Water Recycling in action in South Australia: a review of agricultural and municipal reuse schemes and innovation.

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Abstract Global urbanisation, the growth of mega cities, shanty towns and poor rural communities continues to challenge the water industry. Extremes in weather patterns and environmental disasters demonstrate the need for more robust and flexible water management strategies which encompass recycling. In Australia, water reuse projects have been successfully implemented in agriculture, domestic dual-reticulation, industrial and municipal use. In each case, the recycling process is adapted to suit the end use and regulatory water quality requirements. This paper will present two innovative reuse schemes including associated research which depend upon recycled water from the Bolivar WWTP in South Australia and highlight the issues of quality, risk management and the supply and storage of recycled water.
Keywords Aquifer; agricultural reuse; dual reticulation; Aquifer Storage and Recovery (ASR)

INTRODUCTION

In Australia, water reuse projects have been successfully implemented in agriculture, domestic dual reticulation, industrial and municipal use (Figure 1). Virginia is home to Australia's largest concentration of greenhouse fruit and vegetable production. The Bolivar WWTP Virginia Pipeline Scheme (VPS) is one of the largest schemes in the world and was designed to protect ground water resources in the northern Adelaide Plains (Figure 2). Over-extraction by irrigators has led to a lowering of the water table and infiltration of saline water. Irrigation is essential for crop productivity and prior to the VPS, irrigators relied totally on groundwater extraction to meet crop production. The recycled water is pumped via an 18 km pipeline and is providing 240 growers with 15 million m^3 of recycled water each year.

The recycled water from the Bolivar WWTP is also reused to supply the Mawson Lakes residential and business development with a design capacity of 10,000 people (Figure 2). The development features a state-of-the art recycled water system to complement the potable water supply, and is the first scheme of its type to combine both recycled water and stormwater. The recycled water is mixed with stormwater from the Parafield Stormwater Harvesting Facility and is further chlorinated to produce a Class A recycled water supply. The water is used for toilet flushing, domestic garden watering, and irrigation of municipal parks and gardens and reduces potable water use in the area by up to 50 percent.

To ensure water quality standards are met, a complex fully-automated control system has been designed that represents World's best practice. Public health is protected by a range of strategies including ongoing risk assessments, detailed audit processes, public education programs and online system monitoring. This paper will give an overview of the risk management techniques. Public perception studies were also undertaken at the Mawson Lakes site through a national telephone survey. The influence of risk perceptions, environmental and post-material values, confidence in key public institutions, views on water shortages and water conservation behaviours were analysed (Marks *et al.*, 2006) and are briefly summarised.

