ABSTRACT

This paper outlines the planning, design, documentation and implementation of sustainable water initiatives undertaken for Brisbane City Council’s new Southern Bus Depot at Willawong.

The water initiatives were developed by a multidisciplinary team which included the following disciplines from City Design; town planning, civil engineering, landscape architecture, architecture, stormwater engineering, building services engineering, environmental management and sustainability.

Integrated water management initiatives were conceived at the project’s inception and became a driver of site planning for the development. A schematic Integrated Water Management Plan was developed early in the process through the collaboration of various disciplines. This diagram became a useful communication tool for the team and enabled the successful delivery of the water initiative across the development. These initiatives include: stormwater harvesting through a system of vegetated stormwater conveyance swales and bio-filters, roof water harvesting and stormwater storage for on-site reuse.

By having a clearly described intent for water initiatives the project was also able to secure grants funding through the Community Water Grants Scheme.

The ability to work quickly, collaboratively and between disciplines enabled the successful delivery of the integrated water management initiatives.

INTRODUCTION

The rapid expansion of the Brisbane City Council bus fleet to meet commuter demands triggered the requirement for a new bus depot to be built on the southern outskirts of the City.

This was to be the first complete bus depot to be built by Brisbane City Council in 15 years, and the project offered a great opportunity to reinvent and raise the bar on the design of a facility of this type and to deal with sustainable development issues such as water consumption and the quality and quantity of stormwater runoff.

The Willawong Bus Depot represents a new approach to the production of more sustainable industrial developments of this scale by Brisbane City Council.

PROJECT DESCRIPTION

City Design was commissioned by Brisbane City Council’s City Property section to prepare a design brief for the proposed new bus depot at Willawong to be operated by Council’s Brisbane Transport Unit.

The development of the design brief involved a broad range of design disciplines which included town planning, civil engineering, landscape architecture, architecture, stormwater engineering, building services engineering, environmental management and sustainability.

The delivery of the Willawong Bus Depot occurred over a 3 year period which began in 2006 with construction completed in April 2009.

The bus depot covers an area of 6.35ha and includes the following facilities:
- Bus hardstand for 200 buses
- Car parking for 280 vehicles
- Depot consisting of a collection of buildings connected with breezeways to house drivers and depot staff, 1751 square metres of administration offices, training and meeting rooms, drivers' amenities, cafeteria, and dispatch counter.
- Refuelling and detailing area with a drive through canopy able to accommodate 4 buses at a time, fitted with gas diesel fuelling points and vacuum systems
- Compressed natural gas (CNG) refuelling facility
- Garage building with 17 bay drive through workshop including 2 underbody service pits, gas maintenance platform, das pod crane, reticulated air, oil, water and coolant

The facility was designed to operate 20 hours a day, 7 days a week.

Figure 1 below shows the finished development and its various components.

![Figure 1. Site layout](image)

**PROJECT CONTEXT**

In 2006 our combined dam storage for the city was less than 30%, and water restrictions were being introduced by the newly formed Queensland Water Commission. Water restriction levels at the commencement of the project in 2006 were at Level 3. By the time the project documentation was completed and put out for tender water restriction levels had reached level 6.

This growing consciousness around issues of potable water consumption and the tightening of controls on its use, had a major impact on setting and giving momentum to the water agenda for the project.

The bus depot operator, Brisbane Transport, played an integral part in shaping and guiding the design of the bus depot. With regards to the water initiatives, Brisbane Transport flagged the Yarra Tram’s East Preston Depot in Melbourne as an example of what they hoped to achieve with the Willawong facility.

The Yarra Tram’s East Preston Depot uses rainwater from the roof of the tram shed for washing the trams. They have installed 18 kilolitres of roof water storage for this purpose.

