BEDP ENVIRONMENT DESIGN GUIDE

WATER SENSITIVE URBAN DESIGN IN THE MELBOURNE DOCKLANDS – WETLANDS, STORAGE AND REUSE SYSTEM

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This report describes Water Sensitive Urban Design (WSUD) initiatives in the Melbourne Docklands and outlines experiences from 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 either 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 46: Water Sensitive Urban Design in the Melbourne Docklands – An Overview *and* CAS 48: Water Sensitive Urban Design in the Melbourne Docklands – Raingardens and Bioretention Tree Pits.

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

1.0 INTRODUCTION

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 sites. The variety of WSUD elements that have been incorporated into the design include passive tree watering, bioretention systems (raingardens and tree pits), wetlands and stormwater storage and reuse systems (as described in Section 2). This paper discusses wetlands that form part of a storage and reuse system within the Melbourne Docklands.

The Melbourne Docklands currently boasts a wide range of different WSUD elements across its site. The WSUD measures were, in many cases, the first of their kind to be integrated into such an urban setting. Due to the fact that these were often new designs, and had not been implemented in such a setting previously in Australia, there were lessons learned during the design, construction and operation of these systems that these papers aim to outline. The intent is that documenting the design evolution and the lessons learned relating to the implementation of these devices can provide useful information for future developments.

In part due to the time frame for implementation of WSUD across the site extending over many years (due to the long time frame for development across the site), 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 in the design, construction and operation of WSUD elements in a highly urban setting, and this has resulted in the much more streamlined delivery of WSUD elements.

The implementation of the lessons learned and described in this paper, resulted in a much more streamlined delivery of WSUD elements in future works.

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 infiltrates through the systems, (e.g. tree pits and raingardens) also provide green streetscapes and landscapes with a much reduced need for irrigation.

2.0 CONSTRUCTED WETLANDS IN WSUD

Wetlands are shallow water bodies, extensively vegetated, which employ various natural biological and chemical processes to remove pollutants from stormwater. A key defining feature of wetlands is that they have areas of permanent water.

Constructed wetlands consist of three primary features, an inlet zone or sedimentation basin, macrophyte zone, and provision for high flow bypass. The macrophyte zone is densely vegetated with aquatic plants (macrophytes). Stormwater enters through the inlet zone where coarse sediments settle to the bed before stormwater is conveyed into a macrophyte zone, a highly vegetated shallow area, to remove fine particles and assist the uptake of soluble pollutants, as shown in Figure 1 below. To protect vegetation, high flows are diverted through a bypass channel during storm events.

To maximise pollutant removal efficiency of a wetland of a given size, stormwater treatment wetlands are designed to allow for extended detention. The extended detention depth is the height of water that ponds above the normal water level of the wetland after a rainfall event. An outlet control structure regulates the outflow of the extended detention volume. In most cases this outlet control structure is designed so that the water within extended detention has a 72 hour detention time. Typically this length of time gives an appropriate balance between hydrologic effectiveness and pollutant removal efficiency.

