Strategies for achieving optimal potable water conservation outcomes – a Sydney Case Study

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An essential part of sustainability in any city is to ensure that the city is living within the region's natural water resources. 500,000 new homes will be needed in Sydney in the next 20-30 years substantially increasing water demand. Also, a combination of factors means that Sydney's centralised water supply is likely to decrease rather than increase in the next 20 years. Thus, a decreasing centralised water supply and increasing water demand necessitates the need for Water Sensitive Urban Design (WSUD) and integrated water management. This paper outlines how urban growth and renewal can adopt sustainable water practices using two distinct but interrelated strategies. The first strategy is to optimise the strategic planning that occurs at different levels of government. The second strategy is to optimise the physical relationships between the built form and water usage.

1. INTRODUCTION

> *One of the greatest wants of Sydney is water. Some parts of the town are supplied by carts from a tank in Hyde Park, brought there from a swamp several miles distant by tunnel. This swamp, it was expected, would afford a supply sufficient for a population of 20,000: the population, however now borders upon 30,000 and in many cases a lack of that first of comforts is apparent*. (Hood, 1843)

Sustainability of water supplies and wastewater disposal has never been achieved by Europeans from the moment they established a colony in Sydney Cove in 1788 to the present day. While the sustainability of water supplies was never far from the settlers' mind, sustainable solutions were never adopted. Sydney Cove was chosen for settlement because of a stream of freshwater for drinking and agriculture. However within two years storages were needed due to demand exceeding supply. The first storages built in Sydney were three tanks carved into sandstone on the corner of present day Spring and Bond St. The stream became known as the "Tank Stream".

Concerns over the water quality of the Tank Stream were raised as early development impacted on the catchment area of the Tank Stream. In the Sydney Gazette in the early 1800s the following order appeared -

> "*If any person whatever is detected in throwing any filth into the stream of fresh water, cleaning fish, washing, erecting pigsties near it or taking water out of the tanks, on conviction before a magistrate their home will be taken down and forfeit 5 pounds for each offence to the orphan fund*"

The Tank Stream served as Sydney's major water supply for 40 years until 1826. The water quality of the tank stream had degenerated "into an open sewer" as sewerage was discharged directly into the Tank Stream (Sydney Catchment Authority (SCA), 2004).

Hence, key water supply issues for Sydney were evident from the first years of European Settlement. Reliability of supply, protection of the potable water catchment, water quality and wastewater services all impacted on the sustainability of Sydney. The problem was "solved" in 1826, by taking water further from the settlement. Lachlan Swamps, in present day Centennial Park, was connected to the settlement by Busby's Bore – a 3.6 km tunnel carved out by convict labour. However as Hope (1843) discovered population had already outstripped reliable supply. Sydney's temporary solution in 1826 was "solved" in 1852 with the Botany Swamps, in the 1880s with the diversion of flows from the Upper Nepean into Prospect Reservoir, and in the 1940s and 50s by the construction of Warragamba Dam. In all cases the solution was to expand the supply of Sydney. The issue in the 1820s, 1850s, 1880s and 1940s is the same issue of sustainability that faces Sydney today. A rethink is needed not only for the management of large scale water supplies but also the relationship between the urban built form, water use and local water cycle management. This paper looks at some of the strategies that can be used for optimal potable water conservation and are broadly divided between local technical strategies and regional strategic planning.

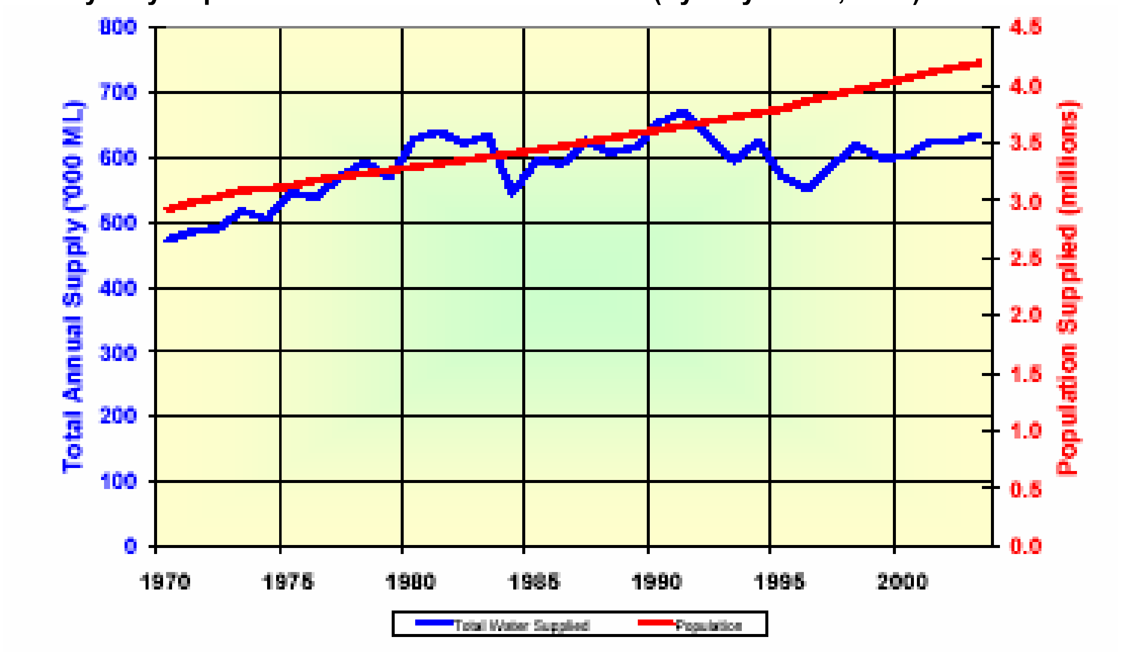
2. SYDNEY – A SNAPSHOT

Sydney, population 4.1 million, is currently experiencing significant growth. Sydney's population increases at a rate of 50,000 people per annum and is expected to reach 4.8 million in 2021 (Westacott 2003). This corresponds to the addition of 26,000 new dwellings a year to the 1.44 million existing dwellings (Knowles, 2004). The need for more housing dwellings has been exacerbated by the decreasing household size, typified by such demographic groups as the "empty nesters".

