# Beneficial Reuse of Treated Produced Water:
## Assessing Feasibility and Sustainability

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## Executive Summary

New Mexico ranks second only to Texas in U.S. oil and gas production, and that production generates large volumes of produced water. Produced water is an industrial wastewater that is currently managed primarily through underground injection for enhanced oil recovery or disposal or recycled for use in completing (fracturing) recently drilled wells.

Currently a significant volume of produced water generated in New Mexico is transported to Texas for disposal – estimated at around 35%. Although there are permit applications for discharge of treated produced water under review by Texas Commission on Environmental Quality (TCEQ), there are currently no draft permits issued for public review nor is there beneficial reuse of treated produced water occurring in the Permian Basin area of Texas. All produced water transported from New Mexico to Texas is disposed in the same manner and at the same cost as produced water generated in Texas.

Because much of New Mexico's oil production occurs in water-stressed areas, treating produced water for discharge, aquifer storage, irrigation, industrial use, or other beneficial uses warrants careful consideration. Beneficial reuse could provide a supplemental water source while reducing reliance on underground disposal. However, it must not be advanced as a water-supply or waste-management solution until its technical feasibility, economic viability, and long-term sustainability have been demonstrated.

Assessing feasibility requires more than determining whether treatment is technically possible. A feasible approach must consistently protect human health and the environment, operate reliably under variable conditions, be financially viable when all costs are considered, and provide water of sufficient quality and quantity for the intended use. This white paper evaluates the state of the science through a review of recently published peer-reviewed research, much of it available through the New Mexico Produced Water Research Consortium (NMPWRC) website, with focus on technical, economic, and sustainability considerations.

Technical feasibility remains promising but unproven. Produced water is a highly variable waste stream, and important knowledge gaps remain regarding its constituents and the performance of treatment technologies across different sources and operating conditions. Demonstrating reductions in total dissolved solids (TDS) or other bulk water-quality measurements is not equivalent to demonstrating that treated produced water can be consistently and safely released into the environment.

Published studies identify constituents that persist through treatment, increase in concentration, or appear in treated effluent even when they were not detected in untreated water. These findings underscore the need to evaluate the complete treatment process—including pretreatment, desalination, and polishing—and to assess known and yet to be fully identified (unknown) constituents of concern and potential treatment byproducts. Longer-duration, larger-volume pilot testing is needed to establish treatment effectiveness and reliability before commercial-scale feasibility can be determined.

Economic feasibility is similarly uncertain. Published cost estimates rely on models and simulations rather than comprehensive operating data from commercial-scale facilities. A meaningful economic evaluation must account for the full cost of collecting and transporting produced water; constructing, operating, and maintaining treatment facilities; securing the required energy; managing concentrated residual wastes; monitoring treatment performance and water quality; and delivering treated water to its intended use. These costs must be evaluated under realistic operating conditions and across the expected

range of produced-water quality and volume.

Energy demand is substantial, particularly for desalination of the complex and highly variable produced water, and management of the resulting concentrate remains a significant disposal challenge. These factors affect both treatment costs and the overall environmental footprint of beneficial reuse. Without reliable, all-in cost information, it is not possible to determine whether beneficial reuse can be financially viable or competitive with existing produced-water management practices.

The consequences of inadequate economic planning extend beyond the profitability of an individual facility. Produced-water treatment facilities have closed or ceased operations in ways that left legacy waste-management problems and environmental contamination. These experiences demonstrate the need for financial assurance, enforceable closure and post-closure requirements, and clear long-term responsibility for residual wastes, facility decommissioning, and environmental impacts. Any permitting framework for beneficial reuse must fully address these obligations before facilities begin operating.

Sustainability also remains uncertain. Produced water is not an independent or renewable water supply; its generation depends on oil and gas production, which varies with market conditions, drilling activity, reservoir performance and depletion, and other factors. This variability creates supply risk for agriculture, industry, or other users that require a dependable long-term water source. Beneficial reuse may help address short-term or regional needs, but available information does not yet support treating produced water as a reliable long-term water-planning solution.

Overall, beneficial reuse of treated produced water, while technically promising, is technically unproven, economically uncertain and limited by unresolved sustainability concerns. The appropriate path forward is a deliberate, transparent, and independently evaluated process that establishes treatment performance, protects human health and the environment, demonstrates full-cost economic viability, and addresses long-term water-supply reliability and waste-management responsibility. Decisionmakers must rely on scientifically defensible, reproducible data—not assumptions—to avoid creating new environmental, public-health, or financial liabilities while attempting to address the oil and gas industry's produced-water management challenges.

## 1.0 Introduction

New Mexico ranks second only to Texas in U.S. oil and gas production, with production concentrated in the San Juan Basin in the northwest and the Permian Basin in the southeast. The 2024 "New Mexico Strategic Water Supply Feasibility Study"[i] (SWS Feasibility Study) states that, as of 2023, the Permian Basin accounted for 84% of the state's gas production and 98% of its oil production, with the remainder coming from the San Juan Basin.

A byproduct of oil and gas exploration and production is produced water, an industrial wastewater generated during the extraction of oil and gas from underground reservoirs. Water naturally trapped with the oil and gas resource, together with a portion of the fluids added during well completion (fracturing) and periodic maintenance, exits the well along with oil and gas throughout the life of the well. Produced water contains elevated salinity levels—often many times the level found in seawater, particularly in the Permian Basin—along with inorganics, organics, and potentially radionuclides. Its composition varies

[i] New Mexico Strategic Water Supply p. 6.

substantially by region, basin, formation, and well, and over time, compounding the challenge of treating this wastewater to the high standard required for intentional release to the environment.

The vast majority of produced water is injected back into the ground, either for enhanced oil recovery (using the injected fluid to extract additional oil from the formation) or through disposal wells permitted for that purpose. Increasingly, produced water is being "recycled"—used to fracture subsequent wells instead of relying on other water, thereby reducing stress on freshwater resources. Maximizing produced water recycling is the "low-hanging fruit" for reducing the volume of produced water to be disposed and water demand on other water resources.

Even when recycling is maximized, remaining produced water still must be managed. Given the water-stressed areas where oil production occurs, treating produced water for discharge, aquifer storage, irrigation, industrial use, or other beneficial uses is worth considering. However, pursuing beneficial reuse requires both assessing and addressing critical knowledge gaps. These include identifying constituents of concern in produced water (a relatively new industrial waste stream being considered for beneficial reuse); assessing treatment technologies capable of treating this highly variable waste to a sufficiently high quality, effectively, and reliably; and ultimately assessing the technical and economic feasibility of this produced water management option.

Progress has been made in narrowing knowledge gaps through collaborative research by the New Mexico and Texas produced water consortia—NMPWRC and the Texas Produced Water Consortium (TXPWC)—as well as through other academic and industry research efforts. However, additional work remains, particularly in demonstrating feasibility, the focus of this white paper.

Feasibility encompasses not only whether something can be done, but also whether it can be done consistently in a way that protects human health and the environment (technical feasibility), is financially viable (economic feasibility), and provides a reliable, long-term water source. If the capabilities and limitations of treatment technologies are not sufficiently vetted, adverse effects on human health or the environment may result. If a treatment process is not economically viable, facility closures can create legacy environmental problems, often without a responsible party to address the resulting impacts. Finally, care must be exercised before a water source that is not reliable and sustainable over the long term can be considered a solution for meeting future water needs.