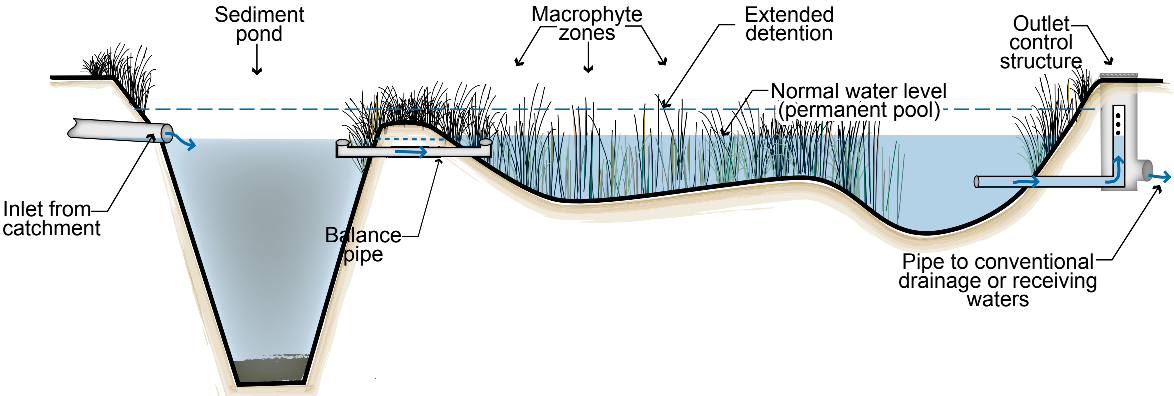

Figure 1. Concept illustration of a typical constructed wetland for stormwater treatment (long section)
(Source: EDAW)

Wetlands can be applied at a range of scales from small local parks to large regions. Wetlands can greatly enhance the landscape value of an area, by integrating it as part of an urban form. Figures 2 and 3 are examples of constructed wetlands for stormwater treatment. Both of these wetlands have been designed with permanent pools. Figure 4 illustrates an example of a variation to the more typical design of a constructed wetland, being an ephemeral wetland (without a permanent pool) located at Bluestone Green in Wyndham Vale, Melbourne.

Figure 2. Wetland with permanent pool, Cairnlea Estate, Melbourne
(Source: EDAW)

Figure 3. Royal Park Wetland, Parkville, Melbourne
(Source: EDAW)

Figure 4. Ephemeral wetland at Bluestone Green, Wyndham Vale, Melbourne
(Source: EDAW)

3.0 DOCKLANDS PARK WETLANDS, STORAGE AND REUSE SYSTEM

Figure 5. Docklands Park Wetlands
Showing foreground water feature and wetland visible under footbridge.
(Source: EDAW)

With the Docklands precinct only partially built, some parts of the WSUD strategy, including WSUD infrastructure, are not yet complete. The intent of the Docklands Park wetlands, storage and reuse system is outlined below. An interim measure to divert flows from the adjacent Batmans Hill Drain catchment is currently being assessed as an opportunity to provide water for the wetlands until full development of the

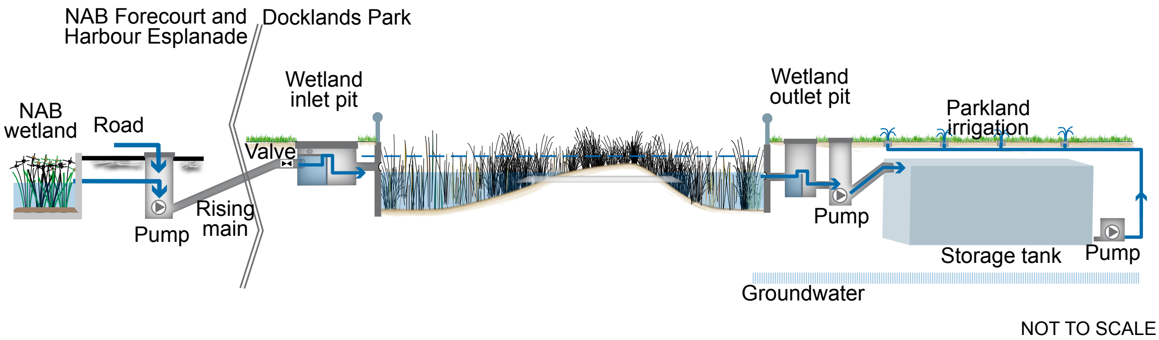

Figure 6. Docklands Park Wetlands, Storage and Reuse System
Concept illustration of long section.
(Source: EDAW)

wetlands' catchment occurs. See Figure 7. A description of the original design intent of the system and the proposed interim measures are provided.

