

# Produced Water Reuse and Recycling: Role in Long-term Water Sustainability

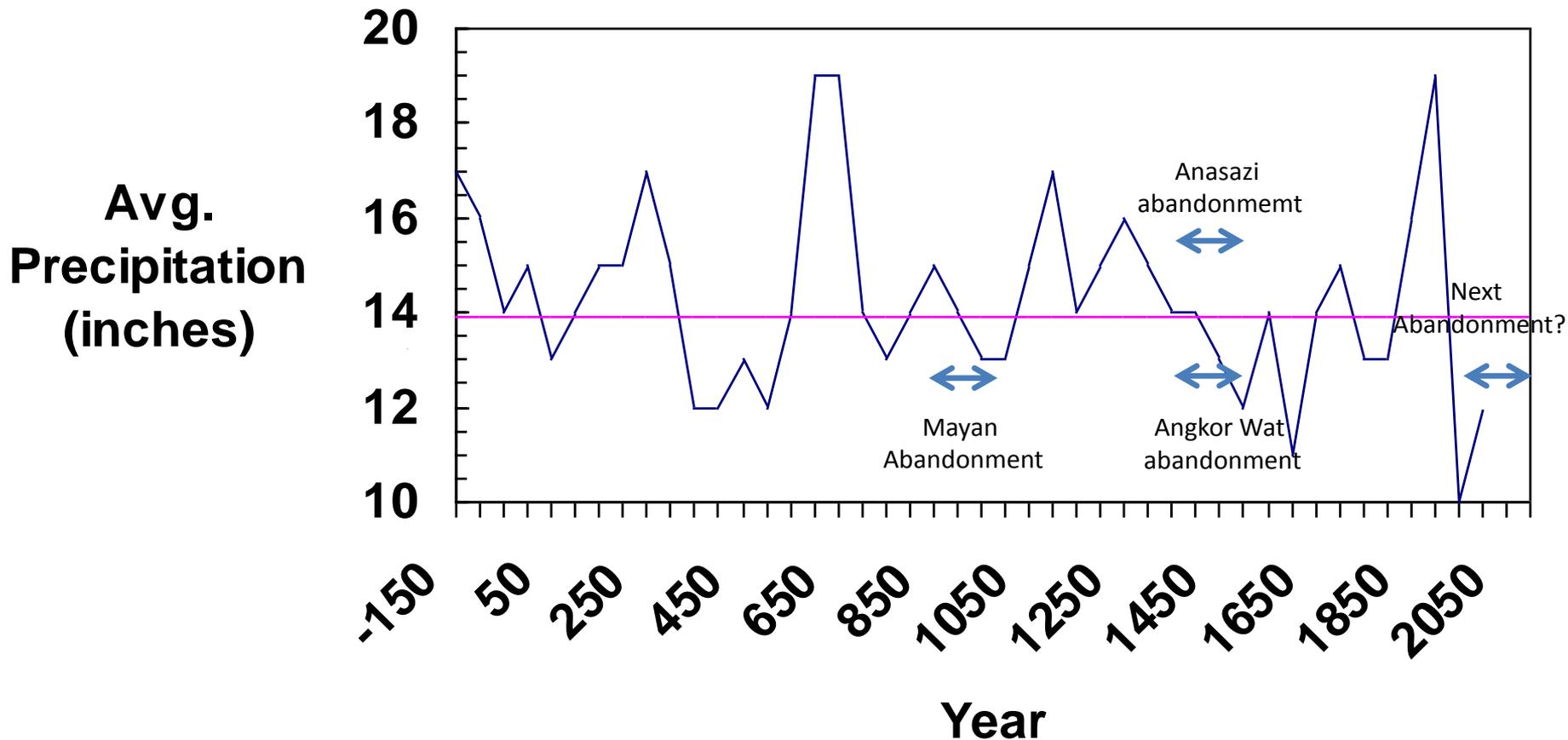
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# U.S. Water History Based on Tree Ring Data

