Dynamic Statewide Water Budget for Water Planning in New Mexico

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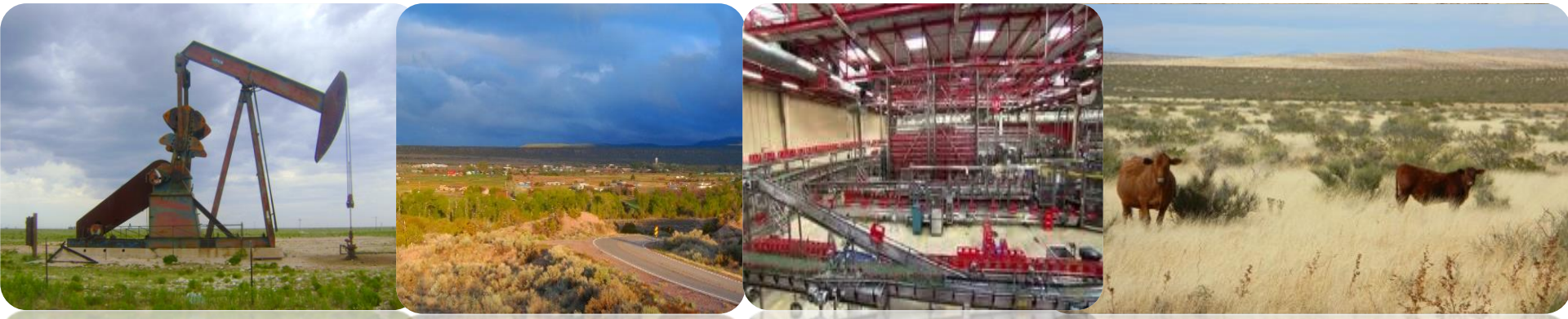
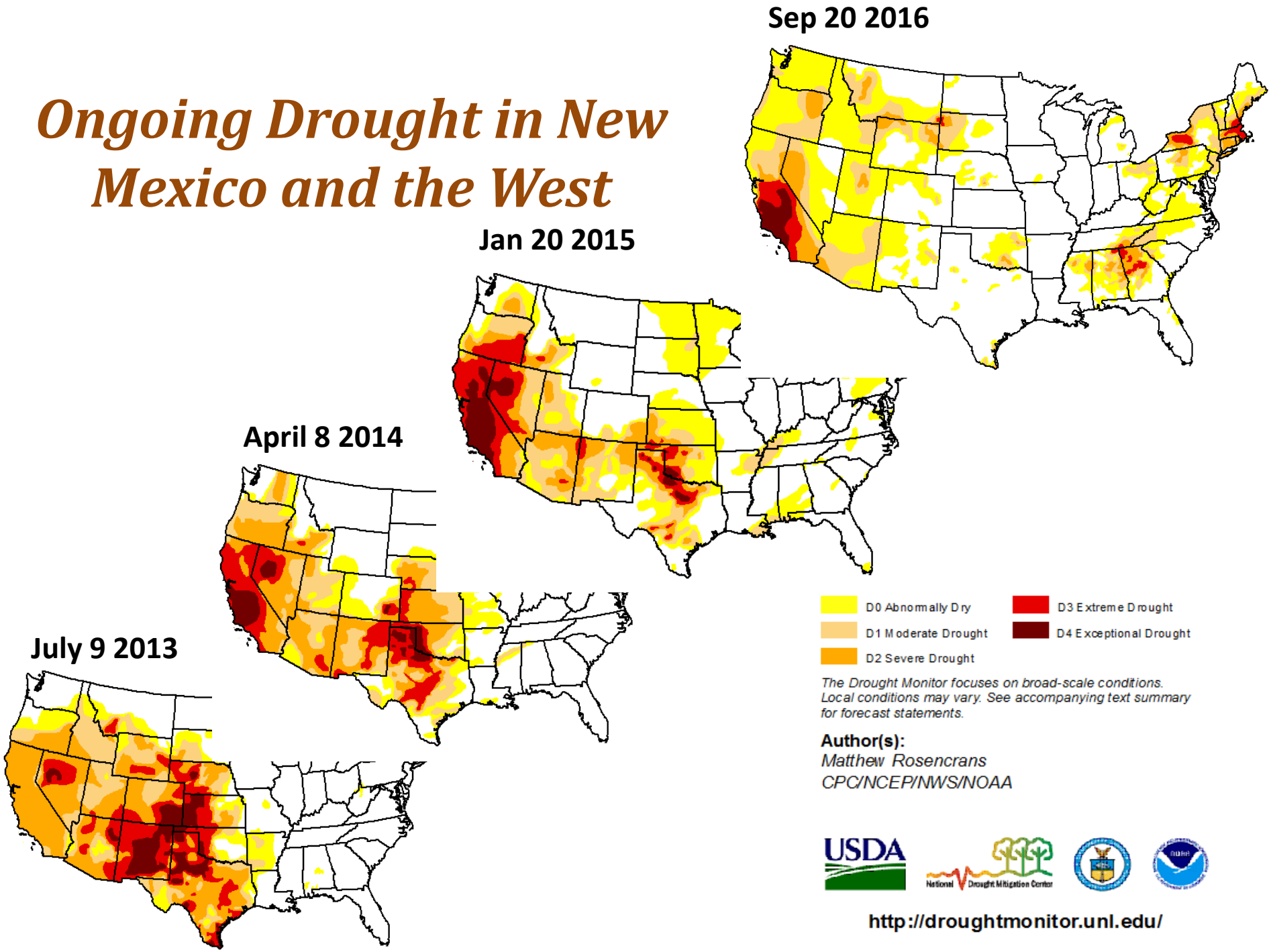
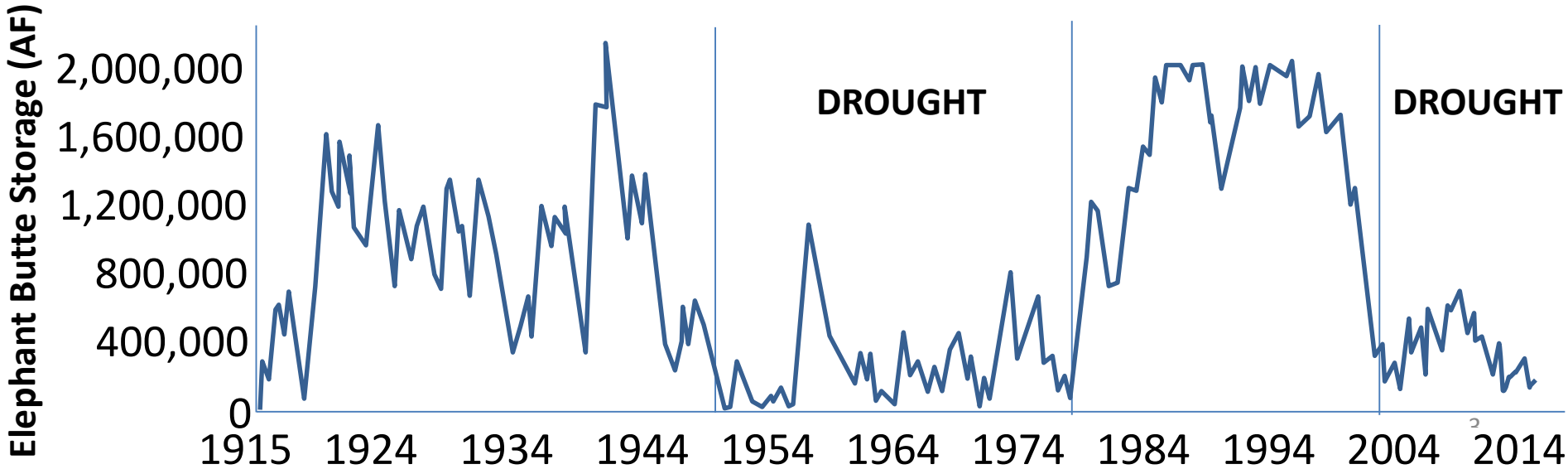
NM STATE UNIVERSITY



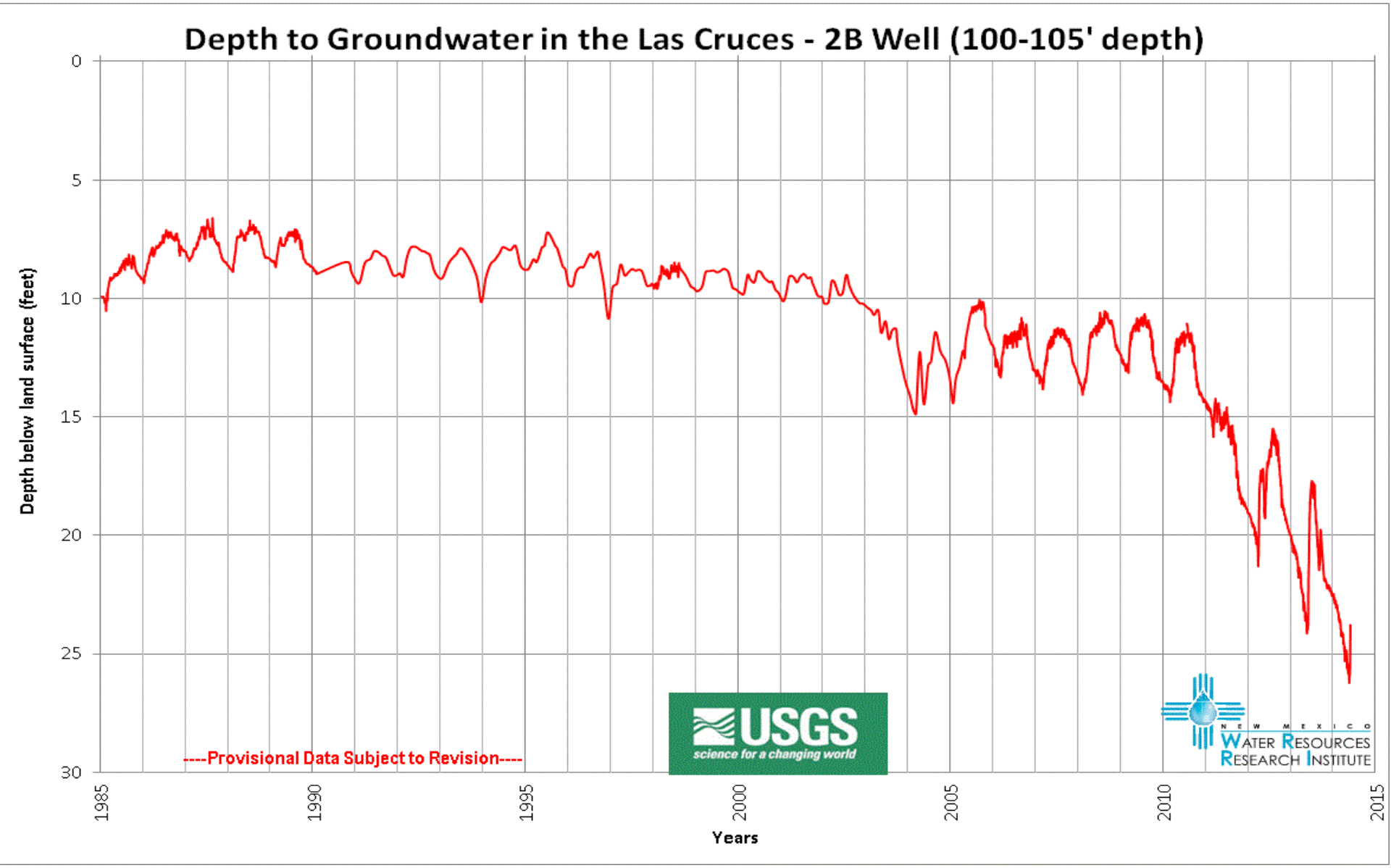
Ongoing Drought in New Mexico and the West



