

RECYCLED WATER IN AGRICULTURE – THEORY TO PRACTICE

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ABSTRACT

With drought conditions persisting across much of Australia, many farmers are looking for opportunities to supplement their irrigation farming business with 'non-traditional' water sources. Recycled water can potentially play an important role in filling this gap.

Agriculture is the largest user of recycled water in Australia, accounting for approximately 66% (~280 GL) of all recycled water used (ABS 2006). This use is spread across some 270 recycled water schemes. Most recycled water in agriculture is used for the irrigation of pastures and fodder crops on both broad acre and dairy farms, and on horticultural properties.

Recycled water for agriculture provides an alternative water source capable of providing greater certainty of water supply, and also offers a valuable nutrient source (equivalent to fertiliser) required for healthy crop production.

The sustainable use of recycled water is not always straight forward, and often requires practical management solutions that complement the existing (or proposed) farming practices.

A team of industry experts has been established to explore the major issues for consideration when using recycled water. A key product of the project is a 'Water Recycling in Pastures and Crops Manual' providing advice on how to access and best manage recycled water. The primary sources of recycled water considered are treated effluent and processing wastewater.

Keywords: recycled water, agriculture, pastures, crops, case studies

1. INTRODUCTION

The production of pastures and fodder crops relies on adequate supplies of water. The provision of water can be solely through natural rainfall, or as is more commonly the case, the application of irrigation to supplement rainfall.

As drought conditions persist across much of Australia, and competition for water resources increases, landholders and irrigation managers are looking for a secure source of water to supplement their irrigation farming business.

The use of recycled water in agriculture has become a more accepted form of irrigation over the past one to two decades, with a shift from a 'disposal' type mentality, to using recycled water as a valuable resource in a sustainable manner.

There are numerous documents available on the management of recycled water, however, there are none that specifically focus on the practical aspect of irrigating pasture and fodder crops with recycled water.

Similarly, there has been minimal opportunity for recycled water experts and industry practitioners to work collaboratively to identify the key opportunities and barriers to the use of recycled water in the pasture and fodder crop industries.

As a consequence, the 'Water Recycling in Pastures and Crops' project was established with support from the Department of Environment, Water, Heritage and the Arts to explore sustainable solutions to the use of a variety of sources of recycled water. A primary component of the project is the development of a manual for farmers and irrigation managers.

This paper provides an overview of:

- Opportunities for recycled water use in the pasture and fodder industries,
- Background to and contents of the recycled water manual,
- Issues being faced by farmers and managers in the sustainable use of recycled water, and
- How these issues are being successfully managed.

2. AUSTRALIAN WATER RESOURCES AND OPPORTUNITIES FOR RECYCLED WATER

2.1. Background

The requirement for irrigation varies considerably across Australia and is dependent on climatic conditions (rainfall and evaporation). In the temperate regions of Australia, pasture and fodder production has traditionally been almost exclusively rainfed. In the warmer climatic zones of the Murray Darling region, production has relied on the supply of irrigation water with rainfall contributing a relatively minor proportion of crop water requirements.

Over the past decades many parts of Australia (rainfed and irrigated) have experienced drought conditions. The drought has highlighted the industries dependence on water availability and the need for water resource management into the future. In recent years, many irrigated regions have experienced low water allocations, which has seriously impacted on production. This has provided mixed fortunes for different industry sectors and has also facilitated a rapid period of adjustment for industry structure and practices.

Understanding the availability of water resources for the pasture and fodder crop industries is critical in determining the potential role for recycled water.

2.2. Australian Water Consumption

Total water consumption in Australia in 2004-05 was 18,767 GL (ABS, 2006). Of this, the agriculture industry consumed the largest volume of water with 12,191 GL, representing 65% of water consumption.

From an agricultural perspective, the main consumers of water were:

- Dairy - 2,275 GL (19%);
- Pasture – 1,928 GL (16%);
- Cotton - 1,822 GL (15%); and
- Sugar - 1,269 (10%).

The pasture and fodder industries are significant water users within agriculture. When combined, the dairy farming, livestock, pasture and grains industries use a significant amount of water, totalling approximately 6,400 GL, or almost 53% of total agriculture water consumption.

2.3. Recycled Water Use

The supply of recycled water represents approximately 2% of total water consumption with a volume of approximately 425 GL (ABS, 2006). It is noted that ABS (2006) considers recycled (reuse) water to be wastewater from sewerage systems, irrigation drainage water and storm water that may have been treated to some extent before being used.

