AUSTRALIAN WATER ASSOCIATION

Desalination Fact Sheet

What is desalination?

Desalination is a water treatment process that is used widely around the world and involves removing the salt (ions such as sodium, chloride, calcium, magnesium, etc) from water to make it drinkable. Many countries use desalination as a way of creating a more reliable water supply that is not dependant on rainfall.

Is desalinated water safe?

Drinking water produced by desalination plants is monitored and tested in the same way as water from a filtration plants and, in Australia, must meet the standards of the Australian Drinking Water Guidelines (2011 – Updated September 2022).

How does desalination work?

There are two main methods that are used to produce desalinated water on a large scale - distillation and reverse osmosis – but other processes are used in certain circumstances.

Distillation

Distillation occurs naturally through heating of saline water, such as in the oceans, resulting in evaporation, then condensation (to form clouds and rainfall). Commercial desalination plants using this process have been in operation since the industrial revolution. An early example of thermal desalination (a ship evaporator and condenser) is in the Western Australian Shipwreck Museum from the SS Xantho wrecked at Point Gregory in 1872.

Large scale water condensers were also set up in the WA goldfields in the 1890s before the construction of the pipeline from Mundaring Dam to Coolgardie in 1902.

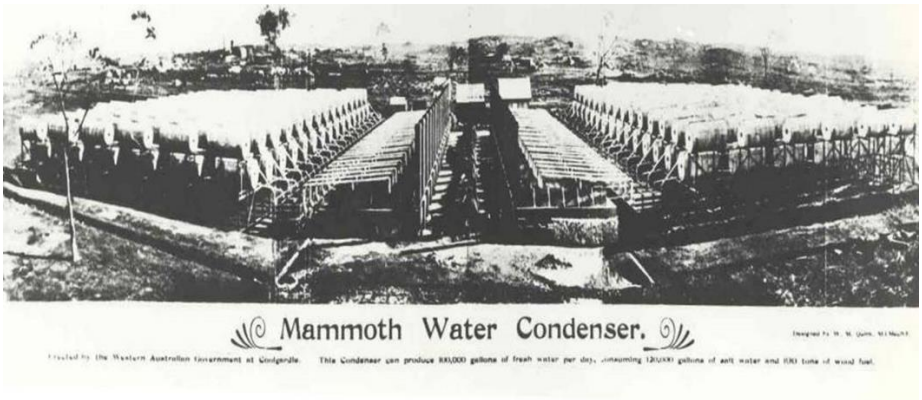


Figure 1: The 0.5 MLD Mammoth Condenser in Coolgardie in 1895

Many large scale distillation plants were established in the Middle East from the 1950s and the process was optimised using multi-effect distillation (MED) and multi stage flash distillation (MSF). These processes required use of exotic alloys to prevent corrosion and were energy intensive. With

the advance of reverse osmosis technology, distillation plants became comparatively uneconomic, and since 2010 all new large scale desalination plants use reverse osmosis membranes to separate salts from water.

Membrane Processes

Reverse Osmosis

Osmosis is a process occurring naturally in many biological systems, such as in every human's' kidney, by which water and dissolved salts are separated. In the reverse osmosis process, pressure is applied to a semi-permeable membrane to allow water to pass but prevent salt passage. Figure 2 shows a sectional view of a typical spiral wound reverse osmosis element which is the fundamental process unit of most commercial membrane desalination plants. Figure 3 shows how a typical seawater reverse osmosis system works.

As the fresh water is driven through the membrane, the remaining water is concentrated and must pass out of the membrane (this is called RO concentrate) to prevent chemical precipitation and scaling on the membrane surface. For a commercial seawater reverse osmosis plant, only about 45% of the seawater fed to the plant is returned as desalinated product water.

