The Upper Rio Grande Simulation Model (URGSIM)

A monthly timestep mass balance model of the upper Rio Grande surface and groundwater system

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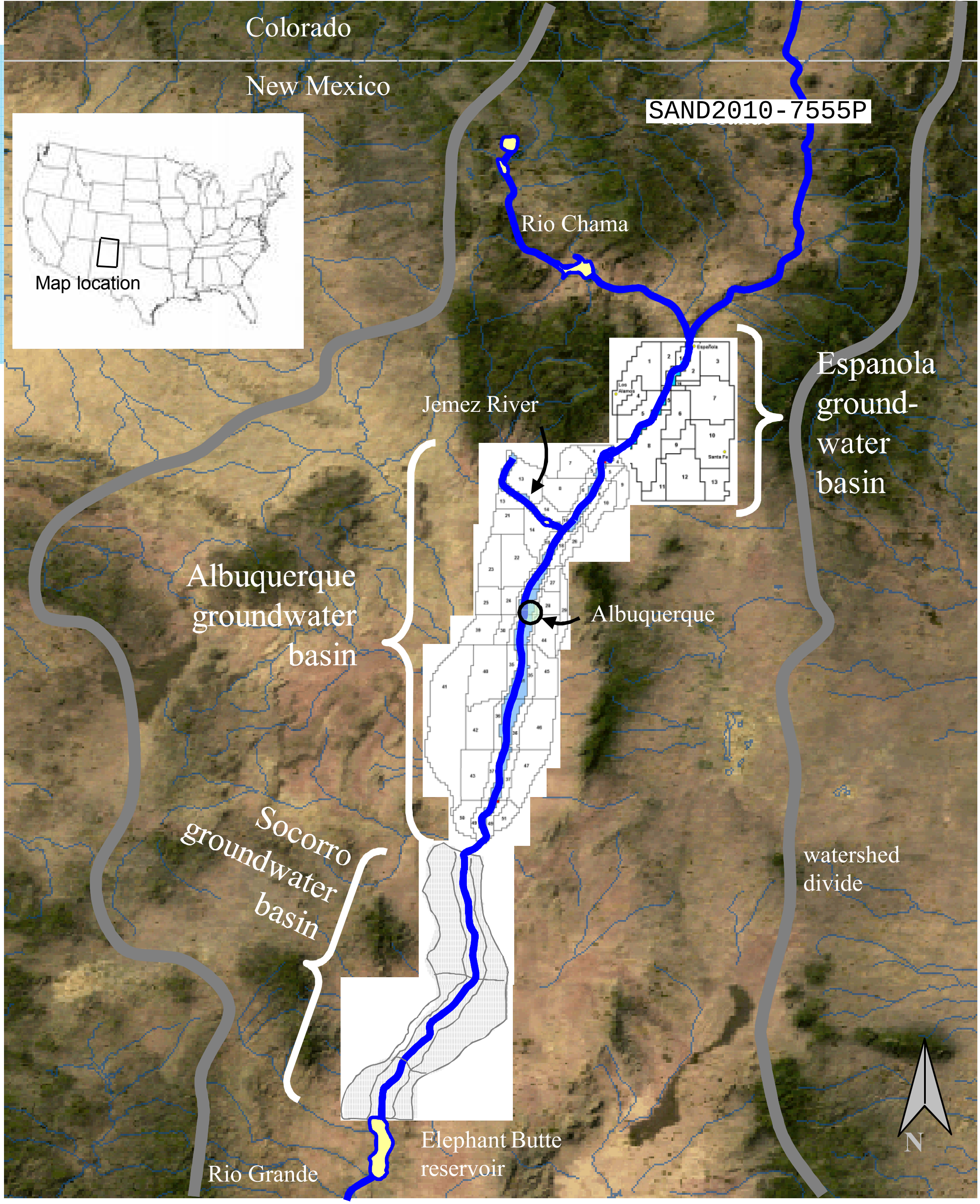

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Upper Rio Grande Simulation Model (URGSIM)

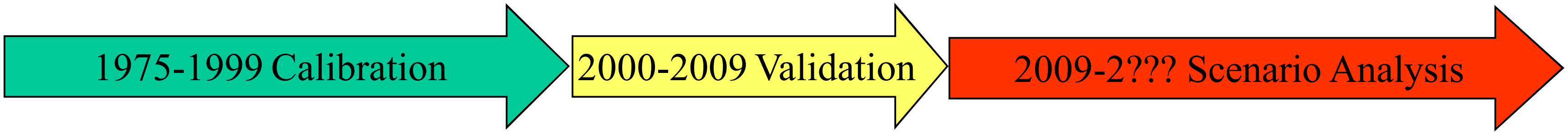
Goal: Fast, user friendly model of the Upper Rio Grande hydrologic system capable of running multi-year simulations in a matter of seconds.

Strategy: Use available surface water (URGWOM), groundwater, evapotranspiration, and human use models and data to build a monthly timestep systems level model of water use through the Upper Rio Grande basin.

- URGWOM
- Hargreaves reference ET equation
- MODFLOW models of Espanola, Albuquerque, Socorro gw basins(USGS, NMOSE)

Temporal resolution and extent:

- Monthly timestep,1975 on



URGSIM model spatial resolution and extent

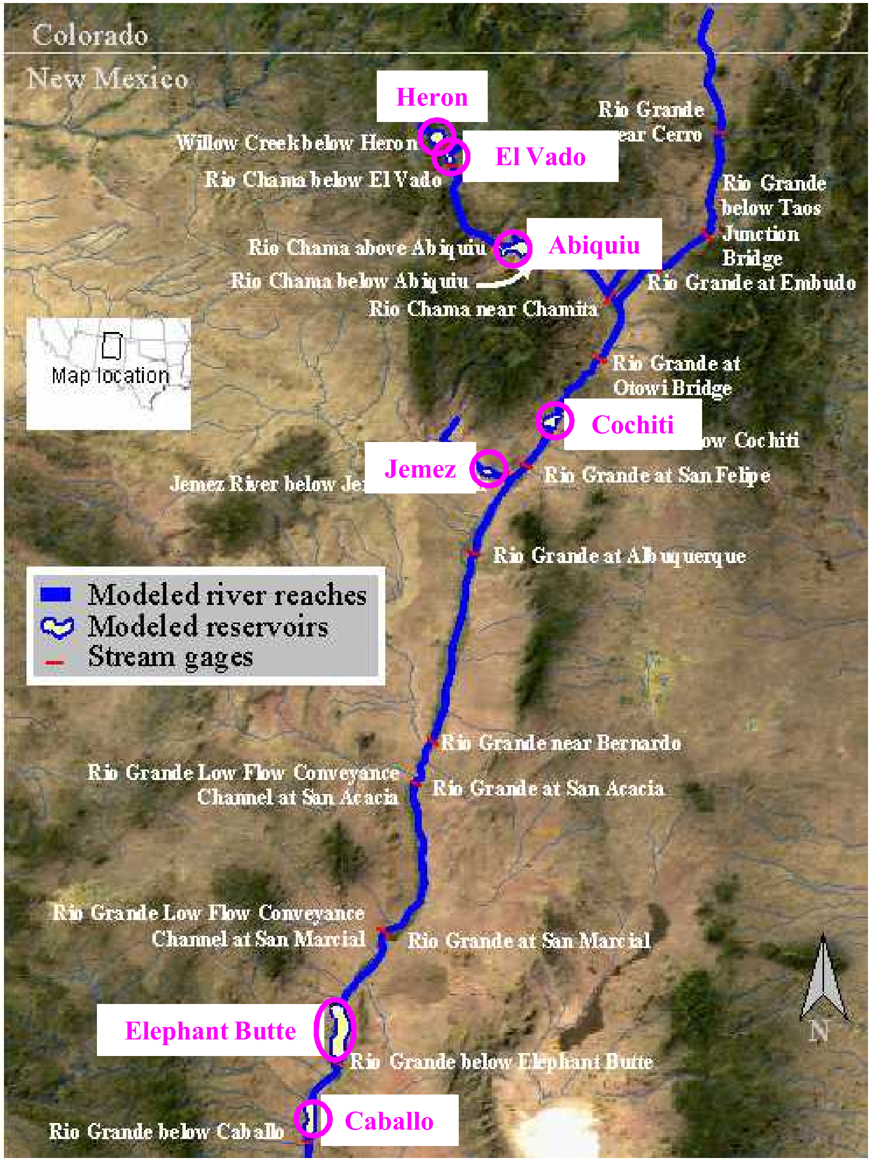
Spatial resolution and extent based on URGWOM model:

- Dominant historical data set is from USGS stream flow gages:

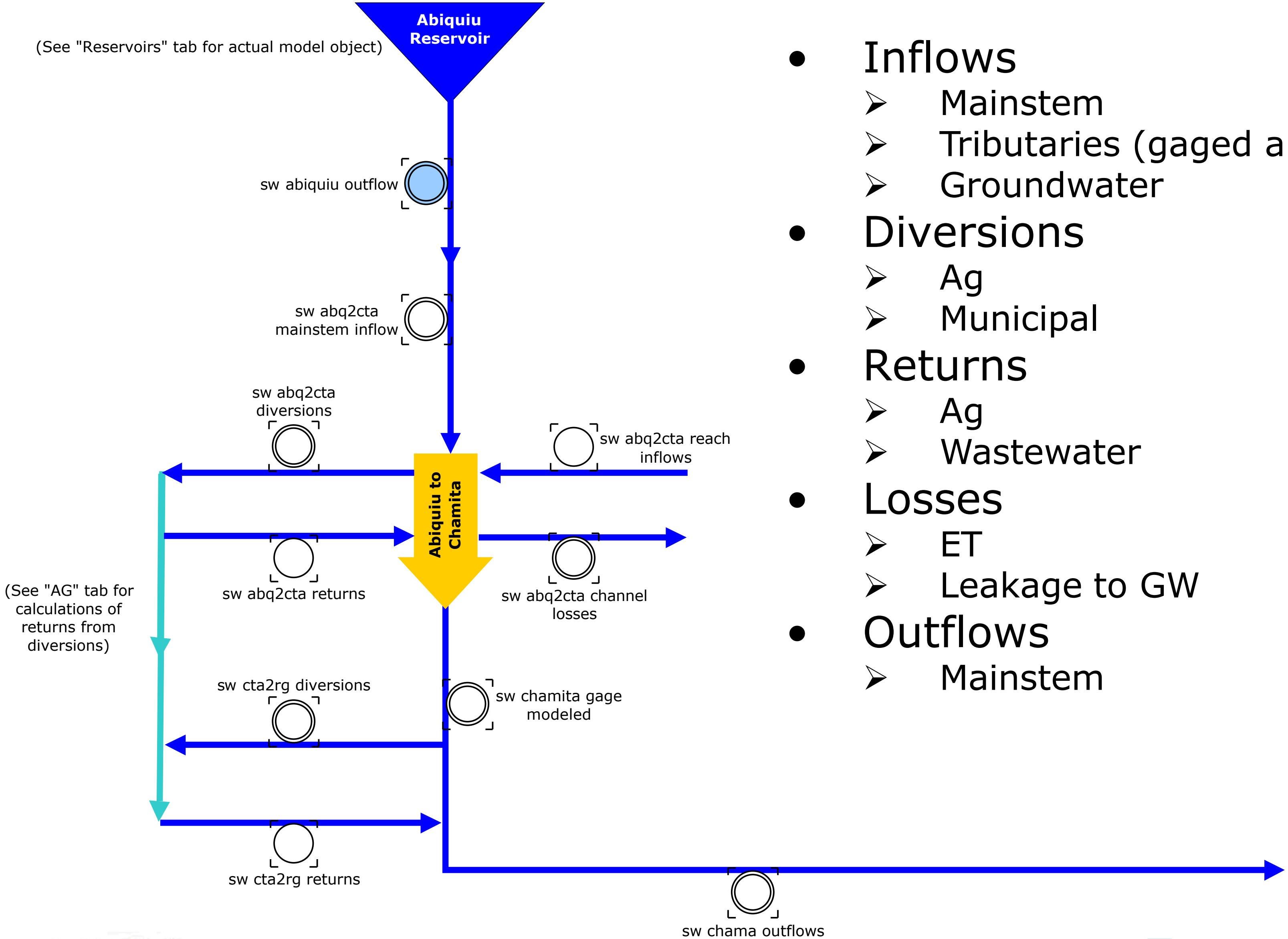
"River reach": gage location based spatial unit of mass balance.

17 river reaches
- 12 Rio Grande
- 4 Rio Chama
- 1 Jemez River

In addition to river reaches, there are 7 spatial mass balance units representing major reservoirs



Monthly reach or reservoir based mass balance (structurally similar to URGWOM conceptual mass balance):



- Inflows
  - Mainstem
  - Tributaries (gaged and ungaged)
  - Groundwater
- Diversions
  - Ag
  - Municipal
- Returns
  - Ag
  - Wastewater
- Losses
  - ET
  - Leakage to GW
- Outflows
  - Mainstem

