ECOLOGICAL ENGINEERING

Western Sydney Parklands – Bungarribee Precinct

WSUD Strategy

June 2007

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Report for: *Landcom*

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1 Introduction

This Water Sensitive Urban Design (WSUD) Strategy for the Bungarribee Precinct of the Western Sydney Parklands establishes principles and options for water cycle management, within the Precinct. The Strategy reflects and integrates site specific water management issues and opportunities with established WSUD principles and objectives, to deliver best practice water cycle management.

This Strategy seeks to identify water management issues that must be addressed for protection of the local environment and receiving waters. Water quality, water conservation and flow management targets have been identified so as to address broader ecological principles to ensure the sustainable management of the Parklands. These water management targets can be integrated with the identified conservation, recreation, infrastructure and open space zones of the Parklands.

This assessment of water management issues identifies opportunities such as the engagement and embellishment of the remnant billabongs between the Sports Zone and Eastern Creek, protection of the biodiversity corridor through the site and establishment of a functional interface zone between development and the biodiversity corridors which protects and enhances these areas. Detailed water management options have been developed for four key areas within Bungarribee Precinct, including the Sports Zone (Section 5), the Airstrip (Section 6), and the Recreation Hub, and Industrial Zone (Section 7).

As a separate component of this project, WSUD Strategies have been established for the development areas adjacent to the Bungarribee Precinct, the 'interface lands'. The WSUD Strategies for the Doonside Residential Development (Ecological Engineering, 2007) and the Huntingwood West Employment Zone (Ecological Engineering, 2006) are consistent with and adopt the objectives and approach identified in this report, but focus specifically on the proposed development in those locations.

The key sections of this report include:

- Site description (Section 2)
- Water management issues (Section 3)
- Water management principles and objectives (Section 4).
- WSUD measures for the Sports Zone (Section 5), the Airstrip (Section 6), and the Recreation Hub, and Institutional Precinct (Section 7).

2 Bungarribee Precinct, Western Sydney Parklands

2.1 Site description

The Bungarribee Creek/Rooty Hill Precinct (Bungarribee Precinct – Precinct 2) is the second of nine precincts that make up the Western Sydney Parklands (Figure 2-1). The Parklands extend from Quakers Hill approximately 4 km to the north of the Bungarribee site (Precinct 1), to Leppington nearly 18 km to the south (through Precincts 3 to 9).

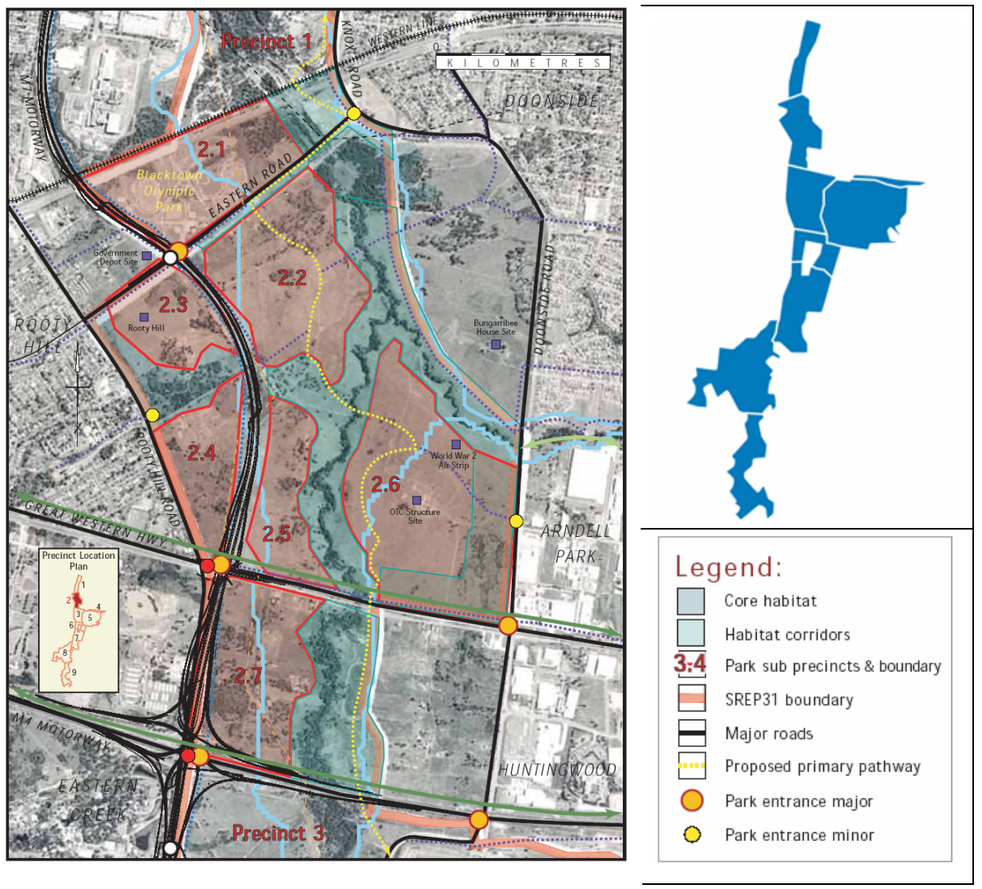

Figure 2-1 Bungarribee Precinct, Western Sydney Parklands (location plan from The Western Parklands, Management Vision)

Eastern Creek flows through the centre of the Bungarribee Precinct, with Bungarribee Creek draining the suburbs of Huntingwood, Arndell Park and Doonside to the east of the site (Figure 2-1). These two waterways form part of the core habitat and riparian corridors of the Precinct and include bushland remnants of Cumberland Plain Woodland. The core habitat and corridors form critical ecological links throughout the Parklands and are integral to the vision of the Parklands.

To complement the conservation areas of the Bungarribee Precinct there are significant areas of public open space to facilitate sport, physical development, economic activity, education, research and recreation programs. These conservation and public open space areas will need to be managed so as to ensure the environmental, social and economic outcomes of the project. Figure 2-2 illustrates the activity areas proposed for the Bungarribee precinct.

Western Sydney Parklands Bungarribee Precinct

Sports Zone *(section 5)*

Airstrip *(section 6)*

Recreation Hub *(section 7)*

Institutional Zone *(section 8)*

Doonside Residential Development *(separate WSUD report)*

Huntingwood West *(separate WSUD report)*

Figure 2-2 Structural Plan for the Bungarribee Precinct

2.2 Water Management Issues

An analysis of the site has identified a series of water management issues that threaten the amenity and ecological values of the site. These issues relate to water quality and hydrology and if unmanaged will increase as a result of development of the site, thereby exacerbating a suite of pollution, erosion and receiving water health issues already present within the Bungarribee Parklands. These issues are discussed in the following sections.

2.2.1 Water Quality

Urban development can threaten the habitat values of waterways by degrading the water quality and increasing the volume of runoff and the frequency of flooding. Urban areas generate higher stormwater flows with greater pollution loads as a result of impervious surfaces and human activity. Stormwater runoff from hard paved areas convey typical pollutants including litter, suspended solids, nutrients, heavy metals, hydrocarbons, oil and grease. As shown in Figure 2-3, the Bungarribee Precinct receives stormwater from a range of external catchments, which bring stormwater and pollutants to the site.

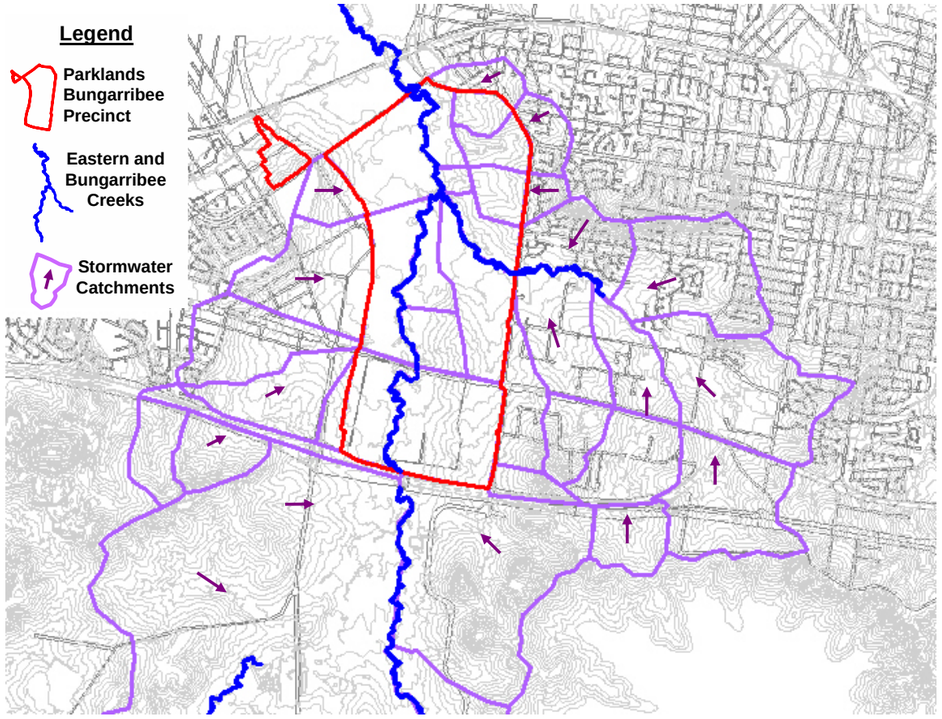

Figure 2-3 The External Stormwater Catchments that discharge to the Parkland and waterways of the Bungarribee Precinct

Addressing pollutants carried in stormwater from activity centres within the zone and from external catchments is important to protect the ecological assets of the Parklands. The WSUD strategies for both Huntingwood West and Doonside configure treatment measures to reduce pollutants carried in stormwater from external catchments in addition to treating stormwater from those development sites. This realises benefits for the waterway downstream. Stormwater pipe discharge points from external catchments need to be identified and addressed, in addition to best practice water management for activity centres within the Precinct.