3.1 Overview

Long Term Design Intent

Docklands Park is 2.7 hectares of open space within Melbourne's Docklands. The adjacent urban area provides an opportunity to harvest and reuse adequate volumes of stormwater to meet a substantial amount of the annual irrigation demand for Docklands Park. Stormwater runoff from the 7 hectare Grand Plaza precinct including Central Pier and Harbour Esplanade between Bourke and Latrobe Streets will drain to a large underground culvert that acts as a mini retarding basin. The capacity of this mini retarding basin has been sized to retain the 3 month ARI (Average Recurrence Interval) event. Stormwater will then be pumped to Docklands Park wetlands, for treatment, via a rising main that runs along the east side of the park.

Figure 6 and Figure 7 show an overview of the system.

Stormwater runoff from the National Australia Bank (NAB) building roof and forecourt (described further in Section 4) also drains to the underground culvert and is pumped to Docklands Park wetlands.

At the wetland inlet pits, valves can be set to allow water to flow freely into the wetlands whenever water is available in the rising main. The wetland inlets contain weirs that set the top water level within each wetland, as shown in Figure 6. When this water level is exceeded water backflows over the weir at the inlet and discharges into a conventional stormwater system which discharges to the Yarra River.

The system incorporates three individual wetlands, totalling 1475m², located within Docklands Park that receive stormwater from catchments via stormwater pipes and a rising main. The wetlands are designed to treat approximately 80 per cent of the annual stormwater runoff generated from the combined catchment. The wetlands have an average detention time of 48 hours. This relatively short detention time was chosen because space was limited in the park and the water is to be reused rather than discharged to a receiving water body. Typically, stormwater treatment wetlands will be designed with a 72 hour detention time.

The wetlands have a variety of macrophyte zones that contain different vegetation depending on the depth at normal water level, and the depth of extended detention, which is 0.5m in this case. A balance pipe is located between the two deep areas, at either end of the wetland, to maintain passage of flow between the deep zones during dry weather.

Under normal operating conditions, water passes though the wetland and is pumped over a weir wall after which it gravity feeds to a storage tank as shown in Figure 6. When the storage tank is full, water is pumped, via a manual switch, back to the overflow weir at the wetland inlet pit and discharged to the conventional stormwater system. There are two separate storage facilities with a total storage volume for the reuse system of 580,000 litres. Having two tanks allows for ease of connection between the wetland outfalls and the reuse storage facilities. The storage volume within the underground storage structures is sufficient meet 80 per cent of the Docklands Park irrigation requirements.

The collection, wetland treatment and storage of stormwater are integrated with other initiatives to make up the overall water reduction and reuse system. Other initiatives include:

- grass species selection for drought tolerance
- soil amendment for water retention
- wind sensors linked to the irrigation system – to ensure maximum efficiency of water use
- rain sensors linked to the irrigation system – to ensure maximum efficiency of water use

The system also incorporates an Ultra Violet (UV) disinfection system (using ultra violet light to reduce pathogens) to reduce the public health risk associated with the use of stormwater for spray irrigation of Docklands Park. UV disinfection occurs on the rising main of the irrigation, immediately prior to the water being used in Docklands Park.

3.1.1 Interim measure

The Grand Plaza precinct, including Central Pier and Harbour Esplanade between Bourke Street and Latrobe Street, makes up a large proportion of the originally intended catchment for the Docklands Park wetlands. As this area is yet to be redeveloped, the large underground culvert that acts as a mini retarding basin is not yet installed (see 'mini retarding basin' in Figure 7) and therefore none of this catchment area is connected to the wetlands.

At present the only stormwater entering the Docklands Park wetlands is water that passes through the NAB wetland and local drainage from Harbour Esplanade.

These flows enter a wet well and are pumped via a temporary pump to the Docklands Park wetland inlet pits. It is also understood that a short to medium term opportunity is being investigated that involves pumping water from the storage, created by a penstock arrangement in the Batmans Hill Drive drain, to the Docklands Park wetlands, to increase volumes of water entering the wetlands until the Grand Plaza precinct is redeveloped and this catchment is connected to the system.

