NEW MEXICO STRATEGIC WATER SUPPLY FEASIBILITY STUDY

FINAL

DEVELOPED BY:
NEW MEXICO ENVIRONMENT DEPARTMENT
EASTERN RESEARCH GROUP, INC.

NOVEMBER 22, 2024

TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... **VII**
1 INTRODUCTION **1**
1.1 Purpose 1
1.2 Context 1
1.3 Description of the Strategic Water Supply 4
1.4 Approach 4
2 PRODUCED WATER **5**
2.1 Description 5
2.2 New Mexico produced water resources 6
2.2.1 Produced water volumes 7
2.2.2 Produced water quality 9
2.2.3 Produced water variability 13
2.3 Current practices for produced water management in New Mexico 14
2.4 Produced water management in other states and countries 16
2.5 Additional information needs and ongoing efforts to support development of produced water resources 18
2.5.1 Sample analysis developments—non-targeted analyses 19
2.5.2 Ongoing and planned research 20
2.6 Potential environmental impacts 21
2.7 Regulatory/permitting issues 22
2.8 Produced water conclusions 23
2.8.1 Produced water volumes and characteristics 23
2.8.2 Characterization needs and approaches 23
2.8.3 Variability and scaling 23
3 BRACKISH WATER **24**
3.1 Description 24
3.2 New Mexico brackish water resources 24
3.3 Deep brackish water basins in New Mexico with potential technical feasibility 26
3.3.1 Española Basin (Santa Fe) 27
3.3.2 Mesilla Basin (Santa Teresa) 27
3.3.3 Albuquerque Basin (Albuquerque) 28
3.4 Brackish water resource development in other states or countries 30
3.4.1 Other states 30

3.4.2 International ... 33
3.5 Additional information needs to support brackish water projects ... 34
3.6 Potential environmental impacts ... 35
3.7 Regulatory/permitting issues ... 36
3.7.1 Governmental oversight ... 36
3.7.2 Water rights ... 36
3.7.3 Appropriating deep non-potable water ... 37
3.8 Brackish water conclusions ... 37
4 POTENTIAL END USES ... 39
4.1 Introduction ... 39
4.2 No discharge scenario ... 40
4.2.1 Green hydrogen ... 40
4.3 Discharge scenario ... 41
4.3.1 Data centers ... 41
4.3.2 Semiconductors ... 42
4.3.3 Solar panel manufacturing ... 43
4.3.4 Electric vehicle manufacturing ... 44
4.3.5 Pumped storage hydropower ... 44
4.3.6 Cement and concrete ... 45
4.4 Potential end use examples ... 46
4.4.1 Example 1: Use in oil and gas well completion operations ... 47
4.4.2 Example 2: Use in refinery operations ... 48
4.4.3 Example 3: Use for industrial cooling for data centers ... 49
4.4.4 Example 4: Use to create cement for wind turbine installations ... 50
4.4.5 Example 5: Use in geothermal operations ... 51
4.4.6 Example 6: Use in industrial cooling for advanced manufacturing facilities ... 52
4.5 Potential end use conclusions ... 52
5 PRODUCED WATER AND BRACKISH WATER TREATMENT ... 53
5.1 Produced water treatment ... 53
5.2 Brackish water treatment ... 57
5.3 Produced water and brackish water treatment conclusions ... 58
6 TRANSPORTATION AND STORAGE ... 58
7 BRINE AND RESIDUALS MANAGEMENT ... 59
7.1 Cost ... 59
7.2 Enhanced resource recovery ... 59
7.3 Improve rate of water recovery ... 61

7.4 Energy security 61
8 ECONOMIC FEASIBILITY 61
8.1 Supply side: water processing cost structure 61
8.1.1 Cost components 62
8.1.2 Treatment of produced water 65
8.1.3 Treatment of brackish water 69
8.2 Demand side: willingness to pay for water 72
8.3 Incentives for private sector participation in the Strategic Water Supply 75
8.4 Incentive duration 76
8.4.1 Short-term subsidies 76
8.4.2 Long-term subsidies 76
8.4.3 Factors influencing project sustainability beyond subsidies 76
8.5 Economic feasibility conclusions 77
8.5.1 Investment risk 77
8.5.2 Project sustainability 77
8.5.3 Complementary funding sources 77
8.5.4 Value of alternative to SWD 78
8.5.5 Costs of closed-loop requirement 78
8.5.6 Treated water quality related to alternative sources 78
8.5.7 Increasing water prices 78
9 CONCLUSION 79
9.1 Produced water 79
9.1.1 San Juan Basin 80
9.1.2 Permian Basin 80
9.2 Brackish water 80
9.2.1 Santa Teresa 80
9.2.2 Albuquerque Basin 81
APPENDIX A: BRACKISH AQUIFER WATER CHEMISTRY 82
APPENDIX B: OTHER SOURCES OF FUNDING FOR UPFRONT COSTS 88
EPA Water Infrastructure Finance and Innovation Act 88
U.S. Bureau of Reclamation 88
Clean Water Act State Revolving Fund 88
U.S. Department of Energy 88
New Mexico Programs 89
APPENDIX C: NMED RESPONSES TO PUBLIC COMMENTS 90

LIST OF TABLES

Table 1. Produced water volumes and injected* volumes, 2017–2023 8
Table 2. TDS data for produced water from conventional wells in the Permian and San Juan Basins in New Mexico 12
Table 3. Produced water management practices for New Mexico, 2021 15
Table 4. Española Basin: Summary of water chemistry 27
Table 5. Mesilla Basin: Summary of water chemistry 28
Table 6. Albuquerque Basin: Summary of water chemistry 29
Table 7. Number of U.S. municipal desalination plants by state 32
Table 8. Summary of SWS potential end uses 39
Table 9. Estimated produced water SWS project costs: Permian Basin 67
Table 10. Estimated produced water SWS project costs: San Juan Basin 67
Table 11. Net costs for produced water projects: Permian Basin 69
Table 12. Net costs for produced water projects: San Juan Basin 69
Table 13. Cost references from desalination plants 70
Table 14. Brackish water project cost estimates 72
Table 15. Water price by use 73
Table 16. Project costs and end user payments: Permian Basin produced water 74
Table 17. Project costs and end user payments: San Juan Basin produced water 74
Table 18. Project costs and end user payments: Brackish water 74
Table 19. Cost components of SWS projects 78
Table A-1. San Luis Basin: Summary of water chemistry 82
Table A-2. Española Basin: Summary of water chemistry 82
Table A-3. Albuquerque Basin: Summary of water chemistry 83
Table A-4. Socorro-La Jencia Basins: Summary of water chemistry 83
Table A-5. San Marcial and Engle Basins: Summary of water chemistry 83
Table A-6. Palomas Basin: Summary of water chemistry 84
Table A-7. Mesilla Basin: Summary of water chemistry 84
Table A-8. Jornada del Muerto Basin: Summary of water chemistry 84
Table A-9. Estancia Basin: Summary of water chemistry 85
Table A-10. Mimbres Basin: Summary of water chemistry 85
Table A-11. San Agustin Basin: Summary of water chemistry 85
Table A-12. Tularosa Basin: Summary of water chemistry 86
Table A-13. Roswell Artesian Basin: Summary of water chemistry 86
Table A-14. Capitan Reef aquifer: Summary of water chemistry 86

Table A-15. Raton and Las Vegas Basins: Summary of water chemistry 87
Table A-16. High Plains aquifer: Summary of water chemistry... 87
Table A-17. San Juan Basin: Summary of water chemistry.. 87

LIST OF FIGURES

Figure 1. Projected increase in water demand from 2010 to 2060: High projection. 3
Figure 2. Intersection of desirable SWS project location characteristics. 5
Figure 4. Produced water volumes in the Permian and San Juan Basins. 9
Figure 5. Produced water injection volumes in the Permian and San Juan Basins. 9
Figure 6. Locations of gas, oil, and SWD wells in the San Juan (NW) and Permian (SE) Basins. 16
Figure 7. Map of potential brackish water regions in New Mexico. 25
Figure 8. Saline groundwater use by water use category, 1985–2010. 30
Figure 9. Number of U.S. municipal desalination plants by membrane type and time built. 31
Figure 10. U.S. municipal desalination concentrate disposal option use by location. 33
Figure 11. Produced water treatment process. 55
Figure 12. Flow chart of brackish water and produced water sourcing, treatment, and use for no discharge and discharge scenarios. 62
Figure 13. Desalination CAPEX and OPEX costs. 63
Figure 14. CAPEX/OPEX spending by category and plant type. 64

EXECUTIVE SUMMARY

This feasibility study presents an analysis of the technical and economic viability of the proposed New Mexico Strategic Water Supply (SWS), including considerations for the use of incentives to attract private sector participation in the initiative. The study only considers industrial end uses under two scenarios that reflect expectations for development of relevant regulations: closed-loop projects with no environmental discharge of treated water (near term) and projects with environmental discharge (longer term).[1] It focuses on defining project characteristics, such as locations and end uses, that appear to have a good fit with the objectives and scope of the SWS initiative. The study is also intended to inform the level of funding needed for the initiative as well as a future request for proposals from potential participants in the initiative.

The study explores technical issues related to produced water and brackish water resources, potential end uses, treatment, transportation and storage, brine and residuals management, and economic feasibility.

On September 17, 2024, the New Mexico Environment Department (NMED) submitted a request for public feedback on this study, seeking technical, economic, and legal input from subject matter experts to ensure the feasibility study's thoroughness. The feedback period ended on October 18, 2024, and NMED received 15 responses that aligned with its request. The responses contained several key areas of focus regarding produced water systems, treatment methodologies, economic viability, and the protection of New Mexico's resources and environmental health.

Comments addressed the need for long-term projections on water availability and the importance of considering environmental and public health as the projects move forward; they called for the expansion of pilot projects and closed-loop studies to further advance the science and technology behind water treatment. They also highlighted economic considerations, with suggestions for enhancing the financial frameworks that support sustainable water systems. Overall, these major themes supported the need for a comprehensive approach to addressing the complexities surrounding produced water systems.

NMED assessed feedback based on relevance to the request and consulted internal subject matter experts to determine which comments should be incorporated directly in the study. Appendix C of this report responds to all the feedback NMED received.

[1] For the purposes of this study, "near term" indicates the period over which only closed-loop projects will be contemplated under the SWS, consistent with current regulations. "Longer term" refers to a longer period, over which the Water Quality Control Commission adopts discharge standards that allow environmental discharge of treated produced water.

1 INTRODUCTION

1.1 PURPOSE

This feasibility study presents an analysis of the technical and economic viability of the proposed New Mexico Strategic Water Supply (SWS), including considerations for the use of incentives to attract private sector participation in the initiative. The study only considers industrial end uses under two scenarios that reflect expectations for development of relevant regulations: closed-loop projects with no environmental discharge[2] of treated water (near term) and projects with environmental discharge (longer term). The focus of the study is to define project characteristics, such as locations and end uses, that appear to have a good fit with the objectives and scope of the SWS initiative. The study is also intended to inform the level of funding needed for the initiative as well as a future request for proposals (RFP) from potential participants in the initiative.

1.2 CONTEXT

Developing alternative water sources is a necessity to preserve fresh water; it is crucial for New Mexico's economic and environmental sustainability, as the state faces a decline in surface water and groundwater supplies that is related to climate change and usage patterns.[3] Water shortages have devastating consequences for the state's communities and economy. The development of alternative water sources would also enable the state to attract new industries that are currently constrained by water availability, such as renewable energy, advanced manufacturing, and other opportunities. These industries could create new jobs, increase tax revenues, and diversify the state's economy while preserving freshwater resources.

New Mexico will have about 16 percent to 28 percent lower flow in major rivers over the next 50 years, and less surface water will lead to lower recharge to some groundwater aquifers.[4] Reduced surface and groundwater supplies are expected to result in a shortfall of 750,000 acre-feet (244 million gallons), assuming that the water usage rates from the last decade continue.[5] Annual demand for water has been projected to increase by nearly 440,000 acre-feet (143 million gallons) between 2010 and 2060 under a high-population-growth scenario,[6] with the highest increases in the San Juan Basin planning region, followed by the Middle Rio Grande planning region (Figure 1). The SWS is part of the state's broader 50-Year Water Action Plan, which addresses increased demand and reduced supplies in the future, including water conservation, new water supplies, and water and watershed protection.

---

[2] For the purposes of this study, "environmental discharge" refers to discharge of treated water to surface water or groundwater. It is unrelated to the exploration, drilling, production, treatment, or refinement of oil or gas.

[3] Office of the Governor. (2024). *50-year water action plan*. https://www.nm.gov/wp-content/uploads/2024/01/New-Mexico-50-Year-WaterAction-Plan.pdf

[4] Dunbar, N. W., Gutzler, D. S., Pearthree, K. S., Phillips, F. M., Bauer, P. W., Allen, C. D., DuBois, D., Harvey, M. D., King, J. P., McFadden, L. D., Thomson, B. M., and Tillery, A. C. (2022). Climate change in New Mexico over the next 50 years: Impacts on water resources. *New Mexico Bureau of Geology and Mineral Resources,* Bulletin 164. https://doi.org/10.58799/B-164

[5] Office of the Governor. (2024). *50-year water action plan*. https://www.nm.gov/wp-content/uploads/2024/01/New-Mexico-50-Year-WaterAction-Plan.pdf

[6] New Mexico Office of the State Engineer. (2018). *New Mexico state water plan part II: Technical report.* https://www.ose.nm.gov/Planning/SWP/2018/3-2018_SWP_Part_II_Technical_Report_plusAppendixes.pdf. The study also projects that annual demand will decrease by nearly 147,000 acre-feet (48 million gallons) in a low-growth scenario.

Underground reserves of brackish water and wastewater from the oil and gas industry represent two major untapped water resources that might offset reliance on freshwater resources with appropriate regulatory controls to protect the environment and human health. It has been estimated that between 2 and 4 billion acre-feet (652 trillion to 1,303 trillion gallons) of brackish water exists in New Mexico's brackish aquifers,[7] though information about the quality and volume of water in these aquifers is vastly inconsistent throughout the state due to a lack of aquifer characterization studies for the majority of deep and shallow aquifers in New Mexico.[8] The deep brackish water aquifers[9] in New Mexico are almost entirely undeveloped. The New Mexico oil and gas industry disposes of about 85 million gallons per day of produced water,[10] a byproduct of oil and gas production.[11] These alternative water sources require appropriate treatment—which technological advances are making more feasible—before use.

[7] Office of the Governor. (2023, December 5). *Gov. Lujan Grisham to establish first-of-its-kind Strategic Water Supply—$500 million investment will leverage advanced market commitments.* [Press release]. https://www.governor.state.nm.us/2023/12/05/gov-lujan-grisham-to-establish-first-of-its-kind-strategic-water-supply-500-million-investment-will-leverage-advanced-market-commitments/

[8] The volume estimate of brackish water in New Mexico reported here considers brackish water at any depth, not just brackish water at depths greater than 2,500 feet. Volume estimates of brackish water for specific aquifers in the state are provided in the following sources, though none of them provides a comprehensive estimate for the state as a whole:

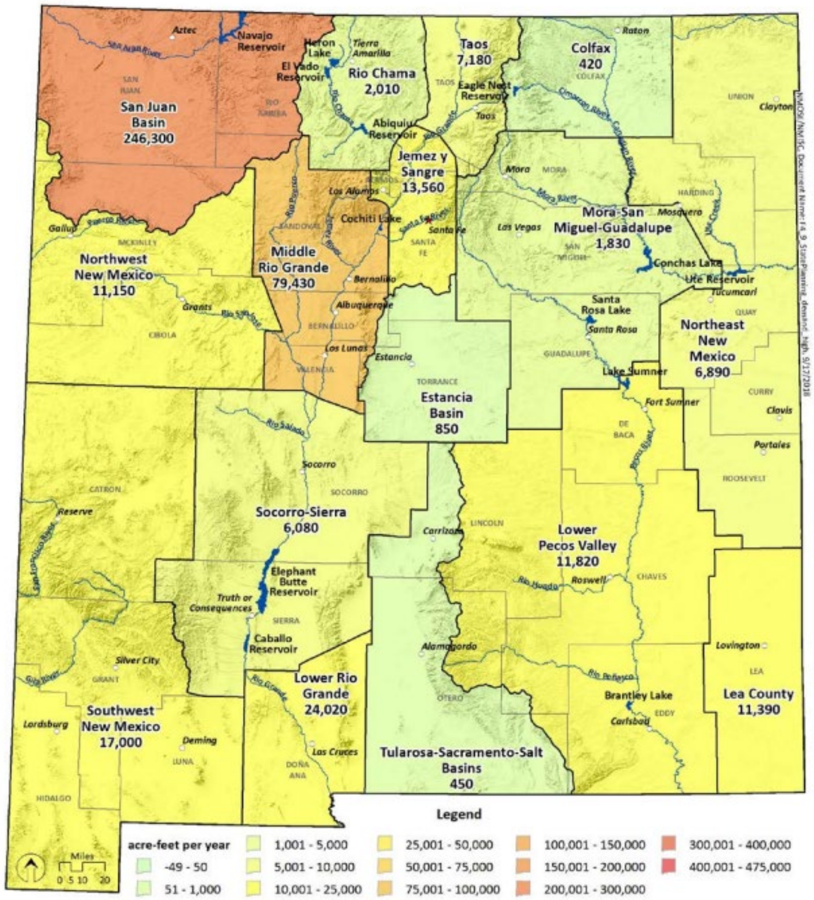
- Hood, J. W., and Kister, L. R. (1962). *Saline-water resources of New Mexico.* Geological Survey Water-Supply Paper 1601. U.S. Geological Survey. https://pubs.usgs.gov/wsp/1601/report.pdf
- McLean, J. S. (1970). *Saline ground-water resources of the Tularosa Basin, New Mexico.* Research and Development Progress Report 561. U.S. Geological Survey. https://pubs.usgs.gov/publication/70139928
- Huff, G. F. (2004). An overview of the hydrogeology in saline ground water in New Mexico. *Water Desalination and Reuse Strategies for New Mexico: Proceedings of the 49th Annual New Mexico Water Conference.* New Mexico Water Resources Research Institute, 21–34. https://nmwrri.nmsu.edu/publications/water-conference-proceedings/wcp-documents/w49/huff.pdf

[9] "Deep brackish aquifers" refer to aquifers at a depth greater than 2,500 feet and salinity greater than 1,000 parts per million of total dissolved solids.

[10] Stoll, Z., Wang, H., and Xu, P. (2024). *Treatment of oil & gas produced water generated in New Mexico for closed-system fit for purposes uses.* New Mexico State University Department of Civil Engineering.

[11] Produced water disposal is generally by injection into deep wells.

Figure 1. Projected increase in water demand from 2010 to 2060: High projection.



From: New Mexico Office of the State Engineer, 2018.[12]

With the SWS, New Mexico would join other states and countries in efforts to develop brackish water resources and reuse treated produced water. Australia[13] and several countries in the Middle East (e.g. Israel,[14] Saudi Arabia[15]) and North Africa[16] have prioritized desalination projects that enable the use of brackish water for agriculture and potable use. Small-scale projects using treated produced water for beneficial uses have been completed in Colorado,

---

[12] New Mexico Office of the State Engineer. (2018). *New Mexico state water plan part II: Technical report.* https://www.ose.nm.gov/Planning/SWP/2018/3-2018_SWP_Part_II_Technical_Report_plusAppendixes.pdf

[13] State Government of Victoria. (2023). *Desalination history.* https://www.water.vic.gov.au/water-sources/desalination/desalination-history

[14] Jacobsen, R. (2016, July 29). Israel proves the desalination era is here. *Scientific American.* https://www.scientificamerican.com/article/israel-proves-the-desalination-era-is-here/

[15] U.S.–Saudi Business Council. (2021, January 7). *Water in Saudi Arabia: Desalination, wastewater, and privatization.* https://ussaudi.org/water-in-saudi-arabia-desalination-wastewater-and-privatization/

[16] Africanews. (2023). *Drought-hit North Africa turns to purified sea wastewater.* https://www.africanews.com/2023/07/27/drought-hit-north-africa-turns-to-purified-sea-and-wastewater

Wyoming, and Oklahoma. Treated produced water is regularly released to surface water in Pennsylvania, although this practice has, in some cases, been linked to increased pollution of waterways.[17] Permits have also allowed discharge of treated produced water in Arkansas and West Virginia. These examples of treatment and use of brackish and produced water are explored in detail below.

1.3 DESCRIPTION OF THE STRATEGIC WATER SUPPLY

The proposed SWS would address the challenge of decreasing water supplies by developing alternative water resources. This would support New Mexico's transition to renewable energy and advanced manufacturing by making water available for these expanding and emerging industrial uses. The SWS would offer an incentive to private sector participants: a commitment to selected businesses to purchase treated water, at specified qualities and quantities, that would reduce the risk of investments needed to build and operate water treatment facilities.

This effort promises to address the New Mexico communities' need for access to freshwater resources. By alleviating industrial demand for freshwater with treated produced and brackish water, competition for this vital resource between industry, agriculture, and residential consumers can be reduced. At the same time, the SWS can support economic development to sustain the New Mexico economy into the future, bringing jobs in advanced manufacturing and other sectors to the state. The SWS would also address concerns about current practices for disposal of produced water from the oil and gas industry—especially issues with seismicity related to deep well injection, which may lead to restrictions on the practice and have potentially severe impacts on the industry and the state economy.

1.4 APPROACH

This feasibility study is based on several sources of information. Earlier this year, the New Mexico Environment Department (NMED) issued a Request for Information (RFI) to gather technical and economic information from individuals, businesses, academia, government agencies, and other stakeholders related to the sourcing, treatment, delivery, storage, and industrial uses of brackish water and produced water. NMED received 50 responses and has incorporated the information from them into its analysis. In addition, meetings with potential SWS participants, New Mexico state government officials, and other stakeholders were used to enhance understanding of the technical, regulatory, and practical issues relevant to the initiative. On June 27, 2024, New Mexico State University (NMSU) hosted "Strategic Water Supply: State of the Science Symposium," a meeting that brought together academic researchers, industry, legislators, tribal leaders, non-governmental organizations, and other stakeholders to discuss the available research results relevant to the development of the SWS. Finally, other available information in published research or other sources was leveraged to inform the study.

The focus of the study is to define project characteristics, such as locations and end uses, that appear to have a good fit with the objectives and scope of the SWS initiative. Location will be a critical factor for SWS projects given the high cost of transportation for water. The characteristics of an idea project location would fall into four categories:

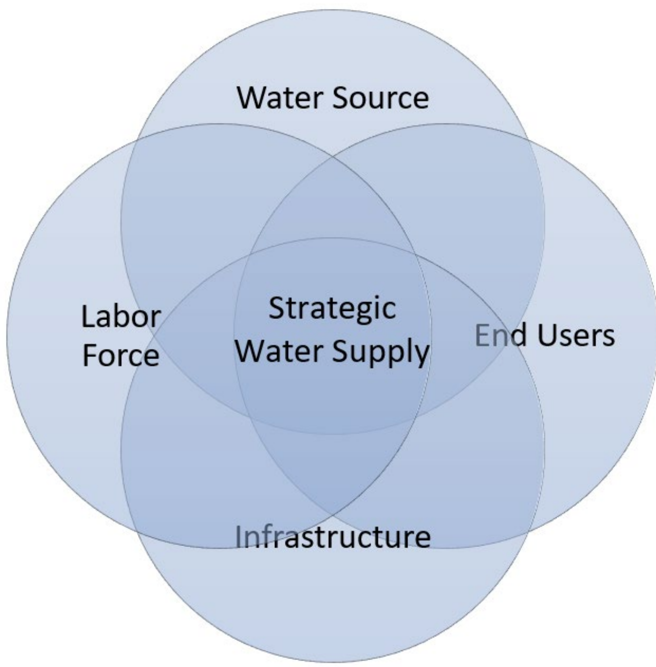
---

[17] Lucas, M. (2024). *Mussels downstream of wastewater treatment plant contain radium, study reports.* https://www.psu.edu/news/engineering/story/mussels-downstream-wastewater-treatment-plant-contain-radium-study-reports

- **Water source.** Locating treatment facilities near water sources can lower transportation costs. In addition, the water quality of different sources may facilitate different project types.
- **Labor force.** Depending on the project type, a labor force with certain qualifications will be needed for both the treatment facility and end users.
- **End users.** Project locations should be near the treatment location; this also lower transportation costs.
- **Infrastructure.** Infrastructure needs will also depend on the project type. They might include transportation infrastructure for end products, as well as access to the electricity grid to support treatment facilities and end users.

As Figure 2 shows, an ideal SWS project location has the right characteristics in as many categories as possible.

Figure 2. Intersection of desirable SWS project location characteristics.



The following sections discuss produced and brackish water sources in turn, followed by other aspects of potential SWS projects. As mentioned above, the study considers two scenarios that reflect expectations for development of relevant regulations: closed-loop projects with no environmental discharge (near term) and projects with environmental discharge (longer term). The study concludes by identifying opportunities for project types in specific locations and associated challenges, applying the lens of desirable key project characteristics described above.

2 PRODUCED WATER

2.1 DESCRIPTION

Produced water is a byproduct of oil and gas drilling and production that primarily consists of naturally occurring, highly saline water but may also include the fluids (i.e., “flowback”) that are initially returned in the first few weeks after a well is hydraulically fractured. After the initial flowback period, the produced water transitions to naturally occurring formation waters. In general, 4–7 barrels (bbl) of produced water are generated for every bbl of oil produced.[18] Produced water quantity, make-up, and quality vary significantly depending on the formation from which the water is extracted. In the San Juan Basin of New Mexico, produced water is lower in salinity than in the Permian Basin of New Mexico. Produced water requires treatment before reuse.

2.2 NEW MEXICO PRODUCED WATER RESOURCES

As produced water is a byproduct of oil and gas production, this section begins with some background on New Mexico's oil and gas industry. New Mexico is the nation's second largest crude-oil producing state after Texas, accounting for 14 percent of total U.S. crude oil production in 2023.[19] Oil and gas extraction accounted for 9 percent of New Mexico's gross domestic product in 2022,[20] not including any indirect or induced impacts associated with the industry. According to the New Mexico Bureau of Geology and Mineral Resources, oil and gas production is primarily in the Permian Basin in the southeast (Lea, Eddy, Chaves, and Roosevelt Counties) and the San Juan Basin in northwestern New Mexico (San Juan, Rio Arriba, Sandoval, and McKinley Counties). The Permian/Delaware is focused on oil production, with the San Juan Basin generally producing more dry natural gas.[21] However, due to the associated gas that is produced with the increased emphasis on crude oil in the Permian Basin, the Permian Basin produces significantly more gas currently than the San Juan Basin.[22] As of 2023, 16 percent of gas was produced from the San Juan Basin and 84 percent was from the Permian Basin.[23] For 2023 oil production, 98 percent was from the Permian Basin and 2 percent was from the San Juan Basin.[24]

A December 2023 analysis by New Mexico's State Investment Council forecasts that, barring a significant decline in the average price of oil, production will likely rise from current levels of

---

[18] New Mexico Environment Department. (2019). *Produced water factsheet.* https://www.env.nm.gov/wp-content/uploads/sites/16/2019/10/Produced-Water-Factsheet_ENGLISH_-FINAL-191010.pdf

[19] U.S. Energy Information Administration (EIA). (2024). *New Mexico state energy profile.* https://www.eia.gov/state/print.php?sid=NM

[20] U.S. Bureau of Economic Analysis. (2024). *Gross domestic product.* www.bea.gov/data/gdp

[21] New Mexico Bureau of Geology and Mineral Resources. (2024). *Frequently asked questions about oil and gas.* https://geoinfo.nmt.edu/faq/energy/petroleum/home.html

[22] New Mexico Oil Conservation Division. (2024). *Statewide natural gas and oil production summary including produced water and injection by month.* OCD Statistics. Data for 2023 originally downloaded 2/13/2024 from https://wwwapps.emnrd.nm.gov/ocd/ocdpermitting/Reporting/Production/ExpandedProductionInjectionSummaryReport.aspx

[23] New Mexico Oil Conservation Division. (2024). *Statewide natural gas and oil production summary including produced water and injection by month.* OCD Statistics. Data for 2023 originally downloaded 2/13/2024 from https://wwwapps.emnrd.nm.gov/ocd/ocdpermitting/Reporting/Production/ExpandedProductionInjectionSummaryReport.aspx

[24] New Mexico Oil Conservation Division. (2024). *Statewide natural gas and oil production summary including produced water and injection by month.* OCD Statistics. Data for 2023 originally downloaded 2/13/2024 from https://wwwapps.emnrd.nm.gov/ocd/ocdpermitting/Reporting/Production/ExpandedProductionInjectionSummaryReport.aspx

around 700 million bbl per year to reach a peak of around 800 million bbl per year around 2030. The optimistic scenario projects peak production to reach 1 billion bbl per year.[25]

2.2.1 Produced water volumes

With oil and gas production trends, the volume of produced water generated by the oil and gas industry has increased by a factor of about 2.4 from 2017 to 2023; data from the New Mexico Oil Conservation Division (OCD) indicate a total estimated volume for 2023 exceeding 2 billion bbl.[26] The increased volume of produced water is driven by activity in the Permian (Table 1), which generates 99 percent of the state's produced water in 2023, with 2,102.3 million bbl per year, compared to 24.1 million bbl per year in the San Juan Basin[27] as well as the type of production—oil production produces significantly more wastewater than gas production. Data in Figure 4 and Figure 5 show trends in the total volumes of produced water generated as well as the volumes injected for disposal or other purposes (e.g., secondary oil[28]) from 2017 to 2023. If oil production continues to increase in the Permian, produced water volumes will also increase, though not necessarily in direct proportion.

A caveat on produced water volumes is that reported values in the state database can be updated by tens of millions of barrels even months or years after the 45-day lag period specified in the reporting requirements.[29] This lag may explain the estimated percentages above 100% in Table 1: produced water production values at the time of download may have been underestimates. Also, there is error/uncertainty in produced water production amounts as they are reported. Additionally, the OCD data do not state clearly that all injected water was sourced within the San Juan Basin.

[25] New Mexico Legislative Finance Committee. (2023). *Money matters: Analysis by the LFC economists*. https://nmlegis.gov/handouts/ALFC%20121123%20Item%201%20General%20Fund%20Consensus%20Revenue%20Estimate%2012.9.23.pdf

[26] New Mexico Oil Conservation Division. (2024). *Statewide natural gas and oil production summary including produced water and injection by month.* OCD Statistics. Data for 2023 originally downloaded 2/13/2024 from https://wwwapps.emnrd.nm.gov/ocd/ocdpermitting/Reporting/Production/ExpandedProductionInjectionSummaryReport.aspx

[27] Ibid.

[28] Secondary oil recovery means injecting water into an oil reservoir to displace oil and move it towards a production well.

[29] New Mexico Oil Conservation Division. (2024). *OCD statistics.* https://www.emnrd.nm.gov/ocd/ocd-data/statistics/

Table 1. Produced water volumes and injected* volumes, 2017–2023

Year	PW Generated: NW Oil Wells (bbl)	PW Generated: NW Gas Wells (bbl)	Total PW Generated: NW Oil and Gas Wells (bbl)	PW Injected: NW (bbl)	% Injected: NW (% of total PW generated)
2017	2,768,333	30,172,152	32,940,485	22,788,439	69%
2018	3,027,168	20,708,727	23,735,895	23,250,850	98%
2019	5,227,376	33,556,791	38,784,167	26,145,527	67%
2020	4,361,311	31,639,771	36,001,082	22,608,646	63%
2021	6,220,095	16,374,183	22,594,278	24,037,871	106%**
2022	6,220,095	19,222,501	25,442,596	27,949,590	110%**
2023	7,933,236	16,135,828	24,069,064	25,314,274	105%**
Year	**PW Generated: SE Oil Wells (bbl)**	**PW Generated: SE Gas Wells (bbl)**	**Total PW** Generated: SE **Oil + Gas Wells (bbl)**	**PW Injected: SE (bbl)**	**% Injected: SE (% of total PW generated)**
2017	768,047,215	74,945,196	842,992,411	773,100,908	92%
2018	888,097,670	121,446,563	1,009,544,233	834,592,835	83%
2019	1,052,941,499	210,265,513	1,263,207,012	935,088,753	74%
2020	1,015,442,900	297,627,274	1,313,070,174	932,684,928	71%
2021	1,204,830,263	382,507,921	1,587,338,184	955,901,679	60%
2022	1,496,753,760	539,151,516	2,035,905,276	993,978,295	49%
2023	1,562,082,322	540,265,233	2,102,347,555	1,000,028,416	48%

Source: Murphy, 2024.[30]

Notes: PW = produced water, NW = northwest (San Juan), SE = southeast (Permian), bbl = barrels.

* Injected volumes do not differentiate between injection for disposal and injection for enhanced recovery.

** Exact reasons for values above 100 percent are unclear but may be due to errors and lags in reporting, the inherent uncertainty in estimates of produced water generation, or uncertainty about whether all produced water injected was regionally sourced.

[30] Murphy, K. (2024). Data summary provided via personal communication. Data originally downloaded from OCD Statistics website: https://wwwapps.emnrd.nm.gov/ocd/ocdpermitting/Reporting/Production/ExpandedProductionInjectionSummaryReport.aspx. Data downloaded on 1/12/2024 for data up through 2022. Data for 2023 downloaded 2/13/2024 due to 45-day lag time for reporting. Note: changes in values have been observed beyond the 45-day lag time.

Figure 3. Produced water volumes in the Permian and San Juan Basins.

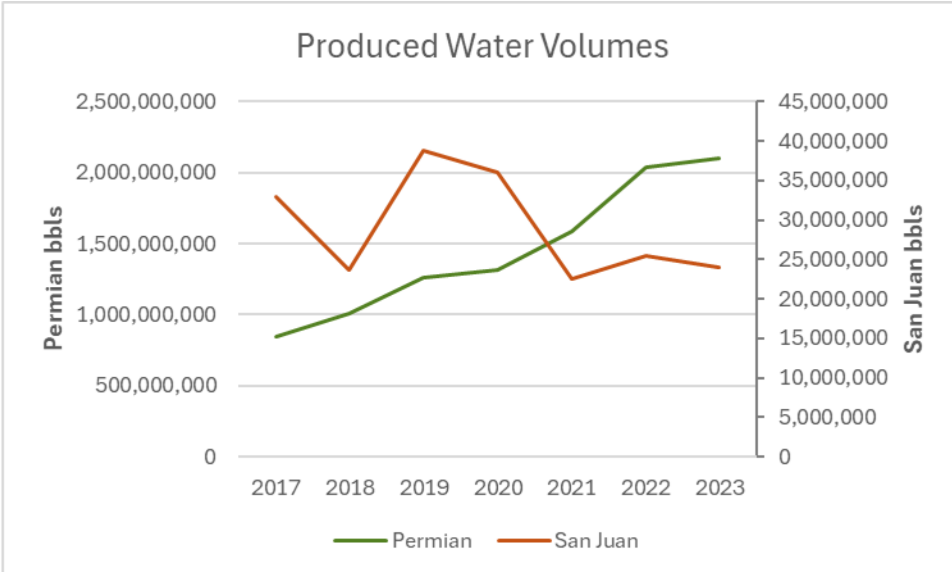
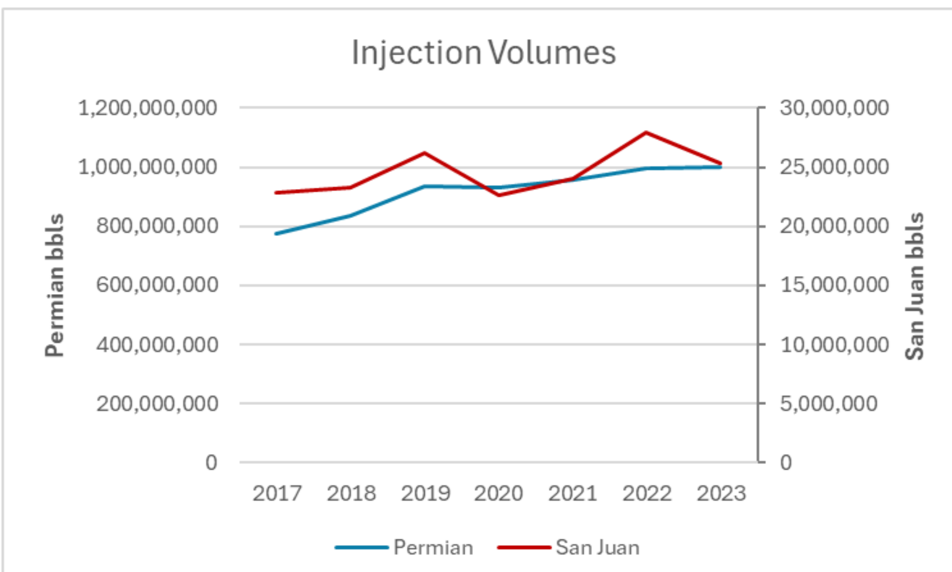


Figure 4. Produced water injection volumes in the Permian and San Juan Basins.



