Regional deployment of portable desalination plants

Summary of findings

Background

In 2018 the Department of Natural Resources, Mines and Energy (DNRME) engaged a contractor to undertake a review of the potential deployment to Queensland regional centres of portable desalination plants to inform consideration of their use to supplement water supplies during extreme drought or emergency situations.

The review provided data on the options and issues for acquiring and installing a portable desalination plant and the operational considerations needed for water supply and drought response planning activities. The review data is for concept evaluation and is not intended to provide recommendations for specific sites.

The review focused on portable reverse osmosis (RO) desalination plants for brackish or seawater, as at the time this was seen as the lowest cost desalination technology. Recently, there have been promising developments in solar distillation plants with potential for reduced costs.

The review was undertaken in four parts:

Part 1: Identification of portable desalination plants that are likely to be available for transport to Queensland regional centres in times of emergency (such as during drought or due to failure of existing water supply or treatment infrastructure).

Part 2: Hypothetical assessment of sample regional sites.

Part 3: Review of practices in other Australian states with respect to the availability and use of emergency desalination for community water supply.

Part 4: Preliminary review of practices in other countries with similar relevant characteristics.

The review findings are summarised below.

Part 1 – Available portable desalination plants

Vendors

A cross section of 18 vendors were requested to provide information regarding their capabilities, costs and plant capacities. Responses were received from several vendors located in Australia and internationally. When reading and using the information presented, allowance needs to be made for the very preliminary nature of the cost figures provided. The lowest vendor prices adopted for the purpose of the review are indicative only and need to be assessed and confirmed by project proponents specifically for each location, taking into account balance of plant (BoP) [1] costs and costs of site decommissioning associated with the clean-up of ponds, tanks and pipes.

A summary of vendor responses is as follows:

- All vendors approached replied with RO as the base desalination technology.
- Several vendors have capabilities to supply small and large capacities of brackish water RO (BWRO) and sea water RO (SWRO) plants ranging from 75 to 300 kL/d (“small”) and from 1 to 5 ML/d (“large”). Custom sizes are also available.
- Subject to asset availability at the time of order confirmation, units can be ready for dispatch within 2 to 3 weeks. Manufacturing a new treatment plant requires a lead time of 8 to 10 weeks. Large plants such as the 5 ML/d capacities might require 14 weeks lead time.

[1] Balance of plant (BoP) costs include the site preparation; feedwater; pumps, pipes, and holding tanks or ponds required for raw water, treated water; RO brine waste (i.e. pre-treatment filter backwash) storage or disposal; the diesel generator and fuel supply and storage tanks, plumbing connections and installation.

Queensland Government

- Delivery costs – small units require $5000 to $15 000 for SWRO units for coastal locations, and $4000 to $8000 for BWRO units for inland locations. Delivering the large units can cost $25 000 to $50 000 (BWRO) and $40 000 to $60 000 (SWRO) for 1 ML/d and 5 ML/d, respectively, but is highly dependent on the remoteness of the site to be serviced.
- Short and longer-term (> 12 months) hire costs, including plant preparation, installation, mobilisation and insurance, but excluding delivery and BoP costs, are shown in Figure 1 for various capacities and two sample vendors that provided relatively comprehensive responses.

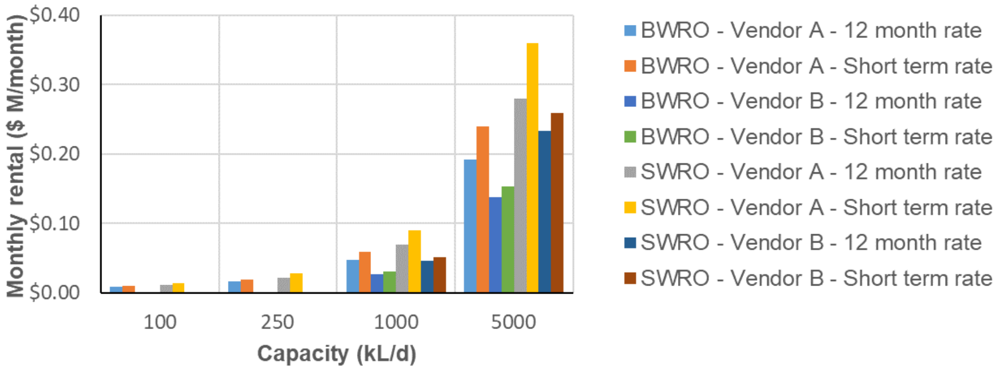

Figure 1: Rental costs from vendors

- A comparison of purchased plant versus hire for a period of 12 months is shown in Figure 2 for various capacities and two sample vendors. Purchase costs include equipment supply (including the membranes), installation and commissioning but exclude BoP costs.

