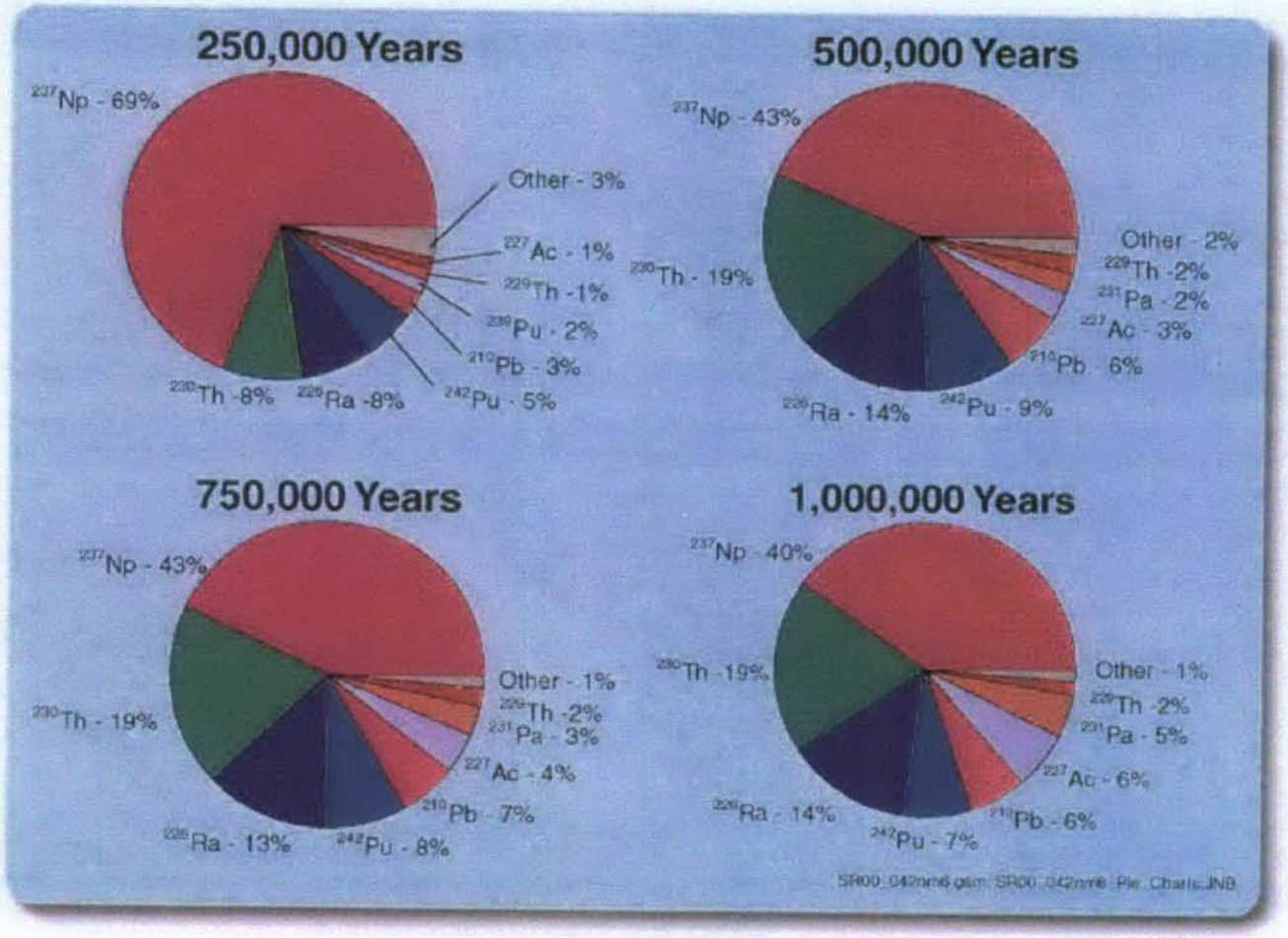
Source: CRWMS M&O 2000 [DIRS 153246], Figure 4.1-6.

