

Linking Urban Planning and Water Planning to Achieve Sustainable Development and Liveability Outcomes in the New Growth Areas of Melbourne, Australia

Dennis Corbett

Abstract—The city of Melbourne in Victoria, Australia, provides a number of 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 a 318 hectare residential development is being planned and where integrated water management options are being 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 argues that an integrated urban planning and water planning approach is fundamental to creating liveable, vibrant communities which meet social and financial needs while being in harmony with the local environment. Further work is required on developing investment frameworks and risk analysis frameworks to ensure that all possible solutions can be assessed equally.

Keywords—Integrated water management, stormwater management, sustainable urban development.

I. 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. In 2011 the world’s population hit seven billion [1], and in this world of seven billion people, the global rural-urban balance of populations has tipped irreversibly in favour of cities [2]. With some projections forecasting that by 2050, seven out of every 10 humans on earth will be living in a city, then our future existence as a species is, inevitably, an urban one [3].

These projections of the future growth rates of our cities highlight the need for an increased focus on urban planning to better achieve sustainable development. 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 [4]. 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” [5].

Australia can provide a number of relevant examples in relation to urbanisation as it is highly urbanised and has one of the most spatially concentrated populations of any country in the world with 87 per cent living in urban areas, including 64 per cent in capital cities [6]. Australia’s National Water Commission has recently identified “catering for rapid population growth” as one of the most important challenges facing the Australian urban water sector [7]. The recent growth in the Australian city of Melbourne provides a number of case studies on the integration of urban planning and water planning and these will be discussed in this paper.

II. BACKGROUND ON MELBOURNE AND ITS 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 [8]. Currently, Melbourne’s outer suburbs are growing faster than any other area in Australia. Between 2010 and 2056 greater Melbourne’s population is projected to increase from 4.1 to 6.4 million, with 39 per cent of this growth (930,000 people) occurring by 2026. Of that 930,000, approximately 60 per cent of this growth is expected to take place in new growth areas [9], [10]. 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. There is increasing community concern that this urban growth will lead to Melbourne becoming a very large and unsustainable city. In noting that Melbourne’s population density has “decreased to unsustainable levels”, the Committee for Melbourne also recently stated that “planning for greater urban Melbourne in the face of population growth and demographic change will be our biggest delivery challenge in 2012” [11].

In considering the question of whether Melbourne can continue to sustain this growth, the Melbourne Water

Dennis Corbett is with Melbourne Water, Australia, (phone +613 9679 7256, e-mail: dennis.corbett@melbournewater.com.au).

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, and manages approximately \$9 billion in water supply, sewerage and drainage assets. Its drainage and waterway assets include more than 8,400 kilometres of waterways, 219 flood retarding basins, 168 wetlands, 22 urban lakes and 6 tidal gates. Melbourne Water's strategic vision statement is "Enhancing Life and Liveability".

III. THE IMPORTANCE OF COORDINATING URBAN PLANNING AND WATER PLANNING FOR SUSTAINABLE OUTCOMES

In planning for the future of the world's cities, there is now a stronger focus on the importance of linking urban planning and water planning. This is in contrast to the previous situation where water planning was delegated a more subsidiary role. Traditional urban planning approaches have focussed on providing transport and buildings to new areas, with the supply of other utility services such as water, sewerage or drainage often having been seen as a secondary consideration. There is now increasing recognition of the requirement to link urban planning and water planning. As has recently been noted, the way we manage urban water influences almost every aspect of our urban environment and quality of life. The nexus between sustainable urban water management and the vitality and prosperity of urban environments is only beginning to be recognised. The links are readily apparent in the economies of water supply and consumption, but can also be found in areas as diverse as public health and wellbeing, productive urban landscapes, climate responsive urban design, carbon footprints and energy efficiencies" [12]. Similarly the International Water Centre has recently stated that understanding the nexus between sustainable urban water management and the vitality, liveability and prosperity of urban communities is one of the most significant challenges of the 21st century [13]. Equally, the International Water Association in adopting its "Declaration on Cities of the Future", with its express purpose of ensuring that their activities contribute to the achievement of sustainable, resilient and liveable cities of the future, has included among its specific intents the need to "encourage the global water community to elevate the role of water management as a central element of sustainable, resilient cities" [14].

