INNOVATIVE AUSTRALIAN URBAN WATER SOLUTIONS FOR NEW ZEALAND

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ABSTRACT

Over the last decade in Australia, prolonged drought and increasing demand have prompted the consideration and implementation of a range of centralised and decentralised technologies and methodologies for the development of alternative water resources and demand reduction. The concept of "Fit for Purpose" water is becoming more prevalent as water users seek to apply alternative water supplies for the most appropriate use.

A series of case studies have been developed to gain insight into the drivers for potable water reduction, and the methodologies utilised for the assessment and development of alternative water sources. While these emerging techniques may not be required immediately to augment the water supply in New Zealand, they may warrant consideration in dry areas such as the Eastern areas of NZ where climate change will further impact water availability.

Potable water substitution covers demand reduction and a wide range of technological options including wastewater recycling, sewer mining, grey and black water recycling, rainwater collection and stormwater harvesting. Given the ongoing public resistance to centralised water reuse, particularly for potable applications, more decentralised options represent a promising alternative, particularly for individual water users seeking to increase the security of supply.

An open-minded commitment to long-term future planning is considered vital. Robust data collection, partnering with industry and education initiatives were also highlighted as key success factors in building a diverse water portfolio for the future.

KEYWORDS

Water recycling, water sources, decentralised water treatment, potable substitution, sewer mining.

1 INTRODUCTION

Over the last decade in Australia, climate change induced drought and population pressures have impacted heavily on traditional potable water supplies, leading to the development a range of technologies and methodologies for the development of alternative water resources. This paper outlines the key drivers for new water resources, and traces recent developments in Australia through a series of case studies. While the immediate application of these solutions may not be required to augment the water supply in New Zealand, they may open up opportunities that have not been considered to date. In particular, these solutions may provide an alternative in areas such as Marlborough, Tasman, Hawkes Bay and Canterbury where pressure on existing water resources in increasing either through prolonged drought or competition for resources.

2 THE GROWING WATER PRESSURES

Over the past decade, water storage levels in supplies to all major Australian urban areas have rapidly declined due to prolonged drought and growing demand in these areas driven by increasing development and population growth. This is typified by Melbourne where a 40% drop in dam levels was experience in 2006, a scenario forecast by CSIRO to occur under the 'severe' climate change scenario in 2050. The declining storage levels are shown in Figure 1.

