menanglepark

MENANGLE PARK WSUD STRATEGY

REPORT PREPARED BY AECOM

June 2010

campbelltown city council

LANDCOM

menanglepark

Menangle Park WSUD Strategy

Document prepared by

Emma James, Courtney Henderson & Tony Wong

AECOM

DRAFT

June 2010

campbelltown city council LANDCOM

CONTENTS

1 INTRODUCTION

The Menangle Park release area is located in south-western Sydney, south-east of Camden and south-west of Campbelltown. The site is within Campbelltown LGA, and is bounded by the Nepean River to the south, the rail corridor to the west, the South Western Freeway and Menangle Road to the east, and a Sydney Water supply channel and coal washery to the north.

The major landholders at Menangle Park include Landcom and Campbelltown Council. AECOM has been engaged to prepare a Water Sensitive Urban Design (WSUD) Strategy for Menangle Park. This WSUD Strategy Report outlines:

- Background information about previous and concurrent studies relevant to the site(Section 2)
- The proposed development (Section 3).
- The nature of the site (Section 4).
- Objectives for WSUD (Section 5).
- Constraints and Opportunities for WSUD (Section 6).
- WSUD Strategy (Section 7).
- Maintenance Considerations (Section 8)
- Costing (Section 9)
- Conclusions (Section 10)

WATER SENSITIVE URBAN DESIGN

Water Sensitive Urban Design (WSUD) encompasses the water related aspects of ecologically sustainable development (ESD). WSUD can integrate the urban built form (including urban landscapes) and the urban water cycle - potable water, wastewater, and stormwater. Protection of aquatic ecosystems is achieved through potable water conservation, wastewater minimisation, and stormwater management. (Figure 1.1)

The following guiding principles of WSUD are centred on achieving integrated water cycle management solutions for new urban release areas and urban renewal developments aimed at:

- Reducing potable water demand through water efficient fittings and appliances, rainwater harvesting and wastewater reuse.
- Minimising wastewater generation and treatment of wastewater to a standard suitable for effluent reuse opportunities and/or to release to receiving waters.
- Treating urban stormwater to meet water quality objectives for reuse and/or discharge to receiving waters.
- Using stormwater in the urban landscape to maximise the visual and recreational amenity, and habitat value of developments.

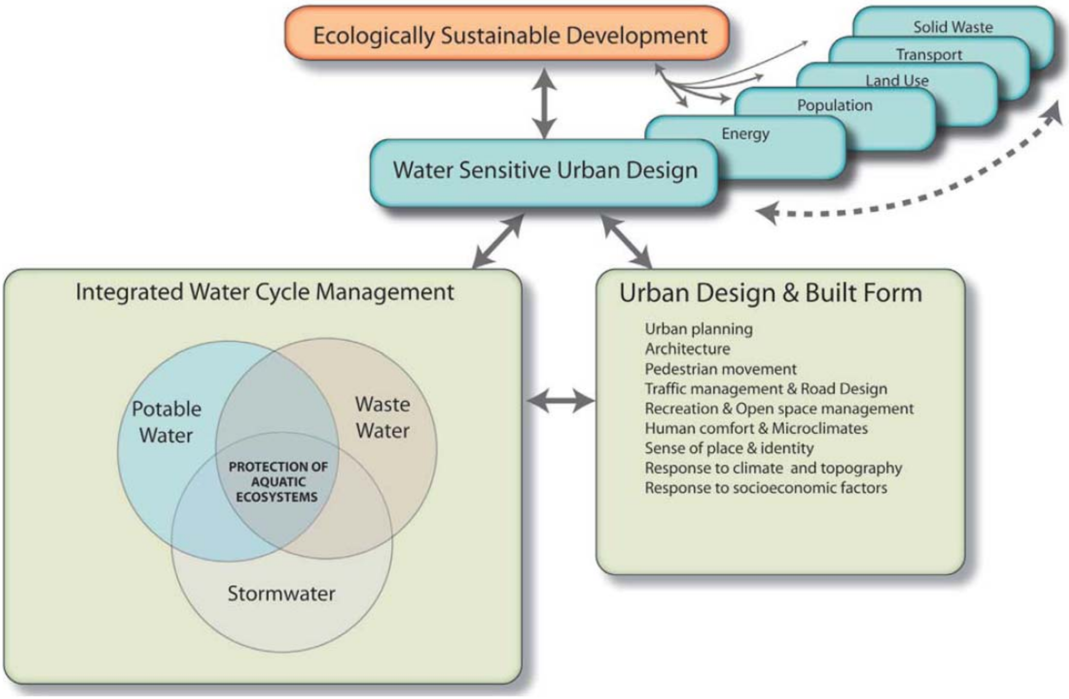

Figure 1.1 - WSUD Framework

2 BACKGROUND

Menangle Park is located in an environmentally sensitive area, due to its close proximity to the Nepean River. Under the (repealed) *Clean Waters Regulations 1972*, the Nepean River was classified as a Class P (Protected) waterway. This required a high level of protection against wastewater nutrient pollution. Pollution from urban stormwater runoff would also need to be similarly managed to protect the waterway. These constraints limited urban development opportunities until 2002, when Sydney Water and the NSW EPA agreed that advancements in technology should make it possible to address these issues sufficiently to allow urban development.

In 2002 a water cycle management study was prepared for Menangle Park (Ecological Engineering 2002 “Menangle Park Release Area Water Cycle Management Options Report”, prepared for Landcom and Campbelltown City Council, August 2002). This report developed broad water cycle management options for the Menangle Park Release Area, which would meet the requirements of the Class P waters regulation and other relevant objectives.

Since 2002, several other studies were undertaken to progress the development opportunities at Menangle Park. During 2003-2004, a series of studies were undertaken to complete a Local Environment Study (LES). These included land capability, air quality, bushfire, flooding, local drainage, heritage, ecology, noise, visual and landscape, socio-economic, transport and infrastructure studies. The LES informed the development of an Urban Design Report in 2005.

Plans for development at Menangle Park were put on hold during late 2005 – early 2006 while it was decided whether to undertake coal mining at the site. In May 2006 the State government decided that urban development should be pursued at the site. In light of this decision and to facilitate development, the LES studies are currently being updated, and a draft Local Environment Plan (LEP) is being prepared.

In November 2008 The Department of Planning has agreed in principle to lowering the yield from 4,200 to 3,600.

A Flora, Fauna and Aquatic Assessment was prepared by Ecological Australia (March 2009) describing the condition of vegetation and the constraints in relation to fauna and aquatic habitat.

Flood studies of the Nepean River and its tributaries were undertaken by GHD and by Campbelltown Council. This work defined the flood detention basin sizing required to attenuate stormwater runoff from the developed catchments to maintain predevelopment peak flow rates and to respond to constraints of existing infrastructure.

A Riparian Corridor Assessment Report was prepared by GHD in December 2007. The report recommended a riparian corridor network for the site. A site visit with the NSW Office for Water (formerly DWE) and Office of the Hawkesbury Nepean in October 2009 resulted in some refinement of the riparian corridor network. An updated Riparian Corridor Assessment Report was prepared in December 2009.
A Vegetation ‘Offset Strategy’ (GHD, December 2009), describes the impact that the development will have on existing vegetation and the areas where rehabilitation and replanting are proposed.

The structure plan for the site has been developed by Urbis in collaboration with the project team. The PCG are intending to exhibit the LEP, Development Control Plan (DCP) and Section 94 Contributions Plan in early-2010.

This WSUD Strategy draws on earlier studies for the Menangle Park site, and interactions with the project team through the refinement of the structure plan for the site. It outlines the design of mitigation measures that can address the impacts of urbanisation on hydrology and water quality.

3 PROPOSED DEVELOPMENT

The site is currently made up of low density rural residential development (Figure 3.1), concentrated on the eastern side of the rail line, opposite the Harness Racing Park. The Glenlee coal washery is located to the north-west of the site (adjacent to the Nepean River). Glenlee House (a heritage item of state significance) is located in the northern part of the site, on the eastern side of the rail line.

Figure 3.1: Existing low density rural residential in the central/northern part of Menangle Park. Note the coal washery marking the north western site boundary in the top left. The new town centre would be located at the bottom left.

The development is constrained particularly by:

- Existing infrastructure including major roads (South Western Freeway and Menangle Road) and the railway line.
- Heritage properties (Glenlee House).
- The existing harness racing club (Menangle Park Paceway).
- Flood extents, particularly in the Nepean River.
- Vegetation of high ecological significance.
- Proposed alignment of the Spring Farm Parkway (a major new road linking areas to the north and east of the site).

Topographic and access constraints also affect some parts of the development (Urbis, Civitas Partnership, 2005). In addition, there are several valuable resources on site, including sand, coal and natural gas. Extraction of these resources may impact on the development immediately or at some time in the future.

The proposed development is for 3,400 residential lots (Figure 3). The estimated occupancy is 3.4 people / dwelling (Social Report), resulting in a total of 11,560 residents.

The majority of lots are 540 – 700m^2, with larger lots (1,000 – 1,500 and 2,000m^2 +) located in the northern and southern parts of the site and in areas adjacent to the South Western Freeway and Menangle Road. Smaller lots (350 – 390m^2) are concentrated in a new town centre and along the southern waterway corridor. Employment lands are proposed adjacent to a rail siding at the north of the site, between the Glenlee Coal Washery and Glenlee House. A primary school is proposed to the north of the town centre.