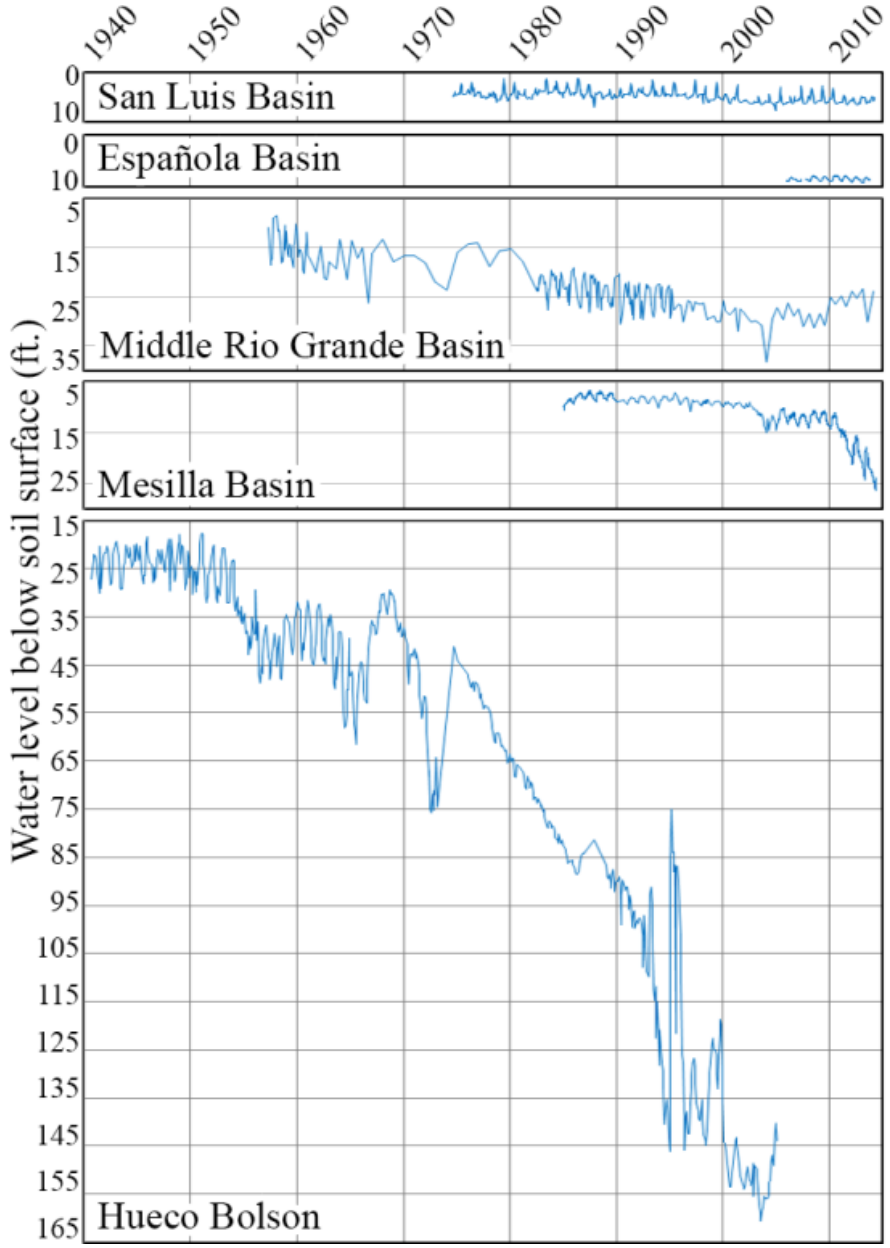
Surface supplies diminished by drought

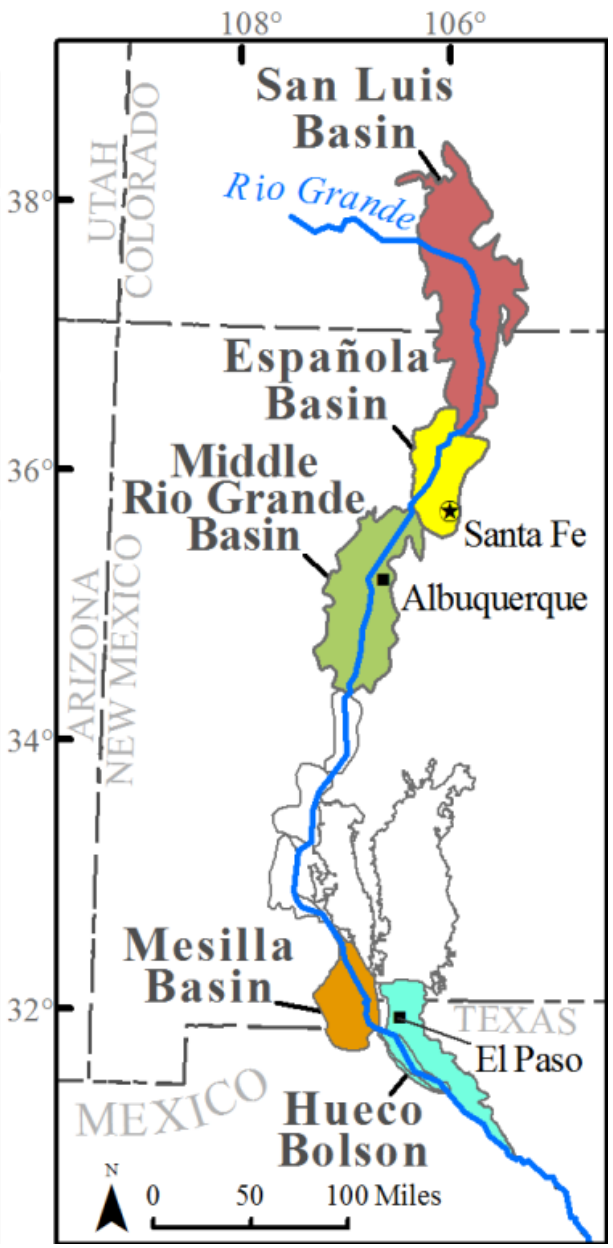


Groundwater drops with less surface water

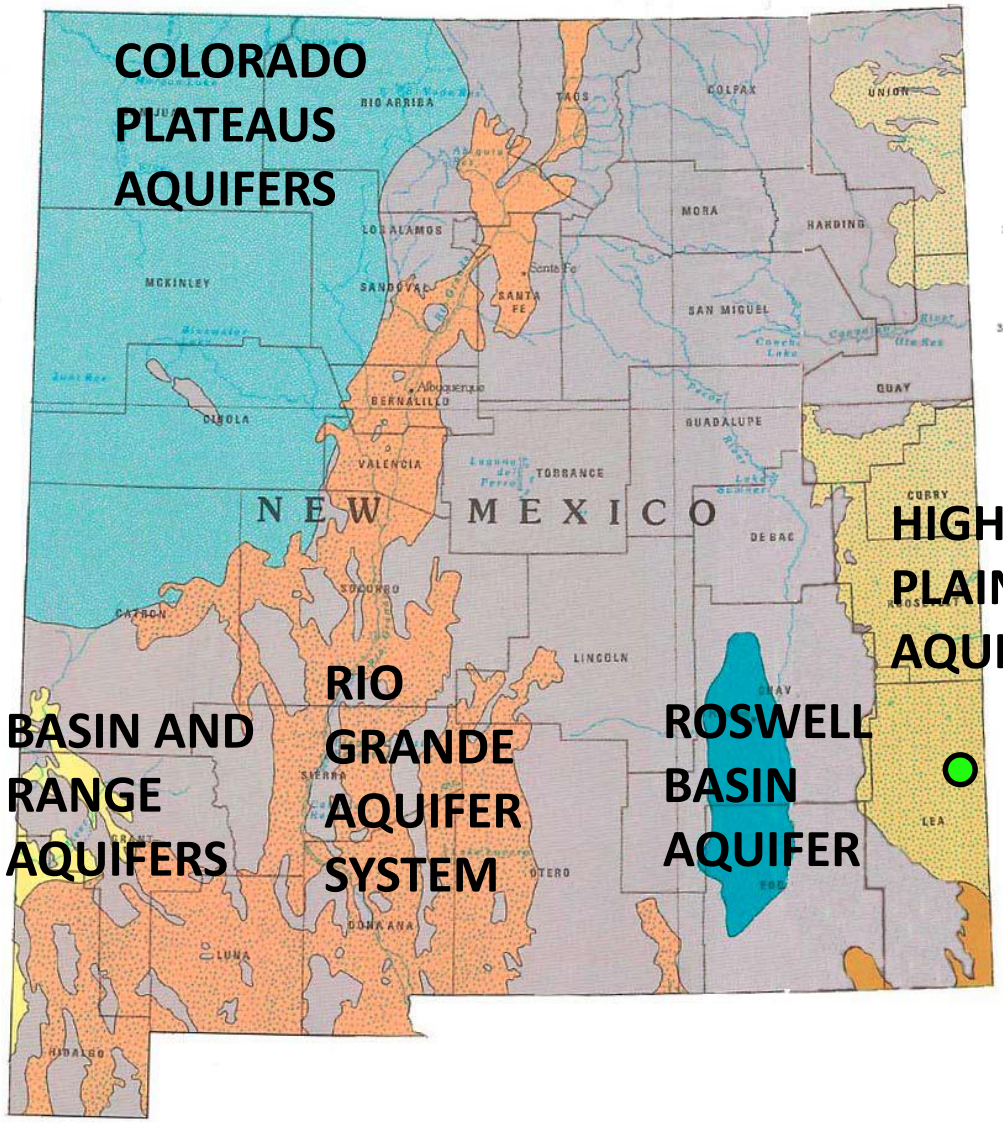


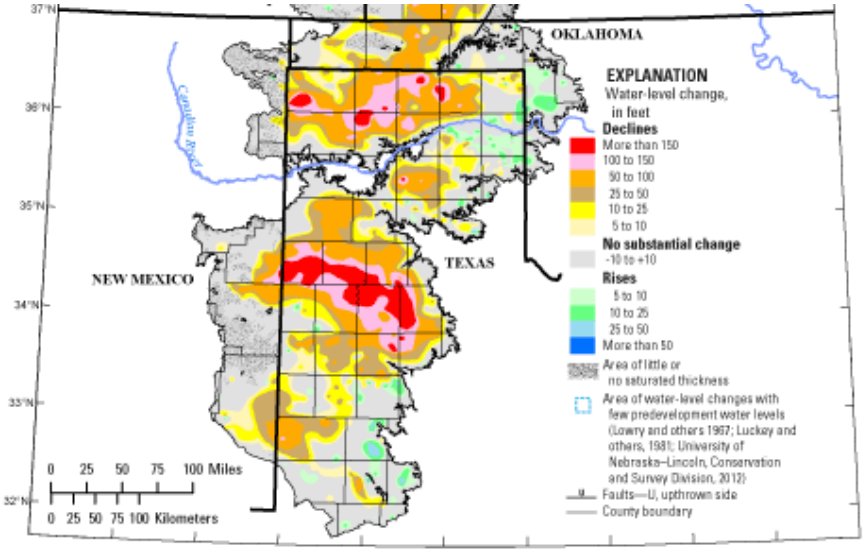
Surface water and groundwater imbalance



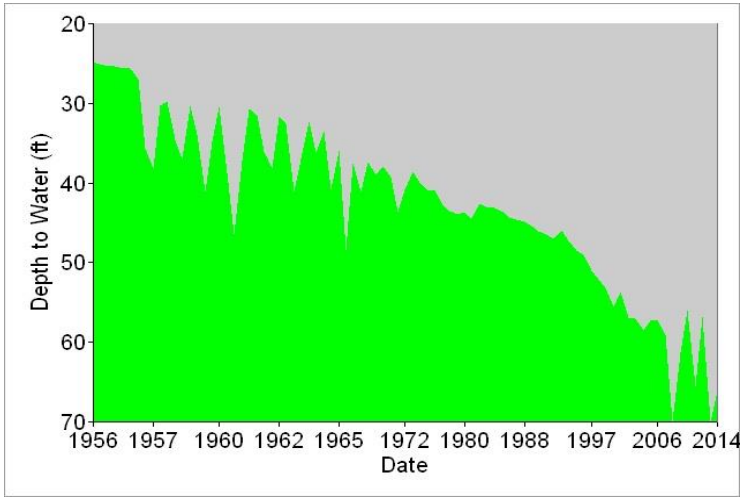


Fossil water aquifers face consistent declines

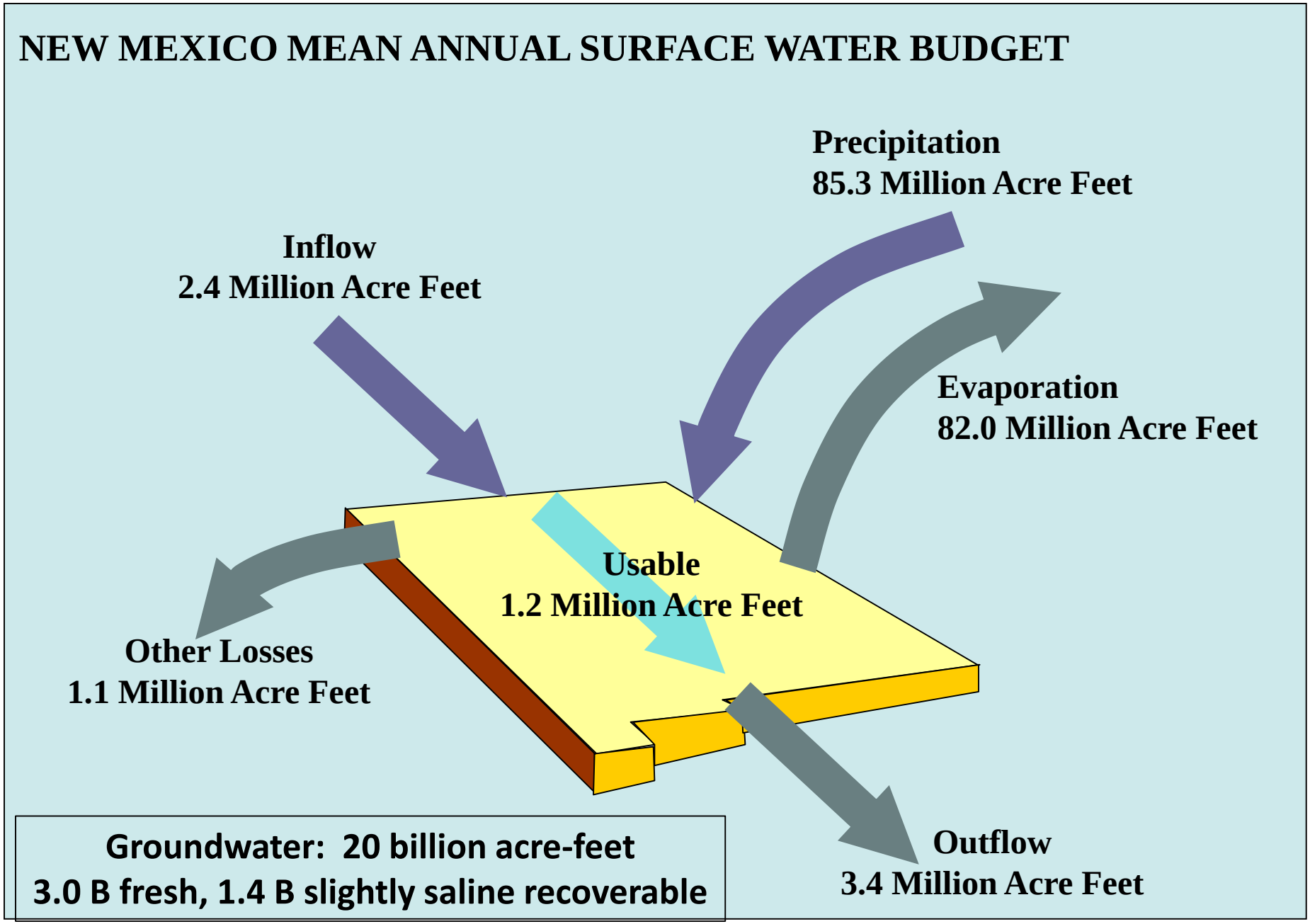




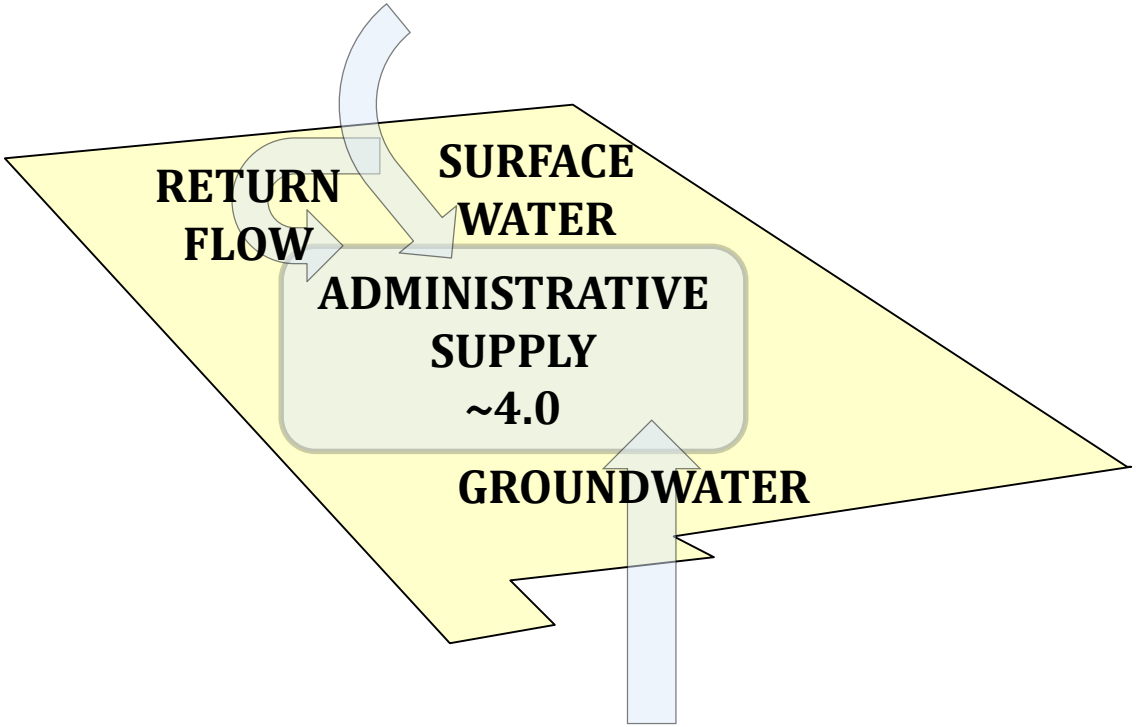
McGuire, V.L., 2013, Water-level and storage changes in the High Plains aquifer, predevelopment to 2011 and 2009–11: U.S. Geological Survey Scientific Investigations Report 2012–5291, 15 p.