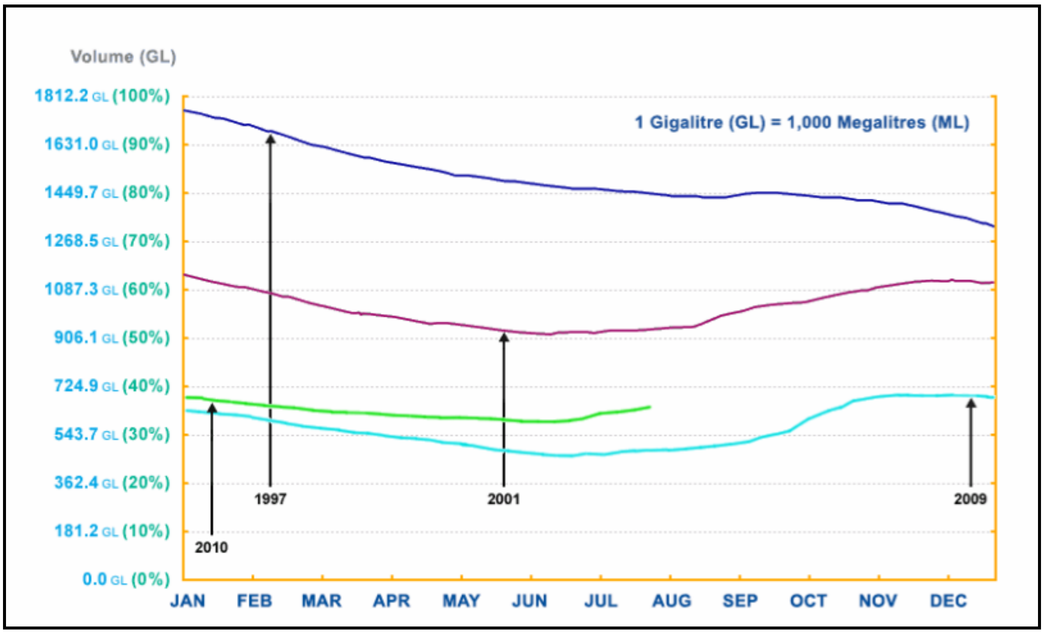

Figure 1: Melbourne monthly water storage volumes, GL (1997, 2001, 2009 and 2010) showing significant drops over the past decade (Melbourne Water, 2010).

In response to the drought, water restrictions have been implemented by the Victorian Government, and the water industry has been forced to consider and implement solutions that may have previously not been considered due to viability. The Level 3A restrictions that were in place until mid 2010 limited irrigation at private dwellings to twice weekly manual and banned car washing with potable water.

The restrictions had a significant impact on large industrial and commercial water users, in particular the irrigation of public grounds and gardens which were limited to one in four facilities on a twice weekly basis. Water authorities have worked closely with the largest industrial, commercial and institutional water users to reduce their consumption, with businesses using more than 10 ML per annum required to complete a water conservation action plan under the Water Management Planning (WaterMAP) program.

In response to the water pressures, reuse and potable water substitution has lead to the wider use of a broad range of technological options, including potable and non-potable recycling, sewer mining, third pipe recycling and stormwater harvesting. These options are discussed further in subsequent sections and key learning's are presented.

3 CENTRALISED SOLUTIONS

The pressure on water supplies in Australia has lead to the fast-tracking of large scale infrastructure solutions. The requirement for increasing potable water supplies has lead to the development of desalination plants in the major urban areas; Perth (two plants, one in construction), Adelaide (in construction), Sydney (operational), Melbourne (in construction) and Gold Coast (operational). The establishment of these plants was in response to increasing uncertainty in the established raw water supplies; however desalination is now being increasingly viewed as a vital future water resource.

Major water recycling infrastructure has also developed rapidly in Australia, including the $2.5 billion Western Corridor Recycled Water scheme in South East Queensland, which comprises of three advanced water treatment plants that provide water to local industrial users, major inland power stations and provision for indirect potable reuse via the Wivenhoe Dam. The two main Melbourne wastewater treatment facilities (Western Treatment Plant and Eastern Treatment Plant) have also been developing recycled water infrastructure that supplies irrigation and industrial water users. Research into potable supplementation via aquifer recharge is a developing area of research, although public opposition to indirect potable wastewater reuse still represents a major barrier to future schemes as evidenced in Toowomba (Hurlimann and Dolnicar, 2009).

While large-scale infrastructure has been developed over a short timeframe in Australia, it has resulted in increasing costs for consumers of water. This relates to the large capital cost of infrastructure and increased operational costs, notably due to higher energy requirements for supply. These factors are important for the future of recycled water infrastructure, as the cost is a significant co-factor with scarcity for driving alternative schemes.

Centralised infrastructure also faces barriers in developed urban areas, with retrofitting of trunk reticulation infrastructure. While new development has increasingly embraced the "third pipe" network, the location of these developments on the urban fringes can be at odds with the location of centralised supply sources. As such, several developments have sought to implement decentralised, closed-loop water schemes such as the Aurora development near Melbourne (VicUrban, 2010).

4 DECENTRALISED OPTIONS

There are a growing number of alternative decentralised water solutions that have been developed in Australia in response to increasing water scarcity and rising costs of water. Water restrictions and stricter regulations, such as those outlined in the Introduction, have mainly impacted major water users such as irrigators and industrial users. In the majority of cases, water users have sought to reduce potable water use by:

- Reduction in demand; and
- Substitution with alternative water sources.