Brisbane Transport had also researched proprietary bus washing facilities that could recycle the bus wash water to reduce potable water consumption from its most water intensive operations.
THE SITE
The site for the bus depot is located 15 kilometres south-southwest of the Brisbane CBD on an area of land that was previously Brisbane's liquid waste disposal site (figure 1). In 2002 Council began remediation works to the area in accordance with the Willawong Site Remediation Plan. These works were completed in September 2006 as work began on the Willawong Bus Depot project.

Figure 1. Site location map
During the early planning phase of the project a number of sites were investigated across the southern region of the city that would be suitable for the construction of the new southern bus depot. However, the remediated Willawong waste disposal site was selected because Council already owned the land, and the project was seen as a means to provide access and services for future light industrial development.

The remediation works carried out on the waste disposal area included filling and capping the area with a 450 millimetre thick compacted clay layer. This was then covered with 100mm of topsoil and seeded with turf grass species. The remediation works were designed to ensure water shed away from the site without ponding and penetrating the subsurface soil layers.

The works also included the construction of an artificial wetland (figure 2) to capture and treat run-off from the western half of the site before it was permitted to enter Blunder Creek. Water quality in this wetland is regularly monitored in accordance with the Willawong Site Management Plan.

![Artificial wetland](image)

**Figure 3. Willawong Bus Depot in relation to artificial wetland**

**PROJECT TEAM STRUCTURE**
The project team consisted of a total of 44 design and technical consultants. Of these 15 were from in-house within City Design.

Almost one quarter of the total number of consultants on the project were involved in the delivery of the water initiatives. They included:

- Architecture
- Ground Engineering
- Environmental Management
- Water Management
- Civil Engineering
- Sustainability
- Landscape Architecture
- Stormwater Management
- Hydraulic Engineering
- Grants

The project team had a very flat structure where all consultants attended and were included in weekly design discussions and reported to a single Design Manager. Due to the highly complex nature of the project, which has been compared to the complexity of designing contemporary hospitals, it was necessary for all consultants to be able to interact and exchange ideas regularly. This studio style team structure worked well in establishing the
early design direction, but did create some confusion/uncertainty over roles/responsibilities during the design development and documentation stages of the project. However this crossing over of ideas between each of the disciplines led to some well integrated outcomes across the project which is evident in the delivery of the water management scheme.

Sustainable Development Co-ordination
The Design Manager was assisted by two members of the project team who were charged with the co-ordination, tracking and reporting on sustainability initiatives throughout all stages of the project. These team members came from architectural and landscape architectural backgrounds. It was also their responsibility to co-ordinate the scoping of grants to support the sustainability initiatives on the project.

MASTER PLANNING
The water initiatives on the project were delivered as part of the overall sustainability strategies developed for the project. The sustainability strategies focused on energy optimisation, Integrated Water Management, passive thermal and ventilation systems, utilisation of recycled material and sustainable construction material selection.

Other strategies in the Master Plan included vehicular circulation, staff and visitor circulation and microclimatic considerations and human comfort. Each of these strategies was further refined during site planning and design development stages.

The sustainability strategy, including the water initiatives, were derived from a process that entailed benchmarking and identifying case studies of similar “Best Practice”, facilities and the development of a broad range of sustainability opportunities.

Sustainability framework
Early in the process, a sustainability framework was established for the project. The initial framework document was intended to focus discussion, generate further ideas and finalise specific sustainability initiatives with a commitments from all involved.

The framework was developed in the absence of any industry recognised sustainability rating tools at the time. Since the completion of the project in 2009, the Green Building Council of Australia has developed, and is about to release, their Green Star Industrial Rating Tool which could be applied in future to similar industrial facilities.

The sustainability framework developed for the project, identified the core sustainability considerations for each of the major design discipline to investigate. This framework document also served to track the progress of these sustainability considerations, and updates were provided to the client at the end of each major design phase of the project.

The following is the list of water specific initiatives to be considered on across the project. These were generated by the sustainability co-ordinators in collaboration with the various disciplines at the beginning of the site planning phase of the project.