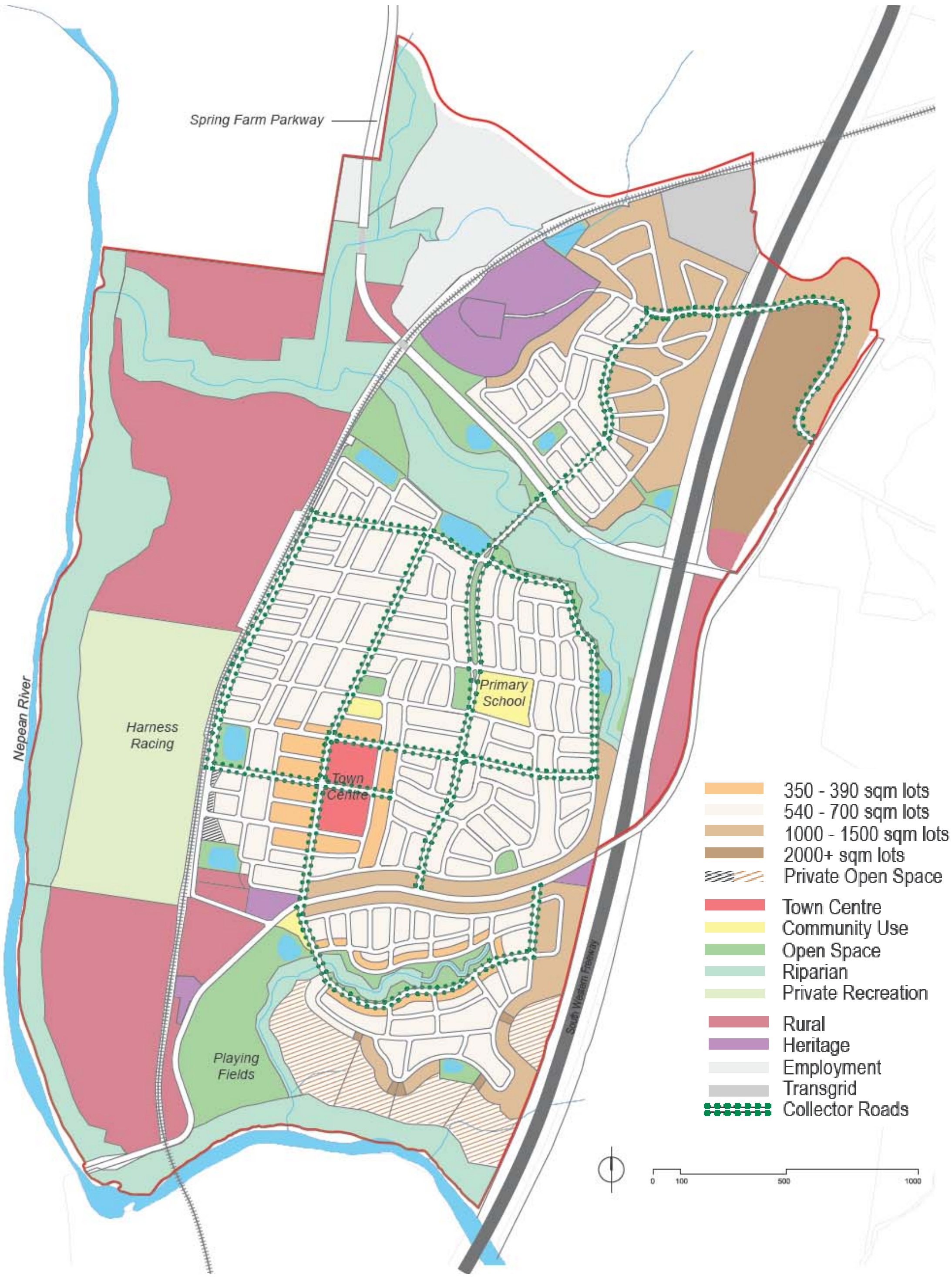

Figure 3.2 Structure Plan (Urbis,24/5/2010) - proposed development layout (3,400 lots)

4 NATURE OF THE SITE

The following sections outline key site characteristics that are relevant to the WSUD strategy, including information on climate, catchments and drainage, water quality, aquatic ecology, topography, geology, groundwater, soils and resources. In this document only the key facts are covered; other reports contain more detail on specific topics. Where relevant the text refers to these other more detailed reports.

4.1 CLIMATE

The rainfall in the area totals on average around 800 mm per year, but rainfall can be highly variable, from around 500 to 1200 mm per year at the 10th and 90th percentiles respectively. A plot of average monthly rainfall at the Campbelltown Swimming Centre (approximately 7 km away) is shown in Figure 4.1. On average rainfall is lowest in winter and early spring (July-September) and highest in summer to early autumn (January-March).

Evaporation at Menangle Park can be described by the data from Prospect Reservoir. This is also shown in Figure 4.1. Evaporation data varies slightly from Prospect (average 44.9mm/month) to the nearby Elizabeth Macarthur site (average 49.9mm/month). The Prospect evaporation data is adequate for water quality modelling for the site.

Figure 4.1 shows that the driest period typically occurs during spring and summer, when rainfall is relatively low and evaporation high.

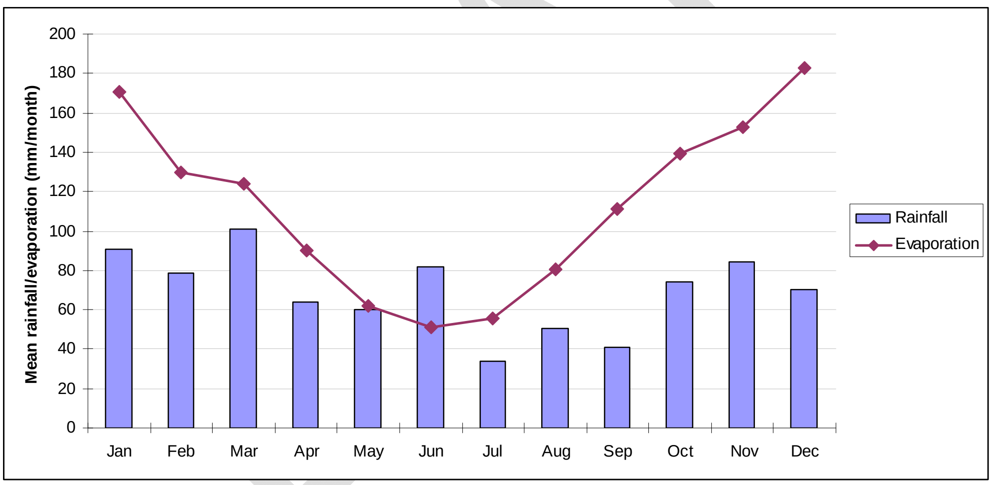

Figure 4.1 Monthly rainfall and evaporation (data source: Bureau of Meteorology)

There are no pluviograph records in close proximity to the site. The nearby Elizabeth Macarthur site provides only daily rainfall data. In order to find a suitable pluviograph record to represent long-term rainfall conditions at the site, a comparison was undertaken between mean annual rainfall data and mean annual number of rain days for available stations in the region. The data was sourced from the Bureau of Meteorology and the results of this analysis are shown in Table 4.1.

Table 4.1: Comparison between rainfall statistics for different stations

Station	Mean annual rainfall (mm)	Mean annual number of rain days
Campbelltown Swimming Centre (reference gauge)	799.1	107.4
Liverpool pluvio station	851.2	109.4
Penrith pluvio station	814.4	83.7
Richmond RAAF pluvio station	782.7	110.2
Lucas Heights pluvio station	1010.7	119.8

Based on the comparison in Table 4.1, Richmond RAAF is considered the most suitable pluviograph station to use at Menangle Park. There is a 40 year data record available from Richmond.

4.2 CATCHMENTS AND DRAINAGE

The NSW Office of Water (NOW, the former Department of Natural Resources or DNR) categorises watercourses based on environmental objectives. In brief, these are:

- Category 1 – Environmental Corridor. To provide biodiversity linkages by maintaining connectivity for aquatic and terrestrial fauna and flora between key destinations. Requires a setback of 20 - 40 m of core riparian zone and 10 m buffer from the top of each bank.
- Category 2 – Terrestrial and Aquatic Habitat. To provide basic habitat and preserve a natural functioning watercourse. Requires a setback of 20 m of core riparian zone and 10 m buffer from the top of each bank.
- Category 3 – Bank Stability and Water Quality. To enhance water quality and prevent erosion. Requires a setback of 10 m from the top of each bank.

The watercourses of the site have been categorised by NOW. The site is drained by several tributaries of the Nepean River. These have been named in previous studies as Creeks N, M, S1, S2 and S3. They are shown in Figure 4.2 and have the following characteristics:

- Creek N drains the northern part of the site (approx 160 ha including the existing coal washery). It also receives flows from upstream of the site. It has been diverted around the coal washery and joins the Nepean River at Bergins Weir, adjacent to the coal washery. The downstream end of Creek N is a Category 1 stream.
- Creek M is the largest creek in the release area and drains approximately 410 hectares of the site as well as receiving flows from upstream of the site. On the eastern side of the site it has several branching tributaries and it drains to the west to join the Nepean River just south of the coal washery. A large part of Creek M has been identified by NOW as a Category 1 stream.
- Creek S1 drains approximately 90 ha in the south-eastern part of the site. It joins the Nepean River between the railway and the Main Southern Freeway. It also receives flows from upstream of the site. Creek S1 has been identified by NOW as a Category 3 stream.
- Creek S2 drains the south-eastern corner of the site (approx 30 ha), as well as receiving some upstream flows. It joins the Nepean River a short distance downstream of the Main Southern Freeway. Creek S2 has been identified by NOW as a Category 3 stream.
- Creek S3 drains part of the western side of the site to join the Nepean River just south of the harness racing club. Creek S3 has been identified by NOW as a Category 2 stream.

In addition to these categorised creeks, some of the area in the southern and western parts of the site drains directly into the Nepean River, including a small drainage line which conveys flow from part of the Menangle Park village area beneath the railway line and to the north of the Harness Racing Club. Further discussion on these creeks as the receiving waters for stormwater runoff from Menangle Park site is provided in section 6.

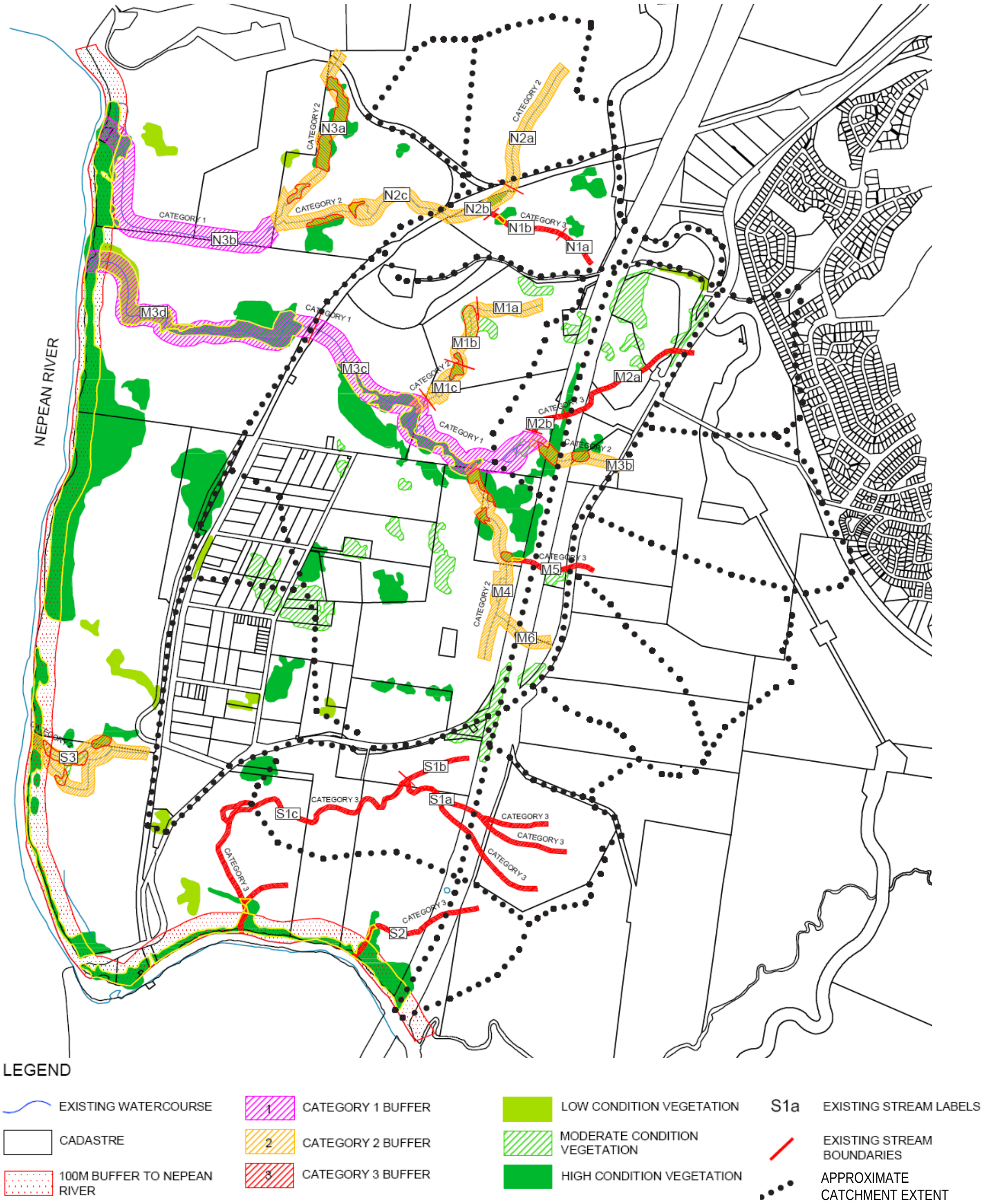

Figure 4.2 Waterways, significant vegetation and riparian categorisation (modified from GHD base figure)

4.3 AQUATIC ECOLOGY

An aquatic ecology assessment was undertaken in 2003 (Bio-Analysis 2003). This report identified pre-development aquatic ecology conditions on the site. It included assessments of habitat, macroinvertebrates and fish, including threatened and endangered species. The Flora, Fauna and Aquatic Assessment prepared by Ecological Australia (March 2009) describes the aquatic habitat within the study area as highly degraded, ranking from poor to moderate in habitat value (Figure 4.3). This is attributed to land clearance, agricultural activities, loss of riparian vegetation, erosion and sedimentation. The assessment did not cover the other waterways on the site. Areas of moderate habitat value were identified where these waterways join the Nepean River. Aquatic habitat is otherwise described as poor, with a section of slightly better condition mapped along the main (Category 1) watercourse that runs through the site.

