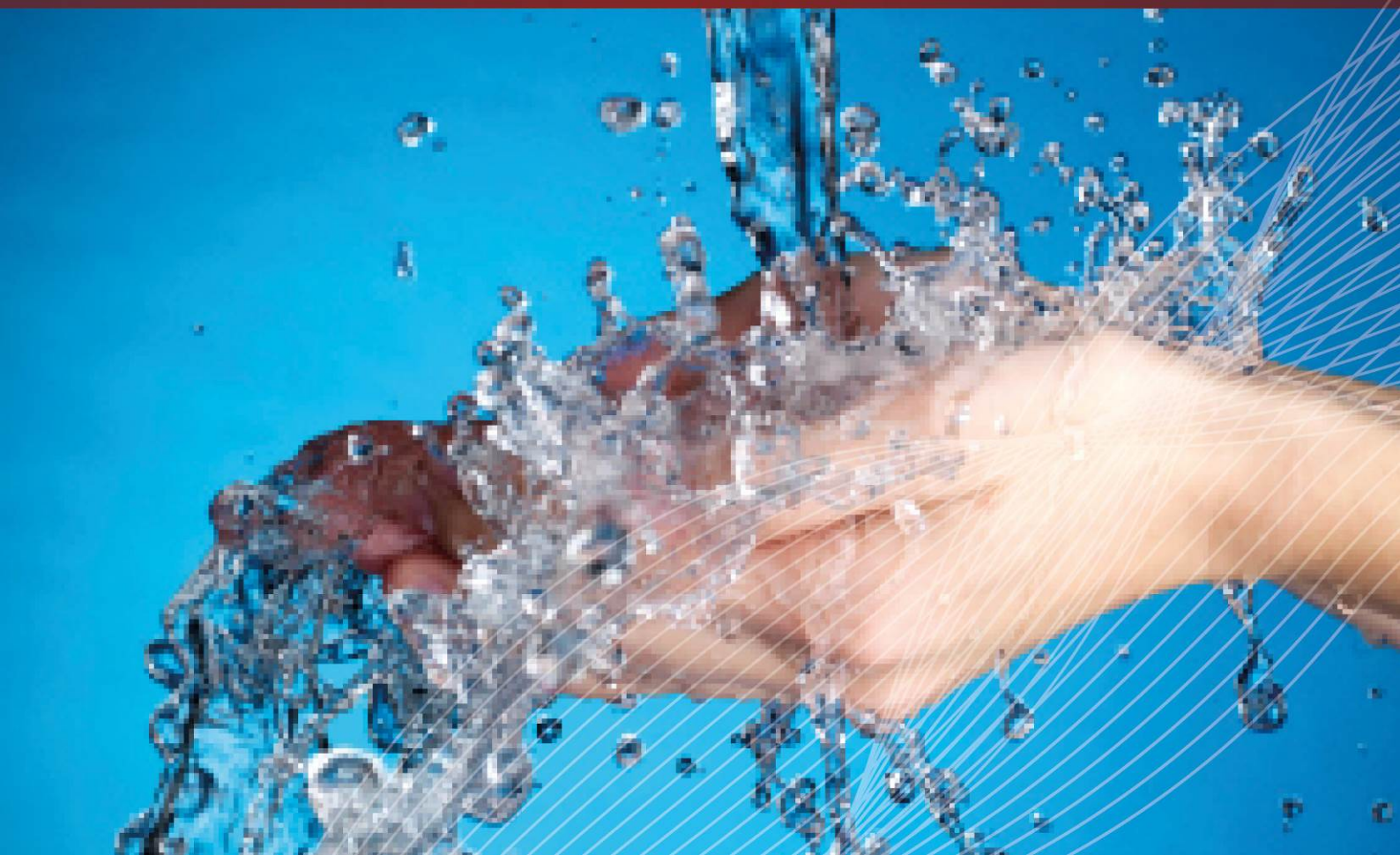
Australian Water Recycling
Centre of Excellence

Project Report

Global Potable Reuse Case Study 7: Beenyup Groundwater Replenishment Trial

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 7: Beenyup Groundwater Replenishment Trial

