USING RECYCLED WATER FOR IRRIGATION

An overview of the issues, opportunities and challenges.

NATIONAL PROGRAM FOR
Sustainable Irrigation

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National Program for Sustainable Irrigation

The National Program for Sustainable Irrigation focuses research on the development and adoption of sustainable irrigation practices in Australia. The Program has sixteen funding partners.

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Solving Australia's water crisis

All Australians, including farmers and urban consumers, are increasingly aware that our water is both scarce and precious. In recent years, water management has been one of the nation's most important electoral issues. Water restrictions have limited urban users' ability to water gardens and wash cars, while irrigators across the country have experienced often drastic cuts in water allocations, affecting food availability and prices.

There are two main approaches to counteracting Australia's water crisis:

1. Use less water overall by using it more efficiently.

2. Identify new sources of supply.

1. Using less water more efficiently

Australians use a total of about 1,300 kL per person per year – half an Olympic-sized pool which equals 2,600 kilolitres (kL) or the equivalent of two bathfuls per day per person. We live in a dry country and enjoy a high standard of living – and are ranked third highest in the global rankings of per capita water use.

Two-thirds of the water is used to grow our food and agricultural exports; the remainder is used by industry and for domestic purposes (around 200 kL per residential property each year).

Domestic water restrictions are a good example of water conservation. They compel people to limit their use of the resource, and there are lots of other conservation measures that people can adopt voluntarily, from taking shorter showers to using water-efficient washing machines. All these measures will deliver marginal gains in reducing demand for domestic water.

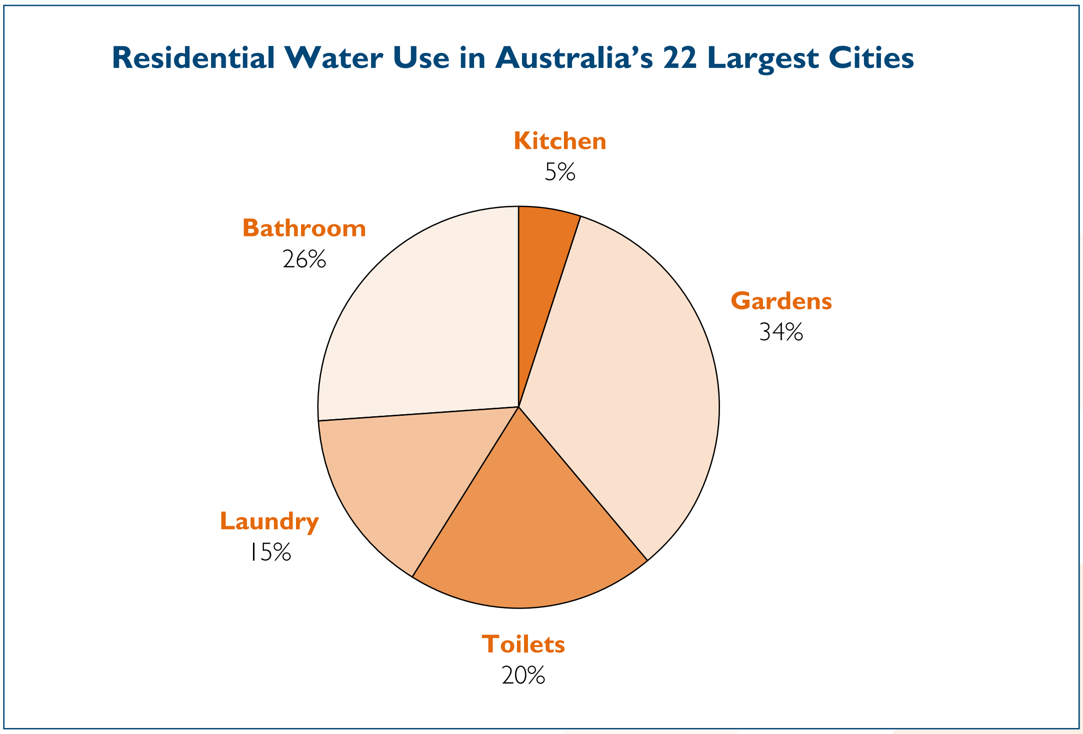
Irrigators can conserve water through measures such as better scheduling of irrigation, selection of appropriate irrigation techniques and system design, and maintenance of pipes and sprinklers. Conserving water can also help increase their production per kL applied.

2. Find 'new' water

Recycling, using water that would otherwise go to 'waste', is one of the options for developing a 'new' water resource. Recycling is both technically and economically feasible, and can create significant quantities of useable water from sources such as run-off and reclaimed and treated effluent.

Recycling water mimics nature by using water over and over again.

At a domestic level, flushing toilets and watering gardens consumes about half the water used in an average house. Recycled water could readily be used for both purposes.



Source: Rathjen et al (2003)

Irrigated agriculture can reuse water from on-farm or from external sources such as recycled treated effluent.

The use of water in cities and farms is closely linked. In both cases there are opportunities to conserve water and to recycle water – and recycled water from urban sources can also be used by agriculture. A growing number of urban schemes are now supplying recycled water from effluent treatment plants to nearby farmers, helping them with an additional source of water and reducing pollution from treatment plant discharges.

Using recycled water

The key to recycling is to match the quality of a water source to particular uses.

Using water that is 'fit for purpose' recognises that not every use requires the highest-quality drinking water and that it is often economically feasible to supply recycled water that is more than adequate for specified uses. For example, recycled water can be used in agriculture, in manufacturing and mineral processing, and to cool electrical power plants.

There are some management challenges to work through, but the main factors that limit the adoption of water recycling are economic (the cost of treatment, storage and delivery) and attitudinal. The latter includes the public debate in a number of Australian cities about infusing recycled water into urban supplies.

Water classes

The quality of recycled water is often defined by State Governments on the basis of public health considerations using a class rating system – usually from A to D, though A+ may be used as well.

The class definitions vary in detail between States, but Class A water is produced using high levels of treatment and is generally suitable for use on irrigated food crops, as well as residential gardens, parks and sports fields, closed-system toilet flushing and fire fighting. Class D water is suitable for irrigating non-food crops, such as turf, woodlots or plantations.

The classifications match potential uses with the treatment the water receives to reduce its level of pathogens, and ensure it is safe from a public health perspective. It does not address other potential contaminants, such as salt or nutrients. These must be considered in a 'fit for purpose' approach.

Possible sources

Recycled water can come from:

- rainwater – roof run-off
- stormwater – street drains and gutters
- agricultural effluent – dairy sheds or piggeries
- irrigation run-off
- industrial or processing 'wastewater' from food processing and wineries
- domestic wastewater
  - wastewater treatment plants (treated effluent)
  - greywater – water from showers and washing machines.

MEDLI

MEDLI® (Model for Effluent Disposal using Land Irrigation) is a computer model for designing and analysing effluent disposal systems for intensive rural industries, agri-industrial processors (e.g. abattoirs) and sewage treatment plants using land irrigation.

It models the effluent stream from production through to disposal, and predicts the fate of the water, nitrogen, phosphorus, pathogens and soluble salts within the effluent.

MEDLI can handle a wide range of industries, such as sewage treatment plants, piggeries, feedlots, abattoirs and dairy sheds, as well as any user-defined waste stream, such as a food processing factory.

MEDLI helps design effluent irrigation systems, including the area required for disposal and the rate at which to irrigate. The attention it gives to the fate of nutrients, pathogens and salts enables users to minimise the environmental impact of irrigating with recycled effluent.

For more information or to access MEDLI, see http://www2.dpi.qld.gov.au/environment/5721.html

Possible uses

Subject to its quality being 'fit for purpose', recycled water can be used for:

- agriculture – to grow crops, pastures, fruit, vegetables, wine grapes and plantation timber
- amenity horticulture – parks, golf courses, gardens
- heavy industry – for washing and cooling in manufacturing, mineral processing and power generation plants
- fire fighting, dust control, road-making, building and construction
- the environment – for recharging groundwater, enhancing environmental flows, watering amenity landscapes, and sustaining wetlands and ponds
- domestic uses – flushing toilets and watering gardens
- drinking water – for direct or indirect potable reuse.

Potable water

Potable water is water that is 'fit to drink' – meeting health-related and aesthetic guidelines as presented in the Australian Drinking Water Guidelines. Recycled potable supplies may be direct (straight from a treatment source) or indirect (mixed with other supplies, e.g. in a stream that is later dammed as a drinking water supply).

In some areas, where treated effluent was first used for horticultural crops, there were concerns about public perception and how consumers might react. However, concerns have subsided following extensive testing and the development of guidelines for the use of such water.

Now the idea of recycling water as a potable supply is dealing with similar issues. For example, the Orange City Council and NSW Government have invested in a scheme to harvest stormwater for recycling as drinking water, and in South-East Queensland highly treated wastewater can be mixed with water in the Wivenhoe dam and then treated again before distribution to consumers (referred to as purified recycled water). However, a 2006 referendum in Toowoomba did not gain public support for recycling treated effluent.

Lilac pipes

Because of the importance of keeping recycled water separate from drinking supplies, a worldwide standard has been established whereby pipes and fittings for recycled water are coloured lilac or carry a lilac stripe. That way it is easy to see the supplies that can only be used for particular purposes and the risk of misuse or contamination is addressed.

Why recycle?

Agriculture and treated effluent or 'wastewater' from industry and processing provide some of the main sources of recycled water in Australia. There are benefits and challenges to recycling water and recycled water is already used in many ways.

Irrigation drainage and livestock effluent from farms are reused for irrigation and washing down yards, e.g. from nurseries, pastures, cotton, rice, dairies, piggeries and feedlots. Treated effluent and wastewaters are used for industrial purposes (e.g. cleaning and cooling) and to irrigate amenity plantings, parks and sports fields, as well as for agriculture (e.g. grapes, fruit and vegetables).

Benefits

Recycling water provides numerous benefits:

- **Less pollution:** Recycling can reduce the level of nutrients and other contaminants going into rivers and oceans. Recycling can turn a waste stream from a source of contamination into a valuable resource. Examples include capturing nutrient-rich irrigation drainage on a dairy farm for re-use on pastures and recycling treated effluent to irrigate crops instead of these 'wastes' ending up in streams or oceans.
- **Water freed up:** Recycling reduces the demand for high-quality potable water by using alternative supplies for activities that do not require such a high standard of water. That 'freed up' water can then be put to better use. The amount of water extracted from the natural environment for human use can be decreased, reducing the stress on rivers, wetlands and aquifers.

- **Additional, more secure, water** (with 'free' nutrients): In cases such as the recycling of treated effluent, it is possible that the users of the recycled water receive a further benefit – gaining a more secure and reliable supply of water that is independent of rainfall and may contain valuable nutrients. This can save irrigators money by offsetting the need for fertilisers, although there are some downsides. See Challenges (below).
- **Increased water use efficiency** on local, regional and national scales: Recycling means that communities and countries get more use, more production and more economic value from scarce water resources. In a world of looming food and water shortages, to do otherwise verges on a failure in our 'duty of care' to the environment and society.

Challenges

Recycling presents a number of challenges. A range of potential contaminants must be managed; the water's quality monitored and its use regulated to ensure it conforms to 'fit for purpose' requirements.

The challenges will vary with water sources and the recycled water's end use. Knowing the source of the water and its likely contents is the key to effective monitoring and management.

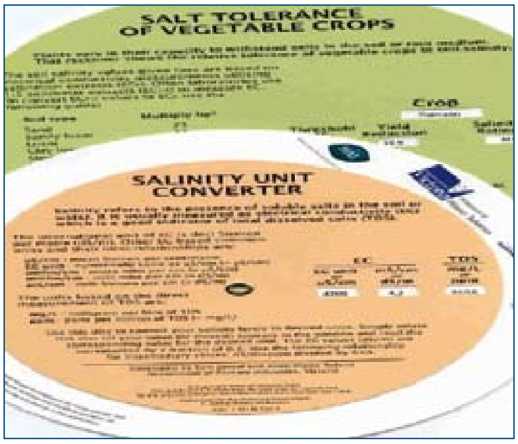
Contaminants

Contaminants can be an issue for recycled water users and may affect the eventual disposal of recycled wastes.

- **Salt:** Many wastewaters are high in salt, which corrodes pipes and accumulates in the soil root zone after irrigation. Drainage waters may become highly saline and must be managed to avoid environmental problems. Saline water may also damage plants directly, and some species are more susceptible than others. Mixing saline water with less-saline sources can avoid or defer difficulties, as can the use of salt-tolerant plants. In other cases, treatment may be needed before use.
- **Sodicity:** Sodium may also build up in soils irrigated with recycled water, leading to 'sodicity' and a decline in soil structure. It can cause soils to become 'hard setting' and less open to water infiltration, often leading to waterlogging.
- **Heavy metals** in solubilised form, including toxic substances such as chromium, lead, mercury salts and arsenite, can be found in wastewaters. Technologies are being developed to remove these, but these practices are costly.

Salinity calculators

To assist irrigators 'salinity wheels' have been developed for vegetable and fruit crops. These two-sided wheels provide a unit converter (calculating conversions between different measures of salinity, e.g. from EC unit to mg/L) and a guide to the salt tolerance of different crops (providing information on the yield reduction likely at different soil salinity levels). They may be obtained from Land & Water Australia.



- **Nutrients.** While water-borne nutrients can offset the need for fertilisers, it is important to monitor their level in recycled water and to budget inputs to meet crop requirements. For some crops (e.g. vegetables and grapes), too much nitrogen at the wrong time will promote vegetative growth at the expense of fruit yield. In all cases, it is important that recycled water does not introduce excessive nutrient loads that may contaminate the area or leak into waterways. In addition, if recycled water is high in nutrients and has to be stored in dams then management (such as aeration) may be required to prevent algal blooms.
- **Chemicals.** Depending on its source, recycled water can contain a range of chemicals, including:
  - Agricultural chemicals: pesticides and herbicides may wash off farm land and enter recycled water.
  - Surfactants (the chemicals that give detergents their cleaning power): They act on the interface between substances and alter 'surface tension'. They can be harmful in the environment, affecting the functioning of membranes and aquatic animals.
  - Pharmaceuticals: effluent and other wastewaters can contain a mixture of pharmaceuticals, including hormones, and other endocrine disruptors that may lead to reproductive problems in humans, animals and fish.
  - Hydrocarbons and oils: can be present in recycled stormwater and may contain cancer-causing substances such as benzene.
  - Industrial chemicals: highly toxic substances such as polychlorinated biphenols (PCBs), can occur in urban waste streams and effluent.
- **Diseases:** Viruses, parasites and bacteria may be transported in recycled water, detrimentally affecting animals, plants and humans. As a precaution against disease transmission, young and vulnerable stock should be stopped from grazing pastures irrigated with recycled livestock effluent for a set number of days (the 'withholding period') after each irrigation. In nurseries, treatments such as filtration, UV radiation or chlorination may be used to guard against the spread of plant diseases in recycled drainage water.

Matching supply and demand

Some sources of recycled water vary seasonally in their quantity and quality – and some users have different requirements at different times of the year.

If supply and demand are out of kilter there can be difficulties for both the supplier and the user. For example, irrigators may want a maximum supply of low-salinity water in summer, when the source may be low in volume, high in salt and poor in quality. Conversely, a supplier may have excess water to get rid of in winter when there is little demand from irrigators. Irrigators must be conscious of not over-loading soils with irrigation water as it can lead to waterlogging, soil structure problems and increased run-off.

Perceptions

The perceptions of potential primary and secondary users of recycled water is one of the main obstacles to recycling, e.g. if irrigators (primary users) or consumers of products irrigated with recycled water (secondary users) are not confident of its quality and safety. Research, monitoring and regulation to ensure water is fit for its use are essential, along with good communication, to address concerns.

Cost

The cost of recycled water is driven by:

- Production or treatment (and byproduct disposal): These costs vary with the quality of the source water and the quality required for the recycled product. In some cases, there can be additional costs involved in disposing of contaminating byproducts from the treatment process.
- Supply and infrastructure: The capital cost of storage and delivery systems must be factored into cost analysis, along with the operating costs of delivery and system maintenance. Many coastal towns and cities have difficulty capturing and storing stormwater and have to pump recycled effluent back up hill, adding to the cost.

- Compliance with regulations: Depending on the source of the recycled water, its treatment and end use, there can be costs in reporting and complying with regulations, as well as monitoring.

When considering costs and pricing, it is important to also assess the costs of alternatives (e.g. other treatments or disposal costs) and the broader environmental and community benefits that come from recycling water, such as reduced pollution, watering ovals and parks, or providing water for important wetlands.

Costs are usually lower if the recycled water is used close to where it is produced. Recycled water is especially feasible when building new urban developments, as the infrastructure may be plumbed-in (as a 'third pipe') during construction.

Applications

Current use in Australia

Recycled water is not a new concept in Australia. For decades, towns and cities have routinely used recycled water for non-drinking purposes, such as watering parks and ovals, industrial uses and irrigation. Many downstream communities in Australia already draw on water supplies that contain wastewater discharged by communities upstream.

The *Australian Guidelines for Water Recycling* have been developed and endorsed by all Australian governments, and provide a sound management framework that ensures recycled water is safe and reliable. See http://www.nepc.gov.au/taxonomy/term/39.

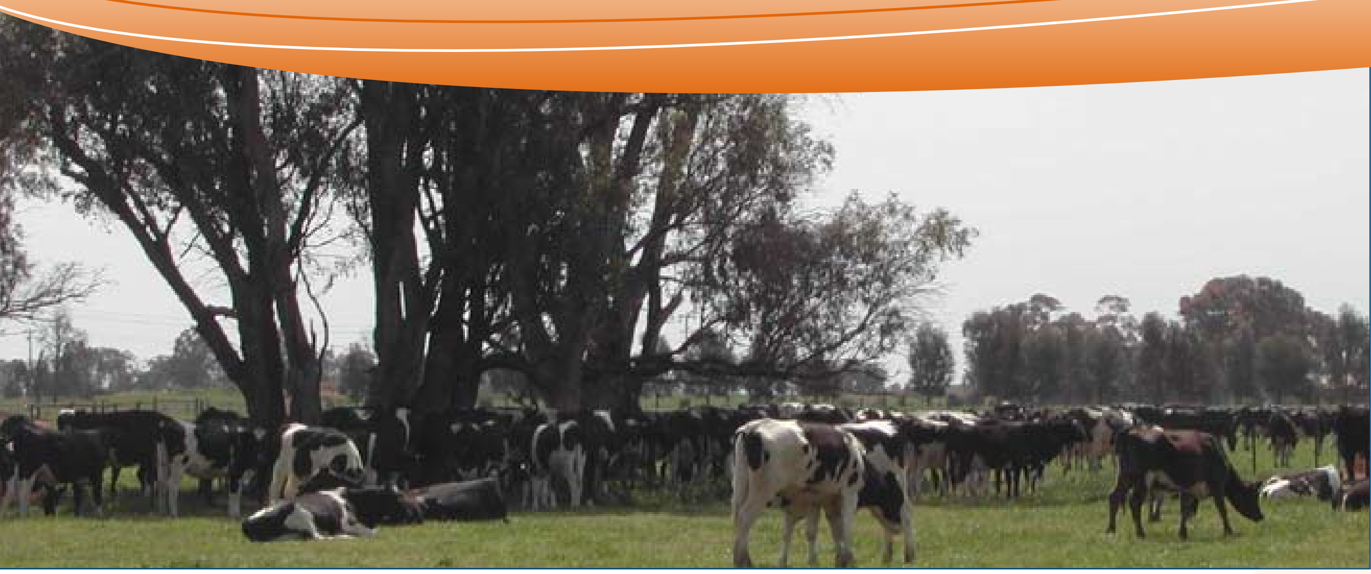
Rural industries: the biggest users

Agriculture used 280 GL of distributed recycled water in 2004/05 according to the ABS, 66% of the total use. Its use has ranged from 104 GL to 423 GL over the past decade, however those figures do not include on-farm reuse or recycling. Allowing for the recycling of irrigation run-off and livestock effluent, the total amount of recycling is likely to be substantially more than from distributed sources alone.

Other big users of distributed recycled water include parks, gardens and sports fields, which consumed 14% of the national total. Parks are among the biggest users of recycled water, using 60 GL or nearly 30% of the recycled water from urban water suppliers.

Urban recycling: on the up

In 2001/02, only a portion of treated effluent was recycled (9% or 166.5 GL across Australia) and large volumes were discharged to streams or the sea.



Much of the treated effluent is generated in cities and major regional centres, making them prime targets for increased recycling and reducing pollution. The recycled water (especially that currently discharged to the sea) could be used to 're-green' city parks and gardens, for toilets in new developments, for industrial purposes or piped to nearby locations for irrigated agriculture. It could also be used to support an expanding urban horticulture industry based on hydroponics, aquaponics and 'rooftop' farming (see below).

The recycling of treated effluent rose sharply between 2001 and 2007. Adelaide was the national leader, lifting its use from 11% to 30% (25 GL), while Melbourne increased 10-fold from 2% to 23% (75 GL). Both cities are now recycling treated effluent for horticultural use. Sydney doubled its use of recycled water from 2% to 4% (21 GL) over the same period. Perth achieved a similar growth from 3% to 6% (7 GL) and Brisbane went from 6% to 7% (6 GL). Nationally, 12% of treated effluent is now recycled.

Rural towns often recycle higher percentages of effluent, due to the nearness of rural or parkland irrigation opportunities, the relatively high costs of alternative treatment and disposal, the sometimes limited supplies of potable water available and the smaller volumes of effluent involved. For example, regional WA is reported to achieve 40% recycling while Dubbo and Orange in NSW achieve near 100% according to the 2007-08 National Performance Report on urban utilities.

Greening cities

'Green buildings' and tramways are emerging in Europe and the USA, where the cooling and amenity value of vegetation is being promoted by initiatives such as replacing bitumen under tram tracks with turf (e.g. Barcelona's Tram Baix), developing buildings with multi-levelled terraced gardens and installing grass-covered roofs. The greenery also buffers street noise and converts the greenhouse gas CO2 into oxygen. Greening cities using recycled water and nutrients offer both increased local food security and environmental amenity.

Tailored guidelines

A number of guidelines have been developed for the use of recycled water that are tailored to specific uses. These include:

- *Guidelines for developing recycled water schemes in horticulture* – www.npsi.gov.au
- *Using Recycled Water in Horticulture. A growers guide* – www.npsi.gov.au
- *Nursery Industry Water Management. Best practice guidelines* – www.npsi.gov.au
- *Using Recycled Water. A Manual for the Pasture & Fodder Crop Industries* – www.rmcg.com.au
- *Irrigation of Amenity Horticulture with Recycled Water* – www.recycledwater.com.au

Key principles for growers

The horticulture growers guide provides some key principles for growers that will be applicable to most irrigated commodities.

- **Planning**. Ensure markets will accept the produce, that all regulations are understood and complied with and that on-farm management will satisfy any additional requirements (e.g. identifying recycled water and keeping it separate from other sources, and avoiding algal blooms in any storage dams).
- **Water quality**. Ensure the water will be of satisfactory quality regarding nutrients, salinity pathogens and other contaminants.
- **Irrigation management**. Determine if special measures will be needed for irrigation, e.g. additional filters, steps to avoid spray-drift, drainage management and any withholding periods.
- **Soil management**. Make provision to monitor salinity and plan to avoid problems (e.g. by using salt-tolerant plants, shandying water with less saline supplies or leaching excess salts) and be ready to deal with sodicity (e.g. by applying gypsum).
- **Fertilisers and nutrients**. Prepare a nutrient budget and fertiliser plan to optimise plant performance and minimise environmental impacts.

Future options

Further development of water recycling involves cost and management challenges, but there is plenty of untapped potential and lots of advantages.

There is also the underlying world-wide need to improve water use efficiency to meet increasing demands for food and healthy environments.

The challenge now is to promote even wider adoption of recycling, both in agriculture and urban centres, where there are considerable volumes of water that are readily available for development.

For more information

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www.npsi.gov.au
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About the Program

The National Program for Sustainable Irrigation defines and invests in research on the development and adoption of sustainable irrigation practices in Australian agriculture. The aim is to address critical emerging environmental management issues, while generating long-term economic and social benefits that ensure irrigation has a viable future.

The Program has 16 funding partners:

Australian Government Department of Environment and Water Resources, Cotton Research & Development Corporation, Gascoyne Water Asset Mutual Co-operative, Gascoyne Water Co-operative, Goulburn-Murray Rural Water Corporation, Grains Research & Development Corporation, Harvey Water, Horticulture Australia Limited, Land & Water Australia, Lower Murray Water, Ord Irrigation Asset Mutual Co-operative, Ord Irrigation Co-operative, South Australian Research and Development Institute, Sugar Research & Development Corporation, Sunwater, and Western Australia Department of Water.

NPSI is managed by Land & Water Australia on behalf of the Partners.

About the NPSI Knowledge Harvest

The NPSI Knowledge Harvest synthesises information from across the Program's projects, highlighting key findings and promoting wider understanding.

The key themes are:

- Irrigation Overview – facts, figures and key concepts about irrigation.
- Water Delivery Systems – the efficient storage and distribution of water for irrigation.
- On-Farm Irrigation Essentials – key principles for efficient irrigation.
- Recycled Water – recycling treated effluent and run-off for irrigation.

Recycling Water

This document is part of the Recycled Water theme. It provides a general overview of issues associated with recycling water, illustrates the opportunities and challenges involved, and lists specialised guidelines currently available for those who are encouraged to give recycling a try.

Others in the series are available from www.npsi.gov.au as they are released.