Valorization potential of major constituents from brackish groundwater desalination brines

NAWI 3.26: Techno-economic Assessment of Brine Valorization from Brackish Water Desalination

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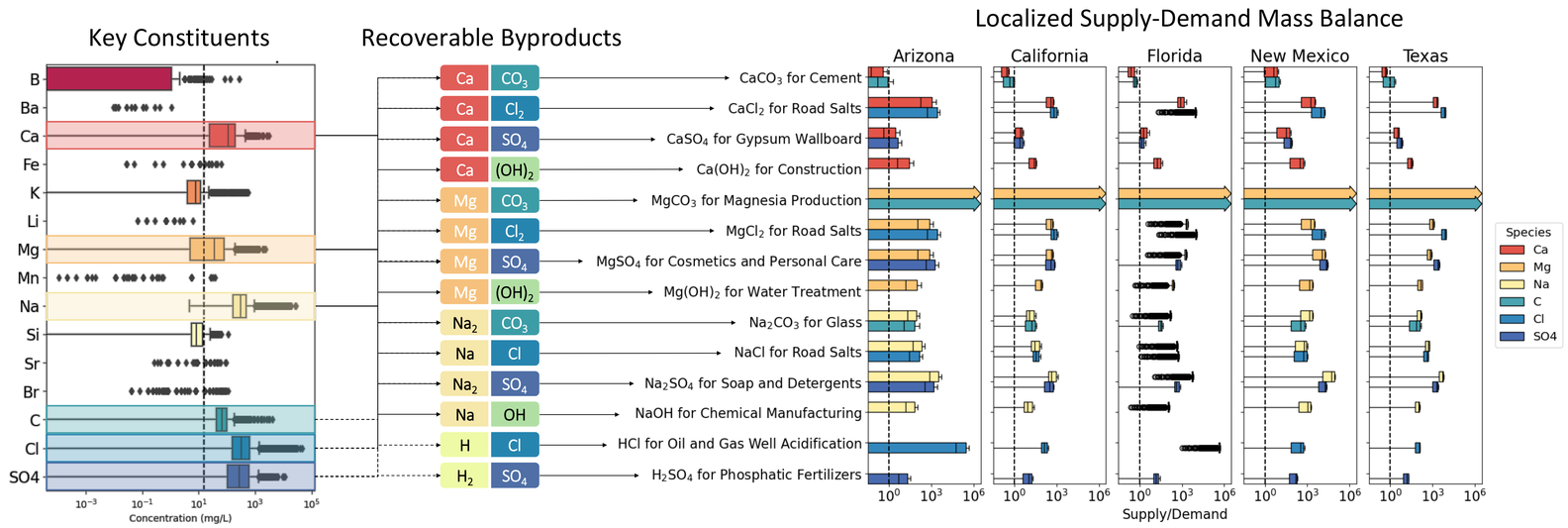
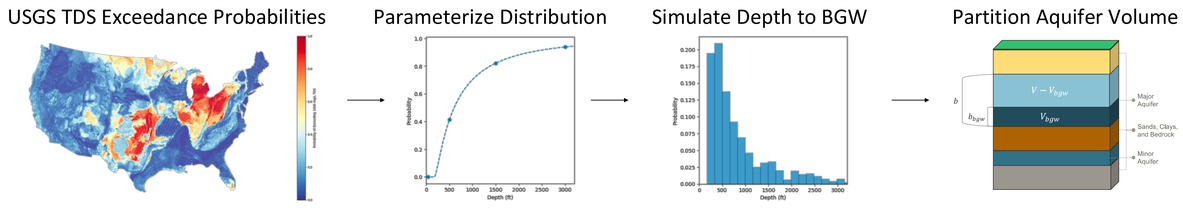
We present a **spatially resolved supply-demand mass balance framework** for brackish groundwater desalination brine valorization. We then demonstrate the utility of this framework through a case study in **5 high priority states**.

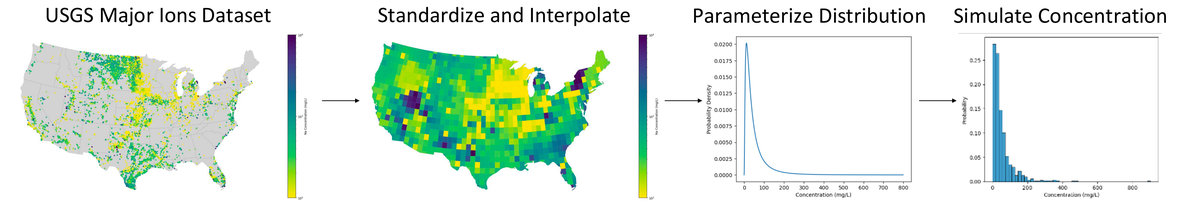


Widespread use of brackish groundwater desalination has been historically inhibited by concerns over waste management, as most traditional brine disposal methods are too economically or environmentally costly to be sustainable in the long-term. Brine valorization, a process through which a set of marketable byproducts are selectively recovered from brine streams, presents an opportunity for desalination facilities to offset waste management costs while mitigating environmental concerns. The viability of this solution, however, is dependent on the suite of byproducts potentially recoverable from brines and the capacity of local markets to absorb them. Here, we present a spatially resolved supply-demand mass balance framework for brackish water desalination brine valorization in the United States.

