U.S. Department of Energy
Office of Civilian Radioactive Waste Management

YUCCA MOUNTAIN PROJECT

# Site-Scale Saturated Zone Model Update and Integration of New Regional and Site-Scale Models

Presented to:
**Nuclear Waste Technical Review Board**


Presented by:
**Al A. Eddebbarh, Ph.D, PE**
**Saturated Zone Department Manager**
**Los Alamos National Laboratory**
**Bechtel SAIC Company, LLC**

**George Zyvoloski, Ph.D**
**Los Alamos National Laboratory**

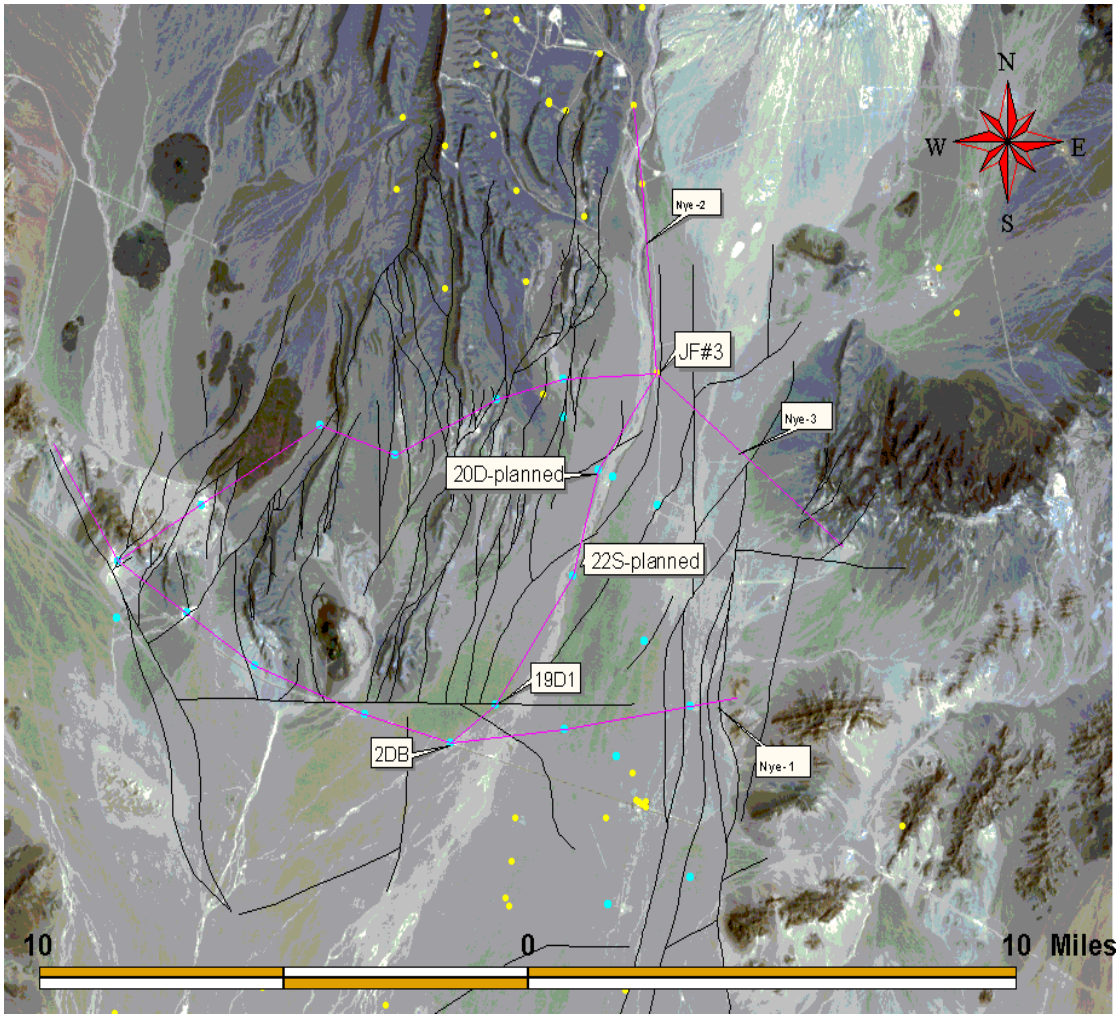

**January 29-30, 2002**
**Pahrump, Nevada**

# Topics of Discussion

- **New data and analyses**
- **Saturated Zone (SZ) flow model update**
- **Integration of regional and site-scale saturated zone models**
- **Multiple lines of evidence to support SZ flow and transport model feeds to Total System Performance Assessment**

