BEDP ENVIRONMENT DESIGN GUIDE

WATER SENSITIVE URBAN DESIGN IN THE MELBOURNE DOCKLANDS – AN OVERVIEW

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This paper outlines Water Sensitive Urban Design (WSUD) initiatives in Melbourne Docklands and discusses experiences from the design, construction and operational phases. Additionally, it captures learnings that have occurred as a result of these experiences. It is hoped these experiences can be used to further inform design, construction and operation of WSUD in subsequent stages of Melbourne Docklands as well as more broadly.

This paper is one of a series of papers that explain the case study. Refer also to the companion papers: CAS 47 Water Sensitive Urban Design in the Melbourne Docklands – Rain gardens and Bioretention Tree Pits *and* CAS 48 Water Sensitive Urban Design in the Melbourne Docklands – Wetlands and Storage and Reuse Systems.

Keywords
bioretention swales, raingardens, tree pits, Water Sensitive Urban Design (WSUD), water storage, water reuse, wetlands

1.0 INTRODUCTION

Melbourne Docklands has been at the forefront of implementing Water Sensitive Urban Design (WSUD) in Victoria as part of the major redevelopment of the Docklands. VicUrban has championed stormwater quality treatment in high density urban areas as well as encouraging stormwater harvesting and reuse for irrigation.

Melbourne Docklands is a 200 hectare urban renewal project of premium mixed use development in the heart of Melbourne. The redevelopment of the site provided opportunities to incorporate WSUD into a large scale urban development at a variety of scales including regional, local precinct and individual site scale. The varieties of WSUD elements that have been incorporated into the design include bioretention systems (raingardens and tree pits), wetlands and stormwater storage and reuse systems (as described in section 1.4).

1.1 WSUD Drivers

A key driver for WSUD implementation in Melbourne Docklands is the desire of the Docklands Authority to demonstrate 'best practice' water management in a major city redevelopment site. The Docklands Authority sister organisation, the Urban and Regional Land Corporation (URLC), had a similar policy for greenfield development as leaders in the development industry. The URLC later merged with the Docklands Authority to become the Victorian Urban Development Authority (VicUrban).

A specific aim for WSUD at Melbourne Docklands was to protect the water quality of Victoria Harbour, located within the Melbourne Docklands. Victoria Harbour is poorly flushed and is thus subject to a high risk of poor water quality as a result of polluted urban stormwater run-off entering the harbour. Initial stormwater management proposals for areas draining to Victoria Harbour involved pumping run-off, in events up to the 100 year Average Recurrence Interval (ARI) event, across to the Yarra River. The application of WSUD introduced stormwater detention, treatment and reuse, reducing stormwater discharges to the environment, reducing pumping rates and costs, and thus reducing pollutants entering Victoria Harbour by reducing the frequency of stormwater discharges to the harbour.

1.2 WSUD Objectives

The water management objectives for the site, which directed the inclusion of WSUD elements into the design, are:

- **Stormwater treatment:** The treatment of stormwater to meet best practice management objectives for pollutant load reduction, to protect downstream receiving waters. These objectives include a reduction from predicted untreated pollutant loads, under developed conditions of:
  - 80 per cent reduction for total suspended solids (TSS)
  - 45 per cent reduction for total phosphorus (TP)
  - 45 per cent reduction for total nitrogen (TN).
- **Minimising potable water use across the site:** Potable water demand reduction through the capture and reuse of stormwater for open space irrigation and through the minimisation of water consumption on the site (demand management).
- **Flood management:** The management of flood flows by capturing and storing/detaining stormwater on the site, which can then be used to reduce public open space irrigation demands.

Estimates in the companion papers, of the likely water quality benefits of each of the WSUD systems installed were made using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC, developed by the former CRC for Catchment Hydrology). No water quality monitoring has been performed on the Melbourne Docklands WSUD systems because of monitoring costs and the complexity associated with thorough stormwater event monitoring programs.