## 2.0 Produced Water Volumes

According to the NMPWRC 2025 Fact Sheet[ii], approximately 2.74 billion barrels of produced water were generated in New Mexico in 2025. This volume is equivalent to approximately 315 million gallons per day, or 353,000 acre-feet per year.

Approximately 99% of the statewide volume of produced water is generated in the New Mexico portion of the Permian Basin, primarily in Lea and Eddy counties in the southeastern part of the state. The remaining 1% is generated in the San Juan Basin in northwestern New Mexico. Produced water volumes have increased in recent years, although future generation will fluctuate with oil and gas activity driven

[ii] https://nmpwrc.nmsu.edu/science-simplified/docs/1-Produced-Water-Volumes-and-Management-in-New-Mexico-By-the-Numbers---Final.pdf.

by multiple factors including economic and geopolitical conditions.

Current management of produced water in New Mexico includes approximately 24% injected into disposal wells, 17% used for enhanced oil recovery, and 24% recycled for use in oil and gas well completions. The remaining 35% of produced water generated in the Permian Basin region--approximately 950 million barrels per year or about 122,000 acre-feet per year-is transported to Texas for disposal at the same per barrel cost as oil and gas producers in Texas.

Beneficial reuse could provide an alternative management option, but produced water is challenging and costly to treat. Its high salinity, variable composition, and broad range of constituents of concern require multiple, energy-intensive treatment technologies to reliably generate treated water of a quality that protects human health and the environment.

## 3.0 Challenges to Beneficial Reuse of Produced Water

Produced water is a complex fluid whose composition varies among oil and gas basins and subbasins and formations, as well as over the productive life of an individual well. Produced water typically contains TDS at concentrations many times higher than seawater (typically in the neighborhood of 35,000 TDS). In the Permian Basin, TDS concentrations average approximately 100,000 mg/L and can approach 200,000 mg/L. High salinity is only one consideration when evaluating treatment for discharge or potential beneficial reuse. Produced water also contains a broad range of inorganic and organic constituents, as well as potentially naturally occurring radionuclides.

These constituents may originate from several sources. Formation water consists of ancient seawater trapped in the geologic formation with oil and gas. Other constituents are introduced through chemicals used during hydraulic fracturing or added over the life of a well to maintain production. Information about maintenance chemicals is not readily made publicly available and significant number of the hydraulic fracturing chemicals (10% to 25%[iii]) are treated as proprietary or confidential business information, therefore protected from being publicly disclosed. Research also indicates that additional constituents may form through chemical reactions under the high-temperature and high-pressure conditions present within a well resulting in constituents exiting the well along with the produced water that were not originally present in the formation or added as part of well completion and operation.

This variability presents significant challenges to characterization of produced water and to design treatment processes capable of consistently and reliably managing changing conditions.

Foundational research published in in 2020 on produced water from across the U.S. identified more than 1,100 chemical compounds potentially present in produced water. Of those identified, only 25% had approved analytical methods (methods available to regulators for establishing treatment standards, and methods routinely run by commercial labs) and only 14% had toxicity values available for developing risk assessments.[1]

The lack of analytical methods and toxicological information on constituents potentially present in produced water is a significant challenge to designing and monitoring treatment processes, as well as implementing regulatory programs to ensure effluent discharges are appropriate for the designated use while remaining protective of human health and the environment. According to the SWS Feasibility

[iii] https://pmc.ncbi.nlm.nih.gov/articles/PMC10872473/pdf/nihms-1951029.pdf.

Study, "Produced water can have a wide range of organic and inorganic constituents, both naturally occurring and introduced. However, publicly available data on produced water in New Mexico are patchy in coverage and generally do not have data for a significant range of analytes."[iv]

Progress has been made since the establishment of the NMPWRC along with other research efforts by academia, industry and TXPWC. Most of this research is based on lab studies with some smaller scaled and limited duration field studies conducted evaluating treatment processes, treated effluent qualities, and greenhouse plant studies. More recently these studies are being scaled up to more effectively evaluate treatment capabilities and limitations, analytical testing for constituents including non-targeted analyses (a process to attempt to narrow the knowledge gaps of unknowns--constituents of concern potentially present but for which analytical methods do not exist), and aquatic and plant toxicity testing. But these scaled pilot studies are in initial stages of operation, not yet running at full capacity. It will be months (possibly a year or more) before published data and treatment process evaluations will be sufficient to further narrow knowledge gaps on robust treatment efficacy, reliability, and cost. As stated in the recently published "Produced Water in New Mexico: A Critical Review of Recent Toxicity and Risk Assessment Literature"[v]:

> *Additional work not addressed by the recent literature is still needed, particularly related to characterizing unknown produced water constituents, advancing knowledge related to the toxicity and risk of known substances found to be present in produced water, understanding the risks posed by the variability of constituents (and concentrations) in produced waters, and the fate and transport of residual constituents in treated and "post-treated" waters when they are released to the environment.*

## 4.0 Feasibility of Beneficial Reuse of Treated Produced Water

As stated, feasibility encompasses not only whether something can be done, but also whether it can be done consistently in a way that protects human health and the environment (technical feasibility), is financially viable (economic feasibility), and provides a reliable, long-term water source. If the capabilities and limitations of treatment technologies are not sufficiently vetted, adverse effects on human health or the environment may result. If a treatment process is not economically viable, facility closures can create legacy environmental problems, often without a responsible party to address the resulting impacts. Finally, a water source that is not reliable and sustainable over the long term should not be considered a solution for meeting future water-planning needs.

Beneficial reuse of treated produced water is neither easy nor inexpensive. Decisions cannot be based on assumptions or incomplete information, but on scientifically defensible, reproducible data and analysis. Decision makers must get it right; therefore, demonstrating feasibility is critical to inform developing a regulatory framework and leading industry practices.

### *4.1 Technical Feasibility*

Treating produced water to a quality appropriate for beneficial reuse presents numerous technical

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[iv] New Mexico Strategic Water Supply p. 23.
[v] Produced Water in New Mexico: A Critical Review of Recent Toxicity and Risk Assessment, 2026 p. 21 https://www.amigosbravos.org/wp-content/uploads/2026/10/IEc-NM-PW-White-Paper-10-26-2026.pdf.

challenges, many of which have been noted previously but warrant further discussion. Produced water is a complex and highly variable industrial wastewater whose composition can change over time and across geographic locations. Elevated salinity is only one concern; the water may also contain numerous inorganic, organic, and other constituents that can complicate treatment. For some potential contaminants, analytical methods or toxicity information remain limited mandating the need to include non-targeted analysis (addressing the unknown unknown question – you won't find what you aren't looking for) - complicated, non-standardized, and emerging area of study; adding to the difficulty of determining the concentrations at which treated water can be used without harming human health or the environment.

Experience treating produced water for beneficial reuse is limited. Few full-scale facilities in the United States have treated this waste stream for beneficial reuse, and several permitted facilities have closed, some leaving legacy environmental sites that have not been remediated. There are currently no permitted produced water treatment facilities operating for this purpose in the Permian Basin in either New Mexico or Texas. This limited operating history constrains the amount of real-world information available to evaluate treatment reliability, facility performance, and the ability to consistently meet water-quality requirements over time.

