Submission
No 46

INQUIRY INTO A SUSTAINABLE WATER SUPPLY FOR SYDNEY

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Date Received: 17/02/2006

Subject:

Summary

The Secretariat
General Purpose Standing Committee No5
NSW Legislative Council
Parliament House
Macquarie Street
Sydney NSW 2000

Dear Mr Cohen,

I am pleased to forward to you CSIRO's formal submission to the NSW Legislative Council Inquiry into a Sustainable Water Supply for Sydney as requested in your correspondence of 6th January 2006.

CSIRO has made significant and successful investments in urban water research in the past decade. Fields covered include, but are not limited to - sustainability of urban water systems, stormwater management, wastewater management, water reuse, recycling, aquifer storage and recovery, management of urban rivers, management of urban storages, lifecycle cost of urban water systems and externalities associated with their provision, treatment technologies, implications on city systems of climate change, receiving environment quality and the economics/cost of water, wastewater and stormwater systems. The skills and disciplines are now all part of the National Research Flagship – Water for a Healthy Country and it is from the work of the Flagship across Australia's major cities that the content of this submission is based.

Accordingly, the focus of this submission is to provide a broad perspective of the water management options potentially available to supply water for Sydney together with brief commentary on the influence of key factors "beyond the water cycle" that also can influence water management decisions.

A comprehensive analysis of potential water supply options for Sydney could be undertaken similar to the work the Flagship has recently completed for the WA Premier's Water Task Force. This work detailed all additional supply options and equally importantly, prices per kilolitre across multiple sources – including surface water, groundwater, stormwater, reuse, tariff policy, infrastructure, demand management, trading with rural water entitlements, catchment management options.

CSIRO would be pleased to provide further information as required to the Committee. Should you wish to follow up any matters in this submission, please contact Alan Gregory, Program Leader, Urban Waterscapes, Water for a Healthy Country National Research Flagship on (02) 9490 5486 and alan.gregory@csiro.au.

Yours sincerely,

Warwick McDonald
A/g Director, Water for a Healthy Country

A sustainable water supply for Sydney

NSW Legislative Council General Purpose Committee No.5

CSIRO Submission

February 2006

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Executive summary

The submission responds to the NSW Legislative Council General Purpose Standing Committee No 5 Terms of Reference for the Inquiry into a Sustainable Water Supply for Sydney.

Most of the concepts and work referred to are part of the Urban Waterscapes research program under the *Water for a Healthy Country* National Research Flagship. This program is examining means by which urban water systems can be made more sustainable.

This submission includes comments on most areas covered by the Terms of Reference, with a primary focus on points (c) and (d). It is not an attempt to provide a comprehensive analysis of future water management options for Sydney, but to provide enough information so that the Committee members can gain some insight into the critical issues affecting urban water management and to the strategic thinking across Australia.

There are no blanket solutions. Rather, solutions will involve multiple components tailored to local circumstances and managed as an integrated or systems-based approach to urban water management. The WA Government slogan of "sustainability through diversity" summarises these concepts.

Like other major Australian cities, Sydney faces significant challenges with regard to urban water management. Figures compiled in association with Water Services Australia suggest that Sydney, Brisbane–Gold Coast, Melbourne and Perth are all in a similar situation. That is, by 2030, accommodating for population growth and climate change, all of these cities require substantial additional supply. This supply deficit for the four cities at 2030 is estimated at about 800GL – or more than the amount Sydney uses now annually. Assuming there was no additional supply this broadly equates to a reduction per capita in consumption of between 40 and 50%.

Clearly such a reduction in per capita use is not feasible so that additional supply MUST be found.

Specifically for Sydney our suggestions include:

- undertaking a systems-based analysis of all supply options, similar to the successful work undertaken by the WA Water Corporation and CSIRO to the WA Premier's Water Task Force
- From this assessment, investing substantially in key supply opportunities, building on much of the successful work already undertaken by Sydney Water and NSW agencies.
- Key supply opportunities are likely to include tariffs to reduce consumption, increased incentives to facilitate further demand management, reuse "fit for purpose" water supply, engineering works such as further improvements in leakage control and pressure management, catchment management to facilitate increased water yield from dam catchments, water sensitive urban design and further planning controls for new developments and if the costs are not excessive, desalination and trading [and piping / pumping] water from rural users.

Sydney, Sydney Water and the related agencies already have had numerous urban water management successes –the last 700,000 Sydney residents have been catered for in terms of water supply with no net increase in total water consumption. Our urban water industry, by international standards is efficient; the quality of services provided is high; water use in urban areas has been curbed and treatment and disposal of wastewater has improved significantly.

This submission emphasises that the way forward is to build on these successes in a systematic manner.

Introduction

Drivers of change

The following section briefly discusses the major external drivers impacting on urban water management.

Population growth and variable supply

Sixty four percent of Australians live in our capital cities[1]. City populations are expected to increase by up to 35% over the next 25 years. About 30%, or one million of these additional people will live in Sydney.

Sydney residents, like other city dwellers have become accustomed to having reliable, safe, low cost, and plentiful water supplies available for use. Because of Australia's highly variable climate and our primary reliance on surface water supplies, we need to store large volumes of water to maintain service reliability during drought periods. In response to population growth and exacerbated by one of the worst droughts since European settlement, our cities are reaching the limits of reliable water availability from their supply catchments.

City	Consumption 2030 GL/Y	Current per Capita Consumption (Unrestricted Usage) KL/Y	Per Capita Consumption required in 2030 with no increase in supply KL/Y	Reduction In per capita consumption %
Brisbane	**255**	**210**	**103**	**51%**
Gold Coast	**99**	**147**	**78**	**47%**
Melbourne	**659**	**159**	**93**	**41%**
Perth	**313**	**171**	**102**	**41%**
Sydney	**884**	**174**	**80**	**54%**

Problem – Australia's key cities must find at least a 40% reduction per capita consumption in the next 25 years (growth in supply of ~ 800GL/yr

IGL = 1billion litres

Healthy waterways

As a consequence of growing city populations and urban development, there is increasing stresses on downstream waterways due to stormwater runoff and effluent discharges. There are therefore increasing pressures to allocate more water from existing water resources to improve the ecological health of our rivers and streams. The major challenge for water regulators is to allocate sufficient water to the environment while meeting increasing demands for consumptive use.

[1] ABS Australian Demographic Statistics (3101.0)

As the current drought has deepened, there has been an increasing community and political focus on water availability and the demand–supply balance. Wastewater and stormwater pollution issues quickly re-emerge during higher rainfall periods and are equally important considerations. Increasing intensities of storm events due to climate change could exacerbate wastewater and stormwater impacts. Future options such as distributed water recycling and stormwater harvesting, or closed loop urban developments such as the Delphi Lend lease Development Caroline Springs in Melbourne may provide opportunities that lessen these impacts.

Climate change

The potential impact of continued climate change is a key uncertainty influencing water resource planning. On the west coast, inflows to Perth's water storages have declined by 52% since pre 1970's climate conditions. The situation for Perth is summarised in the following figure:

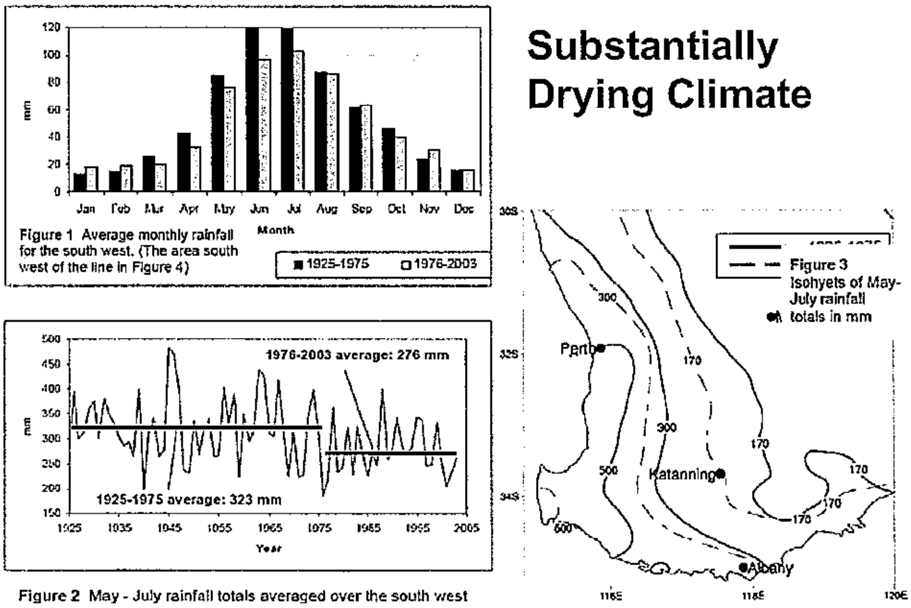
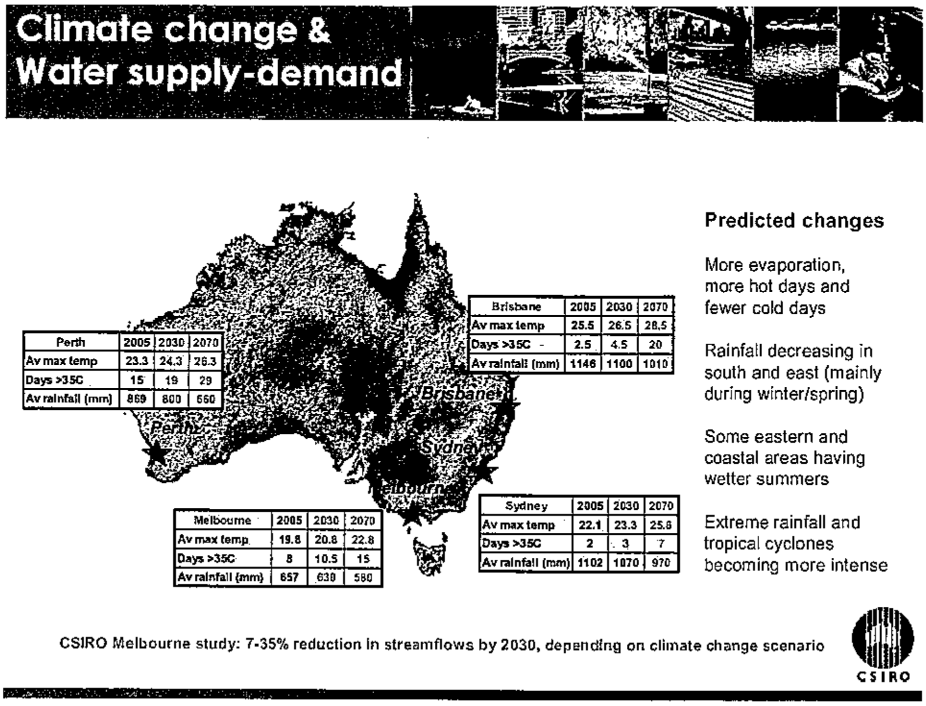


Figure 2 May - July rainfall totals averaged over the south west

Should similar trends occur on the highly populated east coast, Australia's major cities will be dramatically affected by reduced water availability. These cities rely almost totally on surface water, unlike Perth, which supplements its supplies from significant groundwater reserves. A summary of the predicted climate change for Sydney, Melbourne, Brisbane and Perth is presented in the following figure.



A recent CSIRO climate impact study undertaken in collaboration with Melbourne Water indicates that climate change is likely to continue to reduce streamflows into Melbourne's water storages by 7% to 35% by 2050, depending on the assumed climate change scenario[2]. The research also undertook a qualitative assessment of potential water system impacts that include:

- Reduced water supply due to lower stream flows
- Increased risk of bushfires in supply catchments
- Reduced waterway health due to changes in base flows and higher temperatures
- Increased risk of flooding and sewer over flows due to increased rainfall intensity
- Increased potential for corrosion and odours in the sewerage system due to higher temperatures
- Increased risk of pipe failure in the sewerage system; and
- Increased risk of wastewater salinity due to rising sea levels, affecting water recycling potential.

These impacts will vary from city to city but highlight the need to explore the implications for future water management options in more detail.

Technology advancement

Technological advancement has greatly enhanced urban water management. Further significant technological advancements in water treatment, information technology, nano-technology, sensor technology, bio-markers, bio-technology and energy production are expected over the coming decades. These will provide opportunities to supply and manage water in new ways, both at large and small scale. Some of these may include:

[2] Melbourne Water Climate Change Study (2004), CSIRO & Melbourne Water

- Water use efficiency – development and use of waterless or "intelligent" water appliances that minimise water use without compromising service utility, intelligent irrigation systems, remote water management systems; real time consumer feedback on water use; and development of drought tolerant plants, lawns and landscapes.
- Process efficiencies – new membrane treatment technologies that reduce energy use and costs; water storage materials, coatings and embedded sensors that help to manage water quality, intelligent measurement and optimisation of water use in industry; application of photovoltaic and fuel cells.

Technology innovation will challenge the traditional "big infrastructure" water service paradigm in favour of a shift to smaller scale "closed loop" water cycle solutions that can be implemented incrementally as required to meet demand.

The Water for a Healthy Country National Research Flagship is embarking on a Collaborate Cluster to research opportunities in improved membrane technology, including the opportunities for biomimicry. This involves key universities across Australia and is likely to include researchers from both the University of NSW and Sydney.

Demand Management

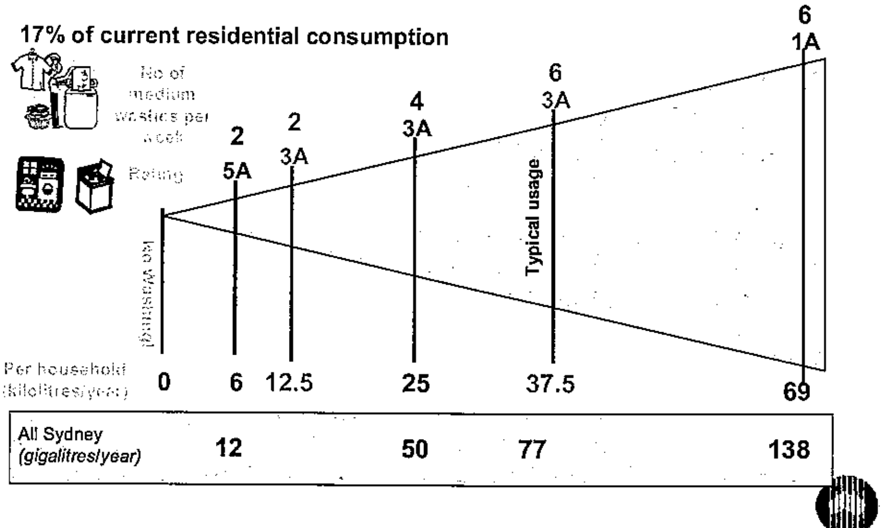
The levels of adoption of existing technology are part of the strategies encompassed by the term Demand Management. Sydney has been successful in markedly reducing domestic demand and working with industry to both reduce demand and reuse water.

The following figures are based on assumptions for Sydney and highlight the potential for technological and behavioural changes to dramatically impact water consumption associated with household uses. In the example of washing machines, the graphic shows that if householders ensured wash loads more closely matched machine capacity (that is, reduced the frequency of washing) and the machines were water efficient, then significant savings could be made over coming years. A similar analysis is presented for showers where shower duration is assessed as the behavioural component.

Water efficiency is defined as meeting the same service outcome (clean clothes in the washing machine example) using less water. Influencing customer behaviour, as well as driving sales of low water using appliances, will have a major impact on water requirements of our cities in the future. Clearly there is an important need for detailed understanding of water use in urban areas. CSIRO has worked, and is continuing to work, in a number of major urban centres across Australia to assess the effectiveness and scope of a range of water efficiency measures.

