OPTIMISATION OF EXISTING RETARDING BASINS FOR STORMWATER TREATMENT AND REUSE

Author/s:
Justin Lewis, IWM Specialist - Stormwater, Corporate Strategy, South East Water
Michael Brown, Development Planning, Waterways, Melbourne Water Corporation
James Hodgens, Development Planning, Waterways, Melbourne Water Corporation
Keith Johnson, IWM Project Director, Strategy, South East Water

ABSTRACT

The water industry faces the emergent challenge of understanding and optimizing the potential of alternative water sources as part of an overall Integrated Water Management (IWM) approach to water management that addresses a range of objectives across the water cycle. This paper explores how multiple objectives can be met in regard to potable water substitution, stormwater treatment, waterway ecology protection and stormwater retardation through a single asset.Water Sensitive Urban Design (WSUD) is a relatively new approach to stormwater treatment which uses systems, such as wetlands, swales, or infiltration systems and is becoming increasingly popular within Australian cities.

This paper reports on the issues encountered and lessons learnt during the installation and operation of a range of experimental WSUD retrofits into existing retarding basins (RB). Traditional RB's have been constructed to mitigate localized flooding risk by slowing and storing water to reduce runoff peaks and attenuate flows.

As concerns about receiving waterways and stormwater quality treatment have become paramount, wetlands to treat stormwater and attenuate flows have proliferated. A further development on this theme is stormwater harvesting which will be seen in the next generation of RB retrofits. A case study will be provided to demonstrate the feasibility of this proposal where a system has been designed to treat stormwater pollutants, reduce flow peaks and substitute potable water to a 58 allotment residential development in Narre Warren, Victoria.

Melbourne Water the waterway manager in Melbourne has retrofitted a suite of RB's across its network using various treatment train complexities.

When meeting the multiple objectives through the retrofitting of RB's consideration is needed in regard to the hydraulic treatment integrity of the system and the water quality required for end use. For example some systems consist of a sedimentation pond and underground storage tank while others are complex comprising elements such as a gross pollutant trap (GPT), sedimentation pond, wetland and bioretention trench with anoxic zone for enhanced nutrient removal and finally a UV disinfection unit for pathogen removal to a standard consistent with the national guidelines.

RB retrofits do not compromise the hydraulic flood protection of the system and appear to be a promising tool for stormwater quality treatment, stormwater harvesting and aquatic ecosystem protection.

INTRODUCTION

With the perceived threat of climate change looming and the current reality of severe drought impacting many countries, there has been a shift from traditional water management strategies to the sustainability principles that underpin Water Sensitive Urban Design (WSUD). One fundamental tenet of WSUD is to manage urban stormwater as a resource and to protect the ecological value of receiving waterways.

Past decision making behind a range of WSUD installations, recycled water and stormwater harvesting projects across South East Australia have in some instances lacked rigour and a considered framework as to how these installations form part of an IWM approach. Alternate water supply projects have in some instances been staccato in nature with the primary driver being receipt of funding to address a local need.

Traditional water management considers water, sewage and stormwater, groundwater and waterways as separate entities. However, there is an emerging need to explore the interdependencies of the urban water cycle as part of an IWM framework to optimise asset integration and to account for the drivers of change. To address this need South East Water (SEW), in collaboration with Melbourne Water and Southern Rural Water, are currently developing an IWM strategy for the South Eastern region of Melbourne.

Whilst there is no universal definition of IWM, it can be viewed as providing the most sustainable mix of all possible water solutions for our customers and communities. An inherent part of IWM is better understanding the relationship between energy and water. A further issue is to raise community consciousness around water issues by giving visibility to water infrastructure for example, through WSUD.

The **four key** objectives for the IWM Strategy for the south east region are; ***to provide customer choice*** by offering a range of alternate water supply options, ***to optimise resources and infrastructure***, ***to improve the health of waterways*** and the water environment including groundwater and finally ***to create community value*** through the provision of water for social benefit and amenity.

CONJUNCTIVE USE OF ASSETS: RETARDING BASINS

A key regulatory driver for IWM strategy is the Victorian Government's Central Region Sustainable Water Strategy (CRSWS) which requires metropolitan water authorities to invest in recycling projects aimed at substituting 10 GL of potable water by 2030.

