WATER RESOURCES MANAGEMENT AT MAWSON LAKES, SOUTH AUSTRALIAAN INNOVATIVE DUAL WATER SUPPLY SYSTEM: DEVELOPMENT OF THE SCHEME AND COMMUNITY ATTITUDES

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Key Words

Australian water policy, dual water supply, aquifer storage and recovery, water recycling, community attitudes, water cycle management, pricing

1 INTRODUCTION

This paper focuses on the role of dual water supplies in meeting water demand and contributing to sustainability. Barriers to the successful implementation of dual supplies will be discussed. These barriers include price, policy and community acceptance. International examples will be drawn upon. The dual water supply at Mawson Lakes in South Australia will be used a case study. Results of a recent survey of the community, prior to the reclaimed water use commencing will be presented indicating results of interest to water policy developers. The paper presents a background to global water shortages including the discussion of a number of techniques employed to deal with water scarcity, including; demand management, technology expansion and wastewater reclamation and reuse.

It is widely recognised that the world is facing a water crisis (Falkenmark and Lindh 1993). This water crisis is occurring as a consequence of a growing world population, accelerating urbanisation, increasing per capita water consumption, and anthropologically driven climate change. Many cities find themselves challenged to meet increasing demands for water, with the added complexity of ageing and inefficient infrastructure. Added to this is the problem of mismatched population distribution and water availability. Techniques employed to combat water scarcity include, but are not limited to: technology expansion, demand management and water reuse.

Traditionally additional water supples have been sourced through technology expansion ie the construction of larger dams or sinking of deeper ground water wells. Rapid population growth in Mexico City provides one such example. In 1982 Mexico City pumped water from a distance of 100km away and 1,000m below the city. By the 1990's the city required additional withdrawals 200km away and 2,000m lower (Falkenmark and Lindh 1993). Construction of the South-to-North Water Transfer Scheme recently began in China. This controversial project proposes to divert water along 3 main channels from the Yangtze River in China's south to the Yellow River in China's north. The project requires substantial financial commitment and grossly manipulates China's natural water courses. Compensation for those in water exporting regions has not been seriously considered. In the past, sections of the project have been commissioned only to be suspended when conflict between importing and exporting regions arose (Liu 1998).

Many western cities have implemented demand management techniques in an attempt to meet demand for water. Demand management techniques include; pricing, community education, restrictions on use, and the development of alternate water efficient products. Demand

management techniques have been argued to have limited impact on relief from water shortage (Boland 1986; Okun 2002). Of the American experience with demand management, Boland (1986) believes motivation for the adoption of demand management practices is often crisis avoidance rather than economic efficiency with measures introduced to cope with crisis tending to loose acceptance as the crisis passes. An Australian study by Syme (Syme, Williams et al. 1989) suggested that demand management techniques are most successful when the community perceives the need is real, as in time of drought. Success of demand management techniques has often been labelled seasonal or short term. Due to the limited capacity of demand management, many cities combine demand management with the search for additional sources of water in order to meet demand.

2 WASTEWATER RECLAMATION AND REUSE

Wastewater recycling and reuse is becoming increasingly realised as an alternate source of water. The principle behind wastewater reclamation is that, not all uses require water of potable quality. This is in line with the view of the United Nations Economic and Social Council, who in 1958 stated, 'no higher quality of water, unless there is a surplus of it, should be used for a purpose that can tolerate a lower grade (United Nations 1958).' This statement however, does not take into consideration environmental flows. The benefits of wastewater reclamation and reuse are extensive and include; additional water supply, avoidance of technology expansion, and reduced disposal of wastewater to sensitive environments.