Sydney & Washing Machines – Potential Water Use 2030

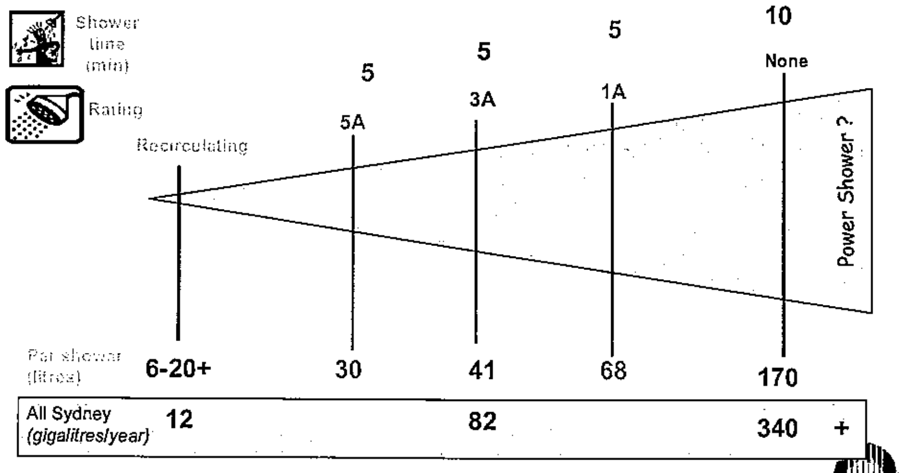
17% of current residential consumption



Assumes: 2M households, A rating 34 l/kg, 3A rating 18.5 l/kg, 5A rating 9 l/kg

Sydney & Showers – Potential Water Use 2030

25% of current residential consumption



Assumes: Sydney population 5.4M, 5A rating 6l/min, 3A rating 8.25 l/min, no rating 17 l/min

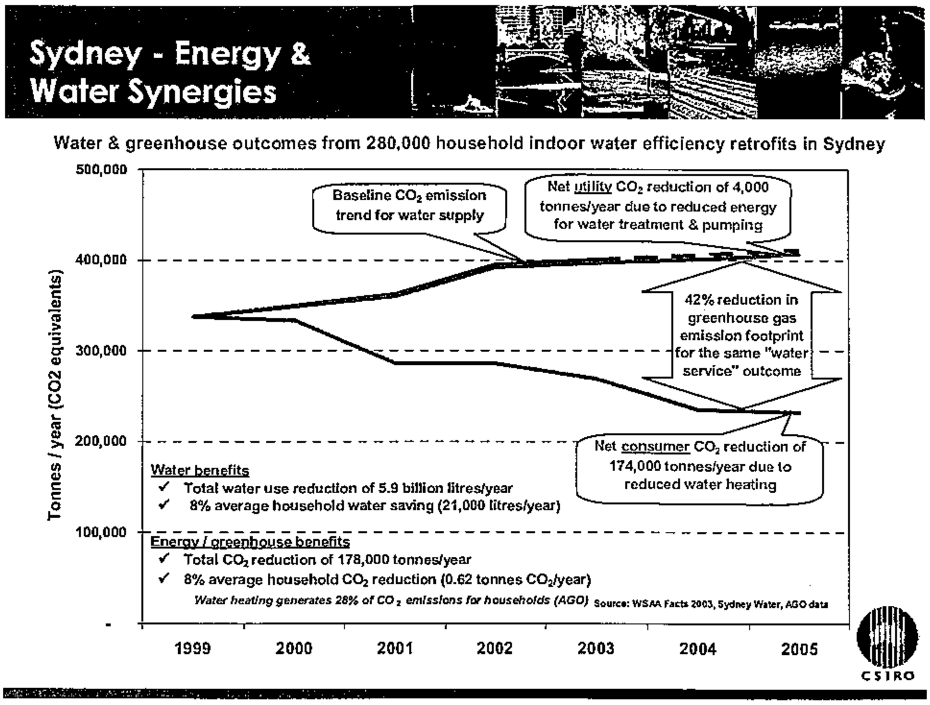
Water and energy

There are strong links between water and energy systems. Energy is used to treat, transport and heat water, and water is used to produce energy. Water utilities are among the largest energy users in each state and water is a major production input for coal, gas and nuclear power generation facilities. Customer usage of water, particularly hot water, is a major driver of the growth in total energy demand. The efficient end use of water is fundamental to efficient energy use and reducing greenhouse emissions.

Growing water demand, higher water and wastewater treatment standards, more water recycling and desalination will accelerate energy demands for water supply. Water managers will be under greater environmental and financial pressure to manage energy use, find ways to offset greenhouse impacts and utilise renewable energy sources.

Understanding water and energy systems interactions, co-system costs and benefits, and related greenhouse impacts of water system choices will become increasingly important. A key challenge is to provide water service strategies that enhance the sustainability of urban water systems without exacerbating greenhouse impacts or increasing service risks.

The figure demonstrates the substantial positive greenhouse contribution if the next suite of major subdivisions in Sydney were fully fitted to existing Water Sensitive Urban Design standards. Note that while some carbon is saved from reduced water pumping, the significant saving is in the less energy consumed in hot water heating.



Public health

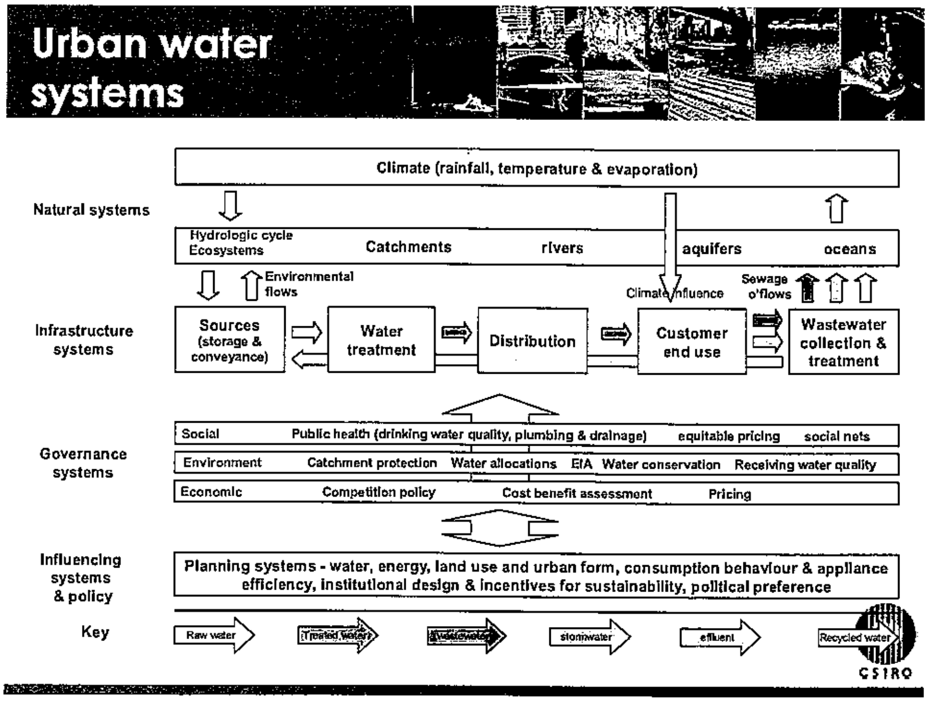
A major driver for the development of our existing separate water, wastewater and stormwater systems was the desire to protect humans from the infectious material in our wastes and from the physical risks of flooding. A major objective of conventional water systems has been to separate drinking water supplies from human wastes and they have been successful in reducing the incidence of water borne disease.

While there are many opportunities to rethink the way urban water services are provided to enhance their long term sustainability, we need to ensure that public health is not put at risk and the high standard that cities like Sydney have reached is maintained.

Integrated urban water management

Integrated urban water management is an emerging approach that takes a comprehensive approach to urban water service provision, viewing water supply, stormwater and wastewater as components of an integrated physical system, recognising that the physical system operates within an organisational framework and a broader natural landscape (Mitchell, 2004).

It aims to develop more sustainable water service solutions based on increased understanding of the complex interactions between these interrelated systems. Building the understanding of these system and process linkages is complex meaning the achievement of sustainable water systems is an evolutionary process rather than a clear and measurable objective. A city as a "system" is depicted in the following figure. All components must be evaluated for opportunities.



Most major city planning and water agencies are moving towards this "adaptive" approach, refining planning decisions over time as better information emerges from experience or from new research.

The successful development and implementation of integrated systems-based strategies is also reliant on improved quantification of integrated system risks and understanding the resilience of systems to change. For example, the selection of future water servicing options may be different if climate change impacts are taken into account, or the design of a governance system for decentralised water reuse systems may be different depending on how, and by who, such a service is to be delivered to consumers.

This integrated systems view is a key foundation for moving urban water systems to more sustainable configurations and reflects the following principles (Mitchell, 2004):

- Consider all parts of the water cycle, built and natural, surface and sub-surface, recognising them as an integrated system
- Consider both anthropogenic and ecological requirements for water
- Consider the local environmental, social, cultural and economic context
- Include all stakeholders in the process
- Strive to balance short, medium and long term environmental, social and economic needs.

