NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: **SIGNIFICANCE OF HYDROCHEMICAL DOMAINS IN THE SATURATED ZONE AT YUCCA MOUNTAIN**

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SATURATED-ZONE (SZ) TECHNICAL ISSUES

- Amount of local recharge through repository block
- Extent of mixing in upper part of SZ
- Efficacy of matrix diffusion
- Leakage between regional carbonate aquifer and volcanic aquifer—which direction
- Delineation of upgradient and downgradient flow paths
- Travel times and fluxes along flow paths
- Identification of discharge sites

ADDRESSING THESE TECHNICAL ISSUES

- Conduct sampling and analyses of ground water (WT-24, SD-6, SD-11,SD-13, other WT wells, and existing downgradient supply wells)

- Evaluate and integrate existing and new analyses into a hydrochemical/isotopic spatial data base

- Refine map of hydrochemical/isotopic ground-water domains

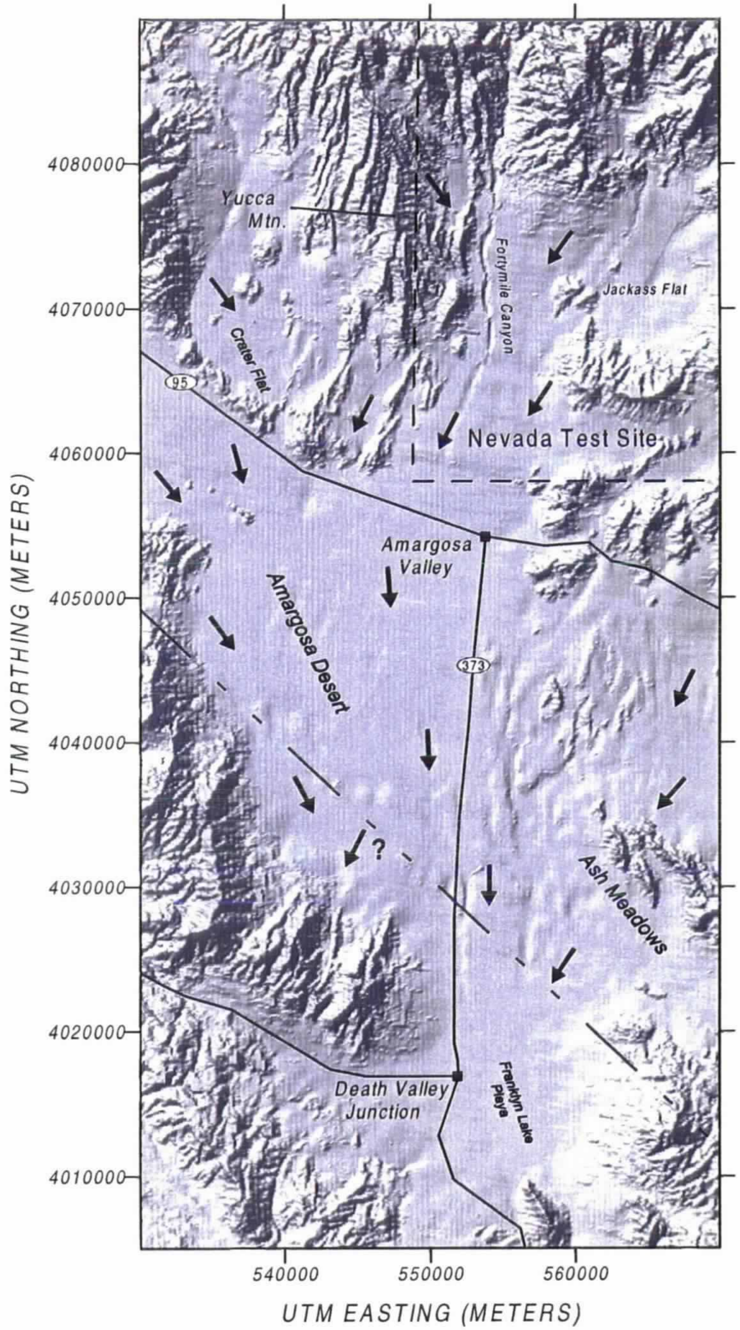
- Integrate domains and flow paths into regional and site-scale flow models