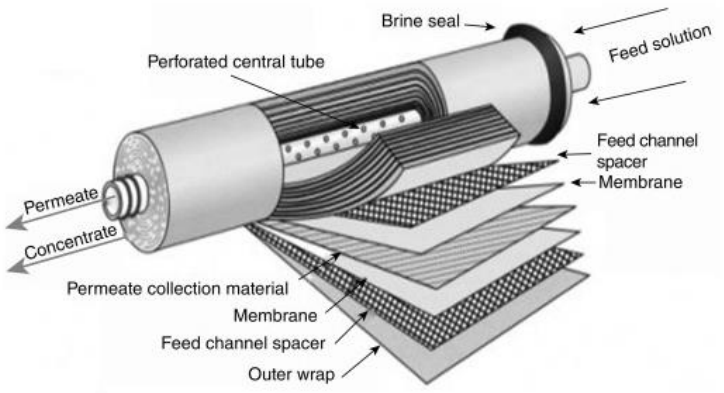


Figure 2: Typical Construction of a Reverse Osmosis Element

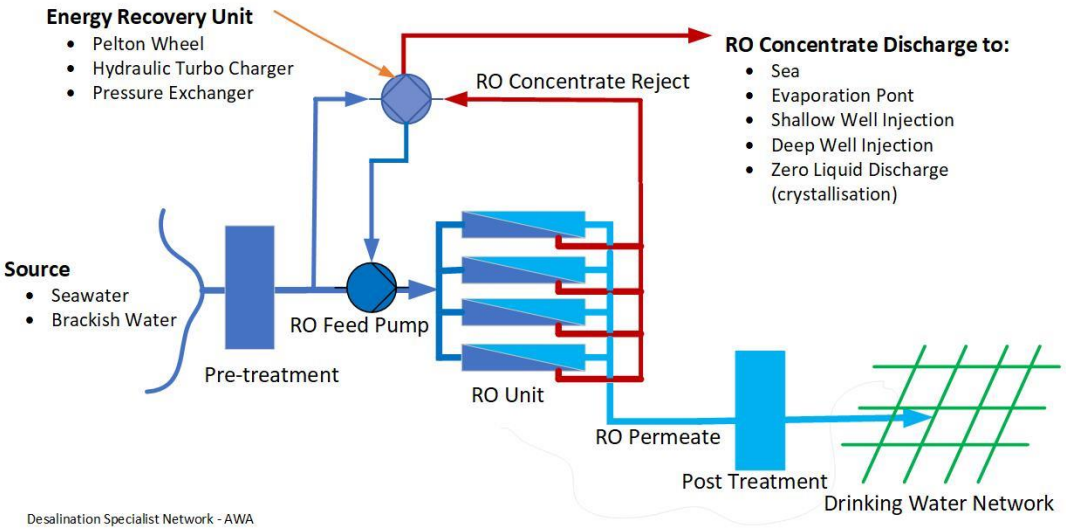


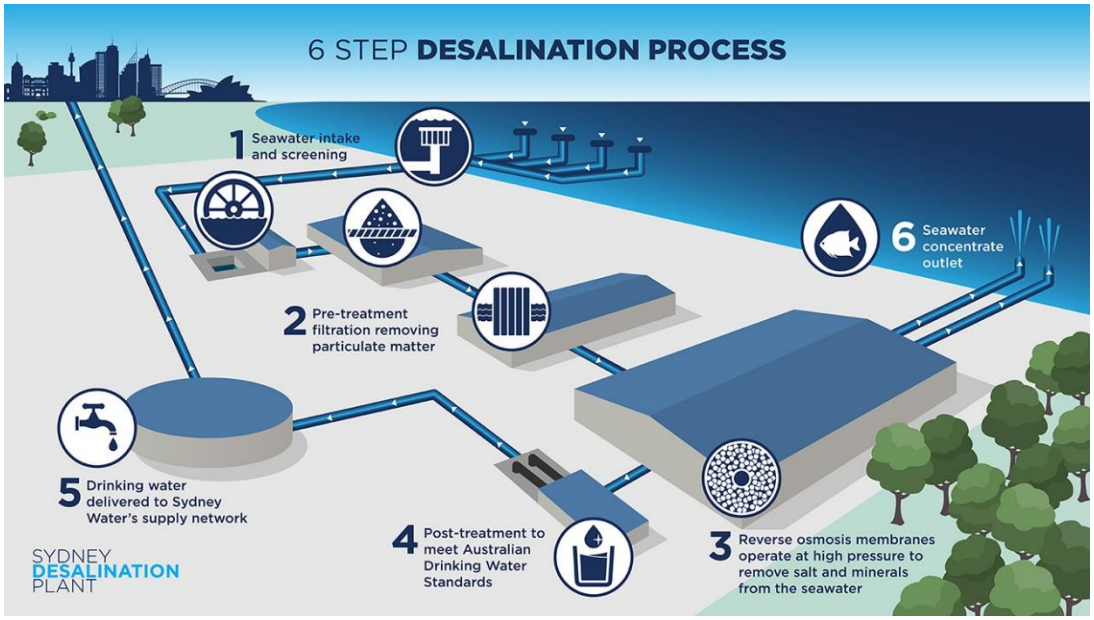
Figure 3: Typical Single Pass Reverse Osmosis System *[Source M Roomi]*

