National Guidelines on Water Recycling – Managing Health and Environmental Risks – Impact Assessment

A report prepared by Marsden Jacob Associates for the Natural Resource Management Ministerial Council/Environment Protection and Heritage Council

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Executive Summary

ES.1. The increasing focus of water planners on water recycling comes from a greater awareness of the limits to our current and future water supplies during a period of expanding demand. An appreciation of the weaknesses of previous national guidance has resulted in different jurisdictions across Australia producing their own differing guidelines and frameworks to protect human and environmental health in their own areas, at the expense of a consistent best practice approach across all jurisdictions in Australia.

ES.2. Building on the approach taken to drinking water supply, state and federal jurisdictions are moving towards a consistent national approach to water recycling using a best practice risk management framework, under the 'Draft National Guidelines on Water Recycling' (hereafter, "the Guidelines") being developed by the Environment Protection and Heritage Council and the Natural Resource Management Ministerial Council.

ES.3. Marsden Jacob Associates (MJA) has been commissioned to undertake an assessment of the likely economic impacts of a move to this national risk management framework.

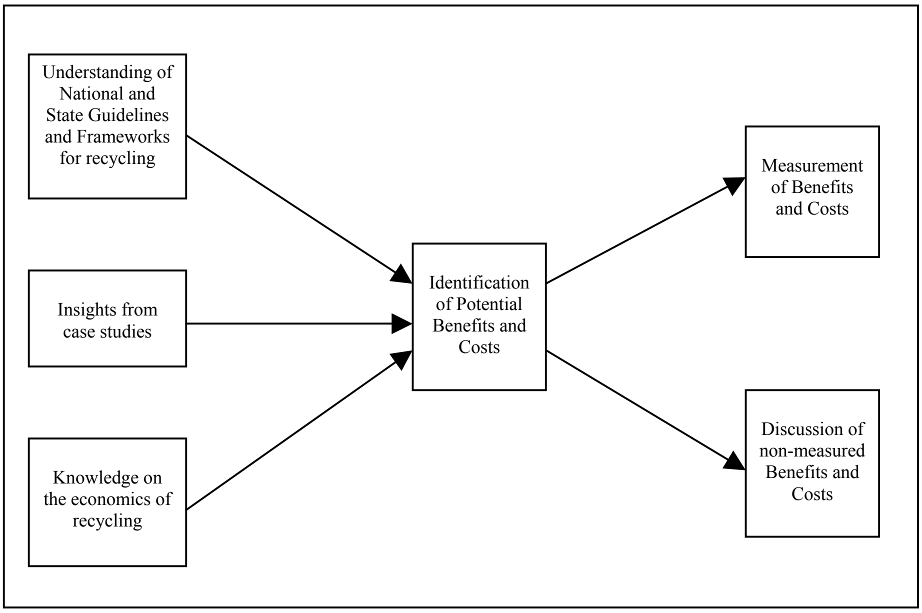
Approach

ES.4. MJA's approach to the project (demonstrated diagrammatically in Chart ES1 below) has been to incorporate several components, namely:

- an understanding of the draft national and state guidelines and frameworks (found in Attachment A);
- insights from several case studies; and
- background knowledge on the economics of recycling in Australia.

ES.5. These components have informed an understanding of the potential benefits and costs of a move to the Guidelines. The benefits and costs have then been quantified where possible, and discussed where values are not readily available.

Chart ES1. MJA Analysis Structure



Benefits of National Guidelines

ES.6. From a health and environmental perspective, the major benefit of the Guidelines is in the best practice protection of human and environmental health during a period of expansion in water recycling which will bring more recycled water into situations of potential human contact than was previously the case.

ES.7. Furthermore, although not directly addressed in the Guidelines, the return of water to rivers and wetlands for environmental flows is prospectively a very significant benefit given their unique ecosystems as well as their recreational values. This could be achieved through reduced initial take from rivers, as well as by recycling and returning water to rivers after primary use. Although associated values of environmental flows are likely to be substantial and are becoming better understood, they are not readily expressed in dollar terms.[1]

ES.8. From a narrow economic perspective, the benefits of the national framework arise from several sources, including potentially more fit-for-purpose solutions and increasing consumer confidence.

ES.9. By facilitating greater flexibility and innovation, the Guidelines are likely to encourage greater expansion in water recycling activities over the longer term. Some projects that would otherwise have been precluded may be more likely to go ahead, or could be undertaken at lower cost through development of a 'fit for purpose' water recycling response. A case study of the Iluka Resources mining operation provides a useful demonstration of this concept.

[1] An understanding of the values people place on environmental goods such as clean water, healthy ecosystems and the number of species of fish, bird and other fauna in Australian rivers and wetlands can be developed using 'non-market valuation' techniques which estimate people's willingness to pay for improved environmental outcomes. Several studies have been undertaken in the Australian context, including: Bennett, J. et al (2001).

ES.10. While potentially assisting a number of 'marginal' projects, the major identified economic benefit of the Guidelines is the maintenance and strength of consumer and supplier confidence associated with accepted best practice frameworks, and the imprimatur of the health and environmental agencies of all Australian Governments on water recycling in Australia.

ES.11. This consumer confidence is necessary to underpin the expansion in the use of recycled water over the next two decades as demand for water increases with population growth, and is compounded by expected climate change reductions to available supplies from traditional sources such as existing dams and groundwater areas.

ES.12. Consumer confidence in water recycling is integral to consumer acceptance and demand, and a scare or incident in one jurisdiction could affect confidence nationally and for several decades. The Sydney Water scare of 1997 is an example of this. Such a loss of confidence could greatly restrict water recycling options in the future, when the economics of water recycling are steadily improving. In this timeframe the efficiency (and cost) of water treatment technologies are expected to improve, facilitating more rapid expansion in recycling.

ES.13. It is important to note that consumer attitudes to recycled water differ depending on use. Several studies have been undertaken on this topic (a brief summary is found in Attachment C), and while attitudes appear to be softening over time, they differ depending on end use and perceived associated risks.

The need for greater recycling

ES.14. Australian domestic water consumption per capita is the second highest in the world (Australian Academy of Technological Sciences and Engineering, 2004)[2]. Total demand for low-cost water for potable, industrial, agricultural and environmental uses continues to grow, a situation which is expected to remain as populations grow, and industry and agricultural sectors expand[3]. Indeed, a recent WSAA report has highlighted the impact on per capita water consumption of the growth in single person households in Australian capital cities (WSAA, 2005: 5)[4].

ES.15. Growing awareness of the environmental flow needs of our rivers and wetlands and greater societal values being placed on their health results in even greater demand for high quality water in Australia.[5] For example, the South Australian Government is expected to begin lobbying for the purchase of tradable water entitlements from

2 The United States of America is the largest domestic consumer of water per capita.

3 For example, the Western Australian Water Assessment (2000) predicts that water consumption in WA will double in 20 years.

4 The paper demonstrates that "Population growth is the main driver of increases in domestic water consumption in each city. However, in each case, when household change is taken into account, projected water demand is considerably higher than is the case if demand projections are based just on population growth. This is because, as average household size decreases, average per capita water use within households increases."

5 Evidence of growing awareness of declining river health can be found in the Living Murray initiative, developed by the Murray Darling Basin Commission (MDBC, 2005).

willing sellers to restore 'environmental flows' to the River Murray (The Age, September 29 2005).

ES.16. Meanwhile, low-cost water supply options remain relatively limited. Dams and groundwater supplies approach their viable extraction limits and decision-makers turn to more innovative water supply options such as desalination and water recycling, while attempting to limit water requirements through demand management options.

Current recycling

ES.17. Recycling is currently occurring on a small scale. The economics of recycling will continue to improve as population growth pushes demand, traditional sources are downgraded and currently available low cost water sources become fully utilised. Thus, the recycling targets (such as the 20% treated water recycling target for 2010 for Victoria) which have been set for several states are likely to become financially justifiable in the medium term.

ES.18. However, the willingness of consumers to use recycled water is dependent on their confidence that recycled water is safe to use and that the intended applications will be managed to promote sustainable environmental outcomes. Consumer confidence surveys suggest that confidence and trust is built over time. Moreover, it is reinforced when trusted institutions and authorities give their collective endorsement.

ES.19. Thus, the investment in confidence building now is an essential foundation for the realisation of any economic benefits that can be expected to be achieved in the future. Compared with the significant required expenditure in source development in coming decades, the cost of this investment is low.

ES.20. Increased recycling will result in avoided costs from the reduction in the need for potable water, and may allow for substitution of higher cost options and therefore reduce the overall cost of source development.

Economic Assessment

ES.21. The impact of the new guidelines on the narrow economic benefit cost analysis is not substantial. Under plausible take-up rates and cost scenarios, increased recycling associated with the new guidelines will have little impact on the net costs of source development. Such analysis does not include the substantial environmental and social benefits that can be expected from an increased take-up.

ES.22. For individual projects, the net costs of water recycling vary widely reflecting the method of treatment, the costs of pipelines and transport and the alternatives for disposal of sewage effluent. For large scale treatment using membrane technologies located downstream from secondary wastewater treatment plants, treatment costs ex plant are typically around 60 cents per kilolitre. The total direct cost of recycling must also take account of transportation and any extra costs that should be associated with the upstream processes.

ES.23. Also, discussion of unit costs of recycled water at the household level should note that the increased investment in demand management (e.g. water saving devices and responses to price increases) will act to increase the per ML cost as water available for reuse is reduced, but only when recycling is at high levels and demand management is very effective.

ES.24. The modelling analysis does not include the costs associated with transportation of recycled water. Overall, for there to be a net benefit from large scale recycling the costs of transportation broadly need to be lower than the benefits ascribed to improved reliability of supply and restoring minimum flows to Australia's rivers.

ES.25. The magnitude of these parameters will vary from location to location. However, an indication of this magnitude of the potential benefit of maintaining and enhancing confidence in water recycling can be obtained by making the simplifying assumption that the costs of transporting recycled water from the treatment plant to places of use are equal to the benefits of either reduced diversions from rivers or by return to them. (In the absence of this assumption it is not possible to proceed other than on a detailed case-by-case basis.)

Case Studies

ES.26. Project case studies have been chosen to demonstrate a plausible impact of a move to the Guidelines, such as:

- a 'fit for purpose' water recycling project based on a risk management approach to recycling (for example, Mawson Lakes and Iluka Resources); or
- the critical role of appropriate management and guidelines in protecting consumer confidence (Leidsche Rijn water quality incident and Inkerman Delux).

ES.27. Key lessons which can be drawn from case studies included in our analysis are:

- the risk management approach encourages flexibility in water management which encourages innovation and adaptation in water recycling developments, as seen in the Mawson Lakes case study;
- similarly, the risk management approach using fit-for-purpose water recycling schemes which properly manage health and environmental risks can result in savings to project costs, as seen in the Iluka Resources example;
- comprehensive coverage in managing all risks associated with the entire water cycle is needed to provide optimal outcomes, as demonstrated in the Pimpama-Coomera case;
- public confidence in water management more generally is paramount to the growth in water recycling, as demonstrated in the Dutch example. The Dutch water incident further reminds us that dual reticulation guidelines are also needed when using recycled or other sources of non-potable water;
- public confidence and understanding grows gradually, but can snowball over time and across projects, as demonstrated in the Mawson Lakes case study which was supported by the confidence achieved through the Virginia Pipeline and Willunga Basin schemes;

- project partnerships with trusted institutions can greatly increase public confidence in water recycling projects, such as in Mawson Lakes and Inkerman Deluxe; and
- the value of reduced demand on potable supply for a major city can be estimated from the planning schedule showing the expected sequence, costs and increase in supply from each new addition to source capacity. Value is directly related to assumptions relating to shifts in mean rainfall due to climate change.

Economic model

ES.28. MJA's economic model compares these two cases over a 25 year period, using discount rates at 6% with appropriate sensitivities. The modelling confirms the benefits of developing and introducing the Guidelines, sensitive to parameter assumptions relating to the margin between recycling costs and the LRMC, the level of compliance and administrative costs for industry, government and water service providers.

ES.29. It is not feasible to make measured predictions on the direct economic impacts of the Guidelines, given the unpredictable take-up of the Guidelines in different jurisdictions. As such, if there is a benefit, we assume that the greatest benefit will be in the imprimatur of a national approach supported by all jurisdictions, supporting public confidence over time. This analysis is indicative only, and is designed to demonstrate the effects of an assumed doubling of recycling as a result of the guidelines. MJA does not predict a doubling of recycling due to the guidelines, but demonstrates the net benefits to the economy of this occurring. We then examine sensitivities.

ES.30. Core results emerging from the modelling are as follows:

- the prime economic benefits associated with the introduction of the guidelines are linked to greenfields developments . This is no surprise, especially since the cost of savings of potable water are already large. The benefits associated with increased recycling in greenfield areas are estimated to range from a loss of $73 million to a benefit of $156 million according to whether the cost of the recycled water is a high 80 cents/kL or a low 20 cents/kL;
- for brownfield developments the benefits range from a positive $120 million to losses of $100 million in present value terms. This reflects the generally high cost of recycling in brownfield systems unless they are favourably located in terms of a ready market for the use of that water or its return to rivers;
- aggregate benefits combining the two sources are dominated by the net benefits arising from the greenfields. The aggregate net benefits are estimated to range from around $170 million to a negative $58 million according to the cost of recycled water. For estimates between 20 to 50 cents of the cost of recycled water in greenfield situations, the total benefits from both sources are wholly positive.

Non-quantified benefits and costs

ES.31. There are several other benefits which have not been quantified in the analysis:

- **benefits from improved environmental flows and outcomes**. Recycling has the potential to return substantial volumes to the rivers and to assist in the restoration of essential flows, both in terms of volumes and their variability. These benefits are not quantifiable directly, although there is tangible evidence of their importance as exemplified by decisions by the Murray-Darling Basin Ministerial Council and the decisions of the NSW and Victorian Governments to establish Water for Rivers to acquire water for environmental flows in the Snowy River and River Murray;
- **reduced ocean outfalls** for coastal cities and therefore impacts on marine ecosystems; and
- **benefits from water source diversification and reduced likelihood of restrictions**. Recycling has the potential to reduce reliance on rainfall dependent sources of water and therefore diversifies sources and reduces the risk of supply. In doing so, recycling reduces the likelihood of volumetric restrictions and their impact on garden and horticultural industries. The Western Australian experience indicates that these costs are substantial and there is similar evidence of substantial costs being incurred as a result of restrictions across Australia (The Australian Newspaper, 7 September 2005, p.5).[6]
- **avoided costs to human health and source development of a health scare**. Although there is no assertion in this paper that current state-based approaches to recycled water have been deficient in protecting human health, it is recognised that the risk-based approach using HACCP[7] multiple barriers is a best practice approach to water management (potable or recycled). As such, there are substantial potential benefits to the avoidance of a health incident relating to recycled water.

  The avoidance of these costs is of material benefit which may be quantifiable but which are not quantified in our current modelling.

ES.32. For any water service provider, the schedule of future source developments should be set to meet agreed reliability levels under an assumed rainfall/streamflow scenario (whether explicit or implicit). The Long Run Marginal Cost (LRMC) of water based on this schedule therefore assumes that there will be no restrictions beyond the levels allowed in the water service provider's targets for reliability performance.

ES.33. Nonetheless, restrictions on water use are a method of sharing the costs of 'congestion' i.e., the excess of demand over available supply at current prices. The costs of the substantial economic losses resulting from restrictions on water use therefore provide an indication of these 'congestion' costs and therefore of the extent to which the shadow prices of water inclusive of these congestion costs are above the prices shown in the tariff schedules.

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6 The cost to the total Australian nursery and gardening sector of water restrictions in the past 12 months (to September 2005) is estimated at $200 million.

7 Hazard Analysis and Critical Control Point

ES.34. These costs occur in two dimensions: first, in any market, restrictions reduce the consumer amenity and welfare as measured by consumer surplus; second, restrictions reduce economic activity in directly affected industries such as garden supplies and horticulture. These latter impacts have been explored in detail in Western Australia and led to a much higher priority being attached to avoiding sprinkler bans.

Purpose

1. The purpose of this study is to assess the economic benefits and costs of a coherent national approach to water recycling under the draft 'National Guidelines on Water Recycling' being developed by the Environment Protection and Heritage Council and the Natural Resource Management Ministerial Council. Marsden Jacob Associates (MJA) has been commissioned to undertake this assessment.

2. The study is an economic assessment of benefits and costs of moving to a national framework for water recycling. While environmental and social elements will be discussed where appropriate, this study is not a 'Triple Bottom Line' cost/benefit analysis. Nor is there scope in this study to undertake survey activities regarding community sentiment or other related issues, or broader non-market valuation studies of people's willingness to pay for recycled water. Whilst these would be very valuable contributions to a cost benefit analysis study, they are outside the scope and budget of this analysis. However, MJA's review has necessarily had to identify and articulate, within the context of this study, the rationale underpinning the move to a national framework.

3. The purpose of this paper is to describe and report on the evaluation. Importantly, this report uses a number of case studies to illustrate identified benefits and costs of the move to a national framework for water recycling. Importantly, the paper:

   - reviews the context and rationale for the investment in the development and application of the new National Guidelines in place of the current regimes in individual states. Attachment A provides detailed descriptions of the different state frameworks, and the national framework, against relevant criteria;
   - examines several major case studies to draw lessons and insights on the cost and benefit of the application of the Draft Guidelines;
   - examines investment in evaluation framework and methodology undertaken;
   - defines a 'base case' scenario in the absence of National Guidelines and scenarios for the future with the Guidelines in place – following a thorough analysis of the different existing state frameworks as well as the national framework; and
   - evaluates indicative costs and benefits where appropriate, and discusses those which are not readily quantifiable.

Context

4. The increasing focus on water recycling in Australia reflects increasing awareness of the limits of water supply relative to current and expected demand, and a reduction in the uncertainties associated with the health and environmental risks posed by reuse of wastewater effluents and greywater. The combination of drought, climate change and increasing demand for water use, for industrial and agricultural uses as well as for environmental flows (despite limited supply) is leading to exploration of different water source and use options involving the entire water cycle. These include surface water supplies, groundwater and stormwater harvesting, desalination of seawater, integrated water cycle management (IWCM), application of water sensitive urban design (WSUD) and wastewater recycling.

5. Until recently there had been little attention focussed on the different possibilities associated with wastewater reuse such as centralised treatment operations. One reason for this is that in the past, the economics of water recycling precluded its full exploration, as potable (and irrigation) water supplies were more plentiful at relatively low cost. The technological capacities of different recycling options have largely been limited, and have come at high cost (again relative to inexpensive potable water). Moreover, the adverse economics of the past had been compounded by an incomplete understanding of human health and environmental hazards and their associated risks. This has limited the extent and variety of recycled water uses sanctioned by government departments and regulatory bodies. Importantly, these elements have combined to result in limited public understanding, acceptance and demand for recycled water. All aspects are now in the process of changing

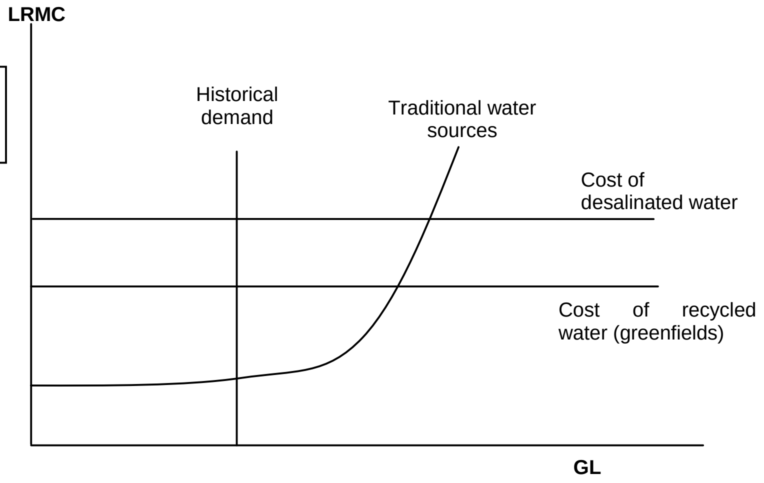
6. This is illustrated in Graph A of Box 1, where historical demand is low and the cost of water from traditional sources is also low. The use of recycled water could not be justified on purely economic grounds.

7. More recently, while potential water supplies from low-cost traditional sources have become more restricted and demand has increased, other factors cited have tended to improve over the past decade, altering progressively the current landscape of water use and supply in Australia. Expert knowledge of associated human health and environmental hazards has increased, and recycling technologies are also now arguably both safer and lower cost. The use of HACCP procedures promotes better control over the end-product and its application at the point of use. Combined with recognition of the otherwise reduced supply options facing the community, there is evidence that public interest, understanding and acceptance of recycled water use for different purposes continues to grow.