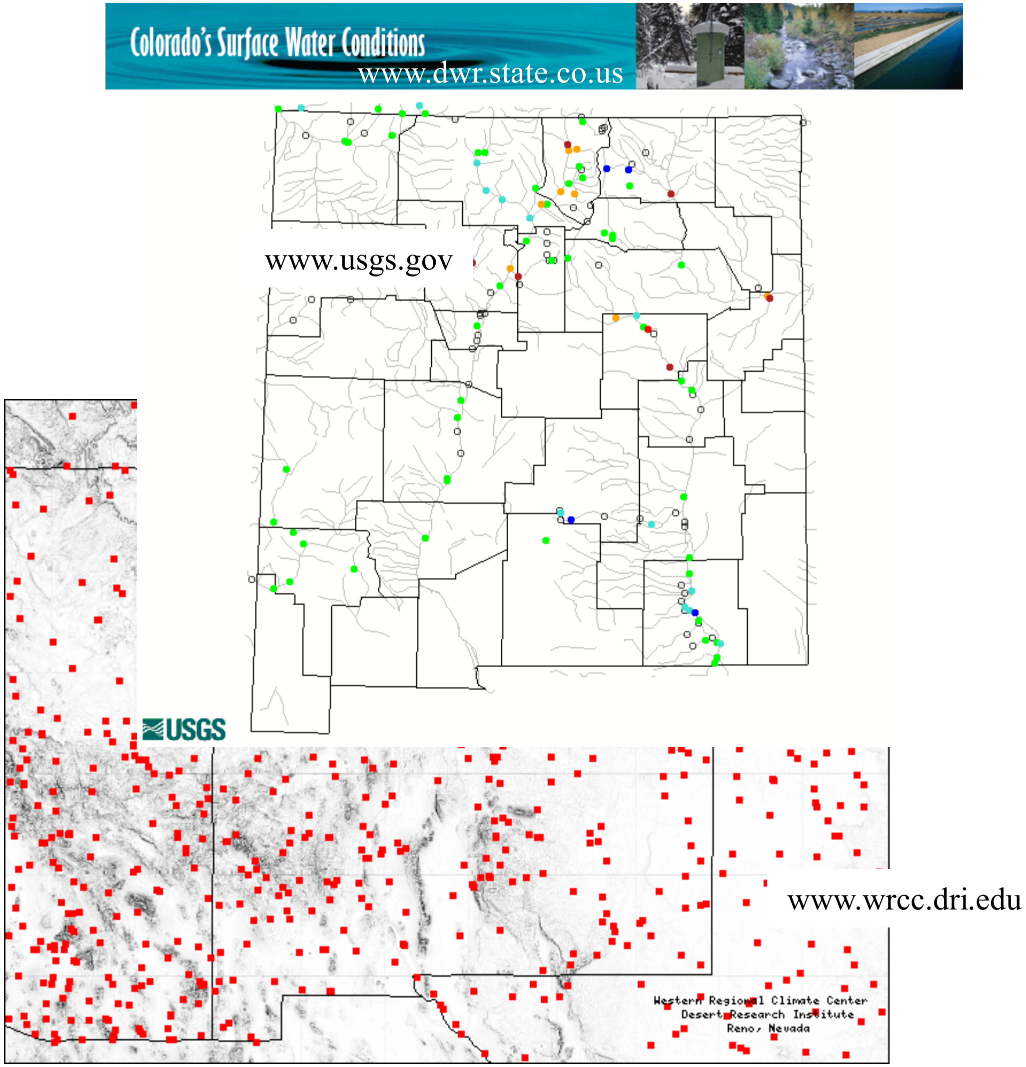
URGSIM temporally varying input data requirements:

1. Hydrologic
   - USGS and CODWR gaged flows
   - GW basin recharge
   - Reservoir precipitation

2. Climatic
   - Climate station temperatures
   - Reservoir pan evaporation
   - Reservoir precipitation

3. Agricultural/Riparian
   - Riparian area
   - Irrigated agricultural area

4. Operational
   - Historical irrigation diversions



URGSIM hydrologic inputs (where the H_2O enters):

- Gaged SW inflows (USGS and CODWR):
  - Rio Grande near Lobatos
  - Costilla Creek near Garcia
  - Red River below Fish Hatchery
  - Rio Pueblo de Taos below Los Cordovas
  - Embudo Creek at Dixon
  - Rio Blanco above Blanco Diversion
  - Little Navajo River above Little Oso Diversion
  - Navajo River above Oso Diversion
  - Rio Chama at La Puente
  - Rio Ojo Caliente at La Madera
  - Rio Nambe below Nambe Falls Dam
  - Santa Fe River above Cochiti
  - Galisteo Creek below Galisteo Dam
  - Jemez River near Jemez
  - North Floodway Channel near Alameda
  - Tijeras Arroyo near Albuquerque
  - South Diversion Channel near Albuquerque
  - Rio Puerco near Bernardo

- Ungaged SW inflows:
  - All reaches above Central at Albuquerque
  - Calibration term for 1975-2000 sw mass balance

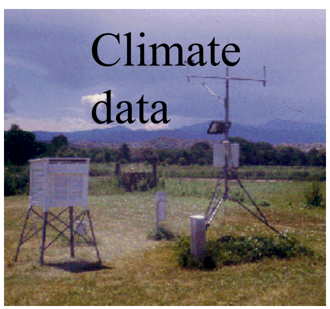
- GW inflows to river:
  - All reaches above Rio Grande – Rio Chama confluence
  - Based on winter sw gaged flow analysis

- GW recharge:
  - All reaches from Rio Grande – Rio Chama confluence to Elephant Butte
  - Based on regional GW flow model values

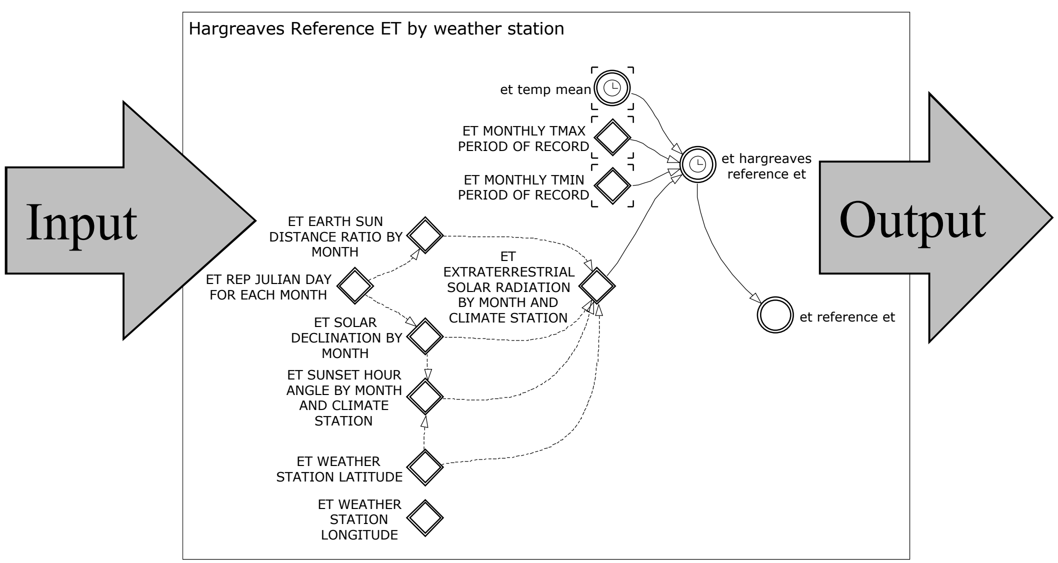
- Reservoir precipitation:
  - Heron, El Vado, Abiquiu, Cochiti, Jemez, Elephant Butte, Caballo
  - Volume depends on reservoir area

Modeling ET

- Reference ET (ET_o) calculated with climate data using Hargreaves equation: ET_o= f(latitude, date, monthly tmax, tmin, tmean)
- Vegetation coefficients calculated for riparian and ag plant species



ET Module



Reference ET
Veg Coefficients
Potential ET

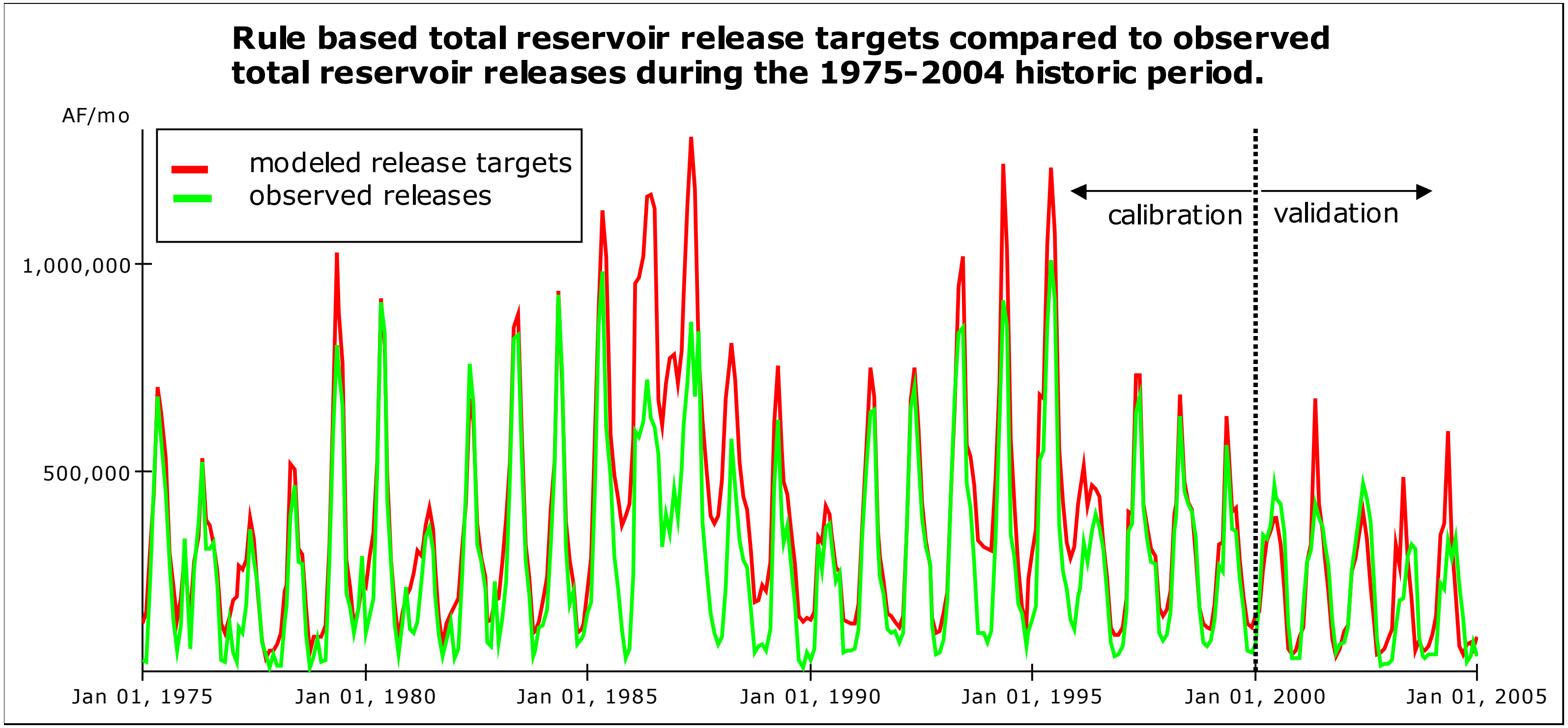
- Actual ET used by model is smaller of potential ET and water available to riparian vegetation or irrigated crop

Reservoir rules: Calibration and validation analysis

• Reservoirs in upper Rio Grande are managed for a variety of objectives including flood control, storage, minimum flows, and interstate compacts that have been incorporated into the model following URGWOM methods.

• These rules can explain most, of 1975-2004 reservoir releases.

• Discrepancies are due to operations changes and subjective flexibility built into the system that can be exercised by water managers.



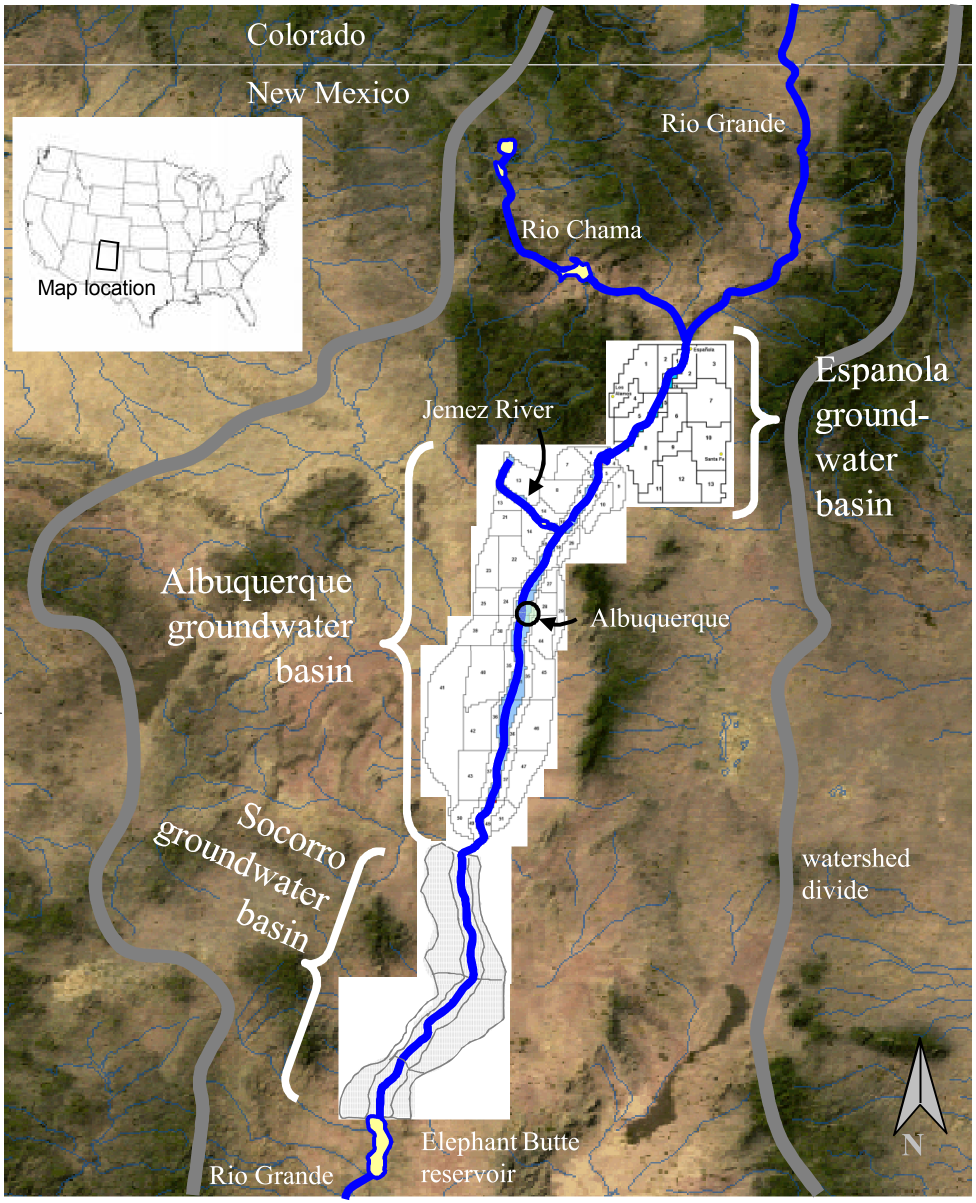
Dynamic sw-gw modeling in upper Rio Grande river system

Goal:

- A rapid and physically based, dynamic represenation of sw-gw interactions in Rio Grande river system coupled directly to dynamic surface water model.

