Produced Water Treatment and Reuse for Water, Energy, and Environmental Security and Resiliency

Western Regional Partnership
Water Resource Management Strategies Webinar
February 4, 2021

Mike Hightower, Program Director

NM Produced Water Research Consortium

Western Regional Partnership Goals

- Building Resilience in the West for America's Defense, Energy, Environment and Infrastructure through Enhanced Collaboration among Federal, State and Tribal Entities.
- Explore tools and resources needed to build resilience to **s**upport the diverse missions of Federal, State and Tribal entities in the WRP Region
  - Resilient Energy Infrastructure
  - Resiliency of Airspace in the WRP Region
  - Disaster Mitigation
  - Water Security

WATER RESOURCE MANAGEMENT STRATEGIES Webinar:

- Identify best practices and new technologies for implementing water resource management strategies to:
  - reduce water demand, increase supply reliability, improve quality, reduce flood risk, restore ecosystems, and ensure equity.
- Identified gaps are water management practices and technologies that can support water security, resilience, and sustainability.

System-level Natural Resource Management Plan

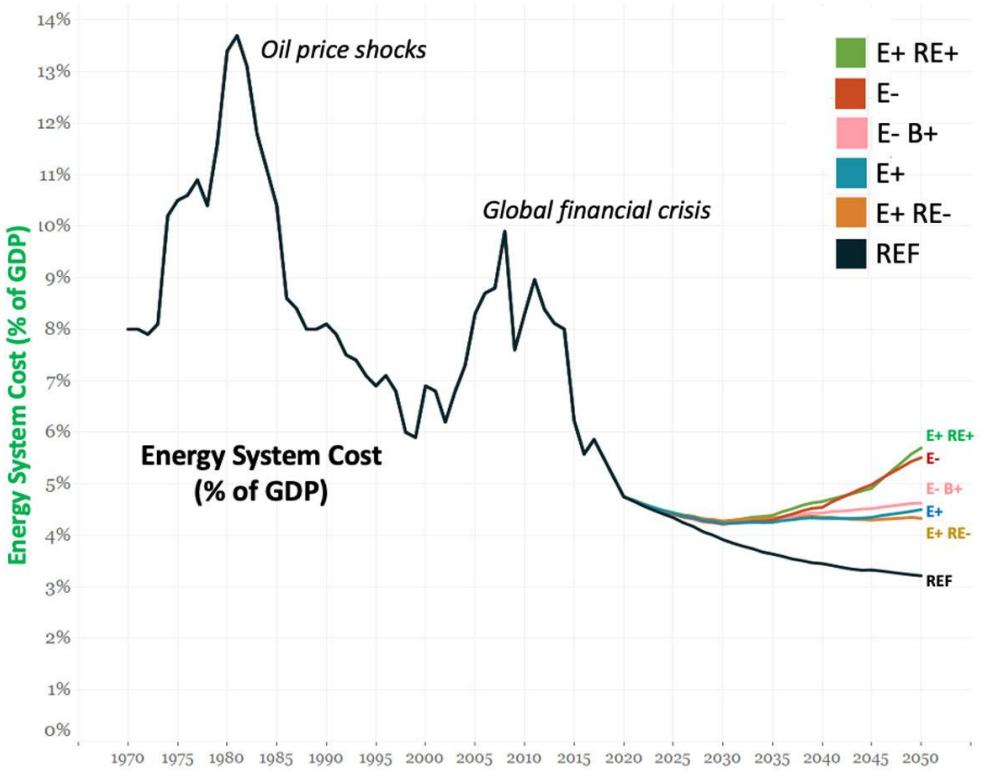
Performance Characteristic	Definition and Metrics
Safe	Safely supplies resources to end user
Secure	Protection of supply infrastructure from intentional disruptions
Reliable	Provides services when and where needed in spite of small disruptions
Sustainable	Can be maintained indefinitely with minimal impact on natural resources (air, land, water, energy, environment, ecology}
Cost Effective	Provided at affordable cost ($ are a limited resource for many)
Resilient	Ability to prepare for and adapt to changing conditions and withstand and recover rapidly from natural disruptions

Integrated systems-level resources management for assured and sustainable socio-economic, ecological, and environmental performance

Recent Evaluation of 100% Renewable Energy by 2050

	REF ~AEO 2019	E+ high electrification	E- less-high electrification	E- B+ high biomass	E+ RE- renewable constrained	E+ RE+ 100% renewable
CO_2 emissions target		- 0.17 $GtCO_2$ in 2050				
Electrification	Low	High	Less high	Less high	High	High
Wind/solar annual build	n/a	10%/y growth limit	10%/y growth limit	10%/y growth limit	Recent GW/y limit	10%/y growth limit
Existing nuclear	50% → 80-y life	50% → 80-y life	50% → 80-y life	50% → 80-y life	50% → 80-y life	Retire @ 60 years
New nuclear	Disallow in CA	Disallow in CA	Disallow in CA	Disallow in CA	Disallow in CA	Disallowed
Fossil fuel use	Allow	Allow	Allow	Allow	Allow	None by 2050
Maximum CO_2 storage	n/a	1.8 Gt/y in 2050	1.8 Gt/y in 2050	1.8 Gt/y in 2050	3 Gt/y in 2050	Not allowed
Biomass supply limit	n/a	13 EJ/y by 2050 (0.7 Gt/y biomass) [*No new land converted to bioenergy*]		23 EJ/y by 2050 (1.3 Gt/y biomass)	13 EJ/y by 2050 (0.7 Gt/y biomass) [*No new land converted to bioenergy*]	

PRINCETON UNIVERSITY



PRINCETON UNIVERSITY

Included – air, CO2 storage, land for biofuels, energy mix, more transmission and batteries, cost

Not included – water, security, resiliency, socio-economic impacts, other CO2 sources

Water-related Economic Concerns by 2030

Today one in five people live in areas of water stress.

This is expected to rise to two in three.

Demand for water is set to outstrip supply by 40%.

Business as usual water management will put at risk $63trillion or 1.5 times today's entire global economy.

Water will have more rapid and unavoidable consequences for some businesses than carbon

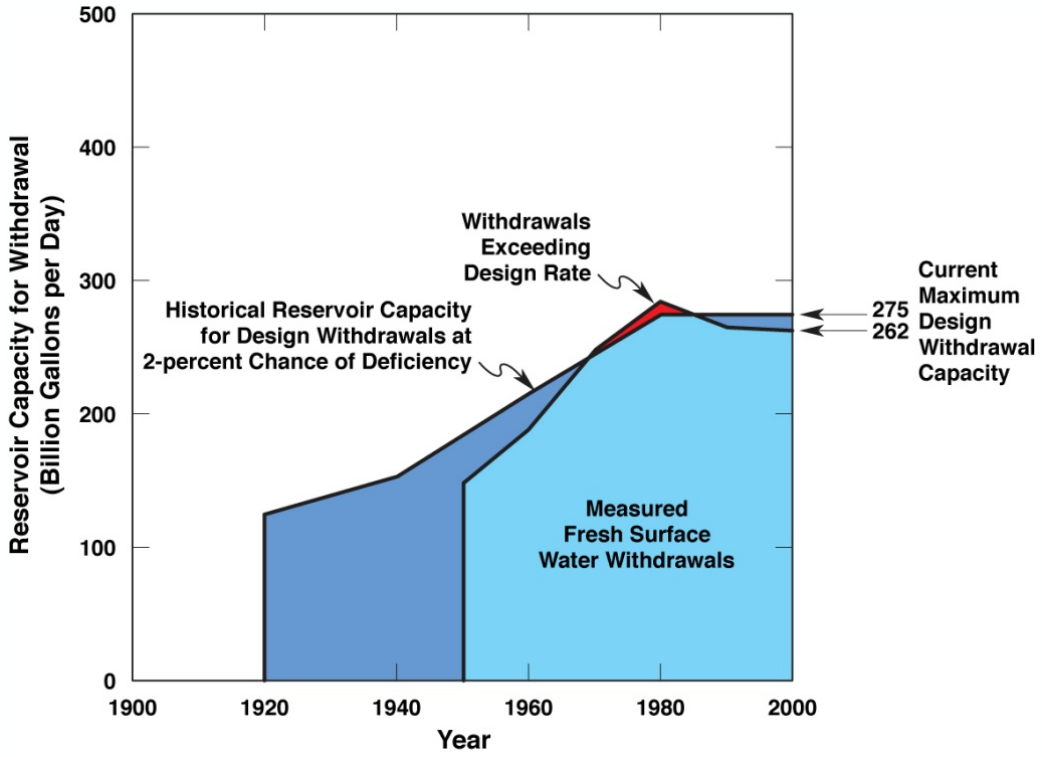
Goldman Sachs

" Investors know how damaging inaction, inappropriate action or delaying interventions on water-related issues can be… The global economy will favor business that take a pro-active approach to water stewardship."

