Albany Seawater Desalination Plant
Zero Liquid Discharge Study - Summary

Technical Partner

This desktop study was commissioned by Water Corporation and undertaken by Jacobs, an independent engineering consultancy.

This document is prepared by Water Corporation and is a highly summarised version to support community and stakeholder engagement, providing a clear overview of the study's key findings.

Purpose of the Study

Due to climate change and population growth, there is a projected increase in demand for drinking water. Water Corporation is investigating potential areas for a future seawater desalination plant near Albany. This initiative aims to ensure a secure and sustainable water supply for the Lower Great Southern Towns Water Supply Scheme (LGSTWSS) beyond 2030.

The purpose of this study was to assess whether zero liquid discharge (ZLD) technologies could be used to manage brine waste from a potential seawater desalination plant in Albany. It aimed to identify environmentally responsible options that eliminate liquid waste, while considering technical feasibility, cost, and local conditions.

It relies on data provided by Water Corporation and other sources and does not include site investigations or water sampling; findings may change if input data is later found to be inaccurate or incomplete.

Technology Options Considered

Seven options were assessed, combining reverse osmosis with different brine management technologies:

1. **Option 1 – Reverse Osmosis + Outfall**
   This option involves using reverse osmosis to treat seawater and discharging the brine back to the sea via an outfall pipeline with a number of diffusers. This is the typical method of brine discharge for seawater desalination plants.
2. **Option 2 – Reverse Osmosis + Evaporation Ponds**
   This option combines reverse osmosis with evaporation ponds for brine disposal.
3. **Option 3 – Reverse Osmosis + Evaporator + Crystallizer**
   This option combines reverse osmosis with evaporators followed by crystallizers.
4. **Option 4A – Reverse Osmosis + Ultra-high Pressure Reverse Osmosis (UHPRO) + Evaporation Ponds**
   This option further concentrates brine from the reverse osmosis system by ultra-high pressure reverse osmosis, and the final brine is discharged to evaporation ponds.
5. **Option 4B – Reverse Osmosis + Osmotically Assisted Reverse Osmosis (OARO) + Evaporation Ponds**
   This option further concentrates brine from the reverse osmosis system by osmotically assisted reverse osmosis, and the final brine is discharged to evaporation ponds.

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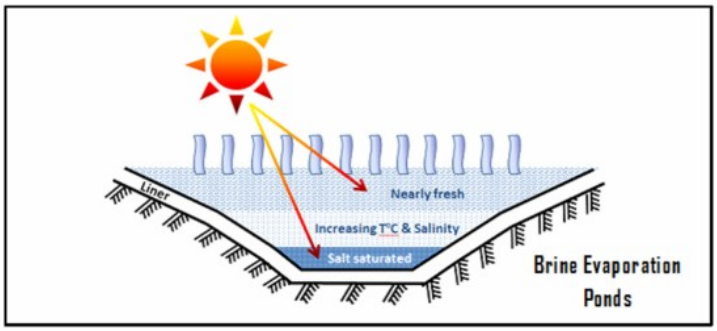
6. **Option 5A – Reverse Osmosis + Ultra-high Pressure Reverse Osmosis (UHPRO) + Evaporator + Crystallizer**
   This option removes the salt from the brine produced by the ultra-high pressure reverse osmosis using evaporators and crystallizers.
7. **Option 5B – Reverse Osmosis + Osmotically Assisted Reverse Osmosis (OARO) + Crystallizer**
   This option removes the salt from the brine produced by the osmotically assisted reverse osmosis using crystallizers only.

Evaporation Ponds

Evaporation ponds are large, excavated areas used to store brine from reverse osmosis, allowing water to evaporate and leave behind salt, which is periodically removed and disposed of offsite. They must be lined to prevent groundwater contamination, and leak detection systems are recommended to monitor liner integrity.

Their effectiveness depends heavily on climate—dry, warm conditions with low humidity are ideal. In wetter areas like Albany, evaporation is slower, requiring much larger pond areas. Multiple ponds are typically used to allow for maintenance and salt removal without disrupting operations.

To work out how much land is needed for evaporation ponds, different scenarios were considered. Pond sizing was calculated using detailed water and salt balance modelling, taking into account local climate conditions like rainfall and evaporation. This approach ensures the design is realistic and robust, rather than relying on simple averages.



Evaporators and crystallizers

Evaporators and crystallizers are used to treat salty brine by heating it to remove water and leave behind solid salt. The evaporator reduces the volume by turning water into steam, and the crystallizer turns the remaining concentrated brine into salt crystals. These crystals are then dried to form solid waste. The system also produces clean distilled water that can be reused.

