The Contribution of Integrated Water Management to Achieving Environmental Protection and Sustainability Outcomes in the New Urban Areas of Melbourne, Australia

Integrated water management, stormwater management, sustainable urban development

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The city of Melbourne in Australia provides examples of how a growing city can integrate urban planning and water planning to achieve sustainable urban development, environmental protection, liveability and integrated water management outcomes, and move towards becoming a "Water Sensitive City". Three examples are provided – the development at Botanic Ridge, where urban development and integrated water management options are being planned and implemented using a "triple bottom line" sustainability investment approach; the Toolern development, which will capture and reuse stormwater and recycled water to greatly reduce the suburb's demand for potable water, and the development at Kalkallo where a 1,200 hectare industrial precinct development is planned which will merge design of the development's water supply, sewerage services and stormwater system. The Paper concludes that integration of urban planning and water planning is fundamental to achieving sustainability outcomes. More work is required on developing investment and risk analysis frameworks to ensure that all scenarios can be assessed equally.

1. Introduction

Achieving sustainable development continues to remain a priority for the governments of the world, especially in attempting to deal with population growth, increasing expansion of our cities, and climate change. Indeed, the Brundtland (1987) definition of sustainable development – to meet the needs of the present without compromising the ability of future generations to meet their own needs – has never seemed more urgent or more challenging [1]. Water issues play a very key role in sustainable development, and as the United Nations Environment Program has commented, "water is not only the most basic of needs, but is also at the centre of sustainable development" [2].

2. Background on Melbourne's recent urban growth

Melbourne is Australia's second largest city and currently has a population of around 4.1 million. Since 2001, Melbourne has gained 605,000 new residents, up 17 per cent, rapidly pushing out the urban boundary in every growth corridor. No other city in Australia has ever recorded growth of this size [3]. Whilst Melbourne is a growing city, it is also a sprawling city and its population density has recently decreased, reinforcing that much of Melbourne's urban growth has been outwards not upwards. In considering the question of whether Melbourne can continue to sustain this growth, the Melbourne Water Corporation has a key role. Melbourne Water is a statutory corporation fully owned by the State Government of Victoria, and is a water resources manager, providing water, sewerage and recycled water services to retail water businesses, and waterways and drainage services to the greater Melbourne community. Melbourne Water's strategic vision statement is "Enhancing Life and Liveability".

3. Liveability, Water Sensitive Cities, Water Sensitive Urban Design and Integrated Water Cycle Management

In planning for the cities of the future, a number of key objectives and desired future states currently guide the thinking. Key related concepts being put forward include those of Water Sensitive Cities, Water Sensitive Urban Design (WSUD), Integrated Water Cycle Management and the concept of Liveability.

The origins of alternative water provision in Australia can be traced back to the phrase "Water Sensitive Urban

Design" and its creation in 1994 to describe "a new approach to urban planning and design, based on the premise that traditional water supply, sewage disposal and drainage practices which rely upon conveyance and centralized treatment and discharge systems cannot be sustained in the long term" [4]. WSUD is about the integration of water cycle management into urban planning and design. WSUD is commonly used to reflect a relatively new paradigm in the planning and design of urban environments that is "sensitive" to the issues of water sustainability and environmental protection [5]. The concept of the water sensitive city has evolved from the principles of WSUD, and this concept is now a goal of the Australian Government's National Water Initiative [6]. In relation to "water sensitive cities", a recent definition is: "a water sensitive city is a city which integrates water supply, sewerage, stormwater and the built environment. A city that respects the value of urban waterways and a city whose citizens value water and the role it plays in sustaining the environment and society" [7].

The similar terms of Integrated Water Management (IWM) and Integrated Water Cycle Management (IWCM) are also used in relation to the range of innovative water outcomes that governments are looking to achieve, and it has been noted that the concept of IWCM developed from a number of sources including WSUD [4]. The broader concept of "liveability" is also now increasingly used by governments as a desired future outcome and as one of the benefits of linking urban planning and water planning. Clearly the concepts of WSUD, Water Sensitive City, Ecologically Sustainable Development, IWCM and Liveability share a number of aspects and are strongly linked. They all share a focus that includes the need to identify and capture the integrated water opportunities offered by urban development and avoiding many of the typical water cycle problems of traditional urban development, as well as integrating the various parts of the water cycle and water assets into urban development for cost effective and appropriate outcomes.

4. Achieving Integrated Water Management in Melbourne's growth areas

Over the last 10 years, the Victorian Government has released a number of strategies on its plans for managing the urban growth of greater Melbourne, with the most recent being in 2010 which brought an additional 43,600 hectares into the urban growth zone and available for development [8].

