



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



# Death Valley Regional Groundwater Flow System

Presented to:  
**U.S. Nuclear Waste Technical Review Board Panel  
on the Natural System**

Presented by:  
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U.S. Geological Survey  
Water Resources Discipline

**March 9-10, 2004**  
**Las Vegas, Nevada**

# Team Project

- **Wayne Belcher (NV)**
- **Joan Blainey (AZ)**
- **Claudia Faunt (CA)**
- **Mary Hill (NRP)**
- **Randy Laczniak (NV)**
- **Carma San Juan (YMP)**
- **Don Sweetkind (GD)**



# Topics of Discussion

- **Overview and conceptual model**
- **Geologic emphasis**
- **Tasks**
- **Groundwater flow model description**
- **Fluxes to site-scale Yucca Mountain Project (YMP) model**
- **Report outline, knowledge exchange, and potential future work**
- **Questions and discussion**

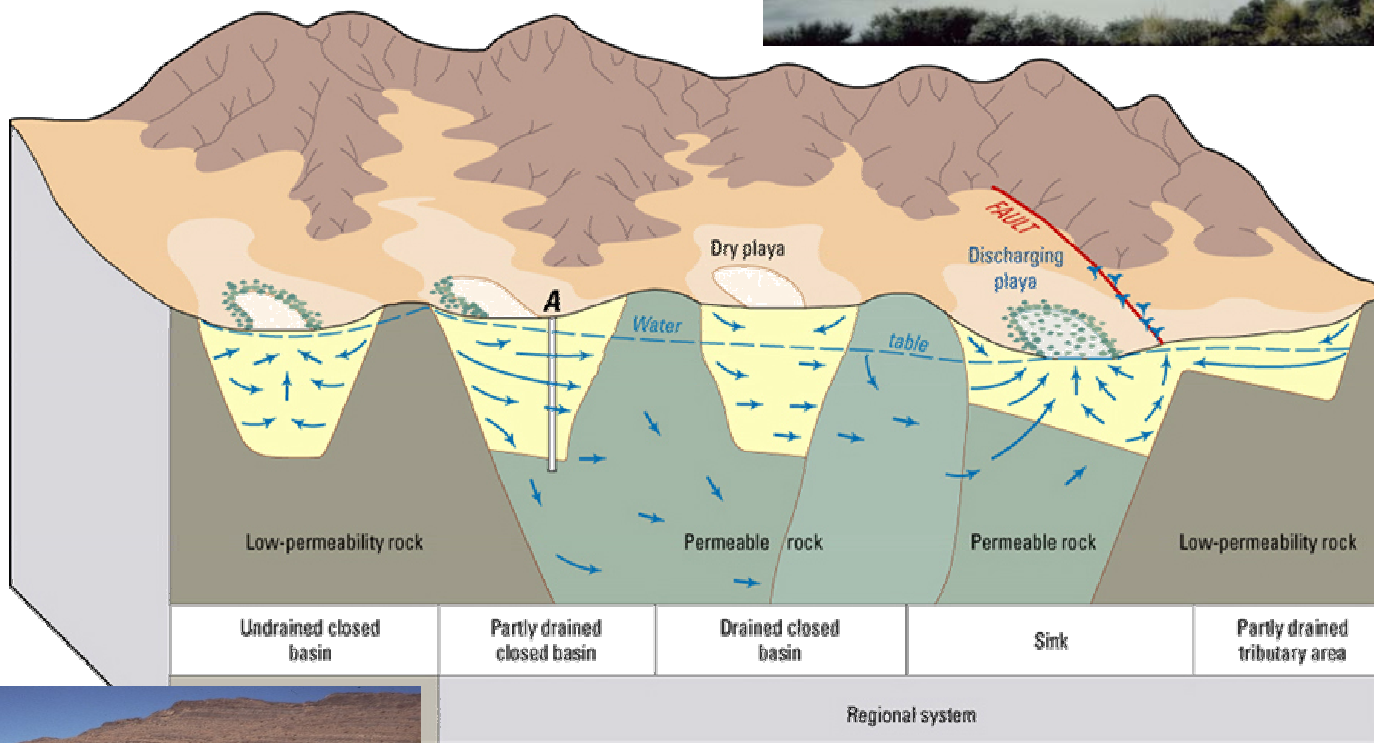


# Death Valley Regional Flow Model Area

- Large area with complex geology
- Potential high-level nuclear waste repository, Yucca Mountain, Nevada
- Groundwater flow paths from Nevada Test Site
- Update of previous modeling efforts
- Constructed using MODFLOW-2000
- Time period 1913-1998



# Conceptual Model(s) of Groundwater Flow System



**A** Surface

Allevium - Volcanic clasts with clay and silt beds, may include channel deposits
Basalt - Lost circulation zone at base
Allevium - Tuffaceous
Tuffaceous sandstone or tuff
Marl or freshwater limestone Lost circulation zone at top
Volcanic sandstone or tuff
Sandstone and gravel
Gravel and Paleozoic blocks
Paleozoic carbonates with lost circulation zones

Permeable rock



**EXPLANATION**

Areas of ground-water evapotranspiration

- Phreatophytes
- Discharging playa

# Geology is Half the Equation

$$KA = Q/(dh/dl)$$

$$Q/(dh/dl) = KA$$

- **Framework**

- Unit geometry/truncation
- Location of high K zones
- Groundwater barriers
- Heterogeneity/anisotropy
- Actually doesn't provide K