In Melbourne over the past 11 years as a result of drought, inflows to water supply storages have dropped by 30% from around 550GL to 380GL. Annual average demand for Melbourne is 430GL. To address this shortfall the Victorian Government introduced water restrictions and initiated the construction of a 150GL/yr desalination plant and the north-south pipeline that allows Melbourne to access rural water for urban use. Whilst these actions have improved security in the short to medium term further optimisation of alternate water supplies is necessary at the local precinct level as part of an IWM strategy.

It is estimated that around 400 GL of stormwater is generated annually across Melbourne (Melbourne Water, 2010). This water can provide a source of alternative water to both reduce its impact on the environment and reduce the consumption of potable water. This alternative supply of water can service private and public requirements, including community assets such as recreation ovals and parks which otherwise could not be watered under water restrictions.

As part of SEWs IWM strategy, investigation into the Conjunctive Use of Assets such as Retarding Basins (RB's) has been initiated in line with the strategy objective ***to optimise resources and infrastructure***.

RETARDING BASIN EVOLUTION (1960-1995)

Melbourne Water and South East Water are currently investigating opportunities to make better use retarding basin land, and the potential to capture, store and treat stormwater within the retarding basin, whilst not compromising its hydraulic function, is one option being investigated. Melbourne Water currently manages over 160 RB's within the Melbourne metropolitan area. Whilst the implementation of WSUD and stormwater harvesting schemes to new greenfield developments can be accommodated as part of the planning phase, retrofitting large WSUD installations in urban brownfields provides a far greater challenge due to the footprint or land area required for such retrofits. RB land is significant in area and usually centrally embedded in high density urban areas and has great potential for large scale WSUD retrofits (Hodgens, 2010).

The Melbourne Metropolitan Board of Works (MMBW) began constructing RB's in the 1960's to mitigate stormwater flows and localized flooding risk by slowing and storing water to reduce runoff peaks and attenuate flows.

Early RB's were fully excavated box shaped basins with steep embankments and spillways. Functionality of early RB's was limited due to public safety concerns, with basins having grassed floors and minimal trees planted on embankments. The majority of RB's were fenced off due to safety concerns with some larger RB's utilised as sporting fields. (Hodgens, 2010)

In the 1980s the State Governments Waterway program had a focus on open space with a number of waterway concept plans being developed. As a result RBs were designed to integrate with their natural environments. This type of design continued until 1995 when Melbourne Water's Nitrogen Reduction Strategy commenced.

1995-2005

During this period existing retarding basin land and new retarding basin land within Greenfield sites was designated for regional stormwater quality treatment (SWQT). Whilst large unvegetated infiltration basins have been found to be effective at reducing stormwater peak flows they are less suitable for SWQT (Dechesne *et al.,* 2004).

To address water quality concerns wetlands were constructed to deliver industry best practice reductions of nitrogen by 45% Phosphorous by 45% and Total Suspended Solids by 80% in stormwater runoff entering Port Phillip Bay

2005 – PRESENT DAY

Whilst flood prevention is the primary reason for the construction of retarding basins, they can also be of great value to the community, by providing recreation opportunities, natural habitat and biodiversity values and, of ever increasing importance, a source of non potable water (Hodgens, 2010).

The next generation of RB design includes many components of previous SWQT. New initiatives include some online linear retarding basin wetland systems such as the Marriot Wetland in the Lyndhurst Scheme. These online retarding basins/wetland systems are a new way of working with developers in that they combine both a RB function and a wetland function in the one system which optimises available land area for development

Despite pollutant removal, potable substitution and restoration of natural hydrology and the benefits of stormwater harvestings schemes being well established, they have to date been largely restricted to public open space (POS) irrigation projects (Fletcher *et al* 2007). The demand profile of such POS schemes requires large storages to meet seasonal demand (Mitchell *et al* 2005). To ensure optimisation of both the original RB asset and potential harvestable volumes of water, SEW and Melbourne Water have developed projects that utilise recycled stormwater that incorporate **both** seasonal and non-seasonal demand. Two such examples of next generation Retarding Basin optimisation that will be discussed in this paper are the Troups Creek West stormwater harvesting scheme for a residential area and the Avoca St RB retrofit project for commercial and non residential use.