Sustainability considerations
Urban Design & Architecture
  - Urban Water conservation, harvesting and recycling.

Landscape Design
  - Minimise potable water use and improve water quality for downstream ecosystems.
  - Water efficient irrigation system comprising subsoil drip irrigation system with automatic timers and rainwater and soil moisture sensor control override.

Hydraulic services / Potable Water
  - Reduced potable water consumption through – efficient use of, or avoidance of evaporative or water cooling tower systems, provision of low consumption plumbing fixtures to conserve water, water saving fixtures eg dual flush toilets (6/3 litre) & auto flush urinals;
- Water systems monitoring and management - Water sub-meters installed on all major water uses (irrigation, wash-down, hot water services), linked to a BMS to provide a leak detection system;
- Water harvesting & recycling systems - sourcing landscape irrigation from on-site rainwater collection or recycled site water; and grey water, black water or rainwater collection systems.

Environmental Pollution
- Best practice stormwater management - On-site treatment / filtration of stormwater
- Best practice sewage management - outflows to sewage system reduced by waterless or 5A rated urinals, 4A or better toilets, grey water collection from showers & hand-basins fully used for irrigation or toilet flushing, on-site sewage treatment eg. sewage passed through mechanical water recovery for use on site

From the beginning, issues related to water were not seen as the responsibility of any one discipline. In order to manage all water related issues, it became obvious that it was necessary to develop an overall water strategy for the project.

Integrated Water Cycle Management Plan
The Integrated Water Cycle Management Plan (IWCMP) began its life as a series of discussions between various disciplines on the project which needed to be recorded and clearly articulated to the client in order to garner support and funding. This initial functional diagram also established a scope to assess the feasibility of the potential elements.

Ultimately the IWCP for the Willawong Bus Depot aimed to substitute mains sourced potable water with other fit for purpose sources that were generated within the project site. It also aimed to mitigate any actual or potential negative impacts of the Bus Depot on the local catchment, and protect the health of the downstream environment of the artificial wetland and Blunder Creek.
SITE PLANNING
The nature of the site, its location and the elements required for the bus depot were considered in the very earliest stages of the design process. This led to the formulation of a site layout plan that responded to the unique combination of conditions and aimed to mitigate a wide range of potential environmental impacts from the project, whilst delivering the functional requirements of the development.

Functionality
There were a number of functional requirements that interacted with one another that were brought together through the site planning process in order to develop the final layout for the development. These included:

- Microclimatic conditions
- Vehicular movements;
- Safe-ways and circulation;
- Water management; and
- Building orientation for climate and energy optimisation.

Figure 5. Site planning functional diagrams

IWCP feasibility
During the site planning phase many of the elements making up the IWCP were assessed to substantiate their feasibility and value for money.

One of the first elements of the IWCP to be assessed was the black and grey water treatment proposals.

The decision to bring sewer to the site was driven largely by the desire to enhance potential returns on the rest of Area 4 which was being developed as industrial land in conjunction with the development of the bus depot. This decision made it less cost effective to treat black and grey water on-site.
Further to this, early calculations based on probable roof areas identified that there would be significant volumes of water that could be harvested from roofs at a lower cost than retrieving water from black and grey water treatment processes. Also the depot was likely to produce relatively low outputs of black and grey water through the use of water efficient fittings and fixtures.

At the time of the development South East Queensland water restrictions prevented irrigation from a potable water supply. Due to the need to provide 100% of the water for irrigation from a non-potable water source, water from the roof water tanks was not viable as these were to be topped up from the potable mains supply. Water for irrigation purposes therefore had to come from a totally separate source.