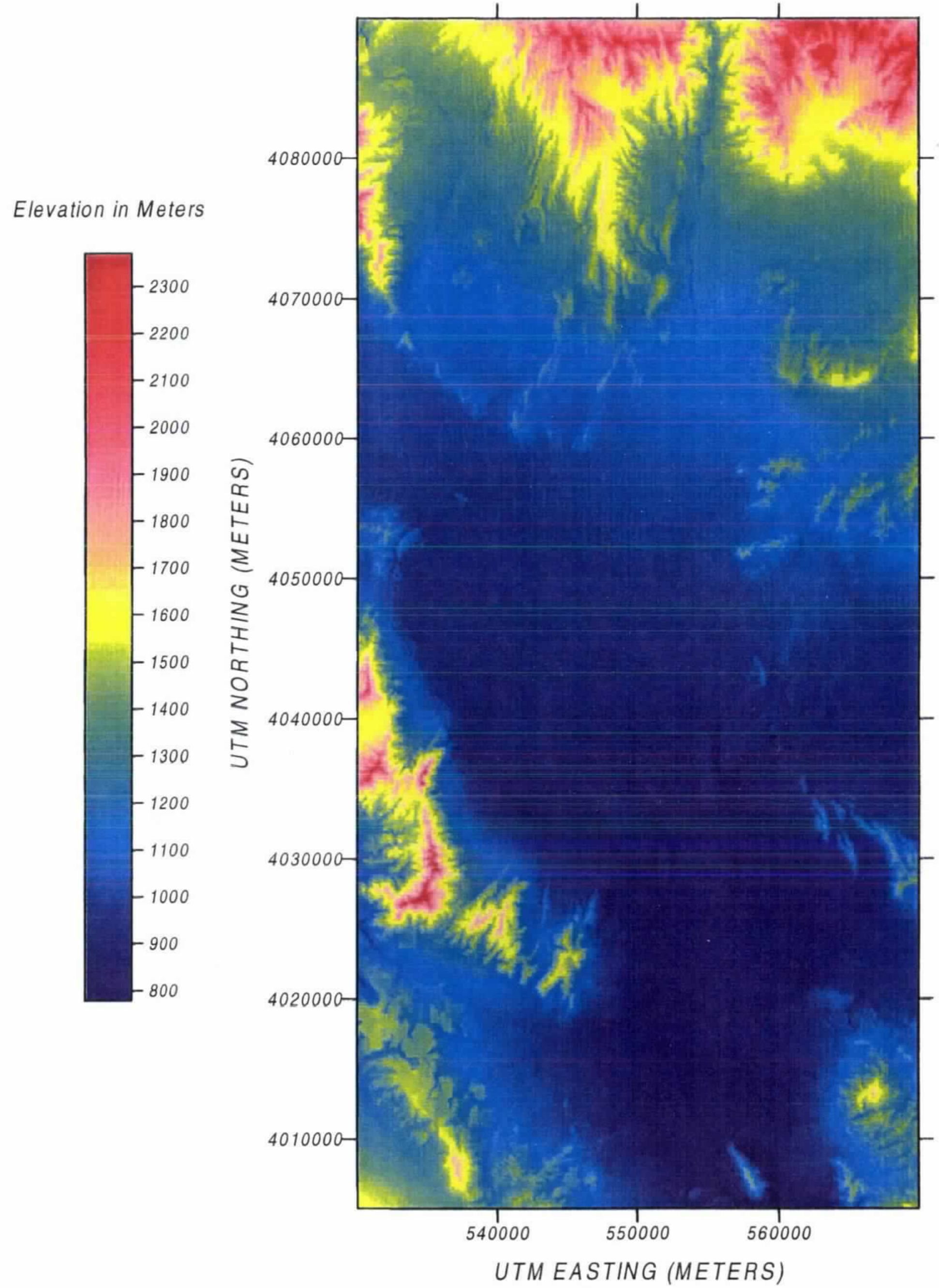
PROGRESS REPORT

- Existing data have been compiled for area that includes Yucca Mountain flow system

- Data are displayed spatially on shaded relief maps using SURFER© to construct isopleths of hydro-chemical and isotopic parameters

- Qualifications
  - Data points not optimally spaced for gridding
  - Isopleths may not honor all points
  - Lateral variations may not be continuous
  - Possible vertical variations not considered


Yucca Mtn.
Fortymile Canyon
Jackass Flat
Crater Flat
95
Nevada Test Site
Amargosa Valley
Amargosa Desert
373
?
Ash Meadows
Death Valley Junction
Franklin Lake Playa
4080000
4070000
4060000
4050000
4040000
4030000
4020000
4010000
UTM NORTHING (METERS)
540000
550000
560000
UTM EASTING (METERS)