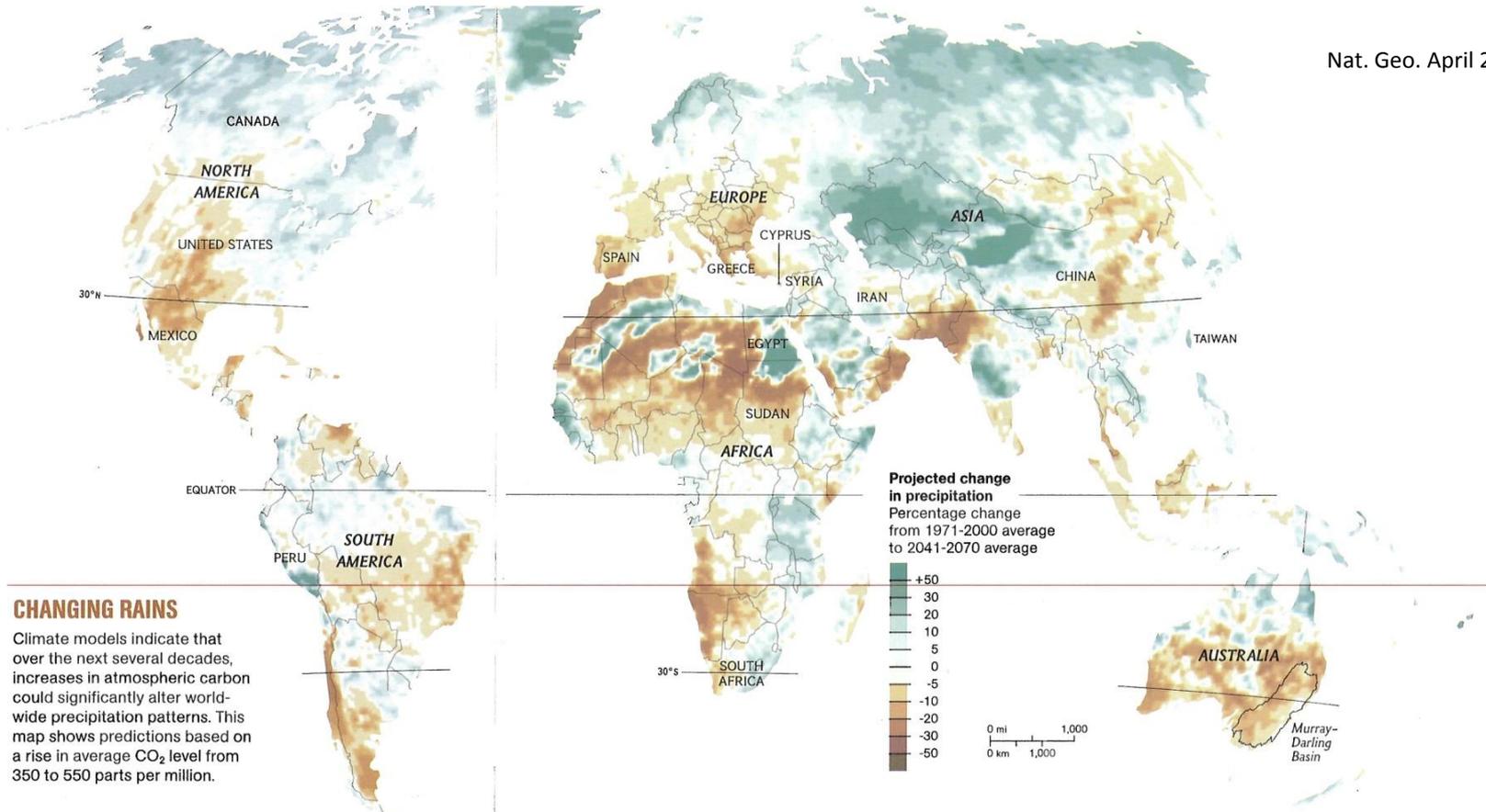


Univ. of Arizona – Tree Ring Research Lab – 50 year averages

**The southern U.S. and the mid-latitudes are in the 100th year of a 300 year arid cycle - not a drought**

# Climate Changes will Impact