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Attachment J
ADP operation assessment,
Aurecon



Adelaide Desalination Plant
Asset Stewardship Review

Summary Report
SA Water

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Contents

Summary Report	1
Background	1
Water security and customer service	1
Purpose	2
Extent of assessment	2
Standby modes	3
SA Water risks	3
Lessons learned	3
Comparative analysis with other desalination plants	6
Membrane performance in standby modes	6
Analysis and results	7
Recommendation	8
Confirmation of impartiality and disclosures	9
Glossary	10

Tables

Table 1 Reference desalination plant	4
Table 2 Lessons learned from other similar desalination plants for standby modes	4
Table 3 Advantages and disadvantages of the two standby modes	5
Table 4 Major Impact Risk Assessment Summary	7
Table 5 Risk Assessment Total Summary	7
Table 6 Glossary	10



Summary Report

Background

On 12 December 2012, SA Water's Adelaide Desalination Plant (ADP or the Plant) was formally handed across from the Design and Construct contract to the Operation and Maintenance (O&M) contract and a two-year proving period commenced. The proving period was successfully completed in December 2014. The ADP is operated by AdelaideAqua Pty. Ltd. (AAPL or the Operator), a partnership comprising of Acciona Agua Adelaide Pty. Ltd. and Trility Pty. Ltd. AAPL has a 20 year O&M contract with SA Water to manage the ADP and commenced the third year of the O&M Contract in 2015. The Plant services the water demands of the Adelaide metropolitan supply network system, in accordance with SA Water supply demands.

The asset stewardship review was conducted to provide an understanding of how the plant operation can be optimised to maximise its useful life and asset value.

Water security and customer service

At the maximum plant production rate of 100 gegalitres per annum (GL/a), the ADP can produce on average approximately 50% of Adelaide's current drinking water needs; providing the only climate-independent source of water for the city. Although this provides some water security for Adelaide, the ADP is only one of a number of strategies that are being incorporated to meet the city's forecast growing water needs.

Since the ADP has been supplying water to the Adelaide metro region customers have experienced a noticeable improvement in water quality, including taste, colour and odour. In addition, the continuous addition of desalinated water to the Adelaide water distribution system has improved health protection for Adelaide water customers. It has improved the stability of the disinfection residual throughout the plant service area and has reduced the level of regulated disinfection by-products.

The overall corrosion potential of the drinking water has also been reduced, as the desalination plant can regulate water stability by the addition of alkalinity and hardness to the desalinated water. A further benefit associated with the ADP operation is the improved overall reliability of water delivery, taking into consideration the advanced age of the Happy Valley conventional water treatment plant (over 20 years), which also supplies potable water to the desalination plant service area.

ADP is integrated into the drinking water distribution network, and together with the North South Interconnection System (NSIS), water from ADP can be transferred extensively throughout the Metropolitan Adelaide Water Supply System to mitigate operational and strategic supply risks.

The benefit of interconnectivity of ADP and the wider network utilising the NSIS, increases operational resilience and security of supply to the distribution network from supply disruption at Happy Valley water treatment plant specifically, and also the ageing water infrastructure across the wider water treatment plants, storages and network.



Purpose

SA Water commissioned Aurecon, in conjunction with Water Globe Consulting, to undertake an independent assessment of two modes of water production (standby) and make recommendations on the preferred mode with respect to the asset condition. The assessment evaluated the likely impact of each production mode on the plant and its condition, to the point in time where it is handed over to SA Water after completion of the operations and maintenance contract.

The ADP is designed to flexibly produce and deliver up to 300 ML/d of drinking water. It consists of two independent treatment systems (RO Plant No. 1 and RO Plant No. 2), each of which can produce up to 150 ML/d of drinking water in 30 ML/d increments. The plant is designed to operate in increments of 10% or 30ML/d, to respond to variable supply demands. SA Water has prescribed two potential water production regimes for which the optimum operational mode to preserve and maintain the asset is sought.

A key assumption is that the ADP facility and all associated equipment is maintained in accordance with the contract obligations. There is a clear intent and responsibility for the Operator to adequately maintain the plant asset under all modes of production.

