PERMITTING FIT-FOR-PURPOSE TREATMENT AND REUSE OF PRODUCED WATER

SUMMARY OF CURRENT AND EMERGING STATE DISCHARGE REGULATIONS

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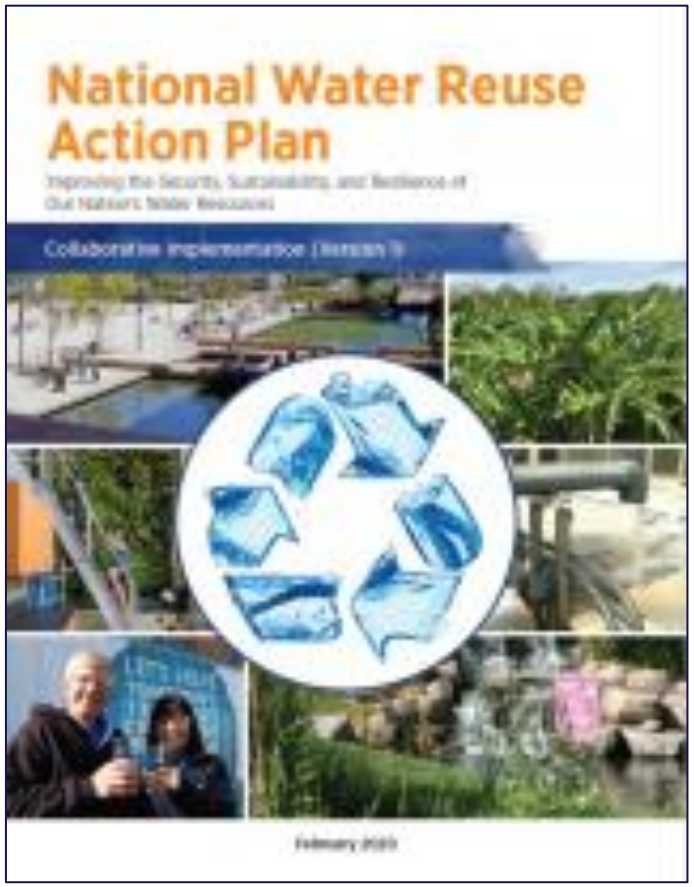
WATEREUSE® 2024 SYMPOSIUM

REMOVING BARRIERS, ELEVATING OPPORTUNITIES

Presentation Overview

- Review of EPA's National Water Reuse Action Plan efforts for produced water.
- Short overview of produced water -
  - variations in quality, federal guidelines and directions
- Information on regional produced water treatment drivers and current and emerging state discharge regulations.
- Audience discussion of regulatory and economic drivers and trends in fit-for-purpose treatment, recycling, and reuse of produced water.

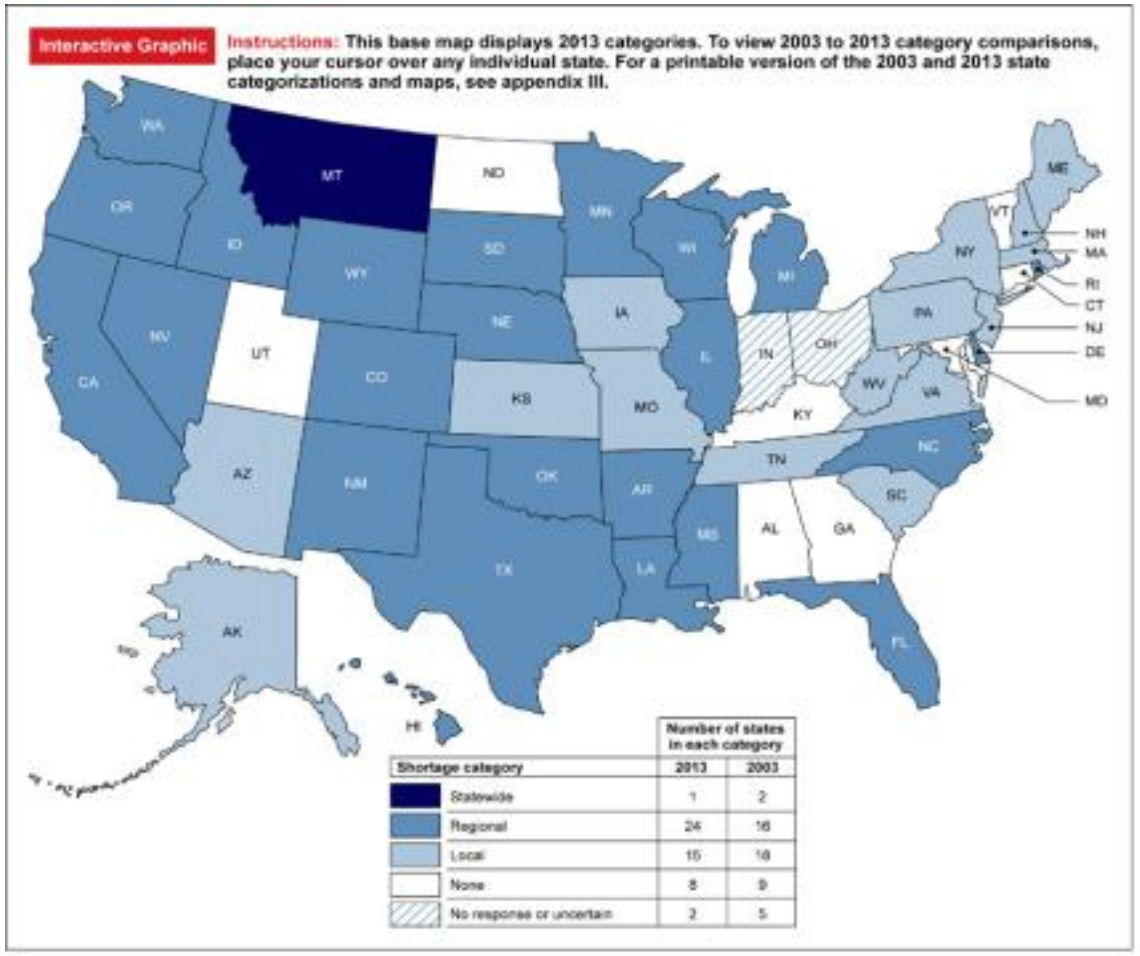
2020 EPA National Water Reuse Action Plan