Temperatures, Precipitation, Evapotranspiration, and Runoff

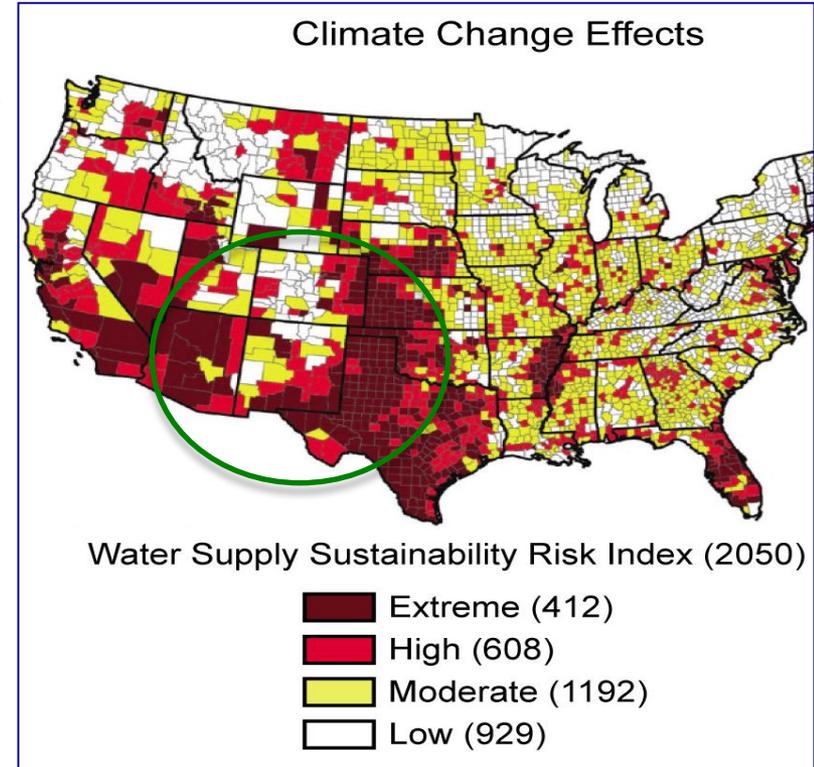
Nat. Geo. April 2009 from IPCC



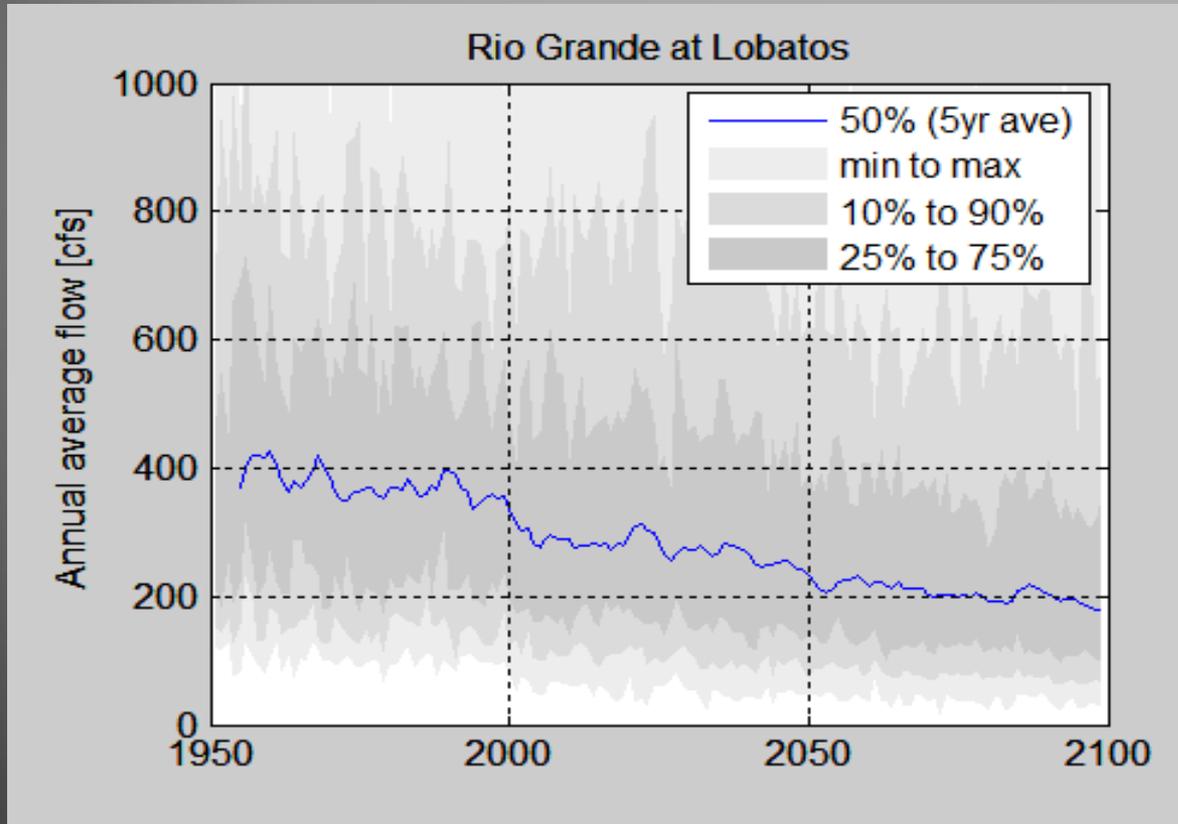
Mid-latitude population and grain belts will be strongly affected