This growth will be incorporated into greenfield areas in the south-west including Bringelly where a "mini-city" of 300,000 people, or a city the size of Canberra, has been proposed (Nicholls, 2004) and the north-west sector where up to 60,000 lots are being considered for release (Shelter NSW, 2003). Driven by the NSW State Government's policy on containment embedded in State Environmental Planning Policy (SEPP) 53, 70% of development over the last ten years has been the infill of existing areas, particularly in Sydney's inner city. The NSW Government set a target to have 65% of new homes built in multiple unit dwellings. Currently this split between infill and greenfields is being reviewed (Nicholls, 2003). However, it can be expected that higher density housing will continue for some time due to current Government direction on transport planning and other social services. This style of development will need to adopt specific WSUD strategies to ensure long term sustainability.

Currently Sydney's demand for water is 635 GL/yr. The demand and population trend can be seen together in Figure 1. The safe yield of Sydney's Water supply is determined by the conditions set in the Sydney Catchment Authority's operating license and is currently set at 600 GL/yr. Hence, Sydney's demand is 35 GL/yr than its current safe yield.

Figure 1 Sydney Population and Water Demand trends (Sydney Water, 2003)



Approximately 70% of metered water is used for residential purposes and equates to 825 litres per person per day for a single household dwelling and 495 litres per day for an apartment dwelling (Sydney Water, 2003a).

More than 70% of Sydney's water supply discharges as wastewater directly to the ocean predominantly through the deep ocean outfalls of Malabar, Bondi and Manly (Sydney Water, 2003b). The majority of Sydney's wastewater only receives primary treatment. Two percent of Sydney's wastewater is reused and this includes residential reuse schemes, industrial reuse schemes, and agricultural reuse schemes (Sydney Water, 2003b).

3. STATE AND REGIONAL PLANNING STRATEGIES – A SUMMARY

In March 2002, the NSW Environment Minister Bob Debus announced the "indefinite deferral" of the construction of the Welcome Reef Dam (SCA, 2002). This "deferral" is the single biggest driver, at a state level, of water conservation and sustainable water use in the Sydney region. Unlike the 1820s, 1850s, 1880s and 1950s Sydney is attempting to cap its potable water use – albeit "indefinitely". Significantly the announcement was made when Sydney was above its safe yield. This measure cannot stand alone and if it did it would be simply like tightening the belt to reduce weight. Sydney's water supply management is at a critical point and new solutions from water efficiency to alternate water supplies are being listened to with a favourable ear.

Coupled with increased demand, environmental flows need to be considered to maintain the health of the Hawkesbury-Nepean river system. A release of 20% translucent flows and 80 percentile transparent flows would reduce the current safe yield of Sydney's water supply to approximately 450 GL/yr (Smith, 2003). Environmental flows may be less than this but will still reduce the safe yield to 500 GL/yr (Woodford, 2003). Already, the Minister for the Department for Energy and Utilities and Sustainability (DEUS) has already suggested this may be "a bit ambitious". If it is not politically unpalatable half of this shortfall can be met by increasing the probability of water restrictions from 3 days out of every 100 to five or even 10 days out of every 100 days.

The state government has set two general measures to help Sydney reduce water use. The first was Sydney Water Corporation's (SWC) Operating Licence which states that:

> *Sydney Water must take action to reduce the quantity of water (other than re-use water) it draws from all sources to … 329 litres per capita per day by 2010/2011 (being a reduction of 177 litres per capita per day or 35% from the 1990/1991 baseline)* (Sydney Water, 1994).

SWC thus has responsibility and leadership of water conservation in Sydney. No particular funds were earmarked by the government for SWC to provide this although the Independent Pricing and Regulatory Tribunal (IPART) (2003) confirms that "the Tribunal's pricing decision ensure it (SWC) will have sufficient revenue available to meet these commitments". SWC responded, five years later, with a Demand Management Program (DMP) and this will be discussed in more detail in the following section.

Once it was identified that Sydney and, in particular, SWC was not on target to meet its Operating Licence target the government established a Chief Executive Officers (CEOs) Taskforce and a Water Expert Panel (WEP) to deal with Sydney's "insatiable" demand for water. The Water CEOs Taskforce chaired by the CEO of the former EPA is to develop a Sustainable Water Strategy (SWS) for Sydney (Sydney Water, 2003a). With this taskforce the responsibility for Sydney's sustainable water supplies has started to shift. The SWS looks at a range of options including an extension of efficiency options, various effluent reuse projects, pricing reform, desalination and Shoalhaven transfers (Sydney Water, 2003).

One of the most significant proposals that is emerging from the SWS is the idea of a Water Efficiency Trading Scheme (WETS). The basic premise is that when demand exceeds the safe yield SWC would be required to pay a much higher cost for water – up to the retail cost of water (Schott, 2003). This would provide up to $30 million annually based on current excess demand and current retail prices. This provides a source of funding for private tenders (including SWC) to competitively tender for water conservation projects which would return guaranteed water savings. Projects that have been suggested that could be implemented include bulk stormwater capture and leakage reduction.

At the same time that Minister Debus announced the policy of indefinite deferral of Welcome Reef Dam in Sydney he also announced the formation of a WEP to examine a "total water cycle approach" to managing Sydney's future water supplies (SCA, 2002). The expert panel's jurisdiction includes the three streams of the urban water cycle.

By October 2004 all new buildings in Sydney will need a Building Sustainability Index (BASIX) Certificate. Under BASIX the NSW Government has set a target of 40% reduction of mains water compared to an average single or multiple lot dwelling (DIPNR, 2004). Significantly BASIX will not allow off site water reductions to be counted for sub division developments (David Eckstein pers.

comm.). Thus the 40% reduction must come from any measures that the development implements *on site*. Any measures to reduce potable consumption off-site (eg wastewater reuse for nearby golf course, playing fields, agricultural area) will not be given any credit under the 40% reduction. This seems inconsistent with the market based trading philosophy in the WETS scheme discussed above.