NOTE: ^{237}Np = neptunium-237, ^{99}Tc = technetium-99, ^{129}I = iodine-129, ^{239}Pu = plutonium-239.

Figure 3.1.1-2. Contribution of Radionuclides to the TSPA-SR Mean Annual Dose at Four Times

99Tc - technisium 99

Np - Neptunium



155_0006.ai

155_0006.ai

Source: CRWMS M&O 2000 [DIRS 153246], Figure 4.1-19b.

NOTE: Ac = actinium; Np = neptunium; Pa = protactinium; Pb = lead; Pu = plutonium; Ra = radium; Th = thorium.

Figure 3.1.2-2. Key Radionuclides Affecting Mean Annual Dose for the Nominal Scenario over 1,000,000 Years Using the TSPA-SR Base-Case Models

EPA Standard

- Sets dose limit
  - 15 millirems per year – all sources
  - 4 millirems per year groundwater source – same as Safe Drinking Water std for radionuclides
- Sets compliance period
  - Time of geologic stability – 1 million years
- Sets compliance boundary – set to make it easier for Yucca
  - 11 miles down gradient – NTS southern boundary
- Sets dilution factor
  - Dilutes most contaminated stream in 3,000 acre feet of groundwater

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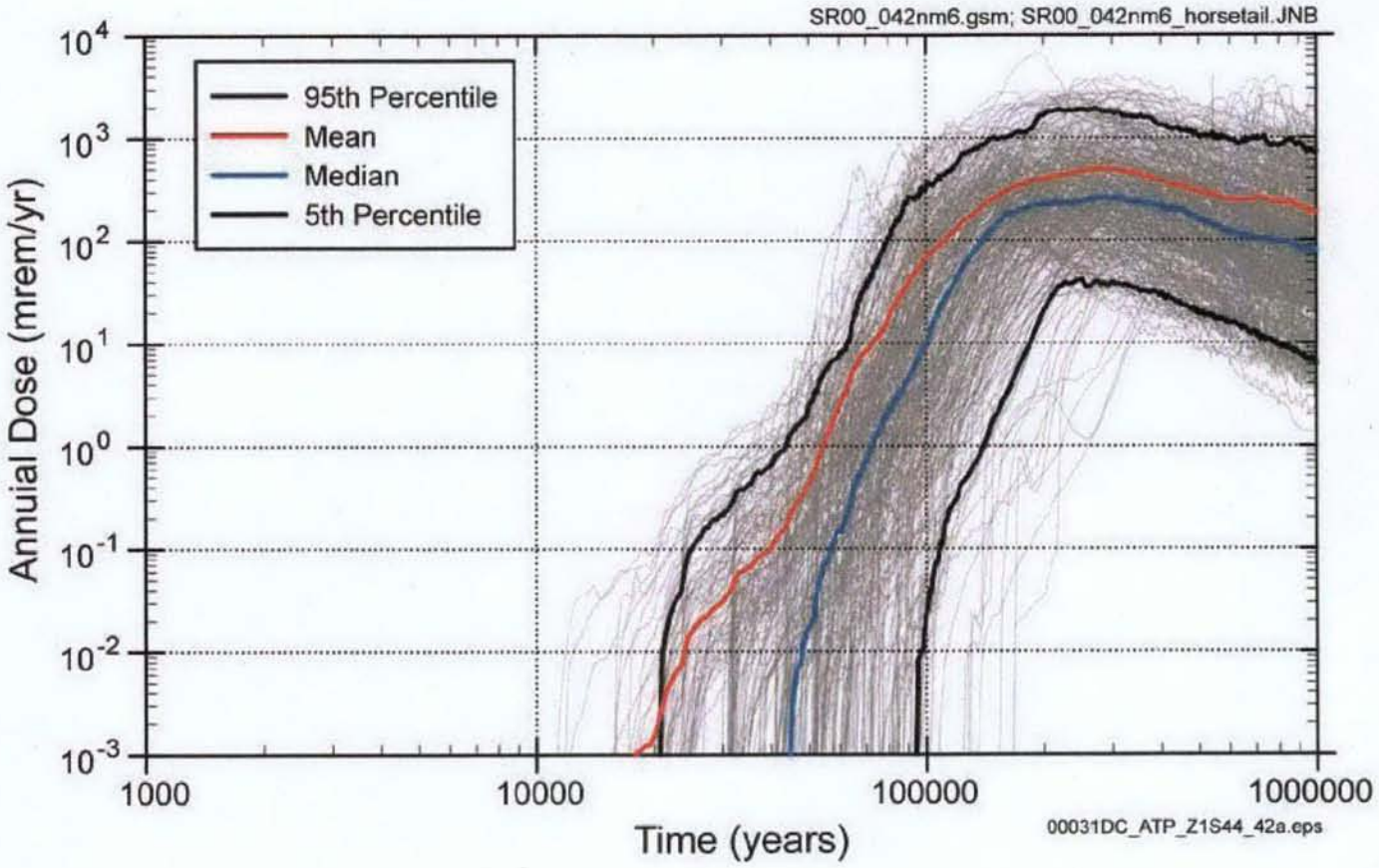
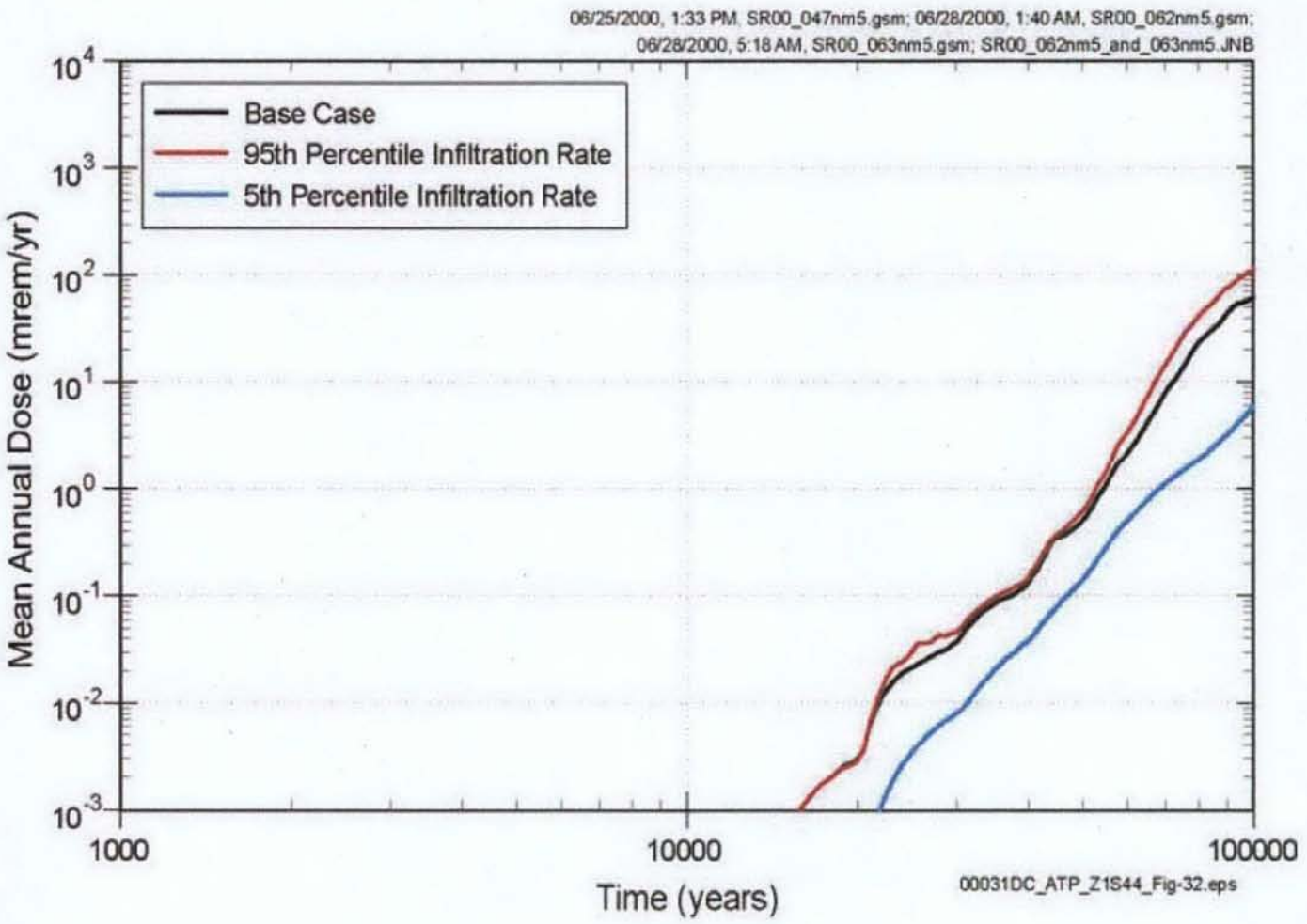
  - Probabilistic risk calculation with over 1,000 variable parameters – many bounded
- The two most sensitive parameters
  - Infiltration rate
  - Waste package failure time