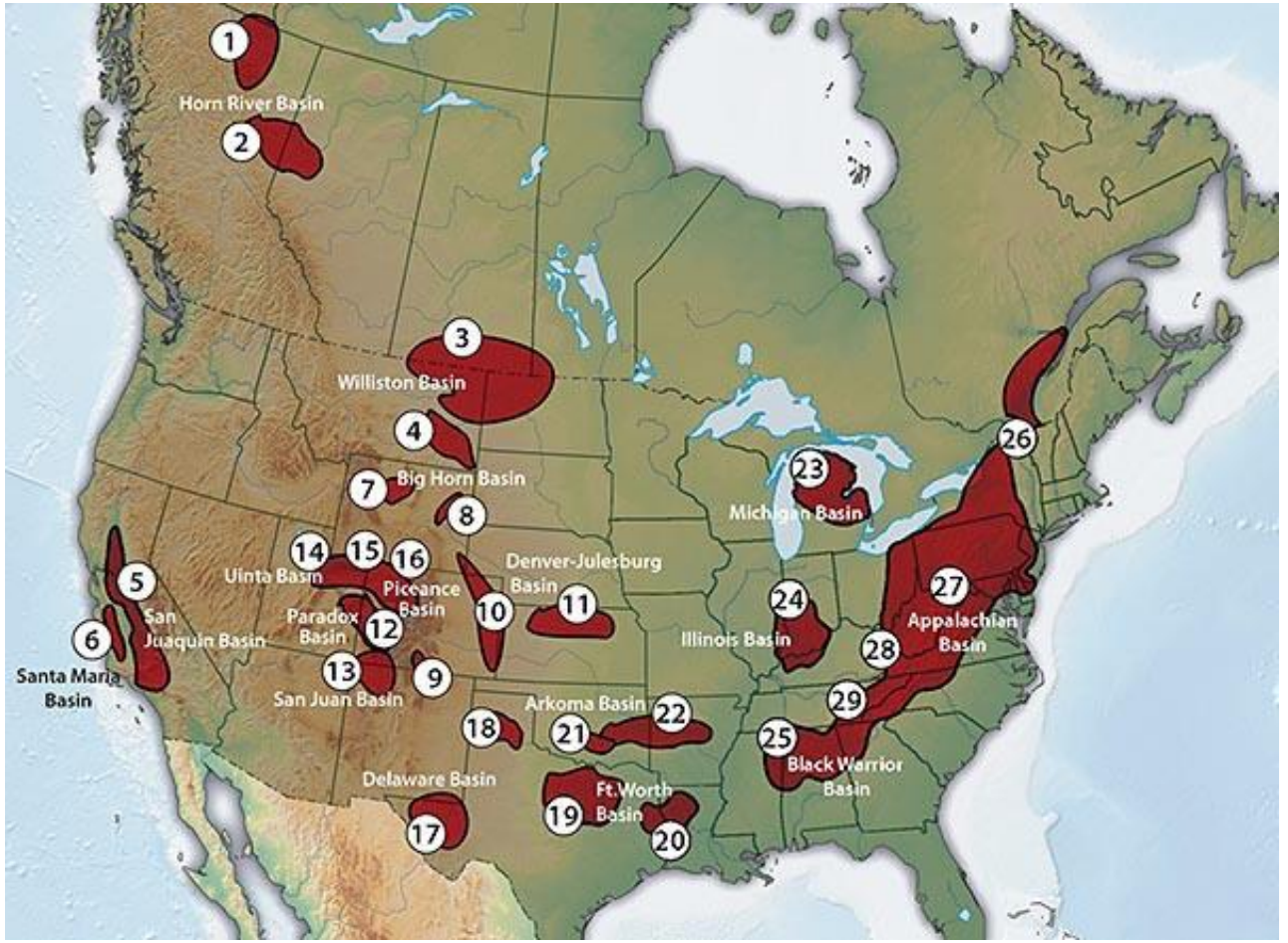
Two of the United Nations' Sustainable Development Goals **are water reuse as key to a more sustainable future.**

- Focus on the fit-for-purpose treatment and reuse of waste water
- Five major programmatic areas:
  - Thermo-electric cooling water
  - Agricultural waste water
  - Municipal waste water
  - Produced water
  - Storm water
- Produced water milestones in Section 2.4.2 of the WRAP include collaboration and outreach with WRA and industry

Why Consider Treating and Reusing Produced Water



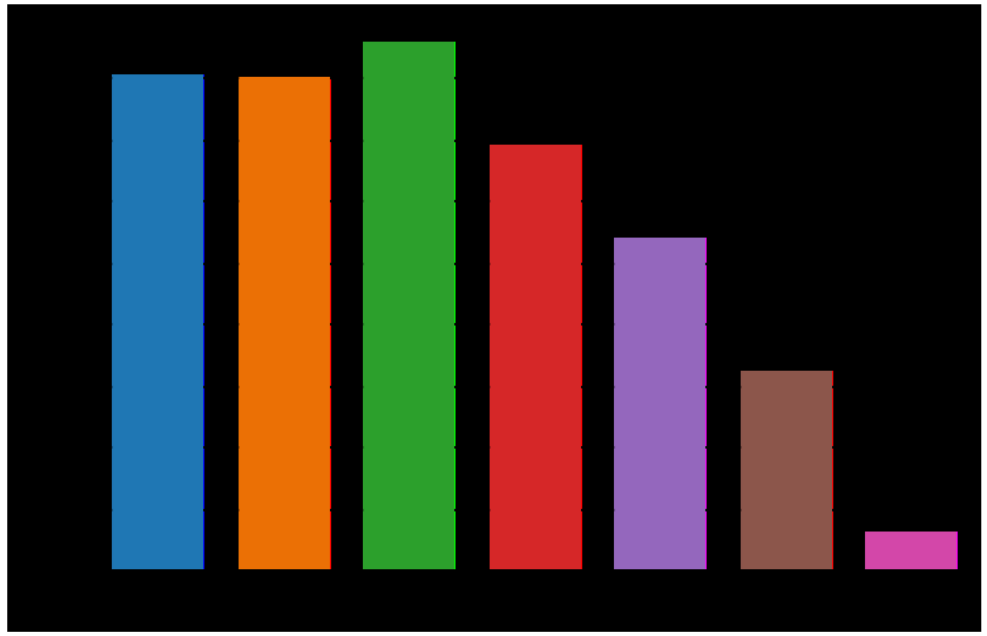
State Water Stress



Unconventional Oil and Gas Basins

Public Support for Fit-for-Purpose Treatment and Reuse of Produced Water?