The agriculture industry used the majority of the recycled water in 2004-05 at 280 GL or 66% of the total recycled water available. The highest use of recycled water was by the grains industry (118 GL or 42%) followed by the dairy (79 GL or 28%) and pasture (40 GL or 14%) industries. The majority of recycled water consumed by the grains industry was drainage water supplied by irrigation/rural water providers.

When the dairy farming, livestock, pasture and grains industries are considered collectively, the total volume of recycled water use is approximately 237 GL representing almost 85% of the total agriculture recycled water consumption.

There is enormous diversity in the type of recycled water schemes existing across Australia. A recent review and subsequent analysis (Radcliffe 2004; Boland et al, 2006) identified about 270 agricultural recycled water schemes, with almost 100 schemes involving irrigation of pastures/fodder crops and 17 schemes relating to irrigation of dairy pastures.

While these schemes are important from a regional perspective, the total contribution of recycled water to agricultural water use is relatively minor (2%).

2.4. Future Trends in Water Resource Use

The future availability of water for irrigation is likely to decline, due to the impacts of climate change and competition from other users (environment, urban, industrial). These impacts will significantly influence the production of pasture and fodder crops.

The pasture and fodder industries will be required to adopt technologies and best management practices in order to improve on-farm water use efficiency. At the same time, there will be considerable pressure for water delivery infrastructure to be upgraded and reconfigured to improve delivery efficiencies.

In order to stay viable and productive, the pasture and fodder industries will most likely need to access 'non-traditional' sources of water, that while fit for purpose, are likely to have higher concentrations of contaminants (e.g. salt, nutrients) that require specialised management.

Recycled water is one source of water that has the potential to increase in availability to the pasture and fodder industries and could potentially supplement irrigation requirements and provide a relatively secure supply of water.

However, trends in recycled water use and competition for this source of water are similar to more traditional sources of water (eg river water). Whilst recycled water availability is expected to increase across Australia, adoption is likely to continue to increase in urban environments as amenity and production horticulture and high value industries require additional water resources. These end users are close to where the greatest volumes of recycled water are produced minimising transport costs.

The potential for recycled water use in pasture and fodder crop industries is more likely to occur in regional areas where there are significant volumes of recycled water. This is highlighted by the volume of recycled water currently being discharged to streams (30 GL) and the ocean (47 GL) by the major regional water authorities in Victoria (VWIA, 2007). The total volume of recycled water currently available for discharge is approximately 112 GL with almost 35 GL of this being reused (eg irrigation).

The water that continues to be discharged could readily be used by the pasture and fodder industries and would provide a number of advantages in the regional context including:

- Irrigation can occur close to the source
- Pastures and fodder crops have a high water requirement utilising large volumes of water
- Irrigation infrastructure is generally already existing
- Production is suitable using Class B and C water significantly reducing treatment costs.

The extent of the pasture and fodder crop industries throughout Australia and its demand for water presents real potential for increased recycled water use.

3. RECYCLED WATER USE MANUAL

The 'Water Recycling in Pastures and Crops Manual' has been developed in conjunction with water and agency experts and the agriculture industry.

3.1. Stakeholder engagement and review

The key elements of the manual were determined in conjunction with a reference group established to represent the interests of the agriculture and water industries and relevant

government agencies. The reference group had a wealth of expertise related to recycled water and irrigation and met on three occasions to discuss issues and ensure effective delivery of the project. Once a final draft was developed, a broader network of experts (including growers and policy makers) reviewed the manual. The final version of the manual has incorporated knowledge from across Australia.

The reference group and broader network were critical components of the project. These groups ensured that there was a greater mutual understanding of issues facing industry sectors and contributed to increased collaboration.

3.2. Purpose and Contents

The manual is primarily focused at Australia's pasture and fodder crop farmers, however it will be a valuable resource for recycled water scheme managers and state regulatory staff. The manual may also provide a basic resource for consumers and the general community.