Electrodialysis Reversal
The electrodialysis reversal (EDR) process utilises electric potential, rather than pressure as in the reverse osmosis process, to move the salts through membranes. This process is generally only economical for desalination of brackish water (total dissolved solids less than 5,000 mg/L) but is used commercially in particular situations.

How does a typical seawater desalination treatment process work?

A typical seawater desalination treatment process is shown in Figure 4 and consists of several treatment process units in series, summarised as follows:

1. Seawater is drawn in and initial screening (e.g. drum or band screen) is provided to remove large particles (e.g. seaweed)
2. Pre-treatment to filter the water to remove the majority of particles – media (or conventional) filtration or membrane filtration
3. Desalination to remove salt (as above)
4. Post treatment –
    a. Remineralisation by dosing carbon dioxide and hydrated lime to ensure the water is not corrosive to distribution infrastructure and has a satisfactory taste
    b. Disinfection by dosing chlorine to ensure the water is safe to distribute to customers
5. Transfer – pumping to interface with the distribution network
6. Concentrate is dispersed to the ocean with appropriate design to ensure effective dispersal and minimal environmental impact
7. Residuals Management (not depicted below) – treatment, including dewatering, of solid waste material from the pre-treatment and remineralisation processes for off-site disposal.



Source: Sydney Desalination Plant

Figure 4: Schematic of Typical Seawater Reverse Osmosis System

Desalination in Australia

Australia has more than 1,000 desalination plants, mostly small scale, to desalinate marine and brackish water for various uses. The total desalination capacity across Australia is about 880 GL of

water per year. Five major urban centres in Australia have a total seawater desalination capacity of 534 GL per year.
Source: https://www.water.vic.gov.au/water-grid-and-markets/victorian-desalination-project/desalination-background/desalination-history
Source: http://www.bom.gov.au/water/waterinaustralia/files/Water-in-Australia-2019-20.pdf

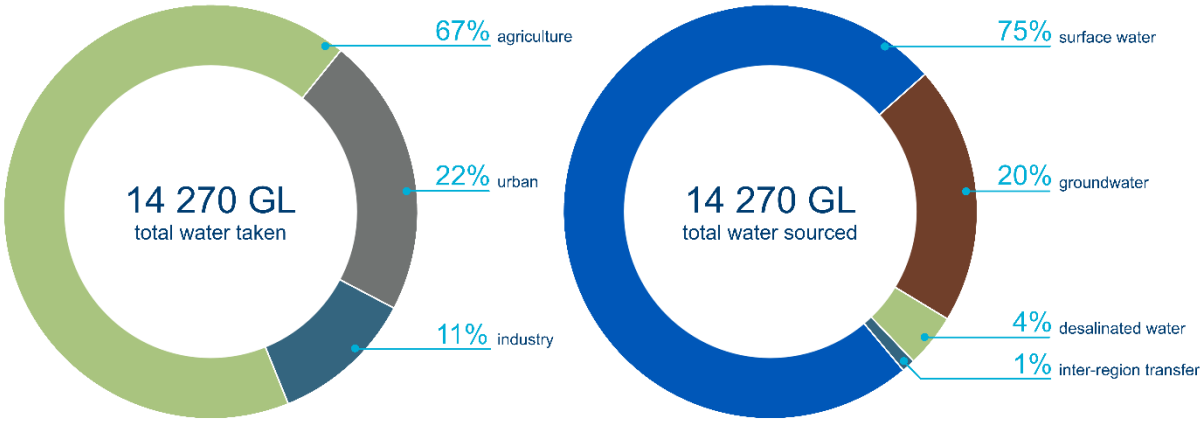
Table 1: Summary of Australian large scale municipal desalination plants