The Government has also revised SEPP No. 4 to increase the number of cases where installing a rainwater tanks is exempt from development consent. This has been combined with a rebate program by SWC for the installation of rainwater tanks. As a side note, DEUS also manages a webpage with a few comments on the advantages of rainwater tanks.

SWC over the last 10 years has had the major responsibility for water conservation at a regional level. SWC chose a ‘minimal approach’ for the first five years relying on changes to billing practices, two part tariffs and water restrictions (IPART, 2003). It was only in 1999 that a DMP was developed with a five year budget of $80 million (ISF, 2004). The program has been based on a Least Cost Planning (LCP) Model developed by the Institute for Sustainable Futures (ISF) in collaboration with SWC and with ongoing development by SWC. The LCP model is a decision making tool allowing alternative options to be ranked by the cost of the project per kL of water saved (White, Milne and Riedy, 2003). While allowing for assessment of other variables such as energy use, stormwater impact, or community acceptance, the difficulty in quantifying these measures has meant that the emphasis of the assessment has been on $/kL. Thus the decision making process is based on the least net present value (NPV) of the project cost to provide the greatest NPV water savings or what ISF refers to as “picking the low hanging fruit” (White and Mitchell, 2003). The least cost planning model has consistently shown that water efficiency measures are the best value options to implement and thus SWC have adopted water efficiency as a major component of the DMP.

While the LCP model is criticised as being fundamentally flawed in its assessment (Coombes, 2003) it is difficult to argue against the first maxim of *reduce, reuse and recycle*. Water efficiency is simply source reduction by another name. Source reduction has many other potential benefits including reduced energy use and reduced wastewater flows. Source reduction also has flow on benefits throughout the whole water infrastructure system and in general should be pursued aggressively before any source expansion. SWC has implemented a wide range of initiatives under the DMP that fit into the category of source reduction including residential indoor retrofit, residential outdoor water efficiency, active leak reduction and business efficiency.

Significantly the Water CEOS have also adopted the fundamental approach of the LCP model. SWC is actively engaged in evaluating the options tabled by the Water CEOs using the LCP model (Sydney Water 2003a). Thus the decision making framework is similar in both strategies and would be expected to give similar results.

SWC, as well as others, have also advocated price reform. SWC’s view is that “retail price restructure is essential to achieve a sustainable water demand/supply position for Sydney” (SWC, 2004). SWC supports the introduction of higher tariffs for water usage for all customers and/or “an inclined block tariff”. WSAA (Sydney Water, 2004) research supports the idea that price increase reduces demand as price inelasticity for water is in the order of -0.3 for an increase in water tariffs of 0 to 40%. Out of all the tariff models, including excess usage charges, seasonal charges and environmental charges, SWC supports a step priced increase for domestic customers at 300 to 400kL to target the 20% of users who use more than 40% of Sydney’s water.

4. STATE AND REGIONAL PLANNING STRATEGIES –WAYS FORWARD

Sydney needs a framework that should shape the decisions that are made about how Sydney can reduce its water demand. Sydney as yet has no single plan for the development of a sustainable water management strategy. Sydney Water has a DMP which tries to achieve with limited money the best water savings it can achieve. Yet this has not been enough. The Water CEOs of the various state departments were called in and they have delivered a range of interesting options and attempted to put dollars and water conservation numbers to those options. Again this has not delivered an overarching framework that determines what project options may be necessary and when they will be necessary.

4.1. Outline of an Overarching Framework

As a city, the first step is to understand the residential demands in better detail as they are the major driver in increased water usage. A number of water demand scenarios should be compared to the existing situation. The existing situation is currently being mapped out by SWC. However more detailed metering information is required to verify the water usage break down by appliances and fixtures, and garden and other outdoor uses.

Based on the maxim of reduction at source, a number of scenarios can be developed. These would include a range of efficiency options of water saving devices and fixtures including showers, taps, dishwashers, and clothes washing machines. These scenarios can be applied to new dwellings and existing dwellings.

Indoor water efficiency, can be achieved by mandating water efficient appliances as has been done for 6/3 dual flush toilets. Only AAA+ appliances should be sold in NSW and this is a natural continuation of the work done by the National labeling program. To accelerate the program income-based financial rebates and incentives can be provided. If this turnover is not sufficient to reduce water demand the program can be accelerated by requiring water efficiency, similar to BASIX, when houses are sold or as a requirement of a Development Application. Older appliances, especially washing machines, could be part of a buy back scheme and removed from the housing stock.

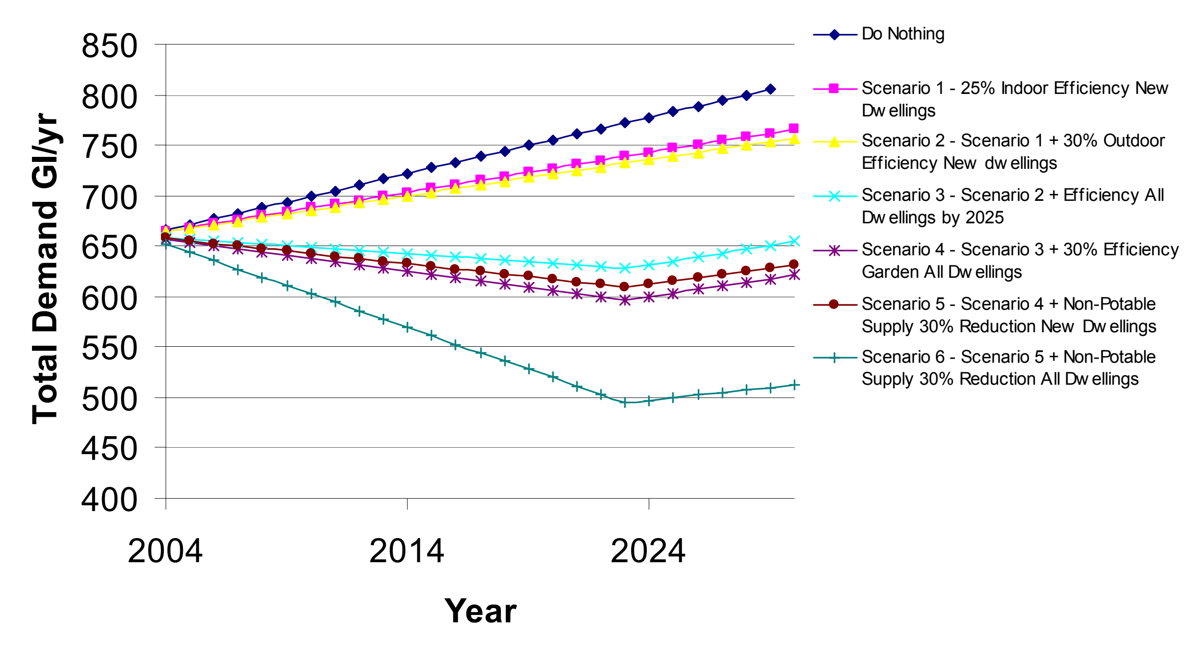
A second scenario can be based on targeted reductions in outdoor water use. There are a variety of options that can achieve this target from planting natives to xeroscape planting to more efficient garden irrigation systems to pricing reform and mandatory water restrictions. Due to the variety of options which could be used and different community preferences the best way to present these options at a broad level is as a target of 10%, 20% and 30% reductions for outdoor garden water use. This can be applied to new and existing dwellings also.

Delivering outdoor water efficiency gains is pricklier and requires a more comprehensive system to provide water efficiencies. Blanket schemes such as stepped pricing reform and mandatory water restrictions will be the most comprehensive, reliable and immediate. Waterwise gardens and native planting requires a shift in cultural patterns and aesthetics. These aesthetics have a significant inertia and thus changes will be more likely to occur in the medium to long term.

The next scenario involves a mandatory non-potable supply for toilet flushing and garden irrigation. This is based on an assumption that any external increase of supply, such as increased Shoalhaven transfers, desalination or extraction from groundwater, is less sustainable than reusing or recycling. This leaves a suite of options for increasing supply by the means of providing a non-potable supply of water for appropriate uses. The “low hanging fruit” in terms of a non potable supply are new dwellings. With the implementation of BASIX from 2004 onwards, all new dwellings will require a non-potable supply to meet a 40% reduction. However by 2020 this will still leave the majority, approximately 65% or 1.5 million dwellings, with mains water for all uses. A scenario has been postulated that requires all existing dwellings to have a non-potable supply phased in over 20 years.

A preliminary analysis of the impact of these residential scenarios on Sydney’s water balance is shown in Figure 2. They have been projected into the future for the next 25 years, a typical planning horizon for large scale infrastructure investment. The scenarios are additive and hence Scenario 2 includes Scenario 1 and so forth. There have been a number of simple assumptions made for this assessment. The current demand is taken to be 825 L/d for single dwellings and 495 L/d for multi-units (SWC, 2003a). Industrial, commercial, leakage and government use is assumed to be constant over time. Indoor efficiency is assumed to give a reduction of about 30% while a 30% reduction for outdoor efficiency is also plotted. The efficiency scenarios 1 to 4 show that efficiency will not be enough to reach even the current safe yield. Plotting the third level of options – a second non-potable source assuming a 30% demand reduction of an efficient dwelling (to replace toilet flushing and most irrigation use) use shows that this has a small impact. If all dwellings were to be retrofitted (at substantial cost) it can potentially reduce the demand to 500 GL/yr in 20 years. However after this point the demand starts to creep up as population increases and no more gains can be made by retrofitting existing houses.

Figure 2 Sydney Demand Scenarios



What is readily apparent when discussing strategies for large scale urban areas such as the city of Sydney is that decision making rapidly becomes complex. A quick analysis of processes involved in Sydney's two most significant strategies, the DMP and SWS, shows that the current decision making process is far from adequate. The DMP uses a least cost planning approach and SWC (2003a) claims that it is

> *current best practice in resource management as it considers demand management solutions equally against options to increase supply capacity. It also takes into account all significant tangible costs and benefits, including non-market impacts where possible.*

The key to this statement above is "where possible". It is not possible to evaluate the tangible benefits and costs of building a low $/kL option, and hence least cost, such as the Welcome Reef Dam with a medium $/kL reuse option such as Georges River reuse pipeline. Is it possible to compare the sustainability "disbenefits" of the Shoalhaven being dammed and the ecological benefits of reduced effluent to coastal marine environments? The situation becomes even more complex when "total water cycle planning" is considered because not only does the Georges River improve water conservation it also solves a capacity problem in the Malabar sewage treatment system, by increasing capacity of the sewer network. Hence this makes any comparison on the cost of the project difficult. Is it possible to portion out the cost of the project 50% wastewater project and 50% water conservation project and hence halve the $/kL of the Georges River project? Is it possible to determine the percentages and what do they actually mean? Can other significant benefits of a reuse pipeline such as the avoidance of sewage overflows, which will cost Sydney Water $2 billion over the next 20 years, be incorporated (Sartor, 2003). Overflows are so significant that more is spent on average in one year than in 5 years expenditure for the DMP. Large capital outlays and the impact of debt servicing is also another significant cost that needs to be considered.

Another significant difficulty in least cost planning is that the analysis of options requires a good estimate of capital and operating costs. For options that are unfamiliar, unknown and unproven this is difficult. For example, it is very difficult to assess the cost of a decentralised treatment and reuse system for Sydney because the regional authorities in Sydney do not have any local examples to get costing information. Also, there is no industry established in Sydney to achieve this and thus current costs for decentralised systems maybe higher than if a competitive industry were established. There are also regulatory and legislative barriers to unknown and "unproven" systems further increasing the costs.