Some riparian vegetation remains along this category 1 watercourse and these protected sections of watercourse retain geomorphic values, with a small channel within the wide floodplain of primarily alluvial sands. The majority of the vegetation in the riparian area is disturbed pasture with several significant weed infestations (e.g. Blackberry).
An important opportunity exists to enhance riparian vegetation and habitat value along this corridor.
An Endangered Ecological Community (EEC) is identified within the floodplain (Sydney Freshwater Wetlands, to the south of locations 7 & 8 in Figure 4.3, also mapped as high conservation vegetation in Figure 4.2). The freshwater wetlands are a foraging/roosting area for the Japanese/Latham's Snipe.

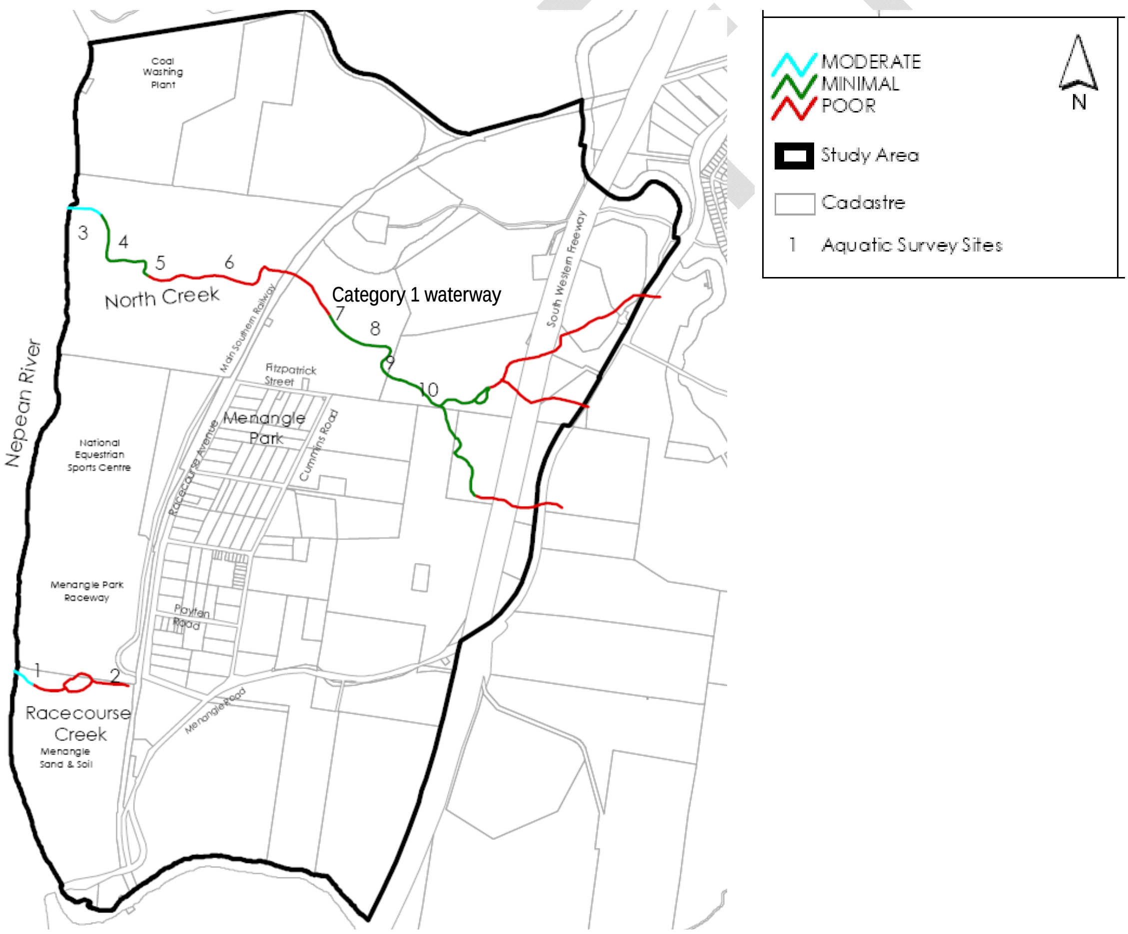

Figure 4.3 Aquatic Habitat Value from Ecological Australia (2003)

4.4 WATER QUALITY

At present, the areas of residential development on site are not serviced by sewer and the presence of septic systems is having some impact on water quality. GHD (2004) reported that faecal coliform concentrations exceeded guidelines for the Nepean River in previous water quality analysis results. This was thought to have been due to the failure of onsite wastewater treatment systems, and the pumping of these systems to the stormwater network. The Flora, Fauna and Aquatic Assessment prepared by Ecological Australia (March 2009) documented macroinvertebrate SIGNAL analysis indicated severe water pollution at 7 of the 10 sites investigated.

There are also stock and horses on site at present, which may also contribute to faecal coliform contamination, as well as suspended solids and nutrients in urban runoff.

4.5 TOPOGRAPHY

Slopes on the site range from less than 3% in the low-lying areas alongside the creeks and the Nepean River, increasing gradually to a maximum of around 15-25% on the top of hills. There are isolated slopes greater than 25% such as existing road and railway embankments. The slope analysis from the 2004 Land Capability Study (Douglas Partners) is included as Figure 4.4.

Generally the stormwater treatment measures proposed in this report are best suited to slopes of 1- 3% and therefore the dark blue areas in Figure 4.4 present ideal opportunities for WSUD treatment elements.

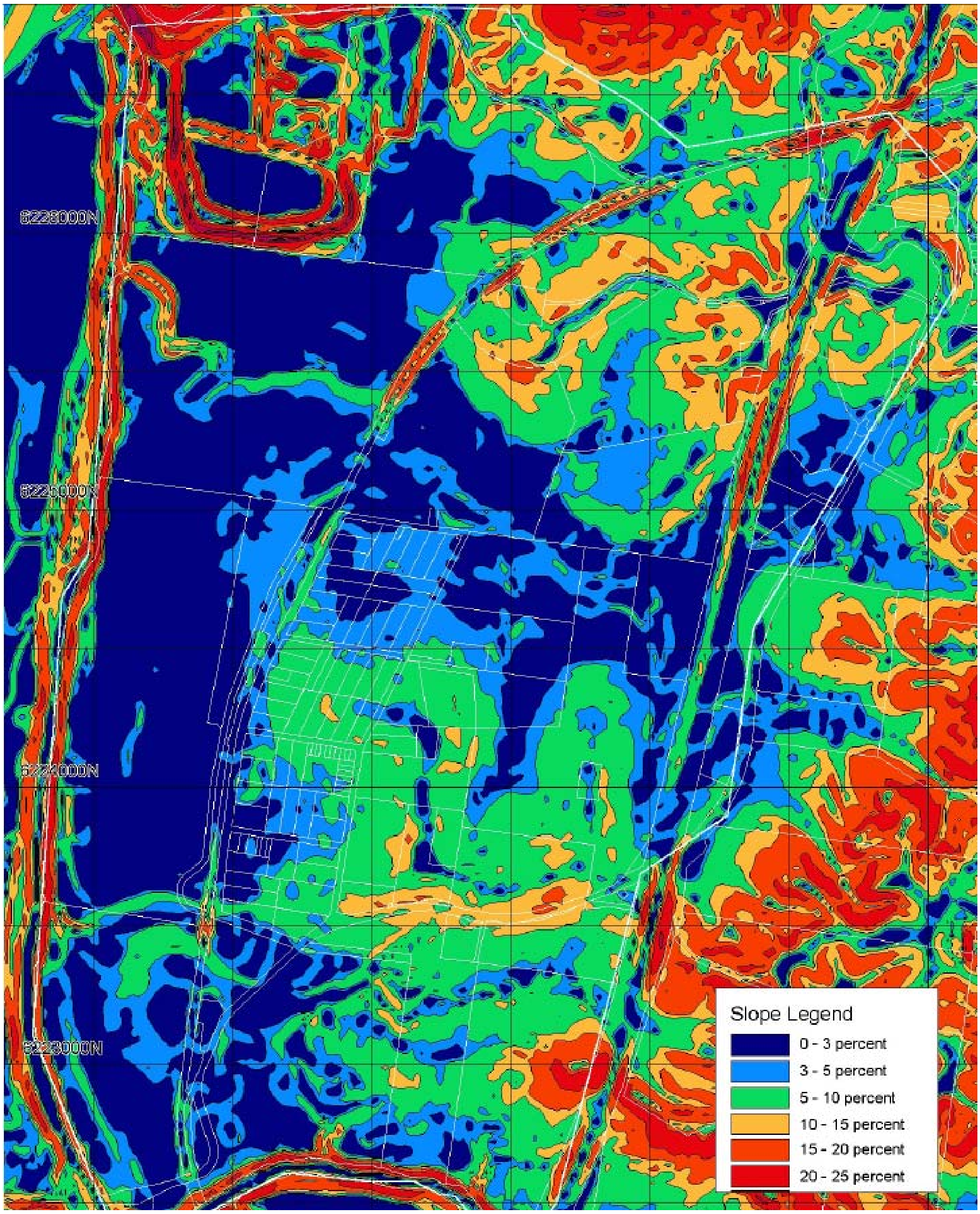

Figure 4.4 Slope analysis from Douglas Partners (2004)

4.6 GEOLOGY, GROUNDWATER & SOILS

The site is predominantly underlain by Wianamatta Group shales. These weather to clayey soils with relatively low permeability. In the central part of the site there is an extensive wind blown sand deposit. The elevation of the site at more than 60 m AHD means that there is a negligible risk of Potential Acid Sulphate Soils (PASS) (Douglas Partners 2004).

Salinity is a potential issue, particularly in the vicinity of the more elevated drainage lines in the north and south of the site (Douglas Partners 2004). Due to this issue, it would be important to ensure that stormwater treatment measures in these areas, including basins, wetlands, ponds and bioretention systems, are lined to avoid impacts on groundwater. Infiltration measures should be avoided in areas where salinity is identified.

Douglas Partners (2004) found that groundwater on the site was generally shallow and saline, particularly in the Wianamatta Group shales. This could be an issue where excavations are undertaken on site, potentially intercepting the shallow groundwater table and resulting in saline groundwater collecting in the base of the excavated area. This may need to be monitored and liners used where saline groundwater is expressed if water management features are to be incorporated into the excavated areas.