SR00_042nm6.gsm; SR00_042nm6_horsetail.JNB
95th Percentile
Mean
Median
5th Percentile
Annuial Dose (mrem/yr)
10^4
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
1000
10000
100000
1000000
Time (years)
00031DC_ATP_Z1S44_42a.eps


06/25/2000, 1:33 PM, SR00_047nm5.gsm; 06/28/2000, 1:40 AM, SR00_062nm5.gsm;
06/28/2000, 5:18 AM, SR00_063nm5.gsm; SR00_062nm5_and_063nm5.JNB
Base Case
95th Percentile Infiltration Rate
5th Percentile Infiltration Rate
Mean Annual Dose (mrem/yr)
10^4
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
1000
10000
100000
Time (years)
00031DC_ATP_Z1S44_Fig-32.eps

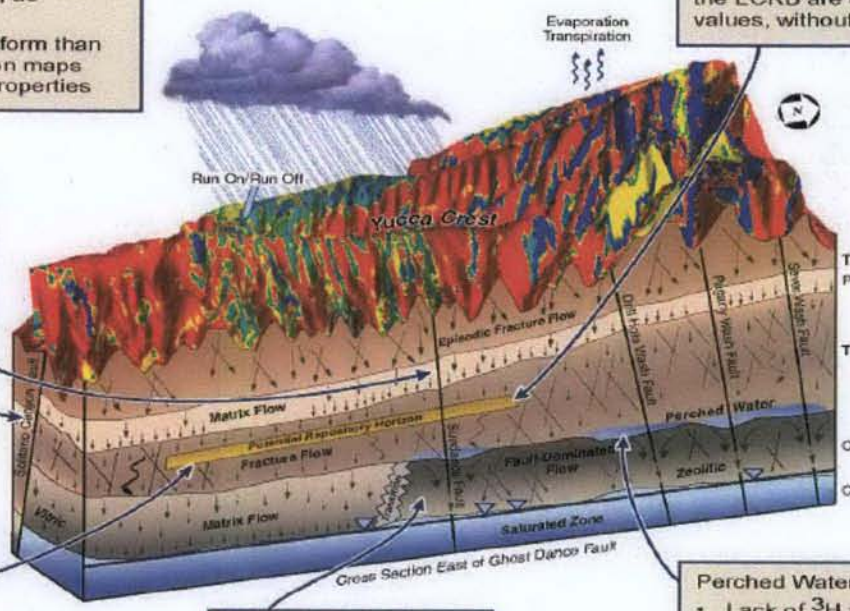
Cl concentrations lower under repository than in north and south ramps, as indicated by infiltration maps

- Percolation fluxes more uniform than those predicted by infiltration maps and calibrated hydrologic properties