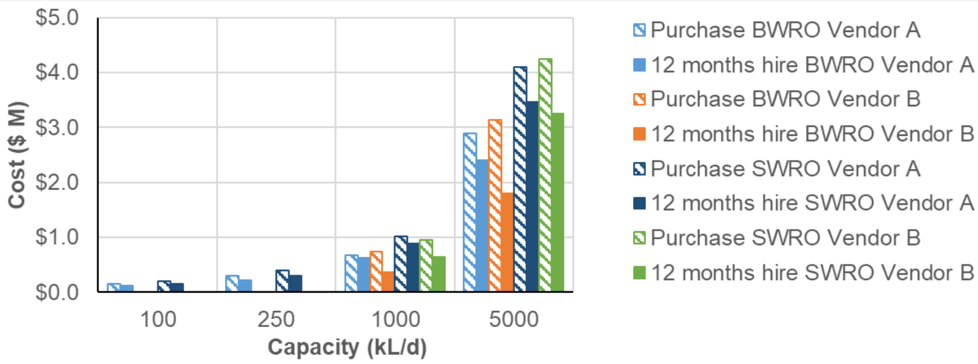

Figure 2: Purchase costs versus 12 months hire

- Power and chemical costs for operations are highly dependent on the site, capacity and water quality. Indicatively:
  - BWRO feed water of a TDS<2500 mg/L would require around 0.7 to 0.8 kWh/kL. As the TDS increase to <8000 mg/L, the power requirements approach 1.1 to 1.2 kWh/kL. SWRO requires on average 3 to 4 kWh/kL.
  - The chemical costs for the disinfection and remineralisation[2] ranged between $0.12 to $0.20 per kL for the disinfection and remineralisation[3]. Other chemical costs (mainly for membrane cleaning) ranged between $0.20 to $0.23 per kL.
- The minimum hire period is specified by some vendors to be 2 to 3 months, yet in cases of emergency, vendors can be flexible. The hire period starts when the container leaves the vendor's warehouse and ends when it is returned back to the warehouse. The transport, installation, commissioning, and start-up time, combined with the decommissioning and demobilisation time, can be 1 to 2 months.
- Despite the very flexible fleet of hire units available in the market, including tens of individual containers and several combinations of process capacities and equipment (RO, microfiltration,

[2] This is usually done with a post-filter that contains some form of calcium or magnesium.

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ultrafiltration etc.), a certain degree of 'tailoring' is almost always required at each site to meet water quality requirements.

Water service providers

The Australian Army owns and frequently deploys a number of mobile water filtration and desalination units (both brackish RO and seawater RO) for its purposes. Formal inquiries regarding their availability for deployment elsewhere in times of emergencies were not made.

Torres Strait Island Regional Council (TSIRC) owns and operates several seawater desalination units across the islands. Their fleet consists of 11 permanent plants on 5 islands and another 7 portable plants for emergency supplementary supply and supply to other islands. It is not expected that any of these would be available for ready deployment elsewhere in times of emergencies. Further information on the operation of TSIRC desalination facilities is provided in Appendix A.

Several private industry owners of desalination plant were identified, particularly within the energy and resource sectors, as well as tourism enterprises. However, all of these units had been purchased as an essential supply source and again it is not expected that any would be available for redeployment in times of emergencies.

Part 2 – Sample regional sites

Six sample regional sites were identified and assessed to develop an understanding of the specific issues related to the emergency deployment of desalination plant in Queensland. The sample sites were selected to be representative of potential applications across Queensland including three inland sites, two coastal sites and an island site.

The groundwater at inland sites was assumed to be brackish with elevated pH, metals and hardness. Typical saline properties were assumed for seawater.

Concept (desk-top) design and costing was undertaken for each site including consideration of the following:

- Water requirements
- Available brackish and saline water sources including:
    - source water quantity and quality
    - indicative treatment issues
    - suitable available plant.
- Time required to transport to the site, set-up and connection of the plant to the distribution system.
- Nominal costs including the upfront charge for plant (purchase or hire), transport to site, set-up, connection, decommissioning and transport back to base.
- Nominal operational costs including plant lease rates, fuel, maintenance and membrane replacement.
- Site locations/details.

