

Australian Water Recycling
Centre of Excellence

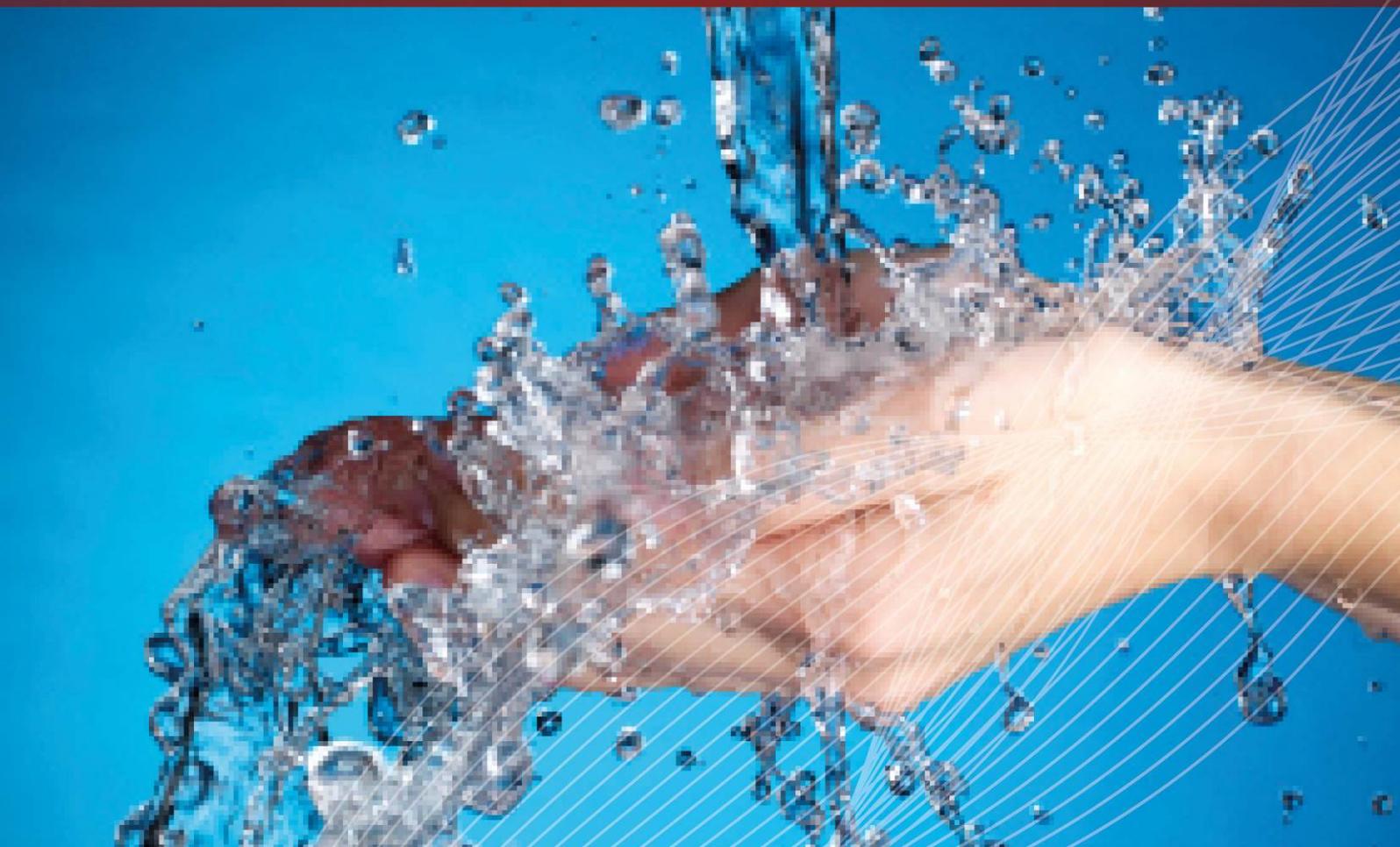


Project Report

Global Potable Reuse Case Study 3: NEWater, Singapore

A report of a study funded by the
Australian Water Recycling Centre of Excellence

University of New South Wales, November, 2014



Global Potable Reuse Case Study 3: NEWater, Singapore

This report has been prepared as part of the National Demonstration Education and Engagement Program (NDEEP). This Program has developed a suite of high quality, evidence-based information, tools and engagement strategies that can be used by the water industry when considering water recycling for drinking purposes. The products are fully integrated and can be used at different phases of project development commencing at “just thinking about water recycling for drinking water purposes as an option” to “nearly implemented”. The information contained in this Case Study was first published on the Public Health pages of a University of New South Wales Wiki website in 2012.