Table 1 outlines the key characteristics of this emerging paradigm for urban water management.

Table 1 - Characteristics of the old and emerging urban water system paradigms

The Old Paradigm	The Emerging Paradigm
Human waste is a nuisance. It should be disposed of after treatment.	Human waste is a resource. It should be captured and processed effectively, used to nourish land and crops.
Stormwater is a nuisance. Convey stormwater away from urban area as rapidly as possible.	Stormwater is a resource. Harvest stormwater as a water supply, and infiltrate or retain it to support aquifers, waterways and vegetation.
Demand is a matter of quantity. Amount of water required or produced by different end-users is the only parameter relevant to infrastructure choices. Treat all supply side water to potable quality, and collect all wastewater for treatment.	Demand is multi-faceted. Infrastructure choice should match the varying characteristics of water required or produced for different end-users in terms of quantity, quality, level of reliability, etc.
One use (throughput). Water follows one-way path from supply, to a single use, to treatment and disposal to the environment.	Reuse and reclamation. Water can be used multiple times, by cascading from higher to lower quality needs, and reclamation treatment for return to the supply side of infrastructure.
Gray infrastructure. Infrastructure is made of concrete, metal or plastic.	Green infrastructure. Infrastructure includes not only pipes and treatment plants, made of concrete, metal and plastic, but also soils and vegetation.
Bigger/centralised is better for collection system and treatment plants.	Small/decentralised is possible, often desirable for collection system and treatment plants.
Limit complexity and employ standard solutions. Small number of technologies by urban water professionals defines water infrastructure.	Allow diverse solutions. Decision makers are multidisciplinary. Allow new management strategies and technologies.
Integration by accident. Water supply, wastewater and stormwater may be managed by the same agency as matter of historical happenstance. Physically, however, three systems are separated.	Physical and institutional integration by design. Linkages must be made between water supply, wastewater and stormwater, which require highly coordinated management.
Collaboration=public relations. Approach other agencies and public when approval or pre-chosen solution is required.	Collaboration=engagement. Enlist other agencies and public in search for effective solutions.

Source: Pinkham (1999)

Response to the Inquiry Terms of Reference

The following sections discuss the specific points of the Terms of Reference with primary focus on points c) and d).

The environmental impact of the proposed desalination plant at Kurnell

There is no need for CSIRO to comment at length on the environmental impact of the proposed desalination plant. Others will fulfill this role. Three main potential areas of impact warrant listing:

- Potential Site Impacts
- Intake and Outlets
- Greenhouse Gas Emissions

A Note on Kurnell and Reuse - An innovative opportunity that might need to be considered is for the Kurnell plant to be designed to also treat both Cronulla and Malabar wastewater streams. While direct potable reuse is not yet accepted by the Australian community, perhaps attitudinal shifts in the next 5 to 10 years will make this option acceptable to the community.

At the moment CSIRO is working with proponents such as Toowoomba and Goulburn Councils to design indirect potable systems. Likewise CSIRO's work in Western Australia with the Water Corporation is towards indirect potable use – in this case through Managed Aquifer Recharge. The social attitude figures from Perth studies demonstrate that the Australian community may not yet be supportive of direct potable use.

% of people who would drink reclaimed water

Personal attitude	Direct via pipe	Indirect via aquifer (MAR)
Would drink	13	31
Uncertain	43	51
Would **not** drink	44	18

The environmental assessment process associated with the proposed desalination plant

It is not within CSIRO's remit to provide specific comments on the environmental assessment process for the proposed desalination plant.

Methods for reducing the use of potable water for domestic, industrial, commercial and agricultural purposes, including sustainable water consumption practices

Water demand per capita has been static or declined in most capital cities, including Sydney, over the last twenty years. This has been due to market changes such as reduced water intensive heavy industries, improved household appliance efficiency in showers, toilets and washing machines, water pricing reform and significant investments in demand management initiatives by governments.

While reducing per capita demand has slowed the rate of volumetric demand growth, population growth will continue to drive demand for more water. Figures and projects for Australia's key four cities were provided in the Introduction (see page 4).

There are two fundamental approaches for reducing the demand for potable supplies:

1. Improve the efficiency of water use
2. Substitute supplies from alternative sources such as wastewater or stormwater;

Our submission describes options to improve the efficiency of water use in this section (in response to terms of reference point c). Sourcing alternative water is described in response to terms of reference point d).

Improving the efficiency of water use

Water efficiency means using less water to achieve the same service outcome or benefit for the consumer. It supports the principle that consumers do not want a specific volume of water, they want the service outcome provided from the use of the water, such as clean clothes, clean dishes, toilet waste removal or a pleasant landscape. If these same outcomes can be achieved by adopting improved end use technologies or changing water use practices then the demand for the resource is decreased with no loss of service amenity.

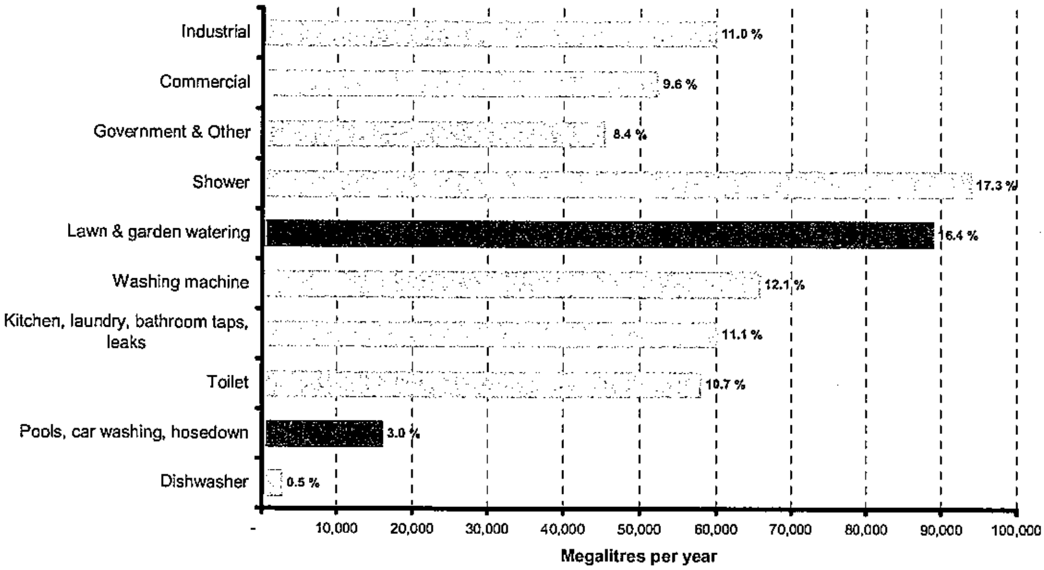
Improved water efficiency can also generate substantial benefits in terms of reduced energy use and reduced waste generation and is generally a lower cost option than building additional infrastructure to harness and supply more water, even without taking these benefits into account.

The results of demand management programs across Australia and overseas have consistently demonstrated that the adoption of smarter water use technology and practices at individual household or business level collectively can result in significant and lasting demand reductions. Demand management has been pursued to various degrees in all Australian capital cities over the last few years. Sydney has been at the forefront of this national trend due largely to the water conservation targets included in Sydney Water's operating licence, with reported water demand savings of 35 GL/year since 2000 (Sydney Water, 2004).

Reducing water use in Sydney

The figure below provides an estimate of how the people of Sydney use potable water when not in restrictions (Sydney Water, 2004). This type of end use analysis is now being used by many city water agencies and provides insight into where there is potential to further reduce water demand. The end use breakdown can vary markedly from city to city in Australia depending on local climate, the makeup of the market, housing density, or consumer characteristics. For example, outdoor demands in Perth are estimated to be about 41% of total use, compared to 19% in Sydney. Accordingly, demand reduction strategies may vary from city to city depending on local opportunities.

End use of potable water



Opportunities for further reductions in domestic water use

The residential sector uses over 70% of Sydney's water and is the prime driver of demand growth. Approximately 75% of domestic demand occurs inside the home, the remainder used outside.

The major opportunities for improved end use efficiency inside homes are showers, washing machines and toilets.