1.3 WSUD Elements in Melbourne Docklands

All of the following elements are designed to provide stormwater treatment to either protect downstream environments or produce water of suitable quality for reuse. They can also take a variety of forms, be applied at various scales and are used to enhance the landscape of an area. The location of the elements is shown in Figure 1 and a short description of each element is outlined below. These WSUD elements are described in more detail in separate EDG Case Study papers (as mentioned above).

1.4 Docklands Park Wetlands, Storage and Reuse System

The Docklands Park wetlands storage and reuse system comprises three water quality treatment wetlands located within Docklands Park; a tank storage for the treated water, a UV disinfection system and connection to the irrigation system for Docklands Park.

The system is designed to take future run-off generated from the Harbour Esplanade site, which is currently under development. In the meantime, water for the wetland, storage and reuse system is sourced from a storage located in the Batmans Hill Drain. The

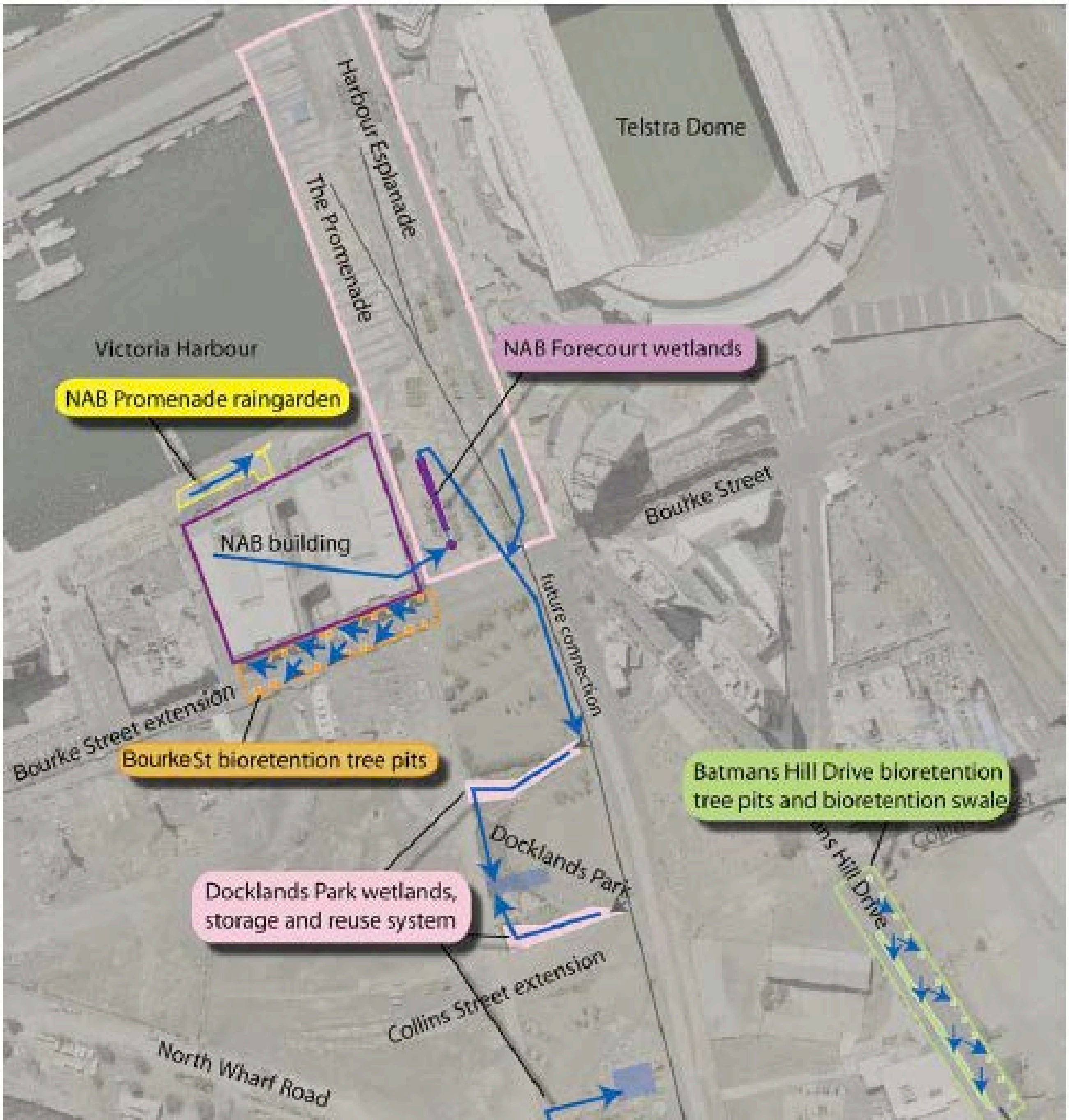

Figure 1. Location of WSUD elements in Melbourne Docklands
Source: EDAW

Batmans Hill outfall drain is of adequate size such that storage can be created using a penstock arrangement without jeopardising the capacity of the drain during high flows. Small volumes of water that are discharged from the NAB forecourt wetland are also pumped to the Docklands Park wetlands.

This system is designed to provide sufficient volumes of treated stormwater to meet 80 per cent of the predicted average annual irrigation demand for Docklands Park.

1.5 NAB Forecourt Wetlands

The NAB forecourt wetland is a small wetland designed to treat runoff from the nearby NAB building to best practice standards (removal of 80 per cent total suspended solids, 45 per cent total nitrogen and 45 per cent Total Phosphorus from post development loads). The wetland is located within the forecourt of the building in a highly urbanised space and has been designed to complement the surrounding urban landscape.

Discharges from the NAB Forecourt wetland are pumped up to the Docklands Park wetland and therefore make a small contribution to the irrigation supply for the park. Evaporative losses in the wetland and pumping of treated discharges to the Docklands Park wetland substantially reduce the need to discharge untreated water to Victoria Harbour.

1.6 Bourke Street Tree Pits

The Bourke Street tree pits are designed to capture the run-off from the Bourke Street extension roadway and the surrounding footpaths. The tree pits provide best practice stormwater quality treatment while forming an important part of the urban landscape, in the form of street trees.