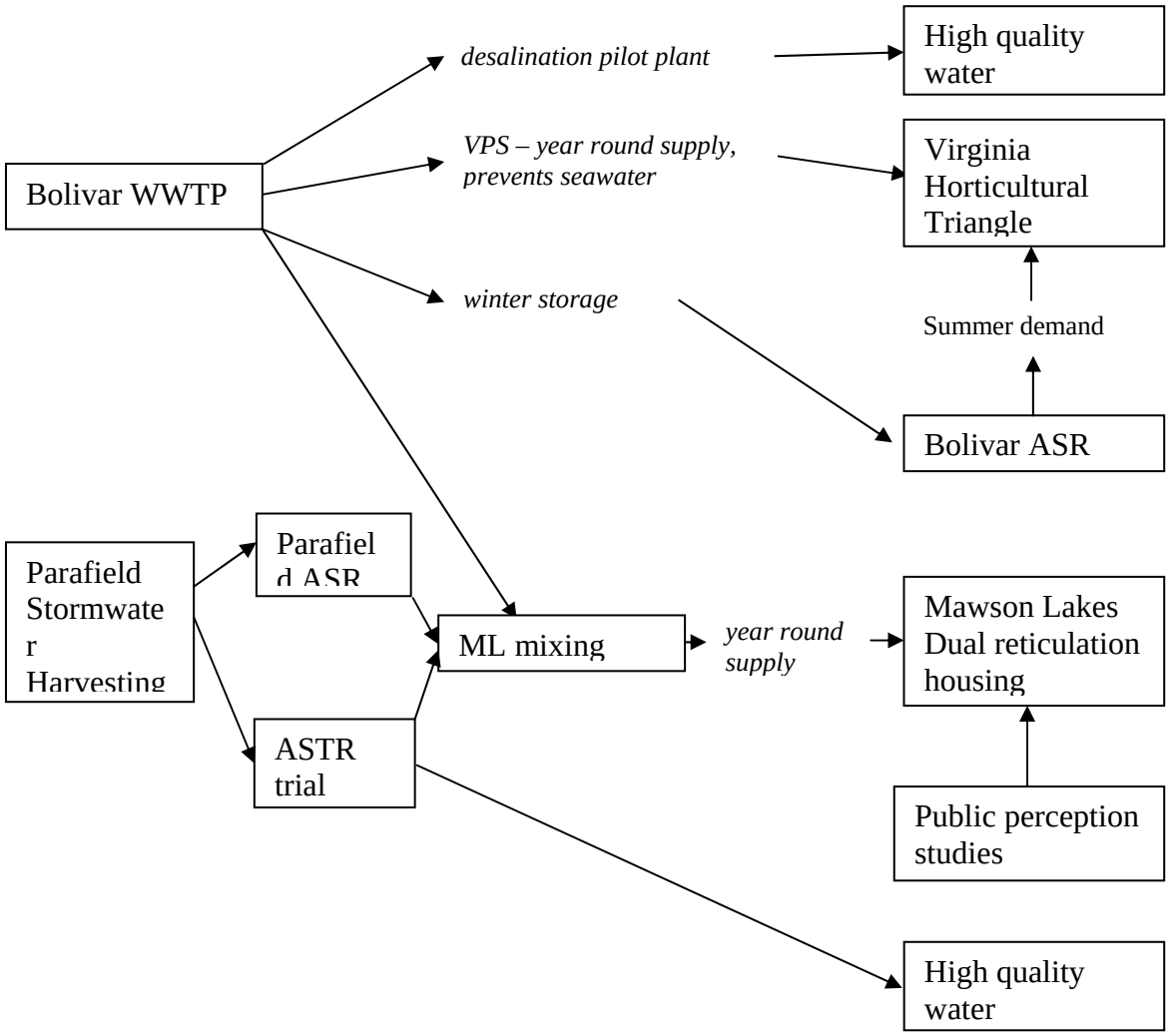


Figure 1. Summary of water reuse activities within 20 km in northern Adelaide, South Australia.

In winter or when demand for recycled water at Virginia and Mawson Lakes is low, the recycled water is discharged to the sea. Research has been undertaken to evaluate options for storing and retrieving the recycled water through Aquifer Storage and Recovery (Figure 3). The project involved the injection of recycled water diverted from the VPS into a brackish limestone aquifer for subsequent reuse during the summer irrigation season. This paper will also present some of the key findings of this research.

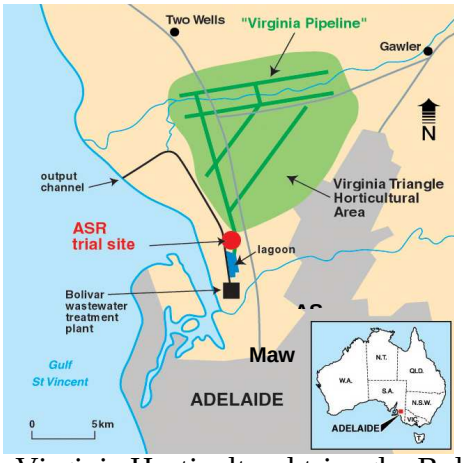


Figure 1. Location of the Virginia Horticultural triangle, Bolivar wastewater treatment plant (WWTP), Bolivar pipeline scheme (VPS) Mawson Lakes and the Bolivar ASR trial site and

Parafield Gardens ASTR demonstration site.
Salinity in wastewater also affects the long term viability of reuse schemes. Pilot plant trials have been undertaken at the Bolivar WWTP encompassing microfiltration and reverse osmosis to improve recycled water quality for the VPS and Mawson Lakes scheme. Preliminary results of this work will also be presented (see section 6 below).