- **Hydrology**

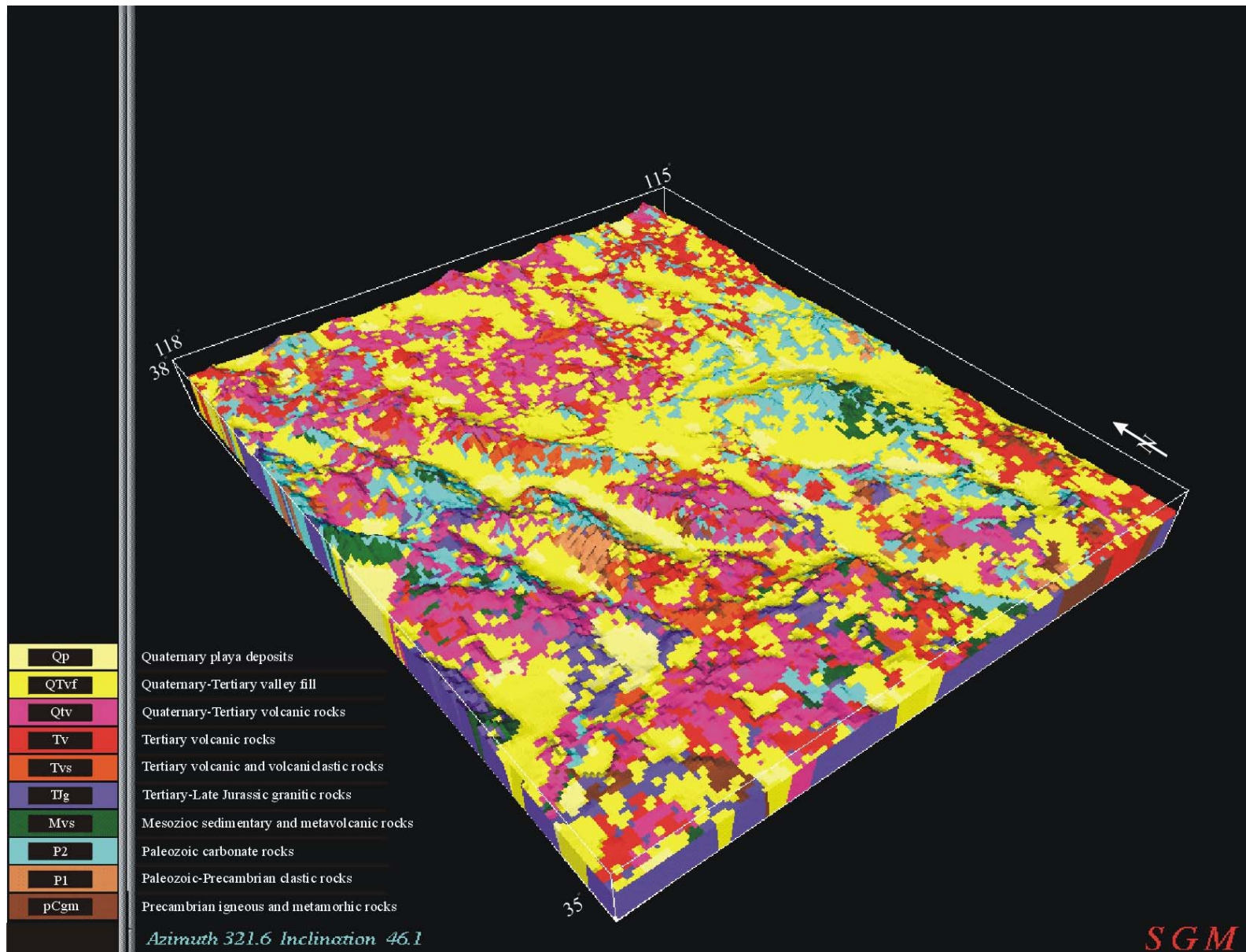
- Model observations (hydraulic heads and discharge rates)
- Weighting/error factors for calibration
- Constrains K



# Comprehensive Geologic Interpretation in Support of the Regional Flow Model

- **Synthesis of geologic maps**
- **Interpretation of regional tectonics**
- **Regional geologic cross-sections**
- **Geophysical interpretations**
- **Stratigraphic analysis of tertiary basins**
- **Hydrologic significance of structural and stratigraphic elements**





Preliminary





# Does Complex Geology Demand a Complex Flow Model?

- **Ultimately depends on flow model**
  - Availability of hydrologic data
  - Justified level of geologic detail
- **Need to understand regional framework**
  - Cross-section interpretations
  - Representation of structural zones
- **Complexity is required in Death Valley region**
  - Scale of geologic features
  - Previous modeling experience



# Tasks

- 1. Complete transient model and report**
  - Status reports (various dates)
  - Report to review (September 30, 2003)
  - Report completed (September 30, 2004)
- 2. Model enhancements (various deliverables)**
  - Additions to MODFLOW (HUF, depth decay)
  - Model consistency
  - Predictive capability
  - Decision analysis



