Death Valley Regional Groundwater Flow System

Presented to:

U.S. Nuclear Waste Technical Review Board Panel on the Natural System

Presented by:

Claudia Faunt, Ph.D., P.E.
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)

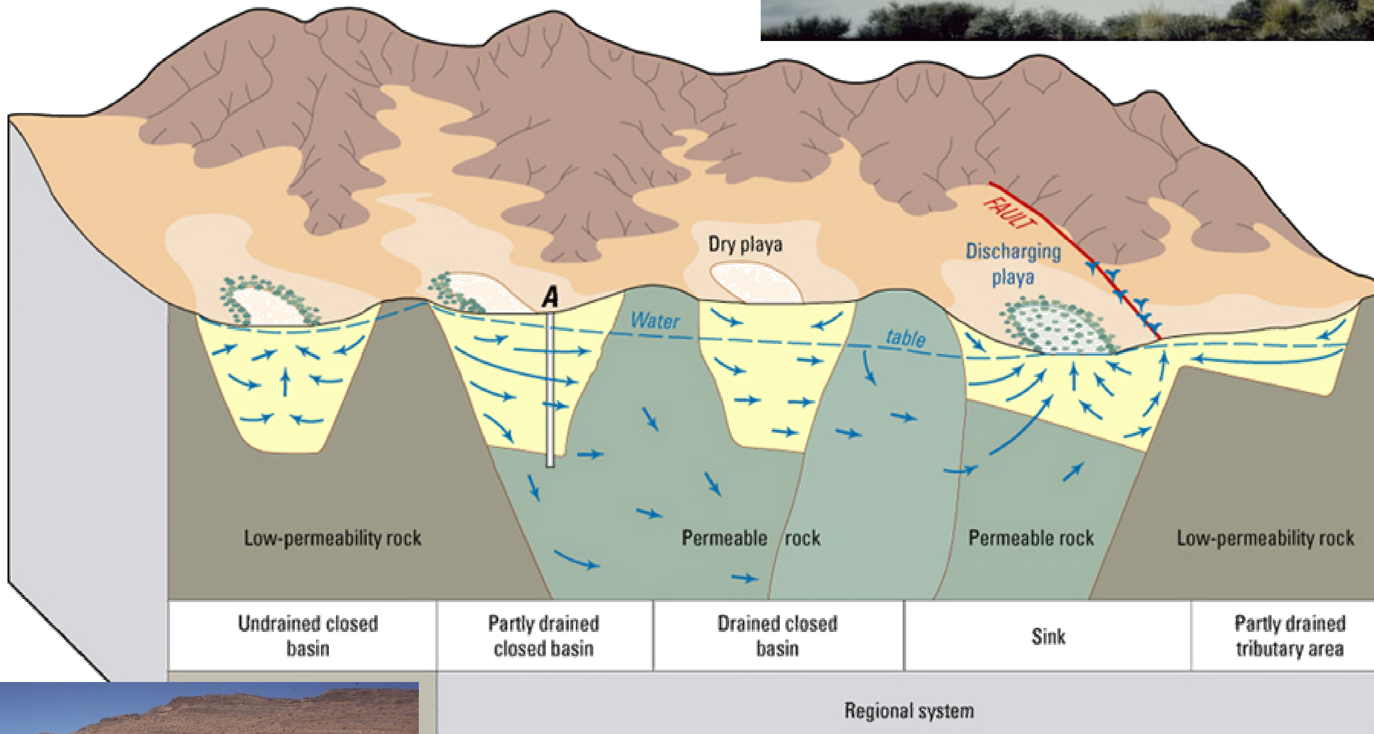
Topics of Discussion

- 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

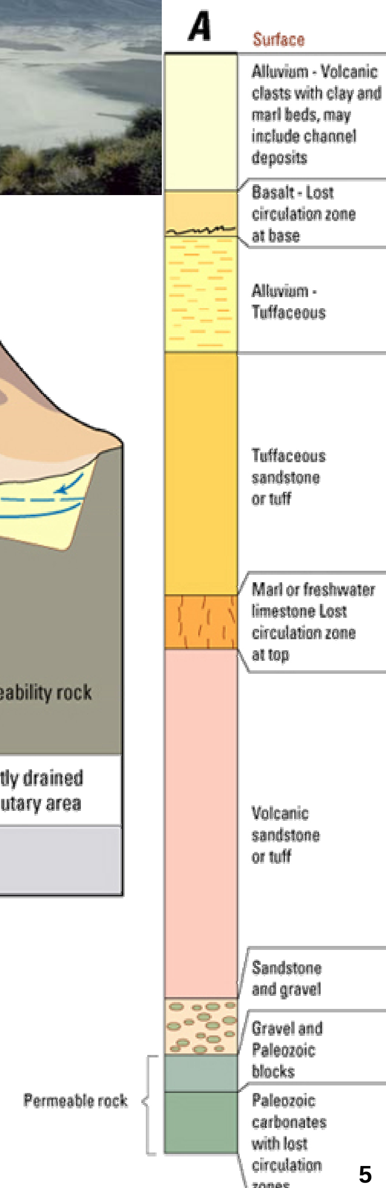
Conceptual Model(s) of Groundwater Flow System



EXPLANATION

Areas of ground-water evapotranspiration

- Phreatophytes
- Discharging playa



Geology is Half the Equation

KA = Q/(dh/dl)