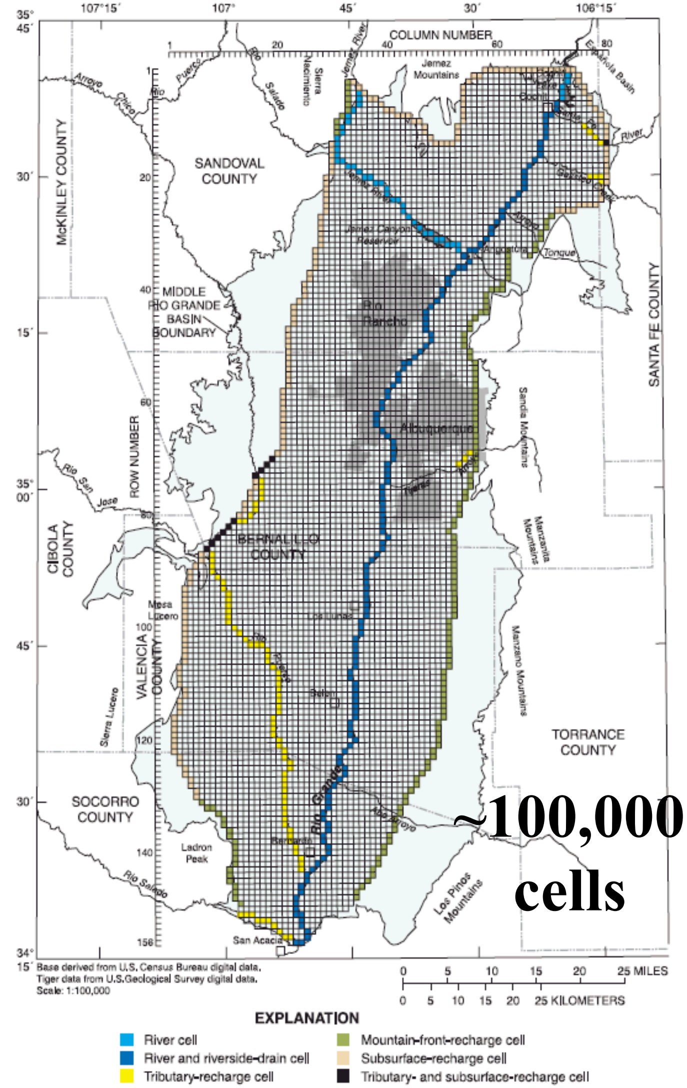
Strategy:

- Use spatially explicit groundwater models to calibrate spatially aggregated versions in Powersim (system dynamics software).
- Three spatially explicit models of interest:
  - Espanola Basin (Frenzel 1995)
  - Albuquerque Basin (McAda et al 2002)
  - Socorro Basin (Shafike 2005)

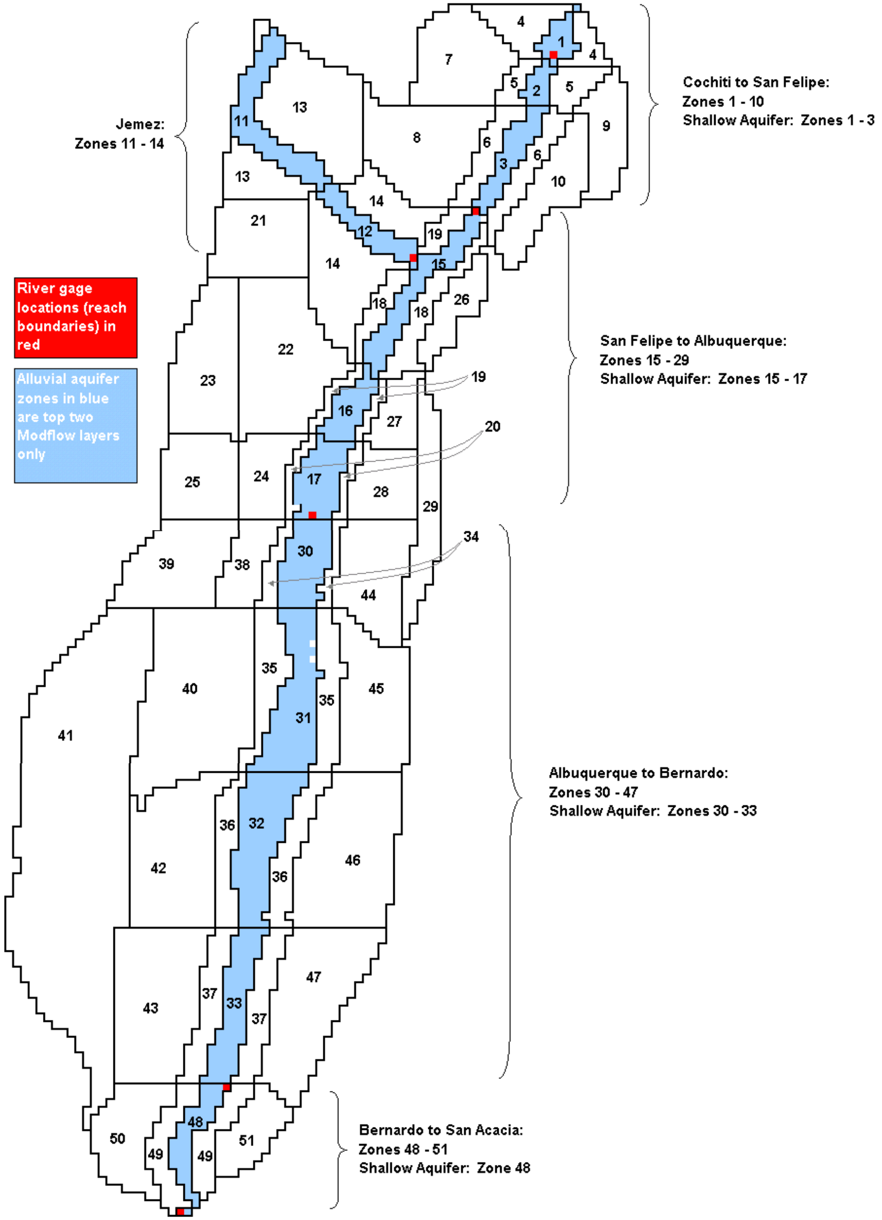


Albuquerque Basin: Aggregated to 51 zones

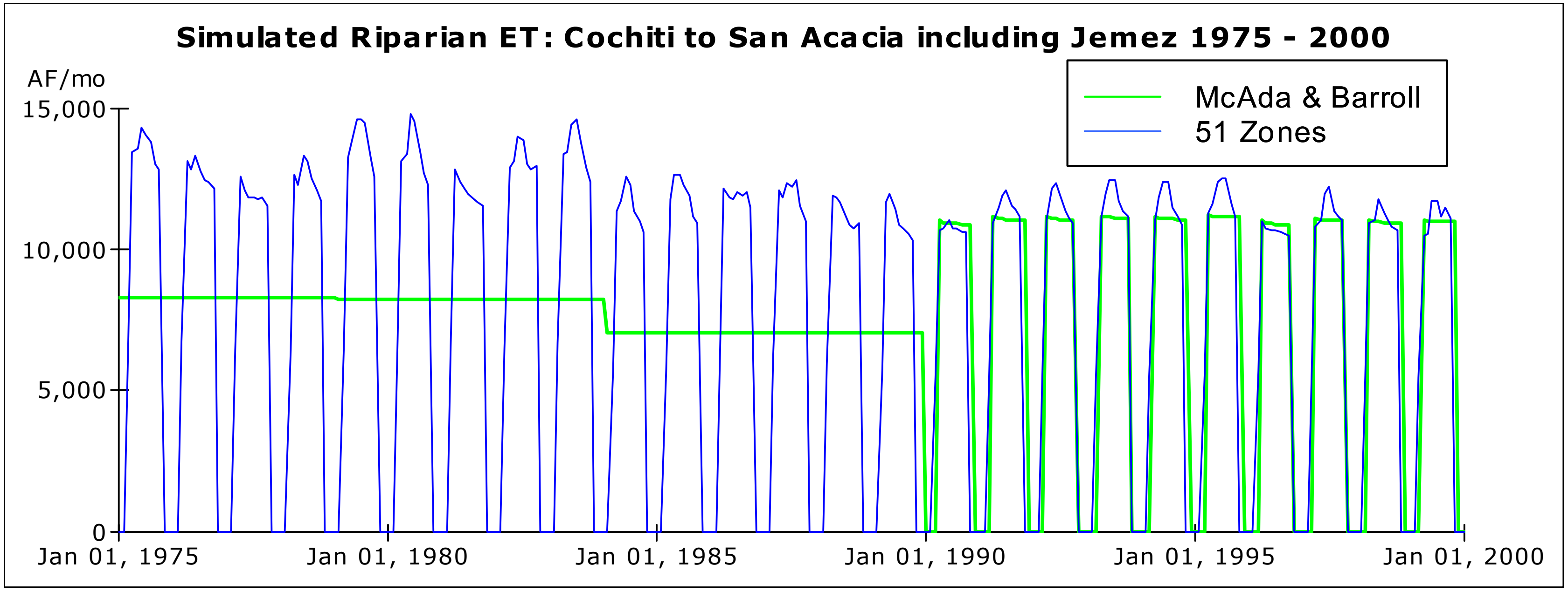
McAda and Barroll 2002, Figure 7. Albuquerque Basin MODFLOW model extent.