In relation to how such sustainability goals are being achieved in Victoria, sustainability outcomes have been incorporated in Victorian legislation for some time, with the key legislation in Victoria for water planning and urban planning – (being the *Water Act 1989* and the *Planning and Environment Act 1987*), both specifically including the achievement of sustainable development in their objectives and purposes. In relation to the issues of water planning and urban planning in Victoria, in 2011 the Victorian Government announced its intention to establish Victoria as a world leader

in liveable cities and integrated water cycle management with a visionary plan to make urban landscapes more sustainable and liveable; drive generational change in how Melbourne uses rainwater, stormwater, and recycled water to provide better water service and reduce Victoria's footprint with regard to energy and water use, and drive integrated projects and developments in Melbourne and regional cities to better use stormwater, rainwater and recycled water [9]. Subsequently in 2012, the Victorian Government released a detailed Implementation Plan to commence these intentions, and Figure One below shows the Government's vision and associated objectives to support the vision.

Examples of integrated projects that start to address this vision will be discussed in this Paper. It is also important to understand how the approach being advocated by the Victorian government, and the individual projects that it is implementing, fit into the broader and related policy objectives of "Liveability", "water sensitive cities", "water sensitive urban design" and "Integrated Water Management".

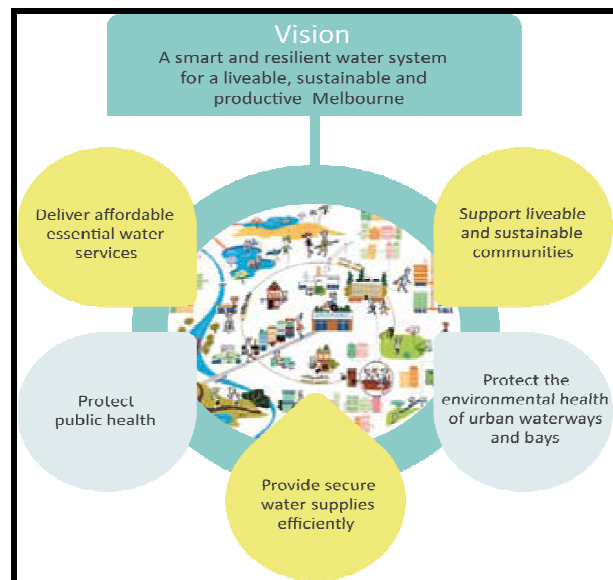


Fig. 1 The Government of Victoria's Vision (2012) for Melbourne's water systems and the specific objectives to achieve this vision

IV. 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 Livability.

In understanding the development of new approaches to link water planning and urban planning, the concept of WSUD is an important one. 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” [15].

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 [16]. WSUD advocates the need to incorporate all aspects of water planning into urban development and planning from the earliest stages, thereby hopefully maximizing the opportunities for context-sensitive water cycle management and encouraging the continuation of natural water processes within an urban environment [4]. Essentially, WSUD is about putting in place a range of measures that are designed to avoid, or at least minimise, the environmental impacts of urbanisation. In Australia, Melbourne has been recognised as the leader in the development of WSUD [17]. This integration of the urban water cycle into urban design also sits well with key European planning and water initiatives such as the European Union Water Framework Directive which has integrated water management for all water types as one of its key aims [18], [19].

The key principles of WSUD adopted by Melbourne Water are “to protect natural systems, integrate stormwater treatment into the landscape, protect water quality, reduce runoff and peak flows, and add value while minimising development costs” [20]. At the national level, the Australian governmental agreement of the National Water Initiative defines WSUD as “the integration of urban planning with the management, protection and conservation of the urban water cycle that ensures that urban water management is sensitive to natural hydrological and ecological processes” [21]. The Melbourne experience in implementing WSUD shows that whilst much has been achieved, considerable issues remain, and that the challenge of moving from demonstration projects to a situation where WSUD is “mainstreamed” across the key partner organisations is still being addressed [22].

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 [21]. 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” [23]. Similarly a water sensitive city has been characterized as having: total water cycle management; higher levels of community involvement in decision making; and a focus on maximising the community benefits that come from water management projects [24]. The words “Water Sensitive” define a new paradigm in integrated

urban water cycle management that integrate the various disciplines of engineering and environmental sciences associated with the provision of water services including the protection of aquatic environments in urban areas. WSUD is the process and Water Sensitive Cities are the outcome [16]. It has also been stated that in working toward the goal of developing water-sensitive cities, WSUD provides a foundation for key design elements such as site design, urban planning, stormwater management, water quality treatment, and water conservation; and offers the tools required to create a hydrologically and ecologically functional landscape [25].