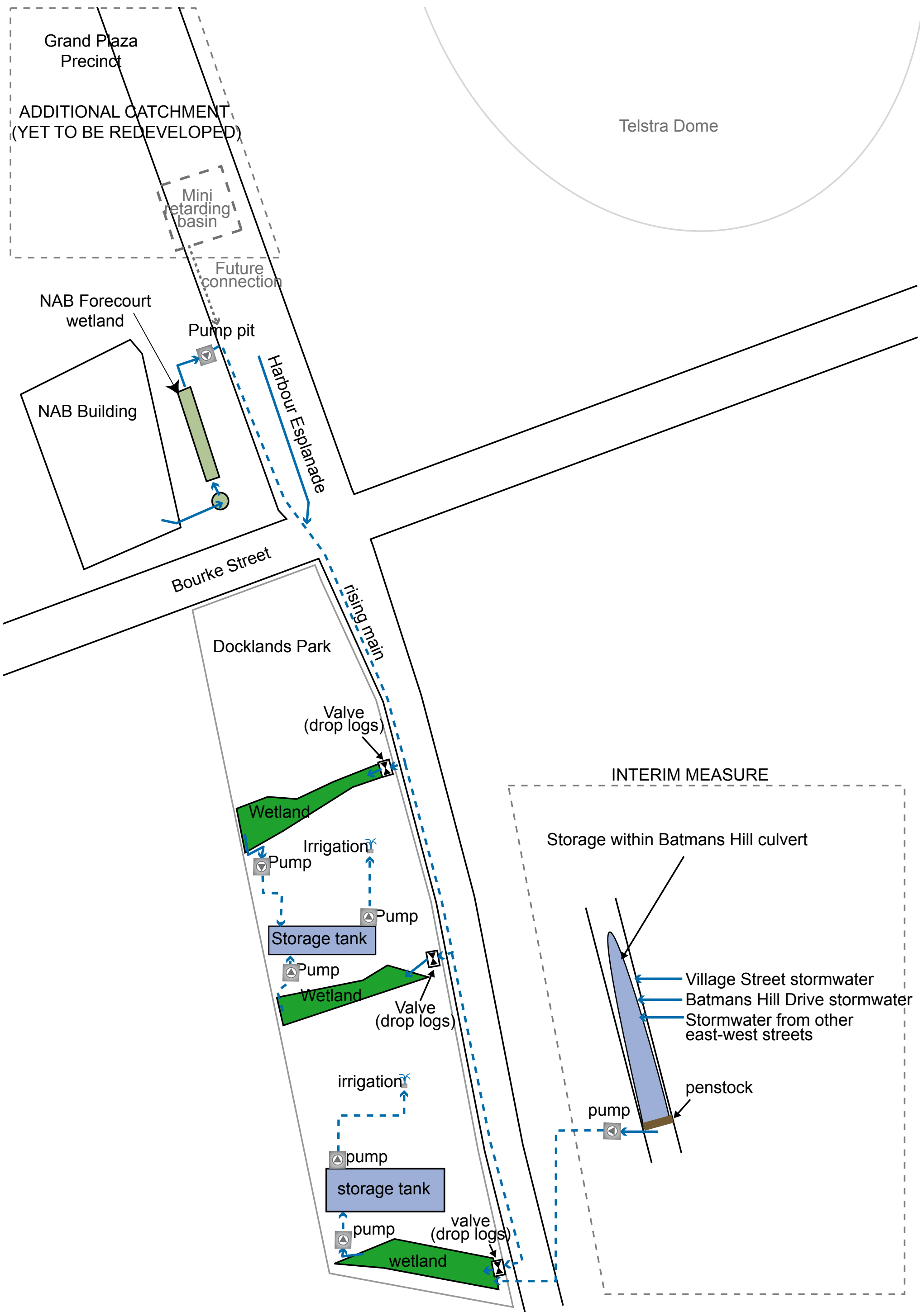

Figure 7. Concept illustration of Docklands Park Wetlands, Storage and Reuse System in plan view
(Source: EDAW)

Figure 8. Docklands Park Wetland integrated with the public open space and landscape design
(Source: EDAW)

Project Objectives

The wetlands form part of the overall reuse scheme within the Docklands Park area, and have the primary objective of water quality treatment, as well as playing an important role in the landscape design of the park. The wetlands reduce stormwater pollutant loads prior to storage and reuse.