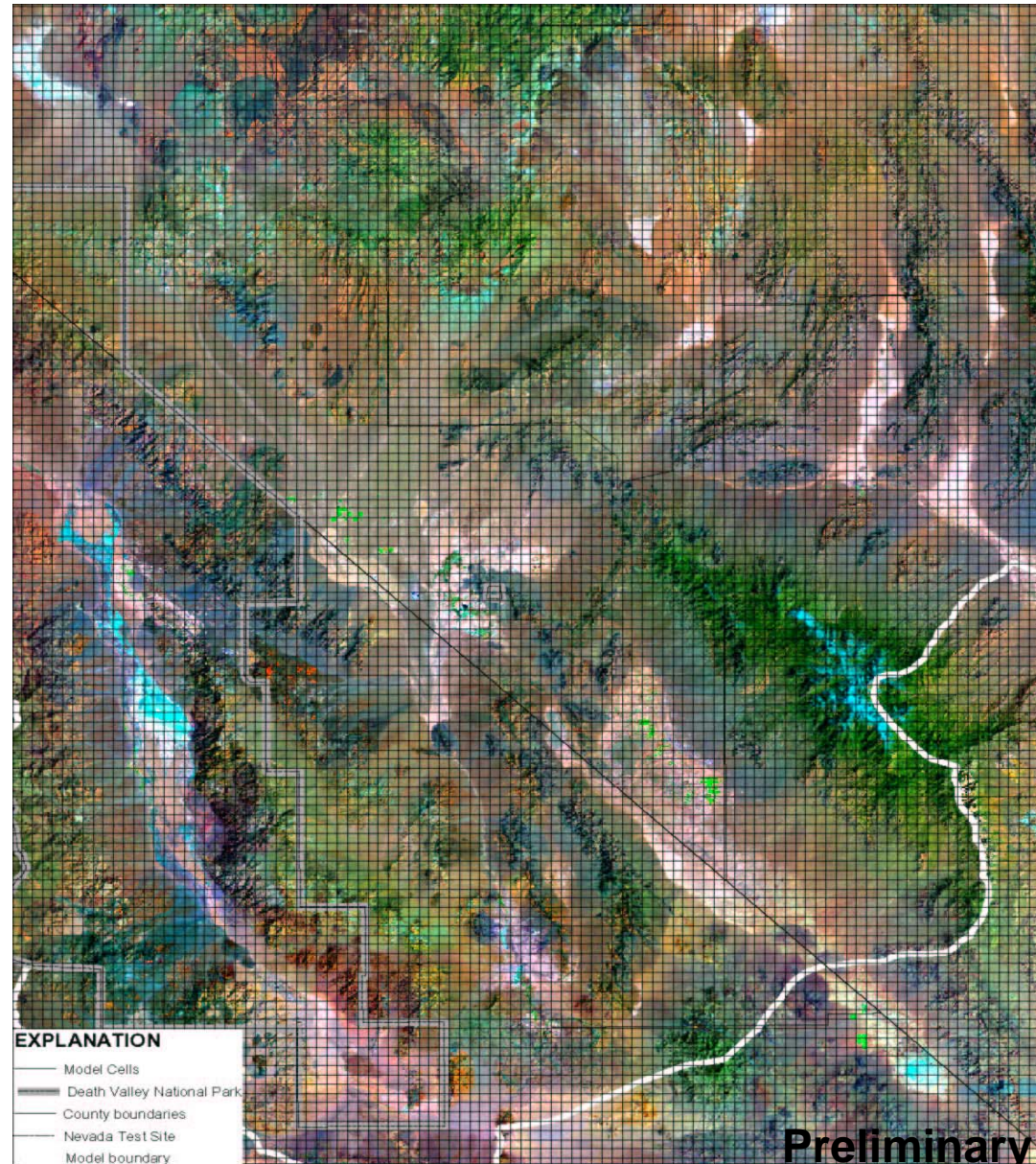
# Report Outline

- Edited by Belcher
- Part A: Introduction (Belcher)
- Part B: Conceptual model of the regional geology and hydrogeology (by Sweetkind, Faunt, and Belcher)
- Part C: Conceptual model of the regional hydrology (by Faunt, D'Agnese, and O'Brien)
- Part D: Hydrogeologic evaluations (by San Juan)
- Part E: Hydrogeologic framework model (by Faunt, Sweetkind, and Belcher)
- Part F: Numerical model of groundwater flow (by Faunt, Hill, Blainey, O'Brien, and D'Agnese)
- Appendices: Databases and data sources (Bedinger and Harrill)

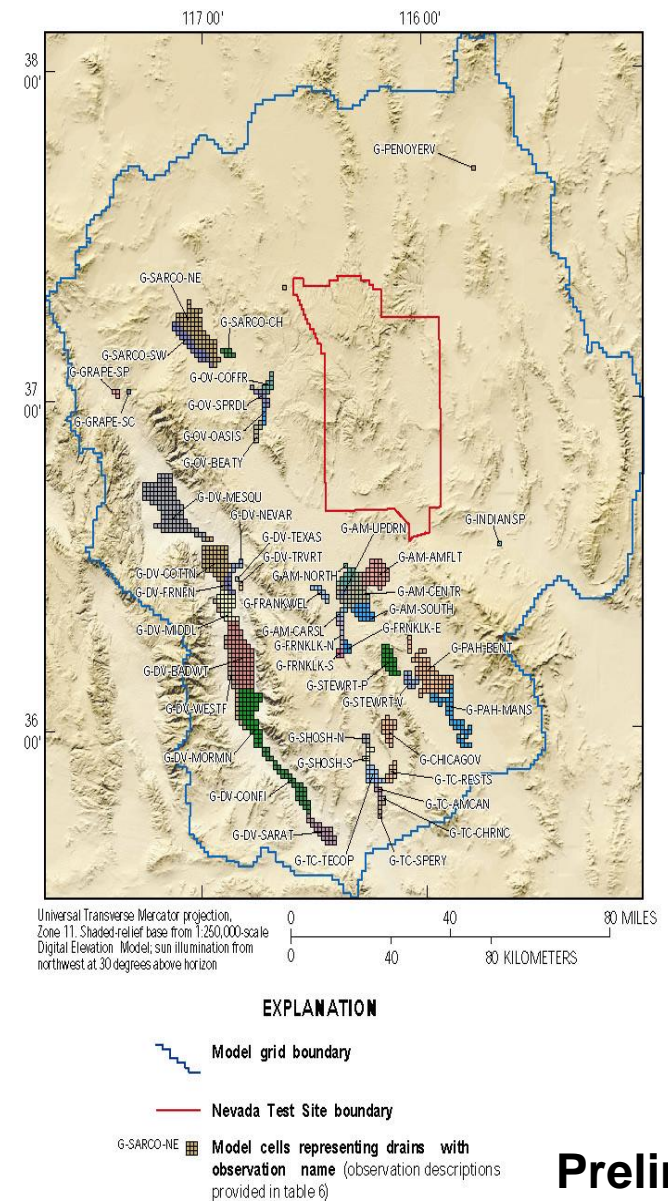
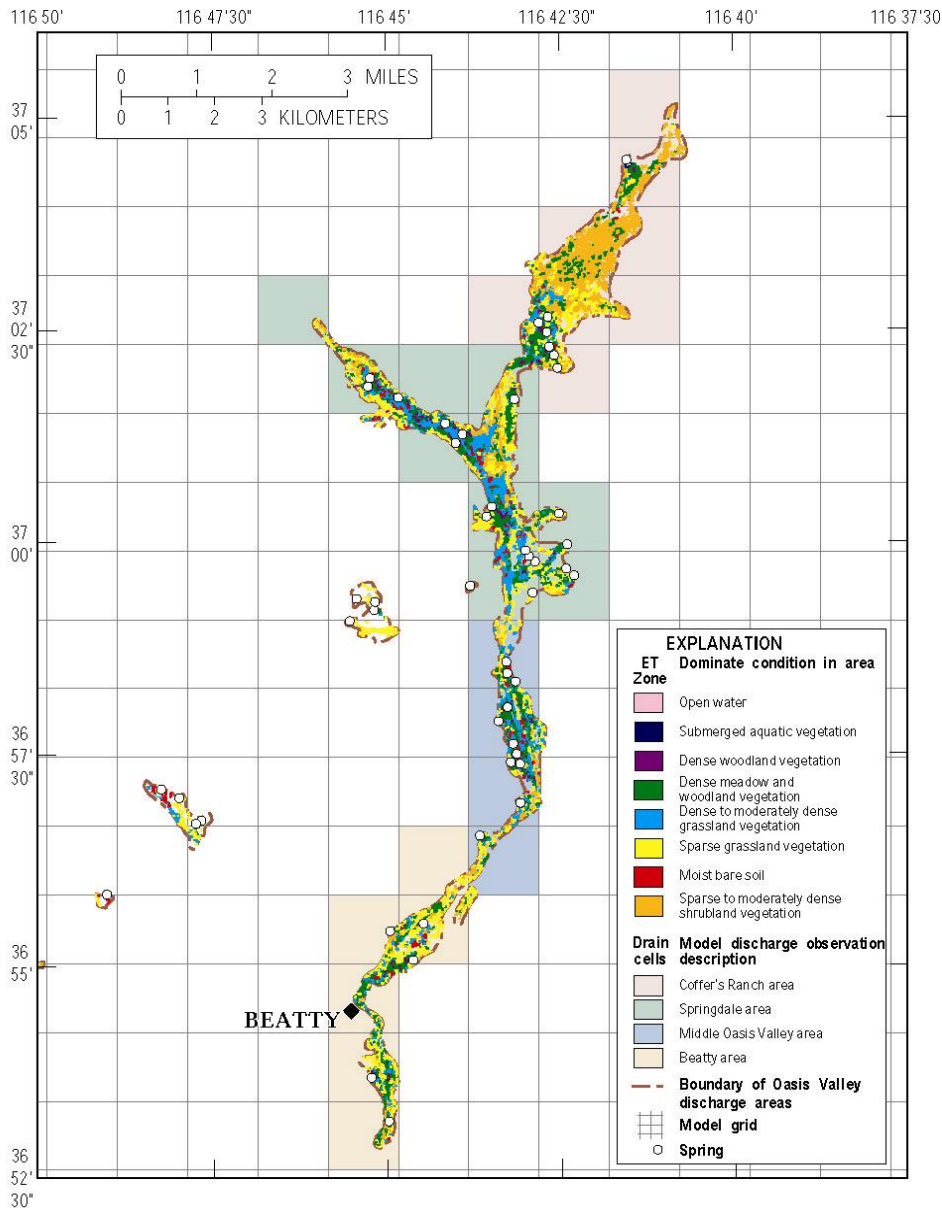