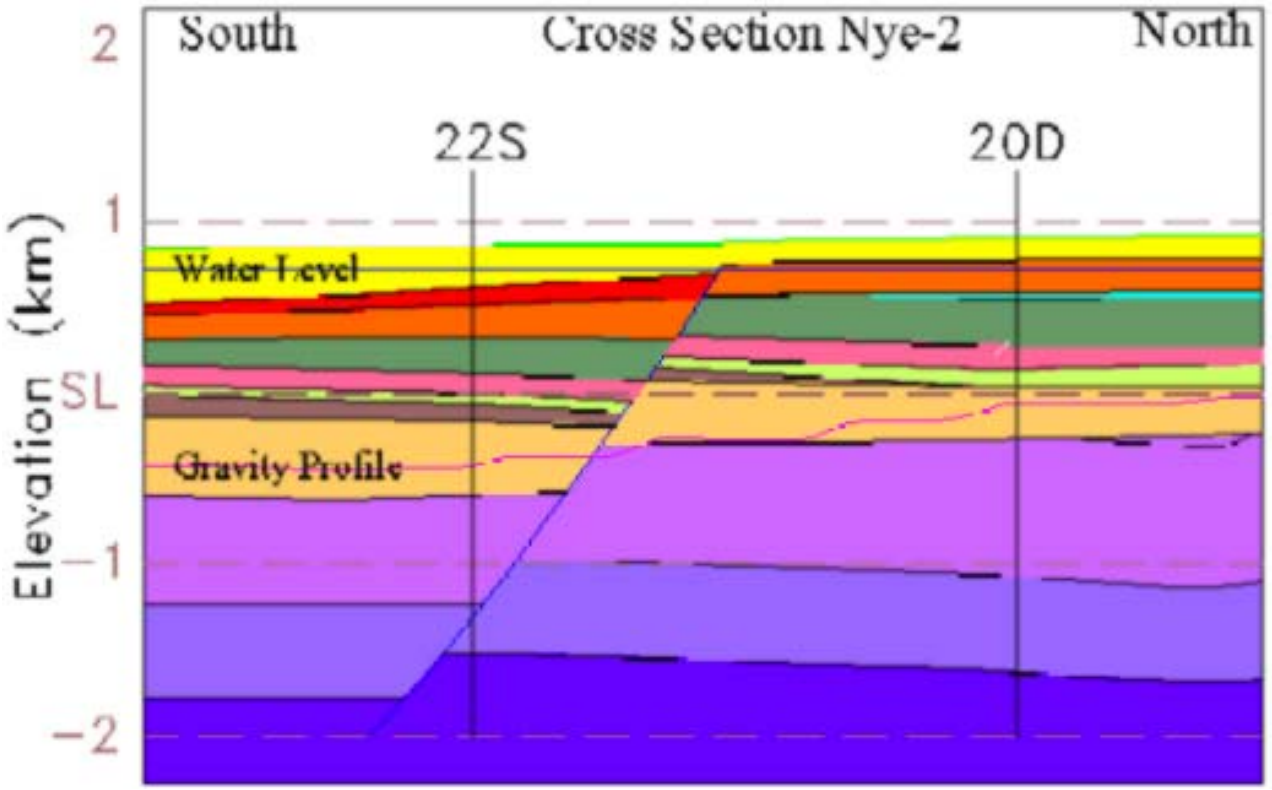
# New Data and Analyses

- **Location of new geologic cross sections**

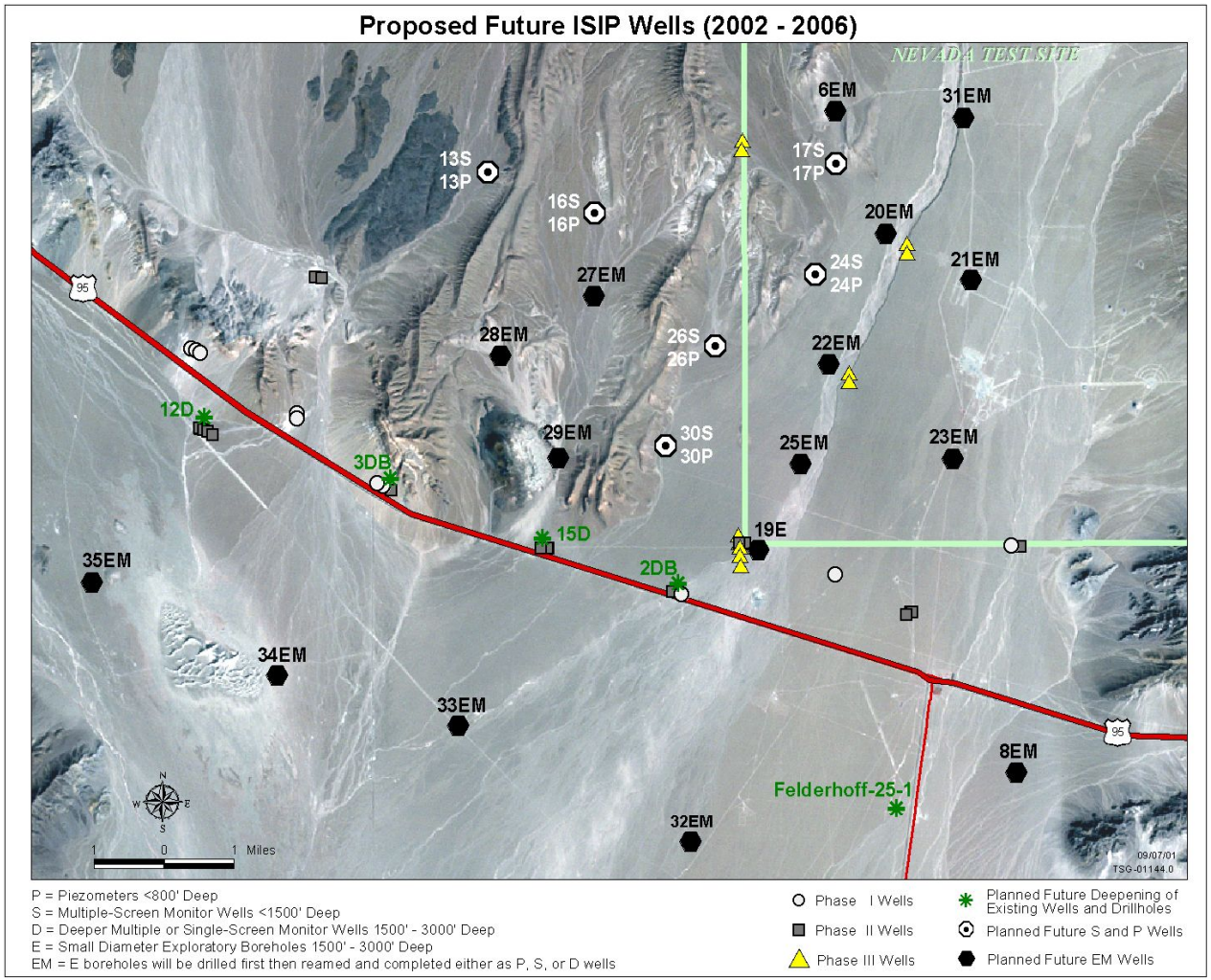


# Cross Section
# Nye County - 2

- **New data reduces uncertainty in the alluvial/tuff transition zone**



# Location of Existing Nye County Wells and Planned Future Nye County Wells



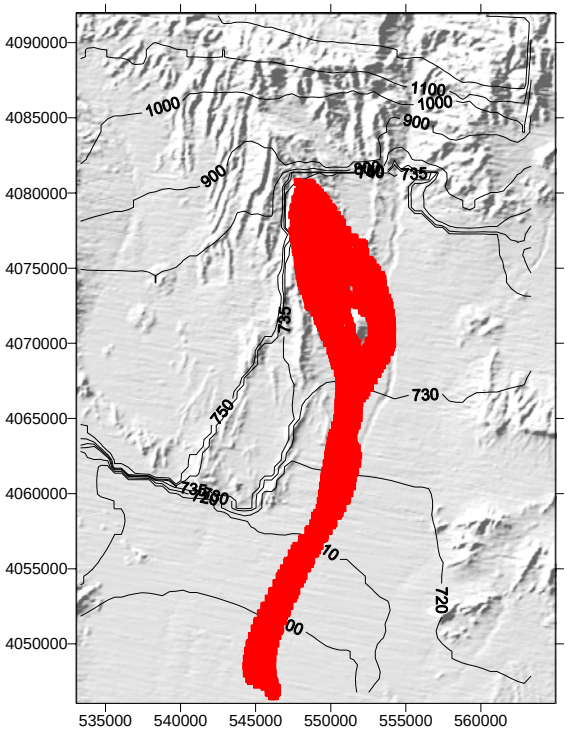
# SZ Site-Scale Flow and Transport Model

- **3-D model implemented with