4.2. Decision Making Processes

The complexity of analyzing two different options by giving an extremely limited analysis of two options was presented earlier. But there are perhaps 10 or more regional strategies that could be considered viable options which increase the complexity substantially. These include various reuse options, such as irrigation reuse along the Hawkesbury, reuse for environmental flows, a comprehensive rainwater tank program, a comprehensive stormwater reuse program, residential wastewater reuse schemes such as Rouse Hill, and decentralised options such as greywater reuse. It also includes supply options including increased groundwater extraction, Welcome Reef, increased Shoalhaven transfers to the Hawkesbury Nepean and desalination. Currently there is no decision making tool adequate for assessing these options.

Any decision making tool needs to assess environment, social and financial sustainability in line with recent thinking on sustainability. To do this, better data collection is needed for all the significant options. Data collection needs to be broad and include energy use, impacts on aquatic water quality and quantity, and material use. On the financial side, it needs to include full costs associated with options including costs avoided due to the need downsize infrastructure or avoid infrastructure investment.

If environmental, social and financial sustainability are not integrated into decision making then Sydney's water conservation strategy will be piecemeal and inadequate to contain Sydney's water demand within safe yields. It will leave Sydney open to inappropriate "off-the-shelf" large scale solutions that can be provided by private investment companies and large international engineering organizations who promote large scale projects. The Northside storage tunnel is a prime example of this occurring in Sydney. The NSW Government is already under pressure to dilute its planning powers.

Services Sydney (SS) "an infrastructure development company" has applied for access to Sydney's sewerage services (Services Sydney, 2004). SS has put forward plans to interconnect the three large ocean outfall systems, North Head, Bondi and Malabar. A water reclamation plant and wet weather overflow storage facilities are proposed to provide advanced water treatment. In the second stage of the project tertiary treated water will be pumped back to the base of Sydney's catchment dams for environmental flows. SS also notes the potential in the long run for indirect potable reuse – similar to Singapore's "New Water" scheme. SWC rejected an offer to develop the project in partnership with SS after discussions were held. SS is now currently seeking a Public-Private-Partnership with the NSW Government and to compete with SWC for provision of sewerage services in the retail market. The proposal is currently before the National Competition Council seeking access to the sewerage system under the Trade Practices Act. Governments are swayed by these proposals because they do not have to outlay capital expenditure and they perceive that the risk of the project can be passed from the government to the private company. Considering that three major ocean outfalls provide only high rate primary treatment it is difficult to understand how SS can provide "lower cost sewage treatment facilities" and can be financially viable without substantial public investment or significant increases in retail sewerage service costs. Without a robust, valid decision-making framework in place, it will be difficult to assess schemes such as this. Combined with the current politico-economic environment Sydney may be locked into large scale infrastructure projects that are inefficient and non-optimal solutions. In terms of the actual technical detail of the proposal, SWC's inland STPs, including the Georges River STPs, seem to be a more valid option for environmental flows. These treatment plants require less treatment upgrades than the effluent at the major coastal plants. Distance wise they are also much closer to Warragamba dam, considerably reducing pumping, pipe length and energy costs.

Price reforms are an important part of strategic planning. Earlier, a discussion of SWC support for retail price reforms was described. Not surprisingly, SWC is not a supporter of a *wholesale* step tariff (Sydney Water, 2004). A wholesale tariff however is "essential" especially if combined with the safe yield. The increase in revenue should be used to fund water conservation initiatives as is proposed under the WETS scheme. However the actual administration of the WETS scheme should not be on a haphazard "first come, first served principle" based on the best that is offered by companies bidding for the work. It should be coordinated into a decision making framework based on a regional strategy. Otherwise, WETS will suffer from the same piecemeal "planning" process as the Services Sydney example above.

5. PLANNING STRATEGIES – LOCAL LEVEL CASE STUDY 1: ROSEBERY

After having discussed the strategies at a regional level, strategies at a local level will be explored. These strategies are primarily designed to harness the capacity for creating greater sustainability within a process of urban change and renewal - at the point of (re)development of land for residential housing. The strategies will be illustrated using case studies from recent experiences in implementing WSUD strategies.

Rainwater either from roofwater harvesting or stormwater harvesting from streetscapes is considered the most viable, cost effective, form of water recycling for small to medium developments. Sydney, as discussed in Section 1.1, is dominated by infill and multi unit development. For these developments a better understanding of how water savings can be achieved in terms of integrated water cycle management needs to be understood.

Figure 3 Typical development ratios for multi-storey developments

A typical ratio of roof area to number of floors and the ratio that has been used for this analysis is shown in Figure 3. As the number of floors increase, the roof area per unit decreases substantially.

Figure 4 shows the % of toilet demand met plotted against the roof area available per unit. Rainfall data used is for the Sydney CBD based on the premise that the greatest demand for multi-storey developments is in Sydney's inner city. The cutoff point for achieving a reasonable demand is approximately 20m^2/person for a 2kL storage per person which corresponds to 3 or 4 stories high. If the size of the storage is increased to 5 kL/person then 4 and 5 storey buildings can be reasonably serviced by roofwater. However there is little gain in going above 5 kL/person of storage as there is little extra return.