Treated water emergency demands ranging from 0.2 ML/d to 1.1 ML/d were considered with total costs ranging from $1.2 million to $3.7 million for a 12 month period.

The cost breakdown for 12 months operation at the six sample sites is presented in Figure 3. Sites 1 to 3 were BWRO treatment and sites 4 to 6 were SWRO treatment. Proportional averages for three BWRO sites are indicated in Figure 4 and for three SWRO sites in Figure 5.

The annual cost of labour (i.e. operators from an external entity or vendors) was assumed to be $180 000 per annum including salary, travel and accommodation. RO is not a simple technology and requires specific knowledge and trouble-shooting skills. This expertise is not easily obtainable for remote and inland locations. Vendors also offer training for local staff.

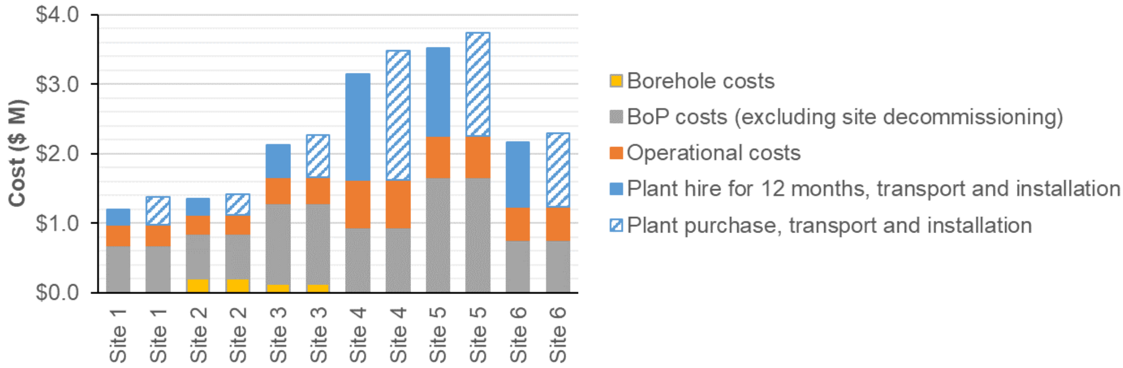

Figure 3: Cost breakdown for the six sample sites

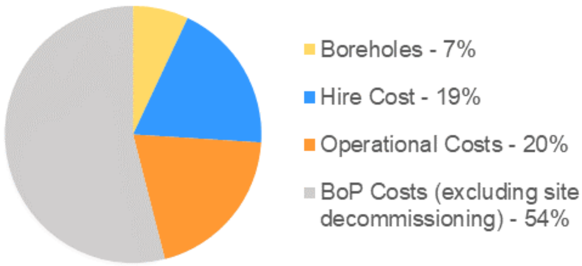

Figure 4: Contribution (%) of each of the different components of costs in the hiring scenario for the BWRO units (average of the three sites)

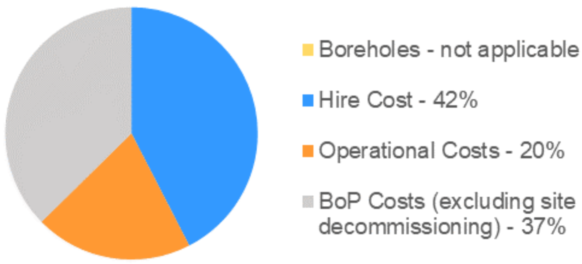

Figure 5: Contribution (%) of each of the different components of costs in the hiring scenario for the SWRO units (average of the three sites)

For the purpose of these assessments the emergency demand was down-rated to 50% of normal demand for non-remote areas (based on experiences during the millennium drought) and 80% for areas where reduction of consumption was considered more difficult e.g. for remote areas (due to a range of health and lifestyle reasons – drawing experience from TSIRC) or tourist centres. Water service providers should assess the appropriate down-rating for their specific circumstances.

Downtime for scheduled maintenance and cleaning/backwashing of the membranes and other equipment was considered as 20% except for one of the coastal sites where 50% was considered due to large tidal effects on the intake.