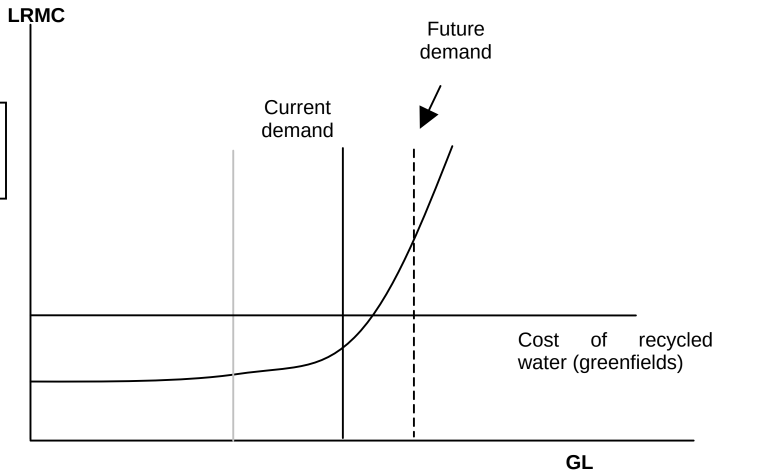
8. This is demonstrated in Graph B of Box 1, where demand continues to expand out, and the cost of traditional water sources is increasing. At the same time, the cost of recycled water is decreasing with technology. As these trends are likely to continue, recycled water will become more economically feasible

Box 1 The Water Sector and the Economics of Water Recycling

Graph A



Graph B



9. Public acceptance of recycled water for any use is, however, dependent on the level of confidence expressed in safety and compliance mechanisms and on trust in the institutions. For example, 89% of respondents to a study in the UK agreed with the statement that *"I have no objection to water recycling as long as safety is guaranteed"*. Similarly, Australian studies indicate that the proof of safety is a key element in community acceptance. Indeed, trust in water authorities and independent experts was considered essential to people's willingness to use recycled water. This was considered important to overcome people's lack of trust in technology (the most frequently noted reason for people opposing the use of recycled water for agriculture, park irrigation, and potable consumption) (Po *et al*, 2004: pp 11-16).[8]

10. It is important to note that consumer attitudes to recycled water differ depending on use. Several studies have been undertaken on this topic (a brief summary is found in Attachment C), and while attitudes appear to be softening over time, they differ

[8] Marsden Jacob Associates' summary of these surveys is located at Attachment C.

depending on end use and perceived associated risks. There is naturally greater resistance to potable consumption of recycled water than other uses such as in toilet flushing and garden watering (Brisbane City Council, 2000). Recycled water used for agricultural irrigation purposes depends significantly upon perceptions of associated health risks (University of Queensland, 2001).

11. Current health and environmental frameworks governing wastewater reuse are administered by each state and are largely founded on explicit guidelines and standards for the management of water recycling. These frameworks have the characteristic of tending toward prescription and are often viewed favourably by the water service providers, property developers and industry by providing reasonable certainty as to what is required.

12. With increasing recognition of the importance of recycling as a potential option in water supply strategies, and the recognition that recycling need not remain a peripheral option, there has been a convergence of thinking towards a national approach based on current best practice. Following from the Australian Drinking Water Guidelines 2004, this has involved the development of a 'risk management framework' approach to human health and environmental protection, rather than a more 'prescriptive'[9] approach to regulation. These have become all the more important as the present and expected expansion of recycled water will occur in areas in closer proximity to human contact, potentially affecting a larger proportion of the population.

13. As such, water recycling programs are now an essential part of future water strategies across Australia, and all jurisdictions are developing programs to address wastewater reuse as part of integrated water cycle management. This increasing attention has led to the preparation of a coherent national approach to water recycling under the Environment Protection and Heritage Council and the Natural Resource Management Ministerial Council. The draft 'National Guidelines on Water Recycling' are being developed to provide guidance to all Australian jurisdictions, combining a risk management framework approach with current best practice benchmarks and controls.

14. This substantial investment in the future requires an understanding of the benefits and costs associated with the foreshadowed approach. The relevance of the economic evaluation reported here (of the likely economic impacts of moving to a national framework for wastewater reuse) lies in its exploration of the expected costs and benefits of a national approach to wastewater recycling, and changes to the economic incentives of wastewater recycling that the national framework brings.

15. The demand for, and thus the level of investment in recycled water sources is heavily dependent on consumer attitudes and acceptance of recycled water. From an economic perspective, the guidelines can be seen as reducing risk, uncertainty and information gaps in order to promote a more efficient allocation of resources (in

9 The term 'prescriptive' in this context relates to a 'rule-based' approach to regulations (for example, recycled water on golf courses requires grade A recycled water), as opposed to a 'risk management approach' to recycled water management (risks to human health and the environment of using recycled water on golf courses should fall below a defined tolerable risk). The term is not intended to imply that the guidelines are enshrined and enforceable by law.

economic terms) and utilisation of water. Changes to supply will reflect the associated costs of treatment and compliance with government regulation.

Drivers of water recycling

16. The advent of a national risk-based approach to water recycling should not be seen as the fundamental driver of an expected increase in water recycling. The fundamental drivers are likely to be the availability of other options, comparable costs and policy directions. Rather, the Guidelines should be viewed as an instrument with which to facilitate the planned and expected increase in water recycling in the future, through ensuring public confidence throughout this expansion, and encouraging innovative approaches resulting in cost savings at the margin.

17. This is not to say that our base case scenario of 'prescriptive' rule-based approach has been in any way deficient in ensuring public confidence through protecting human health to date. However, what is asserted here is that the goal of prescriptive management was ultimately to protect human health, whereas the goal of National Guidelines can be seen as safely promoting the expansion of water recycling while protecting human and environmental health.

18. That is to say that the major goal and expected benefit of the Guidelines is to protect human and environmental health (and thus, consumer confidence) throughout a period of unprecedented expansion in water recycling in the coming decades.

19. Other drivers of water recycling include security of supply, in that recycled water is not closely correlated with rainfall and streamflow, and the environmental benefits of decreased ocean outfalls and higher environmental flows.

Climate Change and Long Run Marginal Cost

20. The term 'long run marginal cost' (LRMC) as relating to the water industry refers to the cost over the longer term of adding a volume of water to existing supplies. As such, it reflects future capital costs (such as building dams or desalination plants) as well as operating and transportation costs. Typically, when a city has low water demand (reflecting a low population, for example) and ample supplies, its LRMC is low. However, as a city grows and exhausts is lower cost water options, such as the most suitable dam sites, it must bring on-stream to its water source development schedule some higher cost water from less suitable dam sites, or desalination for example. As such, its LRMC rises.

21. The source development schedules and the associated LRMCs for major cities are not, as yet, widely published in the Australian water industry. Such information is available, however, for the Perth system and for the Melbourne system. The LRMCs are, respectively, around $1.00 (ERA, 2002, p.13)[10] and 21 cents/kL (MJA analysis of ESC 2005, p.13 and 22)[11]. Sydney's LRMC has recently been estimated at between

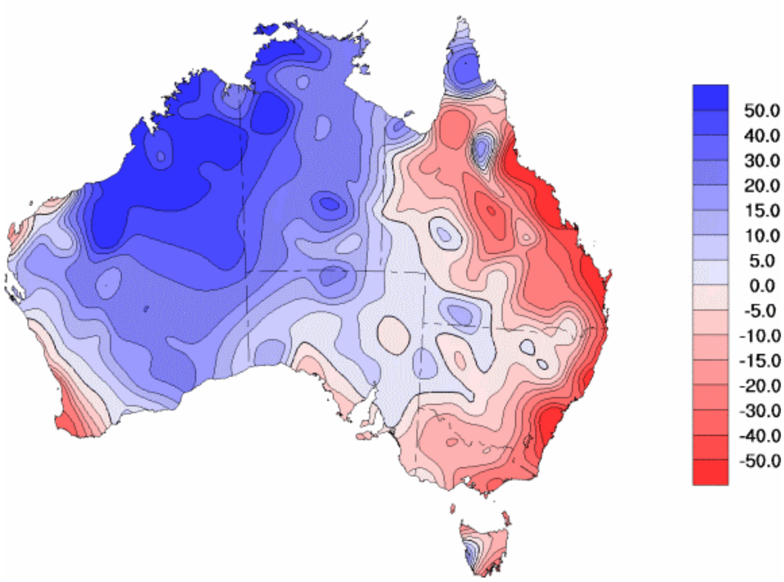
[10] This figure is subject to review in the final document, and is likely to be lower.

[11] MJA calculated a weighted average retail charge and divided by 1.3 to account for the statement that retail bulk water charges are 130 percent of LRMC.

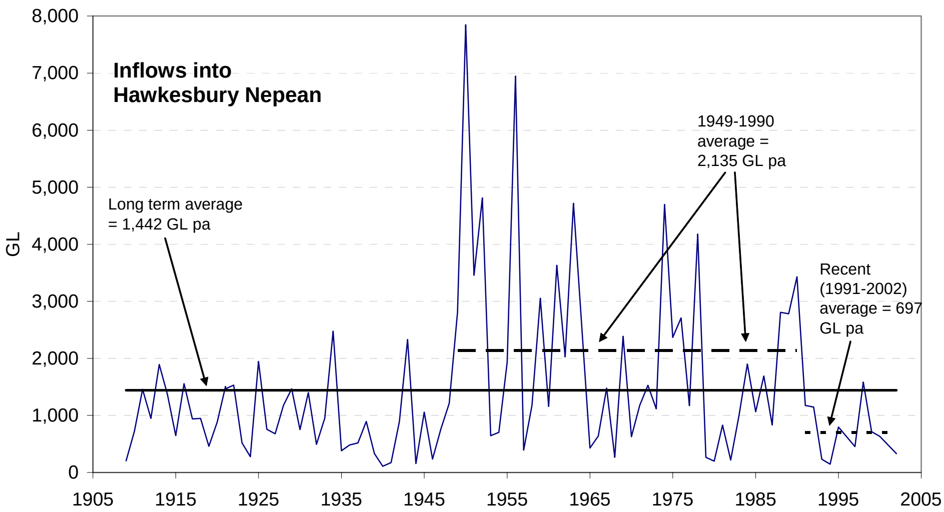
$1.20 and $1.50/kL by the Independent Pricing and Regulatory Tribunal (IPART September 2005, p.99). Such variation is likely to reflect differences in location and situation but importantly it also reflects the very substantial effects on differing assumptions on the importance of climate change.

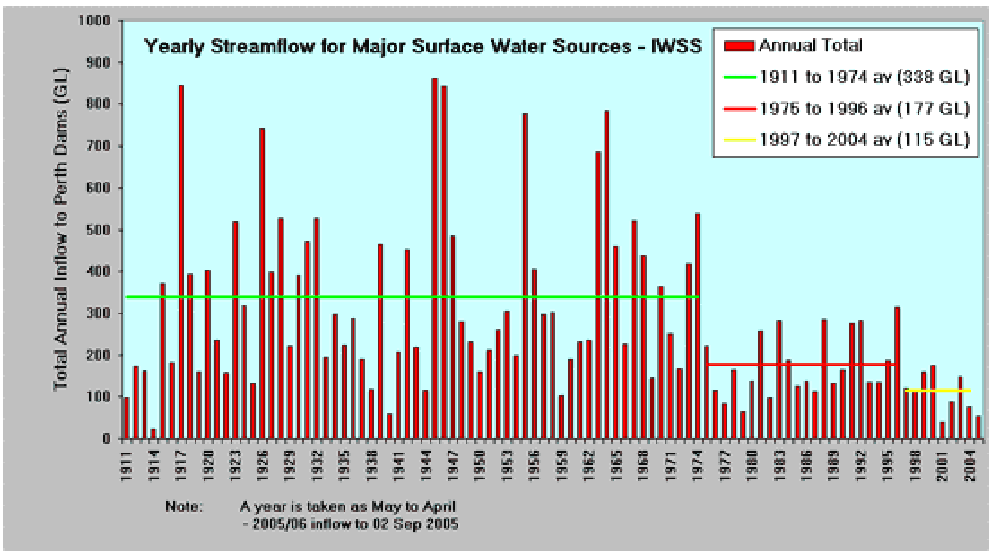
Box 2: Evidence of Climate Change

Trend in rainfall based on 1950-2003 period (mm/10 yrs)



Dam inflows : Sydney and Perth





Sources : Provided by Bureau of Meteorology, HNRMF (2004), Water Corporation (2005)

22. An assumption about climate change can markedly affect a city's estimate of LRMC, as climate change is thought to affect rainfall and inflow into dams and groundwater supplies. Higher temperatures associated with climate change can impact on water supplies through drying soils and increasing evapotranspiration, reducing runoff. For example, traditional modelling of water sources uses up to 100 years of historical data. If we accept a 'step change' in climate in recent decades, we see that average rainfall in the most recent 30 years or even 8 years is significantly lower than the 100 year average (see Box 1 for the Sydney and Perth examples).

23. The more aggressive the assumption on climate change, the higher the LRMC. If the LRMC for the Perth system is estimated on the same conventional basis as is the Melbourne system, then there is effectively no difference between the estimates. On the other hand, in line with CSIRO projections, and the increasing realisation of the impacts of climate change on rainfall and streamflow, all water authorities in southern and eastern Australia are likely to move in the direction of the Water Corporation's assumptions. This readjustment appears to be now in process, and is included in our modelling below. Box 2 demonstrates the trend in temperatures experienced in Australia since 1950, and streamflow in Sydney and Perth catchments over the past century [12].

Scale of water recycling

24. Water recycling covers a range of scales:
    - individual/household systems which are treated and reused on-site, and can be a single household or apartment complex;
    - small area systems which source water from several buildings and reuse them in that area, for example the Pimpama-Coomera development on the Gold Coast, caravan parks or industrial zones;
    - large area systems, typically from centralised treatment plants such as the Virginia Treatment Plant in South Australia, for residential or agricultural use; and
    - industrial systems, which often process wastewater internally (such as breweries).

25. Generalised discussion of the economics of different scales of recycled water systems suffer from the case-specific factors which affect economic viability in each water recycling scheme. However, some generalisations can assist our understanding:
    - larger scale water recycling projects can reduce the unit costs of processing;

[12] A complete scientific consensus on the impacts of climate change on water resources does not exist, and experts tend to give a range of estimates for the likely impact of climate change on temperatures and streamflow. However, on the basis of recent studies undertaken by MJA (including two workshops involving Australian climate experts from CSIRO and the Bureau of Meteorology, in 2003 and 2005), MJA considers these climate change assumption to be realistic.

- transportation costs, in contrast, increase the unit cost of recycled water the further the recycled water must travel for processing, and to end use. Existing pipe systems transporting potable water and wastes often cannot be used due to the need to keep recycled and other water systems separate;
- centralised recycling from existing wastewater treatment plants benefits from a large existing supply of water for recycling, however may suffer from large transportation costs if a high-volume customer cannot be found nearby;
- decentralised water recycling systems for urban or residential use can benefit from lower connection and transportation costs and are sometimes more economical, but are limited to specific circumstances (Dimitriadis, S. 2005);
- the economics of greywater recycling for domestic use are similar, and studies suggest that medium-sized recycling schemes servicing 1200 to 12,000 households can be the most economic (Booker N., 2000); and
- the economics of new or 'greenfields' developments typically far exceed those of existing or 'brownfields' developments, due to the higher costs of retrofitting pipe systems in existing developments, and the overall benefits of an 'integrated urban water management'.[13]

Generic benefits and costs of recycling

Benefits of increased water recycling

26. As noted above, the analysis looks at the benefits of the impact of the guidelines on take-up of recycling. Recycling benefits have been identified across a number of projects in Australia (and overseas).

27. For example, the US Environmental Protection Authority noted the following benefits from recycling:
    - *decrease the diversion of water from sensitive ecosystems*
    - *decreasing wastewater discharges*
    - *reducing and preventing pollution*
    - *create or enhance wetlands and riparian habitats (EPA (2005).*

28. Similarly in Australia, the Eastern Recycling Scheme in Victoria expects recycling benefits to include:
    - *providing a secure long term supply of water for industry*
    - *increased economic development through additional water being available for agriculture and industrial expansion*

13 For a full discussion of IWMS, see CSIRO, 2004

- *employment opportunities due to a potentially wider range of economic activities reliant upon high security water*
- *improving the health and productivity of stressed rivers providing additional environmental flows*
- *contributing to the long-term health of lakes and associated wetlands through increased volumes and improved quality of river inflows*
- *improving the marine environment by decreasing the volume of treated effluent discharged to the ocean;*
- *assisting in securing long term supplies of drinking water to meet population growth in urban and regional centres*
- *providing alternative water supply infrastructure for urban and regional centres*
- *mitigating the risk of reduced water yields from water catchments due to bush fires, climate change and prolonged drought.*

Costs of increased water recycling

29. Recycling is not costless and in evaluating the net benefits, these costs must be taken into account including:
    - costs of retrofitting residential areas to use recycled water can be prohibitively high;
    - recycled wastewater must be managed appropriately and risks properly assessed to protect human and environmental health;
    - with increasing water recycling, the costs of an outbreak become higher in terms of the number of people/size of area contaminated, and subsequent damage to public confidence; and
    - the opportunity cost of current uses of wastewater must be considered.

Water recycling targets

30. While water recycling is now identified as a major potential water source, in practice it remains minor, and since 1996/1997 there has been little increase (Table 1).

Table 1: Recycled water use as a proportion of treated water

	Proportion recycled (%)	
	1996-97	**2001-02**
State / Territory		
New South Wales	7.3	8.9
Victoria	4.6	6.7
Queensland	11.6	11.2
South Australia	9.9	15.1
Western Australia	6.1	10.0
Tasmania	2.3	9.5
ACT	0.8	5.6
Northern Territory	4.8	5.2
Australia	7.3	9.1
Capital cities		
Sydney		2.3
Melbourne		2.0
Brisbane		6.0
Adelaide		11.1
Perth		3.3
Hobart		0.1

Source: ATSE (2003) *Water Recycling in Australia*, p. 7

31. A number of governments appear to be working toward making firm recycling targets. In the cases of Victoria, Western Australia, South Australia and the ACT, these are set targets for their water organisations:

- the Victorian government has set a target of 20% recycling of Melbourne's wastewater by 2010 (DSE Victoria);
- the Western Australian government has set a target of recycling 20% of wastewater by 2012. Regional WA already achieves 40% reuse (Government of WA 2003, pp.31-34);
- South Australia has a 30% metropolitan wastewater recycling target and 24% country target for 2005 (both are unlikely to be met) (Government of SA 2004, p.17);
- the ACT Government has set a target of reusing 20% of treated water by 2013 (ACT Government 2004, p.4).

32. Others are moving toward or have not set 'firm' targets:

- Queensland's South East Regional Plan Part F:

The Queensland Government has developed guidelines for the use of recycled water and is currently preparing the SEQ Water Recycling Action Plan. This plan will coordinate the State's involvement in water recycling as a key element of integrated urban water management. It will identify issues and options for further uptake of water recycling and nominate targets and strategies for water recycling in the industrial, *commercial and rural sectors. It will link to other initiatives, including the SEQRWSS and Sustainable Housing Codes.*

- NSW is seeking to recycle 70 GL in Sydney by 2011. This would be equivalent to 12% of Sydney's drinking water supply (Government of NSW 2005).
- Tasmania transferred the onus for these targets to local government:

All municipal councils should take an active role in investigating and evaluating all possible uses for wastewater, establishing goals and targets for re-use (Department of Primary Industries 2000, p12*).*

33. The Northern Territory has not set goals for water recycling.[14]

34. Any discussion of water recycling targets should be cognisant of the fact that some state targets are best described as 'aspirational' rather than firm. That is, despite a target being set, the economic feasibility of achieving this has not been evaluated. Thus, reliance on these targets as a proxy for demand may overstate the case, but in the absence of a demand projection model this is a useful approach. MJA takes this general approach in its modelling.

Need for National Guidelines

35. The impetus for National Guidelines has also come from scientific and technical advisors and health and safety regulators, as deficiencies in existing approaches were identified and the scope to do better confirmed.

One problem is that the Draft National Guidelines for water reuse in Australia, the NWQMS Guidelines for Sewerage Systems, Use of Reclaimed Water (NHMRC and ARMCANZ 2000) are not sufficiently detailed to provide a nationally consistent approach to treatment and recycling of sewage effluent, and are not directly applicable to greywater or stormwater. In addition, state and territory governments have developed their own guidelines, a situation that has led to some inconsistencies and a lack of uniformity for recycling.

Further difficulties are the lack of defined criteria for system management and the singular focus on water-quality parameters, which might deter potential users and suppliers of recycled water. Satisfactory National Guidelines will promote the long-term planning and development of reuse schemes (NRMMC &EPHC 2005, p2).