Wastewater reuse can have two major applications; potable and non-potable uses. Wastewater reclamation occurs most frequently for non-potable purposes which including predominantly irrigation and industrial uses. There is presently limited domestic application of waste water reuse, although domestic dual supples are becoming increasingly popular initiatives, and will be discussed later in this paper. The benefits of direct potable reuse are still widely debated, with little uptake of such application, due to concern for public health and a lack of community acceptance. Indirect potable reuse occurs frequently throughout the world, most commonly resulting from upstream disposal and subsequent downstream use (Hamilton and Greenfield 1991). Many argue that direct potable reuse should be practiced in favour of dual water supplies and non-potable reuse, arguing direct potable reuse is more economically and environmentally beneficial and that dual water supplies use unnecessary infrastructure (Law 1995).

Our research with the Mawson Lakes population in South Australia has led us to conclude that direct potable reuse is not yet viable yet in Australia. Direct potable reuse will only be viable once community acceptance of non-potable reuse has been established for a period of time and the perceived need of direct potable reuse is present – much like the success of demand management and perceived need for such measures. The importance of dual water supplies lies in them acting as a stepping stone to direct potable reuse, playing an important example to the community for the gradual acceptance of more personal reuse. In Australia 2 direct potable reuse schemes were abandoned after community support was not present these were Maroochydore, Queensland and Quakers Hill, New South Wales. Both of these proposed schemes went through extensive community consultation in the first phase of the projects, but were still abandoned.

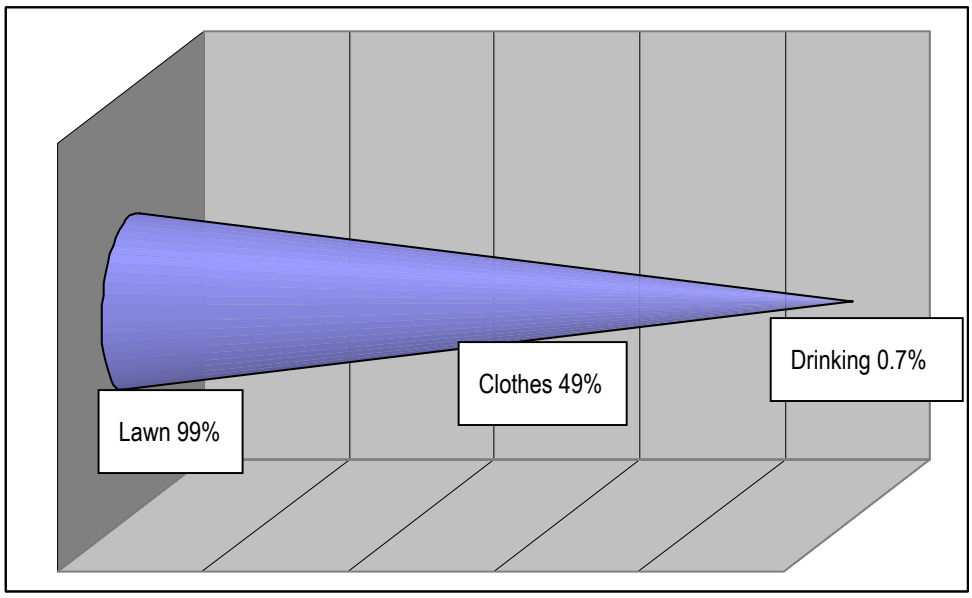
3 COMMUNITY ACCEPTANCE

Community acceptance of reclaimed water use is critical to the successful implementation of such schemes. As with the Australian examples above, a number of reuse schemes in America were abandoned after community acceptance was absent (Okun 2002). The acceptance of water recycling projects depends largely on the attitudes of the community, without public acceptance, water recycling projects will struggle to be successfully implemented. Despite the evidenced

importance of community acceptance of water recycling, there has been little research conducted throughout the world. In 2001, Dillon identified the highest research priority for water research in Australia was addressing the public acceptance of water reuse (Dillon 2001).