The Aquifer Storage Transfer and Recovery, research project is located near Mawson Lakes and involves injecting urban stormwater harvested via the Parafield Stormwater Harvesting Facility into a brackish aquifer and recovering it as water fit for continuous supply at a potable water quality.
The scope and results from this scheme will be presented at this conference as it forms part of the case study of the RECLAIM WATER project.

2. Virginia Horticultural Triangle

Bolivar wastewater treatment plant (WWTP) is the largest plant in Adelaide, South Australia having a typical maximum flow of 150 ML/d. The treatment process comprises of: screen and grit removal; primary sedimentation; secondary treatment using nitrifying/denitrifying activated sludge and stabilisation lagoons before disposal to the St. Vincent Gulf. Primary sludge and waste activated sludge is gravity thickened before undergoing mesophilic anaerobic digestion followed by air-agitated drying/lagoon stabilisation. Disposal of biosolids is mostly to agricultural land as a soil conditioner. Effluent reuse is an integral part of the treatment strategy as it avoids the need for full nutrient removal. This provides an alternative water resource for a range of uses including crop, garden and public space irrigation as well as car washing and toilet flushing using the Virginia Pipeline Scheme (VPS) and Mawson Lakes scheme. Class "A" effluent is produced (BOD <20 mg/L, *E. coli* <10/100 mL, turbidity $\leq$2 NTU, SS <20 mg/L and pathogens <1/mL).

In order to meet these water quality requirements, lagoon effluent is polished using coagulation and flocculation, dissolved air flotation-rapid gravity filtration (DAFF) and chlorination. The Virginia Horticultural Triangle (VPS) is an important economic region for South Australia producing 12% of the states agricultural produce. The bulk of the recycled water produced at Bolivar (>11 GL/year, 2003) is used for irrigation in the VPS.

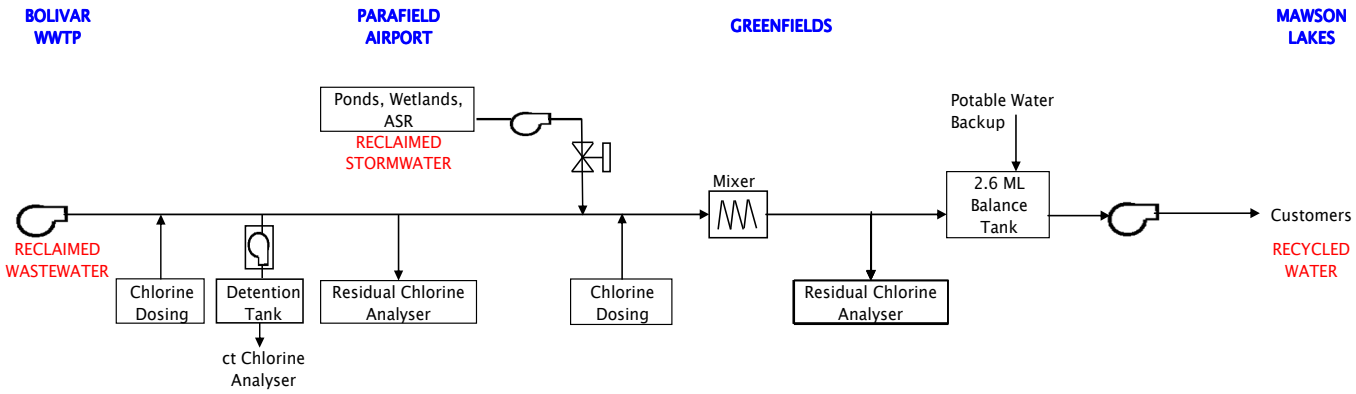
3. Mawson Lakes dual Reticulation Scheme

Mawson Lakes is a residential, commercial, educational and technical development north of Adelaide with 4300 allotments and will be able to cater for about 11,000 residents by 2010. The development is the first large scale dual reticulation scheme in Australia to utilise water from different sources: stormwater, effluent and potable mains water. The objective is to achieve a 50 % reduction in the use of potable water across a major urban development. The recycled water is used for irrigation, car washing and toilet flushing.

Key aspects of the recycling scheme: system features and control; community and industry education; property audits; reticulation network audits; operating procedures; emergency response plans and training of operators, constructors and call centre staff.