FEHM software code has domain 30 km x 45 km x 2750 m below water table**
- **Hydrogeologic framework model contains 19 units**
- **Orthogonal grid with 500 m horizontal spacing and variable resolution in the vertical direction**
- **Flow model calibration used automated inversion**
- **Model calibration and validation uses data including**
  - **Water level measurements in wells**
  - **Inferred flow paths from hydrochemical data**
  - **Upward hydraulic gradient from carbonate aquifer**
  - **Ranges of measured permeability**

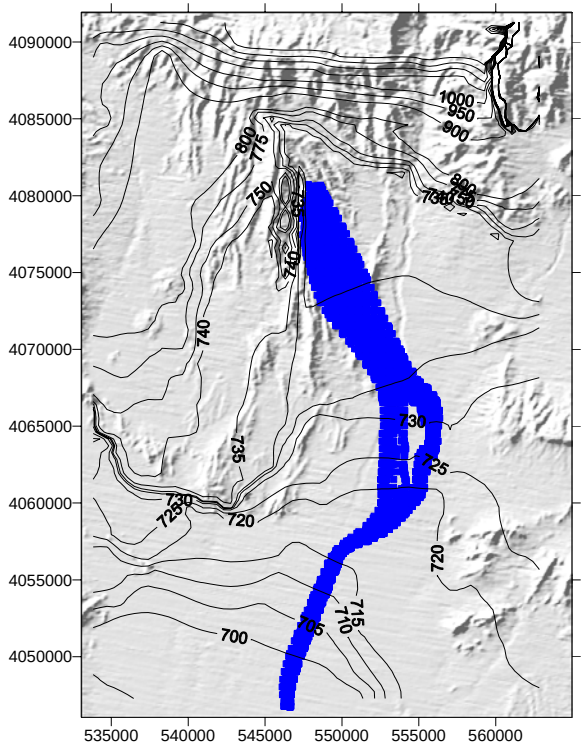
# Numerical Model

- **Boundary conditions**
  - **Specified Head (sides: regional potentiometric surface)**
  - **Specified Flux (top: recharge map)**
- **Water budget**
  - **Regional fluxes are calibration targets**
  - **Steady state model, no change in water storage**
  - **Numerical mass balance error is negligible (0.00002)**