In England, research found there was broad conditional support for water recycling (Jeffrey and Jefferson 2001). 86% of respondents agreed they have no objection to water recycling as long as safety is guaranteed. This study found using recycled water from second party or public sources was less acceptable to the population surveyed. In California, an assessment of community attitudes to the use of reclaimed water found the more personal the proposed use of recycled water is, the less favoured it becomes – there is a greater acceptance for the use of recycled water for irrigation of golf courses then for potable use (Bruvold 1979). These results were replicated in survey of the Mawson Lakes population in South Australia. Participants were asked what they think about the use of recycled water in general, for use on the lawn, for clothes washing and drinking. The graph below displays these results. The graph shows a significant decreasing is support for water reuse as the proposed use became increasingly personal.

Graph One: Support for water reuse at Mawson Lakes, South Australia



4 WASTEWATER RECLAMATION IN AUSTRALIA

A series of events in the 1990's accelerated the implementation of water recycling initiatives in Australia, this resulted in the growth in availability of high quality reclaimed water and opportunities for reuse (Dillon 2001). These events included;

The emergence of the awareness of environmental flows in water resources management policy

The deteriorating state of rivers and acknowledgement of nutrient discharge limits

COAG (Council of Australian Governments) competition policy which initiated new private sector investment in water infrastructure and the adoption of a wider range of technologies in wastewater treatment.

Current water recycling initiatives in Australia include reuse of reclaimed water for urban, residential, industrial and agricultural purposes. This includes recycling of greywater and stormwater, water efficient urban design, and dual water supplies in greenfields residential

subdivisions. Aquifer Storage and Recovery (ASR) is being investigated for the seasonal storage of recycled water, to eliminate evaporation loss encountered through surface storage methods. A number of Australian water recycling initiatives are discussed below to demonstrate the diversity of such initiatives in Australia.

The Virginia pipeline scheme in South Australia has been devised to divert treated wastewater from the Boliver sewage works for use in horticulture. The scheme stores seasonal water using trail ASR, and avoids wastewater discharge into the sea (Parker 1998). The scheme allows the horticultural businesses in this arid area to flourish, without detrimental impact to the surrounding environment or ground water levels.

Wastewater reclamation for snow-making is occurring at Mt Buller in Victoria's Alpine area after a successful trial period in 2001. This allows the resort to operate for the whole of the season (Tonkovic and Jeffcoat 2002). Wastewater reclamation for snow making purposes requires additional treatment for pathogen removal, due to the fact that humans have such close contact with the snow, and the fact that during the process of snow making there is potentially vaporisation of the reclaimed water. Reclaimed water is made into snow in North America. The objective of this process is to create an alternate wastewater disposal method, or store the reclaimed water during winter months when biological treatment is ineffective.

Reclaimed wastewater is widely used for low grade industrial purposes. Uses include; road making, vehicle washing and dust suppression. At the Port Kembla steelworks up to 20,000 m^3/day of reclaimed water is used for quenching coke ovens. Freshwater was previously used. This has allowed the water authority to defer major water supply expansion works (Anderson 1996). At the Eraring power Station near Newcastle, up to 4000 m^3/day of reclaimed water from the local sewage treatment plant will be treated before being fed into the existing demineralisation plant to provide boiler feed water. The power station will save approximately $A1 million per year in water charges while the water authority will save the cost of a 15 km transfer main required for ocean outfall (Anderson 1996).

5 DUAL WATER SUPPLIES – BARRIERS TO THEIR SUCCESSFUL IMPLEMENTATION

There are a number of dual water supplies throughout the world serving vastly differing population sizes and circumstances. In both the US and Japan there are over 200 communities being served by dual systems in parts of, or all of these cities (Okun 2002). The source of the non-potable water supply varies for each community and includes; reclaimed wastewater, stormwater, seawater, and other sources of water which are a lesser quality. Dual water supply systems have the potential to reduce potable water demand by 50% (Anderson 1996; Marks 2000). They reduce disposal of wastewater to sensitive environments and avoid technology expansion, making a substantial contribution to sustainability.

The viability of dual water supplies has been widely debated in the international water community. The three main issues requiring resolution to ensure successful implementation and viability of dual water supplies are as follows:

- *Community Acceptance* – As discussed previously in this paper, community acceptance of dual water supply systems is critical for their success, yet there has been limited research conducted on this very topic.