TROUPS CREEK STORMWATER REUSE PROJECT

In 2006 SE Water commenced an investigation into stormwater reuse. A VicUrban infill development (58 lots) was in the planning stage at Narre Warren North and with mutual interests in sustainable water practices, a Memorandum of Understanding was subsequently signed to consider stormwater harvesting from the adjacent Troup's Creek wetland which is managed by Melbourne Water (refer figure 1).

The Troup's Creek Scheme employs novel thinking to a concept that is commonly used in residential recycled water estates in that treated stormwater is used to supply non potable demand instead of Class A recycled water.

PROJECT DESCRIPTION

The project involves harvesting 10 ML/year of stormwater from the Troup's Creek wetland, treating the stormwater using a treatment train of pre-chlorination, pressure dual filter media, granular activated carbon, UV and chlorination then distributing the water to customers using a dual pipe network. A diagram of the project is shown in Figure 2.

The treatment plant was designed using the National Recycling guidelines which required extensive water quality testing to characterise the stormwater within the Troup's Creek system.

Likewise, the hydrology assessment concluded that water could be supplied with a 96% reliability. This is conservative as it was determined using a higher demand of 17 ML/ year.

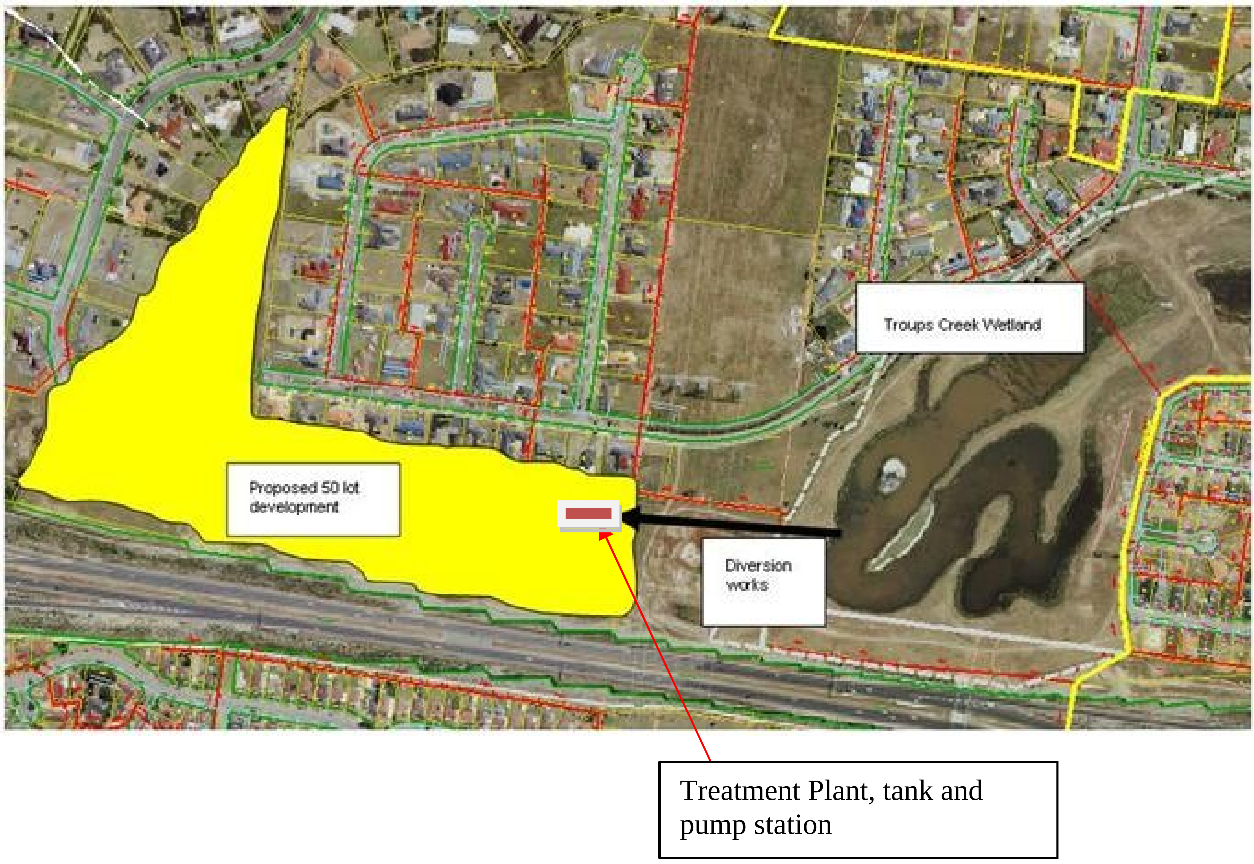

Figure 1. Schematic of the Troup's Creek Stormwater Harvesting Scheme

TREATMENT PROCESS