Monte Carlo Simulation of Brackish Groundwater Constituent Supplies

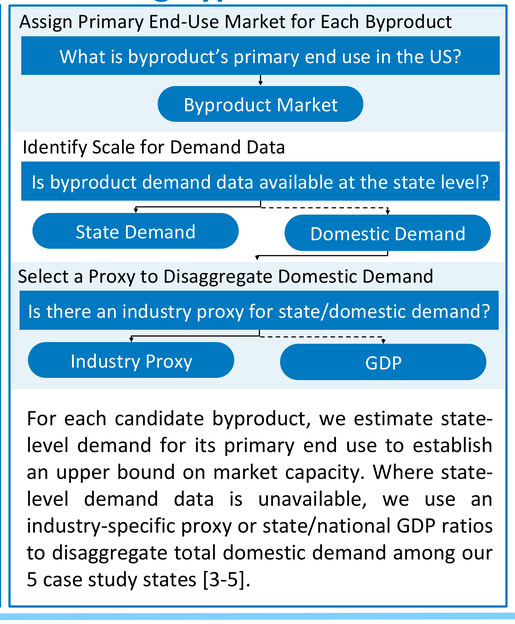


Volume. We use USGS groundwater TDS exceedance probability maps [1] to parameterize a lognormal cumulative distribution function for predicted depth to brackish groundwater in each cell of a 1˚x1˚ grid of the US. Our Monte Carlo simulations use depth values sampled from these distributions to partition total aquifer volumes from [2] into fresh and brackish extents.



Concentration. To characterize the composition of brackish groundwater, we use the USGS Major Ions dataset [1] to calculate the median and standard deviation of sample concentrations of key constituents across our 1˚x1˚ grid, interpolating missing values using the Inverse Distance Weighting (IDW) Method. We then use these statistics to parameterize a lognormal CDF from which to sample.

Estimating Byproduct Demand



For each candidate byproduct, we estimate state-level demand for its primary end use to establish an upper bound on market capacity. Where state-level demand data is unavailable, we use an industry-specific proxy or state/national GDP ratios to disaggregate total domestic demand among our 5 case study states [3-5].

NAWI CONNECTIONS

Period of Performance: September 2023 – Present

Topic Area: Data Modeling and Analysis

This work contributes to NAWI's ongoing efforts to develop standardized methods for assessing technology performance potential to align work across research areas.

NAWI Leverage:

In conducting this study, we leveraged NAWI's extensive network of academics and industry professionals to assemble a board of stakeholders with extensive knowledge of brackish water resources, brine generation, and target end-use markets. The collective expertise of this stakeholder board has helped us to streamline our byproduct screening process, narrowing our focus to only the most promising valorization pathways.

KEY FINDINGS AND CONCLUSIONS

We find that, in most cases, the byproduct supply theoretically recoverable from brackish groundwater falls on a similar order of magnitude to state-level demand, a promising indicator for feasibility of market penetration. However, in some states, particularly New Mexico, the demand for brine byproducts is not sufficiently high to absorb the recoverable supply, which could be problematic for brine valorization efforts in these regions.

REFERENCES

Adkins, Caroline, et al. *Valorization potential of major constituents from brackish groundwater desalination brines*, 2025 (under review).

1. Stanton, Jennifer S., et al. *Brackish groundwater in the United States*. No. 1833. US Geological Survey, 2017, doi:10.3133/pp1833.
2. Niazi, H., et al. *Global Geo-processed Data of Aquifer Properties by 0.5° Grid, Country and Water Basins*. v1, MSD-LIVE Data Repository, 2024, doi:10.57931/2307831.
3. *Ullmann's Encyclopedia of Industrial Chemistry, Electronic Release.* Wiley-VCH, Weinheim 2025, doi: 10.1002/14356007.
4. *Metals and minerals: U.S. Geological Survey Minerals Yearbook 2023.* v1, U.S. Geological Survey, 2023, doi:10.3133/mybvl.
5. US EPA. *Water Treatment Chemical Supply Chain Profiles*. 2022, https://www.epa.gov/waterutilityresponse/water-treatment-chemical-supply-chain-profiles.

ACKNOWLEDGEMENTS

This material is based upon work supported by the National Alliance for Water Innovation (NAWI), funded by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), Industrial Efficiency and Decarbonization Office under Funding Opportunity Announcement DE-FOA-0001905. This material is also based upon work supported by the National Science Foundation Graduate Research Fellowship Program under Grant No. DGE-2146755. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation or the U.S. Department of Energy.

This material is based upon work supported by the National Alliance for Water Innovation (NAWI), funded by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), Industrial Efficiency and Decarbonization Office, under Funding Opportunity Announcement DE-FOA-0001905.