With this expansion of the urban growth boundary, the Victorian Government put in place a detailed program of urban master planning. Central to this is the work being coordinated by the Growth Areas Authority (GAA) in the production of Growth Corridor Plans for each of the five main growth corridors around Melbourne. Individual Precinct Structure Plans (PSP) are also currently being developed and these are the formal

***Figure 1**. Waterways Estate, Braeside.*

planning requirement for the development of these areas. PSPs have a key role in contributing to the achievement of integrated water management and sustainable urban development in the new growth areas of Melbourne. Between 2011 and 2013 approximately 45 new PSPs will be developed for Melbourne's growth areas. Each PSP also requires an Integrated Water Management Plan. Melbourne Water has a key role in working with the GAA in the development of PSPs and in the preparation of IWM Plans. In relation to the on ground roll out of PSPs, Melbourne Water develops and implements plans known as "Development Services Schemes" ("Schemes") for future urban development areas which aim to protect the natural environment and provide a safe level of flood protection for new urban communities. Currently there are around 180 such Schemes in place around Melbourne. Their primary focus is to prepare cost effective plans for servicing urban growth. The specific infrastructure and assets specified in each Scheme are then constructed, with developers required to provide the required funding as part of their legal requirements for development. Schemes are prepared to plan the infrastructure required to ensure new urban development meets appropriate standards for flood protection, water quality, waterway health and amenity [9]. As part of the move towards more integrated water management, the past few years have seen a greater focus on what additional water and waterway benefits can be provided in these new growth areas – including stormwater harvesting opportunities and infrastructure for the use of recycled water from treatment plants, as well as greater use of biofilters, wetlands, river health rehabilitation and biodiversity programs [10].

A key initiative in Victoria in relation to better water planning is the IWM requirements in the Victorian Planning Provisions, known as Clause 56.07; these com-

***Figure 2**. Somerfield Estate, Keysborough.*

menced in 2006 and form the IWM provisions relating to residential subdivision. The Clause requires that all new subdivisions of greater than two lots must treat stormwater onsite to the best practice standard, as defined in the Urban Stormwater Best Practice Environmental Management Guidelines [11]. Clause 56.07 attempts to mandate the implementation of water sensitive urban design. Clause 56.07 mandates the treatment of stormwater to achieve best practice water quality objectives for all residential subdivisions. The stormwater pollutant performance objectives required are: Suspended solids 80% reduction from typical urban load; Total phosphorus 45% reduction from typical urban load; Total nitrogen 45% reduction from typical urban load; and Litter 70% reduction from typical urban load. The assets required to deliver Clause 56 are paid for and constructed by developers through their involvement in Melbourne Water's Development Services Schemes.

5. Case studies of Integrated Urban and Water Planning

5.1 The Botanic Ridge development

The Botanic Ridge development is located approximately 50 km southeast of Melbourne; it was included in the extension of the Melbourne Urban Growth Boundary in 2010, and the Botanic Ridge PSP covering 318 hectares sets out a 15 year plan for the development of 3,250 new homes accommodating 9,000 residents [12]. One of the key environmental performance requirements to be met in planning the development at Botanic Ridge was the management of stormwater runoff from the development. While the land within the precinct drains reasonably well, the areas immediately downstream of Botanic Ridge are prone to water-logging, particularly during winter and spring months. Urban development on a "business as usual" scenario in the Botanic Ridge precinct would generate increased 'low flow' volumes of water in the drainage system especially during winter and spring. Unless mitigation measures were implemented as part of the development, this susceptibility to water-logging would be exacerbated, threatening the usability of downstream properties. As part of investigating the most suitable integrated water management options for the precinct, including the need to address the additional "low flow" volumes of stormwater, a number of options were considered by Melbourne Water, the GAA, consultants SKM and the relevant water retail corporation South East Water. A number of key assumptions informed the development of water solutions for the precinct including that the additional "post development" stormwater runoff flow rate would be 1,382,400 litres per day over the 183 days of the winter and spring season. This would result in a potential stormwater amount of 253 million litres over the winter spring period and around 504 million litres per year required to be managed. The integrated water management options considered were:

1. Rain Water tanks – this would involve the installation of mandated rainwater tanks reticulated to toilets, laundry and external garden taps for each of the 3,250 lots within Botanic Ridge. It was acknowledged that this option would only partially capture the required target volume and that it would only involve the stormwater runoff from house roofs being captured and used – stormwater runoff from roads and overland flow would still flow downstream.
2. An onsite water treatment plant and inclusion as part of the recycled water network – this would involve a local water treatment plant to treat the 1,382,400 litres per day flows and then the incorporation of this water into the recycled water system within the Botanic Ridge precinct. Infrastructure required would include a number of pumping stations and water pipelines, a water treatment plant and a 40,000 litre storage tank. The four water quality wetlands already proposed to be built in the precinct would be utilised to provide a level of water quality treatment before the water was pumped to the treatment plant and the end product would then be of sufficient quality to be used by the local community for purposes including laundry, toilet and garden use.
3. Direct sewer diversion – this option involved using upgraded sewerage pumping stations and sewer pipelines planned for the development to deliver the additional stormwater flows into the sewer network operated by South East Water. A potential problem with this option is that it would only be able to operate, ie discharge stormwater into the sewerage network, when there is capacity within the sewerage system – there was therefore no guarantee that

stormwater would be discharged during peak sewerage flows.