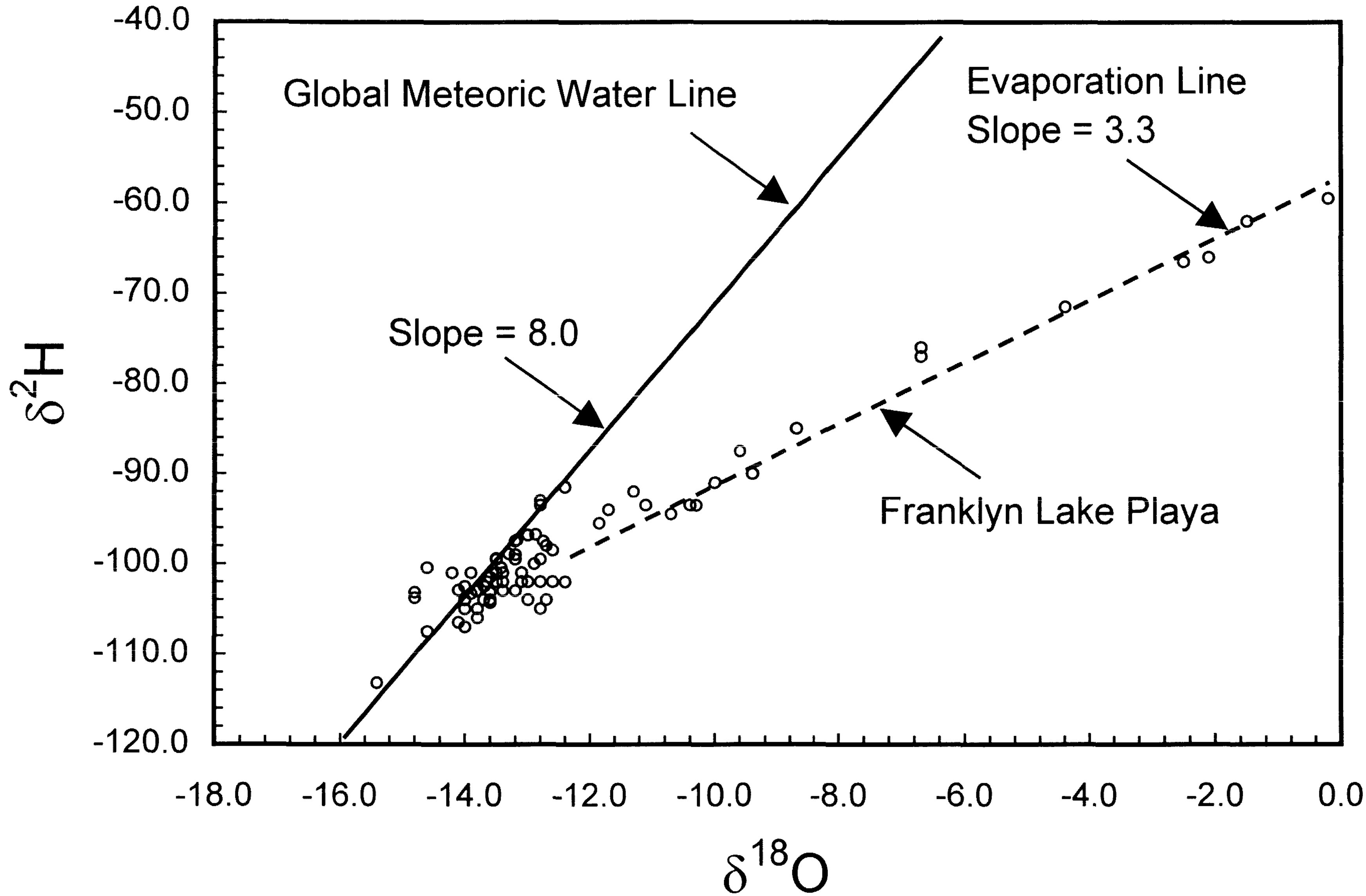

Elevation in Meters
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
4080000
4070000
4060000
4050000
4040000
4030000
4020000
4010000
UTM NORTHING (METERS)
540000
550000
560000
UTM EASTING (METERS)

HYDROCHEMICAL/ISOTOPIC DATA

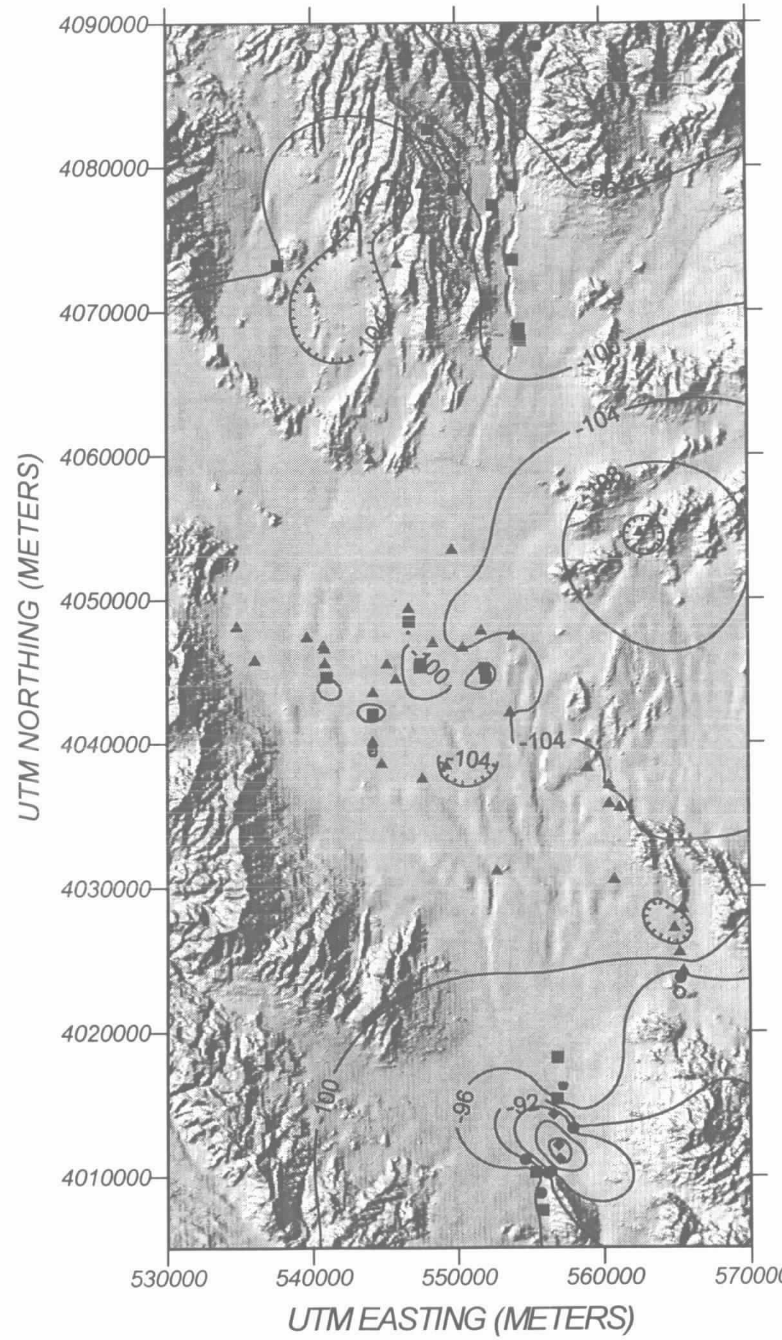
- Major dissolved elements, some minor and trace elements

- Isotopes
  - Stable ($\delta^{18}O$, $\delta^{2}H$, $\delta^{13}C$)
  - Radioactive (Tritium, ^{36}Cl, ^{14}C)
  - Radiogenic ($\delta^{87}Sr$, $^{234}U/^{238}U$)

- Major analytical need—method for unambiguous dating of ground water


Global Meteoric Water Line
Slope = 8.0
Evaporation Line
Slope = 3.3
Franklyn Lake Playa
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
δ^2H
-18.0
-16.0
-14.0
-12.0
-10.0
-8.0
-6.0
-4.0
-2.0
0.0
$\delta^{18}O$