Identify all potential reuse applications that you would support for the use of treated produced water to conserve the use of New Mexico's freshwater supplies, if the water is treated and regulated to standards that prove it to be safe to use and protect human health and the environment?

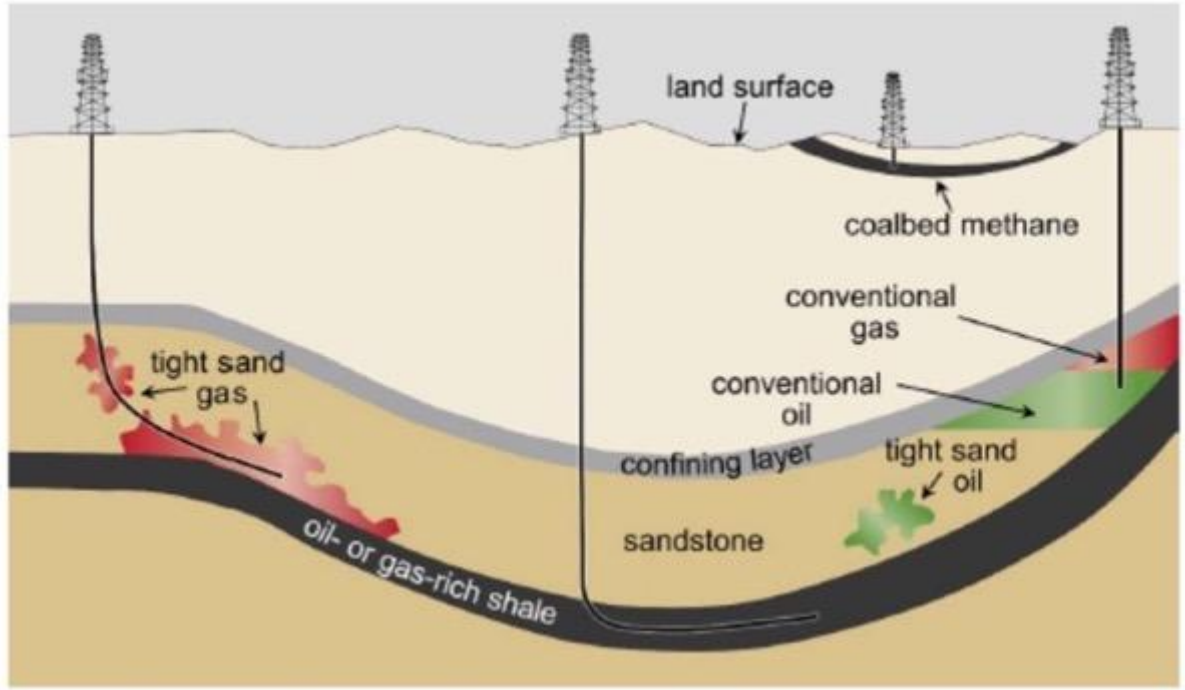


2022 and 2023 Combined NMPWRC Survey Results

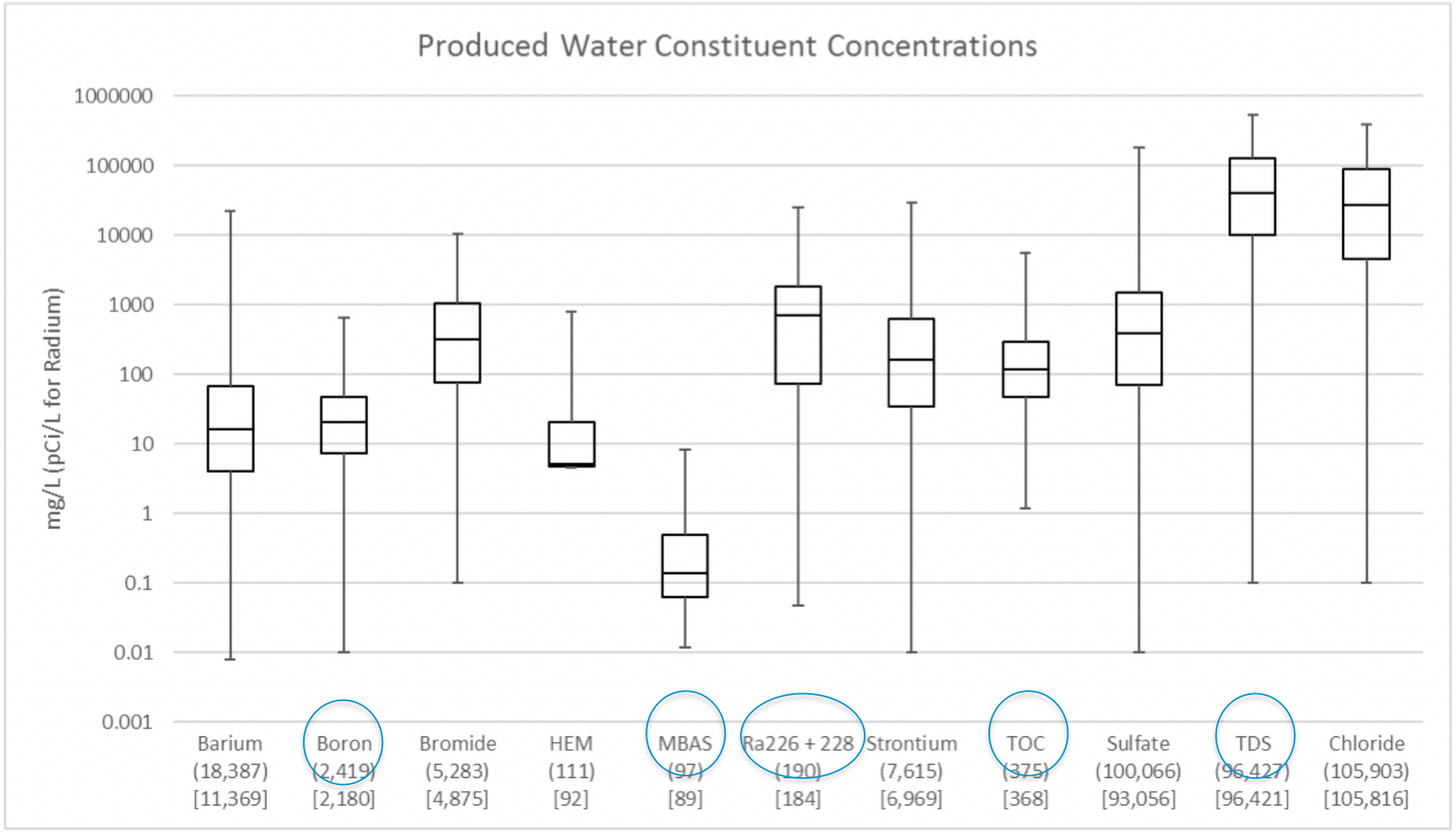
- Uses inside the oil field - such as construction, drilling and fracking, concrete mixing, and dust suppression **(61%)**
- Industrial uses outside the oil field - such as construction, power generation, manufacturing, etc. **(61%)**
- Agricultural uses, such as irrigation for non-edible crops (e.g., cotton) **(65%)**
- Multiple agricultural uses, e.g., irrigation, rangeland restoration, livestock watering, etc. **(53%)**
- Supplemental drinking water supplies **(41%)**
- I need more information to support the reuse of treated produced water **(25%)**
- No, I would not support the reuse of treated produced water for any use outside of the oil field **(5%)**