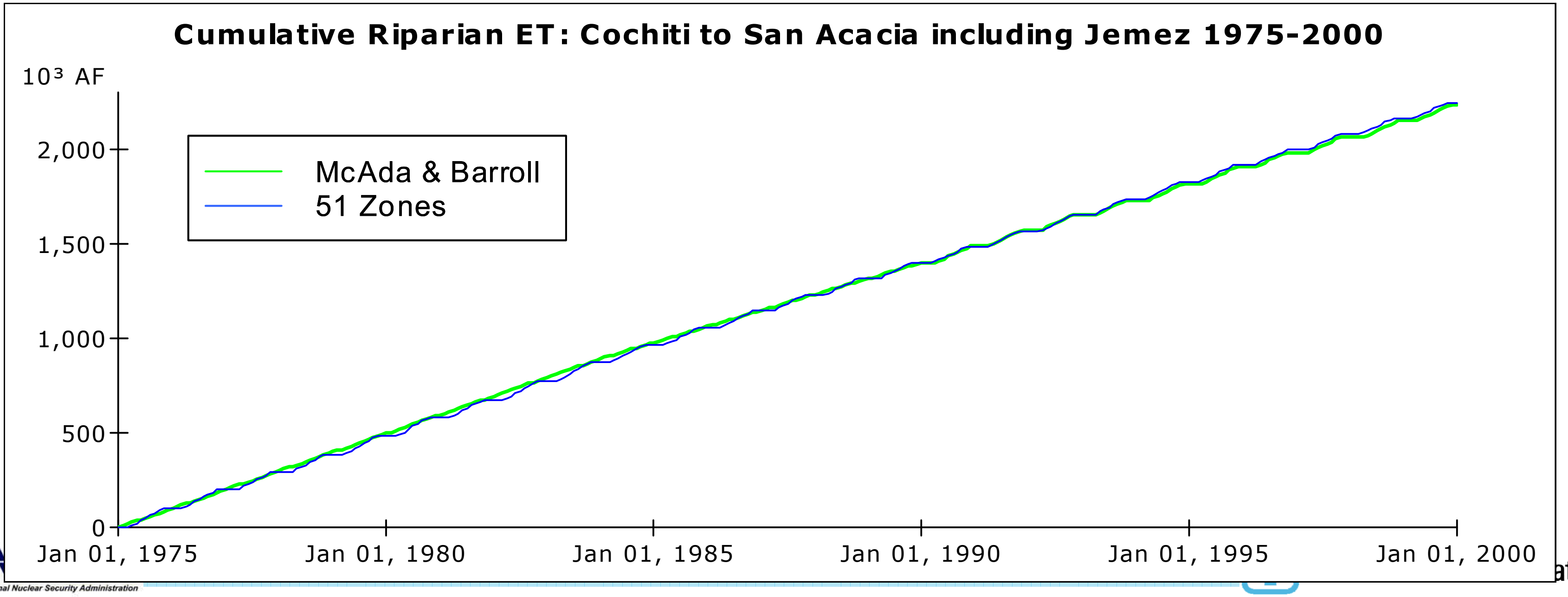


~100,000 cells

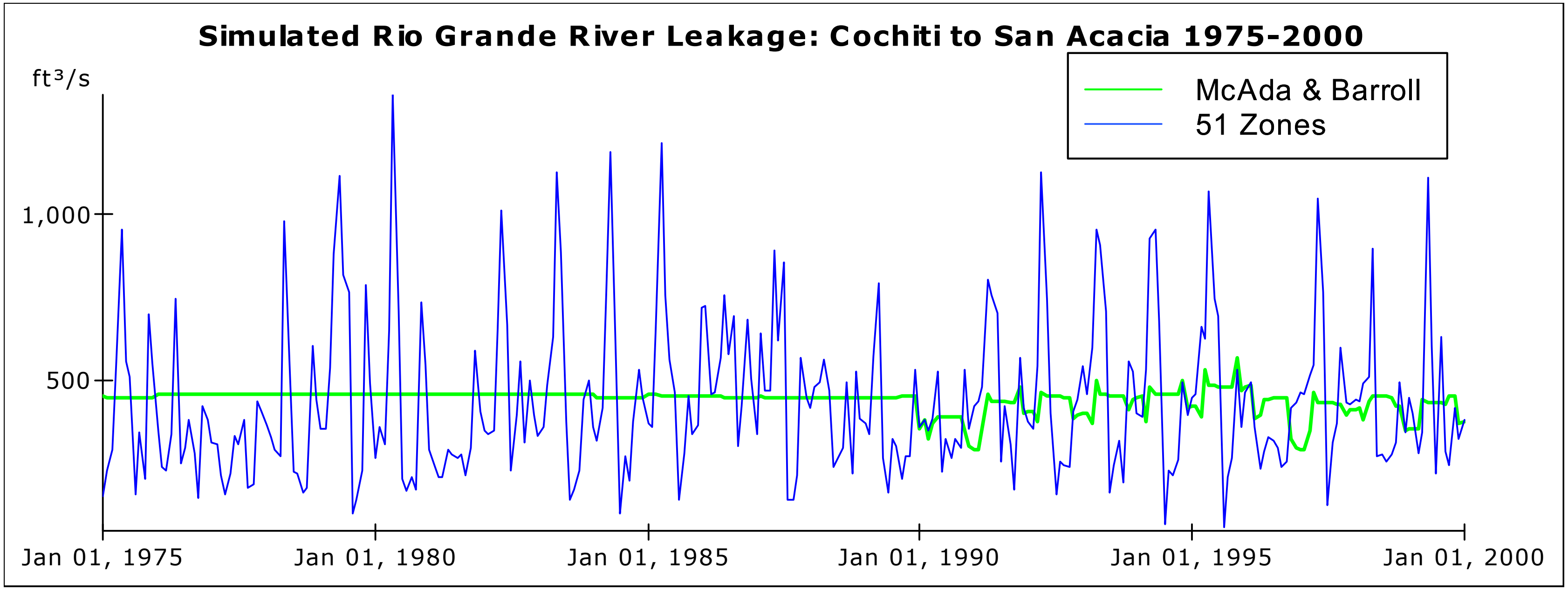


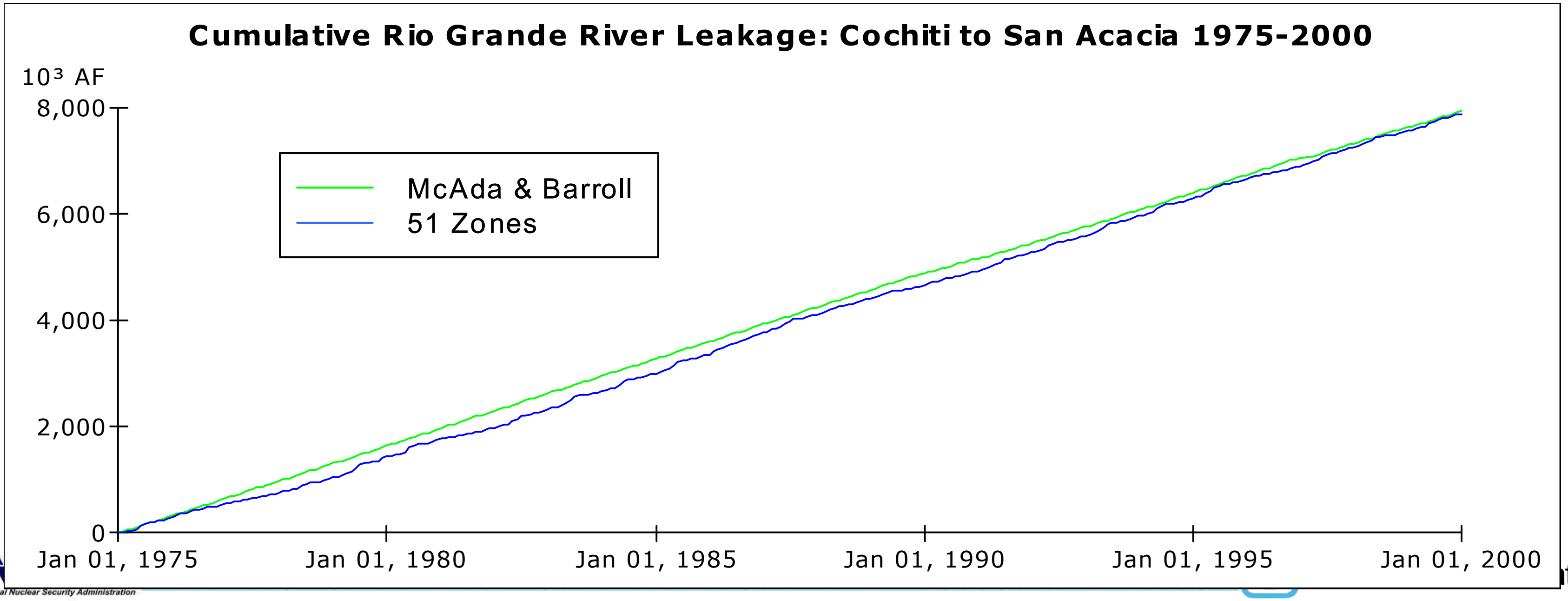
Calibration of head dependent ET



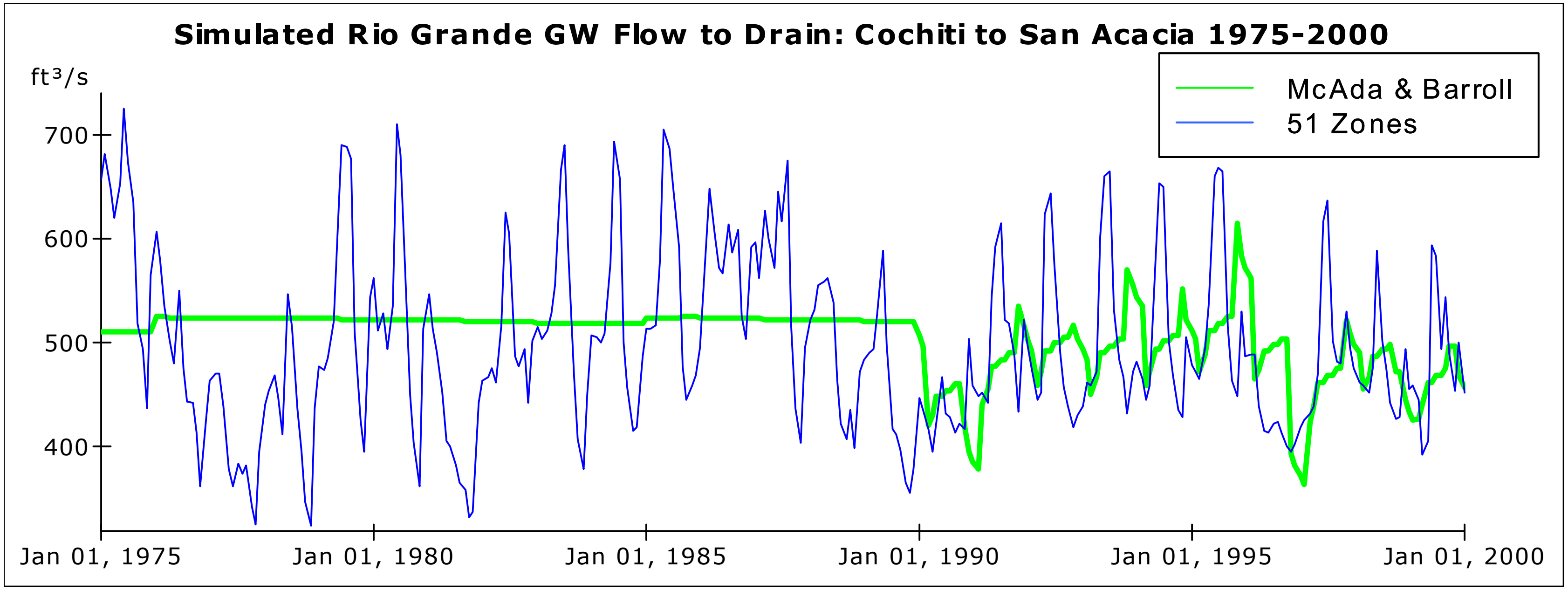


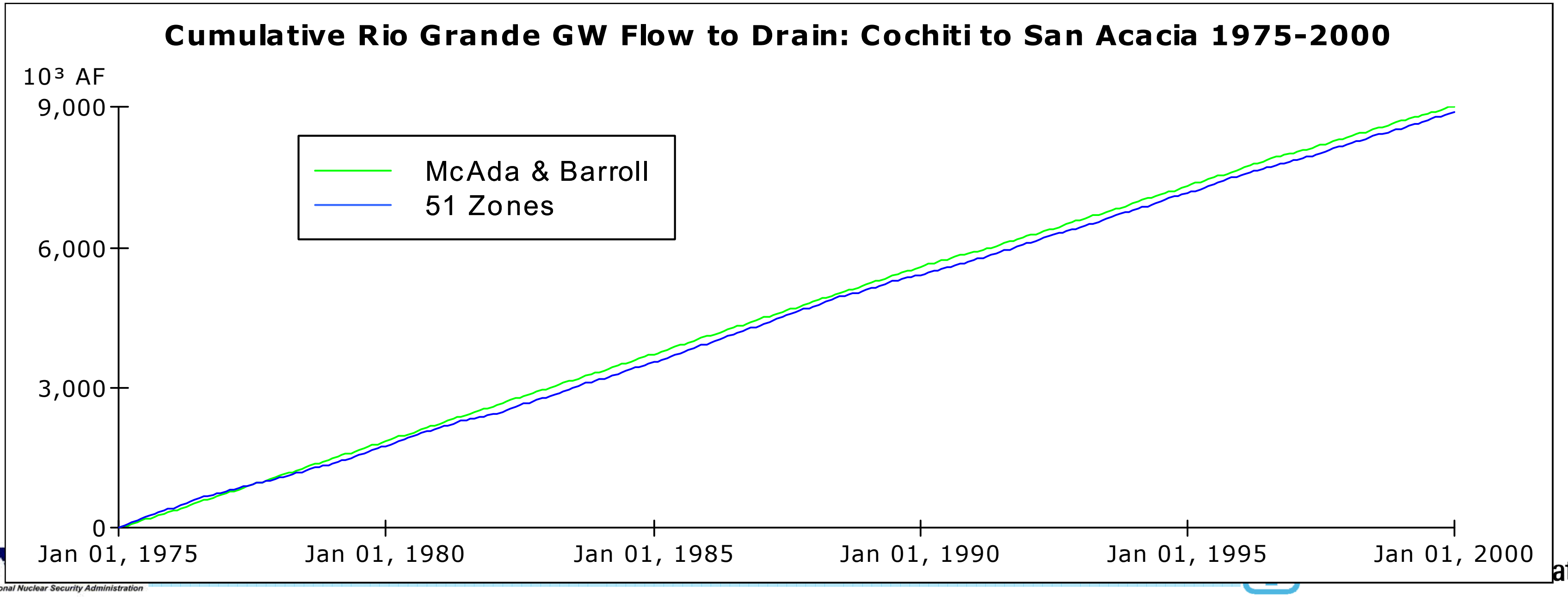
Calibration of head dependent river leakage





Calibration of head dependent flow to drains

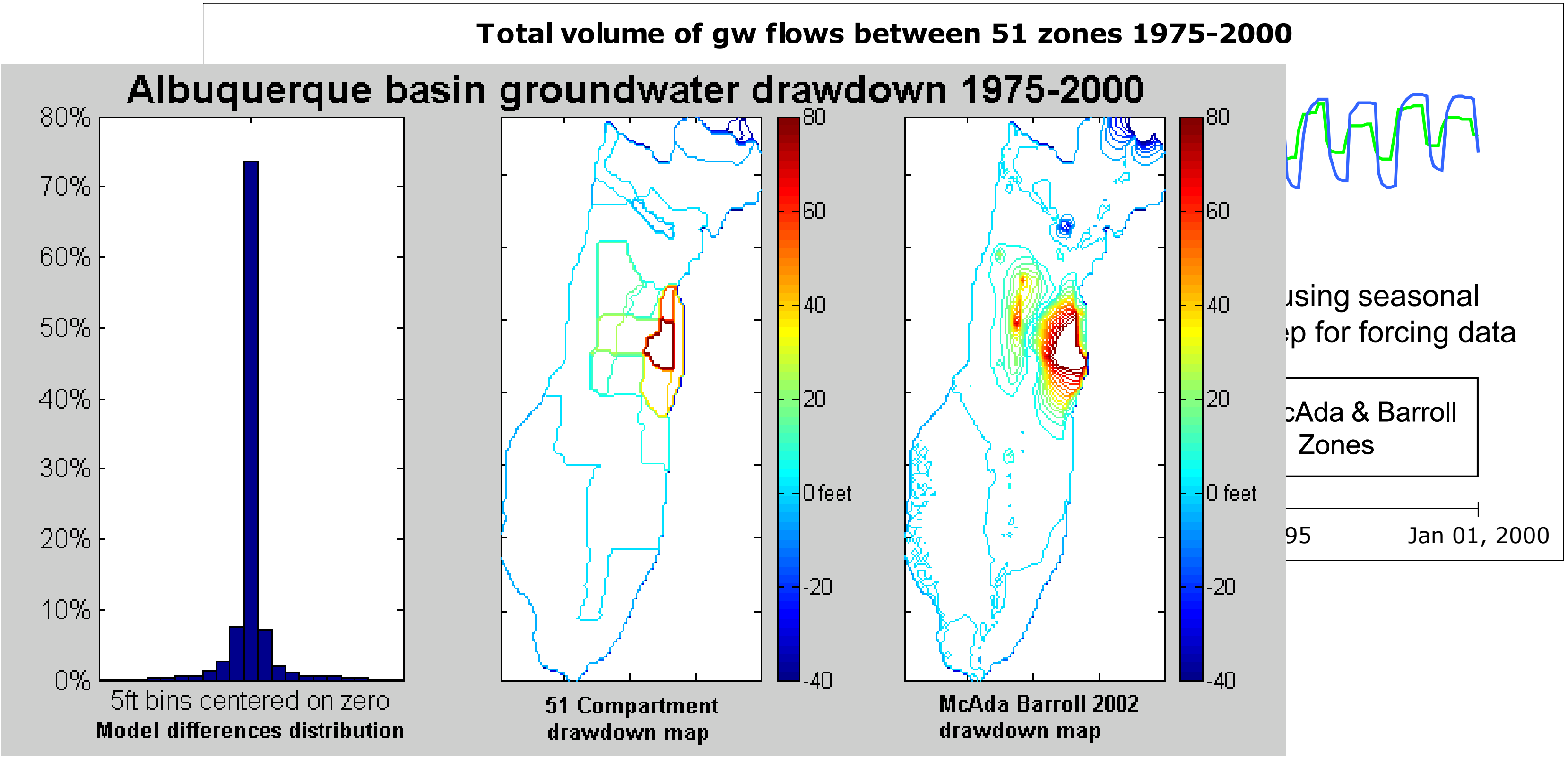




Evaluation of spatially aggregated gw model 1975-2000

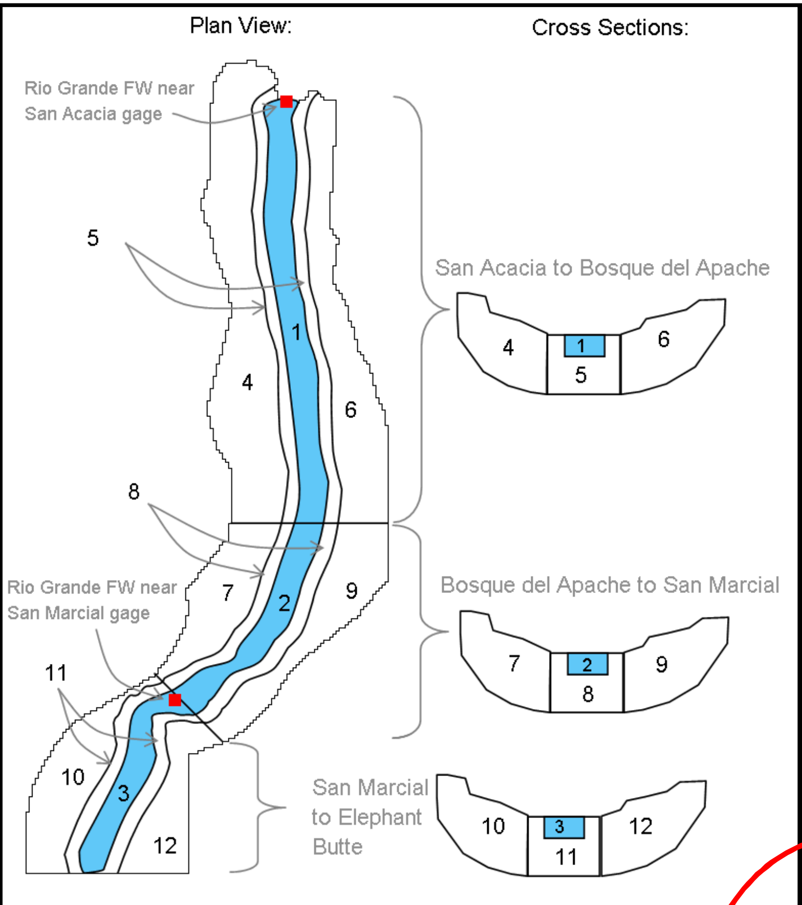
How much is lost to spatial aggregation?