Pilot-scale testing is helping to address these gaps, but the available operational record is still developing. As evidenced by the following review of published peer-review papers, only a limited number of small-scale pilot projects have tested robust treatment processes in the Permian Basin. Although a couple of scaled pilot projects are now coming online, sufficient operational data from scaled pilot projects will require months if not a year to collect, followed by additional time for careful analysis and validation. Until that work is complete, important questions will remain about treatment performance, reliability, and the feasibility of beneficial reuse at full scale.

### *4.2 Economic Feasibility*

Less progress has been made in evaluating the economics of robust produced water treatment. This is partly attributable to the limited number of scaled pilot projects that have operated long enough to establish reliable treatment performance, resource requirements, and costs. Although a few research articles provide treatment cost estimates, the underlying assumptions and cost components are often unclear. It is difficult to determine whether reported estimates represent the full cost of moving produced water from its point of generation through treatment and ultimately to a beneficial end use.

All-in cost estimates must account for the entire treatment process, as well as management components. These costs include collecting and transporting produced water to the treatment facility and then to the location of beneficial reuse; constructing and financing the treatment facility over its useful life; operating and maintaining the facility, including labor, routine maintenance, and energy; and properly managing the residual waste streams generated during treatment. Omitting any of these components can materially understate the actual cost and create an incomplete picture of economic feasibility.

Energy requirements are particularly important because they affect both treatment cost and the availability of sufficient power generation capacity. Robust treatment of large volumes of high-salinity Permian Basin produced water could require an estimated one to three gigawatts of new generating capacity for large-scale implementation. The significant qualifier in the prior sentence is "could". At this point, power requirements are not known only estimates, again because of the lack of actual in-field measurements at scaled pilot projects. For context, one gigawatt can supply approximately 750,000 to 1.1 million homes.

Additionally, the water footprint of power generation must be factored into the evaluation. Power generation requires water, and substantial power requirements could create correspondingly significant water demands—an especially important concern in the already water-stressed region where oil and gas production occurs. Therefore, any assessment whether beneficial reuse is economically feasible at scale must consider, along with treatment performance, the ability to secure reliable power at this scale, the water required for power generation, and the capacity to absorb all associated costs.

### *4.3 Sustainability*

From a long-term water-planning perspective, produced water must be viewed as a finite and variable supply rather than a permanent new water source as well as the fact that generating power to treat produced water requires water and increases the carbon footprint of the entire oil and gas production process. Produced water generation is directly tied to oil and gas production, which changes over time in response to oil and gas development, reservoir depletion, economics, and broader energy-market and geopolitical conditions. Although the timing of peak production is uncertain, the SWS Feasibility Study identified 2030 as one possible projection and a recent peer-reviewed article projected 2039 (specifically referenced later in this report). Regardless of the precise date, produced water volumes will vary and ultimately decline as oil and gas production varies.

This dependence creates a material supply risk for businesses, agricultural operations, or other users that may rely on treated produced water. A reduction in drilling or production—whether caused by an economic downturn, declining resource productivity, or reduced dependence on fossil fuels—would reduce the quantity of produced water available for treatment and reuse. Potential end users could therefore face changes in supply volume, reliability, or cost, and ultimately the disruption or termination of service.

## 5.0 Assessing Feasibility of Beneficial Reuse of Treated Produced Water

Research efforts are progressing to develop scientifically defensible, reproducible data and analysis moving the needle in filling critical knowledge gaps to inform potential treated produced water beneficial reuse policy and practices. Research projects evaluating treatment processes have been conducted and documented in peer-reviewed papers. The following summarizes relevant peer-reviewed articles, unless otherwise noted, posted on the NMPWRC website.

### *5.1 Assessing Treatment Technologies*

***Advancing produced water quality via integrated mechanical vapor recompression: Chemical and toxicological characterization, hazard identification and mitigation***

Tarazona Y., Alexander, J., Hightower, M., Delanka-Pedige, H., Wang, H., Xu, P., Zhang, Y., 2026[2]

***Summary of Research***

The research objective of this study was to evaluate multi-barrier treatment train—pilot-scale mechanical vapor recompression (MVR) distillation followed by granular activated carbon (GAC) and zeolite polishing—could sufficiently remove chemical contaminants and reduce toxicity in highly saline Permian Basin produced water (PW). The study used chemical characterization, whole-effluent toxicity testing,

and testing of zebrafish development and gene expression to assess biological effects.

Main points related to assessing feasibility of technologies pilot tested include the following.

- MVR reduced TDS, total organic carbon (TOC), and total petroleum hydrocarbons, but distillation alone did not consistently eliminate toxicity; acetone and 2-propanol persisted or increased, requiring GAC/zeolite polishing.
- The tested volume was not reported. Up to 1,500 barrels (bbl) were available in three 500-bbl tanks, but tank fill levels were not stated.
- Pilot testing duration was not specified; winter and summer temperature references only suggest testing during different seasons.
- Polishing reintroduced some inorganics: sodium increased from 0.62 to 28.9 mg/L, chloride from 1.5 to 27.2 mg/L, sulfate from below detection to 8.86 mg/L, and silica from less than 0.370 to 14.7 mg/L.
- Treatment or equipment may have introduced contaminants, including furans, volitive fatty acids (VFAs), and per- and polyfluoroalkyl substances (commonly known as "PFAS"), so observation was made that the process itself must be evaluated as a potential source.
- Tetrahydrofuran appeared only after GAC/zeolite treatment at 0.0213 mg/L, possibly from polymeric components or sample cross-contamination; the source requires further investigation.
- High VFA concentrations were attributed to compressor lubrication-oil leakage rather than normal MVR partitioning.

**Knowledge Gaps to Inform Feasibility**

| Key Element | Observations |
|---|---|
| **Pilot Test Scale/Duration** | Small-scale pilot project in which no more than 1,500 bbl of produced water may have been treated. |
| | Duration of treatment testing was not reported. |
| **Knowledge Gaps/Need for Further Study** | A reduction in bulk parameters, such as TOC or TDS, does not necessarily indicate that the concentration of every individual constituent decrease at each treatment stage. |
| | Concentrations of several constituents increased during treatment including PFAS compounds, particularly during the distillation process. This finding warrants greater scrutiny of subsequent polishing steps, which must serve as the final barrier preventing the release of these constituents in beneficial-reuse applications. |
| | In addition to increases in the concentrations of some constituents during treatment, the treatment stream contained constituents that were not detected in the untreated produced water. Whether these constituents originated from treatment-system materials, process malfunctions, or a combination of sources, their presence demonstrates the need to test the complete treatment train at a larger scale and for a sufficient duration. |

***Pilot-scale evaluation of hypersaline produced water treatment and reuse via freeze desalination and seawater reverse osmosis: Organic removal, aquatic and human cell line toxicity studies***

Edirisooriay, E.M.N.T., Lopez, A. A., Smith, D., Senanayake, P., Weerasinghe, P. S., Zhang, Y., Delanka-Pedige, H., Xu, P., Wang, H., 2026[3]

*Summary of Research*

This pilot-scale study evaluated a multistage treatment train that treated hypersaline Permian Basin PW for beneficial reuse. The treatment system consisted of fractional freeze desalination (FD), GAC, seawater reverse osmosis, and final polishing. The pilot project is described as a "proof-of-concept" pilot study (p. 2, p. 16).

