Water Sensitive Urban Design in the Australian Context

Synthesis of a conference held 30 - 31 August 2000, Melbourne, Australia

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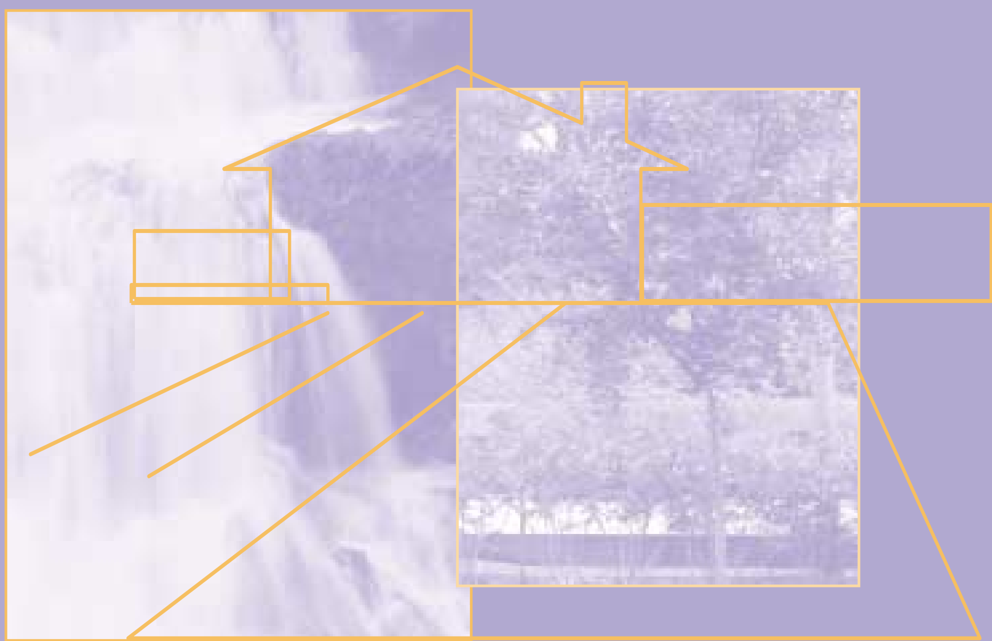

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Sara D. Lloyd

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Preface

A cultural change is occurring in urban stormwater management. Environmental aspects are becoming a major focus, with potentially profound effects on our traditional approach to drainage. There are now parallels with the state of stormwater management in Melbourne during the 1920's and 30's. At that time there were few, if any, standards for flood management and drainage. Environmental data, such as rainfall and run-off, to support good planning and design were unavailable. There were limited resources for implementing a backlog of works to relieve already significant problems in existing urban suburbs and disagreement about who should pay for works and how funds should be raised. What emerged was a recognition that good planning was as important as good engineering in avoiding future problems.

Water Sensitive Urban Design (WSUD) is something of a catch-all term for environmentally sustainable water resource management in urban areas. In Melbourne, WSUD is gaining prominence as we recognise the need for a new approach to managing urban stormwater to minimise the impact of urban development on our waterways and bays. More recently the broader aspects of WSUD dealing with water conservation have also begun to gain more attention and interest.

In adopting a water sensitive approach to urban development, we are confronted by a number of problems including, a lack of clear and agreed standards for the environmental management of urban stormwater, a lack of environmental data and performance data on WSUD measures to support planning and design and so on. It took years to resolve and move on from these issues in the 1920's and 30's, and it will take some time to make progress today.

Melbourne Water initiated the *Water Sensitive Urban Design in the Australian Context* conference in August 2000 to help strengthen the network of developers, local authorities and researchers interested in WSUD. What emerged was a sense of excitement about confronting these issues and a willingness to challenge convention. A strong partnership has been established in many parts of Australia between local authorities, developers and research institutions resulting in innovative urban developments incorporating significant water sensitive elements. From these projects we are learning a great deal and building confidence in WSUD as a practical approach to urban water management.

This synthesis of the conference outcomes will help us to focus on the major obstacles to progress and to more confidently manage the transition to more sustainable urban water management.

Chris Chesterfield
Team Leader, South East Catchment Planning
Melbourne Water Corporation

Executive Summary

Rapid urban growth in Australia over the last 30 years is resulting in an expanding footprint of urban-related impacts on the environmental, economic and social values of our receiving waters. In addition, consolidation of urban areas is increasing pressure on existing drainage infrastructure. Increasing emphasis placed on the importance of protecting receiving water values by water managers and the broader community is prompting a shift in what is considered appropriate land and water management practices for urban catchments. Consequently, there is a growing enthusiasm and support for a fundamental change in the way urban water resources are managed.

The *'Water Sensitive Urban Design - Sustainable Drainage Systems for Urban Areas'* conference was held in Melbourne last year to highlight and explore the opportunities and impediments to the adoption of Water Sensitive Urban Design (WSUD). WSUD is the term used to describe a new approach to urban planning and design that offers sustainable solutions for integrating land development and the natural water cycle. Integrated stormwater management systems, one component of WSUD, aims to minimise the impact of urban development on receiving waters. WSUD provides the planning framework and management practices required to achieve both cost-effective solutions and enhanced environmental outcomes.

Four major categories of issues were identified by conference participants as being the most important to the advancement of WSUD practices in Australia: the regulatory framework; technology and design; assessment and costing, and marketing and acceptance. The key impediments to the widespread adoption of Water Sensitive Urban Design aligned with these issues are:

- An effective regulatory and operating environment does not exist at the state or local government level
- The current culture and technical skill of local governments and water authorities do not support the changes required for the assessment, approval, construction and maintenance of development schemes based on the principles of WSUD
- Institutional fragmentation of responsibilities in the urban development and approval process creates difficulties in working across administrative boundaries and impedes collaboration between organisations
- Poor construction site management practices lead to reduced effectiveness or failure of Best Management Practices
- Insufficient information on the operation and maintenance of structural Best Management Practices in WSUD leads to local government concern about their long-term viability
- There is limited quantitative data on the long-term performance of Best Planning Practices and Best Management Practices in WSUD
- The assessment of project costs require an examination of externality costs and currently there is no established procedure to guide this aspect of a life cycle cost analyses
- The market acceptance of WSUD needs defining

Despite the impediments listed above, numerous WSUD projects have been completed. This demonstrates how the benefits associated with WSUD projects often significantly outweigh the current impediments.

This synthesis collates and summarises the key issues raised by conference participants and focuses on existing barriers to the adoption of WSUD principles. The report offers possible solutions to help overcome both short-term and long-term issues in applying WSUD principles.

Acknowledgements

The information presented in this document draws on the content presented by keynote speakers, members of panel sessions and the 170 or so participants who attended the Water Sensitive Urban Design conference held in Melbourne, August 30 - 31, 2000. Appendix A provides an outline of the conference agenda.

The following keynote speakers and members of the panel sessions contributed to invaluable, open discussions by drawing on their experiences with Water Sensitive Urban Design.

- Dr Peter Ellyard
- Dr Mike Mouritz
- Dr Andrew Speers
- Assoc. Prof. Tony Wong
- Assoc. Prof. John Argue
- Mr Andrzej Listowski
- Mr Bernie Porter
- Mr Barry Murphy
- Mr Colin Pitman
- Dr Stephen Hancock
- Mr Tony McAlister
- Mr Tim McAuliffe
- Mr Garry Reynolds
- Ms Helen Gibson
- Ms Esther Kay
- Mr Peter Coombes
- Mr Gary Spivak
- Mr Gary Kerrans
- Mr Claude Cullino
- Mr Stephan Axford
- Mr Mark Sheppard
- Mr Stephan Hains

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- Caroline Carvalho (Melbourne Water Corporation)
- Tony Wong, David Perry and Russell Mein (Cooperative Research Centre for Catchment Hydrology)

1 Introduction

Water, sewerage and stormwater infrastructure in Australian cites has been developed since settlement with little regard for the ecological integrity of our receiving waters. Much of this aging infrastructure requires augmentation, to cope with population increases in urban centres. In addition, there is a widespread realisation of the need to consider asset renewal or replacement strategies that protect and/or enhance the environmental values associated with receiving waters. Consequently, the opportunity now exists for a fundamental change in the way we manage our urban water infrastructure. At the *'Water Sensitive Urban Design - Sustainable Drainage Systems for Urban Areas'* conference held in Melbourne during 30 - 31 of August 2000, many participants associated with the water industry voiced their support for this change.