Risk management for recycled water in an urban environment
A number of detailed risk assessments were undertaken covering: design, process, construction commissioning and operations. These assessments resulted in operating procedures, construction procedures, water quality monitoring programs, emergency response plans, reporting protocols and

training requirements.



- The risk management processes highlighted a number of high level risks and controls were devised and implemented for the system.

4. Bolivar ASR Trial

The Bolivar WWTP produces effluent at a constant rate throughout the year, but irrigators at Virginia have a significant water demand for only 4-8 months of the year. The VPS scheme increased from 8 GL in 1998/99 to 15 GL in 2002/03. The scheme has a capacity of 32 GL in annual terms but peak daily capacity will be exceeded before seasonal capacity. If demand continues to grow, additional water could only be made available if the winter flow is stored for summer reuse. The Bolivar Reclaimed Water ASR project was undertaken to determine the technical feasibility, economic viability and environmental sustainability of subsurface storage and therefore identify whether this option was viable. The trial included a single ASR well connected to the reclaimed water pipeline. The target aquifer for storing water was the second Tertiary Aquifer (T2).

Before injection commenced, preliminary investigations included laboratory and field studies, groundwater modelling and community consultation. Approximately 360 ML of reclaimed water was injected and 240 ML was recovered over two cycles. An understanding of clogging, unclogging, movement, mixing and water quality changes has been gained by the project team (Dillon *et al*., 1999). The risks which were identified and addressed during the course of the trial included:

- Growth of opportunistic pathogens indigenous to the aquifer
- Injected water reaching water supply wells
- Irreversible clogging of well and nearby aquifer
- Well/ aquitard instability due to pressure changes
- Recovered water containing excessive amount of brackish native groundwater
- Aquifer storage capacity inadequate for economic ASR

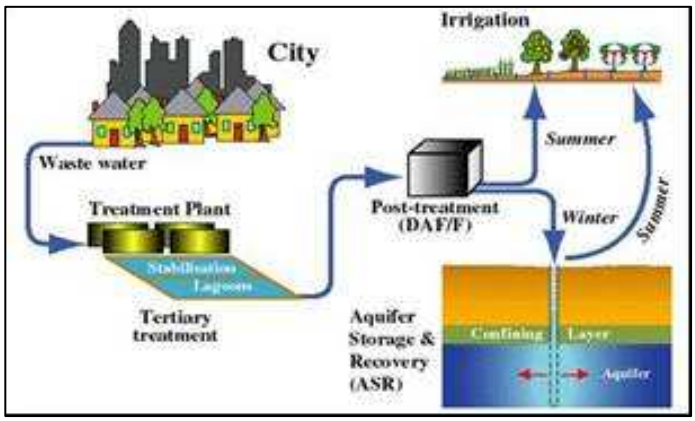


Figure 3. The Bolivar WWTP and ASR trial.

The trial was found to be economically feasible, excluding water treatment and pipeline costs, it was found that the cost of the recycled water ASR is between 8 and 18c/KL depending on the volume of water recovered per well, the depreciation rate and the assumed working life of wells and pumps (Dillon and Toze, 2005)

The distribution of the injectant in the aquifer was identified by collecting water quality data from 8 fully penetrating observation wells and 8 shallower piezometers. The contrasting quality of injectant and groundwater enabled studies of geochemical reactions, fate of NOM, attenuation of DBP, EDC's, pathogens, nutrients, metals and suspended solids. Well clogging has been studied and maintained. Recovery efficiency was found to be high and not an impediment to economic operation.

5. Conclusions

This paper highlighted the reuse activities and innovative approaches that are being evaluated to storing and reusing recycled water in South Australia. All of the reuse options presented in this paper provide information and assist with the development of new schemes. Most of the projects were undertaken with a risk management framework which provide information on range of issues that need to be addressed by public health, environment and natural resource regulators and managers. An integrated approach looking at all possible reuse solutions needs to be taken into account when choosing the best option.

6. References

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Marks,J. S., Martin B. and Zadoroznyj M. (2006). Acceptance of water recycling in Australia: National baseline data. *Water* **33**(2), 151-157.