Holding tanks or ponds required for raw water, treated water, RO reject and wastewater (i.e. pre-treatment filter backwash) storage or disposal constitute a significant component for the design of each plant (particularly at inland sites). The RO brine evaporation ponds for inland sites (i.e. BWRO) sites contribute 12-18% of the total cost.

Alternative methods for brine disposal include discharge to rivers, land application, deep well injection, sewer discharge and dust control.

The logistics and costs of site decommissioning associated with the clean-up of ponds, tanks and pipes were not included as part of the BoP, as the extent of this will be dependent on site conditions. These costs are potentially significant,
especially for inland sites e.g. large brine ponds.

The RO plant purchase and hire costs were similar, when considering a hire period of just over 12 months.

Timeline considerations

The timeline for deployment of a portable desalination plant is dependent on:

- existing RO plant availability/manufacture time
- the extent of work needed to connect into a distribution network
- the level of waste stream management implemented
- vailability of adequate borehole water sources (inland only)

Indicative timelines for deploying plant during emergencies are indicated below and shown graphically in Figure 6:

- Complete tie-in into distribution network and detailed management of brine waste:
  1. Inland sites: 8-16 weeks (with borehole installation and distribution network tie-in being the limiting factors).
  2. Coastal/island sites: 8-10 weeks (with RO plant supply and distribution network tie-in being the limiting factor).
- Incomplete tie-in into distribution network (i.e. distribution of water to community at treatment plant) and minimal management of brine waste:
  3. Inland sites: 3 days to 16 weeks (with borehole installation and distribution network tie-in being the limiting factors).
  4. Coastal/island sites: 3 days to 10 weeks (with RO Plant supply being the limiting factor)
- Balance of plant:
  5. Distribution network tie-in approximately 8 weeks however very much site dependent
  6. RO brine evaporation ponds for inland sites are large but can be staged in setup and for the initial period tanks can be used. Allow 8 weeks for the first stage.
  7. Source water infrastructure such as borehole installation may take 2 to 16 weeks (note that there is considerable uncertainty for this period and significant site dependency)

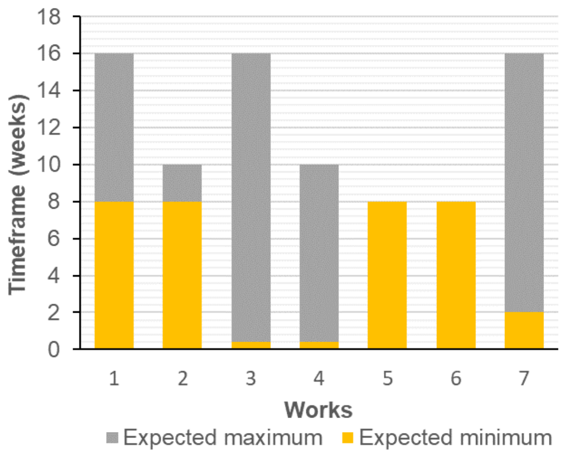

Figure 6: Approximate timeframes for deploying plant during emergencies

Part 3 – Practices in other Australian states

The study did not identify any other state government guidelines that specifically covered deployment of mobile desalination plants for emergency community water supply. However, a small number of examples were identified in the different states that involved deployment of containerised water treatment systems for water supplies. Some were semi-permanent and mostly associated with resource industries. Examples are provided below:

- The New South Wales Lower Hunter Water Plan was developed to ensure there is sufficient water supply to residents and businesses and to respond to severe droughts. The plan has identified potential sites for temporary, land-based RO plants for drought management. Hunter Water is currently undertaking planning and preparatory work to enable such temporary RO plants to be implemented at short notice.

- Tasmania has provided eight mobile filtration plants for its regional areas and connected four towns by delivery mains to upgrade their water supply, but these plants are permanent.
- Western Australian mines hired RO plants over 2 to 5 year periods until their permanent water treatment plants were built. Denmark, a coastal town located on Wilson Inlet, purchased an RO plant as a backup water supply in response to their drought in 2014, but the RO plant had not been in use prior to 2018.
- South Australia, Victoria, and Northern Territories have installed RO units on a permanent basis for community services and mines operations.

Part 4 – Practices in other countries

No data was found on policies or guidelines from other countries on the temporary deployment of portable desalination plants as a response to an emergency. The available information is limited to general guidelines by local and national governmental water authorities advising the water utilities and community members to plan and have preparedness actions such as securing alternative and/or temporary water supplies where needed. A few examples were found which involved military aid initiatives in situations of floods and cyclones.