# Alternate Conceptual Models



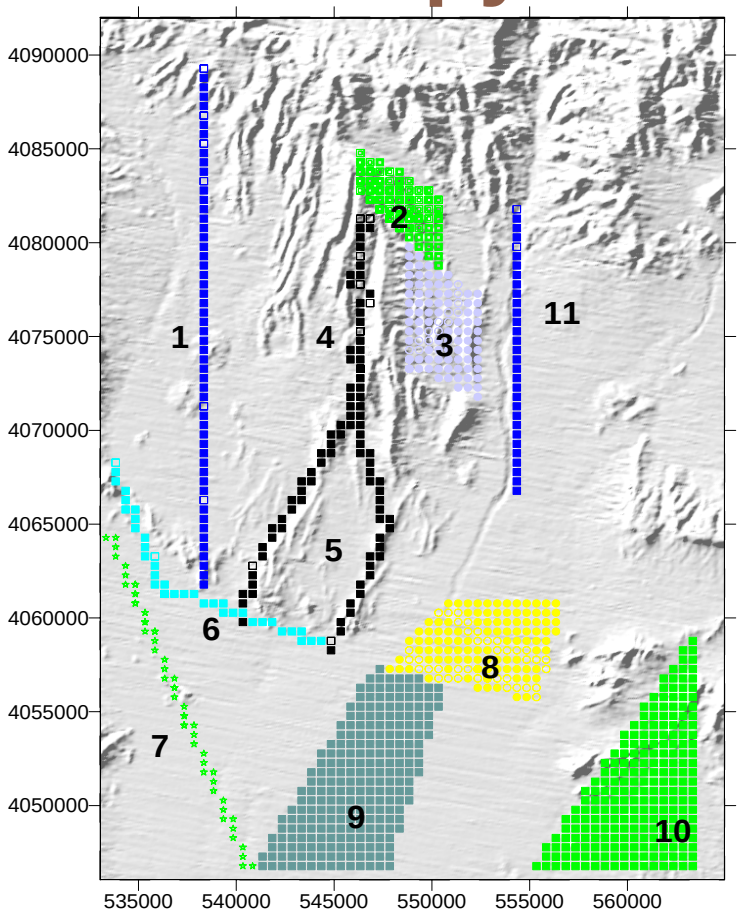

**Original model used in TSPA-SR with EW barrier**




**Newer model used in the expected case analysis with no EW barrier**

# Anisotropy

- **Vertical to Horizontal (1:10)**
  - **Carbonates, undifferentiated, some volcanics, alluvium**
  - **Faults (Solitario, Fortymile, Crater Flat, etc.) have higher vertical conductivity**




**Features in the SZ Model**

1-Crater Flat Fault
2-Northwest Trending Fault Zone
3-Imbricate Fault Zone
4-Solitario Canyon Fault
5-Solitario Canyon Fault Splays
6-Highway 95 Fault
7-Bare Mountain Fault
8-Alluvial Uncertainty Zone
9-Lower Fortymile Wash Zone
10-Spotted Range-Mine Mountain Zone
11-Fortymile Wash Fault

- **Horizontal E-W to N-S (1:5)**
  - **Yucca Crest to Fortymile Wash, length of Yucca Mountain**
  - **Top to 200m Depth (volcanic not carbonate)**
  - **Very little effect**

# New Calibrated Model

- **New data**
  - **Hydrogeology**
  - **Water level map**
- **New grids**
  - **Several different resolutions**

# Integration of Regional and Site-Scale Flow Models

- **Both the regional-scale flow modeling performed by the USGS and the YMP site-scale flow models continue to evolve**
- **The most recent USGS regional-scale flow model is in review**
  - **Differs from the model available at the time of the SR mainly in that it includes more stratigraphic detail**

# Plan to Integrate the Regional-Scale and Site-Scale Flow Models

- **Use the same hydrostratigraphic frameworks**
- **Use the same zones to subdivide hydrostratigraphic units for parameter estimation**
- **Use the numeric grids that coincide in the vertical and horizontal directions**
- **Extend to the same depth**
- **Use consistent hydraulic properties**
- **Use consistent boundary fluxes**

# Examples of Multiple Lines of Evidence

- **Evaluation of single and cross-hole permeability data**
- **Groundwater carbon-14 ages**