- *Showers* represent the largest residential indoor use of water at about 17% or 94GL/year of city water use. The current market penetration of AAA-rated water efficient showers is estimated to be approximately 40%, taking into account the 280,000 households who have participated in Sydney Water's retrofit program since 2000 (Sydney Water, 2004). Assuming all remaining and new showers in Sydney are AAA rated (under 9 litres/minute flow), water savings of approximately 28 GL/year would be achieved by 2025. [refer previous figure]
- Taking the wider integrated systems view, these water savings would also reduce greenhouse emissions by an estimated 800,000 tonnes / year (CO_2 equivalents) due to reduced energy use for household water heating. To put this in perspective, Sydney Water's net annual greenhouse emissions from all water and wastewater operations is 370,000 tonnes/year (WSAA, 2004).
- *Clothes washing* represents the next largest component of residential indoor consumption at about 12% of city water use. Increasing market acceptance of AAAA rated water efficient washing machines is a positive trend to reduce water use for clothes washing, with sales of about 35% of the washing machine market (Sydney Water 2003). Assuming a 15% of the market is currently water efficient, water savings in excess of 30 GL/year would be achieved by 2025 if all new machines were AAAA rated. [refer previous figure]
- *Toilets* represents 11% of total consumptive water use. The introduction of dual flush toilets in the 1980's has dramatically reduced water demand for toilet flushing as single flush toilets have been progressively replaced. At least 60% of toilets are now dual flush and recently an even more efficient AAAA rated model was introduced to the market. If the remaining single flush and all future toilets are of the new type, water use will be reduced by about 9 GL/year by 2030.

Achievement of the above opportunities will be supported by the implementation of the national Water Efficiency Labelling Scheme, targeting mandatory water efficiency labelling for shower heads, toilets, washing machines and dishwashers. A 2003 report undertaken for the WEL committee (Environment Australia) estimates that water savings of 64 GL/year would accrue across Australia by 2016 with the implementation of Water Efficiency Labelling (Wilkenfield, 2003).

This equates to a water use saving of about 6.4% for the products subject to the scheme and 5.2% in total household indoor water consumption. The overall costs of the program are projected to be about $172 M (net present value, 10% discount rate) over the period 2004-16, and the total value of water and energy savings is projected to be about $507 M, giving an overall net benefit of nearly $336 M, and an overall benefit/cost ratio of about 2.8. Approximately 30% of these benefits will occur in Sydney.

Ideally, following the implementation of this initiative, minimum water efficiency standards should be introduced nationally to ensure that only water efficient appliances can be purchased.

Other methods to accelerate take-up of efficient appliances include retrofit programs, such as Sydney Water's current programs, rebates, or other economic incentives for appliance purchasers. Retrofits have proven very successful for showers in Sydney. Washing machine rebate programs in Sydney, Perth, Melbourne, Brisbane and Canberra have succeeded in transforming the market across Australia, on average increasing consumer awareness and sales of efficient front loading machines from 10% to over 35% of the market. Virtually all toilets sold in the market today are dual flush, however, there may be opportunity to accelerate turnover through incentive programs.

Residential *outdoor* consumption represents 19% of total consumption and at over 100 GL/year, the single biggest component of Sydney's demand. This water use is dispersed across the 1.5 million households and is discretionary in nature. Research indicates that many householders have strong personal attachments to their gardens and value the "nurturing" aspect of maintaining a healthy garden (A. Boerema, pers. Comm.). For this reason, people tend to apply considerably more water to their gardens and lawns than is actually required to maintain the health of the plants.

There have been two distinct public education approaches to influence outdoor water use - the demand management programs targeting voluntary but permanent changes in water use behaviour and the drought restriction campaigns that carry an appropriately stronger non-voluntary message for short-term behaviour change, supported by penalties. It is difficult to precisely measure the impacts of these campaigns. The drought restrictions have been very successful in reducing demand, albeit with some assistance from intermittent rainfall in the demand catchments that has helped to relieve demand pressure.

The drought campaigns clearly highlight the potential to reduce outdoor water use under normal operating conditions, without substantially affecting garden health or lifestyles. Demand in Sydney has dropped by more than 80 GL/year during the restrictions. Even if only 50% of these savings could be realised on an ongoing basis through smarter irrigation practices, garden design or plant selection, the 40 GL/year savings are substantial and can be achieved at a relatively low cost.

Possible practical strategies to achieve this could include:

- Ongoing community education and introduction of permanent community standards to minimise wasteful watering practices. This is already proposed as part of the Metro Water Plan.
- Development of a state or national garden plant rating and labelling scheme, similar to the appliance scheme, that provides science-based information to consumers about water application rates under different soil conditions when they purchase plants and establish their gardens and irrigation systems. This could also be linked to the WSAA Smart Approved WaterMark scheme currently in place for irrigation systems and other outdoor products. It would also provide a clear basis for allocation of points under the current BASIX scheme for outdoor efficiency. The lack of defined rating system is currently a constraint under BASIX.

- Development of neighbourhood scale smart irrigation technologies for residential gardens. These technologies have been used for some time for rural applications, linking weather station driven controllers to remote irrigations systems to optimise water application for prevailing local conditions. There is no reason why the same type of technologies could not be adapted for residential water efficiency, with individual household irrigations systems tuned to the individual garden's water requirements but linked to a smart suburb based weather station by wireless communication.

Pricing is an important opportunity to control demand. Opportunities to increase the sensitivity to price signals include moving to individual metering for all dwellings, and increasing the variable component of the charge by linking wastewater charges to water charges. Further analysis of pricing opportunities in Sydney is recommended.

Reducing industrial and commercial water use

The business sector in Sydney uses about 30% of total water supplied. Experience in Sydney and elsewhere has demonstrated that on average, businesses can typically achieve a 15% reduction in water use through the implementation of relatively low cost initiatives. These may range from improved maintenance practices and leak repair, staff education, replacement of water fittings and fixtures, improved cooling tower operation. In many cases significantly larger savings can be achieved if companies are prepared to invest time and capital into management systems and technologies that will either use water more efficiently or reuse their wastewater onsite. In some cases, water use reductions of up to 70% have been achieved.

In the case of Sydney, if a minimum 15% reduction could be achieved across all businesses additional savings of approximately 15 GL/year could be realised.

The major barrier to pursuing these benefits is the economics of implementing solutions. Many potential projects fall outside corporate investment return criteria and do not proceed, even though the longer term returns on these investments are very good. This could be improved with better incentives for business to overcome these barriers. The Demand Management Fund being implemented in the Metro Water Plan is an excellent initiative to stimulate further take-up in the business sector.

Agricultural water use efficiencies

The agricultural sector is the second highest consumer of water in the greater Sydney area using approximately 100 billion litres (100GL) of river water per year (NSW Govt 2004). This usage is a similar amount to that currently used on residential gardens. Irrigators participating in water wise on the Farm across NSW saved around 25% of their usage (NSW Govt 2004) suggesting around 25GL/year water could be saved in the Sydney area by adopting similar approaches.

Reducing water loss

There are drinking water distribution systems in some parts of the world where less than half the water produced reaches consumers. Fortunately, water distribution systems in Australian cities are in considerably better condition, with most water utilities benchmarking in the top 25% of utility leakage control performance worldwide. While it is quite feasible to identify and control leaks that are visible at the surface or can be detected below ground, it is not possible to eliminate water loss from city water distribution systems. There is always a level of 'background' leakage from leaks too small to be detected, the majority being at house service connections. Sydney has over 1.4 million such connections.

The International Leakage Index (ILI) is the industry standard for estimating system leakage performance. A score of 1.0 indicates that only background (undetectable) leakage is occurring; a score of below 3.0 indicates a reasonably good level of loss control performance. The majority of Australian city utilities score below 2.0, with Sydney currently achieving 1.8 (WSAA, 2005), reported as 10% of supply or 53 GL/year (Sydney Water, 2004).

The economic balance of searching for and repairing leakage and of controlling it to an acceptable level (termed the 'Economic leakage level' (ELL)), is a complex issue (Lambert *et.al.*, 1999). Typically a leakage percentage below 10% or even 15% may not be economic to pursue, purely from the value of water lost. In other words, the effect of hunting down, identifying and repairing the leakage costs more than the value of water saved. The intrinsic ELL varies depending on the area, the cost of bulk water and the hydraulic characteristics of the network.