The concept of "Fit for Purpose" water is becoming more prevalent as water users seek to apply alternative water supplies for the most appropriate use. The following case studies have been developed to gain insight into the drivers for potable water reduction, and the methodologies utilised for the assessment and development of alternative water sources.

4.1 DROUGHT PROOFING RACING - RACING VICTORIA

Racing Victoria undertook an assessment of eleven racing venues around Melbourne to investigate alternative water supply options and water management strategies (Aurecon, 2004). The study was primarily in response to the application of strict water restrictions due to the extended drought conditions, and in consideration of the potentially major impact that restrictions could have on the racing industry as a whole. Three of the courses were also listed within the top 200 potable water users in Victoria, and therefore subject to mandatory Water Management Planning (WaterMAP) requirements at the time.

The study was undertaken in two phases; a review of current practices and development of alternative sources and methods, and a detailed review of each race venue.

It was identified that total water use at the eleven courses was around 860 mega-litres per annum (ML/annum), with 650ML/annum sourced from public water supplies. The majority of water use (around 75%) was for grassed track irrigation, or dust suppression on dry tracks. Water for domestic or stabling use varied greatly between venues and was influenced by the number of race meetings, and level of training facilities.

Water conservation measures such as the planning of irrigation and use of control systems were already in use at many venues due to the requirements for good turf growth and track preparation requirements. Measures for potable water reduction, such as water-efficient fittings, were identified as more costly options that could be implemented on new buildings, or through renewal of existing facilities.

A number of alternative water sources were reviewed for each course, including:

- Rainwater/stormwater collection;
- Surface water abstraction;
- Groundwater abstraction;
- Recycled water;
- Greywater and blackwater recycling; and
- Sewer mining.

While the majority of the racing facilities had implemented alternative water supplies, drought conditions had also affected these sources through dropping storage levels and increasing salinity levels.

A framework was developed to review the alternative options, with a number of recommendations made for each specific racing venue. These schemes were then prioritised utilising a ranking system that took into account the value of the water source, and also potential wider impacts on financial loss and the racing industry at large. Favoured options included installation of on-site drainage, utilising recycled water from neighbouring schemes. Overall, 478ML/annum of savings were identified in the study that will be progressed by Racing Victoria through an overall water strategy. 60ML/annum has been saved at Moonee Valley racing club through a stormwater harvesting system and installation of water efficient fittings.

Figure 2: Waterless track installation at Bendigo Jockey Club (Smart Water, 2010a).

An example of innovation that has been developed by Racing Victoria has been the development of a waterless track at the Bendigo Jockey Club (Smart Water 2010a). The synthetic track consists of a sand, polymer fibre and wax binder mixture, and has resulted in water savings of 12ML/annum. The installation of the synthetic track had a total cost of around $1 million, with the race course estimated to contribute around $32 million to the local economy, Installation of the track was supported by Smart Water funding, a collaborative fund established by the retail water companies in Victoria to support water initiatives. Racing Victoria plans to implement this track surface at other venues around Victoria.

4.2 MONASH UNIVERSITY WATER STRATEGY

In order to meet their commitment to a sustainable environment, Monash University developed a water strategy (Aurecon 2007c) which included; a review of legal and regulatory requirements, risk analysis for non-potable water sources, and academic engagement. The strategy was then applied to six Monash campuses to comprehensively develop a series of conservation measures and alternative water supplies to reduce consumption of mains supplied water.

National and state-based regulations and guidelines encompassing stormwater, grey water reuse, recycled sewage, treated effluent, rainwater, groundwater abstraction and surface water abstraction were collated, and future requirements considered in a long-term timescale.

The risk analysis encompassed the areas of water sources (cost, availability, regulations, and perception), storage and distribution (Capex, Opex, planning, and aesthetics), end use (exposure and water quality) and management (regulations, skills/training, and implementation). Part of the risk matrix is shown below in Figure 3.