Jurisdiction	Desalination Plant/s	Predominant end use	Initial Investment $B June 2023*	Capacity GL/year (ML/d)	Completion date	Further information
WA	**Kwinana**	**Municipal**	**0.6**	**45 (135)**	**2006**	Dual media pre-treatment (pressure), partial two pass RO Water Corporation
QLD	**Tugun (Gold Coast)**	**Municipal**	**1.127**	**45 (133)**	**2009**	Dual media pre-treatment (gravity), partial two pass RO (flexible), 3 modules of 44 ML/d. SEQ Water
NSW	**Kurnell**	**Municipal**	**2.5**	**91 (250)**	**2010**	Dual media pre-treatment (gravity), partial two pass RO (flexible), 2 modules of 125 ML/d. Sydney Desalination Plant
VIC	**Wonthaggi**	**Municipal**	**4.6**	**150 (450)**	**2012**	Dual media pre-treatment (pressure); two pass RO, 3 modules of 150 ML/d Melbourne Water
SA	**Pt Stanvac**	**Municipal**	**2.3**	**100 (300)**	**2012**	Membrane pre-treatment (submerged), full two pass RO, 2 modules of 150 ML/d SA Water
WA	**Binningup**	**Municipal**	**1.8**	**100 (300)**	**2013**	Membrane pre-treatment (pressure), two pass RO, 2 modules of 150 ML/d Water Corporation

***CPI escalation of publicly available project cost at completion to June 2023**

Below is a summary of the surface water storage, desalination capacity, desalinated water supplied and recycled water supplied by region.

Figure 5: Water taken by use category and source in 2019-20



Source: Bureau of Meteorology, *Water in Australia 2019-20,* pg 5
http://www.bom.gov.au/water/waterinaustralia/files/Water-in-Australia-2019-20.pdf

Figure 6 compares the capacity of large-scale desalination and recycled water plants for major Australian capital cities before and after construction of the six major Australian desalination plants with overall use of water in those cities from desalination and recycled water.

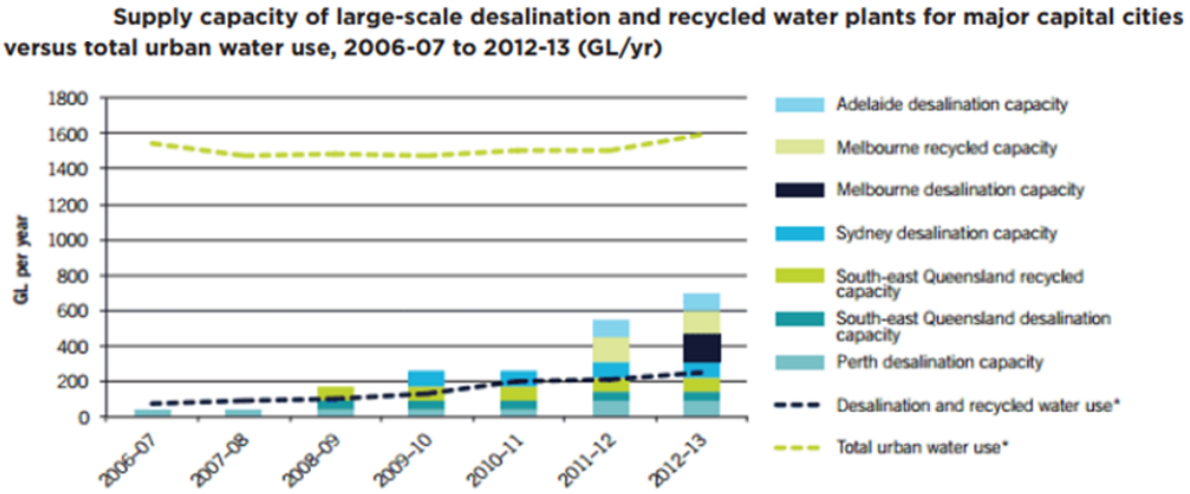


Figure 6: Proportion of City Water Supply Capacity Available from major Australian Municipal desalination plants during the period when they were constructed