1. Set all source terms (recharge, wells, river leakage, etc.) to be the same as in the MODFLOW run, and run the 51 zone model.
2. Compare water movement between the zones, and drawdown.

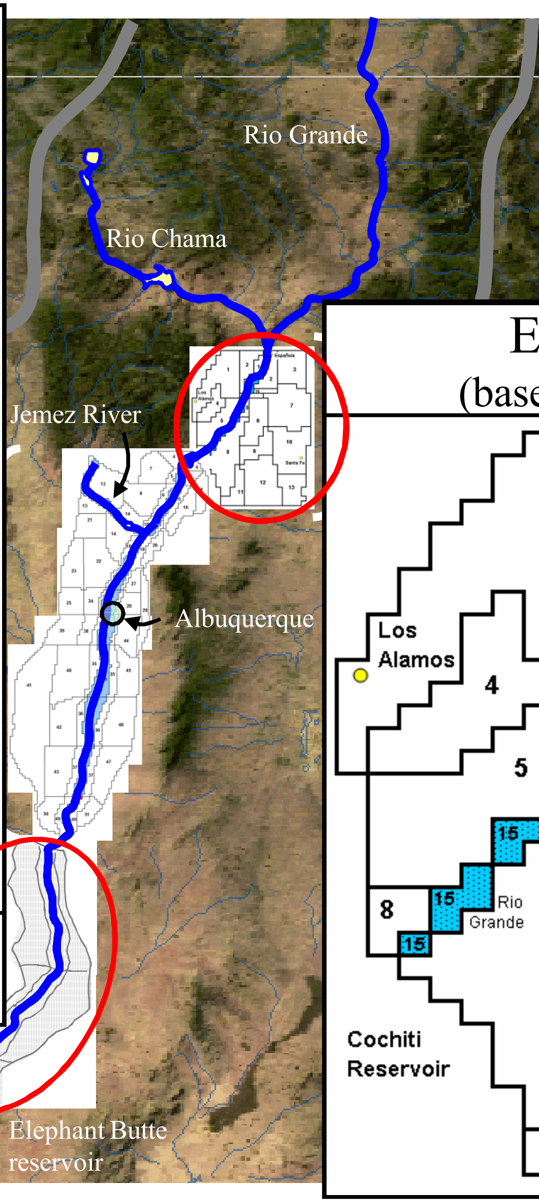


3. Spatially aggregated model captures the first order gw system behavior.

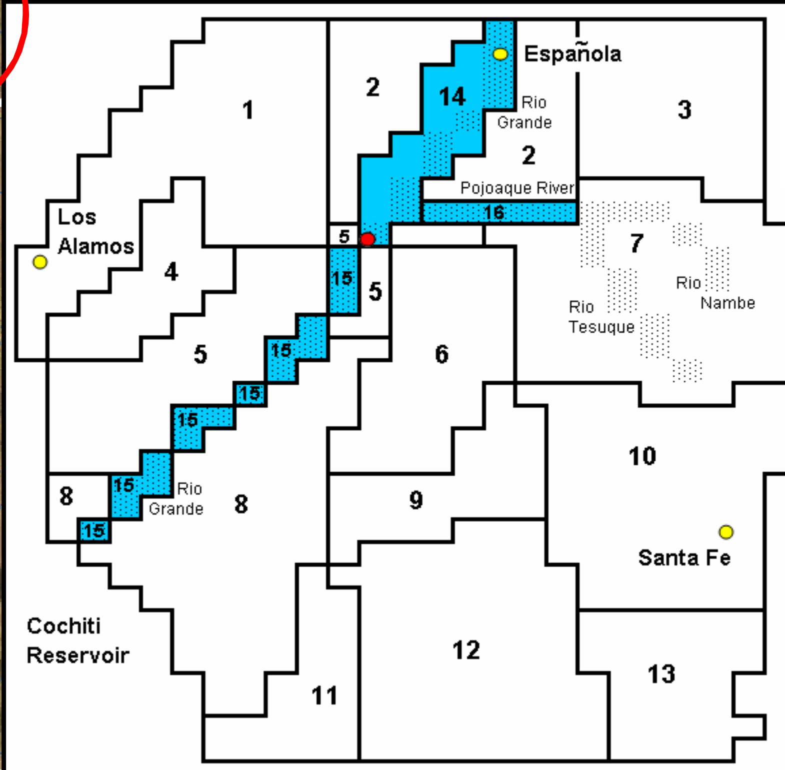
Other spatially aggregated groundwater models:



Socorro GW Basin
(based on Shafike 2005 model)

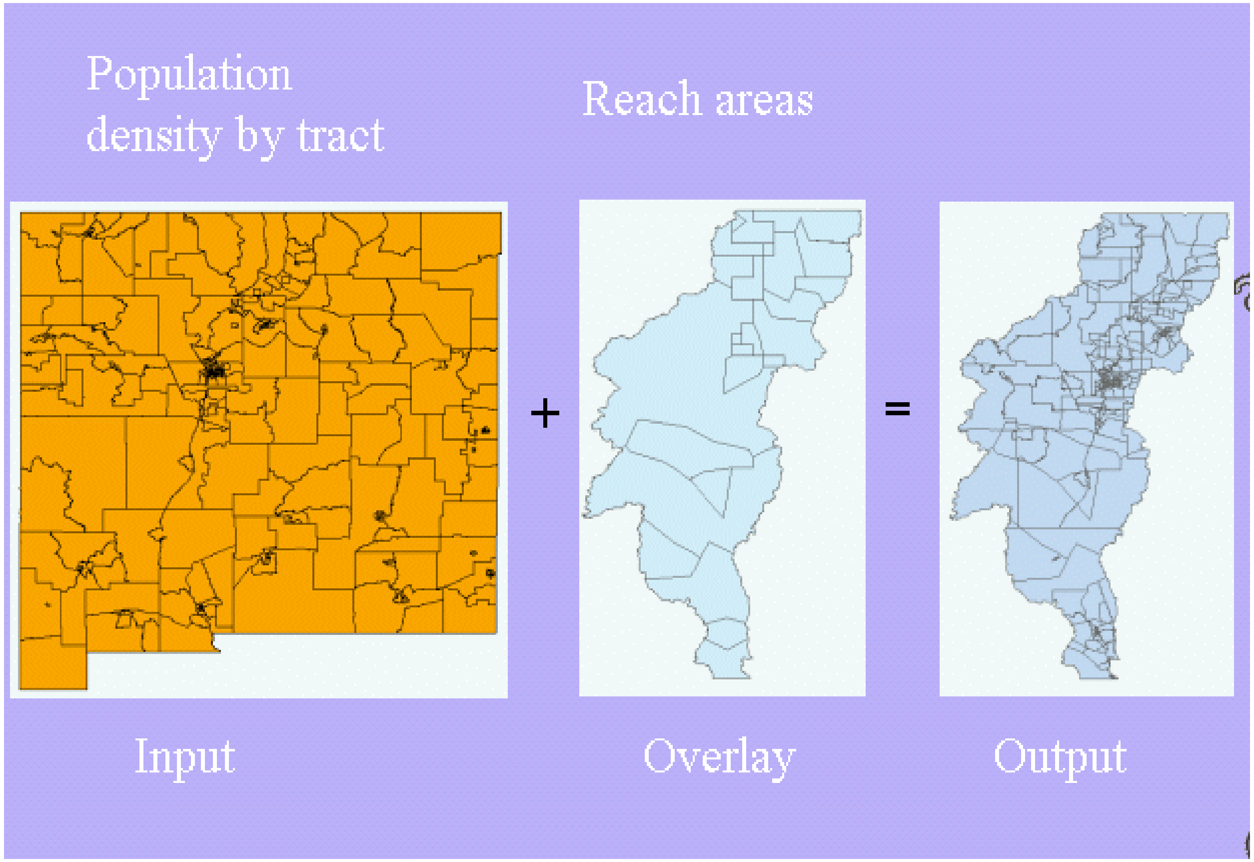


Espanola GW Basin
(based on Frenzel 1995 model)



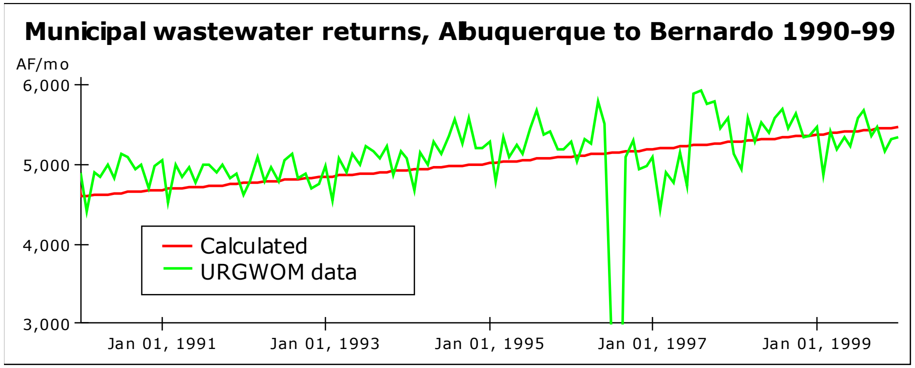
Scenario (2005-2045) demand: Urban and non-urban populations

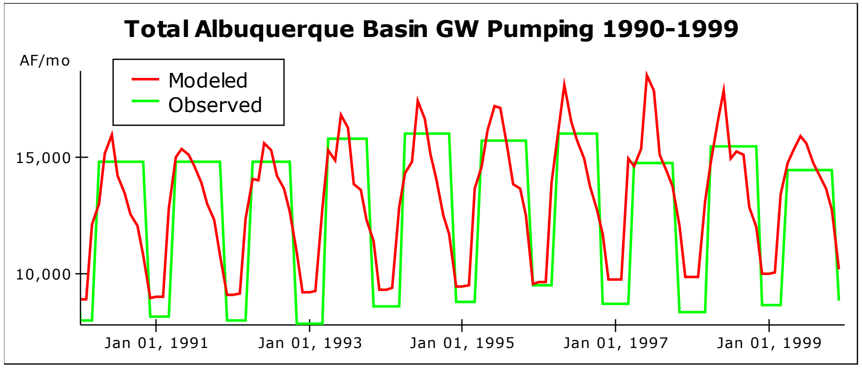
1. Reach based population projections for urban and non-urban areas based on 1990 and 2000 census data:

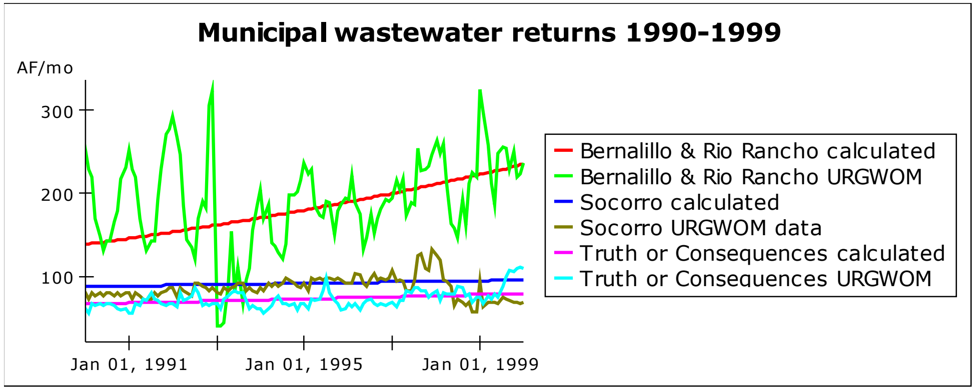


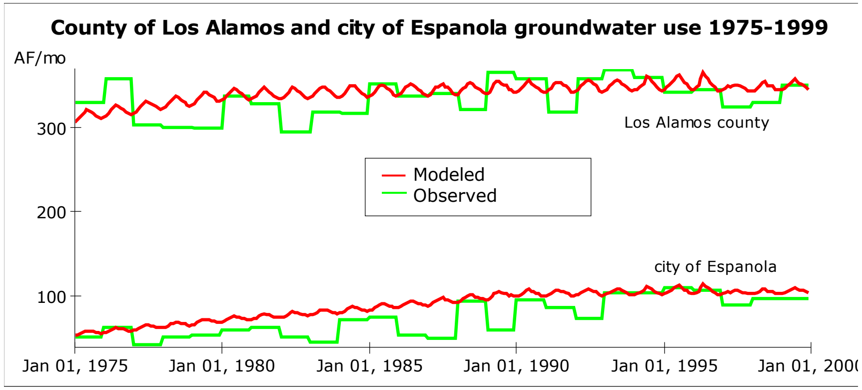
Scenario (2005-2045) demand: Indoor vs outdoor use

2. Estimate total per capita use as (total gw withdrawals)/(associated population)
3. Estimate urban indoor per capita use as (wastewater returns)/(associated population)
4. Estimate non-urban indoor per capita use as (septic returns)/(associated population)
5. Estimate effective outdoor use as difference between indoor and total use.