- **Eurizon Capital**

CDP

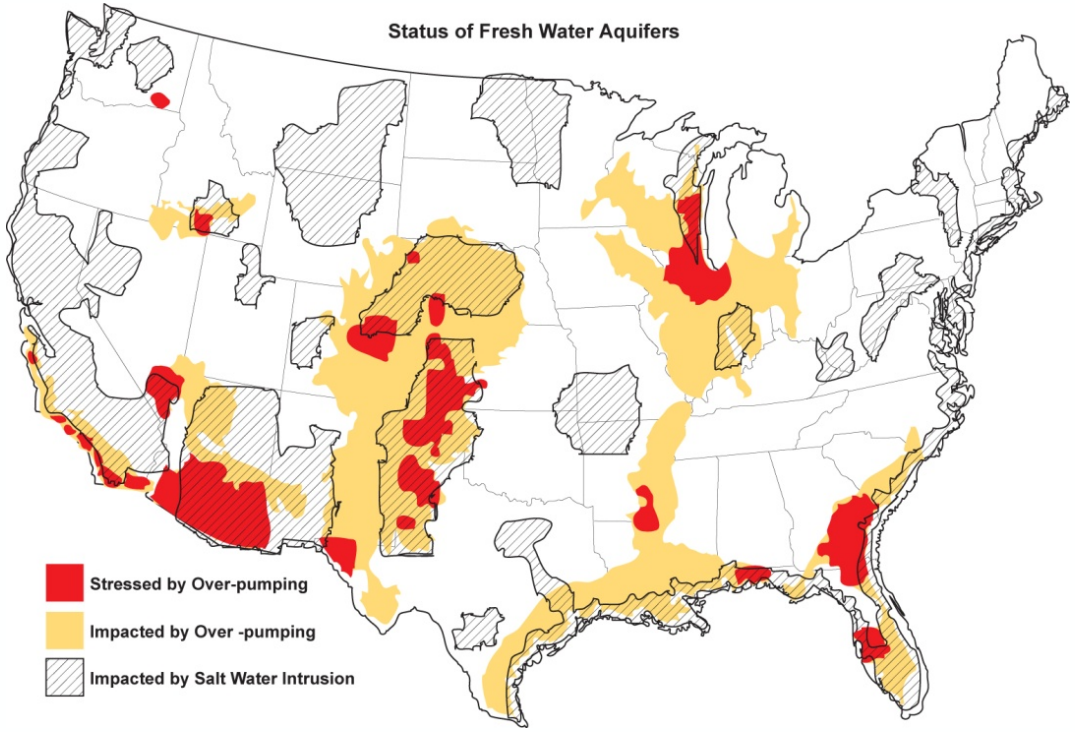
Fresh Water Availability Issues Driving Non-traditional Water Reuse



(Based on USGS WSP-2250 1984 and Alley 2007)

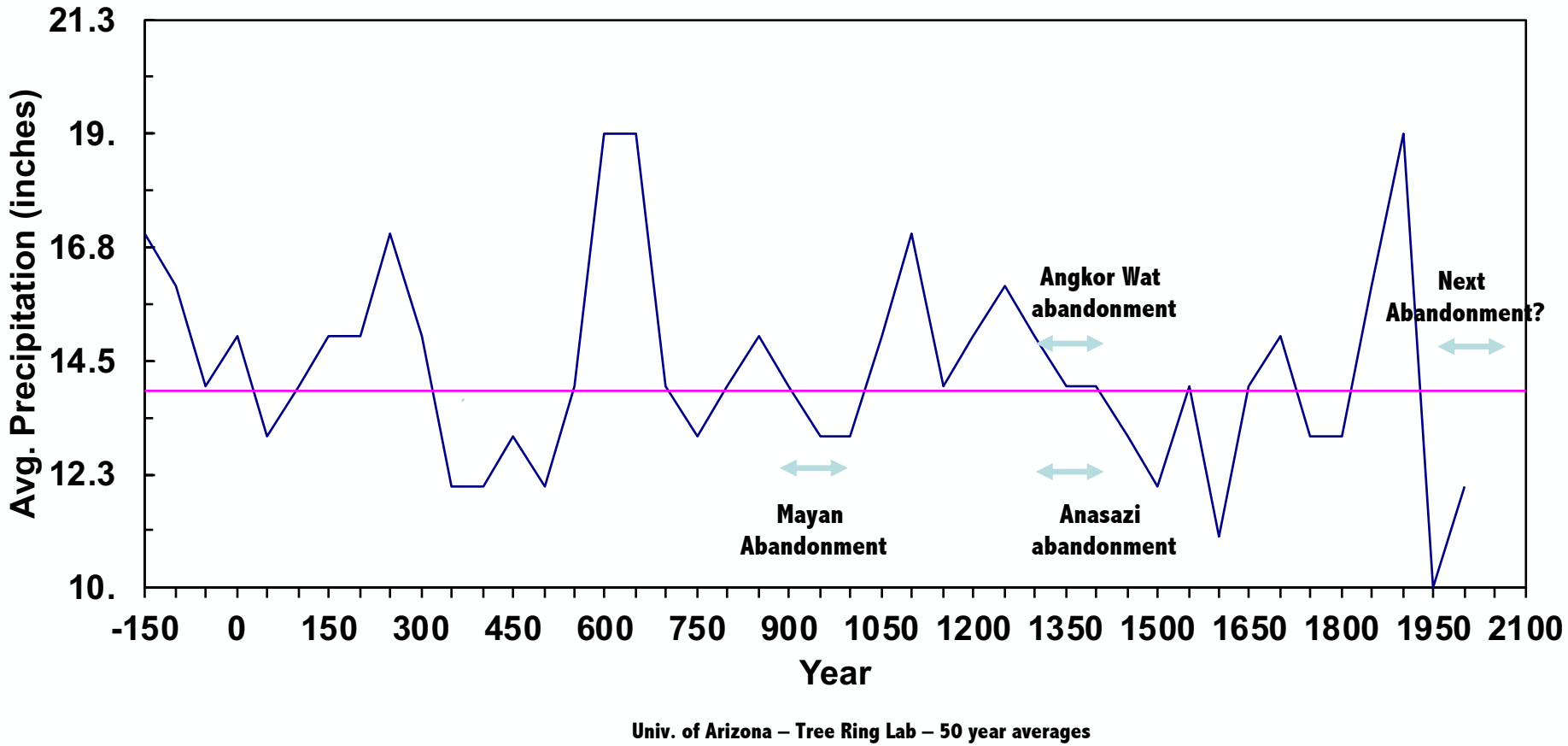
- No new surface water storage capacity since 1980

- All major groundwater aquifers overstressed



(Shannon 2007)

Southwest Climate History from Tree Ring Data



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

The southern U.S. and the mid-latitudes are in the 130th year of a 300 year arid cycle - not a drought