The assessment included informing SA Water of the experiences and lessons learned from similar seawater desalination plants in Australia and the United States. The assessment assists SA Water to understand the asset risks and opportunities associated with placing ADP in a standby mode for extended periods following a proving period.

In addition to providing an understanding of the industry best practice from other operating facilities, the assessment has also encompassed relevant information from academic research, industry publications and technical papers.

Extent of assessment

The basis of the assessment for asset stewardship is from the owner's perspective (SA Water), rather than the Operator (AdelaideAqua). The key assumptions are as follows:

- The scope of the assessment is the Adelaide Desalination Plant (ADP) and Transfer Pump Station (TPS) to the distribution point into the Happy Valley Water Treatment Plant
- The asset will be returned to SA Water at the completion of the 20-year Operations and Maintenance contract period, over which time AAPL will meet their contracted obligations (including plant maintenance under all operating regimes)
- Cold and Hot Standby were the two scenarios assessed
- The benchmark asset performance is the normal operating mode, with a variable production rate from 0 to 300 ML/d at full continuous operation.

The following items are outside the scope of this report:

- Interviews or interactions with AAPL
- Commercial and financial review of the AAPL O&M Contractor under either of the two proposed operating scenarios.



Standby modes

The two specific ADP standby modes considered in the study are:

- Cold Standby which has zero production
- Hot Standby which operates in a pattern of minimum production.

Cold Standby is defined as the plant operational mode under which the ADP is not producing and delivering any potable water to the drinking water distribution system for a period of one year or longer.

Hot Standby is the plant mode of operation where the ADP plant runs at 30ML/d for 9 months and then zero production for 3 months, cycling across both production facilities at the plant.

SA Water risks

The main benefit experienced by other reference plants using Cold Standby, is that this mode of operation allows the achievement of a significant reduction in the plant's annual O&M costs, as compared to continuous plant operation and Hot Standby.

The key risks associated with this Cold Standby mode of operation for SA Water to consider are:

- The notably longer time period needed to return the plant to 100% production capacity
- Intake structures may be exposed to higher rates of deterioration and biological growth when the intake is idle. Capping of the intake pipe usually does not prevent the intake structure from accumulating heavy growth and structural damage
- The pre-treatment and RO membrane ageing process is accelerated when these membranes are kept in preserving solution for a long time (typically more than 1 year)
- When restarted after long periods of preservation (usually more than 1 year), pre-treatment and RO membranes can exhibit a loss of permeability and lower efficiency in salt rejection and fresh water production. This may be higher than that of membranes that are operated continuously under the proposed Hot Standby regime or kept in preserving solution for less than 6 months and operated intermittently
- RO and UF membrane guarantees may be lost if the membranes are kept continuously in preserving solution for over 2 years
- Plant reliability may be negatively impacted because motorised equipment (such as valves, pumps and motors) left idle over long periods of time may develop permanent loss of efficiency and may be more prone to failures (i.e. less reliable). These items are not in contact with water, which is favourable from a durability perspective.

In summary, Cold Standby decreases O&M costs in the short term, but if extended for more than two years, is likely to cause accelerated loss of plant asset value for key components, such as the plant intake, pre-treatment and RO membranes, as well as pumps, valves, mixers and other motorised equipment.

The key benefit of Hot Standby is that it allows some reduction in plant O&M costs, while still maintaining the plant in complete readiness to produce between 0 and 100% of its design capacity at very short notice. In addition, under this mode of operation the plant maintains its reliability, equipment and membrane guarantees at levels that are comparable to continuous plant operation. The hot standby mode of operation is also expected to enhance the useful life of the UF and RO elements by 10% to 20% and reduce their replacement rate.

Lessons learned

This asset stewardship review involved understanding the lessons learned from industry and from the operation of similar scale seawater desalination plants from Australia and the United States.

Through published material available in the public domain, we have been able to consolidate the plant characteristics, performance and lessons learned for the following desalination plants:

- Sydney
- Melbourne (Wonthaggi)
- Gold Coast (Tugun)
- Tampa Bay, Florida, USA
- Santa Barbara, California, USA.