36. There was also an identified lack of flexibility in existing frameworks which were seen to prevent innovative approaches. A CSIRO report commissioned with the Australian Water Association noted that:

Current guidelines, standards and regulations have been developed for conventional urban water systems, and as a result are not always

14 Discussion with Daryl Day, NT Power & Water Authority, September 2005.

> *appropriate for proposed designs which have adopted an integrated approach, and do not usually accommodate innovation. Guidelines, standards and regulations, by their nature, tend to lag behind leading edge practice, but more flexibility is required to foster innovation whilst protecting public health and the environment* (CSIRO 2004).

37. The Guidelines are being developed in an environment of tightening demand supply balances in many localities and a realisation that recycled water provides a significantly underutilised resource in Australia (House of Representatives 2005, 6.1, 6.20, 6.34). Increasing the uptake of recycled water faces a number of barriers:

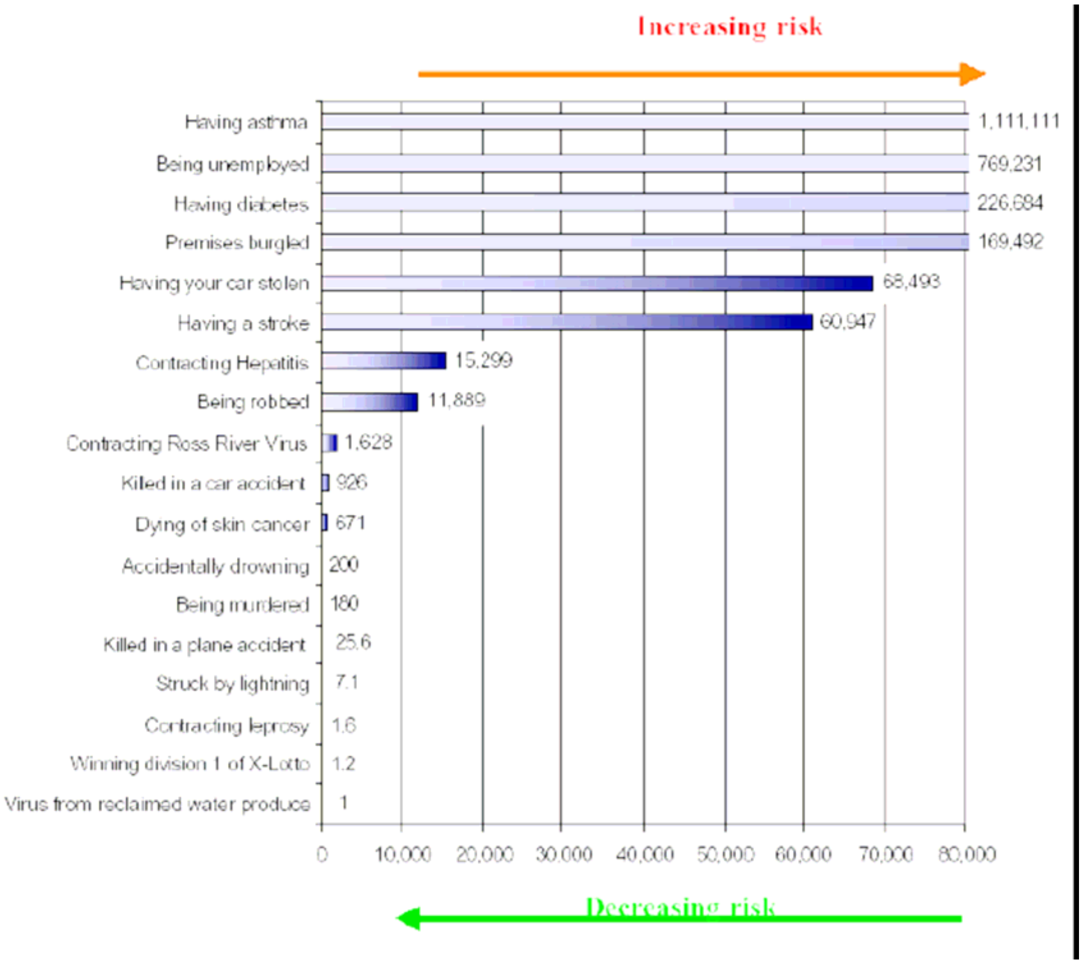
> *The main barriers to re-use of water in Australia are issues of public confidence, health, the environment, reliable treatment, storage, economics, the lack of relevant regulations, poor integration in water resource management, and the lack of awareness.* (Dillon 2002).

38. The Australian Academy of Technological Sciences and Engineering (ATSE) found:

> *The bottom line is that the Australian community is far more sensitive to very small health risks that might flow from any hazards implicit in using recycled water than they are to other, much higher probability risks over which they perceive they have more personal control.* [p. 140]

39. This is highlighted by a graphical analysis comparing the risk of viral disease from eating vegetables irrigated with reclaimed water meeting WHO standards (10^{-6} to 10^{-7}) (Shuval *et al* 1997, pp 15-20)[15] with other risks (Chart 1). As mentioned above, the risks to human health and the environment depend on level of treatment and end use.

Chart 1: Comparisons of the number of people likely to experience various events over a year from each ten million Australians.



Source: ATSE 2004 p. 141

40. In this context, guidelines on the provision of water recycling are a key instrument in providing assurance to the public of the quality of the reclaimed water. MacDonald and Dyack (2004, p11) noted that:

Overall acceptance of reuse has been shaped by:

15 "A risk assessment approach was developed to arrive at a comparative risk analysis of the various recommended wastewater irrigation microbial health guidelines for unrestricted irrigation of vegetables normally eaten uncooked. The guidelines compared are those of the WHO and the USEPA/USAID. The laboratory phase of the study determined the degree of contamination of vegetables irrigated by wastewater. Based on these estimates of the risk of ingesting pathogens, it is possible to estimate the risk of infection/disease based on the risk of infection and disease model developed for drinking water by Haas et al. (1993). For example, the annual risk of infectious hepatitis from regularly eating vegetables irrigated with raw wastewater is shown to be as high as 10^{-3}. **The study indicates that the annual risk of succumbing to a virus disease from regularly eating vegetables irrigated with effluent meeting WHO guidelines (1,000 FC/100mL) is negligible and of the order of 10^{-6} to 10^{-7}.**" [emphasis added]

- *trust in authorities and scientific information;*
- *positive attitudes towards the environment and environmental stewardship; and*
- *seeing that the decision making process is fair.*

Need to change approach

41. Research in Western Australia found that the public would be more accepting of assurances of safety where the issuer had been established for a number of years, had a good safety record and was not monetarily nor politically driven. Linked to this is the importance of trust in the technology which has been seen as an important element negatively impacting acceptance. Po *et al* (2004, p. 2) note that *"the public trusted the experts and government to make the right decision…"*.[16]

42. This suggests that in promoting community acceptance, evidence on the quality of recycled water should be supported by rigorous scientific evidence preferably from an independent or authoritative source.

43. The earlier prescriptive approach used in Australia would appear less strong on both these accounts. ATSE (2004) in reviewing recycled water in Australia noted regarding the current guidelines:

> *The Australian and States' Reclaimed Water Guidelines vary one from another, and generally place primary emphasis on bacteriological standards.* [p. 130]

44. Public confidence in the appropriateness of health standards is likely to be compromised if jurisdictions within Australia each have different standards. In addition, the reliance on output standards means that this prescriptive approach focuses on detection of failure rather than prevention. ATSE continues:

> *Excessive emphasis on numerical guidelines can lead to a reactive style of water management rather than a preventive approach.*
>
> *The* [previous National] *Guideline* Use of Reclaimed Water *sets out the quality required of reclaimed water and extent of monitoring that might be anticipated for secondary and tertiary treated effluents for various potential uses. … A risk management approach is missing from the document and its strong orientation towards land application for agricultural production provides only limited guidance for use of recycled water in the urban environment, and that primarily for amenity horticulture.* [p. 131]

45. In contrast, a risk-based approach has been identified as providing the necessary scientific rigour.

> *The approach to standards in the water industry is changing. water authorities have to provide greater assurance of water safety to consumers and industries. This has put more emphasis on risk*

[16] See also Po et al 2005.

management, quality assurance and process control within the Australian water industry. Managers are moving towards understanding the risks associated with processes and focussing quality control away from end-point testing and towards control of the critical operations earlier in the process. This is the philosophy behind Hazard Analysis and Critical Control Point (HACCP).

…The 2003 revision of the Australian Drinking Water Guidelines incorporates a risk management approach that is based on HACCP principles. … This involves describing the process with the aid of flow diagrams, analysing hazards (and assessing associated risks), determining Critical Control Points and critical limits and determining monitoring, corrective actions and verification procedures. The result is production with higher quality assurance and a greater opportunity to correct non-conforming (or potentially unsafe) product, minimising wastage and re-work and hence, reducing costs. This approach is particularly beneficial for public water supplies in which managing contaminated water in complex distribution systems is not simple [p. 131]

46. The development of the national risk-based guidelines provides greater assurances for the public regarding the quality of reclaimed water and its suitability for alternative uses.

47. This risk-based approach (with a particular focus on HACCP) has been adopted from food safety and is applied as a fundamental principle in the Australian Drinking Water Guidelines (ADWG 2004). The multiple barrier approach provides the mechanism to ensure the safety of recycled water by controlling the potential hazardous constituents of water.[17]

48. A risk management approach acknowledges that single (or even limited multiple) input/intermediate/output criteria may not give efficient responses in terms of minimising harms and maximising the efficient use of (water) resources including the cost of supply.

Risk management is the decision-making process involving considerations of political, social, economic and engineering factors with relevant risk assessments relating to a potential hazard so as to develop, analyse and compare regulatory options and to select the optimal regulatory response for safety from that hazard. Essentially risk management is the combination of three steps: risk evaluation; emission and exposure control; risk monitoring (www.bio.hw.ac.uk).

Identified costs and benefits of the Draft National Guidelines

49. The benefits and costs of achieving stronger confidence in recycling will vary by location and situations across Australia in the coming decades. It is therefore not possible to describe and quantify in a simple, comprehensive and certain manner the precise costs and benefits of a move to National Guidelines. MJA has therefore taken

[17] To borrow from WHO's description of the reason for its drinking water approach (2004, p1)

an approach to illustrate and dimension the costs and benefits of the new Guidelines. As noted, these are:

- an examination of relevant case studies;
- high level modelling of the benefits and costs across Australia for greenfield and brownfield residential areas;
- discussion of the unquantified benefits and costs.

50. In evaluating the benefits and costs of developing and implementing the national framework, it is important that the analysis distinguishes between the benefits and costs of the introduction of the Guidelines and the benefits and costs associated with recycling. These latter impacts are important of themselves but are only relevant for this analysis where the impact of the guidelines affects the likelihood or efficiency of recycling, or increases recycling due to greater confidence in recycled water.

51. For the purposes of this analysis it is beneficial to separate the different elements of costs and benefits from adopting the (risk-based) National Guidelines.

52. The most important element in the evaluation of the impact of National Guidelines must be the consideration of what will be its impact on the nature and level of recycling in coming decades.

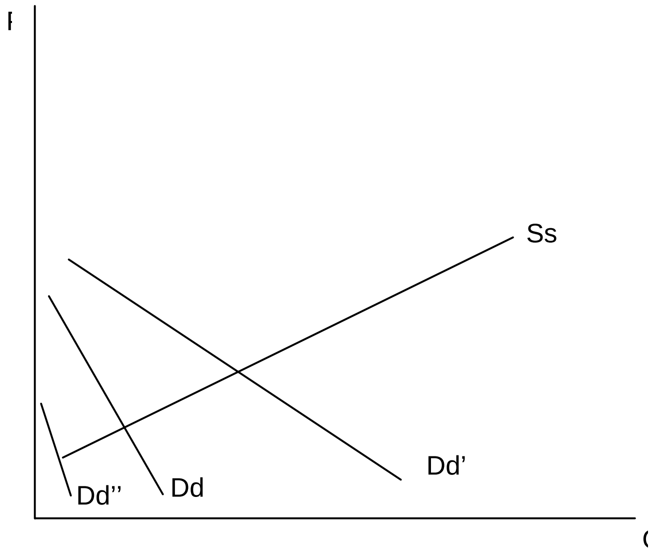
53. A risk-based approach may impose costs or benefits on proponents of recycling or on government agencies charged with evaluating proposals or safeguarding public health. Such costs and benefits may include transfers of tasks between these institutions. In effect, these relate to the cost of supply of recycling. On *a priori* grounds across major developments, these are unlikely to have a material effect on recycling.

54. A significant benefit of the risk management approach is that it requires the formal evaluation of the broad range of factors that impact on hazards and mitigating policies associated with, in this case, recycling and the re-use of treated wastewater.

55. The major impact of the guidelines will reflect the *raison d'etre* for government regulation in the first place – the protection of human and environmental health. The economic side of the same coin is that the Guidelines will provide the basis to grow over time public confidence in water supply and wastewater re-use.

56. This strengthened confidence is needed to underpin potential increases in the demand for recycled water. We can envisage current demand as being represented by the line Dd in the chart below. If we consider the targets for recycling represent the potential increase in recycling, this would result in a significant increase in demand (to say, Dd'). However, this increase will be founded on public confidence in the recycled water – whether for the crops that use it for irrigation, for potential substitution of potable for industry or dual pipe applications for residential schemes.

Chart 2: Notional Demand for Recycled Water



57. Conversely, a collapse in confidence by the public (from a health scare for example) may see demand for recycled water fall back toward or to below current low levels (Dd''). The Guidelines will be a necessary condition, though not sufficient, for the expansion of demand for recycled water towards its potential. A full analysis of the underlying economic theory is outlined in Attachment B.

Comparison of existing state and future National Guidelines

58. A full assessment of the differing state frameworks and comparison of these with the proposed national framework is provided in Attachment A.

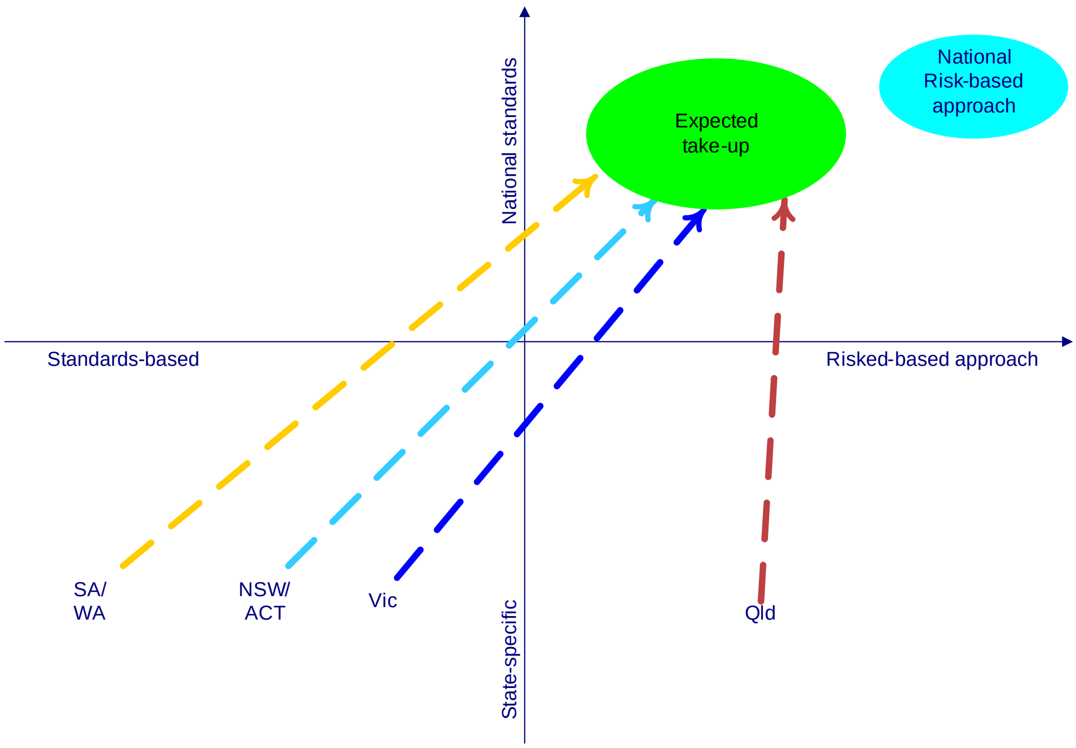
59. In practice, there is no uniform base case applicable to all states, since different state jurisdictions have different bases or starting points. Queensland has already developed draft state guidelines which are consistent with the approach suggested in the Guidelines, as have the Victorian Draft Dual Pipe Guidelines[18]. Other jurisdictions possess different frameworks which are more or less prescriptive, despite variations between them.

60. MJA has taken the view that the previous *NWQMS Guidelines for Sewerage Systems, Use of Reclaimed Water (NHMRC and ARMCANZ 2000)* were insufficiently detailed to provide a consistent national approach, and have been incorporated to differing degrees (or overlooked) in the individual jurisdiction frameworks. As such, they are incorporated into the base case only so far as they have influenced state frameworks.

61. Chart 3 below illustrates these concepts.

18 The full title of these guidelines is "Draft Guidelines for Environmental Management: Dual Pipe water Recycling Schemes – Health and Environmental Risk Management". Currently available from: http://epanote2.epa.vic.gov.au/EPA%5Cpublications.nsf/PubDocsLU/993?OpenDocument

Chart 3: Comparison of existing and future frameworks by state



62. Implementation of the new National Guidelines by the individual states is also likely to differ between jurisdictions as different states initially adopt the national framework to differing degrees, for the purposes of comparing a coherent national framework with separate state structures it is necessary to make some simplifying assumptions. As such, we assume that the states will ultimately incorporate the national risk management framework along with best practice recommendations in more or less a similar way to Queensland and for dual pipe in Victoria, which have each adopted an approach consistent with the proposed national framework.

63. This involves moving from a largely prescriptive format for most states, to a structure involving risk management (left to right on our diagram). This also involves moving from separate state guidelines, to a more consistent national approach. It should be noted that MJA does not anticipate the risk-based approach to replace completely existing state guidelines. Rather, there are a number of functions that will likely remain, including permits, approvals, and specific procedures for use. As with Queensland and Victoria, there are important practical state frameworks which will remain, but which will need to be made compatible with the national risk management approach.

Case studies

64. A number of case studies can be used to demonstrate the potential for 'fit for purpose' recycling strategies developed using a risk management framework. Although the use of a risk management framework is relatively new, several innovative recycled water projects across Australia have been identified for possible use in case studies, examples of which include:

Olympic Village	New South Wales
Rouse Hill	New South Wales
Eastern Irrigation Scheme	Victoria
Great Western	Victoria
Iluka Resources	Victoria
Inkerman Deluxe	Victoria
Great Western	Victoria
Eastern Irrigation Scheme	Victoria
Mawson Lakes	South Australia
Virginia Pipeline Scheme	South Australia
Luggage Point	Queensland
Various golf courses, recreational parks, etc.	Australia wide

65. The list is not intended to be exhaustive, but to demonstrate the broad range of projects that have been canvassed for use in the case studies.

66. Existing projects fall essentially into two categories:

- **Category 1:** Those projects which by nature of the recycled water use and associated risks, demand a high quality water specification, equivalent to Class A water quality or higher.
- **Category 2:** Those projects that demonstrate the benefits available, even at this early stage, of the use of a risk management framework to determine fit for purpose water quality specifications resulting in net benefits to the proponents and the broader community.

67. Where projects involve the use of the equivalent of Class A recycled water, then arguably these project have already attracted market interest, and as a consequence, the controls on the development and operation of these schemes can be considered

equivalent to those that would apply under the Guidelines. These projects are therefore unlikely to demonstrate measurable economic benefits in moving from the existing state-based guidelines to National Guidelines. Rather, the Guidelines would merely preserve the controls for attaining consumer confidence in recycled water.

68. Where projects have been promoted on the understanding that a given water quality specification is desired, but under a risk-based approach it can be demonstrated that a specification that is more fit-for-purpose should apply, then clearly savings (or costs) can be identified. Examples of projects in this category include Iluka Resources and Port Lincoln.

69. Golf courses and recreational areas including parks and sporting ovals would also fall into this category. For example, in South Australia, the majority of golf courses using recycled water use the equivalent of Class B recycled water. In many of the other states canvassed, the equivalent of Class C recycled water quality is more generally used. Analysis of the risks associated with these enterprises could result in the equivalent of Class C recycled water in some cases. The use of Class B recycled water for golf courses has largely been promoted on the small incremental cost in proceeding from Class C to Class B, and that Class B offers lower health risk.