# Evaluation of Single and Cross-Hole Permeability Data

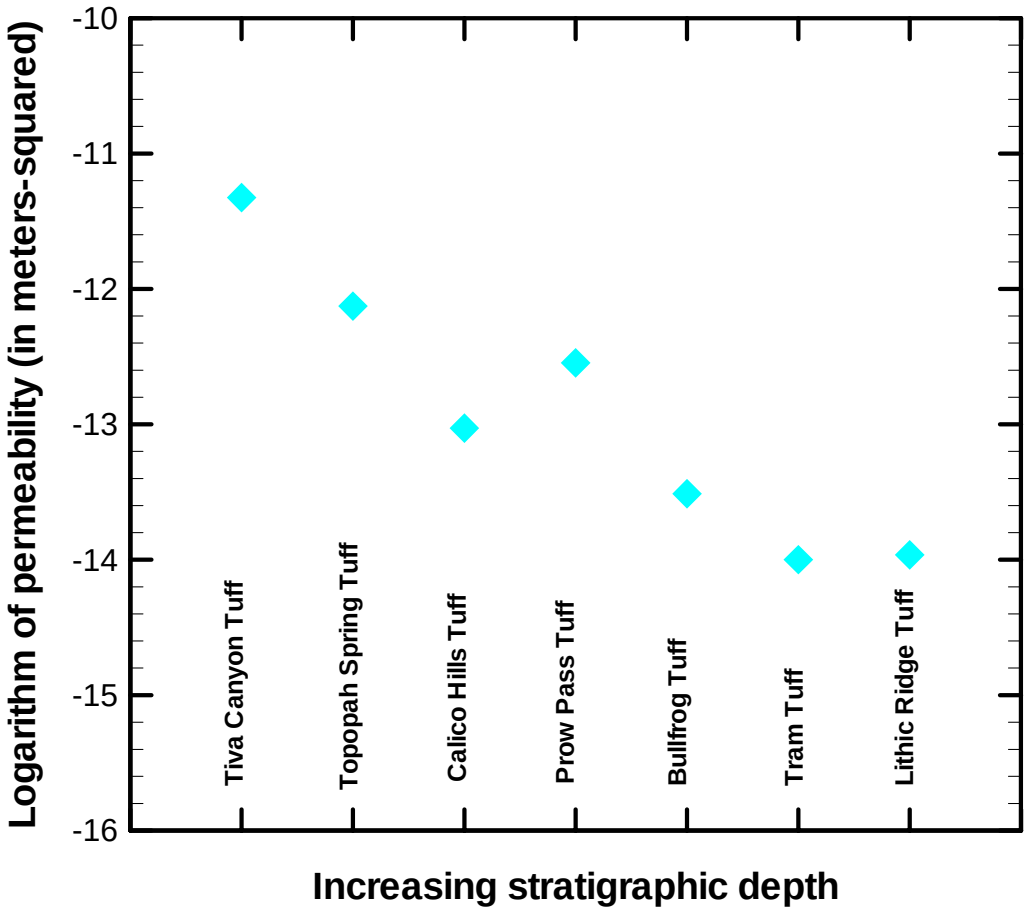
- **Combined unsaturated zone (UZ)/SZ single-hole permeability data indicate a decrease in permeability with depth, consistent with the trend expected because of increases in overburden stress and mineral alteration with depth**
- **In contrast, cross-hole permeability data from the c-wells show an increase in permeability with depth, counter to the expected trend**

# Evaluation of Single and Cross-Hole Permeability Data

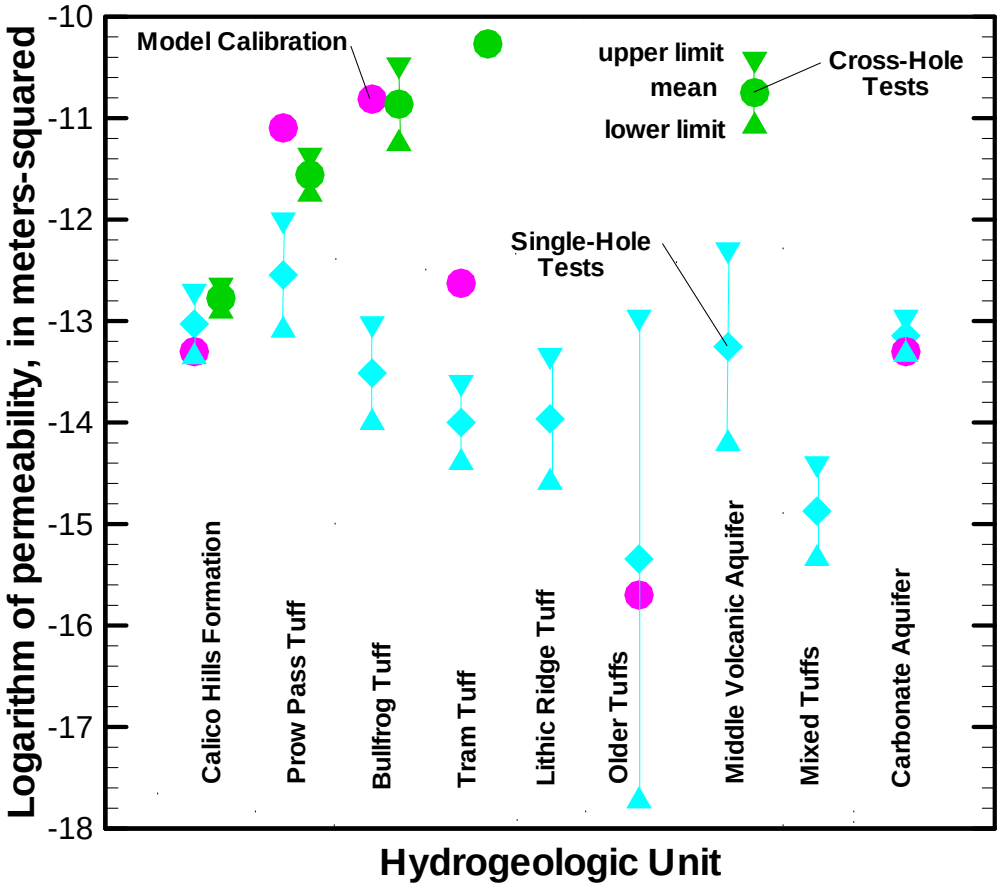
(Continued)