Each plant has operating characteristics that informed the ADP asset review and the report recommendation. A summary of each reference plant assessed in the report is given in Table 1 below.

Table 1 Reference desalination plant

Seawater Desalination Plant Location	Current operation mode	Plant Maximum Production Capacity (ML/d)	Plant Minimum Operational Turndown (ML/d)
Adelaide, South Australia	Proving period ¹	300 ML/d	30 ML/d
Sydney, New South Wales	Cold Standby	250 ML/d	40 ML/d
Melbourne (Wonthaggi), Victoria	Cold Standby	444 ML/d (150 GL/a)	Minimum order of 50 GL/a
Gold Coast, Queensland	Hot Standby	125 ML/d	41 ML/d
Tampa Bay, Florida, USA	Warm Standby ²	95 ML/d	13.4 ML/d
Santa Barbara, California, USA	Cold Standby	25 ML/d	12.5 ML/d

1. Hot Standby commenced on 1 January 2015
2. Warm Standby is where the plant alternates between hot and cold standby

Table 2 below is a summary of the best practices and lessons learned from the reference plants that may be considered for application in the ADP if the plant is to be operated in Cold Standby or Hot Standby.

Table 2 Lessons learned from other similar desalination plants for standby modes

Cold Standby	Hot Standby
<ul style="list-style-type: none"> ■ Cold Standby mode of operation shouldn't be extended beyond two years, as the plant's permanent performance will potentially be reduced. For periods longer than two years the membranes should be stored in standard preserving solutions, to reduce significant permanent loss of productivity and performance 	<ul style="list-style-type: none"> ■ Operation in Hot Standby usually provides greater retention of asset value and longevity
<ul style="list-style-type: none"> ■ This mode requires the longest time to return the plant to full production capacity 	<ul style="list-style-type: none"> ■ Periodic plant shutdowns for 6 to 8 months are not likely have negative impacts on plant performance or the asset in the long-term
<ul style="list-style-type: none"> ■ Plant reactivation after the Cold Standby mode will take months to achieve full production after the water is ordered 	<ul style="list-style-type: none"> ■ Prior to initiating Hot Standby, complete an inventory of all water areas that were stagnant during standby and provide for flushing and draining of those areas


Cold Standby	Hot Standby
<ul style="list-style-type: none"> ■ Cold Standby longer than 15 years will potentially result in significant loss of the overall asset condition and value 	<ul style="list-style-type: none"> ■ Run the plant intake and outfall systems continuously, to maintain its conveyance capacity and prevent excessive fouling by marine growth in the intake
	<ul style="list-style-type: none"> ■ Flush all steel piping after every shutdown and fully automate membrane flushing
	<ul style="list-style-type: none"> ■ Inspect and passivate plant components prone to corrosion
	<ul style="list-style-type: none"> ■ Test the plant's ability to return to full operation at least quarterly and complete weekly dry run operations of rotating equipment
	<ul style="list-style-type: none"> ■ It is important for the asset owner to monitor the plant performance closely. Preventive and active maintenance of equipment is beneficial in ensuring that full production can be achieved expediently.

Table 3 below is a summary of the advantages and disadvantages for each of the two operating modes considered for the ADP.

Table 3 Advantages and disadvantages of the two standby modes

Description	Advantages	Disadvantages
Cold Standby	<ul style="list-style-type: none"> ■ Reduced corrosion, due to less exposure to sea water ■ Enhanced safety through reduced activity ■ Improved longevity of dynamic components normally in contact with water ■ Reduced energy and chemical consumption ■ Higher O&M cost savings 	<ul style="list-style-type: none"> ■ Mean start-up time for the plant will be longer when production is required ■ Availability of trained operators ■ Impact for on call delivery of water to full production ■ If Standby Mode extends beyond two years, plant performance will be reduced
Hot Standby	<ul style="list-style-type: none"> ■ Asset readiness and availability are maintained for full production ■ Faults and problems can be addressed progressively ■ Required maintenance of ancillary and building services is reduced ■ Able to maintain skilled operator workforce ■ Electrical transformers can remain energised ■ Membrane life expectancy is increased and the replacement cycle should benefit SA Water at handover 	<ul style="list-style-type: none"> ■ Durability impact due to intermittent wetting of equipment ■ Impact on reliability of PLC, instrumentation and controls, due to intermittent operation

Despite the Plant operating mode, it is essential for the operator to comply with equipment manufacturers' guidelines and recommendations, in order to maximise asset operability.