The authors found the following (pp. 16-17).

- Freeze desalination still requires optimization and scale-up investigation. The authors state that "The FD stage is currently under optimization" and that ice-crystal growth behavior and associated separation mechanisms will be investigated as scale-up progresses**.** They also identify ongoing work to improve energy efficiency, consistency of water quality, and understanding of separation mechanisms at each treatment stage**.**

- "Ongoing efforts focus on improving energy efficiency, maintaining consistent water quality, and elucidating separation mechanisms at each treatment stage. Standard WET assays employ conventional acute and chronic endpoints that capture effects on mortality, reproduction, and growth, but may be insufficient for comprehensive hazard identification. Future work should investigate subtle molecular and physiological responses to unidentified PW constituents using enzyme- based assays and advanced molecular techniques. This study highlights the critical need for advanced analytical approaches, such as non-targeted analysis and suspect screening coupled with effect-directed analysis, to link chemical composition, unknown compounds, and transformation products interactions to toxicological outcomes."

**Knowledge Gaps to Inform Feasibility**

| Key Element | Observations |
|---|---|
| **Pilot Test Scale/Duration** | 10-month pilot test but primarily operated in batch mode so should not be interpreted as 10 months of uninterrupted continuous treatment. |
| **Knowledge Gaps/Need for Further Study** | Freeze desalination requires optimization and scale-up investigation. |
| | Study highlights the critical need for advanced analytical approaches, such as non-targeted analysis and suspect screening coupled with effect-directed analysis, to link chemical composition, unknown compounds, and transformation products interactions to toxicological outcomes. |

***Separation performance in pilot-scale fractional freeze desalination and reverse osmosis for produced water reuse***

E.M.N. Thiloka Edirisooriya, Adrianne Lopez, Danielle Smith, Punhasa S. Senanayake, Yanyan Zhang, Himali M.K. Delanka-Pedige, Pei Xu, Huiyao Wang, 2026[4]

*Summary of Research*

This study explores a pilot-scale approach to treating produced water using a combination of fractional freeze desalination (FD) and reverse osmosis. It investigates how effectively this hybrid system can remove salts and contaminants to make the water suitable for reuse.

Like the observations in the previous paper, although the 10-month pilot produced encouraging treatment and toxicity results, this is a short duration pilot test. Longer duration testing is needed to more fully

evaluate treatment process operations. Batch operation is important when interpreting the 10-month duration.

Long-term water quality consistency remains an issue. The authors explicitly report that variation in raw produced water quality affected FD stability and occasionally caused treated water constituents to exceed reuse criteria. Consequently, frequent produced water monitoring and adaptable post-treatment are important if the technology is applied to produced water with changing chemistry.

**Knowledge Gaps to Inform Feasibility**

| Key Element | Observations |
|---|---|
| **Pilot Test Scale/Duration** | 10-month pilot test but primarily operated in batch mode so should not be interpreted as 10 months of uninterrupted continuous treatment. |
| **Knowledge Gaps/Need for Further Study** | Freeze desalination requires optimization and scale-up investigation. |
| | Long-term water-quality consistency identified as issue. |
| | Raw produced water quality affected FD stability and occasionally caused treated water constituents to exceed reuse criteria. |

***Comprehensive cytotoxicity assessment of treated produced water from thermal distillation using human cell lines.***
Wijekoon, S., Tarazona, Y., Hightower, M., Wang, H., Xu, P., Zhang, Y., 2025[5]

***Summary of Research***

The study evaluates PW from the Permian Basin treated by two pilot-scale thermal desalination systems—low-temperature thermal desalination (LTD) and MVR—followed by GAC and zeolite polishing.

The study concludes that both pilot-scale thermal systems were effective at eliminating the major cytotoxic effects associated with untreated Permian Basin PW. However, a key qualification to the authors' favorable conclusion is that thermal desalination should not be considered a complete treatment process by itself**.**

The pilot project was of limited size. The LTD flow rate was stated at 500 bbl/day (approximately 20,000 gal/day). Although the TDS concentration range of produced water feed to the MVR was specified, the volume and duration of pilot testing was not provided.

Primary concluding recommendation on treatment limitations stated: “Further development of thermal distillation and post-treatment technologies is warranted to mitigate potential VOCs [volatile organic compounds] carryover and ensure consistent product water quality.” (p. 10).

**Knowledge Gaps to Inform Feasibility**

| Key Element | Observations |
|---|---|
| **Pilot Test Scale/Duration** | The pilot project was of limited size. The LTD flow rate was stated at 500 bbl/day, the produced water feed to the MVR was not stated. |
| | Duration of treatment testing was not reported. |
| **Knowledge Gaps/Need for Further Study** | Recommendation on treatment limitations: “Further development of thermal distillation and post-treatment technologies is warranted to mitigate potential VOCs carryover and ensure consistent product water quality.” |

***Treatment of produced water from the Permian Basin: Chemical and toxicological characterization of***

***the effluent from a pilot-scale low-temperature distillation system***
Tarazona, Y., Hightower, M., Xu, P., Zhang, Y., 2024[6]

***Summary of Research***

The study evaluates a pilot-scale, low-temperature thermal distillation system treating hypersaline produced water from Permian Basin oil and gas operations. Its principal purpose was not simply to demonstrate salt removal, but to determine whether the resulting distillate could be suitable for beneficial reuse, particularly surface water discharge.

This was a small-scale pilot test. Exact flow rates and duration of testing weren't specified; the paper did state that the distillation unit was operated for 18 days.

Of note, this article stated: "Therefore, based on the organic chemical characterization carried out in the present study, about 96.78% of the organic fraction present in the distillate remained unidentified. This outcome highlights the limitations of current standard extraction techniques, such as liquid-liquid extraction, and detection methodologies such as using GC/MS [gas chromatography-mass spectrometry], when it comes to thoroughly characterizing the organics in treated PW, as well as underscores the need for the use of advanced, comprehensive targeted and non-targeted chemical characterization together to reveal and enhance our understanding of "unknown" chemicals in PW." (p. 8).

**Knowledge Gaps to Inform Feasibility**

| Key Element | Observations |
|---|---|
| **Pilot Test Scale/Duration** | Small scale pilot test, distillation unit operated for only 18 days. |
| **Knowledge Gaps/Need for Further Study** | Based on the organic chemical characterization carried out in the present study, about 96.78% of the organic fraction present in the distillate remained unidentified. |

### *5.2 Assessing Irrigation/Plant Growth*

***Plant growth, ion dynamics, and microbial communities in soils irrigated with treated produced water for sustainable agriculture***
Senanayake, P. S., Zhang, Y., Edirisooriya, T. E.M.N., Lopez, A., Smith D., Xu, P., Wang, H., 2025[7]

***Summary of Research***

The study evaluates whether treated PW can be used sustainably for agricultural irrigation in the Permian Basin. The authors conducted a nine-month greenhouse experiment in Midland, Texas**,** comparing clay-rich and sandy-loam soils irrigated with treated PW formulated at nominal TDS concentrations of 500, 1,000, and 1,500 mg/L**,** with desalinated groundwater serving as the control. The work examined not only plant growth but also soil quality, ion movement and accumulation, organic compounds, and bacterial and fungal communities. The primary crop evaluated in detail was alfalfa, although Mexican feather grass, red yucca, and mesquite were also included.