After an extended detention time in the Troup's Creek wetland, water is treated to meet health objectives under National recycling guidelines. Treatment involves running feedwater through a treatment train of pre-chlorination, pressure dual filter media, granular activated carbon, UV and chlorination. The feedwater quality has high variances in colour which has necessitated an additional slow sand filter trial in conjunction with standard water quality treatment to determine which treatment process achieves the greatest reductions in colour.

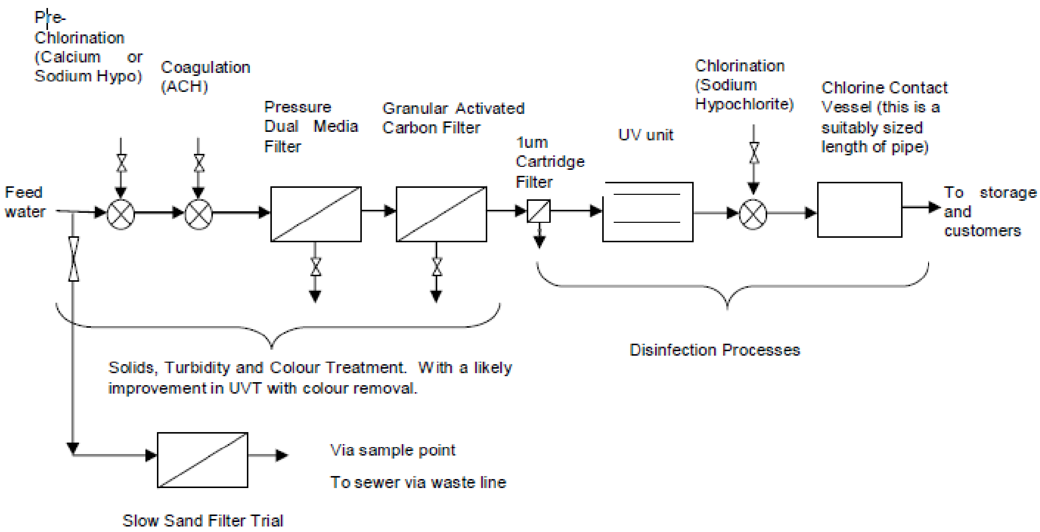

Figure 2. Schematic of the Troup's Creek Stormwater Treatment Plant

The above plant will include and allow for manual bypass of process units (ie cartridge filter) to allow for piloting and determination of the lowest operating cost configuration for stormwater reuse. Appropriate instrumentation (turbidity meter, pH meter, UVT analyser, free chlorine analyser), are included in the process train to ensure that adequate treatment is achieved. Flow metering has been allowed for on the inlet and outlet of the plant as well as a separate meter to monitor potable water use for potable backup supply into the recycled water main.

AVOCA STREET, HIGHETT RETARDING BASIN RETROFIT

The Avoca Street Retarding Basin was identified by South East Water as having potential for stormwater harvesting.

Melbourne Water investigated various options for the site ranging from full use of the site to a part use of the site, and with the support of South East Water and the City of Bayside, the area around the Avoca Street retarding basin has been investigated for potential demand for the use of the stormwater.

The objective of this project is to test the application of stormwater harvesting within the Avoca Street retarding basin with the view to refining its application across other retarding basin sites.