Produced Water - a by-product of Oil and Gas Production

- Water can be 0.5-50 times the volume of oil produced.
- Produced water can contain high levels of minerals and organic compounds from geology and hydrocarbon contact plus drilling and completion chemicals.
- Quality varies by location, formation, and type of well.
- Not a designated hazardous waste



Produced Water Quality – Treatment Often Needed for Reuse



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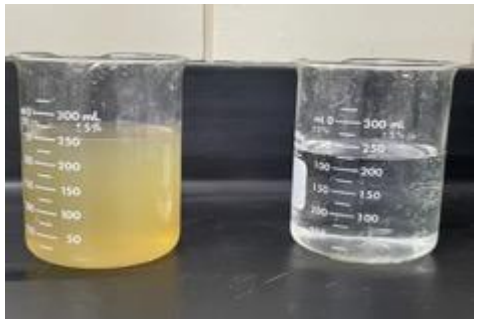
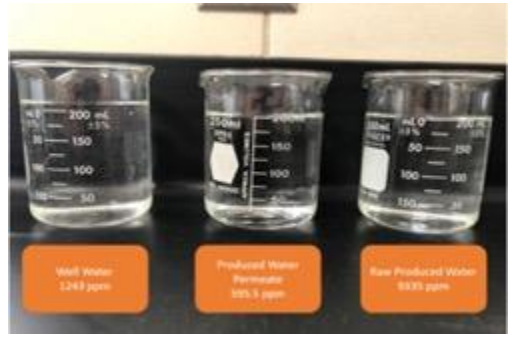


Permian Basin

Permian Basin



San Juan Basin

Federal Guidelines for Produced Water Treatment and Reuse

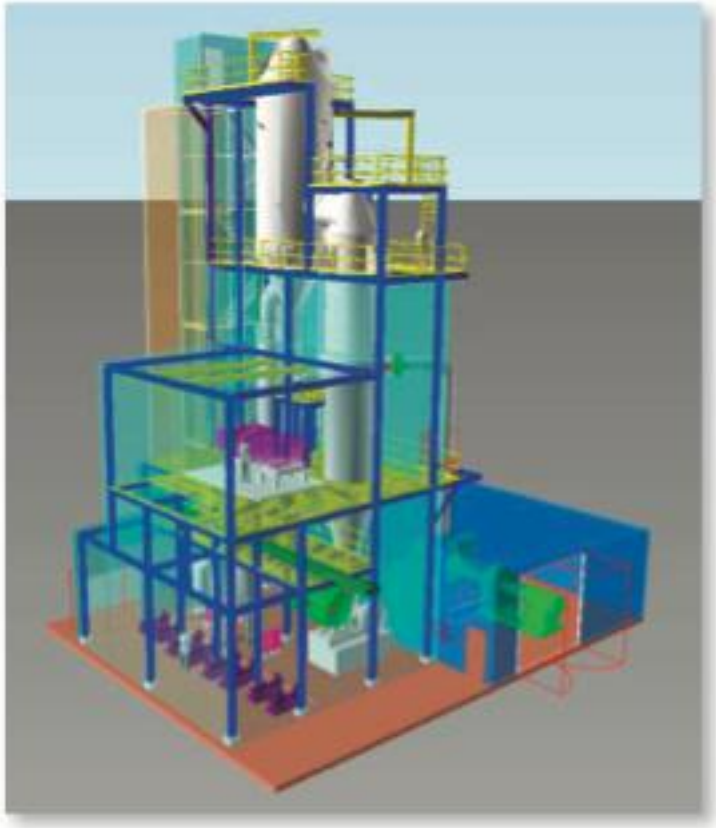
Table 1: On-Shore Oil and Natural Gas Wastewater (Except Coalbed Methane)