Existing water budgets ~~are~~ were static and imprecise

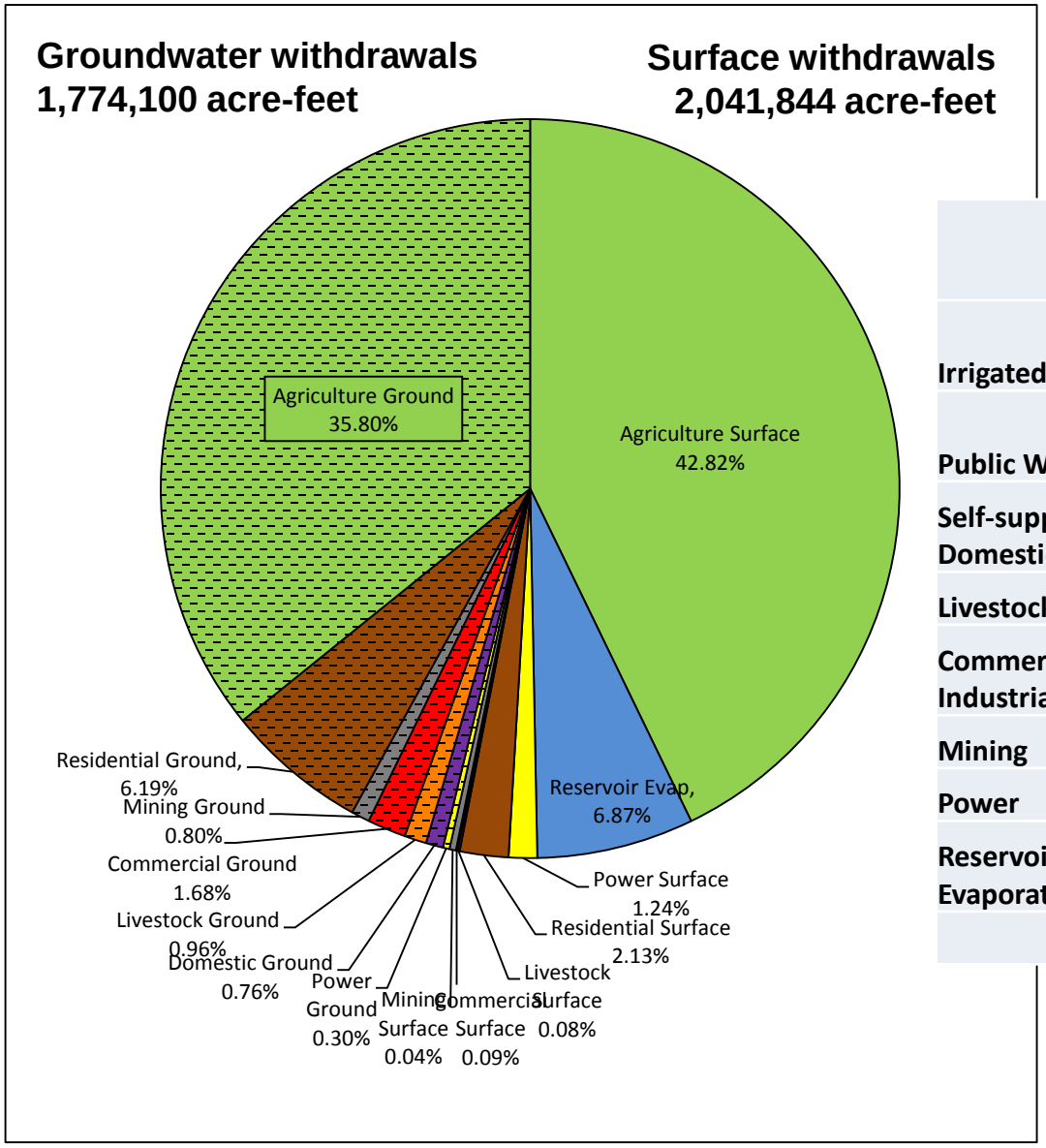


The administrative supply is well known



FLUXES IN MILLION ACRE FEET PER YEAR

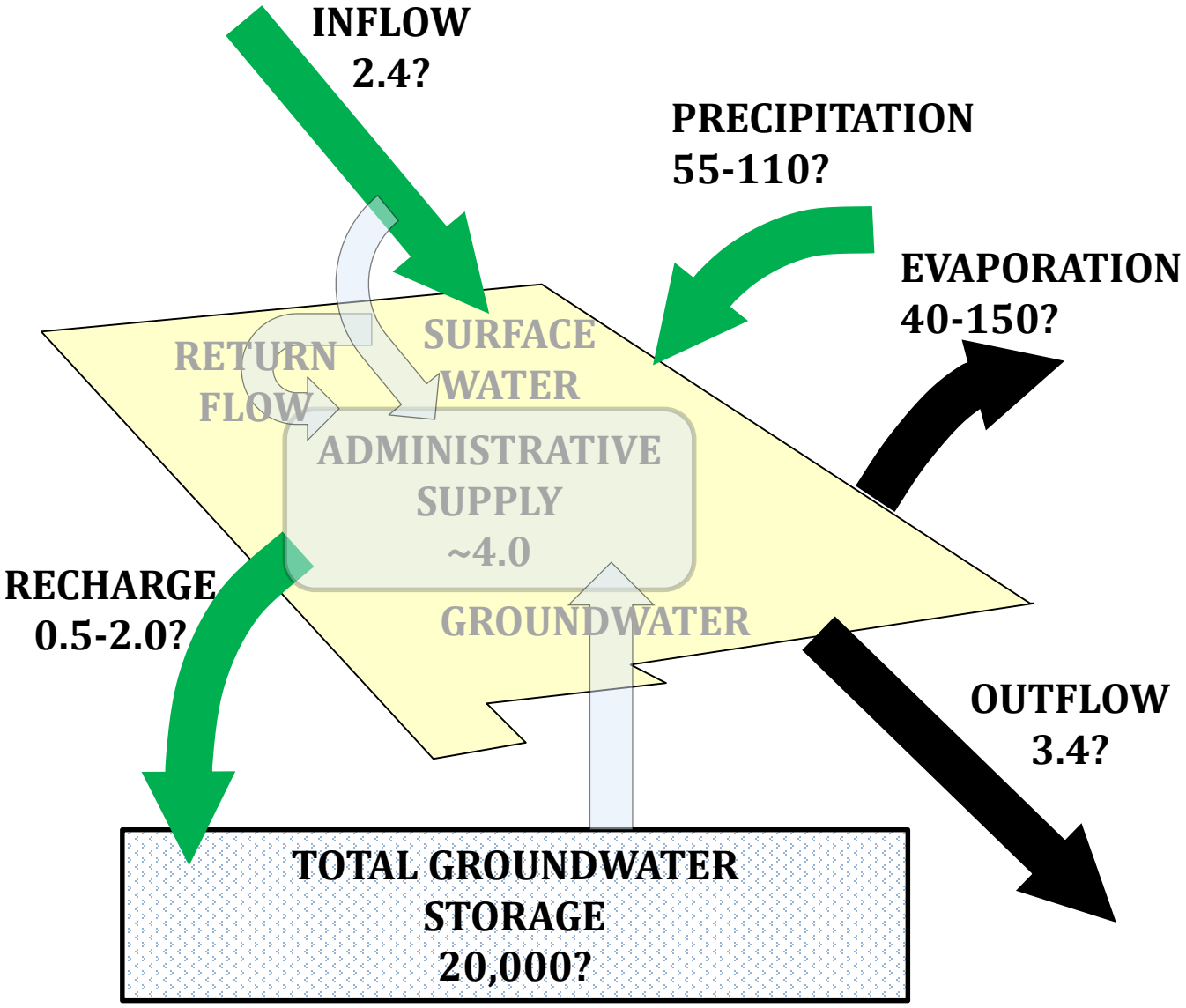
New Mexico Water Withdrawals - 2010 (percent of 3,815,944 total)



	Surface Water	Groundwater	Total Extraction	% Total
Irrigated Agriculture	1633940	1366215	3000155	78.62
Public Water Supply	81114	236296	317410	8.32
Self-supported Domestic	0	28952	28952	0.76
Livestock	3431	36749	40180	1.05
Commercial / Industrial	2864	64269	67133	1.76
Mining	10845	30714	41559	1.09
Power	47434	10905	58339	1.53
Reservoir Evaporation	262216	0	262216	6.87
	2041844	1774100	3815944	

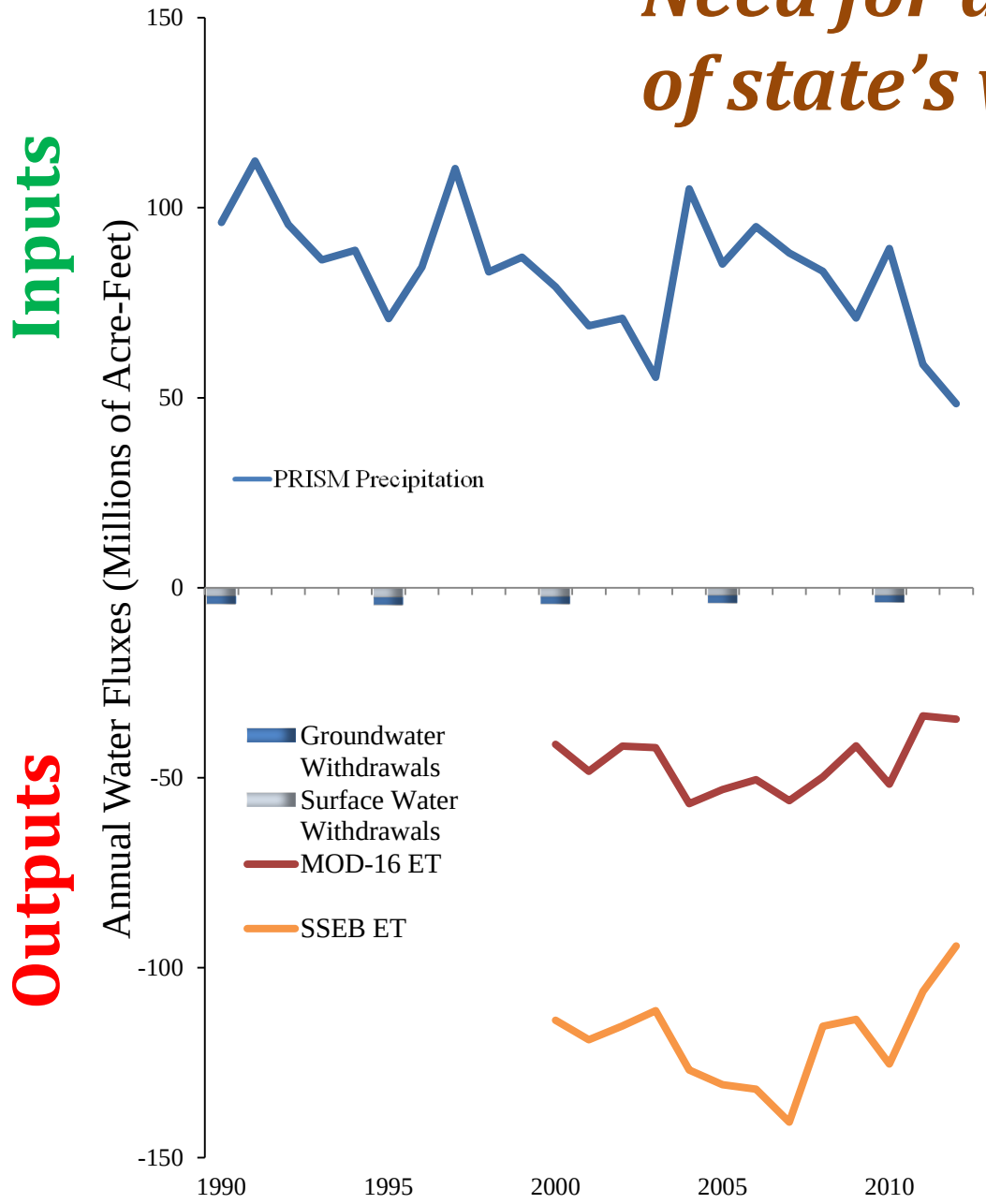
Longworth, et al. 2013. *New Mexico Water Use by Categories 2010*. NMOSE Technical Report 54.

Total supply is not well known



- Needed is a comprehensive assessment of New Mexico's water resources to provide a holistic view of New Mexico's water future

Need for dynamic assessment of state's water resources



- Precipitation is highly variable and greatly exceeds total water use
- Evapotranspiration (ET) consumes most of the precipitation in the state but model estimates are not yet accurate

Precipitation data courtesy of : PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu, created 5 May 2014

Water use data courtesy of : 90, 95, 00- Brian C. Wilson (NM OSE), 05, 10 John Longworth et al (NM OSE) accessed from http://www.ose.state.nm.us/publications_technical_reports_wateruse.html accessed on 15 May 2014

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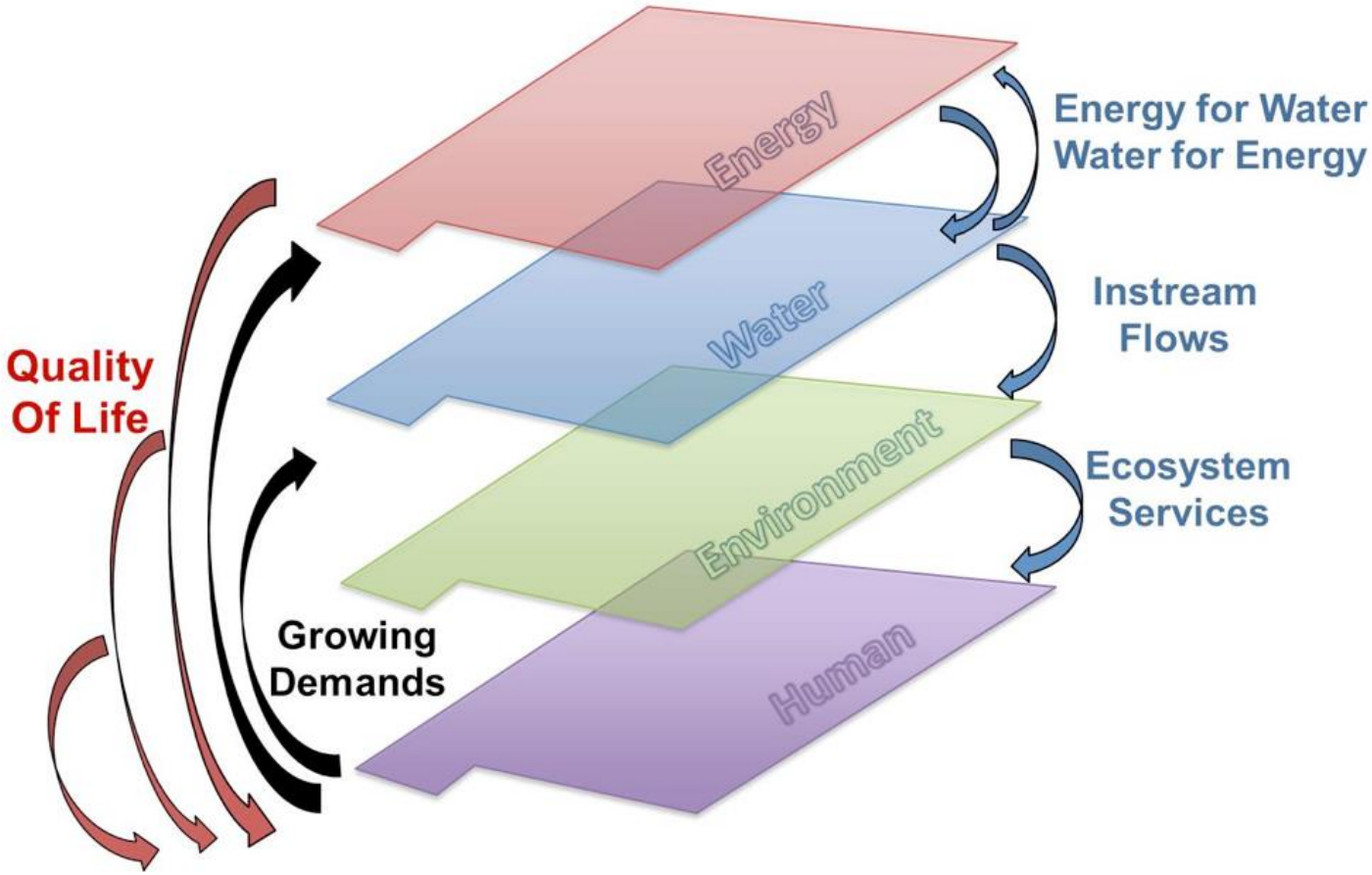
Cutting edge aspects of statewide water budget

- Dynamic – updated within one or two years
- Comprehensive – includes water inputs and outputs
- Accessible – web delivered
- Science based – utilizing latest information

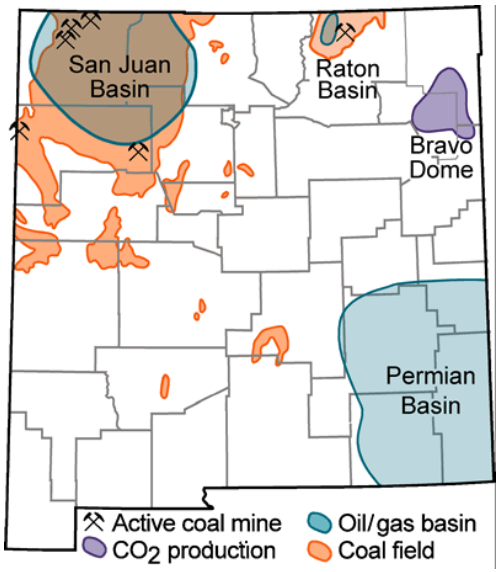
NSF NM EPSCOR - Social Natural Science Nexus

Objective: Develop a statewide system dynamics model that integrates energy, water, the environment, and human perspectives



Social Natural Science Nexus

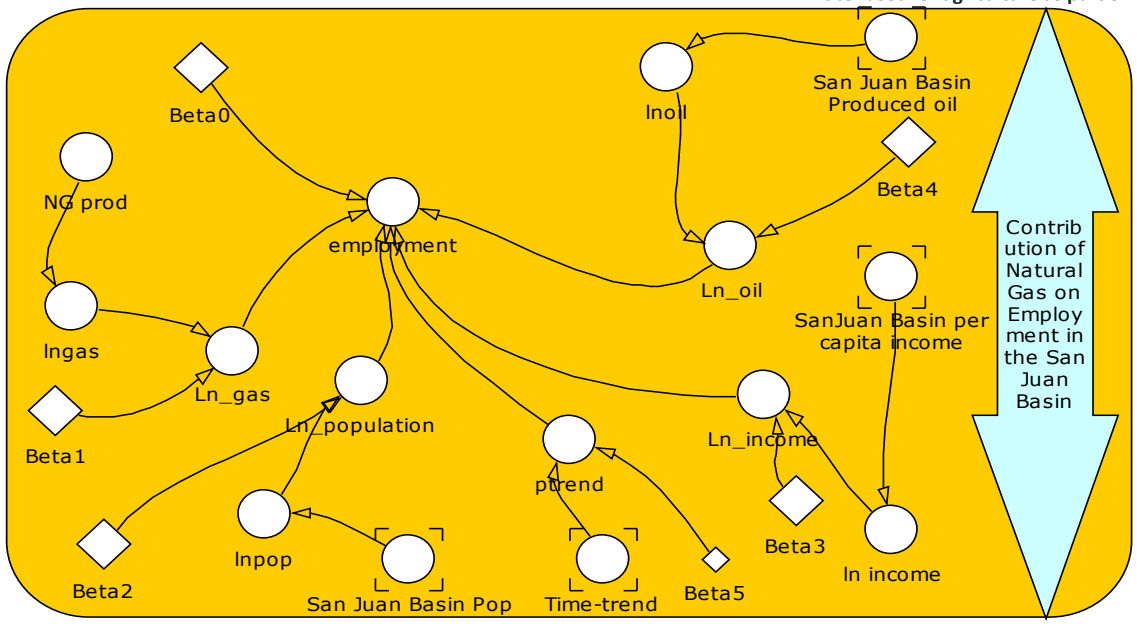
Approach: Build statewide water budget and use as a framework for integrating energy, water, environment, human perspectives