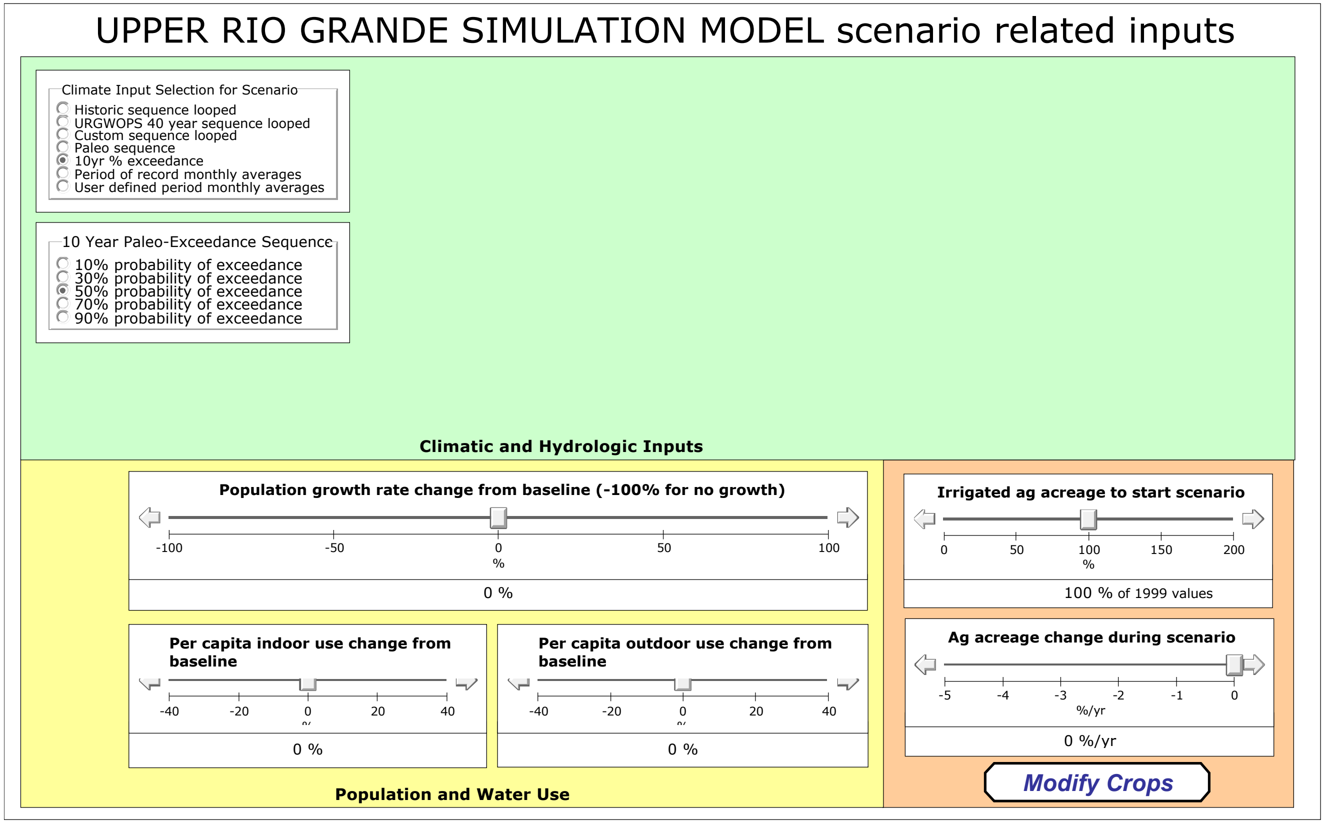






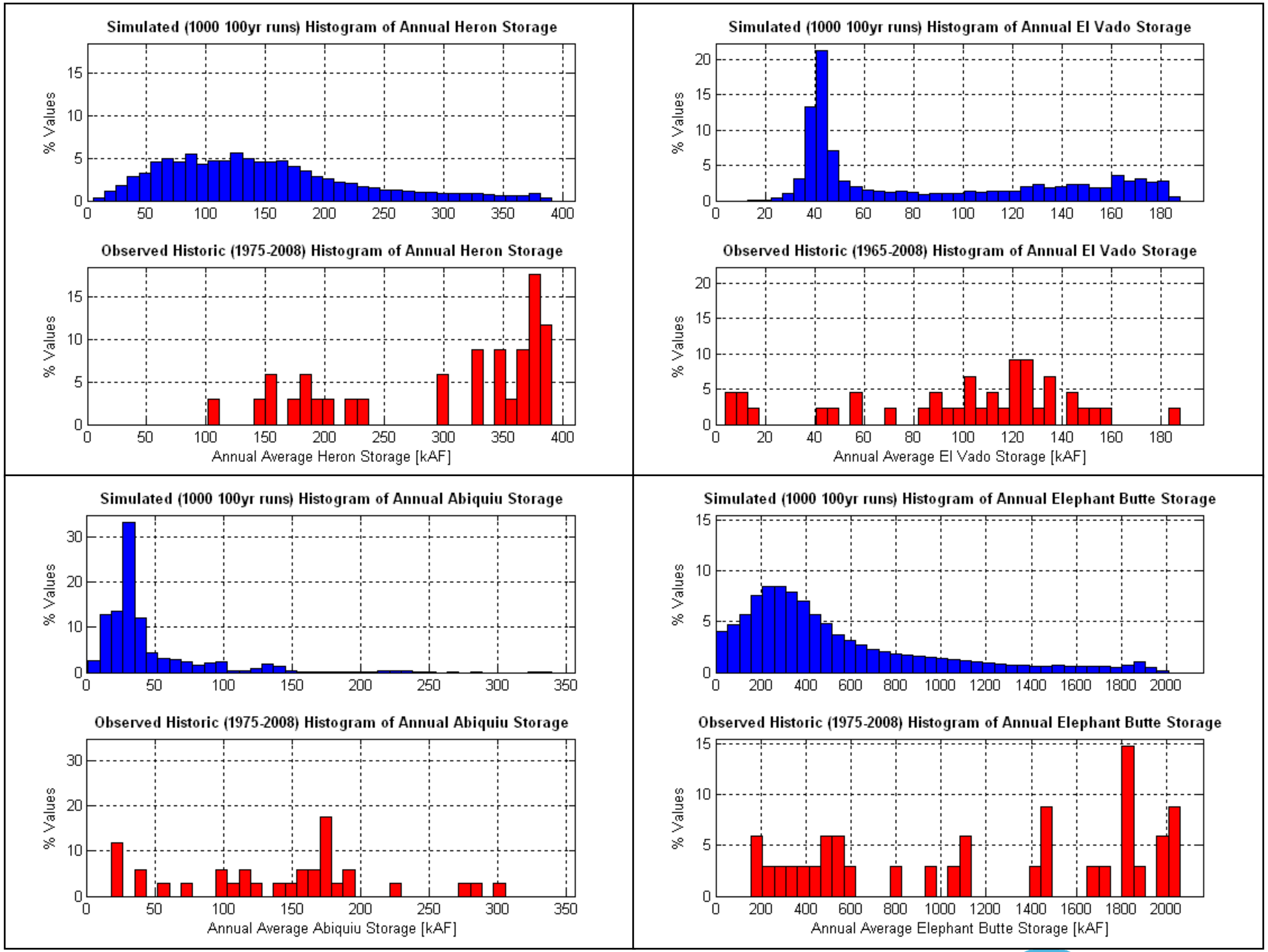
Graphic User Interface:

- Software platform utilized (Powersim Studio) supports rapid GUI creation
- Easy manipulation of selected model inputs
- Real time scenario analysis
- URGSIM GUI under development



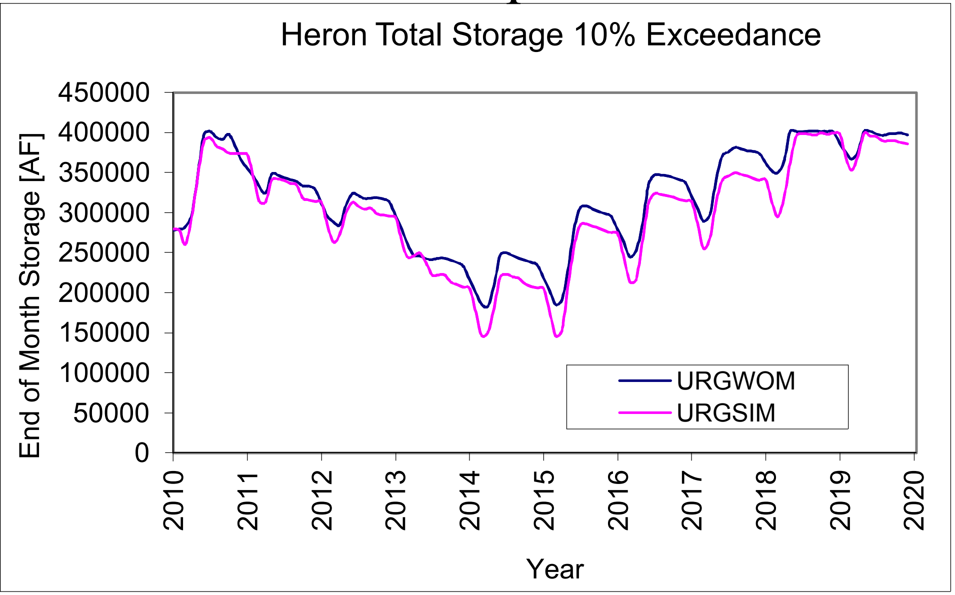
Model results: stochastic hydrology – reservoir storage

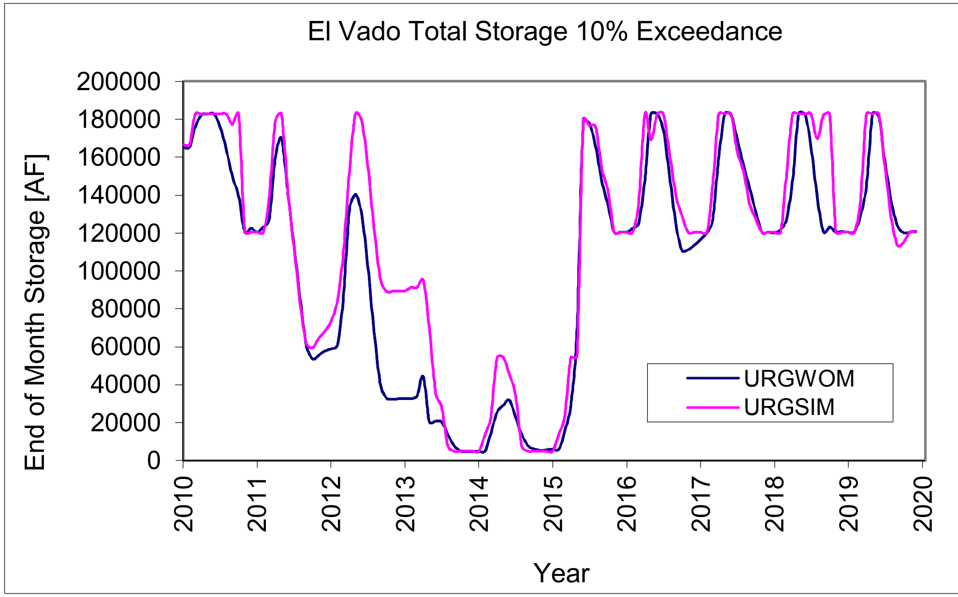
Use the model to run 1000, 100 year long climate sequences based on 400 years of tree ring data:

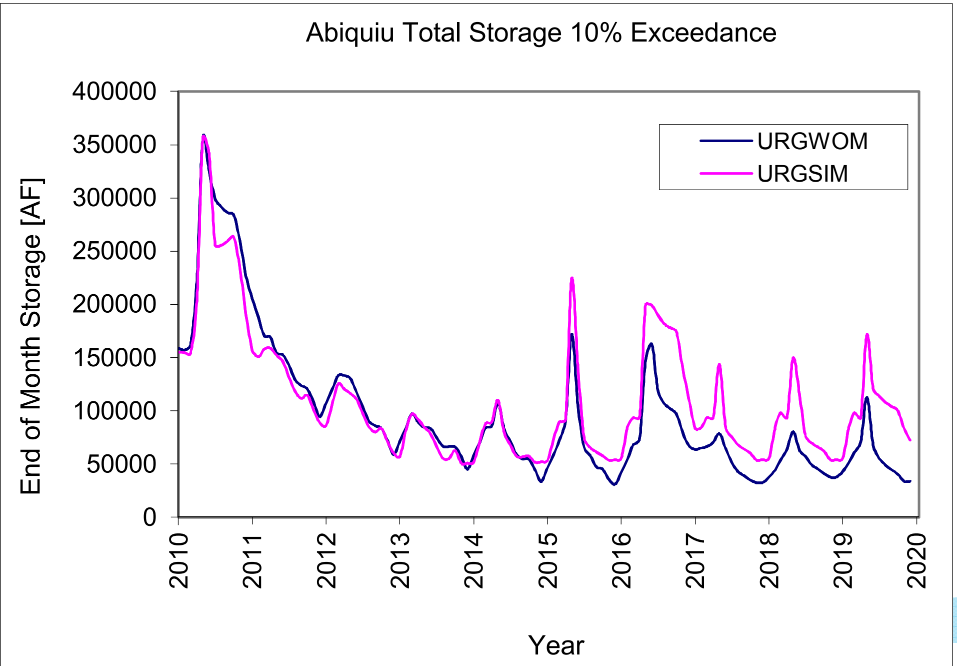


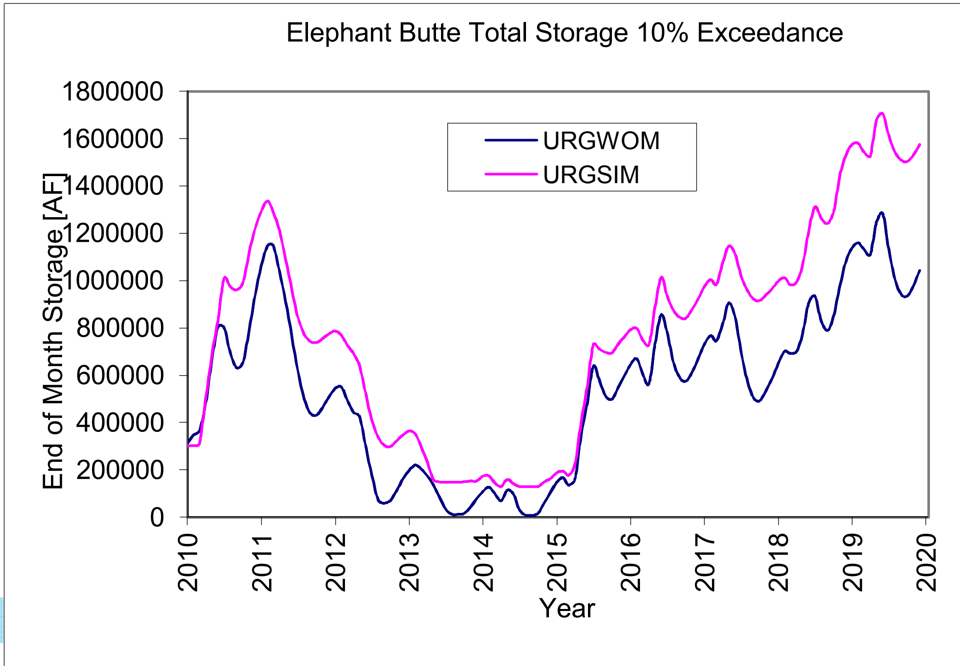
Model results: comparison to URGWOM planning runs