- South East Water have investigated the local demand for water in relation to Melbourne Water's retrofitting of the Avoca St Retarding basin with a stormwater treatment wetland, open storage pond and UV disinfection system. A concept plan has been developed for the scheme that shows the distribution of stormwater to seven customers upstream from the Melbourne Water Avoca Street Retarding Basin. The volume harvested is expected to be 60 ML/year.

- City of Bayside has indicated an interest in a small scale stormwater harvesting scheme which will involve the passive release of stormwater from the retarding basin site using existing drainage infrastructure to subsequently irrigate open space downstream. Each downstream site will require onsite wet wells, pumps, storage tanks and UV disinfection systems. The volume harvested is expected to be 7 ML/year.

For funding of this project, South East Water has divided the project into 2 packages.

Package 1 relates to Melbourne Water's retrofitting of the Avoca St Retarding basin with a stormwater treatment wetland, open storage pond and UV disinfection system. The aim of this scheme is to maximise the use of stormwater and hence has a commitment to an extensive pipe network to distribute stormwater to users. Package 1 proposes to harvest in excess of 60 ML/year of stormwater that provides potable substitution and significant reduction in nitrogen load to Port Phillip Bay. A concept plan has been developed for the scheme that shows the distribution of stormwater to seven customers from the Melbourne Water Avoca Street retarding basin.

This is to be a joint project between SE Water, Melbourne Water and Bayside City Council capturing, storing and treating stormwater at the Avoca Street retarding basin. The management responsibilities for this project are yet to be finalised, however it is likely that SE Water will be responsible for managing the pipe distribution of stormwater to the customer property boundaries, while Melbourne Water will manage the operation of the retarding basin.

Package 2 relates to Melbourne Water's retrofitting of the Avoca St Retarding basin with a stormwater treatment wetland and open storage pond storage. The aim of this package is to provide a small scale stormwater harvesting scheme which will involve the passive release of stormwater from the retarding basin site using existing drainage infrastructure to subsequently irrigate open space downstream. The downstream site will require onsite wet wells, pumps, storage tanks and UV disinfection systems. The volume harvested is expected to be 7 ML/year.

SITE

The proposed site is the Melbourne Water Avoca Street Retarding Basin site (Melway 77C10) and the underground drain is the Gilarth Street Main Drain. The site is located in Highett in the City of Bayside. Bayside City Council is committed to conserving water and protecting the beneficial uses of its waterways through integrated urban water management projects and has a Sustainable Water Management Plan that is targeting a reduction in water consumption by 30% from 2000/1 levels by 2010/11

Figure 3. The Avoca St Retarding Basin

CATCHMENT AREA

The Avoca Street Retarding Basin has a catchment area of 110.07 Ha. Almost the entire area is either residential or industrial. The zonings, land use and respective areas are shown in tabular form below.

ITEM	CATCHMENT TYPE	AREA (Ha)
1	Residential 1 (R1Z)	41.29
2	Business 3 Zone (B3Z)	51.35
3	Public Use Zone 5 (PUZ5)	8.20
4	(MUZ)	0.85
5	Business 1 Zone (B1Z)	0.67
6	(PPRZ)	0.77
7	(RDZ2)	6.93
TOTAL		**110.07**

POTENTIAL YIELD FROM THE GILARTH STREET MD

The MUSIC Modelling system was utilised to determine the yield from the catchment. Based on an average rainfall of 650mm per year, the total runoff yield is 354ML/year and for a dry year (468mm rainfall/year), the runoff yield is 255ML/year.

For a retarding basin on a pipe drainage line, the drainage system is an artificially modified system and likely to support stormwater harvesting with minimal or no risk to natural systems.

To determine the harvestable catchment yield at the retarding basin site, a water balance modelling assessment was undertaken and a number of storage options were examined. The yield estimates have varied using two different hydrology consultants and a midpoint design value of 70ML/year has subsequently been adopted.

ELEMENTS OF INFRASTRUCTURE

WATER QUALITY TREATMENT INFRASTRUCTURE

Stormwater inflows will be treated via a treatment train consisting of a gross pollutant trap, sedimentation basin, wetland and UV disinfection system

The system infrastructure that essentially delivers the stormwater quality functions are the Silt Trap, Wetland and UV system.