2.2.2 Produced water quality

Total dissolved solids (TDS) is a commonly used parameter for indicating overall produced water quality (i.e., salinity). However, produced water is a complex mixture with a number of constituents of concern for human and environmental health effects and for operations (e.g., scaling). These constituents can be naturally occurring or introduced as additives in fracturing fluids:[31,32,33]

- Suspended solids, oils, and grease
- Salts (dissolved solids)
- Dissolved organics (e.g., petroleum hydrocarbons, volatile and semi-volatile compounds)
- Heavy metals and metalloids (e.g., chromium, arsenic)
- Iron, calcium, and other scalants
- Dissolved gasses (e.g., hydrogen sulfide, ammonia)
- Naturally occurring radioactive material
- Chemical additives for hydraulic fracturing
- Microorganisms

The chemical additives for hydraulic fracturing fluid themselves constitute an extensive list of ingredients added to fracturing fluids in low concentrations: acids, biocides, breakers, clay stabilizers, corrosion inhibitors, scaling inhibitors, non-emulsifiers, iron control agents, gelling agents, friction reducers, and cross-linkers.[34] Some additives are claimed to be confidential business information, limiting the amount of information about them that is publicly available. This also makes it more difficult for investigators to perform a full characterization of the flowback portion of the produced water because some specific constituents are unknown.

Publicly available data on produced water chemistry in New Mexico are relatively limited, including in terms of the water quality parameters and analytes. Basic produced water data in New Mexico can be obtained from the New Mexico Produced Water Data Portal, created by the New Mexico Produced Water Research Consortium (NMPWRC). It is a free, publicly accessible database of all currently available produced water quality and quantity data in New Mexico. The portal currently accesses data for quarter townships, with monthly data on produced water quantities as well as available data on water quality.[35] The portal allows for displaying trends for a number of parameters and constituents (TDS, turbidity, pH, total organic carbon, sodium, chloride, total petroleum hydrocarbons, gross alpha and beta, uranium, thorium); all of these are not available for all entries.

[31] Hightower, M., Gross, T., and Xu, P. (2021). NM produced water data portal. *NM Produced Water Research Consortium—Year-end Meeting, December 1-2, 2021.* https://nmpwrc.nmsu.edu/files/NMPWRC-Data-Portal-Session-all-combined.pdf

[32] Society of Petroleum Engineers (SPE). (n.d.). *Challenges in reusing produced water*. https://www.spe.org/en/industry/challenges-in-reusing-produced-water/

[33] Jiang, W., Xu, X., Hall, R., Zhang, Y., Carroll, K. C., Ramos, F., Engle, M. A., Lin, L., Wang, H., Sayer, M., and Xu, P. (2022). Characterization of produced water and surrounding surface water in the Permian Basin, the United States. *Journal of Hazardous Materials, 430*, 128409. https://doi.org/10.1016/j.jhazmat.2022.128409

[34] Jiang, W., Lin, L., Xu, X., Cheng, X., Zhang, Y., Hall, R., and Xu, P. (2021). A critical review of analytical methods for comprehensive characterization of produced water. *Water, 13,* 183.

[35] New Mexico Produced Water Research Consortium and the Ground Water Protection Council. (2024). *New Mexico produced water data portal.* https://nm.waterstar.org/

Another relevant data source is the National Produced Waters Geochemical Database (PWDB),[36] maintained by the U.S. Geological Survey (USGS). Its information comes from a variety of sources, but most of the New Mexico data were obtained from the former New Mexico Water and Infrastructure Data System (NM WAIDS) website.[37] The USGS database can accommodate entries for large number of organic and inorganic constituents, but most New Mexico entries do not have comprehensive data, and many samples do not have all major ions. The most recent sampling dates for the Permian and San Juan entries are 2001 and 2004, respectively, and they are from conventional oil and gas wells (current Permian production is primarily unconventional, and significant hydraulic fracturing occurs in the San Juan as well). Limited data exist for unconventional well produced water within these basins, but PWDB data do illustrate generally higher TDS in the Permian than in the San Juan (Table 2).

Other analyses show similar trends. An analysis of 46 produced water samples from unconventional operations in the Permian Basin yielded TDS concentrations ranging from 100,830 to 201,474 milligrams per liter (mg/L), with a mean of 128,651 mg/L.[38] Another Permian Basin study used the USGS PWDB and the NM WAIDS database to demonstrate notable geochemical differences in produced water among formations and among different regions of the basin (Northwest Shelf, Delaware Basin, Central Basin Platform).[39] In the San Juan Basin, another team of researchers used the New Mexico Produced Water Quality Database (vs) and found that "[m]edian TDS in the San Juan is less than 15,000 mg/L in contrast to the Permian, where it exceeds 100,000 mg/L."[40] For comparison, fresh water is generally considered to have a TDS below 1,000 mg/L, with the U.S. Environmental Protection Agency's (EPA's) secondary drinking water standard (not mandatory or enforceable) for TDS set at under 500 mg/L.[41]

---

[36] U.S. Geological Survey. (2023). *U.S. Geological Survey National Produced Waters Geochemical Database* (ver. 3.0, December 2023). https://www.usgs.gov/tools/us-geological-survey-national-produced-waters-geochemical-database-ver-30-december-2023

[37] Cather, M., Lee, R., Gundiler, I., and Sung, A. (2005). *NM WAIDS: A produced water quality and infrastructure GIS database for New Mexico oil producers.* Final Technical Progress Report. New Mexico Petroleum Recovery Research Center, DE-FC26-02NT15134.Foot

[38] Jiang, W., Xu, X., Hall, R., Zhang, Y., Carroll, K. C., Ramos, F., Engle, M. A., Lin, L., Wang, H., Sayer, M., and Xu, P. (2022). Characterization of produced water and surrounding surface water in the Permian Basin, the United States. *Journal of Hazardous Materials, 430*, 128409. https://doi.org/10.1016/j.jhazmat.2022.128409

[39] Chaudhary, B. K., Sabie, R., Engle, M. A., Xu, P., Willman, S., and Carroll, K. C. (2019). Spatial variability of produced-water quality and alternative-source water analysis applied to the Permian Basin, USA. *Hydrogeology Journal, 27*(8), 2889–2905.

[40] Zemlick, K., Kalhor, E., Thomson, B., Chermak, J., Graham, E. J. S., and Tidwell, V. C. (2018). Mapping the energy footprint of produced water management in New Mexico. *Environmental Research Letters, 13*(2), 024008. https://doi.org/10.1088/1748-9326/aa9e54

[41] New Mexico Bureau of Geology and Mineral Resources. (2015). *Brackish and saline groundwater in New Mexico.* New Mexico Earth Matters. https://geoinfo.nmt.edu/publications/periodicals/earthmatters/15/n2/em_v15_n2.pdf

Table 2. TDS data for produced water from conventional wells in the Permian and San Juan Basins in New Mexico

Measurement	Permian Basin	San Juan Basin
Number of records	7,847	2,744
Date range	1928–2001	1917–2004
Mean (mg/L)	90,344	20,512
Median (mg/L)	62,098	14,156
90^{th} percentile (mg/L)	216,394	40,822
10^{th} percentile (mg/L)	9,200	2,386

Source: USGS, 2023.[42]

The TDS and other basic water quality data do not address concerns over the many possible other constituents in produced water and the implications for treatment and or health should discharge be permitted. Recent work by NMPWRC researchers has begun to address the need for thorough chemical analyses of produced water. A 2022 study characterized Permian Basin produced water, analyzing for over 300 analytes including organics, inorganics, and radionuclides.[43] In 14 produced water samples from unconventional wells in the Delaware (Permian) Basin in New Mexico, 91 of those analytes were detected. The mean ammonia concentration was 432 mg/L. Several radionuclides were detected (radium, uranium, thorium, polonium, and plutonium); the mean level for total radium (radium-226 plus radium-228) was 469.3 picocuries per liter. Targeted analysis of organic compounds yielded concentrations for 28 compounds. The volatile organic compounds (VOCs) with the highest concentrations were benzene, toluene, ethylbenzene, and xylenes (BTEX), although some VOCs may have been lost during transit and storage. Other compounds quantified were semivolatile organic compounds (SVOCs) (of which phenol and pyridine had the highest concentrations) and alcohols (methanol, ethanol). Diesel-range, gasoline-range, and motor-oil-range organics were also identified. In one sample, five per- and polyfluoroalkyl substance (PFAS) compounds were detected. Out of the five, only one PFAS compound (perfluorohexanesulfonic acid, PFHxS) is regulated in the U.S. EPA National Primary Drinking Water Regulation.[44] The PFHxS concentration measured in produced water was 40 times lower than EPA's enforceable Maximum Contaminant Level. Because these samples had been treated for injection for disposal, some compounds may not have been associated with hydraulic fracturing fluid. This study illustrates the range of compounds that can be present and the need for more sampling, including raw produced water before any treatment.

---

[42] U.S. Geological Survey. (2023). *U.S. Geological Survey national produced waters geochemical database* (ver. 3.0, December 2023). https://www.usgs.gov/tools/us-geological-survey-national-produced-waters-geochemical-database-ver-30-december-2023

[43] Jiang, W., Xu, X., Hall, R., Zhang, Y., Carroll, K. C., Ramos, F., Engle, M. A., Lin, L., Wang, H., Sayer, M., and Xu, P. (2022). Characterization of produced water and surrounding surface water in the Permian Basin, the United States. *Journal of Hazardous Materials, 430*, 128409. https://doi.org/10.1016/j.jhazmat.2022.128409

[44] U.S. Environmental Protection Agency. (2024). *Per- and polyfluoroalkyl substances (PFAS): Final PFAS National Primary Drinking Water Regulation.* https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas

A composite geochemical database for coalbed methane produced water quality in the Rockies included more than 600 data points in the San Juan Basin, with data for metals, radionuclides, and limited hydrocarbons.[45] Total recoverable hydrocarbon was detected, as well as BTEX.

2.2.3 Produced water variability

Produced water volumes and chemistry can vary both geographically (e.g., by geologic formation, between basins, among oil and gas fields), by whether that water is treated for disposal vs. reuse, and temporally (e.g., with time after the hydraulic fracturing process). When a well is hydraulically fractured, the initial flowback water is generally less saline than the water produced weeks later, and it will contain hydraulic fracturing fluid ingredients. After the initial flowback period, the water being produced shifts to an increasing proportion of more saline native formation fluids, with a significantly different composition. The initial flowback rate can also be higher than the rate of produced water generation during the well's production phase; the volume of flowback is also variable, depending on site-specific factors such as reservoir fluid pressure and amount and collection time.[46]

As examples of efforts to determine variability:

- A principal components analysis of coalbed methane produced water tied variability in produced water quality to the geology and geochemistry of the coalbed formations as well as recharge.[47]
- For volume, OCD data show that within the same district, total produced volumes can vary significantly among operators.[48]

Assessment of variability is needed to ascertain treatment needs and reuse options. However, some of the variability in quantity and quality will be dampened during aggregation of produced water by midstream oil and gas produced water companies. With networks of piping for transport of produced water, storage capabilities, and the ability to treat the water and handle management (e.g., including recycling and disposal), midstream companies can service several operators each. They play a significant role in produced water management in New Mexico—although many producers manage their own produced water—and that role is expected to grow.[49] Where produced water is managed by such a provider, detailed analyses at individual production sites may have received less attention than monitoring the quality of the aggregated produced water. However, this also means that contaminants will be introduced and pooled during aggregation, including any that were not anticipated and not included in a targeted list of analytes for the waters.

---

[45] Dahm, K. G., Guerra, K. L., Xu, P., and Drewes, J. (2011). Composite geochemical database for coalbed methane produced water quality in the Rocky Mountain Region. *Environmental Science and Technology, 45*, 7655–7663.

[46] Fajfer, J., Lipinska, O., and Konieczyńska, M. (2021). Hydraulic fracturing flowback chemical composition diversity as a factor determining possibilities of its management. *Environmental Science and Pollution Research, 29*(11), 16152–16175. https://doi.org/10.1007/s11356-021-16432-7

[47] Dahm, K. G., Guerra, K. L., Munakata-Marr, J., and Drewes, J. E. (2014). Trends in water quality variability for coalbed methane produced water. *Journal of Cleaner Production, 84,* 840–848.

[48] New Mexico Oil Conservation Division. (2024). *C-115 produced water by operator by year.* OCD Statistics. https://www.emnrd.nm.gov/ocd/ocd-data/statistics/

[49] Boyd, D. (2023). Third-party companies expanding water treatment, reuse and disposal capabilities. *The American Oil and Gas Reporter.* https://www.aogr.com/magazine/editors-choice/third-party-companies-expanding-water-treatment-reuse-and-disposal-capabilities

Scaling issues for data aggregation and produced water management were explored in a 2022 case study in the Permian Basin of New Mexico (Eddy and Lea Counties). The researchers conducted spatiotemporal analysis of produced water generation and demand and concluded that a 1.1-mile grid scale was a sufficient level of data aggregation to support produced water management decisions.[50]

2.3 CURRENT PRACTICES FOR PRODUCED WATER MANAGEMENT IN NEW MEXICO

Produced water in New Mexico may be managed by injection for disposal via saltwater disposal (SWD) wells (Figure 6); injection for enhanced oil recovery; reuse for drilling, well work, well stimulation (including hydraulic fracturing), or other facility uses; and pitting and evaporation. As noted above, midstream companies handle significant amounts of produced water in New Mexico, managing any necessary treatment and conveyance for disposal or reuse. The exact percentages of produced water managed by midstream providers vs. producers are not readily available.

Produced water management differs between the Permian and San Juan Basins. OCD data show that the estimated percentage of produced water injected in 2023 is higher in the San Juan than in the Permian, where the injected proportion has decreased from 92 percent in 2017 to 48 percent in 2023, despite increases in volumes (Table 1).[51] The OCD data are, however, limited in not differentiating between injection for disposal and injection for secondary oil recovery. Produced water volumes and injection volumes are both increasing in the Permian, while the San Juan data for 2017–2023 show increases and decreases but not a consistent trend.

Recycling of produced water for use in oil and gas production has increased in the Permian due to advances in industry practice, technological advances, and freshwater scarcity. The New Mexico OCD data for injection volumes in Table 1 do not include volumes reused for new well stimulation, and "injection" is understood to include only injection within New Mexico. The decreased percentage of produced water that is injected in the Permian (Table 1) indicates increased use of other means of management, such as reuse for new well stimulation or transport to Texas for disposal via injection. OCD data on water use for stimulation of new wells specify volumes of produced water used[52] and can be compared to data on total produced water to estimate the percentage of produced water reused for new well stimulation. In 2023, about 223 million bbl of produced water were used in well stimulations out of about 2.126 billion bbl of produced water generated. This suggests that about 11 percent of produced water was reused for new well stimulations. In 2021, 12 percent was reused; in 2022, 13 percent was reused.

---

[50] Sabie, R. P., Pillsbury, L., and Xu, P. (2022). Spatiotemporal analysis of produced water demand for fit-for-purpose reuse—A Permian Basin, New Mexico case study. *Water, 14*(11), 1735.

[51] New Mexico Oil Conservation Division. (2024). *Statewide natural gas and oil production summary including produced water and injection by month.* OCD Statistics. Data for 2023 originally downloaded 2/13/2024 from https://wwwapps.emnrd.nm.gov/ocd/ocdpermitting/Reporting/Production/ExpandedProductionInjectionSummaryReport.aspx

[52] New Mexico Oil Conservation Division. (2024). *Water use summary report.* Data downloaded 2/14/2024. https://wwwapps.emnrd.nm.gov/OCD/OCDPermitting/Reporting/Wells/WaterUseSummaryReport.aspx

The combination of injected and reused produced water does not account for all produced water generated. The remaining percentages (27 percent for 2021, 37 percent for 2022, and 41 percent for 2023) may correspond to produced water transported for injection into SWD wells in Texas. According to a 2023 news article, an estimated 34 percent of the produced water from the Delaware Basin in New Mexico was being sent to Texas for disposal via SWDs. The associated volume is 1.8 million bbl of produced water per day. The magnitude of this practice is causing induced seismicity in the basin and necessitating restrictions.[53]

Reuse estimates vary with the method of estimation and definitions of categories. The results of a questionnaire to state agencies by the Ground Water Protection Council (GWPC) indicated that in 2021, 20.2 percent of produced water in New Mexico was reported to be reused within the oil and gas industry for drilling, well work, well stimulation, or other facility uses (see Table 2).[54] The GWPC statistics also indicate that a small portion of produced water in the state is evaporated in lined pools (Table 3), although the authors of the GWPC report note that the true amount is likely higher because operators only reported volumes when requested by OCD. The GWPC data indicate that 717 million bbl were injected during 2021, which is less than reported in the OCD data in Table 1.

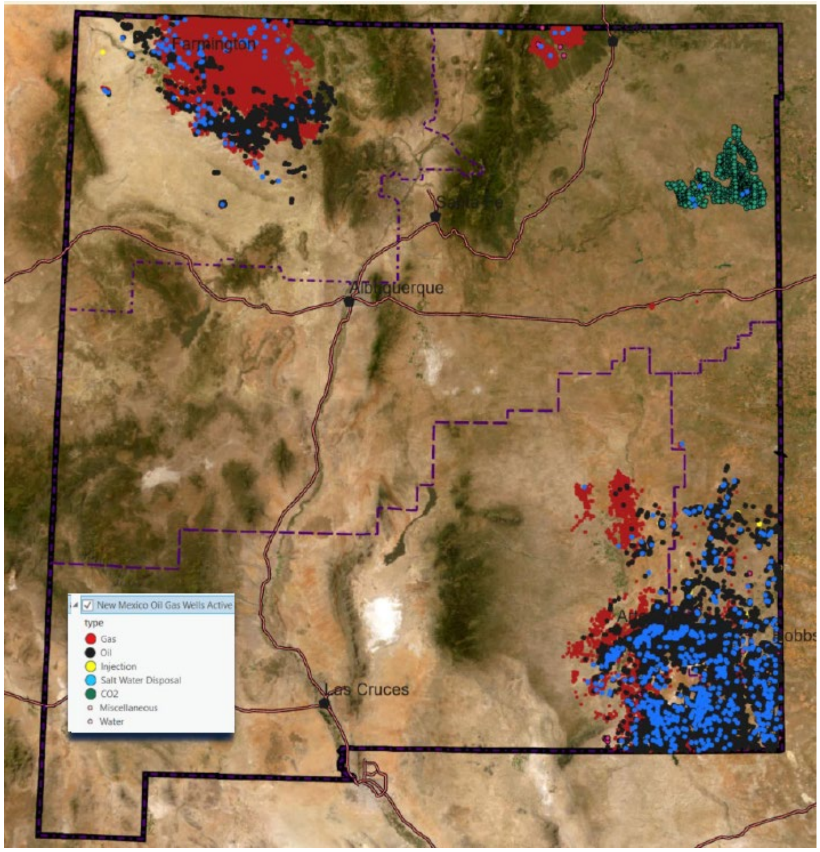
Table 3. Produced water management practices for New Mexico, 2021

Management Practice	Total Volume of Produced Water Managed by That Practice (bbl/year)	Percentage of Produced Water Managed by That Practice
Injection for disposal by operator	717,435,541	79.6%
Evaporation	1,762,644	0.2%
Reuse within the oil and gas industry	181,970,412	20.1%
Other	29,225	<0.01%
Total	901,197,822	100%

Adapted from: GWPC, 2022.[55]
Note: "Other" represents the volume of produced water that was spilled and not recovered.

[53] Patton, P. (2023, January 21). Texas is giving away revenue and taking New Mexico's waste. *Dallas Morning News.*
[54] Groundwater Protection Council. (2022). *U.S. produced water volumes and management practices in 2021.* https://www.gwpc.org/wp-content/uploads/2021/09/2021_Produced_Water_Volumes.pdf
[55] Groundwater Protection Council. (2022). *U.S. produced water volumes and management practices in 2021.* https://www.gwpc.org/wp-content/uploads/2021/09/2021_Produced_Water_Volumes.pdf

Figure 5. Locations of gas, oil, and SWD wells in the San Juan (NW) and Permian (SE) Basins.



From: Murphy, 2024.[56]
Note: Dashed purple lines delineate OCD districts.

2.4 PRODUCED WATER MANAGEMENT IN OTHER STATES AND COUNTRIES

Other major oil and gas producing states use a variety of strategies for produced water management. Texas produced the largest quantity of crude oil and natural gas in the nation in 2022.[57] In 2021, total produced water volume in Texas was estimated at 8,107,645,550 bbl (approximated from volumes handled via various management practices).[58] According to Texas Railroad Commission data compiled by GWPC,[59] most produced water is injected. In 2021, about 43.7 percent of produced water was injected for disposal by the operators, 32.1 percent

[56] Murphy, K. (2024). Testimony background information: GIS maps and charts. New Mexico Environment Department. Data originally from OCD GIS Hub, map produced by NMED. https://ocd-hub-nm-emnrd.hub.arcgis.com/
[57] U.S. Energy Information Administration. (2023). *Texas state profile and energy estimates.* https://www.eia.gov/state/?sid=TX
[58] Groundwater Protection Council. (2022). *U.S. produced water volumes and management practices in 2021.* https://www.gwpc.org/wp-content/uploads/2021/09/2021_Produced_Water_Volumes.pdf
[59] Groundwater Protection Council. (2022). *U.S. produced water volumes and management practices in 2021.* https://www.gwpc.org/wp-content/uploads/2021/09/2021_Produced_Water_Volumes.pdf

was used for secondary oil recovery, and 32.1 percent was injected for disposal at commercial facilities.[60] No produced water was reported as having been used for beneficial reuse in 2021.

Arizona's produced water production has decreased in recent years. The amount of actively producing wells has also declined. In 2021, produced water volume in Arizona totaled 10,715 bbl, with 100 percent of produced water being injected for disposal.[61] Oklahoma was the nation's sixth-largest producer of natural gas and crude oil in 2023.[62] In 2021, total produced water volume in Oklahoma was 1,744,894,591 bbl. About 56 percent of produced water was injected for secondary recovery, 30 percent was injected for disposal by the operator, and 14 percent was injected for disposal commercially or offsite.[63] Colorado was the nation's fourth-largest producer of crude oil and eighth-largest producer of natural gas in 2022.[64] In 2021, total produced water volume in Colorado was 280,460,737 bbl. Colorado's produced water management approaches vary more than other states', with 56 percent of produced water injected for disposal by the operator, 31 percent injected for secondary recovery, 7 percent reused within the oil and gas industry, 5 percent discharged to surface waters, 1.6 percent injected for disposal by a third party, and less than 0.01 percent evaporated or infiltrated by unlined sump.[65]

In Kern County, California, treated produced water has been used to irrigate crops, including food crops.[66] The produced water is treated by oil producers, then sent to local water districts, which blend it with water from other sources before sending it to agricultural users for irrigation.[67] The four local water districts that use treated produced water monitor its quality and are overseen by the regional water board.[68,69] However, there are caveats:

- Produced water from hydraulically fractured wells is not allowed to be used for agricultural purposes.

---

[60] Groundwater Protection Council. (2022). *U.S. produced water volumes and management practices in 2021.* https://www.gwpc.org/wp-content/uploads/2021/09/2021_Produced_Water_Volumes.pdf

[61] Groundwater Protection Council. (2022). *U.S. produced water volumes and management practices in 2021.* https://www.gwpc.org/wp-content/uploads/2021/09/2021_Produced_Water_Volumes.pdf

[62] U.S. Energy Information Administration. (2023). *Oklahoma state profile and energy estimates.* https://www.eia.gov/state/?sid=OK

[63] Groundwater Protection Council. (2022). *U.S. produced water volumes and management practices in 2021.* https://www.gwpc.org/wp-content/uploads/2021/09/2021_Produced_Water_Volumes.pdf

[64] U.S. Energy Information Administration. (2023). *Colorado state profile and energy estimates*. https://www.eia.gov/state/?sid=CO

[65] Groundwater Protection Council. (2022). *U.S. produced water volumes and management practices in 2021.* https://www.gwpc.org/wp-content/uploads/2021/09/2021_Produced_Water_Volumes.pdf

[66] California Water Boards. (2016). *Frequently asked questions about recycled oilfield water for crop irrigation.* https://www.waterboards.ca.gov/publications_forms/publications/factsheets/docs/prod_water_for_crop_irrigation.pdf

[67] Cawelo Water District. (2024). *Recycled produced water.* https://www.cawelowd.org/recycled-produced-water/

[68] California Water Boards. (2016). *Frequently asked questions about recycled oilfield water for crop irrigation.* https://www.waterboards.ca.gov/publications_forms/publications/factsheets/docs/prod_water_for_crop_irrigation.pdf

[69] Cawelo Water District. (2024). *Recycled produced water.* https://www.cawelowd.org/recycled-produced-water/

- Produced water in California generally has a higher starting quality than New Mexico's produced water.[70] TDS in California's produced water ranges from less than 2,000 mg/L to over 30,000 mg/L,[71] with Kern County produced water often under 10,000 parts per million (ppm);[72] this is significantly less saline than produced water from the Permian Basin and generally less saline than San Juan Basin produced water.

Produced water from coalbed methane in Wyoming can be discharged to surface waters[73] and is also used for irrigation and livestock.[74] Wyoming's coalbed methane produced water typically has a very high starting quality; entries for the Powder River Basin in the USGS PWDB[75] indicate a median TDS of about 7,000 mg/L. Produced water with relatively low TDS values may in some cases only need minimal treatment to be safely used in discharge applications.

A few companies have received National Pollutant Discharge Elimination System (NPDES) permits for treated produced water in other states, although the starting quality of the untreated produced water handled by these plants is unclear. Fairmont Brine Processing had an NPDES permit for its produced water treatment plant in West Virginia that began operating in 2014, but the plant was closed in 2018.[76] Southwestern Energy received a permit to discharge treated produced water into the White River in Arkansas, but the operation was closed due to high operating costs. Eureka Resources had a produced water treatment plant in Wysox, Pennsylvania, that had a permit to discharge into the Susquehanna River after extracting salts and disposing of other contaminants separately, but it was shut down in August 2024.[77]

2.5 ADDITIONAL INFORMATION NEEDS AND ONGOING EFFORTS TO SUPPORT DEVELOPMENT OF PRODUCED WATER RESOURCES

More data are needed on produced water quality and how it varies over space and time to inform the development of treatment technologies and management approaches.[78] Existing

[70] Edalat, A., and Hoek, E. (2020). *Techno-economic analysis of RO desalination of produced water for beneficial reuse in California.* https://www.mdpi.com/2073-4441/12/7/1850

[71] Edalat, A., and Hoek, E. (2020). *Techno-economic analysis of RO desalination of produced water for beneficial reuse in California.* https://www.mdpi.com/2073-4441/12/7/1850

[72] Groundwater Protection Council. (2023). *Produced water report: Regulations & practice updates.* https://www.gwpc.org/wp-content/uploads/2023/06/2023-Produced-Water-Report-Update-FINAL-REPORT.pdf

[73] The Ruckelshaus Institute of Environment and Natural Resources. (2005). *Water production from coalbed methane development in Wyoming: A summary of quantity, quality, and management options.* https://www.uwyo.edu/haub/_files/_docs/ruckelshaus/pubs/2005-cbm-water-final-report.pdf

[74] Groundwater Protection Council. (2023). *Produced water report: Regulations & practice updates.* https://www.gwpc.org/wp-content/uploads/2023/06/2023-Produced-Water-Report-Update-FINAL-REPORT.pdf

[75] U.S. Geological Survey. (2023). *U.S. Geological Survey national produced waters geochemical database* (ver. 3.0, December 2023). https://www.usgs.gov/tools/us-geological-survey-national-produced-waters-geochemical-database-ver-30-december-2023

[76] U.S. Environmental Protection Agency. (2024). *Fairmont brine site.* https://response.epa.gov/site/site_profile.aspx?site_id=16192

[77] 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.* https://paenvironmentdaily.blogspot.com/2024/08/eureka-resources-shuts-down-standing.html

[78] Hightower, M., Gross, T., and Xu, P. (2021). NM produced water data portal. *NM Produced Water Research Consortium—Year-end Meeting, December 1–2, 2021.* https://nmpwrc.nmsu.edu/files/NMPWRC-Data-Portal-Session-all-combined.pdf

publicly accessible data do not contain the needed level of information for the San Juan and Permian/Delaware Basins in New Mexico. Where data are present, they often comprise primarily inorganic constituents, sometimes only TDS concentrations. As noted in Section 2.2.2, a large number of inorganic and organic constituents can occur in produced water.

In addition to a broader suite of metals and organics, researchers specifically note the need for determining PFAS and radionuclide concentrations, including temporal and spatial distributions.[79] Concern has also arisen that important constituents may be missed even in more thorough analyses because they are not expected or claimed as proprietary (for hydraulic fracturing additives) and therefore not included in a targeted analyte list.

Assessment of toxicity is also needed. Though it is less crucial for a closed-loop reuse scenario, toxicity information is a valuable complement to chemical analyses, especially if discharge of treated produced water is an eventual possibility. A 2020 study developed a framework for identifying constituents of concern in produced water. The study used toxicological hazard data to build the framework, and one of the observations was that 56 percent of the compounds evaluated had not been studied for safety or toxicity mechanisms. Additionally, there was insufficient information to conduct a risk assessment for 86 percent of the compounds.[80]

2.5.1 Sample analysis developments—non-targeted analyses

Non-targeted analysis (NTA) is an area of active research that could allow better characterization of the complex chemistry of produced water. It is an evolving discipline that expands analyses beyond a targeted list of specific compounds in order to gain as much information as possible about a sample. Targeted analysis requires determining ahead of time which constituents to analyze for and allows for quantification; NTA captures a broad set of data from which the compounds and chemical classes present are then identified through a variety of data analysis techniques.

Produced water has many constituents beyond the usual targets in general discharge and reuse standards. This complex composition requires testing that can address the potentially broad suite of compounds, including newly found contaminants that are not routinely analyzed.[81] Targeted analysis of a specific set of analytes risks missing constituents that may pose human health and ecological safety concerns; NTA is a potentially valuable approach for more comprehensive characterization.

NTA methods entail separation of constituents followed by a form of detection. A frequently used analytical method for NTA is liquid chromatography–mass spectrometry, or LC-MS (the LC is the separation step, and the MS is for detection of the separated compounds). Compounds can be detected at very low concentrations (below parts per trillion). NTA is useful for screening

---

[79] Jiang, W., Xu, X., Hall, R., Zhang, Y., Carroll, K. C., Ramos, F., Engle, M. A., Lin, L., Wang, H., Sayer, M., and Xu, P. (2022). Characterization of produced water and surrounding surface water in the Permian Basin, the United States. *Journal of Hazardous Materials, 430*, 128409. https://doi.org/10.1016/j.jhazmat.2022.128409

[80] Danforth, C., Chiu, W., Rusyn, I., Schultz, K., Bolden, A., Kwiatkowski, C., and Craft, E. (2020). An integrative method for identification and prioritization of constituents of concern in produced water from onshore oil and gas extraction. *Environment International, 134,* 105280.

[81] Delanka-Pedige, H. M., Young, R. B., Abutokaikah, M. T., Chen, L., Wang, H., Imihamillage, K. A., Thimons, S., Jahne, M. A., Williams, A. J., Zhang, Y., and Xu, P. (2024). Non-targeted analysis and toxicity prediction for evaluation of photocatalytic membrane distillation removing organic contaminants from hypersaline oil and gas field-produced water. *Journal of Hazardous Materials*, *471*, 134436. https://doi.org/10.1016/j.jhazmat.2024.134436

and guiding choices for further targeted analysis.[82] Results can also be used for qualitative toxicity assessments based on molecular formula and structure information.[83] While thousands of constituents can be detected in a single NTA analysis, the results are considered operational and semi-quantitative, and data interpretation requires expert judgment.

There are currently several areas of ongoing development for NTA.[84] Data analysis methods are evolving, and the libraries of spectra against which to compare the LC-MS results require ongoing development to support identification of compounds and chemical classes. Analytical challenges such as matrix effects need to be taken into consideration. Also, because a variety of specific techniques are used, results may not be comparable among laboratories. NTA is not widely performed at this time, although some commercial laboratories do perform it.

2.5.2 Ongoing and planned research

In line with the abovementioned needs, researchers with NMPWRC have been working to characterize the water quality of raw and treated produced water. These efforts include sampling and analysis to assess the effectiveness of produced water treatment in the San Juan and Permian Basins. Work on the analytical aspects of characterization includes development of an "NPDES+" targeted analyte list containing about 400 constituents, toxicity testing, and NTA for organic constituents.[85] For detailed produced water characterization, a three-step combination of targeted analysis (i.e., NPDES+ analyte list), whole effluent toxicity (WET) testing, and NTA is being developed to produce information useful for environmental and human health considerations.