Discharging Facility	Surface Discharge Purpose	Applicable ELGs	TBELs
On-shore oil and natural gas extraction facility	General discharge	40 CFR part 435, subpart C	No discharge of pollutants to surface waters
On-shore oil and natural gas extraction facility	West of the 98th meridian for specific uses in livestock or wildlife watering	40 CFR part 435, subpart E	Must be of good enough quality; also, daily maximum effluent limit for oil and grease of 35 mg/L
Stripper wells	General discharge	40 CFR part 435, subpart F	No specified limitations; TBELs developed by permitting authority on a BPJ basis
Coalbed methane (CBM) extraction facility	General discharge	40 CFR part 435, subpart H	No specified limitations; TBELs developed by permitting authority on a BPJ basis
Centralized waste treatment (CWT) facility	N/A	40 CFR part 437	For specific pollutant and limitations, see 40 CFR part 437

Ref: Oil and Natural Gas Produced Water Governance in New Mexico – Draft White Paper November 2018

Federal Guidelines on Produced Water

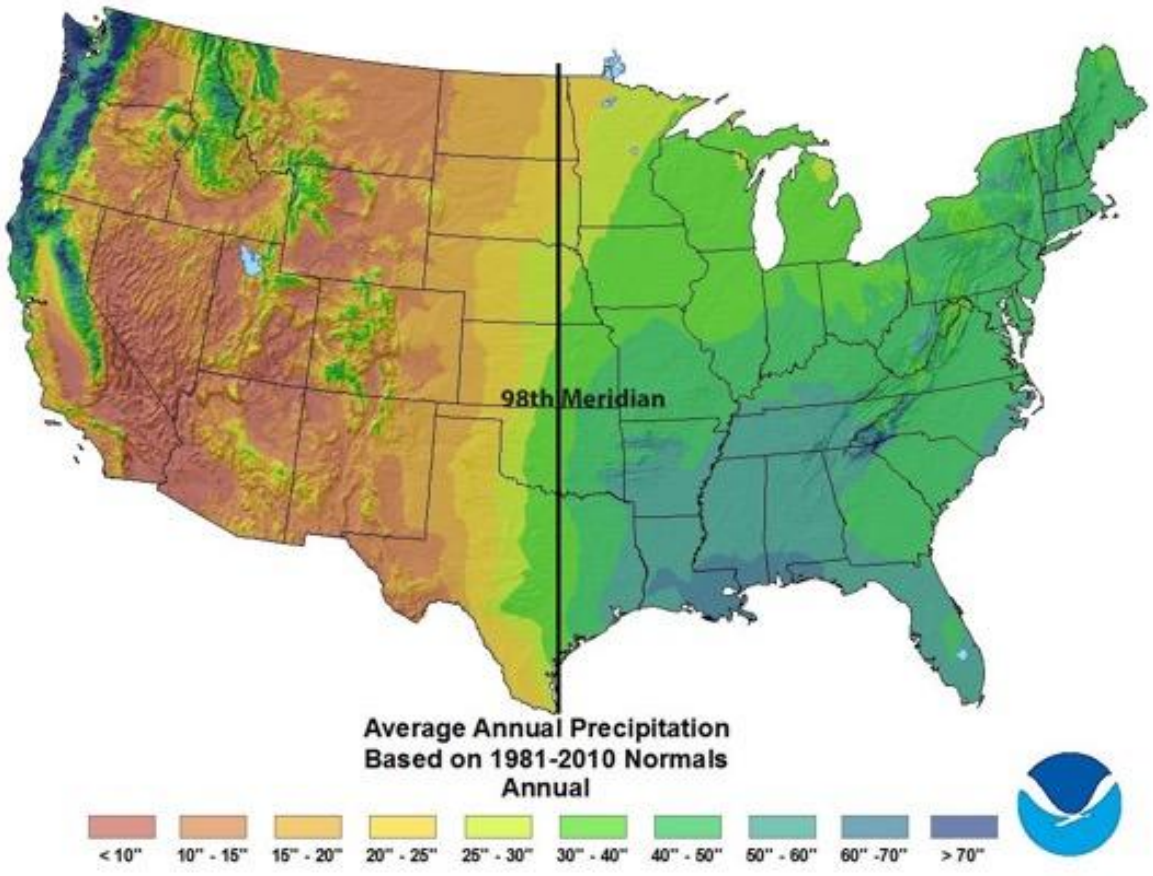
- 40 CFR 435 Subpart C– Oil and Gas Extraction Point Source Category
  - Produced water is defined as “the water brought up from the hydrocarbon-bearing strata during the extraction of oil and gas, and can include formation water, injection water, and any chemicals added downhole or during oil/water separation process”
  - Unconventional produced water prohibited through a POTW
  - Zero discharge of produced water unless sent to a centralized water treatment (CWT) facility, **except west of the 98th Meridian**



Schematic of a Pennsylvania CWT Plant

Produced Water Treatment and Reuse for Discharge

- 40 CFR 435 (Subpart E) – On shore facilities west of the 98th Meridian can discharge produced water if it has a use in agriculture or wildlife propagation when discharged to waters of the U.S.
- 40 CFR 435.51(c) "can be used if produced water is of good enough quality for wildlife or livestock water or other agricultural uses and is actually put to such use during periods of discharge"
- 40 CFR 435.52(b)
  - Max oil and grease – 35 mg/l