Stormwater runoff was identified as the best source of alternative water supply for irrigation. However the cost to provide in-ground onsite storage seemed high for the benefit that would be derived. The more cost effective solution was to treat stormwater onsite to meet stormwater code requirements, and to allow it to discharge to the existing artificial wetlands before returning it to the site for irrigation. This had a number of benefits. Firstly it would ensure the quantity of water flowing to the wetland was much the same as prior to the development of the bus depot, thus maintaining the viability of the wetland. Secondly, water drawn from the wetland and delivered to the site for irrigation would receive a greater level of treatment and water quality could be monitored under the existing water quality monitoring program under the legally binding Willawong Site Management Plan.

Rainwater harvesting with tanks dispersed throughout site have a combined storage capacity of 750 kilolitres. This water is treated through UV sterilisation process and used for all applications throughout site with the exception of cold water to showers, hand basins and sinks as well as for fire fighting and back-up supply to tanks.

**DESIGN DEVELOPMENT**
Further refinement of each component within the IWCP occurred during design development

**Water supply options**
With the deletion of black and grey water treatment, options for non-potable alternative water supply sources were limited to roof water and stormwater. What required resolving was how best to move water around the site to ensure that water was available for all purposes where it was required. The solution was to ensure that all tanks on the site were linked to ensure water harvested from any roof could be used wherever it is required on the site.

**Water demand reduction**
During the design development phase overall water demand was reduced through:

- The avoidance of evaporative or water cooling tower systems;
- Low consumption water saving fixtures were used, and all fixtures are minimum 3 star WELS rated or greater, ranging up to the most efficient 5 star WELS rating;
- Dual flush with water consumption of 4.5/3L with exception of stainless steel toilets in garage where the maximum design efficiency is 6/3L;
- Urinals using 0.8L per flush (above 4 stars WELS rating). (Waterless urinals were not incorporated into design due to client specified operational requirements.);
- Water efficient irrigation system comprising automatic soil moisture sensor control with subsoil drip heads; and
- Bus wash system incorporating a water recycling system with particulate filter, four-stage biological treatment, micro-filtration and UV disinfection to produce “Class A” recycled water.
**Storage**

Storage capacity for 750 kilolitres of roof water is provided with 2 x 330 kilolitre; one each connected to the Depot building and Garage and 10 x 10 kilolitre tanks associated with the refuelling and bus detailing canopy.

The tanks are all above ground for two reasons: firstly to avoid excavation of the landfill capping, and secondly to heighten the awareness of roof water harvesting and its use across the site.

**Water consumption monitoring**

An important component of the Integrated Water Cycle Plan is the ability to monitor consumption to assess performance, drive further efficiency and show compliance with the facility’s Water Efficiency Management Plan (WEMP).

Water sub-meters have been installed on all major water uses (irrigation, wash-down, and hot water services), and are linked to a building management system (BMS) to provide a leak detection system.

There are a total of 6 water sub-meters throughout the site – 2 in each building. This includes 1 non-potable (rainwater) supply and 1 potable (mains) supply to each building.

Additional sub meters have been included to monitor the following the bus wash, hot water supply to the garage, and hot water service in the depot building.

**Stormwater design**

The design of the stormwater system for the site became very much a joint process involving Landscape Architecture, Civil Engineering and Stormwater Management.

Large areas of hard pavement exposed to the sun throughout the day can generate significant amounts of heat. The earliest schemes for the bus depot incorporated landscaped zones through the bus hard stand as a means to lessen the heat build-up generated by the tarmac area. It was recognised that these zones would have to cope with hot dry and often windy conditions, which would result in high evapo-transpiration rates. The importance of water within these landscape areas became obvious to their long-term success.

The landscape design aims that were established for the stormwater elements included:

- The flow of stormwater needs to be seen as a positive element in the landscape, and should be treated as a feature as opposed to a waste product to be hidden and removed from the site as quickly as possible;
- Stormwater should be redirected to planting areas to reduce reliance on irrigation and to improve plant health and vigour; and
- Ensure that the water infiltration does not compromise the integrity of hard stand areas.