The ecotoxicity of produced water subcomponents on different organisms has not been fully determined; such information is needed for risk management and assessing treatment needs.[86] Recently, the research team at NMSU developed a non-targeted chemical analysis workflow to identify organic compounds and predict their toxicities using EPA's Cheminformatics Modules software. The predicted putative toxicity characteristics of organic contaminants were used to evaluate the efficiency of membrane distillation in treating produced water from the Permian Basin. Overall, NMSU researchers found that NTA together with toxicity prediction provides a competent, supportive tool to assess treatment efficiency and potential impacts on public health

---

[82] Delanka-Pedige, H. M., Young, R. B., Abutokaikah, M. T., Chen, L., Wang, H., Imihamillage, K. A., Thimons, S., Jahne, M. A., Williams, A. J., Zhang, Y., and Xu, P. (2024). Non-targeted analysis and toxicity prediction for evaluation of photocatalytic membrane distillation removing organic contaminants from hypersaline oil and gas field-produced water. *Journal of Hazardous Materials*, *471*, 134436. https://doi.org/10.1016/j.jhazmat.2024.134436

[83] Delanka-Pedige, H. M., Young, R. B., Abutokaikah, M. T., Chen, L., Wang, H., Imihamillage, K. A., Thimons, S., Jahne, M. A., Williams, A. J., Zhang, Y., and Xu, P. (2024). Non-targeted analysis and toxicity prediction for evaluation of photocatalytic membrane distillation removing organic contaminants from hypersaline oil and gas field-produced water. *Journal of Hazardous Materials*, *471*, 134436. https://doi.org/10.1016/j.jhazmat.2024.134436

[84] Delanka-Pedige, H. M., Young, R. B., Abutokaikah, M. T., Chen, L., Wang, H., Imihamillage, K. A., Thimons, S., Jahne, M. A., Williams, A. J., Zhang, Y., and Xu, P. (2024). Non-targeted analysis and toxicity prediction for evaluation of photocatalytic membrane distillation removing organic contaminants from hypersaline oil and gas field-produced water. *Journal of Hazardous Materials*, *471*, 134436. https://doi.org/10.1016/j.jhazmat.2024.134436

[85] Xu, P., Young, R., Zhang, Y., and Stoll, Z. (2024). Recommended technologies for produced water. *Strategic Water Supply: State of the Science Symposium.* June 27, 2024, Las Cruces, New Mexico.

[86] Xu, P., Zhang, Y., Jiang, W., and Hu, L. (2022). *Characterization of produced water in the Permian Basin for potential beneficial use.* NM WRRI Technical Completion Report No. 398. https://nmwrri.nmsu.edu/publications/technical-reports/tr-documents/tr398.pdf

and the environment during produced water reuse.[87] In other toxicity work, researchers at NMSU have applied WET to treated produced water to evaluate the ability to treat produced water to non-toxic levels through a treatment train that includes thermal distillation.[88,89] It was found that thermal distillation achieved significant reductions in raw produced water constituents including salinity, major ions, heavy metals, ammonia, and organics. Adding polishing steps (granular activated carbon and zeolites) further improved water quality, rendering the water non-toxic according to WET testing. (See Section 5 below for further discussion of produced water treatment.)

NMPWRC's future research plans include pilot demonstration projects for testing produced water treatment trains; targeted and non-targeted analysis of water, plants, and soils; and WET. Research also aims to develop a human health and environmental risk assessment framework for managing risks associated with fit-for-purpose reuse.[90] Such continued research on characterization and treatment effectiveness is also needed to support the development of formal water quality standards for environmental discharge of treated produced water. These standards are necessary to ensure human health and environmental safety in addition to meeting the needs of end users.

2.6 POTENTIAL ENVIRONMENTAL IMPACTS

The potential environmental impacts related to the reuse of treated produced water outside the oilfield include:

- **Potential human health and environmental impacts.** As noted above, research is ongoing to identify potentially harmful constituents (via targeted and non-targeted analysis) in produced water to ensure that these are addressed with appropriate treatment before environmental discharge and that this information is also available in case of spills.
- **Disposal of residual constituents.** All treatment methods eventually require disposal of residual constituents—which is important and can be very costly. For produced water, the main residual constituent is brine (salt), but other constituents found in the source water will also need to be disposed of. Disposal issues are discussed in detail below in Section 7.

---

[87] Delanka-Pedige, H. M., Young, R. B., Abutokaikah, M. T., Chen, L., Wang, H., Imihamillage, K. A., Thimons, S., Jahne, M. A., Williams, A. J., Zhang, Y., and Xu, P. (2024). Non-targeted analysis and toxicity prediction for evaluation of photocatalytic membrane distillation removing organic contaminants from hypersaline oil and gas field-produced water. *Journal of Hazardous Materials*, *471*, 134436. https://doi.org/10.1016/j.jhazmat.2024.134436

[88] Tarazona, Y., Hightower, M., Xu, P., and Zhang, Y. (2024). Treatment of produced water from the Permian Basin: Chemical and toxicological characterization of the effluent from a pilot-scale low-temperature distillation system. *Journal of Water Process Engineering*, *67,* 106146.

[89] Tarazona, Y., Wang, H. B., Hightower, M., Xu, P., and Zhang, Y. (2024). Benchmarking produced water treatment strategies for non-toxic effluents: Integrating thermal distillation with granular activated carbon and zeolite post-treatment. *Journal of Hazardous Materials*, *478,* 135549.

[90] Tarazona, Y., Wang, H. B., Hightower, M., Xu, P., and Zhang, Y. (2024). Benchmarking produced water treatment strategies for non-toxic effluents: Integrating thermal distillation with granular activated carbon and zeolite post-treatment. *Journal of Hazardous Materials*, *478,* 135549.

- **Energy use associated with water treatment.** Desalination is an energy-intensive process.[91] The energy source to support desalination projects should be considered within the context of the state's decarbonization goals.

2.7 REGULATORY/PERMITTING ISSUES

The Produced Water Act (PWA) provides jurisdictional and legal clarity over produced water in New Mexico. It states that ownership and liability for produced water are limited to the entity in possession of the water, and it gives regulatory authority over the reuse of produced water within oilfields to the New Mexico OCD.[92] Section 11.P of the PWA clarifies that the Environment Department has regulatory authority over uses of produced water outside of oilfields and tasks the Water Quality Control Commission (WQCC) with adopting regulations on the reuse of produced water outside of the oil and gas industry.[93]

Those regulations ("Ground and Surface Water Protection—Supplemental Requirements for Water Reuse") have not been adopted as of November 2024, but they are currently being developed and considered as part of an ongoing rulemaking process. As of November 2024, the draft regulations would only allow the use of treated produced water outside oilfields for closed-loop demonstration and industrial projects with no discharge that might directly or indirectly affect ground or surface water. For demonstration and industrial projects, the proposed rule establishes a process that requires submitting a produced water notice of intent to NMED's groundwater quality bureau, upon which NMED will determine whether the project meets requirements set forth in the rule.[94] The proposed rule states that no discharge permits for treated produced water will be issued until standards specific to treated produced water are developed and adopted. In addition, the proposed rule prohibits treated produced water discharge to surface waters of the state.

Under the Clean Water Act, 40 CFR 435 subpart E, the discharge of treated produced water is allowed west of the 98th meridian into surface waters for agricultural and wildlife propagation applications if it meets NPDES standards.[95] While New Mexico does not have primacy over implementing and administering NPDES permitting within its borders, NMED would have to certify any NPDES permit for discharge of treated produced water. OCD prohibits surface discharges of produced water within the oilfield. For uses of produced water outside the oilfield, the PWA requires permitting from NMED. NMED's proposed rule states that the department shall deny certification of any federal permit proposing to discharge untreated or treated produced water to a surface water of the state.

---

[91] U.S. Department of Energy. (2019). Desalination. In *Powering the blue economy: Exploring opportunities for marine renewable energy in maritime markets.* https://www.energy.gov/sites/default/files/2019/09/f66/73355-7.pdf

[92] Produced Water Act. (2019). House Bill 546, New Mexico Legislature. https://www.nmlegis.gov/Sessions/19%20Regular/final/HB0546.pdf

[93] Produced Water Act. (2019). House Bill 546, New Mexico Legislature. https://www.nmlegis.gov/Sessions/19%20Regular/final/HB0546.pdf

[94] New Mexico Environment Department. (2024). *Water reuse.* https://www.env.nm.gov/wp-content/uploads/2024/05/Second-Amended-Proposed-Reuse-Regulations-20.6.8-NMAC-2-Ext.pdf

[95] U.S. Code of Federal Regulations. (2024). *40 CFR 435 Subpart E.* https://www.ecfr.gov/current/title-40/chapter-I/subchapter-N/part-435

2.8 PRODUCED WATER CONCLUSIONS

2.8.1 Produced water volumes and characteristics

- More than 2 billion bbl of produced water were generated in New Mexico in 2023 according to OCD data. Of this amount, 99 percent was generated in the Permian Basin.
- In terms of general quality, San Juan produced water is significantly less saline (median below 15,000 mg/L TDS) than Permian produced water (median above 100,000 mg/L TDS). This makes it easier to treat than Permian produced water.
- 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.

2.8.2 Characterization needs and approaches

- Work is ongoing to better characterize produced water characteristics. Several considerations have been raised with respect to thorough characterization of produced water chemistry and toxicity:
    - Some constituents may not be anticipated and therefore may not be analyzed for in targeted lists of constituents.
    - Some additives in hydraulic fracturing fluids are claimed as proprietary, making characterization challenging.
    - Radionuclides and PFAS have been raised as specific data needs in addition to a broad range of organic constituents.
    - One study noted a lack of adequate toxicity data for many produced water constituents.[96]
- Better understanding of the constituents in produced water and their toxicities is needed for implementing appropriate transport safeguards and to be prepared for emergency response and cleanup in case of a spill or leak.
- NTA is evolving and shows promise for screening and as a complement to targeted analysis. Combining it with a targeted list and WET testing can provide useful environmental and human health information about produced water.
    - Such an approach can be used to test treatment effectiveness by obtaining a baseline on raw produced water and doing the same testing on treatment effluents.
    - NTA is not yet routinely used. NTA methods will ultimately need to be efficient and available if they are to be more commonly employed for evaluating treated produced water.

2.8.3 Variability and scaling

- Produced water is known to vary both spatially and temporally in both quantity and quality. Variability needs to be understood to plan treatment (such as inlet equalization)

[96] Hightower, M., Gross, T., and Xu, P. (2021). NM produced water data portal. *NM Produced Water Research Consortium—Year-end Meeting, December 1-2, 2021.* https://nmpwrc.nmsu.edu/files/NMPWRC-Data-Portal-Session-all-combined.pdf

that will consistently produce enough treated water with the desired quality for an end user.

- SWS projects will need to be scaled appropriately to match volumes that individual producers or midstream water management companies can treat to consistently produce the needed volume.
- Produced water in New Mexico is managed mainly through a combination of injection for disposal or secondary oil recovery (about 48 percent in 2023), reuse for new well completions (about 11 percent in 2023), and transport across state lines for disposal via injection well in Texas. The estimated proportion of produced water sent to Texas has increased from 27 percent of the total in 2021 to 41 percent in 2023. These percentages correspond to volumes of about 432 million bbl in 2021 and over 877 million bbl in 2023. An article estimated the daily amount transported to Texas from New Mexico to be 1.8 million bbl in 2023.[97] Given this enormous amount of produced water, thought will need to be given to how many (and what capacity of) projects would ultimately be needed—independent and part of the SWS—to meaningfully reduce the amount of produced water being disposed of via SWD wells.

3 BRACKISH WATER

3.1 DESCRIPTION

"Brackish water" generally refers to water found in the natural environment that has a higher salinity than freshwater and has a TDS concentration of 1,000–10,000 mg/L.[98] Water that has a TDS above 10,000 mg/L is considered to be saline or brine. As part of the SWS, New Mexico is currently considering and evaluating the feasibility of using deep (below 2,500 feet) and non-potable (over 1,000 mg/L TDS) water to diversify the water supply and reduce the demand on New Mexico's freshwater supplies. These resources are largely undeveloped due to the costs of characterizing the deep aquifers, constructing wells, and water treatment.

3.2 NEW MEXICO BRACKISH WATER RESOURCES

New Mexico has deep brackish water aquifers that could be a valuable source of supplemental water for the state. This section's discussion is mainly based on available data from existing water wells; more data are needed to better understand how this resource could contribute to New Mexico's SWS.

The New Mexico Bureau of Geology and Mineral Resources (NMBGMR) reviewed data available for 17 regions to explore brackish water potential.[99] Figure 7 shows where these 17 regions are.[100] The colors indicate the average TDS based on regional approximations: blue indicates lowest TDS levels, followed by purple, orange, and finally red. Each region has unique

[97] Patton, P. (2023, January 21). Texas is giving away revenue and taking New Mexico's waste. *Dallas Morning News*

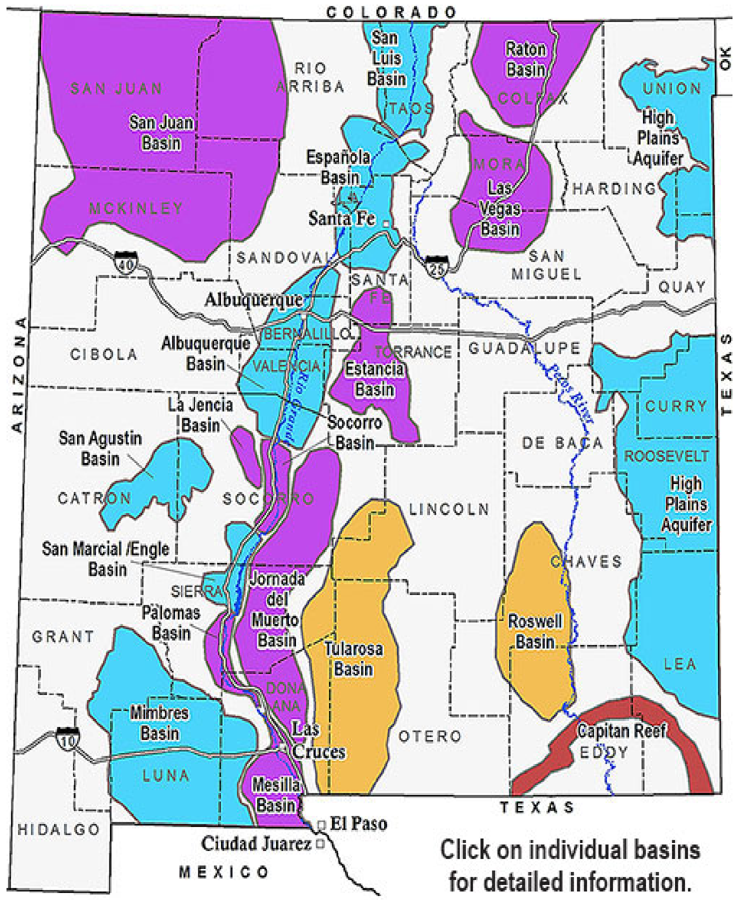
[98] Units for TDS are provided in either ppm or mg/L, which are equivalent measures. These units are used interchangeably in this report.

[99] The 17 brackish water regions identified are: San Luis Basin, Espanola Basin, Albuquerque Basin, La Jencia Basins, Palomas Basin, Mesilla Basin, Jornada del Muerto Basin, Estancia Basin, Miembres Basin, San Agustin Basin, Tularosa Basin, Roswell Basin, Capital Reef, Raton Basin, Las Vegas Basin, High Plains Aquifer, and San Juan Basin.

[100] New Mexico Bureau of Geology and Mineral Resources. (2023). *New Mexico: Regional brackish water assessments.* https://geoinfo.nmt.edu/resources/water/projects/bwa/home.html

characteristics (such as geologic setting, aquifer characteristics, and recharge and discharge areas). Site-specific studies are needed to validate TDS values represented in this Figure 7.

Figure 6. Map of potential brackish water regions in New Mexico.



From: NMBGMR, 2024.[101]

Notes: Assessment of brackish water resources using data from existing water wells. Regions are colored based on average TDS. Blue: TDS below 1,000 mg/L; water is considered potable. Purple: TDS between 1,000 and 3,000 mg/L; water is considered slightly brackish. Orange: TDS between 3,000 and 10,000 mg/L; water is considered brackish. Red: TDS above 10,000 mg/L; water is considered saline or brine. These results are based on regional approximations. Site-specific studies are needed to confirm them.

A 2016 report[102] from NMBGMR provides an overview of data available for each of these 17 regions. Appendix A provides tables showing a summary of water chemistry associated with each region. The data set includes water samples collected from existing wells, which in most cases are domestic, irrigation, or water supply wells. At the time of the study, deep wells (more

[101] New Mexico Bureau of Geology and Mineral Resources. (2024). *New Mexico: Regional brackish water assessments.* https://geoinfo.nmt.edu/resources/water/projects/bwa/home.html

[102] Land, L. (2016). *Overview of fresh and brackish water quality in New Mexico.* New Mexico Bureau of Geology and Mineral Resources. https://geoinfo.nmt.edu/publications/openfile/downloads/500-599/583/OFR-583_NM_BrackishHR.pdf

than 2,500 feet deep) in brackish water areas were very limited, which biased findings. Based on the data available at the time of the study, deep brackish water resources were best characterized in the southeast and northwest regions of New Mexico. A main finding of the report is that more research is needed to better understand the amount and quality (water chemistry) of brackish aquifer reserves that could supplement New Mexico's water supply.

Though more research and data are needed to understand how, at the state level, New Mexico's brackish water resources could support state efforts to diversify the water supply, the data that currently exist can be used to identify regions where developing brackish water resources may yield the greatest opportunity for public or private beneficial use. In these regions, more localized characterization of the brackish water resource is needed to bring a brackish water treatment project to fruition.

3.3 DEEP BRACKISH WATER BASINS IN NEW MEXICO WITH POTENTIAL TECHNICAL FEASIBILITY

Drawing on the data available to the state, we have highlighted three deep brackish water basins that may be suitable as an alternative water supply. (There may private sector data that would further bolster these findings or indicate other regions that may be suitable.) These basins are described below; headings note which cities may be particularly poised to benefit from desalinated brackish water from them. Note that these basins have higher potential connection with shallower freshwater resources, though more research is needed to verify this occurrence.[103] More research is also needed on deep aquifer recharge rates. Finally, note that the water chemistry data summarized in the tables below are as reported in the 2016 NMBGMR report and do not account for depth.

[103] Timmons, S. Personal communication. New Mexico Bureau of Geology and Mineral Resources.

3.3.1 Española Basin (Santa Fe)

The Española Basin is in the Santa Fe region of north central New Mexico. It has a substantial available data set that was evaluated for the 2016 NMBGMR report. The report finds that warm, mineralized groundwater from the deep regions of the aquifer may contain high TDS levels (as reflected in the maximum TDS value of 30,000 mg/L) as well as elevated levels of arsenic and other undesirable constituents. NMBGMR notes that the data suggest the presence of deep brackish water reserves of an unknown volume in this basin.

Table 4. Española Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	23,000	30,000	430	3,500	1,000	2,180	20,000	1,000	16.2	0.207	2.5	2,499
Minimum	66	92	1	0.025	2.8	35	0.7	0.5	0.042	0.00039	0.0001	5
Mean	556.7	389.5	50.01	15.5	47.2	197.01	93.01	21.05	0.72	0.0068	0.129	585
Median	383	246	39	5.5	22	158	20	8.8	0.44	0.0033	0.004	397

From: Land, 2016.[104]

3.3.2 Mesilla Basin (Santa Teresa)

The Mesilla Basin is in the Lower Rio Grande region, south of Las Cruces in the southern region of New Mexico near New Mexico's border with Texas and Mexico. The 2016 NMBGMR report was able to draw on a large data set for it, though those data were irregularly distributed and lacked records associated with deeper parts of the basin (mean well depth of only 339 feet, maximum well depth of 1,880 feet). NMBGMR finds that there is generally high mineral content and elevated levels of arsenic in the Mesilla Basin.

[104] Land, L. (2016). *Overview of fresh and brackish water quality in New Mexico.* New Mexico Bureau of Geology and Mineral Resources. https://geoinfo.nmt.edu/publications/openfile/downloads/500-599/583/OFR-583_NM_BrackishHR.pdf

Table 5. Mesilla Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	42,800	30,800	962	728	8,590	1,400	4,970	15,300	7.9	0.116	0.107	1,880
Minimum	393	234	0.5	0.1	34	38	20.4	11	0.1	0.00048	0.00005	12
Mean	1,714.4	1,216.5	102.4	23.5	277.4	250.8	309.4	291.3	0.8	0.0101	0.0093	339
Median	1,050	693	68	14.9	130	201.5	160	100	0.6	0.0032	0.0017	270.5

From: Land, 2016.[105]

A forthcoming 2024 U.S. Bureau of Reclamation (USBR) report[106] used data from 239 wells to assess the brackish water resource in the Mesilla Basin. These wells ranged in water depth from 0 to 1,750 feet. The Bureau found that the TDS concentrations are less than 1,000 mg/L in the northern part of the basin; they exceed 1,000 mg/L in the southern part, at points reaching 3,000–35,000 mg/L, particularly at increasing depth. The report cites an estimate from Hawley, 2016[107] that there may be at least 60 million acre-feet (19.6 trillion gallons) of brackish water in the Mesilla Basin.

3.3.3 Albuquerque Basin (Albuquerque)

The 2016 NMBGMR report includes an exceptionally large data set for the Albuquerque Basin (relative to the other brackish water basins in New Mexico). These data indicate that water quality in the basin is generally good (less than 1,000 mg/L TDS), though the deeper portions of the basin remain unexplored and therefore the water quality at greater depths remains unknown. The 2016 report does indicate that there are high levels of arsenic as well as potentially high mineral content.

[105] Land, L. (2016). *Overview of fresh and brackish water quality in New Mexico.* New Mexico Bureau of Geology and Mineral Resources. https://geoinfo.nmt.edu/publications/openfile/downloads/500-599/583/OFR-583_NM_BrackishHR.pdf

[106] U.S. Bureau of Reclamation. (2024). *Assessment and implementation framework for transboundary brackish groundwater desalination in south-central New Mexico.* https://www.usbr.gov/research/dwpr/DWPR_Reports.html

[107] Hawley, J. W. (2016). *Challenges and opportunities for brackish groundwater resource development in New Mexico—Prediction hydro-science from an octogenarian hydrogeologist's perspective.* https://aquadoc.typepad.com/files/uli-nm_whitepaper.pdf

Table 6. Albuquerque Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	29,400	27,000	685	305	2,200	120	13,100	6,800	6.4	0.610	0.077	2,020
Minimum	240	163	0.3	0.1	4.5	50	8.2	0.1	0.1	0.000	0.000	7.5
Mean	1,204.4	880.9	88.8	21	95.7	224.9	280.8	97.5	0.8	0.010	0.006	416.6
Median	645	427.5	59.7	11	42	183.5	89.8	21.3	0.5	0.005	0.004	260

From: Land, 2016.[108]

A 2008 aquifer test report prepared by the geoscience and engineering consulting firm INTERA for Sandoval County, a county just north of Albuquerque, estimated that there could be between 576,000 and 2,657,280 acre-feet (188 and 866 million gallons) in the groundwater below Sandoval County in the Rio Puerco aquifer.[109] The Rio Puerco aquifer is a confined aquifer at a depth of 3,500 feet that overlaps geographically in some places with the Albuquerque Basin. The findings of the aquifer test report served as the basis for a 2011 preliminary engineering report prepared for Sandoval County.[110]

Rio Rancho is the most populous city in Sandoval County. NMBGMR provided information on two deep wells in this region, northwest of Albuquerque: POD 1 (drilled to a depth of 6,460 feet below ground level) and POD 2 (drilled to a depth of 3,840 feet below ground level). POD 1 had a TDS of 12,400 mg/L (for a sample collected in 2011 under uncertain purge conditions); POD 2 had a TDS of 12,000 mg/L (for a sample collected in 2008 midway through a 30-day flow test, after the pre-sample purge was completed).

[108] Land, L. (2016). *Overview of fresh and brackish water quality in New Mexico.* New Mexico Bureau of Geology and Mineral Resources. https://geoinfo.nmt.edu/publications/openfile/downloads/500-599/583/OFR-583_NM_BrackishHR.pdf

[109] INTERA Incorporated. (2008). *Draft Sandoval County Rio Puerco Basin Water Development Project Aquifer Test and Analysis Report.*

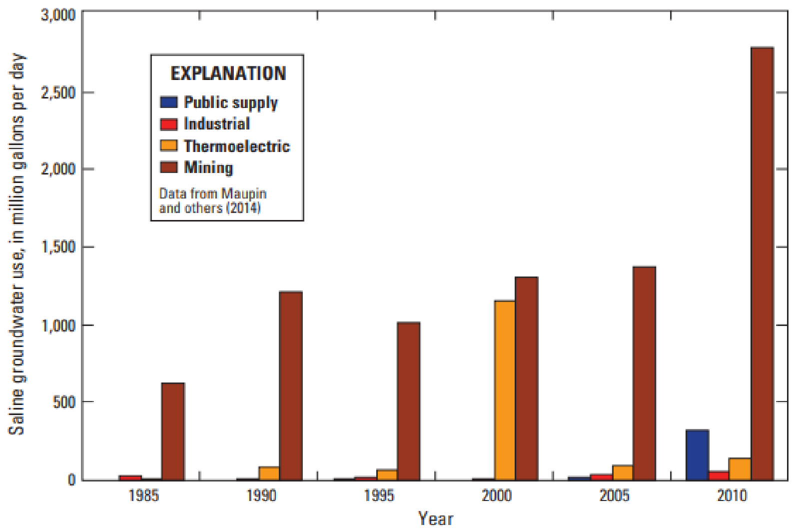
[110] CDM. (2011). *Sandoval County wholesale water supply utility desalination treatment facility preliminary engineering report.* https://www.sandovalcountynm.gov/wp-content/uploads/2017/06/PER_Revised_Submittal20110415.pdf

3.4 BRACKISH WATER RESOURCE DEVELOPMENT IN OTHER STATES OR COUNTRIES

3.4.1 Other states

Within the U.S., brackish water has been used in a variety of industries, as shown in Figure 8. Brackish groundwater use in the U.S. has increased by about 400 percent between 1985 and 2010, with the largest use of this water being for mining (including oil and gas).

Figure 7. Saline groundwater use by water use category, 1985–2010.



From: USGS, 2017.[111]

Municipal desalination water treatment facilities can be found throughout the U.S. A 2018 report from USBR documents characteristics of U.S. municipal desalination plants.[112] Only 3 percent of these facilities treat seawater; the other 97 percent are inland facilities that treat either brackish surface water, groundwater, or wastewater. From 1969 to 2017, 406 municipal desalination facilities with capacities of 25,000 gallons per day and above were built, 86 of them between 2010 and 2017.

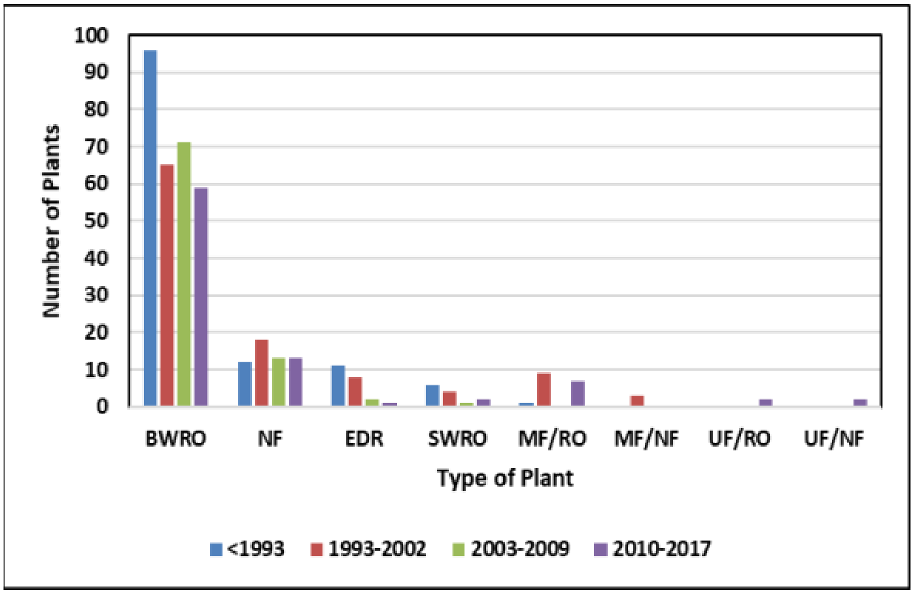
The USBR 2018 report on the 406 municipal brackish water treatment facilities in the U.S. outlines the different treatment processes used at these facilities. Two facilities use reverse osmosis (RO) followed by a thermal (evaporation/distillation) process. All other facilities used membrane-only processes for desalination: brackish water reverse osmosis (BWRO), nanofiltration (NF), electrodialysis reversal (EDR), and seawater reverse osmosis (SWRO). Some of the facilities used advanced pretreatment processes such as microfiltration (MF) and ultrafiltration (UF). Figure 9 shows the number of plants evaluated in the USBR 2018 report, organized by membrane type and period of construction.

---

[111] U.S. Geological Survey. (2017). *Brackish groundwater in the United States.* Professional Paper 1833. https://pubs.usgs.gov/pp/1833/pp1833.pdf

[112] U.S. Bureau of Reclamation. (2018). *Updated and extended survey of U.S. municipal desalination plants.* Desalination and Water Purification Research and Development Program Report No. 207. Reclamation: Managing Water in the West. https://www.usbr.gov/research/dwpr/reportpdfs/report207.pdf

Figure 8. Number of U.S. municipal desalination plants by membrane type and time built.



From: USBR, 2018.[113]

Florida, California, and Texas have the most municipal desalination plants in the U.S, as shown in Table 7. from the 2016 NMBGMR report. Based on data from 2010–2017, the average municipal desalination plant size was 7.1 million gallons per day (MGD) in California, 5.57 MGD in Florida, and 1.4 MGD in Texas.

[113] U.S. Bureau of Reclamation. (2018). *Updated and extended survey of U.S. municipal desalination plants.* Desalination and Water Purification Research and Development Program Report No. 207. Reclamation: Managing Water in the West. https://www.usbr.gov/research/dwpr/reportpdfs/report207.pdf

Table 7. Number of U.S. municipal desalination plants by state

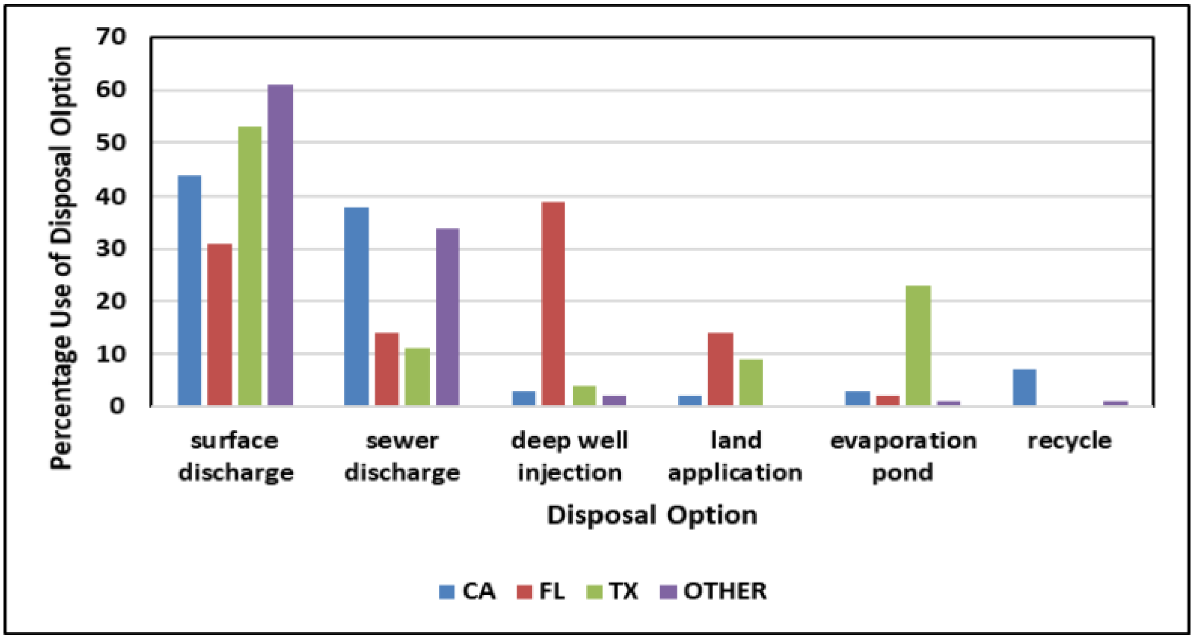
State	Number of Plants
Florida	**167**
California	**58**
Texas	**52**
North Carolina	18
Iowa	16
Illinois	12
Arizona	10
Colorado	10
Ohio	8
North Dakota	7
South Carolina	6
Virginia	6
Kansas	6
Utah	3
Massachusetts	3
Montana	3
New Jersey	3
Alaska	2
Minnesota	2
Missouri	2
Nebraska	2
Nevada	2
New York	2
Oklahoma	2
Pennsylvania	2
Alabama	1
Georgia	1
Michigan	1
Mississippi	1
South Dakota	1
Tennessee	1
Washington	1
Wisconsin	1
West Virginia	1
Wyoming	1

From: USBR, 2018.[114]

The USBR 2018 report also collected data on the concentrate management strategy used by each of the 406 municipal desalination facilities in its data set. Figure 10 shows the percentage of these facilities that use different concentrate management strategies.

[114] U.S. Bureau of Reclamation. (2018). *Updated and extended survey of U.S. municipal desalination plants.* Desalination and Water Purification Research and Development Program Report No. 207. Reclamation: Managing Water in the West. https://www.usbr.gov/research/dwpr/reportpdfs/report207.pdf

Figure 9. U.S. municipal desalination concentrate disposal option use by location.



From: USBR, 2018.[115]

The Kay Bailey Hutchison Water Treatment Plant in Texas is the world's largest inland desalination plant, with a capacity to treat up to 27.5 MGD of brackish groundwater.[116] About 83 percent of the water is recovered for use, while the rest is produced as a concentrate. The concentrate is disposed of through deep-well disposal.[117]

3.4.2 International

Internationally, brackish water management varies. In the Middle East and North Africa, it is the highest priority, with many countries researching ways to use and/or clean brackish water. In Egypt, farmers in the northern Nile Delta have transitioned agricultural lands to fish farms because of the availability of brackish water. In southern Tunisia, RO is being used to desalinate brackish water for use as drinking water. The Tunisian government subsidizes investments into desalination and plans to increase desalination capacity to 50 million cubic meters per day by 2030. In the United Arab Emirates (UAE), membrane desalination is used to convert brackish

---

[115] U.S. Bureau of Reclamation. (2018). *Updated and extended survey of U.S. municipal desalination plants.* Desalination and Water Purification Research and Development Program Report No. 207. Reclamation: Managing Water in the West. https://www.usbr.gov/research/dwpr/reportpdfs/report207.pdf

[116] U.S. Bureau of Reclamation. (2014). *Estimating the cost of brackish groundwater desalination in Texas.* Final Report Submitted to the Texas Water Development Board. Reclamation: Managing Water in the West. https://usbr.gov/gp/otao/estimating_cost_brackish_groundwater_desalination_texas.pdf

[117] Texas Water Development Board. (2012). *Cost of brackish groundwater desalination in Texas.* https://www.twdb.texas.gov/innovativewater/desal/doc/Cost_of_Desalination_in_Texas.pdf

water into water suitable for irrigation. In Yemen, brackish water is used to irrigate tolerant crops near the coastline, while brackish water is used for rock cutting in the highlands.[118]

Desalinated brackish water accounts for more than 20 percent of all water used in Gulf Cooperation Council (GCC) countries, which includes Bahrain, Kuwait, Oman, the UAE, Qatar, and Saudi Arabia. In Kuwait, Bahrain, Qatar, and the UAE, over 50 percent of total water used is desalinated brackish water.[119] Based on current desalination capacity and expectations for technological advancement, desalination capacity in GCC countries is expected to increase to 40 million cubic meters per day by 2050.[120]

3.5 ADDITIONAL INFORMATION NEEDS TO SUPPORT BRACKISH WATER PROJECTS

Though there are data that suggest areas that may be most promising for developing brackish water resources (e.g., Santa Fe, Santa Teresa, Albuquerque), full characterization of these resources at the local level is needed to site wells and understand the treatment processes needed to treat the brackish water to the end user's desired quality. This type of localized characterization may be pursued by the public sector or by private industry, depending on the purposes of the projects involved.