10% exceedance sequence:



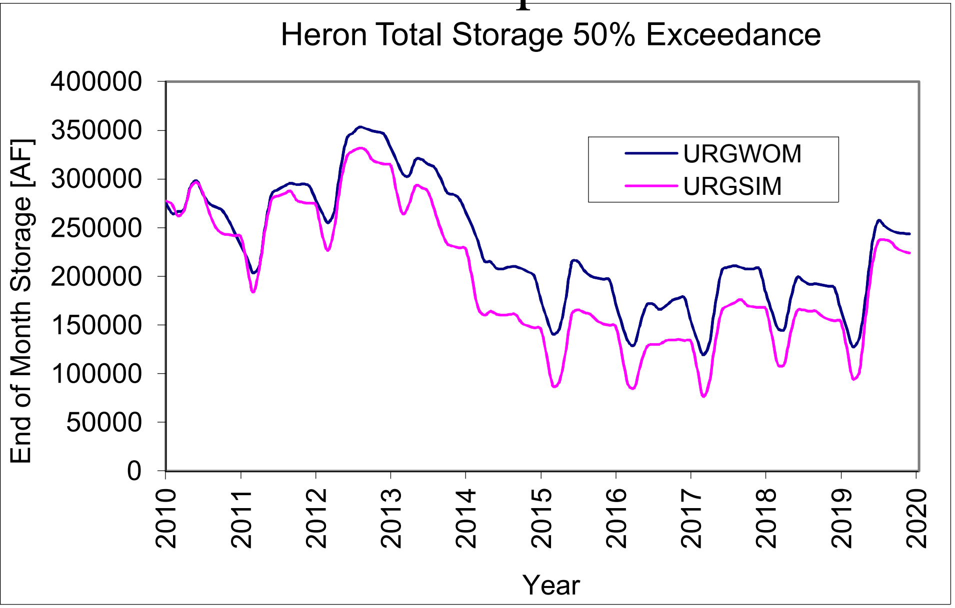


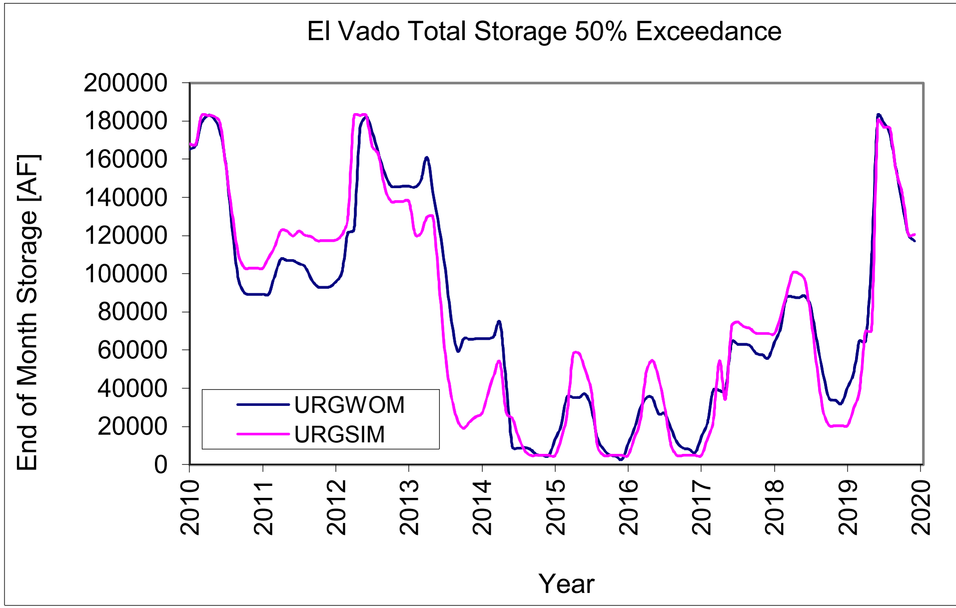


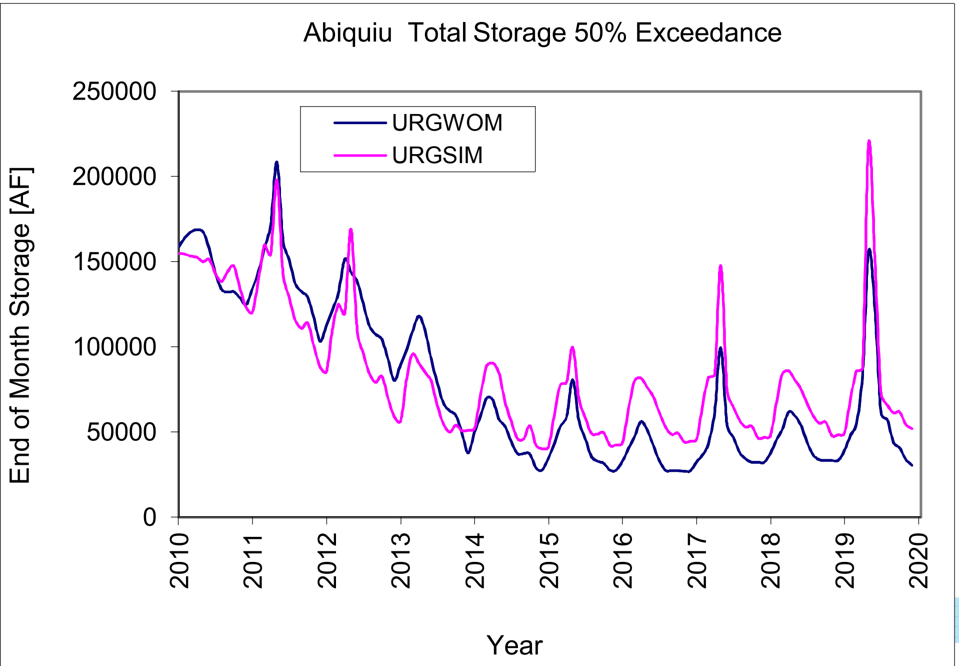


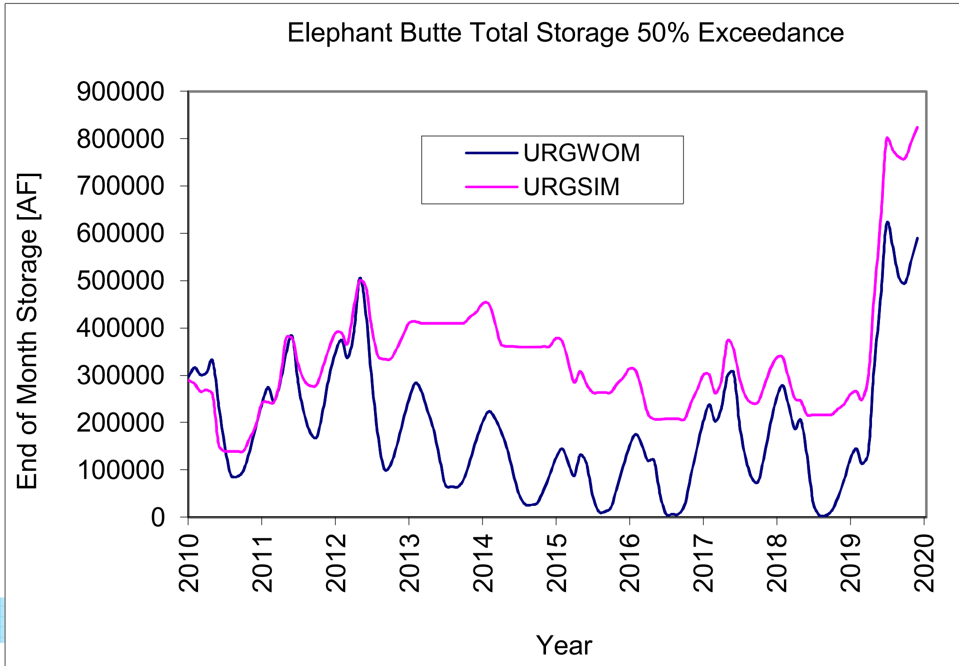
Model results: comparison to URGWOM planning runs

50% exceedance sequence:



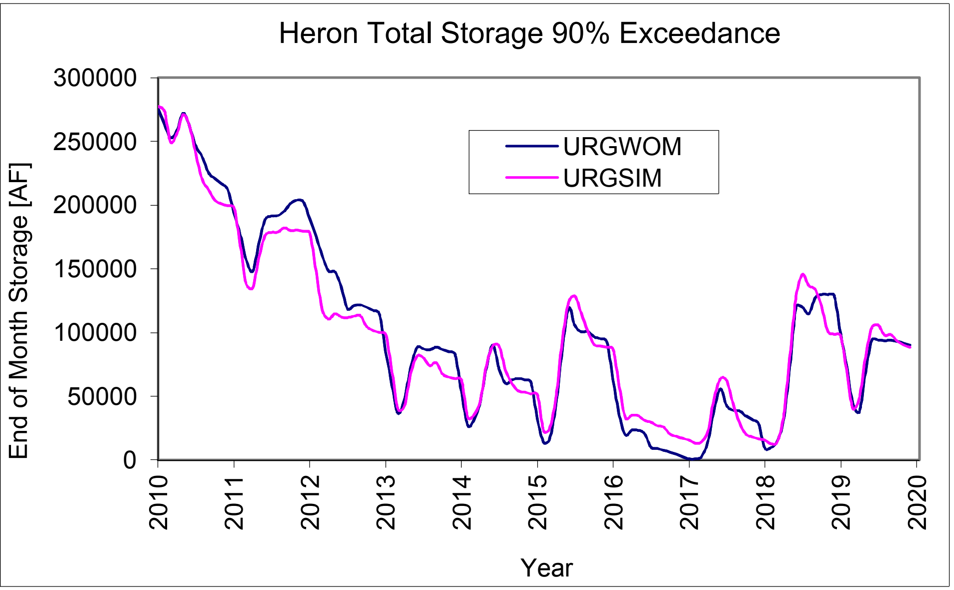


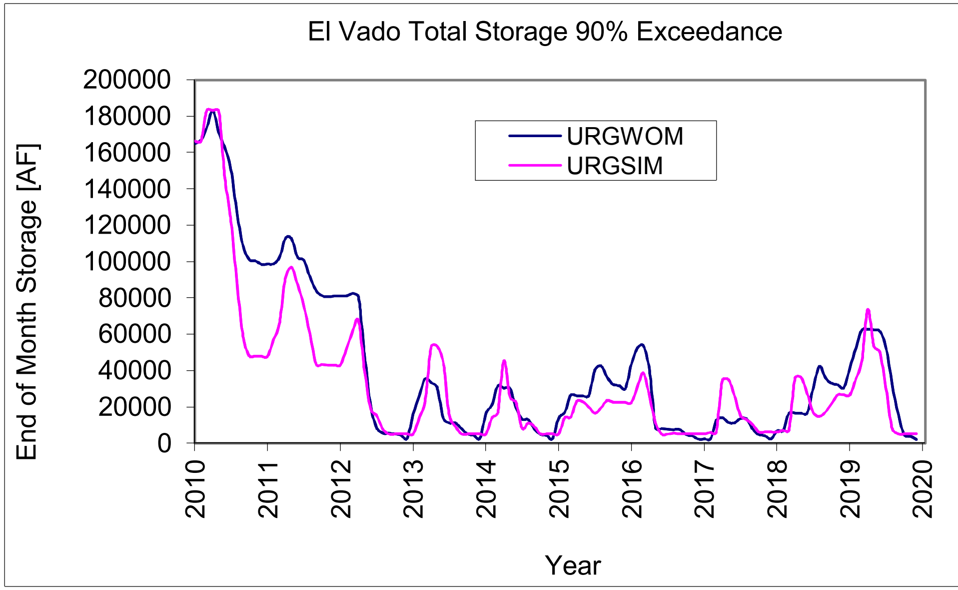


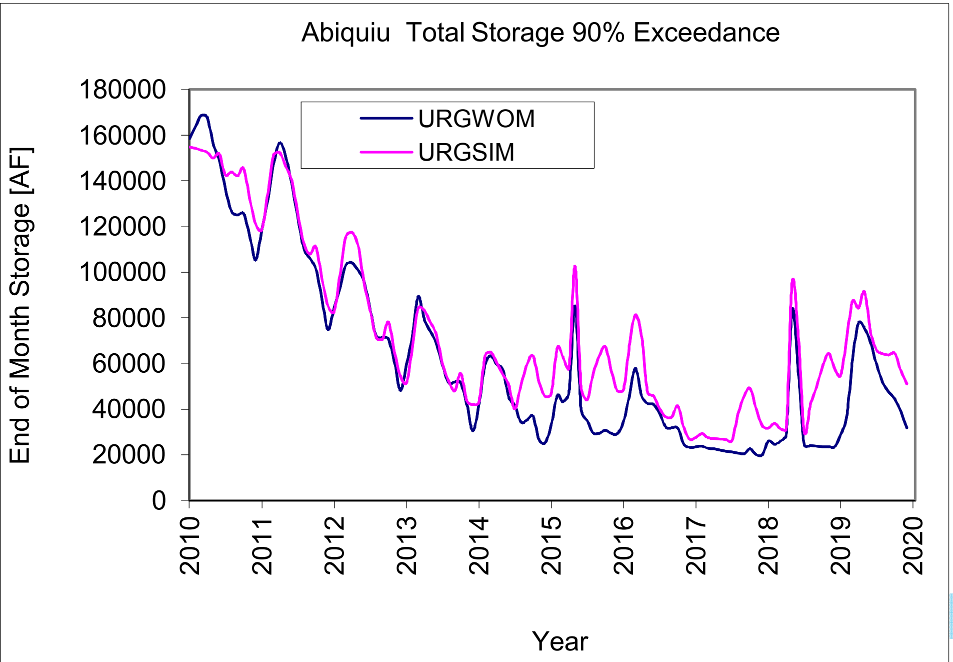


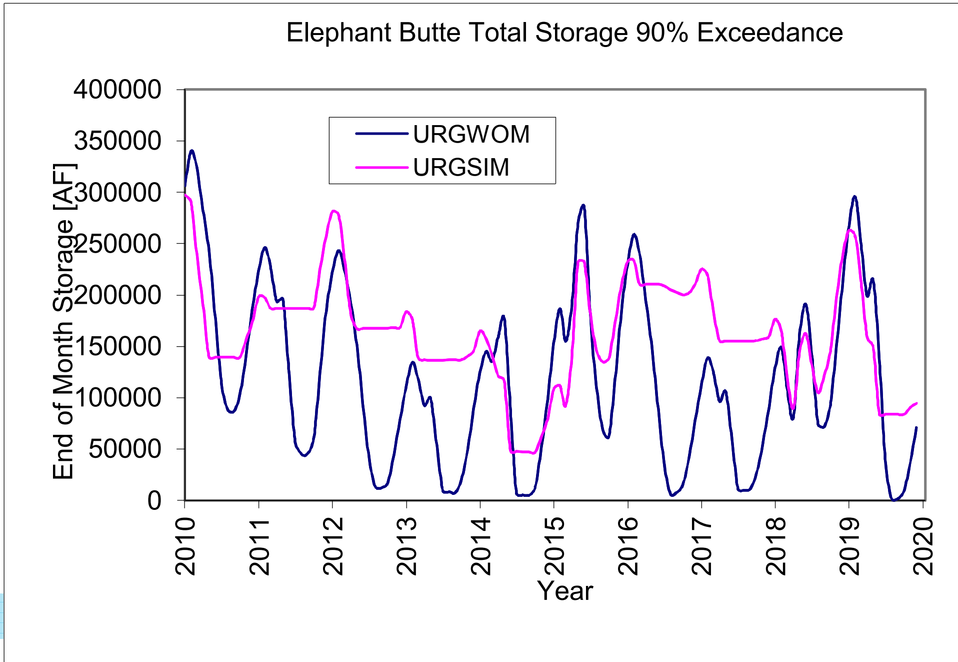
Model results: comparison to URGWOM planning runs