System Performance Optimized 2050 Energy Portfolio

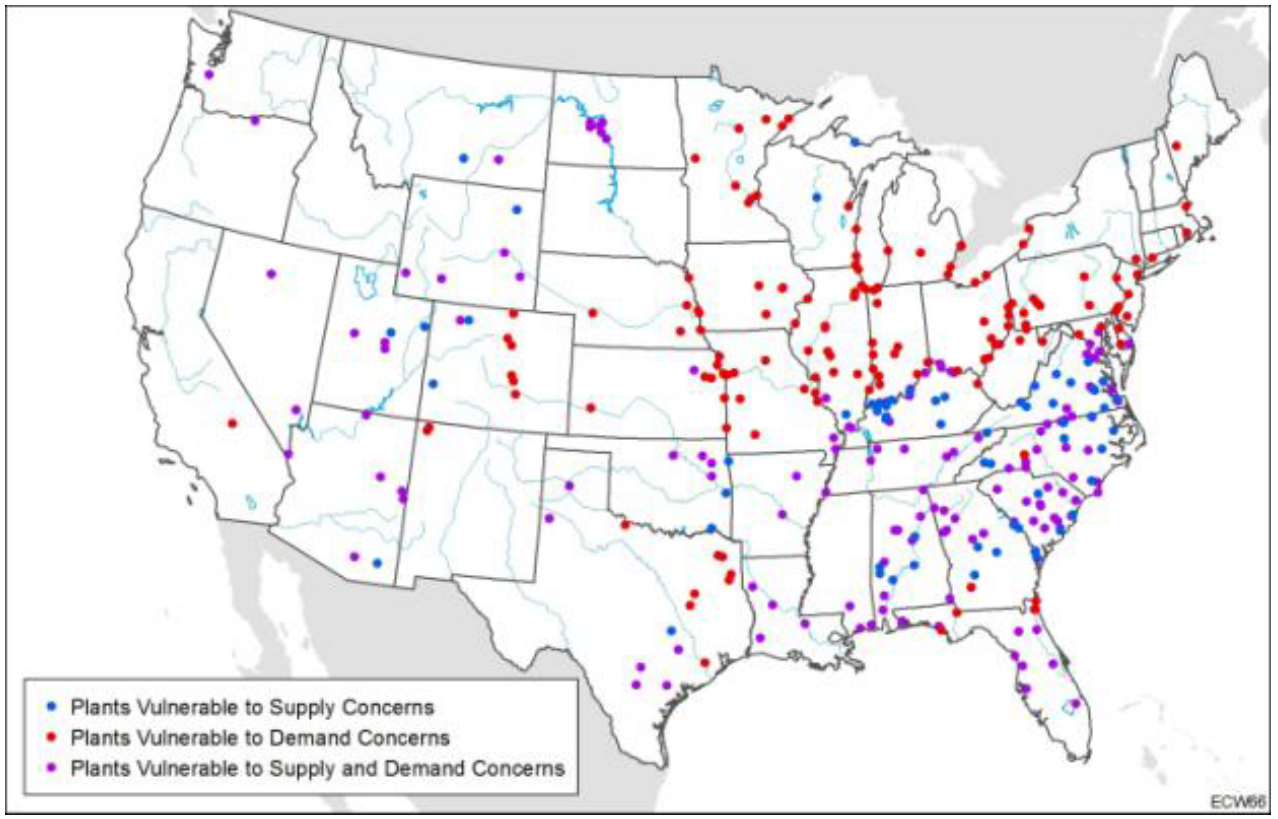
- Collectively, EEI's member companies are on a path to reduce their carbon emissions at least 80% by 2050, compared with 2005 levels.
  - The switch from coal to natural gas and renewable energy has been the single most effective tool over the past decade for reducing carbon emissions
  - all of this has been done while keeping rates steady and while ensuring that electricity remains affordable and reliable.
- It is important to us that we lead on clean energy in a way that gives us all the options, including making sure that we maintain existing nuclear and that we are still able to use natural gas to help achieve our clean energy targets.
- To eliminate the last 10% to 20% of emissions. …. we need advanced renewables, long-duration energy storage and demand efficiency, advanced nuclear, hydrogen, carbon-capture, use, and storage, … and getting critical transmission and energy grid infrastructure built more quickly.

Tom Kuhn, president of the Edison Electric Institute, the association of U.S. investor-owned electric companies. Jan. 26, 2021

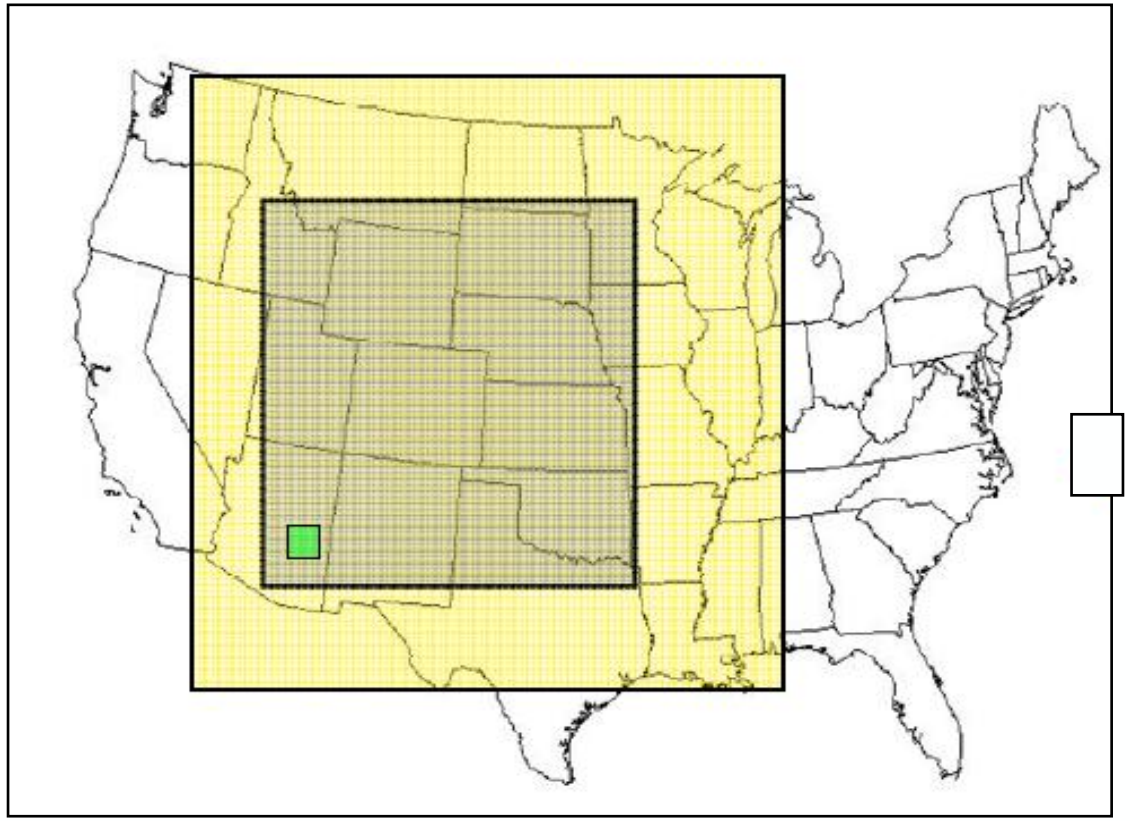
2050 Electric Power Targets Based on System Performance Optimization

10% Coal
30% Natural gas
10% Nuclear
50% Renewables
(Wind, Solar, Hydro, Biomass)

Thermoelectric Power Plants with Water Supply and Demand Concerns



Land Needed for Biofuel to Replace 50% of Current Petroleum/Diesel using: Corn, Soybean, Algae