Full characterization will require collecting more data. This could be done through various methods. The costliest of these is drilling new deep exploratory wells—though that cost could be avoided through partnering with oil and gas companies to collect information from oil and gas exploratory wells. For example, oil and gas companies could allow more data to be collected from their wells before they are plugged and abandoned. Similarly, the cost of drilling new wells could be avoided by using "orphan" wells. Orphan wells are wells that were used by the oil and gas industry but were not plugged after they stopped producing and do not have a solvent owner of record. There are over 1,700 orphan wells in New Mexico.[121] Oil and gas companies could also share data from the shallow (approximately shallower than 2,500 feet) portions of their wells. Sharing these data with the state would help further characterize groundwater resources without requiring drilling new wells. Repurposing seismic lines from the oil and gas industry could also be a way to gather data for further subsurface resource characterization. Geology mapping and other techniques such as transient electromagnetic (TEM) and magnetotelluric surveys[122] could also be used to characterize these deep brackish water resources.

---

[118] The Joint Water-Agriculture Ministerial Council. (2022). *The status, treatment methods, and use of brackish water in the Arab region.* https://www.aoad.org/Mini%20Fifth%20Meeting/3-5%20the%20use%20of%20brackish%20water/The%20status,%20treatment%20methods,%20and%20use%20of%20brackish%20water%20in%20the%20Arab%20region%20EN.pdf

[119] Dawoud, M., Alaswad, S. O., Ewea, H. A., and Dawoud, R. M. (2020). Towards sustainable desalination industry in Arab region: challenges and opportunities. http://dx.doi.org/10.5004/dwt.2020.25686

[120] Dawoud, M., Alaswad, S. O., Ewea, H. A., and Dawoud, R. M. (2020). Towards sustainable desalination industry in Arab region: challenges and opportunities. http://dx.doi.org/10.5004/dwt.2020.25686

[121] New Mexico Energy, Minerals and Natural Resources Department. (2022). *Orphan well clean-up work begins.* https://www.emnrd.nm.gov/officeofsecretary/wp-content/uploads/sites/2/orphan_wells_cleanup_11_2022.pdf

[122] Gonzalez-Duque, D., Gomez-Velez, J. D., Person, M. A., Kelley, S., Key, K., and Lucero, D. (2024). Groundwater circulation within the mountain block: Combining flow and transport models with magnetotelluric observations to untangle its nested nature. *Water Resources Research, 60*(4), e2023WR035906. https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2023WR035906?af=R

Aquifer testing (e.g., pumping tests) can be done to understand what capacity desalination plant the aquifer can support. Characterization will also provide data to answer the question of how long the resource will be available based on the expected withdrawal rates. For example, short- and long-term pumping tests can be used to collect information on how the aquifer will perform under the expected pumping rates, to explore how much water it can produce and for how long, and to determine if there are any impacts to surrounding water resources such as nearby shallow aquifers and rivers. Performing pumping tests can also serve as an opportunity to test water quality to identify if there is any variation in water quality within the aquifer. Additionally, characterization efforts to understand the volume of water stored in the deep brackish basins of New Mexico may be an important priority for the state as it plans to diversify its water supply. Regardless of whether characterization is pursued by the public sector or by private industry, the state of New Mexico has a vested interest in the data from these characterization efforts.

3.6 POTENTIAL ENVIRONMENTAL IMPACTS

More data may be needed to understand the potential environmental impacts of withdrawing from New Mexico's deep brackish water aquifers and treating this water. OSE determines whether there will be any residual impacts on water resources (impacts to upper aquifers, rivers, etc.) from proposed exploratory wells based on the currently available data. More data would allow for a more thorough evaluation of potential residual impacts. Though more data will lead to more informed decisions, many environmental impacts could occur, including:

- **Land surface subsidence.** This could occur when sediments compact due to the removal of groundwater. When groundwater is removed, the open pore spaces that remain are filled in by the sediment above, causing the land elevation to decrease. This is referred to as subsidence. Land surface subsidence can damage infrastructure (e.g., bridges, buildings, foundations, underground structures) and could cause saltwater intrusion into freshwater aquifers.
- **Saltwater intrusion into freshwater aquifers.** This could occur if the brackish water aquifer is connected to a freshwater aquifer. A thorough understanding of the region's geologic and hydrologic properties (including the geologic structure of the aquifer, the distribution of hydraulic properties of the aquifer, and the presence of fine-grained confining units that could impede salt water from moving into the freshwater aquifer) is needed to determine whether this may occur. Saltwater intrusion into freshwater aquifers could be a major concern if the freshwater is used for drinking water or other purposes that introducing salt water to the resource would affect.
- **Decreased flow in rivers.** Groundwater pumping can decrease flow in rivers if the water source is hydrologically connected to rivers. It is possible for deep brackish water basins to be hydrologically connected to surface water such as rivers, so studies should be done to ensure pumping from these basins will not affect rivers and other surface water sources. Decreasing flows in rivers could affect species such as fish through changes in water level. Additionally, decreasing flows could affect those who rely on the water for drinking, agriculture, or other uses. Based on current New Mexico law (NMSA Chapter 72[123]), OSE can condition groundwater permits by requiring that any groundwater pumping that affects flows in the Rio Grande be "offset" by retiring other water rights. OSE is responsible for conducting hydrologic modeling to determine whether a new well

[123] New Mexico Statutes Chapter 72—Water Law. (2023). https://law.justia.com/codes/new-mexico/chapter-72/

will affect the Rio Grande. More data would allow OSE to perform a more detailed analysis on potential impacts to the Rio Grande and other rivers.

- **Disposal of residual constituents.** Many processes can be used to treat brackish water, but they all eventually require disposal of residual constituents. For brackish water, the main residual constituent is a salt brine, but other constituents found in the source water—such as arsenic, uranium, and fluoride—will also need to be disposed of. The amount of brine and other constituents generated as a byproduct from brackish water treatment depends on the concentration of each in the source water. Disposing of these residual constituents is a nontrivial factor that can be economically costly and have environmental impacts on the disposal area if not disposed of properly. Technological advances, including mineral recovery, can make desalination more cost effective.
- **Energy use associated with desalinization.** Desalination is an energy-intensive process, of which the energy required to run the treatment processes can account for 40 percent of the overall cost of the water for RO plants.[124] Based on a 2012 report assessing the cost of brackish groundwater desalination in Texas,[125] the power cost ranges from 5.9 to 8.35 cents per kilowatt-hour for the six desalination plants the report's authors evaluated. The energy source to support desalination projects could be considered within the context of the state's decarbonization goals to limit any impact to achieving these goals and more broadly to limit contribution to greenhouse gas emissions. When choosing an energy source, it is important to consider the desalination treatment technology that will be used (for example, thermal desalination or membrane desalination) and the geographic region. Given its potential in New Mexico, solar power may be an appropriate, efficient, renewable energy source to power brackish water desalination plants. For thermal desalination plants, heat from concentrated solar power could be used to efficiently power the desalination process. For membrane desalination plants, electricity from solar power could be used.[126]

3.7 REGULATORY/PERMITTING ISSUES

3.7.1 Governmental oversight

Characterization of brackish water aquifers may be undertaken by both the public and private sectors. Private sector projects that are funded with public monies could be required to share information to increase public confidence that adequate information has been collected, especially regarding the longevity of resources. Currently, OSE requires testing by a certified laboratory for all permitted deep non-potable groundwater. This testing includes open-hole logging, mud logging, cement bond logging, and aquifer testing.

3.7.2 Water rights

New Mexico has a complicated system of water rights. In general, deep brackish groundwater is not subject to appropriation in the conventional water rights system, though the potential

---

[124] U.S. Department of Energy. (2019). Desalination. In *Powering the blue economy: Exploring opportunities for marine renewable energy in maritime markets.* https://www.energy.gov/sites/default/files/2019/09/f66/73355-7.pdf

[125] Texas Water Development Board. (2012). *Cost of brackish groundwater desalination in Texas.* https://www.twdb.texas.gov/innovativewater/desal/doc/Cost_of_Desalination_in_Texas.pdf

[126] IRENA. (2012). *Water desalination using renewable energy.* https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2012/IRENA-ETSAP-Tech-Brief-I12-Water-Desalination.pdf

impacts of deep brackish aquifer development on water resources with associated water rights are assessed by OSE.

3.7.3 Appropriating deep non-potable water

New Mexico's regulatory framework (specifically NMSA Chapter 72, Article 12, Section 72-12-25[127]) allows OSE to permit development of water resources that are deeper than 2,500 feet and have a salinity above 1,000 ppm TDS, as this is considered to be deep non-potable water. The 2016 NMBGMR report on brackish water quality in New Mexico, which used water samples from existing wells, had very limited data from deep wells (more than 2,500 feet deep) in brackish water areas. More research is needed to verify that regions currently identified as potentially suitable deep brackish water basins (Española Basin, Mesilla Basin, and Albuquerque Basin) do in fact have significant water resources at the depth that allows for OSE permitting.

3.8 BRACKISH WATER CONCLUSIONS

- **More data and data sharing are necessary.** To understand how deep brackish water resources can supplement New Mexico's fresh water supplies, a robust understanding of the groundwater basins is needed. This understanding could be based on verified data collected by the state or made available to the state by the private sector. To support this effort, characterization testing guidelines could be established that clearly outline what type of testing needs to be done and what data need to be collected for projects that receive public investment. These guidelines could be established by NMED; OSE; NMBGMR; the Energy, Minerals, and Natural Resources Department (EMNRD); and other agencies that have an interest in data that could be gathered through efforts to characterize brackish aquifers. Characterization testing guidelines could include testing for chemical characteristics (such as major-ion concentrations and constituents of concern) and hydrologic characterizations (such as depth, thickness, flow patterns, recharge rates, aquifer material, residence time, and hydraulic properties). Similarly, public investment to develop brackish water resources could require that any aquifer characterization testing data be shared with the state in a format that can be readily added to a database that enables further analysis and research. By requiring data sharing for any projects that receive public investment, the state will deepen its understanding about the full extent of brackish water resources in New Mexico. This information could be used to determine the best use of resources to advance the use of deep brackish water to diversity the state's water supply. The state agency that will receive the data could create an electronic data system to ensure that data are shared in a readily usable format for regulators. This could mean providing a standard Excel template that all data submissions must conform to. Without requiring data sharing, the state will continue to have a limited understanding of its deep brackish water resources. These data can support long-term water resources planning efforts by the state.
- **Bringing a project to fruition is a lengthy, and sometimes winding, process.** Brackish water desalination projects can take many years, even decades, to bring from concept to completion. Steps involved include siting the appropriate location for the source well, drilling the well, performing water quality tests and pumping rate tests, developing and running a pilot project, and constructing the full-scale desalination

[127] New Mexico Statutes Chapter 72—Water Law. (2023). https://law.justia.com/codes/new-mexico/chapter-72/

treatment plant. Due to the significant cost of the last step, generally all projects include pilot testing to identify and resolve any issues with the treatment process. As a project progresses through each step, more information is gathered that can be used to determine whether the project should progress. For example, results from water quality and pumping rate tests, and findings from the pilot treatment phase, will provide information that can be used to reassess the economic feasibility of the project. Though each project will be different and therefore will have a different time frame, the ongoing work in Santa Teresa can be a reference point for potential project timelines. The Santa Teresa project began as a concept in 2017 and has not yet begun the pilot project phase. Identifying an end user for the brackish water early on may help advance the project in a timelier manner because it can help to constrain the potential uses, and therefore the treatment and production requirements, of the project.

- **There are regions that show promising potential, and a water resource development roadmap could support sustainable management.** Deep brackish water basins near Santa Fe, Santa Teresa, and Albuquerque may be suitable for desalination and could serve as important water sources for these regions, which have a growing need for alternative water sources. These deep brackish waters, and others in New Mexico, are largely nonrenewable because they do not recharge at an appreciable rate. Therefore, carefully considering what the long-term plan is for end users of this water, and the potential impact on other water resources once the water is no longer available, may be an important planning step. For example, if economic development and population growth in a region is fueled by the availability of brackish water resources, what will it mean for the region when that water resource is no longer available? Are there other water resources that can support increased demand? This question could be carefully considered now as the state considers alternative water supplies.
- **Factors such as brine disposal and pumping costs could be key cost considerations.** Brackish water treatment requires disposing of the residual constituents in the water, salt brine being the main constituent. Brine disposal can be very costly—a potentially important part of a project's economic feasibility. Similarly, the cost of pumping brackish water from deep aquifers is high and rises as more water is withdrawn and the water level decreases. This increase is due to the additional energy needed to access the water. The power cost could range from 5.9 to 8.35 cents per kilowatt-hour, based on a 2012 report assessing the cost of brackish groundwater desalination in Texas.[128] As characterization of deep brackish aquifers is completed throughout New Mexico, it will be important to consider whether all of the water in the aquifer can be cost-effectively used, or if it becomes economically infeasible at a certain depth.
- **There may be environmental impacts to consider.** Using deep brackish water as an alternative water source may lead to negative environmental impacts such as land surface subsidence, saltwater intrusion into freshwater aquifers, and decreased flow in rivers. Also, given the state's decarbonization goals, it may be important to consider the energy sources for water desalination treatment plants to understand the impact on achieving these goals.

---

[128] Texas Water Development Board. (2012). *Cost of brackish groundwater desalination in Texas.* https://www.twdb.texas.gov/innovativewater/desal/doc/Cost_of_Desalination_in_Texas.pdf

4 POTENTIAL END USES

4.1 INTRODUCTION

The intention of the SWS is to support industrial projects within New Mexico that align with the state's development goals. One of these goals is supporting clean energy and advanced manufacturing industries that facilitate the clean energy transition and make better use of waste streams for manufacturing to develop a more circular economy. The SWS could provide the water necessary for these industries, many of which require large volumes of water, to operate in New Mexico. Equally important are the state's goals of facilitating local economic development, diversifying the state's economy, and alleviating pressure on the state's freshwater resources. The potential end uses for SWS water discussed below fit under some or all of these development goals.

The potential end uses are categorized under two scenarios:

- A "no discharge" scenario, in which any discharge of SWS water into the environment would be prohibited.
- A "discharge" scenario, in which SWS water could be discharged provided that it met water quality standards set by the state.

End uses that are feasible in the no discharge scenario would also be feasible in the discharge scenario. However, the end uses described in the "Discharge scenario" section below would likely be feasible only in that scenario, either because discharge is necessary for the end use or because of economic constraints that a no discharge scenario would impose on an end use. Table 8 summarizes the end uses discussed in this section.

Table 8. Summary of SWS potential end uses

End Use	Scenario	Type of Use	Approximate Gallons of Water per Day	Water Quality Needed
Green hydrogen production	No discharge	Consumptive	100,000 to 700,000	Higher than potable
Data centers	Discharge	Recirculated	150,000 to 450,000	Lower than potable
Semiconductor manufacturing	Discharge	Recirculated	2,000,000 to 4,000,000	Ultra-pure water
Solar panel manufacturing	Discharge	Recirculated	1,000,000 to 3,000,000	Ultra-pure water
Electric vehicle manufacturing	Discharge	Recirculated	1,000,000 for assembly, 1,000,000 for battery production	Lower than potable for cooling, potable for production
Pumped storage hydropower	Discharge	Recirculated	300,000 to 8,000,000	Lower than potable
Cement/concrete production	Discharge	Consumptive and Recirculated	100,000 to 200,000	Lower than potable for cooling, potable for production

4.2 NO DISCHARGE SCENARIO

4.2.1 Green hydrogen

A potential end use for SWS projects is green hydrogen, which is hydrogen produced using renewable energy. Producing a kilogram of green hydrogen requires about 2.4 gallons of water directly plus another 2.6 to 5.3 gallons for other processes involved in production, such as water purification and cooling, which makes the total about 5 to 7.7 gallons of water per kilogram of hydrogen.[129]

A facility-scale example of green hydrogen production is Plug Power's plant in Woodbine, Georgia, which produces 15,000 kilograms of hydrogen per day and uses an average of 63,400 gallons of water per day in normal conditions and 74,300 gallons per day when more cooling is needed.[130] In its response to the SWS RFI, Plug Power stated that a typical 45 ton per day hydrogen plant (about 41,000 kilograms per day) uses 540 cubic meters of water per day (roughly 140,000 gallons per day). A second example is the Advanced Clean Energy Storage (ACES) hydrogen hub in Delta, Utah, which is expected to produce 100,000 kilograms of hydrogen per day and use 755 acre-feet of water per year (roughly 675,000 gallons per day). The ACES hub is also expected to need 220 megawatts (MW) of power and about 112 acres of land (237 acres if the access roads and utility corridors are included).[131]

The quality of water needed for green hydrogen electrolyzers is quite high. The water needs to have a low electrical conductivity, as water with higher electrical conductivity is less pure and has concentrations of dissolved particles that hinder hydrogen production. In terms of microsiemens per centimeter, or μS/cm (a measurement of conductivity over one centimeter), the water used should have a conductivity of less than 1 μS/cm for alkaline electrolyzers and less than 0.1 μS/cm for proton exchange electrolyzers.[132] For context, the conductivity of tap water is typically between 50 and 800 μS/cm.[133] Plug Power's RFI response recommended slightly less stringent requirements; for proton exchange electrolyzers, it recommended a conductivity less than 350 μS/cm, TDS under 200 ppm, hardness under 150 ppm, and turbidity under 1.5 nephelometric turbidity units. Additionally, there is ongoing research into using untreated seawater and produced water for green hydrogen production using methods such as photocatalytic hydrogen production.[134] Plug Power also stated that it would initially be willing to pay $0.04 per gallon of water that met its quality needs but would want the price of water to come down to $0.01 per gallon in the long run. This is higher than an estimate (from an RFI

---

[129] Ramirez, K., Weiss, T., Kirk, T., and Gamage, C. (2023). *Hydrogen reality check: Distilling green hydrogen's water consumption.* https://rmi.org/hydrogen-reality-check-distilling-green-hydrogens-water-consumption/

[130] Valdez, T. (2022) *Electrolyzers and water: Saving water, powering the world with green hydrogen.* https://www.plugpower.com/water-electrolysis-powering-the-world-with-green-hydrogen/

[131] National Renewable Energy Laboratory. (2023). *Green hydrogen: A briefing for land managers.* https://www.nrel.gov/docs/fy23osti/83885.pdf

[132] Madsen, H. (2022). *Water treatment for green hydrogen: What you need to know.* https://hydrogentechworld.com/water-treatment-for-green-hydrogen-what-you-need-to-know

[133] Fondriest Environmental Learning Center. (2014). *Conductivity, salinity & total dissolved solids.* https://www.fondriest.com/environmental-measurements/parameters/water-quality/conductivity-salinity-tds/

[134] Ahsan, T., et al. (2024). *Photocatalytic hydrogen production with Ag-G-TiO_2: A green energy solution using diverse feedstocks* [Conference presentation]. SWS State of the Science Symposium.

response by Trevi Systems, a water treatment company) that hydrogen companies would be willing to pay $2,000 per acre-foot, or about $0.006 per gallon.

4.3 DISCHARGE SCENARIO

4.3.1 Data centers

Data centers use a considerable amount of water, largely for cooling purposes. Before its recent expansion, Facebook's data center in Los Lunas used an average of 153,000 gallons of water per day in 2020 and had a maximum one-day demand of 1.5 million gallons.[135] Google reported that its data centers used an average of 450,000 gallons of water per day in 2021.[136] For comparison, the average U.S. household uses roughly 300 gallons of water per day,[137] so the Los Lunas Facebook data center, prior to its expansion, had the same daily water use as about 510 households, and the typical Google data center has the same daily water use as 1,500 households. The water demand of data centers is expected to increase over time as the demand for online services and generative AI grows.[138]

Large data centers also require significant amounts of land and energy in addition to large quantities of water. One estimate is that a typical 100,000 square foot data center uses about 20 MW of power.[139] The expanded Facebook data center in Los Lunas takes up about 3.8 million square feet and uses at least 635 MW of power.[140] While the Facebook data center uses renewable energy, other large data centers using fossil fuels could require significant amounts of water for power generation. In 2021, natural gas plants in the U.S. used an average of 2,803 gallons of water per megawatt-hour (MWh), and coal plants used an average of 19,185 gallons per MWh.[141] Trevi Systems estimated in its response to the SWS RFI that data centers would have a willingness to pay between $2,200 and $2,500 per acre-foot of water (roughly $0.007–$0.008 per gallon). However, having examples of what data centers currently pay for water would provide a clearer picture of their willingness to pay.

In terms of the water quality needed for cooling data centers, the main concerns are avoiding corrosion, microbial growth, scaling, and fouling. IBM recommends using relatively high quality water for the cooling loop that comes into contact with computing components, with a

---

[135] Davis, T. (2021, March 14). Facebook data center water use scrutinized. *Albuquerque Journal.* https://www.abqjournal.com/news/local/facebook-data-center-water-use-scrutinized/article_521c48ac-c971-577c-bed2-3b0c7df4b0cc.html

[136] Hölzle, U. (2022, November 21). Our commitment to climate-conscious data center cooling. *The Keyword.* https://blog.google/outreach-initiatives/sustainability/our-commitment-to-climate-conscious-data-center-cooling/

[137] U.S. Environmental Protection Agency. (2024). *How we use water.* https://www.epa.gov/watersense/how-we-use-water

[138] Gordon, C. (2024, February 25). AI is accelerating the loss of our scarcest natural resource: Water. *Forbes.* https://www.forbes.com/sites/cindygordon/2024/02/25/ai-is-accelerating-the-loss-of-our-scarcest-natural-resource-water/

[139] Zhang, M. (2024). *Data center power: A comprehensive overview of energy.* https://dgtlinfra.com/data-center-power/

[140] Schatz, J. (2021, October 27). Facebook offers rare glimpse of Los Lunes Data Center. *The Paper.* https://abq.news/2021/10/facebook-offers-rare-glimpse-of-los-lunas-data-center/

[141] McArdle, P. (2023, June 14). U.S. electric power sector continues water efficiency gains. *Today in Energy.* U.S. Energy Information Administration. https://www.eia.gov/todayinenergy/detail.php?id=56820

conductivity less than or equal to 10 μS/cm.[142] More generally, the American Society for Civil Engineers notes that data centers can use treated effluent and reclaimed water for cooling, but that doing so can reduce the useful lifetime of the data center's equipment.[143]

4.3.2 Semiconductors

Semiconductor manufacturing is an essential industry for the clean energy transition, and production of semiconductors in the U.S. is projected to triple by 2032.[144] Semiconductor manufacturing is also a very water-intensive industry that could benefit from access to SWS water. Intel's Rio Rancho plant, for example, withdrew 756 million gallons of groundwater (an average of about 2 MGD) in 2020. After the recent expansion of that plant, Intel estimated that it would use 1 to 3 MGD.[145] Intel has a special contract with the Albuquerque Bernalillo County Water Utility Authority for a water rate of $118,097.63 per month for non-potable water,[146] but that is only for a portion of the water that the plant uses.

In 2016, Samsung's 2.3 million square foot semiconductor plant in Austin, Texas, which produces about 92,000 wafers per month,[147] was using about 4 MGD, at a cost of $700,000 per month.[148] That amounts to roughly $0.006 per gallon, but it does not account for the plant's 40 percent water recycling rate at the time or any additional costs of treating the water to an ultra-pure standard, so the actual cost per gallon was likely higher. Trevi Systems' estimate for semiconductor plant willingness to pay was $2,500 per acre-foot (roughly $0.008 per gallon). Across the industry, it is estimated that a typical facility uses between 2 and 4 million gallons of ultra-pure water per day,[149] while another estimate put the potential demand of modern plants as being upwards of 5 MGD.[150]

---

[142] IBM. (2021). *Water cooling system specification and requirements.* https://www.ibm.com/docs/en/power8?topic=cooling-water-system-specification-requirements

[143] Ahmad, R. (2024, March 4). Engineers often need a lot of water to keep data centers cool. *Civil Engineering.* American Society of Civil Engineers. https://www.asce.org/publications-and-news/civil-engineering-source/civil-engineering-magazine/issues/magazine-issue/article/2024/03/engineers-often-need-a-lot-of-water-to-keep-data-centers-cool

[144] Semiconductor Industry Association. (2024). *America projected to triple semiconductor manufacturing capacity by 2032, the largest rate of growth in the world.* https://www.semiconductors.org/america-projected-to-triple-semiconductor-manufacturing-capacity-by-2032-the-largest-rate-of-growth-in-the-world/

[145] Associated Press. (2022, January 8). *Computer chip maker to pay $32M for water pipeline.* https://apnews.com/article/technology-business-albuquerque-utilities-water-utilities-1f969c6143dca658d988e5ff2d9fcf14

[146] Albuquerque Bernalillo County Water Utility Authority. (2024). *Water and sewer rate ordinance.* https://www.abcwua.org/wp-content/uploads/2022/07/Section-1-Water-and-Sewer-Rate-Ordinance-1.pdf

[147] Alam, S., Chu, T., LeBlanc, J., Krishnan, A., and Alsheik, S. (2022). *Harnessing the power of the semiconductor value chain.* https://www.accenture.com/content/dam/accenture/final/industry/communications-and-media/document/Accenture-Semiconductor-Value-Chain-Report.pdf

[148] Price, A. (2016, September 26). Samsung's monthly Austin water bill roughly $700,000 a month. *Austin American-Statesman.* https://www.statesman.com/story/news/2016/09/26/samsungs-monthly-austin-water-bill-roughly-700000-a-month/9913815007/

[149] Baskaran, A. (2017). *Waste not, want not—Water use in the semiconductor industry.* https://www.sustainalytics.com/esg-research/resource/investors-esg-blog/waste-not-want-not-water-use-in-the-semiconductor-industry

[150] VerWey, J. (2021). *No permits, no fabs: The importance of regulatory reform for semiconductor manufacturing.* https://cset.georgetown.edu/publication/no-permits-no-fabs/

Most of the water used by semiconductor plants is ultra-pure water, which has very stringent quality requirements. The standards organization ASTM International has a set of standards for ultra-pure water used by semiconductor and other electronics manufacturers, with the type 1 ultra-pure water used by semiconductor manufacturers needing a resistivity greater than 18 megaohms (in terms of conductivity, equivalent to less than 0.056 μS/cm).[151] Semiconductor plants also use water for other purposes, such as cooling, that can be done with water similar in quality to tap water.[152] Besides having access to lots of water, semiconductor plants need significant amounts of energy. The Taiwan Semiconductor Manufacturing Company (TSMC) plant in Arizona, for example, is anticipated to use about 200 MW of power[153] for a plant capable of producing 20,000 wafers per month.[154] Semiconductor plants also need to co-locate with suppliers of certain inputs (e.g., specialty chemicals and gases).[155]

4.3.3 Solar panel manufacturing

An industry adjacent to semiconductors that could benefit from SWS projects is solar panel manufacturing. Assembling solar panels is water-intensive because solar panels use semiconductors, which also means that most of the water needed is ultra-pure. For example, Canadian Solar reported that in 2022, it used an average of 750 tons of water (about 180,000 gallons) and 171 MWh of electricity to make 1 MW worth of solar panels,[156] which is enough power for about 173 homes.[157] Maxeon's future 160-acre plant in Albuquerque, which will be able to produce 3 gigawatts worth of solar panels a year,[158] is expected to use 2.8 MGD.[159]

Cleaning already-installed solar panels, on the other hand, requires a relatively small amount of water, with estimates ranging from 1 to 5 million gallons of water per year to clean 100 MW worth of solar panels,[160] an average of roughly 3,000 to 14,000 gallons per day. About 10 acres

---

[151] ASTM International. (2018). *Standard guide for ultra-pure water used in the electronics and semiconductor industries.* https://www.astm.org/d5127-13.html

[152] Heilweil, R. (2023, July 19). Want to win a chip war? You're gonna need a lot of water. *Wired.* https://www.wired.com/story/want-to-win-a-chip-war-youre-gonna-need-a-lot-of-water/

[153] Arizona Technology Council. (2021). *Utility company makes progress on infrastructure for Taiwan Semiconductor Project in north Phoenix.* https://www.aztechcouncil.org/utility-company-makes-progress-on-infrastructure-for-taiwan-semiconductor-project-in-north-phoenix/

[154] Ford, B. (2023). U.S. semiconductor building boom underway. *PHCP Pros.* https://www.phcppros.com/articles/17786-us-semiconductor-building-boom-underway

[155] VerWey, J. (2021). *No permits, no fabs: The importance of regulatory reform for semiconductor manufacturing.* https://cset.georgetown.edu/publication/no-permits-no-fabs/

[156] Canadian Solar. (2022). *ESG sustainability report.* https://www.canadiansolar.com/canadian-solar_esg-report//wp-content/uploads/2023/08/Canadian-Solar-2022-ESG-Report-vFinal.pdf

[157] Solar Energy Industries Association. (2024). *What's in a megawatt? Calculating the number of homes powered by solar energy.* https://www.seia.org/initiatives/whats-megawatt

[158] Maxeon. (2023, August 10). *Maxeon Solar Technologies selects Albuquerque, New Mexico as site for new 3-gigawatt solar cell and panel manufacturing facility.* [Press release]. https://mediaroom.maxeon.com/2023-08-10-Maxeon-Solar-Technologies-Selects-Albuquerque,-New-Mexico-as-Site-for-New-3-Gigawatt-Solar-Cell-and-Panel-Manufacturing-Facility

[159] U.S. Department of Energy. (2024). *Environmental assessment—Golden Eagle.* https://www.energy.gov/sites/default/files/2024-01/Project%20Golden%20Eagle%20MDS_EA_01_08_2024.pdf

[160] Panat, S., and Varanasi, K. (2022). Electrostatic dust removal using adsorbed moisture-assisted charge induction for sustainable operation of solar panels. *Science Advances, 8*(10). https://www.science.org/doi/10.1126/sciadv.abm0078

are needed to produce 1 MW of solar power,[161] so 100 MW worth of solar panels is around 1,000 acres. For regular cleaning of installed solar panels, water should have a low mineral content and a hardness less than 75 ppm in order to avoid issues with scaling.[162]

4.3.4 Electric vehicle manufacturing

Electric vehicle manufacturing also requires substantial amounts of water. Tesla's 2,500-acre assembly plant in Austin, Texas, uses an average of 2.78 cubic meters (734 gallons) of water per car assembled plus an additional 0.84 cubic meters (222 gallons) for each car's battery pack, with painting and cooling being the most water-intensive processes. The average amount of water used by the automotive industry as a whole for assembling cars is 3.68 cubic meters (972 gallons) per car.[163] The Tesla plant can produce about 375,000 electric vehicles per year,[164] so at peak production it uses a little under 1 million gallons of water per day, on average. Large battery manufacturing plants for electric vehicles need large quantities of water as well; one estimate is that a representative facility uses 440 million gallons per year (about 1.2 MGD), with a majority of the water being used for cooling.[165] Industrial cooling water can have a somewhat lower quality than water for other applications. Tesla uses industrial wastewater to offset freshwater use in its cooling systems.[166] The main concern with cooling water quality is preventing scaling; cooling water should have a hardness no greater than 350–450 ppm and a pH between 6.8 and 7.5.[167]

4.3.5 Pumped storage hydropower

A pumped storage project uses a system of two reservoirs of water to store excess energy generated by other sources and then create hydropower when needed, which is particularly beneficial for intermittent renewables such as wind and solar. Pumped storage requires large volumes of water, both to establish the reservoirs (if the project does not take advantage of existing bodies of water) and to replenish water lost from evaporation. A Southwest Research Institute analysis considered the water needs of three potential pumped storage sites in western Texas.[168] A 50 MW project site would need to be able to store about 200 million gallons in the upper reservoir, 365 million gallons in the lower reservoir, and would need about 117 million

---

[161] Wyatt, J., and Kristian, M. (2021, September 14). *The true land footprint of solar energy.* Great Plains Institute. https://betterenergy.org/blog/the-true-land-footprint-of-solar-energy/

[162] RenewSys. (2022). *Water rules for cleaning solar panels.* https://www.renewsysworld.com/post/water-rules-for-cleaning-solar-panels

[163] Agatie, C. (2023, April 25). Tesla explains how it achieves record breaking water saving at Giga Berlin. *Autoevolution.* https://www.autoevolution.com/news/tesla-explains-how-it-achieves-record-breaking-water-economy-at-giga-berlin-213982.html

[164] Kane, M. (2023, October 23). Tesla's annual vehicle capacity increased to over 2.3 million. *InsideEVs.* https://insideevs.com/news/692819/tesla-production-sites-model-assignment-october2023/

[165] Chumak, D. (2024, April 11). The opportunity for water reuse at battery gigafactories. *Battery Technology.* https://www.batterytechonline.com/battery-manufacturing/the-opportunity-for-water-reuse-at-battery-gigafactories

[166] Agatie, C. (2023, April 25). Tesla explains how it achieves record breaking water saving at Giga Berlin. *Autoevolution.* https://www.autoevolution.com/news/tesla-explains-how-it-achieves-record-breaking-water-economy-at-giga-berlin-213982.html

[167] Efficient Plant. (2008). *Enhanced cooling tower maintenance saves water.* https://www.efficientplantmag.com/2008/10/enhanced-cooling-tower-maintenance-saves-water/

[168] Southwest Research Institute. (2019). *Optimizing West Texas wind and solar energy generation using closed-loop pumped storage hydropower.* https://www.swri.org/sites/default/files/brochures/closedloop-pumped-storage-hydropower_1.pdf

gallons of make-up water per year (around 320,000 gallons per day). A 100 MW project site would need to be able to store around 1.1 billion gallons in the upper reservoir, 1.5 billion gallons in the lower reservoir, and would need about 587 million gallons of make-up water per year (around 1.6 MGD). A 1,000 MW project site would need to be able to store roughly 8 billion gallons in the upper reservoir, 10.5 billion gallons in the lower reservoir, and would need about 3 billion gallons of make-up water per year (about 8.2 MGD).

Pumped storage may need water of much lower quality than other applications. The Southwest Research Institute analysis discusses a 30 MW project in Japan that successfully used seawater for pumped storage. However, this required the use of specific materials to mitigate corrosion of the water pipe and equipment, and a liner was needed to prevent seawater from seeping into the local groundwater from the upper reservoir.[169] The Southwest Research Institute analysis also considers the use of produced water from the Permian Basin. The analysis notes that produced water with TDS and chloride levels similar to those in seawater could be feasible to use in pumped storage from a technical point of view; however, high evaporation rates could result in a buildup in salinity that would need to be managed using lower-salinity make-up water or disposal of some of the reservoir water into SWD wells. Given the potential to use lower-quality water for pumped storage, the water quality needed for pumped storage projects would likely be determined by environmental discharge standards for SWS water rather than the technical quality needs of pumped storage.