90% exceedance sequence:









URGSIM – URGWOM discrepancies

- Heron storage levels are generally comparable
- El Vado storage levels vary mostly due to variations at Elephant Butte and resulting differences in Article VII restrictions between models.
- Abiquiu storage levels vary mostly due to reduced flow target requirements calculated at a monthly timestep.
- Elephant Butte storage levels vary mostly due to differences in middle valley losses calculated by the two models. URGWOM losses > URGSIM losses.

Conclusions:

I. Basin scale, spatially distributed mass balance model.
- Integration of regional surface water dynamics
- Integration of reservoir and diversion operational rules
- Integration of regional groundwater models
- Integration of basin scale sw-gw dynamics
- Integration of potential ET
- Integration of agricultural, riparian, and municipal/industrial/domestic demands

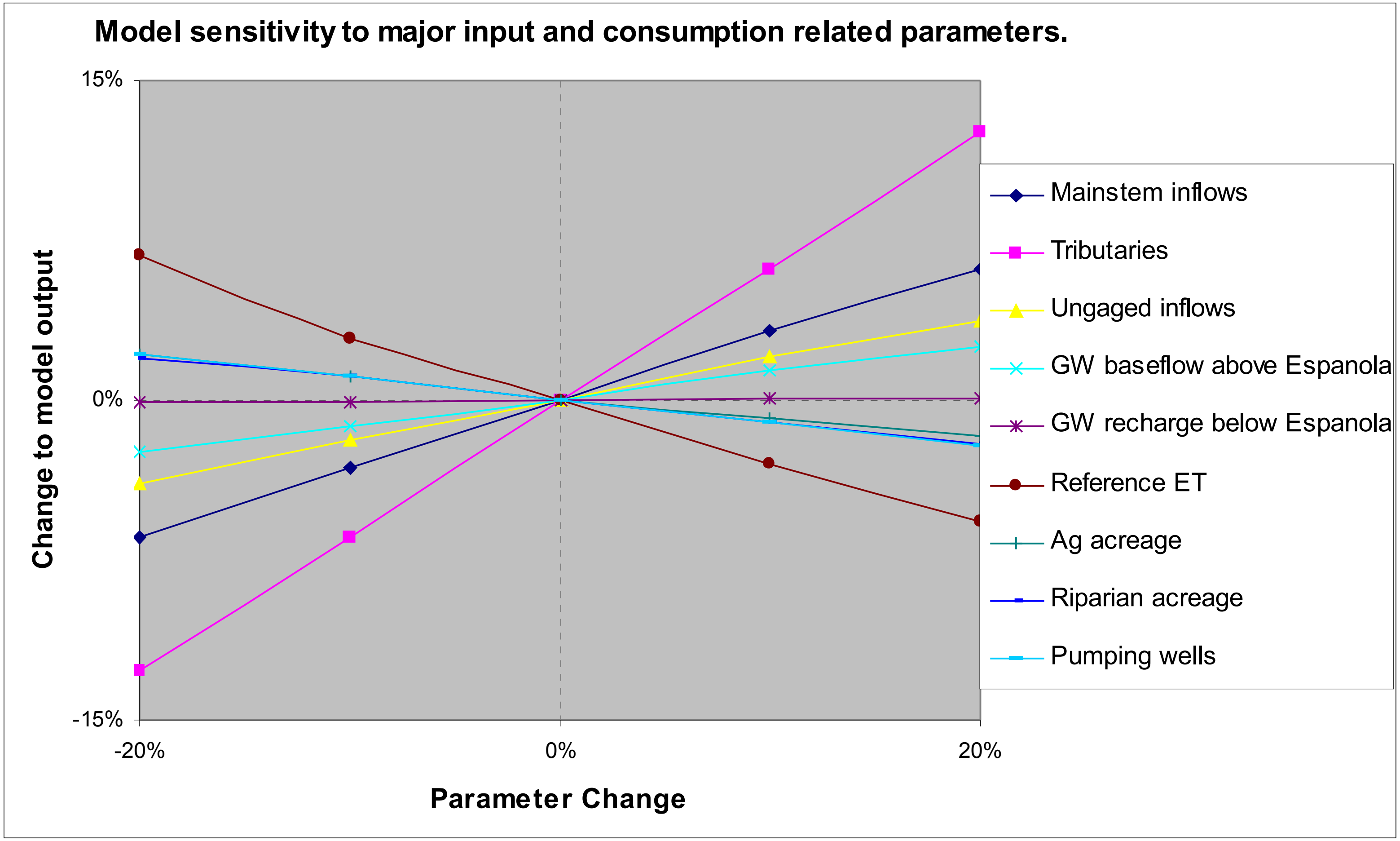
II. Runs quickly enough to be used in real time on a laptop

III. Includes user friendly graphic user interface

IV. URGSIM applications:
- Screening scenarios for further analysis with URGWOM
- Scoping level analysis
- Stakeholder outreach and education
- Rapid scenario analysis
- Climate change analysis

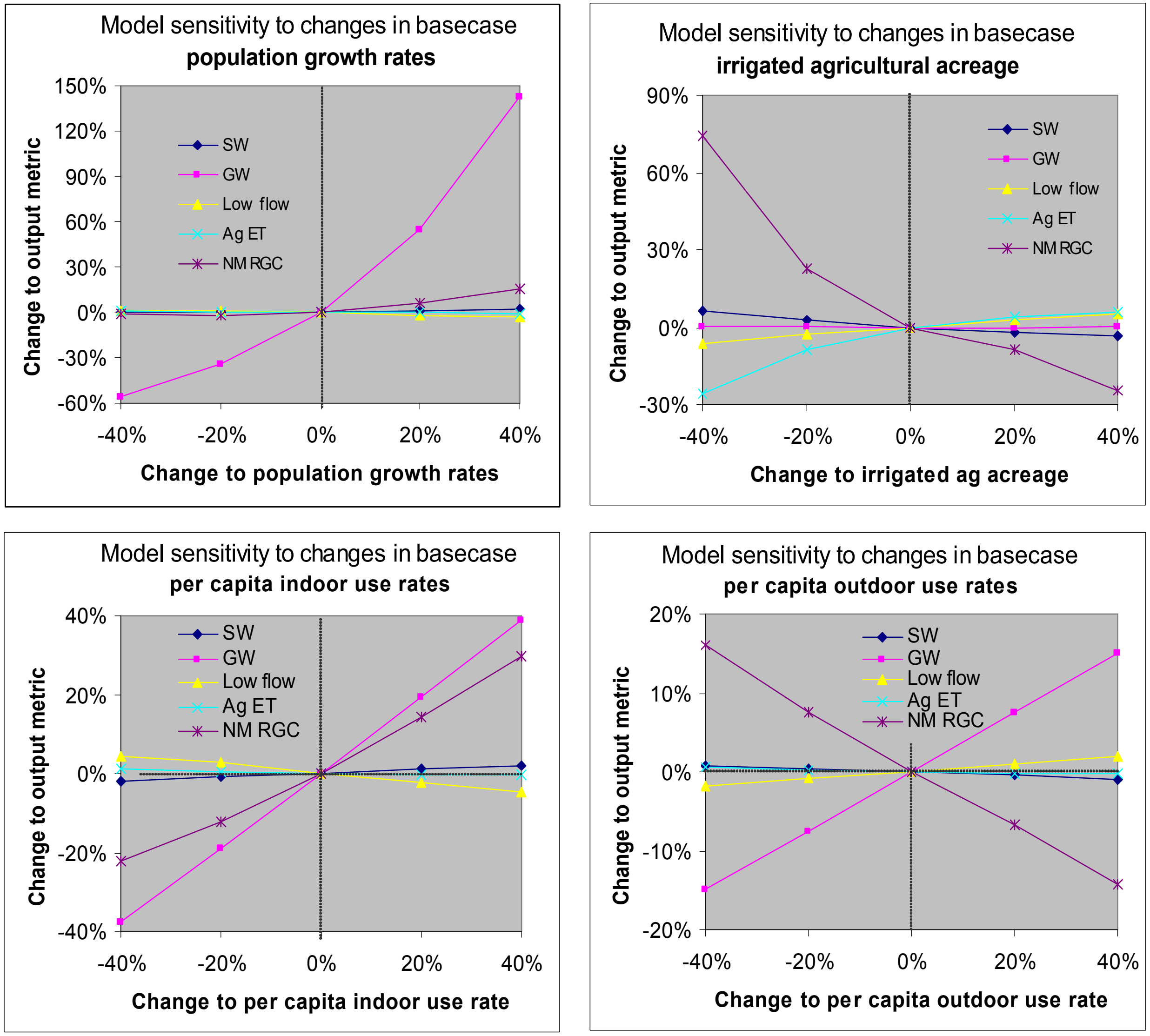
Questions?

Model results: physical model sensitivity



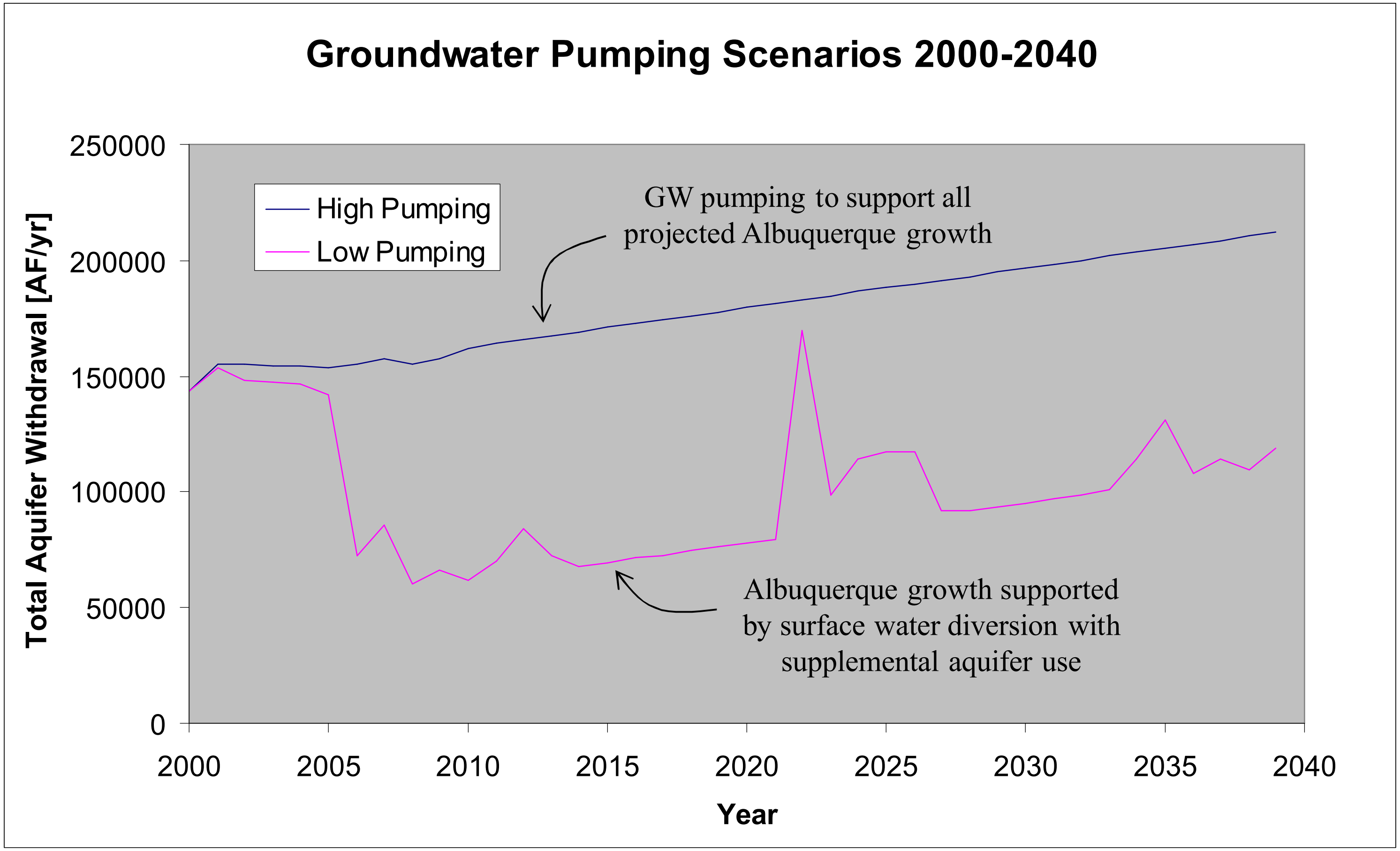
Mainstem inflows, tributaries, and ungaged inflows are all direct functions of surface water gages

Model results: sensitivity to policy related parameters



Robustness Analysis: 2000-2040

Compare spatially aggregated model performance to MODFLOW performance for two Albuquerque related groundwater use scenarios



Robustness Analysis Results

Comparison of results from two models: