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Changing perception of the value of urban water in Australia following investment in seawater desalination

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ABSTRACT

Recent climatic changes and population growth throughout Australia have highlighted the need for more diverse and climate-independent water sources to be introduced to secure local and regional water supplies. Australia is the world's driest inhabited continent and the unpredictable climate means that the Australian population generally requires up to five times the water storage than does an equivalent population in, for example, Europe. Although 85% of its people live within 50 km of the coast, the country has only begun to consider large-scale seawater desalination within the past seven years. The total potable and industrial water consumption in Australia is estimated to be around 50,000 ML/d. In 2005, the total capacity of installed desalination for potable and industrial use was about 0.6% (300 ML/d). This is expected to increase more than seven times to 4% (1,900 ML/d) by 2015. In response to the growth in desalination capacity, the Australian Government has invested $20 m in desalination research over five years and established the National Centre of Excellence in Desalination Australia (NCEDA), a consortium of 14 universities and research organisations. The NCEDA has 33 research projects in progress and has completed a Pilot Scale Test Facility and Desal Discovery Centre to educate schoolchildren in Perth.

Keywords: Seawater; Desalination; Australia; Urban; Perception

1. The Millennium Drought

For a 13-year period between 1997 and 2010, Australia's weather was affected by a prolonged El Nino effect (cooling of the Pacific and Indian Oceans resulting in drier air over the continent and reduced rainfall) and was widely considered to be the worst drought in a thousand years. Many urban areas in the east and south of Australia, dependent principally on water stored in dams, enacted water restrictions. In south east Queensland and inland areas of east and south Australia, water restrictions became very severe, with water use allowed only inside houses for domestic purposes and with requests for people to even limit the length of showers.

However, the length and severity of the drought focused political attention on the problem. With policy generally being predicated on the expectation that rain would fall, it became evident there was a real risk that the drought would continue and some cities, like Goulburn in New South Wales, faced the prospect of actually running out of water. Action occurred in the early 2000s with the Gold Coast City Council

Fig. 1. The Millennium Drought in Australia.

announcing a desalination plant at Tugun, the Queensland Government announcing a large indirect potable wastewater recycling scheme for Brisbane (the Western Corridor project), with a new bulk transfer scheme (the Water Grid); and the New South Wales, Victorian and South Australian Governments all announcing major desalination plants (see Fig. 1). The total potable and industrial water consumption in Australia is estimated to be around 50,000ML/d [1]. In 2005, the total capacity of installed desalination for potable and industrial use was about 0.6% (300 ML/d). This is expected to increase more than seven times to 4% (1,900 ML/d) by 2015.

In contrast, Western Australia's south-west had been experiencing a reduction in rainfall and surface water runoff since 1970, with average intake for Perth's dams reducing from 300 GL/y to around 100 GL/y. This is thought to be a result of climate change where the weather pattern has shifted south, making Perth more arid. Historically dependent on groundwater and surface water supplies (both declining), and a growing population, a decision was taken in 2004 by the Western Australian Government to build Australia's first major seawater desalination plant at Kwinana to provide 45 GL/y for ongoing security of supply.

2. Floods

In 2010, the Millennium Drought broke as a result of La Nina (warming of the Pacific and Indian Oceans) bringing very moist and unstable air over the continent. Severe flooding occurred over Eastern and Southern Australia. However, south-west Western Australia continued to be dry. Much of the desalination and water reuse infrastructure was completed of or near completion when the drought broke out.

With storages replenished and in some cases filled, some people (wise after the event) have questioned the need for constructing desalination infrastructure.

3. The national centre of excellence in desalination, australia

3.1. NCEDA funding and structure

The NCEDA was established in 2009. The NCEDA has received $A20 m in funding over five years for research from the Australian Government's National Water Initiative—National Urban Water and Desalination Plan. The NCEDA comprises 14 Participating Organisations including 13 universities and the Commonwealth Scientific and Industrial Organisation (CSIRO) as shown in Table 1.

Each of the Participating Organisations contributes an annual fee towards administration of the Centre, which entitles them to bid for research funds, and for award of scholarships for honours and higher degree students. The Centre engaged the academic and industrial community in 2009 and published a Desalination Research Roadmap in 2010. The Roadmap has identified gaps in knowledge and guides research effort (see Fig. 2).

The Centre has a vision for desalination in Australia:

Efficient and sustainable augmentation of traditional water sources to provide security against the natural variability of rainfall and potential future impact of climate change.

The Roadmap identified five priority research themes:

Table 1
NCEDA participating organisations

Murdoch University*	WA
Curtin University	WA
University of WA	WA
Edith Cowan University	WA
Flinders University	SA
University of SA	SA
Deakin University	Victoria
Victoria University	Victoria
Monash University	Victoria
University of NSW	NSW
University of Technology Sydney	NSW
University of Wollongong	NSW
University of Queensland	Qld
CSIRO	

*Administering organisation.

Fig. 2. Floods in Eastern Australia, January 2011.

Table 2
Funding sources including cash and in kind for NCEDA 2009–2014

Source	
Australian Government	$20 m
WA Government	$3 m
Partners	$7 m
Sponsors	$1 m
Murdoch University	$11 m
Project partners	$30 m
TOTAL	$72 m

- Pre-treatment.
- Reverse osmosis desalting.
- Novel desalting.
- Concentrate management.
- Social, environmental and economic issues.

The Centre has also received generous cash and in-kind funding from Murdoch University, the Western Australian Government, industry sponsors and project partners estimated to total more $70 m over the five years (see Table 2).

3.2. NCEDA research program

There have been three funding rounds to date through 2010 and 2011, with total Centre funding of $9.6 m. The details of the funding rounds are shown in Table 3, and it can be seen for each dollar of funding from the Australian Government, there has been $2 cash and in kind contributed by partners.

The spread of the 33 projects over the five priority research themes is shown in Table 4, followed by a complete list of projects currently under way. Each of the priority research themes is covered, with a majority of projects in reverse osmosis desalting.

Each project approved in funding Rounds 1, 2 and 3 are shown below, with the Participating Organisation, principal investigator and partners.

3.3. NCEDA funding Round 1 (May 2010)

- Developing highly conductive graphene electrodes for capacitive desalination: **Prof. Linda Zou,** University of South Australia, SA Water.
- Development of a novel low grade heat driven desalination technology: **Prof. Hui Tong Chua**, The University of Western Australia, WA Geothermal Centre of Excellence, BHP Billiton, Worsley Alumina.
- High water recovery inland desalination using membrane distillation with ceramic membranes: **Prof. Joe Da Costa,** The University of Queensland, Victoria University, Ceramipore, Tarong Energy, The Pumphouse.

Table 4
NCEDA projects by priority research theme

Pre-treatment	6
Reverse osmosis desalting	12
Novel desalting	5
Concentrate management	6
Social, environmental and economic issues	4

Table 3
NCEDA funding Rounds 1–3

Funding round	Projects	NCEDA funds	Partners cash and in kind	Total
1	11	$2.8 m	$8.1 m	$10.9 m
2	12	$3.0 m	$6.9 m	$9.9 m
3	11	$3.8 m	$7.6 m	$11.3 m
Total	34	$9.6 m	$22.6 m	$32.1 m

- Nanostructure of diatoms: **Dr Sophie Leterme**, A predictive model for species sustainability: Flinders University, SARDI, SA Water.
- Highly productive and selective bio-organic hybrid membrane water filters: **Prof. Michael Montiero**, The University of Queensland, Stanford University.
- Management of brine disposal into inland ecosystems: **Prof. Ray Froend,** Edith Cowan University, WA Centre of Excellence in Ecohydrology, Rio Tinto (Dampier Salt Ltd), Water Corporation, WA Department of Environment and Conservation.
- Membrane flocculation hybrid system as pre-treatment to brackish water reverse osmosis desalination system: emphasis on chemical use reduction and recovery: **Prof. Vigi Vigneswaran,** University of Technology Sydney, Curtin University, IFTS France, KAUST Saudi Arabia, State Water NSW, Coliban Water, Steriflow Filtration Systems.
- Reverse osmosis brine management by membrane distillation crystallisation: **Prof. Stephen Gray**, Victoria University, CSIRO, CWMWater, Siemens, Osmoflo.
- Public perception of, and response to, desalination in Australia: **Dr Tanya King,** Deakin University, Victoria University, Murdoch University, Edith Cowan University, Melbourne Water, Yarra Valley Water.
- Reuse of reverse osmosis membranes: **Dr Pierre Le-Clech,** The University of New South Wales, Victoria University, Monash University, SkyJuice Foundation, Water Corporation, DOW Chemical, SA Water, Sydney Water.

3.4. NCEDA funding Round 2 (October 2010)

- Assessing and mitigating environmental impacts of SWRO outfalls on marine benthic organisms: **Dr Julie Mondon,** Deakin University, University of Western Australia.
- Tjuntjuntjara remote inland indigenous community solar/waste energy groundwater desalination project: **Dr Trevor Pryor,** Murdoch University, WA Department of Housing, Memsys Clearwater Distribution Pte Ltd.
- Control of organic membrane fouling through limitation and control of extracellular microbial product: **Prof. Goen Ho**, Murdoch University, Environmental Biotechnology Co-operative Research Centre.
- Application of capacitive deionisation in inland brackish water desalination: **Prof. Linda Zou**, University of South Australia, LT Green, Power and Water Authority, SA Water.
- Silica removal from groundwater for reverse osmosis water recovery enhancement and waste brine volume reduction: **Dr Peter Sanciolo**, Victoria University, Hatch, Origin Energy, Minara Resources and University of Texas El Paso.
- Strategies for membrane fouling control in desalination pre-treatment: **A/Prof. Greg Leslie,** University of NSW, Curtin University of Technology; Water Corporation, Veolia, Siemens.
- Fertilizers as draw solutes for forward osmosis desalination: a novel approach for fertigation in the Murray Darling Basin: **Dr Ho Kyong Shon**, University of Technology Sydney, Korea University, Yale University, NSW State Water Corporation, SK Energy.
- Real time detection and management of biofouling conditioning films in seawater reverse osmosis: **A/Prof. Greg Leslie,** University of NSW, University of SA, InPhaze Pty Ltd, SA Water, Sydney Water.
- Development of universally applicable coatings and additives for state of the art reverse osmosis and pre-treatment: **Dr Melina Ginic-Markevic,** Flinders University, Wind Prospects Pty Ltd, SA Water, Siemens.
- Mitigation of biofouling using natural polysaccharide surface coating: **Dr Thuy Tran**, CSIRO.
- Non brittle ceramic hollow fibre membranes: **Prof. Huanting Wang**, Monash University.
- Development of cleaning guidelines for desalination membrane users: **Dr Marlene Cran**, Victoria University, Nalco, Integrated Elements.

3.5. NCEDA funding Round 3 (August 2011)

- Fibre optic sensor for water quality monitoring: **Prof. Kamel Alameh**, Edith Cowan University.
- Transverse vibrational motion enhanced submerged hollow fibre membrane crystallizer: **Prof. Vicki Chem**, University of NSW, Singapore Membrane Technology Centre.
- Modelling, monitoring and control of RO biofouling: **Dr Ralf Cord Ruwisch**, Murdoch Uni-

versity, Nanyang Technological University, AquaMem Scientific Consultants, Valoriza and University of Alicante.

- Smart materials for corrosion management: **Prof. Maria Forsayth**, Deakin University, Monash University, Ohio State University, AECOM, Asis Scientific and AusComposites.
- Evaluation of non chemical pulsed power technology as an antifouling pretreatment for RO desalination membranes: **Dr Tom Yeager**, Victoria University, AquaMem Scientific Consultants and SA Water.
- Assisted forward osmosis for energy savings in RO desalination: **Dr Pierre Le-Clech**, University of NSW, University of Nevada and Singapore Membrane Technology Centre.
- Assessing the biofouling role of microbes in the desalination system; from the intake pipe to the RO membranes: **Dr Sophie Leterme**, Flinders University, Singapore Membrane Technology Centre and SA Water.
- Continuous silica removal during desalination for increased water recovery: **Prof. Stephen Gray**, Victoria University with Origin Energy.
- Brine management guidelines: **Dr Peter Sanciolo**, Victoria University, SmartWater Fund, GWMWater and Integrated Elements.
- Membrane absorption bioreactor hybrid system as a pretreatment to RO desalination: **Prof. Vigi Vigneswaran,** University of Technology Sydney, Gwangju Institute of Science and Technology, King Abdullah Institute of Science and Technology, Singapore Membrane Technology Centre and University of NSW.
- The optimization and improvement of direct filtration pretreatment both organic and biofouling of RO membranes: **Prof. Vigi Vigneswaran**, University of Technology Sydney, ProAlliance, Curtin University, Gwangju Institute of Science and Technology, King Abdullah Institute of Science and Technology, Singapore Membrane Technology Centre and University of NSW.

3.6. NCEDA pilot test facility

The Centre's facilities at Rockingham include a world-class pilot scale test facility. The Rockingham site is built over two aquifers. The deeper confined aquifer is recharged from seawater (the Centre is about 1 km from the sea) and contains a sustainable supply at about 27,000 mg/L TDS (about 80% seawater). There is also a shallow unconfined aquifer recharge from rainfall that is fresh (about 500 mg/L). Water from the two bores can be automatically blended into each of three storage tanks with salinity between 500 and 27,000 mg/L. The blended water can then be supplied continuously via three reticulation systems to nine locations within the pilot plant facility. There is also provision to connect large container plants on a hardstand area at the rear.

Permeate and concentrate from each pilot plant under test are collected in drains, blended and pumped to a recharge bore that injects it into the deeper saline aquifer. Chemical wastewater from cleaning is collected in a third drainage system and automatically neutralised before discharge to the sewerage system (see Fig. 3).

The Pilot Scale Test Facility is managed by Mr Mike Blackwood, a very experienced water industry operator with electrical, control and management expertise derived from both Government and private water sectors. He is assisted currently by Mr George Horvath, a mechanical fitter with 15 years' experience in desal plant construction, commissioning and operation at Osmoflo, the largest Australian desalination company.

3.7. NCEDA Desal Discovery Centre

As part of the Centre's outreach to the Australian community, a Desal Discovery Centre (DDC) has been incorporated into the Centre's infrastructure.

Managed by an experience teacher, Mr Warren Hays, the Centre comprises a state-of-the-art large screen 3D multimedia conference room and an Edulab where schoolchildren can learn in a practical way about water desalination, and indeed broader issues of water chemistry and physics.

The DDC's programme is aligned with the Australian education curriculum and it is expected

Fig. 3. The NCEDA Rockingham Desalination research facility.

Fig. 4. The Desal Discovery Centre Manager Warren Hays with the chief scientist of Western Australia (Prof. Lyn Beazley).

many schools will take advantage of the facility. Curriculum material will also be available for distribution to Australian schools upon request (see Fig. 4).

The Centre is very grateful to the support of the Western Australian Government which has funded part of the Rockingham infrastructure, and three Gold Industry Sponsors, Valoriza, Osmoflo and Trility. who have underwritten the Centre's ongoing operation for five years.

3.8. NCEDA students

The NCEDA is committed to encouraging Australian students (and international students with permanent residency) to study honours and higher degrees in desalination-related topics. There are 20 students who have been awarded NCEDA top-up scholarships totalling $580,000 from each of the Participating Organisations.

3.9. NCEDA people

The NCEDA is also supported by a wide range of very experienced and knowledgeable industry professionals who have been retained by the Centre or who serve on the two advisory committees. The bid to establish the Centre, and early strategic initiatives were managed by Mr David Doepel who became the Centre's first interim CEO.

Key technical support is provided by the Chief Scientific Officer, Prof. David Furukawa. Prof. Furukawa, based in California, has been working in desalination since the commencement of serious reverse osmosis research in the 1960s. He joined the NCEDA in 2009 and continues to provide advice and encouragement to the many participants in the research programme. In recognition of his vast contribution to the desalination industry and the NCEDA, the Vice Chancellor of Murdoch University granted him Honorary Professorial status in September 2011. The Research Advisory Committee is chaired by Mr Rhett Butler of Siemens Water. Rhett has an extensive technical sales background and also leads Skyjuice, a not-for-profit organisation to provide appropriate and affordable water technology to developing countries.

The Centre has a very strong commercialisation focus led by Mr Larry Lopez of Australian Venture Consultants, the Chair of the Centre's Commercialisation Advisory Committee (see Fig. 5).

The Centre's administration is supported by the Chief Operating Officer, Ms Sharon Humphris and consultant Mr Scott Humphries who were instrumental in establishing the Centre. The Research Project Administrator is Dr Misty-Lee Palmer and Administration Officer Ms Carole Lynch. Marketing is managed by Ms Sandie Rawnsley and Media by Ms Tanyia Maxted.

Fig. 5. Prof. Richard Higgot, vice chancellor of Murdoch University, Prof. David Furukawa and Neil Palmer, CEO of NCEDA.

4. Australian desalination plants

Since the first major seawater desalination plant was commissioned in Perth in 2006, a further five major urban plants have been completed or are under construction, representing more than $10b in infrastructure investment [3,4]. There has also been a major potable water recycling scheme constructed in Brisbane (the Western Corridor Scheme) that is capable of producing 230 ML/d of potable grade water. However, at the time of writing, the water is only used for power station cooling as the scheme has not commenced pumping into public water supply reservoirs.

There are also two industrial seawater desalination plants being constructed at Karratha for an iron ore project and a planned plant for Whyalla in South Australia for the Olympic Dam copper–uranium expansion project.

A list of plants is shown in Table 5, and a brief description follows.

4.1. Western Australia

The Perth Seawater Desalination Plant, (PSDP) located at Kwinana on Cockburn Sound, was completed in December 2006. At a peak capacity of 145 MLD, the A$387 million plant was at the time of construction the largest seawater desalination plant outside the Middle East, and Australia's first large-scale desalination facility. It was the biggest single water source feeding into the city of Perth, providing 17% of water needs.

The plant was built by Multiplex-Degremont Joint Venture, in alliance with the Water Corporation. It will be operated for 25 years by ProAlliance, Degremont in alliance with the Corporation. An associated 82 MW wind farm is injecting over 272 GWhr per year into the grid from which the PSDP will be abstracting 185 GWhr per year.

The Southern Seawater Desalination Plant (SSDP) of 150 ML/d capacity near Bunbury was opened in September 2011 and Stage 2 for an additional 150 ML/d has now commenced. The plant was built and operated by the SSDP Alliance with process lead comprising Technicas Reunidas S.A and Valoriza Agua with engineering consultant Worley Parsons and constructor AJ Lucas. Similar to the Kwinana plant, it will be powered by energy from renewable sources.

CITIC Pacific Sino Iron, at Karratha, in the Pilbara, will be one the world's largest mines. To supply both the mine and township, a consortium led by IDE is building a 140 ML/d plant in stages at Cape Preston. The first stage is expected to be delivering water in late 2011 (see Figs. 6 and 7).

4.2. Queensland

Desalination is a key component of both the Gold Coast Waterfuture Strategy and the Southeast Queensland Regional Drought Strategy Contingency

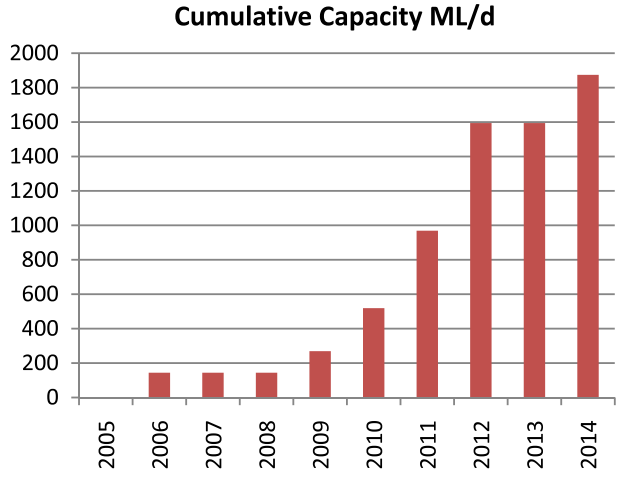

Fig. 6. Cumulative capacity of Australia's seawater RO plants for 10 years 2005–2014.

Table 5
Australia's current and planned large SWRO plants

State	Location	Owner	Process	Capacity ML/d	Status	Completion date
WA	Kwinana	WCWA	MMF/RO	145	Operating	2006
	Bunbury	WCWA	UF/RO	150	Operating	2011
	Karratha	CITIC iron	UF/RO	140	Under construction	2012
SA	Adelaide	SA water	UF/RO	300	Being commissioned	2011
	Whyalla	BHP billiton		280	Planning	2014
Vic	Wonthaggi	DSE	MMF/RO	450	Under construction	2012
NSW	Kurnell	Sydney water	MMF/RO	250	Operating	2010
Qld	Gold coast	SEQ water	MMF/RO	125	Operating	2009
			Total	1,840		

Fig. 7. Location of major Australian desalination plants.

Supply Plan. The plant at Tugun, close to the Gold Coast Airport, has been completed and produces 125 ML/d. A 25 km pipeline delivers the water to the Water Grid, SE Queensland's bulk water supply network. The plant was built by the Gold Coast Alliance, a Veolia-John Holland Joint Venture, in alliance with Gold Coast Water and the State Government. The plant will be operated for 10 years by Veolia in alliance with the Gold Coast Water and the State Government (see Fig. 8).

4.3. New South Wales

Sydney Water has completed a 250 ML/d seawater desalination plant at Kurnell Peninsula, south of Botany Bay. Intake and outfall infrastructure has been sized for ultimate expansion to 500 ML/d. The Blue Water Joint Venture, comprising John Holland Group Pty Ltd and Veolia Water, has designed and built the plant which Veolia Water will operate and maintain for 25 years. Originally owned by Sydney Water, the plant is currently being offered for sale to the private sector. As for the WA plants, the Sydney Desalination Plant will purchase renewable energy to offset all usage.

Fig. 8. Perth seawater desalination plant.

4.4. Victoria

The State Government is building a 450 ML/d desalination plant to ensure reliable supplies for southern Victoria. The site chosen is near Wonthaggi, Gippsland, with intakes and saline outfalls into Bass Strait. It is being delivered as a BOOT by AquaSure, a consortium consisting of Suez Environnement, Degremont, Thiess and Macquarie Capital Group. Construction commenced in 2009 and it is expected to start delivering water by the end of 2012. The $3.5 billion project includes an 85 km pipeline to connect the plant to Melbourne's Cardinia Reservoir, east of the city.

4.5. South Australia

A 300 ML/d desalination plant for Adelaide is currently being commissioned on the former Mobil refinery site at Port Stanvac on St Vincent Gulf, south

of the city. The plant is being built by Adelaide Aqua, a consortium of Acciona Agua, McConnell Dowell, Abigroup and United Utilities Australia.

BHP Billiton, one of the world's largest resources companies produces copper, uranium, gold and silver from its Olympic Dam mining and processing plant near Roxby Downs in the north of South Australia. An expansion project has been approved and includes a seawater desalination plant with a capacity of 280 ML/d. The plant location is at Pt Lowly, near Whyalla, South Australia. There have been concerns about the impact of the RO concentrate on the spawning grounds of a unique species of giant cuttlefish, and significant ecotoxicological testing has been undertaken. The project will include a 320 km transfer pipeline system between Whyalla and the mine at Olympic Dam.

4.6. Thermal plants

Two thermal desalination plants have been constructed recently in Western Australia for industrial applications. These are a 3.6 ML/d MVC plant on the Burrup Peninsula for Burrup Fertilisers Ammonia Plant and a 7.2 ML/d MED plant at Ravensthorpe for BHP Billiton's Ravensthorpe Nickel Plant. The Ravensthorpe plant is currently mothballed (along with the mine) as a result of the 2008/2009 Global Financial Crisis.

4.7. Other potable and industrial plants

There are thought to be more than 1,000 small reverse osmosis plants servicing remote mining and oil and gas sites, power stations, medical (dialysis), food and beverage plants and coastal and island communities. Osmoflo, the largest Australian desalination company, alone has built more than 300 plants since 1991. The first reverse osmosis plant was thought to have been installed by Permutit at Cook, a siding on the Trans-Australian Railway in the Nullarbor Plain in 1968 [2]. The first large-scale brackish water reverse osmosis plant (35 ML/d) was built at Bayswater Power Station in NSW in 1987 for cooling water salinity control.

Much of the inland water is brackish and in some cases hypersaline [5]. In many cases, plants operate at low recovery which means significant volumes of concentrate are wasted to evaporation or injection. The Water Corporation of Western Australia is exploring a number of methods to improve recovery. In conjunction with Australian desalination company Osmoflo, it tested a combination of ion exchange and RO at Yalgoo, inland from Geraldton, termed High Efficiency RO (HERO), to increase recovery from a silica-rich groundwater from 55% to more than 90%. Water Corporation is also piloting electrodialysis reversal (EDR) on similar water at Wiluna and is understood to be achieving more than 85% recovery.

5. Changing perception of the value of urban water

In the eastern states of Australia, the flooding which occurred after the 13-year Millennium Drought has resulted in some people (given the benefit of hindsight) questioning the wisdom of constructing seawater desalination plants. The NCEDA has embarked on a process of informing people through its Desal Discovery Centre, public presentations, training courses, articles and media releases to outline

Table 6
Common misconceptions about seawater desalination and NCEDA responses

Common perception	NCEDA response
Seawater desalination uses too much energy	If all the water used by an average Australian household came from desalination, the energy used to produce the water is about the same as the energy used to run the household refrigerator The cruise ship Queen Mary 2 carries 3,000 passengers. It has 117 MW of installed power—more than enough to desalinate all the water for the whole of Perth (1.7 m people)
Desalinated seawater is too expensive	The increase in the cost of water to per household per week for desalination in one Australian city is about the same as the cost of one glass of beer per household per week
Concentrate returned to the sea destroys the marine environment	The Perth Seawater Desalination Plant has been operating in Cockburn Sound, a relatively confined body of water, for 5 years at 100% capacity. There has been no impact on the marine environment from the diffused concentrate. This has been confirmed by monitoring by the University of Western Australia [6]

some of the basic principles of desalination and water security. There are three common misperceptions about seawater desalination. They are listed in Table 6 along with NCEDA's responses.

Desalination capacity for the five mainland capital cities at the end of 2012 will be about 35% of gross total water demand. This has a profound effect on water security, provided the desalination plants are viewed as "base load" plants and not "peak load" plants. The consequence is greatly increased security of supply which should make water restrictions a thing of the past.

Naturally, there is a premium to pay for insurance of this type—but it is affordable. The potential to supply increased water demand for population growth is another valuable reason to consider seawater desalination. Desalination plants are long-term investments. Their existence has helped many Australians understand the real value of water.

6. Conclusion

To say investment in desalination technology in Australia over the past five years has been astonishing is almost an understatement. A combination of reverse osmosis technological advancement, unit cost reduction, climate change, long-term drought, population growth and Government inaction in the late 1990s and early 2000s has resulted in an expected increase in water supplied by desalination during the ten year period from 2005 to 2015 from less than 100 ML/d to more than 1,800 ML/d. This includes six very large plants to supply Perth, Brisbane, Sydney, Adelaide and Melbourne.

It may be said that desalination has "come of age" in Australia. The Australian Government has recognised this by the establishment of a $A20 m NCEDA funded by the National Water Initiative. Based at Murdoch University in Perth, the NCEDA has also been strongly supported by the Western Australian Government. As an indication of Australia's maturity in desalination, Perth hosted the International Desalination Association's World Congress in September 2011 which was attended by 1,200 international and Australian delegates.

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