Fossil fuels

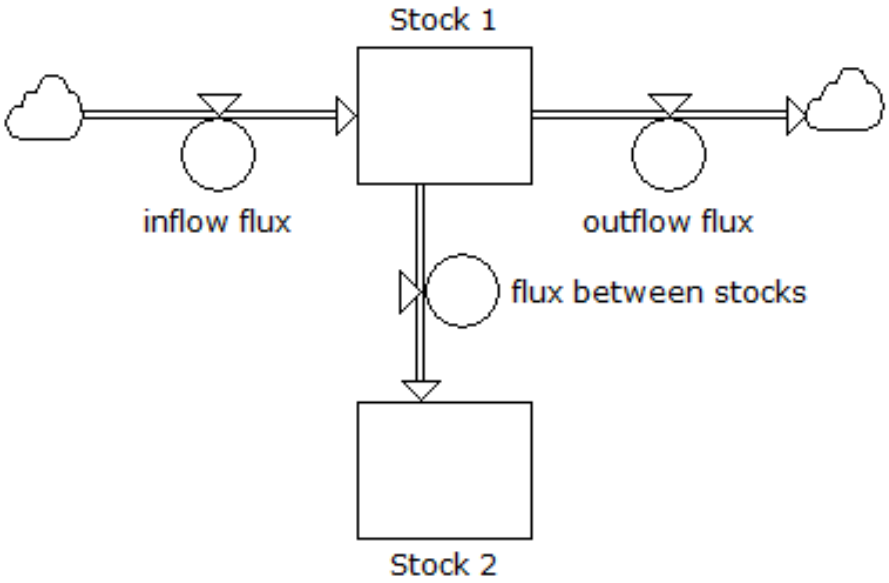
Solar to represent renewables

Water used for agriculture as part of water budget



Systems approach integrating energy and socio economics

Systems dynamics modeling



- Systems dynamics is an approach to model complex systems over time using stocks, fluxes, internal feedbacks and time delays
- Stocks represent storages
- Fluxes represent movement into, out of, or between stocks or external sources
- System dynamics is well suited for accounting- or budget-type models

Collaboration for Dynamic Statewide Water Budget

New Mexico Water Resources Research Institute

New Mexico EPSCoR

NSF

Remotely Sensed Evapotranspiration and Precipitation Assessment

New Mexico Water Resources Research Institute

New Mexico Tech

Oil and Gas Produced Water Assessment

Office of the State Engineer / Interstate Stream Commission

Petroleum Recovery Research Center

Statewide Systems Dynamics Water Budget

Tetra Tech

Sandia National Laboratories

NM State University

UNM

New Mexico Water Resources Research Institute

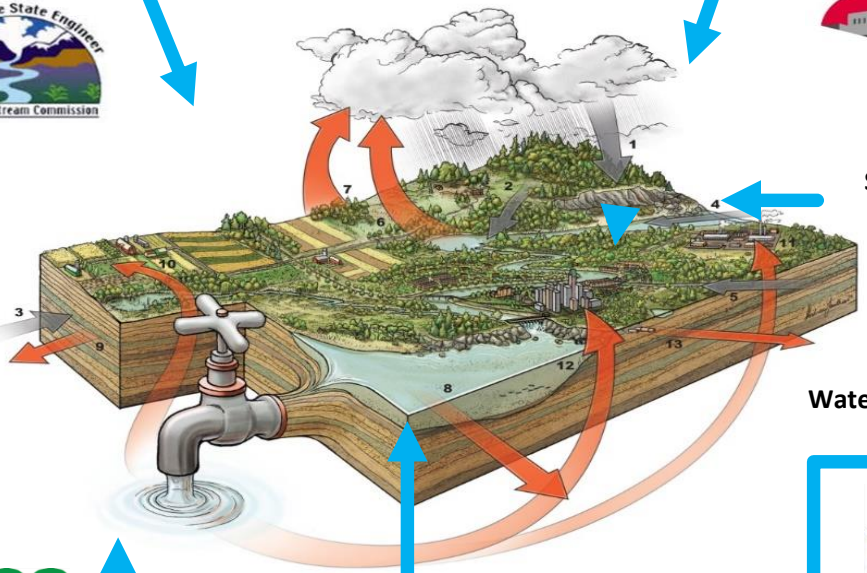
Groundwater Recharge Assessment

New Mexico Tech

Office of the State Engineer / Interstate Stream Commission

USGS science for a changing world

Groundwater Level and Storage Changes



Surface Water Flow Statistics

USGS science for a changing world

Water Use Reporting

New Mexico Bureau of Geology and Mineral Resources, New Mexico Tech, Earth Science for the 21st Century

NM State University

Office of the State Engineer / Interstate Stream Commission

USGS science for a changing world

Office of the State Engineer / Interstate Stream Commission

New Mexico Dynamic Statewide Water Budget

The dynamic, statewide water budget (DSWB) synthesizes water supply and demand information from across the state into a single, easily accessible location, and in such a way that users can view information at a variety of spatial scales. The DSWB provides a holistic view of water resources in the state, helping to support local and regional education as well as planning, to improve stewardship of New Mexico's limited and critically important water resources.

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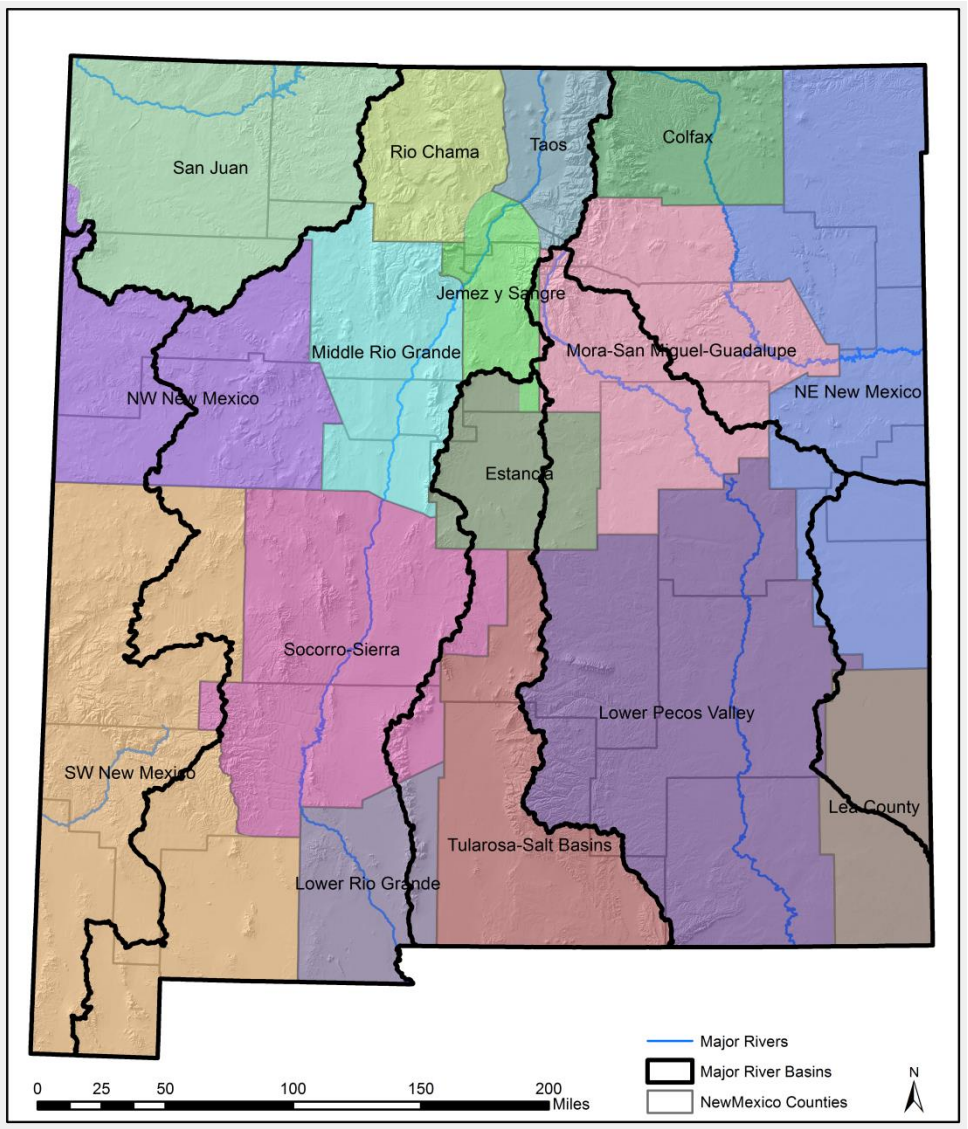
DSWB spatial scales



- 7 Major River Basins
  (black Lines)
- 16 Water Planning Regions
  (colored areas)
- 33 Counties
  (thin grey lines)

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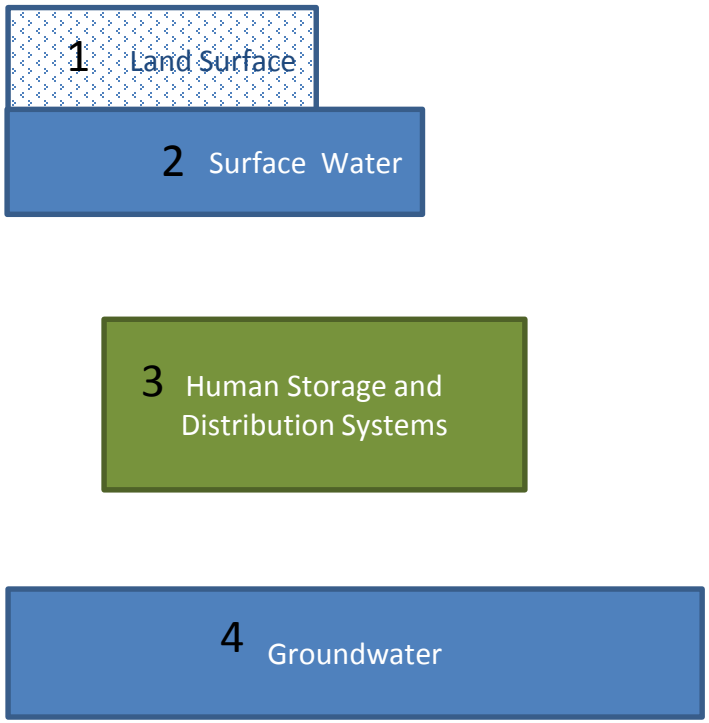
NMDSWB Mass Balance Stocks



1. **Land Surface-** Conceptual representation of soil moisture. The storage in this stock is currently not estimated and changes in storage are assumed to be zero
2. **Surface Water-** Water flowing in rivers and other natural water ways that can be diverted or impounded for human use. No change in storage through time. At each timestep, the fluxes into and out of this stock are balanced.
3. **Human Storage and Distribution Systems-** Water at any given time residing in manmade storage impoundments or distribution systems, such as public water supplies, irrigation canals, and reservoirs. When water is added to storage in a reservoir, it is considered a diversion of available surface water to the human storage system, and when it is released from storage, it is considered a return to the available surface water system.
4. **Groundwater-** Total groundwater storage is largely unknown except for select aquifers throughout the state. Currently the DSWB does not estimate groundwater storage, but it does track changes in storage over the selected time of a model run.

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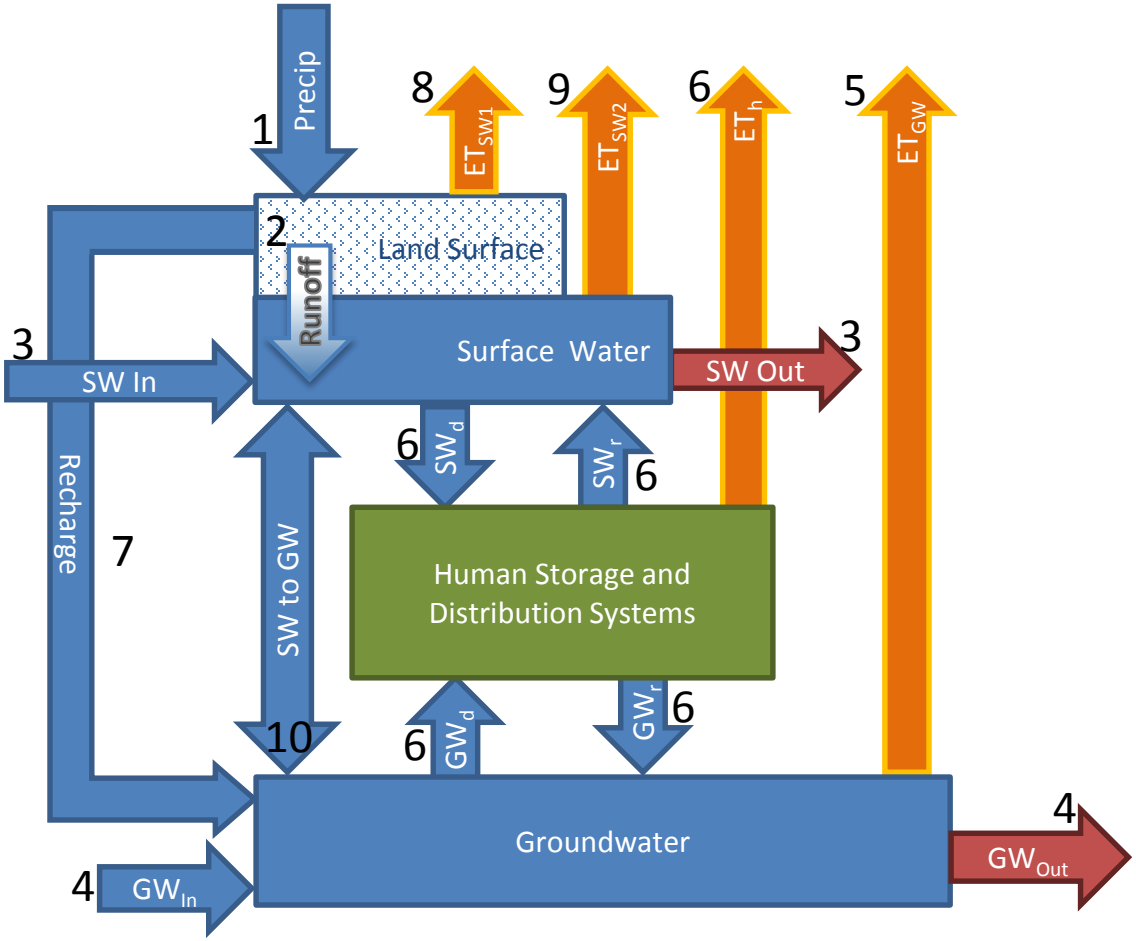
NMDSWB Mass Balance Fluxes



1. **Precipitation**- Monthly PRSIM data aggregated for given spatial scale
2. **Runoff**- Closure term to balance SW stock
3. **Sw_{in}/Sw_{out}**- USGS stream gage data
4. **Gw_{in}/Gw_{out}**- Presently unknown terms. Set to zero to allow for calculation of GW storage chage
5. **ET_{GW}**- Calculation based from USGS NLCD and Hargreaves reference ET estimate
6. **Human use**- Modeled/ data based human/diversions/consumption/ estimated return flows
7. **Recharge**- Model assumes steady state GW system on all non-human terms. Recharge = baseflow + ET_{gw} + GW_{out} – GWin
8. **Landsurface ET**- Closure term to balance Land Surface. Landsurface ET = Precip – Recharge - Runoff
9. **ET_{SW}**- Calculation based ET_{sw2} + estimated ungaged SW return flows
10. **SW to GW**- Closure term to balance Surface Water System