The abstract describes a "nine-month greenhouse experiment," and the methods provide the dates July 11, 2023 to April 22, 2024**.** Plants were acclimated before treated PW irrigation began in September 2023. Soil samples were collected initially and again after 40 weeks of irrigation. This is the irrigation/greenhouse test duration**,** not evidence that the treatment plant itself operated continuously for 40 weeks.

The authors conclude: "Future extended field application across successive growing seasons is

recommended" to evaluate long-term viability. They specifically identify the need to investigate progressive accumulation of residual salts and trace organic constituents and their effects on soil physicochemical characteristics, microbial dynamics, soil health, and crop productivity." (p. 13).

**Knowledge Gaps to Inform Feasibility**

| Key Element | Observations |
|---|---|
| **Pilot Test Scale/Duration** | Nine-month greenhouse experiment. |
| **Knowledge Gaps/Need for Further Study** | Recommend extended field application across successive growing seasons to evaluate long-term viability. |
| | Investigate progressive accumulation of residual salts and trace organic constituents and their effects on soil physicochemical characteristics, microbial dynamics, soil health, and crop productivity. |

***Field evaluation of polished desalinated produced water for alfalfa irrigation in a semi-arid environment***

Saddapalli, T., Kumari, A., Saini, D.K., Trivedi, P., Bangari, M. P. S., Lopez, A., Walker, W. S., Impa, S. M., Jagadish, S. V., K., 2026[8]

***Summary of Research***

A recent peer-reviewed article relevant to the discussion but not currently posted on the NMPWRC website. This study evaluated whether treated produced water (identified in this paper as "polished desalinated produced water" (PDPW)) could supplement conventional groundwater for alfalfa irrigation in the semi-arid Permian Basin. The researchers conducted a field trial in Midland, Texas, comparing PDPW irrigation with Edwards-Trinity Aquifer groundwater. They assessed irrigation-water chemistry, soil characteristics, trace-element accumulation in alfalfa, plant growth and physiology, forage quality, and bacterial and fungal communities in soil and plant tissues. The PDPW was treated through freeze desalination and reverse osmosis, followed by GAC polishing and ultraviolet disinfection.

The paper's principal recommendation is to conduct longer, fully replicated field trials before recommending widespread agricultural reuse. The authors acknowledge that the single treatment plot, single control plot, short observation period, and groundwater blending prevent them from confidently attributing all observed differences to PDPW. Further studies should evaluate continuous irrigation with unblended PDPW, cumulative soil salinity and trace-element accumulation, forage safety, and the stability of soil and plant-associated microbial communities. These recommendations are particularly important because the treatment system could not supply enough PDPW to meet peak summer crop-water demand (pp. 3–4, 15–17).

The paper does not report the treatment system's rated flow rate. It does report that approximately 94,635 liters (25,000 gallons) of PDPW were applied during the study. The treatment system could not produce sufficient water to meet peak summer irrigation demand. Therefore, groundwater supplemented PDPW. During the sampling period, irrigation of the treatment plot consisted of approximately 57% PDPW and 43% groundwater. This is a major limitation when interpreting the results as evidence of the suitability of unblended PDPW.

The experiment used two field plots totaling approximately 3,360 square feet: one irrigated with groundwater and one with PDPW/blended water. Both used subsurface drip irrigation. There was only one plot per treatment, so the experiment lacked true plot-level replication.

**Knowledge Gaps to Inform Feasibility**

| Key Element | Observations |
|---|---|
| **Pilot Test Scale/Duration** | Treatment capacity was insufficient to meet crop water demand, limiting the irrigation evaluation. |
| | The experimental design lacked true plot-level replication, limiting confidence in the findings and their broader generalizability. |
| **Knowledge Gaps/Need for Further Study** | Blending with groundwater confounded attribution of soil changes to treated produced water; future studies should test unblended water with long-term monitoring. |
| | Elevated cadmium concentrations warrant careful consideration of potential forage-safety risks. |
| | The results are preliminary and should be interpreted cautiously until confirmed through multi-year, fully replicated field studies evaluating cumulative effects and continuous irrigation. |

***Produced Water from Oil and Gas Operations in Agronomic and Forage Crop Production: A Review of Implications, Opportunities, and Risks***

Ghimire, G., Cooper, C., Jagadish, S. V., K., Norris, A., 2026[9]

***Summary of Research***

Another recent peer-reviewed article relevant to the discussion but not currently posted on the NMPWRC website. This is a literature review article. The authors reviewed peer-reviewed literature published through January 2026, ultimately selecting 112 studies for detailed consideration. The paper examines the potential for treated oil and gas produced water to serve as an alternative irrigation supply, particularly in arid and semi-arid regions where freshwater resources are increasingly constrained. The review focuses on the effects of treated produced water on soil properties, crop growth and yield, and forage nutritional quality.

The authors conclude that agricultural use of treated produced water presents both a potentially important water-supply opportunity and significant environmental and agronomic risks. That the effectiveness of these approaches has not been adequately demonstrated under long-term field conditions. The review emphasizes that crop responses vary substantially, meaning that a single generic definition of "treated produced water" is insufficient for determining suitability for agricultural reuse (pp. 17–20).

The authors recommend multi-year field studies, cumulative-impact assessments, improved crop-specific water-quality thresholds, standardized monitoring, and decision-support systems that integrate water chemistry with soil and crop response. They also identify development of salt- and trace-element-tolerant crops and cost-effective treatment technologies as important for scaling agricultural reuse. Their conclusion is conditional: produced water could become a managed agricultural water resource, but only with appropriate treatment, regulation, continuous monitoring, and science-based management **(**p. 20).

**Knowledge Gaps to Inform Feasibility**

| Key Element | Observations |
|---|---|
| **Pilot Test Scale/Duration** | The overall evidence base for agricultural reuse of produced water remains immature. |
| | Treatment and remediation performance has not been adequately evaluated across different environmental conditions. |
| | Many of the studies were short-term and conducted in greenhouse settings. |
| **Knowledge Gaps/Need for Further Study** | Long-term field evidence remains limited; multi-year field trials and cumulative-impact assessments are needed. |
| | Most existing studies are short-term or greenhouse-based, limiting extrapolation to commercial field irrigation and broader geographic settings. |
| | Cost-effective, viable treatment technologies and scalability demonstrations remain central research needs. |

## *5.3 Assessing Economics*

***A modeling framework for technical, economic, energetic, and environmental assessment of produced water pretreatment from oil and gas industry***

Lugo, A., Mejía-Saucedo, C., Senanayake, P., Stoll, Z., Sitterley, K., Wang, H., Kota, K., Kuravi, K., Fthenakis, V., Kurup, P., Xu, P., 2025[10]

***Summary of Research***

The paper evaluates pretreatment alternatives for hypersaline Permian Basin produced water using WaterTAP process modeling. The authors developed a modeling framework to compare chemical softening, chemical coagulation), electrocoagulation, and GAC

The authors specifically caution that their results should be viewed as guiding estimates rather than rigid design solutions. The authors recommend pilot-scale and field testing to validate the model predictions and demonstrate scalability**.**

**Knowledge Gaps to Inform Feasibility**

| Key Element | Observations |
|---|---|
| **Pilot Test Scale/Duration** | Evaluated only pretreatment systems. |
| | Does not provide information on all-in costs for treatment. |
| **Knowledge Gaps/Need for Further Study** | Utilizes simulations/models, not data from specific pilot projects. |
| | Pilot-scale and field testing needed to validate the model predictions and demonstrate scalability. |

***Economic feasibility of developing alternative water supplies for agricultural irrigation***

Edirisooriya, E.M.N.T., Wang, H., Banerjee, S., Longley, K., Wright, W., Mizuno, W., Xu, P., 2024[11]

***Summary of Research***

The paper evaluates the economic feasibility of developing nontraditional water supplies for agricultural irrigation**,** particularly in water-stressed areas of the southwestern United States. The authors identify municipal wastewater, brackish groundwater, seawater, and produced water as potential alternative supplies, while emphasizing that their feasibility depends not simply on treatment cost but also on conveyance, storage, concentrate/waste management, energy requirements, water quality requirements, and regulatory compliance**.**

The projected treatment costs are not based on pilot projects (small or scaled) but research utilizing simulations/models (three references) and one on presentation addressing brine management.

The article states: "The treatment costs of produced water are highly variable depending on the presence of different types of contaminants and salinity, which may vary from $0.09/m3 [cubic meter] (produced water with TDS < 500 mg/L in Kern County) to $9.4/m3 to $12/m3 ($1.49/bbl to $1.91/bbl) treating hypersaline produced water (e.g. unconventional produced water in the Permian Basin) using waste heat and state-of-the-art low-temperature (e.g. < 70 °C) thermal distillation technologies [32–35]." (p. 3).

It is important to note that it is unclear whether the above treatment-cost estimates apply only to distillation or also include polishing (a required step, as shown by the papers discussed previously). It is also unclear whether the estimates include infrastructure, labor, maintenance, power, and the costs of transporting water from the source to the treatment facility and from the treatment facility to the point of use.

Additionally, the cost estimates are based on models or simulations, per the citied references in the paper, not scaled field pilot testing.

**Knowledge Gaps to Inform Feasibility**

| Key Element | Observations |
|---|---|
| **Knowledge Gaps/Need for Further Study** | Utilizes simulations/models or reference to conference presentation, not data from specific pilot projects. |
| | Unclear what costs are included in cost estimates. |
| | Details are lacking on if costs for a polishing step after desalination (a required treatment), labor, power, maintenance, infrastructure, and transport to and from treatment are included. |

### *5.4 Assessing Sustainability*

***Produced Water Management in the Permian Basin to Accommodate the Arid West Texas Region: Historical Production, Forecast, and Water Composition***

Bechara E., Watson, M., Gamadi T., Emadibaladehi, H., Hajiyev, E. Tiam, 2026[12]

***Summary of Research***

Another recent peer-reviewed article relevant to the discussion but not currently posted on the NMPWRC website. The paper evaluates long-term management of PW from unconventional oil and gas development across the Permian Basin, focusing on whether excess PW could be treated and beneficially reused to address West Texas water shortages. The authors develop low-, base-, and high-production forecasts through 2070.

In the base case, unconventional PW peaks at approximately 28.8 million bbl water/day in 2039. Assuming treatment at 50% recovery**,** Texas Permian treated PW could provide water equivalent to approximately 18–45% of the West Texas irrigation-water shortage through 2070. The Delaware Basin in Texas is identified as the most attractive general area for treatment because of its relatively low salinity and lower hydraulic fracturing water demand. The study's broader contribution is a county- and formation-informed framework for deciding where PW treatment facilities and beneficial-reuse projects should be investigated**,** rather than demonstrating a particular treatment process.

**Knowledge Gaps to Inform Feasibility**

| Key Element | Observations |
|---|---|
| **Knowledge Gaps/Need for Further Study** | Produced water volume projected to peak in 2039, a little over 10 years from now. |
| | Although a potential short-term water source, long-term water planning requires dependable long-term water sources. |
| | Coupled with dependable water source is the recognition that regional water needs must be factored into accessing potential viable water uses.<br>- Transporting water is expensive adding complexity to determine economic viability and feasibility of beneficial reuse. |

## 6.0 Status of Beneficial Reuse of Treated Produced Water in the Texas Permian Basin

Although the TCEQ accepted applications to discharge treated produced water under the National Pollutant Discharge Elimination System, administered in Texas through the Texas Pollutant Discharge Elimination System (TPDES), no draft permits have been issued. TCEQ is reviewing six permit applications, the oldest of which was submitted almost three years ago. Five applications propose discharges to the Pecos River watershed, either directly into Red Bluff Reservoir or into a tributary of the Pecos River. The sixth application proposes a discharge to Texas's Colorado River, whose headwaters are within the state. The following table summarizes the permit applications.

All six permit applications propose discharges of treated produced water generated in the Permian Basin. Accordingly, no discharges of treated produced water are currently permitted in the Texas portion of the Permian Basin.

**Current TPDES Permit Applications under TCEQ review**

| Applicant | Submitted Date | Permit Number | Location (county) | Discharge (mgd)[1] | Discharge Location |
|---|---|---|---|---|---|
| **NGL Water Solutions Permian LLC** | 12/12/2023 | TPDES ID No. WQ0005445000 EPA I.D. No. TX0145289 | Reeves | 16.9 | Tributary of Salt Creek |
| **Texas Pacific Water Resources LLC** | 4/22/2024 | TPDES ID No. WQ0005454000 EPA I.D. No. TX0145661 | Reeves | 2.73 | Tributary of Salt Creek |
| **Solaris Water Midstream, LLC[2]** | 1/17/ 2025 | TPDES ID No. WQ0005471000 EPA I.D. No. TX0146978 | Reeves Culberson | 10 | Red Bluff Reservoir |
| **Solaris Water Midstream, LLC[2]** | 1/17/2025 | TPDES ID No. WQ0005474000 EPA I.D. No. TX0147206 | Reeves Loving | 10 | Red Bluff Reservoir |
| **Select Water Solutions** | 7/22/2025 | TPDES Permit No. WQ0005495000 | Reeves | 0.42 Ph 1<br>0.84 Ph 2<br>4.2 Ph 3 | Tributary of Salt Creek |
| **Pioneer Water Management LLC** | 1/26/2026 | TPDES ID No. WQ0005505000 EPA ID No: TX0148687 | Midland | 2.52 | Johnson Draw; thence to Mustang Draw; thence to Beals Creek; thence to Colorado River Below Lake J. B. Thomas |

**1** – million gallons per day

**2** – Solaris (also referred to as Aris) has been acquired by Western Midstream

Under legislation passed during the 2026 Texas legislative session, authority to permit the land application of treated produced water was transferred from the Texas Railroad Commission (RRC) to TCEQ. As a result of this transfer, eight land-application pilot projects were transferred to TCEQ. Six of these pilots requested renewal of their authorizations and have been allowed to continue operating while TCEQ develops its land-application rules. TCEQ has also received two new land-application requests, which are under review.