The soils on site, both those weathered from the Wianamatta Group shales and the windblown sand, have high erosion hazard ratings and therefore are susceptible to erosion from increased stormwater flows.

In 2009, Douglas Partners undertook a review of the status of the Land Capability Study written in 2004 to identify if the status of any of the identified site issues had changed in light of more recent designs or information. This review confirmed that the findings of the 2004 study were still applicable, and it made several recommendations to update the salinity, hydrogeological and contamination assessments with more detailed assessments once more detailed site plans and cut/fill analyses were available.

4.7 RESOURCES

There are deposits of coal and natural gas (coal bed methane) at considerable depths under the site. Coalfields underlie the entire release area at depths of around 550-750m (MG Planning, 2004). Closer to the surface there are deposits of wind blown sand.

Sand deposits are concentrated in two areas in the central and western parts of the site, shown in Figure 4.5. The extent of extraction of sand and soil that has occurred adjacent the Nepean River is indicated (southern part of western deposit). Extraction is proposed in part of the western sand deposit, and this will occur before urban development commences. It is understood that this will result in lowered surface levels, however re-filling can be undertaken to some extent. Sand mining will not occur in the other deposit in the central part of the site (eastern deposit).

Extraction of either or both coal and gas may occur in the future and could result in the following impacts relevant to the WSUD strategy:

- Subsidence of the ground surface.
- Differential settlement.
- Damage to infrastructure (including drainage network)
- Changes to drainage patterns.
- Water quality impacts.

Any resource extraction (including sand mining) may have a significant operational water demand. The potential to meet this demand with harvested stormwater from urban areas should be investigated.

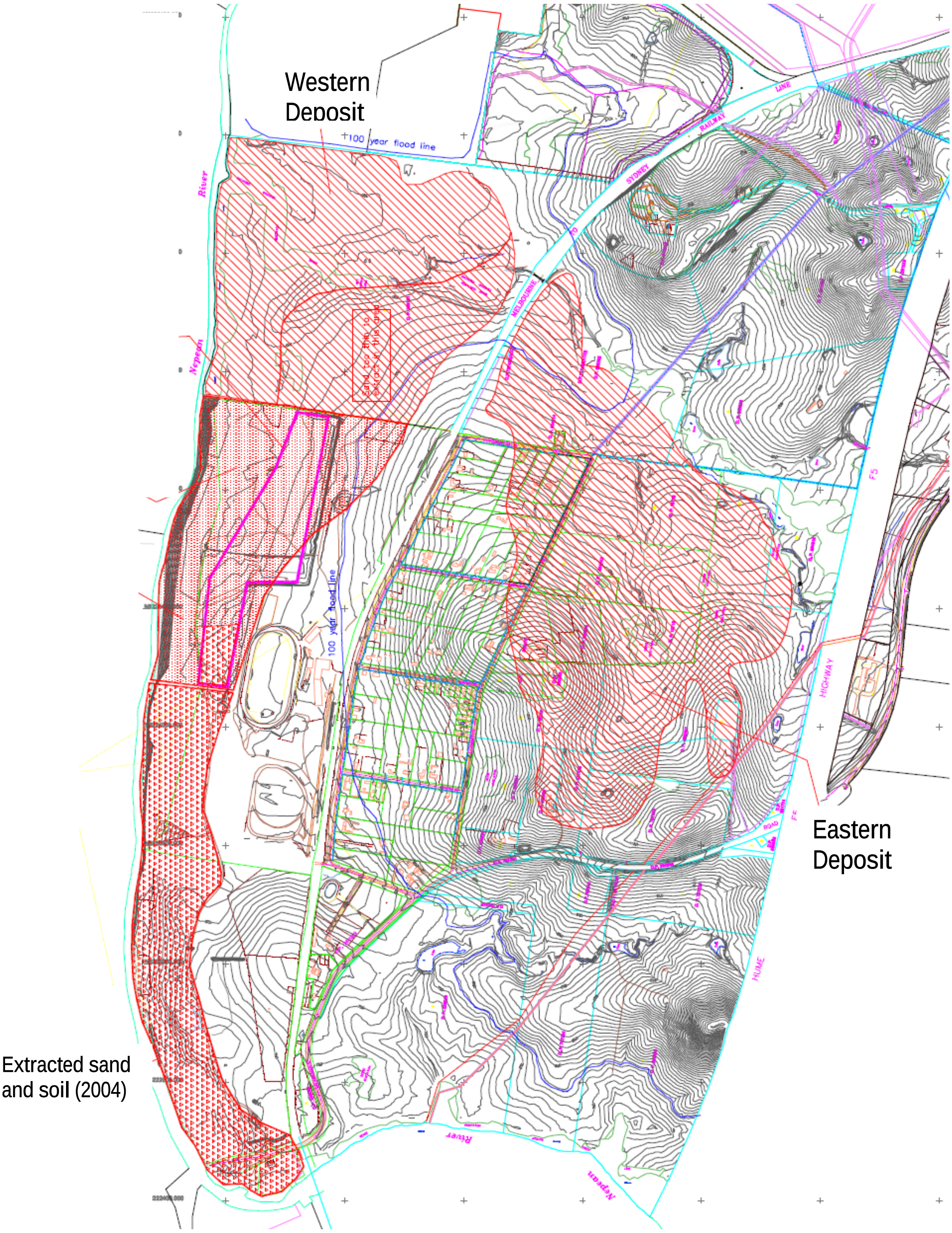

Figure 4.5 Sand and soil deposits at Menangle Park (Harvest Scientific, 2010)

5 WSUD OBJECTIVES

The WSUD principles and objectives presented in Section 1 of this report can be detailed in terms of performance targets to be achieved by the Menangle Park Development. These targets are outlined in Table 5.1.

The targets proposed are consistent with Landcom's WSUD policy and targets, and in many cases extend the minimum standards of State-wide water management objectives for new developments established by the NSW Government. The adoption of more stringent Stormwater Pollution Control targets reflects the ecological importance of the receiving waters and the commitment of Campbelltown City Council and Landcom to mitigate impacts of urban development on the sensitive receiving environment of the Nepean River. Rezoning is proposed for 2010, and development is likely to occur over at least the next decade. Therefore, it is appropriate that planning and the establishment of targets for ecological protection should pre-empt the increasing importance of enhancing sustainability and biodiversity outcomes.

Table 5.1: WSUD objectives for Menangle Park

Objective	Performance Measure and Target
1. Water Conservation	Combination of water efficiency and reuse options for a 45+ % reduction on the benchmarked water use.[1] Stretch target 60+% reduction on the benchmarked water use. Where a reticulated non-potable (recycled) water supply is available the target reduction is increased to 60% with a stretch target for a 70+% reduction on the benchmarked water use.[2]
2. Stormwater Pollution Control [3]	55% reduction in the mean annual load of Total Nitrogen (TN).[3]
	70% reduction in the mean annual load of Total Phosphorus (TP).
	85% reduction in the mean annual load of Total Suspended Solids (TSS).
3. Flow Management [4]	Maintain 1.5 year ARI peak discharge to pre-development magnitude. Stream Erosion Index [4] (SEI) of 2. *Stretch target:* Stream Erosion Index target of 1 (limit the erosion potential of urban waterways to the pre-development erosion potential).
4. Flood Protection	Maintain the 5 year – 100 year ARI peak discharges to pre-development magnitude.
5. Riparian Corridor Management	Provision of riparian corridors to meet the NSW Office of Water's requirements.
6. Wastewater Pollution Control	No dry weather sewer overflows Restrict wet weather sewer overflows to a maximum of 10 overflows each 10 years

Notes:

1. The water conservation target extends the compliance requirement under the NSW government's BASIX scheme for a 40% reduction from the benchmark water use of 90,340 L/p/year (247 L/p/d). A 40% reduction from the benchmark water use is equivalent to 149 L/p/d, a 45% reduction is equivalent to 136 L/p/d).

2. Landcom's WSUD Policy (2010) has identified targets and stretch targets for water conservation for lots and apartments in areas with and without reticulated non-potable water supply. For single residential lots in areas with no reticulated non-potable (recycled) water supply available (target 45% reduction, stretch target 60+% reduction). For single residential lots in areas with reticulated non-potable (recycled) water supply available (target 60% reduction, stretch target 70+% reduction).

Notes for Table 5.1 (continued)

3. The stormwater pollution control and flow management targets in Table 5.1 reflect the recommendations of a report (AECOM 2009) into water quality measures required to meet water quality objectives appropriate for the Hawkesbury Nepean River System consistent with investigations by the Healthy Rivers Commission (HRC) and the commitments of the Statement of Joint Intent (SOJI), 2001. These target reductions exceed Landcom's baseline reduction targets for a 45% reduction in TN, 65% reduction in TP and 85% reduction in TSS.

4. The purpose of the flow management target is for waterway stability - to minimise the impact of frequent events on natural waterways and to minimise bed and bank erosion. The SEI is the ratio of pre to post development erosion potential. The SEI target of 2 implies that post-development stormwater management must limit the increase in erosion potential of urban waterways to no more than twice the pre-development erosion potential. The combination of maintaining the 1.5 year ARI peak discharge to predevelopment magnitude and inclusion of stormwater treatment of frequent storm events (typically up to the 3 month ARI) will limit the SEI to between 1 – 2.

5. The riparian corridor management target is consistent with the NSW Office of Water's classification system and management requirements. The requirements for riparian corridor widths have been established for the site through collaboration with the NSW Office of Water, with the streams identified in Figure 2 and further information provided in the Ecological Assessment Report (GHD).

.

6. The wastewater pollution control targets are proposed due to the sensitivity of the Nepean River receiving waters.

Discussion of each of the objectives and targets in Table 3 is presented below.

1. Water Conservation

The target for a 45% reduction in potable water use compared to a base case scenario (247 L/p/d) of water consumption is complemented by targets to secure alternative water sources for irrigation, to appropriately use recycled water and to provide dual reticulation as a future proofing investment. Landcom's WSUD policy (Project Planning) targets include:

- At least 80% of water use within public open space (e.g. irrigation, top up of water features/ponds) is to be supplied by alternative water sources other than mains potable water.
- Where reticulated recycled water is available, it must be used for appropriately matched uses such as toilet flushing, garden watering, cold water laundry etc.
- All new developments must incorporate a dual water reticulation system to supply non-potable water. Providing this dual reticulation is a future proofing investment to ensure that developments can be serviced at present, and in the future, with water from diverse sources.

Planning and development of the Menangle Park site will occur over the coming decade. It is anticipated that over this period, environmental target (particularly in relation to water conservation) will become more stringent and with the increasing cost of water, conservation measures will be accepted and expected by the community.

A stretch target of a 60 – 70+% reduction on the BASIX benchmark water usage is proposed. Adopting this stretch target for potable water conservation is considered appropriate for the Menangle Park site, to demonstrate more sustainable urban development. This target can be met through a range of water conservation strategies as presented in section 7.2 of this report. Landcom has commissioned a study to develop the water, wastewater and recycled water servicing for the Menangle Park and broader area.

2. Stormwater quality controls

Nepean River Receiving Environment

In May 2006, the *Clean Waters Regulations 1972* was repealed and replaced by the *Protection of the Environment Amendment Act 2005*. Instead of the classification system that defined the Nepean River in this section as "Class P", or Protected Waters, the new Act uses a framework based on the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* 2000 where waterways are classified according to their environmental values, such as swimming, boating, water supply, agriculture and aquatic ecosystems. Regulatory authorities need to consider both the environmental values and the practical measures that can be undertaken at a site to protect the environmental values. This means that while the intent of the legislation is similar to the *Clean Waters Regulations 1972*, the specific requirements may differ from site to site.