- *Water Policy* – There are many legal issues involved in setting up and running water reuse projects in Australia (McKay 2000) and throughout the world. Traditionally water policy has focused on technology expansion rather than conservation, often at the expense of the environment (Wolff and Gleick 2002).

- *Pricing* – It is costly to establish dual water supply infrastructure, and treatment and distribution plants. The appropriate price of recycled water has been widely debated, a balance between price incentive, and real value of the product must be struck. These pricing issues are discussed below.

Dual water systems require high up-front capital to establish the second reticulation system and second household plumbing system. This seems to be at current Australian prices an extra $A1400 to $1750 per allotment at Mawson Lakes. Currently, a 600m^2 block at Mawson Lakes costs $A100,000 on average and a traditional home costs between $A170,000 and $200,000 on average to construct. This is a small additional cost for the individual, but the community saves much more in the avoidance of capital costs, community opposition to dam building, and costs to the environment. The high upfront cost of dual water supplies can be off-set by long term savings, which include; avoidance of technology expansion, reduction in waste disposal treatment costs and benefits to the environment. The public knowledge and acceptance of these long-term benefits is important for supporting projects with high upfront cost.

Okun (2002) believes that while at first glance dual water supply systems might seem costly, several factors common to many cities have made them economically attractive. These factors include;

- Obtaining additional water is generally far more costly because new sources are usually distant – earlier sources having already been developed.

- Reuse of wastewaters reduces the costs of the treatment required for discharge to receiving waters.

- Nutrients in reclaimed water are beneficial for irrigation

- Dual supplies allow urban growth while reducing potable water demand.

In the City of Irvine California, new developments must be built with dual water supply systems for landscape irrigation. Despite initial investment in infrastructure for the system, the dual reticulation has been economically beneficial for users. Sewer charges have been lowered by 36.5% over several years and reclaimed water is sold at 90% of the price of domestic potable water (Irvine Ranch Water District 1994). A tiered water pricing system is predominantly used in California, imposing higher tariffs for higher consumption. The price of reclaimed water is highly variable throughout California, ranging from 75% to 100% of the potable water price. interest loans, tariffs, and property taxes (Byrnes 2000).

There are three well known dual water supply systems in Australia, they are; Rouse Hill and Olympic Village in Sydney and Mawson Lakes in Adelaide. The 2000 Sydney Olympic Village in Newington has a dual water supply, amongst other ESD features. Wastewater and stormwater from the suburb is filtered and treated prior to distribution to residential allotments, commercial buildings, and parklands through the lilac dual reticulation system (Taylor 2003). This recycled water is used for toilet flushing, garden watering, and washing cars. At Newington the recycled water currently costs $A0.775 per 1000 litres, this is 15 cents cheaper than the potable water supply (New South Wales Government 2003).

Rouse Hill is a new residential subdivision north west of Sydney with a dual water supply. The first stage of this development incorporating 12,000 dwellings has recently been completed. The dual reticulation system distributes reclaimed wastewater for non-potable purposes including toilet flushing, car washing, garden watering, fire fighting and park and open space irrigation. The system was installed to reduce potable water consumption and reduce the environmental impact of the population on the major river system nearby which is use for recreational and industrial purposes (Law 1996). At Rouse Hill the cost of recycled water is

$A0.27 per 1000 litres, this is 65 cents cheaper than the potable water supply (Independent Pricing and Regulatory Tribunal of New South Wales 2000). Households are required to pay an annual fixed charge for access to recycled water and drainage services in addition to applicable charges for potable water.

As can be seen from the above dual water supply examples, the volumetric cost of reclaimed water is highly variable. This high variability may be due to factors such as treatment plant location, treatment level, varying energy costs, and government subsidy. For projects to be viable they must always recover full costs. In instances where government subsidies ensure the cost of reclaimed water is competitive with potable water costs, it is often the case that the true cost of potable water is not being recovered. This cost can be calculated when factoring in the cost of imminent technology expansion, alternate source creation and environmental degradation. Reclaimed water infrastructure costs are often met through government bonds and grants, low

6 DUAL WATER SUPPLY AT MAWSON LAKES

Mawson Lakes is a greenfields development in South Australia, with a dual water supply. The development is a joint venture between the South Australian government and private industry (Delfin Lend Lease Consortium). It derived from a more extensive Commonwealth Government project called the Multi Function Polis, a concept originating in the 1970's initiated by the Japanese Government. MFP Adelaide was seen as opportunity to demonstrate environmental challenges at this site and others could be overcome with new environmental management techniques (Hamnet 1998).

The National Capital Planning Authority were commissioned to develop urban design principles for the MFP, their work triggered debate about the future of Australian cities and urban consolidation. The Authority suggested a linear plan, with higher density, the promotion of walking, cycling and public transport use, and the development of water features and an urban forest. The MFP unfortunately failed to gain public acceptance in South Australia because of weakening federal and international support and fears by the local community relating to the creation of a Japanese enclave (Parker 1998). The purpose of the MFP was never well defined. It's failing damaged Australia's reputation internationally as not being able to deal with major projects - except for sporting ones (Hamnett 1998). Having said this, the MFP concept proved to be a catalyst for a series of environmental projects in South Australia, including the Barker Inlet wetlands, and the Virginia Pipeline Scheme.

Mawson Lakes is located 12km from the Adelaide central business district. In March 2003 there were 570 occupied dwellings with a population of approximately 1,500 residents. In 2010, the Mawson Lakes population is expected to total 10,000 residents, 10,000 workers and 5,000 students. The Mawson lakes development has a mandate to develop and incorporate a number of benchmarking innovations including water cycle management and an energy conservation system. An encumbrance on title requires the population at Mawson Lakes to install a dual water supply system in their house at the time of construction. The installation of this dual water supply system must conform to South Australia's Reclaimed Water Guidelines.

The dual water supply encumbrance requires homes at Mawson Lakes to be connected to a non-potable reclaimed water system in lilac pipes and taps in addition to the normal potable mains. Reclaimed water will be sourced from stormwater and wastewater generated by the Mawson Lakes development. Wastewater from the development will be transported to Boliver (8km away) and treated in a wastewater reclamation plant to Class A standard. The reclaimed water will then be transported back to the development for reuse on the residential allotments, for irrigation of public open spaces, and for lake top-up. Stormwater will be harvested from the development, and following primary screening will be renovated through a series of engineered wetlands. The renovated stormwater will be mixed with the reclaimed wastewater prior to

being distributed through the dual water supply system. Aquifer Storage and Recovery (ASR) will be used to balance supply and demand. Reclaimed water will be used on the residential allotments for toilet flushing, garden watering, and car washing. At present mains water is being delivered through the recycled water taps until construction of the reclaimed water system is complete, which is expected to be at the end of 2003.

The recycled water at Mawson Lakes is proposed to be cheaper than the potable water. Information provided by the developer to potential buyers, informed them the dual water supply will be cost beneficial for them. The developer published information stating that while there will be additional building costs associated with the system installation, they anticipate the residents will benefit from on-going cost savings through the availability of recycled water at a lower cost. The actual cost of the reclaimed water has not yet been finalised or disclosed. It is expected the potable supply will attract the supply charge, but in order to keep the total bill lower the reclaimed supply will not have a supply surcharge. The bill for water from this meter will then actually reflect water use in the toilets and external use very clearly. This however, assumes that people will use the same volume of water as without the dual water supply. The cheaper price of the reclaimed water may indeed encourage wasteful water use on lawns etc. It may also encourage some people to use the reclaimed water for clothes washing or other applications. Our long term study will address these issues and the characteristics of the people who adopt these differing behaviours.