δ^2H



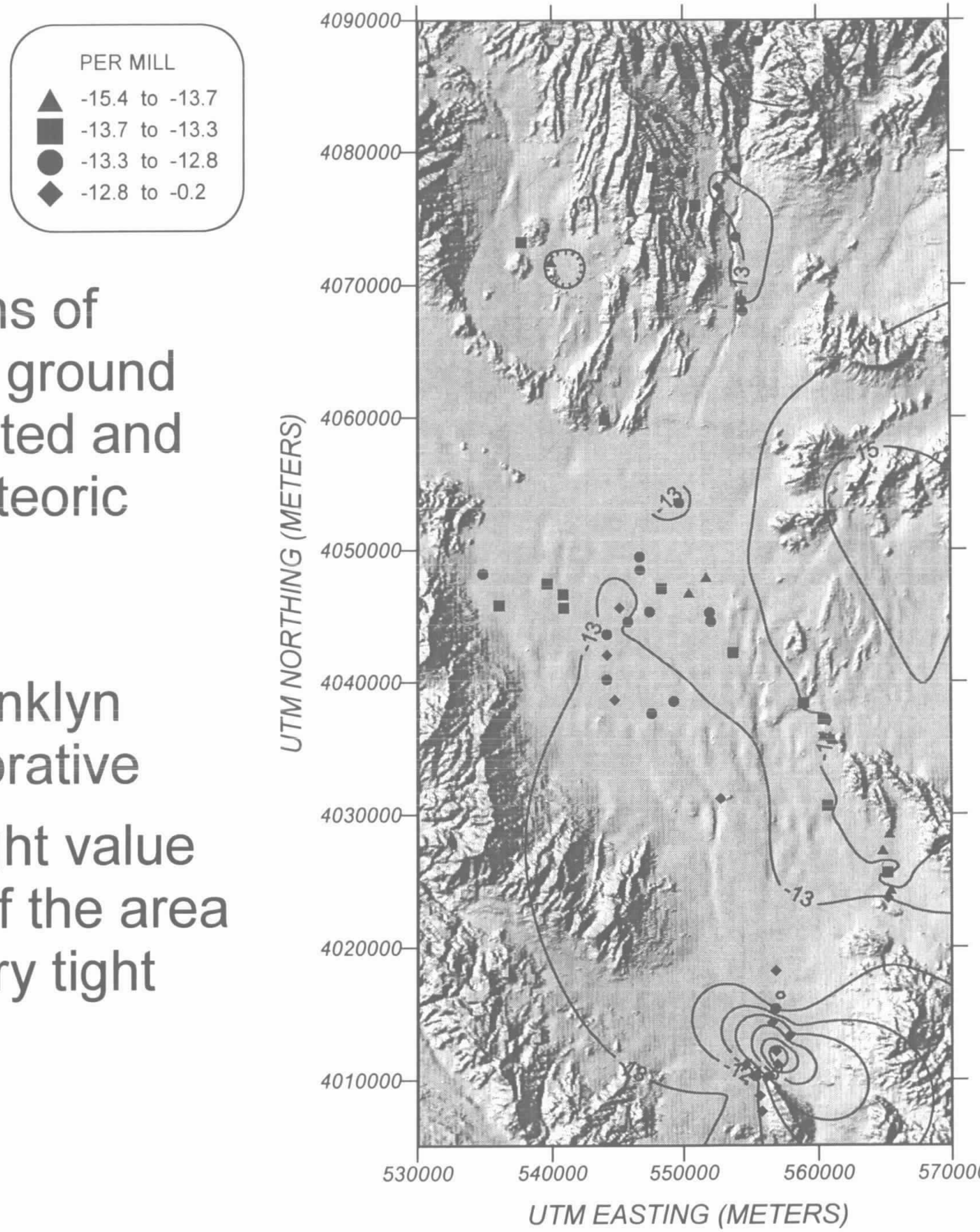
The isotopic compositions of hydrogen and oxygen in ground water are usually considered to be conservative from recharge values. These values are temperature dependent with "colder" precipitation being preferentially enriched in the lighter isotopes. The wide variability displayed here identifies domains of ground water recharged under different climatic conditions in the Holocene and Pleistocene. The heavy values at Franklyn Lake Playa reflect evaporative enrichment.