1.7 Batmans Hill Drive Tree Pits and Bioretention Swale

The Batmans Hill Drive tree pits and bioretention swale are also designed to provide best practice stormwater quality treatment for the surrounding Batmans Hill Drive roadway and the adjacent footpaths and bike paths. Like the Bourke Street tree pits, the Batmans Hill WSUD elements also form an important part of the urban landscape.

1.8 NAB Promenade Raingarden

The NAB promenade raingarden provides best practice stormwater quality treatment for run-off generated from hard surfaces along the promenade area. The raingarden forms part of the landscape and has been integrated into public seating. This raingarden discharges into Victoria Harbour, however the discharge pipe from this raingarden has been carefully located at a specific depth to minimise the impacts of fresh stormwater discharges into the stratified harbour (as noted in CAS 47).

2.0 LESSONS LEARNED AND FUTURE RECOMMENDATIONS

The following section outlines some of the key lessons from design, through construction, to long term maintenance, taken from an analysis of the design, construction and maintenance history of individual WSUD elements within the Melbourne Docklands.

2.1 Design and Construction

Overall Strategy

An overall WSUD strategy for all areas of a large development site is important if the integration opportunities across different precincts are to be captured. Such a strategy should consider the timing for development. Without this each precinct may have individual, unrelated WSUD solutions with some stormwater treated twice as it moves from one area to another. An overall strategy allows for integration of WSUD measures across the whole site, which allows for more cost effective, and efficient treatment solutions. An overall strategy also ensures WSUD devices are located in the most appropriate locations within the landscape. In addition, planning the most appropriate timing of the construction of WSUD elements with respect to the urban development will limit construction damage and ensure sufficient water catchments are available to maintain vegetation within the WSUD systems.

Design Process

Caution needs to be exercised if design intent is not communicated throughout the design and construction phases of a project such as this. If WSUD devices are built from preliminary plans, or have functional design issues that are not resolved prior to construction, the functional intent may not be completely captured in the final built form. The completion of a full design process including concept, functional, and detailed design phases, before construction is commenced will maximise the opportunities for emerging issues to be addressed. This is particularly important for issues such as defining levels to ensure gravity controlled systems function appropriately.