Predicted chloride concentrations in the ECRB are close to measured values, without calibration

Fast-Flow Path:

- Bomb-pulse ^{3}H, $^{36}Cl/Cl$ found near faults, and not in other areas, indicating only localized fast flow zones



$^{36}Cl/Cl$ may indicate longer travel times to repository where PTn is thicker

Proportion of matrix flow in zeolitic units still unresolved

Perched Water:

- Lack of ^{3}H and bomb-pulse ^{36}Cl, indicating no more than a small component of recent fast-flow water

00050DC_ATP_Z1S42_Fig-144.ai

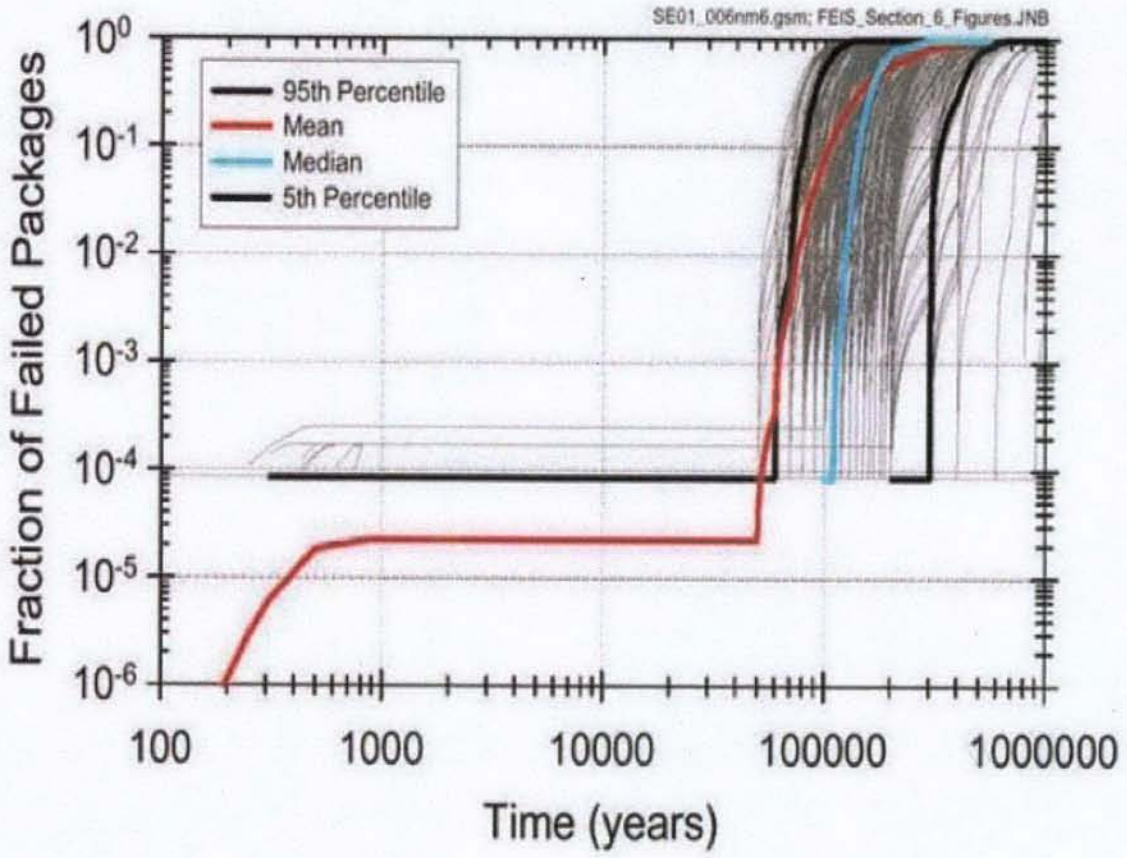
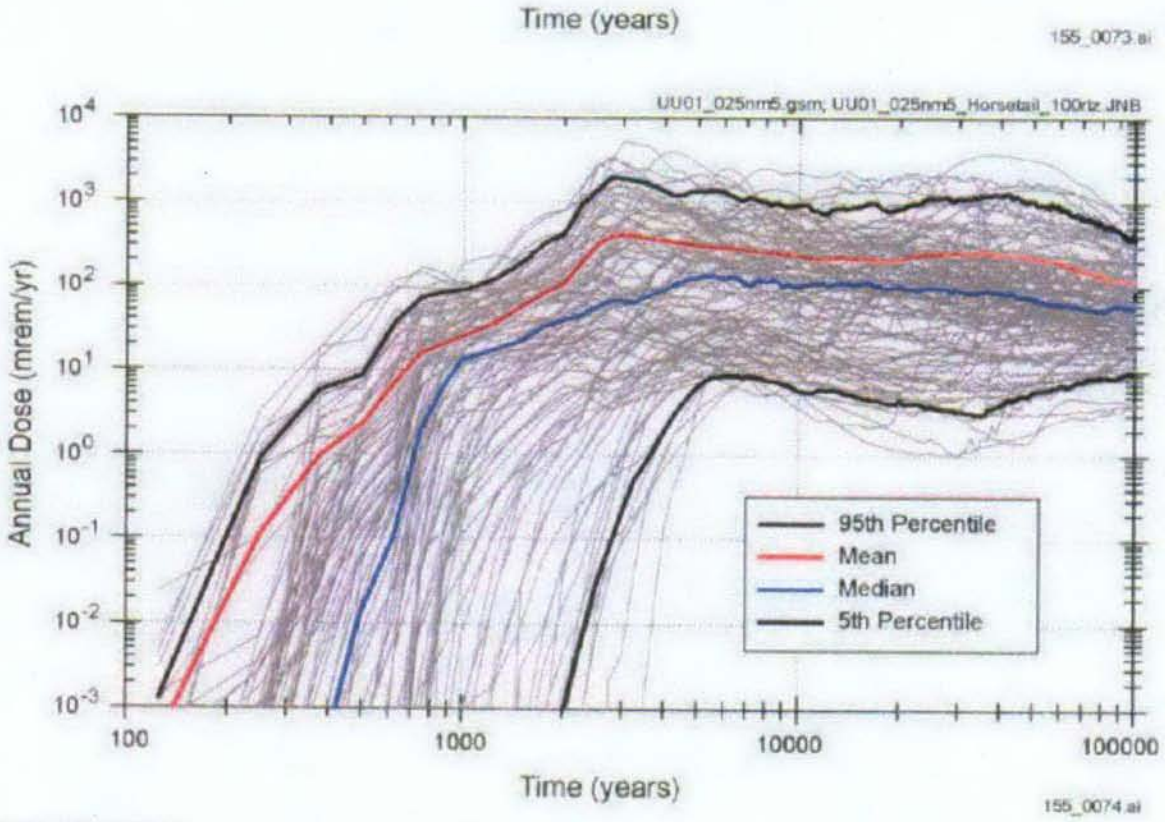


Figure 6-1 Waste-Package Failure Curves for the 70,000-MTHM Inventory and the 5th and 95th Percentiles, and the Mean and Median of these Simulations

(b)



155_0073.ai / 155_0074.ai

NOTE: (a) Comparison of two cases. (b) All realizations and statistics for the case with no seepage during the boiling period. WP = waste package. DS = drip shield.

Figure 3.2.2-9. Annual Dose Histories with and without Seepage during the Boiling Period for the Case with Neutralized Waste Packages and Drip Shields

This calculation assumes no metal containers or drip shields over the containers.

Uncertainty Rules

- Base Case
  - Groundwater standard (4 mr/y) exceeded at between 50,000 and 60,000 years
  - Mean peak dose between 200,000 and 300,000 years at about 500 – 600 mr/y (mostly neptunium)
- No Engineered Barrier
  - Groundwater standard (4 mr/y) exceeded at about 500 years
  - Mean peak dose at about 2,000 years at 500 – 600 mr/y (mostly technesium)

Hydrology Tells

It is not IF

It is WHEN