# Model Discretization

- **1500 m grid cell spacing**
  - 194 rows
  - 160 columns
- **16 layers (top layer > 50 m thick and is convertible), remaining layers follow water table at uniform thickness per layer and get thicker with depth**
- **Discharge represented by drains**
- **Recharge based on infiltration model**
- **Transient simulation (1913-1998)**
- **First stress period is steady state and replaces 2002 model**

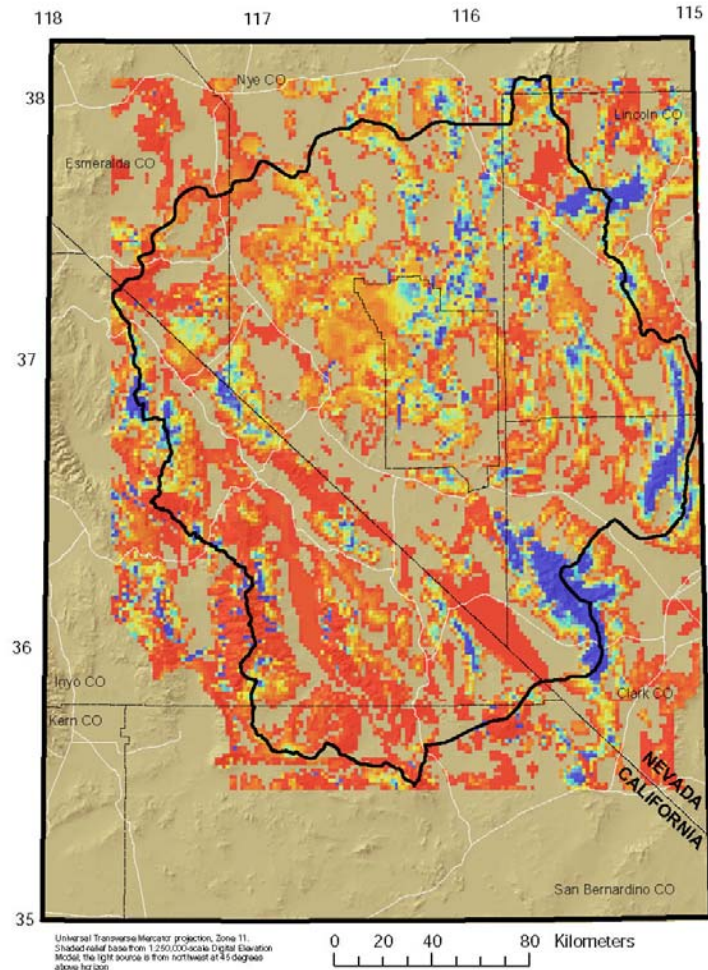


# Discharge Represented by Drains



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# Recharge Based on Infiltration