Water Use and Consumption for Electric Power Generation

Plant-type	Cooling Process	Water Use Intensity (gal/MWh$_e$)		
		Steam Condensing		Other Uses
		Withdrawal	Consumption	Consumption
Fossil/ biomass steam turbine	Open-loop	20,000–50,000	~200-300	~30
	Closed-loop	300–600	300–480	
Nuclear steam turbine	Open-loop	25,000–60,000	~400	~30
	Closed-loop	500–1,100	400–720	
Natural Gas Combined-Cycle	Open-loop	7,500–20,000	100	7–10
	Closed-loop	230	180	
Integrated Gasification Combined-Cycle	Closed-loop	200	180	150
Carbon sequestration for fossil energy generation	~80% increase in water withdrawal and consumption			
Geothermal Steam	Closed-loop	2000	1350	50
Concentrating Solar	Closed-loop	750	740	10
Wind and Solar Photovoltaic	N/A	0	0	1-2

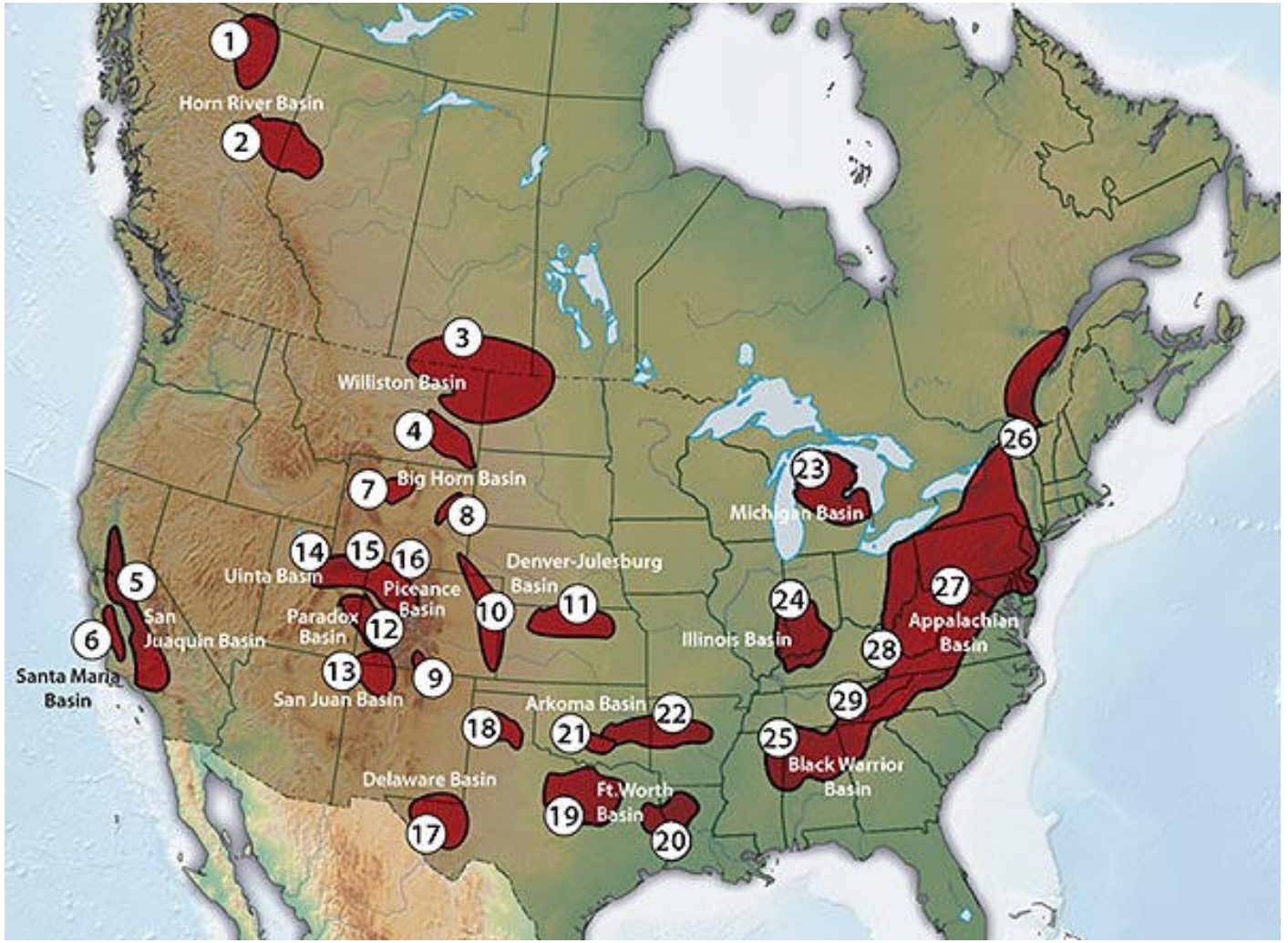
Green Technologies

Lowest Levelized Cost
NGCC, and Wind

Blue Technologies

Dry/hybrid cooling an option in some areas of the west in fall, winter and spring, especially effective with NGCC

Oil and gas shale produced water management is an area of national impact and interest



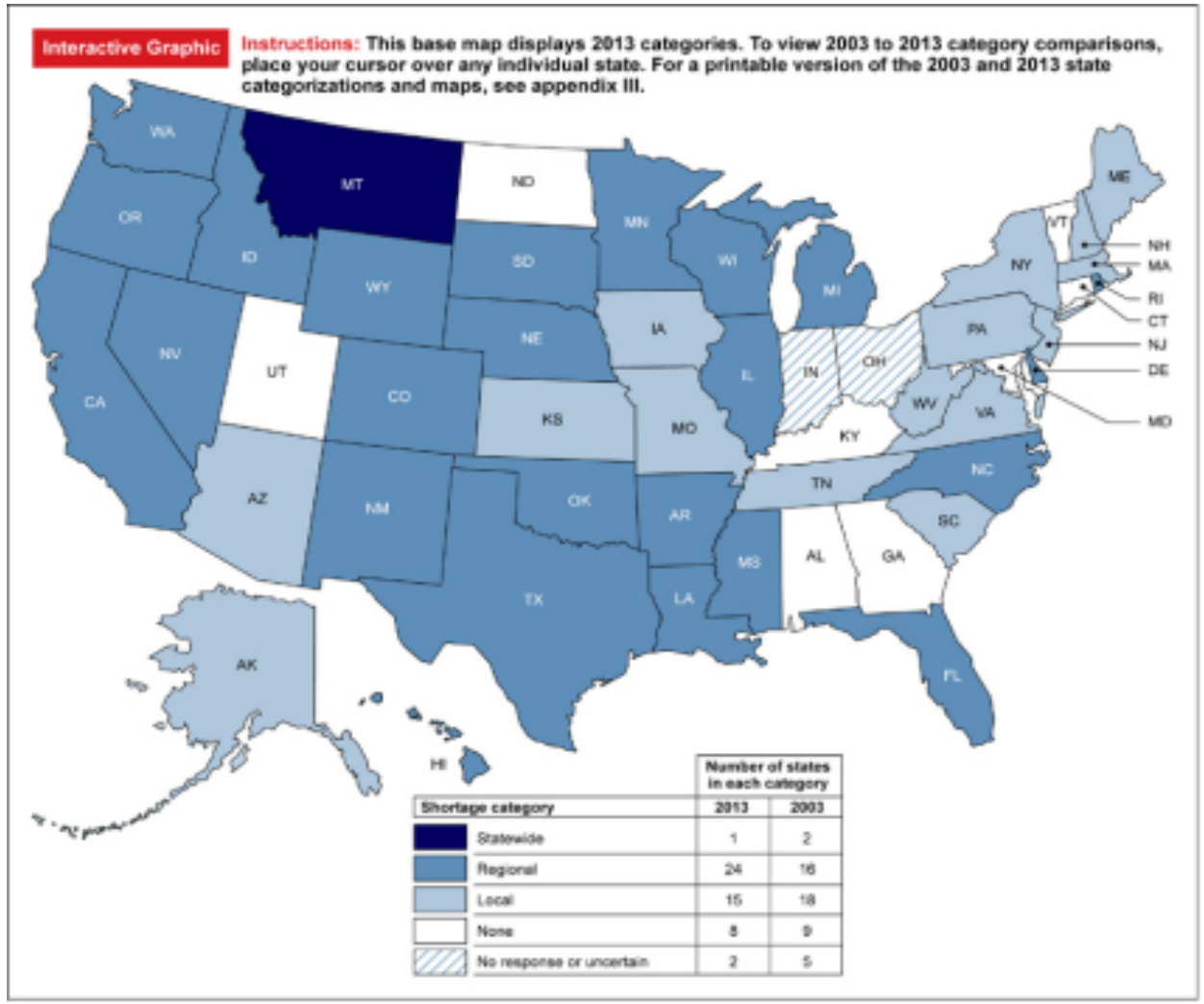
BE BOLD. Shape the Future.