KEY RISKS & ISSUES	STORMWATER		RAINWATER		GREY WATER		RECYCLED SEWAGE	
Collection	On-site or off-site catchments. Collection structures and underground piping networks to be constructed.	M	Roof harvest. Pipe systems to be installed at down pipe collection points to direct roof water runoff to storages.	M	Separation of existing sanitary plumbing in building required to separate out toilet, bathroom and kitchen outflows from usable grey water.	H	Sewer mined from on-site sewer or nearby main. Package treatment unit is required and pipe network to storage to be constructed.	M
Storage	No restriction on storage time. Stormwater may be stored in a tank either above or below ground. If above ground, stormwater may be stored in a dam or a lake.	L	No restriction on storage time. Rainwater may be stored in a tank either above or below ground. If above ground, rainwater may be stored in a dam or a lake.	L	No long-term storage allowed. Grey water must be used within 24 hours of capture.	M	(Presume if treated, can be stored indefinitely).	L
Allowable End Uses	No restrictions at present. Limitations may be applied due to preferred scheme arrangement and its cost and operational impacts.	M	No restrictions at present. Limitations may be applied due to preferred scheme arrangement and its cost and operational impacts.	L	Irrigation, drip or underground but not to be sprayed. Toilet flushing.	M	Depends upon treatment standard	L

Figure 3: Water risk assessment matrix for Monash University (Aurecon, 2007)

The review of the campuses generated a series of short, medium and long term opportunities including implementation of water supply monitoring systems, installation of water saving devices, construction of storage for roof water and stormwater capture, and development of alternative sources such as groundwater or connection to major recycled water schemes.

The key recommendations from the project were:

- Implementation of a structured approach to water saving projects across all campuses, that included integration with research undertaken at Monash University and the project delivery team;
- Improved data gathering including metering and sub-metering of facilities to better understand water demand and development of asset registers to target renewal activities;
- Up-skilling operations teams to effectively manage alternative water supplies and using targeted procurement strategies to improve the efficiency of new facilities, and to identify opportunities to retrofit current buildings.

Monash University is currently undertaking a stormwater research project to investigate risk mitigation in harvesting stormwater from paved surfaces. The project will assess the health risks when utilising stormwater for the irrigation of crops grown for human consumption (Smart Water, 2010b).

4.3 CAULFIELD GRAMMAR SCHOOL – MALVERN CAMPUS

The Caulfield Grammar School undertook a study (Aurecon, 2007a) of alternative water options in response to Stage 3 water restrictions that particularly impacted the irrigation of sports ovals and gardens limiting watering to two days per week. Overall annual potable water use was measured over six years averaging 6ML, with irrigation estimated at around half of this demand.

The review took into account a range of alternatives including groundwater, imported water, rainwater, stormwater, greywater recycling, blackwater recycling and reuse of pool backwash. Water quality was an important factor for stormwater, grey and black water recycling and pool backwash, with restrictions placed on use for lower quality water such as methods and timing of irrigation.

Recommendations from the study included increasing the storage capacity of rainwater collection tanks, implementation of grey water treatment and recycling of pool water after de-chlorination. Longer-term initiatives could include development of a groundwater source and re-laying turf with drought tolerant species of grass. Grey water treatment using an on-site system was also deemed to have an educational benefit to raise awareness of potable water use and opportunities for recycling for irrigation.

4.4 ETIHAD STADIUM WATER MANAGEMENT PLAN

The Etihad Stadium is an iconic stadium in Melbourne, used predominantly for football codes during the winter season. The stadium footprint is around 6.8 hectares and it features a retractable roof that can be opened over the pitch.

Average water consumption at the stadium is around 66ML/annum, which at the time of the study (Aurecon, 2007b) was solely supplied by the public water supply. As a major water user, the stadium was required to produce a water management plan due to ongoing water restrictions in Victoria. Annual water costs were estimated at $127,000, rising to $250,000 by 2012 with the development of new major centralised infrastructure such as a desalination plant.