Therefore currently, six land-application pilot projects are operating under project-specific design and operating conditions, including allowable application rates, groundwater protections, stormwater and precipitation controls, and onsite storage requirements per RRC rules for these pilots. Like permitted discharge of treated produced water, no full-scale permitted land-application operations are currently operating in the Texas portion of the Permian Basin.

## 7.0 Summary

Desalination technologies were generally developed to treat brackish water and seawater. Produced water—particularly in the Permian Basin—can have TDS concentrations many times higher than brackish water or seawater and contain numerous additional constituents of concern, presenting substantial challenges to consistently producing a high-quality effluent. Significant knowledge gaps remain regarding the feasibility of treating produced water for beneficial use, including questions about treatment

performance and reliability, treatment costs, management of treatment residuals, and the long-term dependability (sustainability) of this potential water source. Addressing these questions requires a deliberate and transparent process of data collection, evaluation, and independent review. This process cannot be rushed; otherwise, efforts to solve one water-management problem could create new human health, environmental, or waste-disposal challenges that are more difficult to address.

### *7.1 Work Still to Be Accomplished on Vetting Treatment Processes*

The published studies reviewed are based on laboratory and small-scale pilot projects. Collectively, they emphasize the need for longer-term testing at larger, more representative scales to fully evaluate the capabilities, limitations, and reliability of the complete treatment processes.

As noted in multiple studies, treating produced water requires more than desalination alone. Pretreatment is needed to prepare the water for desalination, while post-treatment polishing is critical to address constituents that remain after desalination and to achieve the required effluent quality.

Some pilot tests detected constituents at higher levels after polishing or that had not been detected in the untreated produced water. As an example, the 2026 article, *Advancing produced water quality via integrated mechanical vapor recompressing; Chemical and toxicological characterization, hazard identification and mitigation*, reported increases in the concentrations and even the introduction (PFAS as an example) of constituents during treatment. The study suggested that these increases may have resulted from treatment-system materials, process upsets, or equipment malfunctions. This possibility warrants further evaluation through larger-scale, long-term testing under representative operating conditions, including periods of startup, shutdown, maintenance, and process variability.

The documented pilot projects varied substantially in scale and duration. One project may have extended over approximately 10 months, although the available information does not establish whether it operated continuously during that period. Other projects operated for only a few weeks or less, and some reports did not clearly document the testing duration. When treatment volumes were reported, they ranged from as much as 500 barrels per day for an unspecified period to approximately 1,500 barrels in total, with some projects treating even smaller volumes. These limited and inconsistently reported operating periods and volumes make it difficult to assess performance under sustained, scaled conditions.

Although the studies reviewed provide useful preliminary information, the available evidence is not sufficient to determine the treatment process's operational effectiveness, reliability, or ability to consistently meet water quality requirements at commercial scale over the long term.

Two larger-scale pilot projects have recently begun operating: one operated by Texas Pacific Water Resources (Texas Pacific) and the other by Western Midstream (Western). Both pilot plants are located near Orla, Texas, south of the Texas–New Mexico state line and near Red Bluff Reservoir. Although both operators have submitted TPDES permit applications, no draft permits have been issued. Therefore, the treated produced water cannot be discharged and must be disposed. If crop irrigation is conducted on the test plots, irrigation water may not leave the site or percolate below the root zone.

The Texas Pacific pilot plant has a rated treatment capacity of 10,000 barrels per day and includes a 20-acre plot for testing land application and crop irrigation. Despite this rated capacity, the plant was recently reported to be operating at approximately 1,000 barrels per day. The facility is still undergoing final

process checkout and commissioning; therefore, sufficient operating and performance data will not be available for several months.

The Western pilot project is operating with a rated treatment capacity of 1,000 barrels per day and includes a 7-acre plot for testing land application and crop irrigation. To date, operating data and performance evaluations have not been publicly released, except for one peer-reviewed paper examining a specific aspect of the treatment process: fouling in a reverse osmosis system. Additional data may be forthcoming, but the publicly available information is not yet sufficient to evaluate the project's overall treatment performance, reliability, or irrigation results.

Several peer-reviewed articles have evaluated crop irrigation using treated produced water. Without exception, these studies emphasize the need for additional evaluation over multiple growing seasons. Longer-term research is necessary to assess treatment consistency, soil conditions, crop performance, constituent uptake, and potential environmental effects. The available literature therefore reflects a strong consensus that more research is needed before broad conclusions can be drawn about the long-term feasibility and safety of this use.

### *7.2 Economic Evaluation of Treated Produced Water for Beneficial Reuse Severely Lacking*

No publicly available peer-reviewed studies have evaluated the actual, all-in cost of treating produced water using operating data from a commercial-scale facility. The limited published studies rely primarily on simulations or models to estimate selected treatment costs and the costs of managing treated effluent and generated waste. Desalinating the high-TDS produced water typical of the Permian Basin is generally expected to achieve approximately 50% water recovery. In practical terms, about half of the influent would become treated effluent, while the other half would remain as a concentrated waste stream requiring further management. Although research is evaluating whether constituents in this waste stream may have recoverable value, current economic assessments generally assume that treatment residuals will require disposal in injection wells. Accordingly, a meaningful comparison with current disposal practices must account for the full treatment train, labor, energy, maintenance, residuals management, and treated-water transportation. Actual operating data have not yet demonstrated that this complete process can be economically competitive with existing disposal options.

Therefore, reliable estimates of all-in treatment costs require operating data from appropriately scaled pilot or commercial facilities collected over a sufficient period to evaluate performance, reliability, and variability. A complete economic assessment should include the following cost categories:

- Collecting and transporting produced water from its point of generation to the treatment facility.
- Constructing the treatment facility, with capital costs amortized over its useful operating life.
- Operating the treatment facility, including labor, energy, process monitoring, and routine and major maintenance.
- Energy demand and associated water consumption is likely to be significant, raising questions about the electric-generation and transmission capacity needed to desalinate large volumes of high-TDS produced water in the Permian Basin.
- Managing, transporting, and disposing of all generated waste streams and treatment residuals.
- Transporting treated effluent to its final point of use, storage, discharge, or other disposition.

Economic feasibility is critical because a treatment facility must remain financially viable throughout its

operating life. If the routine and long-term costs of treating produced water for beneficial reuse exceed available revenues or avoided disposal costs, the facility may curtail operations or close. Past produced-water treatment projects demonstrate that facility closures can leave contaminated materials, untreated waste, and other legacy environmental liabilities, particularly when an operator lacks the financial resources to complete closure and cleanup. These examples underscore the need to evaluate full life-cycle costs, require strong financial assurance including bonding, and establish enforceable closure and post-closure requirements, and clear long-term responsibility for residual wastes, facility decommissioning, and environmental impacts before projects proceed. Any permitting framework for beneficial reuse must fully address these obligations before facilities begin operating. Applying these lessons are critical for New Mexico to avoid abandoned facilities and costly environmental cleanups with no responsible party to shoulder the costs.