Figure 4 Percentage of Toilet Flushing Demand Met

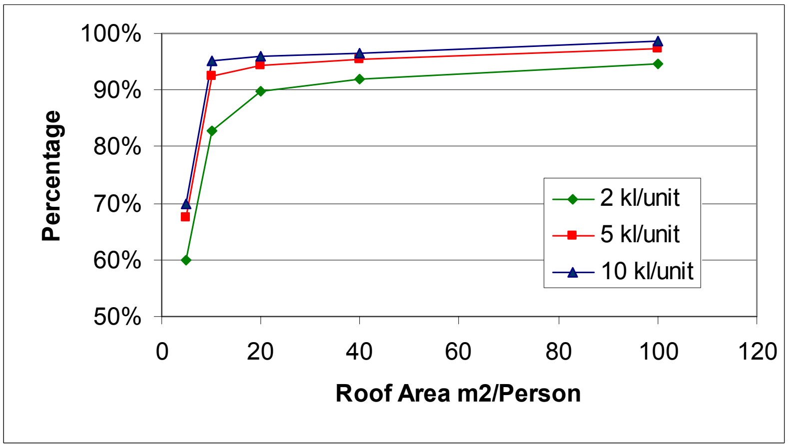
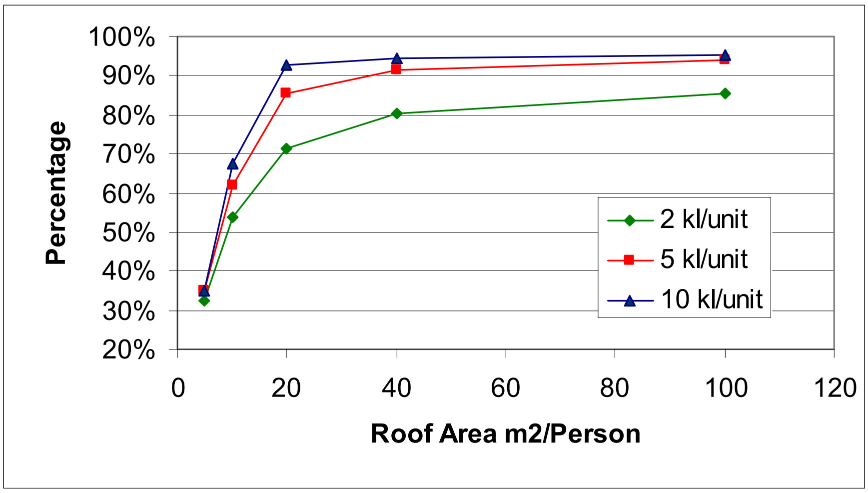


Figure 5 shows a similar analysis reusing harvested roofwater for toilet flushing and cold water laundry washing. The cutoff limit for sizing a roofwater storage is about 5 kL/unit.

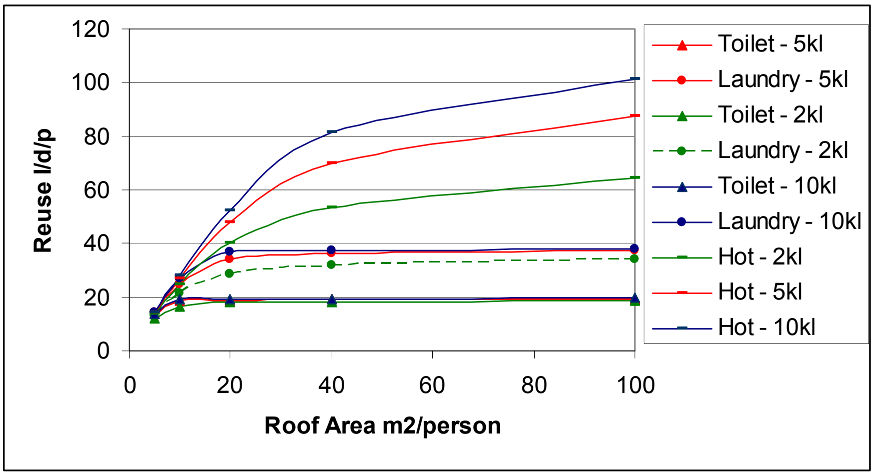
Figure 6 attempts to look at the question of what to plumb a rainwater tank into for a multi-unit dwelling. The first thing to note is that the options are cumulative. Hence the laundry option includes toilet flushing as well. For toilet flushing there is little gain for whatever scale of development in going above 2 kL/storage per unit. This graph also shows that for developments with less than 20m^2 of roof area per person there is little extra gain in water reuse in plumbing into any other use than toilets.

Figure 5 Percentage of Toilet Flushing and Laundry Water Demand Met



At about 20m^2 of roof area per person and above however there is a clear difference in plumbing water into laundry and toilets. For the relatively small extra cost of plumbing into the laundry facilities, potable water consumption reduces by a further 10 L/d for a 2kL/unit storage and about 15 l/d for a 5 and 10 kL storage per unit. Figure 6 also shows that there is little advantage in going above 5 kL/unit of storage per dwelling for toilets and laundry.

Figure 6 Reuse as More End Uses are Plumbed Into Roofwater Storage



Plumbing into all three services, (toilet, laundry and hot water) is not recommended for multi-dwelling units. The roof area per person required is about 40m^2 which is more suited to a single dwelling lower density development. For these dwellings a larger tank is recommended with at least 10 kL/dwelling.

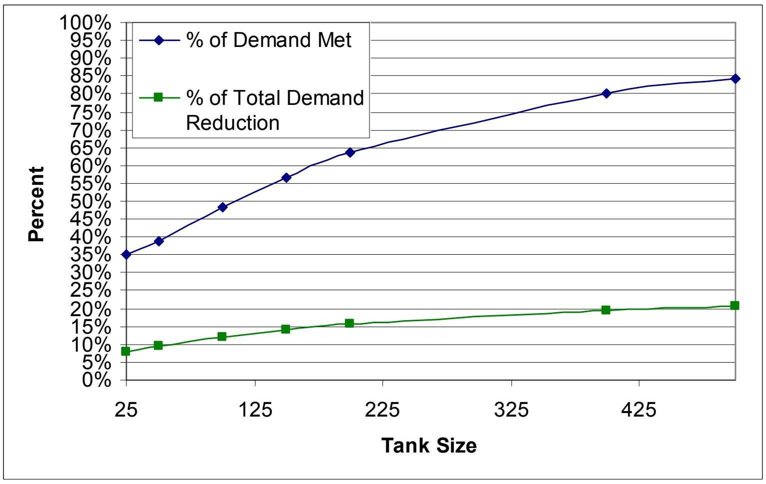
Thus the above analysis shows that around the 4 to 5 storey development a large roofwater storage will be needed or an alternate storage and supply is needed. An alternative is to use stormwater from the whole site into all the uses. A case study will be used to examine the optimum water conservation strategies for medium to high density developments.

The Rosebery site is 1.8 ha in size and will have approximately 260 units on the site with a floor space per person of about 10m^2 and is in the region where roofwater is not feasible as a secondary supply. There are a number of options for reuse for such a site.