There are three fundamental strategies for addressing leakage - passive leak management, active leak management and pressure management. Passive leak management means responding to reported visible leaks and making repairs. This is practiced as routine maintenance by water utilities. Active management involves using detection technology to identify and repair hidden leaks in the system. All the major utilities in Australia have active leak detection programs, with reported reductions in leakage in Sydney of 17 GL/year since 2000.

Pressure management involved the use of pressure reducing valves to control system pressures to minimum acceptable operating levels. Most utilities including Sydney Water are progressively implementing pressure control programs.

The NSW Independent Pricing and Regulatory Tribunal (IPART) has included leakage reduction targets in Sydney Water's operating licence, targeting the achievement of their estimated ELL through all three above strategies. This equates to limiting losses to 105 ML/day (Sydney Water Operating Licence, 2005), an additional reduction in losses of 13-15 GL/year from current levels. The benefit/cost of reducing losses beyond this target would diminish exponentially for each additional GL of reduction pursued.

The costs and benefits of desalination and alternative sources of water including recycled wastewater, groundwater, rainwater tanks and stormwater harvesting

The following section includes commentary on the range of alternative water sources for Sydney. In comparing the costs and benefits of alternative supply options it is important to consider the total system perspective and not just influences at the point of supply. This is because some solutions will:

- increase or decrease wastewater flows and therefore wastewater treatment costs and impacts including energy consumption, greenhouse gas emissions and receiving water quality impacts;
- be more or less susceptible to climate change and be more or less reliable as a source of water;
- utilise or undermine the value of existing infrastructure or water service operations;
- have different levels of public health issues, community acceptance and size of barriers to entry;
- Costs, including life-cycle or levelised costs and economic benefits for example through industry support or employment creation.

Desalination

There are two key issues associated with desalination - increasing the level of inputs of water into the system and the requirement of additional energy to manufacture that water.

From the perspective of water inputs to Sydney, desalination is no different to building a new dam – but it is a more reliable source. However, the additional water input to the system will ultimately mean greater volumes of wastewater discharge which will require additional capacity in the sewer network, wastewater treatment capacity and discharges.

Desalination technologies have advanced significantly over the last decade. The current power consumption for seawater desalination is <3 kWh/m3, which is a 90% reduction in energy use over the past 40 years. This is because of improvements in membrane technology and energy recovery systems. The cost of desalination has also reduced in recent years. By comparison it requires around 0.4 to 0./6 kWh for conventional water treatment; 0/7 to 1.2 kWh for brackish reverse osmosis; and 0.8 to 1.0 kWh for wastewater reclamation (House of Representatives 2005).

CSIRO is investing in membrane technology recognising that this technology – whether it is used for desalination or reuse will become a larger part of the Australian water supply landscape.

Water recycling

A series of research reports were prepared in 2004 for the Australian Water Conservation and Reuse Program, a research program jointly sponsored by the CSIRO and the Australian Water Association in conjunction with other Australian research organisations. The work reviewed many aspects of water recycling issues including:

- integrated water management
- On-site rainwater, greywater, stormwater, and wastewater utilisation techniques
- Stormwater sensitive urban design
- Endocrine disrupting chemicals in recycled water
- Irrigation with recycled water, soil impacts
- Social issues, public perceptions
- economic issues

The following discussion draws on this body of research to highlight the costs and benefits of alternative water systems. The full suite of reports can be made available to the committee if required.

Recycling of wastewater, greywater or stormwater can potentially provide benefit to the environment by two mechanisms, these being:

- Reducing the extraction of water from natural environments and thereby increasing the availability of water for other users, eg. agriculture, industry and improving environmental flows, and
- Diverting wastewater, greywater or stormwater effluent away from natural environments and thereby decreasing the amount of pollutants discharged into these environments.

Water and nutrient balances

In addition to the provision of recycled water for an end use, recycling schemes divert contaminants associated with wastewater and stormwater away from natural environments. Modelling (Gray *et al*, 2000) has shown that wastewater and stormwater reuse can potentially lower the transfer of contaminant loads from urban environments to the natural environment by 30-70%.

Diverting contaminants associated with wastewater, greywater or stormwater away from natural environments, leads to these contaminants being either removed in treatment process sludges or being associated with the end application. If the end application is the watering of agricultural crops or residential gardens, then care must be taken to ensure that these environments are able to handle the contaminant loads. Research into the long term impacts on soil structure of using treated wastewater to water domestic gardens (Bond and Smith, 1999) is being conducted in Canberra, as a joint project between ActewAGL and CSIRO. The main concerns revolve around the amount of salt and boron being returned to gardens.

Residential dual reticulation

Residential dual pipe recycling systems have proven to be successfully piloted in Sydney, with recycled water use representing about 35% of total water use in this area with the recycled water being used for toilet flushing and outdoor watering. However, as average lot sizes in new developments are reducing, limiting garden size, and new toilets are becoming even more efficient, the use of recycled water in new Sydney developments needs to be expanded to other end uses such as washing machines to increase potable substitution and reduce overall infrastructure costs.

The use of recycled water for washing, while unlikely to be a public health issue, may meet strong public resistance. CSIRO's and other research has consistently shown that consumers are less likely to use recycled water the more personal its end use. Further research is required to explore possible acceptance issues and develop engagement strategies to increase uptake.

Another issue that has arisen at Rouse Hill and schemes in other States is the control of inadvertent cross connections between the recycled water systems and the potable supply. At present the NSW recycled water guidelines require property inspections for cross connections every five years. As the numbers of properties connected to recycled water grows it will become increasingly difficult to monitor cross connection risks. CSIRO is reviewing detection technology options to address this issue.

There is very limited information on the actual cost of providing recycled water through dual systems. CSIRO estimate that some 25 GL/year would be saved by 2030 through installing dual reticulation in all new dwellings and that recycled water would be used for all toilet flushing and outdoor demand.

Urban irrigation with recycled water

There are a number of viability issues associated with the use of recycled water for urban irrigation. These include the cost of transport distance versus treatment costs, customer cost of conversion and climate related variability of demand. At current potable water prices many urban irrigation schemes are economic however as water prices rise the viability of such schemes will improve.

The viability of sewer water mining is also variable and highly site-specific depending on access to suitable sewer flows, ability to deal with residuals and customer quality requirements.

On-site greywater and wastewater recycling

Using greywater can save potable water primarily depending upon the end use. Garden irrigation usage potential varies depend on the local soil type, suitability and irrigation area, whereas use for indoor purposes is dependent upon water usage for specific appliances and the household occupancy (Diaper 2004).

As with stormwater schemes, potable water savings associated with greywater use for irrigation are often difficult to quantify as many case studies use the treated water for irrigation of open space or 'greening' of otherwise unirrigated environments. Some examples of potable water savings achievable with greywater reuse are given in Table 2.

Table 2 – Greywater system water savings (Source: Diaper 2004)

Reference	Location	End use	% potable water reduction
Gardner et al., 2003	Gold Coast, Queensland	Potential toilet flushing and irrigation but discharged to sewer[1]	36%[2]
WAWA, 1993	Western Australia	Garden irrigation with 'water wise' gardening	38%[2]
Priest et al., 2003	Perth, Western Australia	Irrigation	4500 to 40, 500 ML/year[3]
Christova Boal et al., 1996	Melbourne, Victoria	Garden irrigation Toilet Toilet and garden	21%[2] 20%[2] 31%[2]
Diaper et al., 2003	Canberra ACT	Garden irrigation	13% to 22%[2]

1 Queensland Sewage and Water Supply Act (1949) does not allow reuse
2 Potential Saving
3 Potential saving for 100% utilisation and range of uptake

Greywater provides a reliable supply of water but flow variations throughout the day requires storage to optimise the use. Wastewater flows and loads will be reduced but this will depend on the level of treatment and the end use. For example reuse of untreated greywater for toilet flushing will reduce wastewater flows but not wastewater contaminant loads. However, reuse of treated greywater for garden irrigation has the potential to reduce both flows and contaminant loads to the sewer.

It is estimated that 10GL/year could be saved in Sydney if residential greywater recycling for garden and toilets occurred with 10% adoption in existing markets.

Potable recycling

Potable recycling of wastewater is an emotive and challenging issue. Many existing Australian and Global cities – including most on the Murray-Darling river system through to Adelaide – already indirectly accept wastewater recycling for potable supplies.