The stadium is characterised by high water use during the winter football season, with the distribution of non-potable demand between irrigation (22%), wash down of facilities (12%), toilet flushing (25%) and the cooling system (8%). The remaining proportion of water is for potable use such as drinking water and food preparation.

In order to reduce mains water demand, a variety of alternative water sources were considered including groundwater, rainwater (roof water), stormwater, saline water (sea water), grey water, and effluent reuse (dedicated supply or sewer mining). Water reduction measures were also assess including the potential replacement of cooling towers with low-water systems, installation of water efficient fittings and the use of mechanical sweepers for cleaning facilities.

An economic assessment of options identified payback periods ranging from 15 years to in excess of 25 years. Options recommended for further detailed assessment included rainwater and stormwater collection and storage for toilet flushing and wash down that was estimated to save around 20ML/annum of potable water.

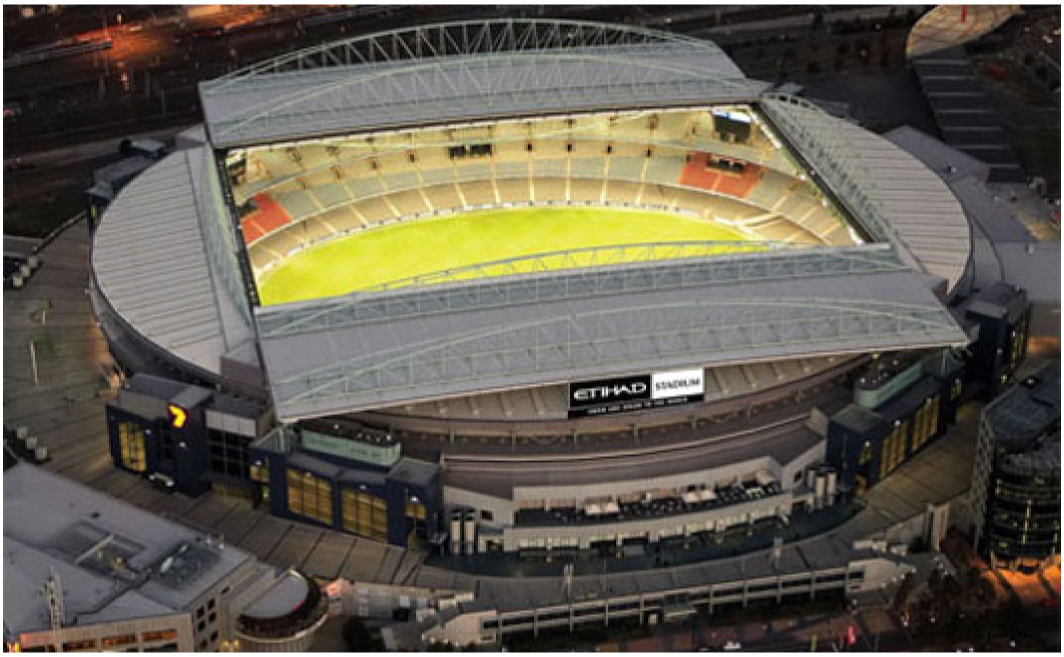

Figure 4: Aerial picture of Etihad Stadium in Melbourne showing the roof structure and surrounding concourse.(Photo sourced from <http://mcscbd2009.wikispaces.com/lhj_etihad_stadium>)

Since the study, Etihad stadium has installed a rainwater harvesting system which has reduced water usage by around 25ML/annum, including 17 storage tanks and a distribution that is fully automated by the stadium Building Management System (Etihad Stadium, 2010). Other initiatives have included water efficient devices (showers, basins and toilets), education of staff and contractors and improvements in irrigation by use of wetting agents.