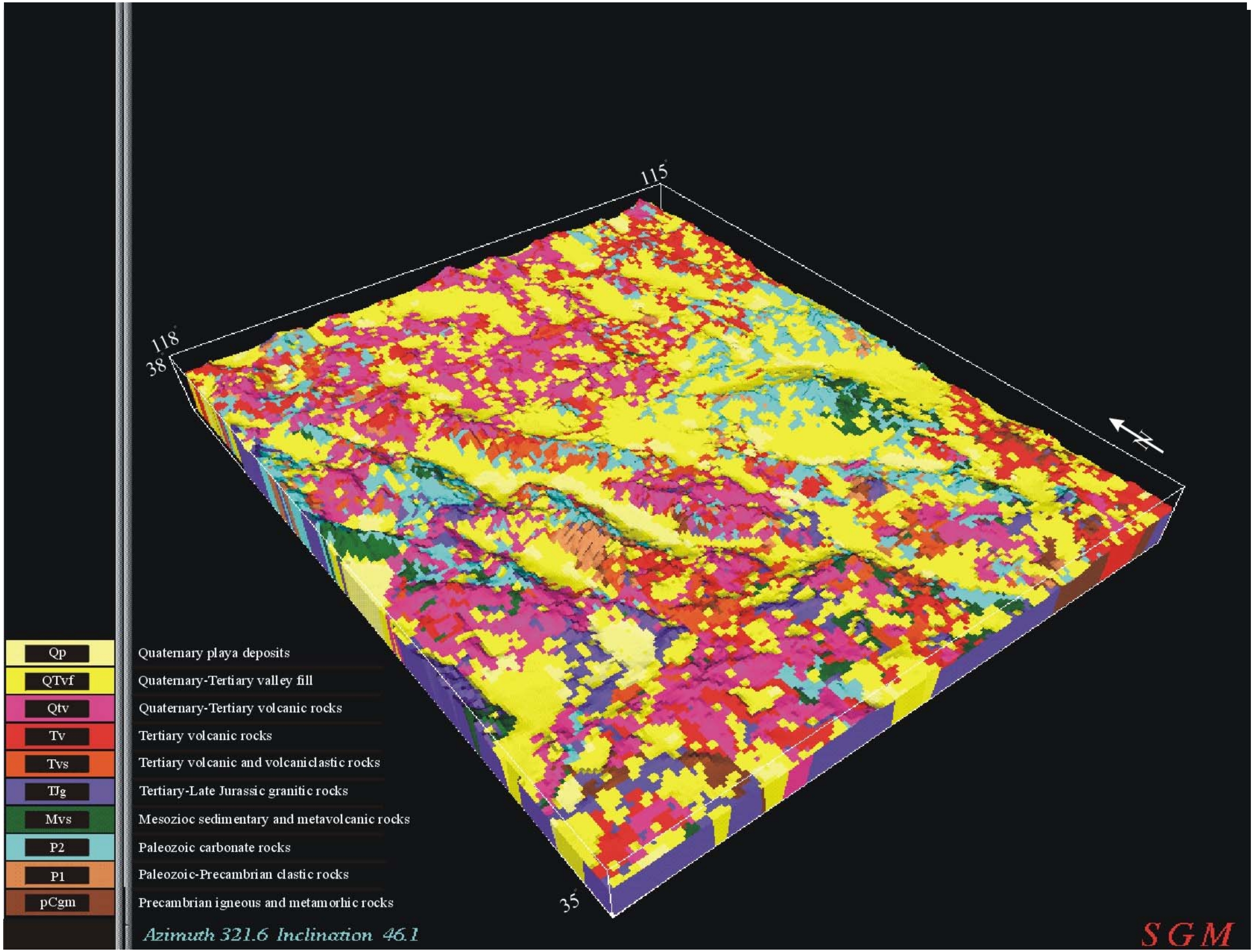
- **Framework**
  - Unit geometry/truncation
  - Location of high K zones
  - Groundwater barriers
  - Heterogeneity/anisotropy
  - Actually doesn't provide K

Q/(dh/dl) = KA

- **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

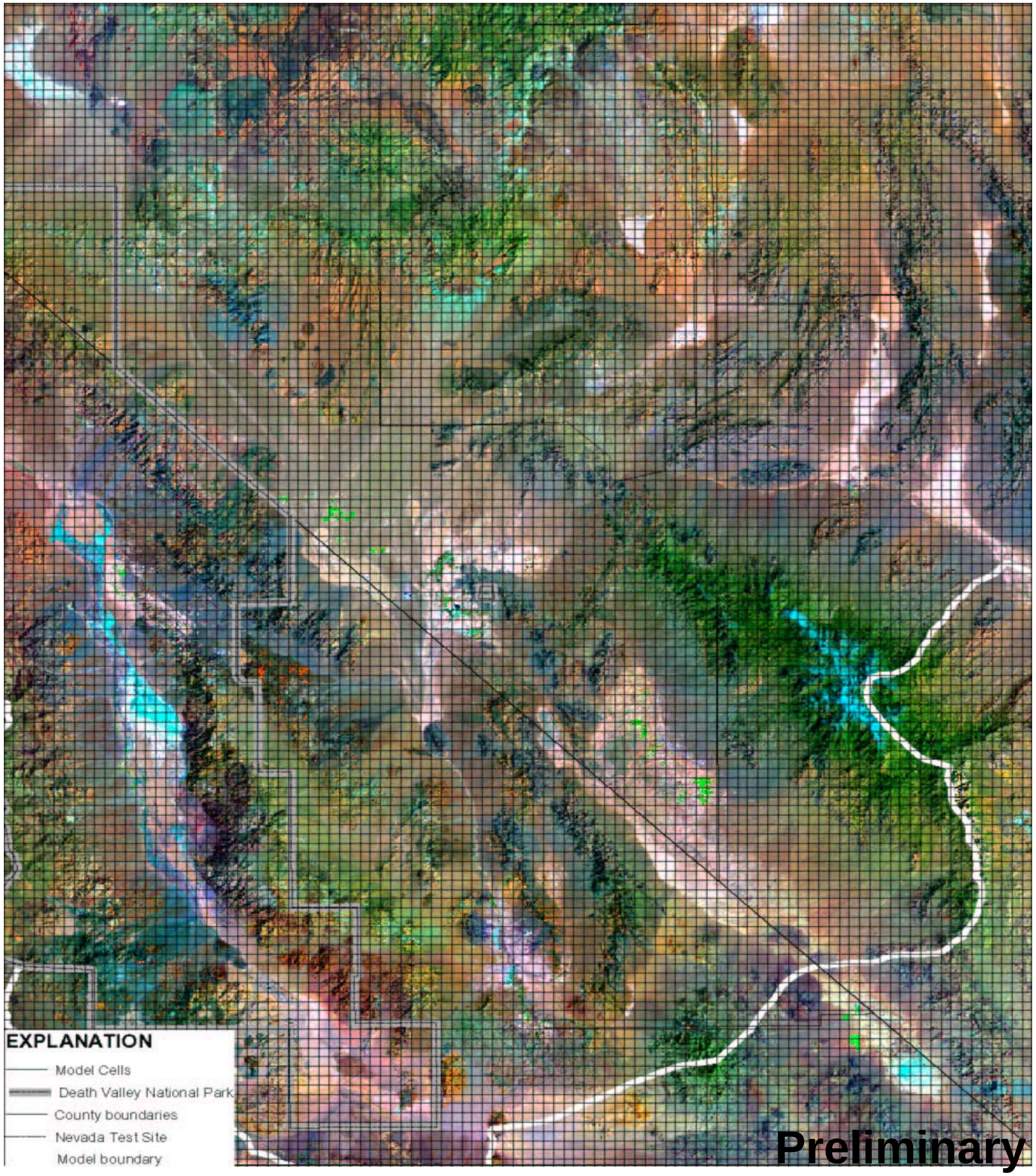
1. **Complete transient model and report**
   - Status reports (various dates)
   - Report to review (September 30, 2003)
   - Report completed (September 30, 2004)
2. **Model enhancements (various deliverables)**
   - Additions to MODFLOW (HUF, depth decay)
   - Model consistency
   - Predictive capability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