4. Constructing a dedicated stormwater pipeline to collect the excess stormwater throughout the precinct and then transporting it 3.4 km via a drainage line to discharge into Western Port Bay.

The investment analysis used seven key criteria to compare the above options, being: certainty and simplicity of delivery including being able to address the biodiversity and cultural heritage issues; that the option clearly solves the issue ie diverts the required amount of water; has a simplicity of management with clear responsibilities for the various organisations involved; will be accepted by the customers in relation to issues such as quality control, odour, colour, and perception of safety; the overall cost to the development considered over a 25 year period on a Net Present Value (NPV) basis; the amount of substitution of potable water that the option achieves; and energy use, being predominantly the pumping costs. The costs for the options varied, with the rainwater tank option being the most expensive with a NPV (2011) cost of around $15 million[1] and the drainage option to Western Port Bay being the cheapest at around $3 million. However using the seven investment criteria described above, the highest ranked option was option 2 above ie the onsite water treatment plant and its inclusion as part of the recycled water network. This option had an estimated cost of around $ 5 million but it scored very high in key criteria such as the substitution of potable water. This option has now been adopted by the relevant authorities as the preferred water solution for the precinct. In relation to the achievement of IWM outcomes, Botanic Ridge provides an example where the investment analysis included a "triple bottom line" assessment. To achieve the triple bottom line of sustainability, total water management proposals must analyze alternatives to address the potentially conflicting goals of financial, environmental, and social issues [13]. Clearly the recommended option for Botanic Ridge is not the cheapest option; however it represents the option with the overall greatest mix of positive benefits for the community whilst also factoring in project cost as a key (but not the only) decision making variable.

5.2 The Toolern project

Like Botanic Ridge, the Toolern development – a new suburb being built in the urban growth area west of Melbourne and expected to house 55,000 residents by 2030 – provides a good example of the kind of integrated urban and water planning being achieved in Melbourne through PSPs. Toolern is set to create a benchmark for Australia by officially becoming its first water neutral suburb in what is one of the lowest rainfall areas in Victoria and also one of the fastest growing urban areas in Australia. The Toolern development will capture and reuse stormwater and recycled water to greatly reduce the suburb's demand for potable water. It will be the first suburb in Victoria where a potable water substitution target is being included in its PSP. This master plan will also ensure the effective integration of stormwater, recycled water and rainfall. Homes in the new development will be supplied with Class A recycled water to flush toilets and water gardens; stormwater will be captured and held in wetlands for treatment and filtration before it is piped to a nearby Water Reservoir and stored for future reuse, such as irrigation for open space management within Toolern and also to ensure that the water flow leaving the reservoir provides environmental flow requirements for the nearby waterway [14]. Up to 3,500 megalitres of stormwater will be harvested in Toolern each year, with a further 2,700 megalitres of "Class A" recycled water supplied by Western Water to flush toilets and water gardens and outdoor spaces [15]. This harvested stormwater will reduce the damaging effects of peak stormwater flows on the local waterways, principally Toolern Creek. The Toolern project provides an example the important role of the urban master plan – the Integrated Water Management proposals for Toolern are incorporated in the PSP – thereby ensuring that the required water infrastructure will be incorporated in all new developments.

The philosophy behind the development of projects like Toolern is that the challenges of population growth and climate variability cannot be met by the traditional approach of centralised water supply systems, reliance on rainfall dependent sources, peak demand planning and by water authorities simply offering "one" source of water [16]. The Toolern IWM project is being driven and implemented by Western Water as the retail water authority serving this area. Any additional costs eg in the additional pipe and pump networks required to move the harvested stormwater around the development and to the reservoir are being met by Western Water. Melbourne Water is ensuring that its assets (eg flood retarding basins) contain the necessary additional land areas to accommodate the required infrastructure especially in relation to the stormwater storage ponds. The Toolern project shows what can be achieved when the land development authority, water authorities and local government work together well in advance of the development and where there is a shared vision to achieve an IWM outcome that delivers real benefits for the community.