The manual provides:

- Background information on recycled water including treatment processes and application in an agricultural context (Section 1)
- Information on how to access recycled water (Section 2)
- Description of the key issues to consider when using recycled water for pastures and crops including checklists and case studies (Section 3) and
- Key terminology and information resources (Sections 4 and 5)

Whilst the manual focuses on the use of recycled water for pastures and fodder crops, the utilisation of these pastures and crops (direct grazing or fodder production) is also important when undertaking risk assessment and considering management changes. The possibilities include:

	Pastures	Crops
Direct Grazing	Grazed in the paddock by livestock – sheep, cattle (beef and dairy), and other species	Pasture is cut and removed – fed as silage or hay
Fodder Production	Crops are directly grazed	Crop is cut and grain and/or straw is fed

A major focus of the manual is ensuring the information provided is practical and targeted towards helping farmers and site operators manage recycled water on a day-to-day basis.

The contents of the manual is summarised below

1 Introduction

- 1.1 What is Recycled Water?
- 1.2 Recycled Water Sources
- 1.3 Recycled Water Uses
- 1.4 The Reclamation or Treatment Process
- 1.5 Recycled Water in Context of Australia's Water Resources

2 How to Access Recycled Water

- 2.1 Guiding Principles
- 2.2 How to Engage with Stakeholders
- 2.3 Key Considerations for Stakeholders

3 How to Use Recycled Water

- 3.1 Guidelines and Risk Management
- 3.2 Planning to Use Recycled Water
- 3.3 Quality of Recycled Water
- 3.4 Major Risks for Users
- 3.5 Management of Recycled Water
- 3.6 Irrigation Management
- 3.7 Environmental Management Plan - Checklist and Monitoring
- 3.8 Case studies

4 Glossary

5 Further Information

3.3. Distribution Pathways

The manual for recycled water provides practical information for farmers and site managers. An important aspect of this project is ensuring that this audience can readily access information and the process of using recycled water is straight-forward. The project has engaged with the agriculture and water industries to ensure that the manual can be readily distributed to the end users. The manual will be electronically available for distribution through industry organisations, water authorities and agriculture/regulatory agencies.

The broader project network has been critical in raising awareness of the availability and usefulness of the manual.

4. CASE STUDIES

The case studies described in the manual provide examples of how recycled water is being managed by landholders and site operators across Australia. They particularly identify the 'major risks for users' that are discussed earlier in the manual and provide practical solutions to the safe and sustainable use of recycled water.

A selection of the case studies are summarised below focusing on issues of shandy requirements, nutrient balance, under irrigation, impacts of the drought and return on capital.

4.1. Shandy Requirements

Campaspe Water Reclamation Project – Earth Tech

The Campaspe Water Reclamation Project services the towns of Echuca and Rochester and provides approximately 1,500 ML/annum of Class B recycled water to a number of dairy and pasture/cropping farms.

The scheme delivers recycled water to more than 1,000 ha of previously irrigated land. To ensure sustainable irrigation is achieved, the scheme has adopted a number of sustainability targets that are strictly enforced (Table 1). The quality of the recycled water (Table 1) requires it to be shandied (diluted) with existing irrigation entitlements from the Goulburn-Murray Water irrigation system to meet the sustainability targets. A shandy ratio of 3:1 (three parts irrigation water : one part recycled water) is undertaken.

Table 1. Campaspe Reclamation Project Sustainability Targets and Recycled Water Quality

Parameter	Target	Median Water Quality
Hydraulic loading - off and on-farm drainage - either on or off-farm drainage - neither	10 ML/ha/annum 7.2 ML/ha/annum 5 ML/ha/annum	-
Salt	<500 EC ($\mu\text{S}/\text{cm}$) applied	1,400 EC ($\mu\text{S}/\text{cm}$)
Nitrogen	<100 kg/ha/annum	40 mg/l
Phosphorus	<40 kg/ha/annum	11 mg/l

Under average climatic conditions, perennial pasture in the Echuca area has an annual irrigation requirement of approximately 9 ML/ha. Therefore, on average, each hectare of perennial pasture receives approximately 2.25 ML of recycled water. Additional irrigation area is required when irrigating with the shandied system (four times more than if the recycled water was applied straight). This requires significant additional investment in infrastructure, monitoring and reporting.

During the development of the Campaspe scheme, considerable effort was undertaken to ensure that the distribution of recycled water to local pasture and crop farmers would be a valuable and sustainable solution.

It is critical that the planning stages consider the shandy requirements of the scheme and ensures availability of sufficient irrigated land area and on-going access to secure and reliable shandy water.