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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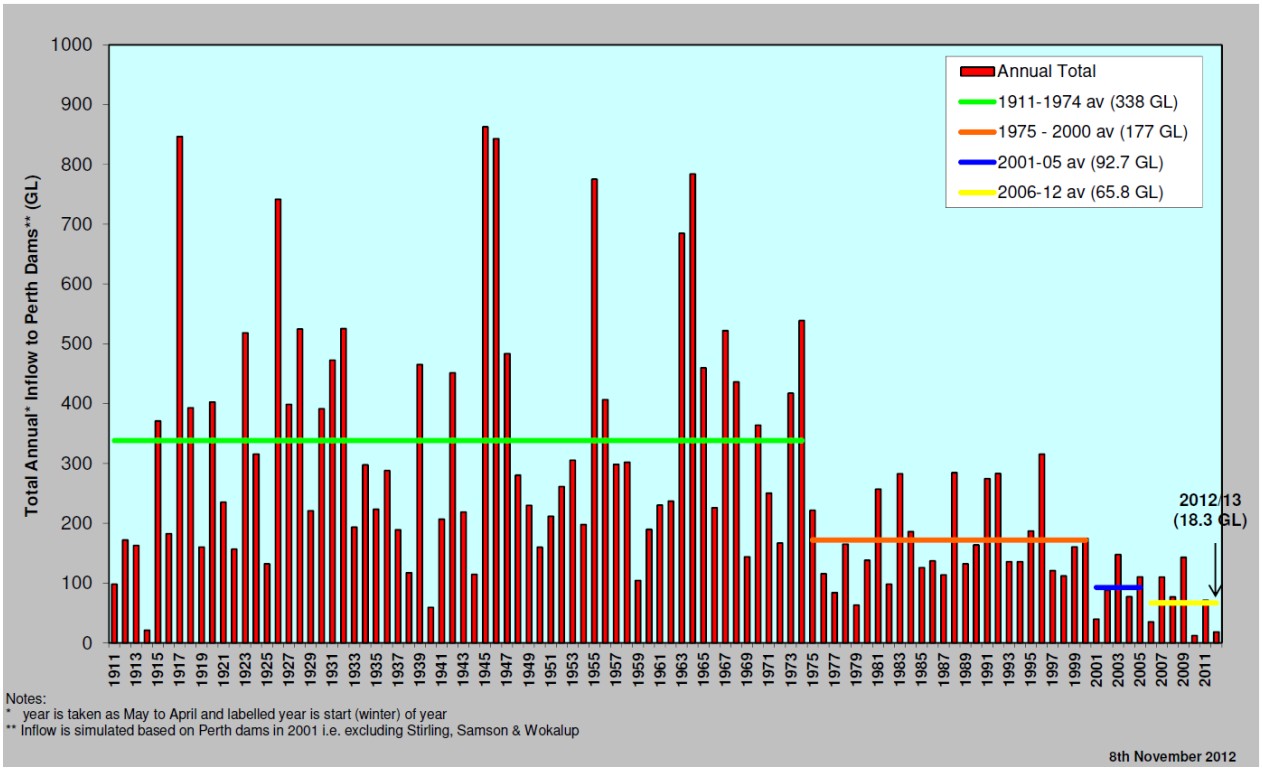
TABLE OF CONTENTS

1. Scheme Overview

Background

Since the mid-1970s and into the 21st century, the south-western region of Western Australia had been experiencing a decline in rainfall in an already dry climate, and in 2010, the region recorded the lowest water inflow to dams to date (Figure 1). Inflow to Perth's dams has dropped from a long-term average of 338 GL/year in the period 1911-1974, to an average of 92.7 GL/year in the period 2001-05 and still further to 65.8 GL/year in the period 2006-12, with only 18.3 GL/year recorded in 2012-13.



Source: www.watercorporation.com.au/D/dams_streamflow.cfm, *accessed 6 February 2013*

Figure 1: Annual rainfall and average inflows to Perth's dams 1911-2012.

The drying climate coupled with continued growth in population has highlighted that Perth needs a water source that is independent of the climate. This prompted Western Australia's Water Corporation to seek additional sources of potable water to augment existing groundwater and surface water sources. Water Corporation instituted a 50-year strategy to address securing Perth's water future. The portfolio of options included increasing water recycling for potable reuse.

In 2006, Water Corporation began plans to institute a groundwater replenishment trial aimed primarily at obtaining sufficient information on the technical, health, environmental and social aspects of such a scheme. Thereafter, Australia's first potable reuse demonstration plant - the Groundwater Replenishment Trial (GWRT), at Beenyup, Perth, Western Australia (Figure 2) - was built with an estimated cost of AU$ 50 million, and incorporated advanced treatment processes within its operations. Pilot testing began in 2006, with the Premiers Collaborative Research Project [1] (PCRP) with background aquifer sample collection occurring in 2009 (whilst the plant was being built). Groundwater recharge began in 2010 and in December of 2012, the trial stage ended. Over the course of the trial, 2.5 gigalitres (GL) of water was pumped into the aquifer.