Water from the Nepean and downstream Hawkesbury River is extracted and treated to provide some of the drinking water for many of Western Sydney's residents, through the Orchard Hills and North Richmond Water Filtration Plants. Water quality controls for these river systems are important to maintain and improve ecosystem health, and to protect the water supply resource for the western Sydney region.

Stormwater quality objectives

There are management objectives that were investigated by the Healthy Rivers Commission (HRC) and through a Statement of Joint Intent (SOJI) in 2001 for sustainable management of the Hawkesbury Nepean River System in response to the Final Reports of the Healthy Rivers Commission Independent Inquiry (released August 1998 and April 1999). All agencies and Councils are responsible for adopting the water quality objectives to use as guidelines for planning purposes. The specified water quality objectives for nutrients are nominated as the criteria to be adopted for the initial phases of an adaptive management regime for water quality. With the special condition dedicated to the protection of the Hawkesbury Nepean River as represented in the SOJI, more stringent targets are recommended.

An investigation was undertaken (AECOM, 2009) to determine appropriate stormwater quality targets for the Menangle Park site, discharging to the Hawkesbury-Nepean River System, that reflect the intent of the SOJI. The analysis led to the recommendation that an appropriate frequency of compliance to the stipulated SOJI water quality targets be set at 93% and 97% of the time for TP and TN concentrations respectively. The recommended corresponding load-based targets for pollutant load reduction of TSS, TP and TN are 85%, 70% and 55%. This represents more stringent stormwater quality targets than are typically adopted currently across Sydney and Australia which nominate pollutant load reduction of 85%, 65% and 45% for TSS, TP and TN.

With the stretch target for stormwater quality for Menangle Park, it will be necessary to incorporate WSUD solutions that extend the conventional WSUD approach. This will involve the bioretention systems that are specifically designed for enhanced nitrogen removal. The report documenting this analysis is included as an Appendix to the Menangle Park WSUD Strategy. The strategy for delivering the identified water quality target is presented in section 7.3 of this report.

3. Flow Management Targets

The flow management targets nominated for Menangle Park are typical of requirements for urban development in NSW. The 1.5 year ARI peak reduction target aims to mitigate erosion of receiving waterways. The 5 year ARI standard is relevant to drainage system design in residential areas, while the 100 year ARI standard is relevant to design of overland flow paths and is the standard for property protection and mitigation of flood hazard.

Recent investigations and refinement of the procedure for defining the stormwater management objective for reducing geomorphic impacts of urban waterways have led to a recommendation of a different measure, the stream erosion index (SEI). In NSW, the Department of Environment, Climate Change and Water (DECCW) has set an objective for waterway geomorphic protection which has been adopted by the Growth Centre Commission for urban developments within designated 'growth centres' of greater Sydney. The recommended method by DECCW is based upon computing the pre- and post-development erosion potential of the receiving waterway. The measures of erosion potential during pre- and post-development conditions are based on calculating the magnitude and duration in which flows exceeds the "channel forming flow". It is anticipated that post-development will result in more frequent occurrence of conditions where stream flow exceeds the channel forming flow of the natural waterway. The NSW objective stipulates this to correspond to 50% in magnitude of the 2-year ARI peak discharge for the catchment in its natural (pre-development) condition.

The SEI is calculated as the ratio of the stream erosion potential of a waterway post-catchment development to the stream erosion potential corresponding to a waterway in an undeveloped natural catchment. The stormwater management objective is for the SEI to range between 1 to 2. This implies that post-development stormwater management must limit the increase in erosion potential of urban waterways to no more than twice pre-development erosion potential, and ideally should match the predevelopment erosion potential. The combination of maintaining the 1.5 year ARI peak discharge to predevelopment magnitude and inclusion of stormwater treatment of frequent storm events (typically up to the 3 month ARI) will limit the SEI to between 1 – 2.

4. Flood Management Targets

The flood management targets nominated for Menangle Park are typical of requirements for urban developments and aim to mitigate impacts of both nuisance flooding associated with the capacity of drainage infrastructure and potentially hazardous flooding in major storm events. Detention basins are used to maintain the pre-development storm discharges in the post-development drainage design scenario for storm discharges for the 5 year to 100 year ARI events. Further details are provided in GHD's Flood Study for the site (GHD, 2010).

5. Riparian Corridor Management

The riparian corridors have been categorised by the NOW. This categorisation sets the rehabilitation targets for these waterways, as per the DWE (2000) Water Management Act 2000. Successful outcomes for riparian corridor management depend on appropriate water quality and flow management, as these parameters provide the foundation of waterway health.

6. Wastewater discharge controls

Given the sensitive receiving environment, limiting sewage discharge to the Nepean River is important. This can be achieved by designing to minimise both leakage in dry weather (exfiltration from the sewer network) and overflows in wet weather (when the sewer capacity can be exceeded due to water seeping into the sewers and illegal connections of household downpipes / stormwater pipes into the sewer network).

A previous Ecological Engineering WSUD report (2002) stated that it would be necessary to prevent overflows from sewers, wastes, pumping stations, treatment works or other parts of a sewerage system into Class P waters. Even though the legislation has changed in relation to 'Class P waters', it is recommended that these are still reasonable objectives for the Menangle Park site. For this reason, some of the proposed targets included:

- No dry weather sewer overflows.
- Restrict wet weather sewer overflows to a maximum of 10 overflows each 10 years.

Sewerage design for the site should aim to minimise exfiltration and infiltration.

6 WSUD OPPORTUNITIES AND CONSTRAINTS

This section summarises key opportunities and constraints to WSUD that should be considered throughout the Master Planning process.

6.1 OPPORTUNITIES

Key opportunities for WSUD presented by this site are:

- Stormwater treatment can be located outside the development footprint along the floodplain of Category 1 'waterway M'. Water treatment wetlands can be located outside the required riparian corridor, on land that is too flood prone for development. These will improve the habitat value of the floodplain by adding wetlands that can be supported by appropriately designed urban hydrology.
- WSUD treatment elements can be designed to be complementary to the riparian corridors, with biodiverse plantings that enhance the waterway rehabilitation measures.
- Where sandy deposits occur (refer Figure 4.5), infiltration of treated runoff may be possible. This is likely to be possible along the Category 1 'waterway M' and in parts of the drainage reserve through the central part of the site that conveys runoff from the central catchment to 'waterway M'. The use of infiltration measures should consider the hydrologic requirements for the existing freshwater wetlands and the expected pathways of infiltrated water and groundwater.
- The impacts on urban hydrology from the proposed development at S1, S2 and S3 can be accommodated for in the design of the rehabilitated waterway. Rehabilitation of these waterways will significantly increase habitat values and amenity and improve water quality.
- Where flood detention basins occur, water quality treatment areas can be co-located in a portion of the detention basins.
- Alternative supplies of water to meet urban water demands can be supplied by water harvesting from roofs and other impervious surfaces associated with the urban development.
- The size of downstream treatment areas can be reduced by integrating water quality treatment systems into the streetscape. These also provide attractive, passively irrigated landscapes.

6.2 CONSTRAINTS

Key constraints to WSUD related to site characteristics are:

- The need to protect the receiving waters of the Nepean River to a standard as agreed in the Statement of Joint Intent (HRC 2001)
- The need to protect vegetation of significant conservation value and riparian zones of creeks on site to the extent required by DECCW (DWE 2008) and agreements with the NSW Office of Water.
- The small size of the detention basins precludes the use of wetlands in some instances where they would be desirable.
- All soils on site are prone to erosion by scour
- Shale derived soils throughout most of the site have sodic subsoils and groundwater in shale derived soils is saline
- Potential for subsidence and differential settlement associated with any coal and gas resource extraction.
- Existing Menangle Park Village and fixed elements of the proposed development, and the location of proposed roads.

The Nepean River is a sensitive receiving environment and is located immediately downstream of the proposed development with a limited buffer zone. Creeks N, M, S1, S2 and S3 all flow directly into the Nepean. The Hawkesbury-Nepean river system downstream of Menangle Park has environmental values including aquatic ecosystems, recreation (including primary contact recreation), irrigation water supply and human consumption of aquatic foods (HNCMA, 2006). Environmental objectives for the Nepean River were investigated by the Healthy Rivers Commission (HRC) as part of their process of inquiry into the Hawkesbury-Nepean system.

Nutrients are a particular concern in the Hawkesbury-Nepean, as the river system is subject to large nutrient loads from urban stormwater runoff and wastewater flows. This has sometimes resulted in algal blooms in the river system, and as urban development continues in the catchment, it is important to manage this risk. Water quality objectives were recommended by the HRC as a starting point for the initial phases of an adaptive management regime. They recommended that for most pollutants, the ANZECC *Water Quality Guidelines for Fresh and Marine Waters* should be adopted. However for nutrients they set objectives specific to the Hawkesbury-Nepean. For tributary streams in urban areas a recommended concentration of 1mg/L of Total Nitrogen and 0.5 mg/L of Total Phosphorus was proposed.

Equivalent load-based objectives have been determined to reflect the intent of the water quality objectives recommended by the HRC. (AECOM, March 2009) The analysis led to the recommendation that an appropriate frequency of compliance to the stipulated water quality targets be set at 93% and 97% of the time for TP and TN concentrations respectively. The recommended corresponding load-based targets for pollutant load reduction of TSS, TP and TN are 85%, 70% and 55%.

In order to meet these targets at Menangle Park, stormwater treatment and wastewater management that minimise nutrient inputs into the Nepean River will be essential.

In addition to the Nepean River, the creeks on site support both aquatic and terrestrial habitat. These creeks need to be protected by:

- Managing the quantity and flow patterns of stormwater runoff, to preserve the natural geomorphology.
- Managing the quality of stormwater runoff into the creeks and riparian zones, to preserve ecosystem health.
- Preserving the riparian zones in line with NSW Office of Water and DECCW's requirements.
- Managing the invasion of weeds in the creek and riparian zone and planting/encouraging the growth of locally indigenous species.

Existing development is already having some impact on the creeks on site. Developments such as the freeway, harness racing club, rural development (including the development upstream of the site), and coal washery have impacted the stream through modifications such as dams, substantial clearing of riparian and catchment vegetation, the construction of roads and culverts across waterways. These activities have impacted the stream form and water quality of the waterways.

The WSUD strategy seeks to mitigate the existing impacts on the waterways of the development site, in addition to the future anticipated impacts of urbanisation. The selection and design of WSUD measures must also consider topography, soil and groundwater characteristics. The key considerations at Menangle Park are:

- Potential salinity impacts from saline soils and groundwater can be managed by maintaining the hydrogeological regime as similar as possible to its natural state. Stormwater treatment measures that increase infiltration to groundwater should be avoided in saline areas, and major excavations are best avoided if they are likely to intersect the water table.
- Soils are relatively erosive and therefore it is important to manage potential erosion impacts of development. Stormwater treatment measures that slow flow velocities by retaining and/or detaining water can be designed to manage this risk.

Potential subsidence and differential settlement following any coal and gas resources extraction are difficult to predict in a quantitative manner, therefore it is difficult to design in advance for this issue. Some of the potential impacts that could occur are

- Increased infiltration to the sewerage network and associated risk of sewer overflows.
- Changed drainage patterns on the surface and in the groundwater system.