In the ongoing challenge to ensure that our growing cities remain or become liveable, sustainable and prosperous, especially in an environment facing ever-more extreme climatic events, this notion of a water-centric, or water sensitive city is becoming recognised as a solution to this challenge [26]. The need to incorporate these water sensitive principles into the design and expansion of cities is also highlighted in the Australian Government’s National Urban Policy which has as one of its key objectives “to ensure our cities take full advantage of the services that our natural environment provides, and do not impose unnecessary costs to future generations, we must protect and enhance natural ecosystems, waterways and biodiversity. This can be done by avoiding and mitigating the impacts on critical environments and by incorporating quality green space, microclimate and water sensitive design into urban systems” [27].

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 [15]. 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. It has recently been noted that “in Victoria, Australia, the emergence of “liveability” as a philosophy of state government that aligns with international concepts of new urbanism means that multiple objectives – such as health, wellbeing, comfort and amenity – need to be met by future investment in water management. As Melbourne Water’s role in the management of stormwater through an integrated water management approach grows, future programs must reflect these challenges and new philosophies”[28].

The Victorian Government has recently stated that: “as our understanding of the urban water cycle has evolved, so too has our understanding of the role water plays in supporting the liveability of our cities and towns. By better recognising these links, we can use water in our environment to deliver multiple benefits. This needs a paradigm shift in the way we think about and manage water, and capture opportunities. In particular, this involves managing water in a way that: better integrates our urban development planning processes and our water planning processes; acknowledges the full costs and benefits of water services within our cities and towns; creates market

based incentives for more adaptive, innovative and productive water management; embeds water efficiency within the community; puts our currently under-utilised stormwater and recycled water resources to better use; focuses on decentralised, local solutions, whilst using our existing large-scale augmentations as efficiently as possible” [9].

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; achieve a range of desirable community outcomes including healthy waterways and provision of water for a variety of uses; link and incorporate all aspects of water planning into urban development and planning from the earliest stages; minimize the impacts of urbanization on the environment, and maximise water's role in sustaining society and communities; and integrate the various parts of the water cycle and water assets into urban development for cost effective and appropriate outcomes. The case studies discussed in this Paper provide examples of how the above goals are being achieved and what are some of the further challenges still to be considered.

V. PLANS TO MANAGE URBAN DEVELOPMENT AROUND MELBOURNE

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 [29]. This expansion of the urban growth boundary followed on from the release in 2002 of the Victorian Government's 30 year plan to manage urban growth and development across metropolitan Melbourne entitled “Melbourne 2030 - Planning for sustainable growth” [30]. “Melbourne 2030” established an urban growth boundary to better manage outward expansion, which the Government of the time believed would be an appropriate tool to facilitate the achievement of a more compact city and to promote sustainable development by directing growth to areas best able to be supplied with appropriate infrastructure and services and by protecting other valuable land from urban development pressures. However due to faster than anticipated urban growth, a revised document entitled “A Plan for Melbourne's Growth Areas” was released in 2005 [31]. This included the establishment of a new government corporation, the Growth Areas Authority (GAA), to oversee urban planning and development in Melbourne's expanding growth areas.

With the 2010 further expansion of the urban growth boundary, the Victorian Government put in place a detailed program of urban master planning that would be required to appropriately plan for this further expansion of Melbourne. Central to this is the work being coordinated by the 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 planning requirement for the development of these areas.

VI. ACHIEVING INTEGRATED WATER MANAGEMENT IN MELBOURNE'S GROWTH AREAS

As mentioned above, 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. PSPs are master plans for whole communities which usually cater for future development accommodating between 10,000 to 30,000 people, and they lay out roads, shopping centres, schools, parks, housing, employment, and the connections to transport and generally resolve the complex issues of biodiversity, cultural heritage, infrastructure provision and council charges. 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 and Conservation Management Plans. The GAA has noted that “Integration of water management in Precinct Structure Planning is a critical element to the creation of better suburbs. Integrated Water Management seeks opportunities beyond ‘business as usual’ to foster innovation and to provide better environmental, health, economic and liveability outcomes in all aspects of water management, supply and disposal. This approach is fundamental to creating livable vibrant communities which meet social and financial needs while being in harmony with the local environment” [32].