There are several considerations for the siting of a pumped storage project. The reservoirs take up significant amounts of land. For example, the 50 MW project from the Southwest Research Institute analysis—the smallest of the three—would require 60 acres for the upper reservoir and 32 acres for the lower reservoir. There also needs to be a substantial elevation difference between the two reservoirs; each of the Southwest Research Institute analysis's proposed Texas sites had an elevation difference of around 400 feet between the upper and lower reservoirs. Additionally, a pumped storage project needs a large source of wind or solar power to store energy from.

4.3.6 Cement and concrete

Cement and concrete production could also be potential end users for SWS projects. Cement is a key ingredient in concrete, acting as a binding agent for other ingredients and making up about 10 to 15 percent of a concrete mixture. For cement production, the "wet process" involves grinding raw materials with water before putting them into the kiln; there is also a need for equipment cooling during cement and concrete production. Major cement companies such as Heidelberg Cement, Holcim, and Cemex use an average of about 250 liters of water per metric ton of cement they produce, which is about 66 gallons.[170] A typical cement plant produces one million metric tons of cement per year,[171] so its annual water use is about 250 million liters, or roughly 200,000 gallons per day. The Tijeras cement plant near Albuquerque produces roughly 450,000 metric tons of cement per year;[172] based on the 250 liters of water per metric ton estimate, the plant can be estimated to use roughly 80,000 gallons per day. Most of the water

---

[169] Rather than having a traditional lower reservoir, the Philippine Sea was used as the lower body of water for this pumped storage project. As such, a liner was only needed for the upper reservoir.

[170] Cemnet. (2021). *The cement industry must tackle water management head on.* https://www.cemnet.com/News/story/171382/the-cement-industry-must-tackle-water-management-head-on.html

[171] MTR Industrial Separations. (2024). *Cement plants.* https://www.mtrinc.com/cement-plants/

[172] New Mexico Bureau of Geology and Mineral Resources. (2020). *Industrial mineral resources in New Mexico.* https://geoinfo.nmt.edu/resources/minerals/industrial/home.html

used by cement plants is for cooling,[173] which does not require a particularly high quality of water. Cemex, for example, has a plant in Colombia that uses sewer water from an ice cream company as cooling water.[174]

Water is also an important component for mixing concrete, making up about 25 percent of the concrete mixture.[175] Potable water is generally preferred for mixing water, as salt and other impurities can interfere with setting, although some non-potable waters could be suitable.[176,177] ASTM International has specific guidelines for the water quality for ready-mixed concrete.[178] Cement production requires a significant amount of power, typically 20–40 MW.[179] Besides a stable energy supply and water, cement factories prefer locations with access to raw materials (e.g., limestone, shale, clay), proximity to transportation infrastructure such as highways and railroads, and an available workforce.[180] Lastly, it is important to note that additional environmental regulations set by New Mexico could apply to cement and concrete produced using water from the SWS if the water were incorporated directly into the final product.

4.4 POTENTIAL END USE EXAMPLES

The following case studies illustrate the benefits of offsetting freshwater resources through water reuse while summarizing state agency jurisdiction.[181]

Under the Oil and Gas Act, the OCD regulates the disposition, handling, transport, storage, recycling, treatment, and disposal of produced water during (or for reuse in) exploration for, drilling for, production of, treatment of, or refinement of oil or gas, including disposal by injection pursuant to authority delegated under the federal Safe Drinking Water Act, in a manner that protects public health, the environment, and fresh water resources.[182]

The PWA provides that: "[f]or uses regulated by the water quality control commission pursuant to the Water Quality Act, a person shall obtain a permit from the department of environment

---

[173] U.S. Environmental Protection Agency. (2023). *Cement manufacturing effluent guidelines.* https://www.epa.gov/eg/cement-manufacturing-effluent-guidelines

[174] CEMEX. (2022). *Water security 2022.* https://www.cemex.com/documents/d/cemex/2022-cdp-water-security

[175] Cemnet. (2021). *The cement industry must tackle water management head on.* https://www.cemnet.com/News/story/171382/the-cement-industry-must-tackle-water-management-head-on.html

[176] American Concrete Institute. (2024). *Technical questions.* https://www.concrete.org/tools/frequentlyaskedquestions.aspx?faqid=703

[177] Sestakova, J. (2022). *Water quality for concrete mixes: Does it matter.* https://www.water-direct.co.uk/water-quality-for-concrete-mixes/

[178] ASTM International. (2024). *Standard specifications for ready-mix concrete.* https://www.astm.org/c0094_c0094m-23.html

[179] Convergent Energy and Power. (2023). *A solid idea: Battery energy storage systems for cement production facilities.* https://resources.convergentep.com/a-solid-idea-battery-energy-storage-systems-for-cement-production-facilities

[180] Agico Cement. (2023). *Guide to cement plants site selection.* https://www.cement-plants.com/guide-to-cement-plants-site-selection/

[181] Section 4.4 of this document was prepared by Jennifer Bradfute, Bradfute Sayer Consulting and Legal Services.

[182] New Mexico Statutes § 70-2-12 (2023). https://law.justia.com/codes/new-mexico/chapter-70/article-2/section-70-2-12/

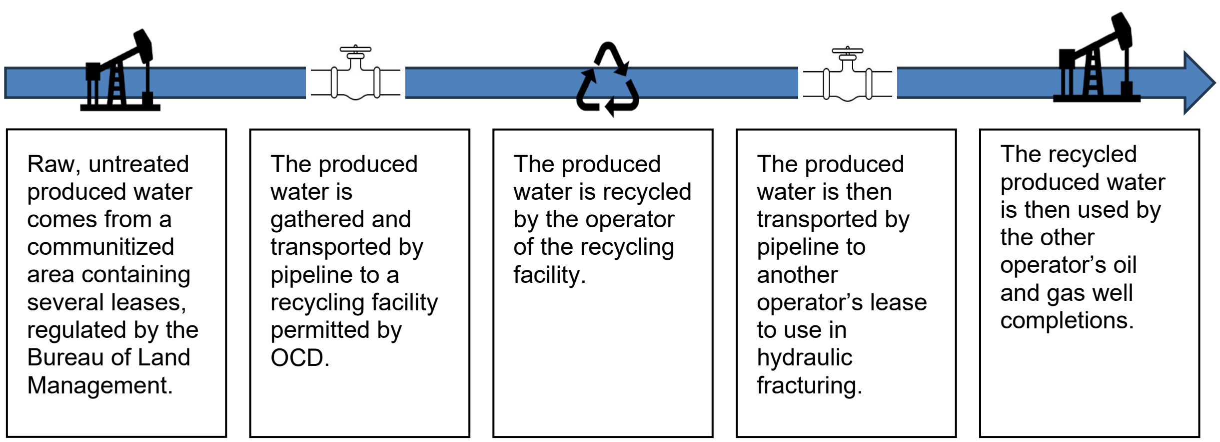
before using the produced water, the recycled or treated water or treated product or any byproduct of the produced water."[183]

HB 546 then amended the Water Quality Act (WQA) to state that WQCC "shall adopt regulations to be administered by the department of environment for the discharge, handling, transport, storage, recycling or treatment for the disposition of treated produced water, including disposition in road construction maintenance, roadway ice or dust control or other construction, or in the application of treated produced water to land, for activities unrelated to the exploration, drilling, production, treatment or refinement of oil or gas; and may adopt regulations to be administered by the department of environment for surface water discharges."[184]

The PWA does not regulate or distinguish "on-lease" vs. "off-lease" uses of produced water as a demarcation of jurisdiction. Instead, the statutes (the PWA, the Oil and Gas Act, and the WQA) direct readers to look at whether produced water is being used for activities related to exploration for, drilling for, production of, treatment of, or refinement of oil or gas—or, instead, if the disposition of the treated produced water is for some other purpose, including road construction maintenance, dust control, other construction, or application to land.

4.4.1 Example 1: Use in oil and gas well completion operations

Estimated freshwater savings: 812,000 to 31,000,000 gallons per year



In example 1, none of these activities are regulated by NMED pursuant to the PWA or the WQA. OCD has jurisdiction over each one because the recycled produced water is being used for activities related to the drilling and production of oil and gas.

In 2023, OCD approved a total of 2,999 applications for permit to drill (APDs).[185] The drilling and well completion process involves the use of cement to secure pipelines and casing, presenting an opportunity for the industry to mitigate freshwater consumption by substituting it with treated produced water.

---

[183] New Mexico Statutes § 70-13-4 (2023). https://law.justia.com/codes/new-mexico/chapter-70/article-13/section-70-13-4/

[184] Produced Water Act. (2019). House Bill 546, New Mexico Legislature. https://www.nmlegis.gov/Sessions/19%20Regular/final/HB0546.pdf

[185] New Mexico Oil Conservation Division. (2024). *OCD statistics.* https://www.emnrd.nm.gov/ocd/ocd-data/statistics/

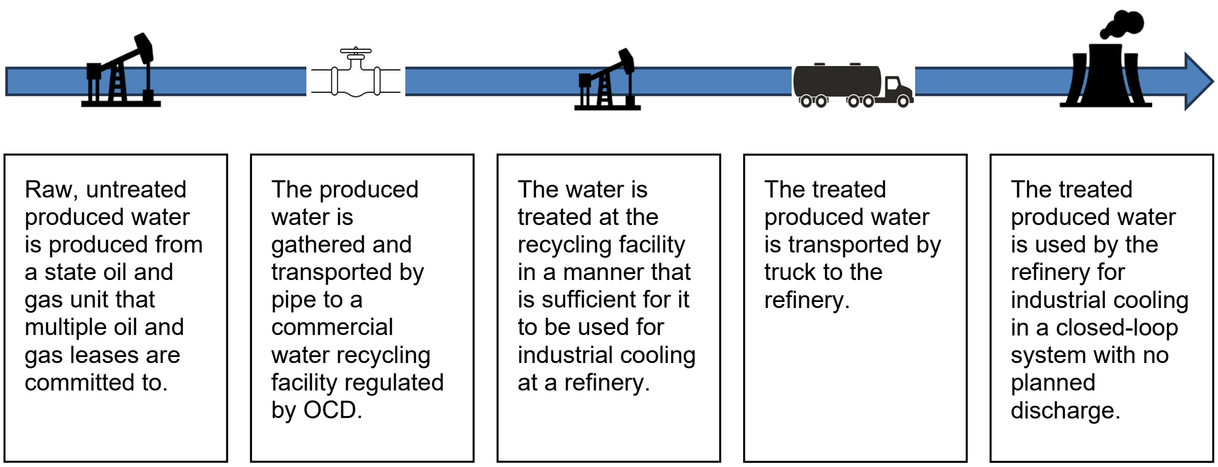
Cement used in drilling (specifically Class C cement, which is intended for surface-to-6,000-foot applications when early strength is essential and is available in all three sulphate resistance levels) consumes about 4.77 gallons of water per cubic foot. The amount of cement required per project varies significantly depending on well depth and dimensions, ranging from 57 to 2,208 cubic feet for typical wells with depths averaging 5,426 feet.[186] Consequently, the volume of water needed per project ranges from 271 to 10,534 gallons.

Given the issuance of 2,999 APDs in New Mexico in 2023, the total water usage for cementing operations across the state is estimated to fall between 812,429 and 31,590,266 gallons per year. This range underscores the potential impact of substituting freshwater with treated produced water in reducing overall water consumption in the drilling process.

According to industry professionals, typical deep wells can exceed 1,000 bbl (42,000 gallons) per project for cementing, which means freshwater savings would surpass 125,000,000 gallons if these projects used treated produced/brackish water.

4.4.2 Example 2: Use in refinery operations

Estimated freshwater savings: 60,200,000 million gallons per year



None of these activities are regulated by NMED pursuant to the PWA or the WQA. OCD has jurisdiction to regulate these activities under the Oil and Gas Act.

The U.S. Department of Energy's Refinery Water Study states that "a typical refinery will use about 1.5 barrels of water to process 1 barrel of crude oil. However, water use can vary significantly, depending on the design of the facility."[187] Given that New Mexico produces about 110,000 bbl of crude oil per day, freshwater savings would reach 60.2 million gallons per year if processes used treated produced water.

---

[186] U.S. Energy Information Administration. (2024). Average depth of crude oil and natural gas wells. https://www.eia.gov/dnav/pet/pet_crd_welldep_s1_a.htm

[187] U.S. Department of Energy. (2016). *Potential vulnerability of US petroleum refineries to increasing water temperature and/or reduced water availability.* https://www.energy.gov/sites/prod/files/2016/03/f30/US%20DOE%20Refinery%20Water%20Study.pdf

4.4.3 Example 3: Use for industrial cooling for data centers

Estimated freshwater savings: 218,718,000 gallons per year

Raw, untreated Produced Water is produced from a well on a large federal oil and gas unit.	The produced water is gathered and transported by pipe to a non-commercial water recycling facility regulated by OCD.	The produced water is then treated at a facility located on the oil and gas unit that treats water from several wells subject to the unit agreement.	The treated produced water is transported off the unit (i.e., "off-lease") to a data center to use for industrial cooling.	The data center uses the treated produced water for industrial cooling in a closed-loop system with no intended discharge.

In example 3, the production and treatment of the produced water is subject to OCD's jurisdiction and authority. However, the WQA requires WQCC to issue regulations on the transportation of the treated produced water to the data center for industrial use, as well as on that use itself.

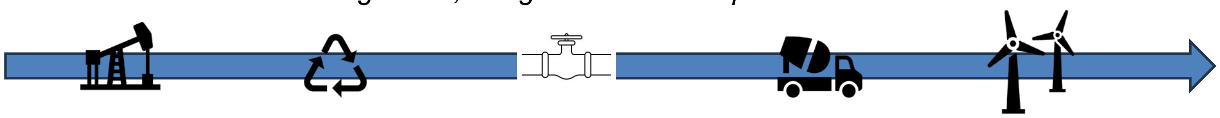
The PWA provides that "[f]or uses regulated by the water quality control commission pursuant to the Water Quality Act, a person shall obtain a permit from the department of environment before using the produced water, the recycled or treated water or treated product or any byproduct of the produced water."

As a result, NMED could issue a permit before the treated produced water is used in industrial cooling. To create certainty for this type of project, NMED could create a streamlined permit (not the groundwater permit that exists today) that requires financial assurance and provides that the use of the water is authorized because there is no allowance for discharge, planned or unplanned.

Per Section 4.3.1, the Facebook data center in Los Lunas used 153,000 gallons of water per day in 2020 and Google reported that its data centers used an average of 450,000 gallons of water per day in 2021. Annually, this equates to 54,468,000 gallons of water and 164,250,000 gallons of water. If Meta continues to operate in New Mexico and Google opens a data center here as well, the combined operation could use 218,718,000 gallons of fresh water annually.

4.4.4 Example 4: Use to create cement for wind turbine installations

Estimated freshwater savings: 105,000 gallons of water per wind turbine installed



Raw, untreated Produced Water is produced from a well on a large federal/state oil and gas unit.	The produced water is then treated at a facility located on the oil and gas unit that is regulated by the OCD.	Some of the treated produced water is transported "off-lease" to a cement mixing business to make cement.	The treated produced water is used to make the cement. There is no intended or planned discharge of the treated produced water.	The cement is then used in to install wind turbines.

In example 4, the production and treatment of the produced water is subject to OCD's jurisdiction and authority. NMED has jurisdiction over the treated produced water after it leaves the unit because it will then be used for activities unrelated to exploration for, drilling for, production of, treatment of, or refinement of oil or gas. To create certainty for this type of project, NMED could create a streamlined permit (not the groundwater permit that exists today) that requires financial assurance and provides that the use of the water is authorized because there is no allowance for discharge, planned or unplanned. However, NMED does not currently issue groundwater permits to cement plants.

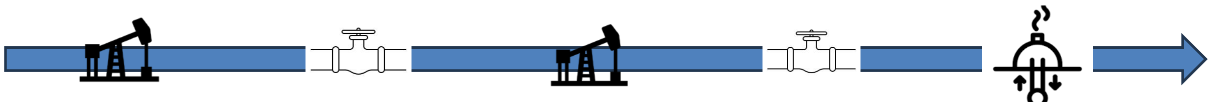
Foundations for a 2 MW wind turbine range from 15 to 20 feet deep and can use up to 30,000 tons of cement. New Mexico in 2023 generated nearly 40 percent of electricity using wind energy, which has a current capacity of 4,400 MW.[188] Continued buildout of wind turbines would require large amounts of water to be used in the cement foundations.

Assuming the average base for a wind turbine is about 10,000 cubic feet, 105,000 gallons of water would be needed per wind turbine. Substituting freshwater in the cement for treated produced water would save 231,000,000 gallons of water if New Mexico doubled its current wind energy capacity and installed 2,200 more turbines.

[188] U.S. Energy Information Administration. (2024). *New Mexico profile analysis.* https://www.eia.gov/state/analysis.php?sid=NM

4.4.5 Example 5: Use in geothermal operations

Estimated freshwater savings: 28,000,000 to 147,000,000 gallons per year



Raw, untreated produced water is produced from an oil and gas lease.	The produced water is gathered and transported by pipeline to a recycling facility permitted by OCD.	The produced water is then treated at a facility on the oil and gas lease that is regulated by OCD.	The treated produced water is transported off-lease to a company to use in geothermal operations.	The treated produced water is put downhole in geothermal wells with adequate casing to protect freshwater zones.

In example 5, the production and treatment of the water is subject to OCD's jurisdiction and authority. NMED will have jurisdiction over the treated produced water after it leaves the unit because it will then be used for activities unrelated to exploration for, drilling for, production of, treatment of, or refinement of oil or gas. EMNRD will have jurisdiction over the geothermal operation. To create certainty for this type of project, NMED could create a streamlined permit (not the groundwater permit that exists today) that requires financial assurance and provides that the use of the water is authorized because there is no allowance for discharge, planned or unplanned.

The consumption of water for geothermal processes is highly variable depending on the configuration of the technology, the cooling systems, and the geothermal reservoir temperature. Currently, New Mexico does not have a geothermal power plant in operation. One facility was acquired in May 2024, but is not operating at this time. The National Renewable Energy Laboratory (NREL) has a table from a 2021 publication listing different configurations and water consumption, which varies from 800 to 4,200 gallons of water consumed per MWh of power generated.[189] NREL states that an average geothermal system generates 4 MWh—that is, 35,040 MW per year.[190] So, depending on the location and configuration, a geothermal operation could use between 28 million gallons and 147 million gallons of water per year.

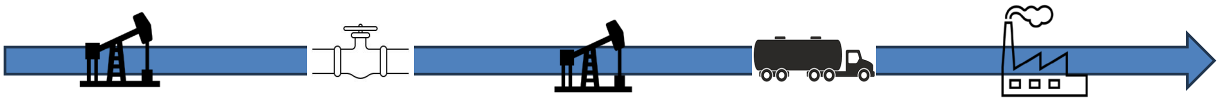
---

[189] National Renewable Energy Laboratory. (2021). *2021 U.S. geothermal power production and district heating market report.* https://www.nrel.gov/docs/fy21osti/78291.pdf

[190] National Renewable Energy Laboratory. (2021). *2021 U.S. geothermal power production and district heating market report.* https://www.nrel.gov/docs/fy21osti/78291.pdf

4.4.6 Example 6: Use in industrial cooling for advanced manufacturing facilities

Estimated freshwater savings: 3,650,000,000 gallons per year



Raw, untreated produced water comes from a well developing several leases committed to a joint operating agreement.	That water is then gathered and transported by a midstream company to a commercial water recycling and treatment facility licensed by OCD.	The water is treated by the midstream company at the recycling and treatment facility to a condition appropriate for use in industrial cooling.	The treated produced water is transported by truck to an industrial site.	The industrial site uses the water for industrial cooling. The water is not discharged or intended to be discharged in this use.

In example 6, the production and treatment of the water is subject to OCD's jurisdiction and authority. However, the WQA requires WQCC to issue regulations on the transportation of the treated produced water to the data center for industrial use, as well as on that use itself.

The PWA provides that "[f]or uses regulated by the water quality control commission pursuant to the Water Quality Act, a person shall obtain a permit from the department of environment before using the produced water, the recycled or treated water or treated product or any byproduct of the produced water."

To create certainty for this type of project, NMED could create a streamlined permit (not the groundwater permit that exists today) that requires financial assurance and provides that the use of the water is authorized because there is no allowance for discharge, planned or unplanned.

Per Sections 4.3.2, 4.3.3, and 4.3.4, the semiconductor industry, solar panel manufacturing, and electric vehicle manufacturing use between 1 and 5 MGD per facility. Assuming one facility from each industry expands into New Mexico, this could consume 10 MGD of fresh water or 3.7 billion gallons per year.

4.5 POTENTIAL END USE CONCLUSIONS

There are several key considerations related to potential end uses for SWS projects:

- The amount of water needed for different potential end uses varies significantly; some projects might need 100,000 gallons per day, while others might need millions of gallons per day.
- The quality of water needed for different potential end uses also varies significantly. Cooling water can have a lower quality than potable water, for example, but other applications need ultra-pure water.
- End users have additional needs besides water, such as land and power, that must be considered when planning a project.
- Under a "no discharge" scenario, the types of end users may be more limited: some end uses require the discharge of water into the environment, while others might not be economically feasible under a no discharge scenario.

- End uses where water is incorporated into the final product, such as cement and concrete production, could be subject to additional regulation by New Mexico.
- Until standards for discharge of treated produced water are developed and adopted in New Mexico, potential end uses are limited. Such limitations are primarily due to a lack of state rules—not technological limitations.

5 PRODUCED WATER AND BRACKISH WATER TREATMENT

While produced water treatment is typically more intense and requires more treatment processes compared to brackish water treatment, both produced and brackish water treatment share similar requirements and processes, such as using desalination to remove dissolved solids. The following sections explore the specific technologies and techniques for produced and brackish water treatment, as well as their applicability, advantages, disadvantages, and other technical considerations.

5.1 PRODUCED WATER TREATMENT

Although typical produced water management consists of injection via SWD wells, produced water treatment and reuse has become an increasingly researched topic due to water scarcity and challenges with current produced water management strategies, such as induced seismicity from injection. While produced water treatment and reuse is still being researched and characterized, several industrial facilities have been treating produced water for various uses and have demonstrated successful full-scale produced water treatment trains and projects.[191] These treatment trains and projects consist of varying treatment technologies, which are selected based off several different parameters, such as untreated produced water quality, desired effluent (i.e., treated) water quality, available land area, regulatory considerations, and brine and residuals management criteria.

Produced water treatment technologies can generally be divided into five main categories: preliminary, primary, secondary, tertiary and desalination, and post-treatment or polishing (Figure 11):[192,193,194,195] The following list provides more detail on these technologies:

---

[191] Cooper, C. M., McCall, J., Stokes, S. C., McKay, C., Bentley, M. J., Rosenblum, J. S., Blewett, T. A., Huang, Z., Miara, A., Talmadge, M., Evans, A., Sitterley, K. A., Kurup, P., Stokes-Draut, J. R., Macknick, J., Borch, T., Cath, T. Y., and Katz, L. E. (2021). Oil and gas produced water reuse: Opportunities, treatment needs, and challenges. *ACS ES&T Engineering, 2*(3). https://doi.org/10.1021/acsestengg.1c00248

[192] Amakiri, K. T., Canon, A. R., Molinari, M., and Angelis-Dimakis. A. (2022) Review of oilfield produced water treatment technologies. *Chemosphere, 298,* 134064. https://doi.org/10.1016/j.chemosphere.2022.134064

[193] Abass, A. O. (2020). Recent advances on the treatment technology of oil and gas produced water for sustainable energy industry-mechanistic aspects and process chemistry perspectives. *Chemical Engineering Journal Advances, 4,* 100049. https://doi.org/10.1016/j.ceja.2020.100049

[194] Gamwo, I., Hossain, A., and Hseen, B. (2022). *Produced water treatment technologies: An overview.* https://www.osti.gov/servlets/purl/1873997

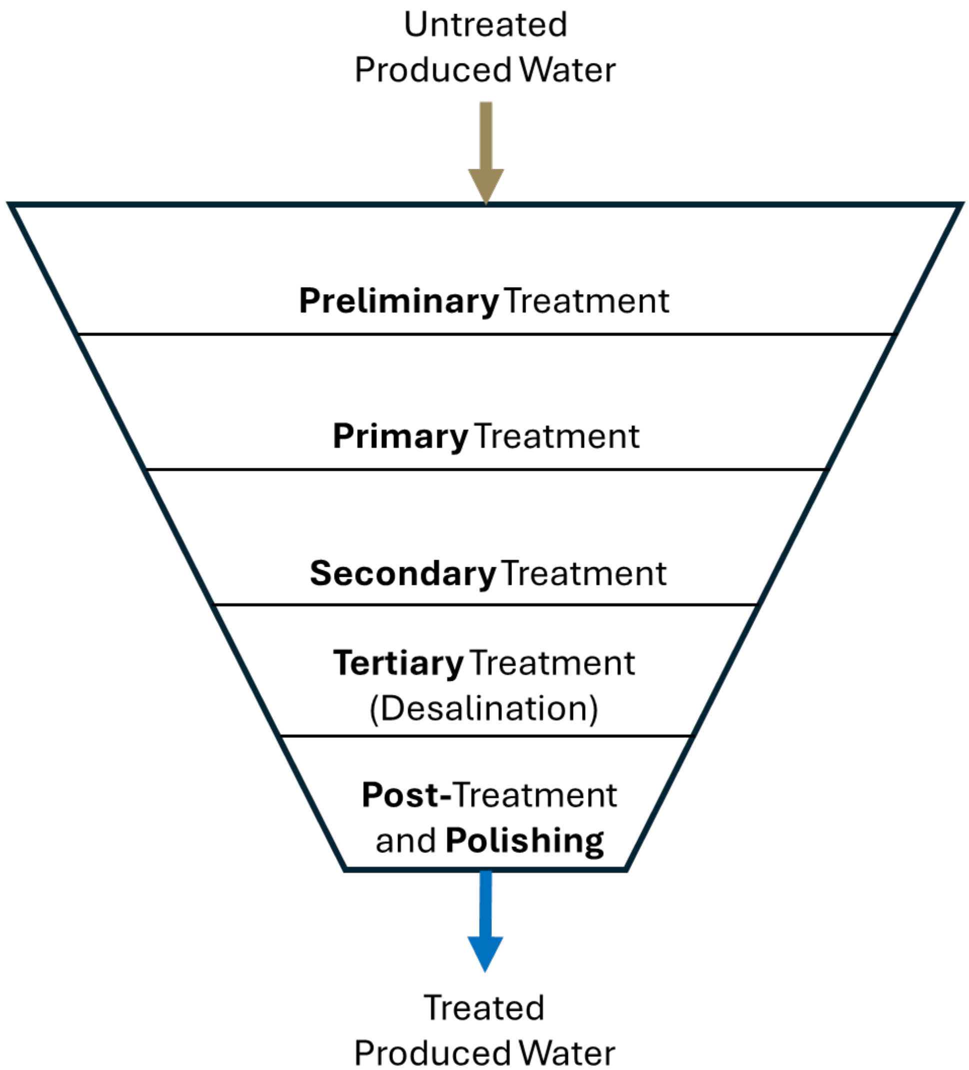
[195] Scanlon, B. R., Reedy, R. C., Xu, P., Engle, M., Nicot, J. P., Yoxtheimer, D., Yang, Q., and Ikonnikova, S. (2020). Can we beneficially reuse produced water from oil and gas extraction in the U.S.? *Science of the Total Environment, 717,* 137085. https://www.sciencedirect.com/science/article/pii/S0048969720305957#s0070

- **Preliminary treatment** technologies generally consist of a basic separation process such as screening and grit removal, in addition to any chemical addition for primary treatment unit processes such as ferric chloride for coagulation and flocculation.
- **Primary treatment** technologies are designed to remove larger suspended particles and oil droplets in the produced water and consist primarily of coagulation/flocculation, sedimentation, and oil-water separation. Specific technologies for oil-water separation include hydrocyclones, skimmers, American Petroleum Institute separators, and corrugated plate interceptor separators.
- **Secondary treatment** technologies are designed to remove much smaller oil droplets and suspended particles, in addition to soluble organic matter and other contaminants. Secondary treatment generally consists of dissolved gas/air flotation, biological treatment (e.g., activated sludge, biologically aerated filters), and certain types of media filtration (e.g., walnut shell, cartridge, gravel, anthracite).
- **Tertiary treatment and desalination** for produced water is generally the most intensive step and is used to remove dissolved solids and other contaminants not removed during the primary and secondary treatment stages.[196] Common technologies used during tertiary treatment include:[197]
    - Membrane filtration, such as MF, UF, NF, RO, electrodialysis (ED), and forward osmosis (FO).
    - Adsorption, such as through granular activated carbon and ion exchange.
    - Absorption, such as macro-porous polymer extraction.
    - Distillation, such as multiple effect distillation (MED), mechanical vapor recompression (MVR) and compression (MVC), multi-stage flash (MSF) distillation, and membrane distillation (MD).
    - Evaporation, such as freeze-thaw evaporation or evaporation ponds.
- **Post-treatment or polishing** is not always required depending on the end use of the treated water; however, it can be beneficial in certain scenarios. This treatment step usually consists of pH adjustment, corrosion inhibition, and disinfection.

[196] Igunnu, E. T., and Chen, G. Z. (2012). Produced water treatment technologies. *International Journal of Low-Carbon Technologies, 9*(3), 157–177. https://doi.org/10.1093/ijlct/cts049

[197] Ibrahim, M., Nawaz, M. H., Rout, P. R., Lim, J.-W., Mainali, B., and Shahid, M. K. (2023). Advances in produced water treatment technologies: An in-depth exploration with an emphasis on membrane-based systems and future perspectives. *Water, 15*(6), 2980. https://doi.org/10.3390/w15162980

Figure 10. Produced water treatment process.



It is important to note that each of the above treatment technologies has its own advantages and disadvantages regarding chemical consumption, energy efficiency and consumption, robustness and sensitivity, biosolids and residual waste stream generation, and reliability and characterization. For example, RO is a very reliable and proven technology with high TDS removal; however, it has relatively high energy consumption, produces a residual waste brine stream, has high pretreatment requirements, and can suffer from membrane fouling, especially at high TDS concentrations.[198] On the contrary, distillation does not have strict pretreatment requirements and is capable of treating water with very high TDS concentrations. However, distillation has much higher energy requirements compared to RO and still produces a significant amount of brine waste. As a hybrid alternative to both membrane filtration and distillation, MD is capable of treating high-salinity waters at low temperatures and high water

[198] Patel, S. K., Biesheuvel, P. M., and Elimelech, M. (2021). Energy consumption of brackish water desalination: Identifying the sweet spots for electrodialysis and reverse osmosis. *ACS ES&T Engineering, 1*(5), 851–864. https://doi.org/10.1021/acsestengg.0c00192

recoveries, although the commercialization of MD is still in early stages, and its long-term reliability is still uncharacterized.[199]

As a final example, advanced oxidation processes do not have any residual wastes, do not have strict pretreatment requirements, are effective against many trace organic compounds, require minimal equipment, and have low energy consumption; however, they are largely ineffective at removing inorganic dissolved solids and have high chemical dosing requirements.[200] It is important to note that the produced water treatment technologies listed above are in different stages of research and do not all have the same reliability and characterization. Advancements for these technologies are still being made, with the goal of achieving increased robustness, treatment efficacy, and energy efficiency.

As stated above, a large disadvantage to distillation and membrane technologies is the production of a residual brine stream. Specifically for membrane technologies, RO and ED can operate at water recovery rates of around 80 percent (therefore producing a brine stream equal to 20 percent of the influent flow). Higher water recoveries can be obtained, but they come at the cost of increased membrane fouling and higher energy consumption. Therefore, until improvements are made to RO and ED to increase water recoveries substantially, brine disposal will be a major challenge, especially for inland treatment operations.

The methods for inland brine disposal include injection, surface water discharge, sewer discharge, evaporation, and crystallization. All of these methods have their own advantages and disadvantages. Brine disposal by injection is very common and inexpensive, but induced seismicity from injection has presented a major challenge for this disposal method. Surface water discharge and sewer discharge are similarly common and inexpensive, but they can have severely negative environmental impacts. Evaporation is a method to reduce the overall volume of the brine by evaporating as much water from the solution as possible, thus generating a more concentrated brine stream.[201] As a form of zero-liquid discharge, crystallization is often employed after evaporation to further remove the remaining water from the brine, thus producing a solid waste. While evaporation and crystallization have low direct environmental impacts compared to the other brine disposal options, they come with their own disadvantages such as high land footprints (in the case of evaporation ponds) and high energy consumption (in the case of crystallizers and evaporators). Overall, brine disposal is a major challenge for RO and ED desalination systems and will be a major consideration regarding specific treatment technologies for produced water treatment.

In addition, the treatment technologies used for produced water highly depend on the raw produced water quality and desired treated water quality. For example, for raw produced waters with TDS concentrations higher than seawater (>35,000 mg/L), thermal technologies (e.g., distillation or evaporation) are usually required, thus resulting in much higher energy demands. The raw produced water quality can also affect treatment performance. In the case of RO, higher TDS concentrations of the raw produced water can result in membrane fouling, higher energy consumption, and decreased water recovery. Where high-quality effluent is required, multiple treatment barriers might be necessary, as well as any post-treatment and polishing

---

[199] Parani, S., and Oluwafemi, O. S. (2021). Membrane distillation: Recent configurations, membrane surface engineering, and applications. *Membranes, 11*(12), 934. https://doi.org/10.3390/membranes11120934

[200] Sanchez-Rosario, R., and Hildenbrand, Z. L. (2022). Produced water treatment and valorization: A techno-economical review. *Energies, 15*(13), 4619. https://doi.org/10.3390/en15134619

[201] Saltworks. (2017). *How to manage brine disposal & treatment.* https://www.saltworkstech.com/articles/how-to-manage-brine-disposal-and-treatment/

requirements for specific end users. Regulations for produced water treatment and reuse will also inform the level of treatment required, with stricter requirements on effluent water quality necessitating higher levels of treatment.

Monitoring for the treated produced water and the various treatment technologies will be necessary as a part of the overall treatment process; however, the level of monitoring required will depend on regulations and any agreements between the treatment facility and the end user. Due to the many organic and inorganic contaminants present in raw produced water, robust water quality monitoring will be needed to determine the overall treatment efficacy and potential impacts of the treated produced water for the end user or other applications.

For end users that require ultra-pure water such as semiconductor, pharmaceutical, solar photovoltaic cell, and green hydrogen manufacturers, additional treatment will be necessary prior to the manufacturing process. Typically, these manufacturers produce ultra-pure water by treating municipal water onsite. This treatment is generally conducted through various filtration, ultraviolet disinfection, and ion exchange processes. Depending on the agreement between the produced water treatment facility and the end user, ultra-pure water treatment could be installed and combined with other treatment processes at the produced water treatment facility, thus saving on manufacturing costs for the end user.

Depending on regulatory requirements, a potentially large cost for the end user will be the disposal of the treated produced water after it has been used in the manufacturing process. For nonconsumptive water uses such as semiconductor, pharmaceutical, and solar photovoltaic cell manufacturing, a “no-discharge” scenario would pose significant challenges, as any process water would have to be evaporated, resulting in extremely high energy consumption to dispose of the process water (i.e., treated produced water). Under a no-discharge scenario, the high costs associated with disposing of the process water would essentially limit any potential end users to those with consumptive water use (i.e., green hydrogen).