70. Three case studies have been developed from the above listing, having regard to the categorisation thus described, as well as two other illustrative case studies. These case studies examined are:

- Mawson Lakes, the major residential development outside Adelaide;
- Iluka Resources, an example of the use of recycled water for industrial processes;
- the Inkerman Deluxe apartment development, in St. Kilda;
- the Pimpama-Coomera proposal on the Gold Coast; and
- Leidsche Rijn, the town outside Utrecht where there was a major ‘water quality’ incident in 2002.

The case studies have been selected on the basis of the differences in approach to recycled water application in a variety of market applications, and not on the basis of predetermined selection criteria.

Mawson Lakes

71. Mawson Lakes is a residential development located 12 km from the CBD of Adelaide. The Mawson Lakes development involves the supply of a Class A recycled water (derived from treated wastewater) combined with stormwater for use in residential home sites. The product water from this process is used for garden watering, toilet flushing, car washing and landscape watering (public open spaces).

72. Currently, there are 3-4,000 people connected to the scheme.

73. The scheme is planned to ultimately supply up to 10,000 people.

Initiative / development

74. The development of the Mawson Lakes project commenced in 1998. The project was promoted as a private development on the basis of using recycled water together with stormwater harvested onsite to reduce potable water demand. In turn, this also reduced demand for a water supply from the River Murray.

75. The initial proposal of onsite harvesting was proven to be uneconomic and a larger scheme initiated through SA Water was subsequently adopted. Under this scheme, the equivalent of a Class A recycled water from the Virginia Pipeline Scheme would be combined with stormwater harvested from the Parafield Airport (City of Salisbury). The harvested stormwater from Parafield is diverted from a drain into a holding basin and then into wetlands adjacent to the development, and ultimately pumped into an aquifer for storage prior to use.

76. The stormwater is treated in wetlands and is combined with the treated wastewater to decrease salinity levels to levels of no greater than 900mg/L. Depending on the salinity of the treated wastewater, stormwater volumes range from 200-400 ML/a, and the Class A treated wastewater volumes range from 400-600 ML/a.

77. A risk management approach was used to develop this revised scheme to ensure that the final product water was 'fit for purpose' at the point of use.

Process of Confidence Building

78. The development at the Mawson Lakes project was promoted from inception on the basis of being environmentally sustainable in that there would be reduced discharge for the environment as a result of the on-site harvesting at source waters and there would be less overall draw on the River Murray.

79. This proposal provided a key focus for the development and its market attractiveness to people who were looking for more sustainable housing development.

80. Other ongoing existing projects, such as the Virginia Pipeline Scheme and the Willunga Basin recycled water scheme, provided supporting confidence to the success of the recycling initiative and overall project environmental sustainability.

81. The role subsequently adopted by South Australian Water, and the Department of Health, in developing the dual pipe supply in 2005, building on the achievements at Virginia and Willunga, provided further confidence to the residents at Mawson Lakes.

82. The HACCP plan developed from the risk analysis, whereby auditing of the controls at both a household level and scheme level provided further surety of compliance and confidence. These controls are consistent with the risk-based approach proposed under the national draft framework.

Role of Guidelines

83. A risk-based approach was used to develop the point of use specification for the water sources (Class A recycled water and stormwater). The approach in this instance, however, predated the draft guidelines. Nevertheless, the frameworks are nearly identical and demonstrate how a risk-based framework can be applied to produce efficient and cost effective outcomes.

Innovation

84. Innovation at Mawson Lakes occurred largely through:

- the adoption of stormwater capture to reduce the salinity of the otherwise recycled water from the Virginia Pipeline Scheme; and
- the use of a fit-for-purpose storage and treatment methods developed under the risk-based framework to enable availability of supply. The aquifer storage system used to hold treated stormwater is the first of its kind in a residential application.

Capital Cost

85. The total cost of the dual pipe scheme including the recycled pipe infrastructure, treatment and storage systems is $14 million. This cost excludes the cost of internal plumbing to households. The combined water (recycled) is supplied to households at a cost of $0.79/kL. While the separate costs of treated wastewater and stormwater are commercial in confidence, they are broadly comparable.

Economic Discussion

86. A proposal involving the use of recycled treated wastewater of the equivalent of Class A quality or stormwater alone was not practical nor was it acceptable to the regulatory agencies. Class A recycled water, on the other hand, satisfied the health requirements when coupled with additional disinfection, but had the potential to impact on the environmental values due to elevated salt levels in the recycled water. Application of this water without further treatment (to reduce the salt concentration) was not cost effective. Nor was it sustainable (without further treatment) if the Class A water was to be used alone for garden watering in the Mawson Lakes area (without the benefits of dilution). Put another way,, the project developer would have to treat well in excess of the ultimate demand of 800 ML/a of Class A recycled water if indeed further treatment was required to reduce the salt, to achieve a water that was fit for purpose.

87. As with most recycling treatment plants, the net production is often less than the actual volume treated as a result of the reject sidestreams that are generated during the treatment process. To achieve a net production of 800ML/a would typically require a gross input of approximately 1,100 ML/a with the reject stream having to be disposed as a brine waste. This in itself not only requires an additional cost for the volume of Class A water treated but it generates a sidestream which further attract costs for disposal.

88. This higher quality treatment of larger volumes would typically require treatment using reverse osmosis membrane (RO) treatment, with an indicative additional capital cost of $5-8 million, as well as ongoing operating costs for treatment and disposal of the waste by product or sidestream.

89. Alternatively, the developer would be forced to source water from the potable supply, resulting in 800 ML/a higher take from the River Murray.

90. The key benefits from this project may be summarised as:

- avoided treatment costs from reverse osmosis membrane treatment in the order of $5-8 million, plus ongoing operational costs;
- use of combined source waters to reduce demand on potable water from the River Murray (estimated at 800 ML/a or $1060/ML, for the ultimate development ($848,000/a);
- environmental benefits to wetlands receiving additional stormwater;
- use of a risk-based approach to make best use of available assets/water sources, thereby:
  - avoiding the costs of treatment and disposal,
  - avoiding the environmental risk of managing and disposing of brine sidestreams, and
  - maximising potable substitution of water from the River Murray; and
- confidence and adaptation.

Iluka Resources

Background

91. Iluka Resources Limited (Iluka) is developing the Douglas mineral sands project in South Western Victoria. Up to 1 ML/day of recycled water will be used for processing the mineral sands concentrate at the mineral separation plant. The actual processing plant is located at Monivae, 20 km south of the mine. The raw product (from the mine) is transported overland to the processing plant. Iluka Resources processes rutile, zircon and other minerals in the sand for use in pharmaceuticals, industrial ceramics and coating systems.

92. The development of the project stems from the need to find suitable water proximate to the site of the mine. Potable water from the nearby town of Hamilton was not available and the opportunity to use recycled water was put forward as the basis upon which development could proceed. It was initially proposed to supply to equivalent of Victoria's Class A recycled water for use in the washing process (reflecting their occupational health and safety concerns), however the State Government in line with the Guidelines, recommended that a more 'fit for purpose' water recycling option could be applied that was more cost effective. This reflected the industrial nature of the mining operation and the fact that the proponents could minimise human exposure through various risk management measures.

93. The recycled water is delivered from a dedicated treatment plant located at Monivae which takes the equivalent of secondary treated effluent as its feedwater source. The secondary effluent is derived from a sewage treatment plant which is managed and operated by Glenelg Region Water Authority at the same site, with the effluent typically disposed offsite using irrigation. This previous arrangement for effluent management has not proved satisfactory for Glenelg Region Water Authority and the opportunity to make the recycled water available to supply Iluka Resources provided

both a long-term contract for sustainable use of the recycled water and a revenue stream for the volume of water reused.

Economic Assessment

94. From an economic perspective, the differences to be assessed are those of moving from Class A recycled water to a more 'fit for purpose' water quality. Given that the wastewater was already being treated for disposal by irrigation, it is not necessary to include the full treatment costs from the raw sewage to a 'fit for purpose' water for use in the mining operation. It is assumed that the base case is treatment to the equivalent of Class A water quality, and the alternative is the 'fit for purpose' arrangement. Benefits and costs reflect the differences between these two options. It is important to note that there is no suggestion that the advent of National Guidelines have resulted in the use of recycled water for the project, rather that the approach of the Guidelines has resulted in a fit-for-purpose arrangement with different costs and benefits.

95. The volume of recycled water to be used in the mineral separation plant is around 200 ML/a and would be the same for either recycling with Class A or a more fit for purpose water. The details of the different costs of Class A water and the fit-for-purpose water are commercial in confidence and cannot be used here. However we can, for the purpose of comparison, use an indicative cost of Class A water (processed from secondary effluent) of around $1000/ML. An indicative cost of a fit for purpose water could be compared with the cost of potable water at $700/ML. At a discount rate of 6% per year, over a 30 year lifecycle, and based on a fixed demand of 200 ML per year, we find a difference in net present value between the two options of over $1 million.

Inkerman Deluxe

Initiative / development

96. The Inkerman Deluxe project consists of a series of apartment clusters of 3-4 storeys in height which, when completed will accommodate 237 apartments in Inkerman Street, St Kilda, Victoria. At present, 110 apartments have been completed and are occupied. Development was initiated by the City of St Kilda who approached Inkerman Developments to develop the site. The local council was particularly interested in using the site as a demonstration for the use of greywater/sustainable stormwater reuse and subsequently received a grant from the State Government for the project.

Process of confidence building

97. The developer initially sought to undertake the project without approvals, other than planning approval, for the reuse system. The reuse system incorporates a recycled pipe network and greywater centralised reclamation plant. The reclaimed or recycled greywater is combined with stormwater for subsurface irrigation of the development landscape. The recycled greywater is also to be eventually used for toilet flushing. The existing apartments currently use potable water for toilet flushing. When the

recycled water becomes available, it will displace the potable water and the potable water will only be used as a back-up in times of system failure.

98. Stormwater which is collected at the site is also stored in a subsurface area but is restricted for use in irrigation only.

99. During the development of the project, retail water company South East Water Limited (SEWL), was invited to assist the development in achieving accreditation and approval for the greywater recycling system. SEWL is currently holding discussions with development authorities, including the Department of Human Services and the Environment Protection Authority (EPA) to finalise the basis upon which the project can proceed.

Role of Guidelines

100. The Victorian Guidelines do not provide a specific objective for water quality where recycled greywater is distributed for use in toilet flushing. Rather, the approach adopted by SEWL has been to use the risk analysis framework of the Guidelines to ensure that the final water quality is fit for purpose.

101. Draft Dual Pipe Recycled Water Guidelines recently released for comment by the EPA include provision for supply of recycled water for use in residential developments. These provisions include risk analysis conducted in accordance with the Guidelines, with the equivalent of Class A recycled water microbiological quality being fit for purpose. In the interim, potable water is used for toilet flushing.

Innovation

102. Innovation to this project largely comes about through the use of greywater which is generated at the site being reused along with stormwater to meet the needs of the development.

103. The greywater collected is treated at a centralised treatment plant. The developer had previously procured a membrane bioreactor for treatment of the greywater but the microbiological quality of the greywater is not widely characterised and further work is currently being undertaken to confirm the required level of pathogen removal through the treatment process. This will ensure that the final product water quality (from the treatment process) is fit for purpose and can be used for the intended application.

104. The innovation of this case study in reclaiming and recycling the greywater, enabling substantial environmental benefits associated with the sustainable use of all source waters derived from the site. The application of the recycled greywater (and collected stormwater) as a potable water substitute on a broader scale also lends application to other multi-cluster type developments generally.

Capital costs

105. The capital cost of the onsite treatment systems cannot be ascertained at this time as the final solution is still being evaluated. In economic terms, the avoided costs

associated with potable water substitution of greywater equate to $770/ML on average (cost of potable water), regardless of the final product of water quality together with reduced costs of centralised collection, treatment and disposal.

106. Given that the outcome from this project regardless would likely be a water quality of the same specification, the final costs of installation of the greywater and stormwater system, and its operation, are not likely to be different. However, the HACCP controls, associated with the application of the draft guidelines in this instance, are considered more likely to result in improved reliability and hence risk management, that in turn can be used to improve consumer confidence.

Benefits

107. The benefits from this project may be summarised as:

- use of greywater (and collected stormwater) for potable water substitution for use in landscape irrigation and in the use of the reclaimed greywater for future toilet water flushing;
- reducing the need for other infrastructure to meet the water demands at the site by use of greywater and stormwater recycling; and
- use of appropriate treatment technology based on a rigorous risk framework to make the greywater fit for purpose so that consumer confidence in these type of developments can be extended to other cluster developments.

Pimpama-Coomera

108. The Pimpama-Coomera residential development on the Gold Coast is supplied with water supply managed by Gold Coast Water. This project highlights not only the possibilities for water conservation available through integrated water cycle management (IWCM) including use of recycled water, but also the importance of each element in the plan to the overall economic viability of the project. The project is on the cutting edge of IWMC:

> *Rainwater will be collected from roofs for household use. The rainwater tank will also be used to slow roof runoff to reduce stormwater flows. Drinking (potable) water will be provided to the house for drinking and cooking, and also as a trickle supply to the rainwater tank to ensure it does not run dry. The wastewater system will be constructed to ensure less stormwater enters the system, reducing the quantities of wastewater transported to the wastewater treatment plant for treatment. Most of the treated wastewater will then be put through further treatment and disinfection processes, including membrane filters, to produce very high quality (Class A+[1]) recycled water for use within the community. Excess recycled water will be pumped underground into an aquifer, where it will be stored until required. When recovered from the aquifer the recycled water will be re-disinfected before being pumped into the recycled water system. Excess treated water that cannot be recycled or pumped to the aquifer storage will be released to the Pimpama River via wetlands, while*

> *stormwater runoff will be treated within the community using various environmentally sensitive measures including swales, bio-retention devices, wetlands and basins.* (Gold Coast Water, 2004, p.ix)

109. A financial summary of the Pimpama-Coomera model is presented below in Table 2. The table demonstrates that a 65 per cent decrease in potable water consumption and an 85 percent decrease in wastewater released to the environment is achievable at an increased overall cost of 6 per cent (the table does not attempt to measure environmental benefits). However, the table also demonstrates the overall efficiency requirements of each element in the cycle. The capital expenditure savings to water of over $45 million in net present value terms result in part from the proposed use of recycled water for fire fighting uses in the development. If this is unable to proceed, the cost savings will be reduced.

110. The 'fire fighting problem' shows the need to deal comprehensively with all risks, otherwise it is possible that one risk may void the economic benefits of managing and mitigating all the others.

111. Comprehensive recycling in large greenfield developments can be achieved at little cost penalty. In the case of Pimpama-Coomera this cost penalty is estimated to be from around 6% to just over 10% of the lifetime costs of a conventional development, the variation depending on the gains from downscaling potable delivery pipes that may be voided by concerns over risks to fire fighter health.

112. The cost penalty incurred however provides a reduction in the need for new potable supply sources. In the case of Pimpama-Coomera this is achieved at a cost of around 17c/kL. This unit cost compares more than favourably with the long run marginal cost (LRMC) of conventional supply sources and newer technologies such as desalinisation.

Table 2: Pimpama-Coomera Model

Item	Conventional	Smart	Difference	Party
Costs ($1000)				
Potable Water - CapEx	101,127	55,062	-46,065	Developer
Recycled Water - CapEx	0	80,895	80,895	Developer
Rainwater tanks - CapEx	0	62,772	62,772	Householder
Wastewater - CapEx	127,339	101,871	-25,468	Developer
Stormwater - CapEx	129,849	66,247	-63,601	Developer
Total CapEx = PV (K)	**358,314**	**366,847**	**8,533**	
Total Operating Costs	**189,651**	**213,600**	**23,949**	**Householder**
Total PV Costs	**547,965**	**580,447**	**32,482**	
Revenue ($1000)				
Periodic Charges	253,864	267,935	14,071	Householder
Dedicated Assets Developer	169,984	113,607	-56,377	Developer
Dedicated Assets Householder	0	62,772	62,772	Householder
Developer Contributions	194,376	205,348	10,971	Developer
Total PV Revenue before tax	618,224	649,661	31,437	
Less Tax	-70,259	-69,214	1,045	
Total PV Revenue after tax	**547,965**	**580,447**	**32,482**	
Water Volumes (ML)				
Potable Water	72,390	25,565	-46,825	
Recycled Water	0	34,211	34,211	
Rainwater tanks	0	12,245	12,245	
Wastewater - Volume leaving property	49,647	44,683	-4,965	
- Volume treated	68,513	44,683	-23,831	
- Volume released into environment	68,513	10,472	-58,041	

Source: Marsden Jacob Associates, 2005.

Leidsche Rijn Water Quality Incident

113. In December 2002, a water quality incident occurred in the new residential area of Leidsche Rijn (in the town of Utrecht) in the Netherlands which resulted in dramatic effects on consumer confidence in water quality. The project was a large scale residential pilot involving the supply of lower quality "household" water sourced from the Rhine River for non-potable activities (toilet flushing, washing machines, garden taps) in up to 30,000 new homes. During the first phase of development (involving 4000 homes) an accidental mains cross-connection with the potable supply resulted in an identified 200 cases of gastroenteritis, associated with the Norovirus group. After intense scrutiny, the Ministry decided that the risks to public confidence in drinking water quality of such an outcome were too high, and in August 2003 the Ministry of Spatial Planning, Housing and the Environment decided to terminate any further large-scale dual water supply schemes for households (Health Stream, 2003).

114. Although in its early stages, this failure of water quality management has resulted in the loss of all potential future dual reticulation schemes of any type (river or recycled water). The cause of the infection was human error (through a fault in the dual reticulation system), and might have been prevented with a more rigorous management during implementation and subsequent stages of the project. A Dutch observer noted that the HACCP system is a good tool to reduce these associated risks.

The long-run marginal cost of potable water supply

115. It is useful to extrapolate to a larger scale the potential impacts of increased water recycling flowing from the move to a national risk-based framework. As such, the following examples illustrate the economic impacts for a city of an increase in water recycling described in the project-based case studies above.

116. For this indicative analysis, we examine the effect of an expansion of water recycling on the long run marginal cost (LRMC) of a city's water supply, given the effects it may have on the city's source development schedule. The term 'source development schedule' relates to the longer term strategy of supplying a city's demand for water with least cost sources. Armed with an understanding of the cost of supplying recycled water under the national framework (from the micro-case studies), we can analyse the cost savings of deferring the development of an additional dam or other water source, over time.

117. Perth provides a pertinent case study of the impact of a new supply option on its source development schedule and therefore its LRMC. Perth is a city with limited low cost water supply options, below average rainfall during the past few decades[19], and increasing expected demand for water for potable supply, agriculture and industrial uses. Recent analysis shows a 10-20% rainfall reduction since 1976, resulting in reduction of runoff to dams in the magnitude of 40-50%, and reduced recharge to groundwater (Government of Western Australia, 2003).

118. The impact of global warming is becoming increasingly accepted as likely to result in an even drier climate in the south west of Western Australia in future (Water and Rivers Commission 2000). Concurrently, the demand for water in Western Australia is expected to double in the next 20 years, due to population increases and expansion to the mining, industrial, services and irrigated agricultural sectors (Government of Western Australia 2003). As a result, Perth is investigating and bringing on-stream a number of high cost source options, most notably desalination at a unit cost of $1.17/kL.

119. The Water Corporation has modelled its expected source development schedule until 2105, comparing expected demand with water supply given existing sources. Where expected demand proves too high for supply from existing sources, the least cost water source option given real world constraints of timing and availability, is added to existing sources. Average costs of supply are adjusted to incorporate this source development. For planning purposes, the Water Corporation models source development with the most recent 8 year average for weather conditions (which reflect lower rainfall in recent years).

[19] And particularly the past decade

120. The impact of a new water source is to push back the need for more expensive source development by several years and reduce Water Corporation's source development costs in present value terms[20]. For say, 10 to 12 GL additional water, the difference between the two source development schedules represents over $110m in NPV terms.

121. A potential wastewater treatment (recycling) plant will incur up-front capital and on-going operating expenses. Assuming the wastewater treatment plant comes on-stream in 2008 at an initial capital cost of $20m in 2007 and ongoing operational costs of $1m per year, then this represents just over $30m (NPV) with the difference in costs around $80m (NPV).

122. As it happens, Perth's sandy soils and heavy reliance on shallow sand aquifers such as in the Gnangara Mound means that recycling of water will be carefully planned and monitored and is currently at low levels. Also, recycled water in Perth currently replaces groundwater rather than potable (which reduces the differences in NPV costs), but there are some indications that groundwater is currently undervalued in Western Australia (URS 2005).

123. Nonetheless, the source development schedule is an essential tool in evaluating the potential benefits of water recycling and other options for future water supply.