The ADP's ability to ramp up to 150 megalitres per day (ML/d) within a short period of time in Hot Standby provides a quicker response than Cold Standby, and provides a capacity to maintain a continuous service in the event of serious power outages or water quality issues such as algae blooms in the reservoirs, poor quality inflow from catchments and elevated salinity from the River Murray.

Comparative analysis with other desalination plants

The Hot Standby mode of operation for the ADP is comparable to that of the Gold Coast desalination plant for both benefits and operational flexibility. Similarly to the Gold Coast desalination plant, the ADP is essential to the high level of reliability and water quality of the water supply in their service areas. Analysis of the distribution system's water quality pre-ADP and post-ADP operation, indicate that in a similar way to the Gold Coast plant, the desalinated water from the ADP has contributed significantly to the water quality in the distribution system.

In addition, both Gold Coast and the ADP improve the reliability of water supply, which, while difficult to quantify in monetary value, is of critical importance to the public utilities responsible for water supply in the plants' service areas.

The mode of operation of the ADP is most similar to that of Tampa Bay Water, where the private operator (a joint venture between Acciona Agua and the American Water Company) has to operate the desalination plant predominantly to address elevated water demand and changes in water quality during the 4 to 6 months of the winter season.

Experience with the operation of the Gold Coast Desalination Plant in Hot Standby, indicates that the ADP operation in Hot Standby should produce measurable O&M cost savings, as compared to the continuous mode of plant operation (i.e. full production).

The time needed to bring the ADP plant to 100% of production capacity under Hot Standby mode is comparable to that of the Gold Coast plant under the same conditions and operational capacity.

Cold Standby practiced at the Sydney Water, Melbourne (Wonthaggi) and Santa Barbara SWRO desalination plants, has shown significant total annual O&M cost savings (i.e. 80% to 90%) compared to full production. This could be achieved under that mode of operation, but such savings are at the expense of the significant increase in time needed to restart the plant to its full capacity.

Membrane performance in standby modes

The following has been observed regarding the effects on the life expectancy of reverse osmosis (RO) and ultra-filtration (UF) membranes:

- The RO and UF membranes will ultimately lose performance permanently if they are left in Cold Standby mode for periods longer than two years
- In Hot Standby mode, the membrane performance will be maintained if they are operated on a nominal 4 week rotation schedule at minimum every 2 years. In this mode, the useful life of the RO and UF membranes is expected to be extended by 30 to 40% beyond the nominal 5 to 7 years expected under normal production. They must be preserved in sodium bisulfide and hypochlorite respectively for the non-operating periods. The useful life of the membranes will be extended by around two years and, accordingly, the total number of membrane elements replaced each year will be reduced.

Analysis and results

The assessment of the preferred operating scenario was informed and assessed using multi-criteria analysis (MCA) and risk assessment processes. The two proposed operating modes were benchmarked against the ADP operating in the normal production mode, where it is able to deliver water up to full production of 300ML/d.

Against the full production base case, the overall MCA results for asset stewardship indicated that the asset deteriorated more in Cold Standby than Hot Standby. Specifically, the key areas that are detrimentally impacted due to non-use when in Cold Standby include the following:

- High voltage power supply and equipment
- Transfer pump station and pipeline to Happy Valley WTP
- Treatment systems including membranes within the ADP.

Impacts from the risks identified in the risk assessment deemed to have major impact are summarised in Table 4 below. It is evident that Cold Standby has more high risks than Hot Standby.

Table 4 Major Impact Risk Assessment Summary

Description	Full Production Base Case	Option 1 Cold Standby	Option 2 Hot Standby
High Risk	0	5	2
Medium Risk	20	16	18

The overall risk assessment results for all impact ratings are summarised in Table 5. The outcome also denoted that Cold Standby has more high level risks, when compared to Hot Standby.