The objectives of the overall scheme are to reduce the use of potable water and reduce pollutant loads to receiving environments by reducing the pollutant load of the stormwater that is discharged from the site. The estimated annual irrigation demand for the park is 12 ML/yr. Modelling has indicated that, given the available catchment area and storage volume within the two underground storage structures, the system is sufficiently sized to meet 80 per cent of Docklands Park irrigation requirements, equating to a reduction in potable water demand of more than 9 ML/year. Additionally, the capture and reuse of runoff on the site reduces the volumes of water that would otherwise require pumping to an appropriate discharge point. Pumping to avoid discharges to Victoria Harbour would otherwise have been required due to the high risk of water quality deterioration as a result of stormwater pollutants (described in more detail in CAS 47).

Catchment and Site Characteristics

The catchment for the reuse system is lower than Docklands Park where the wetlands and storage tank are located Figure 7. As a result, the design includes pumps to move water from the catchment to the wetlands/storage.

Site Constraints

The main site constraint was shallow groundwater. This particularly affected the placement of underground storage tanks used to store the treated water, as well as the construction of these tanks.

The wetlands have vertical concrete walls to maximise the available space for water quality treatment. Additionally, a shorter than desired detention time was chosen as a compromise between the limited space available for wetlands, the volume of stormwater treated and the amount of treatment deemed adequate.

The downstream outlet from the wetland was specially designed to prevent salt backflow from the tidal Yarra River. This design was intended to allow overflow from the storage tanks to drain to the Yarra River, with a flap valve preventing salt backflow. However, the tanks were installed without a gravity overflow outlet and pumping or backflow through the wetlands is the only means of discharge from the system.

Figure 9. Docklands Park southern wetlands
Showing sheer concrete containing walls, used to maximise capacity.
(Source: EDAW)

3.2 Design and Construction Challenges

3.2.1 Communication of Design

The main challenge during the design of the wetlands, storage and reuse system was communicating the function of the wetlands, and their interaction with the drainage infrastructure. The incorporation of landscape and stormwater management initiatives into major redevelopment projects was relatively new at the time. An example of this is a change in the design of the storage system resulting in it being located completely above groundwater. Poor communication of the functional design intent meant that the proprietary product chosen to provide the storage system was changed during construction so the system cannot operate under gravity and requires additional pumps.

As mentioned above, other catchments have been directed to the wetland in response to a reduction in stormwater catchment during the development stages, which assists in providing adequate volumes of water to the Docklands Park wetlands in the interim. The long term effect of increasing the catchment area to any existing constructed wetland needs to be carefully considered, as the result can be a shorter detention time in the wetland than was designed, and therefore a reduction in treatment performance.

3.3 Maintenance and Operation Experiences

3.3.1 Control of Pumps and Other Infrastructure

Due to ongoing changes in design there is little documentation that outlines the operation of the system in its entirety. Frequent design changes, at various design stages and by different disciplines, mean there is no single reference for information on the mechanical elements of the system, and thus there are no single points of reference for control of the system, such as a control panel. Many of the valves and pumps are controlled manually and information on their operation rests with only a few individuals.

3.4 Summary of Lessons Learned

Communication: Communication between constructors and designers is crucial. The function of the concept design needs to be clearly communicated to designers detailers and subsequently to construction contractors. Any changes made during detailed design or construction phases need to be accurately incorporated into a design report.