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About the Australian Water Recycling Centre of Excellence

The mission of the Australian Water Recycling Centre of Excellence is to enhance management and use of water recycling through industry partnerships, build capacity and capability within the recycled water industry, and promote water recycling as a socially, environmentally and economically sustainable option for future water security.

The Australian Government has provided \$20 million to the Centre through its National Urban Water and Desalination Plan to support applied research and development projects which meet water recycling challenges for Australia's irrigation, urban development, food processing, heavy industry and water utility sectors. This funding has levered an additional \$40 million investment from more than 80 private and public organisations, in Australia and overseas.

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TABLE OF CONTENTS

1. Scheme Overview	4
Background.....	4
2. Scheme Infrastructure	4
Operational Monitoring	4
Treatments & Multiple Barriers	5
3. Water Quality & Public Health	6
Assessments of Water Quality.....	6
NEWater water quality data	7
Health effects study	8
4. Public Education & Engagement	8
5. References	8

1. Scheme Overview

Background

Singapore (Figure 1) began conceptualizing potable reuse in the 1970's to deal with the challenges of **population growth, break dependency on Malayan supplies**, and to **supplement their existing reservoirs** ^[1]. However, due to the lack of suitable technology and the high costs associated with the processes at the time, the idea was not pursued.



Figure 1: Location of Singapore.

With suitable technology becoming available plus the improved cost-effectiveness of the reuse process, the first NEWater plant was completed in 2000 and **pilot testing** began (**2000-2002**) directly at a demonstration-scale facility to **evaluate the effectiveness of the treatment trains**. Incorporation of reclaimed water into surface reservoirs (IPR) began in 2003 and with the success of that facility, NEWater has since added three other facilities with a combined capacity of **117 mgd**.

- Bedok Factory – 18 mgd (59 million S\$)
- Kranji Factory – 17 mgd (70 million S\$)
- Changi Factory – 50 mgd (200 million S\$)
- Ulu Pandan Factory – 32 mgd (130 million S\$)

These schemes currently provide water to augment reservoirs (~10% augmented depending on seasonal demand) that serve the entire Singaporean population (**5,399,200 inhabitants**) and to **industries** for non-potable use. The NEWater schemes were sponsored by PUB and the Ministry of the Environment and Water Resources (MEWR). The scheme has been awarded 23 national and international awards ^[2].

Further information on NEWater can be found on the Global Connections Map on the *Water360* website.

2. Scheme Infrastructure

Operational Monitoring

NEWater's **permit** was based on WHO and USEPA guidelines. Their monitoring standards are based on internal operational control limits on surrogate operational parameters, USEPA, and WHO; USEPA unregulated parameters are derived from the Contaminant Candidate Lists (CCL).

Processes are **monitored online** using the online sampling and monitoring program (SAMP) that continuously investigates a set of parameters (TOC, conductivity, pH, turbidity and ammonia levels). In the event there are abnormal operating conditions, the plant would automatically shut down. Incorporated in their operational process is a **preventive maintenance schedule** that was developed based on equipment manufacturer recommendations and operational experience for all the equipment (mechanical, electrical and process equipment - membranes). Their range of employees include operators, maintenance personnel, technicians and engineers, who are all relevantly trained to handle the range of day-to-day events. NEWater is **audited twice a year** by the National Environment Agency (NEA) panel. A panel of **international experts** in the industry also provides ongoing peer advice to the scheme.

Treatments & Multiple Barriers

NEWater reclaims both domestic and industrial wastewater at its sites for potable reuse. NEWater factories monitor incoming feed water quality produced upstream by the water reclamation plant (WRP) which must comply with effluent quality specifications. The majority of industrial trade waste is treated at Jurong WRP (under the Sewerage and Drainage Act) to international discharge standards and sent to ocean outfall or sent for further treatment and recycled as High Grade Industrial Water (Figure 2). The scheme does not experience any significant seasonal variations.