Table 5 Risk Assessment Total Summary

Description	Full Production Base Case	Option 1 Cold Standby	Option 2 Hot Standby
High Risk	0	7	2
Medium Risk	40	67	80
Low Risk	58	25	16

It is important to note that the Base Case scored best, with no high risks, meaning that normal operation at full production is the best mode to preserve the overall asset.

Based on these outcomes, of the two standby options benchmarked against the Base Case, Hot Standby presents a lower risk alternative for overall asset preservation and is the preferred mode of operation.



Recommendation

Based upon the analysis of lessons learned from similar plants and the independent assessments undertaken, from an asset stewardship perspective, Hot Standby is the preferred operation mode to provide the optimum asset condition at year 2032 (end of O&M contract).

The information and data obtained, identified that the Hot Standby mode of operation combines the following asset value benefits:

- Highest plant operational reliability and readiness
- Lower depreciation rate of asset value for the overall facility
- Extended useful life of membranes.

The study has evaluated three basic operational modes for asset stewardship, which are: Normal, Cold Standby and Hot Standby. These modes were appropriate for determining that the preferred asset stewardship standby scenario is Hot Standby.



Confirmation of impartiality and disclosures

Aurecon has been involved with the Adelaide Desalination Plant (ADP) project since April 2008, principally as technical advisor to SA Water. This has included a site presence at the ADP since January 2009 until conclusion in February 2015. Aurecon's tenure has included the construction, operations and maintenance phases.

Aurecon has therefore established a strong technical appreciation of the Adelaide Desalination Plant's operational characteristics and comprehensive asset knowledge. In our capacity as technical advisor, we have provided independent technical opinions and assessments to SA Water. We confirm that in preparing this report we have been balanced, impartial and unbiased in our assessment of the recommended operating mode.

The assessment considered international best practice through reviews of the standby operation of similar saltwater desalination plants, and also emerging technologies and research technical papers. We have engaged with other Australian Water authorities (e.g. Sydney Water), key academic sources (including the University of New South Wales), operators, suppliers and asset owners. To support the above engagement, we have enhanced our knowledge and experience by working in partnership with US-based sub-consultant Water Globe Consulting. Water Globe Consulting has been engaged in the plant commissioning and operational reviews of many Australian desalination plants, such as those in Sydney, Melbourne (Wonthaggi, Victoria) and the Gold Coast. We have also undertaken operational reviews of the Tampa Bay Plant (Florida, USA) and the Santa Barbara desalination plant (California, USA), which included completion of an analysis of the standby modes of operation applied at these plants (comparable to this assignment).

We confirm that both Aurecon and Water Globe Consulting, through this report, are providing an unbiased and independent technical opinion.

Glossary

Abbreviations and acronyms contained in this report together with other terminology and definitions are listed below.

Table 6 Glossary

Term	Definition
ADP	Adelaide Desalination Plant
AAPL	AdelaideAqua Pty Ltd
Cold Standby	Zero production, also known as Mothball
GL/a	Gigalitres per annum
Hot Standby	Minimum Production, also known as short-term standby
Minimum Production	Hot Standby, 30 ML/d production rate for nine months per year (approximately 8 GL/a)
MCA	Multi-criteria analysis
ML/d	Megalitres per day
NSIS	North South Interconnection System
O&M Contractor	AdelaideAqua Pty Ltd
Operator	AdelaideAqua Pty Ltd
Plant	Abbreviation for Adelaide Desalination Plant
RA	Risk assessment
RO Plant #1	Main process building 1, with 150 ML/d or 50 GL/a capacity
RO Plant #2	Main process building 2, with 150 ML/d or 50 GL/a capacity
RO	Reverse osmosis
SA Water	South Australian Water Corporation is a government-owned utility, which provides water and wastewater services to more than 1.5 million people in South Australia
SWRO	Seawater Reverse Osmosis
UF	Ultrafiltration
Zero Production	Cold Standby



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