Case study lessons

124. Key lessons which can be drawn from the above case studies include the following:

- the risk management approach encourages flexibility in water management which encourages innovation and adaptation in water recycling developments, as seen in the Mawson Lakes case study;
- similarly, the risk management approach using fit-for-purpose water recycling schemes which properly manage health and environmental risks can result in savings to project costs, as seen in the Iluka Resources example;
- comprehensive coverage in managing all risks associated with the entire water cycle is needed to provide optimal outcomes, as demonstrated in the Pimpama-Coomera case. The 'fire fighting problem' shows the need to deal comprehensively with all risks, otherwise it is possible that one risk may void part or all of the economic benefits of managing and mitigating all the others;
- public confidence in water management more generally is paramount to the growth in water recycling, as demonstrated in the Dutch example. The Dutch water incident further reminds us that dual reticulation guidelines are also needed when using recycled or other sources of non-potable water;
- public confidence and understanding grows gradually, but can snowball over time and across projects, as demonstrated in the Mawson Lakes case study which was supported by the confidence achieved through the Virginia Pipeline and Willunga Basin schemes;

20 "Net present value" is an economic term commonly used to discount future costs and benefits to their values in the current day, reflecting higher values placed on the present than the future. We have assumed the discount rate at 8 per cent for this exercise.

- project partnerships with trusted institutions can greatly increase public confidence in water recycling projects, such as in Mawson Lakes and Inkerman Deluxe; and
- the value of reduced demand on potable supply for a major city can be estimated from the planning schedule showing the expected sequence, costs and increase in supply from each new addition to source capacity. Value is directly related to assumptions relating to shifts in mean rainfall due to climate change.

125. The benefits of National Guidelines lie in increasing the robustness of an already strong state-based system. By increasing public confidence and acceptance, rather than effectively giving the recycled water to users, a meaningful price may be achieved. By increasing public confidence and acceptance, the rate of take-up of recycling opportunities is likely to be higher.

126. We can explore the benefits and costs of an increasing rate of take-up of recycling due to increased confidence below, using a standard benefit cost framework. This assessment is predicated on:

- there being direct economic benefits from recycling, especially in greenfields situations;
- increased confidence resulting from the move to National Guidelines leading to a faster (higher) rate of take-up of recycling opportunities; and
- increased recycling leading to a commensurate reduction in demand for potable water.

Evaluation framework and analysis

127. An assessment of the economic costs and benefits of a move to the national water recycling framework can be adequately addressed within an economic modelling framework.

128. For the evaluation of the economic impact, benefits and costs of any initiative or investment there must be clear specification of the alternatives to be compared. Thus, a primary purpose of a benefit cost analysis is to evaluate the net benefits of proceeding with an investment compared with a specified alternative (or base) case. The alternative may be do nothing, the status quo or an alternative competing project.

129. For the current study, the base case is assumed to be the status quo. This is not the situation now, but the situation which might be reasonably expected to apply in the future if there are no National Guidelines for water recycling and we continue to rely on separate state-based, largely prescriptive guidelines. The 'with project' case is the situation which is expected to occur in the future with the Guidelines in place.

130. Since both the base case and the with project case relate to the future, then the specification of both must be carefully considered since both must be based on judgements. As a result, scenario approaches supplemented with sensitivity analyses are required.

131. For individual projects, the net costs of water recycling vary widely reflecting the method of treatment, the costs of pipelines and transport and the alternatives for disposal of sewage effluent. For large scale treatment using membrane technologies located downstream from secondary wastewater treatment plants, treatment costs ex plant are typically around 60 cents per kilolitre. The total direct cost of recycling must also take account of transportation and any extra costs that should be associated with the upstream processes.

Rationale for with and without national guideline cases

132. Recycling is currently occurring on a small scale across Australia. The economics of recycling will continue to improve as population growth pushes demand, traditional sources are downgraded and currently available low cost water sources become fully utilised. Thus, the stretch targets, such as '20% recycling by 2010', which have been set by several governments states will likely become financially justifiable in the medium term. It is reasonable to expect similar targets to be met by all states by around 2020.

133. While the estimate of demand as a steady trend in line with low-range population scenarios is not exact, it may be used in the absence of better information. This can be used as a proxy, given that upward pressure from population growth and the growing incidence of single person households will weigh against downward pressures from improving technology and demand management practices (water conservation).

134. However, the willingness of consumers to use recycled water is dependent on their confidence that there will be no health or environmental costs and that recycled water is an economic alternative. Consumer confidence surveys suggest that confidence and trust is built over time. Moreover, it is reinforced when trusted institutions and authorities give their collective endorsement.

135. Thus, the investment in confidence building now is an essential foundation for the expected realisation of the economic benefits in the future. The costs of this investment are, however, immediate including the cost of developing the new guidelines, and the cost of the implementation and application. The net benefits of developing and implementing the Guidelines need to recognise the disparity between immediate costs and the increasing benefits over the long term.

136. In terms of the evaluation, this means we need to recognise the time value of money and bring both benefits and costs to present values.

137. We have defined the base case to be a future where recycling occurs under the current separate state guidelines. These are essentially prescriptive. The term prescriptive also relates to a 'rule-based' approach to water recycling oversight, rather than enforceable laws governing recycled water use. Essentially, under the base case, the existing framework:

- provides a permitting and approvals framework;
- prescribes (or suggests) classes and water quality standards for different recycled water uses. (The new draft Dual Pipe Guidelines (Victoria) include a risk assessment based on the Guidelines to provide the water quality specification);
- defines permissible and not permissible uses; and
- manages health and environmental risks through treatment to meet prescribed classes and use of on-site controls (for example, end-use restrictions, such as spray drift, buffer zones, irrigation control methods, plumbing controls).

138. The alternative case relates to a future for water recycling under the risk-based National Guidelines which provide a coherent national framework for water recycling endorsed by all Australian governments. This alternative scenario of the future possesses several key elements:

- risk management approach to water recycling management;
- 'fit for use' water recycling projects; and
- outlines 'acceptable risk' for human health and various (qualitative) risks for environmental factors.

139. *Prima facie*, the benefits of the stylised alternative case are in a more flexible approach to water recycling management. In comparison to the stylised base case, which may recommend a certain quality of water as appropriate for use on a golf course, the stylised alternative would offer a risk management framework, allowing a 'fit for purpose' recycling project which may involve lower treatment at acceptable risks to human and environmental health.

140. However, the major benefit of the alternative case is that it directly addresses the perceptions of potential consumers and is pro-active in providing frameworks for assurance that will underpin community acceptance and allow greater up-take of recycling.

The base case: future situation without National Guidelines

141. The base case is defined as the future situation for water recycling without National Guidelines. A scenario consistent with this case is as follows:

> The absence of National Guidelines will not affect the concerns in water service providers and Australian communities over water supply reliability and environmental impacts. Increasing evidence of climate change will likely reinforce existing concerns.
>
> Strong community interest in recycling and environmental benefits will lead to continued investment in projects in all states for the purposes of demonstration, testing and establishing base lines for larger scale developments in future.
>
> However, for brownfield situations the economics of water recycling will remain, for the most part, marginal until the cost of incremental water supplies (technically the long-run marginal cost) rises in response to a better understanding of climate risks and variability. This process is currently underway. For sake of clarity this is assumed to have been completed by 2015.
>
> In greenfield situations the economics of water recycling are already robust but health and environmental concerns are constraining the rapid take-up of the potential.
>
> From 2015 onwards major investments in recycling become widespread. Nonetheless, community concerns over the increasing scale and proximity of recycled water to human contact restrict the amount of growth and investment in recycling.
>
> By the year 2020 the amount of recycling that is occurring has increased significantly from current levels, but is nonetheless materially lower than would occur if confidence in the health and environmental safety of recycling had been reinforced further by all governments at an early stage.
>
> Under the base case the combined investment of time and resources by experts and governments in developing National Guidelines would be avoided and the administrative and compliance costs would be kept low by the familiarity, simplicity and clarity of the existing prescriptive state-based guidelines.

The 'with National Guidelines' case

142. The 'with project' case is defined as the future situation for water recycling with National Guidelines. A scenario consistent with this case is as follows:

> The introduction of National Guidelines for water recycling will recognise the concerns of water service providers and Australian communities over water supply reliability and environmental impacts. It will also provide an increased range of options for future water supply and mitigating actions.

Strong community interest in recycling and environmental benefits will lead to continued investment in projects in all states for the purposes of demonstration, testing and establishing base lines for larger scale developments in future. Possibly, the investment in demonstration and testing projects will be higher than would occur in the absence of National Guidelines, but this is not totally clear.

In greenfield situations where the economics of water recycling are more robust, the increase in confidence resulting from the endorsement of recycling by all Australian governments eases constraints on the rate and extent of take-up of recycling potential.

In contrast, in brownfield situations the economics of water recycling will remain, for the most part, marginal until the cost of incremental water supplies (technically the long-run marginal cost) rises in response to a better understanding of climate risks and variability. This process is currently underway. For sake of clarity this is assumed to have been completed by 2015.

From 2015 onwards major investments in recycling become wide spread. Community awareness and familiarity with recycling through the demonstration projects and an enhanced level of confidence resulting from the endorsement of all Australian governments of a common, consistent and agreed approach results in greater acceptance and trust in recycling by responsible authorities and developers. This allows the extent of investment in recycling to be at a higher level than otherwise.

By the year 2020 the amount of recycling that is occurring has increased substantially from current levels, and is driven wholly by the technical and economic characteristics of the opportunities and projects since confidence in the health and environmental safety of recycling has been reinforced further by all governments at an early stage.

Under the with project case, the costs have been incurred through the investment of time and resources by experts and governments in developing the Guidelines. Moreover, additional administrative and compliance costs are likely to be incurred as water service providers and developers and governments become familiar with the risk-based approach.

Net administrative benefits

143. National Guidelines may impact on the overall cost of administering and complying with wastewater recycling regulations. These impacts may represent transfers between sectors or a change in the monitoring approach of say regulatory authorities.

144. Analysis of these costs associated with the new guidelines is frustrated by a lack of clear and identifiable costs which can differentiate between current arrangements and the likely future costs associated with the guidelines. However, associated costs include:

- user compliance with new requirements;
- jurisdictional development of supporting material, and
- jurisdictional implementation and regulation.

145. The differences in these costs between current and future arrangements are unknown, but for the purposes of quantitative assessment they are assumed as $2 million for

development costs in the first two years, and ongoing compliance and administration costs of $1 to $10 million higher than under current arrangements. Full assumptions are explained below. As a conservative estimate, these costs are not assumed to decline over time.

Input parameters

146. The input parameters for the benefit cost assessment are set out below:

- **cost of development of National Guidelines**. These costs are assumed to be $2 million each in the first two years of the analytical period;
- **cost of administration and compliance − existing guidelines.** This cost is unknown and is assumed to be zero for the purposes of the analysis;
- **cost of compliance − National Guidelines**. This cost is not known but it is assumed to be $1 to $10 million higher than under the state-based guidelines. The impact of this assumption is explored through sensitivity analysis;
- **long-run marginal cost of new water supplies**. As mentioned above, source development schedules and the associated LRMCs for major cities are not, as yet, widely published in the Australian water industry. Such information is available, however, for Perth (around $1.00), Melbourne (21 cents/kL) and more recently Sydney (between $1.20 and $1.50/kL) (ERA, 2002, p.13) (MJA analysis of ESC 2005, p.13 and 22) (IPART September 2005, p.99). Such variation is likely to reflect differences in location and situation but importantly it also reflects the very substantial effects on differing assumptions on the importance of climate change.

  The more aggressive the assumption on climate change, the higher the LRMC. If the LRMC for the Perth system is estimated on the same conventional basis as is the Melbourne system, then there is effectively no difference between the estimates. On the other hand, in line with CSIRO projections, and the increasing realisation of the impacts of climate change on rainfall and streamflow, all water authorities in southern and eastern Australia are likely to move in the direction of the Water Corporation's assumptions. This readjustment appears to be now in process. For the sake of clarity we assume it will be completed by 2015 but in reality it could occur earlier, say, 2010;
- **cost of recycling − greenfields**. The cost of recycling greenfields is also locationally specific but the well researched and documented Pimpama-Coomera proposal by Gold Coast Water indicates a delivered cost only 6% above that for potable sources. We assume for the purposes of this analysis ex-plant costs of 80c. The costs of water savings in other developments may be higher or lower and can be examined using sensitivity analysis;
- **cost of recycling – brownfields.** The cost of recycling is critically dependent on the treatment technologies and levels required for the purpose and the cost of transporting the recycled water to where it will be used. The ex-factory costs for wastewater treated through membrane bio-reactors, non filtration and RO plants are relatively well known and range from around 50c/kL up to around 90 cents/kL, primarily reflecting scale and the output water quality;

The transport/distribution costs are locationally specific and widely varying and are often large;

- **discount rate and time period**. In line with guidelines from state Treasuries, the period analysis for the benefit cost evaluation is 25 years beginning in 2005. The base discount rate is 6% with sensitivity analyses of 4% and 8%;
- **slow take-up in brownfields**. Under both scenarios, the take-up of recycling for existing demand is slow (from 7% to 9% until the cost differential changes);
- **annual growth in demand** is set equal to the lowest value for expected population growth forecast by the ABS; and
- **real prices changes**. There are no increases in real costs under recycling or traditional source development except for a step increase associated with climate change adjustments noted above.

147. For many of the above parameters, a range of values is examined. In reporting sensitivities below, it is necessary to use consistent values. For the purposes of these comparisons, we have selected "default" values. These do not necessarily represent our expected value for the parameter. In some cases, we have selected values to focus the analysis on the sensitivity rather than the base case. Table 3 shows the base inputs. The table is separated into two parts:

- a set of common parameters; and
- parameters that vary between the base and with National Guidelines cases.

Table 3: Parameters

Panel A: Common parameters

Parameter	Default	Range
Discount rate	6%	4%, 6%, 8%
"Traditional" water sources		
Current LRMC	$0.40	
LRMC after adjustment	$1.00	
Year of adjustment	2015	2010, 2015
Cost of recycling in brownfields	$0.90	$0.70, $0.80, $0.90, $0.95
Cost of recycling in greenfields	$0.80	$0.10, $0.20, $0.50, $0.80
Current recycling	7%	
Target recycling	20%	
Year target met	2020	
Growth in water demand	0.4%	0%, 0.4%

Panel B: Differential parameters

Parameter	Base case		National Guidelines case	
	Default	Range	Default	Range
Brownfields				
Recycling by adjustment date	9%		9%	
Proportion of target achieved by target date	½	⅓, ½, ⅔, ¾	100%	
Greenfields				
Proportion of growth that uses recycled water	40%	20%, 40%, 60%	80%	60%, 70%, 80%, 90%

148. It is not feasible to make measured predictions on the direct economic impacts of the Guidelines, given the unpredictable take-up of the Guidelines in different jurisdictions. As such, if there is a benefit, we assume that the greatest benefit will be in the imprimatur of a national approach supported by all jurisdictions, supporting public confidence over time. MJA's analysis is indicative only, and is designed to demonstrate the effects of an assumed doubling of recycling as a result of the guidelines. This doubling is reflected in both brownfields and greenfields developments. MJA does not predict a specific increase in recycling due to the guidelines, but demonstrates the net benefits of this occurring. We then examine sensitivities.

Extent of take-up of recycling – Greenfields

149. Under the base case, 40% of potential recycling available in new residential developments is assumed to occur compared with 80% for the 'with project' cost. Reflecting the arbitrary nature of such parameters, they can be varied and inputs explored in sensitivity analysis. New residential development is assumed to increase in line with population growth (assumed a constant 0.4% pa). This assumption understates the magnitude of new residential development each year since it ignores the downward trend in household occupancy rates.

Extent of take-up of recycling – Brownfields

150. Under both cases we assume that there is little increase in the proportion of potable supplies recycled until 2015 by which time the LRMC for potable supply is assumed to have increased materially, for instance due to recognition of climate change. Such increases that occur reflect expansion typically from demonstration projects.

Analytical results

151. The modelling provides estimates of the aggregate benefits and costs for water supplied to Australia as a whole from introducing National Guidelines. The costs and benefits can be separately identified for each of greenfield and brownfield recycling. We describe first the results for the base case based on a 6% discount rate over the 25 year period.

152. The tables used for this analysis show the net present value of the cost of supplying the system with water under the two cases – the base case (current approach) and the with project case (National Guidelines). A negative number indicates that the costs associated with the Guidelines are lower than under the current approach.

153. Core results emerging from the modelling are as follows:

- the prime economic benefits associated with the introduction of the guidelines are linked to greenfields developments (Table 4). This is no surprise, especially since the cost of savings of potable water are already large. The benefits associated with increased recycling in greenfield areas are estimated to range from a loss of $73 million to a benefit of $156 million according to whether the cost of the recycled water is a high 80 cents/kL or a low 20 cents/kL.
- for brownfield developments the benefits range from a positive $120 million to losses of just under $100m in present value terms. This reflects the high cost of recycling in brownfield systems unless they are favourably located in terms of a ready market for the use of that water or its return to rivers (Table 5);
- aggregate benefits using likely assumptions and combining the two sources are dominated by the net benefits arising from the greenfields. The aggregate net benefits are estimated to range from around $170 million to a negative $60 million according to the cost of recycled water. For estimates below 50 cents/kL for the cost of recycled water in greenfield situations, the benefits from both sources are wholly positive (Table 6).

154. Recognising the difficulties in introducing recycling in established areas, this analysis focusses initially on the net benefits from growth through greenfields developments. The table below shows the impact solely of the greenfields take-up at the default rates of 40% under the existing approach and 80% under National Guidelines. The table highlights the sensitivity of these estimates to the assumption on the extra cost of administering the Guidelines (assumed to range between $1m to $10m pa) and to the relative cost of recycling in these growth areas. The table shows both the absolute difference and the proportional effect on total supply costs.

Table 4: Benefits in Greenfield Developments

	Cost of recycling: greenfields			
Administrative costs pa	10c	20c	50c	80c
$1m	–$178m	–$156m	–$92m	–$28m
$5m	–$133m	–$112m	–$47m	+$17m
$10m	–$77m	–$56m	+$8m	+$73m
	Cost of recycling: greenfields			
Administrative costs pa	10c	20c	50c	80c
$1m	–1.2%	–1.1%	–0.6%	–0.2%
$5m	–0.9%	–0.8%	–0.3%	+0.1%
$10m	–0.5%	–0.4%	+0.1%	+0.5%

155. Both analyses show that the benefits of using recycled water become material and consistently so when the cost of producing recycled is below 50c. Not surprisingly, keeping a check on administrative costs will promote gains from promoting recycling.

156. Greater take-up of recycling in established or brownfields developments will also generate benefits, albeit these are not likely to be as significant as in greenfields areas. Assuming that the cost differential between recycled water and the traditional water sources will not be as significant as in greenfields areas, and that until the cost of traditional sources is adjusted recycled will in fact be operating at a higher cost, the estimated benefits will be significantly lower. Table 5 shows the net benefits under a range of recycled water costs of 70c to 95c. For the purposes of this analysis, there are no greenfields benefits.

Table 5: Net Benefits in Brownfield Developments

	Cost of recycling: brownfields			
Administrative costs pa	70c	80c	90c	95c
$1m	–$120m	–$75m	–$30m	–$8m
$5m	–$75m	–$30m	+$15m	+$37m
$10m	–$19m	+$26m	+$71m	+$93m

157. The table below incorporates both the impact of even the low population growth on these net costs and take-up in brownfields sites. Assuming in the greenfields areas that recycling achieves 40% or 80% of this growth (under current and new guidelines, respectively) there are significantly greater benefits. The table assumes recycling costs of the order of 90c in brownfield sites.

Table 6: Overall Benefits in All Developments

Administrative costs pa	Cost of recycling: greenfields			
	10c	20c	50c	80c
$1m	–$192m	–$170m	–$106m	–$42m
$5m	–$147m	–$126m	–$62m	+$3m
$10m	–$91m	–$70m	–$6m	+$58m

158. The benefits from the Guidelines are derived from the difference in the take-up rate of recycling between the two alternatives. The tables below indicate the sensitivity of the analysis to this assumption. For the purposes of establishing a baseline comparison, we have assumed that the cost of recycled water for brownfields developments is 90c and for greenfields is 80c. Table 7 shows the impact of varying the rate at which recycling is taken up in brownfields developments from 20% to 60% and for greenfields developments from 60% to 90%. The figure of –$30m where the take-up rates are equal (60% for both) is equivalent to the benefit from brownfields growth in Table 5 above (assuming costs of 90c and administrative costs of $1m pa).