The findings of the trial concluded that replenishment of groundwater sources using recycled wastewater was a viable option to augment drinking water supplies for the region. During the trial, it was estimated that it would take ~50 years before recycled water was drawn out and used for potable purposes. Water drawn from the aquifer will be used to service the population of 2million in the region. The scheme has won 4 state and national awards to date.

Figure 2: Location of the Beenyup Groundwater Replenishment Trial, Perth, Western Australia.

The trial achieved its objectives and was deemed a resounding success by the state Water Minister who, in August 2013, gave the go-ahead for Australia's first full-scale implementation of a groundwater replenishment scheme using wastewater treated to drinking-water quality standards. Construction of the full-scale scheme began in August 2014. The scheme is being built alongside the trial's advanced water recycling plant in the Perth suburb of Craigie.

Further information on the Beenyup Groundwater Replenishment Trial and on the full-scale scheme can be found on the Global Connections Map and the Potable Reuse Around the World pages on the *Water360* website.

2. Scheme Infrastructure

The Beenyup GWRT is operated by Aroona Alliance. Employed to manage the day to day affairs of the plant include an operations manager, a plant manager, process technical officer, operators, technical advisors and electrical/maintenance personnel. The plant recycles domestic (95%) and commercial/industrial (up to 5% combined) wastewater as their source waters. The plant reclaims **4.5ML/day** which forms 10% of what is injected into Leederville aquifer.

Permits and Operational Guidelines

At the time when Western Australia was considering groundwater replenishment for augmentation of drinking water, policies and regulations related to water recycling for potable reuse did not exist in Australia. The current WA regulatory framework defined effluent from an Advanced Water Recycling Plant (AWRP) as waste which could not be used to replenish groundwater supplies.

Regulation and policy development are overseen by the State's regulators - the departments of Health (DOH) (responsible for protection of public health), Water (DOW) (responsible for protection of water resources), and Environmental Regulation (DEC) (responsible for environmental protection). Water Corporation collaborated with these departments to form an Inter-Agency Working Group (IAWG) who together developed the Groundwater Replenishment Regulatory Framework that was used for regulatory surveillance of the trial project.

The framework was based on:

- Australian Drinking Water Guidelines (ADWG);
- Australian Guidelines for Water Recycling (AGWR) - Phase 2; and
- The Premiers Collaborative Research project (PCRP).

Treatment & Multiple Barriers

The plant utilised secondary treated wastewater, that would otherwise have been discharged into the Indian Ocean, as its source water. At **Beenyup Wastewater Treatment Plant (WWTP)**, wastewater is treated using screening, grit tanks and activated sludge treatment process before progressing to the AWRP. At the **AWRP**, the influent undergoes **UF**, **RO** and **UV treatments** to meet the standards for drinking water prescribe in Australian guidelines. The water is then injected into the Leederville aquifer where it mixes with the groundwater. The WWTP and the AWRP processes form the multiple barriers of the GWRT. Incorporated within this system are **13 Critical Control Points (CCPs)** as indicated below:

- 3 at the WWTP - 2 at the aeration tank; 1 at the sedimentation tank;
- 1 at the feedwater – turbidity;
- 2 at the UF (combined turbidity and Pressure Decay Tests);
- 4 at the RO;
- 2 and the UV; and
- 1 for pH at the final storage.

As part of their source water protection, all industrial and commercial discharge must meet criteria prescribed by Water Corporation's **industrial waste acceptance criteria**. Industries are issued with Industrial Waster Permits and the Corporation undertakes ongoing surveillance programs to monitor wastes of concern. Any trade waste customers discharging into the region are managed by Water Corporation.

A combination of barriers is utilised along the water system (Figure 2).

Operational monitoring

All GWRT processes were validated on commissioning and involved a formal environmental and health approvals process. The trial period was monitored by the State's regulators (DOH, DOW & DEC), and an independent group of technical experts. Ongoing validation of the UF and RO processes were done by the technical advisors and process technical officer of the plant.

The GWRT also had multiple maintenance plans in place derived from industry recommendations of the equipment and infrastructure. At least once per year, the plant was shut down for various maintenance operations that could not be performed whilst the plant was running. As part of their ongoing research, the plant investigates processes such as bio-fouling and monochloramine dosing and buffering of the recycled water.