As well as clear communication between the design team and the construction team, consistency with concept design, and detail design is important. As an example, the original concept for the design of the Docklands Park storage and reuse system was designed as concrete tanks that could be located below the groundwater level, but during value management, the concrete tanks were substituted for an alternate tank design. As these tanks could not be built below the level of the groundwater, the system that resulted requires pumping at many locations between inlets and outlets. The issues that emerge as a result of changes such as these during detailed design and construction can be efficiently addressed with collaboration and communication between designers and constructors.

A series of hold points, or points at which construction cannot proceed without sign off from the original/ concept designers, and construction teams will reduce the risk of losing the intent of WSUD systems with design modifications.

Simplicity of Design and Automation

The final design of the Docklands Park storage and reuse system includes a multitude of mechanical and electrical features within the system. The complexity of the system makes the assessment of problems difficult. There are a number of points where water is pumped and part of the system relies on manual operation.

Ideally stormwater management systems should be designed with the simplest operation possible with water being pumped once or not at all if possible. Where pumps cannot be avoided the installation of a control room should be provided as a single point of reference for operation of the system, reducing the risk of operating errors. The inclusion of simple check meters, including salinity, flow and water level (especially for tanks) can further reduce the risk of operating errors and highlight system issues early.

Investigations continue into how full monitoring and automation of the WSUD systems could maximise its efficiencies. Remote sensing linked to a central control system for the Dockland Park wetland and reuse system could be retrofitted to enable simple monitoring of operations as well as to build in alarms should any mechanical or electrical elements fail.

Customised Design

The Bourke Street bioretention tree pits originally used conventional metal tree surrounds that bear on the surface of the ground below. Due to the need for an extended detention volume (ponding) between the surrounds and the soil level, these unsupported surrounds began to fail. This, and the surrounds being bolted into position, made maintenance of the surface below difficult. As a result, all pit lids were replaced with a customised, free-spanning design. Engineered responses to deal with specific design issues, such as these may be found to be more cost effective in the long term, especially on large scale projects.

On detailed drawings, elements of the design that vary from conventional designs should be clearly indicated. For example, clearly stating that the installation of vertical agricultural pipes for irrigation, as per those commonly used for watering conventional street trees, are not required for bioretention tree pits. These pipes can compromise the pollutant removal function of the system by allowing water to bypass the filter media.

Communication of Functional Design and Information Dissemination

Design reports describing the functional design of WSUD devices are important to ensure the functional intent of the devices is communicated to the construction team. This reduces the risk that decisions made during construction will jeopardise the function of these systems.

Information must be made available to maintenance staff to assist their understanding of the function of the systems implemented and therefore their understanding of the maintenance requirements. Tree pits and raingardens are very similar looking from the surface, to conventional street trees, roadside planting and garden beds, and thus specific directions on maintenance requirements are needed where the requirements differ from that of conventional systems.

The flow of information from the design team to the construction team is important, as is the flow from the construction team to the owner and/or maintainer of the finished project. The provision of design reports, finalised detailed design drawings and maintenance plans at handover, are crucial in ensuring that the design intent is captured during construction and ongoing maintenance activities.

Hold Points in Construction Program

The implementation of measures such as hold points, sign off points and allowance for construction supervision by designers, all aid to ensure that the functional intent of a design is preserved throughout the construction process. Selecting key elements of WSUD systems that require inspection by WSUD designers can avoid costly reworking of systems. For example, the under-drainage of bioretention systems and soil filter media are key elements of their design and functionality, but may not be familiar to conventional contractors. Similarly, hold points for checking vegetation to ensure that the correct species have been provided are important to ensure planting contractors have understood the intended hydrologic regime of each of the planting zones.

Where multiple systems are to be constructed such as a number of bioretention tree pits for example, a hold point at the completion of the first element would ensure issues are resolved early and not carried forward to the next system. Using this approach, identification of the incorrect soil levels in the Bourke Street extension tree pits mentioned in CAS 47, could have occurred after completion of the first tree pit, thus avoiding removal and replanting of all of the tree pits.

Planning and Protection during Construction

There have been times during the construction of the Docklands WSUD elements when delays between construction phases, or ongoing construction nearby, has resulted in damage to part of these WSUD elements, in particular, the filter media. Careful planning to ensure filter media and vegetation are protected are important. This can be done by:

- laying turf over bioretention filter media
- removing the top layer of filter media after construction is finished within the catchment
- lining the top of the media with geotextile mat
- taking vegetated systems offline during establishment and implementing temporary sediment control devices.

2.2 Maintenance and Operation

Maintenance Plans

Due to the innovative nature of WSUD and the limited exposure of industry to the sensitivities of WSUD maintenance, tasks for each WSUD element need to be clearly outlined in a maintenance plan with the delineation of the tasks required. These will include checklists that can be used for record keeping, provide functional descriptions of how the systems work, and can be used by the maintenance contractor to then delineate who is responsible for which aspects of maintenance.

Some elements of conventional landscaping and drainage maintenance can be applied to many WSUD elements. These tasks include litter removal, weeding and inspection of pits and pumps. However other conventional activities are in direct conflict with those required for WSUD. The sweeping of street and leaf litter can foul the surface of the filter media if in excessive amounts, fertiliser application can leach nutrients into downstream receiving waters, tree stake removal can leave cavities that short-circuit the filtration media, removal of dominant vegetation for aesthetics can result in a reduced water quality treatment efficiency and the filling in with soil around street trees to remove tripping hazards can reduce the water quality treatment efficiency by removing the extended detention (ponding) volume.

It is therefore important that information provided or assumptions made about maintenance during the design phase are disseminated and made available to those responsible for maintenance. A thorough maintenance plan with input from designers should be provided to maintenance personnel and should include a description of the intended function of the system. Maintenance plans should address issues such as:

- infilling of holes left by tree stakes
- removal of organic matter build-up such as leaf litter
- removal of sediment build-up after construction phases nearby
- visual checking of the function of the system (e.g. no long-term ponding in bioretention systems)
- street swept litter accumulating on top of filter media.

Establishment Phase Maintenance

Early operation of WSUD elements is often during the vegetation establishment phase. The provision of an establishment phase maintenance plan or simple checklists can assist in delivering adequate maintenance during this crucial early phase. Such documents should outline requirements to remove sediment laden mulch after construction within the catchment is complete, ensure that the extended detention volume (temporary ponding on the surface) is maintained and not filled in, and the assessment of the infiltration rate and water level control appropriate to establish wetland plants. Adequate establishment phase maintenance can greatly reduce the long term maintenance requirements of these systems.

Maintenance Jurisdiction

One of the ongoing issues related to the maintenance requirements of a large site such as Melbourne Docklands, is the dynamic nature of the site boundaries as individual development sites change hands from asset owners, to developers and then to asset managers. This can result in confusion regarding maintenance responsibilities, and this confusion is most likely to occur during the vegetation establishment phase.

In many cases, the jurisdiction of individual maintenance tasks is unclear with regard to WSUD systems. For example, street tree bioretention pits come under three different maintenance contracts. The actual tree comes under one contract, the pit lids under another and there is also a separate contract for street sweeping and gutters, which is also likely to cover the filter media within the tree pit. Maintenance contracts should clearly state whose responsibility the individual maintenance tasks are in situations where the WSUD elements cross conventional maintenance boundaries and, wherever possible, maintenance tasks for WSUD systems should come under a single maintenance contract, and be linked to a maintenance plan. While the knowledge of maintenance requirements of WSUD elements grows within the industry it is important to establish the jurisdictions for maintenance decisions between maintenance contractors and asset owners.

Maintenance Requirements for Individual Sites

Maintenance requirements for individual WSUD elements on a broader scale are likely to vary depending on the profile of the site. High public profile sites, such as the Docklands, have much higher maintenance requirements, particularly in terms of vegetation and litter management. In this context, the public profile and overall aesthetic expectations for a site should be considered when writing maintenance plans and assessing likely maintenance costs.