2.2.2 Impacts of Uncontrolled Stormwater Discharge

Throughout the Bungarribee Precinct stormwater pipes from the neighbouring urban catchments drain directly onto the site without controls. These drains convey stormwater and pollutants, and are associated with erosion points as the discharge pipe is often lower than the surrounding landscape. These discharges are also point sources of nutrient pollution which sustain increasing weed growth. Endangered ecological communities like the Cumberland Plain Bushland are threatened by invasive weeds which out compete native species along drainage lines and riparian corridors. The impacts of stormwater discharge from urban areas external to the Parklands are illustrated in Figure 2-4.

Figure 2-4 Weed growth and disturbance due to uncontrolled discharge of stormwater

2.2.3 Modifications to Hydrology

In an undeveloped catchment, much of the water that falls on a catchment (as rainfall) percolates into the soil where it is either lost through evaporation, evapotranspiration, or flows into groundwater and into the stream. Only a small portion of the rainfall enters the waterway as overland flow.

The proportion of water reaching the stream as overland flow or through piped discharge greatly increases as a result of urban development. Firstly, impervious surfaces prevent water from percolating into the soil, resulting in decreased subsurface flows to the stream. Secondly, opportunities for infiltration are reduced by stormwater infrastructure that ensures that all runoff draining from impervious surfaces is piped to the stream. Water that would have either been transpired by plants or would have percolated into the soil is instead delivered directly to the stream. The result is a stream environment that experiences a significant modification to the natural hydrology observed prior to development. The consequences for the stream hydrology are:

- Reduced stream baseflow
- Peak flows resulting from rain become much larger, but the flows do not last as long
- Channel form complexity is lost as erosion and incision increases in response to changes in sediment supply and flow velocity
- Small to moderate flows that used to recharge baseflow and have very little effect on stream flow, now cause floods that approach or exceed bank-full
- These frequent disturbances combined with a lack of refugia result in a loss of biodiversity and reduced ecosystem functioning (altered food web and nutrient cycling). (Walsh et al 2004).

With increased impervious areas associated with urban development, the volume and velocity of stormwater runoff increases. Attenuation of these increased flows is required to protect the geomorphic form of the receiving waterways, and to moderate downstream flooding. To ensure the sustainability and integrity of the waterways, runoff from urban areas must be treated and controlled to protect the geomorphology of the streams from increased flows.

The bed and banks of Eastern and Bungarribee Creeks have suffered erosion and incision due to the modified flow regime resulting from uncontrolled stormwater runoff from developed urban areas within the catchment. This is shown in Figure 2-5, which illustrates significant erosion along the banks of Eastern Creek. The incision of waterways as a result of erosion caused by modifications to the hydrology also has impacts on the vegetation within the natural flood plain. The inundation of these areas becomes less frequent with a resulting loss of species reliant on the inundation and ecological processes involved in the nutrient deposition cycle within the flood plain. The habitat value of the natural flood plain is reduced as a result of the modifications to the geomorphology of the waterways.

Figure 2-5 Significant erosion along Eastern Creek, just upstream of Eastern Road crossing

Opportunities to address these issues are identified in section 5 through the enhancement of natural billabongs within the floodplain adjacent to the Sports Zone, and in section 6 through the proposed diversion of water from Bungarribee Creek to the 'Airstrip Wetland'.

Design of the proposed development areas within the Zone presents the opportunity to mitigate impacts from stormwater discharge from external catchments and from other impervious areas. Assessment of the opportunities for waterway rehabilitation is also recommended in conjunction with works proposed to protect receiving waterways within the precinct.

2.2.4 Soil Salinity and Water Management

The area surrounding Bungarribee and Eastern Creeks is considered to be of high salinity potential (DIPNR 2002). Saline soils can exacerbate erosion when exposed, and when the watertable interacts with the subsurface soil, salt dissolves into the water, and may rise to the surface, harming vegetation and structures. In such an environment it is necessary to reduce the amount of infiltration that may interact with these soils as excess infiltration can cause the water table to rise in the vicinity of the infiltration.

2.2.5 Water Demand

Irrigation demands within certain areas of the Precinct are expected to be high, particularly for the playing fields within the Sports Zone. Irrigation may also be required to maintain the areas of heavily used public open space, and ensure adequate plant growth in the production landscape. The activity centre for tourism, education and conference facilities may also include elements with significant water use requirements. When these are able to be clearly identified opportunities, for water conservation measures can be assessed.

Non-potable water demands can be met with harvested stormwater or treated wastewater. The water management challenges of addressing increased stormwater runoff from developed areas and external catchments present opportunities to harvest stormwater for reuse. Quaker's Hill STP is located approximately 7 km from the site. Sydney Water is assessing the feasibility of a reuse pipeline from this plant to supply industry (OneSteel) and other sites. The NSW Governments Metropolitan Water Plan identifies Quakers Hill in a broader scheme with Penrith and St Mary's STP for advanced treatment to supply residential non potable demands. Sewer mining is also an option to supply treated wastewater to specifically identified non-potable demands.

The benefits of potable water conservation (through measures to reduce demand and the use of alternative water sources) are significant as it reduces the quantity of wastewater discharged to ecosystems (Hawkesbury-Nepean River), reduces the greenhouse gas emissions associated with water and wastewater treatment and transport processes and reduces the demands on the water supply catchments. Water conservation opportunities are discussed in more detail for the specific activity areas addressed in this report (Sections 5, 6 and 7).

3 Water Management Principles and Objectives

Water management principles for the Precinct have been derived from best practice standards and planning policies related to the Parklands, as well as in response to the site opportunities and constraints. The following water management principles and targets have been established for the Precinct.

3.1 Bungarribee Precinct Water Management Principles

The Western Sydney Parklands Management Vision establishes a range of ecologically sustainable development objectives for the Parklands (DIPNR 2004), including:

- Protect and restore biodiversity values across the Parklands including within core habitat and core habitat needs.
- Manage and restore remnant vegetation within riparian zones and along drainage lines.
- Ensure that development within the parklands maintains and enhances water quality runoff.
- Implement WSUD principles in existing and future development of facilities within the parklands, such as recycling of water from adjacent treatment plants.

The *Sydney Regional Environmental Plan (SREP) 31 – Regional Parklands*, aims to "…promote recreation, biodiversity and heritage conservation and landscape protection for the Western Sydney Regional Parklands". It is supported by the *Development Control Plan No.1 – Interim Regional Parklands Management*. This DCP identifies key natural resource principles including:

- Protect and enhance the natural systems of the parkland.
- Conserve and enhance remnant bushland to ensure protection of biodiversity, threatened species, populations and ecological communities and areas of environmental importance.
- Conserve and enhance watercourses and riparian areas.
- Establish a biodiversity and pedestrian and cyclist movement corridors linking recreation areas and areas of environmental importance.
- Improve long-term Regional Parklands management and establish appropriate management systems (revegetate creek-lines to create good ecological status, control erosion, filter nutrient run-off and re-establish biodiversity links, protect habitat and remnant vegetation).

Based on the above and the site conditions, the following principles are recommended to be adopted for the Bungarribee Precinct:

- Stormwater runoff from development areas within the Parklands as well as from external catchments is to be treated to attain current best practice water quality standards.
- Water conservation through demand management and the use of alternative sources of water to meet non potable demands.
- Post-development storm discharges are to be controlled so as to mimic pre-development storm discharges up to the one and a half year ARI event. This will minimise the adverse impacts of frequent events on the natural waterways and minimise bed and bank erosion.
- Post-development storm discharges up to the 100 year ARI event are to be managed so as to minimise the impact of flood events. Drainage and flooding issues need to be adequately addressed for the protection of people, property and the natural environment.
- The health and biodiversity of the waterways, natural systems and vegetation is to be restored and protected.

3.2 Bungarribee Precinct Water Management Targets

Any development within the Precinct should attain best practice water management targets. The following targets have been identified as industry standard and are consistent with Landcom's WSUD Policy, Blacktown City Council, and best practice targets stated in state and national guidelines. The targets for water conservation, pollution control and mitigation of the effect of increased flow as a result of catchment urbanisation are listed in Table 2.1.

Table 2.1 –WSUD Targets (Landcom's WSUD Policy, consistent with Council targets)

Objective	Performance Measure and Target
1. Water Conservation	(a) Combination of water efficiency and reuse options, 40% reduction on base case.
2. Pollution Control	(a) 45% reduction in the mean annual load of Total Nitrogen (TN).
	(b) 45% reduction in the mean annual load of Total Phosphorus (TP).
	(c) 80% reduction in the mean annual load of Total Suspended Solids
3. Flow Management	(a) Post-development storm discharges controlled = pre-development storm discharges for one and a half years ARI event. The purpose of this is to minimise the impact of frequent events on the natural waterways and to minimise bed and bank erosion.

These targets have been achieved in the WSUD strategies prepared for the for the interface lands adjacent to the Parklands Bungarribee Precinct, namely Doonside and Huntingwood West.