The aim of the conference was to bring practitioners, researchers and policy makers together to draw on their experiences and discuss key issues that support or impede the implementation of Water Sensitive Urban Design (WSUD) in urban catchments. Appendix A provides details of the conference agenda. Invited speakers and panel sessions addressed specific issues and provided a basis for open discussion between participants of the conference. Figure 1 illustrates the breakdown of professions that attended the conference; consultants and representatives from local government making up the greatest proportion.

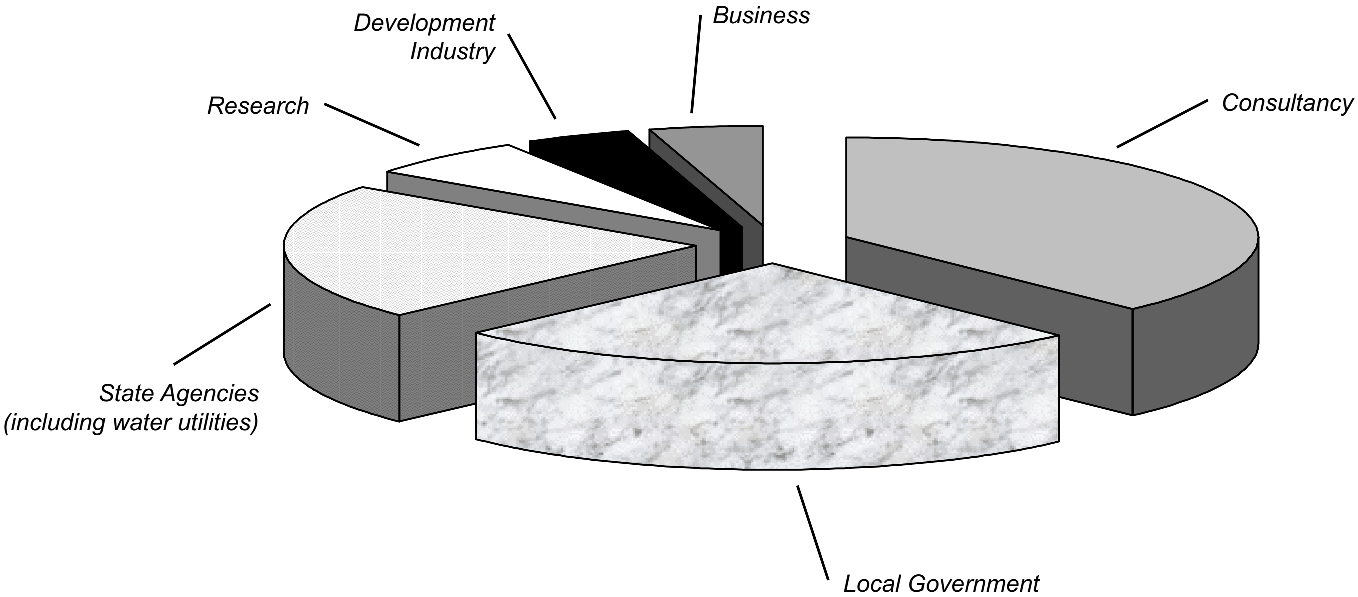

Figure 1. Break down of participants attending the Water Sensitive Urban Design Conference, August 2000

1.1 Scope of this Report

This synthesis draws on the conference participants' presentations and discussions of the major issues in applying sustainable practices to the management of urban water resources in Australia. Potential strategies to overcome some of the current obstacles to the more widespread adoption of WSUD principles in urban planning and design are included.

1.2 What is Water Sensitive Urban Design?

WSUD was first referred to in various publications exploring concepts and possible structural and non-structural practices in relation to urban water resource management during the early 1990s. The emergence of WSUD in Australia is part of a wider movement at an international level towards the concept of integrated land and water management.

In its broadest context, WSUD encompasses all aspects of integrated urban water cycle management, including the harvesting and/or treatment of stormwater and wastewater to supplement non-potable water supplies. To date, individual WSUD demonstration projects partially address planning and design issues associated with fully integrating the urban water cycle. Collectively, the projects highlight the full potential for WSUD.

WSUD aims to minimise the impact of urbanisation on the natural water cycle, and its principles can be applied to the design of a single building or to a whole subdivision. The design of integrated water management systems is evolving towards a practical balance between traditional and WSUD approaches. Whelans *et al.* (1994) defined the objectives or desirable outcomes of WSUD as:

i) To manage a water balance
   - to maintain appropriate aquifer levels, recharge and stream-flow characteristics in accordance with assigned beneficial uses
   - to prevent flood damage in developed areas
   - to prevent excessive erosion of waterways, slopes and banks

ii) To maintain and, where possible, enhance water quality
   - to minimise waterborne sediment loading
   - to protect existing riparian or fringing vegetation
   - to minimise the export of pollutants to surface or groundwaters
   - to minimise the export and impact of pollutants from sewage

iii) To encourage water conservation
   - to minimise the import and use of potable water supply
   - to promote the reuse of stormwater
   - to promote the reuse and recycling of effluent
   - to reduce irrigation requirements
   - to promote regulated self-supply

iv) To maintain water related environmental values

v) To maintain water related recreational values

More recently the Urban Stormwater: Best Practice Environmental Management Guidelines (CSIRO, 1999) listed five key objectives of WSUD for application to urban stormwater planning and design. They are:-

1. **Protect natural systems;** protect and enhance natural water systems within urban developments
2. **Integrate stormwater treatment into the landscape;** use stormwater in the landscape by incorporating multiple use corridors that maximise the visual and recreational amenity of developments
3. **Protect water quality;** protect the water quality draining from urban development
4. **Reduce run-off and peak flows;** reduce peak flows from urban developments by local detention measures and minimising impervious areas
5. **Add value while minimising development costs;** minimise the drainage infrastructure cost of development

These principles collectively call for an enhanced or more considered approach to the integration of land and water planning at all levels of the urban development process (ie. planning, concept design and detailed design). At the conference, one keynote speaker asserted that adoption of a WSUD approach potentially provides a 'tool' for 'catchment repair'.

Consequently, achieving the objectives of WSUD is more than simply constructing a lake and wetland system. Fundamental to the application of WSUD philosophy to water management schemes is the integrated adoption of *Best Planning Practices* and *Best Management Practices.* Figure 2 outlines the steps necessary to achieve WSUD objectives.

Best Planning Practice (BPP) refers to the site assessment and planning component of WSUD. Initially, the physical attributes of a site, such as climate, geology, drainage patterns and significant natural features (eg. wetlands and remnant vegetation) should be identified. Subsequently, an assessment of land capability should be undertaken to ensure the physical attributes of the site are matched to the proposed land-use requirements.

Best Management Practice (BMP) refers to the structural and non-structural elements that perform the prevention, collection, treatment, conveyance, storage or reuse functions of a water management scheme. Selecting the appropriate BMPs to target specific flow management or water quality control function requires the undertaking of a feasibility assessment. This assessment may include the consideration of such factors such as the hydraulic operating conditions and life cycle costs (ie capital and maintenance).

The final site layout is based on the outcomes of the analysis of physical attributes and the land capability assessment. These factors determine the most suitable placement and arrangement of BMPs and site amenities. This process minimises the impact of land-use on the land and water environment. The selection, placement and sequencing of BMPs are important to optimise beneficial outcomes, and to reduce the impact of catchment urbanisation on the receiving waters. This sequencing of BMPs is referred to as the 'treatment train'.

The Importance of Integrating WSUD Principles

An example of poor application of WSUD principles was described and discussed in detail at the conference. In the Wentworth Creek catchment located west of Newcastle, NSW, a 360 ha site was developed using WSUD principles to ensure the protection of the environmental values in the receiving waterway, including Hexham Swamp. A lack of consideration for BPPs resulted in the inappropriate application of BMPs. Unnecessary clearing of vegetation resulted in tonnes of sediment being generated and transported downstream. Such poorly conceived implementation of WSUD principles can undermine key stakeholder (including the community) confidence in these projects. Improved planning and development standards, procedures for approval, and regulation would help prevent similar incidents.

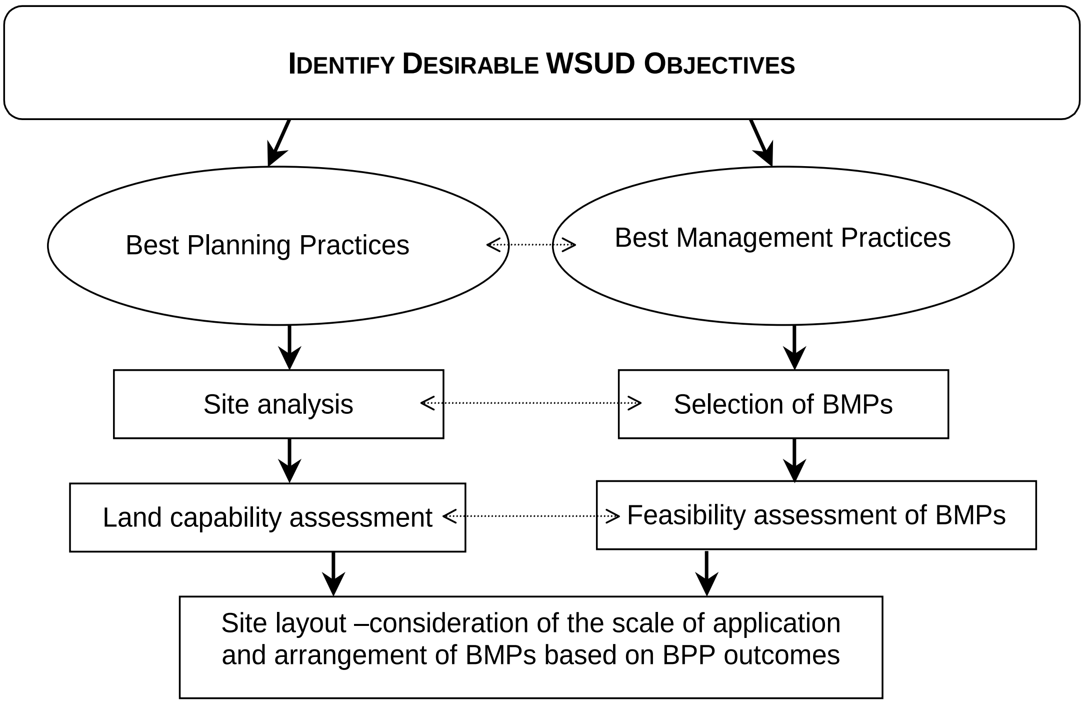

Figure 2. Overview of the steps involved in implementing the WSUD philosophy

2 Current Context of Adoption

The development of WSUD principles were based on environmental planning and design theory and practices. Hypothetical case studies were used to explore improvements to flow management and/or water quality control. However the broader issues, such as difficulties in applying WSUD principles under the current regulatory framework, life cycle costing and community acceptance, remained largely unexplored.

More recently, design concepts have been translated into on-ground works. This experience has been valuable in helping to achieve a better understanding of WSUD benefits and obstacles, in refining technology design, and to create confidence in the approach. Government and research institution support has been vital to the success of many of these WSUD projects; without it, many projects would not have made it past the concept design stage. Recent implementation of BMPs is largely the result of seed funding from state or Federal Government sources such as the NSW Stormwater Trust, the Natural Heritage Trust and Environment Australia's Urban Stormwater Initiative Program. Seed funding encourages organisations to overcome some of the institutional issues that restrict innovation and collaboration, allowing a more holistic approach to integrated water management.

2.1 Significant Case Studies

A number of development projects incorporating elements of WSUD have been completed over the last decade. Five key projects have been selected in this report to highlight the range and scale of WSUD application in Australia. The most widely recognised demonstration site is Homebush Bay, site of the Sydney 2000 Olympics. Smaller scale projects demonstrating unique applications of WSUD practices at the sub-catchment, streetscape and allotment scales include Lynbrook Estate, Figtree Place and the Healthy Home®. On a larger scale, the Mawson Lakes residential development provides an example of integrated urban water management, and demonstrates the potential for WSUD in Australia. These projects provide valuable information on aspects of implementing WSUD and enable an assessment of their performance as a water management scheme. Table 1 summarises the key features of the five demonstration sites described in more detail in Sections 2.1.1 to 2.1.5.

Table 1 Summary of key demonstration sites in Australia

WSUD Project	Development Type	Scale of Adoption	Developer
Homebush Bay, Sydney	Residential estate, state sporting facilities, business park and open space (760 ha)	Catchment and Allotment	Olympic Co-ordination Authority
Lynbrook Estate, Melbourne	300 lot residential estate and open space (55 ha)	Sub-catchment and Streetscape	Urban Land Corporation
Figtree Place, Newcastle	27 unit community housing venture and open space (<1ha)	Streetscape and Allotment	Newcastle Council & Department of Urban Affairs and Planning
Healthy Home®, Gold Coast	Single residential house	Allotment	Chris Prosser Owner/Builder
Mawson Lakes, Adelaide	3,400 lot residential estate, commercial precinct and open space (620 ha)	Catchment and Allotment	Delfin-Lend Lease Consortium

2.1.1 Homebush Bay

Homebush Bay was transformed from an area of landfill, abattoirs and a navy armament depot into an international showpiece for the 2000 Olympic Games using innovative water treatment and conservation measures. The WSUD objectives of the site include protecting receiving waters from stormwater and wastewater discharges, minimising potable water demand, and protecting and enhancing habitat for threatened species. These objectives have been achieved largely by on-site treatment, storage and reuse of stormwater and wastewater.

Stormwater runoff is treated using gross pollutant traps, swales and/or wetland systems. Wastewater is treated on-site using a water reclamation plant. The treated wastewater and stormwater is stored in a disused brick pit, and subsequently used as an alternative water supply for water features, irrigation purposes, toilet flushing and fire fighting. The use of this alternative water source, combined with water saving appliances, can reduce consumption of potable water by approximately 50%, annually. To date, all water quality monitoring data of the recycled water (ie. metals, nutrients, bacteria, viruses) complies with Australian water quality standards. Figure 3 shows the stormwater and wastewater BMP elements integrated into the landscape at Homebush Bay.

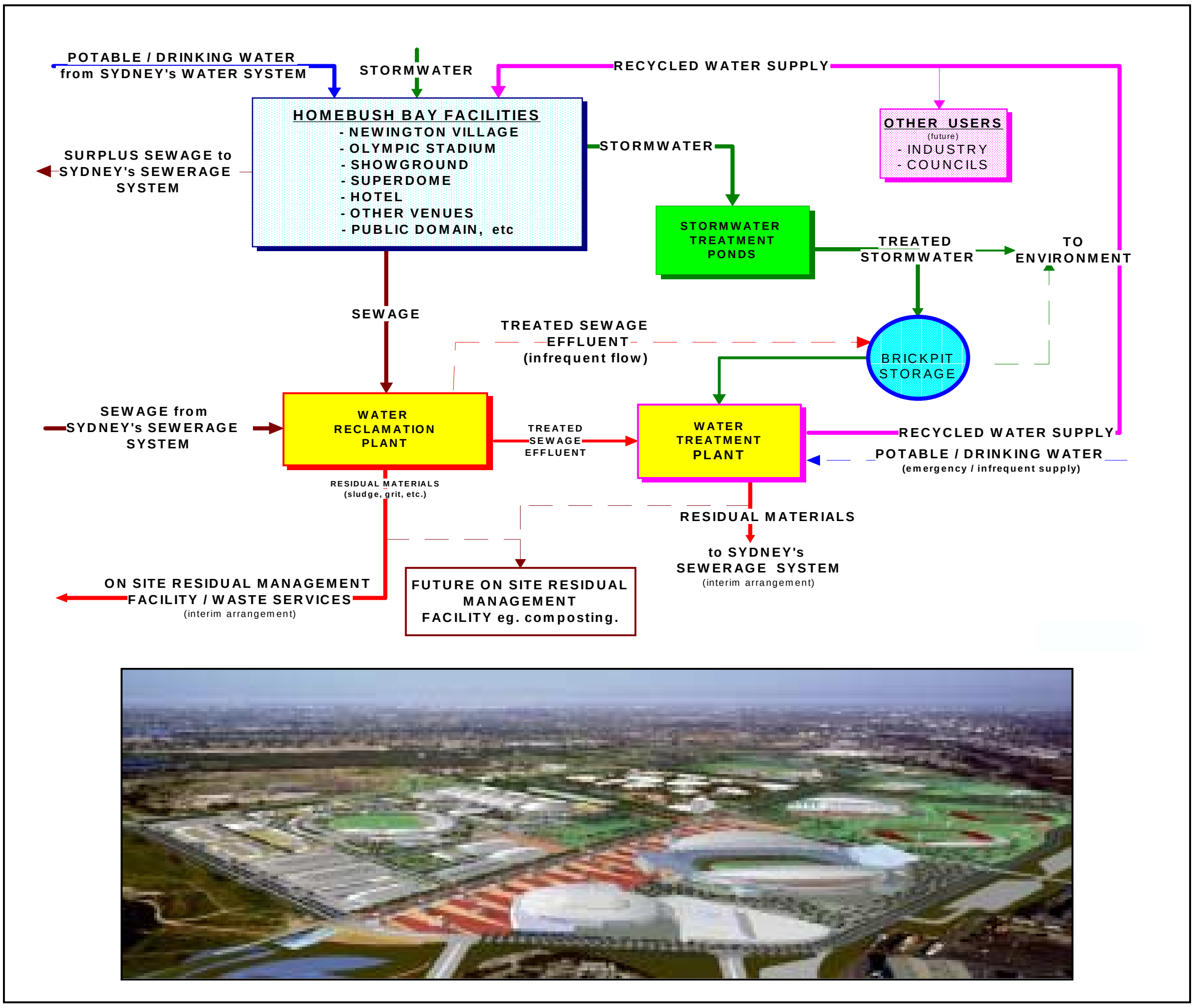

Figure 3. The Homebush Bay water management scheme

WSUD Planning and Design Features at Homebush Bay

- Contaminated soils were reclaimed and treated prior to any construction activities
- Open space plans were modified to conserve the habitat of an endangered frog species
- Stormwater is treated using gross pollutant traps, swales and wetlands to improve water quality
- On-site wastewater is treated using an advanced water reclamation plant
- Recycled water is stored in a disused brick pit
- Stormwater and wastewater is harvested and used in water features, irrigation, toilet flushing and fire fighting
- A dual pipe system exists for potable and non-potable water supply to all buildings
- Water saving appliances are used

For further information contact Andrzej Listowski at listowski@amaze.net.au

2.1.2 Lynbrook Estate

Lynbrook Estate is a greenfield residential development that incorporates WSUD principles at the streetscape and sub-catchment scale. The drainage system is designed to attenuate and treat stormwater flows for the protection of receiving waters. Three stages of the Lynbrook development have been constructed and a further 5 stages are approved for development. The staged approach to construction enabled progressive modification and improvements to the design of the stormwater conveyance system.

The costs of implementing a WSUD stormwater management scheme at Lynbrook were compared with a conventionally designed stormwater drainage system. The comparison shows a cost increase of 5% in the drainage component of the development. As the drainage works component represents only 10% of the overall land development cost, the incorporation of WSUD into the stormwater management system only increased the total development budget by approximately 0.5%. Market response has been positive and the Urban and Regional Land Corporation now intends to implement WSUD practices at other development sites. Figure 4 shows the layout of BMPs integrated into the landscape at the Lynbrook Estate for the treatment and conveyance of stormwater.

Figure 4. The Lynbrook Estate stormwater management scheme

Planning and Design Features at Lynbrook Estate

- The median strip incorporates a bio-filtration system that collects, infiltrates, treats and conveys road and roof runoff along the main entrance boulevard (there is no kerb and gutter along the median strip)
- The nature strips incorporate a bio-filtration system that collects, infiltrates and conveys road and roof runoff from local access streets (a grass swale overlying gravel trench with perforated pipe)
- Secondary treatment of catchment runoff occurs in a wetland system prior to discharging flows into an ornamental lake system
- The infiltration system is gravity fed from the lake to ensure adequate water supply to remnant river red gums
- A pool and riffle design is included as part of the regional floodway

For further information contact Bernie Porter at bporter@urlc.vic.gov.au

2.1.3 Figtree Place

Figtree Place is a 27-unit community housing development incorporating on-site stormwater harvesting and subsequent storage in rainwater tanks and an aquifer. The WSUD objective is to retain stormwater on-site and reduce potable water consumption. The site is designed to contain all runoff (no site overflows) for all rainfall events up to and including a 1 in 50 year event. The stormwater from roof surfaces is pre-treated in sediment traps prior to storage in underground rainwater tanks. Catchment runoff from roads and other impervious surfaces is infiltrated through the base of a dry detention basin and stored in an underground aquifer.

The stored stormwater is pumped from the aquifer as required and used to irrigate garden beds and open spaces, and wash buses at the adjacent depot. Harvested stormwater is also used to supply hot water to each unit ensuring sterilisation of the stormwater for indoor use. Monitoring at the site has shown that the harvested rainwater supplied to the units complies with Australian drinking water standards. Overall the water management scheme reduces high quality mains water demand by approximately 60%. Figure 5 shows the layout of the stormwater harvesting scheme adopted at Figtree Place.

Figure 5. The Figtree Place stormwater harvesting and supply scheme

Planning and Design Features of Figtree Place

- On-site infiltration basin is used to treat road/catchment runoff
- An aquifer storage and recovery system is employed
- Five centralised rainwater tanks collect roof runoff
- Harvested stormwater is used for hotwater services, toilet flushing, irrigation and supplements water for washing vehicles in adjacent bus depot
- A dual pipe system is used for potable and non-potable water supply to each unit
- Water saving appliances are used

For further information contact Peter Coombes at pcoombes@mail.newcastle.edu.au

2.1.4 Healthy Home®

The Healthy Home® is an environmentally sustainable demonstration project incorporating WSUD and energy efficiency principles in a 460m^2 urban allotment. The water management scheme includes both potable water and greywater components. Roof runoff is collected and stored in a 22,000 litre rainwater tank for all internal and external water requirements and is supplemented by mains water if required. A 'first flush device' on each downpipe discards the first two millimetres of roof runoff. The subsequently harvested water is passed through a 20 micron filter prior to consumption.

On-site monitoring of water supply and usage balance found a 54% reduction in mains water demand. Limited monitoring of rainwater quality has found low (yet unacceptable by Australian compliance standards) coliform levels, presumably from birds. All other water quality parameters met the standards. Greywater is currently treated on-site using a recirculating sand filter system. Sewage is not treated as it is prohibited in sewered areas under the Queensland Water Supply and Sewerage Act (1949). UV disinfection units are being installed and are expected to achieve complete coliform disinfection for both roof runoff and greywater. Estimates show a potential 80% reduction in mains water demand when both rainwater and greywater is successfully collected, treated, stored and recycled on-site. Figure 6 shows the design of the water management scheme adopted at the Healthy Home®.