7 FUTURE WATER REUSE RESEARCH AT MAWSON LAKES

A benchmark survey of the Mawson Lakes population was conducted in September 2002, prior to the commencement of reclaimed water use. At the time there were 347 occupied households at Mawson Lakes. 136 of these households were surveyed. Surveys were conducted via the telephone by a professional research company. The survey included open-ended questions regarding proposed use of reclaimed water and a series of 21 attitude and perception statements, answers to which were recorded on a likert scale of 1-5. Broader questions about their reasons for moving to Mawson Lakes, their attitude to environmental protection, and community issues of most concern to them were also covered.

Focus group sessions with key stakeholder groups will be held mid 2003, prior to the reclaimed water use commencing. During the commencement of reclaimed water use, residents' water usage pattens will be observed. After the reclaimed water has been in use for a period of time, a follow up survey of the residents will be undertaken, comparing results with the benchmark survey. Community concerns/issues with the scheme will be identified, as will positive attributes of the scheme and room for innovation. Perceptions of price relativities when compared to potable water will also be explored. We anticipate that this future research will yield fruitful results.

8 RESULTS OF BENCHMARK SURVEY

The benchmark survey provided interesting and useful results about the Mawson Lakes community and their attitudes to a number of water reuse issues including; their willingness to use reclaimed water for various uses, and their willingness to pay for reclaimed water. Trends in response were found between age groups, gender, highest education level and family composition. The strongest trend observed were between age groups which has implications for water policy developers. A summary of the key findings is now presented.

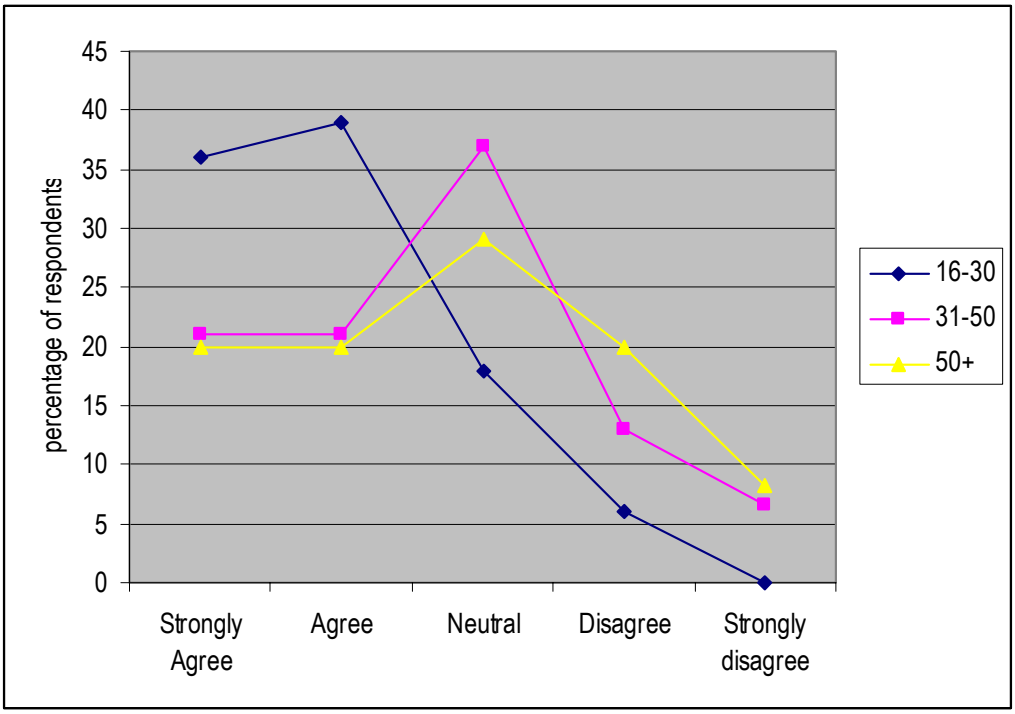
- The dual water supply ranked 11th of 12 factors contributing to the respondent's decision to live at Mawson Lakes. This indicates the dual water supply system was a low priority in the residents' decision to live at Mawson Lakes. The top three contributing factors were the close location to wetlands and parks, the overall location,

and lifestyle. While it was surprising the dual water supply was not a major factor in the respondents' decision to live at Mawson Lakes, it indicates the Mawson Lakes residents surveyed are representative of the general Australian population, not a bunch of environmentalists. While ranking only 11th, there is still strong support for the dual water supply system, when asked whether they would prefer the water system at Mawson Lakes to be standard ie no dual supply, 62% disagreed.