$\delta^{18}O$

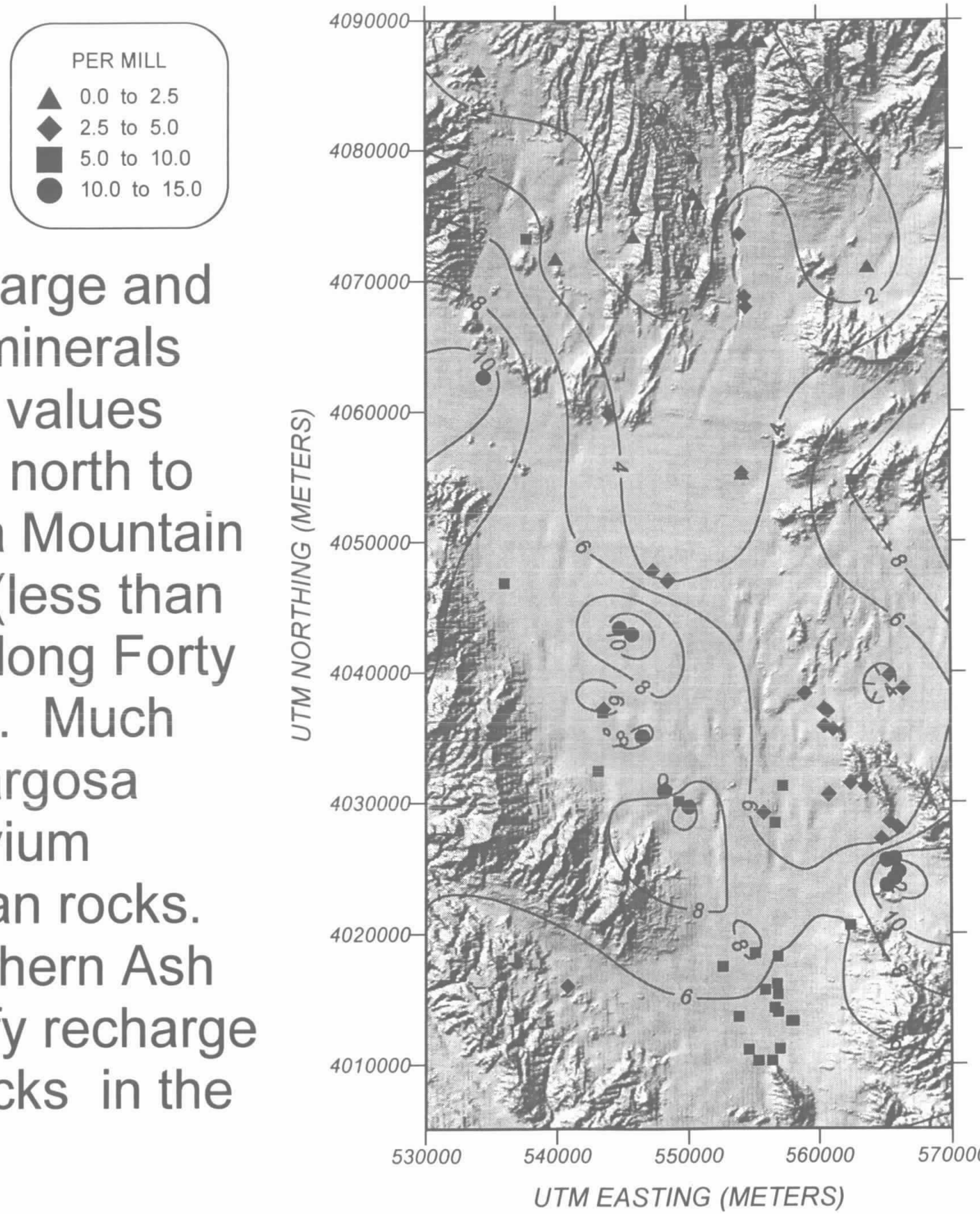
The isotopic compositions of oxygen and hydrogen in ground water are closely correlated and commonly follow the meteoric water line:

$$\delta^{2}H = 8*\delta^{18}O + 10$$

The heavy values at Franklyn Lake Playa reflect evaporative depletion of ^{16}O. The light value in the east-central part of the area is for ground water in very tight Precambrian rocks.



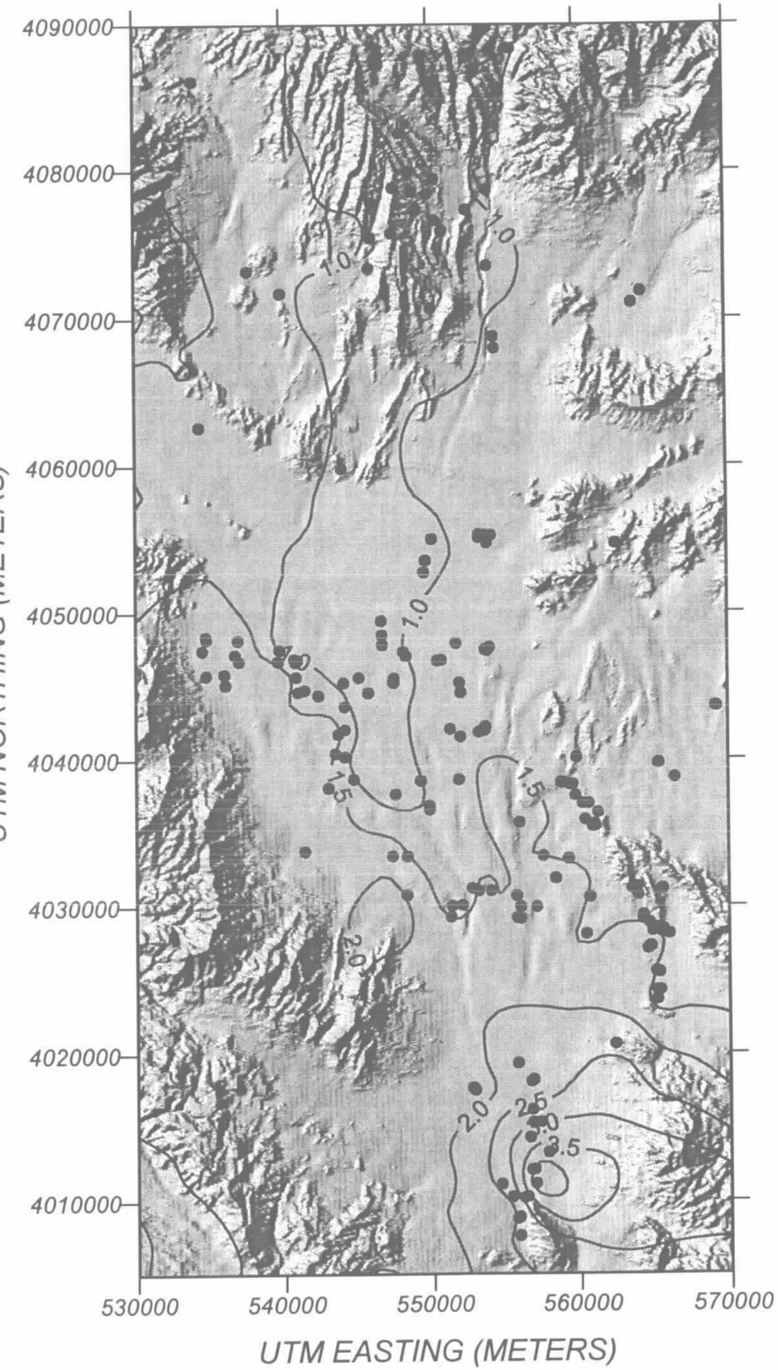
$\delta^{87}Sr$



$\delta^{87}Sr$ values reflect recharge and interaction with aquifer minerals along flow paths. These values increase erratically from north to south. Values for Yucca Mountain proper are typically low (less than 2.0) with larger values along Forty Mile Canyon (3.0 to 3.5). Much larger values in the Amargosa reflect flow through alluvium derived from Precambrian rocks. Large values of the southern Ash Meadows springs identify recharge through Precambrian rocks in the NW Spring Mountains.