To complement the WSUD targets, mandatory WSUD requirements for the development have been identified as:

1. Priority must be given to the use of non-potable water sources for public domain irrigation.
2. Where reticulated recycled water is available from the local water utility, it must be used for appropriately matched uses such as toilet flushing, garden watering etc.

There are a range of measures that can be adopted for greater efficiency in irrigation particularly with respect to playing fields. These include ensuring uniform application of water, understanding terrain and soil properties, irrigating during optimum environmental conditions and maintaining the irrigation system. (Connellan, 2005)

4 Bungarribee Precinct Water Sensitive Urban Design Approach

The WSUD Strategy for the Bungarribee Precinct focuses on the main water management issues identified in Section 2.2, namely pollution control, flow management / hydrology, and potable water conservation. The following approach has been developed identifying water management opportunities to address these issues, in line with the water management principles and objectives identified in Section 3.

This approach has been adopted in the four key activity areas within Bungarribee Precinct; the Sports Zone (discussed in Section 5), the Airstrip (Section 6), and the Recreation Hub, and Institutional Zone (Section 7). This approach has been adopted in the 'interface lands' – Doonside Residential Parcel (Ecological Engineering, 2007) and the Huntingwood West Employment Zone (Ecological Engineering, 2006).

4.1 Stormwater Quality and Pollution Control

To ensure the sustainability and integrity of the waterways, runoff from urban areas must be treated to attain current best practice water quality standards prior to discharge into local waterways. WSUD elements such as gross pollutant traps, bioretention systems, swales and wetlands can be used to reduce pollutants carried from development areas within the Bungarribee precinct. These elements can be located as discrete individual elements, as larger regional elements, or a combination therein. The optimal configuration of WSUD elements is typically determined in collaboration with the landscape and urban design teams.

4.2 Hydrology

With the increase in impervious areas associated with urban development, the volume and rate of stormwater runoff will increase. The attenuation of these increased flows is required to protect the geomorphic form of Eastern Creek, and to limit the impact of flooding downstream. An adequate area must be provided to detain flows greater than pre-development levels for storm events up to the equivalent of the 1.5 year ARI event. The stormwater discharged from developed catchments can be managed so that the vegetation in downstream natural environments and the waterways themselves receive flows that more closely represent the predevelopment hydrology. This is critical for the protection of aquatic habitat in waterways, with specific attention to limiting the critical peak flows, in order to sustain the geomorphic form of the beds and banks.

4.3 Water Conservation

Potable water conservation measures include demand management and use of alternative water sources to meet non potable demands – fit for purpose use of water

- Potable mains water needs to be reduced through demand management including the installation of water efficient fixtures and through use of alternative sources of water based on matching water quality to uses on a "fit-for-purpose" basis.
- The potential of using alternative water sources should be investigated including treated wastewater and harvested stormwater to meet non potable demands on the site.

Where reticulated recycled water is available from the local water utility, it should be used for appropriately matched uses such as toilet flushing, irrigation demands etc.







As the end users and likely potable and non potable water demands are not known at present, it is not possible to develop potable water conservation strategies and assess the feasibility of stormwater harvesting or wastewater reuse. It is recommended that the following water balance calculations are done to determine the most effective way to conserve potable mains water usage through the site:

- Assessment of non potable demands (toilet flushing, irrigation, wash down water, cooling tower, laundry and other possible non potable demands associated with business types)
- Calculation of the reliability of supply to meet non potable demands with suitable tank storage sizes connected to the large roof areas of the Industrial Zone
- Calculation of the reliability of supply to meet non potable demands with a regional storage (located perhaps within the precinct parks), harvesting from all impervious surfaces and plumbed through a common reticulated network to service the Industrial Zone
- Consideration of the likelihood of a non potable water supply being made available from the Quaker's Hill STP (7 km from the site), possibly in conjunction with a water reuse pipeline to service non potable demands within the parklands.

Where a non potable water supply is available, strategic location of areas of vegetation with a high demand for non potable water may assist in bringing microclimate benefits to the Bungarribee Precinct. This opportunity contrasts with demand management measures applicable also to alternative water sources, but warrants further consideration as the detail design for the site progresses.

5 Sports Zone

Within the Western Sydney Parklands Bungarribee Precinct a number of areas have been nominated as particular activity centres. These areas are detailed in the Structural Plan and illustrated in Figure 2-2. This section identifies water management issues and opportunities for the Sports Zone.

5.1 Description of Sports Zone

The Sports Zone is bounded by Eastern Road and the M7 motorway, and is in close proximity to the Rooty Hill Train Station to the north-west and to the Doonside Residential Parcel to the east via pedestrian access over Eastern Creek. The sports complex will include outdoor netball courts and soccer fields as well as a possible indoor sport, cultural/recreation facility to accommodate indoor sports and cultural activities. A large area is provided for spectator car parking, with smaller car parking areas distributed throughout the precinct for access to other proposed facilities. Recreational facilities such as BBQs, toilets, picnic shelters, food stands and commercial opportunities are also envisaged.

The existing four soccer fields and amenities building adjacent to Eastern Road will be retained, with five more fields proposed.

The interface between the Sports Zone and the Parklands presents both opportunities and challenges for water management. The proposed landscape design will acknowledge the unique Parklands setting through the selection of vegetation and landscaping surrounding the courts and playing fields.

The WSUD Strategy for the Sports Zone seeks to address water management within the precinct, as well as protection of the biodiversity corridor and riparian area for Eastern Creek adjacent to the Sports Precinct.

The main elements of the Sports Zone are:

- 9 soccer fields, total area 6.5 ha (9 fields each 105 x 68m)
- Netball courts, surface area 2.2 ha (48 courts each 30.5m x 15.25m)
- Indoor facility, approximately 1 ha roof areas
- Carparks, roads and paving areas, approximately 10 ha
- Landscaped areas (including areas within the carparks) approximately 6.3 ha
- Adjacent vegetation areas, retained and enhanced – to the Parklands boundary

The estimated impervious area due to roads, car parks, roofs, paved areas and courts is 14.2 ha or approximately 50% of the Sports precinct. Stormwater runoff from these surfaces is to be directed to bioretention landscape features within carparks and adjacent to other paved areas, for treatment and reuse. Harvesting the treated stormwater will assist in meeting the demand for water to irrigate the playing fields.

Opportunities to reduce the impervious nature of car parking areas, should be considered as the detail design for this precinct is developed. Car park design presents a significant opportunity to reduce development impacts with pervious materials selected for areas less frequently used. Limiting the increase in impervious surface area associated with the development of the precinct will reduce pollutant transport to Eastern Creek and modification to the hydrology.

Figure 5-1 Proposed Sports Precinct, with soccer fields, netball courts, potential indoor sport, cultural/recreational facility and car parks

5.2 WSUD objectives

The WSUD objectives for the Sports Zone within the Western Sydney Parklands (Bungarribee Precinct) are:

- Improve stormwater quality. Pollutant load reductions of 80% of the average annual load of total suspended solids, and 45% of the average annual load of total phosphorus and total nitrogen.
- Minimise potable mains water use. Alternative water supply options to provide at least 70% of irrigation demand.
- Integrate water management opportunities with the urban design, the parkland interface and natural landforms.
- Protect Eastern Creek and the Parklands biodiversity corridor. Maintain the predevelopment flows to the natural terrestrial system and control flows from the developed catchment into the waterways.

5.3 Water Balance

The sport precinct area covers and area of approximately 27ha. A water balance was developed for the precinct to quantify the water use and stormwater generation through the Precinct. As a component of the water balance, the predevelopment rainfall-runoff has been determined and is presented along with the proposed water uses for the Sports Zone. The water balance includes the following components:

- **Rainfall**: average rainfall of 857mm/yr, with 231ML/yr falls on the 27ha site.
- **Stormwater**: prior to development, the majority of rainfall would infiltrate and taken up through evapotranspiration processes, or to groundwater. Modelling indicates that prior to development only 14% of rainfall (33ML/yr) will be transported from the site as stormwater runoff. The Sports Zone will introduce approximately 14.2ha of impervious surfaces, associated with car parks, roads, paths, netball courts and the indoor facility. This will result in a significant increase in stormwater runoff, and it is estimated that 125 ML/year will run off the site (54% of rain falling on the site).
- **External Stormwater**: An area of approximately 24ha (on the western side of the M7) drains to the site, and consists of a park with two playing fields. Prior to the construction of the M7 stormwater runoff from the catchment would have contributed to additional surface flows across the Sports Zone site draining to Eastern Creek. With the construction of the M7, the drainage has been altered so that drainage is now concentrated to a number of discharge points. Information on the new stormwater infrastructure has not been determined, and the flow path to Eastern Creek for this external catchment and road runoff from the M7 has not been able to be confirmed.
- **Irrigation**: The average annual irrigation requirement has been modelled as 40ML/yr, which assumes an irrigation application of 0.5m/yr (0.5kL/m^2/yr), with the area to be irrigated estimated at 8ha (6.2ha soccer fields and 1.8ha of training areas and feature landscaped areas). The irrigation demand will vary with evaporation and rainfall. The irrigation demand is also critically dependent on the type of grass selected (crop factor) and irrigation practices. This demand can be met with non-potable water.
- **Other non-potable demands**: Estimates of demand for toilet flushing (2 ML/yr) and cooling tower usage (10 ML/yr) have been made. These estimates are preliminary and when more information is available about the anticipated number of participants / spectators and the provision of facilities better estimates can be able made. Technologies are available to significantly reduce or eliminate the need for water usage in building cooling and should be considered.
- **Potable water import**: Approximately 4 ML/yr. Potable water demand estimates have been made, and as with assumed non potable demands. As the details of facilities and usage become known, these calculations can be refined. Potable water usage within the Sports Zone includes showers, hand basins, food preparation and drinking.
- **Wastewater**: Approximately 7 ML/yr. Toilet, shower and hand basin usage are discharged directly to sewer. 15% of cooling tower usage is typically discharged to sewer, and 80% of the quantity assumed to be associated with food preparation is included in sewer discharge estimate.