- As was shown in Graph One, 99% of the respondents were supportive of reclaimed water use on the lawn, support dropping to 50% for clothes washing and only 3% for drinking purposes. In relation to reclaimed water use for clothes washing, an additional 30% of the respondents were unsure of their response with only 20% unsupportive of the use. This may have significant water policy implications. Once the residents are comfortable using reclaimed water use, they may well wish to use this water for clothes washing purposes, as the above results suggest. A policy implication of this is that regulations would then need to legitimise the provision of lilac taps (delivering reclaimed water) in laundries. A recent Australian Study has shown that 26% of an Australian household water use is in the laundry (Loh and Coghlan 2003). Reclaimed water use in the laundry would make a significant contribution to reducing potable water use.

- Questions about the price of reclaimed water were included. The respondents were asked if the potential to save money associated with the dual water supply contributed to their decision to live at Mawson Lakes, to which the response was neutral. They were also asked if the environmental benefits of the dual supply were more important than financial benefits. Respondents quite strongly disagreed with this statement, and there was a significant difference in response between age groups. Younger respondents (18-30 year old) more strongly agreed the environmental benefits of a dual supply system outweigh the financial benefits (chi square = 10.107 asymp. sig =0.006). The results are show in graph two below. It will be interesting to see whether the response to these questions will vary once the price of the reclaimed water is finalised and reclaimed water use has been established for a period of time. With this result and numerous others displaying trends between age groups, there may be implications for water policy developers.

Graph Two: The age attribute in response to statement 'environmental benefits of the dual water supply are more important than financial benefits'



- Results indicated that the members of the Mawson Lakes community surveyed were not concerned about having to use recycled water to flush toilets. 81% of those surveyed indicated they strongly disagree with the statement 'I am concerned about having to use recycled water to flush the toilet.' It will be interesting to see if the response to this question alters after the reclaimed water use commences. A study in Denmark trialling the use of grey water for toilet flushing found the community were concerned with bad smell and colour of the water in the toilet bowl (Albrechtsen 2002). This may be a source of future concern for the community, and if so may indicate to the reclaimed water supplier that total dissolved solid (TDS) levels will have to be lowered and other quality levels altered to suit the customers' expectations. This may have cost and policy implications.

- The respondents were asked if they felt well informed about the dual water supply. Results indicate that the community's knowledge of the dual water supply scheme is not overwhelmingly strong. Studies have found that a community's acceptance of water reuse increases as their knowledge of the scheme increases (Nexus Australia 1999). Advice has been given to the developer indicating that further community education about the dual water supply system would be beneficial. Our further work will assess the role of education to the Mawson Lakes community's attitudes to reuse.

9 CONCLUSION

Dual water supplies have the potential to play an important role in reducing demand for potable water supplies and achieving sustainability. At present there are a number of barriers to successful implementation of dual water supply systems. They have been identified in this paper as being price, policy and community acceptance. These issues are not insurmountable, with more examples to draw from, and careful planning there is capacity for them to be resolved.

Results of this benchmark survey of the Mawson Lakes population provide interesting information to water policy developers. Results of particular interest discussed in this paper include a trend in the age attribute, and the potential interest in reclaimed water use for clothes washing and other uses not yet legitimised.

Results of this survey indicate support for reclaimed water use significantly decreased as the proposed use became increasingly personal. Results indicate that Mawson Lakes residents are positive about the immanent reclaimed water use for non-potable purposes, but are not yet prepared to accept reclaimed water use for potable purposes. Results also indicate that further education of the Mawson Lakes residents about the dual water supply would be beneficial.

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