Conclusions

Water service providers should assess the best drought and/or emergency response strategy for their specific circumstances. This summary of findings has been prepared to assist the consideration of emergency desalination options.

Based on TSIRC operations it may be more efficient in some circumstances (e.g. if source water is variable in quality) to replace membranes every 1 to 2 years, although usual membrane life is 5 years, rather than pre-treat.

Appendix A – Plant Owner Enquiries TSIRC

Over recent years, the Torres Strait Islands have been suffering from lower rainfall levels. The islands depend heavily on rain for water supply, which is stored in lagoons. Their average annual rainfall (2010–2018) is around 1600 mm with very minimal rainfall between June and November (dry season).

Discussions with Torres Strait Island Regional Council (TSIRC) revealed that the council owns and operates several sea water desalination units across the islands. Their fleet consists of 11 permanent plants on 6 islands and another 6 portable temporary plants supplying water for the 9 remaining islands.

Capacities and Practices

The capacities of these 6 temporary plants are:

- 4 x 70 kL/d units
- 50 kL/d unit
- 17 kL/d unit

The plants are not continuously operated (50% to 80% utilisation), producing approximately 50 – 55 kL/d. The operating schedule is based on tidal movement to avoid periods of poor feed water quality. 5 of the 6 larger plants are moved regularly between 7-8 islands, running 80% of the time year round, especially starting August through to January. The 17 kL/d unit is an old unit that serves the population of Ugar (30-50 people). It is too small to be used for any other TSI community as the next smallest population is 150 people.

Technical Specifications and Operation

Due to operational logistics and challenges with installation, a direct seawater intake is considered more practical for the units that are frequently moved between the islands than a subsurface intake (which may be more economical for small permanent sea water desalination installations). The intake is usually set to withdraw the source seawater from around 50 m offshore via a pontoon, into a 10 kL raw water tank.

The raw water (salinity circa 40 000 – 50 000 μS/cm) is pumped via the raw water feed pump into the water treatment train. Some installations are set up with 2 trains of 70 kL/d capacity with 3 RO pressure vessels each. The train usually comprises cascading tanks for turbidity reduction, coagulant dosing, a media filter with 2 μm filter followed by 1 μm filter (cartridge filters) before the RO unit. The 70 kL / day trains have 4 skids (media and cartridge filter, RO skid, permeate, and intake pump skids) plus the clean in place (CIP) skid, all covered by a canvas shelter (Photograph). Ancillary infrastructure also includes a booster pump among other items. The footprint of the unit is around 10 m by 10 m including the tanks and generator set.

Photograph: The different skids of the TSIRC water treatment units

The produced water is then usually sent to the existing permanent water treatment plant raw water lagoon which feeds to the drinking water treatment plant to avoid fluctuating pressures. On occasions, the produced water can be directly pumped into the distribution system. The sludge from the permanent water treatment plants and brine are disposed of responsibly. The brine may be combined with the sludge from the drinking water treatment facility. Alternatively, the brine may be pumped several hundred meters offshore, far from the water intake.

The operational requirements:

- power requirements involve multiple diesel generators (55 – 65 kVA) and 1000 L diesel storage.
- chemicals are mainly, disinfectants, anti-scalants and CIP chemicals
- membranes are replaced every 1 to 2 years although their usual lifetime is 5 years due to source water being variable in quality.
- cartridge filters are changed every 2 to 3 days.

Common maintenance issues encountered include:

- manual backwashing
- generators power handling
- cartridge changing
- desludging.

All installations and maintenance is undertaken by the trained TSIRC staff. If required, TSIRC may establish a service contract with a vendor that includes staff training.

Timeframe and utilisation

The timeframe to mobilise a treatment plant is 3 to 6 weeks and an additional 1 to 7 days to set up. All six plants are frequently in use due to high demand, thus they are not available for deployment outside the islands, especially between August and January when the demand is very high. Except for 2 to 3 months whilst most of the RO plants are on standby, the plants are in continual use and the water security evaluation is usually conducted to forecast only few weeks ahead. Around eight weeks of storage is the typical target. Moreover, it is noted that these units might become a permanent set-up because of the increased demand.

TSIRC indicated that the cost for purchasing the 50 to 70 kL/d water treatment units in relatively recent times was approximately $300 000 each including pre-filtration skids, ancillaries purchase, transportation costs and the generator hire over three months.