4.2. Nutrient Balance
Mixed Farming Enterprises

Achieving nutrient balance with recycled water irrigation can be difficult in some pasture and crop situations. Issues associated with poor agricultural nutrient management are well documented. Recycled water schemes must ensure that nutrient applications are managed in a sustainable manner.

In general terms, dairy pastures have a high demand for nitrogen and phosphorus, with the harvesting of milk from the property providing high levels of nutrient removal (an average dairy farm has maintenance nutrient requirements of approximately 100-120 kg/ha/annum nitrogen and 35-40 kg/ha/annum phosphorus). For the Campaspe Reclamation Project (section 4.1), a nutrient balance would indicate that the dairy farm would be in nutrient deficit provided the recycled water was the only source of nutrients (90 kg/ha/annum nitrogen, and 25 kg/ha/annum phosphorus provided).

However, nutrient demand and removal varies considerably for different crops with the recycled water potentially providing more nutrients than can be utilised by the plant (Table 2).

Table 2. Nutrient balance for a range of crops

Crop	Dairy Pasture	Perennial Pasture	Annual Pasture	Lucerne
Irrigation demand (ML/ha/annum)	6	6	3	6
Recycled water phosphorus concentration (mg/l)	11	11	11	11
Phosphorus loading (kg/ha/annum)	66	66	33	66
Phosphorus Removal (kg/ha/annum)	40	45 (15 t hay @ 3 kg/t)	30 (10 t hay @ 3 kg/t)	45 (15 t hay @ 3 kg/t)
Balance	Excess	Excess	Excess	Excess

Increasing the shandy requirement and spreading the recycled water over a greater area can manage excess amounts of nutrients. Alternatively, growing a crop with a higher nutrient requirement could be considered.

It is critical that the planning stages of a scheme undertake a nutrient balance and consider potential options including cropping system, shandy with alternative water supplies and/or irrigation area.

4.3. Under Irrigation
Goulburn Valley Water Tatura

Under irrigation is a practical consequence of most recycled water schemes. This arises, because legislation requires that a greater irrigation area be developed than can be irrigated in all years (to account for climatic variability and ensure maximum use of recycled water).

In Victoria, recycled water irrigation schemes are required to have sufficient winter storage volume and irrigation area to contain recycled water volumes in a 90th percentile year. In NSW, 50th percentile containment is required.

An approved water balance model is used to determine winter storage volume and irrigation area requirements over a 20-year period. In Victoria, the typical period selected is 1971 to 1991 as it contains a good spread of 'average', 'dry' and 'wet' years.

Goulburn Valley Water has undertaken water balance modelling for their Tatura recycled water scheme that has a current recycled water inflow volume of approximately 1,600 ML/annum. The optimum combination of winter storage and irrigation area predicted by the model is approximately 850 ML of storage and 175 ha of irrigation area (perennial pasture, unshandied).

However, analysis of the model demonstrates that full irrigation will only be achieved in five of the 20 years with the lowest year resulting in only 43% of the irrigation requirement being applied. The average volume applied over the period would be 80% of that required. This variable quantity of water can either be managed through a reduction in the area irrigated, or more likely, reduced volumes applied over the whole area leading to a decline in productivity (unless shandy water or another source of water is available to meet the increased requirement).

While recycled water is capable of providing greater reliability of supply (i.e. there will be some water in all years), the volumes will vary between seasons.

The seasonal variability of recycled water volumes needs to be considered in the planning of a scheme and clearly communicated to landholders. On-going communication is essential to ensure that farmers can balance predicted irrigation requirement with recycled water volumes in storage and likely availability during irrigation season.

4.4. Impact of Drought and Water Conservation Activities Murray Goulburn Leitchville

The drought has significantly impacted on recycled water usage declining from 507 GL in 2000-01 to 425 in 2004-05 (ABS 2006). This decline has primarily been attributed to a reduction in agricultural use, most likely a reflection of the decreases in the availability of water.

The drought has also severely impacted on those recycled water schemes relying on irrigation allocations to shandy with recycled water. In some cases, these allocations have been insufficient to allow the planned shandying to proceed. Schemes managers have had to purchase water to meet the shandy requirements, or negotiate recycled water applications above the sustainability targets for the scheme. The practice of purchasing shandy water has been very expensive (in some cases temporary trade prices have exceeded \$1,000/ML).