- **Fairmont Brine Processing**, a closed produced water treatment facility in West Virginia, has significant legacy contamination, including technologically enhanced naturally occurring radioactive material (TENORM) and Resource Conservation and Recovery Act (RCRA) hazardous waste. The U.S. Environmental Protection Agency documentation from August 2025 reports removal of 46,200 gallons of RCRA mixed liquids and 62,747 gallons of TENORM liquids from the site.[vi]

- **Eureka Resources** operated three produced water treatment facilities in Pennsylvania. Its Standing Stone facility, permitted to discharge into the Susquehanna River, closed after treatment volumes declined. The Pennsylvania Department of Environmental Protection identified unresolved

  wastewater leaks, tanks without functional containment, waste on the ground, and other open permit violations. Eureka plans to close or sell its two remaining Williamsport plants.[vii,viii,ix]

- **Antero's Clearwater** facility in Doddridge County, West Virginia, was designed to convert produced water into fresh water and food-grade salts. It idled less than two years after opening in 2017 because it was not cost-effective, leaving concerns about radioactive and toxic waste.[x]

- **Austin Master Services**' Martins Ferry, Ohio, facility, permitted in 2014, was ordered closed in 2022 after illegal stockpiling of oil and gas waste contaminated soil and water. The company failed to

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[vi] Site Profile - Fairmont Brine Site - EPA OSC Response.

[vii] Hess, D. (2024, August 23). Eureka Resources shuts down standing stone oil & gas wastewater treatment facility; DEP wastewater, waste violations continue from Feb. 2023. *PA Environmental Digest Blog.*

[viii] PA Environment Digest Blog: Eureka Resources Shuts Down Standing Stone Oil & Gas Wastewater Treatment Facility; DEP Wastewater, Waste Violations Continue From Feb. 2023.

[ix] https://paenvironmentdaily.blogspot.com/2026/06/pennlive-attorney-general-sunday-files.html.

[x] Justin Nobel, *In West Virginia, Plan to Clean Up Radioactive Fracking Waste Ends in Monster Lawsuit*, DeSmog (Sep. 19, 2023), https://www.desmog.com/2023/09/19/radioactive-fracking-waste-west-virginia-veolia-antero-clearwater/.

comply with court orders, leaving taxpayers to fund the cleanup.[xi]

### *7.3 Long-term Dependability (Sustainability) of Produced Water*

Long-term planning for beneficial reuse should account for uncertainty in the volume, location, and duration of produced water supplies before substantial investments are made in treatment, conveyance, or end-use infrastructure. Caution is also warranted when encouraging new or expanded commercial operations that require a reliable, long-term water supply. Produced water generation depends on the pace and location of oil and gas production, which in turn respond to economic conditions, technological change, and geopolitical events. These variables can cause produced water volumes to rise, decline, or shift geographically, creating a risk that infrastructure will become underused or stranded before its costs are recovered.

A peer-reviewed article projects that produced water generation in the Permian Basin will peak around 2039. Although significant volumes may continue for decades after the peak, a declining, production-dependent supply does not align with the 50-year or longer planning periods appropriate for major water infrastructure and water-dependent development. A central issue is therefore not only whether produced water can be treated safely and economically for beneficial reuse—questions that remains unresolved—but also which uses would be appropriate if feasibility is demonstrated. Treated produced may warrant consideration (once existing critical knowledge gaps are addressed) use to supplement other supplies or address specific regional short-term needs, but it is not yet proven to provide a long-term solution to water scarcity.

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This white paper is authored by Dan Mueller, P.E., a registered professional Engineer in Texas (#56852), under contract with Amigos Bravos. Mr. Mueller has been a member of the New Mexico Produced Water Research Consortium and the Texas Produced Water Consortium since their inceptions. He was employed by the Environmental Defense Fund from February 2013 to April 2024 and now consults.

[xi] Liz Partsch, *ODNR to Clean Up Brine Waste at Austin master Services Facility*, Farm and Dairy (Aug. 1, 2024), https://www.farmanddairy.com/news/odnr-to-clean-up-brine-waste-at-austin-master-services-facility/834871.html.

## References

[1] Cloelle Danforth et al., *An Integrative Method for Identification and Prioritization of Constituents of Concern in Produced Water from Onshore Oil and Gas Extraction*, 134 **Environment International** 105280 (2020), https://doi.org/10.1016/j.envint.2019.105280.

[2] Yeinner Tarazona et al., *Advancing Produced Water Quality via Integrated Mechanical Vapor Recompression: Chemical and Toxicological Characterization, Hazard Identification and Mitigation*, 511 **J. Hazardous Materials** 142274 (2026), https://doi.org/10.1016/j.jhazmat.2026.142274.

[3] E.M.N. Thiloka Edirisooriya et al., *Pilot-Scale Evaluation of Hypersaline Produced Water Treatment and Reuse via Freeze Desalination and Seawater Reverse Osmosis: Organic Removal, Aquatic and Human Cell Line Toxicity Studies*, 394 **Separation & Purification Technology** 137642 (2026), https://doi.org/10.1016/j.seppur.2026.137642.

[4] E.M.N. Thiloka Edirisooriya et al., *Separation Performance in Pilot-Scale Fractional Freeze Desalination and Reverse Osmosis for Produced Water Reuse*, 622 **Desalination** 119743 (2026), https://doi.org/10.1016/j.desal.2025.119743.

[5] Senuri Wijekoon et al., *Comprehensive Cytotoxicity Assessment of Treated Produced Water from Thermal Distillation Using Human Cell Lines*, 302 **Ecotoxicology & Environmental Safety** 118726 (2025), https://doi.org/10.1016/j.ecoenv.2025.118726.

[6] Yeinner Tarazona et al., *Treatment of Produced Water from the Permian Basin: Chemical and Toxicological Characterization of the Effluent from a Pilot-Scale Low-Temperature Distillation System*, 67 **Journal of Water Process Engineering** 106146 (2024), https://doi.org/10.1016/j.jwpe.2024.106146.

[7] Punhasa S. Senanayake et al., *Plant Growth, Ion Dynamics, and Microbial Communities in Soils Irrigated with Treated Produced Water for Sustainable Agriculture*, 1001 **Science of the Total Environment** 180520 (2025), https://doi.org/10.1016/j.scitotenv.2025.180520.

[8] Teja Saddapalli et al., *Field Evaluation of Polished Desalinated Produced Water for Alfalfa Irrigation in a Semi-Arid Environment*, 44 **Irrigation Science** 120 (2026), https://doi.org/10.1007/s00271-026-01165-7.

[9] Bishnu Ghimire et al., *Produced Water from Oil and Gas Operations in Agronomic and Forage Crop Production: A Review of Implications, Opportunities, and Risks*, 18 **Sustainability** 5283 (2026), https://doi.org/10.3390/su18115283.

[10] Abdiel Lugo et al., *A Modeling Framework for Technical, Economic, Energetic, and Environmental Assessment of Produced Water Pretreatment from Oil and Gas Industry*, 13 **Journal of Environmental Chemical Engineering** 117026 (2025), https://doi.org/10.1016/j.jece.2025.117026.

[11] E.M.N. Thiloka Edirisooriya et al., *Economic Feasibility of Developing Alternative Water Supplies for Agricultural Irrigation*, 43 **Current Opinion in Chemical Engineering** 100987 (2024), https://doi.org/10.1016/j.coche.2023.100987.

[12] Elie Bechara et al., *Produced Water Management in the Permian Basin to Accommodate the Arid West Texas Region: Historical Production, Forecast, and Water Composition*, **Unconventional Resources Technology Conference**, Paper No. URTeC 4495709 (2026), https://doi.org/10.15530/urtec-2026-4495709.