Community acceptance of potable wastewater recycling is the major issue. Po *et al* (2005) recently concluded that knowledge was not a factor in people's decisions to accept recycled products – including wastewater. Rather, trust in the providing organization was of major influence. The provision of comprehensive and open information helps engender trust. While risk was quite strongly influenced by trust, it had only a weak contribution to behavioural intention. The study suggested that by increasing trust in the authorities, people's concerns about risk also diminish.

Groundwater

Historically, groundwater has not provided a major supply source for the Sydney area. The Botany Sands Aquifer provided water for industrial uses in the late 19th to mid 20th centuries but its use has been reduced due to decreasing industrial activities and contamination.

Similar to other potential supply options, the costs and benefits of sourcing additional supplies from groundwater are site specific, depending on the costs of extraction, treatment and distribution costs.

Sydney's geology means that aquifer storage and recharge using stormwater or treated wastewater are unlikely to be part of the additional supply.

Rainwater tanks

Rainwater has been collected from roofs for use within the home since early settlement of Australia. Recent technical innovations have mainly focussed on alternative ways of collecting and storing rainwater. This is to address the limitations of installing the traditional cylindrical tank in smaller urban gardens, as highlighted in some community surveys examining the feasibility of rainwater use in urban areas (Pepperdine, 1995; Maheepala et al., 2003). Some of these innovations include gutter storage systems, flexible storage bladders that can be positioned underneath floors, and modular structural storage units that can be incorporated into fences or buildings (Diaper, 2004).

Climate, end use, collection area and storage capacity all affect the potable water offsets from rain tank installation and use. Modelling shows that areas with consistent higher rainfall and even dispersion of rainfall (e.g. Brisbane) provide improved water savings for the same end uses (Gray, 2004). The potable water substitution achieved from tanks is most effective when the tank water is used constantly. In simple terms, the faster the tank empties the greater the capacity available to capture roof runoff when it rains. Therefore, it is desirable to use the tank water for many daily end uses, not just intermittently on the garden. The easiest way to achieve this is to connect the tank to multiple internal uses, with a minimum operational water level maintained in the tank via a mains top up.

Widespread internal use of rainwater, particularly for potable uses will require systems to ensure the maintenance of water quality. Approaches to this include the use of hot water systems as a disinfection process and point of use filtration devices. Further research is progressing to quantify risks and suitable control methods (Diaper, 2004).

The operating energy requirements and capital costs of rainwater tanks will depend upon the end uses of the water, the required reliability, siting of the storage, and the need for pumping. For example, generally garden irrigation systems do not require pumping for distribution, unless the storage is located underground or the topography dictates pumping. Connecting the tank for indoor uses will require pumping to maintain sufficient pressure for normal operation of indoor appliances and filling toilet cisterns. Recent studies have shown that the intermittent operation of small pumps connected to tanks can be quite energy intensive (Gardner 2006).

Table 3 shows potable water savings achieved from a range of rainwater tank case studies (Diaper, 2004).

Table 3 - Potable water savings in rainwater tank case studies (Source: Diaper 2004)

Reference	*Location*	*End use*	*Tank description and size (kL)*	*% potable water reduction*
McAlister, 1999	Canberra, ACT	Irrigation & toilet flushing	Not stated	20%
Smith, 1999	Sydney, NSW	Irrigation & toilet flushing	Storage guttering (30 L of water/m)	27%
www.unisa.edu.au/water/prototypes/Regent_Gardens.html	Adelaide, SA	Hot water system & kitchen[1]	2 kL	30%
Gardner et al., 2001	Gold Coast, Queensland	All household uses (with potable back-up)	22kL	32%
Apostolidis, 2003	Brisbane, Queensland	Laundry, toilet flushing and hot water supply	20kL	50%
Coombes, 2003(correct year?)	Newcastle, NSW	Irrigation, hot water system and toilet flushing	0.91kL	52%

[1] Ultra-violet disinfection system installed for kitchen uses
[2] Predicted value in combination with greywater

CSIRO estimates that approximately 40 GL/year water could be saved for outdoor usage and toilet flushing in Sydney 2030 if implemented in 50% of new residential dwellings.

Stormwater harvesting

For many years it was the goal of planners to convey stormwater as rapidly as possible away from dwellings. Little regard was paid to quantity or quality issues. Stormwater must be managed in a more integrated way, and is increasingly being seen as a resource that has been undervalued. In comparison to wastewater, stormwater may initially appear to be a more suitable resource for urban use, because of its perceived higher quality.

Due to the intermittent nature of rainfall and the variable quality of stormwater runoff, there are substantial difficulties associated with the use of stormwater. Options for stormwater use include: on-site rainwater tanks, community collection and storage for irrigation and habitat restoration such as a wetland or stream.

The benefits and costs of stormwater use in comparison to alternative sources of water depends on the specific location and the options for demand-side management, assessment frameworks such as least cost planing provide a methodology for determining the best option for the specific location.

There is no comprehensive data presently available on the extent of stormwater use in Australia. Anecdotal evidence would suggest that only a small proportion of stormwater generated from urban areas is utilised. In South Australia, where stormwater use is more advanced and the trend is for more such activity, the portion of total water use supplied by stormwater is still small (WBM Oceanics Australia, 1999). Exceptions to this trend are the cities of Perth and Canberra. In Perth, there is extensive indirect stormwater use due to the prevalence of onsite disposal of roof runoff through spoon drains and extensive use of shallow groundwater bores for non-potable water supply. The city of Canberra uses stormwater from detention basins for non-potable uses, reported as providing 6 percent of its total water needs in the mid 1990's (Anderson, 1996a).

The requirement for stormwater storage is determined by the relationship between the temporal pattern of runoff and that of the water demand. In areas of winter dominant rainfall and summer dominant water demands, a large storage capacity may be required to maximise the potential for stormwater use. An example of this situation is the city of Adelaide, where methods such as aquifer storage and recovery are used to provide the storage capacity required (see Table12). Storage requirements can be substantially smaller in locations where rainfall patterns are more constant throughout the year, such as Canberra and Melbourne.

The main problem with reliance on urban stormwater as a key water source is the reliability of supply through extended dry periods. As a result, the best option is to use stormwater in conjunction with other water resources such as wastewater, to overcome the need for large carryover storage.

Some examples of urban developments that have incorporated stormwater use are provided in Table 4.

Table 4 - Stormwater reuse schemes

Scheme	Description
Fig Tree Place, Newcastle (Coombes et al, 1999)	A 0.6 ha urban site has been redeveloped, containing 27 housing units. The stormwater system involves underground rainwater tanks, which have been fitted with first flush devices, to collect roof runoff. In-house hot water and toilet flushing is supplied from the rainwater tanks and overflow is disposed of on-site through gravel trenches, providing groundwater recharge. Runoff from paved areas flows into a detention basin and groundwater recharge area. Groundwater is drawn for irrigation and bus washing at the adjacent bus station.
Andrews Farm, Adelaide (Dillon et al., 1997)	In April 1993 an Aquifer Storage and Recovery facility was established on the northern fringe of Adelaide. Ephemeral stormwater runoff from a semi-urban catchment is harvested, passively treated, and injected into an underlying confined aquifer. The water is later recovered for landscape and crop irrigation. Water quality testing has shown that the facility provides water suitable for irrigation, and may with time meet drinking water guidelines.
Homebush, Sydney (WBM Oceanics Australia, 1999; Phillips *at al.*1998)	Development of the Sydney Olympics site at Homebush Bay has included a major Drainage and Stormwater Recycling Strategy. Site runoff collected and treated using gross pollutant traps and water quality control ponds/wetlands. The runoff is then directed into the Brickpit Storage, which also receives treated wastewater. Water from the Brickpit Storage is used onsite for irrigation, toilet flushing and other purposes. Maximum demand for recycled water is estimated to be approximately 14 ML/day.
Kogarah Town Square, Sydney (Mouritz, 2000)	The Kogarah Town Square redevelopment covers 1 hectare, comprising of retail and commercial space along with 190 apartments, a public library and underground parking. Stormwater is used for landscape irrigation, toilet flushing, and car washing. Some 17 percent of the water used in the redevelopment will be stormwater; in the order of 5700 kL/year. Solar power is also generated. The project commenced in early 2001 with completion in 2002.