# Southwest & Southern Rocky Mountains

- ▶ The region is delicately balanced in terms of water supplies and demands
- ▶ Impacts of climate change and energy production are acute
- ▶ Important water-energy challenges:
  - Climate impacts
  - Disruptive events: fire, floods, infrastructure failure
  - Fully allocated water rights
  - Growing/shifting population
  - Rapid and extensive energy development
  - Uncertainties in water for power production
- ▶ Established regional energy water partnership



# Projected Rio Grande Flows through 2100



“Results are not predictions, but rather a starting point for dialogue and increased awareness of potential impacts of climate change.”

*Roach et al.*

# Elephant Butte Reservoir NASA Earth Observatory Landsat 8 images

Acquired June 2, 1994  
89% of maximum  
(2.2 Maf)



Acquired July 8, 2013  
3% of maximum



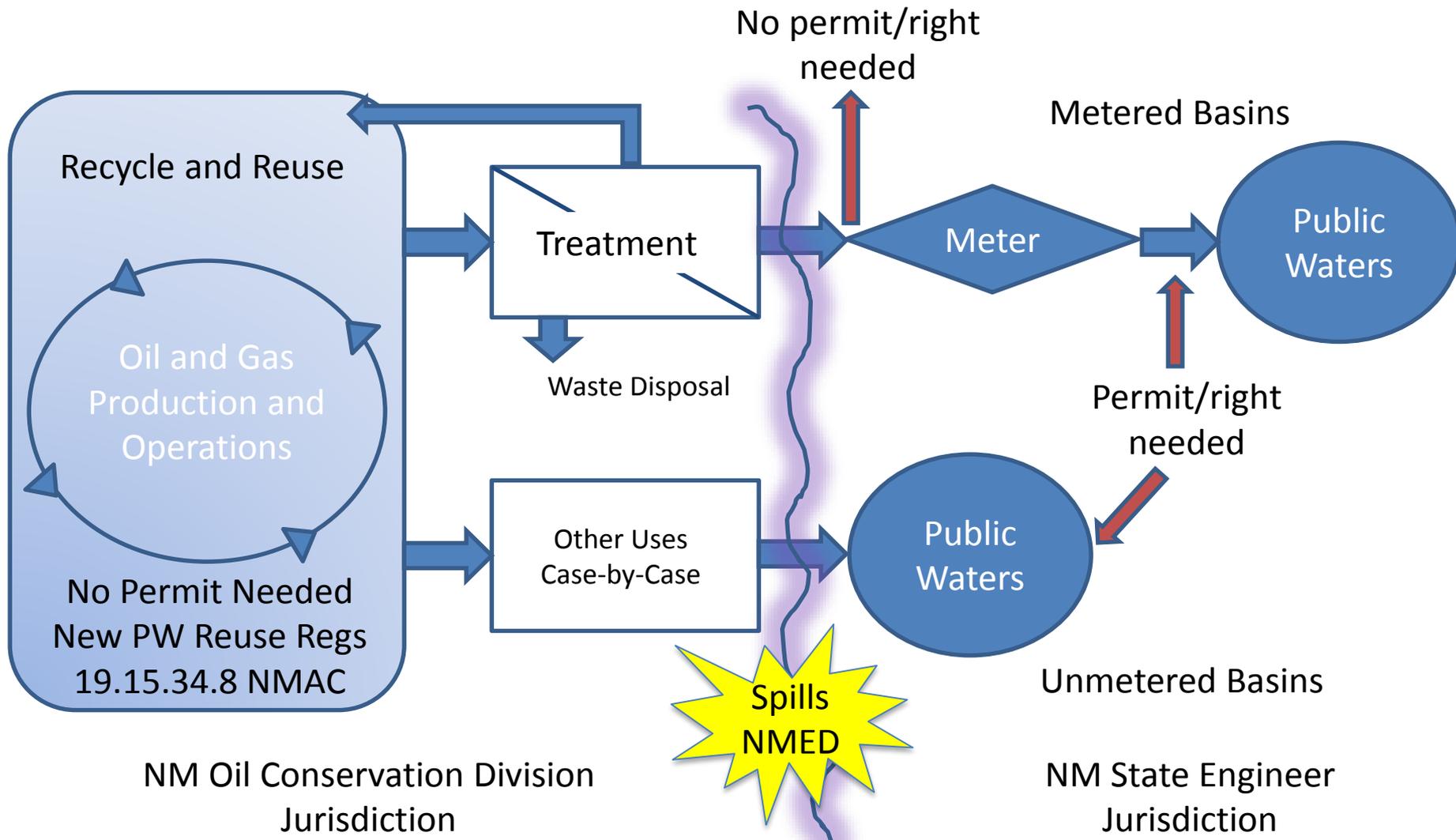
# Recent NM Policy Changes and Adaptations for Future Water Sustainability

- State Energy Policy-Includes Energy-Water Nexus
- Hybrid, alternative cooling and water implementation
- New regulations - recycling of Produced Water
- Brackish Water and Waste Water resource evaluation