The sewerage system can be designed to some extent to cope with this risk, however other aspects would need to be managed adaptively if and when impacts occur.

6.3 WATERWAYS

The following table summarises the condition and characteristics of each of the waterways on site, and describes how the WSUD strategy responds to these conditions. The categorisation refers to the DECCW riparian classification.

Table 6.1: Condition of Northern Waterways (see Figure 6.1: Northern Waterways)

Stream	Category	Condition	Strategic Response
N1	3	Form: Natural geomorphological features mostly absent. Stream highly modified by clearing, grazing and the construction of dams Vegetation: Mostly cleared, remnant pockets of scattered trees belonging to Shale Plains Woodland EEC.	▪ Flow mitigation in flood detention basin 13. ▪ Bioretention system located within in flood detention basin ▪ Runoff conveyed in pipes through urban development
N2	2	Form: Natural geomorphological features mostly absent. Stream highly modified by clearing, grazing and the construction of dams. Vegetation: Mostly cleared of trees, pasture grasses present. Passes through a stand of Riparian Woodland (RFFOCFP – EEC) and Shale Plains Woodland (CPW-EEC) in good to moderate condition	▪ Wetlands to be integrated with the master planning for the employment zone. The water quality treatment areas can provide a buffer to the rehabilitated riparian zones. Flat topography on floodplain ideal for wetland cells to treat runoff from minor catchments. ▪ N2a is outside site boundary. Rehabilitated riparian corridor to begin in lower reaches of N2c. To be rehabilitated as Category 2 waterway.
N3a	1	Form: Natural geomorphological features present where stream is protected by riparian vegetation. Vegetation: Waterway passes through stands of Shale Plains Woodland (CPW-EEC) in good to moderate condition	▪ N3a is outside site boundary. N3a to be rehabilitated as Category 2 waterway.
N3b	2	Form: Waterway has been diverted around Coal Washery	▪ N3b is outside site boundary. N3b rehabilitated as Category 1 waterway.

Figure 6.1: Northern Waterways (see also figure 4.2 for naming of minor waterway reaches)

Table 6.2: Condition of Central Waterways (see Figure 6.2: Central Waterways)

Stream	Category	Condition	Strategic Response
M1	2	Form: Natural geomorphological features mostly absent. Stream highly modified by clearing, grazing and the construction of dams. Vegetation: Mostly cleared of trees, pasture grasses present. remnant pockets of scattered trees belonging to Shale Plains Woodland EEC	▪ Flow mitigation in flood detention basin 4 ▪ Water quality managed in detention basin and floodplain wetland systems ▪ Runoff conveyed in pipes through urban development
M2	3	Form: Natural geomorphological features heavily impacted by culverts and dams Vegetation: Mostly cleared of trees, pasture grasses present. remnant pockets of scattered trees belonging to Shale Plains Woodland EEC	▪ Flat topography along drainage line upstream of freeway presents ideal location for a stormwater treatment wetland. Alternatively streetscape bioretention. ▪ Waterway designed as integrated drainage easement
M3b	2	Form: Natural geomorphological features heavily impacted by culverts and dams Vegetation: Mostly cleared of trees, pasture grasses present.	▪ Drains external catchment, therefore no water quality treatment required ▪ Rehabilitate as Category 2 waterway
M3c	1	Form: Wide floodplain with small channel. Floodplain comprises alluvial sands that would be prone to erosion if hydrology is altered by development Vegetation: High value vegetation along much of the riparian corridor. High value freshwater wetlands occur on the floodplain. Disturbed pasture elsewhere. Several significant weed infestations such as Blackberry	WSUD Strategy ▪ Flow mitigation in flood detention basins 2, 4, 5, 6, 12. ▪ Water quality treatment to be incorporated into flood detention basins and in wetlands on the floodplain. Discharge to be delivered to the floodplain as dispersed, sheet flow. Wetlands to be located outside areas of high value vegetation. Waterway rehabilitation ▪ Waterway rehabilitation design to engage the floodplain as much as possible for flows above approx 1:3month ARI. Wetlands to complement existing vegetation communities.
M3d	1	Vegetation: High value vegetation (Freshwater Wetlands) along upstream section. Downstream section heavily infested by exotic species	▪ M3d is outside site boundary ▪ Will be impacted by sandmining and then rehabilitated.

Figure 6.2: Central Waterways (see also figure 4.2 for naming of minor waterway reaches)

Table 6.2: Condition of Central Waterways (continued) - see Figure 6.2 above

Stream	Category	Condition	Strategic Response
M4	2	Form: Some remnant geomorphic features of value remain including ponds and channel Vegetation: High value vegetation along parts of the riparian corridor. Disturbed pasture elsewhere. Several significant weed infestations such as Blackberry	WSUD Strategy ▪ As for M3c – detention basins and wetlands on the floodplain. Wetlands located outside areas of high value vegetation. Waterway rehabilitation ▪ As for M3c – engage the floodplain and integrate floodplain storage.
M5	3	Form: Natural geomorphological features heavily impacted by culverts and dams Vegetation: Mostly cleared of trees, pasture grasses present	▪ Large allotments provide opportunity for on-site water quality treatment ▪ Rehabilitate as drainage corridor to convey runoff
M6	2	Form: Natural geomorphological features heavily impacted by culverts and dams Vegetation: Mostly cleared of trees, pasture grasses present	▪ Large allotments provide opportunity for on-site water quality treatment ▪ Rehabilitate as drainage corridor to convey runoff

Table 6.3: Condition of Southern Waterways (see Figure 6.3: Southern Waterways)

Stream	Category	Condition	Strategic Response
S1	3	Form: catchment and channel highly disturbed from extensive grazing and dams. Few geomorphic features of value. When catchment is developed, will be prone to erosion if not rehabilitated Vegetation: Catchment and riparian corridor mostly cleared of native vegetation. Pasture grasses and weeds occur throughout. Valuable stand of vegetation at confluence with Nepean. Few vegetation constraints on rehabilitation throughout most of waterway	WSUD Strategy ▪ Flow mitigation in flood detention basin 9 ▪ Water quality treatment to be incorporated into riparian zone buffer and into flood detention basin 9 Waterway rehabilitation ▪ Waterway to be designed and rehabilitated to accommodate future urban hydrology ▪ Grade control (for several metres drop) required at confluence with Nepean ▪ Revegetation to accommodate stream form
S2	3	Form: catchment and channel highly disturbed from extensive grazing and dams. Few geomorphic features of value. When catchment is developed, will be prone to erosion if not rehabilitated. Grade control (for several metres drop) required at confluence with Nepean Vegetation: Catchment and riparian corridor mostly cleared of native vegetation. Pasture grasses and weeds occur throughout. Valuable stand of vegetation at confluence with Nepean. Few vegetation constraints on rehabilitation throughout most of waterway	WSUD Strategy ▪ Flow mitigation in flood detention basin 11. ▪ Water quality treatment to be incorporated into flood detention basin and along drainage pathway through large lots. Waterway rehabilitation ▪ Waterway to be designed and rehabilitated to accommodate future urban hydrology ▪ Flow path for basin discharge to be rehabilitated as a naturalised waterway to convey flows to Nepean River. ▪ Grade control (for several metres drop) required at confluence with Nepean
S3	2	Form: catchment and channel highly disturbed from sand mining, construction activities, grazing and dams. Few geomorphic features of value. When catchment is developed, will be prone to erosion if not rehabilitated. Existing on-line wetland in poor condition. Vegetation: Catchment mostly cleared of native vegetation. Pasture grasses and weeds occur throughout. Valuable stand of vegetation at confluence with Nepean, and extending approx 200m upstream from confluence. Few vegetation constraints on rehabilitation throughout the rest of the waterway.	WSUD Strategy ▪ Water quality treatment to be incorporated into streetscape and into flood detention basin ▪ Existing wetland to be rehabilitated for water quality treatment Waterway rehabilitation ▪ Waterway to be designed and rehabilitated to accommodate future urban hydrology. Waterway design can mostly accommodate existing vegetation of high value ▪ Grade control (for several metres drop) required at confluence with Nepean

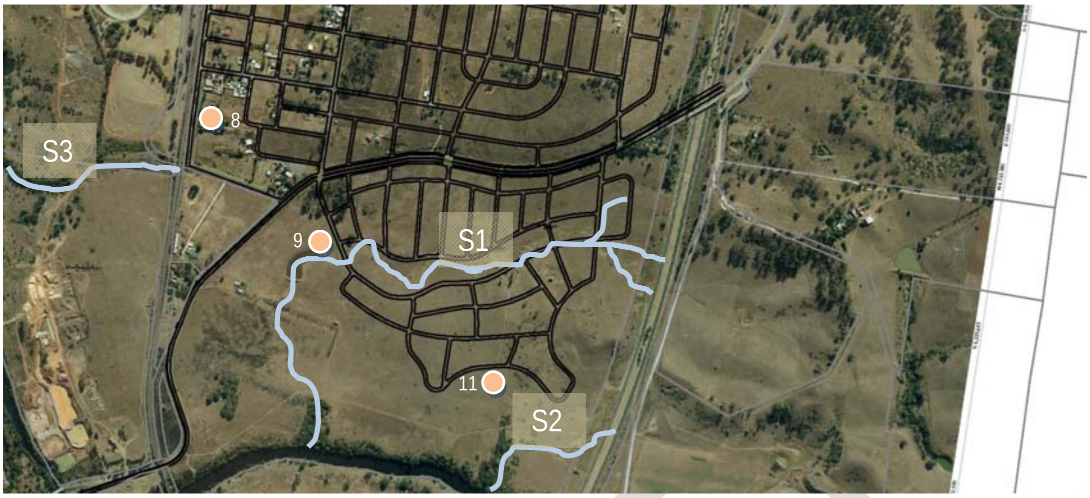

Figure 6.3: Southern Waterways

Table 6.4: Condition of Village Drainage Line (see Figure 6.4: Village Drainage line)

Stream	Category	Condition	Strategic Response
V1	n/a	Drainage pathway culvert beneath rail way, through constructed broad sandy channel just north of the Harness Track. No flow path to Nepean (natural infiltration in very sandy area and landform modification from sand mining). Rural catchment. No natural channel or riparian vegetation.	▪ Water quality treatment – bioretention in detention basin 7 and streetscape. ▪ Rehabiliation of drainage line integrated with master plan for Harness Racing Track. Vegetation and erosion protection along drainage line. Potential harvesting/reuse of Basin 7 discharge prior to infiltration.

Figure 6.4: Village Waterway/Drainage line

7 WSUD STRATEGY

The WSUD Strategy proposes elements to meet the objectives outlined in section 5 for:

- potable water conservation,
- stormwater quality control,
- flow management,
- riparian corridor management and
- wastewater pollution control.

This section outlines a predevelopment and post development water balance to highlight the need for WSUD measures to mitigate urban impacts. This is followed by sections that address each of the WSUD objectives. Within each section the strategy is outlined and the measures proposed are discussed. Time series analysis using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) enables water balance modelling, water quality simulations and assessment of rainwater harvesting options to inform the concept design of the proposed WSUD elements and to demonstrate compliance to the water management objectives for the site.