The challenge for the design of the bus hardstand, was to evenly drain all water to the swales whilst providing very long flat building platforms on three sides of the hardstand area and achieving relatively flat grades suitable for parking busses. This led to the innovative development of a series of detention basins in the pavement centred on the bio-filtration swales (See figure 6). These are designed to over-top and cascaded into the next basin, with peak event overflow through the centre of the hardstand to the discharge point. These basins begin to fill during events larger that a 1 in 50 ARI.
During this phase of the design the Stormwater engineers established sizing and capacity of the bio-filtration swales based on the catchment of each retention basin. The widths of the swales were relatively fixed by this stage so depth and longitudinal grades could be manipulated to some degree to provide the necessary capacity for water holding to enable treatment. Low check-dams were required at intervals along the length of the swales to ensure more even ponding and infiltration through the filter media over the length of the swale.

The planting for the bio-filtration swales was designed to ensure stormwater in-flows rates were not compromised by dense plant growth along the edges of the swales. Low ground covers were selected for these locations with reeds and sedges planted close to ponding locations at the check-dams.

The health of the planting within the bio-filtration swales was important for two reasons. Firstly to ensure maximum nutrient uptake and secondly to reduced dead plant material accumulation which may cause increased nutrient loadings within the swale after dry periods. With this in mind it was decided to provide moisture controlled irrigation to the bio-filtration swales.
DOCUMENTATION
One of the key learnings from this integrated design process is that the studio style team did create some confusion/uncertainty over documentations scope of a number of the design disciplines. Much time was spent sorting and dividing up documentation tasks between disciplines.

The documentation of the bio-filtration swales, for example, occurred across both Civil and Landscape drawing and specification packages. It was necessary to negotiate a point of separation between each discipline’s documentation scope.

The Landscape plans showed surface treatments and planting to the swales whilst specifying filter media and mulch types. The Civil drawing package however provided details related to finished surface levels, grades, excavation profiles, geosynthetic liners, subsurface drainage, pipe and inlet designs, flush kerbs and the interface with the bus hardstand.

OUTCOMES
By taking a holistic and integrated approach to dealing with all aspects of water on the site, the project has achieved some outstanding results in its first year of operation.

The project has been highly successful in delivering potable water consumption reductions as well as contributing to a suite of benefits which include:

- Enhanced site biodiversity;
- Safe and shaded walkways;
- A cooler and more comfortable environment;
- An attractive and appealing workplace;
- Employee awareness of water as a valuable resource; and
- Contributed to employee’s health and wellbeing.

The potable water reduction using alternative water supplies and water efficient fittings and fixtures was expected to be around 52%. However after assessing the water data from the building management system, the actual potable water reductions are in the order of 92%. This equates to non-potable water usage of 1.76 mega litres and potable water usage of only 0.16 mega litres.
But best of all, employees appreciate the green environs of the facility and incidents of employees taking sick leave reduced significantly within months of operations beginning at Willawong.

KEY LEARNINGS
Develop an overall strategy for water for the project which includes all possible water supply and storage options, water demand reduction potentials, consumption monitoring, and a range of stormwater treatment and discharge opportunities.

Express the water strategy in a manner that can be easily communicated to your client, and amongst other design disciplines. This will enable discussion of elements that influence each discipline on the project team and assist in determining their feasibility.

Get stormwater advice early, as WSUD has specific spatial requirements that need to be accommodated early in site planning stages of the project, and often prior to detailed modelling.

Land is a valuable resource and an expensive commodity to our clients. WSUD needs to be more than just a means to deal with water quality issues. It must provide multiple benefits to the project and these benefits need to be understood and supported by all disciplines on the project team and clearly communicated to your client.

A design studio approach is a great way to develop integrated ideas, but care needs to be taken within the documentation stage of the project to ensure all aspects of the design are covered within the various documentation packages.

Above all capitalise on the achievements of others in showing clients and stakeholders case studies and build upon those to provide continued ‘Best Practice’ outcomes.