- EWN collaborations-public and private entities



PNM Afton Gas-fired, Hybrid-cooled Generation

# New Mexico Produced Water Regulatory Framework for Reuse-*a fuzzy dividing line*....



# Alternative Uses for Produced Water to Support Water Resource Sustainability In SW and SRM

- Reuse in oil and gas production
  - Hydraulic fracturing
  - Steamflooding (California)
- Irrigation (after treatment or dilution)
  - Rangeland rehabilitation
  - Non-food (cotton) crops
- Algal biofuel production
- Potash solution mining (proposed)

# Rangeland Improvement

- Watered with ~4000, ~5000 and ~12,000 TDS produced water
  - Limited irrigation, focus to establish (jump start) grasses
  - The Sodium Absorption Ratio (SAR) and Electrical Conductivity (EC) of the soil rose only slightly.
  - Soil conductivity and Sodium Absorption Ratio values remain under critical limits for forage production for most grasses planted
- Chief Intermediate Wheatgrass, Hy-Crest Crested Wheatgrass, and San Louis Slender Wheatgrass had best overall rating for stand establishment
- Land Management Guidance, ~1500 TDS water



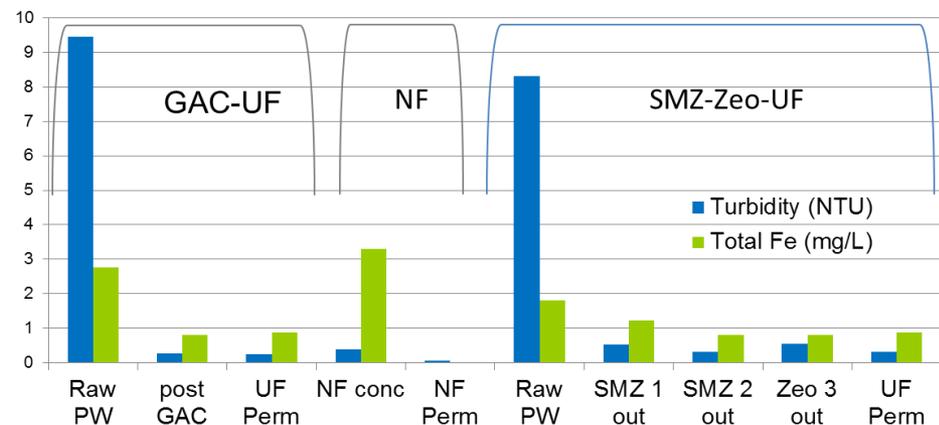
# Produced Water Treatment for use in Rangeland Rehabilitation, Bloomfield NM