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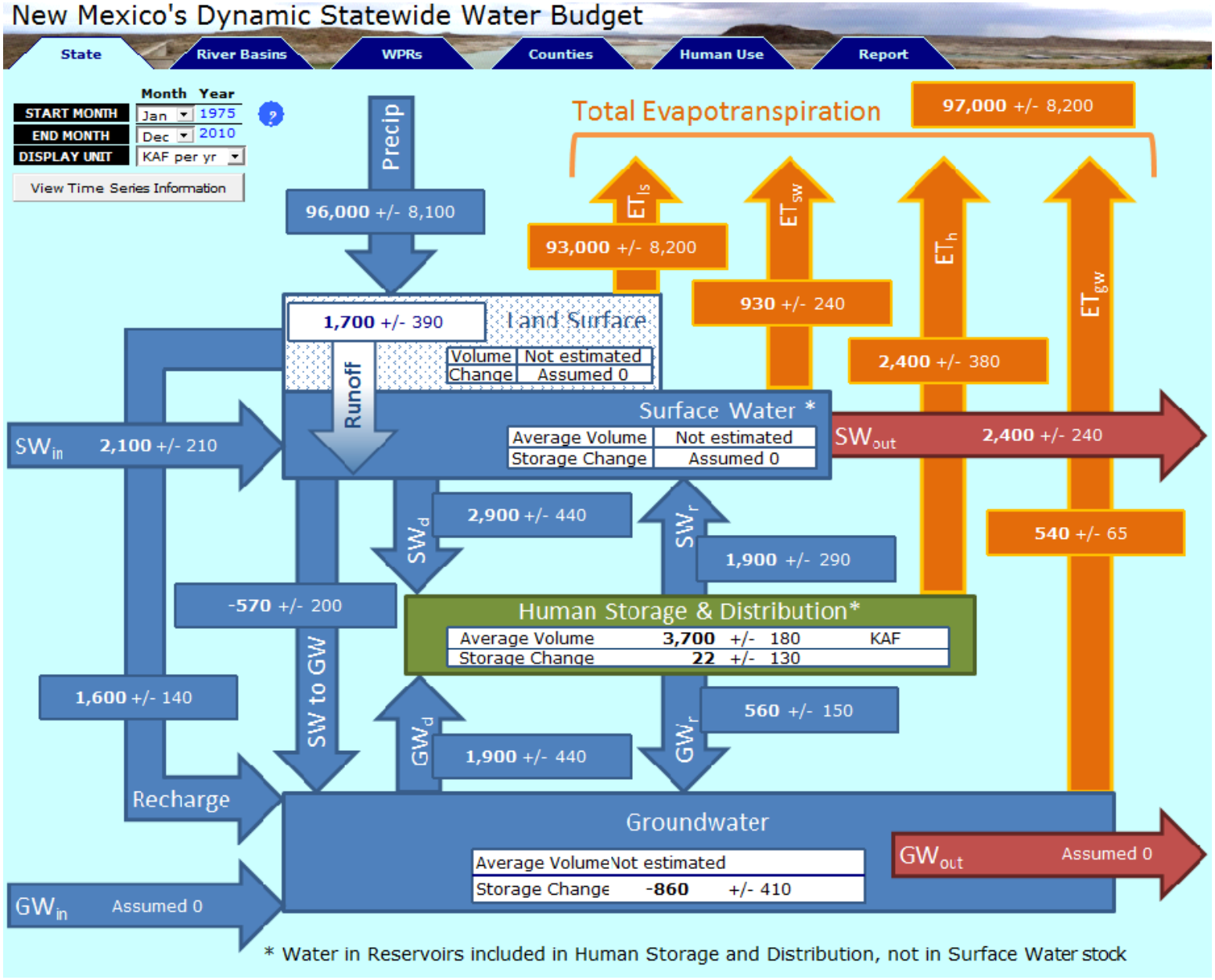
NMDSWB Interface



Mass Balance

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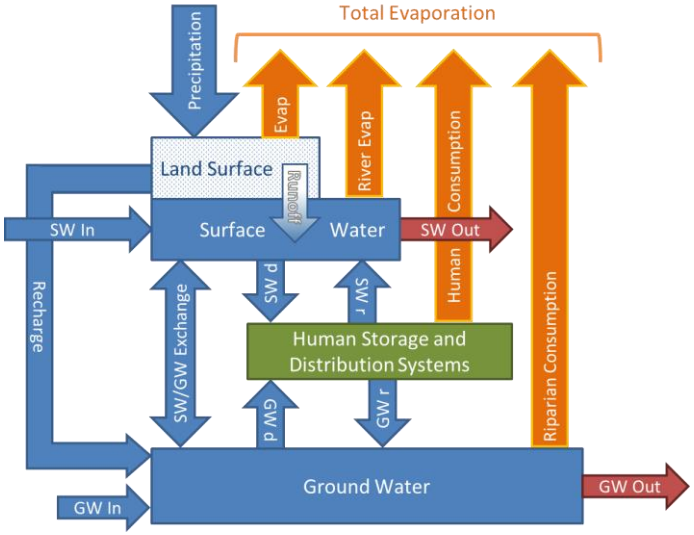
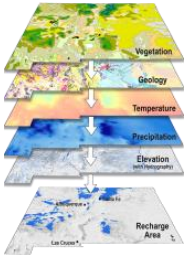
NM statewide water assessment projects

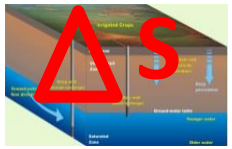


DSWB

Precipitation /ET



Recharge



Groundwater Change

Streamflow

http://nmwrri.nmsu.edu/?page_id=3547

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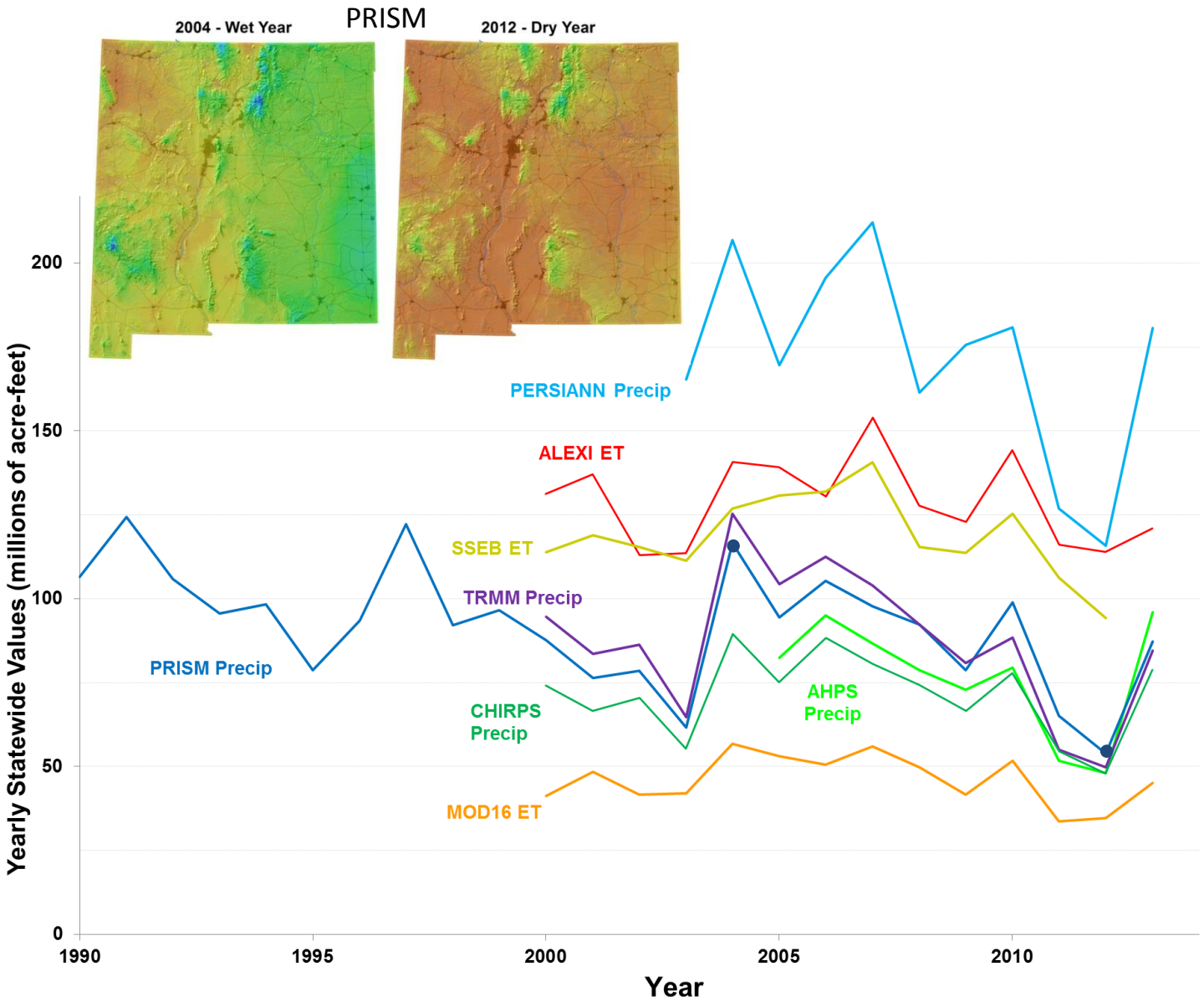
NM statewide remotely sensed precipitation and evapotranspiration measurements



- Precipitation and ET are the largest components of the water balance, yet they are the least accurately measured
- Validate models using land-based measurements to determine most accurate models for future use in New Mexico

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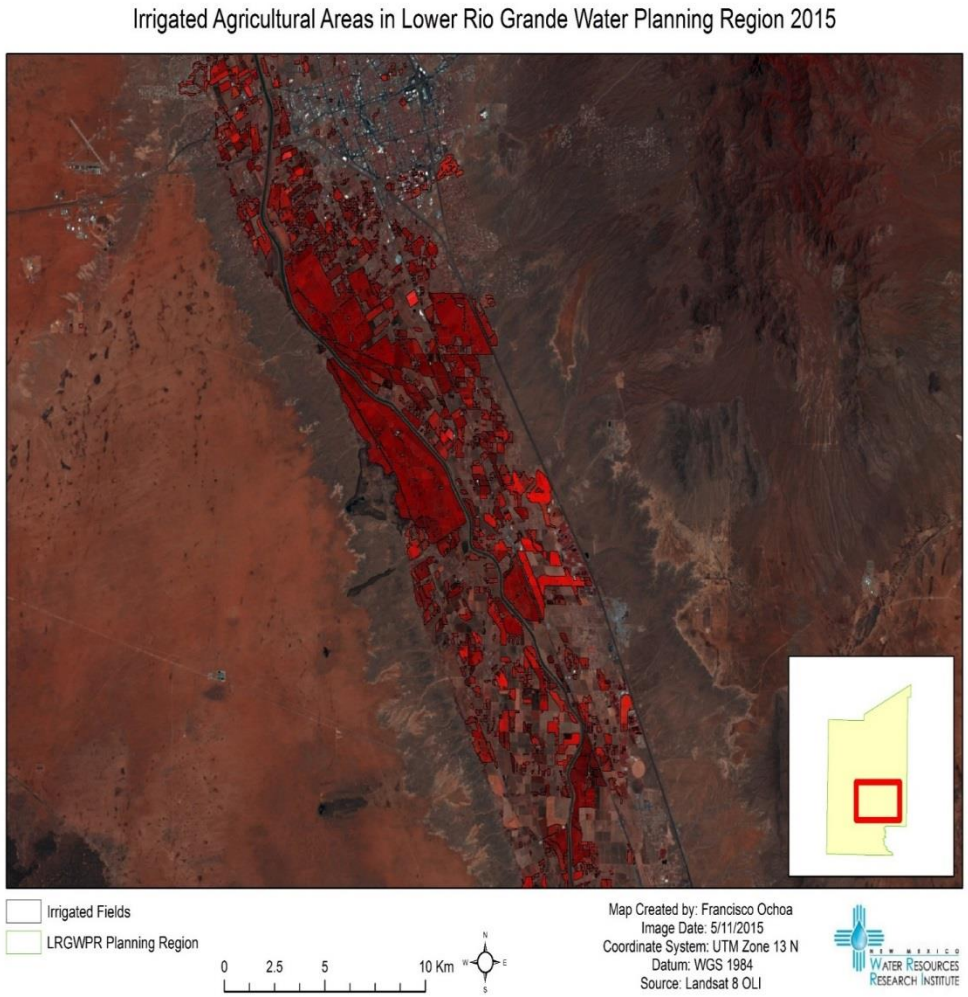
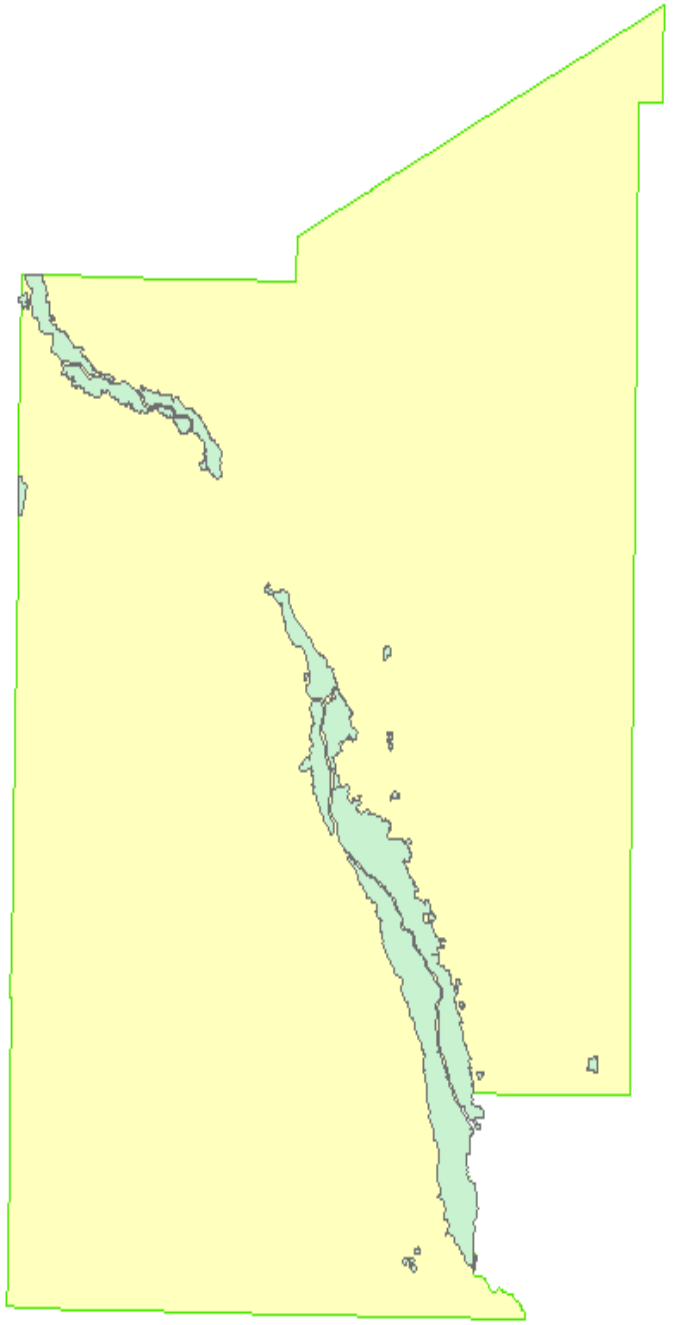
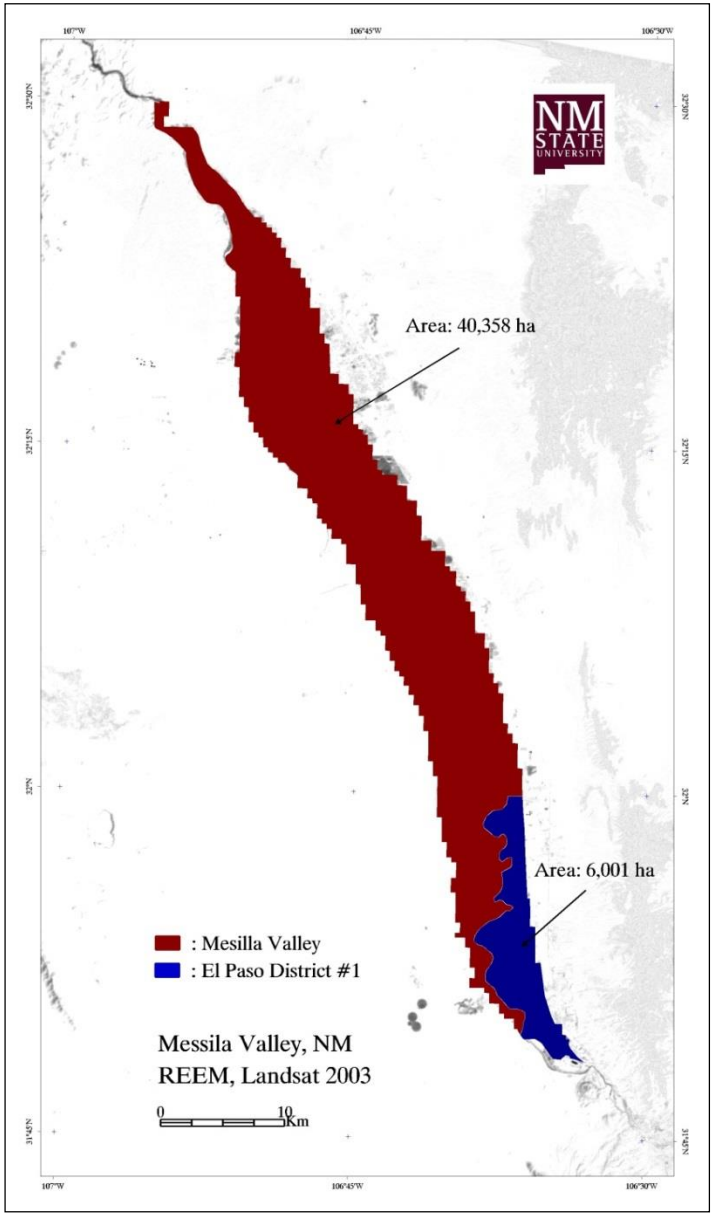
Mask irrigated landscape