Oily Waste Discharge Regulations Not Used for Produced Water

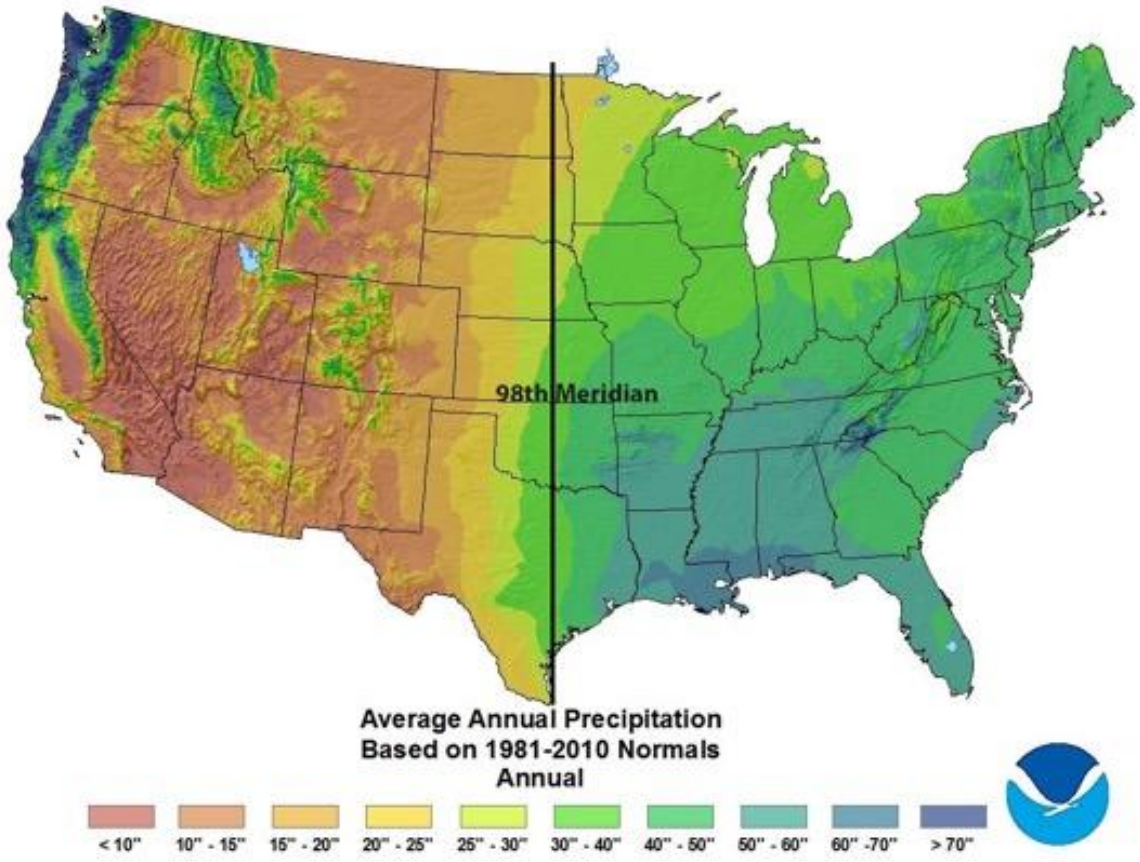
- 40 CFR 437 Subpart B – Oily Waste Water Treatment and Reuse
  - Minimum requirements in mg/L
- Per EPA, these regulatory values considered for industrial waste water rather than for treatment and discharge of produced water
- Produced water often has ~100 major constituents –
  - high salts, high oils and grease, radionuclides, high TPH, etc. not addressed in this regulation

MORE STRINGENT STATE DISCHARGE REG's

Regulated parameter	Maximum daily[1]	Maximum monthly avg.[1]
Conventional Parameters		
O&G	127	38.0
pH	([2])	([2])
TSS	74.1	30.6
Metal Parameters		
Arsenic	2.95	1.33
Cadmium	0.0172	0.0102
Chromium	0.746	0.323
Cobalt	56.4	18.8
Copper	0.500	0.242
Lead	0.350	0.160
Mercury	0.0172	0.00647
Tin	0.335	0.165
Zinc	8.26	4.50
Organic Parameters		
Bis(2-ethylhexyl) phthalate	0.215	0.101
Butylbenzyl phthalate	0.188	0.0887
Carbazole	0.598	0.276
n-Decane	0.948	0.437
Fluoranthene	0.0537	0.0268
n-Octadecane	0.589	0.302

Overview of Current Eastern and Western U.S. Produced Water Recycling and Reuse Regulations

- Recycling – use inside oil and gas
- Reuse – use outside oil and gas
- Eastern State Example
  - Pennsylvania
- Western State Examples
  - Texas
  - New Mexico
  - Colorado
  - California
  - Wyoming



Produced Water Treatment and Reuse in Pennsylvania

- Example Time Period Examined: January 2019 – January 2020 (13 months)
  - From PA DEP Oil and Gas Waste Reporting Website for unconventional PA Operators (Marcellus/Utica)
- Produced Water Recycling
  - The majority of produced water from unconventional wells in PA is pre-treated and recycled for the next well. Most operators store water in above ground containment facilities. Impoundments are banned in PA.
- Injection Wells
  - Only 7 commercial disposal wells in PA. Some PW shipped to Ohio and West Virginia.
- Produced Water Treatment and Reuse
  - Discharge, disposal and road spreading of produced water prohibited. POTWs are not permitted to treat water. Only PADEP approved CWT facilities may treat and discharge. Must meet drinking water standards prior to discharge. Few exist.