4.5 SEWER MINING – COMMONWEALTH GOLF CLUB

The Commonwealth Golf Club, in liaison with South East Water and Melbourne Water, undertook an investigation into sewer mining options for the extraction and delivery of recycled water for irrigation of the Commonwealth, Metropolitan, Yarra Yarra and Huntingdale golf courses (Aurecon, 2010). The Commonwealth golf club is one of many situated in the sand-belt region of Melbourne to the south east of the city. A variety of demand scenarios were considered focused on supply of water during the peak summer irrigation months (up to 440ML/annum).

Sewer mining involves the extraction of raw sewage from nearby sewer mains and treatment to required standards for use on-site. In effect, the sewer mining allows a decentralised form of treatment to be implemented and reduces the volume of sewage that requires treatment at a centralised facility. Sewer mining was identified as an alternative water source that would increase the security of supply for the golf courses.

The first part of the study investigated the feasibility of extraction from the South Eastern Trunk Sewer (SETS), which is around 30km long and connects to the Eastern Treatment Plant. Flow rates were analysed to determine the feasible extraction rates that could be sustained using a pumped system, while maintaining adequate flushing velocities in the trunk main. A flow rate of 983 L/s (or 83ML/day volume) was determined to be available for at least 75% of the day from existing gauge information and network models.

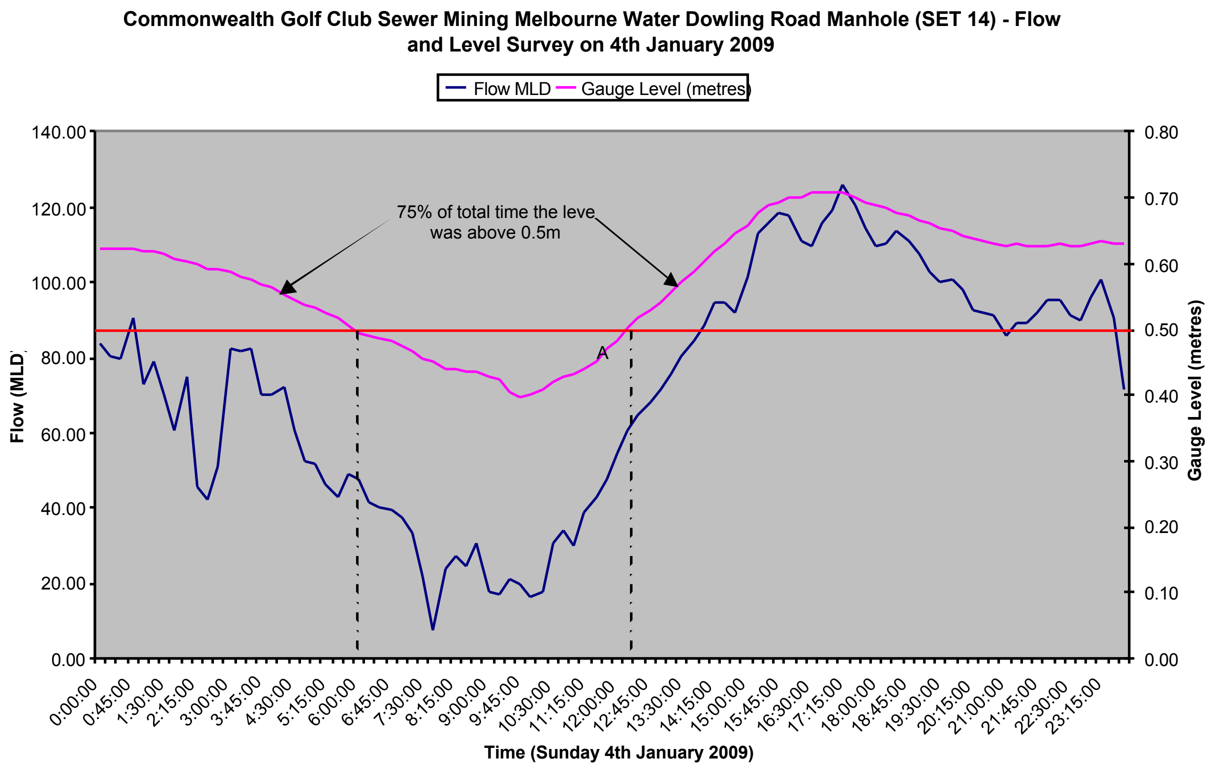

Figure 5: Flow and depth data from gauging in the SETS. The minimum feasible level for extraction is shown by the horizontal line (Aurecon, 2010).