- Coal bed methane produced water was treated with multiple steps for organic, coal fine, and salt removal
- Water was discharged to comparative rangeland plots to evaluate most appropriate quality for vegetation rehabilitation
- Collaborative effort between Conoco Phillips, small businesses, LANL, SNL, Bureau of Land Management, and State of NM



Coal fines accumulating in the modified zeolite filtration medium.

Pretreatment comparison  
GAC-UF to SMZ-UF



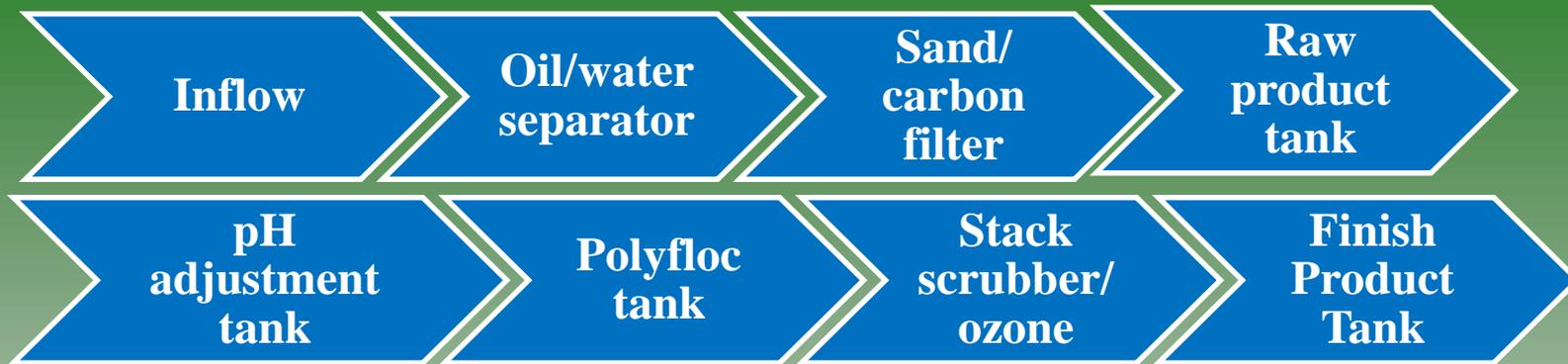
# Produced Water Resource Study in SE New Mexico-Lea and Eddy Counties

- New project with NMSU/WRRI, NMT/PRRC, LANL, NMED, EMNRD
- Focus is reuse of PW as replacement for FW
- Stakeholder engagement and public meetings
- Visits to treatment facilities, regulatory analysis, cost analysis, mapping and quality analysis for future uses, treatment options
- Results available to public via map and database products, final reports



Photo: EJS Graham January 2016

# Produced Water Treatment Process, Jal, NM



- Sampling event on October 4, 2011 at the Jal, NM Facility.
- Sampling points include raw inflow water from an oil well, post oil/water separation, post sand/carbon filtration, post flocculation and post ozone treatment.