Global Annual CO2 Emissions By Country

China *(28%). 10 billion tons.*	*6 tons /cap*	
Rest of the World *(23%). 9 billion tons*		
United States *(15%). 5 billion tons*	*14 tons/cap*	*80% reduction = 2.5 tons/cap*
India *(7%). 2.5 billion tons*	*1.66 tons/cap*	
Russia *(5%) - 2 billion tons*	*20 tons/cap*	
Japan *(3%) 1 billion tons*	*5 tons/cap*	
Germany *(2%) .66 billion tons*	*7.3 tons/cap*	
Iran *(2%)*		
South Korea *(2%)*	*13.2 tons/cap*	
Saudi Arabia *(2%)*		
Indonesia *(2%)*		
Canada *(2%) .66 billion tons*	*16.5 tons/cap*	
Mexico *(1%) .33 billion tons*	*2.8 tons/cap*	
South Africa *(1%)*		
Brazil *(1%)*		
Turkey *(1%)*		
Australia *(1%) .33 billion tons*	*9.4 tons/cap*	
United Kingdom *(1%) .33 billion tons*	*2.2 tons/cap*	
Poland *(1%)*		

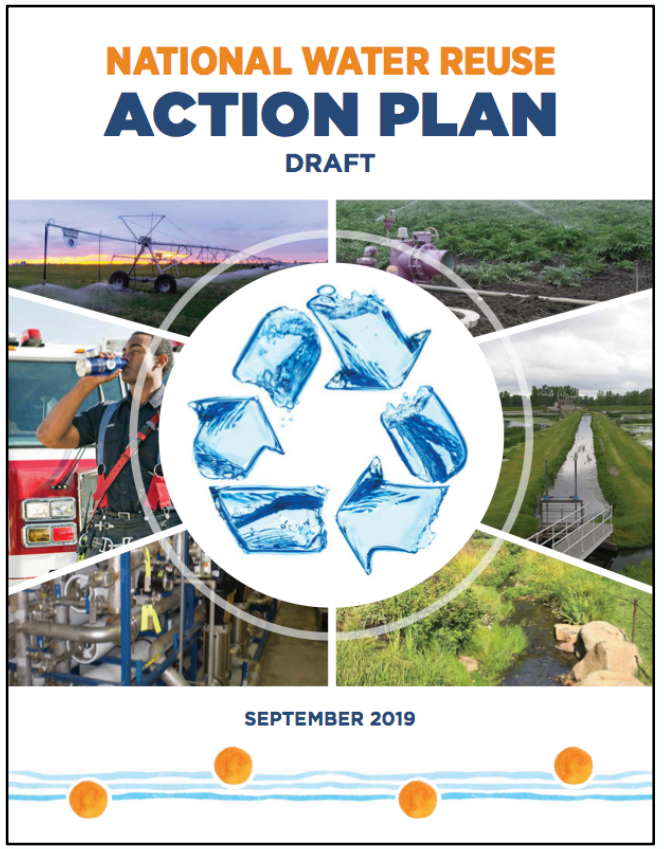
EPA National Initiative on Non-traditional Water Reuse

GAO 2003 and 2013



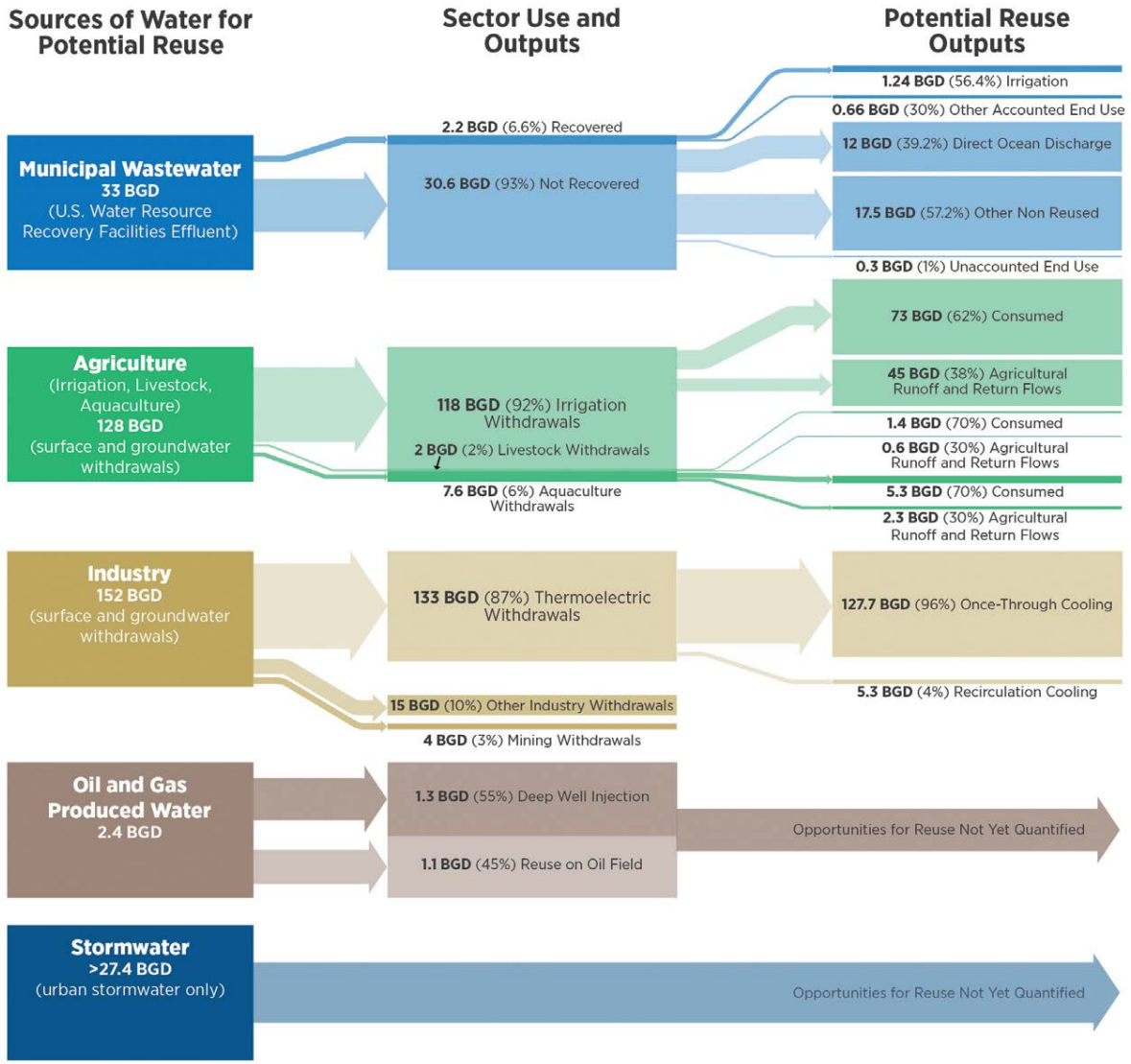
Sources: GAO analysis of state water managers' responses to GAO survey; Map Resources (map).