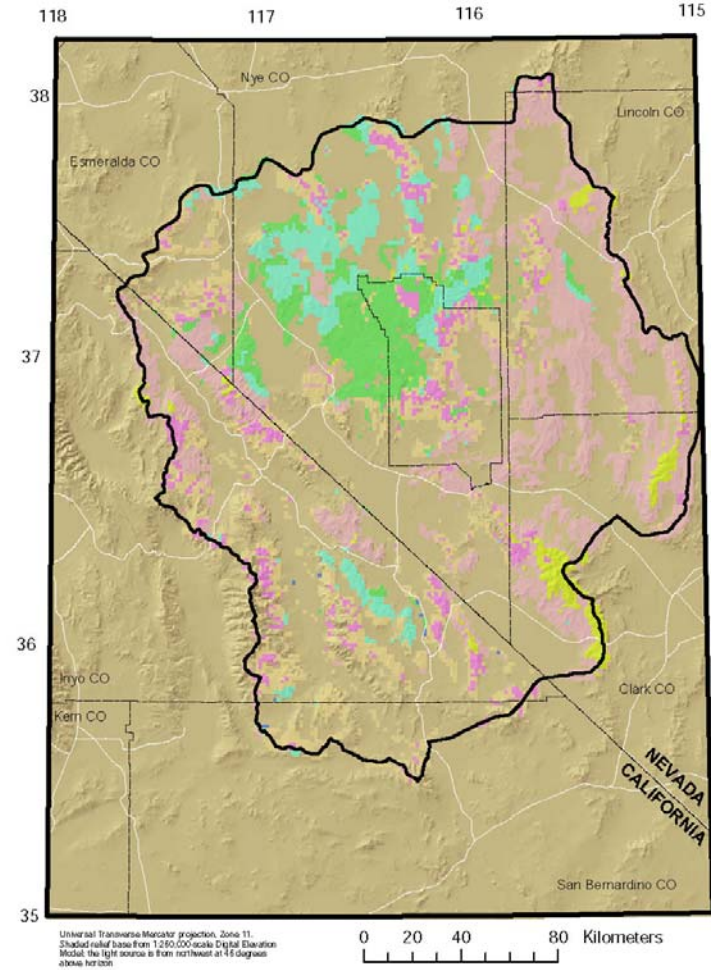


**EXPLANATION**

- Death Valley regional flow system model boundary
- Nevada Test Site boundary
- Major roads

**Recharge (m/day)**

High - 0.000468  
Low - 0.000000



**EXPLANATION**

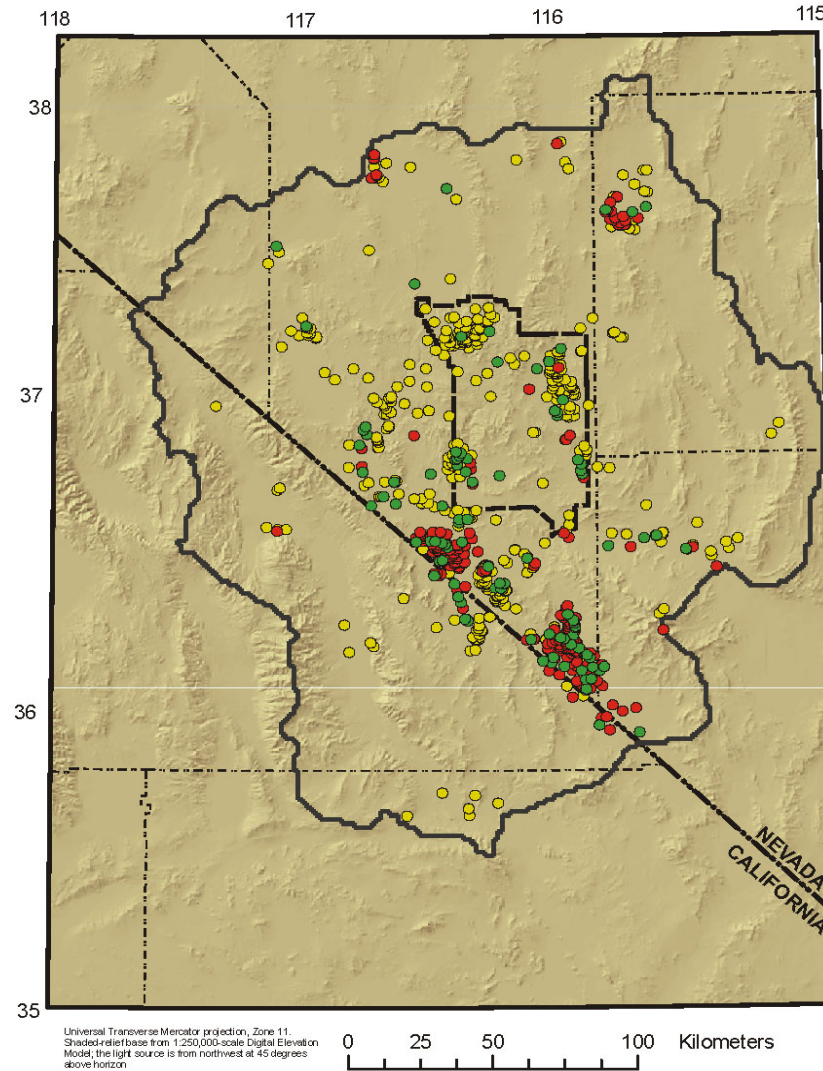
- Death Valley regional flow system model boundary
- Nevada Test Site boundary
- Major roads

**Infiltration Zones**

- None (BCH1)
- High infiltration and high permeability (PCH2)
- High to moderate infiltration and low permeability (PCH3)
- Moderate to low infiltration and high permeability (predominantly alluvial, volcanic, or carbonate aquifers) (PCH4)
- Low infiltration and low permeability (PCH5)
- Moderate to low infiltration and high permeability where the carbonate and volcanic aquifers do not exist, but the alluvial aquifers exist in the upper 5 layers (PCH6)
- Moderate to low infiltration and high permeability where the carbonate aquifer does exist, but volcanic aquifers exist in the upper 5 layers (PCH7)
- Moderate to low infiltration and high permeability where the carbonate aquifer exist in the upper 5 layers (PCH8)