5.3 The Kalkallo project

The proposed development at Kalkallo, a township 28 kilometres north of Melbourne, where a 1,200 hectare industrial precinct development is planned for con-

[1] All dollar figures in this paper are in Australian dollars.

struction over the next 10 to 15 years, provides a further example of where an IWM approach is leading to a sustainable urban development outcome. Yarra Valley Water, Melbourne Water, Hume City Council and the MAB Corporation (as landowner) are working together to merge design of the development's water supply, sewerage services and stormwater system. The project will involve capturing and treating stormwater from a 160 hectare catchment area within commercial land, and will demonstrate how a new development can be built to: reduce the net volume of imported water by up to 90 per cent; decrease the urban runoff into the local streams by 45 per cent above existing requirements; decrease the nutrients discharged into the local streams by 25 per cent above existing best practice; and recover the upfront capital and ongoing operational costs within a 25 year period. The project will deliver around 365 million litres of treated stormwater annually and the stormwater harvesting will result in the reduction of stormwater pollutants discharging into Kalkallo Creek, with an estimated average annual removal of 1.46 tonnes of Nitrogen [17]. The stormwater will be collected via traditional stormwater drains. It will then be treated in a series of constructed wetlands and settling ponds and then stored in a large dam, before passing through a treatment plant, which will produce a drinking-water-quality end product, used to supplement the development's recycled water supply. Eventually, it is hoped it can supplement the potable water supply when rigorous monitoring and data collection demonstrates that it is safe to do so. It is hoped that the WSUD approach being taken at Kalkallo will be a leading example for future cities, as it showcases how urban water infrastructure can be designed differently to deliver a more resilient water solution [18].

6. Discussion and Conclusion

The water and urban planning work being done in the expanding urban areas of Melbourne is starting to incorporate, plan and deliver IWM initiatives that do deliver a wide range of community benefits that go way beyond the more traditional urban planning approach of flood planning and waterway protection. The cases studies considered in this Paper reflect the comment that managing stormwater within IWCM extends to meeting objectives beyond the protection of waterways to supplying fit-for-purpose water and providing amenable landscape and recreational features for communities [19]. The introduction of Precinct Structure Planning for Melbourne's growth areas, and the requirements for an IWM Plan for each precinct, have been of considerable benefit in relation to linking urban planning and water planning. The examples discussed in the Paper show that the precinct level developments at Botanic Ridge, Kalkallo and Toolern are set to achieve significant levels of IWM outcomes, deliver water for community use, and minimize the impacts of the developments on the local waterways. These case studies show how a Water Sensitive City might start to be delivered.

However the achievement of these levels of IWM in the new growth areas and in all PSPs is by no means universal. Not all PSPs around Melbourne are delivering the kinds of IWM outcomes that the three case studies discussed in this Paper are doing. IWM outcomes of the kind discussed in this Paper are not yet "business as usual" around Melbourne. Whilst the case studies discussed in this Paper are examples of the traditional approach to urban design and water-cycle management slowly being reformulated with a focus on resilience, long-term sustainability, and cost effectiveness [20]; there is clearly more work to be done to "mainstream" these kinds of IWM outcomes. Who pays for integrated water management is obviously a key issue as it delivers a range of public and private benefits and by definition involves multiple elements of the water cycle. One of the key issues requiring more work is the development of a robust investment and funding framework for such integrated projects. For Melbourne Water, where traditionally water supply, sewerage, waterways and drainage issues have generally been planned separately, the emergent paradigm of integrated water management means that there is now the opportunity and the imperative to fully examine how these can each be considered as valuable and interconnected components of the urban water cycle. As Martinez et al [21] have concluded, this view of the total urban water cycle increases the range of opportunities for more sustainable solutions to be tailored to local circumstances. In addition to the need for further development of investment frameworks for decentralised water options, as mentioned above, there is also a need for improved risk analysis frameworks. The idea of a common investment framework has been included up by the Government of Victoria in its "Living Melbourne Living Victoria Implementation Plan" [22] as one of the key actions to be undertaken to increase understanding of the benefits that can be achieved by IWM.

In facing the challenges of urban expansion, increased climate risk and variability, and a desire to develop and implement more integrated water solutions that deliver a range of community benefits, Melbourne has implemented a number of precinct specific water solutions that will deliver sustainable urban development and liveability outcomes. However whilst these pilot projects have helped to "prove" the concept and benefits of IWM, these approaches have not yet become mainstream. It is suggested that further work on investment frameworks and the associated area of risk analysis frameworks is required to further progress the consideration of these decentralised solutions and ensure that the growing metropolis of Melbourne can

continue to be at the forefront of managing the urban water cycle to deliver innovative outcomes that make a real contribution to liveability and sustainability.

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