7.1 WATER BALANCE

Predevelopment (existing)

The total development area for Menangle Park covers approximately 423ha (395 ha if the Transgrid and Glenlee Historic site are excluded). The volume of rainfall over this 423 ha area in an average year totals 3,422 ML, based on average annual rainfall of 809 mm/yr (presented in Section 4). The resulting average annual estimates of runoff and infiltration are dependent on a range of factors including topography, vegetation coverage and soil characteristics. MUSIC modelling with generic soil profile parameters suggests predevelopment runoff is approximately 457 ML/yr (less than 15% of rain falling on the site). Thus infiltration and evapotranspiration account for more than 85% of the rainfall onto the predevelopment site. An illustration of the predevelopment water balance is provided in Figure 7.1. This provides the basis for comparison with the post development case.

Post development

The urban water balance for the post development scenario is illustrated in Figure 7.2. The impervious area associated with the development is estimated at 270 ha corresponding to an impervious percentage of 64%. This impervious area includes roads, roofs, footpaths and other hard surfaces. Rainfall onto the impervious areas of the site for the post development scenarios will typically be rapidly conveyed to receiving environments (Nepean River and its tributaries) with traditional drainage design.

The quantity of runoff is significantly increased (more than 4-fold), from 457 in the pre-development case to 2100 ML/yr. In the post development scenario, 60% of rain falling on the site leaves as stormwater runoff (compared with 15% in the pre-development scenario). Infiltration and evapotranspiration is less than half that of the predevelopment case (reduced from 2,965 ML/yr to 1322 ML/yr).

Development of the site will deliver an expected yield of 3,400 dwellings and an estimated 11,560 residents (3.4 people per dwelling). The determination of this estimated occupancy rate is outlined in the social assessment report (Heather Nesbitt Planning, 2010). This report provides a breakdown of the occupancy rate for each dwelling type and an indicative age profile for the site. The expected number of residents and estimates of typical per capita water use enable the water streams to be determined for the post-development scenario.

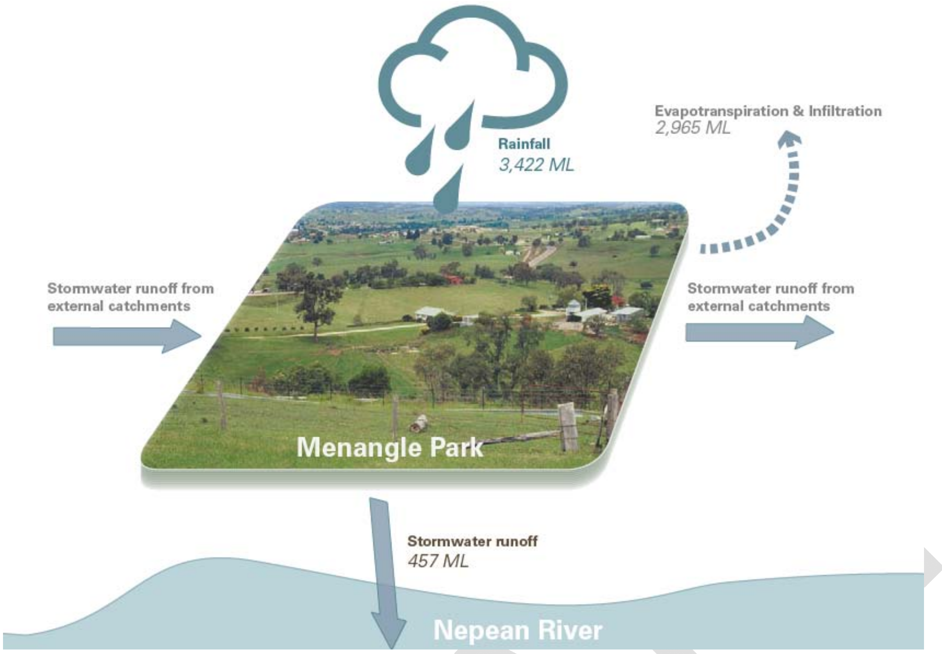

Figure 7.1 Pre-development water balance

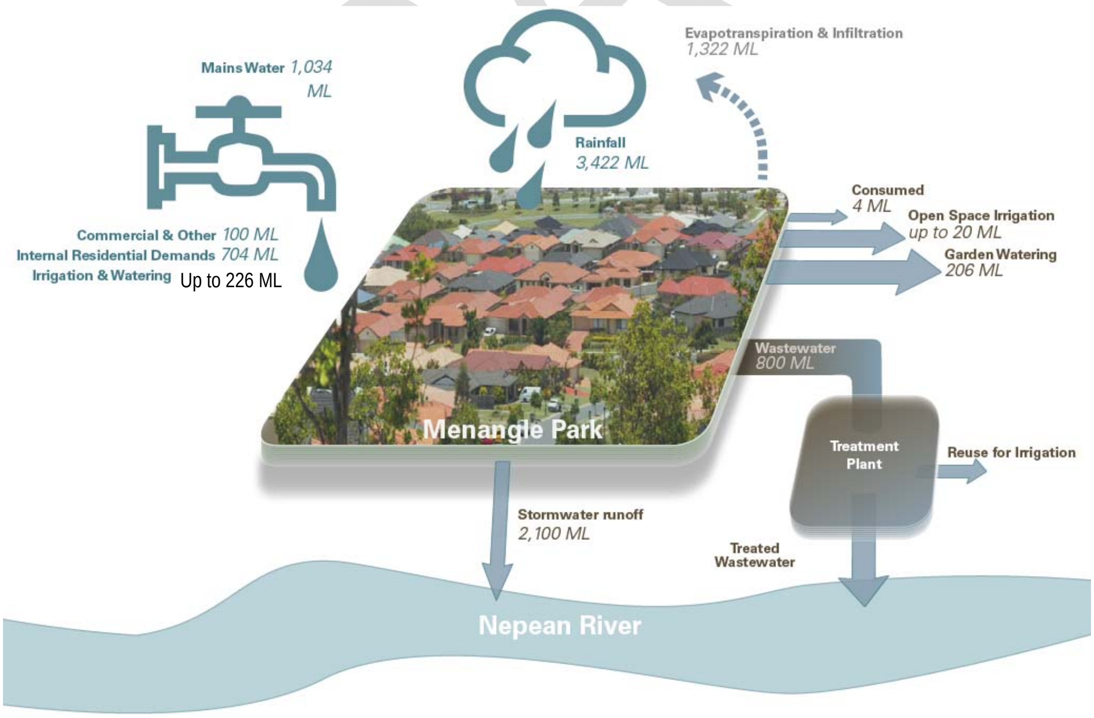

Figure 7.2 Post-development water balance

The estimated demand for water (assuming use of water efficient fixtures like dual flush toilets and efficient shower heads) is approximately 1034 ML/yr, with 704 ML associated with internal residential demand. The increase in stormwater runoff associated with urbanisation of the site (1,643ML/yr) is twice that of the internal residential water demand (457 ML/yr). A proportion (up to nearly 80%) of the water demand can be met with harvested rainwater or stormwater, (for example - hot water supply, irrigation, toilets and laundry). The remaining water demands would be met with potable water, supplied by Sydney Water, from the Macarthur Water Filtration Plant (drawing primarily on the Cataract Dam) – subject to confirmation of capacity and development of potable water servicing strategy.
The majority of household indoor water used would be disposed of via a sewerage network connecting to the West Camden Sewage Treatment Plant which discharges to Matahil Creek, a tributary of the Nepean River approximately 12km downstream of Menangle Park - subject to confirmation of capacity and development of wastewater servicing strategy. A proportion of the sewage treated at the West Camden STP is reused. Pipelines for irrigation of treated effluent from the West Camden STP were constructed in 2009 as the plant capacity was increased from 9 ML/d to 23 ML/d.

The demand for water for irrigation of private gardens is estimated at 206 ML/yr. There would be additional demand for irrigation of public open space areas, playing fields and for irrigation of the grounds of the adjoining Harness Racing Club. The addition of up to 5 ha of irrigated public open spaces would require approximately another 20 ML/yr of water. Stormwater harvesting can typically meet a significant proportion of the irrigation demand, however large storages are required as the demand is strongly seasonal.

Comparison of the predevelopment and post development water balance show that developing the site significantly increases average annual stormwater runoff volumes. There are also potential impacts on water quality and on the health of the receiving waterway. This WSUD strategy aims to mitigate the impacts associated with the changes to the water streams resulting from urban development.

7.2 WATER CONSERVATION

For Menangle Park section 5 of this WSUD strategy identified a water conservation target of a 45% reduction on the BASIS benchmarked water usage and stretch target of 60 – 70+% (consistent with Landcom's WSUD Policy). It is noted that compliance with BASIX is however the minimum legislated requirement, and thus the base case in this discussion on water conservation options.

All residential dwellings in NSW must meet the NSW State Environmental Planning Policy (SEPP) Building Sustainability Index (BASIX) target for a 40% reduction in potable water use compared to a base case scenario. The BASIX benchmark is 90,340 litres of water per person per year (247 L/p/d), based on the average of Sydney households prior to the BASIX scheme introduction. The BASIX assessment tool allows the benefits of specific water conservation measures to be compared based on the expected potable water demand of the household.

The current BASIX target (40% reduction in water use) typically requires the use of:

- water efficient showerheads, toilets and taps,
- a small rainwater tank (2 – 3 kL) connected to either toilets or laundry or hot water and
- garden areas with low water use planting or rainwater used for irrigation

The breakdown of the various internal demands is illustrated in Figure 7.3 and Table 7.1. The daily use per person (Litres per person per day) is tabulated using data from the Yarra Valley Water 2004 Residential End-Use Measurement Study with modifications for assumed uptake of dual flush toilets, showerheads, fixtures and clothes washing machines (MWH, 2006).

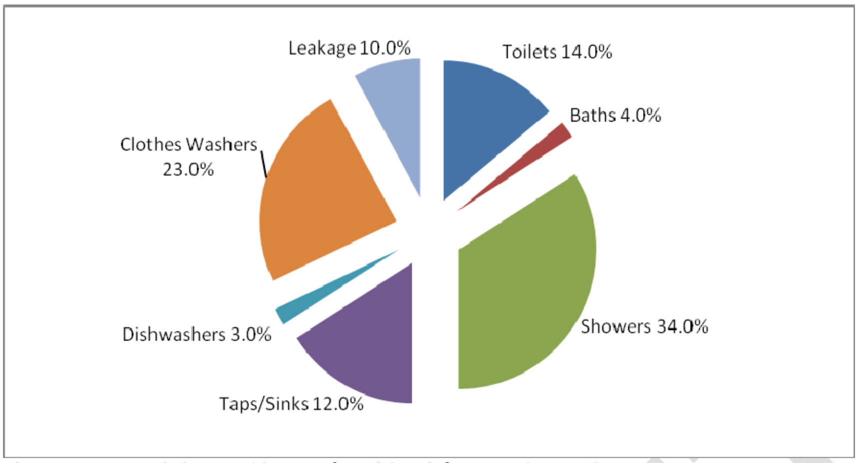

Figure 7.3: Breakdown of internal residential water demands

In Table 7.1, the total water use in L/p/d and equivalent ML/yr describes the internal residential water use for the development, based on 3,400 lots; 11,560 people. The internal water use breakdown for potable demands, hot water demands and non potable uses is provided, with leakage apportioned between the three streams. This breakdown assists in modelling opportunities to use alternative water sources to reduce potable water demand (e.g. rainwater harvesting or stormwater / treated wastewater reuse).

Irrigation of residential garden areas, estimated at up to 206 ML/yr across the development, represents an additional non potable demand (external).