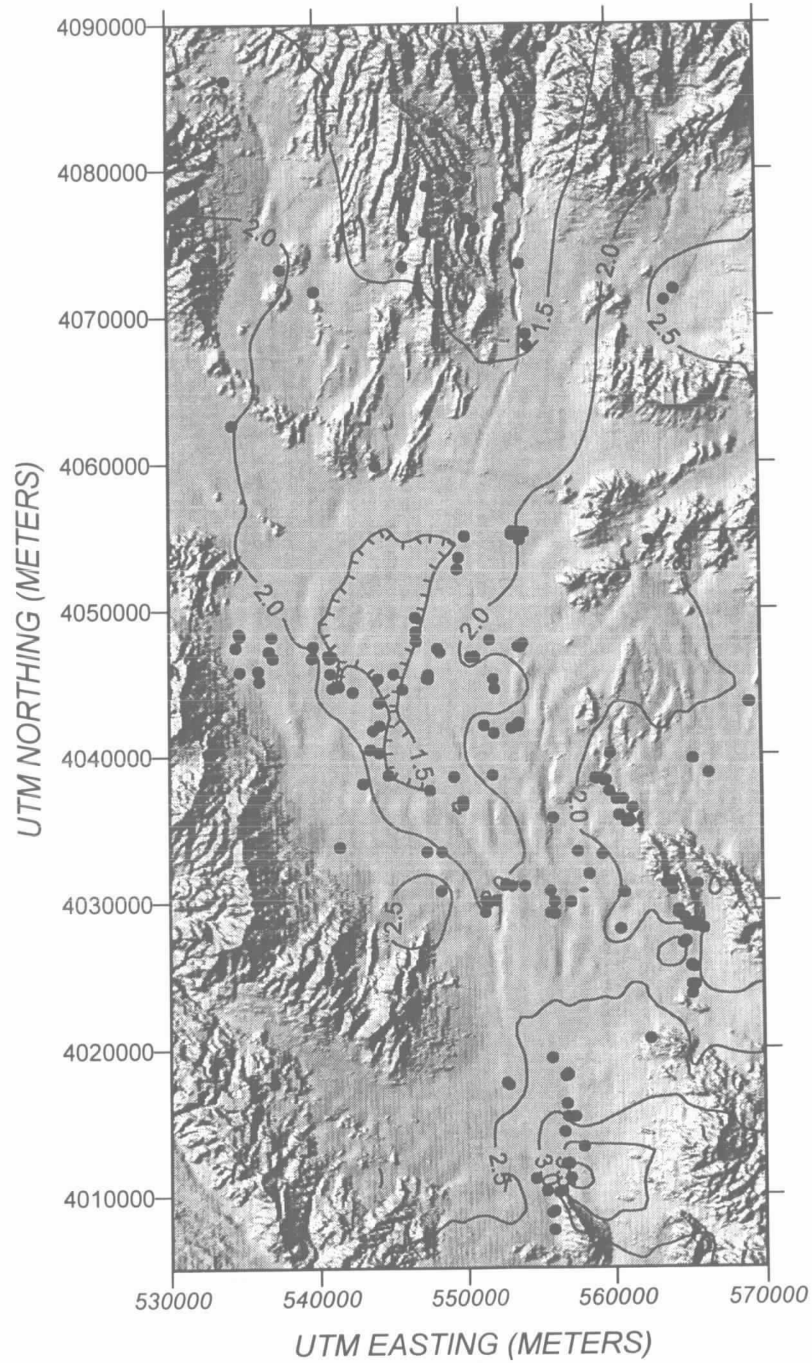
Log Cl^-

Dissolved Cl^- increases from north to south as shown here by a plot of log(Cl in mg/L). A tongue of low Cl water (typically less than 10 mg/L) may extend southward from Yucca Mountain into the Amargosa Desert although well control is not optimum. Dramatic incresases of Cl in ground water at Franklyn Lake Playa and at playas in Death Valley (not shown) are due to evaporative concentration.