EPA 2019

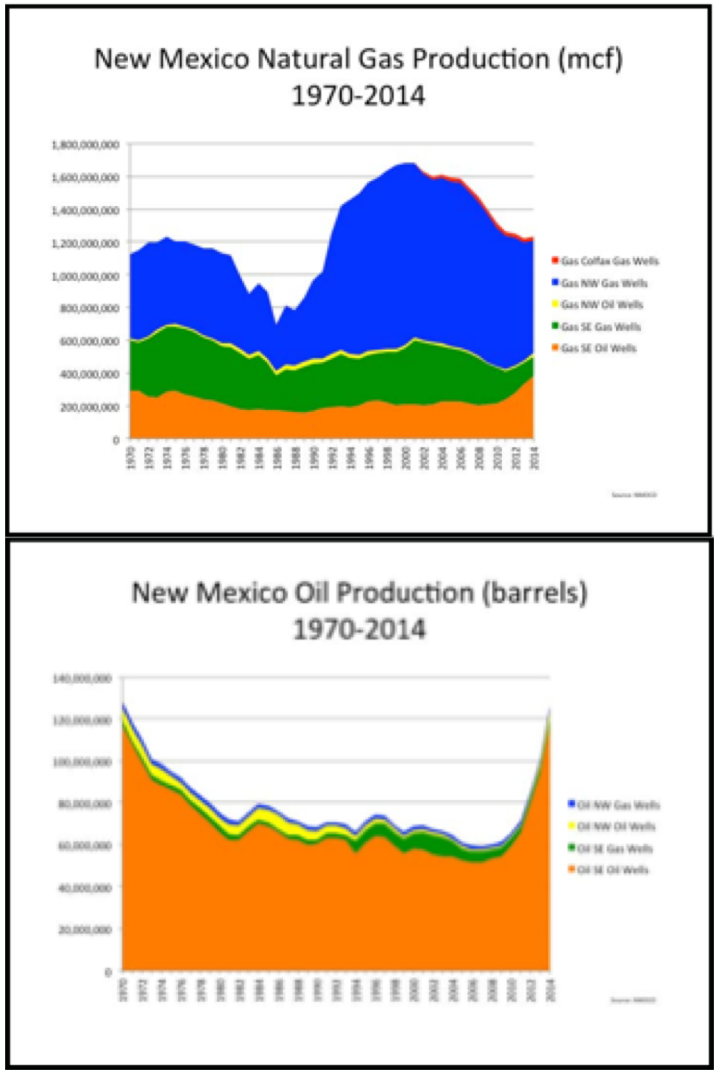


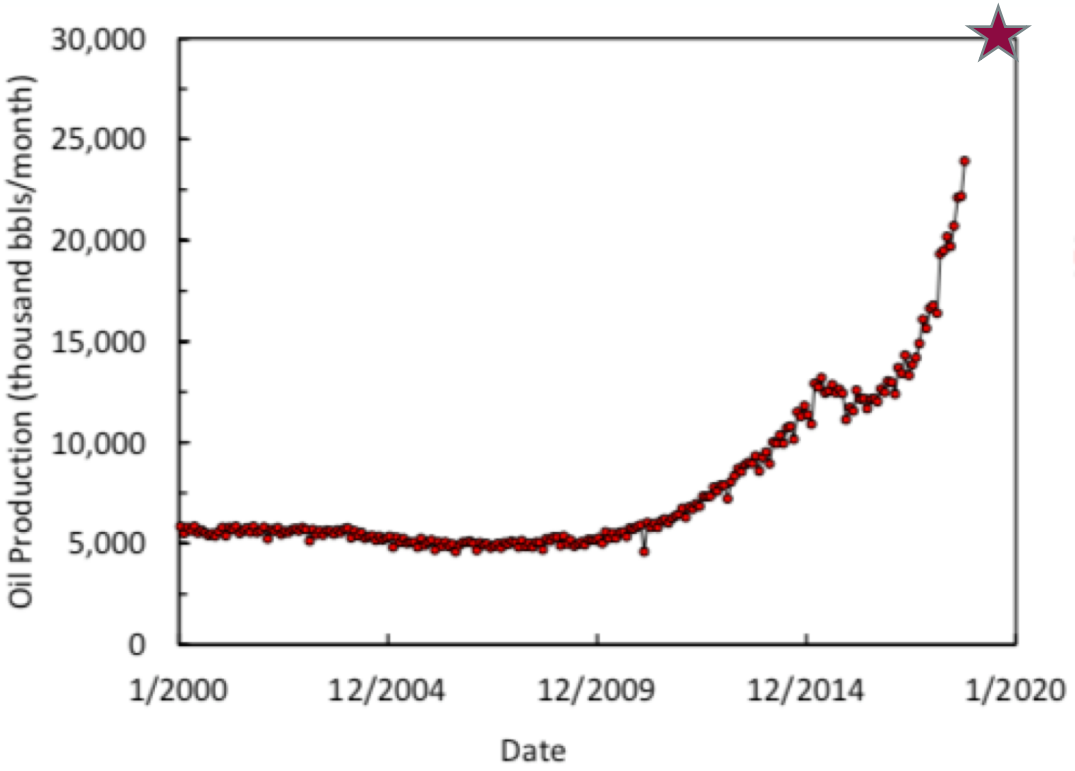
EPA National Water Reuse Action Plan Focus Areas

- Clear potential to reclaim more waste waters for beneficial use
- Sources of water for priority reuse:
  - 33 BGD - Municipal wastewater
  - 128 BGD - Agriculture
  - 152 BGD - Industry
  - 2.4 BGD - Oil and gas produced water
  - >27.4 BGD – Storm water
- Focus on treatment for beneficial reuse
- Leads selected for each area - GWPC and NMPWRC selected to lead produced water efforts



Quantify Produced Water Available for Reuse





Average 4-5 bbls of produced water/ barrel of oil
~4 million bbls produced water/day (3 ABQ's)

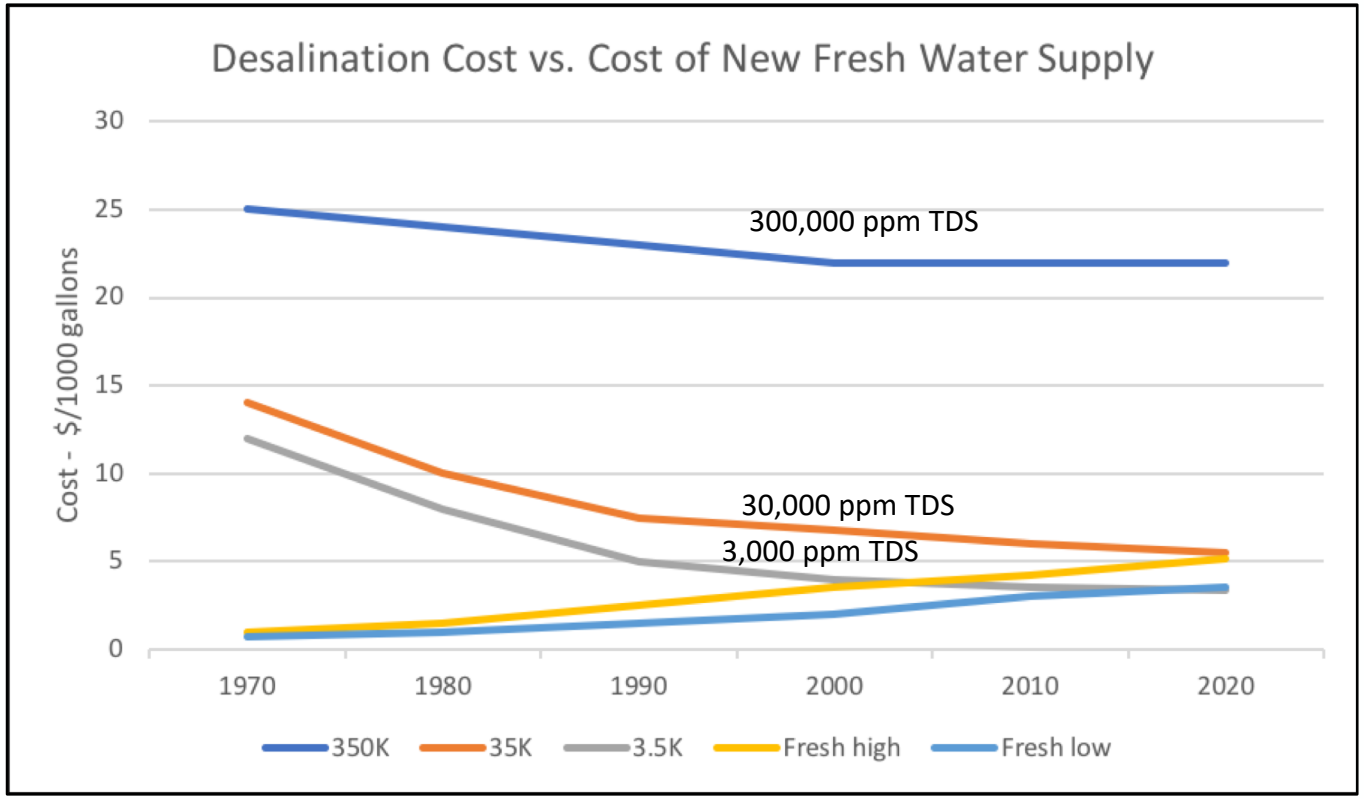
Local Produced Water Treatment Challenges