Preliminary

# Hydraulic Head Observations



## EXPLANATION

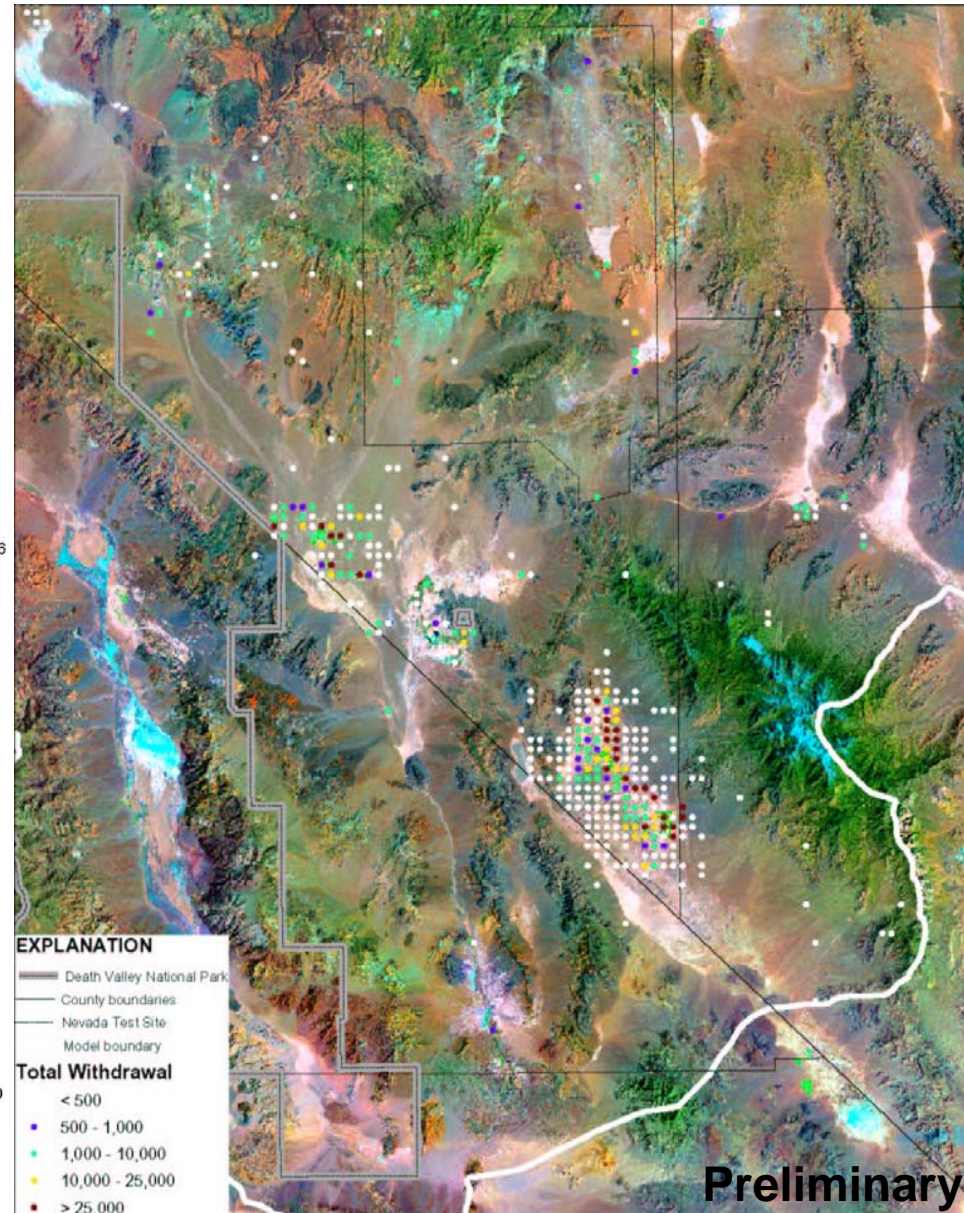
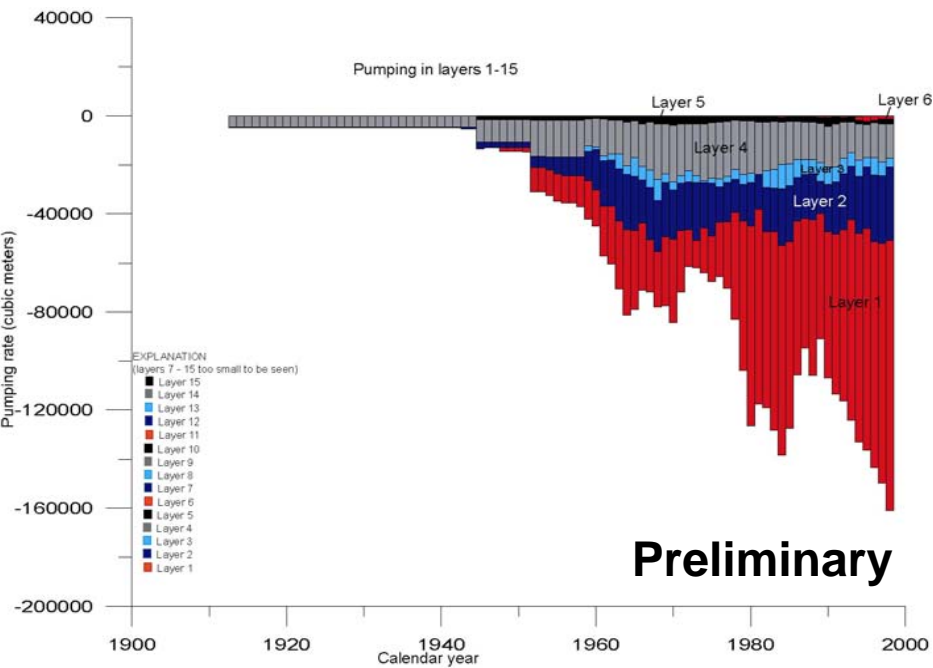
### HYDRAULIC-HEAD OBSERVATION

- Steady state (prepumped)
- Transient (pumped)
- Transient and steady state

Preliminary

# Transient Simulation: Pumping

- **Distribution of simulated wells**
  - **One well combined pumpage per cell**





# Residuals and Simulation

- **Validation**
  - Match discharge (ET and spring flow) rates and heads
  - Qualitative look at hydrochemist
  - Calibrated using parameter estimation
- **Comparison to 2002**
  - Better match to flows
  - More head observations
  - Quantified boundary conditions
  - Transient with convertible upper layer

## EXPLANATION

Head residual (meters)

- < -100
- -100 - -50
- -50 - -20
- -20 - -10
- -10 - 0
- 0 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- > 100

— Simulated Potentiometric surface in model layer 16 (100 m contours)