5.2 BRACKISH WATER TREATMENT

In 2010, there were 649 active desalination plants in the United States, with a total treatment capacity of 402 MGD. Approximately 67 percent of the total treated water was used for municipal purposes, with 18 percent for industry, 9 percent for power, and the remaining 6 percent for other uses.[202] The treatment techniques for brackish water generally consist of either RO, ED, or distillation (e.g., MED, MVC, MVR, MSF). Compared to seawater that can have TDS concentrations greater than 35,000 ppm, brackish water generally has 10,000 ppm TDS or less. However, the concentrations of both TDS and other contaminants can vary greatly between brackish water aquifers. Additionally, brackish water might contain elevated levels of arsenic, minerals, and other undesirable constituents as compared to seawater.

Similar to produced water treatment, the level of treatment and the specific technologies required for brackish water treatment highly depend on the initial water quality and desired effluent water quality. Generally, brackish water treatment is conducted by ED or RO; however, for lower concentrations of TDS, other membrane filtration technologies such as NF or UF can also be effective. It is important to note that a liquid brine waste stream is also produced during brackish water treatment if utilizing RO or ED.

[202] Water Resources Mission Area. (2021). *National brackish groundwater assessment: How is brackish groundwater being used?* U.S. Geological Survey. https://www.usgs.gov/mission-areas/water-resources/science/national-brackish-groundwater-assessment-how-brackish

The most common method of brine disposal for inland brackish water facilities is surface water discharge (47 percent), sewer discharge (42 percent), and deep well injection (9 percent). However, surface water brine discharge is proving to have very negative environmental impacts, and sewer discharge can put a heavy burden on wastewater treatment plants.[203]

5.3 PRODUCED WATER AND BRACKISH WATER TREATMENT CONCLUSIONS

- Produced water and brackish water can be treated effectively to generate high-quality effluent.
- Many treatment technologies are available for both produced and brackish water treatment. However, each specific technology has its own advantages and disadvantages. Treatment trains should be designed with these advantages and disadvantages in mind in order to produce the highest quality effluent possible while minimizing risk and cost. Major considerations for the viability of specific treatment technologies are:
    - Energy efficiency and consumption.
    - Waste and other residuals (e.g., brine, sludge waste, etc.).
    - Chemical consumption.
    - Treatment efficacy (i.e., contaminant removal).
    - Water recovery.
- The level of treatment and specific technologies required for produced water and brackish water treatment highly depend on the initial source water quality as well as the desired effluent quality. Specifically, high TDS concentrations of the initial source water might require more energy-intensive treatment processes and can affect treatment performance (e.g., membrane fouling, water recovery, etc.).
- Regulations and agreements between end users and produced water treatment facilities will ultimately inform the levels of treatment and monitoring required for produced water treatment and reuse.
- Brine disposal is a major challenge to inland produced water and brackish water treatment.
- For end users that require ultra-pure water, additional treatment will be needed prior to the manufacturing process.
- Discharge requirements for the end user will have a significant impact on which types of manufacturers will be able to use treated produced water (i.e., consumptive versus nonconsumptive use).

6 TRANSPORTATION AND STORAGE

Capital and operating costs of developing storage and transportation infrastructure are also important factors in the feasibility and affordability of water processing projects. Depending on the distance and terrain, transporting water from one location to another can be very expensive and energy intensive. For example, a commenter from the RFI estimated that it would cost $1 million per mile for a large aqueduct, but we do not have other reliable estimates for different

[203] Ahdab, Y., and Lienhard, J. H. (2021). Desalination of brackish groundwater to improve water quality and water supply. In A. Mukherjee et al. (Eds.), *Global groundwater: Source, scarcity, sustainability, security and solutions.* Elsevier. https://dspace.mit.edu/bitstream/handle/1721.1/126566/Ahdab-Lienhard-Groundwater_Desalination_Chapter-R1.pdf?sequence=1&isAllowed=y

modes and scales of water transportation. Similarly, we lack data on the costs and benefits of storing treated or untreated water in reservoirs, aquifers, tanks, or other facilities. These costs may vary depending on the quality, quantity, and duration of storage, as well as the environmental and social impacts of the storage infrastructure. Therefore, more research is needed to understand the trade-offs between transporting and storing water vs. using it locally. This would help decision-makers to optimize the allocation and distribution of water resources in a cost-effective and sustainable way.

7 BRINE AND RESIDUALS MANAGEMENT

As discussed above, the oil and gas industry currently disposes of significant volumes of produced water through saltwater injection/disposal wells. This has led to increased seismicity in these regions[204] and containment loss events,[205,206] which in turn have led to concern about this practice. Increased seismic activity has also led to interstate tensions between New Mexico and Texas. There may be other, economically beneficial ways to dispose of residuals from treated produced water, though challenges still remain (technological and regulatory) that warrant further research for viability and cost effectiveness. OCD has had to take steps to curtail injection in parts of the Permian to address seismicity concerns. Similarly, as brackish water resources in New Mexico are explored as an alternative water supply, the metals and minerals that remain after treatment can pose both a challenge and an opportunity.

7.1 COST

Brine and residuals management associated with desalination and treated produced water is nontrivial and can be very costly. If evaporation ponds are used for large amounts of treated water, the needed size for those ponds becomes a concern, with significant associated capital costs. Costs of evaporation ponds for large amounts of water may be prohibitive.

7.2 ENHANCED RESOURCE RECOVERY

Valuable constituents could be recovered from produced water during treatment; these ultimately could be sold to the market and help offset the costs associated with treatment. Valuable constituents that could be recovered include insoluble hydrocarbons, lithium, iodine, and many more.[207] Though not yet proven in practice, brine could also be used to create cement and asphalt in a way that releases significantly less CO_2 than current production

[204] Garthwaite, J. (2022). *Earthquakes from oil field wastewater.* Stanford Doerr School of Sustainability. https://sustainability.stanford.edu/news/earthquakes-oil-field-wastewater

[205] Karanam, V., Lu, Z., and Kim, J.-W. (2024). Investigation of oil well blowouts triggered by wastewater injection in the Permian Basin, USA. *Geophysical Research Letters, 51*(14), e2024GL109435. https://doi.org/10.1029/2024GL109435

[206] Drane, A. (2024, October 2). Mysterious 100-foot geyser of salty water erupts in West Texas oilfield hit by recent earthquakes. *Houston Chronicle*. https://www.houstonchronicle.com/news/houston-texas/texas/article/west-texas-geyser-erupts-19811620.php

[207] Cooper, C. M., McCall, J., Stokes, S. C., McKay, C., Bentley, M. J., Rosenblum, J. S., Blewett, T. A., Huang, Z., Miara, A., Talmadge, M., Evans, A., Sitterley, K. A., Kurup, P., Stokes-Draut, J. R., Macknick, J., Borch, T., Cath, T. Y., and Katz, L. E. (2021). Oil and gas produced water reuse: Opportunities, treatment needs, and challenges. *ACS ES&T Engineering, 2*(3). https://doi.org/10.1021/acsestengg.1c00248

practices.[208] There is also interest in using brine from desalination plants in chlor-alkali electrolysis to produce chlorine and sodium hydroxide.[209]

There are several existing technologies for extracting resources from brine. Resources can be precipitated from brine using evaporation ponds or mechanical thermal evaporation methods, then separated and chemically treated. Precipitation of resources from brine can also be facilitated using chemical methods that target specific compounds. Membrane methods that are used in desalination, such as RO, FO, osmotically assisted RO, NF, and ED, can be tailored to extract specific compounds from brine for enhanced resource recovery.[210]

However, these methods face barriers that can limit their economic viability.[211] Many of them, particularly mechanical thermal evaporation and ED, are energy-intensive processes. Evaporation ponds are less energy intensive, but require significant amounts of land and the use of liners to prevent brine from leaking out into the environment. Chemical precipitation, meanwhile, sometimes requires a one to one (or higher) ratio of chemical reagents to the target compound, and the value of the compounds targeted by chemical methods might only be slightly higher than the cost of the chemicals needed to extract them. Given these potential constraints, it will likely be important to characterize the concentrations of resources within SWS waters before treatment to assess the viability of enhanced resource recovery for a given project.

Although there do not currently seem to be any large-scale operations extracting resources from desalination brines, several companies and initiatives are working on enhanced resource recovery. A company called Upwell Water is investing in a plant to extract gypsum and hydrochloric acid from the brine of the Kay Bailey Hutchison desalination plant in El Paso.[212] The company Element3 Resources recently extracted lithium from Permian Basin produced water in a pilot project.[213] One of the RFI respondents, Enviro Water Minerals, has worked on designs for a number of enhanced resource recovery technologies and is currently assessing their feasibility for desalination projects in the Middle East. A California company called Magrathea Metals has extracted small quantities of magnesium from desalination brines and other saline solutions in pilot projects and is currently scaling its technology.[214] Oregon State University is piloting brine mining technologies in a partnership between academia, industry,

---

[208] New York University Abu Dhabi. (2023). *Climate challenge—Kemal Celik.* https://nyuad.nyu.edu/en/news/latest-news/science-and-technology/2023/may/climate-challenge-kemal-celik.html

[209] Sharma, P. P., Mohammed, S., Aburabie, J., and Hashaikeh, R. (2023). Valorization of seawater reverse osmosis brine by monovalent ion-selective membranes through electrodialysis. *Membranes, 13*(6), 562. https://doi.org/10.3390/membranes13060562

[210] Sharkh, B. A., Al-Amoudi, A. A., Farooque, M., Fellows, C. M., Ihm, S., Lee, S., Li, S., and Voutchkov, N. (2022). Seawater desalination concentrate—A new frontier for sustainable mining of valuable minerals. *npj Clean Water, 5.* https://doi.org/10.1038/s41545-022-00153-6

[211] Sharkh, B. A., Al-Amoudi, A. A., Farooque, M., Fellows, C. M., Ihm, S., Lee, S., Li, S., and Voutchkov, N. (2022). Seawater desalination concentrate—A new frontier for sustainable mining of valuable minerals. *npj Clean Water, 5.* https://doi.org/10.1038/s41545-022-00153-6

[212] Mendoza-Moyers, D. (2023). Incoming $100 million facility looks to turn brine waste into water, expand El Paso's water supply. *El Paso Matters.* https://elpasomatters.org/2023/11/21/facility-to-boost-el-pasos-water-supply/

[213] McEwen, M. (2024, March 9). Oil report: Advances made in extracting critical minerals from produced water. *MRT.* https://www.mrt.com/business/oil/article/mineral-extraction-produced-water-18761317.php

[214] Robbins, J. (2024, May 15). In seawater, researchers see an untapped bounty of critical metals. *Yale Environment 360.* https://e360.yale.edu/features/desalination-saltwater-brine-mining

and government.[215] Brine mining is also planned to be incorporated into the NEOM initiative in Saudi Arabia.[216]

7.3 IMPROVE RATE OF WATER RECOVERY

Current technology allows for a water recovery rate from brackish water of about 83–85 percent. If this rate of recovery were increased, it would be possible to produce a smaller volume of brine for a given amount of treated water. Reducing the volume of brine can reduce disposal costs significantly. To improve the rate of water recovery, constituents such as calcium carbonate, silicas, and others must be removed. Constituents can be removed by different methods and at different stages of the treatment process, but regardless of the method chosen there will always be solids that need disposal.

7.4 ENERGY SECURITY

Recovering the metals and minerals in brackish water resources could provide energy security to the U.S. and decrease energy dependence on nations such as China.

8 ECONOMIC FEASIBILITY

NMED has considered using advance commitments to purchase treated produced water and treated brackish water to incentivize private sector investment in constructing and operating water treatment facilities. Advance contracts for treated water purchases could decrease the risk in these investments by providing certainty that a buyer will purchase treated water at specified qualities and quantities, for a specified price, over a given period of time. NMED is also considering other incentives and funding models as well.

This section explores the purchase commitment price that water treatment businesses would need in order to participate in this initiative, with calculations for the net present value of a purchase commitment. This purchase price is then compared to the price that potential end users might be willing to pay for treated water. The SWS might be able to close the gap between the price that water treatment facilities would need and the price that end users would accept in order to incentivize private sector investment. End user willingness to pay for treated water is presented in relation to project costs. This section also discusses the incentive mechanism and duration of the SWS.

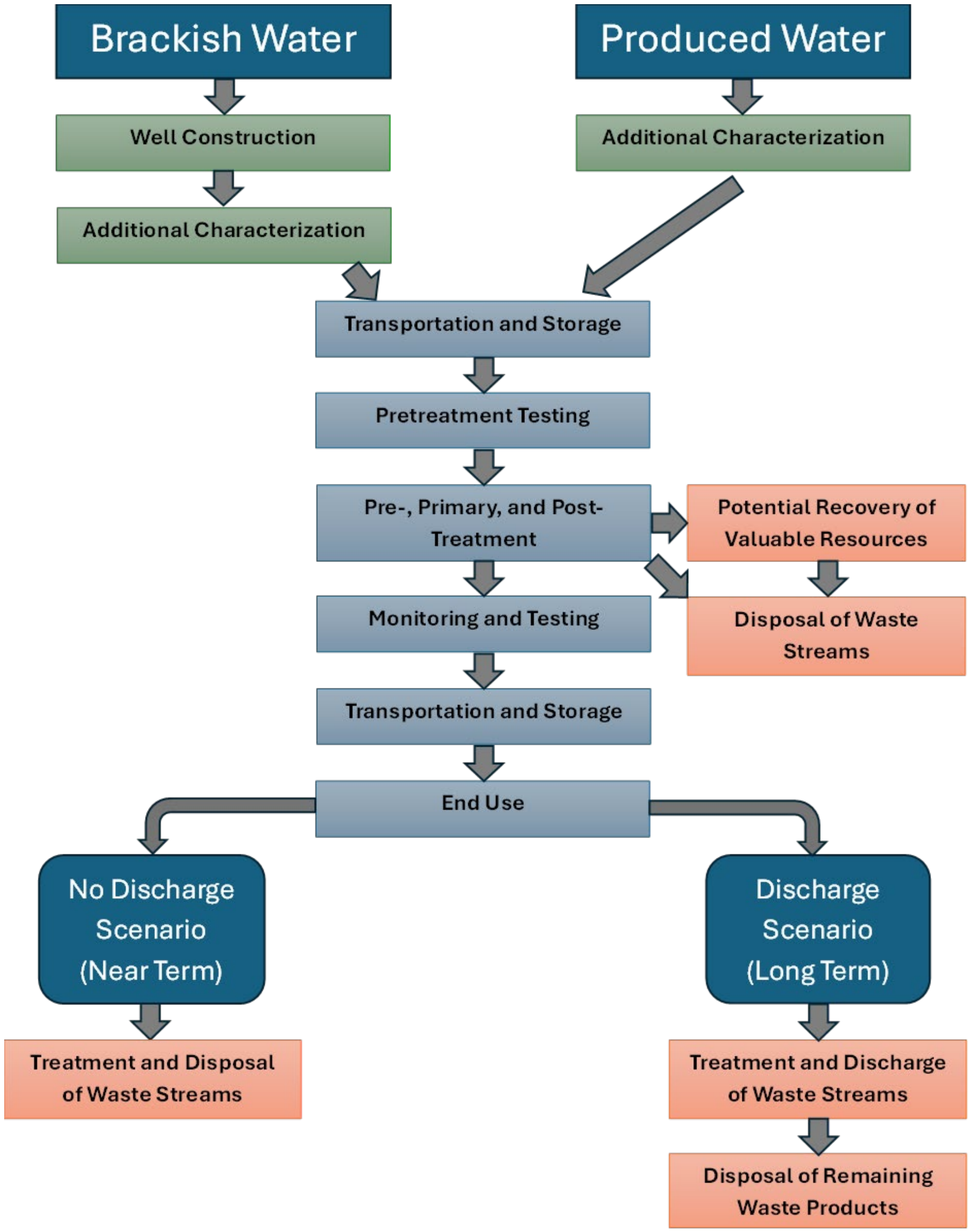
8.1 SUPPLY SIDE: WATER PROCESSING COST STRUCTURE

Water processing costs vary depending on the source, method, and goal of treatment. Figure 12 illustrates the components of a project from source to end user, each step having implications for project costs and potential revenue streams.

[215] Oregon State University. (2023). Brine miners: Extracting value, reducing waste. https://research.engr.oregonstate.edu/brineminers/home

[216] Voutchkov, N., et al. (2023). Innovative system for separation of monovalent salts from seawater brine for beneficial use. *Smart Water Magazine.* https://smartwatermagazine.com/news/neom/innovative-system-separation-monovalent-salts-seawater-brine-beneficial-use

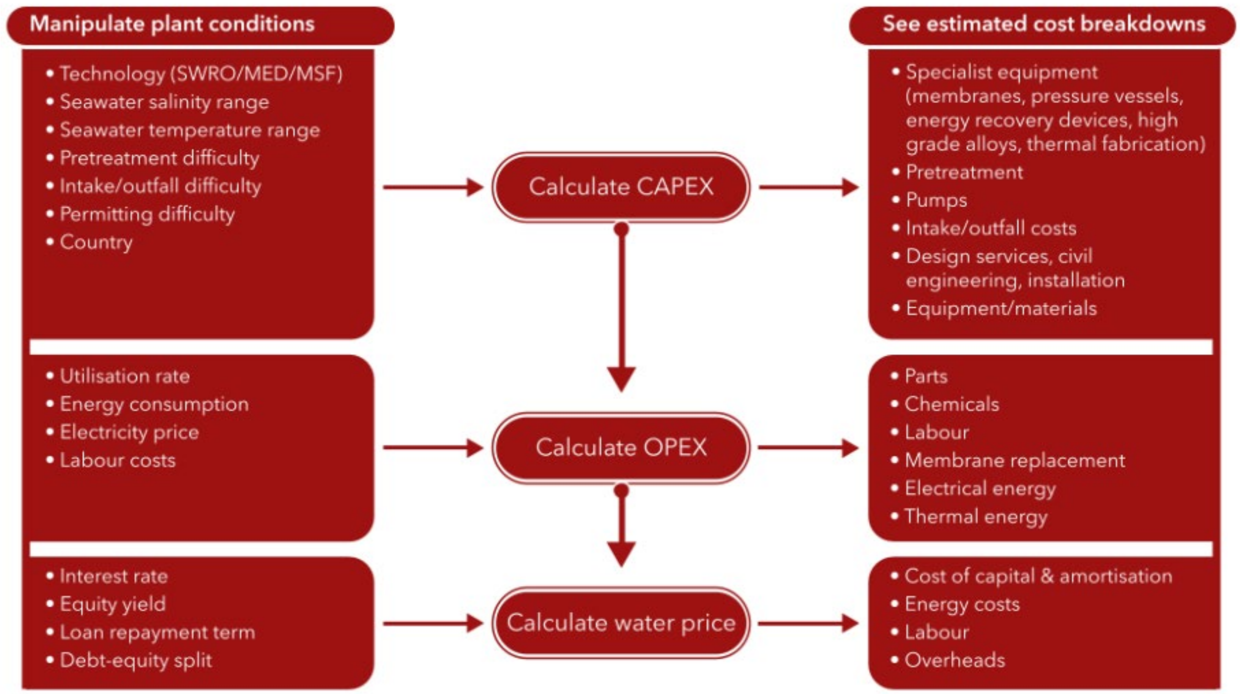
Figure 11. Flow chart of brackish water and produced water sourcing, treatment, and use for no discharge and discharge scenarios.



8.1.1 Cost components

Costs associated with water treatment can be broadly grouped into capital expenditures (CAPEX), such as construction costs, and operation and maintenance expenses (OPEX), such as labor, energy, and membrane replacement. Figure 13 presents the major water processing costs associated with the respective CAPEX and OPEX categories, showing the large number of factors affecting water treatment cost estimates.

Figure 12. Desalination CAPEX and OPEX costs.



From: Global Water Intelligence (GWI) DesalData Report, 2024.[217]

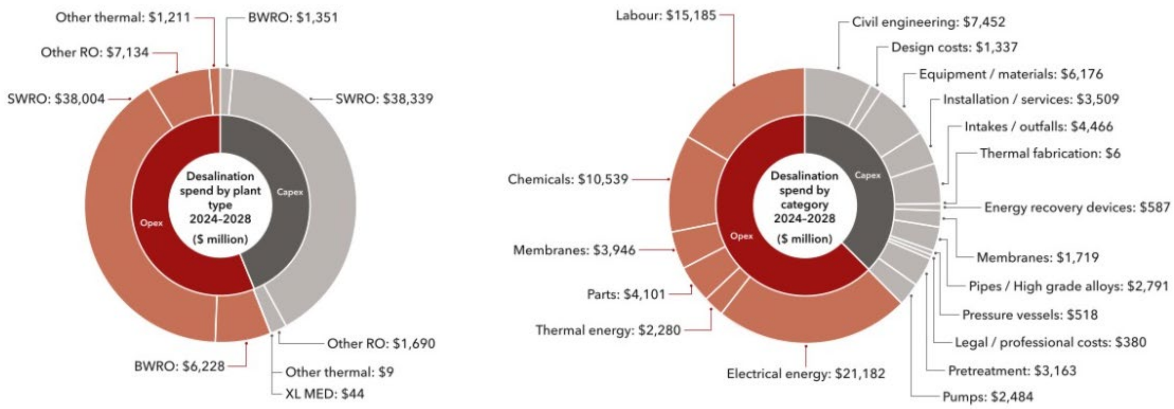
Further dissecting water treatment costs, Figure 14 shows that OPEX accounts for approximately 62 percent of the cost of water for an average desalination plant.[218] The major OPEX categories are energy, labor, and chemicals, which together account for around 82 percent of the operational costs. The most relevant CAPEX categories correspond to land, equipment, buildings, and design. Other indirect costs, such as insurance and project overhead, also contribute to CAPEX. In terms of OPEX, the major costs are chemicals, labor, energy, and maintenance.

Unfortunately, the lack of consistent data about different facilities makes it difficult to directly compare the specific components included in each estimate. However, the costs of a RO desalination system largely correspond to electrical energy, capital, and maintenance costs, as shown in Figure 14. These costs compose about 90 percent of the total desalination system costs.

[217] GWI DesalData. (2024). *GWI DesalData report.* https://www.desaldata.com/, © GWI DesalData.com, Media Analytics Ltd.

[218] These estimates include saltwater and brackish water desalination and different processing technologies, which may have different cost structures.

Figure 13. CAPEX/OPEX spending by category and plant type.



From: GWI DesalData Report, 2024.[219]

Energy costs are a key component of desalination plant costs due to the extensive power required. For a given TDS level, energy is the most important factor in evaluating the cost of a desalination. The cost also depends on the technology that the water treatment system employs. Due to its comparatively small energy demand and the lower overall water-producing cost, RO desalination is one of the most widely accepted desalination techniques. RO can also operate through the regular electric grid, making it easier to adopt. In contrast, one of the main disadvantages of thermal systems is the large amount of energy required, which also limits their capacity to work within non-centralized water treatment systems.

The levelized cost of water (LCOW) is a commonly used indicator for comparing different water treatment systems. After accounting for the water production capacity, the LCOW is calculated by adding all the annual costs (operation and maintenance) with the amortized construction costs. The LCOW is governed by feedwater quality, treatment processes and goals, plant capacity, concentrate disposal and waste management, climate, land availability, and energy prices. LCOW initially decreases sharply as plant capacity increases, reaching a stable level for larger plant capacities. However, despite the economies of scale of treatment infrastructure, decentralized systems can reduce costs by minimizing storage and distribution costs.

[219] GWI DesalData. (2024). *GWI DesalData report.* https://www.desaldata.com/, © GWI DesalData.com, Media Analytics Ltd.

Per Edirisooriya et al. (2024), the following are approximated costs for different technologies and plant sizes:

- BWRO generally has the lowest treatment costs, ranging from $0.09/bbl for a 630-bbl/day plant (100 cubic meters/day) to $0.06/bbl for a plant with a capacity of 6,290 bbl/day (1,000 cubic meters/day).
- Microfiltration reverse osmosis (MF-RO) treatment of municipal secondary or tertiary effluent has costs from $0.43/bbl for a 630-bbl/day plant (100 cubic meters/day) to $0.25/bbl for a 6,290-bbl/day plant (1,000 cubic meters/day), then decreases to $0.094/bbl for a 243,660-bbl/day plant (38,754 cubic meters/day).
- An advanced oxidation step using ultraviolet light and hydrogen peroxide (H_2O_2) can be added to MF-RO to further polish product water quality. The LCOW when including this step is estimated at $0.50/bbl, $0.28/bbl, and $0.20/bbl for a 630-bbl/day (100 cubic meters/day), 6,290-bbl/day (1000 cubic meters/day), and 244,000-bbl/day (38,800 cubic meters/day) plant capacity, respectively.

Two key elements stand out for the purpose of this analysis. First, BWRO has a low processing cost, making it less costly than some non-potable water sources currently used for irrigation. Second, treated water costs are highly variable depending on their specific project characteristics.

These treatment costs directly reflect how LCOW changes depending on desired water quality and plant size. However, water treatment costs can vary throughout a plant's life cycle. For example, Edirisooriya et al. (2024) mentions that brackish water desalination costs at the Kay Bailey Hutchinson Desalination Plant in El Paso, Texas, increased by over 30 percent from $0.06/bbl to $0.084/bbl when its feedwater TDS increased from 2,000–2,500 mg/L to 2500−3600 mg/L.

The cost structure of water processing plants also implies a trade-off between operational and capital costs. The LCOW, which includes both types of costs, is lower for bigger plants. Firms that choose smaller plants with lower capital costs can potentially implement them faster, but they tend to have higher operational costs. On the other hand, bigger plants may need financial support for longer in order to become profitable, increasing total SWS costs. Ultimately, the choice between these water processing technologies will depend on factors such as long-term water demand forecasts, energy costs, and funding availability for larger projects.

The trade-off between operational and capital costs that affects water processing plants also impacts potential energy sources, which are crucial due to the high energy needs of processing water. Renewable energy technologies, such as wind or solar power, usually have high capital costs but low operational costs, as they do not rely on fuel prices or water availability. However, they also face challenges with intermittency, storage, and grid integration, which may raise their overall costs. Desalination technologies, on the other hand, have more stable and predictable operational costs, but they change depending on the quality of the input water, the energy source, and the size of the plant. Therefore, firms must weigh the trade-offs between capital and operational costs, as well as the risks and uncertainties associated with different technologies, when selecting the best water supply option. Notably, the chosen duration for the incentive structure of the advance market commitment (AMC) can affect firms' financial planning and, thus, their technology choices, as discussed further below.

8.1.2 Treatment of produced water

The treatment costs of produced water vary substantially depending on salinity and the presence of different types of contaminants. Processing costs have been estimated at $1.50/bbl to $1.91/bbl to treat hypersaline produced water (e.g., unconventional produced water in the Permian Basin) using waste heat and low-temperature thermal distillation technologies.[220]

A 2022 report by Kanalis Group[221] for NMPWRC states that San Juan Basin produced waters have a TDS range of 10,000 to 30,000 ppm. This water quality is usually treated with BWRO or SWRO membranes. On the other hand, Permian Basin produced water has higher levels of organics and TDS and can range from 30,000 to 150,000 ppm TDS. Produced waters that exceed 50,000 ppm need thermal treatment technologies, which generally make produced water treatment six to ten times more costly.

Estimated costs for potential SWS projects are presented below for the two major oil and gas–producing regions in New Mexico: the Permian and San Juan Basins. Raw produced water quality differs between these two regions, with higher salinities in the Permian requiring more expensive treatment processes. NMSU has estimated per-barrel costs for 1- and 5-MGD water treatment facilities in these two regions, assuming a thermal process is used in conjunction with post-treatment polishing in the Permian, and less expensive membrane technology is used in the San Juan.[222] In addition, two RFI respondents (Aquality Solutions and HF Sinclair) provided estimated prices they need to be paid per barrel to cover their costs to treat produced water for industrial use in these two regions.[223] We calculated the present value of project costs based on facility capacity, per-barrel costs or prices, and project timeframe.[224] The present value of SWS support is the value of upfront costs (i.e., capital costs) plus the present value of annual costs over the period of support. Table 9 and Table 10 summarize the estimated project costs for produced water projects in the Permian and San Juan Basins, respectively.[225]

---

[220] Edirisooriya, E. M. N. T., Wang, H., Banerjee, S., Longley, K., Wright, W., Mizuno, W. and Xu, P. (2024). Economic feasibility of developing alternative water supplies for agricultural irrigation. *Current Opinion in Chemical Engineering, 43,* 100987. https://doi.org/10.1016/j.coche.2023.100987

[221] Kanalis Group. (2022). *Bench-scale treatment study of produced water from the southern San Juan Basin New Mexico: volume 1.* https://nmpwrc.nmsu.edu/files/Kanalis-Final-Report-NMPWC-Approved-Vol-1.pdf

[222] Xu, P. (2024) *Research on treatment of produced water for reuse.* Legislative Finance Committee, Water Subcommittee. https://www.nmlegis.gov/handouts/ALFC%20061124%20Item%208%202024%20update%20of%20NMPWRC%20for%20LFC.pdf

[223] Estimated project costs for Aquality Solutions are included in both regions, as no region was specified in their RFI response.

[224] A 2 percent real discount rate is used in all calculations of present value presented here, to be consistent with NMSU methodology.

[225] Projects presented in Table 9 and Table 10 are sorted based on the geographic location of the projects, including sources that presented estimates for both basins.

Table 9. Estimated produced water SWS project costs: Permian Basin

Component	NMSU	NMSU
End Use	Industrial and commercial applications	Industrial and commercial applications
Capacity	1 MGD	5 MGD
Cost/Price of Treated Water ($/bbl)	$1.89–$2.14	$1.12–$1.52
Timeframe	20 years*	20 years*
SWS Project Cost	$269 million–$304 million	$796 million–$1.08 billion

*Timeframe of 20 years assumed based on timeframe used in NMSU study for Santa Teresa, discussed in more detail below.

Notes:

- After debt service, Aquality Solutions expects the price for the treated produced water to be between $1.20 and $1.30 per barrel. The pricing for treated water has been developed using a "cost plus" model that incorporates a 20 percent return.
- Discount rates used by RFI respondents in price calculations were not disclosed in these submissions.
- Aquality Solutions estimated the timeframe to be a minimum of 5 years.

Table 10. Estimated produced water SWS project costs: San Juan Basin

Component	NMSU	NMSU	HF Sinclair	Aquality Solutions
End Use	Industrial and commercial applications	Industrial and commercial applications	Hydrogen production	Industrial applications
Capacity	1 MGD	5 MGD	0.5 MGD	4.2 MGD
Cost/Price of Treated Water ($/bbl)	$1.47–$1.59	$0.70–$0.95	$0.55–$1.00	$1.50
Duration of Agreement	20 years*	20 years*	5 years	5 years
SWS Project Cost	$209 million–$226 million	$497 million–$675 million	$11 million–$20 million	$258 million

*Timeframe of 20 years assumed based on timeframe used in NMSU study for Santa Teresa.

Notes:

- HF Sinclair's RFI response assumed the use of existing recycling facilities' infrastructure.
- After debt service, Aquality Solutions expects the price for the treated produced water to be between $1.20–$1.30/bbl. The pricing for treated water has been developed using a "cost plus" model that incorporates a 20 percent return.
- Discount rates used by RFI respondents in price calculations were not disclosed in these submissions.

- Aquality Solutions estimated the timeframe to be a minimum of five years.

In addition to the costs of constructing and operating a treatment facility, the costs of a produced water treatment project will also be impacted by water transportation and storage needs, as well as potential disposal cost savings and the value of potentially recoverable minerals. No specific information was provided by NMSU and RFI respondent estimates of treatment cost of transportation and storage, disposal cost savings, or potential revenue from recovering valuable minerals. Therefore, we assume these factors are excluded from their estimates.

Transporting produced water between the source, treatment facility, and end user adds to project costs. For example. an additional upfront project cost would be large-diameter pipeline, which could cost approximately $1 million per mile. To reduce costs, we expect that project designs will minimize the need for transportation as much as possible by locating treatment facilities and end users in proximity to water sources. Establishing pipelines for transportation involves logistical challenges and costs related to securing rights of way, though these costs are not considered in this report.

Diverting produced water for treatment and reuse instead of disposal will reduce disposal costs. Oil and gas companies currently pay disposal costs for SWD, which is estimated to be approximately $0.70–$1.00/bbl. It may be reasonable to assume that oil and gas companies will be willing to pay up to their current disposal costs to participate in a project that would divert produced water away from disposal. However, the midstream operations that aggregate produced water from many production wells for disposal or reuse will likely continue to be involved in projects due to their existing transportation infrastructure, expertise, and relationships. The continued involvement of midstream companies implies an associated cost. Therefore, we assume potential cost savings of less than what oil and gas companies currently pay for disposal.

We have calculated project costs to include 25 miles of large-diameter pipeline and savings of $0.50/bbl for avoided disposal costs. Approaches for recovering valuable minerals from produced water are still under development, and we have not included the impacts of any potential revenue in our estimates. While it is reasonable to assume that projects will require storage to accommodate fluctuations in water demand, we have not included any estimates of the costs of storage. These rough estimates of cost savings for avoided disposal and the additional costs for water transportation are included when calculating net project costs. Table 11 and Table 12 present these net project cost estimates.

Table 11. Net costs for produced water projects: Permian Basin

Component	NMSU 1 MGD	NMSU 5 MGD	Aquality
Initial Project Cost	$269 million– $304 million	$796 million– $1.08 billion	$258 million
Disposal Cost	$71 million	$355 million	$86 million
Transportation Cost for 25 miles	$20 million	$20 million	$24 million
Net SWS Project Cost	$218 million– $253 million	$461 million– $745 million	$196 million

Note: Disposal costs calculated as the present value over a project's lifespan.

Table 12. Net costs for produced water projects: San Juan Basin

Component	NMSU 1 MGD	NMSU 5 MGD	HF Sinclair	Aquality
Initial Project Cost	$209 million– $226 million	$497 million– $675 million	$11 million– $20 million	$258 million
Disposal Cost	$71 million	$355 million	$10 million	$86 million
Transportation Cost for 25 miles	$20 million	$20 million	$24 million	$24 million
Net SWS Project Cost	$158 million– $175 million	$163 million– $340 million	$25 million– $34 million	$196 million

Note: Disposal costs calculated as the present value over a project's lifespan.

8.1.3 Treatment of brackish water

As discussed previously, for use outside the oilfield, it is more common to treat brackish water than produced water. Table 13 provides examples of specific desalination plants, including their LCOW, capital cost, and capacity. The cost ranges demonstrate that actual economic feasibility will rely on specific parameters (e.g., feedwater TDS, plant scale) of specific projects.