# Growing algae in Produced Water



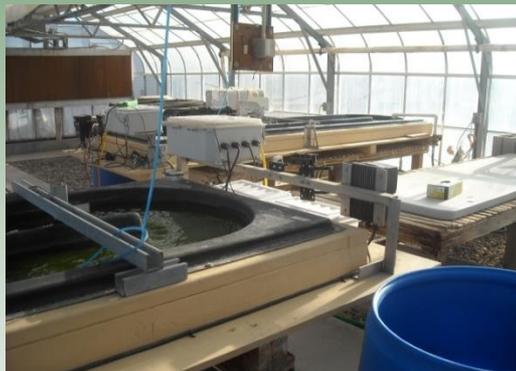
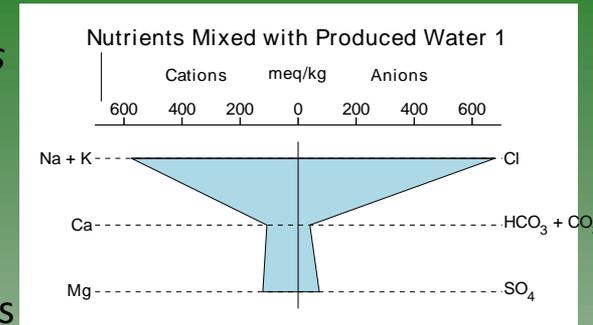
## Lab Scale-LANL

*N. Salina* 1776; *Scenedesmus+Tetracystis*

Salinity 10,000-30,000 mg/L

Testing various salinity ranges (10,000-30,000 mg/L); Cu:Zn ratios;  $\text{HCO}_3^-$  concentrations (200-1,000 mg/L)

Modeling used to optimize media recipes



## Pilot Scale-Texas Agrilife Pecos

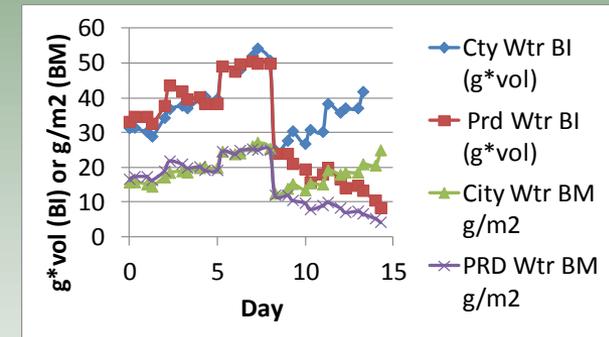
*N. Salina* 1776;

salinity 19,000-28,000 mg/L

OD=0.6-0.8; AFDW=0.35 g/L;

BI=8-50 g/L

Exhibited low tolerance to higher salinity range



## Field Scale-Eldorado Biofuels

*Scenedesmus+Tetracystis (Jalgae™)*;

Salinity 11,000-13,000 mg/L

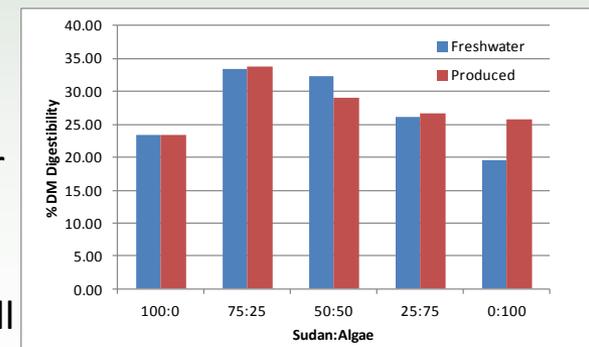
Growing consistently in treated PW

Low concentration commercial fertilizer sources of N, P, K

$\text{HCO}_3^-$  concentrations ~700-900 mg/L

Diluent fresh water from local stock well

Quality is similar to FW samples



# Recent Energy Water Program Plans Include Produced Water Treatment and Management

- **Technology RDD&D**

- *Thermoelectric Cooling Improvements*
- *Waste Heat Recovery in Energy Systems*
- *Process Water Use Efficiency and Quality*
- *Traditional and Non-traditional Hydropower Improvements*
- *Alternatives to Fresh Water Use in Energy Production Using Advanced Materials and Processes*
- *Desalination Improvements*
- *Net-Zero Municipal Wastewater Treatment*
- *Sensors*
- *Deployment*

- **Analysis and Modeling**

- *Integrated Analytical Platforms*
- *Decision Support Tools*

- **Policy Framework**

- **Stakeholder Engagement**

- **International Diplomacy**