Notes: Capacity-related data was derived from the 2009-10 Urban NPR (pp. 7-8_ and the Water Services Association of Australia (WSAA) report card 2009-10 (p. 5). Data includes only major projects that have a supply capacity of at least 40 GL. *Use data was sourced from the 2012-13 Urban NPR dataset and is the total for Sydney, Melbourne, south-east Queensland, Perth and Adelaide. Where data was missing for these utilities over the time series, the most recent year of data was assumed for the missing years. Source: National Water Commission, National Performance Report 2012-13

Benefits of desalination

Desalination provides a climate-independent source of water for critical human needs and economic development (industry and agriculture in particular). It is an effective way to secure water supplies against the effects of climate change, a growing population and drought. The quality of water from a desalination plant is controllable, thereby enabling water users to receive water of consistent composition, not subject to natural variations.

The cost of desalination

The cost of producing and reticulating desalinated water is a function of a number of factors including:

- plant capacity – economies of scale
- process power use efficiency, influenced by
    - Source water quality, especially salinity and temperature
    - Product water specification (e.g. a tighter product water specification may require treatment through two (or more) passes leading to higher energy use)
    - Flexibility of design to meet operational requirements (multiple trains providing maximum flexibility vs pressure centre design maximising efficiency)
- Location of plant (proximity to water source, end users, energy source)
- Project financing model, and
- Specified reliability/availability (and redundancy)

As a result, the cost of desalinated water ($/kL to end user) is highly variable. For the large-scale municipal seawater desalination projects in Australia, the approximate water cost range is $1.00-$4.00 per kilolitre. For recently constructed very large desalination plants in the Middle East, the unit price of water is around US$0.40 per kL (Aus$0.60 per kL).

Desalination and energy use

- Desalination requires significantly more energy (currently around 3 kWh/kL for a large reverse osmosis plant) than existing conventional water treatment processes.
- The energy used by a seawater reverse osmosis plant equates to around 2 kWh/d of electricity for an average Australian household consumption of 0.6 kL/d. This is about the same as the energy used in running a typical household refrigerator/freezer and about a tenth of the energy required to run a typical 10kW household ducted reverse cycle air conditioning system.
- For seawater desalination, energy use can represent 50-70% of total operating costs; the majority of energy used for pumping water to the required pressure for the reverse osmosis process itself. Reducing this energy consumption is a key focus area for process research and plant designers.

Social, environmental and economic issues

Seawater desalination is more expensive than traditional water resources. However, if water demand exceeds the capacity of rain fed streams, lakes, dams and groundwater, other supply options are required. Desalination can be justified on the grounds that residents of modern “liveable” cities expect sufficient water supply to support their lifestyle with reliability of service, even during droughts and long term shortfalls brought about by climate change.

The impact of climate change has been particularly evident in Perth where changes in rainfall intensity and distribution mean surface water from dams has become constrained and is unreliable. About half of Perth’s water is now sourced from seawater desalination.

The 'carbon footprint' of desalinated water is generally higher than that of rain fed water sources. Many Australian desalination plant owners offset the carbon dioxide production from energy used in desalination plants by purchasing wind and solar energy.

Criticism of Australia's desalination plants

In its 2011 review of Australia's urban water sector, the Productivity Commission found that while some of the investment in desalination plants "might have been appropriate in the circumstances to maintain security of supply, there is sufficient evidence available to conclude that many projects could have been deferred for a number of years; smaller in scale and replaced with investment in lower cost sources of water".