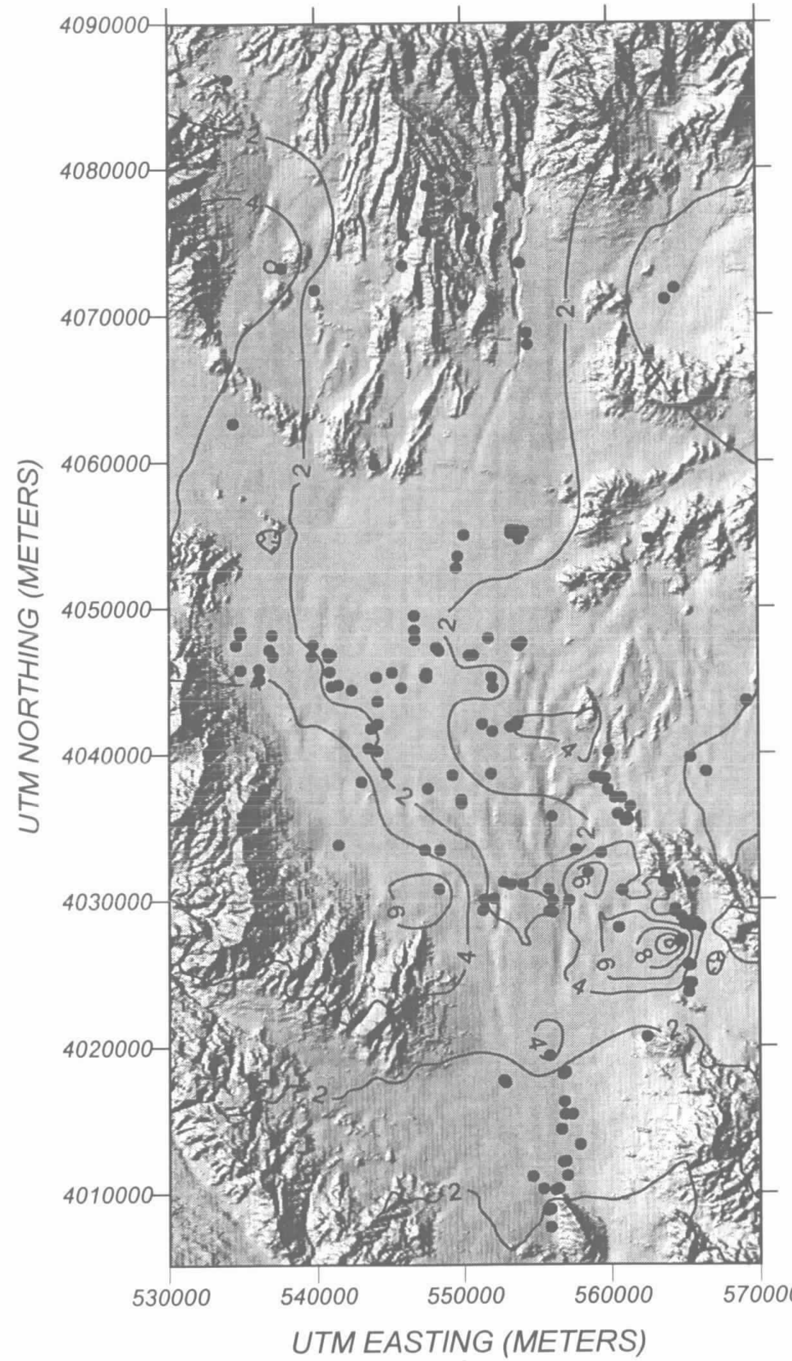
Log SO_4^{-2}

Dissolved sulfate ranges by more than four orders of magnitude from low values at Yucca Mtn. to extremely large values at Franklyn Lake Playa, the latter the result of evaporative concentration. The regional pattern suggests the presence of a plume of low sulfate ground water extending southward from Yucca Mountain analogous to several other chemical and isotopic attributes.



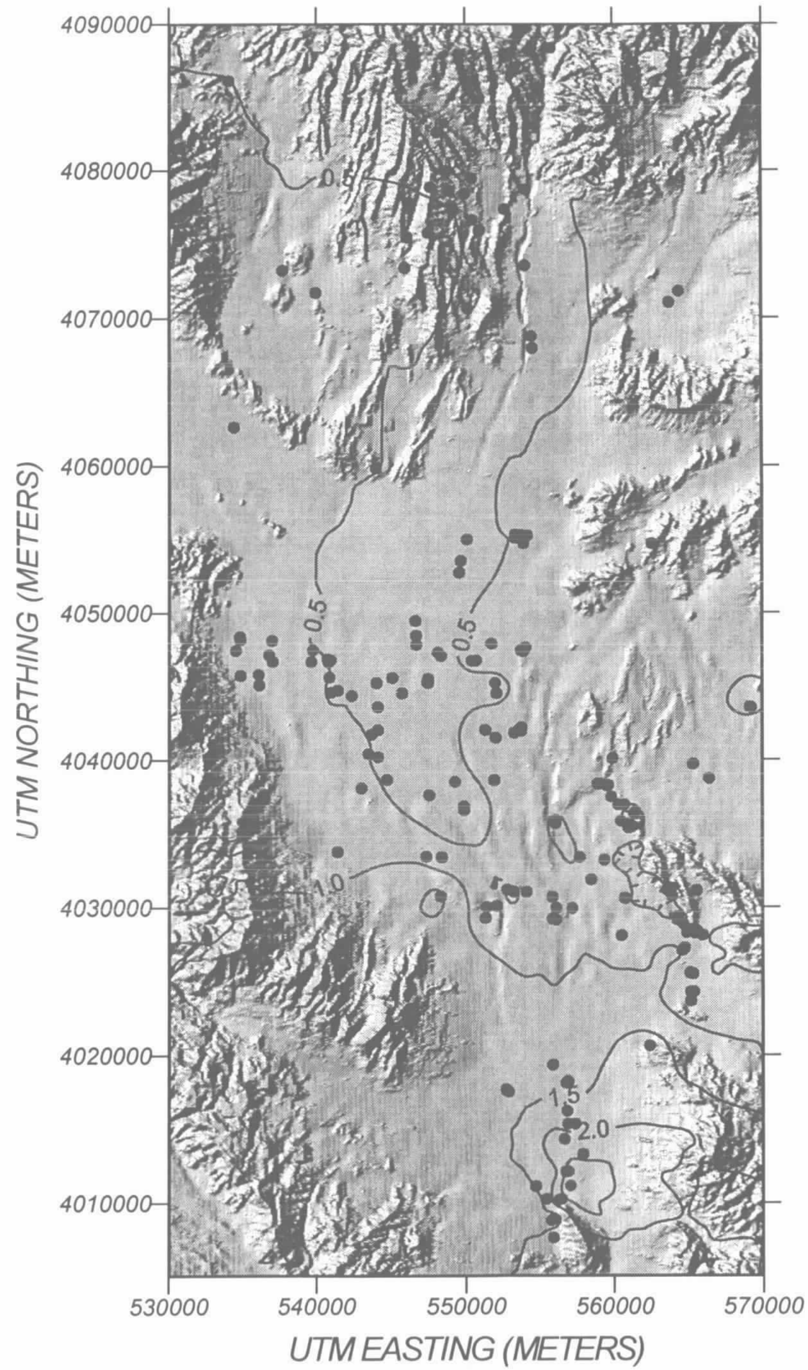
(Ca+Mg) in equivalents

This and the following illustration show the independent variations in (Ca+Mg) and (Na+K) which are combined in the previous slide as (Ca+Mg)/(Na+K). Considerable variability is shown in (Ca+Mg) with a relatively low concentration domain extending southward from Yucca Mountain. As noted previously, the lower values in Franklyn Lake Playa are the result of precipitation of Ca- and Mg-bearing minerals.