The water balance for the site prior to development is shown in Figure 5-2. This contrasts strongly with the water balance for the Sports Zone as shown in Figure 5-3 with stormwater runoff from the site increasing from 33 ML/yr to 125 ML/yr. Management of the urban water streams is critical for protection of the ecological assets of the parklands.

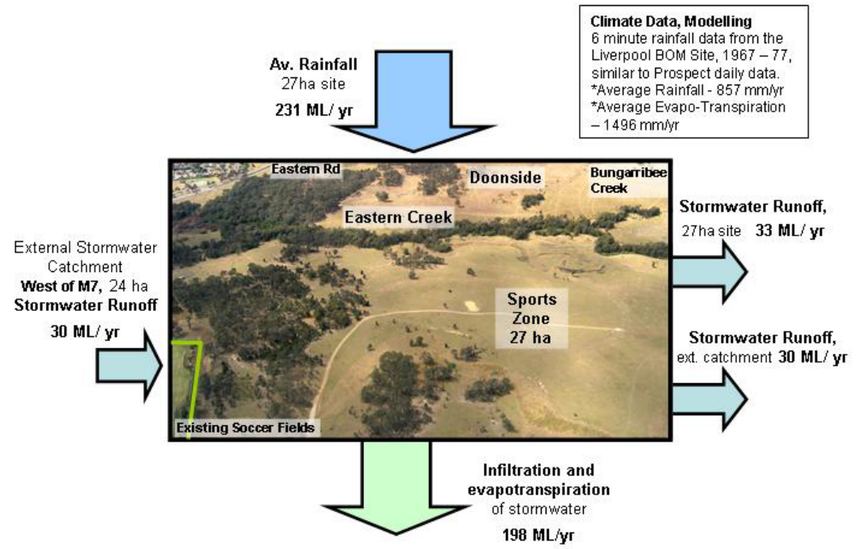

Figure 5-2 Water Balance for the 27ha Sports Zone site (pre development conditions)

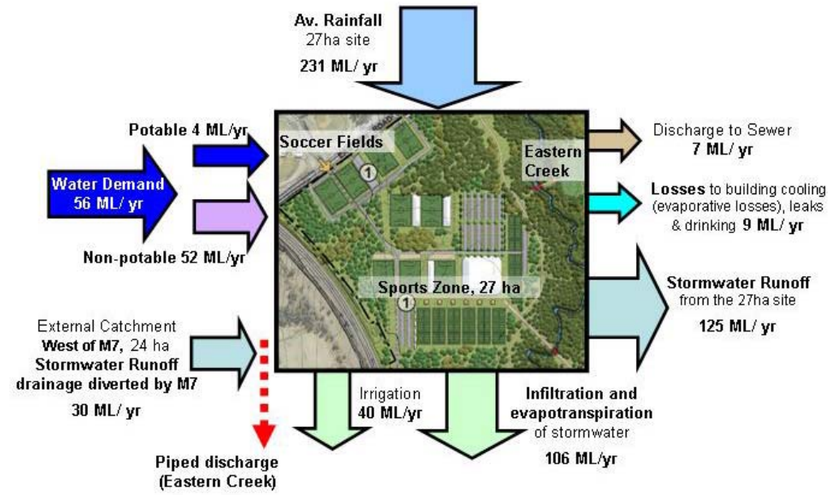

Figure 5-3 Water Balance for the 27ha Sports Zone site

An overview of the Zone is shown in Figure 5-4.

1a.

1b.

1. Area of poor drainage adjacent to the existing playing fields.
A stormwater harvesting water feature may be integrated in to the rehabilitation and access pathways proposed

2. Ponded area near the existing soccer fields (Eastern Road), downstream of drainage line. No clear flow paths exist connecting with Eastern Creek. Stormwater harvesting will assist in managing urban runoff from impervious areas.

3. Erosion point typical of uncontrolled flow paths, cut through the western bank of Eastern Creek (near Eastern Road). Stabilising a connection point with Eastern Creek will assist in managing flow paths.

4a.

4b.

4. Floodplain billabongs, can be enhanced to create a feature with habitat value using vegetation that would have been supported by the natural flood plain hydrology. The most suitable flowpath connection to Eastern Creek for the majority of the site is through these billabongs. (see section 5.4.3)

6. Existing amenities building
Rainwater harvesting from roof surfaces will assist in water conservation and meeting irrigation needs for the soccer fields. The large roof areas of the stadium and grandstand proposed will deliver significant benefits.
For runoff from paths, carparks and small buildings without existing guttering a central water feature can be effectively used for stormwater harvesting to meet a high proportion of the non-potable demands of the sports precinct.

5. Existing Vegetation, stormwater runoff from adjacent developed areas would be managed to maintain the flow regime to the significant stand of vegetation in the central part of the site.

4b.

Figure 5-4 Photos from the Sports Zone site

5.4 Water Management Opportunities

The water management opportunities for the Zone have been optimised to reflect the suite of water management objectives identified in Section 5.2. Bioretention systems are recommended to improve the water quality of stormwater runoff from the impervious surfaces. Water efficient fixtures and irrigation practices are important for water conservation. Stormwater harvesting requirements can be met by draining much of the Zone to a water feature (pond) with storage tanks to increase the proportion of non potable water available for reuse. Vegetation selection for bioretention systems and the configuration of the water feature (stormwater harvesting pond) would integrate seamlessly with the landscape design vision and setting within the Parklands. The management of stormwater to maintain the hydrology to natural terrestrial landform is achieved at the interface with the parklands by stormwater harvesting and through management of overland flow paths to Eastern Creek. These opportunities are detailed in the following sections and preliminary costing provided in section 5.5.

5.4.1 Stormwater Quality

Bioretention systems filter stormwater runoff through a vegetated soil media layer. The treated stormwater is collected at the base of the system via perforated pipes, from where it flows to downstream waterways or collected in storages for reuse (Figure 5-5).

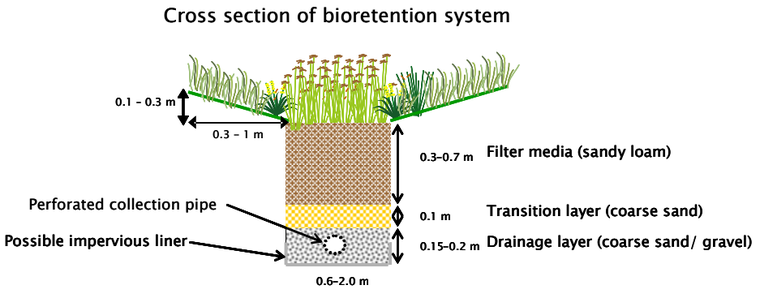

Figure 5-5 Cross section schematic of bioretention system

MUSIC (the Model for Urban Stormwater Improvement Conceptualisation) was used to calculate the treatment area required to meet best practice water quality objectives using bioretention systems to treat stormwater from the Sports Zone. It was found that a bioretention system of 2,700 m² would be required (1.9% of the impervious surface area draining to it). This system was modelled to have 0.1 m extended detention, 0.5 m filter depth, 0.5 mm median particle diameter and a hydraulic conductivity of 100 mm/hr. The treatment area will be less if roof surfaces are directed to rainwater tanks for reuse. Attaining the water quality targets for stormwater runoff prior to being directed to a storage pond or to the Parklands is considered essential.

This treatment area can also be reduced where measures are adopted to reduce the impervious nature of car parking areas. Car parks can be partitioned into "regularly used areas" which require pavement/concrete/asphalt and "overflow parking" which are less used and therefore can be structured turf of similar. Development impacts linked to pollutant transport to waterways and the modification to hydrology are reduced if sections of car parking areas can be configured with pervious surfaces.

5.4.2 Water Conservation

Demand management measures result in a significant reduction in potable mains water use through the use of water efficient appliances and fittings, including dual flush toilets, low flow shower heads and aerator tap fittings. Landscaped areas can be planted with low-water-use and/or indigenous plants, playing fields with grasses with reduced water demand and irrigation technologies and practices can be selected with the objective of reducing water use. Demand management is a particularly cost effective way to reduce water use.

Stormwater harvesting can assist in managing the changed hydrology resulting from the increase in impervious surface areas as well as meeting some of the non potable demand for irrigation of playing fields. The supply of an alternative water source (either harvested stormwater or treated wastewater) for irrigation, toilet flushing and evaporative cooling towers (if used) is also recommended, given the significant water conservation benefits.

Rainwater tanks

Rainwater tank options for the Sports Zone are outlined in Table 5-1. The overall demand for non-potable water for the Sports Zone is large due to the significant irrigation demand for the playing fields (approx 40ML/yr) as well as for toilet flushing and possible cooling tower usage in the indoor facility and other amenities.

To facilitate rainwater harvesting there are large roof areas associated with the potential indoor sport, cultural/recreational facility, and other roof surfaces. The design of these facilities should seek to maximise the collection of roof water from these roofs. The larger the rainwater tanks, the greater the reuse potential, however there are diminishing returns as the tank size and cost increases. The rainwater tank sizes identified in Table 5-1 is an optimal size after which further increases in the size lead to relatively smaller increases in the reuse amount. The tank size can be optimised once the demands to be met from particular roof areas (and connect to centralised irrigation network) are confirmed.