- **Cross-hole test permeabilities at the c-wells increase with proximity of test locations to Midway Valley Fault, suggesting that test results are primarily reflecting the effects of the fault rather than average rock properties**
- **High-resolution numerical simulations of C-wells cross-hole tests are planned to determine permeabilities of the faulted and unfaulted rock**

# Combined UZ/SZ Air and Water-Permeabilities



# Single and Cross-Hole Permeability Data from the SZ



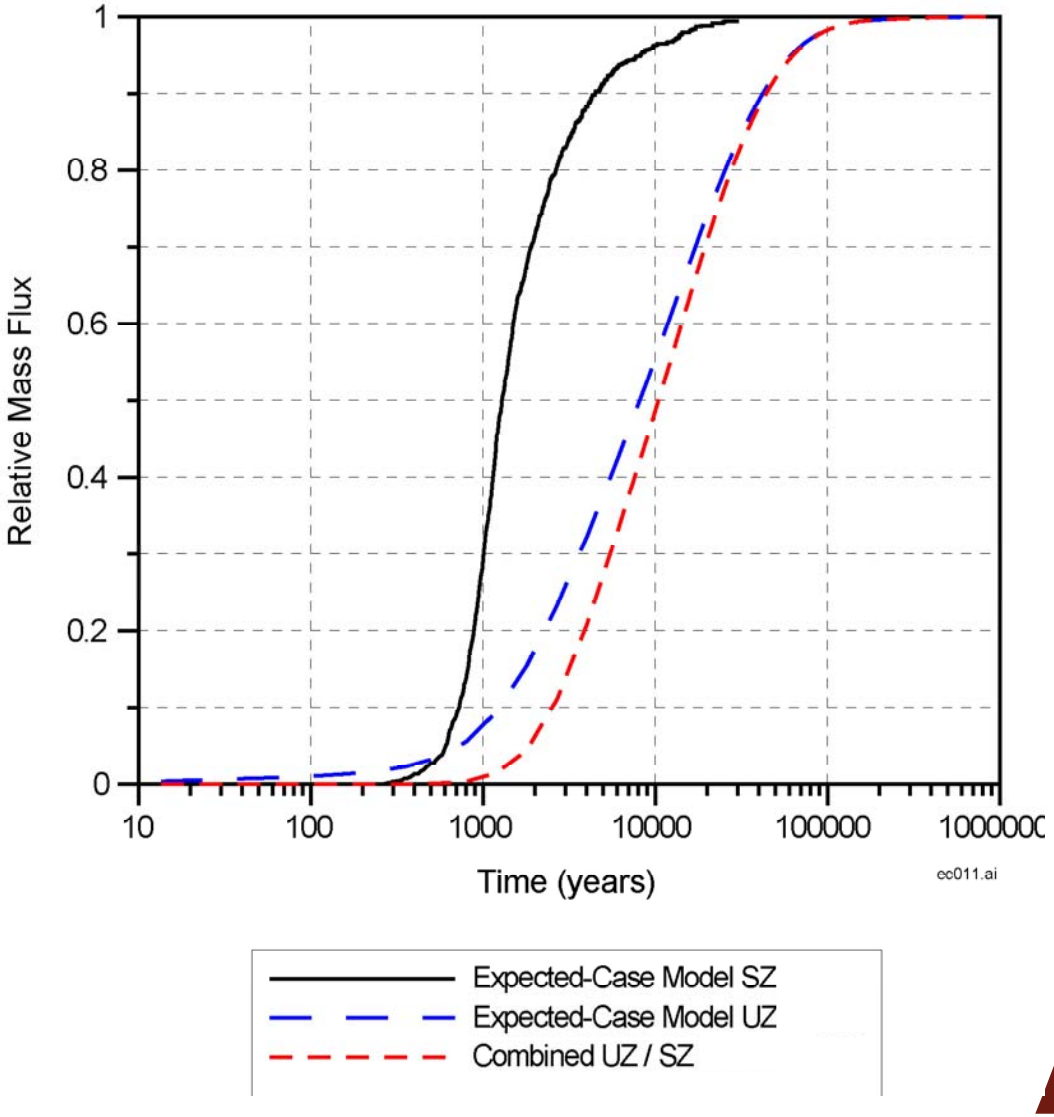
# Total Dissolved Inorganic Carbon-Based Corrections to Groundwater Carbon-14 Ages