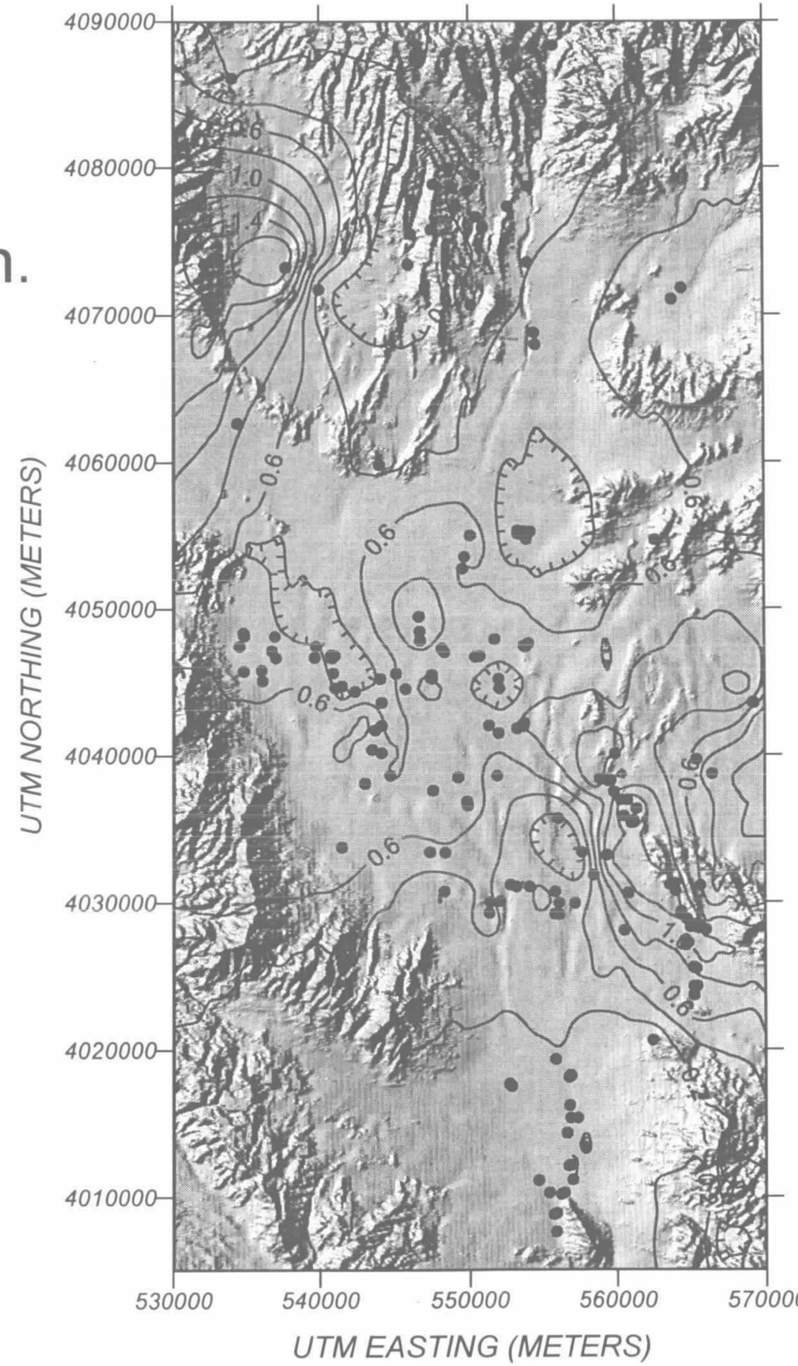
Log(Na+K) in equivalents

Because of the extreme variation in the combined alkalies as a result of evaporative concentration at Franklyn Lake Playa, the log of of (Na+K) is used here to protray the regional variation. The data suggest the presence of a plume of relatively lower (Na+K) water extending southward from Forty Mile Canyon.



(Ca+Mg)/(Na+K)

This ratio decreases westward from Forty Mile Canyon across Yucca Mtn. The steep gradient in Crater Flat is between wells VH-1(east) and VH-2 (west), both producing from the upper vol. aquifer but with very different major ion and isotopic compositions. The contrasting composition of ground water from the regional carbonate aquifer is shown by the large (Ca+Mg) to (Na+K) ratios of the Ash Meadows spring discharge. Lower values in the vicinity of Franklyn Lake Playa reflect enrichment of alkalis due to evaporation and concomitant precipitation of Ca and Mg minerals.



HYDROCHEMICAL/ISOTOPIC GROUND-WATER DOMAINS

YUCCA MOUNTAIN LATITUDE

- Jackass Flat
- Forty Mile Canyon (youngest)
- Yucca Mountain (east and west)
- Crater Flat
    - Central and eastern (=YM west)
    - Western (Bare Mountain)

DOWNGRADIENT DOMAINS

- Amargosa Desert (mixed FMC, YM, CF)
- Ash Meadows (regional carbonate discharge)
- Franklyn Lake Playa (evaporation)