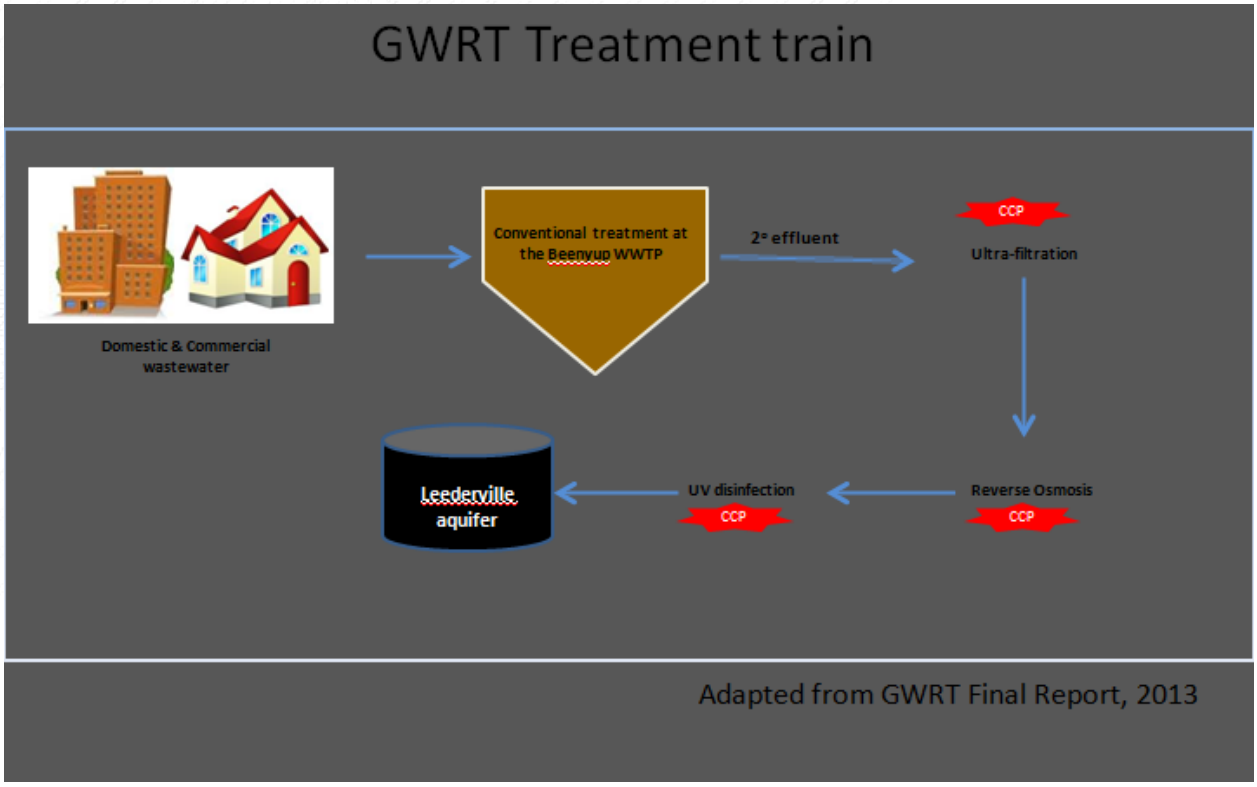


Figure 2: Beenyup Groundwater Replenishment Trial treatment train.

3. Water Quality & Public Health

Prior to the GWRT being instituted, a research project led by the DOH identified 254 water quality guidelines that had to be met at the point of recharge for protection of public health [2]. 292 Recycled Water Quality Parameters (RWQP) were measured against the 254 water quality guidelines to assess water quality. To enable frequent and effective monitoring, the GWRT analysed a subset of **18 key Recycled Water Quality Indicators (RWQI)** yearly that best represent the larger group (the RWQP).

The GWRT analyse ~340 water quality parameters, of which 292 were reported for regulation by the DOH to ensure that human health and environmental standards were protected. The set of 18 RWQI are represented in Table 1 and best represent the larger group (RWQP) of chemical, microbiological, and radiological contaminants with similar properties and characteristics.

The GWRT developed a comprehensive Recycled Water Management Plan (RWMP) to protect public and environmental health. Water quality was analysed throughout the treatment process at the prescribed CCPs. If the prescribed quality parameters were not met at any of these checkpoints, the water was instantly diverted back to the WWTP or an automatic shutdown of the particular treatment process was triggered to prevent water entering the next process step until optimal values were reached. In addition to CCP monitoring, groundwater was consistently monitored via the network of 22 groundwater bores located across five sites at the Beenyup location to detect changes owing to recycled water recharge. Water samples were also independently monitored before and after groundwater recharge to ensure health compliance. As part of the Incident Management Protocol at the GWRT, all breaches are reported to the DOH. At the end of the trial (2012), the GWRT demonstrated that recycled water was a suitable resource for groundwater replenishment with no adverse effects on the receiving aquifer [3].