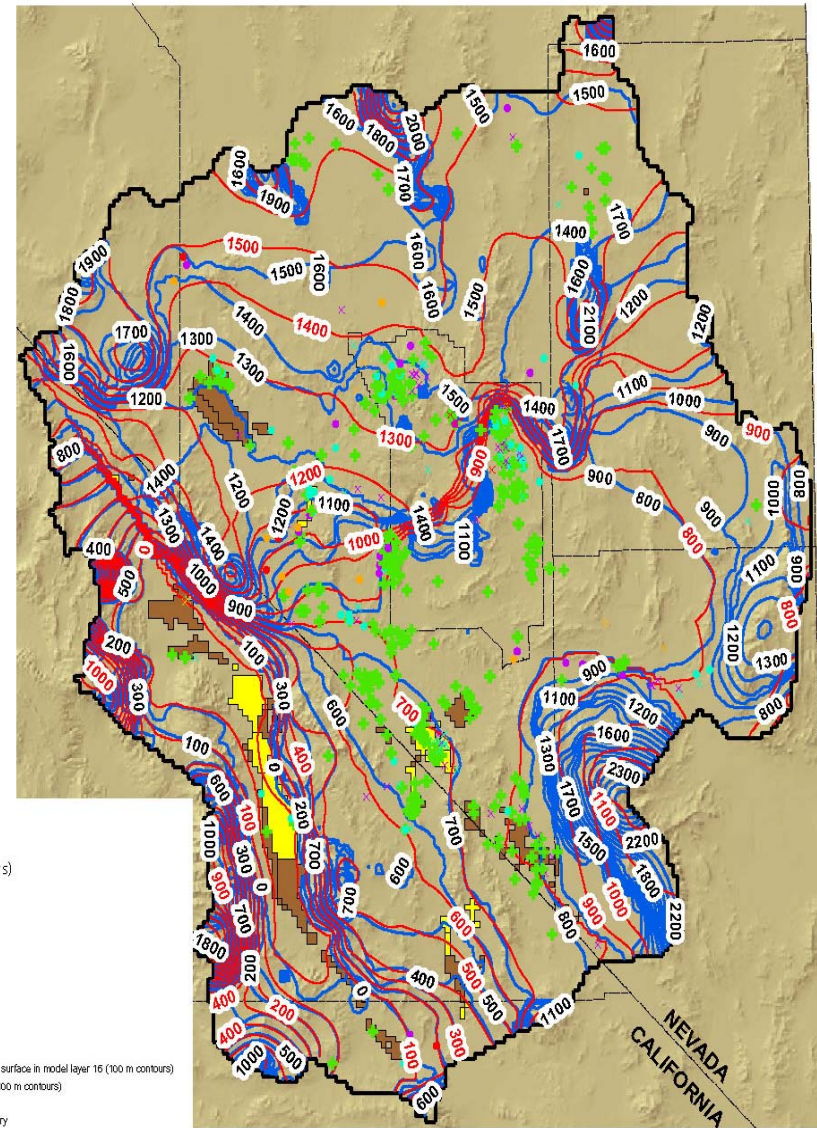
— Simulated Water Table (100 m contours)

— Model grid boundary

— Nevada Test Site boundary

■ Too much OUT: Q out > msrd Q

■ Not enough OUT: Q out < msrd Q



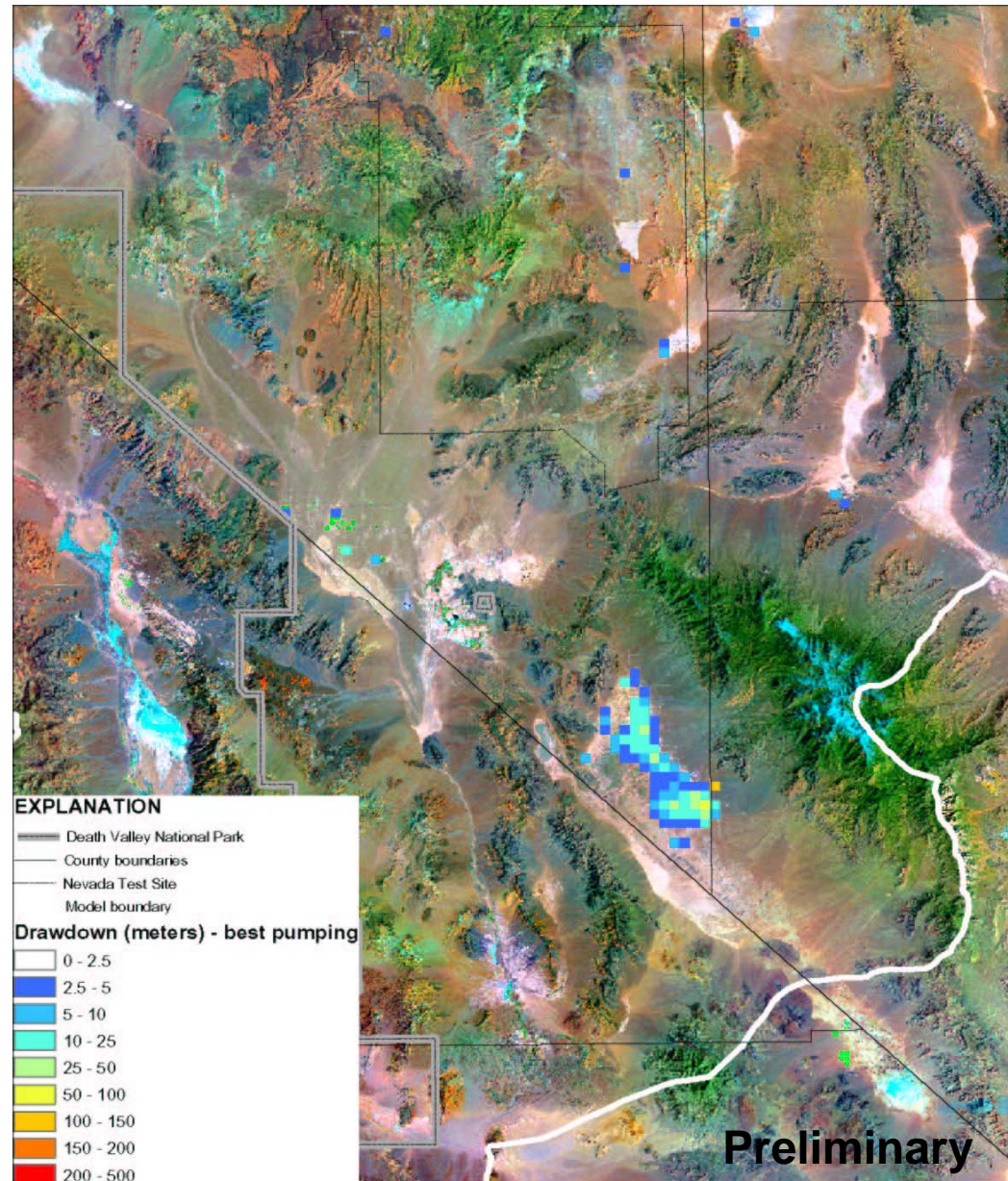
0 12.5 25 50 Kilometers

Universal Transverse Mercator projection, Zone 11.  
Shaded-relief base from 1:250,000-scale Digital Elevation  
Model; the light source is from northwest at 45 degrees  
above horizon

# Preliminary

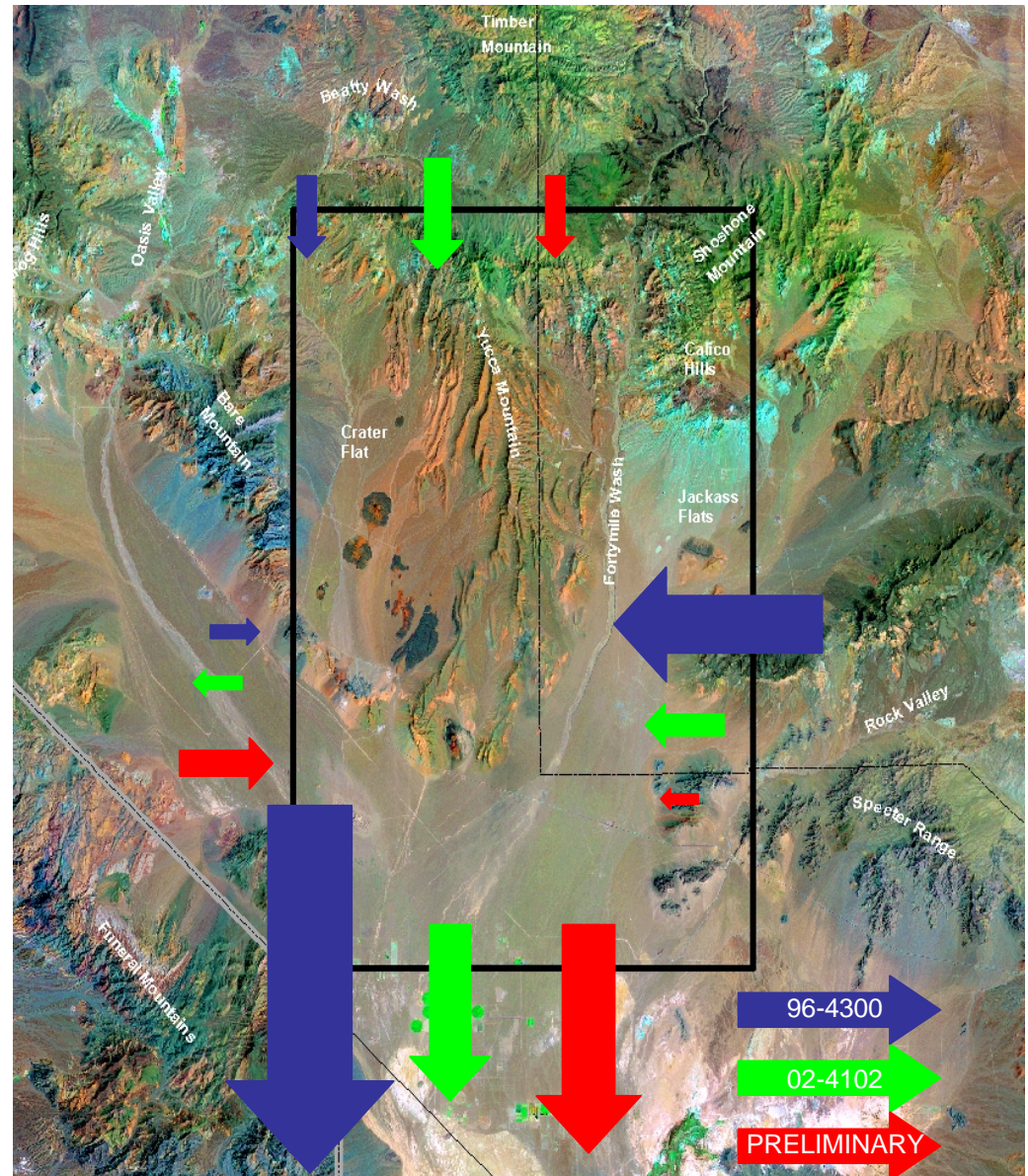
# Comments

- **Regional model**
  - **Good for answering regional questions**
    - ◆ **Examples:**
      - » **Boundary conditions for site-scale models**
      - » **Decrease in spring discharge based on pumping in region**
      - » **Change in water levels based on pumping over time**
      - » **Climate change**
  - **Need more site-specific scale model to address more detailed concerns**



# Fluxes to Site-Scale Yucca Mountain Project Model

	WRI 96-4300	WRI 02-4102	PRELIMINARY
NORTH	-200	-271	-196
EAST	-561	-209	-96
SOUTH	918	430	562
WEST	-119	125	-246



# Knowledge Exchange

## (Promised more than a model)

- **Deliverable 2003: Model input and output (ASCII files, MODFLOW 2000 format)**
- **Proposed deliverable 2004: Integrated Knowledge System**
- **Transform model input and output - world coordinates, Geographic Information Systems (GIS) format**
- **Databases (GIS, Hydrogeologic Framework Model (HFM), Access)**
- **Basic analysis and visualization tools**
- **Proposed tasks 2004:**
  - **Transfer and integrate supporting databases**
  - **GIS - hydrology (recharge, discharge - ET, springs, wells), HFM, well, topography, imagery, geology, geophysics, base maps**
  - **HFM - hydrogeologic data (2-D and 3-D)**
  - **Access - “model-ready” head and flow data**
  - **Transfer and integrate analysis and visualization tools**
  - **Custom tools developed by U.S. Geological Survey (USGS) (ArcGIS-based)**
  - **3-D model**
  - **Data loaded in commercial software**



# The Future – FY05 and On

- **Use local grid refinement to facilitate coordination between regional, Yucca Mountain site, and CAU models**
- **Use new methods to rank the importance of potential new observations, including long-term monitoring**
- **Use new methods to rank the importance of new HFM data**
- **Evaluate the effect of HFM uncertainty on predictions**