Report Outline

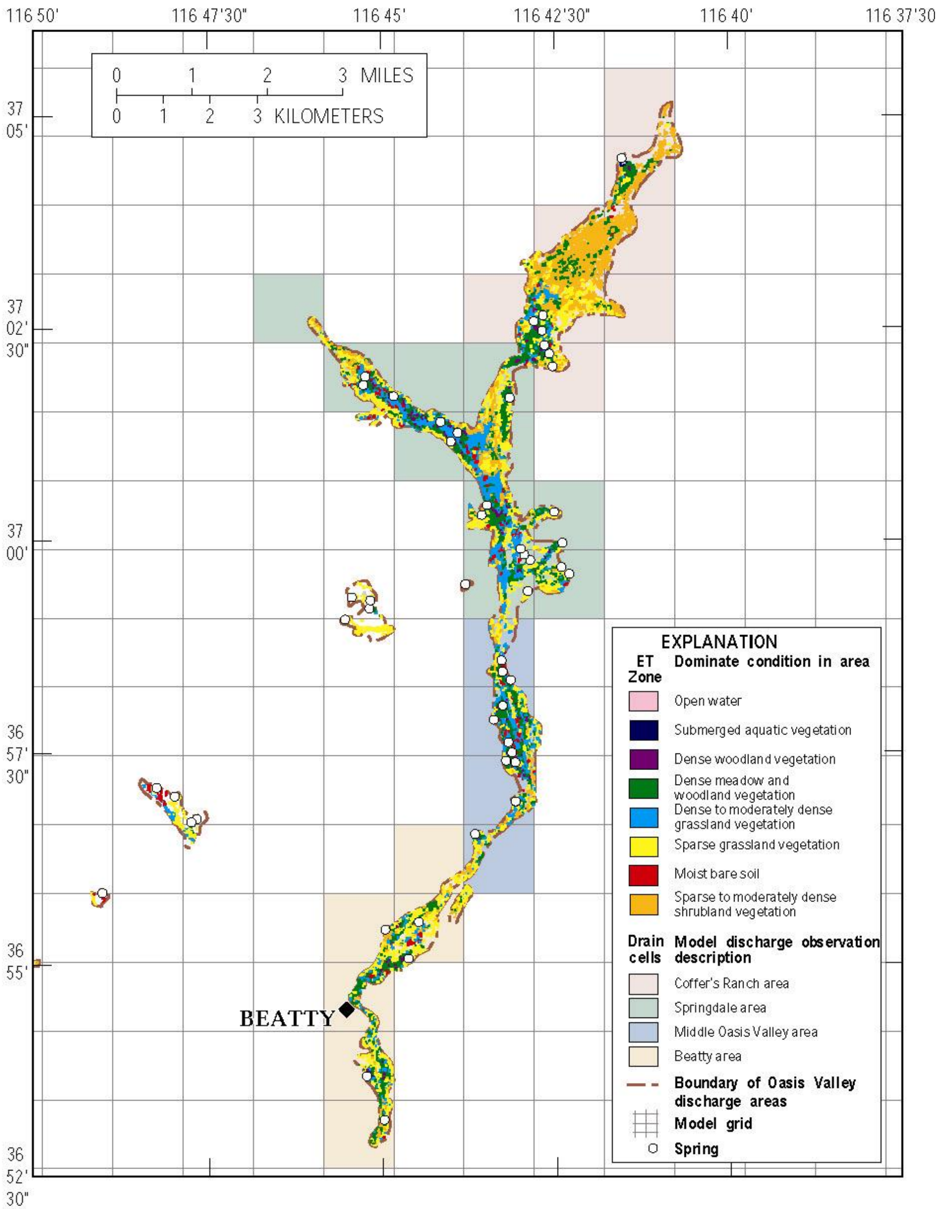
- Edited by Belcher
- Part A: Introduction (Belcher)
- Part B: Conceptual model of the regional geology and hydrogeology (by Sweetkind, Faunt, and Belcher)
- Part C: Conceptual model of the regional hydrology (by Faunt, D’Agnese, and O’Brien)
- Part D: Hydrogeologic evaluations (by San Juan)
- Part E: 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)