While this method can achieve ZLD, it is complex, uses a lot of energy, and the leftover salt is low quality and would need to be sent to landfill. It is not suitable for human consumption due to impurities, and there is no known local demand for low-grade salt. Producing a higher-grade salt was not considered as it would add further complexity and cost.

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Ultra-high Pressure Reverse Osmosis

Ultra-high Pressure Reverse Osmosis **is** an advanced version of standard reverse osmosis that uses very high pressure to squeeze more fresh water out of salty brine. It can handle much higher salt concentrations than regular systems, but it needs specialised equipment and is mostly used in industrial settings. Because of the extreme pressure involved, only a few membrane types are suitable, and there are limited examples of its use in seawater desalination.

Osmotically Assisted Reverse Osmosis

Osmotically Assisted Reverse Osmosis (OARO**)** is another method that helps concentrate brine using a series of membrane stages. It works at lower pressure than UHP-RO and can reach very high salt levels, but it's limited by the risk of salt crystals forming inside the system. OARO is still relatively new and has mostly been used in industries like brine mining and lithium recovery, with few applications in desalination plants so far.

Environmental and Social Impacts

Implementing ZLD technologies in Albany would have significant environmental and social implications:

- **Evaporation ponds** required for some options would demand extremely large land areas—up to 14,000 hectares if located close to the coast. Smaller footprints would be achievable if the brine was pumped long distances inland but would still be 1000s of hectares. This scale of land clearing could impact local ecosystems, biodiversity, and land use planning.
- **Salt disposal logistics** are substantial. Options involving crystallisers could produce up to 392 tonnes of salt per day, requiring up to 17 truck movements daily to transport waste to landfill. Emerging technologies such as brine mining—which aim to recover valuable minerals from brine—are not yet commercially viable. Previous investigations by Water Corporation have found brine mining to be uneconomical, and global progress in this area remains limited.
- **Energy consumption** for ZLD options is significantly higher than standard desalination. Some configurations, such as those using evaporators and crystallisers, require 4 to 6 times more energy, increasing greenhouse gas emissions and placing pressure on local energy infrastructure.
- **Turbo-misters**, which could be used to accelerate evaporation in ponds, pose additional concerns. They are noisy, potentially disruptive to nearby communities, and can cause salt drift, which may damage nearby vegetation, corrode infrastructure, and affect soil quality.
- **Groundwater contamination risks** are present if evaporation pond liners fail. Brine seepage could pollute underlying aquifers, posing long-term environmental risks.
- **Visual and amenity impacts** from large-scale infrastructure, truck traffic, and industrial equipment may affect community perceptions and acceptance of ZLD technologies.

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Key Findings Summarised

#	Description	Land area for ponds	Additional energy use	Solid Salt volume [1]	Average trucks per day for salt transport	Estimated additional capital cost	Estimated additional operating cost
		[ha]	kWh/m³	[t/d]	[Nos]	[$M]	[$M/y]
1	Reverse Osmosis + Outfall	0	Base energy use	0	0	Base cost	Base cost
2	Reverse Osmosis + Evaporation Ponds	14,280	0	0	0	$24,917M	0
3	Reverse Osmosis + Evaporator + Crystallizer	0	22 (6.4 x Option 1)	392	17	$242M	$71.5M
4A	Reverse Osmosis + UHPRO + Evaporation Ponds	6,936	2 (1.5 x Option 1)	0	0	$12,110M	$3.7M
4B	Reverse Osmosis + OARO + Evaporation Ponds	6,120	4 (2 x Option 1)	0	0	$10,691M	$7.0M
5A	Reverse Osmosis + UHPRO + Evaporator + Crystallizer	0	18 (5.4 x Option 1)	378	16	$189M	$63.6M
5B	Reverse Osmosis + OARO + Crystallizer	0	12 (4 x Option 1)	373	16	$133M	$53.6M

Note: The costs provided are best estimates based on currently available data. They do not include any potential expenses related to upgrades to Albany's power supply infrastructure that may be required.

Conclusion

Overall, while ZLD technologies may offer some potential perceived benefits—such as enabling brine recycling—their implementation in Albany would result in significant land-based environmental risks.

Options involving evaporation pond require very large areas of cleared land, making them too costly and impractical for Albany. They pose environmental risks such as potential groundwater contamination and significant land disturbance. Other ZLD technologies, such as those using evaporators and crystallizers, use much more energy than standard desalination methods. These high energy demands would require upgrades to the local power supply, adding further cost and complexity. All ZLD technology options produce significant salt volumes and require a very large number of trucks to transport the salt for final disposal to landfill at the quality produced.