- Produced water quality varies by depth, location
  (10,000 mg/L to > 300,000 mg/L)
- Often Na, Ca, Cl, CO3,and SO4, high scaling
- Can contain hazardous constituents such as: Ra, Ba, Sr, U, heavy metals, organics,
- Fracking chemicals –
  Water and sand –99% to 99.5% by volume
  Friction reducer, Biocide, Surfactants, Thickeners, Scale and corrosion inhibitors, and other trace chemicals
- Surface storage
- Concentrate management and disposal issues and costs – solid, hazardous, radioactive, or mixed waste
- Potentially 100-150 MGD of excess produced water available

Requires safe transport, handling, treatment, storage, and residuals management and disposal

Decreasing Treatment/Increasing Fresh Water Costs

(EWRI Hightower 2018)



2000 Permian Basin
Avg. Produced Water
Disposal costs $2/1000 gal

2020 Permian Basin
Avg. Produced Water
Disposal costs $20-50/1000 gal

Water Quality Requirements for Various Reuse Applications

Produced Water Quality (ppm) TDS	Application	Common Water Quality Requirements (ppm) TDS	Typical Treatment Process
Conventional 10K to 50K 50%<35K 50%>35K	Drinking	500-600	Chemical/membrane/thermal
	Aquifer Storage & Recovery	300-5,000	Chemical/membrane/thermal
	Agriculture and livestock	Class 1 <700, <60% Na, B<0.5 Class 2 2000, 60-75% Na, B<2.0 Class 3 >2000, 75% Na, B~2	Chemical/membrane/thermal
Unconventional 60K to 300K 25%<100K	Rangeland	4,000 – 10,000	Chemical/membrane/thermal
	Surface Flow	600-2000	Chemical/membrane/thermal
	Mineral Recovery	>100K (no discharge)	Chemical/thermal
	Road Constr.	Up to 100,000	Chemical/membrane/thermal

Summary Data on Oil and Gas Operation Impacts on Public and Environmental Health and Safety

< 0.25 miles from oil and gas operations

- Highest level of acute public health impacts and concerns
- Highest occurrence of environmental impacts - noise, air, land. and water pollution and contamination

0.25 - 0.50 miles from oil and gas operations

- Significanlty reduced public health impacts
- Significantly reduced environmental impacts or damage from operations or accidents

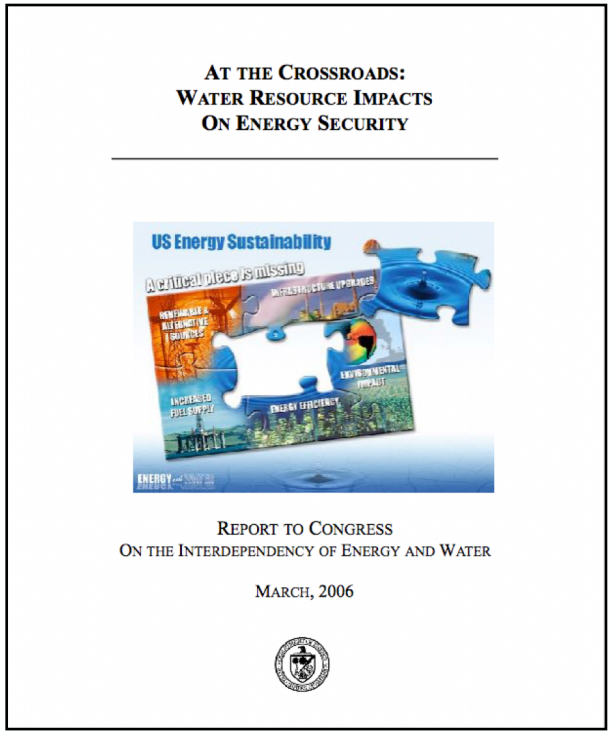
> 0.50 miles from oil and gas operations

- Little observed acute or chronic public health and safety or environmental impacts
- Especially in open, flat, and non-wooded operational areas

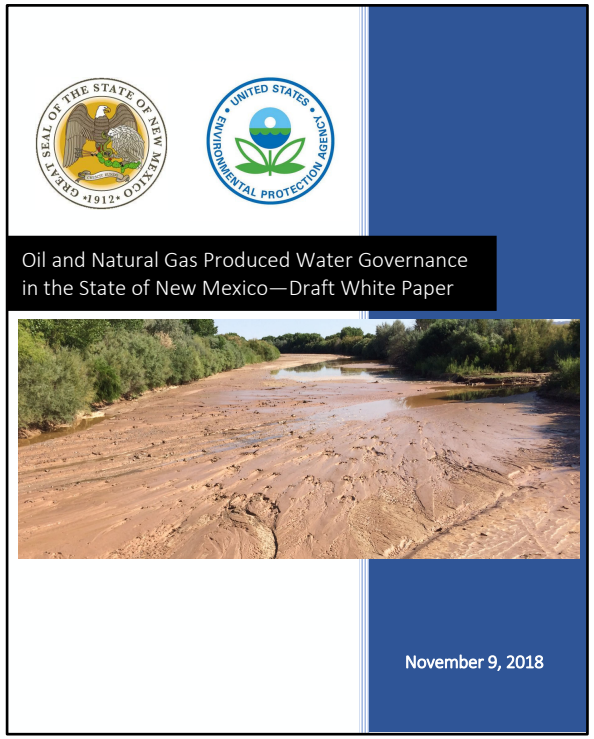
- Highest impacts in populated areas, especially in wooded, rolling terrain
- Highest impacts to permanent residents on small private land parcels in closely aggregated operations
- NM DOH has no record of fracking damaging a personal water supply

Physicians for Social Responsibility-Colorado Symposium - Health Effects of Oil and Gas Development, December 4, 2020.