Design processes: Function, as well as detailed design processes, is important. Constructed wetlands for stormwater treatment require the same design phases as hard infrastructure. Any changes to the design should be reviewed from a hydraulic and ecological perspective, to ensure the design still provides the intended function

Hold points: Designers need to have a review and sign-off at specified points throughout the project to ensure the design intent and functionality of the system is preserved when changes are made.

Centralised controls: Where one (or multiple) pumps cannot be avoided the installation of a control room should be considered to provide a single point of reference for operation of the system and to reduce 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.

Appropriate catchment size: The long term effect of increasing the catchment area to any existing constructed wetlands needs to be carefully considered. The overall result can be a shorter detention time in the wetland than was designed, and therefore a reduction in treatment performance.

4.0 NAB FORECOURT WETLANDS

4.1 Overview

The NAB wetland is to treats collected roof run off from the NAB buildings. Roof run off from NAB Building 1 is directed into wetlands located alongside the building for treatment (Figure 10). The 300m² wetland, which has the shape of an exclamation mark in plan view, is located within a pedestrian walkway. Subsequent development of a precinct-wide water management strategy led to the diversion of a significant proportion of water treated by this wetland to the Docklands Park stormwater storage facility for reuse in irrigation. The wetlands are also intended to be a focal point in the landscape design of the Plaza.

Flows enter the wetland system via underground pipes and via a solid weir located in a high flow diversion pit, which also provides energy dissipation. Flows are directed into the sediment basin which forms the 'dot' end of the exclamation mark. This serves as the inlet zone, with a primary function of flow attenuation and removal of coarse to medium-sized sediment.

Under normal operating conditions, flows move slowly downstream from the sediment basin through two concrete pipes connecting the sediment basin to the main part of the wetland as illustrated in Figure 11. As flows enter the wetland system the depth increases by 100mm, which is the extended detention depth. After moving through the vegetation, treated stormwater exits the wetland via an outlet located at the northern end of the system into an underground pit. At this point, the outflows are pumped via the rising main to the Docklands Park wetland.

When the wetland system is full or too much flow is coming from the roof, inflowing stormwater flows over the top of the diversion weir located upstream of the sediment basin, bypasses the wetland, and flows into the Bourke Street stormwater system.

Figure 10. NAB Forecourt wetlands during initial plant establishment
(Source: EDAW)