- **Option 1:** Utilisation of stormwater and roofwater collected in the one tank for laundry and toilet flushing
- **Option 2**: As roofwater is not sufficient, treated stormwater from the whole site could be used to meet cold water for laundry and toilet flushing while roof water could be used for hot water.
- **Option 3**: Greywater for toilet and public open space irrigation
- **Option 4:** Greywater for toilet and public open space irrigation, treated stormwater and roofwater for laundry and hot water use.

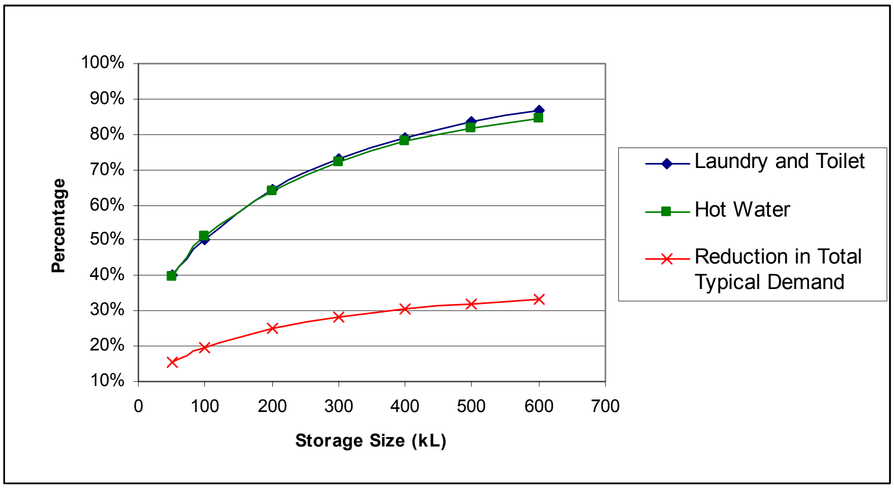
For all options it is assumed that water efficient fixtures are used while current purchasing practices are assumed to continue for washing machines. This would achieve a 27% efficiency gain compared to a typical household; using water data from BASIX (DIPNR, 2004). It is assumed that on average there are 1.8 people per dwelling.

Figure 7 Site Stormwater Reuse Optimisation Curve (Option 1)



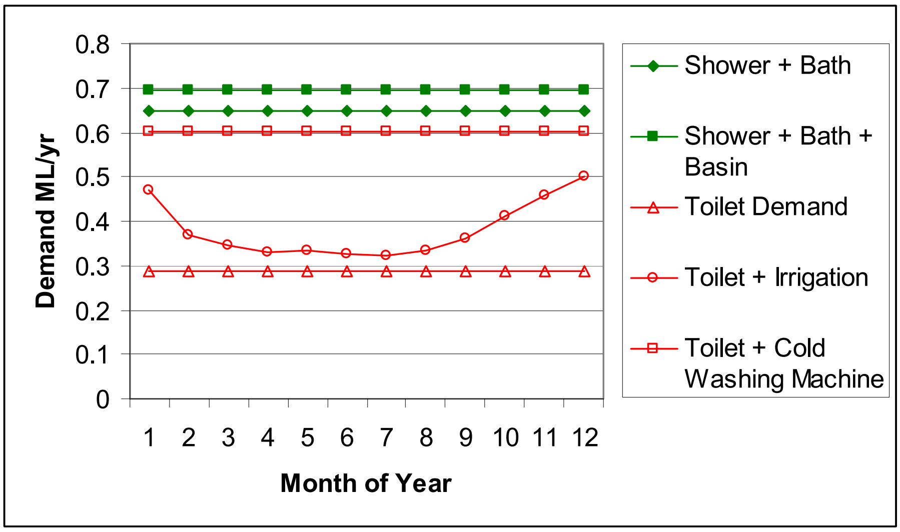
Option 1 involving the collection of roofwater and stormwater from the whole site and storing in a common storage system. The option shows that a storage size of about 125 to 150 kL (approx ½ kL per unit) will provide the required 13% replacement of potable water to meet a 40% reduction in potable water demand (Figure 7). This option could be further expanded to include garden irrigation if there was significant outdoor areas, however in this example it has been assumed that the irrigation demand is negligible compared with the household demand.

Figure 8 Roof water and Treated Stormwater Reuse Optimisation Curve (Option 2)



Analysing option 2 for optimum sizes shows that an optimum storage size for both treated stormwater and roof water is about 100 to 200 kL. This will give a reduction in potable water compared to a typical dwelling of about 20 to 25%. This development with water efficient fixtures would exceed the BASIX requirement of a 40% reduction, not including public open space demand,.

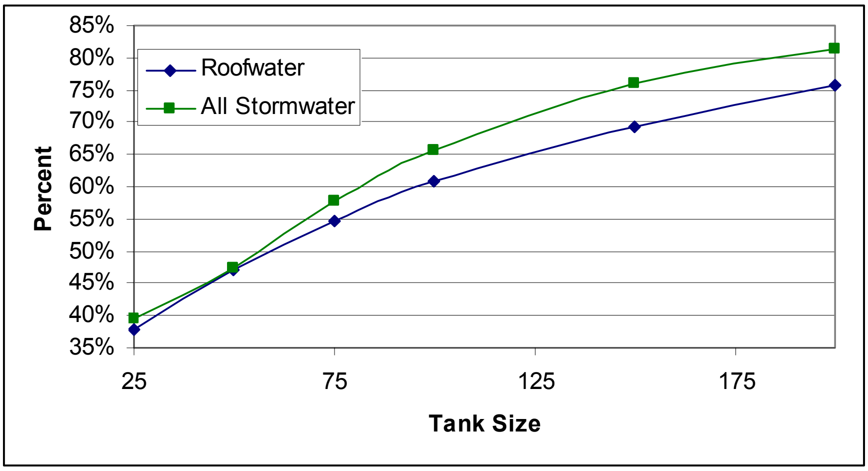
Figure 9 Greywater Supply and Demand Curves (Option 3)



An analysis of option 3 shows that there is an excess of light greywater (wastewater from the shower and bath and basin) compared to the demand for the toilet and irrigation use on site. If the majority of the shower and bathwater is collected and reused for toilet and irrigation demand on the site then an additional 15% reuse can be achieved. This option would meet the BASIX requirement for a 40% reduction. For comparison the best match of the constant greywater supply is for reuse for toilets and the cold water portion of washing machine water use. Currently there are no guidelines for laundry reuse. However the Newington development in Sydney has satisfied the

NSW Health Department that the water quality from treated wastewater is of sufficient quality for reuse in washing machines so it can be expected that greywater would receive the same approval if a certain water quality could be achieved. In all cases, shower and bathwater would be sufficient to meet the demands.