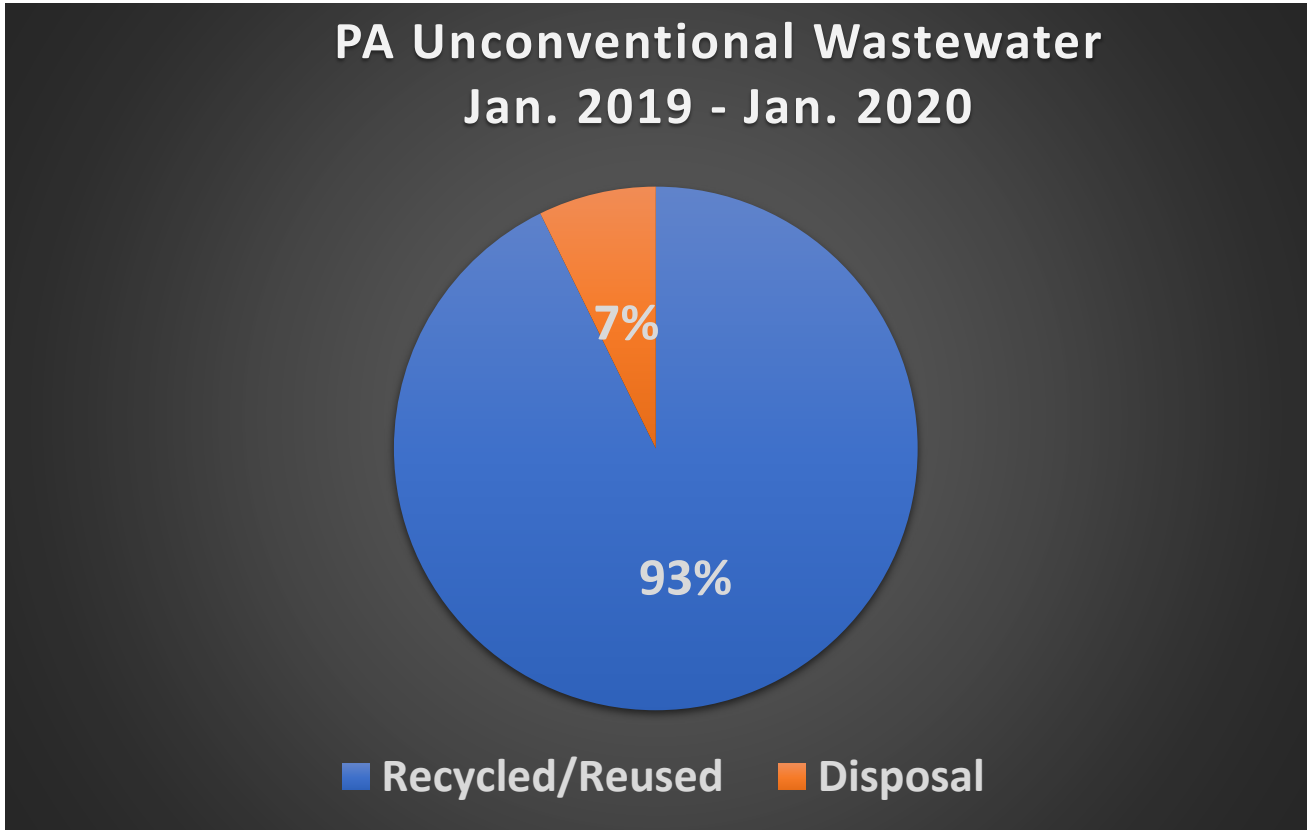
Produced Water Recycling and Reuse in Pennsylvania

Key Takeaways

January 2019 – January 2020*

73,815,044 barrels of wastewater reported by PA Operators

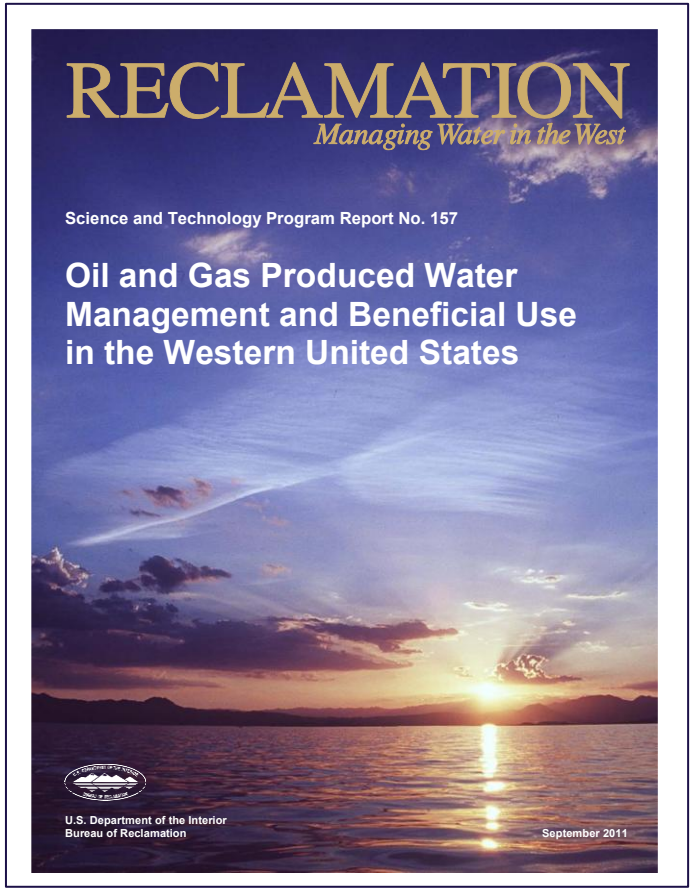
- 68,649,013 barrels recycled or treated for reuse (93%)
- 5,166,031 barrels disposed in injection wells (7%)



Federal Guidance on Produced Water Treatment for Land and Ag Discharge

Parameter	Units	Irrigation Water		
		Class 1	Class 2	Class 3
Total Dissolved Solids	mg/L	<700	<2000	>2000
Sodium	mg/L	400	1000	>1500
Boron	mg/L	<0.5	<2	>2

- Other important irrigation/land application parameters:
  - total organics, ammonia, sodium adsorption ratio (SAR), chlorides, NORM, metals
- For most soils, Class 3 waters are not recommended
- Most produced waters will require treatment and desalination to meet state ag, land, or surface water discharge standards



BOR Report 157, 2011

Current Western States Treated Produced Water Land and Agriculture Regulations for TX, CA, and WY

State	TDS mg/L	Total Constituents Evaluated	Date Developed	Application
California*	1000	~100	1995	Full-scale irrigation
Wyoming	500	~100	2020	Full-scale rangeland
Texas RRC	1000	~50	2024	Pilot-scale rangeland or irrigation

* Conventional produced water only

Texas Treated Produced Water Surface Water Discharge Guidelines

- Current surface discharge standards based on national EPA CWA water quality criteria.
- Testing and analysis shows treated produced water can meet existing surface water discharge criteria.
- Pecos is not a drinking water supply source, but has local ecological benefits
- Companies pursuing NPDES permits with TCEQ