Table 7: Sensitivity to take-up in greenfields areas

Proportion of growth	Under National Guidelines			
Under current approach	60%	70%	80%	90%
20%	–$42m	–$45m	–$48m	–$51m
40%	–$36m	–$39m	–$42m	–$45m
60%	–$30m	–$33m	–$36m	–$39m

159. Table 8 shows the sensitivity of these estimates to different take-up proportions under the current approach. For brownfields, it is assumed that under the Guidelines, the target is met; under the current approach, a range from ⅓ to ¾ of this target is met. It is assumed that for greenfields areas, 80% of growth uses recycled water under the Guidelines; the proportion under the current approach is allowed to vary from 20% to 60%. Under these ranges of inputs, the Guidelines could still be expected to generate net benefits. These benefits would be larger if we assumed that the cost of recycled water in greenfields areas would be lower than 80c.

Table 8: Sensitivity to take-up under current approach

Proportion of growth	Proportion of target met under current guidelines			
Under current approach	⅓	½	⅔	¾
20%	–$63m	–$48m	–$33m	–$26m
40%	–$57m	–$42m	–$27m	–$20m
60%	–$51m	–$36m	–$21m	–$14m

Summary of analysis

160. This sensitivity analysis demonstrates the direct economic impacts which would occur if the Guidelines result in increases in water recycling of roughly double the proportion that would occur without. Estimates of the net economic benefit (in NPV terms) range up to $200 million. Most of these benefits are attributable to greenfields developments.

161. Of course, it would be misleading to suggest that this take-up assumption must hold. There is no plausible method of predicting the increase in water recycling, and this analysis is therefore indicative only. Nevertheless, it is a useful demonstration of what may occur under plausible assumptions. Even under the plausible ranges of assumptions used, a net benefit is demonstrated. The analysis suggests that keeping administrative costs low will be a key determinant of whether there is a net benefit of the Guidelines.

162. The modelling analysis does not include the costs associated with transportation of recycled water. Overall, for there to be a net benefit from large scale recycling the costs of transportation simply need to be lower than the benefits ascribed to improved reliability of supply and restoring minimum flows to Australia's rivers.

163. The magnitude of these parameters will vary from location to location. However, an indication of the magnitude of the potential benefit of maintaining and enhancing confidence in water recycling can be obtained by making the simplifying assumption that the costs of transporting recycled water from the treatment plant to places of use are equal to the benefits of either reduced diversions from rivers or by return to them. (In the absence of this assumption it is not possible to proceed other than on a detailed case-by-case basis.)

164. The case-by-case approach provides an alternative means of viewing the net benefits. As an example, substantial savings in potable supply can be achieved for an increase of 5% to slightly more than 10% of the cost of conventional water and sewerage services to a major new development. (Based on the Pimpama-Coomera development the cost of these potable water savings is around 17 cents/kL). If developments of this nature and cost were encouraged by the Guidelines, then the guidelines would be beneficial if the sum of the apportioned cost of their application and the 5-10% cost of potable water saved were exceeded by the benefits from reliability of supply and environmental benefits.

Non-quantified benefits and costs

165. As discussed above, the assessment of the net benefit of the Guidelines will critically reflect the non-quantified benefits. Many of these benefits may not accrue within the specific catchment; for example, environmental flows may accrue throughout the system. The benefits include:

- **benefits from improved environmental flows and outcomes**. Recycling has the potential to return substantial volumes to the rivers and to assist in the restoration of essential flows, both in terms of volumes and their variability. These benefits are not quantifiable directly, although there is tangible evidence of their importance as exemplified by decisions by the Murray-Darling Basin Ministerial Council and the decisions of the NSW and Victorian Governments to establish Water for Rivers to acquire water for environmental flows in the Snowy River and River Murray. The benefits derived from environmental flows include both benefits for users of the river and non-users;
- **reduced ocean outfalls** for coastal cities and therefore impacts on marine ecosystems; and
- **benefits from diversification and reduced likelihood of restrictions**. Recycling has the potential to reduce reliance on rainfall dependent sources of water and therefore diversifies and reduces the risk of supply reliability. In doing so, recycling reduces the likelihood of volumetric restrictions and their impact on garden and horticultural industries. The Western Australian experience indicates that these costs are substantial and there is similar evidence of substantial costs being incurred as a result of restrictions across Australia (The Australian: 7 September, 2005).[21]

  The avoidance of these costs is of material benefit which may be quantifiable but which are not quantified in our current modelling. Measurement of the benefits of diversification is discussed below under “Other related benefits/costs”.

Avoided Costs

166. There are also some potential avoided health and other costs associated with the move to a national risk-based approach to water recycling. Although there is no assertion in this paper that current state-based approaches to recycled water have been deficient, it is recognised that the risk-based approach using HACCP multiple barriers is a best practice approach to water management (potable or recycled). As such, it is useful to discuss potential avoided costs of a health incident, which occur in two major ways:

- avoided health costs; and
- avoided costs of a collapse in consumer confidence.

Avoided Health Costs

[21] The cost to the total Australian nursery and gardening sector of water restrictions in the past 12 months (to September 2005) is estimated at $200 million.

167. One avoided cost is that of human life and implicit value of lost workdays due to injury associated with a health incident. Although a contentious issue in economics, several studies have been undertaken in a bid to put values to these occurrences. Value of human life has been estimated as roughly between $336,000 to $33.6 million (Dionne et al 2002: 2),[22] and an estimate of the implicit value of an injury is $47,900 (Viscusi, W.K. 1996 p.60).[23] One could expect that a health incident would affect more than one person (the Dutch cross connection incident resulted in 200 cases of gastroenteritis), so the potential costs could be quite substantial. However, as this paper does not attempt to compare the relative risks of the two approaches, this is for illustrative purposes only.

Avoided costs of a collapse in consumer confidence

168. The other avoided cost is the related source development costs to a city of a collapse in confidence for recycled water. To illustrate this, we could assume that the water recycling targets of states or cities tabled above are met. If a health scare was to occur, it has been demonstrated in numerous examples that a collapse in public confidence could result in very low tolerance for recycled water, such that recycled water reverts to levels reflecting minimal human contact. As such, we can envisage the substantial costs to a city/state of an immediate reduction in demand for water recycling from its projected target in 2010 to those of 2001 levels.

169. Furthermore, given the substantial amount of other source water which would be required to meet consumer, industrial and agricultural demand (with no warning) following a health scare, a city/state would not have the luxury of planning for the least cost alternative (such as water trading, which requires long time horizons and substantial consultation). Instead, the quickest option available might need to be taken, which is likely to be relatively high cost (for example, desalination where available).

170. Other effects which might flow from this collapse in confidence include the costs of higher water restrictions, which could feasibly occur as a result. As mentioned above, a recent estimate of the cost to the total Australian nursery and gardening sector of water restrictions in the past 12 months (to September 2005) is estimated at $200 million (The Australian, 7/09/2005).

171. Also, if the recycled water was used in the horticultural or agricultural sectors, there may be economic impacts on produce using the water, as negative public perceptions reduce demand for associated products.

172. It might also be noted that the costs of a health incident which occurs in one state or jurisdiction may not be limited to that state. There could feasibly be large flow-on effects to the rest of the country of an isolated health scare relating to recycled water.

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22 These values were gathered from 61 empirical studies, and are valued in Canadian dollars in 2002 terms. As an indicative estimation, these are roughly comparable to Australian dollars.

23 This estimate reflects people's willingness to bear physical risk, and their implicit value of injury. This is illustrative for a water recycling context, as injury due to recycled water was not explicitly measured.

Other Related Benefit/Cost Issues

173. The development of supplies of recycled water reduces demand for potable water from conventional rainfall-dependent water sources such as dams and shallow aquifers. Since volumes of effluent available for recycling are not highly correlated with rainfall and streamflows, recycling means that the overall risk of the portfolio of supply sources is reduced. Recycling is therefore an important option in any strategy seeking water security through diversity.

174. For any water service provider, the schedule of future source developments should be set to meet agreed reliability levels under an assumed rainfall/streamflow scenarios (whether explicit or implicit). The long run marginal cost of water based on this schedule therefore assumes that there will be no restrictions beyond the levels allowed in the water service provider's targets for reliability performance.

175. Nonetheless, restrictions on water use are a method of sharing the costs of 'congestion' i.e., the excess of demand over available supply. The costs of the substantial economic losses resulting from restrictions on water use therefore provide an indication of these 'congestion' costs and therefore of the extent to which the shadow prices of water are above the prices shown in the tariff schedules.

176. These costs occur in two dimensions: first, in any market, restrictions reduce the consumer amenity and welfare as measured by consumer surplus; second, restrictions reduce economic activity in directly affected industries such as garden supplies and horticulture. These latter impacts have been explored in detail in Western Australia and led to a much higher priority being attached to avoiding sprinkler restrictions.

Conclusions

177. The economics of water recycling in 2005 are not currently conducive to widespread and profitable water recycling in Australia. This is for several reasons, including the low cost of potable water from traditional sources (such as surface waters and groundwater) and the high cost of retrofitting existing housing developments with infrastructure for recycled water use. The costs of recycled water, despite reducing over time, are not currently markedly lower than available traditional sources of water.

178. Furthermore, despite a growing awareness and understanding of recycled water, there is not currently a high demand for recycled water consumers for different uses.

179. However, this situation is not static and it can be expected that over time these factors will change to render water recycling more economically viable in the medium to longer term. Technologies will improve, reducing the cost of recycling. At the same time, as demand for water increases with population and preference for single living, the long run marginal cost of traditional water supplies will increase and more expensive water supply options (such as desalination) brought on-stream. As such, the cost of recycling water can be expected to decrease while the costs of alternatives increase.

180. While public understanding of water scarcity and a growing understanding of recycled water can be expected to increase demand for recycled water over time, this increase is subject to consumer confidence in the effective management of health and environmental risks associated with recycled water quality.

181. This analysis has found that protection and fostering of consumer confidence is the largest indicatively quantifiable economic benefit of the move to National Guidelines for water recycling. Use of HACCP and best practice arrangements for recycled water is clearly the best available method of safeguarding human and environmental health throughout a period of expansion in recycled water supply. This analysis contends that water recycling is likely to expand at a faster rate under the Guidelines than would be the case under separate state guidelines with varying standards and methods of approach.

182. The economic modelling found that if the Guidelines result in twice the increase in water recycling than under existing arrangements, there will be a modest economic benefit in net present value terms over the 25 years of the analysis, in terms of the ‘ex-plant’ costs of recycling. However, the modelling analysis does not include the costs associated with transportation of recycled water. Overall, for there to be a net benefit from large scale recycling, the costs of transportation simply need to be lower than the net benefits ascribed to unquantified benefits.

183. Such unquantified benefits stemming from an increase in recycling attributable to the Guidelines include the possibility of substantial environmental benefits from higher ‘environmental flows’, which increase water flows and subsequent health of rivers and wetlands. The ‘non-market’ values people place on these environmental goods have not been quantified in this analysis, but have been estimated in other contexts.

184. There are also environmental benefits of reduced ocean outfalls, as water recycling reduces the volume of treated effluent discharged to oceans.

185. Another significant benefit from recycling includes greater security of supply, as recycled water is relatively uncorrelated to rainfall, unlike traditional sources.

186. Furthermore, MJA's analysis of the case studies demonstrated the benefits available to individual water recycling programs developing innovative fit-for-purpose responses under a risk management framework.

187. The case studies also demonstrated the critical importance of consumer confidence underpinning recycled water use, by showing what can happen to demand in the event of a health incident in the Dutch context.

188. Water recycling can reasonably be expected to form an important part of water use in Australia in the foreseeable future. The Guidelines protect the largest determinant of demand for recycled water by instituting a nationally consistent best practice approach to recycled water management, improving consumer confidence. Under reasonable assumptions, and assuming that the compliance and administration costs do not inhibit the development of water recycling projects, MJA modelling suggests that the Guidelines will have a net positive economic impact across Australia.

189. For a feasibility analysis of individual recycled water projects, the importance of the administrative and compliance costs may be essential, but the project evaluation will critically reflect transportation costs.

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Bibliography

ACT Government (2004) *Think Water, Act Water: Volume 1 – Strategy for Sustainable Water Resource Management in the ACT*.

Australian Academy of Technological Sciences and Engineering. 2004. *Water Recycling in Australia*. Victoria, Australia.

Bennett, J. and M. Morrison (2001). 'Valuing the Environmental Attributes of NSW Rivers', *Report prepared for the NSW Environment Protection Authority*, Gundaroo: Environmental and Resource Economics

Booker N., 2000. Economic scale of greywater reuse systems. *Built Environment Innovation and Construction Technology*, 16 December 2000.

Brisbane City Council, 2000. *Integrated Water Management Research*, Final Draft Report (unpublished).

Chemical Safety Glossary [Online] [Accessed 15th September 2005] from: http://www.bio.hw.ac.uk/edintox/glossall.htm.

CSIRO, 2004. *Integrated Urban Water Management - A review of current Australian practice*. [Online] [Accessed 27/9/05] from: http://www.clw.csiro.au/priorities/urban/awcrrp/stage1files/awcrrp_9_final_27apr2004.pdf.

Department of Primary Industries, Water and Environment and National Heritage Trust (2002) *Environmental Guidelines for the Use of Recycled Water in Tasmania*, Water Recycling, December.

Dillon, Peter, 2002. "Australia: Water Running to Waste Down Under" *Environment News Service*, 25 July, [Online] [Accessed 12th September 2005] http://www.waterconserve.info/articles/reader.asp?linkid=13608.

Dimitriadis, S. 2005. *Issues encountered in advancing Australia's water recycling schemes.* [Online] [Accessed 27th September 2005] from: http://www.aph.gov.au/library/pubs/RB/2005-06/06rb02.htm#eco.

Dionne, G. et al. 2002. *Statistical Analysis of Value-of-Life Estimates Using Hedonic Wage Method*. April 30, 2002.

DSE Victoria. Victorian Water Trust. 05/07/2005 [Online] [Accessed 20th September 2005] from: : http://www.dse.vic.gov.au/DSE/wcmn202.nsf/LinkView/F2FC43C535683C3FCA256FFE00091C20F8BDECC858787AFCCA257003001BFFE1.

Economic Regulation Authority. 2002. *Inquiry on Urban Water and Wastewater Pricing Draft Report*, 18 March 2005.

EPA (2005) *region 9 : Water Programs – Water Recycling and Reuse: The Environmental Benefits*, [Online] [Accessed 15th September 2005] from: http://www.epa.gov/region9/water/recycling/.

Essential Services Commission, 2005. *Water Price Review, Final Decision*. June 2005.

Essential Services Commission, 2005a. *Water Price Review, Melbourne Water Determination 1 July 2005 – 30 June 2008.*

Gold Coast Water, 2004. *Pimpama Coomera Water Future, Master Plan Detailed Report Volume 1.*

Government of New South Wales, 2005 *Water for Life : Government – Recycling Water* [Online] [Accessed 20th September 2005] from: http://www.waterforlife.nsw.gov.au/government/recycling_water.shtml.

Government of South Australia, 2004. *Green Print SA: Companion Report to the Progress Report on South Australia's Green Agenda 2004*, p. 17.

Government of Western Australia, 2003. *Water Strategy.*

HNRMF (Hawkesbury Nepean River Management Forum), 2004. *Water and Sydney's Future: Balancing the values of my rivers and economy*, Final report of the HNRMF to the Minister for Infrastructure and Planning and Minister for Natural Resources, and the Minister for the Environment.

Health Stream, Issues 30 (June) and 31 (September) 2003. [Online] [Accessed 18th September 2005] from: http://www.waterquality.crc.org.au .

House of Representatives Standing Committee on Environment and Heritage (2005) *Sustainable Cities*, August.

IPART, 2005. *Investigation into Water and Wastewater Service Provision in the Greater Sydney Region (Draft).* September 2005.

MacDonald, Darla Hatton and Brenda Dyack, 2004. *Exploring the Institutional Impediments to Conservation and Water Reuse – National Issues*, CSIRO, report for the Australian Water Conservation and Reuse Research Program, March

Marsden Jacob Associates, 2005. *RUWA Response to the ESC Draft Decision on New Customer Contributions - Follow-up Paper*. May 2005.

Murray Darling Basin Commission. The Living Murray. [Online] [Accessed 26th September 2005] from: http://www.thelivingmurray.mdbc.gov.au/

NRMMC & EPHC, 2005. Draft National Guidelines for Water Recycling, Managing Health and Environmental Risks (October 2005).

Po, M., Kaercher, J.D. & Nancarrow, B.E. (2004) *Literature Review of Factors Influencing Public Perceptions of Water Reuse,* Australian Water Conservation and Reuse Research Program, CSIRO Land and Water, April

Po, Murni, Nancarrow, Blair E, Leviston, Zoe, Porter, Natasha E, Syme, Geoffrey J and Julieanne D Kaercher (2005) *Predicting Community Behaviour in Relation to Wastewater Reuse: What Drives Decisions to Accept or Reject?*, Water for Healthy Country National Research Flagship, CSIRO Land and Water : Perth.

The Age Newspaper. 29th September 2005. "SA Urges Water Buyback to Save Murray". [Online] [Accessed 29th September 2005] from: http://www.theage.com.au/news/national/sa-urges-water-buyback-to-save-murray/2005/09/29/1127804581159.html .

Shuval, H., Y. Lampert and B. Fattal, 1997. "Development of a risk assessment approach for evaluating wastewater reuse standards for agriculture" in *Water Science and Technology* Vol 35 No 11-12 pp 15–20.

The Australian Newspaper, 7 September 2005. (Asa Wahlquist). [Online] [Accessed 20th September 2005] from: http://www.theaustralian.news.com.au/common/story_page/0,5744,16516228%255E30417,00.html

University of Queensland, 2001. *The Perceptions of Key Stakeholders Regarding the Use of Reclaimed Water on Agricultural Land in South East Queensland.*

URS, 2005. *The Gnangara Groundwater Mound – Understanding and Planning Change*. Workshop report prepared for the Department of the Environment. 18 March 2005.

Viscusi, W.K. 1996. *Rational Risk Policy*. Clarendon Press, Oxford. 1998.

Water Corporation 2005. *Yearly Streamflow for Major Surface Water Sources*, [Online] [Accessed 29th September] from: http://www.watercorporation.com.au/dams/dams_streamflow.cfm .

Water Services Association of Australia, 2005. *Impact of Demographic Change and Urban Consolidation on Domestic Water Use.* WSAA.

World Health Organization, 2004. *Guidelines for Drinking-water Quality – Volume 1 Recommendations*, (3rd ed).