Landsat 8 Imagery

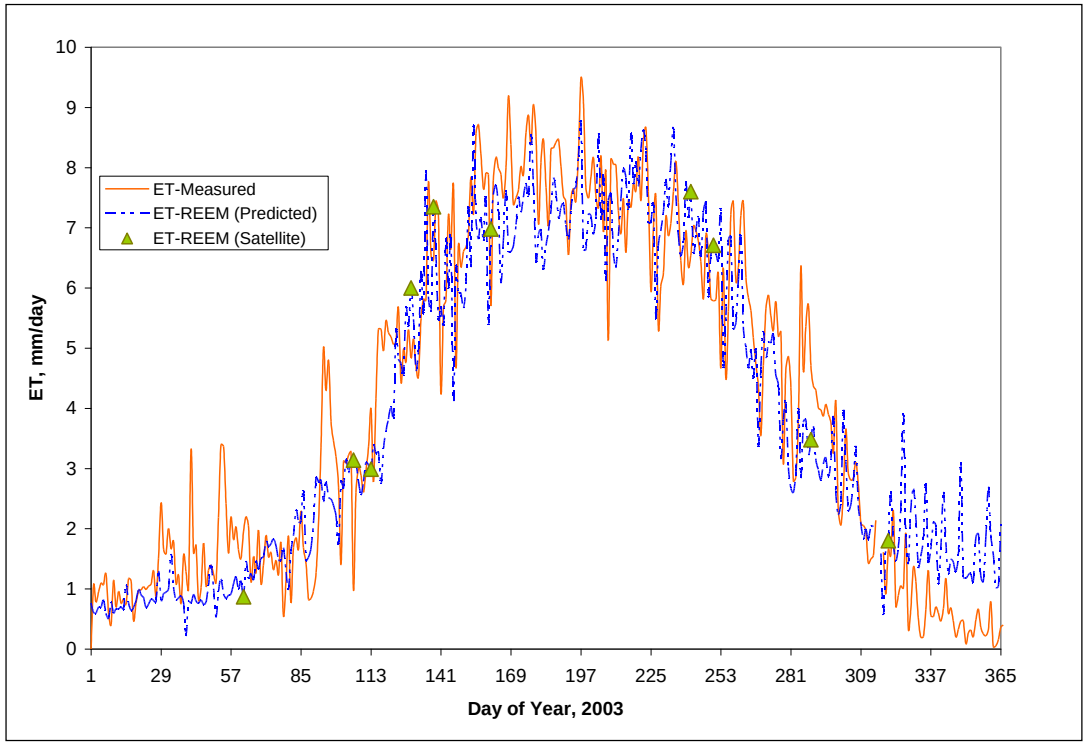
Convert Digital Numbers to Top of the Atmosphere Reflectance



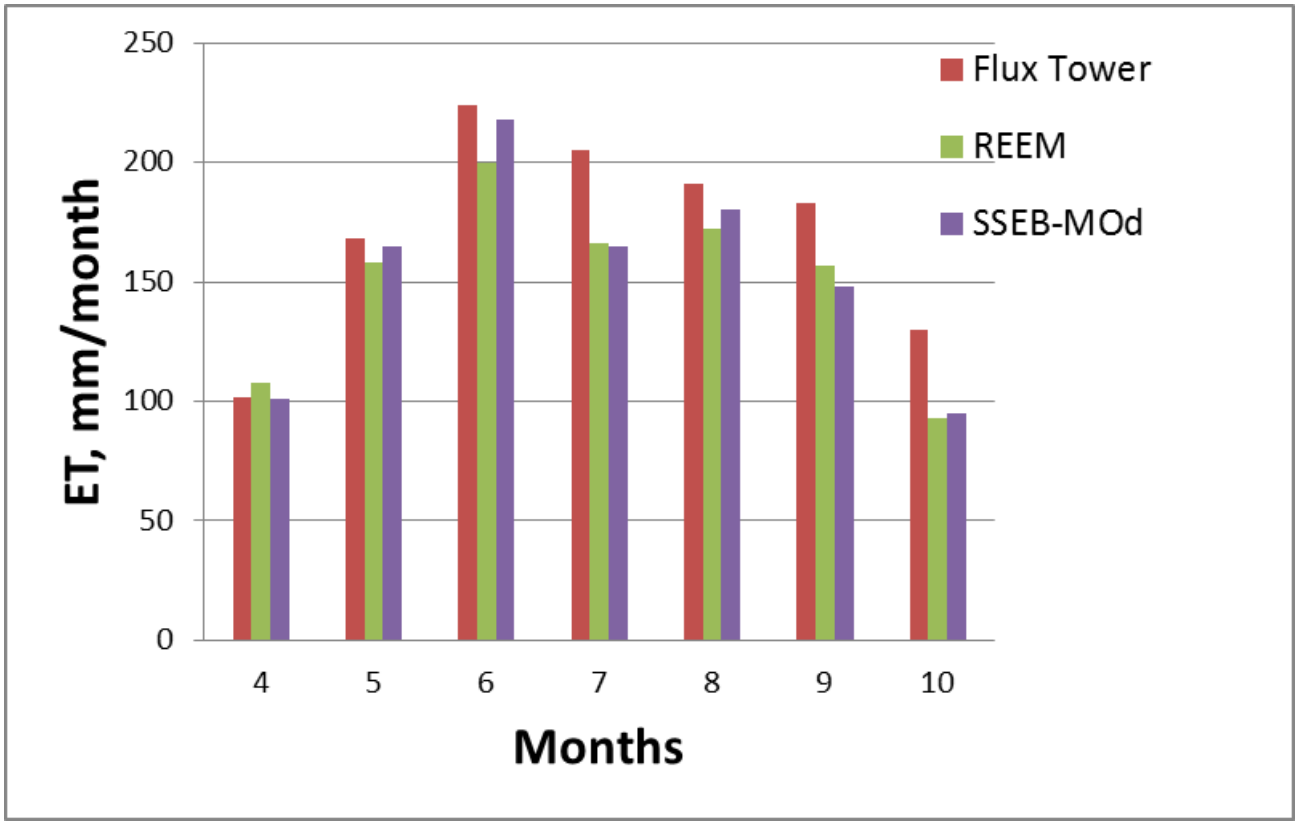




Validation of REEM ET with Satellite and Flux Tower Data



Comparison of ET estimates for Pecans in Mesilla Valley From Remote Sensing, using three different methods

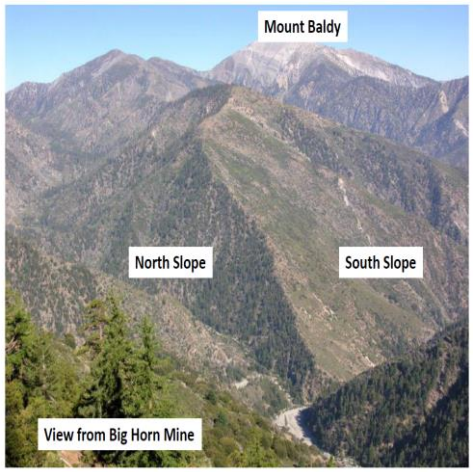


GADGET

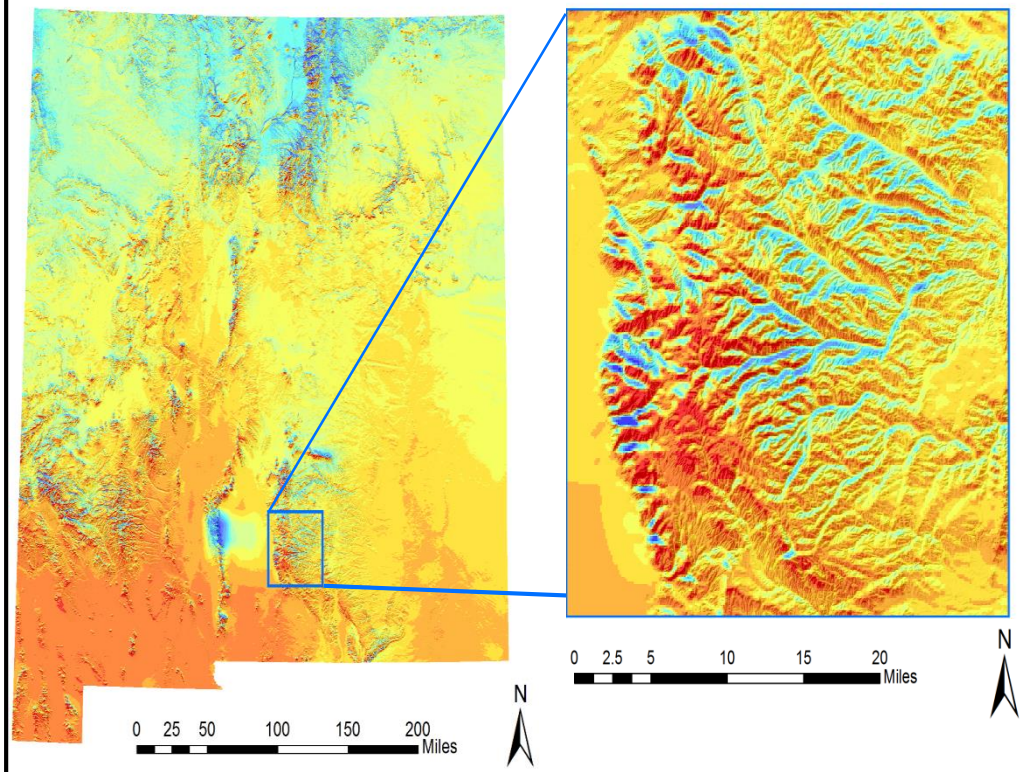
Gridded Atmospheric Data DownscalinG and Evapotranspiration Tools for High-resolution Distributed Reference ET in Complex Terrain

Solar radiation topography-based adjustments

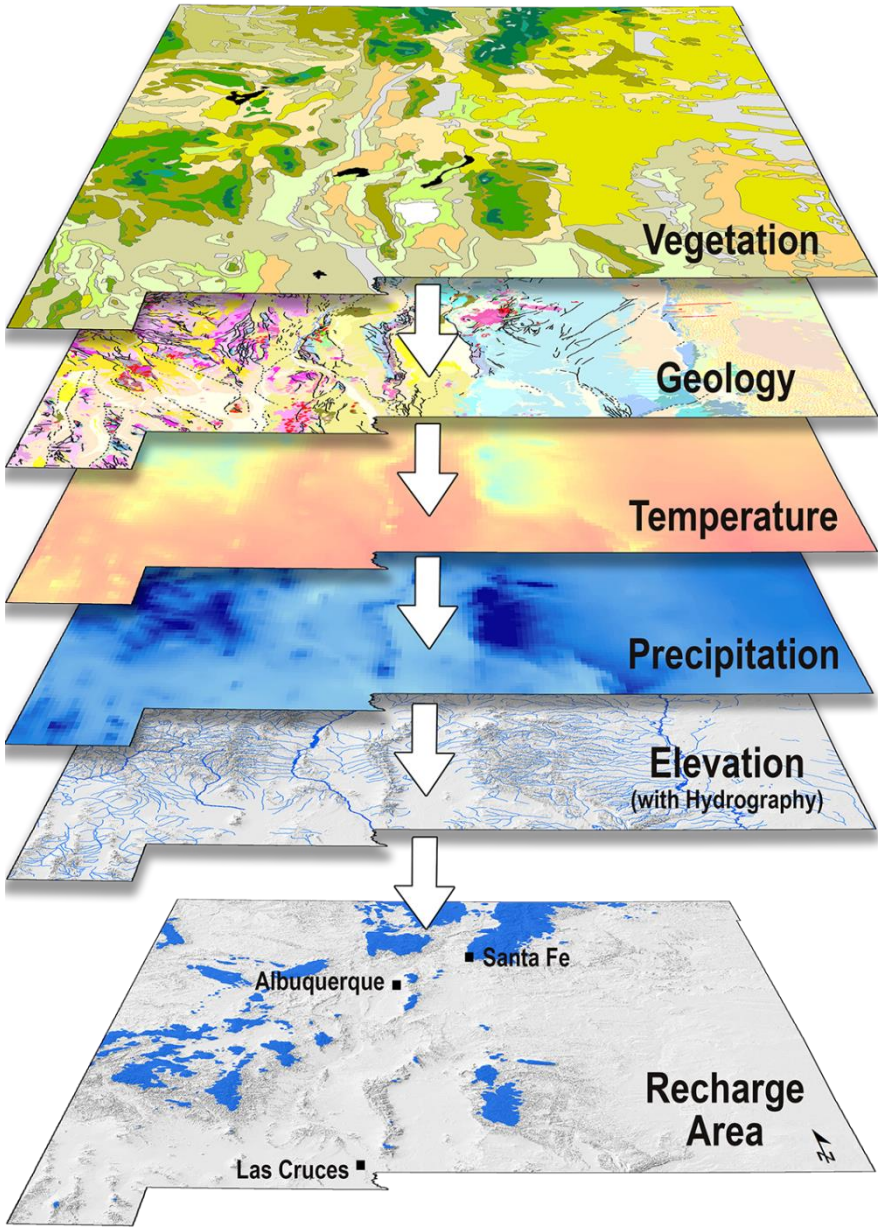
Using 2 for NM



Topographically corrected real-sky solar radiation for 2000



Statewide Recharge Assessment



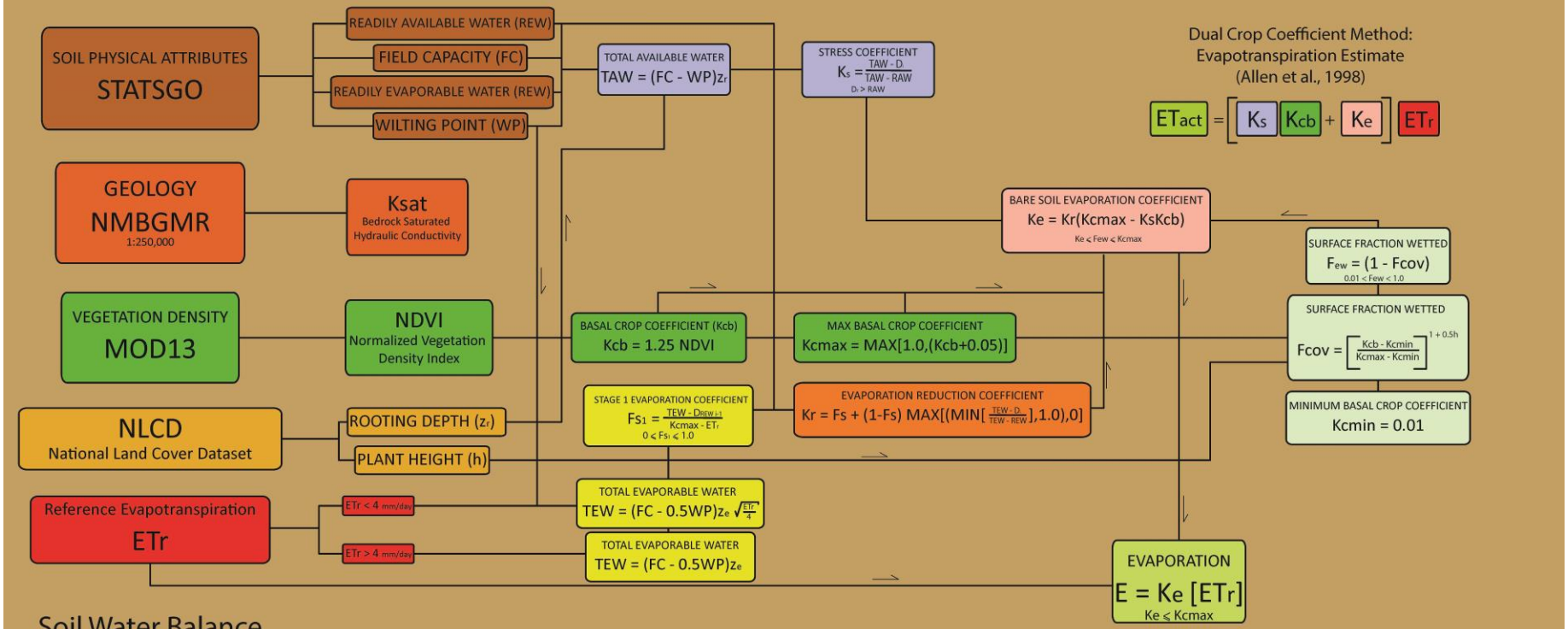
Part of the Statewide Water Assessment, July 2014

- Compiled past recharge estimates in different areas of NM
- Constructed a distributed soil water balance model that estimates diffuse recharge for NM
- Estimated groundwater recharge from high mountain springs (Chloride Mass Balance)

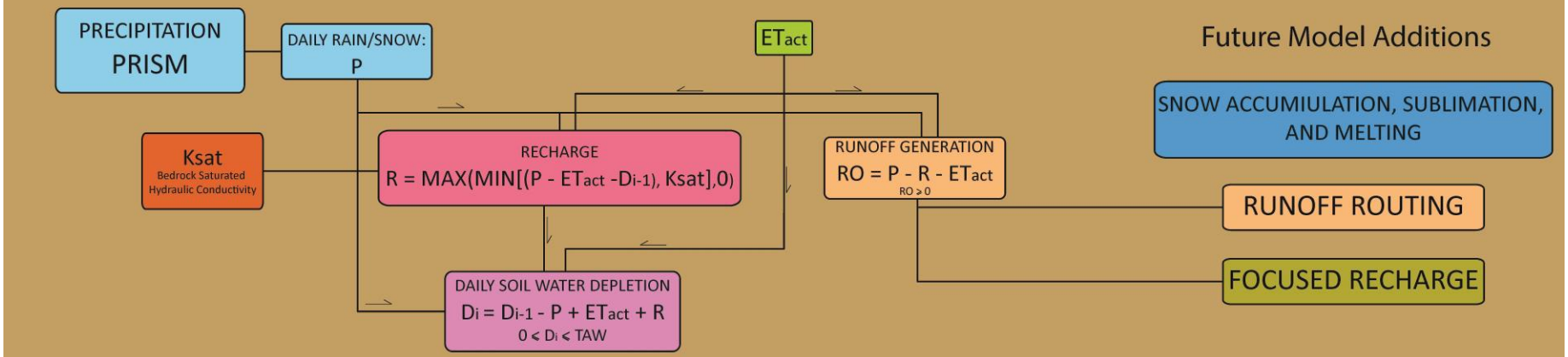
Evapotranspiration and Recharge Model (ETRM)