A technical review of the extraction system was undertaken in parallel, given the engineering challenges including depths to sewer of up to 55m, large sewer diameters (2 to 3m) and the operating environment. A literature search did not identify any previous equivalent sewer extraction systems for a sewer mining application.

A series of extraction points were considered and preference was given to installation of a new shaft immediately adjacent to a major access shaft on the SETS. This enables a weir-type overflow from the sewer into the new shaft, with rotary lobe type pumps located on a pumping platform above a suction chamber. A number of risks were considered including ragging, flooding potential of pumps, noise, odour, operating temperature, construction, reliability and maintenance.

The second stage of the study focused on the requirements for the recycled water treatment plant, and storage/distribution system for the provision water to the golf courses. The treatment train was designed for the delivery of Class A recycled water to meet both EPA and Department of Health requirements, with the raw sewage in SETS determined as predominantly domestic in nature.

The proposed treatment plant consists of:

- Equalisation tanks – to permit 18 hours per day extraction from SETS;
- Biological activated sludge process - including nitrogen removal due to high levels in the raw sewage;
- Flow balancing;
- Membrane system – ultrafiltration membranes for disinfection;
- Disinfection – UV treatment and chlorination.

A variety of conveyance and storage system configurations were considered with part-year and full-time treatment plant operations, with part-year operation coinciding with peak summer irrigation requirements at the golf courses. A 25 year net present cost for the developed options ranged between \$1.76 and \$3.27 per m^3 of recycled water sourced from sewer mining, broadly equivalent to potable water costs. Energy use for sewer mining was estimated at around 1.8kWh/m^3, in comparison with 0.1 kWh/m^3 and 4.5 kWh/m^3 for potable water and desalinated water supplies respectively. These energy requirements demonstrate the need to factor in long-term links between energy and water into water planning in the future.

5 KEY LEARNING'S

The context of short-term water crises in Australia, and associated policy responses, has driven a number of initiatives which have mainly been large centralised infrastructure such as desalination plants or water recycling schemes. These schemes are important elements of a diverse water portfolio, but there is a risk that governments would overlook the importance of building the diversity of sources once these centralised schemes are commissioned (Wong and Brown, 2009). In addition, recent rainfall in many urban catchment areas has increased storage volumes and will likely lead to alleviation of current restrictions in place.

The case studies in Section 4 were developed to give background to the drivers behind the alternative decentralised water sources, with responses mainly to reduce the demand on centralised potable supplies. These studies, while partly mandated by the restrictions, were often undertaken in the context of seeking to increase water security in an uncertain future. The implications of irrigation restrictions on the sports industry and educational facilities could have significant economic impacts.

While New Zealand is generally considered to have abundant water resources, areas of drought in Northland and the eastern North Island have had a significant impact on both domestic and rural water supplies. In the future, drought risk is expected to increase in already drought prone areas in the eastern areas of both islands. Coupled with increasing conflict of water sources in areas such as Canterbury, there are a number of key learning's that can be derived from recent Australian experiences.

5.1 LONG-TERM PLANNING

An open-minded commitment to long-term future planning is vital. The timescale of water issues has been significant in Australia, with infrastructure and consumer behaviour-change delivered in short timescales due to the urgency of the problem. This has been accompanied with a significant cost, and it is unclear whether the decision making process has been robust and optimal, with debate still occurring about fast-tracking assets such as desalination plants.