Table 5-1: Potential rainwater harvesting options

Building	Roof area	Rainfall to tank	Approximate tank size*	Potential reuse per year
Existing Amenities Block at Soccer Fields (along Eastern Road)	~300 m²	220 kL/yr	3.0 kL	35 - 220 kL/yr
Proposed Soccer Grand Stand	2,000 m²	1.5 ML/yr	20 kL	600 - 1,500 kL/yr
Proposed indoor sport, cultural/recreational facility	16,000 m²	11.8 ML/yr	150 kL	5,000 kL/yr

* Assuming that the total roof area is directed to the rainwater tank

Water Feature / Stormwater Harvesting Pond

In addition to rainwater tanks, stormwater runoff from other impervious surfaces (car parks, paths and netball courts) can be directed to bioretention systems for treatment and subsequently harvested for reuse. A water feature can be created which receives the treated stormwater and is

drawn down as the water is reused. Note that evaporative losses will reduce the quantity of water available to be reused and the water body must be configured so that adequate storage is provided within the area available to be drawn down. This can be done attractively with fringing wetland vegetation that can accommodate the variation in water levels and tiering/boardwalk edging to safely allow deeper sections of the water feature to maintain an open water system while providing greater storage available for stormwater harvesting.

It is estimated that the available water storage area is between 1600kL and 2700kL with a draw down of 0.5 – 1m. The possible location of this element is shown in Figure5-6, as a small pond and adjacent linear water feature. With 10ha of impervious surfaces directed to a water storage area with this configuration the modelled reuse is 25 – 30ML/yr (or 60 – 70% of the irrigation demand). When combined with possible rainwater harvesting from the potential indoor sport, cultural/recreations facility, and other roof surfaces, the proportion of the demand met for irrigation and toilet flushing is expected to approach 90%.

There are existing low lying and poorly drained areas on the site. In the regrading of the site to achieve level playing surfaces there are options to provide adequate land forming and contouring to allow the development to be configured as desired, and to eliminate areas with poor drainage adjacent to the existing soccer fields. The linear water feature and stormwater harvesting pond discussed can be integrated with the development layout as illustrated in Figure 5-6. Note additional bioretention areas would be configured around roads and netball courts, integrating with proposed landscaping.

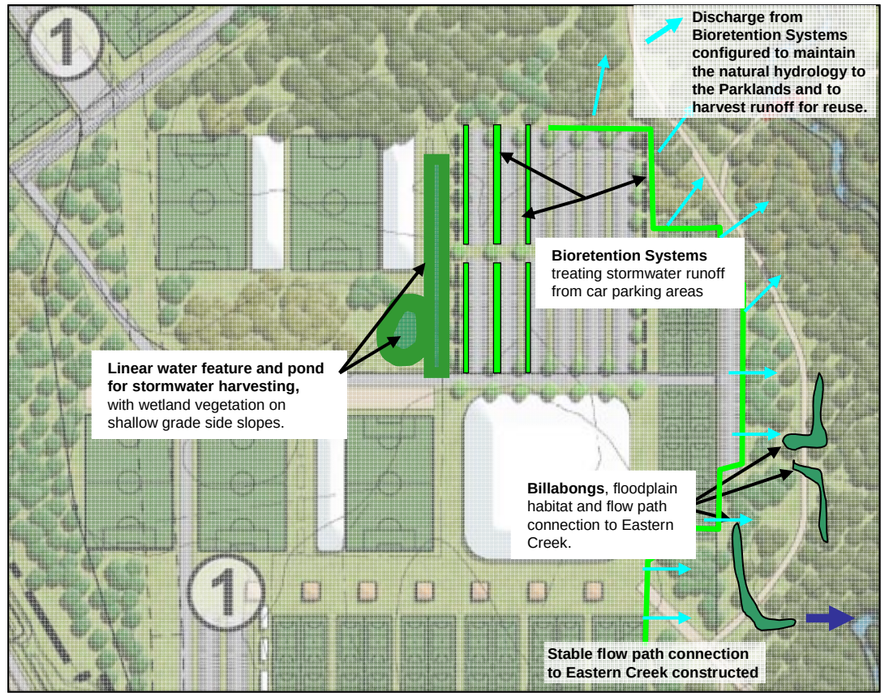

Figure 5-6 Stormwater harvesting water feature and car park bioretention systems

5.4.3 Hydrology

Presently there are no defined waterways conveying surface flows from the site to Eastern Creek. The majority of rainfall would infiltrate and be subsequently lost through evapotranspiration with only a small portion entering Eastern Creek as overland flow. Any increase in runoff due to development of the area will significantly alter the hydrology and have potential impacts on the receiving environment. To minimise these impacts discharge of stormwater runoff from the Sports Zone would be managed so as to mimic the predevelopment surface and subsurface flows and therefore maintain and enhance the vegetation within the biodiversity corridor.

Stormwater harvesting within the Sports Zone will be an important element in managing stormwater flows from the site. The water balance (Figure 5-3) quantifies the increase in average annual stormwater runoff from the developed impervious areas of 33ML/yr to 125ML/yr. The function of the water feature proposed as part of this strategy assists in managing the hydrology of the developed site and would address drainage issues, include improvement of stormwater quality and facilitate stormwater harvesting to meet non potable demands.

Discharge from proposed linear bioretention systems at the interface with the parklands can be configured so as to mimic the natural hydrology to the Parklands. This will also have the effect of distributing stormwater flows rather than concentrating stormwater discharge points. Flows exceeding predevelopment levels would be harvested for reuse and provision made for overflow occurring in large storm events.

Stormwater from the Sports Zone would either be directed to the stormwater harvesting water feature or to bioretention systems on the interface with the Parklands. Provision for overflow

occurring in large storm events would direct flow to the three floodplain billabongs (location indicated in Figure 5-6), with flow paths designed to reduce the risk of erosion. Avoiding erosion associated with the concentration of uncontrolled flow paths is particularly important with the dispersive saline soils found in the region (as illustrated in point 3, Figure 5.4). The connection to Eastern Creek would be designed to ensure stable discharge of flows from up to approximately the 1 in 100 year ARI storm event. It would operate infrequently as discharge to the natural flood plain would be maintained in efforts to mimic the predevelopment hydrology. Stormwater harvesting, natural distribution of surface runoff and re-engaging the natural floodplain are important factors for sustainable water management in this Zone.

Under natural conditions the three remnant billabongs on the flood plain between the Sports Zone and Eastern Creek would play an important role in the ecological process and nutrient cycle of the floodplain and waterway. However, this area has been highly modified as a result of removal of vegetation, grazing and changes to the natural hydrology of Eastern Creek and its floodplain inundation. As a result these critical interactions between the creek and floodplain no longer occur. This project presents an opportunity to enhance these billabongs through revegetation, reinstating their natural wetting and drying processes, via runoff from the Sports Zone. Once rehabilitated, these areas would be significant natural features of ecological, aesthetic and educational interest adjacent to the Parklands walking / cycle paths.

5.5 Costing Water Management Opportunities

Preliminary cost estimates of the water management measures as proposed above are outlined in Table 5-2. These estimates serve as a guide to the overall financial planning of the development prior to the detailed design stage where costs are able to be more clearly defined. A cost range is presented and it reflects the significant variation in preliminary cost estimates for any given stormwater treatment measures and their corresponding sizes.

Table 5-2: Costs of water management measures in the Sports Zone

	Water Management Opportunity	Indication of Capital Cost	Indication of Annual Maintenance Cost
1	Bioretention systems (2,700 m^2)	$ 150,000 – $ 500,000	$ 50,000
2	Water efficient fixtures and irrigation practices	Minimal incremental cost above basic requirements for these items.	
3	Rainwater tanks – Existing Amenities Block (3kL) – Soccer Grand Stand (20 kL) – Indoor Facility (150 kL)	 $ 5,000 $ 20,000 $ 50,000	 $100
4	Stormwater harvesting water feature (wetland and pond) 4,000 m^2	$ 250,000 – $ 650,000	$ 5,000 – $ 15,000
5	Controlling discharge of stormwater runoff to maintain the hydrology to the Parklands	The design of bioretention systems and the drainage infrastructure can address this issue with minimal incremental cost.	
6	Stabilisation of overland flow paths to Eastern Creek	The stabilisation works required at particular locations would need to be detailed in order to provide costing.	

5.6 Conclusion

The recommended strategy for water management at the Sports Zone addresses water conservation, water quality and the management of stormwater runoff from the site to maintain appropriate hydrology to the receiving environment.

Bioretention systems can be integrated into the landscaping proposed within car park areas, along the Parkland interface and through the general complex. These soil filtration systems will ensure that stormwater pollutant loads are reduced to meet best practice targets. The area required is estimated at approximately 2,700 m^2, with a cost of between $150,000 – $500,000 depending upon the configuration and landscaping requirements.

Water efficient fixtures, rainwater tanks and stormwater harvesting are important to reduce potable water demands. The large roof surfaces of the indoor facility and other roof surfaces can be used to effectively harvest significant volumes of water to meet non potable demands. Similarly stormwater runoff treated in bioretention systems can be harvested in a combined water feature / wetland. The estimated cost for a 4,000m^2 water feature is between $250,000 and $650,000.

The configuration of discharge from bioretention systems and management of flow paths can be designed to maintain an appropriate hydrology that will protect the receiving environments. This is important for both the sustainable long term management of both the terrestrial vegetation and the waterways of the Parklands.