- 1D distributed soil water balance model
- Estimates the partitioning of precipitation into runoff, evaporation, transpiration, and deep percolation
- Water is stored in three layers of soil, which include stage 1 and stage 2 evaporation layers, and a root zone transpiration layer.
- The soil water depletion (*D*) is tracked on a daily time step and recharge occurs when soil moisture exceeds total available water (*TAW)*

New Mexico Statewide Water Assessment:
Conceptual Model of Evapotranspiration and Recharge Algorithm



Soil Water Balance



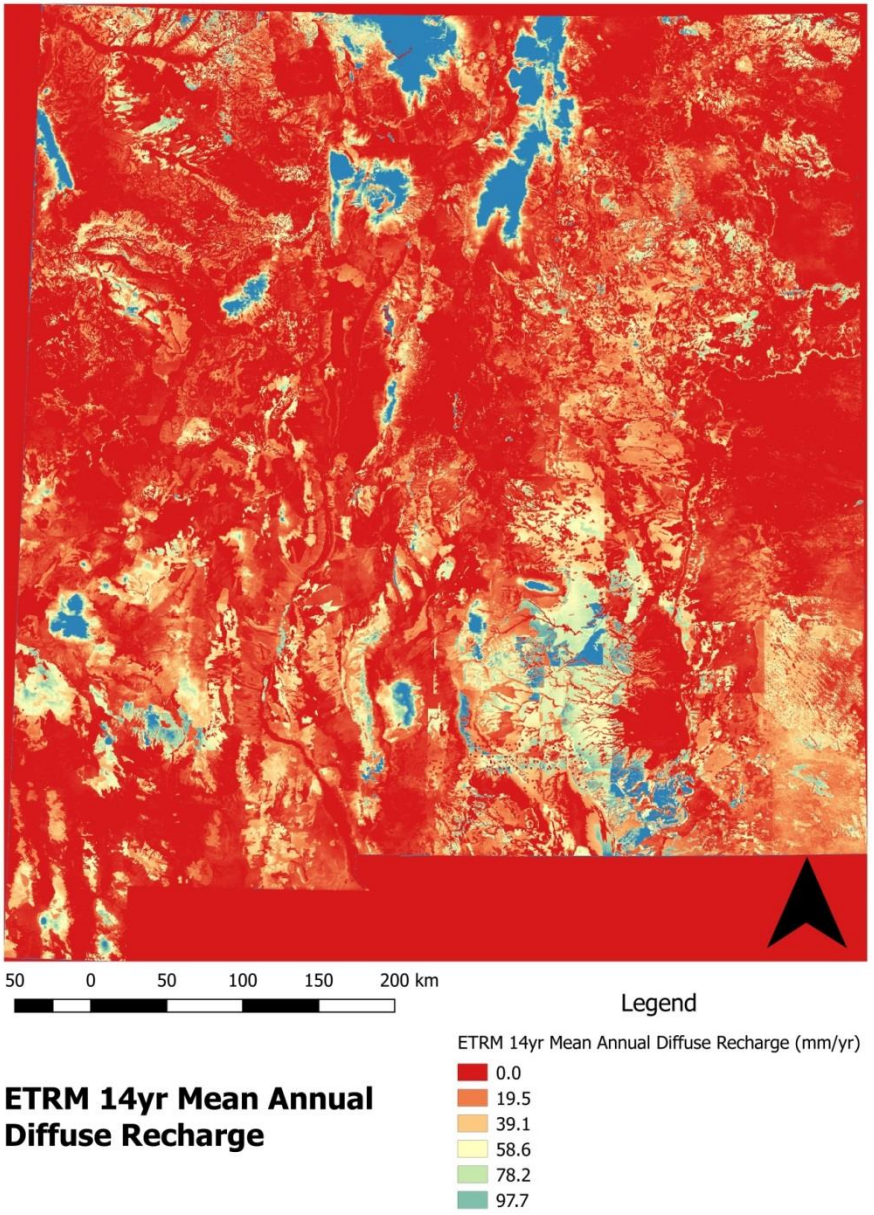
Where D_i is the current day and D_{i-1} is the previous day. This model performs all functions above daily.

Future Model Additions

- SNOW ACCUMIULATION, SUBLIMATION, AND MELTING
- RUNOFF ROUTING
- FOCUSED RECHARGE

Recharge Map

- Annual mean diffuse recharge (2001 – 2014)
- Focused recharge – Esther Xu is working on adding this estimate to the model
- Total available water (TAW) – Gabriel Parish is working on improving this estimate



Statewide Water Level Change Analysis

Alex Rinehart, Ethan Mamer, Trevor Kludt, Brigitte Felix, Stacy Timmons and Cathryn Pokorny. NM Bureau of Geology.

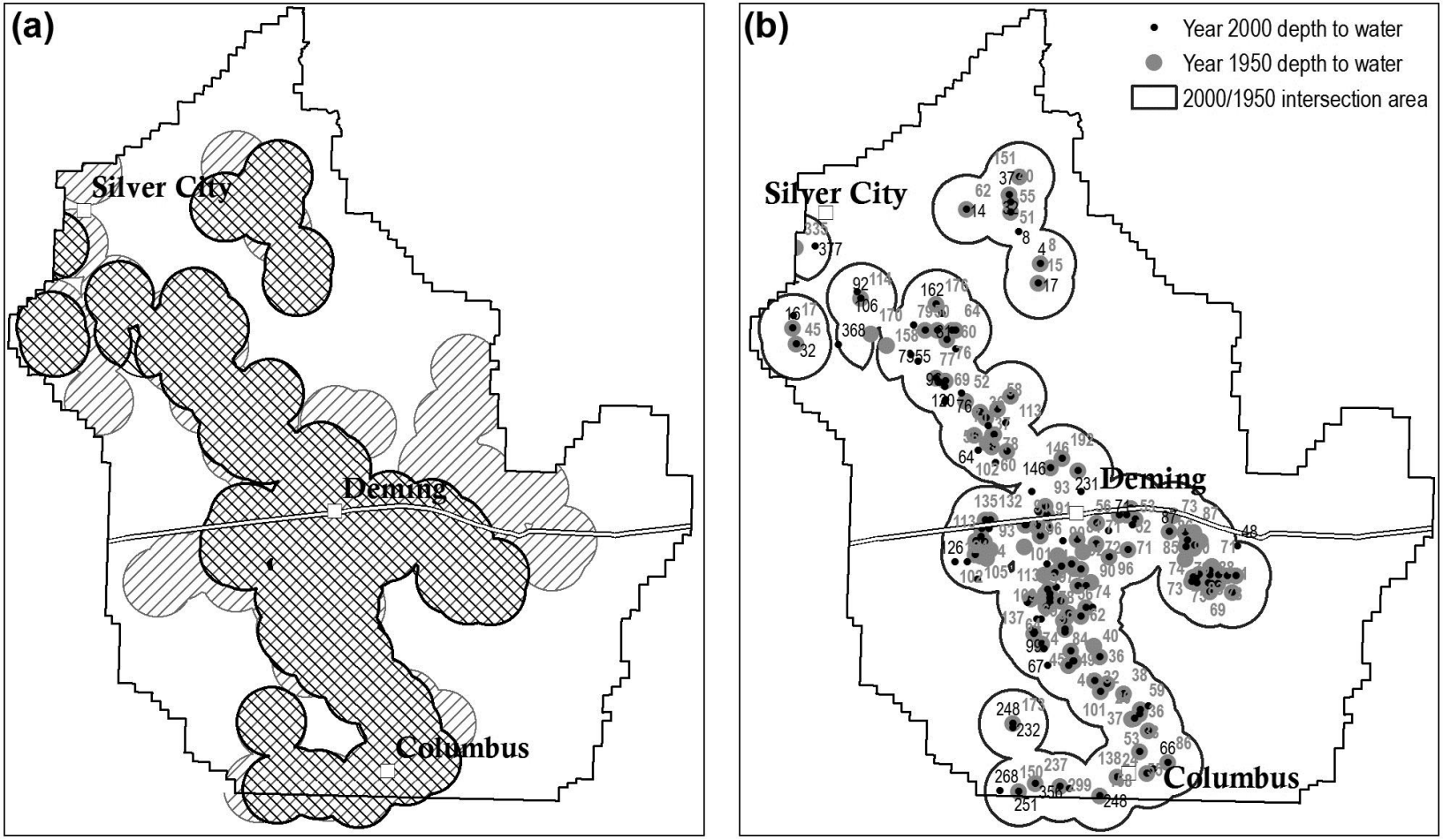
In collaboration with
Nathan Myers (USGS) and Mike Johnson (NMOSE)

19 September 2016

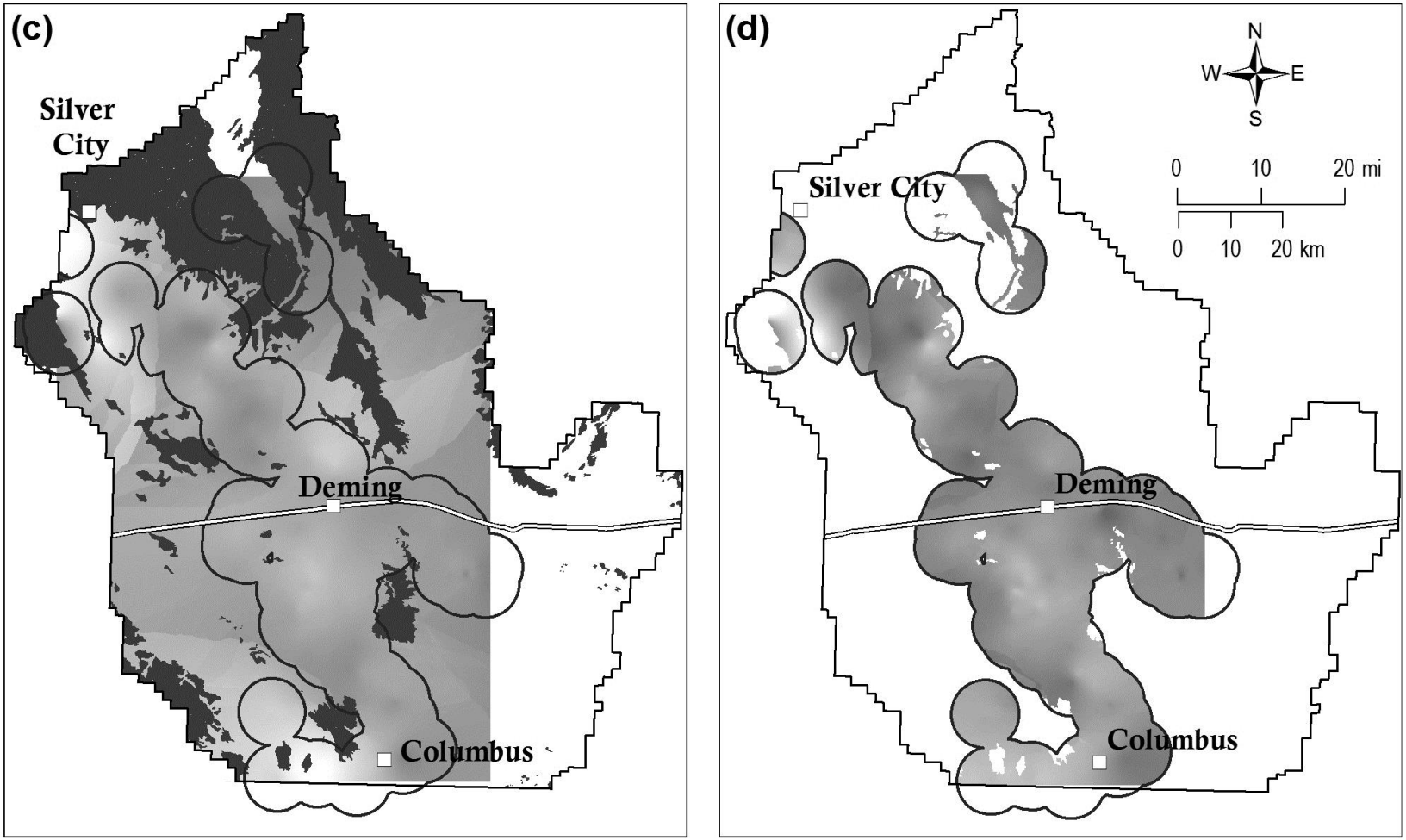
What We Have Done

- Producing groundwater storage **change** estimates
  - over the historical record
  - at decadal time steps
  - for unconfined basin-fill aquifers
  - At HUC-8 spatial scale
  - across New Mexico.
- We have completed analysis for all of the Rio Grande rift basins and Rio Grande tributaries.

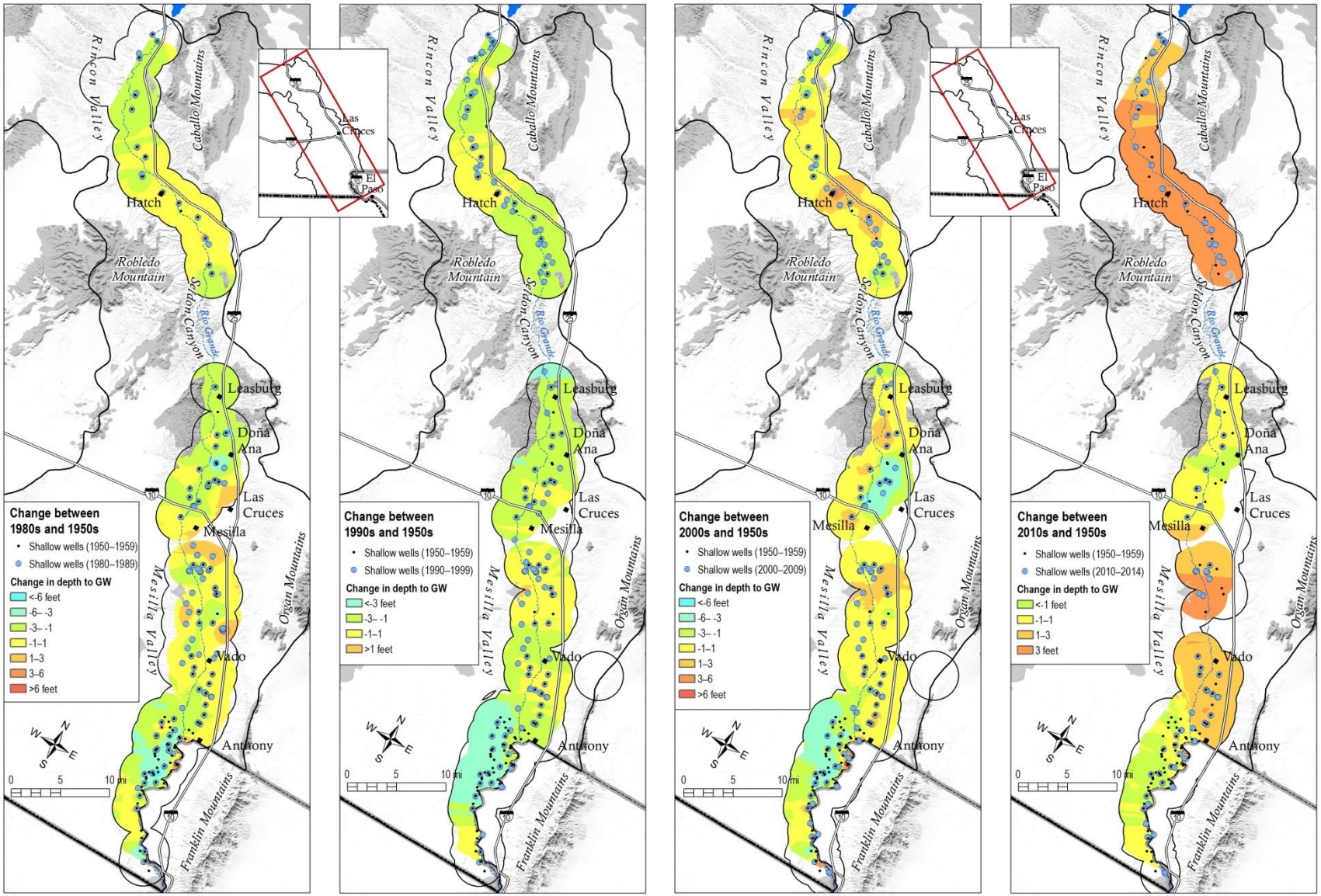
How We Did It – Review, Find Correlation Length, Intersect Two Decades



How We Did It—Cut Bedrock, Interpolate, Clip to Correlated Region.