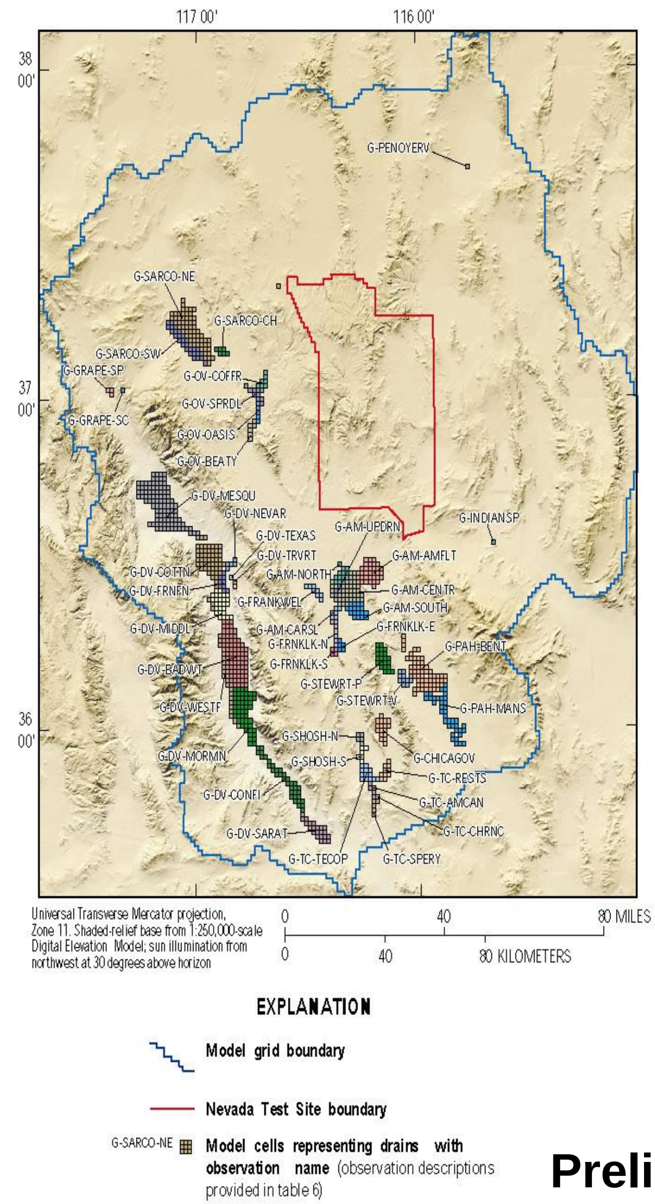
Model Discretization

- **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**



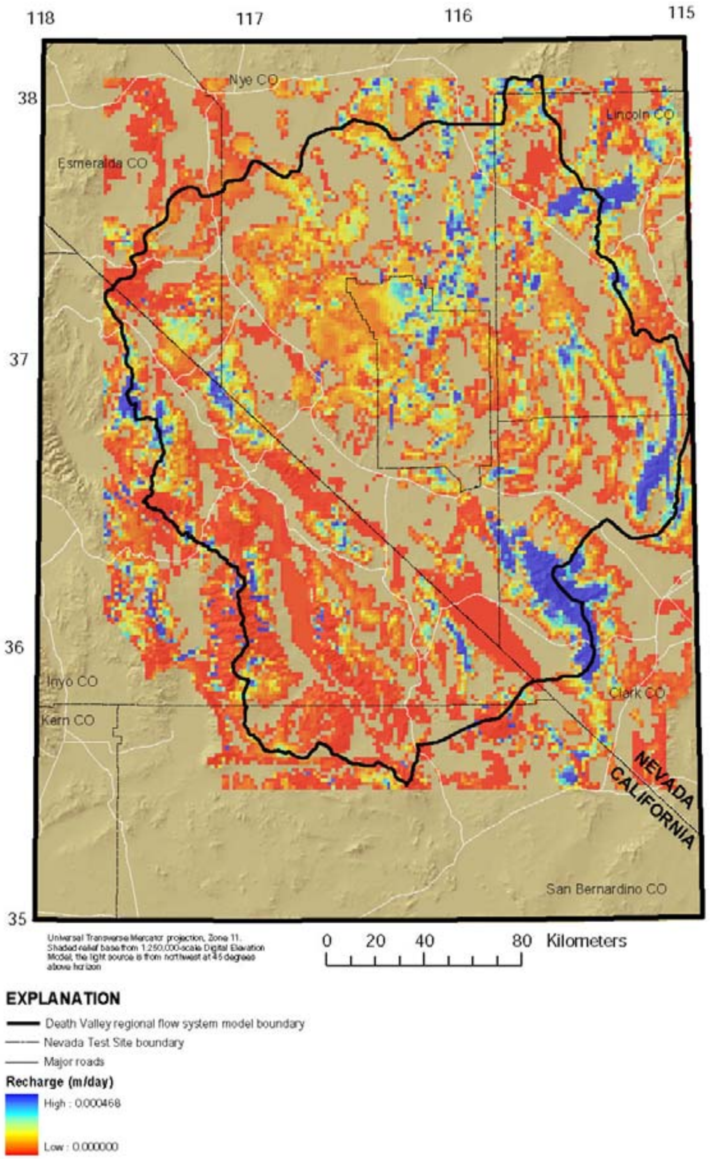
Discharge Represented by Drains

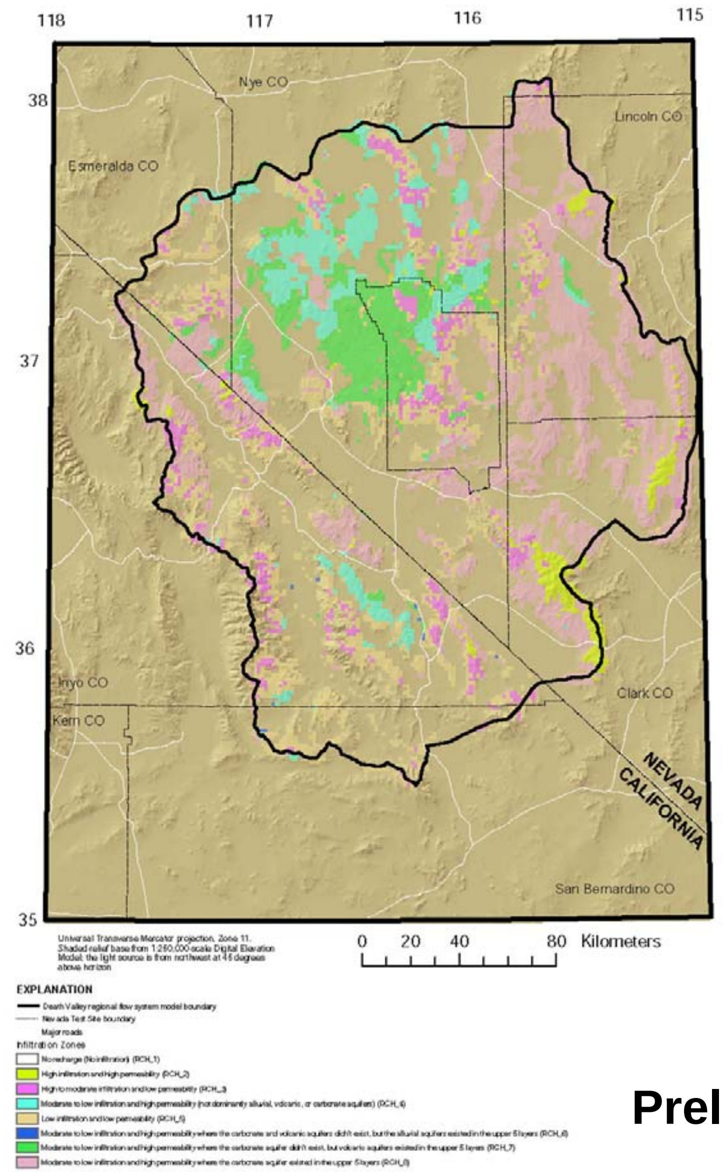




Preliminary

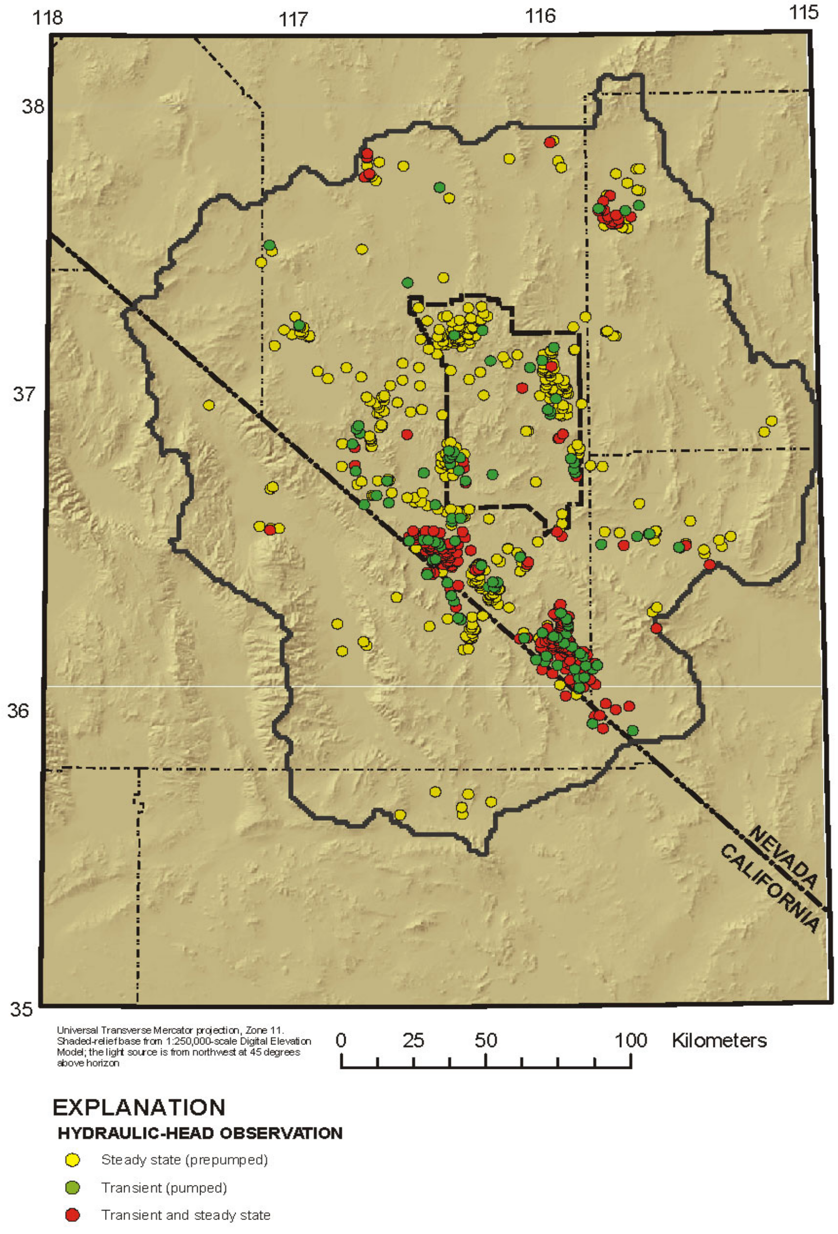
Recharge Based on Infiltration





Preliminary

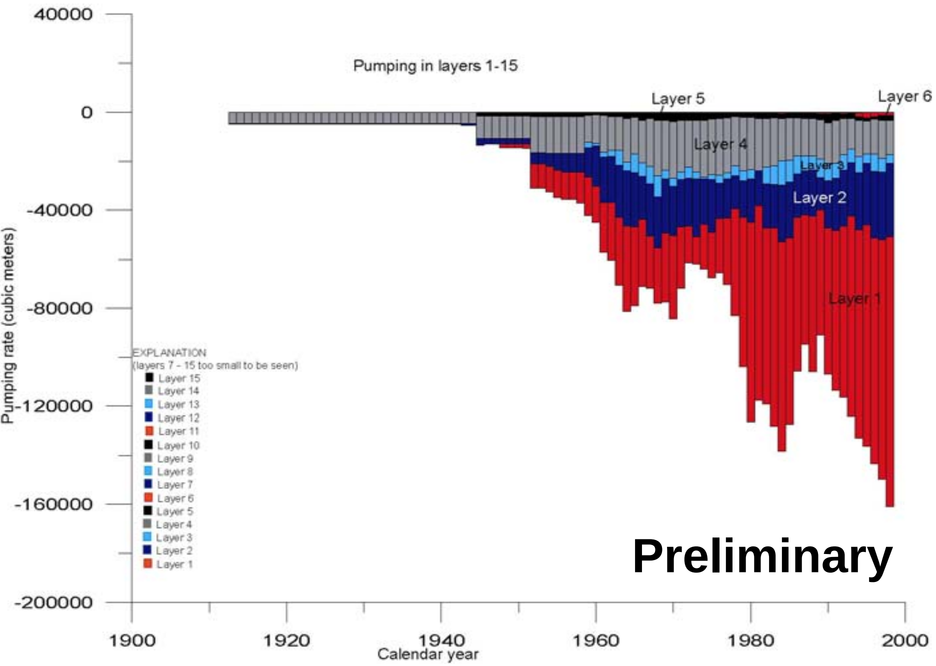
Hydraulic Head Observations

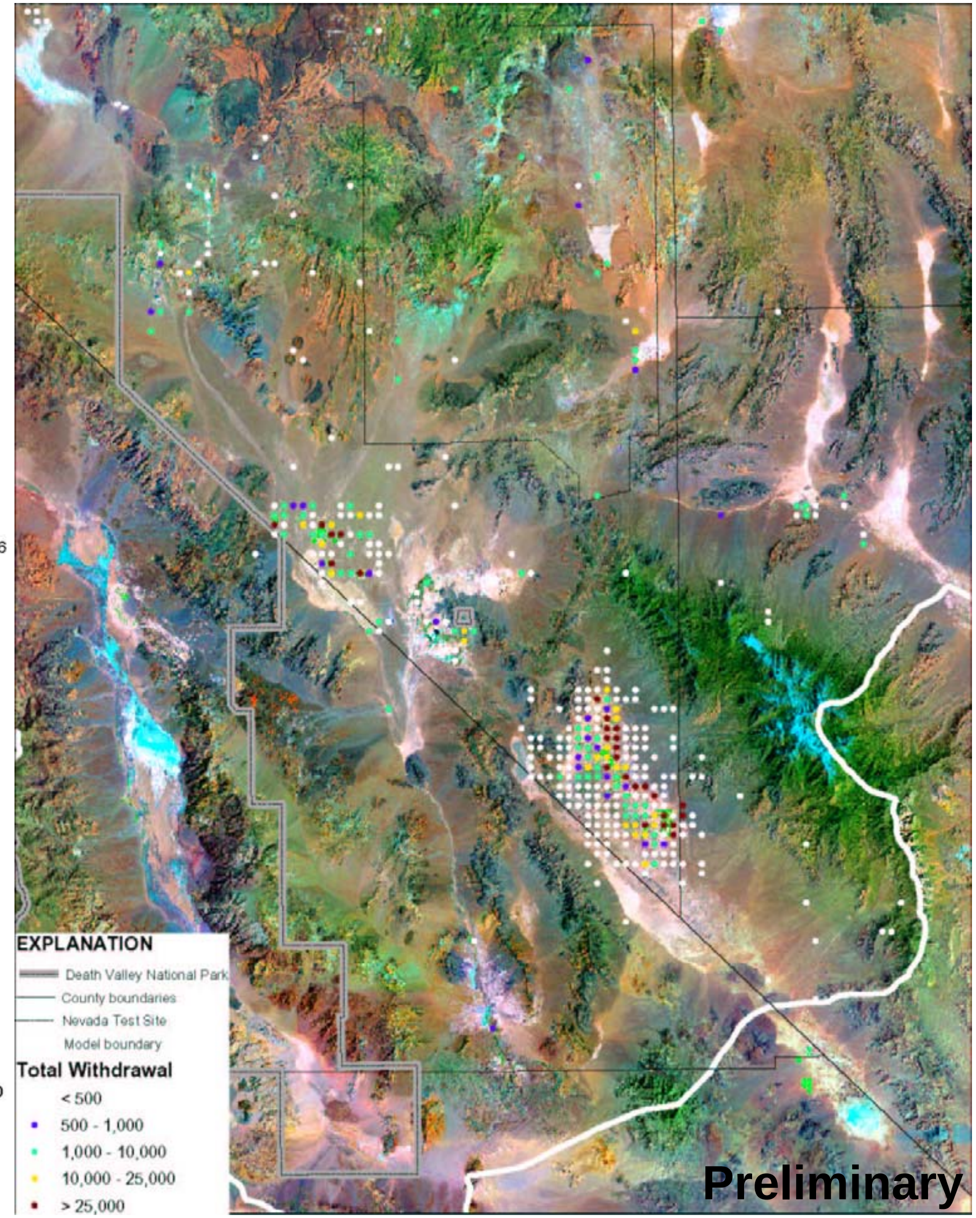


Preliminary

Transient Simulation: Pumping

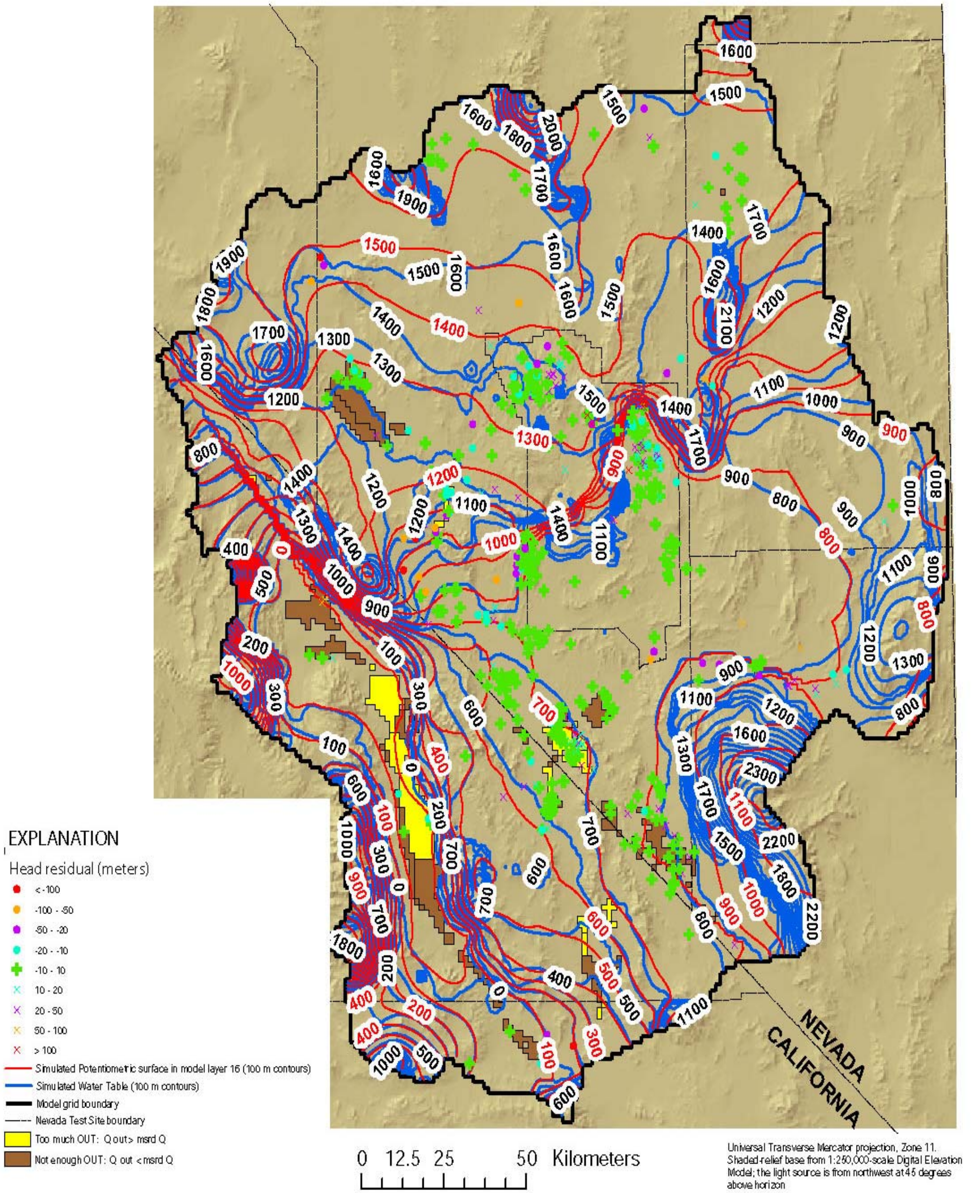
- **Distribution of simulated wells**
  - One well combined pumpage per cell





Residuals and Simulat

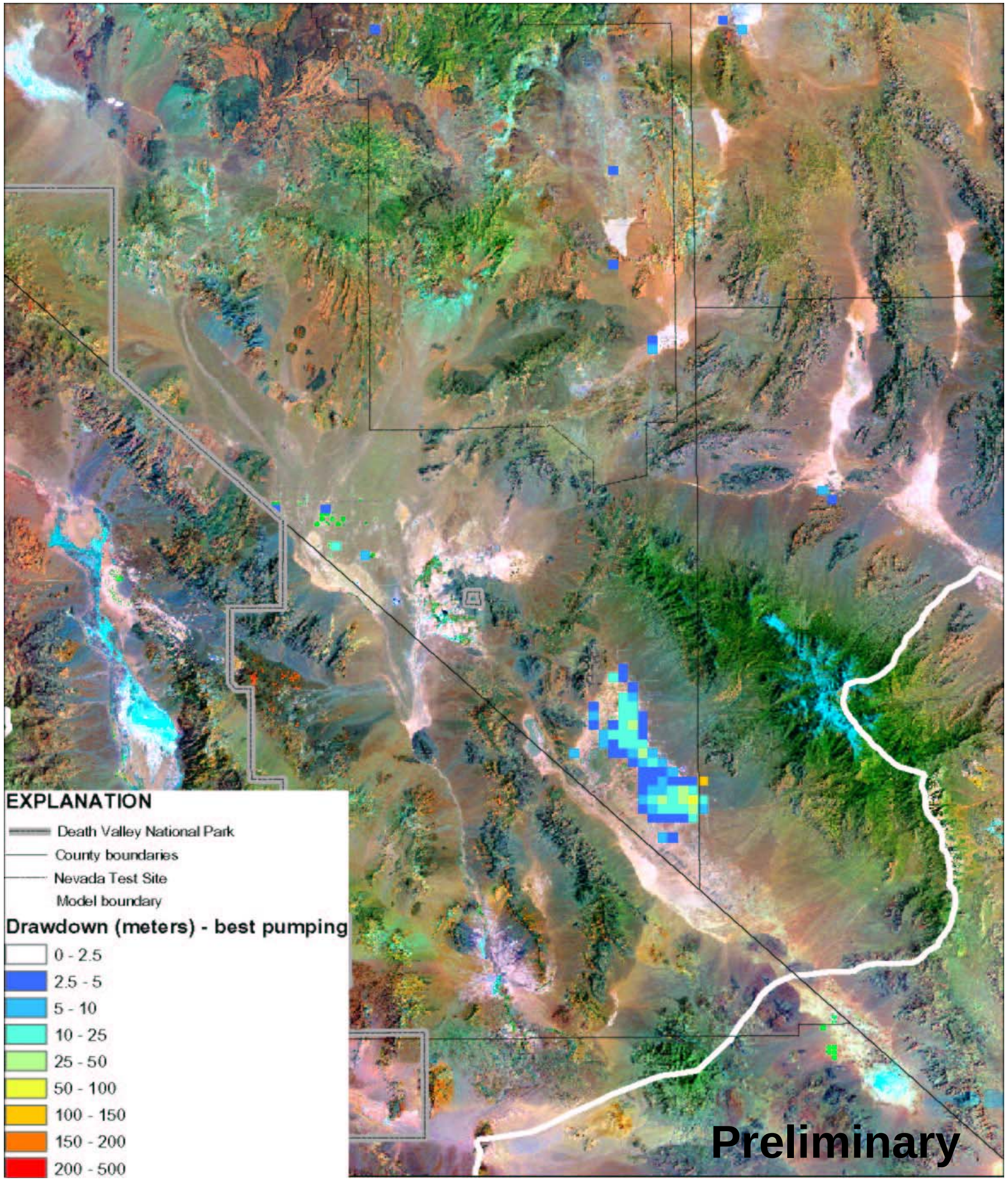
- **Validation**
  - **Match discharge (ET and spring flow) rates and heads**
  - **Qualitative look at hydrochemist**
  - **Calibrated using parameter estimation**
- **Comparison to 2002**
  - **Better match to flows**
  - **More head observations**
  - **Quantified boundary conditions**
  - **Transient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



Preliminary

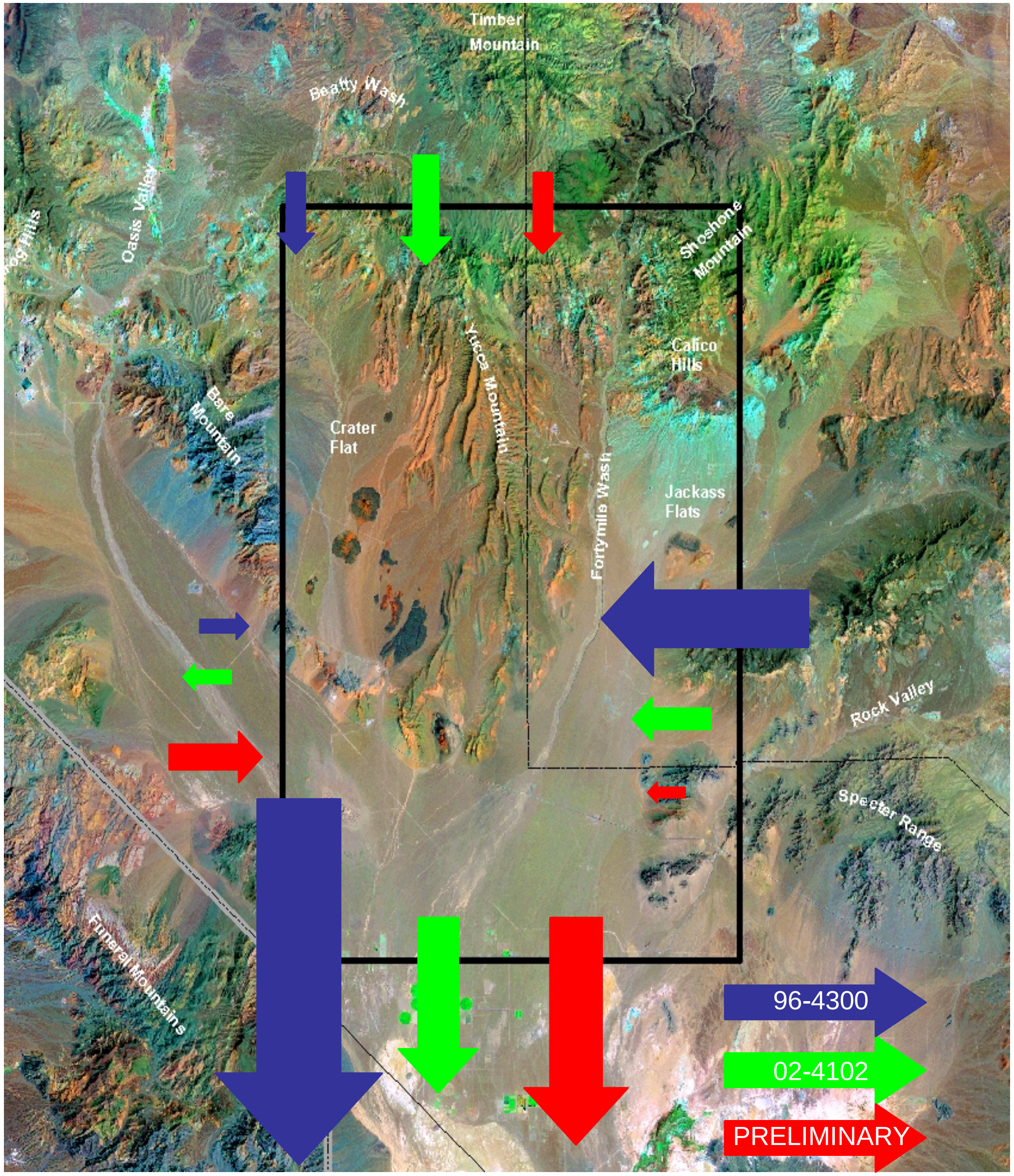
Comments

- **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