6 Air Strip Promenade

This section identifies water management issues and opportunities for the Airstrip Promenade.

6.1 Description of Airstrip Promenade

A former airstrip, used during World War II, is located on the southern side of Bungarribee Creek, just to the west of Doonside Road. The area is generally grassland at present. The proposed development of this area aims to create a functional water feature, possible café area, constructed Sydney Coastal River-flat Forest habitat, road and parking access point into the Parklands and location for model airplane enthusiasts.

6.2 Description of Bungarribee Creek Catchment

The Bungarribee Creek Catchment covers nearly 700ha (Figure 6-1). At least half of this largely developed catchment is covered by impervious surfaces which contribute to a marked change in the hydrology for waterways downstream. Within the development site (downstream of Doonside Road), Bungarribee Creek is in a generally good condition. However, development within the Bungarribee Precinct and the resulting increased conveyance of upstream flows will have a damaging effect on the creek, resulting in more creek disturbance, loss of biodiversity and declining waterway health.

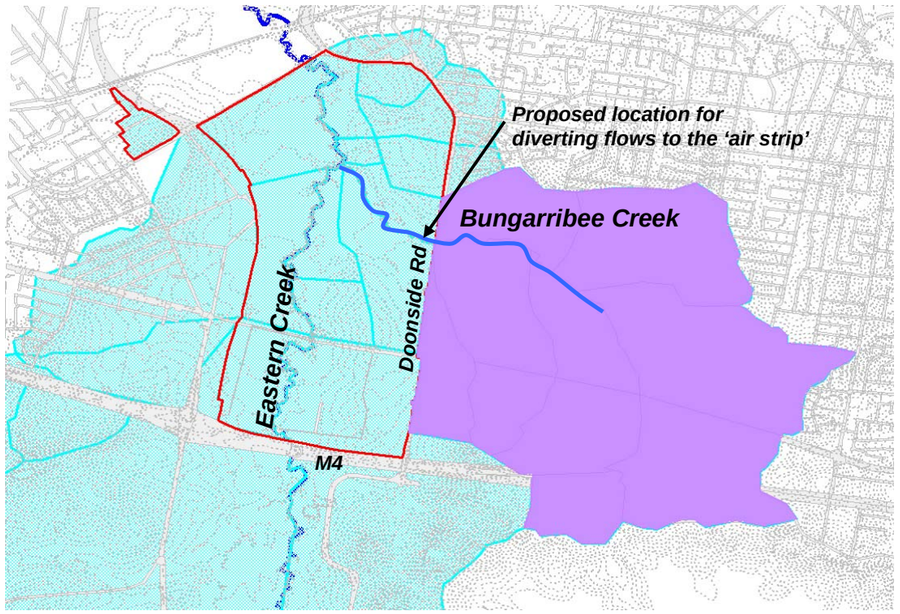

Figure 6-1 Stormwater harvesting water feature and car park bioretention systems

The Doonside Road bridge crossing Bungarribee Creek was built in 1999 as part of upgrades for the 2000 Olympics. In its previous form, the road crossing acted as a barrier to higher flows entering the Bungarribee Precinct, assisting to maintain the geomorphology of the creek. With the upgrade of the road, significantly larger flows are conveyed downstream at a greater velocity leading to scouring and erosion of the creek which is now evident just downstream of the road (Figure 6-2). Downstream of the road crossing the channel has been eroded, increased dramatically in width and reeds grow across the full width. If these erosive flows continue without abatement it is likely that the channel erosion will continue further downstream leading to creek widening and further loss of biodiversity and waterway health.

Figure 6-2 Bungarribee Creek at Doonside Road Crossing

Sections of Bungarribee Creek between Doonside road and confluence with Eastern Creek (1.3km length) are in good condition with the natural channel form and vegetation preserved. The creek has a healthy stand of Casuarina along its banks, and there is limited erosion at this stage.

6.3 Proposed Diversion Structure

The opportunity exists to use part of the Parklands area to intercept, divert and treat some of the frequent events from the upstream catchment, so as to lessen their impact on the waterways, and to return the waterway hydrology closer to its pre-development state. Approval would be required from DNR to restrict flows within Bungarribee Creek with a structure such as a slotted weir. The benefits to the waterway realised through interception of the upstream flows include:

- reduce peak flows and erosion in the waterways downstream of the proposed diversion
- reduce the stressors on the riparian areas along these waterways
- preserve the natural form of Bungarribee Creek downstream of Doonside Road
- engage the natural flood plain to reduce shear stress and erosion
- improve water quality
- create urban water features with environmental functionality

A slotted weir can be used to restrict flows from the upstream urban catchment, thereby protecting Bungarribee Creek. Spanning the width of the existing channel the slotted weir would be approx 10m width, and 1.5m elevation. To convey the predevelopment flow the slot would be approximately 4m width. A lateral weir (earthen embankment) at lower elevation would divert excess flows to the airstrip (Figure 6-3).

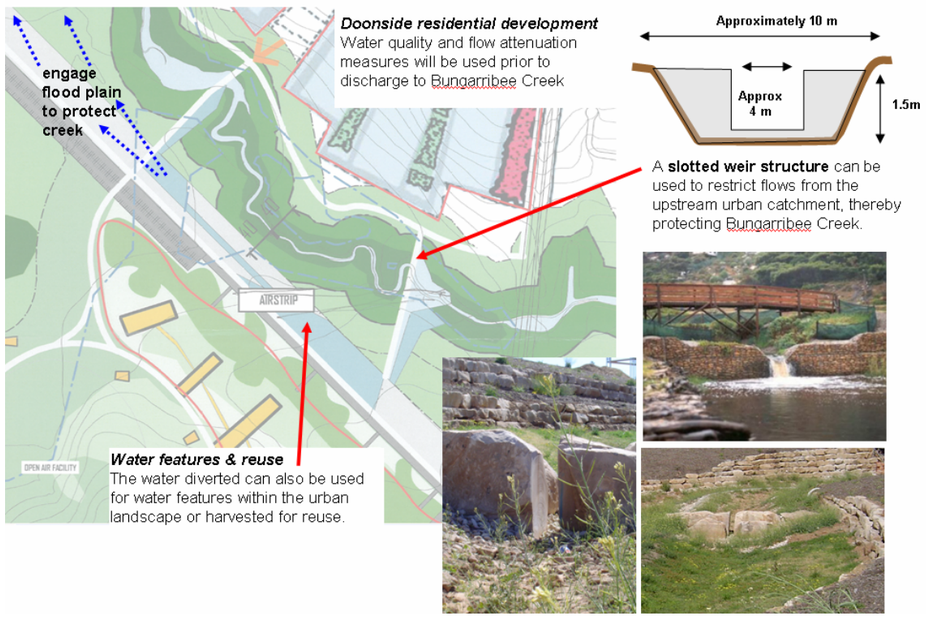

Figure 6-3 Diversion structure

The flows exceeding the 1.5 year predevelopment peak flow for the large developed catchment are intercepted and the vegetated bund earthen embankment on edge of riparian zone directs the water to the flood plain (Figure 6-4). The reduction in flows conveyed by Bungarribee Creek will provide protection of the creek geomorphology and rehabilitated riparian zone. The depth of water and flow paths through the Parklands would be controlled to ensure that walking paths, sensitive vegetation and car park areas would be protected from excessively large flows. In large rainfall events the diversion weir will overtop and flood waters will be conveyed safely along Bungarribee Creek. The design would ensure that there are no adverse flooding impacts as a result of the proposed modifications.

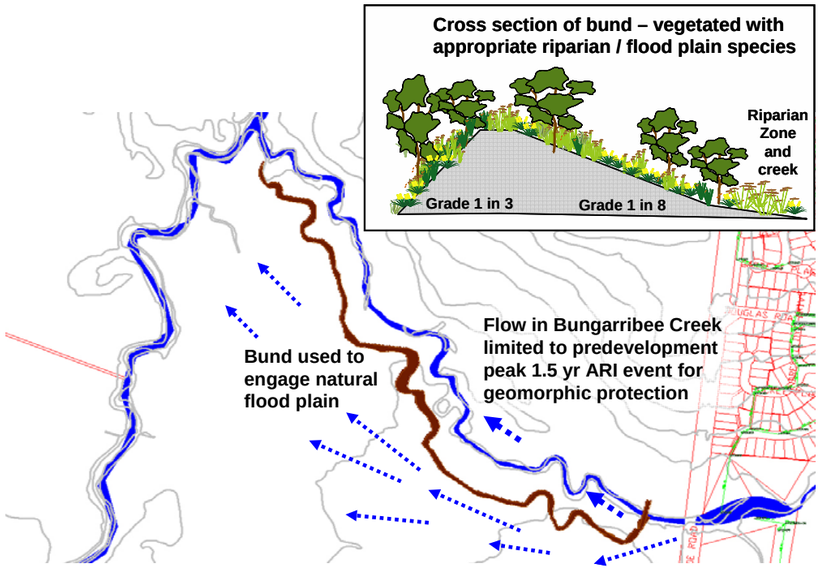

Figure 6-4 Bund adjacent to Bungarribee Creek engages the flood plain

6.4 Proposed Water Quality Treatment

The diversion of water from Bungarribee Creek presents the opportunity to address water quality through a linear constructed wetland along former airstrip. This feature integrates urban design objectives for the area with the option for an open water feature, a visual interpretation of the airstrip form and ecological function (both water quality and provision of harvested water for reuse).