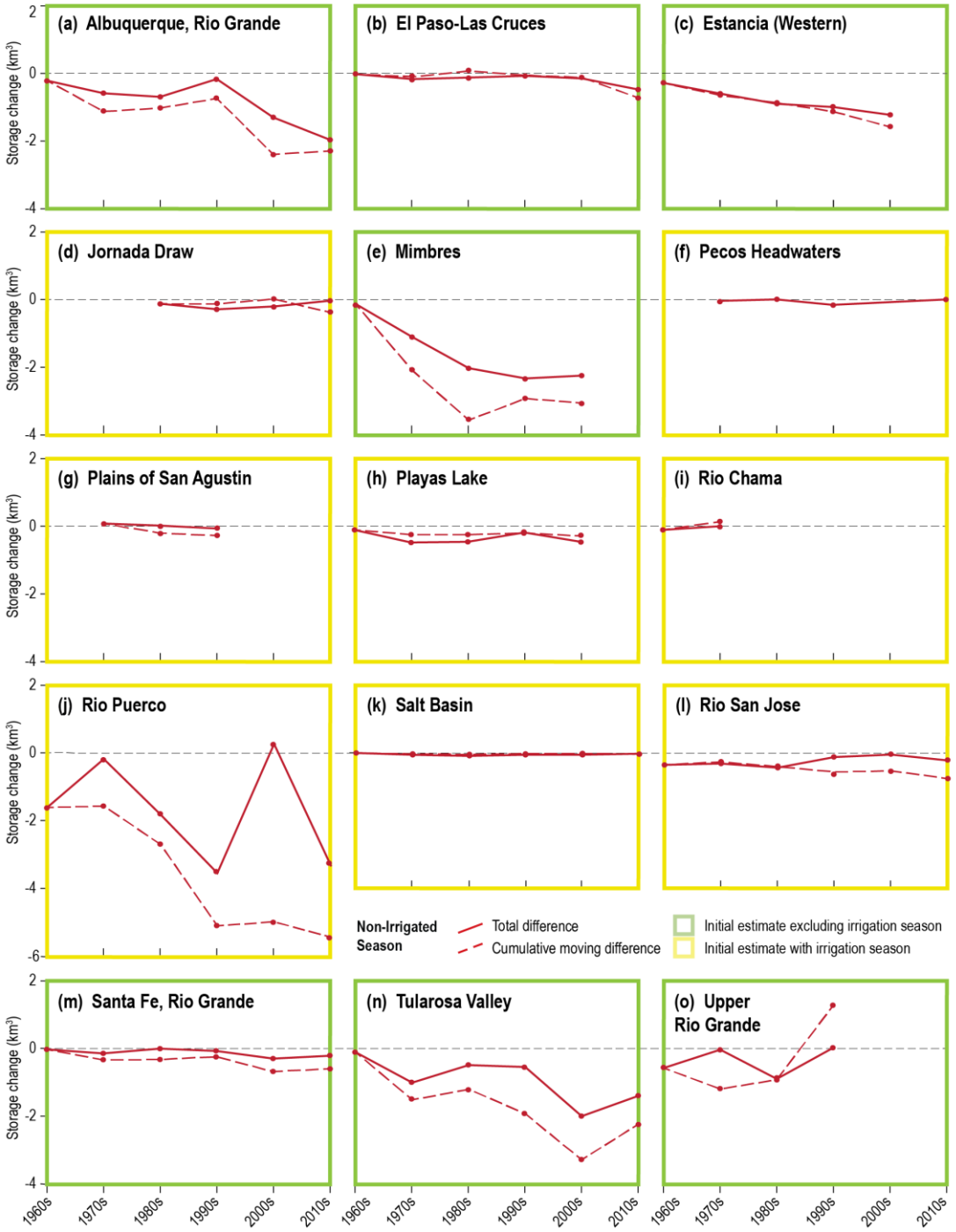


What We Found—Basin Example



What We Found

- Overall, groundwater storage is dropping.
- Most confident around populated areas.
- Least confident in non-irrigated rural regions.



USGS New Mexico StreamStats

USGS

Washington StreamStats

Basin Characteristics Report

Date: Thu Nov 6 2014 20:49:28 Mountain Standard Time
NAD27 Latitude: 47.1678 (47 10 04)
NAD27 Longitude: -120.8336 (-120 50 01)
NAD83 Latitude: 47.1676 (47 10 03)
NAD83 Longitude: -120.8348 (-120 50 05)

Parameter	Value
Area that drains to a point on a stream, in square miles	206.49
Mean Basin Elevation in feet	3640
Minimum Basin Elevation in feet	1810
Maximum Basin Elevation in feet	7360
Relief (maximum - minimum elevation), in feet	5540
Mean basin slope in percent	36.7
Percent of area with slope greater than 30 percent	59.5
Percent of area with slope greater than 30 percent and facing North	11.9
Area-weighted forest canopy, in percent, computed from NLCD 2001 canopy dataset	50.9
Mean annual precipitation, in inches	40.6

Peak-Flow Streamflow Statistics

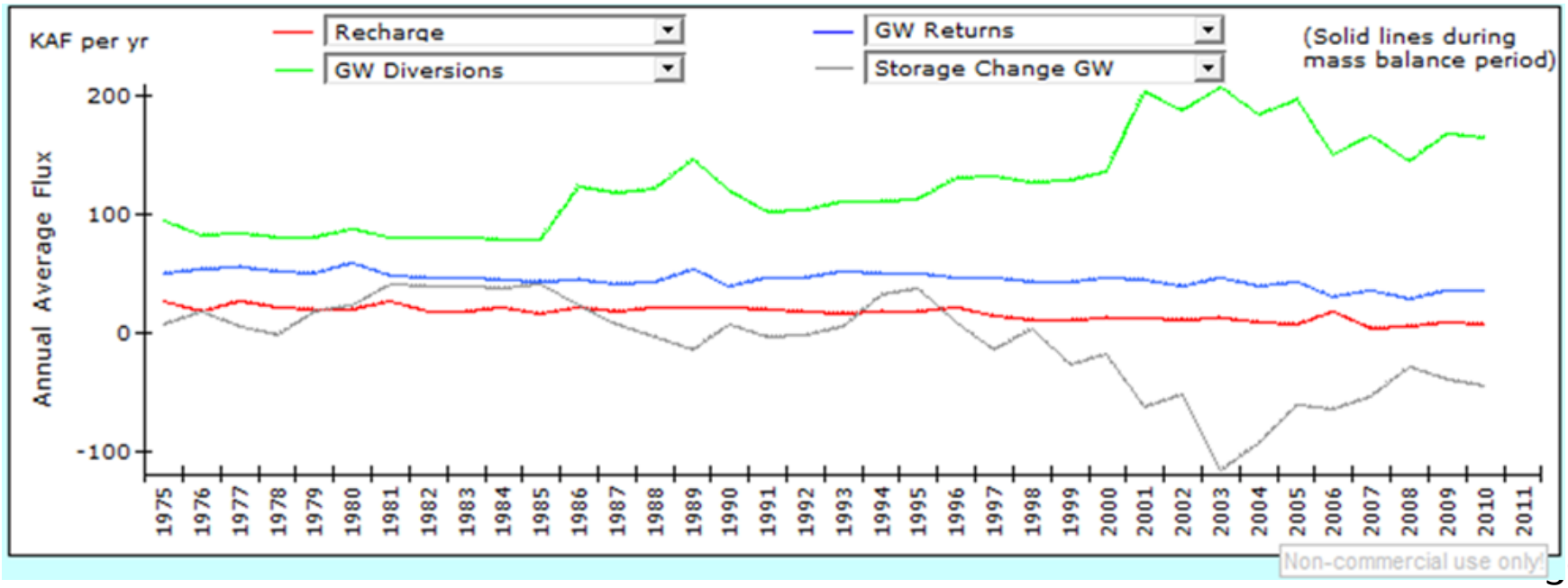
Statistic	Flow (ft^3/s)	Standard Error (percent)
PK2	1130	96
PK10	2340	63
PK25	3060	56
PK50	3660	53
PK100	4290	52

USGS
science for a changing world

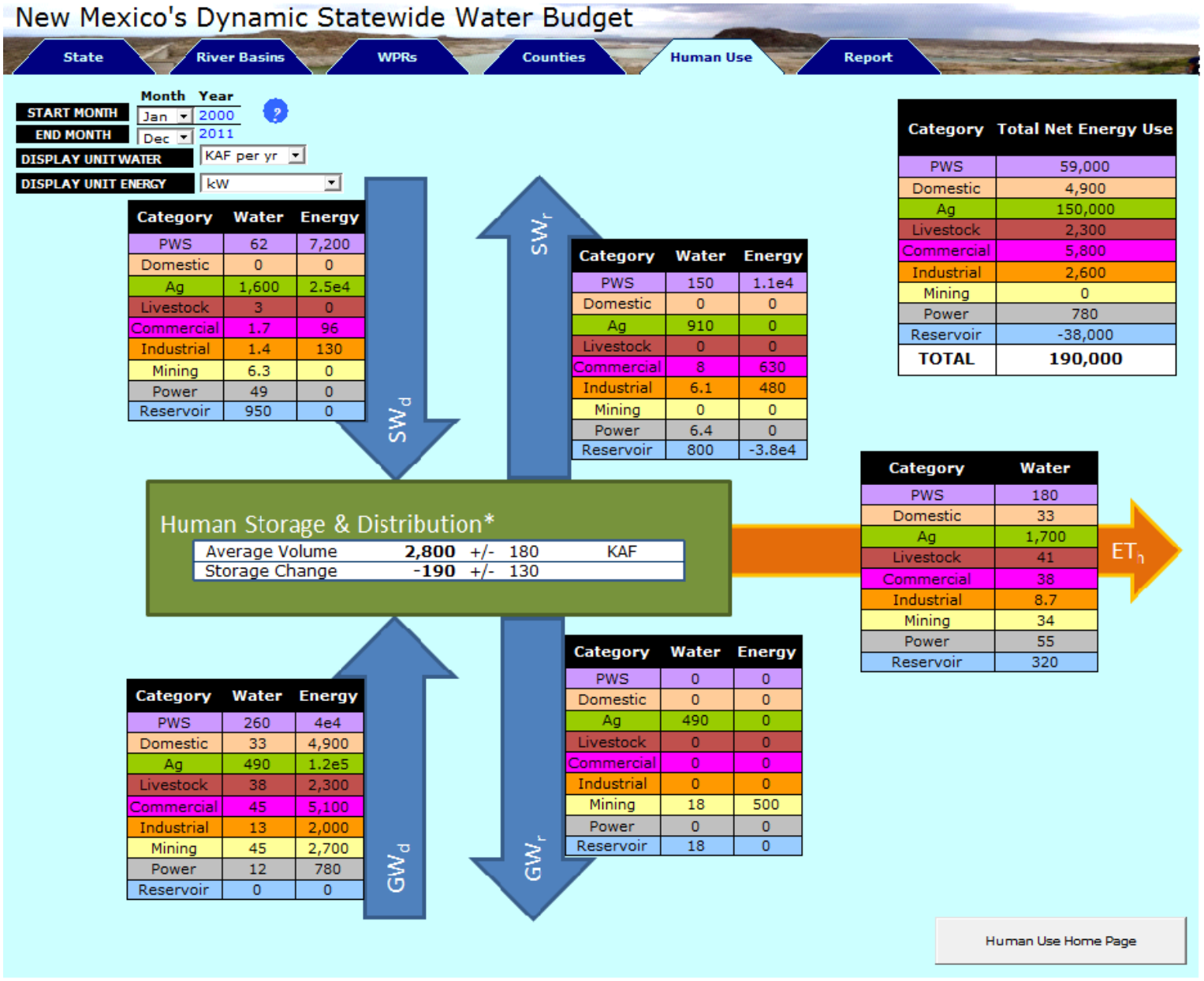
Social Natural Science Nexus

MAJOR ACCOMPLISHMENTS

- Dynamic statewide water budget shows impacts of drought on groundwater storage decline
- Ongoing work is showing energy cost of pumping groundwater compared to use of gravity-fed surface water



NMDSWB Interface

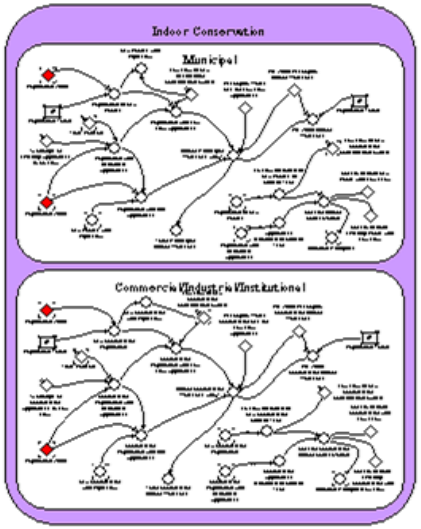


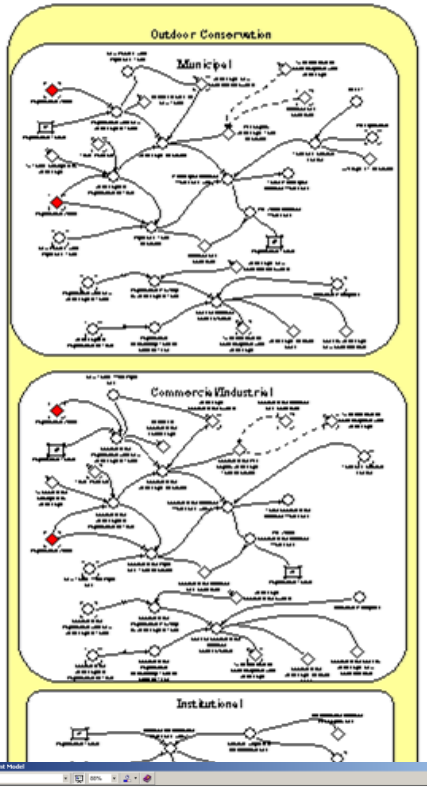
Human Mass Balance

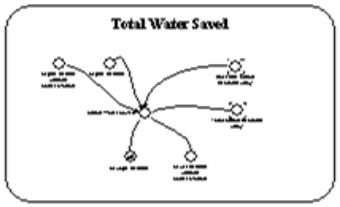
NEW MEXICO WATER RESOURCES RESEARCH INSTITUTE

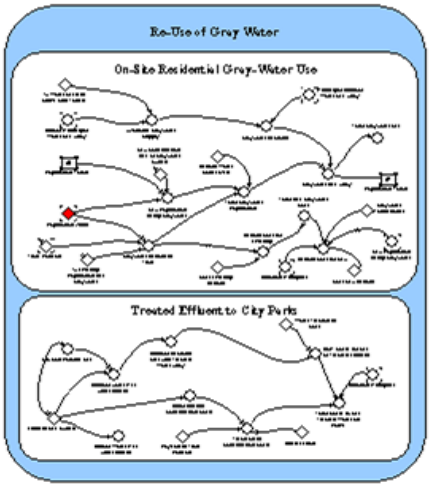
TETRA TECH

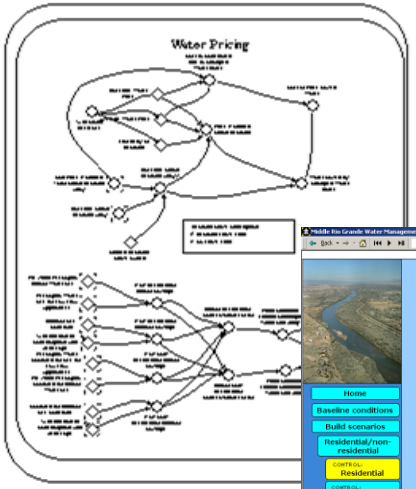
System dynamics participatory modeling

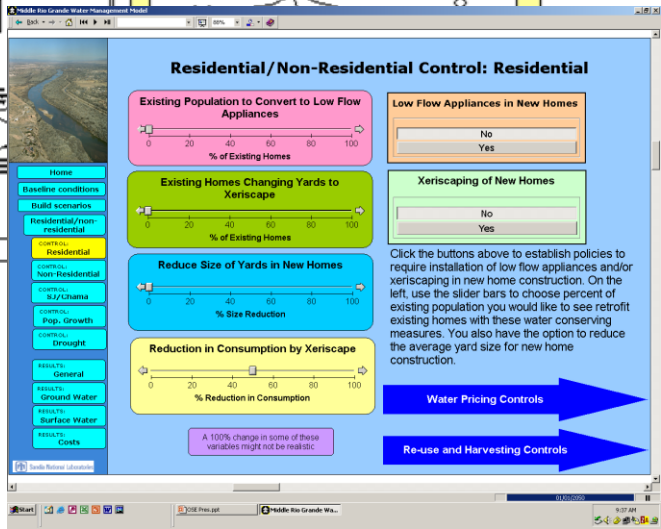












http://waterbudget.nmwrri.nmsu.edu/


THANK YOU