Part of the stormwater management problem is the complex institutional arrangements that exist in many areas. A single stormwater system in Sydney can, for example, be under the jurisdiction of four different bodies.

Related to this issue is the lack of a pricing regime for stormwater. Presently, in many areas, stormwater charges are, more or less, taxes, with no relationship being drawn between the demand placed on the system and the price paid. There is also often a very tenuous link between funds raised and capital works programs to improve a particular system. Cross-subsidisation between stormwater and wastewater and water systems undoubtedly still exists in many cities. Poor institutional arrangements and pricing structures work against integrated stormwater planning and use of stormwater as a resource.

Comparing costs and benefits

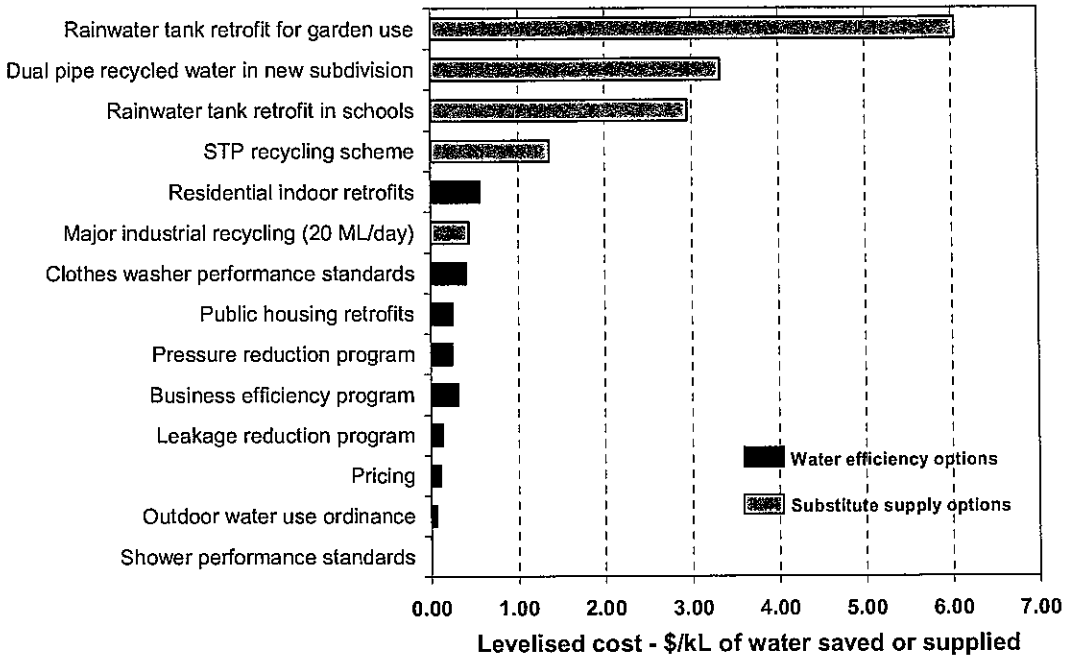
What is certain is that a broad mix of demand reduction and supply options will be required to meet future water needs. A diversified approach is also sensible from a risk management perspective as sourcing water from a variety of sources will improve system reliability and the resilience of the total system to changing circumstances such as climate change.

Another challenge when comparing cost and benefits is that there are often significant tradeoffs between the variables mentioned above. Some options may have water supply benefits at the expense of greenhouse emissions or wastewater impacts. Others will have high levels of social acceptance but be poor from an economic or environmental perspective. While the direct costs and benefits of alternatives can be valued, many of the indirect or unintended costs and benefits (externalities) cannot readily be accounted for in option assessment.

One approach that has been used to provide a common economic comparison between alternatives is least cost planning. This method aims to assess the cost effectiveness of alternative demand reduction and supply options on a common basis. It assesses the costs and benefits from a 'cost to the community' perspective, in terms of the unit cost to reduce water through demand management or supply more water from an alternative or new source. The economic value of an externality can be included if it is available, but like all other methods are limited by the ability to readily provide such values for many externalities.

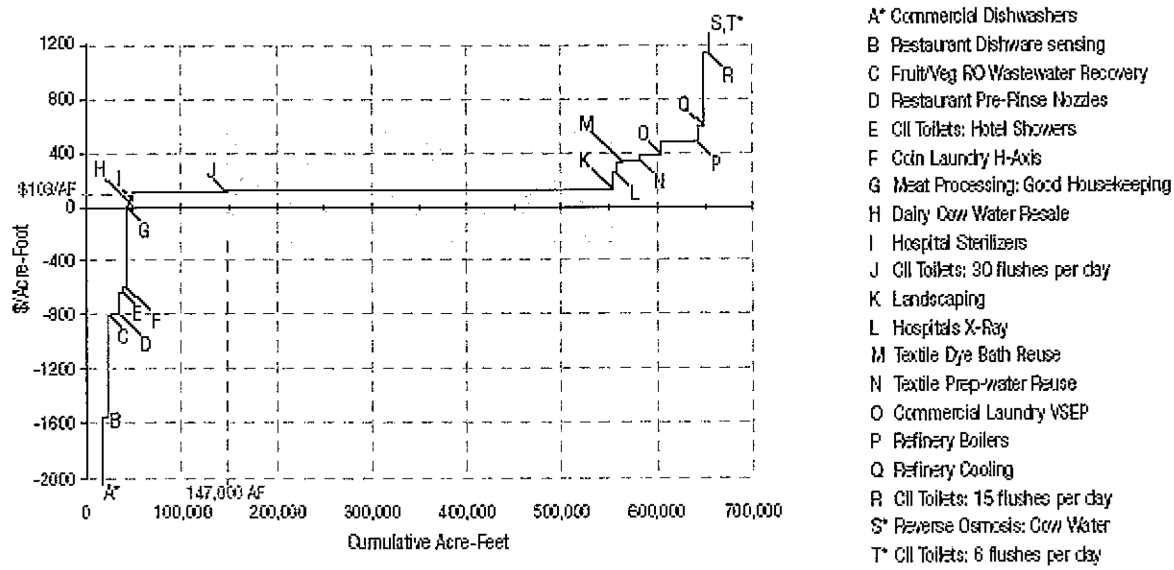
A significant least cost planning study was undertaken for Sydney Water by the Institute for Sustainable Futures in 1998. Howe and White, (1999) summarise levelised costs for a number of demand management options designed to meet Sydney Water's Operating License Targets. This study highlighted the linkages between the water supply and sewerage system components of the water service business are critical, and that water efficiency programs can be strongly justified on economic grounds. The following figure shows a typical ranking of demand and supply side options using least cost planning (Sydney Water, 2003). It demonstrates the relative cost effectiveness of demand side options when compared to supply initiatives. Note - energy costs and benefits are not included in this ranking.

Example of least cost ranking of alternative for Sydney



The following figure shows the results of a least cost analysis in California that plots the relative unit costs and cumulative water savings of a wide range of options applicable to local opportunities and conditions. This analysis includes additional quantification of 'co-benefits' including the benefits of avoided energy use. The options showing a negative cost are actually providing a net economic gain for Californians while providing additional water for the community (Gleick *et al*, 2003).

Californian example of least cost analysis of residential options



The tender process and contractual arrangements, including public-private partnerships, in relation to the proposed desalination plant

CSIRO has no remit to comment on the specifics of the tender process for the planned Sydney desalination plant.

Other relevant matters

The other main issue that CSIRO would like to draw attention to is the need to consider cities as systems. While the *Water for a Healthy Country* National Research Flagship is concentrating on the components that comprise the water system and to some degree the energy system of a city directly linked to the water system, a city is effectively a linked set of systems across water, energy, transport, ecology, emergency services, lifestyles etc. The challenge before us is to adequately portray this total system in a manner that allows water supply, use and reuse options to be accurately assessed in terms of benefits and costs across the entire city system.

Conclusion

There is substantial scope for Australia's urban water systems to be redesigned to improve environmental, economic and social outcomes. The scope is greatest in those areas of new or re-development.

Australia's cities are all moving towards a systems based approach as they seek answers to the supply shortfall. Undertaking further detailed investigation of supply options in Sydney is essential, would build on the multiple excellent initiatives already underway and place solutions like desalination in full context. This is essential if we are to foster informed community debate as to the next steps in Sydney's infrastructure investment.

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