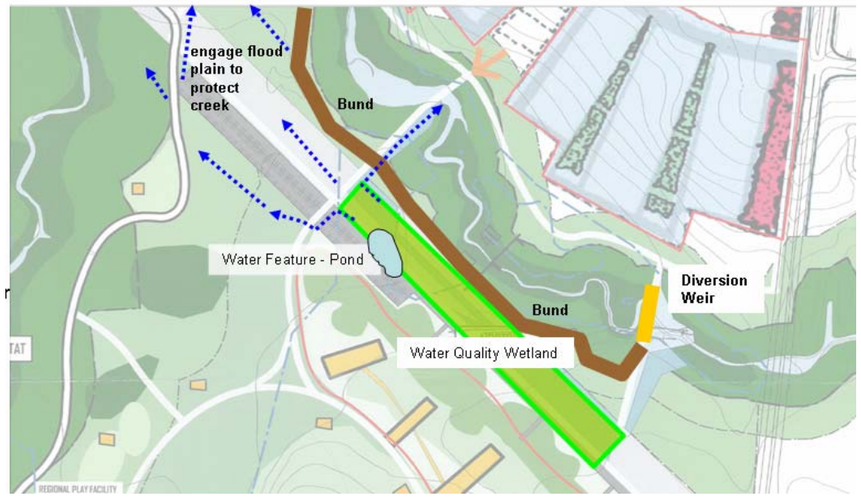

Figure 6-5 Water Quality – Linear Constructed Treatment Wetland

6.5 Costing

The costing is detailed in Table 6.1 for the elements required to intercept, divert and treat the water from Bungarribee Creek for the protection of this waterway downstream of Doonside Road. The estimated annual maintenance cost for the constructed wetland is $30,000.

Table 6-1: Costs of water management measures for the Airstrip Precinct

Item	Unit Cost	Unit	Amount	Total
Diversion Structure	$50,000	items	1	$50,000
Bund 1500m				
• Earthworks	$15	m^3	10,000	$150,000
• Top soil	$35	m^3	5400	$190,000
• Vegetation	$15	m^2	18000	$270,000
Wetland (2 ha) earthworks, structures and vegetation	$50	m2	20,000	$1,000,000
TOTAL				**$1,660,000**

6.6 Conclusion

The Doonside Road Bridge (built in 1999) which crosses Bungarribee Creek has resulted in modification to the geomorphology of the creek with flows conveyed downstream at a greater velocity leading to scouring and erosion of the creek. The proposed development within the Airstrip Promenade aims to enhance the ecological value of the area and to create a vibrant community space. This presents an opportunity to address threats to the waterway from its existing urban catchment. To ameliorate the erosion problems with Bungarribee Creek and enhance the natural environment within the Airstrip Promenade it is proposed to intercept, divert and treat some of the frequent events from the upstream catchment, so as to lessen their impact on the waterways, and to return the waterway hydrology closer to its pre-development state.

7 Recreational Hub and Institutional Zone

This following section identifies water management issues and opportunities for the Recreational Hub and Potential Institutional Zone.

7.1 Description of the Zone

The recreational hub (Area 3, **Figure 7-1**) is intended to be a recreational open space area with BBQ and picnic facilities, a large event space and regional playground in addition to providing a location for revegetating and translocating native grasslands for conservation value. The development of the institutional zone (area 4, **Figure 7-1**) proposes the inclusion of tourism, educational and commercial recreation facilities. A significant parking area for cars and coaches would be provided in addition to conference facilities and a tourist information centre. The various options under consideration may result in specific constraints and opportunities in relation to water management. Optimal strategies can be developed to assess the challenges presented.

Figure 7-1 Recreational Hub (3), institutional zone (4) and Airstrip Promenade (2)

The Zone is bounded on the south by the Great Western Highway, on the east by Doonside Road and on the west by Eastern Creek. The Airstrip Promenade and Bungarribee Creek define the northern boundary. Figure 7-2 highlights the area and the contours showing a drainage depression from the south-west corner of the site flowing around the site to Eastern Creek.

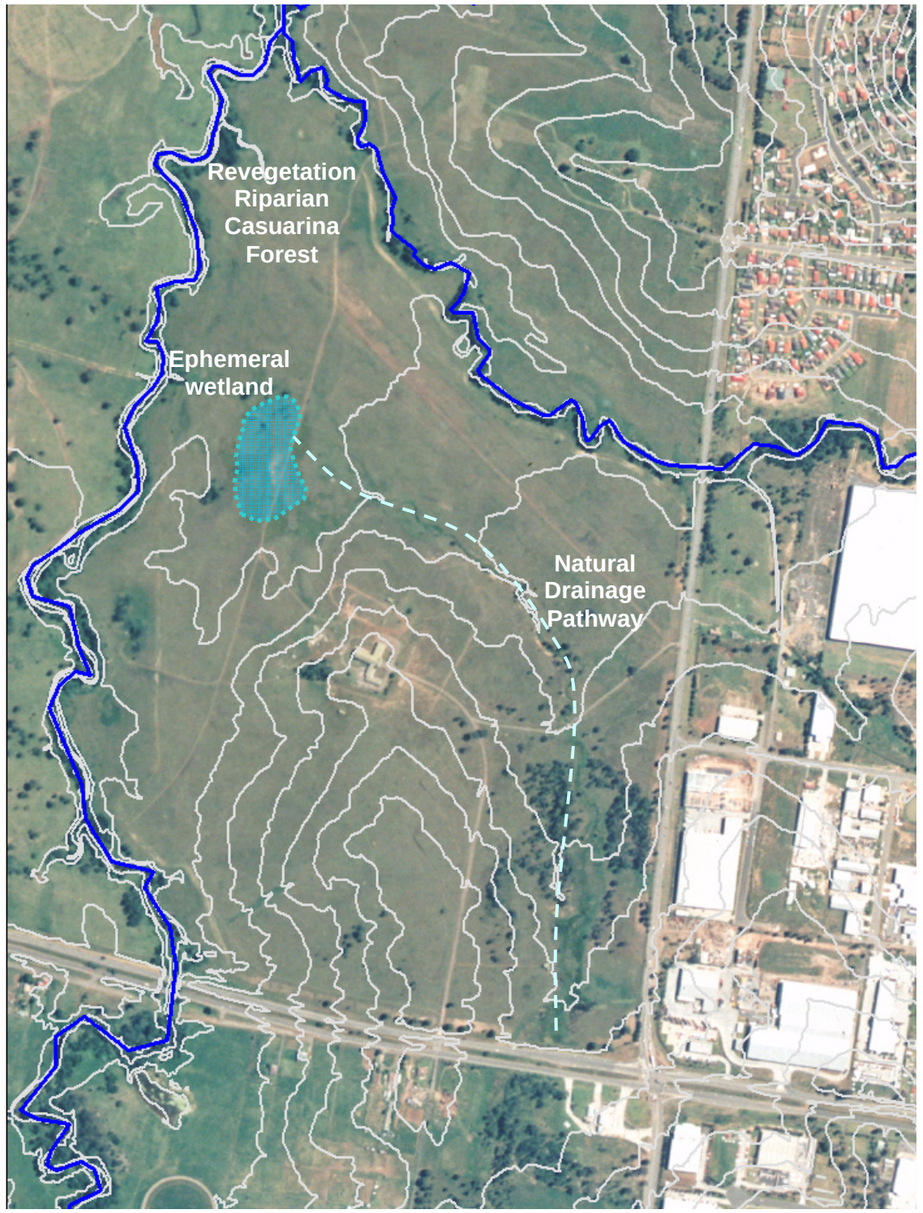

Figure 7-2 Existing contour and aerial photo of the Recreational Hub and Institutional Zone

There are minor stormwater connections across Doonside Road which discharge to the drainage pathway through the site. The drainage depression is the flow path for major flood events (that exceed the capacity of the minor drainage system) for a catchment of approximately 20ha from the south of the Great Western Highway (East of Doonside Road). A flow path will be required to ensure safe passage of significant storm events. A swale to improve water quality from the upstream catchment could be configured within the required overland flow path. This would also assist in managing the contributing flows from the development area.

Flows through the depression drain around the Zone and dissipate to an ephemeral wetland area. There is no direct connection to Eastern Creek at this point through the flood plain. Development within the Institutional Zone will increase stormwater runoff and exacerbate flows which could lead to erosion of the waterway if not carefully managed. A connection to Eastern Creek may be needed to cater for the more frequent flows from the developed catchment.

The development of the Zone will result in significant regrading of the site. Stormwater drainage can be addressed with underground pipes where required, however there are opportunities to sensitively integrate the development with the existing site landform. Consideration of the existing topography and natural drainage pathways is essential in moving from the initial concept planning for this area to the detailed configuration. Accommodating a swale following the natural depression through the site towards the broad floodplain area south of the confluence of Eastern and Bungarribee Creek would assist in addressing water quality in addition to integrating the required overland flow path for extreme storm events. The area also has significant native grasslands of moderate conservation value, which will influence the configuration of the development layout and integration with drainage requirements. The revegetation of the biodiversity corridor has the potential to recreate a riparian Casuarina forest near the confluence of Bungarribee and Eastern Creeks.