Pecos River Discharge Criteria

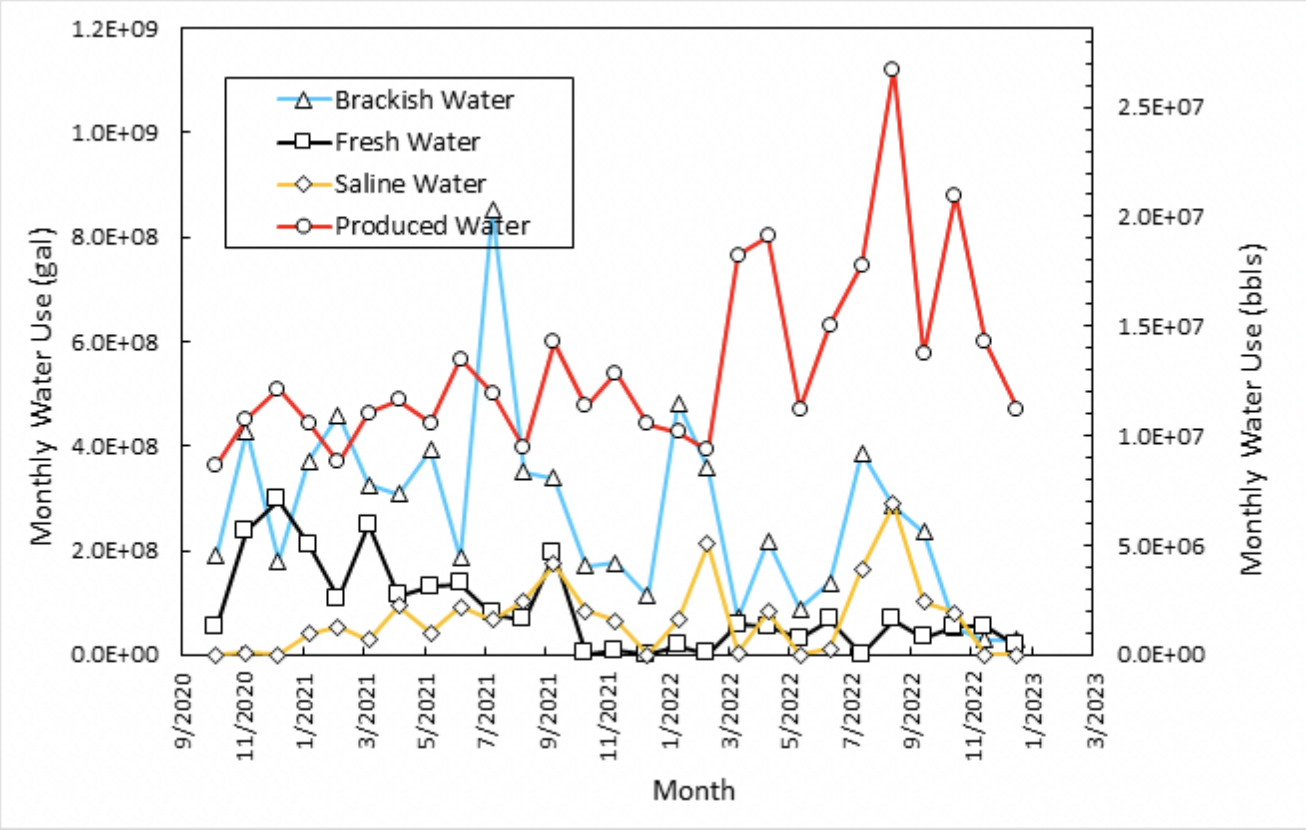
New Mexico - At the TX State Line
41 aquatic impact constituents
110 - human impact constituents
Water quality – 3600 ppm TDS

Texas - Below NM State Line
45 aquatic impact constituents
110 – human impact constituents
Water quality – 4000 ppm TDS

Produced Water Recycling in Colorado

- Goal: To reduce the use of freshwater and increase the recycling of produced water in oil and gas operations.
- March 2024 – Deliver to General Assembly a review of guidance documents and case studies of best practices for infield reuse and recycling of produced water.
- December 2024 - provide recommendations to Energy and Carbon Management Commission for new rules to require statewide reduction in fresh water use and increase in use of produced water in oil and gas operations.
- Toxicological method evaluation (2025).

Affect of Produced Water Recycling Regulations on Fresh Water Use



Current Water Use in Drilling and Fracking

State	Fresh Water Use	Produced Water Reuse
New* Mexico	5%	80%
Texas	50%	50%

* Fresh water use regulation change in 2019, more restrictions proposed in 2024

Produced Water Treatment and Recycling in New Mexico

- More recycling inside oil and gas
  - Treatment and reuse of produced water in plugging and abandoning orphan wells
  - Similar use in repurposing abandoned oil and gas wells for brackish water wells
  - Get more oil recovery and lower SWD operational costs with ‘clean brine’

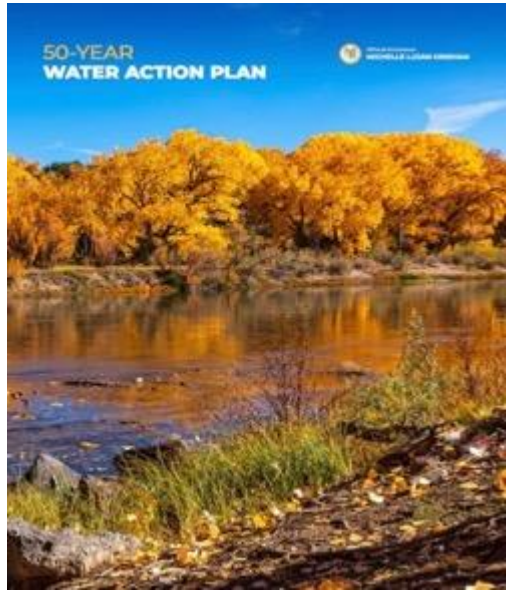
NMPWRC Thermal Technology Testing

Produced water thermal treatment - fresh water for cementing and 10# brine for re-drilling before cementing

- $2/bbl for fresh water and $3/bbl for 10# brine
- $25 M in federal funding

Produced Water Treatment and Reuse in New Mexico

- Preserve and increase fresh water supplies by treating produced water for uses outside oil and gas as part of NM WATER ACTION PLAN
- May 2024 – Submit draft guidance to Water Quality Control Commission for treatment and reuse of produced water for industrial uses having no discharge – greenhouses, hydrogen production, industrial cooling water, semiconductor manufacturing, etc.
- November 2024 – Additional submittal to Water Quality Control Commission for treatment and reuse of for additional applications.



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