Source: https://www.pc.gov.au/inquiries/completed/urban-water/report/urban-water-volume1.pdf

Support for desalination

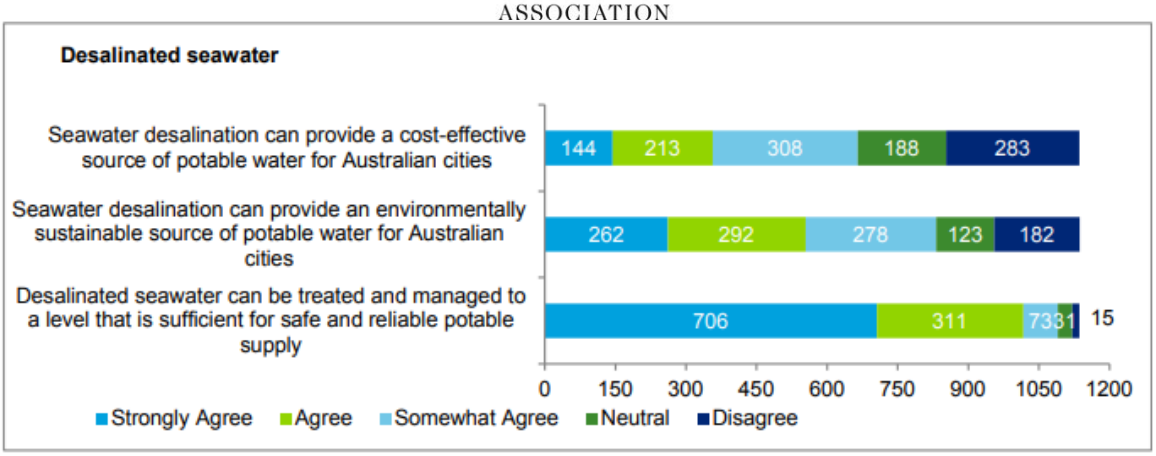
The frequency and duration of severe droughts in Australia, and the realisation that desalination can provide benefits to network resilience both during and outside drought, has altered perceptions somewhat. This is evident in the current thinking and analysis by state authorities that it is prudent to either use existing desalination capacity in a more flexible manner, or to start planning for additional capacity to future-proof reliable water supply.

A recent example is in the Greater Sydney Water Strategy (2022) which argues for a raft of measures to assist building a sustainable and resilient water supply, including greater utilisation of existing desalination capacity while continuing planning for new rainfall-independent supply options. Other jurisdictions are moving in a similar direction.

Sources: https://www.pc.gov.au/inquiries/completed/water-reform-2020/report
https://water.dpie.nsw.gov.au/__data/assets/pdf_file/0006/527316/greater-sydney-water-strategy.pdf

The Australian water sector's view on desalination

In the AWA/Deloitte 2014 State of the Water Sector Report 2014 an overwhelming number of respondents (96%) believed that desalinated seawater can be treated and managed to a level that is sufficient for safe and reliable potable supply (Figure 7). However views on whether it is an environmentally sustainable and cost effective source of potable water varies across jurisdictions.



Source: AWA/Deloitte 2014 State of the Water Sector Report,
http://www.awa.asn.au/uploadedfiles/State_of_the_Water_Sector_Report_2014_FINAL.pdf

Figure 7: The Australian Water Sector's Views on Desalination

Source: AWA/Deloitte 2014 State of the Water Sector Report

Ensuring secure water supplies

In the face of growing challenges of climate and population growth, the whole portfolio of water supply augmentation and demand management options should be assessed for a system. Good, robust collaborative planning between the industry, regulators and communities is also required.

Figure 8: The Southern Seawater Desalination Plant, Perth

For more information about desalination in Australia

International Desalination and Reuse Association
https://idadesal.org/

Water Corporation (WA)
https://www.watercorporation.com.au/Our-water/Desalination

SEQ Water (Qld)
http://www.seqwater.com.au/water-supply/water-treatment/desalination

Water for Good (SA)
Correct link: https://www.sawater.com.au/water-and-the-environment/south-australias-water-sources/seawater

Melbourne Water (Vic)
http://www.melbournewater.com.au/whatwedo/supply-water/Pages/Desalination.aspx

Sydney Desalination Plant (NSW)
https://sydneydesal.com.au

Sydney Water (NSW)
https://www.sydneywater.com.au/water-the-environment/how-we-manage-sydneys-water/water-network/desalination.html