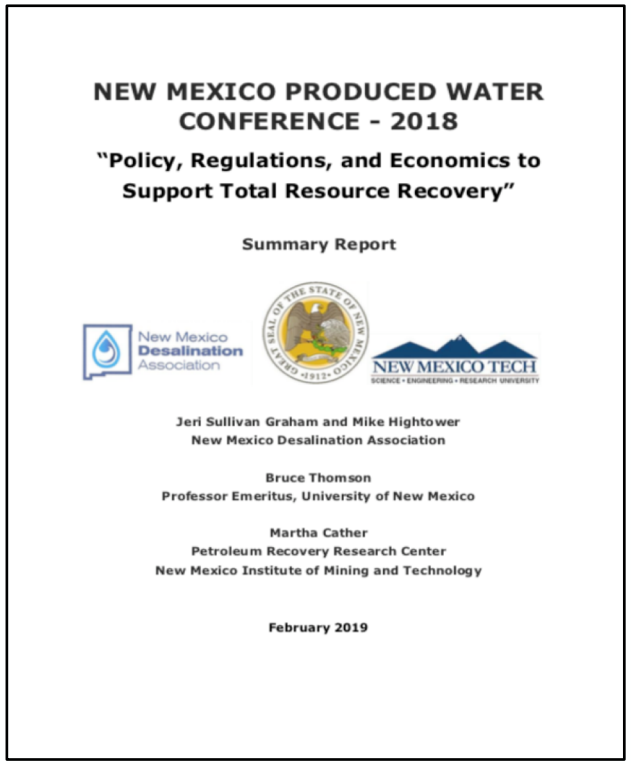
Recent New Mexico Efforts on Produced Water Treatment and Reuse



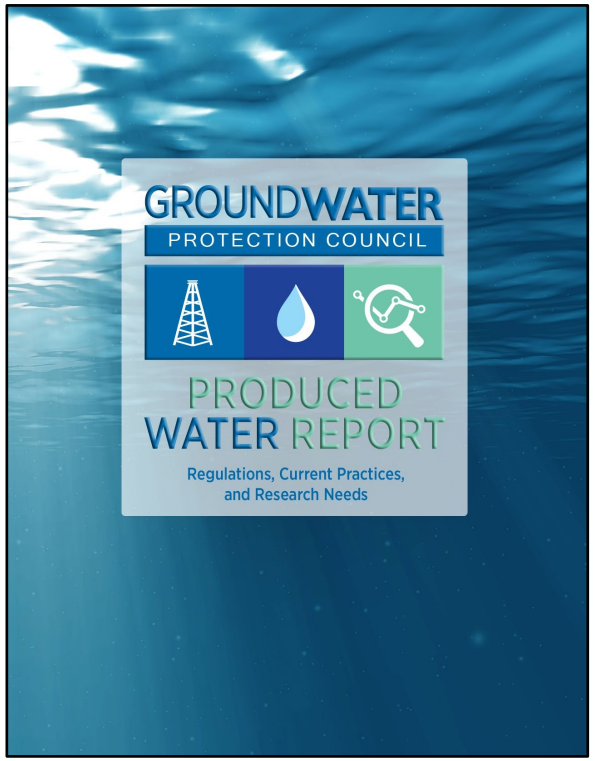
Sandia, Los Alamos, DOE 2004



NMED, OSE, EPA 2017-18



NMED, OSE, EMNRD 2017-19



EMNRD 2016-19

NM 2019 Produced Water Act, HB 546

- Through the Act, statutory and regulatory authority for the reuse of produced water was modified:
  - Reuse inside oil and gas sector remains under the Oil Conservation Division (OCD) of the NM EMNRD,
  - **Reuse outside the oil and gas sector, was designated to the NM Environment Department (NMED).**
- The Act encourages produced water reuse outside oil and gas to:
  - enhance fresh water sustainability,
  - reduce or eliminate fresh water use in the oil and gas sector,
  - support new economic development opportunities,
  - maintain public and environmental health and safety.

This regulatory transition is an emerging trend in the oil and gas sector – OK, TX, CA

NMPWR Consortium Organization

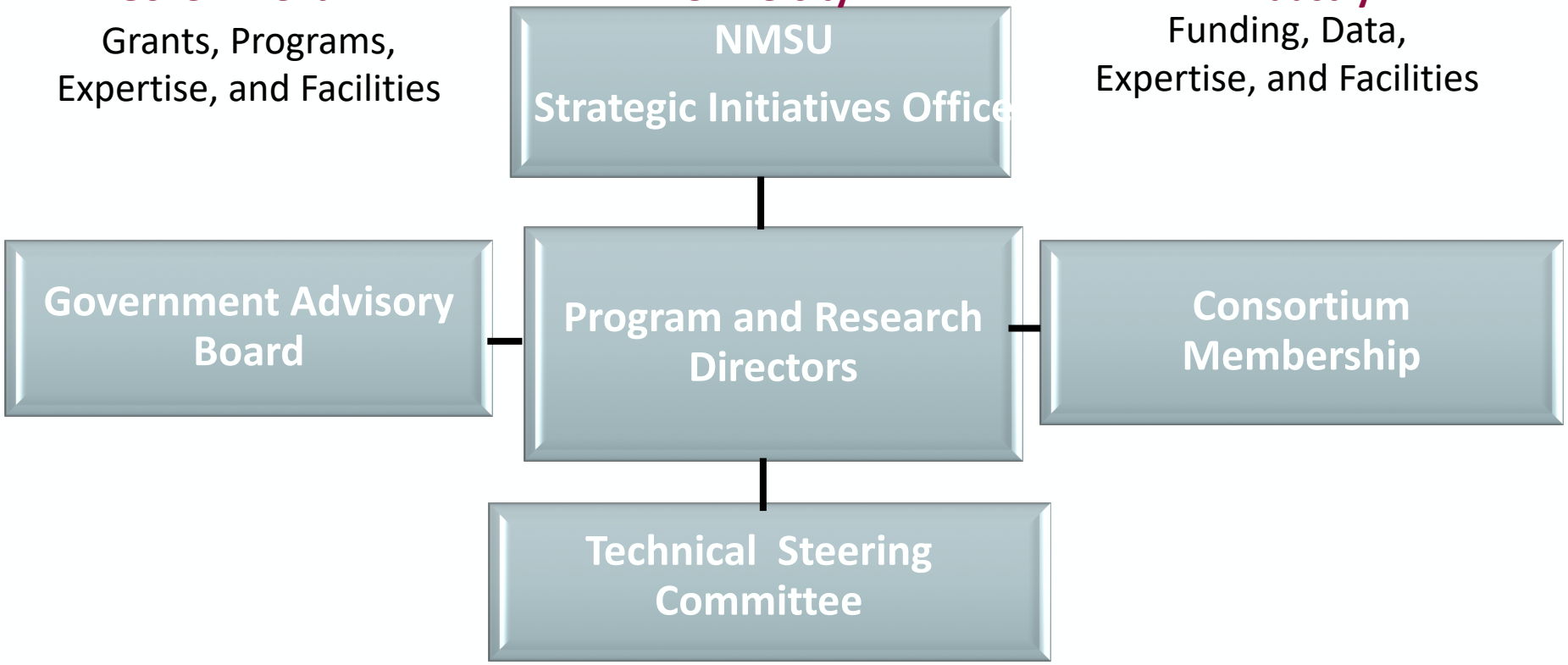
Government

Grants, Programs,
Expertise, and Facilities

University

Industry

Funding, Data,
Expertise, and Facilities



Modeled after DOE Innovative Treatment Remediation Demonstration Program and EPA Environmental Technology Verification (ETV) and EPA SITE Program

Consortium Project Efforts

2020						
2021						
2022						
2023						

More extensive research, demonstration and testing efforts are shaded – Large focus on field-scale cost and performance testing and evaluation

Consortium Research Focus for 2021

- Current research priorities are on:
  - Technical risks
    - Bench and pilot-scale treatment technology cost and performance,
    - Sampling, monitoring, and chemical analysis improvements,
    - Produced water quality and quantity data portal,
    - Socioeconomic, environmental, ecological cost-benefit risk analyses of reuse
  - Environmental, ecological, and public health and safety risks
    - Quantitative toxicology evaluations, analyses, and assessments using WET and greenhouse-based bioaccumulation studies
    - Treated produced water relative risk analysis – NPDES+ or NPDES- vs other treated waste waters
  - Public education and outreach on relative risks

https://nmpwrc.nmsu.edu