Record of Maintenance

The Melbourne Docklands site currently employs a number of full-time staff for various maintenance activities. Many other WSUD asset managers combine maintenance of WSUD assets with other maintenance activities such as general drainage or landscape maintenance. As a result it is often not possible to determine the time spent, and therefore associated costs, for maintenance of individual WSUD elements across a site. The provision of a clearly defined maintenance plan, or checklists, could assist maintenance contractors in estimating the likely cost involved for the maintenance of WSUD features. Additionally, there would be a benefit in developing checklists that enhance the record keeping of maintenance that actually occurs for these devices. The development of such a record sheet should be done in conjunction with maintenance personnel to ensure it is used effectively.

3.0 CONCLUSIONS

With the increasing pressures of climate change, drought, population growth and urban consolidation, urban landscapes are now being called on increasingly to deliver multiple functions, including that of providing ecosystem services for improved stormwater quality, and reducing demand on potable water supplies. While WSUD has evolved from its early emphasis on stormwater quality management to encompassing an integrated urban water management approach, the widespread adoption of WSUD for stormwater management is still very much in its infancy. The Melbourne Docklands currently boasts a wide range of different WSUD elements across its site and serves as an important point of reference to aid the widespread adoption of WSUD. The WSUD measures were, in many cases, the first of their kind to be integrated into such an urban setting. These were often new designs that had not been implemented in such a setting in Australia previously. The overall experience has been one of adaptive learning in the implementation of WSUD in this context.

In part due to the long-term time frame of WSUD implementation across the Docklands over many years, as well as VicUrban's support of innovation, many of the lessons learned, as described in this paper, have influenced the design, construction and operation of other WSUD elements on the site. In this way, the Melbourne Docklands site has greatly supported the evolution of the design, construction and operation of WSUD elements in a highly urban setting.

As a result of the successful implementation of WSUD across the Melbourne Docklands site, all stormwater captured on site is treated to best practice objectives for pollutant removal. Additionally, millions of litres of water will be captured, treated and reused to enhance the landscaped areas of Docklands Park. Passive watering of many of the WSUD elements, as stormwater infiltrated through the systems such as in the tree pits and raingardens, also provides green streetscapes and landscapes with a much reduced need for irrigation.

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BIOGRAPHY

Kerrie Burge is an ecologist with EDAW with skills in water chemistry, aquatic ecology and environmental impact assessment. Kerrie graduated from Monash University with first class honours, and has experience in the field of urban stormwater management, with a particular focus on vegetation specification for WSUD elements such as bioretention systems and wetlands. She has skills in hydrologic modelling including the use of the MUSIC tool, and has worked with the Facility for Advancing Water Bio-filtration at Monash University on a number of projects including filter media specification for bioretention systems.

Robin Allison is an environmental engineer with specialist skills in urban stormwater management, particularly delivering WSUD. His experience includes urban development, water policy development, research on stormwater treatment devices, and redevelopment projects at many scales. He has given many industry seminars and training courses. His expertise covers the investigation, planning, design, construction supervision and project management of water infrastructure.

Dr Tony Wong is formerly a founding partner of the consulting firm Ecological Engineering which is now EDAW. He is also CEO of the Facility for Advancing Water Bio-filtration at Monash University. Tony has over 25 years of experience in the fields of water resources engineering and management, advancing ESD, particularly in integrated urban water cycle management and WSUD. His expertise has been gained through consulting, research, and academia. Tony provides strategic advice to governments, and the land development industry, on sustainable urban water management and has led the development of many state and corporate policies on WSUD.

Dr Peter Breen is a Principal of EDAW's Ecological Engineering practice area in Melbourne and has published on aquatic botany, wetland, stream and lake ecology, stormwater and wastewater treatment, water quality management and restoration ecology and has authored or co-authored over 100 papers and delivered numerous presentations. His research and design expertise has contributed to urban stream ecology in Australia, where Peter established and led the urban ecology group in the Cooperative Research Centre for Freshwater Ecology at Monash University from 1992 to 2001, as well as best practice stormwater management objectives and guidelines on the design of constructed wetlands, waterways, bioretention systems and lakes. Peter remains a director of The Facility for Advancing Water Biofiltration, a joint venture between EDAW and Monash University.