Melbourne Water works with the GAA in relation to developing IWM Plans for each PSP. These produce specific waterplans based on each precinct's needs. Specific examples will be discussed later in this Paper. In relation to the on ground roll out of PSPs, Melbourne Water develops and implements plans known as “Development Services 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, taking into account a number of elements including orderly planning and equitable cost sharing. The specific infrastructure and assets specified in each Development Services Scheme are then constructed, with developers required to provide the required funding as part of their requirements under the *Water Act 1989* [33] and the *Planning and Environment Act 1987* [34].

Development Services 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 [35]. Whilst these issues are still

vitality important, it is also becoming increasingly important for Development Services Schemes to also make provision for aspects of integrated water management, especially stormwater harvesting. Accordingly, 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 [36].

VII. PLANNING POLICY INITIATIVES

A key initiative in Victoria in relation to better integration of urban planning and water planning is the IWM requirements in the Victorian Planning Provisions which form part of the planning regulatory regime under the *Planning and Environment Act 1987*. The relevant section of the Victorian Planning Provisions is known as Clause 56.07; these commenced in 2006 and form the IWM provisions relating to residential subdivision. This clause aims at managing water more responsibly and sustainably, and is vital in protecting the health of Melbourne's waterways and bays by reducing pollutants and excessive flows. 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 [20]. Clause 56.07 attempts to mandate the implementation of water sensitive urban design.

The relevant objectives of Clause 56.07 in relation to urban run-off are: to minimise damage to properties and inconvenience to residents from urban run-off; to ensure that the street operates adequately during major storm events and provides for public safety, and to minimise increases in stormwater run-off and protect the environmental values and physical characteristics of receiving waters from degradation by urban run-off [37]. Clause 56.07 mandates the treatment of stormwater to achieve best practice objectives for all residential subdivisions. To assist in achieving these objectives, the Best Practice Environmental Management Guidelines for Urban Stormwater describe the level of stormwater treatment necessary to comply with these regulatory requirements; the 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.

VIII. CASE STUDIES OF INTEGRATED URBAN AND WATER PLANNING

A. The Botanic Ridge Development

The Botanic Ridge development is located approximately

50km 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 [38]. In relation to the goals set for this development by the GAA, these include: "a place of beauty, where excellence in landscape, architectural and urban design contribute to a strong 'sense of place', while also addressing important visual and environmental performance requirements" [39].

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 Sinclair Knight Merz 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 of 1,382,400 litres per day 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 and the drainage option to Western Port Bay being the cheapest at around \$3 million. Using the seven investment criteria described above, the highest ranked option was option 2, 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 [40]. 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.

B. 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 [41]. 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 [42]. 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 [43]. 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.

C. 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 construction 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 [44]. The project received \$10 million funding from the Australian Government in 2009.

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 [45].

IX. DISCUSSION AND CONCLUSION

The IWM outcomes being obtained in the new growth areas of Melbourne show how urban planning and water planning can be linked to deliver sustainable water outcomes. Picking up on earlier legislated commitments in Victoria to sustainable development, 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 [46]. In a broader sense, these projects are also responding to community expectations that more consideration should be given to social and environmental issues and impacts in the choice of water servicing options [47]. 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 and are examples of the statement that a Water Sensitive City requires the transformation of urban water systems from a focus on water supply and wastewater disposal to more complex, flexible systems that integrate various sources of water, operate through a combination of centralised and decentralised systems, deliver a wide range of services to communities (eg ecosystem services, urban heat mitigation) and integration into urban design [48].

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 [25]; there is clearly more work to be done to "mainstream" these kinds of IWM outcomes. Who pays for IWM 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 [49]. 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 IWM 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. This view of the total urban water cycle increases the range of opportunities for more sustainable solutions to be tailored to local circumstances [50].

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. It has also been noted that the design and planning of decentralised water systems responds to the opportunities and limitations presented by the locality, and that this means that care needs to be undertaken in generalising understanding drawn from a single example, thereby highlighting the need for a risk analysis framework that factors in these contextual outcomes [47]. This idea of a common investment framework has been included up by the Government of Victoria in its "Living Melbourne Living Victoria Implementation Plan" [51] as one of the key actions to be undertaken to increase understanding of the benefits that can be achieved by IWM, including improved liveability

outcomes.

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 livability 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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