The Concept Design Summary reported the intention that the wetland be configured to provide vegetation and storm flow residence times consistent with the attainment of the following stormwater quality treatment performance targets:

- Total suspended solids < 10 mg/litre
- Total nitrogen < 1.0 mg/litre
- Total Phosphorus < 0.1 mg/litre

These targets were set because of the storage and reuse elements of the project.

POTENTIAL VOLUME ALLOCATION

A review of the study area confirmed initial commitment from three key sites to be the focus of the investigation that could use stormwater for irrigation of open spaces for a total potential recycling volume of up to 62 ML/year.

ID	Site	Potential Usage (ML/year)*
1	Sandringham East Primary School	3
2	Sandringham Secondary College	8
3	Cheltenham Driving Range	8
4	Cheltenham Memorial Park	9
5	Tulip Street Reserve	12
6	Sandringham Golf Club	18
7	Gills Nursery	4
		62

- Based on pre-restriction historical data.

INTELLIGENT NETWORKS TO OPTIMISE STORMWATER HARVESTING VOLUMES

Intelligent network solutions are broadly defined as emerging technologies and systems, which have the potential for significant benefit to water service delivery, integrated water management, and customer value enhancement.

Intelligent network solutions have great potential to optimise stormwater harvesting schemes. The key to maximising potable substitution from stormwater harvesting schemes is ensuring that volume is always available in storages in order to intercept incoming flow volumes.

In the Avoca St Scheme preliminary work has commenced looking at the potential of fitting "dump valves" to the 7.6 ML open store. These "dump valves" or motorised gates developed by Suburban Water Pty Ltd. on the open store in the RB would be operated from a central server by "Smart Modules". Smart modules receive inputs such as water depth and flow rates to designated drains and storages. This central server would have a telemetry function that is linked to the Bureau of Meteorology rainfall Radar site. Prior to rainfall events "dump valves" could be enacted which release flows from the open storage to downstream receiving tanks. This timed release of water would draw down water levels in the open store and enable greater stormwater inflows to be captured for each rainfall event

Other Smart Modules could also be installed at Avoca St to control or operate wetland diversion structures in emergency situations.

FUTURE CHALLENGES FOR RB RETROFIT SCHEMES

The adoption of stormwater use to substitute potable supplies will largely depend on the environmental and social values that can be achieved to offset any additional cost beyond conventional potable supplies. This requires improved understanding the environmental priorities across the region.

Recent research has demonstrated the importance of reducing runoff frequency to the consequent health of receiving water ecosystem health (Walsh *et al.,* 2005) & (Ladson *et al* 2005).

Changes in stream hydrology due to urban stormwater runoff are well established. The increased volumes and magnitude of storm flow, coupled with increased total annual runoff volumes and reduced baseflows in winter and summer are key factors implicated in the degradation of urban waterways. (Walsh *et al.* 2010).

The challenge for urban waterway managers is twofold. The optimization of stormwater harvesting from RBs and other WSUD installations needs to not only capture, store, treat and deliver maximum volumes of treated stormwater for potable substitution but in addition, stormwater harvesting schemes need to also mimic the pre development hydrology of the site in order to truly protect and enhance urban waterways.

Walsh *et al.* 2010 have identified four critical objectives for stormwater managers to address in order to maximise the protection of receiving waterways.

1. To minimize uncontrolled stormwater flows. It is essential to retain and treat via WSUD as much stormwater as possible within the catchment in order to prevent untreated piped flow reaching waterways
2. Ensure infiltration flow rates to streams do not exceed predevelopment rates
3. Ensure infiltration flows to streams meet ANZECC guidelines for ecosystem protection and,
4. To achieve the aforementioned three objectives it will be necessary to retain or lose stormwater runoff via indoor use, irrigation and evapotranspiration. (Walsh *et al.* 2010)

COMMUNITY

Research on the community has shown a high acceptance for treated stormwater when compared to treated effluent. Mitchell *et al*. (2006). This may be a short term perception issue, but nevertheless there has always been general support for stormwater harvesting.