Table 13. Cost references from desalination plants

Type	Water cost ($/bbl)	Capital cost	Costs components included	Capacity	Source
BWRO	$0.07–$0.09	$91 million	LCOW	27.5–33 MGD	Pei Xu, 2023, New Mexico Legislature Handout[226]
BW	$0.08	NA	Cost to process 10,000 ppm TDS water	100 MGD	Ashok Ghosh (RFI)
BW	$0.10	NA	Average cost of treated brackish water from 7 treatment plants in Texas in 2011 (adjusted for inflation)	NA	NONA Technologies (RFI)
BWRO	$0.12	$54 million (~$10 million according to alternative source)	RO recovery of about 80% to achieve potable water of about 800 mg/L TDS	2.8 MGD (potable water)	New Mexico Legislature Handouts[227,228]
BW/SW FO	$0.13	NA	Cost to process 100,000 ppm TDS water	100-MGD	Ashok Ghosh (RFI)
BWRO	$0.13–$0.16	$143 million	LCOW	12.2 MGD	Pei Xu, 2023, New Mexico Legislature Handout
BWRO	$0.13–$0.26	NA	Unspecified	NA	Water Technology[229]

226 Xu, P. (2023). *Desalination research facing New Mexico's 21st century water challenges.* https://www.nmlegis.gov/handouts/ALFC%20062723%20Item%2010%20Brackish%20water%20desalination%20Pei%20Xu%202023_6_28_edits.pdf

227 New Mexico Legislature. *Alamogordo regional water supply: New Mexico's first large-scale municipal desalination project.* https://www.nmlegis.gov/handouts/STTC%20101713%20Item%205%20Alamogordo%20Desalination.pdf

228 Xu, P. (2023). *Desalination research facing New Mexico's 21st century water challenges.* https://www.nmlegis.gov/handouts/ALFC%20062723%20Item%2010%20Brackish%20water%20desalination%20Pei%20Xu%202023_6_28_edits.pdf

229 Water Technology. (n.d.). *SAWS brackish groundwater desalination plant, San Antonio.*

Type	Water cost ($/bbl)	Capital cost	Costs components included	Capacity	Source
BW EDR	$0.24	$100 million	LCOW	6 MGD	Pei Xu, 2023, New Mexico Legislature Handout
BW	$0.37	$3 million	LCOW	0.5 MGD	Jacob's Well (RFI)
N/A	$0.42–$0.84	NA	LCOW	NA	Baryon (RFI)

For the SWS, estimated project costs are presented below for brackish water projects, based on an NMSU feasibility study for a project in Santa Teresa[230] and two responses to the RFI. The NMSU study provides an estimate of the upfront costs ($269.4 million) and the present value of annual costs ($43.9 million) for a 5-MGD desalination facility. These estimates were used to calculate a per-barrel cost to treat brackish water. In addition, two RFI respondents (Jacob's Well and NONA Technologies) provided estimated prices per barrel that they would need to cover their costs to treat brackish water for industrial use. These prices were used with facility capacity and timeframe to calculate total project cost. The NMSU estimates include several costs that may not be included in the estimates from the RFI respondents: supply wells and supply lines to the treatment facility, disposal wells and disposal lines, and other supporting infrastructure such as connections to the distribution system. Table 14 summarizes the estimated project cost estimates for brackish water projects.

[230] Xu, P. (2023). *Water desalination feasibility study for Santa Teresa.* Science, Technology and Telecommunications Committee. https://www.nmlegis.gov/(X(1)S(3laa5nopicwuk2i5u3m0c4m0))/handouts/STTC%20103023%20Item%208%20Santa%20Teresa%20Brackish%20water%20desalination.pdf

Table 14. Brackish water project cost estimates

Component	NMSU	Jacob's Well	NONA Technologies
End Use	Potable	Industrial applications	Semiconductors, chemical processing or manufacturing
Annual Capacity	5 MGD	0.5 MGD	1 MGD***
Cost/Price of Treated Water ($/bbl)	$0.36*	$0.37**	$0.23
Duration of Agreement	20 years	10 years	20 years
Project Cost	$256 million	$14 million	$33 million

*ERG calculated per-barrel costs based on NMSU estimates of upfront and annual costs.

** The cost per barrel for Jacob's Well is $0.37 for the first 10 years with capital costs included, then $0.28 after capital costs are paid off.

*** NONA Technologies' capacity is based on a suggested minimum of 1 MGD.

8.2 DEMAND SIDE: WILLINGNESS TO PAY FOR WATER

To incentivize end users to participate in SWS projects, treated water must be priced at a level they are willing to pay. Understanding the current freshwater rates for industrial users in the regions of interest provides insight into what end users might be willing to pay. One of the main challenges in assessing the willingness to pay for water by use is the lack of consistent and comparable data on the prices and costs of diverse sources and qualities of water. The RFI responses provide examples of the current or expected prices of treated brackish and produced water for various uses. Still, they vary widely depending on the location, volume, treatment method, and end use of the water.

Based on the RFI responses and further exploration of alternative data sources, Table 15 presents a range of water prices for different uses. Treated water prices vary widely depending on initial and objective water quality, ranging from $0.16/bbl for municipal irrigation and uses not involving direct human contact to $1.90/bbl for green hydrogen and $2.50/bbl or more for certain uses. In Santa Teresa, the Camino Real Regional Utility Authority charges industrial users who use over 100,000 gallons of freshwater per month a rate of $5.00 per 1,000 gallons ($0.21/bbl) for use over 100,000 gallons per month. For the Albuquerque area, the Albuquerque-Bernalillo County Water Utility Authority charges about $2.14 per 100 cubic feet ($0.12/bbl) for freshwater for industrial uses. In the San Juan Basin, the city of Farmington has freshwater rates for industrial users ranging from $4.59 to $5.26 per 1,000 gallons ($0.19–$0.22/bbl). In the Permian Basin, the city of Carlsbad charges $98.47 per 1,000 gallons of freshwater for industrial users ($4.14/bbl). However, whether this rate would be applied to manufacturing companies is unclear; Carlsbad's water statutes define industrial property as "all of the property used in connection with a business in which a product is manufactured or used by a common carrier, utility or governmental agency," but defines industrial water user as only including water hauling, brine production, oilfield servicing, oil and gas production, and resale of water for non-domestic purposes. If manufacturing companies fall under the commercial water rate instead, the commercial rate would be $2.62 per 1,000 gallons ($0.11/bbl) for use over 500,000 gallons per month.

Table 15. Water price by use

Use/Category	Price ($/bbl)	Detail	Source
Industrial	$0.08	Price of freshwater for industrial users in Las Cruces	City of Las Cruces
Industrial	$0.12	Price of freshwater for industrial users in Albuquerque and Bernalillo County	Albuquerque Bernalillo County Water Utility Authority
Industrial	$0.18	Price of freshwater for industrial users in Los Lunas	Los Lunas Water Division
Industrial	$0.19–$0.22	Range of prices for nonresidential users of freshwater in Farmington	City of Farmington
Industrial	$0.21	Price of freshwater for industrial users in Santa Teresa for monthly usage over 100,000 gallons	Camino Real Regional Utility Authority
Industrial	$0.26–$0.32	Expected price for data centers, hydrogen companies, and semiconductors	Trevi Systems (RFI)
Industrial	$0.32–$0.58	The expected range of what some industries are willing to pay for treated water	OneWater P3 Gurus (RFI)
Industrial	$0.52	Price of desalinated water from the Carlsbad desalination plant	Global Water Farms (RFI)
Industrial	$1.68	What Plug Power would initially be willing to pay for fit-for-purpose water for hydrogen (short term)	Plug Power (RFI)
Industrial	$0.42	What Plug Power would be willing to pay for fit-for-purpose water for hydrogen (long term)	Plug Power (RFI)
Industrial	$1.93	Expected price for hydrogen	Infrastruk (RFI)
Landscape irrigation	$0.15	Expected price for landscape irrigation	OPUS 2G (RFI)
Oil and gas	$0.50–$1.50	Price range currently paid by the oil and gas industry for freshwater	NGL Water Solutions (RFI)
Oil and gas	$0.50–$1.50	Oil and gas companies' cost for freshwater	NGL Water Solutions (RFI)

Use/Category	Price ($/bbl)	Detail	Source
Oil and gas	$2.55–$10.00	Price paid by Texas oil and gas companies in 2022 to treat produced water	Global Water Farms (RFI)

Prices for industrial water by utilities in the geographics considered the most likely candidates for SWS projects (Carlsbad, Farmington and Santa Teresa) were used as an estimate of how much an industrial end user would be willing to pay for treated produced or treated brackish water. With these prices, facility capacity, and project timeframe, total payments from end users were calculated and compared to project costs. Table 16, Table 17, and Table 18 show net project costs and payments from end users to calculate an overall total for each project. In areas where alternative water sources are limited or unavailable, industrial end users may be willing to pay more in order to have a reliable water source at the quantities that they need for their facility.

Table 16. Project costs and end user payments: Permian Basin produced water

Project	Net Project Cost	Payment from End Users	Net Project Cost Minus Payments from End Users
NMSU 1 MGD	$218 million–$253 million	$16 million	$202 million–$238 million
NMSU 5 MGD	$461 million–$745 million	$78 million	$383 million–$667 million
Aquality	$196 million	$19 million	$177 million

Table 17. Project costs and end user payments: San Juan Basin produced water

Project	Net Project Cost	Payment from End Users	Net Project Cost Minus Payments from End Users
NMSU 1 MGD	$158 million–$175 million	$30 million	$128 million–$145 million
NMSU 5 MGD	$163 million–$340 million	$149 million	$13 million–$191 million
HF Sinclair	$25 million–$34 million	$4 million	$20 million–$30 million
Aquality Solutions	$196 million	$36 million	$159 million

Table 18. Project costs and end user payments: Brackish water

Project	Net Project Cost	Payment from End Users	Net Project Cost Minus Payments from End Users
NMSU	$256 million	$149 million	$107 million

Project	Net Project Cost	Payment from End Users	Net Project Cost Minus Payments from End Users
Jacob's Well	$14 million	$8 million	$6 million
NONA Technologies	$33 million	$30 million	$3 million

8.3 INCENTIVES FOR PRIVATE SECTOR PARTICIPATION IN THE STRATEGIC WATER SUPPLY

NMED is considering using advance commitments to purchase treated produced and treated brackish water to incentivize private-sector investment in constructing and operating water treatment facilities. Two forms of advance commitments are AMCs and advance purchase commitments (APCs). AMCs are commitments to potential suppliers as a group, while APCs are commitments to individual suppliers.[231]

Both AMCs and APCs are considered “pull” mechanisms. Unlike “push” funding, which directly finances upfront costs such as construction or research and development, “pull” funding incentivizes the end product. For AMCs and APCs, pull funding can encourage firms to invest in capacity and production to meet future demand that is guaranteed by the contract. In the context of water processing, a pull funding mechanism can be especially advantageous for several reasons:

- **Risk mitigation.** Pull mechanisms mitigate risks associated with high upfront investments by guaranteeing a market for their product, thus encouraging investment in innovative solutions that might otherwise be deemed too risky.
- **Information asymmetry.** Governments often lack the specific technical knowledge required to make informed decisions about water processing technologies. Pull mechanisms allow firms to determine the most efficient and cost-effective technologies rather than governments picking technologies.
- **Dynamic efficiency.** Pull mechanisms promote dynamic efficiency by rewarding successful outcomes rather than funding the research and development process. Firms are motivated to continuously improve and adapt their technologies to meet the contract’s requirements, leading to better water processing solutions over time.
- **Capacity building.** Water processing requires substantial infrastructure and capacity development, particularly infrastructure, with a cost structure characterized by high initial investment and low marginal costs. By incentivizing private-sector investment, AMCs and APCs promote more rapid expansion of water treatment capacity, which is crucial for addressing water scarcity.

Pull mechanisms like AMCs and APCs offer a strategic way to encourage investment in water processing technologies. They leverage market forces to overcome information asymmetries and incentivize firms to develop and scale up efficient and effective water processing solutions, meeting societal needs without the need for direct government involvement in the technological development process. This pull structure is particularly beneficial for complex and essential services like water processing, where the end goal is clear, but the path to achieving it is not.

[231] Thornton, I., Wilson, P., and Gandhi, G. (2022). “No Regrets” purchasing in a pandemic: making the most of advance purchase agreements. *Globalization and Health*, *18.* https://globalizationandhealth.biomedcentral.com/articles/10.1186/s12992-022-00851-3

8.4 INCENTIVE DURATION

Analyzing the trade-offs of different incentive durations is crucial in determining the most effective subsidy strategy for companies with high capital costs. This section analyzes short-term (e.g., five years) and long-term (e.g., 15 to 20 years) subsidies to explore how varying the length of the subsidy period impacts financial outlays, investor confidence, and long-term sustainability, considering factors such as alternative source prices, variable costs, technological advancements, and market demand. Understanding these dynamics helps craft a balanced approach that supports initial project development while ensuring viability beyond the subsidy period.

8.4.1 Short-term subsidies

- **Increased investor confidence.** A substantial upfront subsidy may attract investors by reducing initial capital costs and avoiding long-term policy uncertainty, encouraging them to commit to the project.
- **Risk of unsustainability.** Companies need to achieve profitability or break-even status quickly after the subsidy period ends. Shorter subsidies require a rapid ramp-up in efficiency and client acquisition.
- **Operational readiness.** Projects that can amortize costs quickly (as seen in some produced water projects) are more likely to thrive under a short-term subsidy. However, projects with longer payback periods may struggle.

8.4.2 Long-term subsidies

- **Lower annual subsidy costs.** Spreading the subsidy over a longer period reduces the annual financial outlay, imposing a lower cost on New Mexico’s yearly budget.
- **Extended support.** Long-term subsidies provide a safety net, allowing companies more time to stabilize operations, refine processes, and build a customer base.
- **Dependency risk.** Prolonged financial support might lead to dependency if companies rely on subsidies rather than looking for new clients and potential users.
- **Higher overall costs.** Over time, the cumulative cost of a long-term subsidy may be higher than initial estimates, especially when accounting for unexpected increases in operational costs.

8.4.3 Factors influencing project sustainability beyond subsidies

- **Alternative source prices.** The prices of alternative water sources are likely to rise over the course of the subsidy, potentially making subsidized projects more competitive after the funding stops.
- **Variable costs evolution.** Operational costs such as energy, labor, and maintenance will evolve over time. Projects with decreasing or stable variable costs are better positioned for long-term success.
- **Technological advancements.** Innovations in water treatment technologies can reduce costs and improve efficiency, enhancing the sustainability of projects beyond the subsidy period. However, subsidized investing in large plants based on current technologies could indirectly hinder the adoption of future advancements.
- **Market demand.** Steady or growing demand for treated water, influenced by industrial growth and regulatory changes, supports project viability.

- **Regulatory environment.** Changes in regulations, particularly those affecting water quality standards and disposal requirements, can impact the cost structure and market dynamics for treated water.
- **Partnership opportunities.** Encouraging partnerships with private investors, local governments, and industries can spread financial risks and enhance the resource pool for these projects.

Balancing short-term and long-term subsidies involves weighing the trade-offs between immediate financial outlays and long-term sustainability risks. Considering more scenarios such as alternative source prices, variable costs, technological advancements, and market demand can further the analysis.

8.5 ECONOMIC FEASIBILITY CONCLUSIONS

The SWS would address the gap between the price water treatment suppliers need in order to cover their capital investment and operating costs and the price end users are willing to pay for treated water. The estimates in Section 8.2 provide a rough idea of the level of funding needed to support produced water and brackish water treatment projects through the SWS. Considering disposal cost savings and payments from end users, the analysis concludes that:

- Produced water projects are estimated to cost between $13 million and $191 million in the San Juan Basin and between $177 million and $667 million in the Permian, varying by project capacity and duration of support.
- Brackish water projects are estimated to cost between $3 million and $107 million after considering payments from end users for projects with varying capacities, although much of the difference in cost is likely due to the omission of well construction and other costs in the RFI responses.

The duration of funding and consideration of end user payments can substantially affect required funding levels for projects. Additional findings of the SWS economic analysis follow below. Key findings from the economic analysis include both long-term strategic considerations and immediate cost factors that directly impact project funding needs.

8.5.1 Investment risk

The SWS addresses investment risk by committing to purchasing treated water at a given price, with risks related to the volatility of a potential market for treated water being transferred to the state of New Mexico. This assumption of risk has important implications for the state, especially if a potential end user identified as the offtaker for a project is no longer operational (for existing facilities) or fails to materialize. Undertaking water treatment projects in areas where multiple end users may be available to utilize treated water would reduce this risk.

8.5.2 Project sustainability

As discussed above, the sustainability of a project beyond the life of an incentive depends on a treatment facility's ability to cover operating costs in an unsubsidized market, which assumes there will be an end user willing to pay a price sufficient to cover operating costs. The state's commitment is unlikely to last over the envisioned lifespan of a facility. However, it is difficult to project what operating costs and end users' willingness to pay will be in 10 or 15 years.

8.5.3 Complementary funding sources

The amount of support necessary to incentivize a project through the SWS will decrease if other funding sources for capital investments are available. Appendix B describes other potential sources of capital funding.

8.5.4 Value of alternative to SWD

Concerns about seismicity related to SWD may lead to constraints on current produced water disposal practices. These constraints could severely limit oil and gas production activity and increase the amount that the oil and gas industry is willing to pay for alternatives to SWD, such as diversion to a treatment facility for reuse outside the oil and gas industry. In that case, the need to subsidize produced water treatment may decrease or be eliminated.

8.5.5 Costs of closed-loop requirement

The SWS requirement that projects be closed-loop with no environmental discharge of waste streams associated with treated brackish or produced water may impose significant additional costs on end users and may need to be reflected in pricing of water to compensate for costs related to this requirement. These costs may be prohibitive, limiting potential projects in a no-discharge scenario to consumptive uses, such as hydrogen production.

8.5.6 Treated water quality related to alternative sources

The treated water generated by some of the above-referenced projects can achieve high purity which is valuable in specific industrial applications, such as ultra-pure water for chip manufacturing. This would increase the selling price above the reference used from local utilities, increasing projects profitability.

8.5.7 Increasing water prices

Calculations presented here assume that water prices from local utilities are constant over time. With increasing scarcity and new federal requirements to remove emerging contaminants, such as PFAS, it may be true that the price of water from local water utilities for industrial uses will increase over time, especially over longer timeframes (e.g., 20 or 30 years). One estimate from a 2008 report from NMSU projected that the price of water in New Mexico would be 15 percent to 60 percent higher in 2030 compared to 2000, depending on different climate change scenarios.[232]

Immediate cost considerations directly affect the project's funding needs. It is crucial to understand and account for these factors, described in Table 19, as they introduce variability and potential volatility into cost estimates.

Table 19. Cost components of SWS projects

Cost Component	Description
Well Construction	Well drilling and construction costs for brackish or produced water vary significantly by site and are often excluded from CAPEX estimates.
Plant Construction Costs	The specific plant cost and configuration may depend on feedwater quality and target output water quality.
Variable Water Quality Costs	Treatment costs depend on feedwater quality (e.g., TDS levels); higher salinity or contaminants raise costs, particularly affecting the Permian Basin.

[232] Hurd, B., and Coonrod, J. (2008). *Climate change and its implications for New Mexico's water resources and economic opportunities.* Technical Report 45. New Mexico State University. https://pubs.nmsu.edu/research/economics/TR45.pdf

Cost Component	Description
Pipeline and Transport	Transportation from source to treatment facilities and to users requires pipeline infrastructure and rights of way, plus installation costs specific to each location.
Energy Costs	Energy-intensive treatment methods are sensitive to energy prices, a major OPEX component, especially for thermal desalination required for produced water.
Storage Requirements	Water storage infrastructure is necessary to manage fluctuations in supply and demand but is not included in initial cost estimates.
Disposal and Waste Management	Costs for managing waste streams, especially in closed-loop systems with strict environmental requirements, add to both CAPEX and OPEX.
Alternative Revenue Sources	Cost savings from avoided disposal and potential revenue from byproduct recovery (e.g., minerals) can offset costs, though these are unpredictable and generally not included in the initial estimates.

Accurately estimating and incorporating these specific cost factors into project planning is essential for the economic feasibility of SWS-supported water treatment projects. By understanding the full range of expenses—from short-term contributors to CAPEX and OPEX to long-term strategic considerations—stakeholders can make informed decisions about funding levels and incentive structures. The SWS initiative can potentially make water treatment projects viable by addressing both these strategic and operational funding needs, but carefully inspecting projects long term costs and end users willingness to pay is key to ensuring long-term success and sustainability.

9 CONCLUSION

This feasibility study provides a review of technological and economic considerations for developing the envisioned SWS. Below, the lens of desirable characteristics presented above (Section 1.4) is applied to discuss potential locations and project types for produced water (Section 9.1) and brackish water (Section 9.2) that appear to fit well within the objectives and scope of the SWS. The discussion includes two scenarios that reflect expectations for developing relevant regulations: closed-loop projects with no environmental discharge (near term) and projects with environmental discharge (longer term). The study concludes with some overall findings to inform the development of the SWS.

9.1 PRODUCED WATER

The two major oil and gas producing regions in New Mexico offer ready supplies of raw produced water that might supply new treatment facilities. In general, produced water will entail higher treatment costs than brackish water, though treatment facilities may obtain raw produced water for free or even be paid to take the water. Both regions have a limited local labor force, are relatively remote (requiring transportation of any end products), and lack existing end users in the target sectors (e.g., advanced manufacturing, renewable energy generation and storage). In a closed-loop scenario, hydrogen production projects may be a good fit, as they represent a consumptive use of water. Hydrogen production may require an additional alternative water supply for cooling needs due to discharge associated with cooling systems that would be costly to manage or eliminate. In a scenario with environmental discharge, additional project types become feasible. In either scenario, a project with a single end user that might be attracted to develop in this region includes the risk that the end user may not materialize or may not remain operational through the lifespan of the treatment facility.

9.1.1 San Juan Basin

Given lower salinity levels of produced water in the San Juan Basin, treatment costs will be lower for projects undertaken in this region. While overall produced water volumes are lower than in the Permian Basin they are likely to be sufficient to support a treatment facility in this area.

9.1.2 Permian Basin

The lower water quality of raw produced water in the Permian Basin translates to higher treatment costs, though research indicates that treatment trains can be assembled to remove identified contaminants. The abundance of produced water being generated in this region means that source water will be readily available. Projects that divert water from disposal are potentially more viable, as suppliers may be willing to pay a treatment facility to take the water, and larger scale projects may contribute to addressing issues around current disposal practices. Otherwise, many of the same considerations that apply to the San Juan Basin also apply to the Permian Basin.

9.2 BRACKISH WATER

There has been some exploration of brackish water basins in New Mexico that informs the feasibility of developing brackish water treatment projects in these regions. Regions requiring further investigation meet multiple criteria that make them potentially promising places to develop brackish water supplies. Namely, these regions are developed or will be developed, need water to support existing or envisioned industrial uses, and have relatively good data available compared to other regions in New Mexico. While additional water quality characterization is needed, treatment costs for brackish water projects are expected to be lower than for produced water projects. End uses with more stringent water quality requirements, such as semiconductor manufacturing, may be more suitable for brackish water projects. Limitations on discharge for brackish water projects need to be clarified, but if there are no closed-loop requirements, an expanded set of potential end uses may be feasible for brackish water projects. The possibility of having several potential end users in proximity to each other reduces the risk that there might be no offtaker for projects in these areas. This section discusses the opportunities and challenges associated with developing brackish water resources in two places that meet these criteria: Santa Teresa and Albuquerque.

9.2.1 Santa Teresa

Located in the southern region of New Mexico near the border with Texas and Mexico (part of the Lower Rio Grande region), Santa Teresa is a region with great economic development potential because it is a land port of entry to Mexico, has a growing industrial base, and has an increasing population. An ongoing lawsuit from Texas against New Mexico and Colorado arguing that New Mexico's groundwater withdrawals along the Lower Rio Grande are violating the Rio Grande Compact has made it clear that New Mexico must diversify its water supply in this region if economic growth is to continue.

In recognition of the high need for water in this region, as well as an aquifer that could be a suitable brackish water source, a pilot project is ongoing to provide additional information on the characteristics of the aquifer that is necessary to decide whether the project is viable and what specific treatment technologies would be appropriate. The development and planning for this project have been ongoing for over five years.[233] As discussed above, a feasibility study has been completed with estimated project costs for facilities of different sizes. The experience so far with the potential Santa Teresa project may help illustrate the time and resources required to bring a brackish water treatment project concept to the point where potential funding sources, such as the SWS, might be explored. It is unclear whether the current timeline for additional characterization work necessary to inform project design is in line with SWS timelines.

9.2.2 Albuquerque Basin

The Albuquerque metropolitan area is located in the Albuquerque Basin. As the Albuquerque metropolitan area continues to grow, there will be more demand for water in this already water-stressed region. The Albuquerque Basin may provide an alternative water supply. Though the Albuquerque region generally has brackish water supply potential through the Albuquerque Basin, careful consideration must be given to the location of treatment and the location of end users.

[233] Falk, M. (2019, January 29). Desalination plant could supply Santa Teresa with water. *KRWG Public Media.* https://www.krwg.org/regional/2019-01-29/desalination-plant-could-supply-santa-teresa-with-water

APPENDIX A: BRACKISH AQUIFER WATER CHEMISTRY[234]

Table A-1. San Luis Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	7,140	2,720	630	190	570	620	1,820	415	20	0.06	0.055	3,180
Minimum	94	73	0.74	0.012	2.3	1	1.5	0.2	0.05	0.0001	0.0002	10
Mean	446.8	330.4	56.3	10.4	34.9	160.3	90.5	13.1	0.99	0.0028	0.0056	424
Median	330	245	37.2	8	21	145	31	5.9	0.48	0.001	0.0029	300

Table A-2. Española Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	23,000	30,000	430	3,500	1,000	2,180	20,000	1,000	16.2	0.207	2.5	2,499
Minimum	66	92	1	0.025	2.8	35	0.7	0.5	0.042	0.00039	0.0001	5
Mean	556.7	389.5	50.01	15.5	47.2	197.01	93.01	21.05	0.72	0.0068	0.129	585
Median	383	246	39	5.5	22	158	20	8.8	0.44	0.0033	0.004	397

[234] Appendix A tables are from: Land, L. (2016). *Overview of fresh and brackish water quality in New Mexico.* New Mexico Bureau of Geology and Mineral Resources. https://geoinfo.nmt.edu/publications/openfile/downloads/500-599/583/OFR-583_NM_BrackishHR.pdf

Table A-3. Albuquerque Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	29,400	27,000	685	305	2,200	120	13,100	6,800	6.4	0.610	0.077	2,020
Minimum	240	163	0.3	0.1	4.5	50	8.2	0.1	0.1	0.000	0.000	7.5
Mean	1,204.4	880.9	88.8	21	95.7	224.9	280.8	97.5	0.8	0.010	0.006	416.6
Median	645	427.5	59.7	11	42	183.5	89.8	21.3	0.5	0.005	0.004	260

Table A-4. Socorro-La Jencia Basins: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	7,640	7,590	460	780	1,218	590	5,150	1,420	4.3	0.053	0.141	560
Minimum	210	143	6.4	1.2	10.7	86	6.8	4	0.1	0.0005	0.0004	8
Mean	1,394.5	1,001.6	99.9	30.5	141.8	276.5	322	152.6	0.58	0.011	0.01	158
Median	920	645	73.5	15	80	240	195	58.5	0.41	0.006	0.006	121.5

Table A-5. San Marcial and Engle Basins: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	4,450	2,400	220	30	620	195	590	1,300	2.87	0.012	0.0076	600
Minimum	249	177	20	1.6	11	136	6.1	3.7	0.2	0.002	0.003	50
Mean	1,366	704.3	88.9	9.2	152.6	157.3	94.9	279.7	1.4	0.0037	0.0047	327
Median	840	456	72	8.1	79	141	71	78	1.05	0.002	0.004	300

Table A-6. Palomas Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	6,470	5,060	640	250	1,200	491	2,900	1,420	6.8	0.02	0.062	442
Minimum	216	147	7.2	0.1	18	28	13	3.5	0.2	0.0004	0.001	14
Mean	1,944.5	1,296.7	141.7	24.3	312.1	216.2	339.1	418.1	1.4	0.0028	0.011	106
Median	1,480	921.5	130	18	199	214	150	190	0.8	0.002	0.006	67

Table A-7. Mesilla Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	42,800	30,800	962	728	8,590	1,400	4,970	15,300	7.9	0.116	0.107	1,880
Minimum	393	234	0.5	0.1	34	38	20.4	11	0.1	0.00048	0.00005	12
Mean	1,714.4	1,216.5	102.4	23.5	277.4	250.8	309.4	291.3	0.8	0.0101	0.0093	339
Median	1,050	693	68	14.9	130	201.5	160	100	0.6	0.0032	0.0017	270.5

Table A-8. Jornada del Muerto Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	9,750	6,440	570	1,100	810	418	7,300	360	12	0.015	0.0448	6,044
Minimum	274	191	3.3	0.2	14	32	14.8	2.42	0.1	0.001	0.0016	40
Mean	2,138.7	1,354.2	149.2	75.5	149.4	198.1	1,079.2	61.1	1.37	0.0034	0.0105	489.4
Median	1,690	729	70	35	93.8	180	622	39.5	1	0.0025	0.0074	350

Table A-9. Estancia Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	22,300	18,100	1,130	1,350	3,500	1,990	7,600	5,500	6.2	0.006	0.007	1,070
Minimum	233	207	1.7	0.3	6	92	9.1	2.7	0.1	0.0002	0.0018	7
Mean	1,713.6	1,287.9	183.4	73.5	202.3	312.2	517.4	174.4	0.93	0.0018	0.004	197
Median	861	614	120	32	41	274	153	31.9	0.7	0.0012	0.004	180

Table A-10. Mimbres Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	21,900	14,300	1,200	140	980	468	2,000	6,900	18	0.038	0.016	2,115
Minimum	226	168	2	0.1	10	270	3.9	2.5	0.1	0.00042	0.002	14
Mean	852	616.6	48.2	12.9	98.5	343	125.9	76.4	2.3	0.0083	0.0083	339
Median	495	360.5	30	8.2	56.5	290	42	16	1.1	0.0051	0.0087	240

Table A-11. San Agustin Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	40,800	1,440	750	72	410	459	580	16,000	6.7	0.016	0.009	5,327
Minimum	150	120	0.8	0.05	6.5	30	1.9	0.4	0.1	0.001	0.0005	11
Mean	820.5	341.1	39	8.4	69.4	174.4	37.9	155.2	1.1	0.0046	0.0028	271
Median	400	250	21	6	43	163	20	18	0.7	0.004	0.002	180

Table A-12. Tularosa Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	160,000	256,922	3,070	11,900	73,500	663	87,900	83,000	100	0.1	0.19	6,015
Minimum	235	100	2	0.06	7.6	20	0.31	0.1	0.1	0.00006	0.00004	6
Mean	3,850.5	3,183.5	229.8	155.9	988.9	195.9	1,161.1	826.3	1.4	0.0047	0.034	365
Median	1,700	977	126	49	58.8	198	539	130	0.6	0.001	0.02	243

Table A-13. Roswell Artesian Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	176,000	58,300	2,560	1,900	9,000	876	9,600	115,000	95	0.01	0.018	5,506
Minimum	101	1.33	23	5.5	1.6	126	59	3	0.1	0.001	0.0009	11
Mean	4,993.3	3,547.9	349.7	132.9	676.8	281.6	1,095.2	1,202	1.8	0.003	0.0084	435.9
Median	3,090	2,175	304	90	115.5	253.5	854	465	0.7	0.002	0.0085	322

Table A-14. Capitan Reef aquifer: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	196,078	184,227	5,902	2,046	46,700	784	4,970	107,949	1.9	0.001	0.001	5,713
Minimum	602	364	48.9	32.6	5.1	56	14.3	10	0.1	0.001	0.001	327
Mean	64,412.8	54,046.5	1,555.6	737.5	15,021.1	338.7	2,204	29,959.8	0.69	0.001	0.001	3,285
Median	39,000	26,900	1,240	463.4	2,357.5	271	1,862.9	13,800	0.5	0.001	0.001	3,250

Table A-15. Raton and Las Vegas Basins: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	9,320	65,300	504	8,100	8,100	1,360	46,000	1,700	7	0.009	0.005	975
Minimum	347	230	2.8	0.75	22	183	1	5	0.1	0.001	0.001	6.7
Mean	1,788.1	2,335.5	134.9	188.6	639.8	438.2	1,272.2	130.3	1.2	0.0018	0.0016	160
Median	1,280	964.5	80	27.5	108.5	353.5	202.5	27.5	0.7	0.001	0.001	82.5

Table A-16. High Plains aquifer: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	18,400	15,100	574	1,150	3,100	518	7,530	5,900	33	0.0126	0.139	1,645
Minimum	306	203	3.4	0.9	1	138	1.8	1	0.2	0.0006	0.0005	15
Mean	1,132.5	995.9	79.9	49.5	116.1	225.2	242.7	137.9	1.9	0.0043	0.011	215.5
Median	639.5	436	58.5	24	39.5	220	75	40	1.4	0.0041	0.0058	185.5

Table A-17. San Juan Basin: Summary of water chemistry

Value	Specific Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	As (mg/L)	U (mg/L)	Well Depth
Maximum	83,300	57,300	2,200	955	16,000	1,724	15,000	34,000	15	0.058	1.21	9,803
Minimum	205	56	0.28	0.01	7.7	220	1.8	0.1	0.1	0.00001	0.0003	5
Mean	3,158.2	2,373.3	102.2	30.8	614.2	381.8	822.3	401.7	1.5	0.0017	0.057	765.6
Median	1,700	1,125	46	11	240	310	350	23.6	0.8	0.001	0.0055	397.5

APPENDIX B: OTHER SOURCES OF FUNDING FOR UPFRONT COSTS

EPA WATER INFRASTRUCTURE FINANCE AND INNOVATION ACT

The EPA's Water Infrastructure Finance and Innovation Act fund is a loan program for public and private entities that can be used to support brackish water desalination as well as alternative water supply projects, which would likely include produced water recycling. The program supports late-stage development, construction, property acquisition, and project capital requirements. Projects must have a minimum cost of $20 million (or $5 million for small communities) in order to qualify. The loan can cover up to 49 percent of a project's cost and can have a repayment period of up to 35 years at an interest rate based on a comparable-term U.S. Treasury bond.

U.S. BUREAU OF RECLAMATION

Another source of federal funding is USBR's Title XVI Water Reclamation and Reuse Program, which has the express purpose of funding water recycling and desalination projects in the western United States. The Reclamation and Reuse Program can provide up to 25 percent cost-shared funding, with a per project maximum of $30 million. Other subsets of Title XVI include the Desalination Construction Program and the Large-Scale Water Recycling Program, both of which received hundreds of millions of dollars from the Bipartisan Infrastructure Law. These programs also provide up to 25 percent cost-shared funding for projects, with the Large-Scale Water Recycling Program supporting projects with a minimum total cost of $500 million. Title XVI funding can be used to support the planning, design, and construction costs of desalination and water reuse projects.

CLEAN WATER ACT STATE REVOLVING FUND

The Clean Water Act State Revolving Fund could potentially be used to support desalination projects. Each state administers its own fund, which is funded by the federal government and state contributions and can issue loans, loan guarantees, and debt purchases for a wide variety of water projects. Since 2015, New Mexico has typically disbursed $15 million to $25 million from its revolving fund each year for loans durations of up to 30 years, with an interest rate of 2.375 percent for private entities and between 0 percent and 1 percent for public entities. Using the state revolving fund to support SWS projects could face some difficulties; the fund prioritizes projects that focus on protecting water quality rather than supplying water, and the eligibility of private projects is more limited than public projects.

U.S. DEPARTMENT OF ENERGY

Green industry end users for the SWS could take advantage of U.S. Department of Energy loan programs that received billions in funding from the Inflation Reduction Act. One option is the Title 17 Clean Energy Financing—Innovative Energy and Innovative Supply Chain program, which can be used by green hydrogen, solar, and wind manufacturers, as well as other green industries. The Innovative Energy and Innovative Supply Chain program can also support projects related to critical minerals. As water treatment projects for the SWS could potentially supply critical minerals in addition to treated water, those treatment projects might be able to qualify for this loan program. Loans from the program typically cover 50 percent to 70 percent of a project's total costs and are typically over $100 million in value.