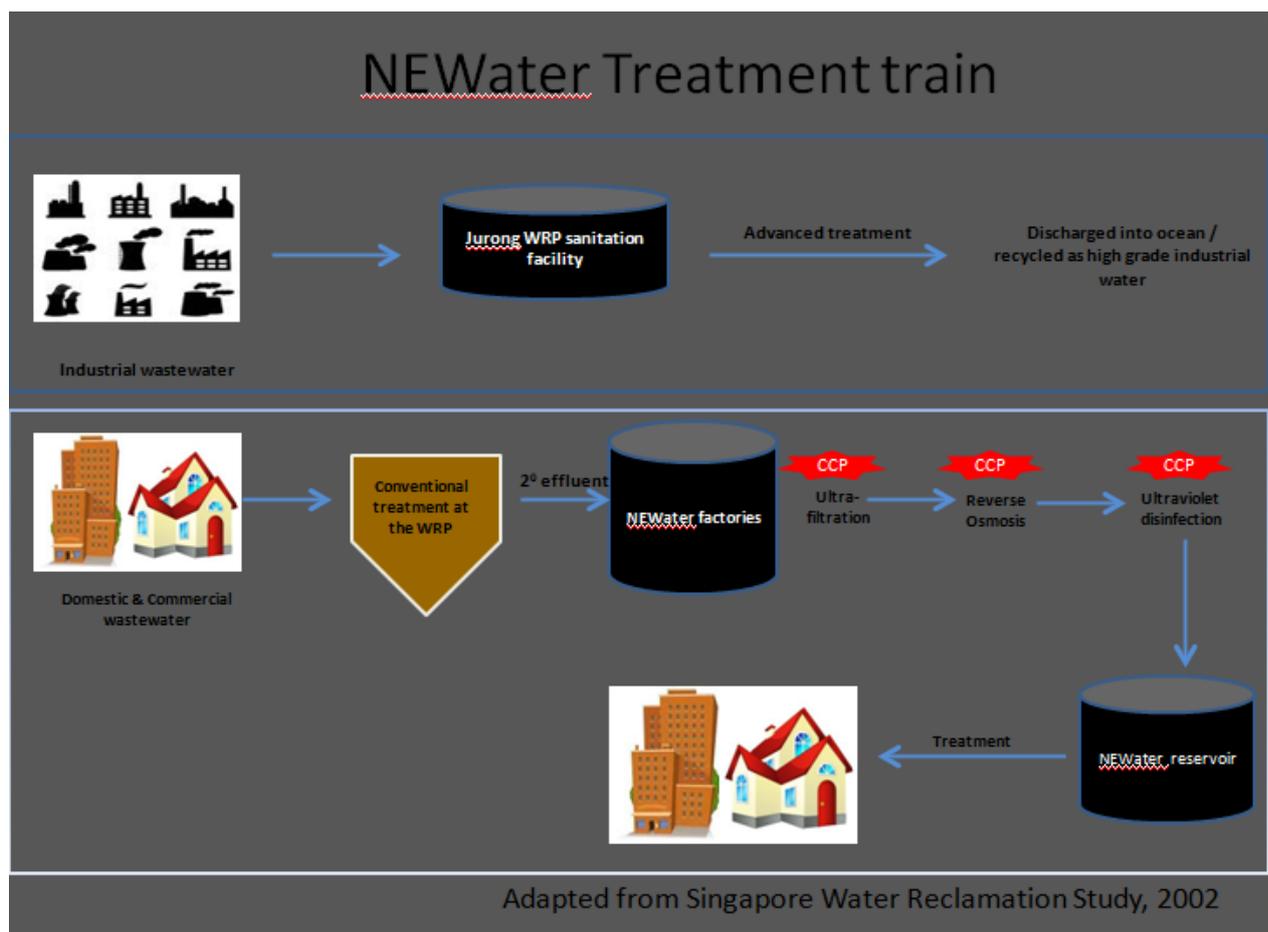


Figure 2: Singapore NEWater treatment train.

NEWater incorporates **11 barriers** within its processes which include its **pre- and advanced treatments** plus the **reservoir** (Table 1).

Table 1: NEWater pre-treatment and advanced treatment barriers.

Pre-treatment	Advanced Treatment
Coarse Screens remove large debris	UF
5mm fine screens remove small debris	RO
Primary Sedimentation Tank	UV disinfection
Bio-reactor	
Secondary Sedimentation Tank	

3. Water Quality & Public Health

Two **public health units** collaborate with NEWater: the **NEA** and the **Health Sciences Authority**. For the protection of public health, finished product water is tested weekly as part of SAMP for parameters listed on the critical control point (CCP) list. Final water quality is approved by the **Environmental Public Health unit**. In the event of water quality breach, **supply of water ceases within 8 minutes** of breach detection. Incidents are reported to the NEA. Because NEWater is not used for direct potable use but augmented into a reservoir before traditional drinking water treatment, no community notification or public communication plan was considered necessary for the reclamation process. An independent survey of community attitudes conducted by Forbes Research in 2002 showed a 98% acceptance rate of recycled water, with 82% respondents indicating that they would drink NEWater directly and 16% indicating they would drink it mixed with reservoir water.