- **Corrected groundwater $^{14}C$ ages are 11,000 to 17,000 years. The uncorrected ages are 12,000 to 18,000 years at the selected boreholes**
- **Corrected groundwater $^{14}C$ ages are consistent with the combined UZ/SZ unretarded advective transport**

# Saturated Zone Data used in the Expected Case

- **Stratigraphy and hydrochemistry from new Nye County Wells**
- **Hydraulic and tracer testing from the Alluvial Testing Complex**
- **Calibration of different conceptualizations of the Large Hydraulic Gradient**
- **Evaluation of boundary to the accessible environment**

# Transport Time Breakthrough Curves for the UZ, SZ, and Both Zones Combined



# Summary

- **A scientifically defensible model of saturated zone flow and transport at Yucca Mountain has been developed**
  - **Calibrated to hydrogeologic data**
  - **Some testing of transport conceptual models has been completed**
- **Nye county data are being incorporated**
- **Data collected since completion of models supporting TSPA for Site Recommendation are consistent with the bases used for these models**

# Summary
(Continued)

- **Current data collection and modeling efforts are designed to**
  - **Reduce uncertainties**
  - **Relax conservative assumptions**
  - **Further validate conceptual models**
- **Efforts continue to improve consistency between the site-scale and the regional-scale models**
  - **Unified hydrologic model**
  - **Same vertical extent**

# Backup

# Results of DIC-Based Groundwater $^{14}C$ Age Corrections

| Borehole | $^{234}U/^{238}U$ activity ratio | $^{14}C$ activity (pmc) | DIC, as $HCO_3$ (mg/L) | Log $P_{C02}$ (atm) | Log (IAP/$K_{calcite}$) | $q_{DIC}$ | Uncorrected $^{14}C$ age (years) | Corrected $^{14}C$ age (years) |
|---|---|---|---|---|---|---|---|---|
| USW G-2 | 7 to 8 | 20.5 | 127.6 | -2.352 | -0.791 | 1 | 13,100 | 13,100 |
| UE-25 WT #17 | 7 to 8 | 16.2 | 150.0 | -1.958 | -1.175 | 0.86 to 0.96 | 15,040 | 13,750 to 14,710 |
| UE-25 WT #3 | 7 to 8 | 22.3 | 144.3 | -2.413 | -0.515 | 0.89 to 1. | 12,400 | 11,430 to 12,380 |
| UE-25 WT #12 | 7 to 8 | 11.4 | 173.9 | -2.327 | -0.313 | 0.74 to 0.83 | 17,950 | 15,430 to 16,390 |
| UE-25 c #3 | 7 to 9 | 15.7 | 140.2 | -2.458 | -0.319 | 0.92 to 1. | 15,300 | 14,570 to 15,300 |
| UE-25 b#1 (Tcb) | ---- | 18.9 | 152.3 | -1.892 | -0.757 | 0.84 to 0.95 | 13,770 | 12,350 to 13,300 |
| USW G-4 | ---- | 22.0 | 142.8 | -2.490 | -0.305 | 0.90 to 1. | 12,500 | 11,630 to 12,510 |
| NC-EWDP-2D | 4 to 5 | 23.5 | 158.0 | -2.330 | -0.450 | 0.81 to 0.91 | 11,970 | 10,250 to 11,200 |