*Toward a Disaster Resilient California*

# Innovations in
# DESALINATION

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Briefing held: **FEB. 2023**

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**Photo:** Charles E. Meyer Desalination Plant in Santa Barbara, California | Florence Low / Calif. Dept. of Water Resources


## SUMMARY

- Current desalination technology most often uses reverse osmosis to separate salt and other contaminants from water.
- Desalination produces freshwater that meets the highest water quality standards, but high costs and environmental impacts limit the role it currently plays in California's water portfolio.
- Experts across California's preeminent academic and research institutions are exploring ways to improve desalination and drive down costs.
- As the costs of desalinated water approach parity with other freshwater resources, many new applications for desalination can be imagined.


## DESALINATION FOR **WATER SECURITY**

As California braces for what may be a fourth year of historic drought conditions (even despite record rainfall this January), **desalination** is receiving renewed interest as a tool for securing drought-proof water supplies.

**Seawater desalination**—where salt and other impurities are removed from seawater, resulting in pure freshwater—already contributes to water resilience for several coastal Californian communities like San Diego and Santa Barbara. Further inland, **brackish groundwater** is desalinated to serve communities like Newark and Irvine. With 840 miles of coastline, some have asked why California hasn't yet pivoted to this seemingly endless supply of water as a solution to its water challenges.

Most desalination today is accomplished with **reverse osmosis** (see next page). While this technology has come a long way since first being developed at the University of California Los Angeles in the 1950s, desalination is still prohibitively costly for many communities. However, as climate change threatens California's (and much of the world's) freshwater supplies, researchers are working to change the equation and reimagining ways that desalination could contribute to water security.

## DESALINATION **CHALLENGES**

### HIGH ENERGY DEMAND

Significant energy is required to desalinate water. Energy accounts for more than one-third the operational costs of running desalination plants.

### BRINE DISPOSAL

Desalination results in a hypersaline byproduct known as "brine." Brine disposal can be costly—especially for inland brackish water desalination plants—and may negatively impact marine environments.

### IMPINGEMENT AND ENTRAINMENT

Intake pipes of coastal desalination plants can have inadvertent effects on marine organisms, including **impingement** (pinning larger organisms against intake screens) and **entrainment** (pulling in and transporting organisms through the pipes). Subsurface intake pipes (placed underneath the ocean floor) can all but eliminate these types of impacts. However, subsurface intakes are not feasible for many locations and are considerably more expensive.

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## SELECT EXPERTS

The following experts can advise on desalination:

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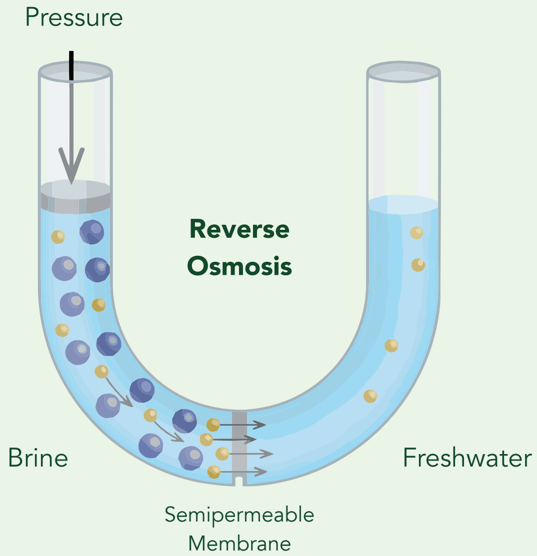


**Figure:** A diagram of reverse osmosis via semipermeable membrane. Modified from Wikimedia Commons.

## HOW IT WORKS

**Most desalination plants rely on reverse osmosis to remove salt and other impurities from seawater and brackish water, but what does that mean?**

When two solutions are separated by a semipermeable membrane (i.e., a membrane that allows water molecules to pass, but nothing else), there is a natural tendency for water to move from the more dilute solution to the more concentrated solution. This process is known as **osmosis**.

**Reverse osmosis** works when pressure is applied to the more concentrated solution. With enough external pressure, water molecules will be driven through the membrane in the other direction—towards the more dilute solution. This results in freshwater on one side of the membrane and a concentrated salt solution, known as brine, on the other.

## Mitigating Membrane Fouling

Seawater contains many contaminants beyond salt. As water is forced through the semipermeable membrane, these materials can get stuck to the membrane, clogging the pores. This is known as **membrane fouling**. Frequent membrane fouling significantly increases operational costs for desalination plants, reduces the lifetime of membranes, results in poorer water quality, and decreases plant production.

Researchers like **Dr. Sunny Jiang** at UC Irvine are working to identify sustainable solutions to reduce membrane fouling. For example, Dr. Jiang is exploring early warning systems that could alert operators to contamination in the desalination chambers. She is also investigating other options for pretreatment that reduce contaminants before they are introduced to the desalination chambers

## Synergies with the Power Grid

A lot of energy is required to create the pressure necessary for reverse osmosis. Should desalination come to play a larger role in California's approach to drought resilience, the demands these facilities will place on the state's electrical grid are not insignificant.

One option for reducing the energy burden created by desalination plants is to optimize the timing of their operations so they draw energy only when other demands for energy are low (or when the state's renewable resources are abundant). **Dr. Meagan Mauter's** team at Stanford are exploring how best to coordinate the operations of desalination and other water treatment facilities with the state's evolving energy grid.

## Brine as Thermal Energy Storage

Desalination plants generate a hypersaline byproduct known as **brine**. Brine disposal remains a significant challenge for desalination. Often, these extra salty solutions will be diluted with waste freshwater before being returned to the ocean. Though the brine is diluted, it still saltier than typical seawater and can negatively impact the marine ecosystems where it is deposited.

**Dr. Reza Baghaei Lakeh's** team at Cal Poly Pomona have demonstrated that this brine can be repurposed for thermal energy storage systems, thus creating value from what would otherwise be costly waste.

## Inland Desalination?

Though most often discussed in the context of seawater, desalination has applications beyond the coast. For example, California has plenty of brackish groundwater, particularly in the Central Valley. As costs of desalination decrease, this oft-overlooked water resource may become a cost-effective solution for resolving some key challenges facing the region.

For example, due to poor drainage, salts and other contaminants have been accumulating in these soils. Agricultural runoff could be desalinated, the freshwater recycled to irrigate fields, and the brine disposed or repurposed—a process that would essentially flush salt from the soil. **Dr. David Sedlak** and other researchers with the National Association for Water Innovation are exploring the potential for desalination to achieve "pipe parity" (i.e., cost competitiveness with alternative water resources) in the San Joaquin Valley.