Acceptance was found to be highest for household scale or large (centralised scale) systems, as opposed to neighbourhood or cluster schemes operated by a body corporate. Acceptance was found to be greater for rainwater use on gardens than stormwater. However, in general acceptance was greater for treated stormwater than treated effluent. Mitchell et al. (2006)

It is hoped that sites such as Troup's Creek and Avoca Street will provide a well managed demonstration site where findings are transparent, which will assist in shaping current and future community attitudes.

RELEVEVANT LEGISLATION

The principal guiding policy document associated with stormwater harvesting in Victoria is the Central Region Sustainable Water Strategy (CRSWS) which sets the following allocation rules for stormwater in urban areas:

- *If stormwater is flowing to the sea via a drain, all of the stormwater may be harvested;*
- *If stormwater is flowing to a stream from an existing development, assume up to 50 per cent of existing stormwater can be harvested for consumptive use and 50 per cent is reserved for the environment. If there is a scheme to harvest more than 50 per cent of the resource a study is required to assess the implications for the environment;*
- *If stormwater is generated from a new development, all of it is available for consumption with the aim of the development having no impact on catchment run–off.*

As it stands these allocation rules promote a degree of stormwater harvesting and reuse. However, they lack the robustness to institutionalise stormwater harvesting across the region. Investigations as part of the SEW IWM strategy have identified policy gaps in the CRSWS. An allocation framework for stormwater harvesting is required. The Allocation Framework needs to address the ownership of stormwater, issues surrounding the equity of granting stormwater diversion licenses and maximising quantities of stormwater harvested, to achieve the best outcome for both the community and receiving waterways.

CONCLUSIONS

A key tenet of Integrated Water Management is to optimally address the interdependencies between waterway management, demand management, asset management, lifecycle assessment and ground water management to deliver best practice outcomes for the community and the water environment.

The conjunctive use of assests in the form of retrofitting retarding basins with WSUD installations such as wetlands or biofiltration trenches to deliver improved waterway
health, water supply options and public amenity exemplifies the principles of IWM

Retarding Basins have evolved from single function installations providing a flood mitigation service through to multi functional centres of stormwater quality treatment, refuges for biodiversity, new opportunities for Public Open Space and of crucial importance in the context of climate change a new source of potable substitution.

As WSUD technology improves, and our understanding of the precise mechanisms of in stream ecosystem degradation as a result of stormwater are refined, the importance of RB retrofits in an urban context will be be further recognised.

It is hoped that RB retrofits controlled by intelligent networks will help deliver not only improved water quality but hydrological conditions that mimic predevelopment levels

REFERENCES

Dechesne M., Barraud, S., Bardin, J.-P (2004) Indicators for hydraulic and pollution retention assessment of stormwater infiltration basins. *Journal of Environmental Management,* 71, 371-380.

Hodgens, J (2010) Discussion Paper review of Melbourne Water's Retarding Basins For Multi Use Purposes. *Internal Publication*

Fletcher, T. D., Mitchell, G., Deletic, A., Ladson, A., & Séven, A. (2007). Is stormwater harvesting beneficial to urban waterway environmental flows? Water Science and Technology, 55(5), 265-272.

Ladson, A. R., Walsh, C. J., & Fletcher, T. D. (2006). Improving stream health in urban areas by reducing runoff frequency from impervious surfaces. Australian Journal of Water Resources, 10(1), 23-34.

Mitchell, V. G., McCarthy, D. T., Fletcher, T. D., & Deletic, A. (2005). Optimising storage capacity for stormwater utilisation. Paper presented at the 10th International Conference on Urban Drainage, Copenhagen, Denmark.

Mitchell VG, Hatt B, Deletic A, Fletcher TD, McCarthy D, Magyar (2006) Technical Guidance on the Development of Integrated Stormwater Treatment and Reuse Systems, *ISWR Technical report 06/01.*

Walsh, C. J., Fletcher, T. D., & Ladson, A. R. (2005). Stream restoration in urban catchments through redesigning stormwater systems: looking to the catchment to save the stream. *Journal of the North American Benthological Society, 24*(3), 690-705.

Walsh,C.J, Fletcher, T.D, Hatt, B.E., & Burns, M.(2010) New generation stormwater management objectives for stream protection:Implementation at multiple scales to restore a small stream. (in press)