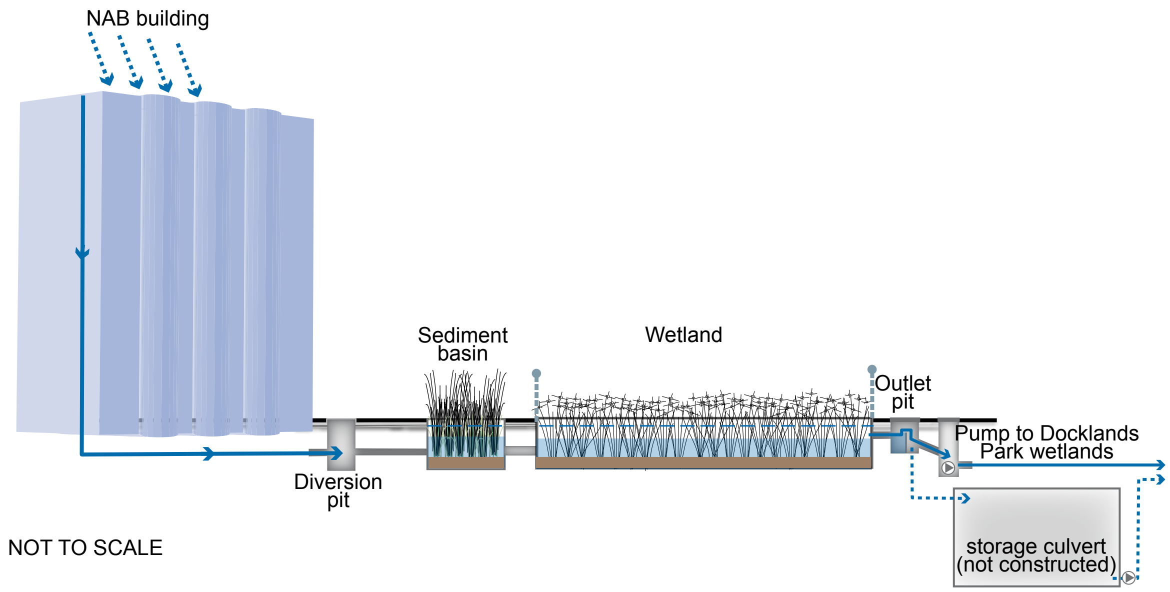

Figure 11. NAB Forecourt wetland – concept illustration of long section
(Source: EDAW)

The wetland has 300mm of permanent water to support the wetland vegetation. The water depth can increase to 400mm during storm events with an allowance for 100mm extended detention. The base of the wetland has a soil depth of 300mm to support the vegetation, and the wetland system is fully contained within a waterproof membrane.

Project Objectives

The primary objective for the development of this system was to improve water quality in order to protect downstream receiving waters. The wetland is designed to achieve best practice stormwater treatment objectives with a predicted pollutant removal efficiency of 80 per cent of total suspended soils (TSS) and 45 per cent of total nitrogen (TN) and total phosphorous (TP) compared to typical untreated run off.

By contributing water to the Docklands Park wetlands, the project contributes to the reduction of potable water demands for irrigation of Docklands Park. Additionally, the capture and reuse of runoff on the site reduces the volumes of water that would otherwise require pumping to an appropriate discharge point. Pumping would be required, as mentioned above, to avoid discharges to Victoria Harbour.

Catchment and Site Characteristics

Although the stormwater run off from the awnings and balconies of the NAB building discharges directly to Victoria Harbour, the approximately 1 hectare of NAB Building No.1 roof is treated by NAB forecourt wetlands.

Site Constraints

The main constraints for the site were public safety issues such as tripping and drowning associated with creating water bodies in heavily populated spaces.

4.2 Design and Construction Challenges

4.2.1 Communication of Functional Design (Addressing Trip Hazards)

As per the earlier example, the main issues in realising this wetland were related to its innovative nature, and inadequate communication between the concept designers, the detailed designers and the constructors. The safety concerns for a wetland in such a prominent pedestrian location were not clearly resolved during the initial design process.

A particularly large aquatic macrophyte species was chosen to ensure that once established, it would clearly delineate the wetland, and thus avoid a trip hazard. However, this species was substituted during construction, and the resultant replanting with the originally specified plants delayed plant establishment. To address the safety issues, in the absence of the originally specified plants, a permanent fence was erected that has diminished the visual impact of the original design.

Figure 12. NAB Forecourt wetlands
The chain link handrails were required to be retrofitted to increase pedestrian safety
(Source: EDAW)

4.3 Maintenance and Operation Experiences

4.3.1 Maintenance During Establishment

During the establishment phase, a bloom of floating macrophytes occurred in the wetland. Such blooms of algae and floating macrophytes are common during the establishment phase of permanent water, particularly when systems have newly placed topsoil that becomes saturated and releases nutrients. The growth of this floating macrophyte was substantial and persisted for long enough to smother the newly planted vegetation and result in the loss of most plants.

4.4 Summary of Lessons Learned

Communication: Communication between constructors and designers is crucial. The function of the concept design needs to be clearly communicated to detailed designers, and subsequently to construction contractors. Any changes made during detailed design or construction phases need to be accurately incorporated into a design report.

Removal of nuisance plant growth: In a relatively small area, nuisance growth such as floating macrophytes should be manually removed to prevent wholesale loss of existing vegetation. A high level of maintenance for aquatic vegetation during the establishment phase can greatly improve the long term survival of the vegetation and reduce replacement and/or maintenance costs into the future.

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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.