Figure 10 Optimum Tank Size for Cold Water Laundry Use (Option 4)



The fourth option would be to collect half the light greywater for toilet flushing and use a smaller rainwater tank for the cold water in the washing machine. A smaller tank size of 25 to 50 kL would allow a further reduction of 5 to 6% (i.e. ~38% of laundry demand) on the 15% saved by reusing greywater for toilet flushing. This would be a combined water saving of approximately 50% for the site.

Thus there are 4 competing strategies which are capable of meeting a 40% or greater reduction in potable water conservation. The best strategy will depend on a number of issues including the particular site, its situation within the catchment, the over-riding environmental objectives on a catchment scale and economics. Over-riding principles include the principle of water fit for purpose - the lowest quality of reuse water should be used for the least risk water reuse application.

6. PLANNING STRATEGIES – LOCAL LEVEL CASE STUDY 2: PRINCE HENRY

There are competing demands at local and catchment levels for the use of rainwater. Through the use of another case study at Prince Henry (PH) in the eastern suburbs of Sydney this paper will outline how different policies and strategies to reduce potable water can impact on optimal solutions for water conservation.

Figure 11 Prince Henry Development Site (Landcom, 2004)

Many councils have adopted mandatory rainwater tank policies in Sydney for all new developments. Randwick City Council RCC in the eastern Suburbs of Sydney is the consent authority for PH. RCC Rainwater Tank Policy (2003) requires all new developments to install a rainwater tank for collection and reuse. For single dwellings there are no exemptions and a minimum of a 2kL tank is required. For multi-unit dwellings a site specific analysis is required to identify the optimum size but is not mandatory if there are site constraints. In addition, Landcom (2004) has released a WSUD policy. The policy sets a target for 40% reduction in potable water use in comparison to the base case for typical household types. The water conservation target has also been incorporated into its Triple Bottom Line reporting process (Landcom, 2003a).

Landcom (2003a) released a masterplan for the redevelopment of the site. The site is to be a residential development for approximately 1900 people with 880 new dwellings and 100 age care 'beds'. The majority, 75%, of the new dwellings will be apartments with approximately 100 single dwellings (Landcom, 2003b). As can be seen in Figure 11 the site is adjacent to the Coast Golf Course.

The majority of stormwater from the site currently discharges to the golf course. While the golf course harvests this stormwater for reuse during periods of water restrictions, the majority of irrigation on the course is with potable water. The golf course uses approximately 65 ML/yr and wishes to increase their water utilisation to 125 ML/yr by installing a second irrigation network. The golf course has an interest in maintaining or increasing the runoff from the site to increase its ability to harvest runoff.

The new development will have a potable demand of approximately 155 ML/yr assuming an average of 180 kL/yr for apartments and 300 kL/yr for single households (Sydney Water, 2003a). The developer wished to achieve a conservation target of 40% for the site which required a reduction in water use of about 60 ML/yr.

A water strategy was developed which showed that the conservation target could be partly met by using water efficient fixtures; achieving a reduction of 20% or 30 ML/yr. The second component of the strategy involved a communal storage facility located on golf course land (leased by the golf course but owned by Landcom). Approximately 27.5 ML/yr can be saved by reusing stormwater from the PH site for irrigation of community owned lands and public owned space . A storage size of 2,500 kL is required to provide this.

The third component of the water conservation strategy was to look at water conservation on a community scale. The golf course was a significant user of water and any measure that the PH development could do to increase the supply of non-potable water to the golf course could also provide significant water conservation achievements. Thus, all stormwater flowing to the golf course, the majority of the site, is harvested and directed into two of the golf course's existing storages. Landcom is also constructing a third water storage, approximately 3000 kL, to increase storage capacity and hence its potable water conservation. Thus the golf course increases its capacity and reliability of irrigation and the savings in potable water conservation are increased.

An analysis was made on a community scale of the impacts of implementing rainwater tanks on all dwellings within the PH site. This analysis showed that there was almost no increase in the conservation of water by adopting rainwater tanks for all dwellings *on a catchment scale*. This was because any increase in reuse onsite meant that there was a corresponding decrease in reliability of the golf course harvesting and reuse capacity. Thus, as the marginal costs for increasing the golf course capacity was also much smaller than the marginal costs for providing water reuse for single or multi-unit dwellings, the use of rainwater tanks were not recommended.

However, because of RCC mandatory rainwater tank policy for single dwellings PH was required to install rainwater tanks on all single dwelling properties, despite the findings of the analysis which showed that this was robbing Peter to pay Paul.

Further problems arose when the Department of Infrastructure, Planning and Natural Resources (DIPNR) decided that BASIX would not allow community scale water savings to be applied. Its mandatory 40% saving must be only for the development under consideration. Currently Landcom is in negotiations with DIPNR about the feasibility of reusing on a community scale.

PH as a case study shows planning tools need to be flexible and adjusted to the conditions on site. Mandatory planning controls for rainwater tanks or water conservation targets while essential for drawing a line in the sand need to be flexible and consider the *scale* of reuse. Likewise, the appropriate implementation of rainwater tanks needs to be considered on a catchment scale and not simply a local or development scale. If these considerations are not taken into account there will not only be issues of equity and ownership of water, similar to those in rural areas, but also inefficient infrastructure outcomes and non-optimal water conservation outcomes.

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