Table 1: Summary of key recycled water quality indicators and parameters for the Beenyup GWRT.

Recycled water quality indicators (RWQI)	Parameter
Inorganic chemicals	Boron
	Nitrate as Nitrogen
Organic chemicals	1,4-Dioxane
	Fluorene
	1,4-dichlorobenzene
	EDTA
	Octadioxin
Nitrosamines	NDMA
Inorganic disinfection by products	Chlorate
Other disinfection by products	Chloroform
Phenols	2,4,6-trichlorophenol
Pharmaceuticals and personal care products	Carbamazepine
	Diclofenac
Hormones	Estrone
Pesticides and herbicides	Trifluralin
Microorganisms/Pathogens	MS2 Coliphage
Radioactive compounds	Alpha particle activity
	Beta particle activity (-K40)

Beenyup GWRT water quality data

A more comprehensive list of parameters, guideline values, and final product water values for the Beenyup GWRT for the period 2010-2013 is presented in Table 2.

Table 2: Parameters, guideline, and final product water values (2010-2013) for the Beenyup GWRT.

RWQI	Units	Final product water average				Guideline value
		2010	2011	2012	2013	
Microorganisms						
Coliphage (MS2)	pfu/100mL	<0.6	0.413	0.281	0.269	<1
Inorganic Compounds						
Boron	mg/L	0.09	0.0788	0.0933	0.0969	4
Nitrate	mg/L	1.8	2.323	1.533	2.231	11
Disinfection By-Products						
Chlorate	mg/L	<0.01	<0.01	<0.01	<0.01	0.7
Chloroform (LOR - 0.05 µg/L)	µg/L	0.225	0.299	0.505	0.773	200
N-nitrosodimethylamine (LOR - 1 ng/L)	ng/L	1.8	2.3	1.242	2.43	100
Hormones						

Estrone	ng/L	<1.0	<1.0	<1.0	<1.0	30
Other Organic Chemicals						
Ethylenediamine tetraacetic acid (1 µg/L)	µg/L	3.25	3.25	3.25	<10	250
Herbicides and Pesticides						
Trifluralin (ng/L)	ng/L	<1	0.9	<1.0	<1.0	50
Pharmaceuticals, Personal Care and Household Products						
Diclofenac (LOR - 0.05 µg/L)	µg/L	<0.050	<0.050	<0.050	<0.050	1.8
Carbamazepine (LOR - 0.05 µg/L)	µg/L	<0.050	<0.050	<0.050	<0.050	100
Polycyclic Aromatic Hydrocarbons (PAHs)						
Flourene	µg/L		<0.10	<0.10	<0.10	200
Radionuclides						
Gross alpha activity	mBq/L	<16	16.4	13	17.333	500
Gross beta activity minus K40	mBq/L	62.8	40	66.667		500
Volatile Organic Compounds						
1,4-Dichlorobenzene	µg/L	0.17	0.0939	0.155	0.139	40
Dioxins and Furans						
1,4-Dioxane	µg/L	<0.10	<0.10	<0.10	0.108	50
Octadioxin	pg/L		2.8	7.667	18	9000
Phenols						
2,4,6-trichlorophenol	µg/L		<1.0	<1.0	<1.0	20

Notes: N/A – not analysed
Zero value – not detected

4. Education and Engagement Strategies

- Community engagement commenced in 2004 (community advisory panel: health professionals, ecological activists and members of the public)
- Tours of the plant were conducted
- Online forums were implemented
- Surveys conducted (by phone) to gauge how the community felt about groundwater replenishment
- Community consistently supported the trial with 76% support for a full-scale scheme
- Visitors center at the GWRT plant continuing to engage community
- Plant can be followed on social media (Facebook, twitter, YouTube, etc)
- Newsletters and community engagement sessions with people who live near the facility
- The GWRT also has a communications team who handle and address any complaints received.

5. References

1. ↑ Department of Health (2009). **Premier's Collaborative Research Program (2005-2008): Characterizing Treated Wastewater For Drinking Purposes Following Reverse Osmosis Treatment**, Department of Health, Western Australia, Perth, WA, Australia.
2. ↑ Buyder et al., (2009). **Characterising treated wastewater for drinking purposes following reverse osmosis treatment. Western Australia: Department of Health.**
3. ↑ Groundwater Replenishment Trial Final Report May (2013). Water Corporation.