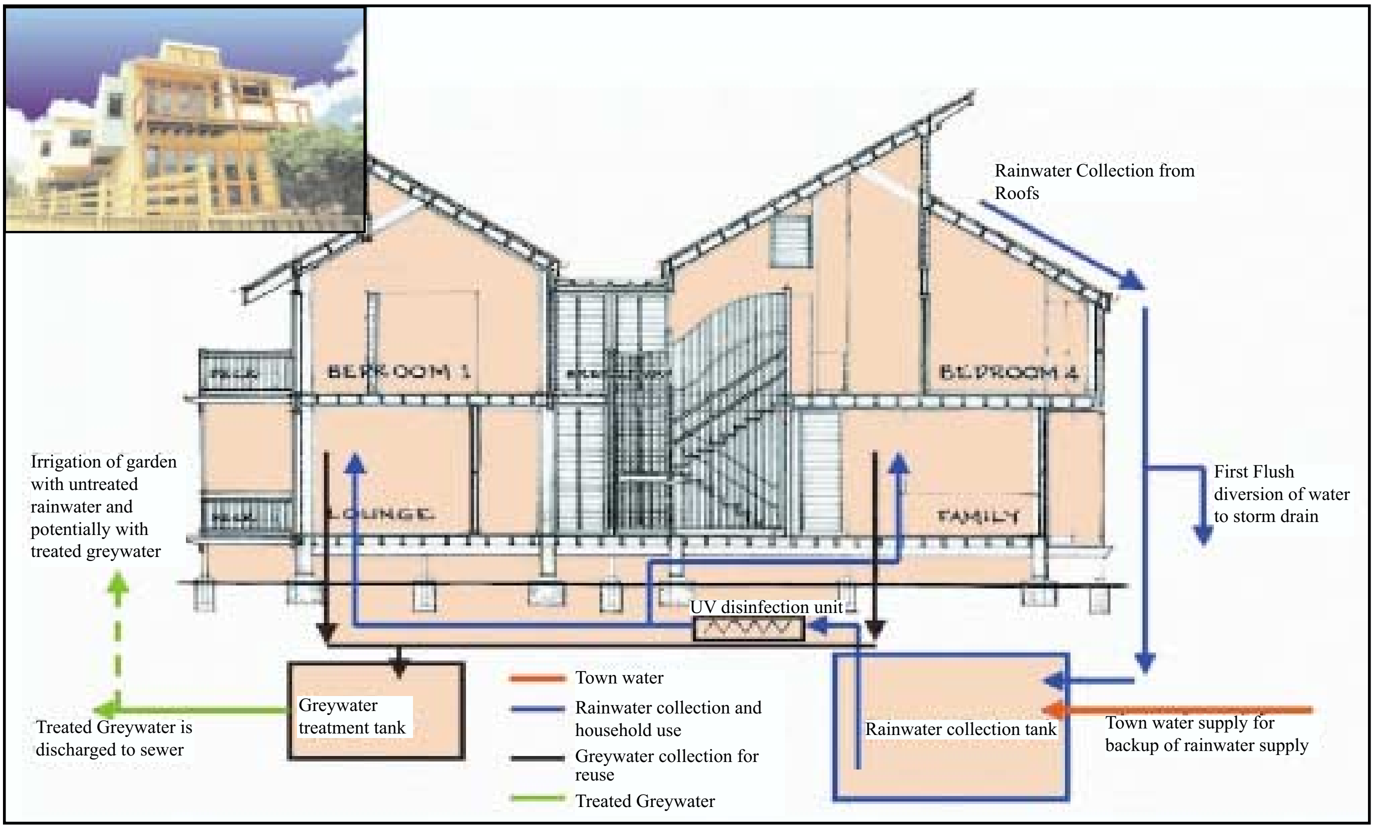

Figure 6. The Healthy Home® water management scheme

Planning and Design Features in the Healthy Home®

- Roof runoff is collected and stored in underground water tanks for household use
- Downpipes are fitted with first flush devices
- Potable water passes through a 20 micron filter
- A recirculated sand filter greywater system is employed
- Water saving devices are used throughout the house

Sourced: Gardner et al. in Dillon (2000). For further information contact Chris Prosser at ghealthi@fan.net.au

2.1.5 Mawson Lakes - A Vision for WSUD

The conference participants' vision for WSUD is to ultimately provide a holistic approach to the urban water cycle involving the integration of potable and non-potable supply systems and stormwater and wastewater management systems. Mawson Lakes, 12 km north of Adelaide's CBD, is the first attempt at achieving this vision and is currently under construction. The development aims to provide a model of social, economic and conservation in the urban context.

Stormwater generated from impervious surfaces will be treated in a series of wetlands. Wastewater will be treated in an advanced treatment plant located on the development. Both the treated stormwater and wastewater will be stored in groundwater aquifers for reuse. A 70% reduction in the annual consumption of mains water supply is expected. All houses have a dual supply pipe system; one conveying potable water, the second supplying non-potable water from the groundwater aquifers for toilet flushing and outdoor use. Public open space will also be irrigated with recycled water supplied from the aquifers. Figure 7 shows the BMPs integrated in the residential development at Mawson Lakes.

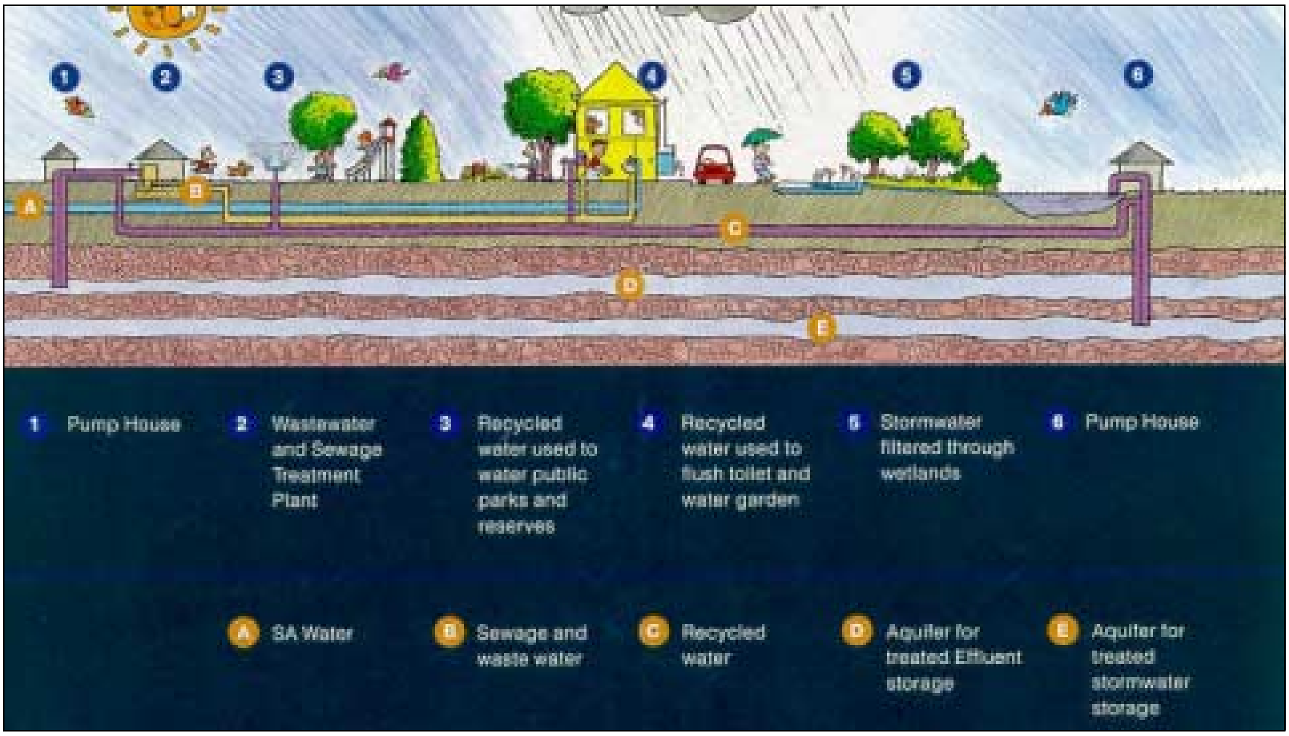

Figure 7. The Mawson Lakes water management scheme

Planning and Design Features at Mawson Lakes

- Runoff from roofs and roads will be treated in wetland systems
- Wastewater will be treated on-site in an advanced water reclamation plant
- Aquifer storage and recovery system will be used for treated stormwater and wastewater
- Treated stormwater and wastewater will supply irrigation, toilet flushing and car washing needs
- A dual pipe system will be used for potable and non-potable water supply to all buildings

For further information contact Hemant Chaudhary at hchaudhary@salisbury.sa.gov.au

3 Identifying the Issues Related to the Adoption of WSUD

Based on a review of the individual presentations, audience discussions and panel sessions at the conference, four major issues (shown in the inner circle of Figure 8) have been identified as the most important to address in advancing the concept of WSUD. These are: the regulatory framework; assessment and costing; technology and design; and marketing and acceptance. This section discusses each of the four major issues in more detail.

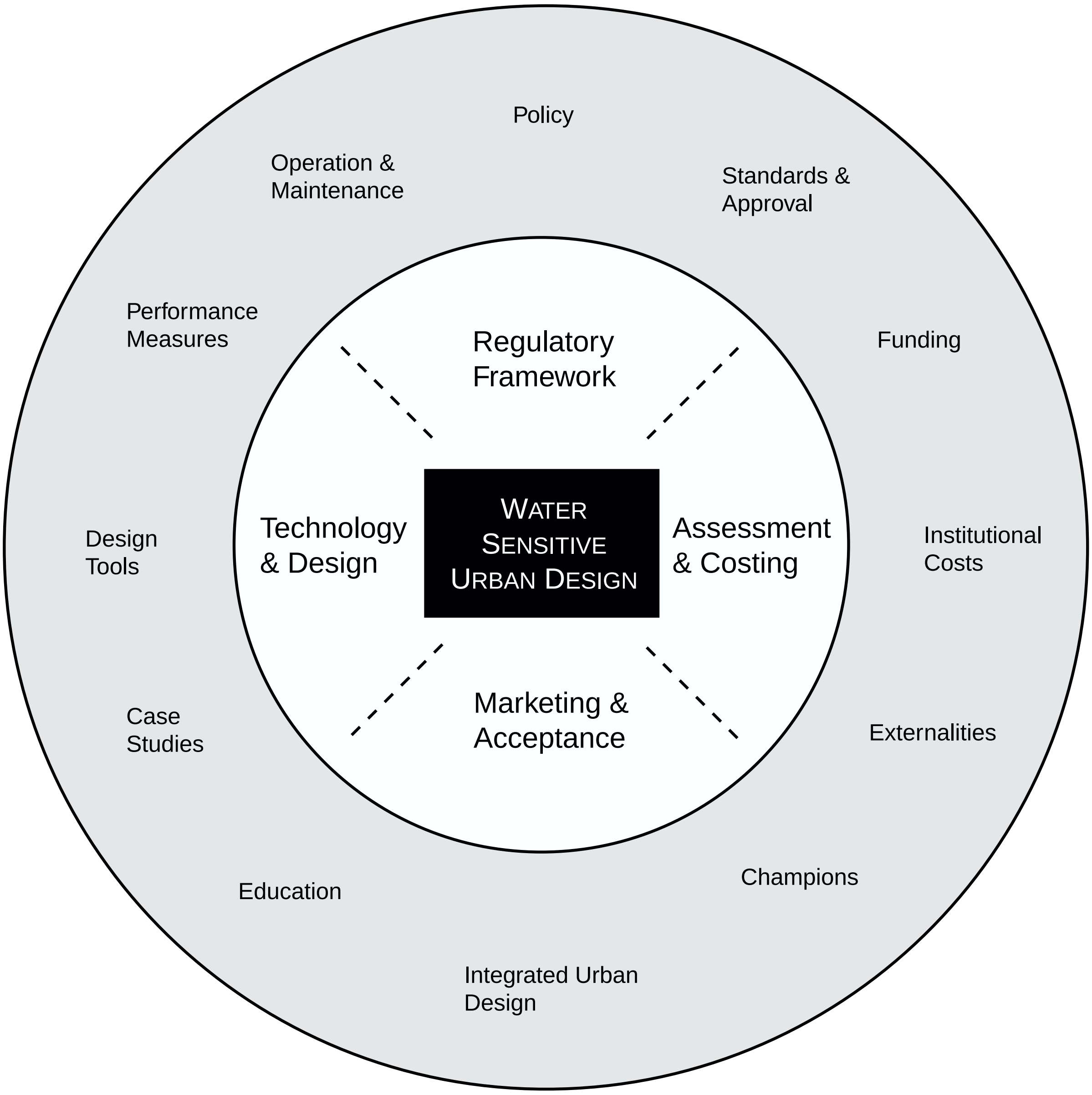

Figure 8. Key components to successfully integrating Water Sensitive Urban Design into urban development projects

3.1 Regulatory Framework

The current regulatory framework for the design of urban water infrastructure is prescriptive and does not readily allow for innovation. Sustainable water management should aim to meet our current community needs and minimise the impact to the surrounding environment now and in the future. In most Australian states, current institutional arrangements dictate that the responsibilities for water supply, stormwater, wastewater and groundwater management are separated within or between organizations. This fragmentation of responsibilities creates difficulties in getting different organisational sectors to work together in a positive manner across administrative boundaries.

Throughout Australia there are few, if any, examples of integrated land-use and water management objectives in planning and development guidelines. Consequently assessment and approval of integrated water management schemes is difficult. It was evident from conference discussions that integrated water resource management requires a collaborative approach between state and local governments to create an effective operating environment for WSUD practices. Policy, codes and guidelines need to be amended to facilitate this.

Current regulatory impediments however, have not prevented all local governments from developing innovative WSUD projects. As discussed below, planning policy and standards have been successfully used to promote and encourage the adoption of Best Practice in the urban development process.

Planning Policy

Brisbane City Council (BCC) has recently rewritten its planning policy to encourage the adoption of WSUD principles. BCC's 'City Plan' now specifies WSUD as the preferred option unless it can be discounted on the grounds of issues such as safety or on-going maintenance requirements. Implementation of this policy will require standards and approval procedures to be redrafted to incorporate WSUD planning and treatment measures. A key issue is the skills and capability of town planners and engineers to approve water sensitive concept designs. BCC plans to implement education and training programs for key stakeholders and provide guidelines for assessment and approval standards to address these types of issues.

Local Development Standards

Attempts to reduce the effects of urban consolidation on catchment hydrology can be controlled by the use of local development standards. For example, control over the extent of total site imperviousness can be achieved by the requirement of structural decoupling methods. Structural de-coupling methods, such as on-site rainwater tanks or infiltration soakways could be required in situations where the impervious area following development exceeds a 50% increase. The use of standards such as this can be an effective method to control development in high risk or vulnerable areas. Implementing local standards effectively requires a cultural change led by raising community awareness of the regulations and rigorous enforcement by local government.

3.1.1 Standards and Approval Processes

Local government is generally responsible for approving development applications and specifying the development standards to be met. These standards are often based on rigid engineering conventions and do not allow for an innovative or integrated approach to water management. At the conference, some participants were concerned that the skill and culture of local governments and water authorities was not generally sufficient to support the changes required to assess and implement projects involving WSUD. This creates a reluctance to accept the perceived risks involved in approving and implementing WSUD projects.

Awareness and education of senior and middle management is required to promote WSUD within local government and water authorities. Training workshops are required to raise workplace skills of employees to a level suitable to meet WSUD assessment and approval needs. To help overcome these types of problems conference participants suggested that, ideally, the regulatory framework for these developments should formulate a set of questions and objectives to be met by the urban development industry. The 'assessment' for approval would then be for developers to demonstrate how the proposed design solutions would achieve the objectives.

3.2 Technology and Design

Much of the technology required to achieve WSUD principles is available and, in many instances, is in the ground and operational. However, often the BMPs are not integrated into the landscape to form a treatment train. Instead they are located in isolation from one another and consequently do not provide an integrated water management system. No single BMP can provide an integrated solution to water resource management. It is the cumulative benefits derived from the implementation of BPPs and BMPs, that achieve WSUD objectives.

Two key issues in the design and construction stages of a water management scheme that can influence the long-term effectiveness of the system are the use of multi-disciplinary design teams and the protection of BMPs during construction activities. These two issues are discussed in further detail in the following sections.

Multi-disciplinary Design Teams

Using multi-disciplinary teams to develop concept designs promotes good integrated urban design. In the past, a single-disciplinary approach to the design of landscape features, such as urban lakes and wetlands, has led to stakeholder disapproval due to issues such as poor water quality, inappropriate landscaping or weed invasion. On the other hand, many good WSUD concepts developed using multi-disciplinary design teams are not successfully translated from design intent to the final product. In these early stages of applying WSUD principles, it is critical for the designer to clearly communicate the design intent to contractors to ensure proper construction and the success of the final product.

In the selection and design of integrated water management systems, it is also important for multi-disciplinary design teams to consider the inherent problems resulting from misapplication of WSUD technology. For example, the harvesting of all stormwater at a site would impact on the sustainability of the receiving waters. Harnessing the skills of a range of relevant disciplines and professions will ultimately provide cost effective solutions, based on considerations of local site constraints.

Sediment Control to Ensure the Integrity of Best Management Practices

A significant risk to the design performance of WSUD technology is the potential for massive generation of sediment during construction activities. Poor construction site management generates large sediment loads potentially leading to reduced effectiveness or failure of BMPs and impacts on the environmental values of the receiving waters. The integrity of BMPs such as swales and infiltration systems are particularly sensitive to poor construction site management. Hence, the planning, adoption and enforcement of sound construction site practices for on-site control of runoff and sediment is critical.

Local government is predominantly responsible for controlling the development industry. Some local governments in Australia require an Environmental Management Plan (EMP) for the construction site to be submitted with any development application. In the case of WSUD, the EMP needs to include consideration of the construction sequence of the various WSUD elements to protect them from sediment loads. Regulating the site construction activities is largely a local government responsibility that applies whether an EMP is prepared or not. The examples below demonstrate successful enforcement of planning and development controls to minimise the generation of sediment on construction sites.

In Melbourne, the City of Casey (local government) passed a local by-law requiring every builder to provide a rubbish container, portable toilet and adequate sediment controls on each allotment. Hydroseeding, sediment fences and hay bales were all used at the Lynbrook Estate to rapidly stabilise the construction site, and protect the swales and bio-filtration systems from sediment laden runoff during the house construction phase. Failure to abide with the by-laws incurs a penalty notice and fine for committing the offence. Re-offenders, or those who fail to pay the fine, can be prosecuted in the Magistrates Court for up to $2000.

Similarly, in Port Stephens, NSW, contractors are repeatedly fined, with fines increasing in value, for poor practices adopted on construction sites. If an individual or company is fined more than three times, their attendance at educational training sessions is compulsory. If poor practices continue the contractors are denied access to the site.

3.2.1 Operation and Maintenance

There is limited quantitative data on the long-term performance of WSUD technology. A lack of information on operation and maintenance practices for BMPs leads to concerns within local government about the long-term viability and costs associated with water management schemes. The awareness of operation and maintenance practices by operations and maintenance staff is critical to guarantee the success of WSUD projects. Some possible strategies to clearly define operation and maintenance procedures include:

- Providing staff education and training,
- Developing inspection routines
- Preparing checklists with clear identifiable indicators of inadequate system performance; and
- Preparing provisional action plans to promote prompt action to rectify problems as they arise.

These activities aim to ensure that staff clearly understand the objectives of WSUD and are familiar with the maintenance programs associated with WSUD.

Outsourcing Responsibilities

Outsourcing maintenance to appropriately skilled contractors is an option where local government staff do not have the required skills in long-term maintenance of BMPs. Alternatively, partnerships with private sector businesses can be considered, particularly in complex issues such as performance monitoring where a high level of expertise is required to gain useful and informative data.

Associated Maintenance Costs

Some WSUD infrastructure may have lower capital costs but increased maintenance costs compared with traditional designs. This may shift some of the costs from the developer to local government and is a major issue for local government. Comparisons between conventional infrastructure and WSUD scheme capital and maintenance costs are planned as part of the on-going assessment of some of the existing demonstration projects. Currently however, no quantitative information from WSUD demonstration projects supports the claim of higher maintenance costs to local government. Interestingly, the Salisbury Council in South Australia, cites the reduction of local government expenditure on open space irrigation as a major reason for the adoption of WSUD in large-scale developments.

3.2.2 Information Transfer and Adoption

Much of the information required to address technology issues is currently in academic papers and not readily available to industry, local government and the general public. There is a need for this information to be appropriately repackaged in a form that better meets the specific needs of stakeholders. One attempt to do this is the proposed publication of a guide to Australian urban stormwater quality. The publication will establish national standards for the best design techniques in the development of BMPs, which would enable more specific manuals to be developed for a range of bio-geographical conditions.

At the other end of the information transfer spectrum, developers of the Lynbrook Estate provide new residents with information pamphlets and a short video about the objectives of WSUD, the stormwater BMPs located in their streetscapes and further downstream, and how they can be involved in protecting the system.

3.3 Assessment and Costing

Research institutions such as CSIRO, the Cooperative Research Centre for Catchment Hydrology and the University of Newcastle are currently addressing the need for modelling tools to select and optimise potable water supply, stormwater and wastewater management. The CSIRO Urban Water Program is investigating WSUD in its broadest context by integrating water supply, wastewater, and stormwater management schemes to assess a range of urban design configurations; the aim is to provide economic solutions based on specific site constraints and social acceptability. Scenarios, including pipe size optimisation, reduced water pressure management, peak water demand management and water harvesting and recycling options, have shown potential for improved cost and performance efficiency.

The Cooperative Research Centre for Catchment Hydrology is working on developing a modelling toolkit that aims to optimise stormwater management schemes for quantity and quality control. This will enable users to estimate stormwater pollutant loads from different land-uses, define their impacts on receiving waters and predict the effectiveness of stormwater BMPs. The models will be integrated into a Decision Support System that will enable the exploration of cost-effective solutions to stormwater management issues.

Ensuring cost effective water management schemes requires examination of externality costs. Conference participants flagged the inclusion of externality costs as extremely important when assessing cost effectiveness, because WSUD potentially provides a higher level of protection for the environment and quality of life for urban communities. While the capital cost of conventional infrastructure may be less than WSUD infrastructure initially, the long-term environmental cost of the conventional approach is likely to be much greater. However, externality costs are extremely difficult to calculate because no established procedures on how to undertake life cycle cost analyses currently exist as part of conventional infrastructure planning.

3.3.1 Promoting Cost Effective Water Management Schemes

To date, the consideration of simple costing 'offsets' to produce cost neutral outcomes has, in a number of instances, been sufficient to convince developers to incorporate WSUD practices into their developments. One developer of a housing estate in Pittwater, Sydney found the costs associated with the installation of 1200 rainwater tanks across the estate (one per property) were offset by the savings associated with the reduction in size of a downstream nutrient management pond, due to the reduced volume of annual runoff from the site.

Alternatively, covenants have been used at some developments to ensure that housing designs complement the environmental values of the development. The 'Waterways' development in Melbourne uses covenants to regulate the orientation of houses to minimise and maximise natural heating effects in summer and winter, impose requirements for properties to install a rainwater tank for garden watering, and restrict cat ownership to protect wildlife in the adjacent wetlands. These types of restrictions can increase the capital cost of housing and thereby potentially force market price up; however, long-term savings by property owners (which may compensate for the increases in capital costs through reduced lighting, heating and cooling costs) are yet to be quantified.

The design of BMPs needs to consider practicality in the implementation phase of the technology. An emphasis on 'off-the-shelf' construction components can minimise the cost associated with customised WSUD infrastructure. Using 'off-the-shelf' components in the design of BMPs also minimises indirect costs associated with contractors by who may otherwise add a contingency amount to their project price.

New, innovative 'green' technologies and businesses are being rapidly established and may provide reduced capital and life cycle costs of some elements of WSUD technology.

3.4 Marketing and Acceptance

The market acceptance of WSUD needs defining. Nevertheless, there is widespread acceptance by developers that water features within urban developments help sell real estate and that 'softening' the urban landscape can be a key marketing tool. Landscape architects play a fundamental role in driving the changes required for WSUD in the urban landscape through their influence on urban design. Landscape design is one of the ways our industry can promote the adoption of WSUD as aesthetic values can strongly influence community and market acceptance.

There are many ways to integrate water into the urban landscape. Estates incorporating WSUD can be designed to look like 'conventional' developments or can be designed to feature and promote their differences. Many BMPs associated with WSUD promote retaining as much of the natural environment as possible, and include vegetated treatment facilities (ie swales and wetlands) in the streetscape and open space landscape. Furthermore, many of the structural measures (ie, infiltration systems and water tanks) can be located underground and out-of-sight. Consequently, the aesthetic values associated with WSUD ultimately enhance the urban environment.

Urban design has an important role in driving the changes required in the urban landscape by influencing community perceptions of the associated aesthetic and social values. Changing community perceptions of what open space should represent will be an integral component in helping make the transition from conventionally designed open spaces to multi-functional parklands. This will involve the community gaining an understanding that a sustainable environment is not necessarily the same in appearance as the majority of urban parklands created in the past.

Conference participants suggested that the scale at which WSUD is applied influences the level of public acceptance. For example, the wider community generally accepts irrigation practices using harvested stormwater or recycled water in parklands, sporting facilities, and open spaces. However, a much larger proportion of the community would be concerned if similar water management schemes were applied at the allotment scale, especially if it involved any physical contact.

Adoption of WSUD practices at the streetscape or catchment scale enables the associated benefits to be demonstrated to the community and can be used to educate and gradually change any misconception of water management schemes that may exist. The progressive integration of WSUD practices into the streetscape and at the catchment scale, in the first instance, will help to allay community concerns over unfamiliar aspects of WSUD. Ultimately, this approach is likely to increase community acceptance of alternative water management schemes involving greywater or blackwater reuse.

The marketing of WSUD to the community will be a key driving force for the widespread adoption of WSUD. A lack of data on community perceptions of and preferences for water management schemes however, limits our current understanding of how to market WSUD effectively. Participants at the conference discussed the development of a rating system for environmental sensitive design as one possible strategy to market WSUD. Just as with energy efficiency ratings for white goods, a star rating system for WSUD would provide a basis for public recognition of 'environmental friendliness'.

3.4.1 Community Education

Community education about WSUD has many issues to address; from empowering the community with a sense of ownership of their local stormwater assets to informing the community about future changes to water resource management. Community education will help to reduce public concerns generated by the unfamiliar aspects of water management schemes (for example issues of stormwater harvesting and wastewater treatment and reuse). Ultimately, individuals should be sufficiently informed for them to choose the source of their water supply (ie. potable, stormwater, greywater or blackwater) and accept the associated costs.

4 Conclusions

The deterioration of aquatic ecosystem health in urban catchments is predominantly due to a poor consideration of the impact current water engineering practice has on the urban water cycle. These impacts and factors such as aging water infrastructure and water supply shortages, are prompting stakeholders in the land development and water industries to consider the validity of alternative approaches to current practice. This is an exciting opportunity to 'progressively revolutionise' the land development and water management industry.

Water Sensitive Urban Design is evolving as a means to improve on conventional water engineering practice by integrating the urban planning and design process to facilitate a more holistic approach to managing urban water resources. Urban water reform in Australia has adopted an interdisciplinary approach that is proving fundamental to understanding the complex issues. This approach also ensures the impediments to urban water reform are addressed competently. To date, numerous WSUD demonstration projects have been constructed, with varying degrees of the integration of BPPs and BMPs. Examples of these practices adopted at different scales (ie catchment, streetscape and allotment) show the potential for fully integrated water management schemes in urban catchments.

The outcome of discussions held at the *Water Sensitive Urban Design - Sustainable Drainage Systems for Urban Areas* conference highlighted the current level of participant expertise and 'know how' to develop and operate sustainable water management schemes. The conference helped cement the foundations for a paradigm shift of urban water resource management practice within industry. The major challenge ahead of us now is modifying institutional frameworks, amending urban planning regulations and assisting stakeholders with developing their skills to facilitate a widespread adoption of WSUD practices. Once these issues are addressed, new forms of urban development with enhanced human, environmental and economic outcomes will be created, leading to a sustainable future for the urban water cycle.

5 FURTHER READING

ARMCANZ and ANZECC (2000) Australian Guidelines for Urban Stormwater Management, National Water Quality Management Strategy, Report No. 10; Agriculture and Resource Management Council of Australia and New Zealand Environmental and Conservation Council, Canberra, p.72.

CSIRO (1999). Urban Stormwater: Best Practice Environmental Management Guidelines. Melbourne, CSIRO Publishing: 268p.

Dillon, P.J. (2000). Water Recycling Australia, Proceedings of the First Symposium Water Recycling Australia, Adelaide, 19-20 October, CSIRO and AWA, 139p.

Evangelisti, M. and Mouritz, M. (1994). Water Sensitive Urban Design Seminar. How Do You Do It? 12th September, Perth, Australia: 235p.

Evangelisti, M., Moran, T. G. and Mouritz, M. (1993). Water Sensitive Design - A Tool for Urban Integrated Catchment Management, Prepared for Melbourne Parks and Waterways, Melbourne Water Corporation: 33p.

Melbourne Water (2000). Water Sensitive Urban Design: Sustainable Drainage Systems for Urban Areas, Collection of papers from the 1st Water Sensitive Urban Design conference, Melbourne, 30th - 31st August.

Mobbs, M. (1998). Sustainable House, Choice Books: 187p.

Mouritz, M. and Newman, P. (1997). Sustainable Urban Water Systems: Issues and Opportunities, Urban Water Research Association of Australia, CSIRO Research Report No. 116, 78p.

Nancarrow, B. E., Jorgensen, B. S. and Syme, G. J. (1995). Stormwater Management in Australia: Community Perceptions, Attitudes and Knowledge, CSIRO Research Report No.95, 169p.

Nancarrow, B. E., Syme, G. J. , Morris, N. P., Jorgensen, B. S. and Casella, F. C. (1998). Stormwater Management in Australia: The Feasibility of Neighbourhood Action and Community Information, CSIRO Research Report No.142, 167p.

Schueler, T. E. (1995). Site Planning for Urban Stream Protection, Washington Metropolitan and the Centre for Watershed Protection: 232p.

Schueler, T. R. (1987). Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Washington, Washington Metropolitan Water Resource Planning Board: 185p.

WSUDRG (1989). Water Sensitive Residential Design: An Investigation into Purpose and Potential in the Perth Metropolitan Region, Water Sensitive Urban Design Research Group, Western Australia Water Resources Council, 81p.

Whelans, C., Halpern Glick Maunsell and Thompson, P. (1994). Planning and Management Guidelines for Water Sensitive Urban (Residential) Design, Prepared for the Water Authority of Western Australia: 32p.

Wong, T. H. F., Breen, P. F. and Lloyd, S. D. (2000). Water Sensitive Road Design - Design Options for Improving Stormwater Quality of Road Runoff. Cooperative Research Centre for Catchment Hydrology and the Cooperative Research Centre for Freshwater Ecology, 74p.

APPENDIX A - CONFERENCE AGENDA

Day 1 - Wednesday 30th August

Master of Ceremonies - Mr Chris Davis (Executive Director, Australian Water Association)

9.00-9.30	Dr Peter Ellyard (Adjunct Professor in Intergenerational Strategies and Futurist) Topic: Water in a Planetist Future
9.30-10.15	Dr Mike Mouritz (Director, Integrated Planning, Kogarah Council, NSW) Topic: Water Sensitive Urban Design - Where To Now?

Morning Tea Break

10.45-11.15	Mr Andrew Speers (Director, Urban Water Systems Program, CSIRO) Topic: Integrated Urban Water Cycle
11.15-11.45	Assoc. Prof. Tony Wong (Program Leader, CRC for Catchment Hydrology) Topic: Water Sensitive Urban Design - A Paradigm Shift in Urban Design
11.45-12.30	Prof. John Argue (Adjunct Professor of Water Engineering, Urban Water Resource Centre, SA) Topic: Stormwater ‘ Source Control’ Design Procedures for WSUD: Some Issues and Examples

Lunch Break

1.30-2.15	Mr Andrzej Listowski (Development Manager, Water Cycle, Olympic Coordination Authority) Topic: Sydney Olympic Project, Homebush Bay
2.15-2.45	Mr Bernie Porter (Project Manager, Urban and Regional Land Corporation) & Mr Barry Murphy (Principal, Murphy Design Group, Landscape Architects) Topic: Water Sensitive Urban Design at Lynbrook
2.45-3.15	Mr Colin Pitman (Director of Contacts, Salisbury Council, SA) Topic: The Paddocks Wetlands

Afternoon Tea Break

3.45-4.15	Mr Stephen Hancock (Senior Principal, AGC Woodward-Clyde) Topic: Groundwater Management
4.15-4.45	Mr Tony McAlister (Associate, Water Quality and Environmental Management, WBM Oceanics Australia) Topic: Water Sensitive Urban Design
4.45-5.15	Mr Tony McAuliffe (Director of Policy and Planning, Water and Rivers Commission, WA) Topic: Implementation Issues in WA

Day 2 - Thursday 31st, August

Workshop Panel Sessions

	Stream 1	*Stream 2*
9.00-10.15	Regulatory Framework	Technology and Design
10.45-11.45	Local Government Regulations	Operation and Maintenance
11.45-12.45	Integrated Water Cycle	Urban Design Aspects

Regroup

1.45-2.15	Mr Stephen Hains (CEO, Portland House Group) Developers Perspective
2.15-3.15	Report Back and Summary
3.15-3.30	Mr Brian Bayley (Managing Director, Melbourne Water Corporation)

Close of Conference