The drought has also contributed to the declining quality of recycled water. With many households and businesses using water more efficiently there has been less dilution of recycled water contaminants occurring resulting in an increase of salt and nutrient levels.

Murray Goulburn's Milk Processing Factory in Leitchville, has similarly seen an increase in recycled water concentrations from the recycling of water within the factory. The recycled water at Leitchville is a combination of good quality permeate water, and poorer quality treated factory wastewater that contains significant proportions of salt, nitrogen and phosphorus.

The contribution of permeate water and treated factory wastewater has generally been approximately 1 for 1. Following an initiative from Murray Goulburn to recycle the permeate water in the factory the ratio has altered, resulting in a final recycled water product much higher in salt and nutrient concentrations (salinity 2,010 to 2,890 EC; nitrogen 78 to 95 mg/l; phosphorus 23 to 34 mg/l). As a consequence, the shandy for the scheme has increased from 1:5 to 1:8 (recycled water to shandy water) requiring additional irrigation area and shandy water, and in this instance, extension of the recycled water distribution pipeline.

It is critical that the impacts of drought and water conservation be considered during the planning stages. The impacts of water conservation measures should be thought through

with a strategy for addressing these consequences established ie identify externalities of a project.

4.5. Return on Capital

Greengrove Effluent Irrigation Facility – Dubbo City Council, Hassall and Associates

The Greengrove Effluent Irrigation Facility is Dubbo City Council's first recycled water irrigation facility and a major infrastructure project. The key elements of the facility include a 1,090 ML winter storage, 12 km of pipeline to the farm and 4.8 km of internal pipelines and 208 ha of irrigation area. The scheme was developed to utilise recycled water for the production of fodder crops. The total cost of the scheme was in the order of \$6.8 million including land purchase, environmental studies, design and pre-construction, groundwater monitoring bores, pipe supply and construction, centre pivots and on-farm infrastructure, pumps and project management.

In 'return on investment' terms, the project will never recover costs. Income generated from the farming operations will contribute to operating costs.

This project highlights that recycled water schemes should be considered more broadly than using a return on investment perspective. The costs and benefits of establishing and operating a recycled water scheme for agriculture need to be considered against any other alternatives.

For the Greengrove scheme, the alternative was constructing a tertiary treatment facility that treated the water to a very high standard, suitable for discharge to the environment. At the time of establishing the Greengrove facility, Council identified a number of drivers for change including:

- Increasingly stringent environment standards and difficulty meeting these standards at the existing treatment plant;
- Encroachment of the urban area towards the existing treatment plant;
- Need to re-centralise Dubbo by growth of urban development in West Dubbo;
- New occupational health and safety standards (the old plant was incapable of meeting these standards and could not be easily modified); and
- Discharge fees to the environment (estimated at approximately \$200,000/annum).

Assessment of these factors, resulted in the recycled water irrigation scheme selected as the most appropriate option. It provides a safe and sustainable recycled water solution that presents minimal risk.

It is critical that the broader economic benefits and costs are considered in the assessment of options for recycled water use. These must consider the costs of alternatives, the environmental and social costs and the concept of fit-for-purpose. Return on investment is a narrow tool for analysing options.

5. CONCLUSION

The pasture and fodder crop industries are significant consumers of water. These industries are also broadly dispersed across regional areas of Australia.

The future prosperity of the pasture and fodder industries relies on continued access to secure sources of water. It is likely that alternative water supplies including recycled water will contribute greater volumes to total water consumption in the future.

The use of recycled water for the pasture and fodder industries will most certainly occur in regional areas where the end user is close to the supply and the water requires minimal treatment.

While there are many advantages to the utilisation of recycled water, there are also some challenges associated with its management. This project has explored the key issues for stakeholders involved in the adoption of recycled water for pasture and fodder crops with the view to addressing and overcoming the major barriers.

The water recycling in pastures and crops manual has provided a tool to facilitate the use of recycled water through practical and applicable information. The manual promotes the safe and sustainable use of recycled water.

Of particular interest are the case studies, which highlight the potential impediments to the use of recycled water and provide recommendations on how the risks associated with these issues can be minimised.

Irrigation of pasture and fodder crop industries with recycled water is likely to increase as sustainable reuse solutions are further developed in regional Australia. Learning from previous experience and promoting current knowledge on sustainable application should assist the acceptance of recycled water.

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