The fast-tracked response was in marked contrast to dropping water storage levels over the period of a decade. While the challenge of long-term planning of infrastructure is not new, rapidly evolving technology in areas such as desalination mean that the feasibility of water options is dynamic in nature. Therefore, options currently being considered in Australia cannot be fully ruled out in the long-term in New Zealand. Decentralised options seem to offer the greatest opportunity to deliver a flexible platform for alternative water resource development, particularly when incorporated into long-term planning.

The concept of "fit for purpose" supply could provide a paradigm in which to evaluate a wider range of water options, with wider social and environmental benefits. In New Zealand, the viability and applicability of alternative water sources such as stormwater reuse and wastewater recycling for urban areas may be questionable, however they have notably have already been incorporated on a smaller-scale into new residential developments. Keeping 'all the options on the table' and staying abreast of new developments in technology and research are national challenges for water planners in New Zealand.

5.2 DATA, DATA AND DATA

The case studies have highlighted the value of collecting and collating high quality data over a long period of time, particularly in the area of demand monitoring. This value is realised during strategic water planning exercises, whereby the risk and reward of alternative water sources can be evaluated directly for multiple uses. In addition, the efficacy of demand reduction strategies can be assessed, to determine the viability of options and realistic timeframes for implementation.

Data collection is an emerging issue in New Zealand with the impending introduction of National Regulations for Water Metering. This is planned to see an estimated 98% of water takes greater than 5 litres per second metered by 2016, compared to the current metering of large water takes estimated at 30% (Environment Canterbury, 2010). Such information will be invaluable in monitoring demand, and identifying priority actions into the future.

5.3 PARTNERING

The majority of case studies presented were driven by requirements from water authorities to produce water strategies in response to increasing restrictions. However, in many cases, the water strategies were viewed as a partnership to facilitate a reduction water demand, thereby leading to decreased pressure on bulk supplies for the water authority, and increased security of supply for the consumer. This 'partnering' culture has been continued through the setting up of funding mechanisms such as Smart Water (Smart Water, 2010c) that seek to promote innovation and bridge the costs of developing alternative water supplies or demand reduction initiatives.

It is envisaged that similar cooperative partnerships between large water users and authorities in New Zealand could be feasible and lead to significant savings in water.

5.4 EDUCATION AND AWARENESS

Recent water restrictions in Australia have significant raised awareness of water issues, and lead to marked changes of behaviour, particularly in the residential context. Campaigns such as Target 155 (Target 155, 2010) aiming to reduce per capita demand to 155L per day have achieved significant reductions in water use in major metropolitan areas of Australia. A recent MWH Gauge 2010 survey (MWH Australia, 2010) showed that 95% of respondents recognised their responsibility to make good use of water, with significant concern with Australia's water supply not being able to support significant population increases in the next five years. 82% of people believe they have changed the way they use water, although this may not last as half of people would be less careful with decreased restrictions. The challenge is to maintain high community awareness of water issues, even in periods of rainfall.

The use of a risk assessment framework has been fundamental to the development of alternative water resources, and is the most common approach used by authorities to consider public health and environmental impacts. This methodology may also prove useful as an education tool, and for use in consultation around water reuse options.

6 CONCLUSIONS

A series of case studies were reviewed to outline the key drivers and responses to ongoing water shortages in Australian urban areas. The introduction of compulsory water planning for high water users has given renewed focus on "fit for purpose" water supplies and demand reduction, particularly in industries that rely on irrigation.

Potable water substitution covers demand reduction, and a wide range of alternative water supply options including wastewater recycling, sewer mining, grey and black water recycling, rainwater collection and stormwater harvesting. Decentralised options represent a promising alternative, particularly for individual water users seeking to increase the security of supply.

An open-minded commitment to long-term future planning is considered vital. Robust data collection, partnering with industry and education initiatives were also highlighted as key success factors in building a diverse water portfolio for the future.

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