Attachment A : Comparison of National Guidelines and State approaches

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
Draft National Guidelines						
▪ **Wastewater / Greywater** ▪ Does not consider stormwater or recycling from industrial or commercial uses	. ▪ The Draft National Guidelines provide a risk-based framework to ensure consistency in approach for the selection of an appropriate quality of recycled water. ▪ The permit and regulatory framework of the State or Capital Territory guidelines, including the health/environmental agencies still applies.	▪ National Water Quality Management System (NWQMS), Guidelines for Sewerage Systems, Use of Reclaimed Water (NHMRC and ARMCANZ 2000) (*Note- these predecessor guidelines are not considered sufficient to provide an authoritative national approach and do not consider greywater*) ▪ Australian Drinking Water Guidelines (NHMRC - NHMRC 2004) provide a framework for drinking water quality and World Health Organisation Guidelines for Drinking water Quality (WHO 2004) use water safety plans. Both of these approaches use a risk-based framework incorporating Hazard Analysis and Critical Point (HACCP) principles.	Guidelines build on the approach developed under NHMRC-NRMMC 2004 Australian Drinking Water Guidelines Guiding principles are predicated on: ▪ the protection of public and environmental health, and should never be compromised; ▪ implementing a preventative risk management approach; and ▪ application of control measures commensurate with the source water and intended use. ▪ ongoing assurance and the use of corrective procedures to maintain performance objectives Approach is predicated on the following elements: – commitment to responsible use and management of recycled water quality; – assessment of the recycled water system; – preventative measures for recycled water management;	▪ Use of risk management approach ▪ Application of control measures QCP and CCP"s under approved HACCP plans ▪ Use of preventative measures and multiple barriers to manage hazards ▪ Monitoring of compliance and application of corrective actions	Provides a general framework for all recycled water uses, including: ▪ agriculture/horticulture; ▪ municipal, including parks, gardens, urban recreational and garden spaces; ▪ residential third pipe schemes, including garden watering, toilet flushing, car washing, clothes washing; ▪ fire control; ▪ industrial uses such as cooling water greywater treated onsite for: ▪ residential garden watering; ▪ car washing; ▪ toilet flushing; ▪ clothes washing Uses not directly covered: ▪ indirect potable (aquifer storage); ▪ direct potable; ▪ environmental flows	The preparation of a risk-management plan is integral with the implementation of this guideline. The principles are: ▪ communicate, engage and consult; ▪ establish the context; ▪ identify the risks; ▪ analyse the risks; ▪ evaluate the risks; ▪ treat the risk; and ▪ monitor and review

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
			– verification of quality and environmental sustainability; – management of incidents; – employee awareness and training; – community involvement and awareness; – validation, research and development; – documentation and reporting; – evaluation and audit; – review and continual improvement.			
NEW SOUTH WALES						
Reclaimed water centralised treatment	▪ Sewage management systems with capacity of over 2500 equivalent persons (EP) or 750 kilolitres per day are regulated by the EPA through environment protection licences ▪ Local Councils are responsible for regulating all systems not licensed by the EPA (ie systems under 2500 EP). Local council regulation is through	▪ The NSW Guidelines for Urban and Residential Use of Reclaimed Water (NSW Recycled Water Coordination Committee, 1993) These guidelines are predominantly applicable to the development of large dual reticulation schemes, which are centrally managed ▪ Guidelines for the Utilisation of Treated Wastewater on Land (Draft, EPA)	Urban and residential re-use systems: Microbiological quality ▪ Faecal coliforms <1/100mL; ▪ Coliforms <10/100mL (in 95% of samples); ▪ Virus < 2/50L; ▪ Parasites < 1/50L Other physico/chemical parameters include: ▪ Turbidity, pH and colour ▪ Salts and nutrients ▪ Heavy metals and pesticides Point of use:	▪ Provides general information on treatment trains, storage, distribution systems, monitoring, commissioning, and operation; ▪ General guidance provided on site systems including pipework controls, cross connection and backflow prevention, and community information.	'Permissible' uses include: ▪ residential garden irrigation; ▪ toilet flushing; ▪ car washing and other outdoor such as washing paths; ▪ firefighting; ▪ passive recreation waterbodies; and ▪ ornamental water bodies. Uses not permissible include: ▪ drinking; ▪ cooking; ▪ bathing; ▪ clothes washing; ▪ swimming; and	Not available

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
	an approval to install and operate for each individual site ▪ EPA regulates all supply authorities who operate dual reticulation urban re-use schemes ▪ EPA regulates treated wastewater onto land (not covered under guidelines)		▪ Coliforms <2.5/100mL geometric mean (5 samples), and <25/100mL (95% samples); ▪ Chlorine residual (<0.5 mg/L)		▪ irrigation of crops for human consumption which are neither processed or cooked. *The draft Environmental Guidelines for Industry: The Utilisation of Treated Effluent by Irrigation* (NSW EPA 1995) will likely source microbial guidance from national reclaimed guidelines. In-soil contaminant limits, including site selection, licensing etc will be similar to NSW Biosolids Guidelines limits. Guidelines for the Utilisation of Treated Wastewater on land (Draft), based on disinfected secondary effluent include: ▪ municipal landscape watering; ▪ irrigation of pasture, crops, orchards, vineyards and forests; ▪ water for construction purposes, dust suppression and sewer flushing; and ▪ groundwater recharge	
Reclaimed water household level treatment	▪ Local Councils are responsible for regulating all systems not licensed by the EPA (ie systems under 2500 EP). Local council regulation is through an approval to install and operate for each individual site.	▪ Environment and Health Protection Guidelines – On-site Sewage Management for Single Households (NSW Department of Local Government). Currently under review, also supplemented by a number of technical sheets.	▪ Specifies broad performance objectives, ie protection of surface waters. Does not contain specific guidance on limits etc for effluent management - see NSW Health Guidance below.	▪ Contains broad advice on management controls, aimed mainly at local government as regulators of systems. ▪ Provides information on regulation, planning considerations, site and system selection, as well as system design, operation and management.	▪ Does not contain specific guidance on effluent uses, see NSW Health Guidance below. NSW Health – Advisory note 4 – Effluent Treatment Standard Required for Particular Land Application Systems. ▪ Total coliforms < 30/100mL specified for subsurface or low level	

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
					surface irrigation. ▪ Total Coliforms of < 10/100mL for indoor uses toilet flushing and clothes washing ▪ Requires discharge at depth > 300 mm for undisinfected effluent. Requires secondary treated effluent disinfected to relevant level for other uses.	
Greywater centralised treatment	▪ Requirements are as per "reclaimed water – centralised treatment"					
Greywater household level treatment	▪ As per 'reclaimed water household (on-site) level treatment'	▪ Greywater reuse in sewered single domestic premises (NSW Health, 2000)	▪ Total coliforms < 30/100mL specified for subsurface or low level surface irrigation. ▪ Total Coliforms of < 10/100mL for indoor uses toilet flushing and clothes washing ▪ Requires discharge at depth > 300 mm for undisinfected effluent. Requires secondary treated effluent disinfected to relevant level for other uses.	▪ Contains broad advice on management controls. ▪ Aimed mainly at system users. ▪ Provides information on greywater sources and quality legislation and the roles of agencies, site and system selection and design.	▪ Allows irrigation, toilet flushing and laundry use depending on level of treatment and disinfection.	

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
SOUTH AUSTRALIA						
Reclaimed water centralised treatment	▪ All reclaimed water schemes require approval by the Department of Health (DH) under the Public and Environmental Health Act. ▪ Schemes with a capacity exceeding 100 persons (catchment) or 1000 persons (non-catchment) require licenses under the Environment Protection Act. ▪ DH approval deals with protection of human health. ▪ EPA license deals with protection of the environment.	▪ South Australian Reclaimed Water Guidelines (Treated Effluent) ▪ ANZECC Water Quality Guidelines for Fresh and Marine Waters (This document is largely used to indicate guideline chemical values for different uses.) ▪ Draft Guidelines for Sewerage Systems- Use of Reclaimed Water (National Water Quality Management Strategy, 1996)	Four classifications of water quality requirements are set ranging from Class A to Class D. Each class is defined in terms of microbiological & chemical/physical quality. Class A represents the highest quality. Microbiological quality is expressed in terms of thermotolerant coliforms (E.coli): Class A <10 org/100ml (median) Class B <100 Class C <1000 Class D <10,000 Specific removal of viruses, protozoas and helminths may be required with all classes of reclaimed water Chemical requirements derived from ANZECC Guidelines for Fresh & Marine Water Quality	▪ Management is achieved through a balance of treatment and on-site controls. The latter include end use restrictions on spray drift/buffer zones, irrigation method controls and plumbing controls. ▪ Minimum treatment is required for reuse based on primary with lagoon stabilisation or full secondary ▪ All systems require signage and marking of key plumbing installations. ▪ Monitoring results to be provided to DH/EPA. ▪ Schemes subject to an EPA license to furnish an annual report to the EPA. ▪ Irrigation management plans are required for all schemes. ▪ Non-compliance with set conditions to be reported immediately.	The reclaimed water guidelines provide guidance on use for a range of applications including: ▪ agricultural irrigation ▪ municipal use (parks, public gardens, sports grounds, dust suppression etc) ▪ residential (non-potable) use ▪ environmental use (wetlands) ▪ industrial use ▪ firefighting. Guidance is also provided on storage options including ASR. ▪ Almost all uses of reclaimed water will be considered. The exceptions are potable use and human consumption, aquaculture (after consultation with primary industries department). ▪ No specific guidance is provided for hydroponic use. This is permitted on a case by case basis. ▪ Specific guidance provided on Agricultural Irrigation, Municipal Use, Recreational Use, Environmental Uses (Wetlands), Industrial Use, Aquifer Storage and Recovery ▪ Design, management and operation of Winter	

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
					Storages ▪ Irrigation Management Plans These guidelines do not cover hydroponics, food chain aquaculture and domestic greywater reuse.	
Reclaimed water household level treatment	▪ On site systems require approval under the Public and Environmental Health Act. ▪ Standard systems can be approved by Local Councils all others by DH.	▪ Standard for the Construction, Installation and Operation of Septic Tank Systems in South Australia including Supplement A Aerobic Sand Filters; and ▪ Supplement B Aerobic Wastewater Treatment Systems	▪ On site use is restricted to spray/drip/subsurface irrigation of landscape areas, trees and shrubs. Food crops cannot be irrigated except for drip/subsurface irrigation of fruit and nut trees. ▪ Treatment is intended to achieve <10 E.coli, < 20mg/L BOD, < 30 mg/L SS.	▪ Schemes can be audited & orders issued for remedial action if required under Public & Environmental Health Act. Off-site impacts can also be dealt with under the Environment Protection (Water Quality) Policy. ▪ Approval can require proof of maintenance contract, & centralised management is being considered.	▪ None discussed.	
Greywater centralised treatment	▪ Requirement for approval from DH under the Public and Environmental Health Act.	▪ Greywater/sullage systems - DH information guide ▪ For larger systems requirements will generally be consistent with those specified in the SA Reclaimed Water Guidelines	▪ Water quality requirements will generally be consistent with those specified in the South Australian Reclaimed Water Guidelines.	▪ Management controls would be consistent with those applied to reclaimed water for human health protection. ▪ Large schemes may also require an EPA license.	▪ Greywater reuse supported, however proponents often underestimate potential health, environmental and aesthetic (odour) impacts.	
Greywater household level treatment	▪ Permanent systems require approval from DH under Public & Environmental Health Act.	▪ Greywater/sullage systems DH information guide	▪ Requirements generally consistent with those required for on-site reuse of domestic sewage.	▪ Management as per on-site reuse of domestic sewage.	▪ Household reuse supported but as above, potential impacts underestimated	

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
TASMANIA						
Reclaimed water centralised treatment	Regulatory or permit framework relates to: ▪ State policy on Water Quality Management 1997; ▪ Land Use Planning Permits under the Land Use Planning Approvals Act 1993; ▪ ANZECC Water Quality Guidelines for Fresh and Marine Waters ▪ Environment Protection Notices under Environmental Management and Pollution Control Act 1994. This key document is used to regulate sewage treatment plants into two categories. 1. Plants above 100kl/day (Level 2) are in turn regulated by the Environment Division of the Department of Primary Industries, Water and Environment (DPIWE) who assess the environmental	▪ *Environmental* Guidelines *for the Use of Recycled Water in Tasmania 2002*	▪ Presumptive technology based requirements and demonstrative quality requirements. ▪ Based on use of three classes of reclaimed water viz. Class A, Class B and Class C ▪ Tasmania uses the mandatory 10,000, 1000 10 thermotolerant coliform indicator systems as proposed by the NWQMS ▪ Physio/chemical limits as prescribed by ANZECC Water Quality for Fresh and Marine Water for specific applications and for reference for the development of catchment management plans and policies	▪ Technology; ▪ Use of Quality Management Systems incorporating: 1.1.1. quality standards for treatment and reuse systems 1.1.2. quality assured design 1.1.3. controls on tradewaste (as a source water to the treatment plant) 1.1.4. effluent standards and treatment reliability ▪ Agreements between suppliers and users ▪ Use of Environmental Management Systems (EMS), contingency planning, environmental monitoring and reporting (Level 2 schemes require monthly reporting) ▪ Environmental Management Plan for Water Recycling or Site Management Plan for Level 2 schemes.	focussed on: ▪ Urban/residential recycling ▪ Agricultural use ▪ Industrial applications Guideline accepts: ▪ Toilet flushing; ▪ Garden watering and open space irrigation; ▪ Fire protection systems Guideline does not provide guidance on: ▪ Laundry systems; ▪ Fire fighting; ▪ Indirect or direct potable eg hot water systems; ▪ Swimming pools and related recreational uses. Guideline doesn't specifically prohibit any uses, however, the absence of guidance makes various uses unlikely to receive approval. Excludes potable re use.	Not available

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
	effects and sustainability 2. Plants less than 100kl/day (Level 1) are regulated by local government. ▪ Irrigation Authorities established under the Local Government Act 1993; or ▪ Supplier User Agreements between Wastewater Treatment Plant operator and user ▪ An Environmental Management Plan is required for all Level 2 reuse systems.					
Reclaimed water household level treatment	▪ Council Special Connection permit, Sewers and Drains Act 1954 ▪ Plumbing Regs ▪ Accredited Devices list, Emission Limit Guidelines, Building Standards	▪ Environmental Guidelines for the Use of Recycled Water in Tasmania Dec 2002, ▪ AS1547; and ▪ AIEH "On-site Guidelines" in draft form	▪ Disinfection for accredited systems; ▪ Environmental standards in Emission Limit Guidelines; and ▪ Soil sustainability as in AS1547	▪ Use of approved systems under Plumbing regs	▪ Soil sustainability issues, limitations of approved systems list	
Greywater centralised treatment	▪ Sewers and Drains Act prohibits greywater recycling in sewerage districts	▪ None	▪ None	▪ None	▪ No greywater g/l ▪ Health Department see greywater reuse as high risk particularly in urban areas, soil sustainability SAR problems, nutrient loadings	
Greywater household level treatment	▪ Council Special Connection permit, Sewers & Drains Act 1954		▪ Disinfection for accredited systems ▪ Environmental standards in Emission	▪ Local Government case by case ▪ Disinfection standards ▪ Soil sustainability AS1547.	▪ No greywater g/l ▪ Health Department see greywater reuse as high risk particularly in urban	

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
	▪ Plumbing Regs ▪ Accredited Devices list ▪ Building Standards		Limit Guidelines ▪ Soil sustainability as in AS1547		areas, soil sustainability SAR problems, nutrient loadings	

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
VICTORIA						
Reclaimed water centralised treatment level	▪ Reuse schemes operated in accordance with the guidelines are exempt from the need for a Works Approval and Licensing ▪ Recycling schemes involving environmental discharge require Environment Improvement Plan (EIP) to demonstrate compliance. ▪ Where EIP approved prior to scheme commencement, then: 1. schemes involving Class A reclaimed water require EPA and DHS endorsement 2. schemes >1Ml/d require EPA or Auditor approval 3. schemes involving significant animal effluent also require DPI endorsement 4. schemes sourced from industrial effluents also require EPA or Auditor endorsement ▪ Where the scheme is not in accordance with guidelines, it is	▪ Guideline for Environmental Management (2002): Use of Reclaimed Water describes acceptable uses and water grades. ▪ Guideline for Wastewater Irrigation (1991) describes irrigation management for protection of soils and water bodies. ▪ Guidelines for Environmental Management: Disinfection of Reclaimed Water (2003) ▪ NWQMS Guidelines for Sewerage Systems- Use of Reclaimed Water ▪ NWQMS Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2003)	The documentation is focused on reclaimed water as well as providing guidance for other potential sources ▪ Compliance is focussed on: ▪ endorsement by the relevant State department ▪ community liaison ▪ customer agreements ▪ risk identification and management Four Classes of reclaimed water, Classes A, B, C and D. For Classes A, B and C the treatment process also includes disinfection step for pathogen reduction Emphasis is on protection of public health through pathogen reduction and application of physio/chemical limits to reflect treatment plant performance Urban use would typically necessitate 'Class A' water with the following median values Microbiological quality ▪ <10 E.coli/ 100ml, ▪ < 1 helminth/l, ▪ < 1 virus/50l, and ▪ < 1 protozoa/50l Physio/chemical limits Turbidity ≤ 2 NTU pH, 6-9 1 mg/l chlorine residual (or	▪ Treatment and distribution system reliability controls ▪ Meeting the treatment objectives for the particular class of water ▪ Specifying acceptable uses and site specific controls. Eg pigs must not be fed or exposed to pasture or fodder produced or irrigated with reclaimed water sourced from human beings or allowed to drink reclaimed water ▪ Additional controls in the form of labelling can apply where the fodder is for a broader market ▪ Class A water is suitable for produce washing providing the growers have HACCP processes in place ▪ Guidelines only permit use of reclaimed water for aquaculture where non human food chain scenarios apply ▪ Specific controls on residential and municipal applications, environmental flows, groundwater recharge, industrial use and sensitive land uses ▪ Site selection and environmental management, through use of EIP framework ▪ Other controls applied through application of: 1. Plumbing controls eg AS 3500; 2. Cross connection inspections; 3. Community education; 4. Signage measures; 5. monitoring and reporting,	Guidance accepts: ▪ Toilet flushing; ▪ Garden watering and open space irrigation; ▪ Fire protection systems; Guideline doesn't provide guidance on: ▪ Laundry systems; ▪ Fire fighting; ▪ Indirect or direct potable use eg hot water systems; ▪ Aquaculture ▪ Swimming pools and related recreational uses. Guideline doesn't specifically prohibit any uses, however, the absence of guidance makes various uses unlikely to receive approval.	

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
	necessary to obtain a Works Approval and License ▪ Reuse exemption from Works Approval and Licensing (EPA Regulations 1996- Scheduled Premises and Exemptions		equivalent disinfection), ▪ The principal focus for Class A reclaimed water is demonstrating that the treatment train can achieve sufficient log removal of pathogens (as determined from the raw wastewater to the product water) ▪ Class A schemes require DHS endorsement, with quality verification for each scheme assessed on an individual basis ▪ Contaminant limits based on ANZECC Guidelines for Fresh and Marine Water Quality and outcome of land capability assessment. ▪ Nutrient reduction is covered case-by-case eg depending on surface water risks. ▪ Use of potable water to limit salinity impacts is acceptable practice. ▪ Use of other source waters to meet minimum treatment standards is not acceptable practice	including the pre commissioning phases of Class A reclaimed water schemes ▪ Irrigation Management Plan (IMP) for large scale water users.		

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
Reclaimed water household level treatment	▪ Treatment and recycling of recycled water from sewage treatment systems <5,000L/d (septic tanks) is administered by local councils. ▪ Permit process requires environmental discharge, hence 100% in-house recycling is not captured	▪ Certificate of Approval CA35/95 and Australian Standard AS1547; ▪ Septic Tanks Code of Practice, EPA publication 891, 2003 ▪ Code of Practice – Septic Tanks, 1996?	▪ Council permits are based on EPA approved treatment plant designs. ▪ Different requirements applied to sewered and unsewered areas. ▪ Household wastewater must be contained within allotment boundaries ▪ Use of sustainable practices that include wet years	▪ Plumbing regulations impose management controls on in-house plumbing. ▪ Local councils need to assess irrigation proposals against EPA Certificate of Approval CA35 and Australian Standard AS1547, which describe treatment standards and management practices for above and below ground irrigation.	▪ Focus is on sub-surface or drip irrigation. ▪ Guidance does not include in-house use such as toilet flushing or clothes washing.	Risk level equal to or less than that associated with discharging in sewer.
Greywater centralised treatment level	General framework applied for centralised sewage treatment is used.					
Greywater household level	General framework applied for household greywater treatment is used, however, targeted guidance and controls are being developed. Direct use of greywater on gardens without treatment does not require permits.	Reuse Options for Household Wastewater Publication 812.	Contact relevant water authority and municipal council.	None applicable	Focus is on sustainable reuse at the household level using a variety of approaches Excludes reuse for toilet flushing	

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
QUEENSLAND						
Reclaimed water centralised treatment level	Guidelines are not mandatory at this stage State Laws: ▪ Environmental Protection Act ▪ Integrated Planning Act ▪ Water Act 2000 ▪ Plumbing and Drainage Act 2002 ▪ Health Act 1937 ▪ Food Act 1981 ▪ Workplace Health and Safety 1995 Local Laws: ▪ All Councils required to prepare and implement a Planning Scheme, which identifies what level of assessment is applicable to different forms of development. Federal Laws: ▪ Commonwealth Environment Protection and Biodiversity Conservation Act 1999 ▪ Commonwealth Trade Practices Act 1974 Some projects are subject to an Environmental Impact Assessment and include: ▪ Projects of 'state	▪ Guidelines have followed from the Queensland Water Recycling Strategy, 2001 ▪ The Queensland Government supports a national approach, with the Guidelines aligned with the Draft National Framework for Management of Recycled Water Quality and Use **Guidance for fresh and marine water quality:** ▪ ANZECC Guidelines for Fresh and Marine Water Quality used for setting water quality objectives for users **Guidance for agricultural and industrial wastewater:** ▪ Environmental Code of Practice for Queensland Piggeries ▪ Queensland Dairy Farming Code of Practice ▪ National Beef Cattle Feedlot Environmental Code of Practice **Guidance for aquifer storage and recovery:** ▪ Code of Practice for Aquifer Storage and Recovery (South Australia)	Guidelines do not recommend particular treatment processes for recycled water. Actual water quality used in any particular application will depend on the outcome of the risk assessment completed as part of the Recycled Water Management Plan (RWMP). The RWMP uses the risk-based framework approach developed for the NHMRC/NRMMC Australian Drinking Water Guidelines (2004) Importantly, the Guidelines promote sustainable use predicated on the principles of: ▪ Protection of public and environmental health ▪ Use of risk management approaches ▪ Application of appropriate control measures and water quality requirements at point of use Adopts 5 classes of water for differing uses viz: ▪ Class A+, domestic and commercial property use, food crops (consumed raw) and retail nurseries and industrial purposes incl.	▪ Integrated Planning Act outlines the process and controls under the Integrated Development Assessment System (IDAS) for the development of a project including engagement of community and stakeholders, agency participation to establishment of agreements and policy for use. ▪ Environmental Impact Statement (refer earlier for triggers under IDAS) ▪ Environmental Management Plan (EMP) as required under IDAS or as part of the Environmental Management System (EMS) for operation ▪ Health and Environmental Risk Assessment as part of the RWMP Use and supply of recycled water includes a number of controls: ▪ Systems under the control of the water service provider ▪ Integrity testing for dual reticulation ▪ Plumbing controls ▪ Cross connections ▪ Differentiation of pipe systems ▪ Domestic use of recycled water ▪ Irrigation with recycled water incl. signage, etc ▪ Buffer zones ▪ Use of mass balances ▪ Irrigating public lands and open spaces, and all other uses ▪ ▪ Use of hazard control tables for	▪ domestic and commercial property use; ▪ public open space irrigation; ▪ irrigation of food crops; ▪ irrigation of retail and wholesale nurseries; ▪ irrigation of pasture, stock watering and stockyard wash down; ▪ irrigation of non-human food chain crops including trees, turf and cotton; ▪ industrial and municipal purposes including wash down and dust suppression; ▪ fire fighting ; ▪ supplementing raw water sources, including ground water; and ▪ environmental purposes, including recreational water bodies not used for swimming or boating. As with the Draft National Guidelines, potable reuse is not covered by the Queensland Guidelines	Preventative risk management framework which has been aligned with the Draft National Guidelines. The risk management framework is based on the NWQMS Australian Drinking Water Guidelines (NHMRC and NRMMC 2004) and applies Hazard Analysis and Critical Control Point (HACCP) principles to development of recycled water projects.