Another Department of Energy program is the Advanced Technology Vehicles Manufacturing Loan Program, which can be used for industries such as electric and hybrid vehicle, electric vehicle battery, and charging infrastructure component manufacturing. The program provides loans at U.S. Treasury rates.

NEW MEXICO PROGRAMS

In addition to federal funding sources, New Mexico has several incentives that it offers to large industrial projects. Discretionary funding from the Local Economic Development Act can be used to reimburse some of the land, construction, and infrastructure costs of manufacturing projects that support the state's economic development goals. The size of the incentive varies based on factors such as a project's total investment, job creation, and quality of jobs created. In 2021, the Local Economic Development Act was expanded to allow 50 percent of state and local gross receipts taxes on the construction costs of projects to be reimbursed for projects with total construction costs of $350 million or more.

Other state incentives include industrial revenue bonds, where a company leases land from a local government in order to abate property taxes for up to 30 years, and the High-Wage Jobs Tax Credit, which offers tax incentives for the first four years of a project's operation for urban jobs created with wages over $60,000 and rural jobs created with wages over $40,000.

APPENDIX C: NMED RESPONSES TO PUBLIC COMMENTS

Comment	NMED Response
Would be beneficial to also specify infrastructure for water conveyance, i.e. conveyance of water from source/point of water storage to treatment facility. Contingent to proximity of water source to treatment facility, piping systems could be a means of conveyance, as an alternative to trucking the water to treatment facility	Author added comment to text.
Another dimension I would include is the economic expenditure involved in infrastructure development associated with treatment facilities. Economic expenditure is also tied to project location, as transportation costs of capital equipment/materials for development of treatment related infrastructure would depend on the proximity of various vendors/suppliers/distributors to project site.	Author added comment to text.
The economics don't make any sense. The study explains how the SWS proposes to use state funds to purchase liability for the significant economic and environmental risks inherent in produced water handling, transport and treatment processes from the oil and gas industry but fails to make a convincing economic argument as to why the state should adopt that risk. Presumably the "new water" the plan purports to generate is the actual value that the state would receive in return for assuming these enormous liabilities for the oil and gas industry at such a tremendous loss, but that "new water" is extremely unlikely to meet the projections in the Governor's 50-Year Water Action Plan. It is more likely to leave a legacy of contamination, damaged aquifers, hazardous waste, stranded assets and harms to workers and public health.	The SWS does not contemplate the state taking on liability for the produced water but rather as providing financial certainty and dealer to connect supply with demand. The question of liability is valid and should be explored.
Would be good to generically list the type of other costs here, to better reinforce the message.	The authors added a table with a description of the main costs associated with a project in section 8.5.
Conditional to market demand, another potential consumptive end use of treated produced water could be steam generation for industrial uses.	Author added comment to text.
The additional energy generated from the installation of the new wind turbines could potentially be used by the produced water recycling and treatment facilities for their electricity needs, thus facilitating a sustainable, cyclic system.	Author added circular economy as a key theme.

Comment	NMED Response
It is not clear which bullet points correspond to which end-uses. For industrial reuse that does not have any discharge, are any of the characterization needs or approaches required?	If there is no discharge required, NMED would provide a response to a letter of intent (LOI) from the project confirming no discharge permit is required.
Improving the relationship between a conclusion and end-use would be valuable to avoid confusion. Ex. A green hydrogen end-user or data center will have their own, internal specifications for the water quality. Thus, toxicity assays are not required.	Beyond the scope of this feasibility study.
Water recovery and water recovery rate. Time consumption and long-term performance are also major considerations.	Ongoing research question.
Additionally, ongoing research points to the potential of using AOPs in combination with UV light/catalysts for the remediation of PFAS compounds	Ongoing research question.
An alternative approach, as elucidated in pages 39 and 40 of this document, is to have a treatment train with multiple pre-treatment steps, prior to RO. This can minimize the membrane fouling potential and ameliorate RO treatment effectiveness, thus contributing to a higher water recovery.	Project, site, or technology specific consideration.
A pilot scale system of the postulated treatment train, with the selected treatment technologies, would be beneficial, as characteristics of raw water are variable across sources. This would aid in determining the effectiveness of the overall treatment train, resulting in a more informed judgement towards implementing a full-scale treatment train.	Author added comment to text.
Even for high concentrations of 40,000 to 50,000 ppm, if a treatment technology such as RO is supplemented with a combination of pre-treatment technologies, such as coagulation, biological treatment, chemical adsorption/ion-exchange, it could be a viable alternative to thermal treatment technologies.	Ongoing research question.
Furthermore, additional space would possibly be required for collection and storage of residual constituents, prior to disposal	Author added comment to text.

Comment	NMED Response
The study repeatedly references “closed loop” projects but fails to fully address the increased risk of accidental spills and discharge to land and water as a result of the SWS. During the Water Quality Control Commission (“WQCC”) hearing NMED gave sworn testimony that, according to the “notice of intent” process in its proposed produced water rule, authorized “closed-loop projects” are “not necessarily non discharge.” (WQCC 23-84, 5/16/24, Fullam, at 77.) Discharge includes spills and leaks that are inevitable at industrial scale, as well as the certainty of spills during transport of large quantities of produced water outside of the oil field. The study also fails to note that NMED gave sworn testimony that the illegal and inadequate “notice of intent” process in the pending Wastewater Reuse rulemaking has no size limitations or restrictions on location, adding to the risks associated with discharge. (WQCC 23-84, 5/16/24, at 106-110.)	NMED's NOI process considers risk of discharge in the determination of a no discharge decision.
The study briefly mentions the problem of residual waste without any serious discussion of the costs and risks related to disposal of the significant hazardous waste streams generated by the proposed treatment methods. It notes that: All treatment methods eventually require disposal of residual constituents. For produced water, the primary residual constituent is brine (salt), however other constituents found in the source water will also need to be disposed of. Disposing of these residual constituents is a nontrivial factor that can be very costly. (pg 20) Those other constituents include Naturally Occurring Radioactive Materials (NORM), PFAS and other components of fracking fluids, organics, ammonium, and heavy metals, all hazardous to human health. The study provides no quantitative or qualitative data about this hazardous residual waste stream and proposes no solutions for safe disposal.	Author added comment to text.
It might be useful to add where the majority of the PW disposal is occurring i.e., Lea, Eddy, and San Juan counties.	Author added comment to text.
The sampling method also affects the characterization results, because the surface condition is very different from the reservoir condition. The parameters include temperature, total organic carbon, oxidation-reduction potential, and total dissolved oxygen.	Project, site, or technology specific consideration.
Would be good to specify the type of dissolved solids against which AOPs are ineffective, as trace organic compounds/dissolved organic matter are also a type of dissolved solids.	The authors clarified in section 5.1 that AOPs are largely ineffective against inorganic dissolved solids (i.e., salts, minerals, etc.).

Comment	NMED Response
The study provides examples of produced water treatment and reuse in other states but fails to note the resulting environmental and health impacts resulting from those uses. For example, the study points to NPDES discharge permits for treated produced water that have been issued in other states, citing specifically Eureka Resources in Pennsylvania, but fails to note that all of Eureka Resources three “treatment” facilities have been shuttered, its fourth planned one has been shelved and the company is on the verge of bankruptcy. The Eureka Resource facilities have left a wake of contamination, pollution and harmed workers, including one who died. The study mentions the discharge of treated and untreated produced water into streams in Wyoming, where it notes the high quality of the produced water in the state without also documenting the fact that affected waterways in Wyoming are now deemed “incapable of supporting aquatic life”, and Pennsylvania, where treated produced water discharged into streams and rivers delivered high doses of radium to downstream organisms.	The authors added text to section 1.2 referencing the research linking treated produced water discharge from a Pennsylvania plant to increased radium levels downstream. The authors also added text to section 2.4 acknowledging that the Eureka Resources plant was closed in August of 2024. The reference suggested by the commenter about Wyoming produced water management appears to be about untreated produced water released in violation of permit terms, which is not relevant to the discussion of legal produced water discharges described in section 2.4. NMED is working to address concerns regarding human health and the environment through consultation with NMSU, research meetings, and upcoming rulemakings.
I believe the 25% less water stat was focused on surface water. This definitely impacts aquifers but could be a lot more than 25% less by 2072 – but it’s not known. Reference on this is also here: https://geoinfo.nmt.edu/publications/monographs/bulletins/164/	The 50 Year Water Action Plan references studies that estimate a 25% reduction in both surface water and aquifers.
This needs a citation from OSE and careful review from their staff on water rights regulations. Of all the data presented below, NONE technically fits this category for depth. This could be emphasized.	In general, deep brackish groundwater is not subject to appropriation in the conventional water rights system, though the potential impacts of deep brackish aquifer development on water resources with associated water rights are assessed by OSE.
Develop water modelling scenarios that project the impact of extreme climate variations (prolonged droughts, high temperatures) and demographic variations beyond 50 years, with a focus on the resilience of water supply.	The 50 Year Water Action Plan includes modeling for groundwater.
I don’t think this adds to the understanding of the differences in volumes between the regions. I think it is sufficient to say that the Permian generates 99 percent. Also, the math doesn’t seem right if the Permian generates 99% of PW, how is it only 87 times more?	The multiplier of 87 was deleted for improved clarity.

Comment	NMED Response
It seems like the initial flowback would be more representative of the injection fluid. Yes, that would be more dilute than formation water if that is saline and the injection water is fresh water. However, that might not be the case if produced water is used for the injection fluid.	Project, site, or technology specific consideration.
pCi/ to pCi/L	Corrected spelling error.
DS value to TDS value	Corrected spelling error.
Unfinished Sentence	Deleted partial sentence.
Multiple comments on using gallons and acre-feet in the same paragraph and throughout the doc.	The authors added additional conversions from acre-feet to gallons so that all acre-feet measurements are also reported in gallons.
The term of “localized characterization” is confusing. It seems that Fig.8 in the 2016 NMBGMR report already covers the localized characterization (as shown in Tables 4, 5, 6 and 7).	Reviewed by author but did not update text.
Clarify and check facts here. I don’t think this is the right use of the “inland desal” concept. Inland desal (as we’re considering in NM) means using groundwater and being land locked. The facilities noted here may be on land, but I suspect many of them are adjacent to oceans. Or maybe this just means it’s treating groundwater (not seawater).	Clarified what is considered an "inland" facility based on the definition used in the USBR report cited in this paragraph.
Disposal, not injection. It is dropped in well and reaches aquifer by gravity – not injected. It’s a big difference in the energy cost.	Author updated text.
VOCs & BTEX - define acronyms when they are used for the first time. It may also be helpful to add a nomenclature to the report.	Definitions for previously undefined abbreviations were added, and unnecessary and redundant abbreviation definitions were removed.
That is a very limited discharge for industry	To be considered in future rulemaking.
Near term / long term definition	Added an explanatory footnote (#1, Executive Summary).
It would be helpful if jurisdictional boundary between NMED/NMOCD is provided. Clarification related to discharges or unintentional releases for O&G activities, and a determination if amendments to the Oil & Gas Act are required to give NMED this authority would also be helpful.	Per the Produced Water Act, NMED has jurisdiction for all activities related to produced water use, transportation, and storage outside of oil and gas operations. Within oil and gas

Comment	NMED Response
	operations, EMNRD's Oil Conservation Division retains authority.
High-growth scenario - reference other scenarios / define high growth scenario	Added a footnote (#6, section 1.2) presenting the low-growth scenario estimate.
Is this projected shortfall of 750,000 acre-feet/year by 2072 inclusive of the projected increase in demand of 440,000 acre-feet/year between 2010 and 2060? It would be helpful to state the full projected deficit and normalize to a single projection year (2060 for example).	The source for the estimated shortfall does not provide details as to what it does or does not include. Unfortunately, these estimates are from different sources that use inconsistent timeframes.
Recommend adding a paragraph regarding scope of the SWS. For example, will this SWS initiative be used for agricultural irrigation of biofuel crops? Or non-food crops such as cotton?	The Strategic Water Supply does not contemplate use for anything other than advanced manufacturing, industrial use, and supporting the new energy economy at this time. There is no suggestion that it be used either for biofuels or any non-food crops.
Is it intended to read "In correlation with the increase in Oil & Gas production trends, the volume of produced water...". State the actual increase "From xx in 2017 to xx in 2023".	The suggestion to state the volumes of produced water rather than the magnitude of increase was not incorporated, but the volumes are reported in table 1. The text has been rephrased to emphasize the difference in produced water volumes between the San Juan Basin and the Permian Basin.
It would be helpful to describe the increased volume is predominantly because of the type of production in the regions (gas vs oil) as wells produce significantly less water than oil wells. Clarifying that this is not only driven by the increase in Permian activity but also the nature of that activity helps to fully understand the differences.	Author updated text.
Suggest that treated (desalinated) produced water characteristics should be included in the study. The remaining analytes after desalination are critical to understand.	Ongoing research question.

Comment	NMED Response
It would be helpful to the reader to know if these samples were treated for injection or for disposal (or both), these actions are not mutually inclusive, and treatment varies. What were they treated with and what is the inferred impact (i.e. algaecides were added to PW that was used as well stimulant and as such analytes associated with the algaecide additive are not anticipated to be naturally occurring and/or be anticipated in discharged PW).	Author added comment to text.
It was mentioned earlier in the document that flowback is when they have the highest "level" of COC, suggest taking another look.	The first paragraph in Section 2.2.3 was revised to reflect the comment and confirm that the sections of the chapter mentioning flowback are internally consistent.
Unclear what the connection between drinking water standards and brine disposal are. They are separate. This can infer that DW standards mean that the brine needs to also be below these MCLs before disposal, which is not the case and misleading.	Author added comment to text.
The capital costs of brine disposal are prohibitive for many applications, as the ability to inject the brine is limited. Therefore, evaporation ponds are typically cited but are expensive at >$300,000/acre. Dozens of acres would be required for a small, 1 MGD facility operating at 85% recovery. [...] My point is CapEx for brine disposal/management is way more daunting and prohibitive than OpEx for Brackish water.	Ongoing research question.
This analysis overestimates the water use by about 2x and barely touches on the vast electrical demand required to accomplish such a feat. A 100 MW electrolyzer will require ~ 250,000 gpd of ultrapure water but - as the size suggests - requires 100 MW of electricity. This is ~ 2,400 MWh of electricity, and at a price of $0.06/kWh, costs ~$144,000/day just in electricity. Furthermore there is a constrain on building out electrical infrastructure as there are still supply/demand imbalances and critical components like transformers cannot be acquired easily. It is my understanding that the time lags for getting renewable projects up and running are on the order of ~ 3-5 years due to permitting.	Project, site, or technology specific consideration.
They recirculate their cooling loop, so your calculation overestimates water requirements.	The example Plug Power green hydrogen plant referenced in section 4.2.1 was changed to a different Plug Power plant to reflect the updated example and water consumption numbers from the cited reference.

Comment	NMED Response
This is for their feed water to the ultra pure water treatment plant. Their electrolyzer require ultra pure water w 15 megohm resistivity, < 0.05 ppm of salinity (TDS) and hardness and turbidity concentrations near zero.	Project, site, or technology specific consideration.
If you run the numbers just on OpEx costs, water is ~ 3% of a green hydrogen's total OpEx, when the cost of electricity is included. Therefore, some wiggle room is warranted.	Project, site, or technology specific consideration.
18 million MOhm or 18 MOhm?	Author updated text.
This data can be updated based on the 2024 GWI desal data.	The authors found a database of GWI desalination projects (https://www.globalwaterintel.com/projecttracker?filters%5BInclude+archived+projects%5D=Include+archived+projects), however, it was not open source or available to the public. Additionally, the GWI database appeared more limited and did not have the same kind of data as the current source.
Double check abbreviations	Definitions for previously undefined abbreviations were added, and unnecessary and redundant abbreviation definitions were removed.
An important missing component of this section is the ability to which these deep groundwater resources may or may not be recharged. In some cases, these resources have taken millions of years to accumulate and in others meaningful recharge may not be possible. This should be acknowledged both as a limitation for development (i.e. this is a nonrenewable resource which will run out at an unknown time) and in recognition of the potential to further exacerbate New Mexico's water scarcity challenges down the road by promoting dependence on these waters by communities or industries.	Author added comment to text.
We understand information is limited but encourage additional evaluation here. We would appreciate showing any differences between information obtained at various well depths as this is likely very pertinent to deep brackish water development. We note that the mean and median for both the Española and Albuquerque Basins, as well as the median for the Mesilla Basin are potable water, 1,000 TDS or below. The report should clarify explicitly that the data summarized in these sections are for water chemistry available to the NMBGMR, regardless of depth.	Author added comment to text.

Comment	NMED Response
We are deeply concerned about this potential for impacts to shallower groundwater and surface waters. We underscore the Environment Department's finding that additional research is needed. We believe full funding of the Aquifer Mapping Program to better understand these deep groundwater resources is necessary for any part of this brackish water proposal to move forward.	For consideration in the implementation of the 50 Year Water Action Plan.
We understand the need to minimize costs but encourage the Environment Department to review these exploratory wells thoroughly. We are concerned that the spatial and geologic siting bias of industry wells has the potential to systematically bias characterizations of deep aquifer hydrology, size, quality, and connectivity to surface and shallow groundwaters.	For consideration in the implementation of the 50 Year Water Action Plan.
We are deeply concerned about this potential and underscore the study's note that a thorough understanding of geologic and hydrologic properties is needed before this proposal can move forward.	Project, site, or technology specific consideration.
We are deeply concerned about this potential and underscore the study's note that additional study is needed to be reasonably sure pumping will not impact surface waters.	Project, site, or technology specific consideration.
Regulations around groundwater extraction at 2,500 feet or more include exemptions for non-potable water for "oil and gas exploration and production, prospecting, mining, road construction, agriculture, generation of electricity, use in an industrial process or geothermal use" we encourage the Environment Department to further explore this with the Office of the State Engineer and ensure the appropriate regulations are in place to place any requirements needed to protect the public's interests.	For OSE's consideration in the implementation of the 50 Year Water Action Plan.
We highlight that this is not required in statute. It should be noted in the report that currently public notification is all that is statutorily required. OSE may require pertinent data to be collected but is not required to, nor are those data outlined in statute. We also highlight that without additional information on the characterization of deep aquifers, it may not be possible for the OSE to make an appropriate determination, despite the agency's best intentions. Depending on the amount that brackish groundwater development moves forward, this may require additional personnel and certainly additional staff time than is currently allocated of existing personnel and this should be considered as part of the overall cost of moving forward.	For OSE's consideration in the implementation of the 50 Year Water Action Plan.

Comment	NMED Response
We are deeply concerned about this aspect of the proposal and highlight the study's finding that disposal of residual constituents is a nontrivial factor that can have significant negative consequences for the environment and overall economic feasibility of the proposal. We also highlight that there is an environmental justice component that must be acknowledged here and considered in how and where disposal will be completed.	Acknowledge that disposal of waste is a significant ongoing question for research, economics, and regulation.
It should be noted in the report that this is currently at the discretion of the agency (see earlier comment.)	Author updated text.
We encourage the Environment Department to explore further that all necessary regulations are in place to both ensure that any requirements that should be placed on development of this deep groundwater are able to occur and that sufficient protections are in place for existing water rights owners.	For OSE's consideration in the implementation of the 50 Year Water Action Plan.
Water at this depth is not currently permitted. Please see earlier comment on use exemptions and obtain clarity from the OSE.	For OSE's consideration in the implementation of the 50 Year Water Action Plan.
For reuse Iron content would be more important, it would be helpful if this is considered. If TDS is determined to be more important it would be helpful for readers to reference the citation.	An existing citation was appropriate. The bulleted list and text above it in section 2.2.2 have been revised to address comment.
Suggest clarifying this statement for the reader, explaining why this conventional well data may (or may not) be representative: "limited data exists for unconventional well PW within these basins, which we expect to have potentially higher TDS than conventionally drilled wells, due to...."	Author updated text.
It would be helpful to the reader to know if these samples were treated for injection or for disposal (or both), these actions are not mutually inclusive, and treatment varies. What were they treated with and what is the inferred impact (i.e. algaecides were added to PW that was used as well stimulant and as such analytes associated with the algaecide additive are not anticipated to be naturally occurring and/or be anticipated in discharged PW).	For consideration during rulemaking.
A targeted list of analytes is defined based on a broad representation of produced water. Therefore, the stated premise is not correct. The actual fact is that the targeted list of analytes is so broad that it is very conservative for PW samples. This is proven by the great percentage of analytes that are non-detect.	For consideration during rulemaking.
It would be helpful to include information on the quality of treated water currently used by water districts. This will help determine the appropriate treatment standards for produced water, even with higher TDS levels.	For consideration during rulemaking.

Comment	NMED Response
It would be helpful to include the water quality in the referenced states for a full picture comparison.	Text in section 2.4 has been added to acknowledge the data gap regarding produced water quality data in the referenced states. A fuller exploration of additional data is beyond the scope of these revisions.
"Existing publicly accessible do not contain" - incomplete sentence?	Author updated text.
This conclusion narrowly focuses on the availability of mammalian toxicity data for the list of constituents. There are other ecotox, QSAR (quantitative structure activity relationships), or NAMs (new alternative methods) data available to support assessments. It would be helpful to expand for a full conclusion.	For consideration during rulemaking.
It would be helpful to provide consideration to footprint, construction impacts, species and habitat impacts, impacts to WOTUS and state waters, plant and equipment emissions, etc. for the construction and operation of pipelines and treatment facilities, and for the additional environmental impacts of continuous trucking and operations. Should consider Environmental Justice concerns, impacts to communities, etc.	Project, site, or technology specific consideration.
Is the jurisdiction at the geographical boundary of the oilfield or is this referencing "downhole" use? clarify.	Produced water management inside the oil and gas industry, or "in the oilfield," means produced water management associated with the exploration, drilling, production, treatment or refinement of oil or gas, including recycling for oil and gas production and disposal of in underground injection wells.
This prohibition language is in conflict with nearly all opportunities for reuse of treated produced water.	For consideration during rulemaking.
One bullet point is a different font	Author updated text.
Utilize volume, "From XX in 2021 to XX in 2023".	The text in section 2.8 has been rephrased and volumes added.
These are examples for sanitary wastewater treatment.	Author updated text.
Sewer is a transport example, not a disposal example.	Author updated text.
Once the water is in the hands of the end user, per an agreement on the terms of water quality, the water is now owned by the end user. The treated water is no longer "produced water" or "brackish water" or "saline water", it is now inlet water to the end user. The end user will be responsible for managing its wastewater. If the end user is concerned about specific constituents, it should be addressed by the inlet water specifications that the reuse water supplier must meet.	Project, site, or technology specific consideration.

Comment	NMED Response
Added references 170a and 170b, but the footer has pushed references 172 and 173 off the page.	Added suggested text and references.
The conclusion is very restrictive on reuse of treated produced water. Most all opportunities do not fit into a “non-discharge’ criteria. The conclusion should address the need to be open to discharge scenarios.	For consideration during rulemaking.
Noting our objection to public subsidies for the treatment and commodification of oil and gas wastewater, we do appreciate that the Feasibility Study provides different scenarios for quantifying the amount of public subsidies that would be needed to achieve various projects in the SWS. These range from between $3-$107M for brackish water, and up to $667M for Produced Water. If the state would like to play a role in the treatment of produced or brackish water, the state should impose fees on industry, as Secretary Kenney and Rebecca Roose alluded to at the Legislative Finance Committee meeting on September 16th. We had hoped that this would be mentioned in the Feasibility Study, but we saw only Advanced Market Commitments and Advanced Market Purchases mentioned (Section 8.3). It is not clear if funds for such commitments or purchases would be raised through bonds that rely on the Severance Tax Permanent Fund or what the exact funding mechanism would be. The 2025 legislative session is fast approaching, and it is highly problematic that the Department has not yet clarified what type of funding mechanism it will propose for legislative approval, whether funds would be expenditures or loans/investments paid back by industry, and how risks would be apportioned between the state and developers.	To be considered in legislation and rulemaking.

Comment	NMED Response
We highlight here Section 8.5 of the study which states, “Value of Alternative to SWD: Concerns about seismicity related to SWD may lead to constraints on current produced water disposal practices, which could severely limit oil and gas production activity and increase the amount that the oil and gas industry is willing to pay for alternatives to SWD, such as diversion to a treatment facility for reuse outside the oil and gas industry. In that case, the need to subsidize produced water treatment may be reduced or eliminated.” We have two comments about this section. First, if the price of freshwater available to industry accurately reflected its scarcity–in other words if the price were higher and truer to its real value to our society–then the industry might find it necessary to put up the capital required to clean its wastewater. Second, in lieu of market solutions, even if the state intervenes, it will face risks about the long-term availability of produced water required to meet throughput levels to support financial feasibility. It is already widely acknowledged that other factors are likely to slow production by 2030 beyond increasing constraints on current disposal practices. In many respects, these other factors elevate our concern that the use of public funds to treat and commodify oil and gas wastewater has little to do about addressing projected water supply shortages and more to do with propping up oil and gas production in the state and acquiescing to its attendant adverse impacts to climate, environment, and public health.	For EMNRD's consideration in the implementation of the 50 Year Water Action Plan.
Related to our comment above, industry has had access to freshwater at far too low a price for some time (Section 8.2 is a useful summary of this pricing data, thank you). Therefore, any critical minerals mined out of wastewater should not, in our opinion, be solely owned by those companies. If, as Section 8.1.2 suggests, they are able to recover critical minerals such as lithium from the wastewater, the revenue from those critical minerals should be shared with the State in proportion to the risks assumed and by accounting for the effective subsidy provided by the far too low price provided to industry to acquire freshwater.	For consideration during legislation.

Comment	NMED Response
One of the stated goals of the Strategic Water Supply is to support industrial projects within New Mexico that align with the State's development goals (Section 4.1). Examples cited are green hydrogen production, data centers, pumped storage hydropower, and cement/concrete production. It is worth noting, however, that no RFIs were submitted by companies that were interested in using treated water for any of those uses except green hydrogen (and of course some companies submitted for hydrogen projects that are less than "green.") Therefore, there is no reason to believe that the State will find off-takers for these projects, potentially leaving taxpayers on the hook for a much larger subsidy than those cited in #4 above. Hydrogen is also the only type of reuse listed that the feasibility study lists as "no discharge" (see Table 8). Given that the rule before the WQCC would prohibit discharge, then really the only industrial project that would be allowed is green hydrogen. We wonder, then, if the SWS will become mainly a subsidy for green hydrogen.	To be considered in legislation and rulemaking.
The principal determinant of the quality of oil produced water is whether the well is unconventional, I.e., fracked. All Permian Basin produced water is from unconventional wells. Also, it is commingled in complex arrangements with midstream companies. Therefore, this statement fails to inform the reader of the most relevant facts. It is highly likely that the quality does vary in the Permian Basin "depending on the formation" but that statement is scientific theory. The quality of produced water generated by operators is a closely held trade secret, thus the design of the NM Produced Water Research Consortium's database design limits geographic location precision to a very large area for raw produced water samples contaminant concentrations data.	Ongoing research questions.
Other clear evidence is omitted, such as the energy requirements for desalination of produced water and its carbon footprint.	Project, site, or technology specific consideration.
This report merely cautions that the energy requirements might not be in line with New Mexico's goals to reduce carbon emissions, without addressing the amount of energy or carbon at issue.	Project, site, or technology specific consideration.
Treatment of Permian Basin produced water to create a high-quality water stream, and a concentrated waste stream has not been done at field scale.	Project, site, or technology specific consideration.

Comment	NMED Response
The OCD Statistics page cited in this report on October 15 shows 2023 produced water subtotals from SE oil wells at 1,690,000,000 barrels, with 589,000,000 more from SE gas wells.	The 2023 data as cited agree with the data download we worked with. The data were, however, downloaded on 2/13/2024. This is now clarified in a footnote (#31, section 2.2.1). The values are different now. The text notes that reported volumes have been known to change over time months after the 45-day lag time. It appears the 2023 data were changed again between 2/13/2024 and now.
Please cite references. Australia, Israel, and the United States have also used brackish water for potable uses.	Added references in section 1.2 for examples of brackish water desalination in other countries.
I checked the citation, and it sent me to a GIS data download page and not a map. The map doesn't have a legend, north arrow, or scale bar. Artesia, Santa Fe, Hobbs, and Aztec appear to be in the wrong locations, or are those the "basins"? Are the colored areas hydrocarbon basins or aquifers (not clear in the map)? If they are hydrocarbon basins, please cite the source of the data. What are the purple dashed lines? It is difficult to read some of the city labels (e.g., Farmington).	The author deleted this map, as it was largely duplicative of, and of lesser quality than, figure 7.
This column is unclear to me. If this is PW injection and EOR it seems like a misleading number when the rest of the table is focused on PW. As stated in the text, we don't know the source of injection.	Text in section 2.3 has been edited to note that the OCD data don't explicitly state whether all injected PW is sourced within the San Juan.
For 2021-2023 in San Juan Basin, the injected PW has higher volume than total PW. The injection wells in San Juan Basin were getting PW from other Basins nearby? An explanation may be needed.	Text in section 2.3 has been added to note possible reasons for estimates that exceed 100%.
Some of those data go pretty far back if I remember correctly. We did a project with Martha in 2016, and she received a bunch of newer Permian WQ data from one of the producers and I thought she updated the database. Those data were also used for the analysis in: Chaudhary, B.K., Sabie, R., Engle, M.A., Xu, P., Willman, S. and Carroll, K.C., 2019. Spatial variability of produced-water quality and alternative-source water analysis applied to the Permian Basin, USA. Hydrogeology Journal, 27(8), pp.2889-2905.	The suggested reference has been added to the paragraph above Table 2.
Please cite this reference: https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas	The suggested text has been added in section 2.2.3 along with reference to USEPA PFAS MCL's.

Comment	NMED Response
We published a case study that starts to make this assessment: Sabie, R.P., Pillsbury, L. and Xu, P., 2022. Spatiotemporal Analysis of Produced Water Demand for Fit-For-Purpose Reuse—A Permian Basin, New Mexico Case Study. Water, 14(11), p.1735.	Reference has been added with brief text in section 2.3 on the purpose and conclusions.
Please cite these two recent publication on toxicity studies: 1. Tarazona, Y., Hightower, M., Xu, P., Zhang, Y. (2024). Treatment of produced water from the Permian Basin: Chemical and toxicological characterization of the effluent from a pilot-scale low-temperature distillation system. Journal of Water Process Engineering, 67, 106146. https://doi.org/10.1016/j.jwpe.2024.106146 2. Tarazona, Y., Wang, H. B., Hightower, M., Xu, P., Zhang, Y. (2024). Benchmarking produced water treatment strategies for non-toxic effluents: integrating thermal distillation with granular activated carbon and zeolite post-treatment. Journal of Hazardous Materials, 478, 135549. https://doi.org/10.1016/j.jhazmat.2024.135549	References have been cited with brief mention of the work in section 2.5.2.
If these volumes are only injected produced water, suggest adding "PW" to column heading.	The column heading has been edited to note PW parenthetically.
This statistic can be confusing for readers who do not understand the volume of gas vs oil production in each of these regions and typical PW generation from oil vs gas wells. This can be misconstrued to mean that Gas wells in the NW produce more water than gas wells in the SE. Suggest tying to production and normalized as PW/BOE, or removed.	The two columns have been deleted for brevity and clarity.
It would be helpful if details or reference is provided supporting the statement.	Author updated text.

Comment	NMED Response
Results from NTA are operational and reflect the methods of ionization, separation and detection. Plus, it is semi-quantitative and relies on matching of spectra to available libraries. It requires expert judgement to assist the interpretation. Recent NMSU work (https://www.sciencedirect.com/science/article/pii/S030438942401015X) show a limited number of peaks in treated PW. And in treated PW the major stressors are usually inorganics like ammonia (https://www.sciencedirect.com/science/article/pii/S0304389424021289)	The text has been edited to reflect the comment in section 2.5.1, and the two references were added.
It would be helpful to include a citation.	Reference to Hightower et al. (2021) has been added.
It would be helpful to include a citation.	Added reference to Hawley, 2016.
I believe the 25% less water stat was focused on surface water. This definitely impacts aquifers but could be a lot more than 25% less by 2072 – but it's not known. Reference on this is also here: https://geoinfo.nmt.edu/publications/monographs/bulletins/164/	Edited text in section 1.2 to reflect estimated reduction in river flow in NMBGMR report.
Not sure what this map should be showing, but well points for active wells are not well labeled and all of it is very hard to see. What do the different colored polygons represent? Should this have a legend?	We have deleted this map, as it was largely duplicative of, and of lesser quality than, figure 7.
Clarify and check facts here. I don't think this is the right use of the "inland desal" concept. Inland desal (as we're considering in NM) means using groundwater and being land locked. The facilities noted here may be on land, but I suspect many of them are adjacent to oceans. Or maybe this just means it's treating groundwater (not seawater).	Clarified what is considered an "inland" facility based on the definition used in the USBR report cited in this paragraph.
The Governor's announcement is not an appropriate citation for this estimation. It should be noted that this citation is referring to all brackish groundwater in New Mexico and not only the deep brackish groundwater that is being discussed as treatable for the Strategic Water Supply. Brackish groundwater above 2,500 feet is being used for various purposes across the state. It should be underscored here that there are still unknowns surrounding the volume of water, particularly at the levels proposed for the Strategic Water Supply.	Added footnote (#8, section 1.2) to clarify what is included in the reported volume estimate and added references that provide additional volume estimates for various aquifers in New Mexico.

Comment	NMED Response
We understand information is limited but encourage additional evaluation here. We would appreciate showing any differences between information obtained at various well depths as this is likely very pertinent to deep brackish water development. We note that the mean and median for both the Española and Albuquerque Basins, as well as the median for the Mesilla Basin are potable water, 1,000 TDS or below. The report should clarify explicitly that the data summarized in these sections are for water chemistry available to the NMBGMR, regardless of depth.	Added a sentence to the end of the first paragraph in Section 3.3 clarifying that the data in the tables is based on data available to NMBGMR regardless of depth.
Suggested text insert: "New Mexico has taken the very "first step" to assessing the toxicity and risk to human health and the environment: "to properly assess risk, having an a priori understanding of the ecotoxicity effects of PW [produced water] to different organisms is necessary for both risk management and in helping to define the most toxic components and necessary treatment strategies prior to PW [produced water] discharge and reuse."	The authors inserted text in section 2.5.2 referencing the study, including stating that understanding how produced water subcomponents impact different organisms is needed for risk management and for assessing treatment needs.
Suggested text insert: "New Mexico Oil & Gas Association submitted into the record an April 2024 peer-reviewed scientific report that states: "[I]dentifying unknowns using solely targeted techniques is nearly impossible due to the complex composition of PW, the lack of appropriate internal standards, and unreasonably high analytical costs for the multitude of potential constituents. Most of the existing literature on PW treatment technology evaluations is based on limited targeted analyte removals and therefore does not demonstrate human health and ecological safety in long-term reuse applications."	The authors inserted text in section 2.5.1 referencing the study, including noting that targeted analysis of a specific set of analytes risks missing constituents that may pose human health and ecological safety concerns.