Assessments of Water Quality

NEWater monitor for ~**316** water quality parameters (a few examples are presented in Table 2). To date, they have performed over 127,000 tests on samples from treated wastewater and NEWater.

Table 2: Examples of key NEWater water quality monitoring parameters.

Water Quality Category	Parameter
Physical parameters	Turbidity
	Colour
	Conductivity
	pH
	Total hardness
Chemical components	Fluoride
	Nitrate
	Sulphate
	Total trihalomethanes
Metals	Aluminium
	Iron
	Manganese

	Zinc
Bacteriological indicators	Total coliform bacteria
	Enterovirus
	Heterotrophic plate counts

NEWater water quality data

A summary of key parameters of interest, permit limits, and water quality values for the past 5 years (2009-2013) is presented in Table 3.

Table 3: NEWater water quality data 2009-2013.

Parameter	Units	Final Product Water Average					Permit Limits by USEPA/WHO/EPH
		2009	2010	2011	2012	2013	
Microbiological Indicators							
Heterotrophic plate Counts	cfu/100ml	66	447	1120	139	75	< 50,000 (USEPA)
Total Coliforms	cfu/100ml	< 1	< 1	< 1	< 1	< 1	Not Detectable
<i>E. Coli</i>	cfu/100ml	< 1	< 1	< 1	< 1	< 1	Not Detectable
Physical and Organoleptic Constituents							
Colour	Hazen	< 5	< 5	< 5	< 5	< 5	< 15 (EPH)
Turbidity	NTU	0.11	0.13	0.14	0.12	0.11	< 5 (WHO)
Total Trihalomethanes (TTHMs)	µg/L	5.5	5.8	5.1	5.1	5.5	< 80 (USEPA)
Macro Elements							
Aluminium	mg/L	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	0.05-0.2 (USEPA) / 0.2 (WHO)
Ammonia (as N)	mg/L	0.20	0.21	0.20	0.14	0.09	< 1.2 (WHO)
Chloride	mg/L	2.262	2.738	2.760	2.998	3.253	250 (USEPA/WHO)
Fluoride	mg/L	0.11	0.14	0.15	0.14	0.21	4 (USEPA) / 1.5 (WHO)
Iron	mg/L	0.004	0.004	0.005	0.004	0.004	0.3 (USEPA/WHO)
Manganese	mg/L	0.003	0.003	0.003	0.003	0.002	0.05 (USEPA/WHO)
Nitrate (as N)	mg/L	0.73	0.70	0.90	0.90	0.82	10 (USEPA)/11 (WHO)
Nitrite (as N)	mg/L	0.03	0.03	0.03	0.03	0.02	1 (USEPA)/0.91 (WHO)
Sulphate	mg/L	0.21	0.26	0.24	0.26	0.28	250 (USEPA/WHO)

Health effects study

A health effects testing program was conducted to investigate whether there were any associated toxicological health effects with wastewater reuse. The study was conducted on mice over a **two-year** period to test for **chronic toxicity** and **carcinogenic potential**. Aquarium medaka fish were also tested over two generations on potential toxic, carcinogenic and reproductive health. The results concluded that the water produced had **no adverse health effects** ^[3]. No ongoing health studies are currently underway. Other ongoing research projects investigate the use of direct osmosis high salinity for the cleaning of RO membranes, closed circuit desalination to increase the recovery of RO brine as well as sensors to detect membrane integrity.

4. Public Education & Engagement

- PUB engaged local, international and trade media in their engagement initiatives. They also conducted roadshows and dialogue sessions with key stakeholders and the public.
- 24 hour call centre and cases forwarded to the relevant departments for investigation before taking any appropriate action.
- Bottling of NEWater with more than 10 million bottles distributed.
- NEWater Visitor Centre - public education with first-hand experience of NEWater treatment.
- Information briefings at schools and community centres.
- Documentary feature film.

5. References

1. ↑ Law, I. (2003). **Advanced reuse—from Windhoek to Singapore and beyond**. Water May: 44-50.
2. ↑ <http://www.pub.gov.sg/water/newater/Pages/default.aspx>
3. ↑ Singapore Water Reclamation Study (<http://www.pub.gov.sg/water/newater/NEWaterOverview/Documents/review.pdf>)]