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
	significance' ▪ Projects that include an ERA on the site (new STP with >21 EP) ▪ Projects subject to local government requirements under planning provisions ▪ Other projects involving assessable or self-assessable development as specified in Schedule 8 of the Integrated Planning Act.		firefighting and ASR. ▪ Class A for generally unrestricted use on food crops (not consumed raw), public open space, and for the same uses as Class A+ except that the risk of human contact is lower ▪ Class B is for pasture with dairy animals, incl. a holding period ▪ Class C is largely for use on recreational areas where there is restricted access, pasture/fodder for animals without a holding period and for closed systems in industrial applications ▪ Class D is for irrigating non food crops Specification provided on supply and use of recycled water incl: protection and maintenance of distribution and supply system together with controls	collection, treatment and use integral with the RWMP		

Water source	Regulatory or permit framework	Relevant guidance documents	Water quality focus and specifications	Key management controls	Position on key uses	Risk Management Framework
Reclaimed water household level treatment						
Greywater centralised treatment level		▪ Queensland Guidelines for the Use and Disposal of Greywater in Unsewered Areas				
Greywater household level		▪ Queensland Guidelines for the Use and Disposal of Greywater in Unsewered Areas				

Attachment B: Economic perspective on benefits and costs

Essential to an evaluation of the economic costs and benefits of a move to the national framework is the longer term effect of the Draft National Guidelines on consumer confidence in wastewater reuse and the costs of supplying it. These effects can be separated into two types:

- static effects; and
- dynamic effects.

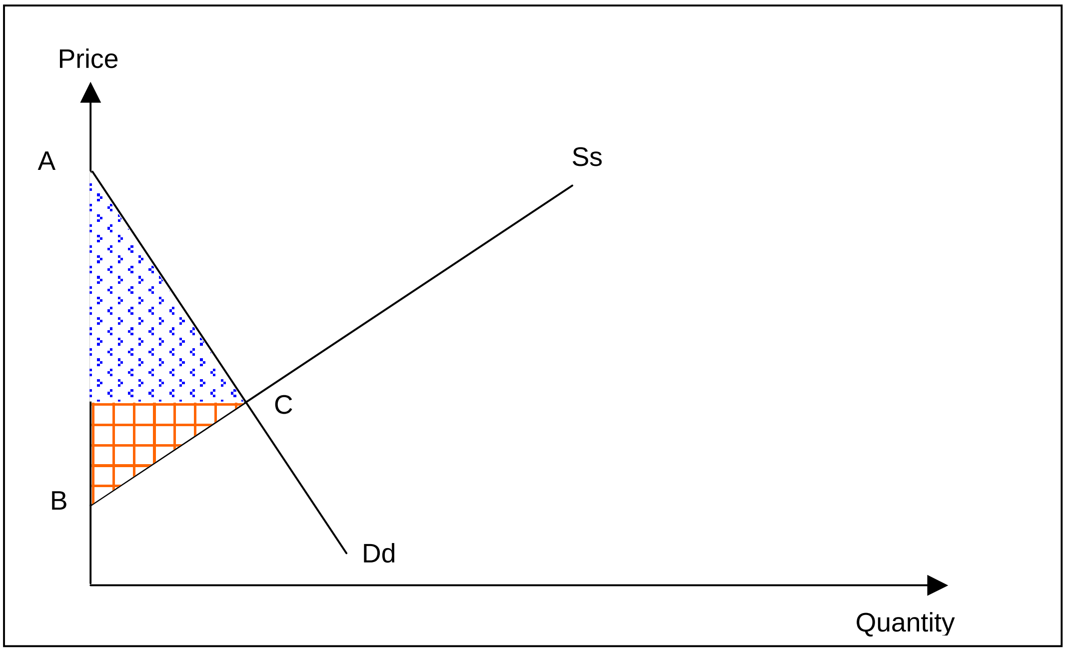
The static effects on efficiency result from the direct effect of consumer confidence in water recycling on consumer demand. Any significant increase in consumer confidence will tend to shift consumer demand for recycled water outwards. Similarly, any change that negatively affects consumer confidence can be expected to shift the demand for recycled water inwards. This can be demonstrated diagrammatically. An outward shift of demand (assuming an upward sloping supply curve) will tend to result in more scope for wastewater recycling (in terms of volume recycled, or number of people or communities using recycled water) and a higher price for recycled water (reflecting higher willingness to pay). In economic terms, these are larger consumer surpluses and producer surpluses.

While the Guidelines and indeed current practice covers geographical areas as large as the state or nation, there is no state or national market for water (the Murray Darling Basin notwithstanding). The chart below illustrates current demand for recycled water in one geographical area. There is no necessity for each market to be identical nor would we want them to be. However, in terms of examining the impacts of the Draft National Guidelines, we would expect the broad impacts to be consistent across markets.

As noted above, the measure of the benefit to society is the sum of the two surpluses (ABC):

- Consumer Surplus and
- Producer Surplus

Chart B-1: Market for Recycled Water



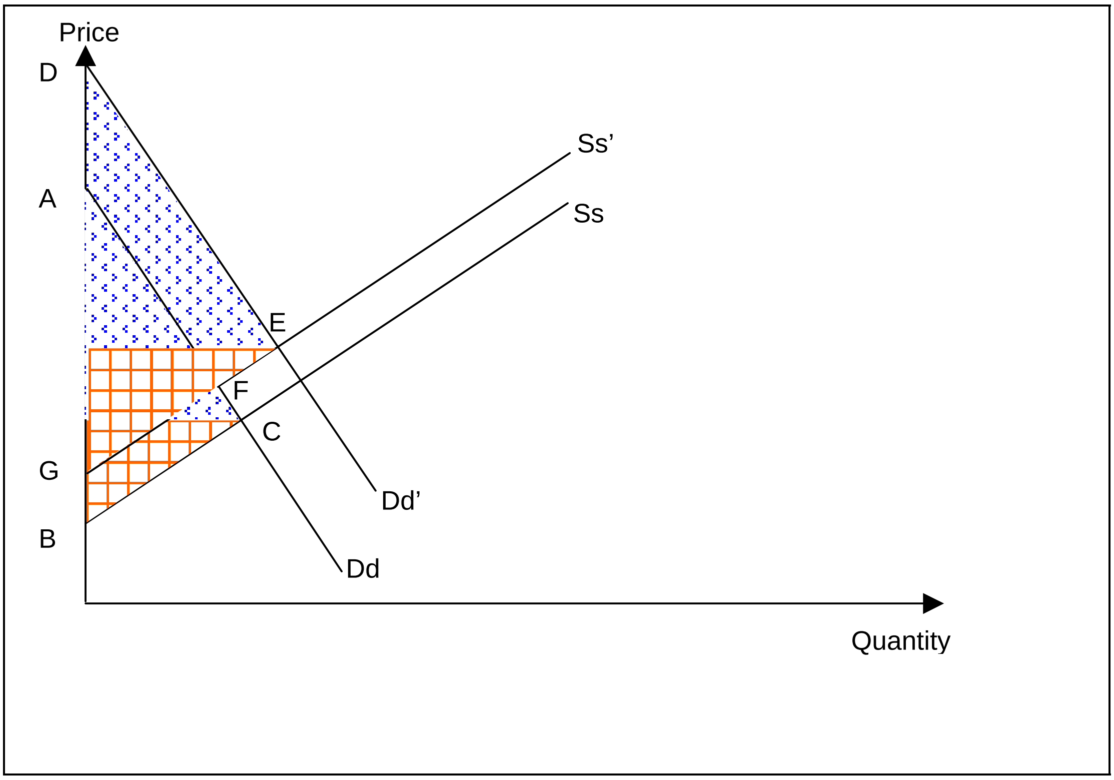
Complementary to this market are the markets for potable and other substitute water. One of the key goals of the Draft National Guidelines is to promote recycled water as a substitute for these alternative sources. If successful, this will lead to a shift in the demand for recycled water (move to the right) from Dd to Dd'.

Depending on the relative slopes of the curves and the movements in these curves, these changes may lead to an increase take-up of recycled water. This is illustrated in the chart below. The new total benefit is DEG. The net benefit under these circumstances is represented by the area (DAFE) less the area (BGFC).

In contrast to the above discussion of demand, shifts in supply for recycled water reflect changes to the cost of supplying that water, be those higher administrative costs of compliance, or in higher treatment costs due to more stringent regulations associated with the new framework. If the move to a national risk-based approach results in net increased costs for suppliers in each market, then we would expect the supply curve to increase (shift inwards, or up) from Ss to Ss'. Higher costs of supplying treated wastewater will tend to shift the supply curve up, reflecting higher costs per output. Conversely, lower unit costs for supplying recycled wastewater will tend to shift the supply curve out. It can be expected in our example that application of a new framework is likely to result in higher supply costs, at least in the short term.

However, if the Draft National Guidelines enable suppliers to provide cost effective fit-for-purpose water at a cheaper price than currently, the supply curve will not increase by as much and indeed may fall. Such a movement would lead to increased net benefits compared with the example directly above and also increased usage.

Chart B-2: Net economic benefits



Dynamic effects on efficiency reflect how the national structure fits with the pre-existing state regulatory and permit structures, and how these affect incentives to recycle water. If we assume that the existing state structures are predominantly prescriptive in their guidance (which is largely the case with the exception of Queensland and to a lesser extent, Victoria), then the application of the national risk management framework can be expected to result in important changes to state frameworks, and incentives to recycle. The extent and nature of these changes depend largely on the decision rule adopted by state bodies charged with oversight of water recycling. The decision rule can be grouped into two broad options:

- if the prescriptive state regulations are kept as base requirement levels, and the risk management framework is used only to exceed these base levels (i.e., where risk exceeds base level, apply stricter requirements), incentives to recycle water will be damaged; and
- if the existing state regulations are kept as a default, but risk management provided as a flexibility option (where risks can be demonstrated to be below tolerable levels, state regulations can be relaxed), incentives to recycle water will be fostered.

It is apparent that the latter is the option most likely to be taken by state jurisdictions, however it is considered that a thorough exploration of both options will be helpful.

The economics of changes in consumer confidence

In this assessment, it is important to highlight that we are not comparing a projection of the Draft National Guidelines with a static base case. Clearly, prescriptive approaches to water recycling have protected human health and the environment adequately to date, and there is no reason to assume that this would not continue. However, a risk management approach which continually updates and has several checks and balances transparently covering all known and assessable hazards and risks is likely to result in superior outcomes to separate state-based prescriptive approaches.

It may be useful to separate and outline the different possible macroeconomic effects of a move to National Guidelines, in contrast to a continuation of separate state-based prescriptive arrangements. This involves comparing likely future scenarios relating to the take-up of National Guidelines and the others reflecting a continuation of separate state based prescriptive approaches. While predicting future scenarios is necessarily subject to uncertainty (and predicting with fine detail would be unhelpful), with the use of some simplifying assumptions it is possible to illustrate broadly the economic effects of different scenarios. As such, we identify two different but related effects which illustrate economically the different outcomes we might expect from a move to National Guidelines:

- effects on consumer confidence; and
- effects on the supply of recycling under the two options.

Effects on Demand - Consumer Confidence

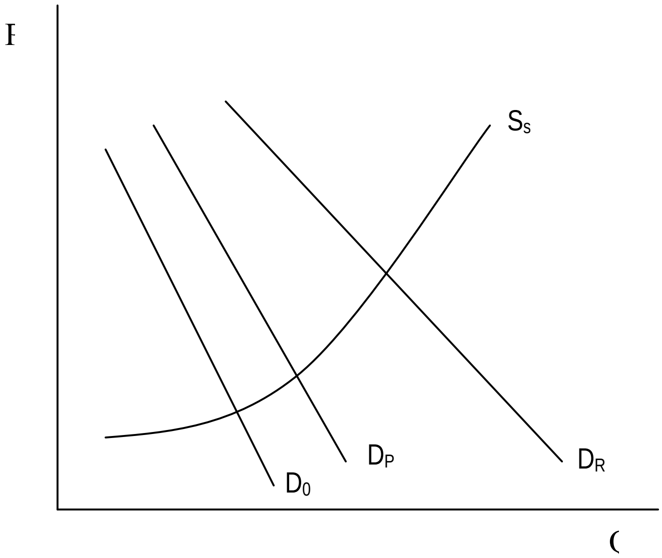
It is not unreasonable to assert that National Guidelines, endorsed by each separate jurisdiction is likely to promote greater consumer confidence than the alternative of separate state-based prescriptive approaches. While separate jurisdictions will continue to manage the human and environmental safety of their states and territories, this management will be underpinned by broader national standards reflecting international best practice. This increase in confidence is expected to result from two elements of the national framework:

- the risk management framework; and
- consumer trust in a national framework.

If we accept that both of these elements will contribute to higher levels of consumer confidence relative to the alternative, in terms of an economic analysis this will result in an outward shift in consumer demand for recycled water. This can be illustrated graphically, in Chart B-3. In this chart, original demand for recycled water is relatively low (D_0), reflecting the high cost, low confidence in and understanding of recycled water. We can expect that demand for recycled water will grow over time, as technology lowers costs, the costs of traditional sources (such as potable water) rise, and understanding of water issues grow through education.

However, whereas separate state-based prescriptive guidelines might see a expansion of consumer demand for recycled water outwards of the magnitude of the shift from D_0 to D_P, public confidence in National Guidelines might be expected to expand even further, in this example out to D-D_R. Thus, even where separate jurisdictions have adopted a risk management approach, the greatest effects on consumer confidence are achieved where it is consistent with the national framework.

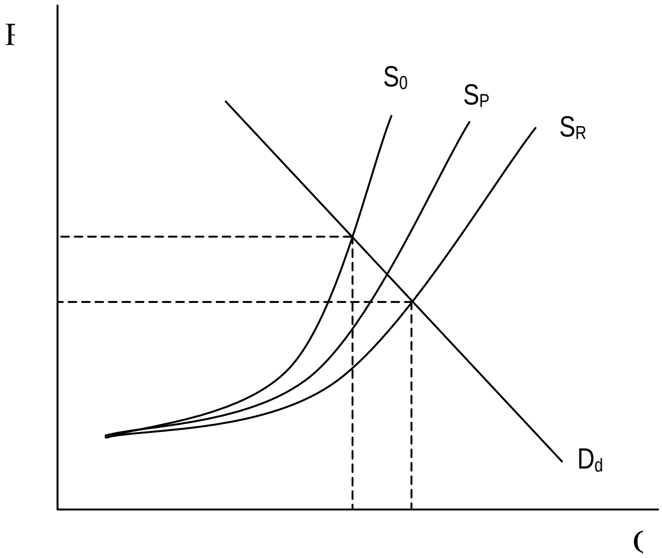
Chart B-3: Effects on Consumer Confidence



Effects on Supply

Given the increase in demand outlined above and water recycling targets specified earlier, it is natural to expect an increase in supply of recycled water. We can assume this will occur under National Guidelines or the alternative. However, it is likely that supply would shift out (expand) to differing degrees under the different scenarios. Through the flexible, transparent best practice risk management framework we might expect a large range of innovative recycling options, allowing supply to shift substantially to meet higher demand. Under the alternative, however, there may be water recycling options that are rejected by prudent regulatory bodies because they do not meet the prescriptive guidelines in place in their prospective jurisdictions. This can be demonstrated diagrammatically in Chart B-4.

Chart B-4: Effects on Supply



In this chart, we assume one demand curve, and original supply is quite low (line S_0). Under separate state prescriptive frameworks, supply will expand or shift out over time (to line S_1). However, this expansion can be expected to be restricted somewhat by the need to manage the risks to human and environmental health under separate prescriptive frameworks, delaying some growth and preventing some innovative options through the need to avoid an outbreak which may destroy public confidence. Under National Guidelines, we might expect a greater expansion of supply (to line S_R), as the risk assessment approach facilitates a greater range of recycling options into the future. Given the definition of consumer and producer surplus explained above, this larger shift in supply reflects higher volumes of water recycled and larger consumer surplus on the part of the Draft National Guidelines.

An example of this may be found in recycling for indirect potable use, which is directly covered by neither the Draft National Guidelines nor the alternative, but is currently being investigated by the Water Corporation in Perth and the Toowoomba City Council among others. Once the Draft National Guidelines are entrenched, it may be a natural progression to include water recycling for indirect or even direct potable consumption under those frameworks in place. This would also benefit from being achieved on a consistent national level.

There may also be a case for higher confidence of suppliers of recycled water, once the Draft National Guidelines become better understood and accepted. Innovation may be fostered as suppliers develop greater confidence in the flexibility of the Draft National Guidelines to facilitate different recycling options.

Attachment C: Surveys of consumer attitudes

The effects of the national framework on consumer attitudes to wastewater reuse are pivotal to the assessment of costs and benefits. Underpinning this analysis will be relevant survey data reflecting consumer sentiment to wastewater recycling, and an assessment of likely changes to these attitudes in response to the national framework. There have been a number of recent studies undertaken into consumer attitudes and sensitivities to wastewater reuse that MJA has drawn from. Some of these are summarised below.

The Australian Research Centre for Water in Society (ARCWIS) has undertaken a number of inquiries into evidence of public acceptance of use of reclaimed water and reuse, with particular focus on wastewater reuse schemes. We have focussed where possible on those schemes that have not involved potable reuse (direct or indirect). In Australia, studies were undertaken by Sydney Water (with respect to Rouse Hill), Melbourne Water, J Marks regarding Mawson Lakes and M Warren for Virginia (SA) and by CSIRO in Western Australia.

Early implementation of reuse schemes (such as in the US in the 1960s) was rarely accompanied by public consultation. Po et al (2004, p. 2) note that "*the public trusted the experts and government to make the right decision…*". More recent accepted schemes include Irvine Ranch and Monterey County Water. In these cases, the community was aware of water issues "***for decades***". Indeed the latter had 20 years of planning. Even so, officials felt the need to undertake a supplementary food safety study to assuage farmer concerns. In both cases, there was extensive education and promotional investment.

In Australia, community opposition to reuse have been successful on the Sunshine Coast (Qld) focussing on potential impacts of hormones. In the US, opposition has successfully focussed on the 'Yuck" factor and the phrase "Toilet to Tap" is often used. In San Diego, strong community education and support and a marketing campaign that promoted "purified water" was dissipated through an opposition campaign that became politically linked (wastewater would be taken from affluent areas and reused in low and medium income areas).

The ARCWIS analysis suggests that:

- public education and outreach programs must be proposed before the project is conceived;
- further that water recycling should be considered as part of a series of options. Indeed, for many people recycling may only be considered when there are no other options. At the very least, the community must be part of the choosing;
- community consultation should not be a selling process;
- an important element of education is the acknowledgement of community fears of risk and the addressing concerns;

- opposition to risk may reflect concerns about the technology. Further, risk assessment by individuals may ignore the benefits from the technology; and
- successful reuse projects should be identified and communicated as part of the education process.

The analysis also identified situations where recycling has been opposed. These highlight the "yuck" factor, the contagious effect of fear – particularly when fanned by political opposition, and the fear of impacts on children.

However, importantly, overall studies in Australia have demonstrated a general positive attitude to water recycling.