7.2 Opportunities for WSUD

The optimal strategy for the inclusion of WSUD measures for both the Recreational and Institutional Zone will be depend on the specific details of the development, particularly in terms of the impervious surface area replacing existing grassland and subsequent stormwater runoff as well as the quantum of water demands. To guide the masterplanning process as the detail of the zone is refined, the following discussion is presented as potential WSUD opportunities. These WSUD opportunities include:

- Enhancement of the natural waterway and ephemeral wetland.
- Stormwater management of the car parking and other impervious / development areas, encompassing both water quality and hydrology.
- Reduction in potable mains water consumption including toilet flushing demands, air conditioning and irrigation demands.

7.2.1 Enhancement of the natural depression and ephemeral wetland

Development of the Recreational and Institutional Zone will lead to a greater proportion of runoff from the site which may be directed into the existing ephemeral drainage pathway surrounding the Zone and the downstream wetland. As this waterway is not categorised, it is possible to enhance this watercourse and embellish with an urban edge to suit the character of the development. This opportunity will assist with configuration of a required overland flow path for major storm events.

The ephemeral wetland can also be modified to receive and treat flows from the development and act as a connection point between Eastern Creek and the Zone. This system could be enhanced to operate in a similar way as the billabongs adjacent to the Sports Zone.

7.2.2 Stormwater management of Car Parks and other impervious areas

In adopting a WSUD approach and with an understanding of embodied energy, car park design presents a significant opportunity to reduce development impacts. Car parks can be partitioned into “regularly used areas” which require pavement/concrete/asphalt and “overflow parking” which are less used and therefore can be structured turf of similar. This will limit the increase in impervious surface area associated with the development of the Zone and thereby reduce pollutant load transport to Eastern Creek and the modification to the hydrology (peak flows and volumes of stormwater runoff discharged).

In terms of the regularly used areas, the pavement selection is important to ensure heat is dealt with appropriately. Efforts to shade the car parks as much as possible are recommended and will enhance the aesthetic outcomes.

Bioretention systems or other measures to meet best practice water quality targets are required. Bioretention systems can provide efficient treatment of stormwater through fine filtration, extended detention and biological uptake of stormwater pollutants. They also provide flow retardation and are particularly efficient at removing nitrogen and other soluble or fine particulate contaminants. Bioretention systems are not intended to be infiltration systems in that the dominant pathway for water is not via discharge into groundwater. Rather, they convey collected water to downstream waters with any loss in runoff mainly attributed to maintaining soil moisture of the filter media itself (which is also the growing media for the vegetation). Runoff is filtered through a fine media layer as it percolates downwards. It is then collected via a perforated pipe and flows to downstream waterways or can be directed to storage for reuse.

Water quality treatment measures, stormwater harvesting opportunities and overland flow paths can be configured to mitigate adverse impacts from the changes to the hydrology of the developed site.

Figure 7-3 Green Car Parks – with shading, bioretention systems and careful material selection







7.2.3 Reduction in potable mains water demands

A water balance can be determined once the type of development has been defined. This will enable non-potable demands to be assessed and the appropriate rainwater or stormwater harvesting measures to be considered and integrated with the proposed development design. Similarly, treated wastewater can be used to meet non-potable demands, particularly if connection is possible to a proposed reuse pipeline from the Quakers Hill STP (at present proposed to service industry demand). The non-potable demands include toilet flushing, air conditioning and irrigation needs.

There are also ways to reduce demand with water efficient fixtures including dual flush toilets, tap aerators and closed loop air conditioning systems or other advanced cooling technologies. To reduce irrigation demands the vegetation selection is important in addition to investment in optimal irrigation technologies and management systems to improve the turf / soil condition and increase the efficiency of application and scheduling.

Demand management and the use of alternative water sources to meet non-potable demands are both important elements for the water conservation strategy recommended for the Zone.

7.3 Conclusion

Development of the Recreational Hub and Institutional Zone proposes the inclusion of a large event space, playground, native grasslands conservation area, and development related to tourism, educational and commercial recreation facilities. The existing drainage depression and ephemeral wetland area present opportunities for enhancement with integration of WSUD and landscaping opportunities. Selection of materials and the design of car parking areas can significantly reduce the development impacts related to impervious surface area and pollutant transport. Stormwater management measures tailored to the development would address both water quality and the hydrology from the developed catchment. Demand management and the use of alternative water sources to meet non-potable demands are both important elements for the water conservation strategy recommended for the Zone.

8 Conclusions

This WSUD strategy outlines the objectives and corresponding opportunities for sustainable water management in the Bungarribee Creek Precinct of the Western Sydney Parklands. The strategy proposes an approach for stormwater pollution control, flow management and water conservation within the Bungarribee Precinct, as well as detailed water management options for the Sports Zone (Section 5), the Airstrip (Section 6), and the Recreation Hub, and Institutional Zone (Section 7).

The Bungarribee Creek/Rooty Hill Precinct (Precinct 2) is the second of nine precincts that make up the Western Sydney Parklands. Eastern Creek flows through the centre of the precinct, joined by Bungarribee Creek from the east of the site. These creeks form part of the core habitat and riparian corridors within the Western Sydney Parklands. The core habitats areas include bushland remnants of the Cumberland Plain Woodland endangered ecological community. The preservation of the core habitats is assisted by the creation of the habitat corridors, forming critical ecological links throughout the Parklands. The conservation of these areas is integral to the vision of the Western Sydney Parklands.

To complement the conservation areas of the Bungarribee Precinct there are significant areas of public open space to facilitate sport, physical development, economic activity, education, and recreation programs. The development areas within the Parklands will generate stormwater pollution as a result of increased impervious surfaces, traffic, and practices that result in a variety of pollutants entering the stormwater drainage system at elevated concentrations. With the increase in impervious areas associated with the proposed development, the volume and velocity of stormwater runoff will increase. Water quality treatment and attenuation of these increased flows is required to protect water quality, the geomorphic form of Eastern Creek, and to prevent worsened downstream flooding. The site occurs in an area of high salinity risk and precautions need to be taken to avoid exposing the sodic subsurface soils. Care must also be taken to prevent any increase in infiltration to the groundwater.

Though management of the site may seem complex due to the multiplicity of land uses ranging from protected habitat to commercial areas, the site offers considerable opportunities for water management. The proximity of urban impervious surfaces and external catchments adjacent to an abundance of public open space facilitates stormwater harvesting and reuse. Runoff from paved or impervious surfaces can be captured and used to irrigate the public open spaces. Roof runoff can be captured in rain tanks, to supply water for the Park's amenities. The local proximity of a wastewater treatment plant (7 km) provides an opportunity to reuse treated wastewater supplied through a reuse pipeline to meet the large irrigation requirements areas within the Precinct. These initiatives are likely to be less costly than traditional dependence on potable water supplies, have significant broader ecological benefits and will be well regarded by the public for whom the Parklands are intended to service.

The WSUD strategy has been developed so as to form the basis of site specific strategies for developments within the Precinct, and set targets for stormwater pollution and flow control, and water conservation. The strategy is based on the water management principles and objectives of the state and local government and Landcom planning policies.

These principles are designed to protect stream health and promote water conservation. The water management principles adopted for the Bungarribee Precinct are:

- Stormwater runoff from development areas within the Parklands as well as from external catchments is to be treated to attain current best practice water quality standards.
- Water conservation through demand management and the use of alternative sources of water to meet non potable demands.
- Post-development storm discharges are to be controlled so as to mimic pre-development storm discharges up to the one and a half year ARI event. This will minimise the adverse impacts of frequent events on the natural waterways and minimise bed and bank erosion.
- Post-development storm discharges up to the 100 year ARI event are to be managed so as to minimise the impact of flood events. Drainage and flooding issues need to be adequately addressed for the protection of people, property and the natural environment.
- The health and biodiversity of the waterways, natural systems and vegetation is to be restored and protected.

The application of these principles and targets to individual precincts within the broader Parklands will result in varying elements based on the specific opportunities and site constraints and reflect the activities proposed within that precinct. Detailed water management options have been developed for nominated areas within Bungarribee Precinct, including the Sports Zone (Section 5), the Airstrip (Section 6), and the Recreation Hub, and Institutional Zone (Section 7). As a separate component of this project, WSUD Strategies have been established for the Doonside Residential Parcel (Ecological Engineering, 2007) and the Huntingwood West Employment Zone (Ecological Engineering, 2006).

The water management elements proposed for the Sports Zone address water quality, water conservation and management of the modifications to the hydrology. Bioretention systems improve the water quality of stormwater runoff from the impervious surfaces. Rainwater tanks, water efficient fixtures and stormwater harvesting will ensure conservation of potable water. The management of stormwater to maintain the hydrology to natural terrestrial landform is achieved through stormwater harvesting by managing flow paths at the interface with the Parklands and to Eastern Creek.

The geomorphology of Bungarribee Creek is vulnerable to scouring and erosion resulting from existing urban flows from its large developed catchment. The proposed Airstrip Promenade development aims to enhance the ecological value of the area and to create a vibrant community space. This presents an opportunity to address threats to the waterway from its existing urban catchment through the interception, diversion and treatment of frequent events from the upstream catchment, so as to lessen their impact on the waterways, and to return the waterway hydrology closer to its pre-development state. The diversion and wetland are integrated with the vision for the Promenade.

The Recreational Hub and Potential Institutional Precinct include a large event space, playground, native grasslands conservation area, and development related to tourism, educational and commercial recreation facilities. The existing drainage depression and ephemeral wetland area present opportunities for enhancement with integration of WSUD and landscaping opportunities. Car parking areas can be designed to significantly reduce the development impacts. Stormwater management measures tailored to the development would address both water quality and the hydrology from the developed catchment. Demand management and the use of alternative water sources to meet non-potable demands are both important elements for the water conservation strategy recommended for the precinct.







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