Table 7.1: Breakdown of internal water demands

Usage	Total Water use		*Potable (cold)*	*Hot Water*	*Non-Potable*
	L/p/d	ML/yr	*ML/yr*	*ML/yr*	*ML/yr*
INTERNAL					
Toilets	22	90.7	-	-	*90.7*
Baths	3	13.0	*2.6*	*10.4*	-
Showers	52	220.3	*66.4*	*153.8*	-
Taps/Sinks	25	103.6	*27.6*	*76.0*	-
Dishwashers	3	13.0	*10.4*	*2.6*	-
Clothes Washers	37	155.5	-	-	*155.5*
Leakage	12	51.8	*9.3*	*21.1*	*21.4*
SUB-TOTAL INTERNAL	154	647.8	*116.3 (18%*)*	*263.9 (41%)*	*267.6 (41%)*

(18%) – percentage of potable (cold) water demands as proportion of total internal water use for the development. Similarly for hot water and non potable demands, each 41% of total internal water demands.*

Rainwater Tank Sizing

Rainwater tanks can reduce potable water demands by providing an alternative water supply to meet demands for toilet flushing, laundry use and irrigation. The reliability in meeting non potable demands for a given harvestable roof area was modelled using MUSIC. Rainwater tank sizing curves can guide the appropriate selection of rainwater tank sizes for individual dwellings by demonstrating the effectiveness of increasing the tank size on the 'reliability of supply' (percentage of the modelled demands that can be met with the available harvested water).

Figure 7.4 shows a sizing curve for a 250 m^2 roof area, assessing the reliability in supplying rainwater for toilet flushing, irrigation and laundry demands. A 2 - 3kL tank gives 45 - 53% reliability of supply. This correlates to a potable water saving of 60 - 71 kL/yr/dwelling or 202 - 239 ML/yr for the development. The rainwater tank sizing curves enable the point of diminishing returns to be identified and demonstrates that additional water savings can be realised with a slightly larger tank size (5kL) than that required to meet the minimum BASIX requirement of typically 2 – 3kL.

The cost for a rainwater tank is approximately $5,000 per dwelling. The total cost for the development is $16.8 million (based on 3,400 lots). This cost is typically borne by the householder.

As a ratio of capital cost to annual water reuse, small rainwater tanks results in a dollar value per ML of $21 - $25/ML. This is considerably higher than the cost for alternative strategies with greater water savings.

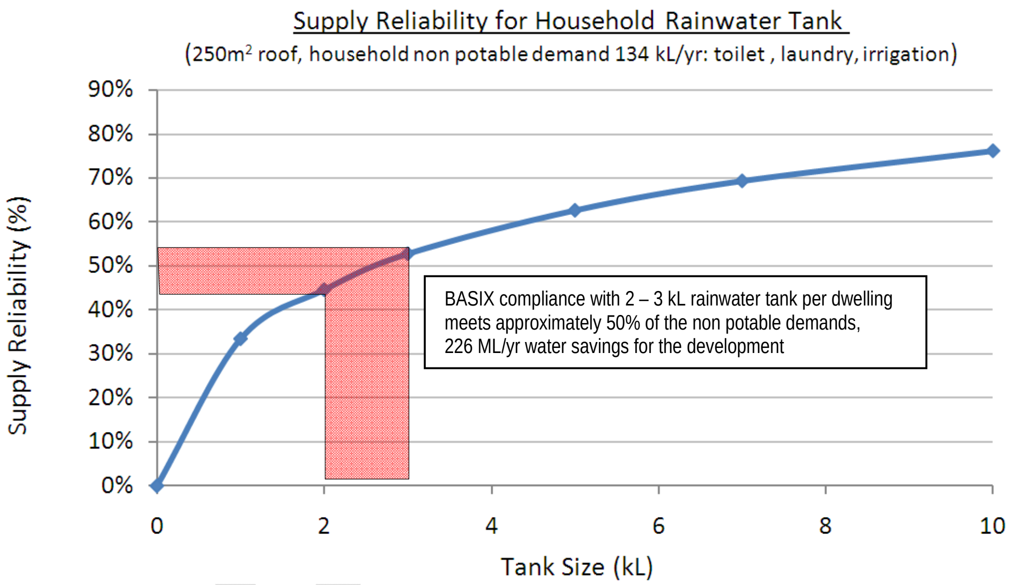

Figure 7.4 Household Rainwater Tank Sizing Curve - toilet, laundry, irrigation

Fit-for-purpose use of water

A significant proportion of the urban water demands do not require water of a quality suitable to drink. Alternative water sources may include treated wastewater, harvested stormwater and rainwater harvested from roof surfaces. Alternative water sources can be used to meet demands for water of a lower standard – for example treated wastewater can replace drinking quality water currently used for toilet flushing, laundry use and irrigation. Fit-for-purpose use of water enables a reduction in the quantity of potable water imported to the site (to meet water conservation targets) and reduced environmental impacts associated with water extraction from reservoirs, transfer and treatment.

Fit-for-purpose use of water matches water of an appropriate quality from the various urban water streams with water demands. This approach is an effective mechanism to reduce demand for scarce potable water resources and meet water conservation targets.

A matrix of fit-for-purpose domestic water use matches the water quality of various sources with suitable or preferred uses. This approach enables optimum water conservation outcomes to be achieved. The preferred uses for the various water sources are listed below:
Potable water: cold water demands in the kitchen, laundry and bathroom
Harvested Rainwater: hot water demands in the kitchen, laundry and bathroom
Treated Wastewater (or Harvested Stormwater): garden irrigation, and toilet flushing

A fit-for-purpose approach extends the use of rainwater tanks for BASIX compliance, resulting in significantly greater potable water savings and associated benefits. Additional 'dual reticulation' infrastructure is required to facilitate the use of treated wastewater or harvested stormwater to meet non potable demands. It should be noted that the cost for such infrastructure is typically less for a large development areas than the cost for individual rainwater tanks.

Rainwater can be used to meet hot water demands (for showers, hot water taps etc), as effective disinfection can be achieved through the hot water system. A high reliability of supply can be achieved with even a small rainwater tank due to the relatively high constant daily demand for hot water. This ensures rapid drawdown on the tank, and hence available storage volume for most rainfall events.

Dual Reticulation

There has been some significant advancement in technology for water recycling over recent years, leading to many innovative applications of small-scale water reuse schemes. There are already technologies for stormwater harvesting and reuse, greywater reuse, sewer mining and local wastewater treatment plant and it is anticipated that they will become more and more cost effective for a range of development scales over the next ten years. It is also anticipated that local and statewide standards for water recycling will be established within the next decade. The benefits of these technological advancements can only be realised if the necessary reticulation infrastructure are in place in developments being planned today.

In assessing the water conservation strategy for this project, it is apparent that there are significant benefits in providing a dual reticulation network. The construction of a dual reticulation network in a greenfield development is cost effective and allows the development to benefit from future advancements in water recycling technologies. Such a system can ultimately maximise water conservation, minimise the transport of water and wastewater from the site, and minimise treatment costs of water and sewerage, as well as possibly off-setting any costs associated with augmentation of the downstream sewage carrier. Through provision of a dual reticulation network and infrastructure for supplying an alternative source of water, the entire non potable demand for each house could be met, corresponding to potable water savings of approximately 450 ML each year. This would allow a stretch water conservation target to be met, with the site achieving more than a 60% reduction on benchmarked water use. The dual reticulation network would be plumbed to supply reuse water for toilet flushing, garden watering and cold water laundry.

The benefits of dual reticulation include:

- significantly greater potable water savings (and reduced impacts associated with supplying potable water)
- reduction in discharge of pollutants to the Nepean River (through reuse of stormwater or treated wastewater)
- cost effectively essential infrastructure for Greenfield sites
- allows for flexibility in the most cost effective water sources – as base pipe network can be the conduit for a any future non potable water source
- ensures residents of Menangle Park can access cheaper water for their non potable demands where a recycled water source is available (IPART stipulate charges for non potable water at 80% of those for potable water)
- resilience to the expected increasing variability in rainfall with climate change that is likely to make rainwater tanks less effective in terms of supply reliability

There are some risks with irrigation of treated waste water as it is typically higher in nutrient concentrations and in salt levels. The use of treated waste water for irrigation needs to be carefully managed to ensure there is not excess irrigation leading to surface runoff with high nutrient concentrations. Salts can build up in the soils and have negative impacts on soil structure and plant growth. Stormwater is preferable as the source for irrigation as these risks are able to be mitigated. Treated wastewater is the preferable source for toilet flushing and cold water laundry demands. The human health risks are managed with adequate disinfection of either treated wastewater or harvested stormwater.

The cost for the dual reticulation network is estimated at $5 - $8.4 million dollars, ($1,500 - $2,500 per lot). The water supply for the dual reticulation network can be obtained from a range of sources including treated stormwater, onsite wastewater or from sewer mining where wastewater is extracted from a nearby sewer carrier. Treatment of all these sources of water will be required to ensure appropriate public health and environmental standards are met. The treatment and supply of non-potable water using either an on-site treatment plant or through pipeline connection to West Camden STP is estimated at up to $10 million, bringing the total approximate cost per lot to $4.5 - $5.5k per lot. This is comparable to the cost associated with the use of rainwater tanks but has a superior potable water conservation outcome, i.e. 452 ML/yr compared with 226 ML/yr for the rainwater tank option).

As a ratio of capital cost to annual water savings, dual reticulation options (C and D in the follow section – and downstairs) result in a dollar value per ML of between $8 - $12 /ML. This is considerably competitive with a range of options, but enables s=higher than the cost for alternative strategies with greater water savings.

Existing Infrastructure

Figure 7.5 illustrates the proximity of a number of water assets in the vicinity of the site that have the potential to facilitate enhanced water conservation outcomes. It is acknowledged that this is the baseline infrastructure and may not have the capacity to service the Menangle Park site. Further investigation is required to ascertain the capacity constraints and identify if there is a case for augmentation of this infrastructure or preferable alternatives. Landcom has commissioned MWH to assess the optimum water servicing strategy in collaboration with Sydney Water. (Infrastructure Report, Lean & Hayward, Jan 2010)

An upgrade and amplification of the existing West Camden Sewage Treatment Plant (STP) was completed in late 2009. Improvement in the STP's treatment processes increased the capacity to cater for population growth in the region, provides opportunities for effluent re-use and reduces nutrient discharge to the Nepean River. The advanced tertiary sewage treatment level at the West Camden STP produces effluent of suitable quality for either reuse of discharge to the Nepean.

A reuse pipeline has been constructed to supply up to 5 million litres per day of high quality recycled water to the Elizabeth Macarthur Agricultural Institute, located 9km from the STP. The 300mm diameter pipeline cost approximately $3 million and transfers tertiary treated effluent to a 60 ML earth dam located on the Agricultural Institute. This dam is located approximately 3 km from the Menangle Park site.

Sugarloaf Dam is located adjacent to the eastern boundary of the site. The SCA (Sydney Catchment Authority - SCA), no longer use the 100 ML dam (originally intended to provide for sedimentation control). They propose to breach the dam wall. Council has discussed opportunities with the SCA on site, but the SCA does not want to retain the dam and consider their decision final on the partially breach the dam wall. There may be an opportunity to retain a smaller water storage volume (20 ML) or use the site for a small reservoir, connected by a harvesting pipeline to distributed water storages within detention basins.

Stormwater harvesting as part of an urban development at the nearby UWS site may provide an opportunity to expand the reuse network and facilitate investment in the sewer mining to provide treated wastewater to meet a greater proportion of non potable demands. There is potential for collaborative grant applications to the federal government for large scale stormwater harvesting initiatives.

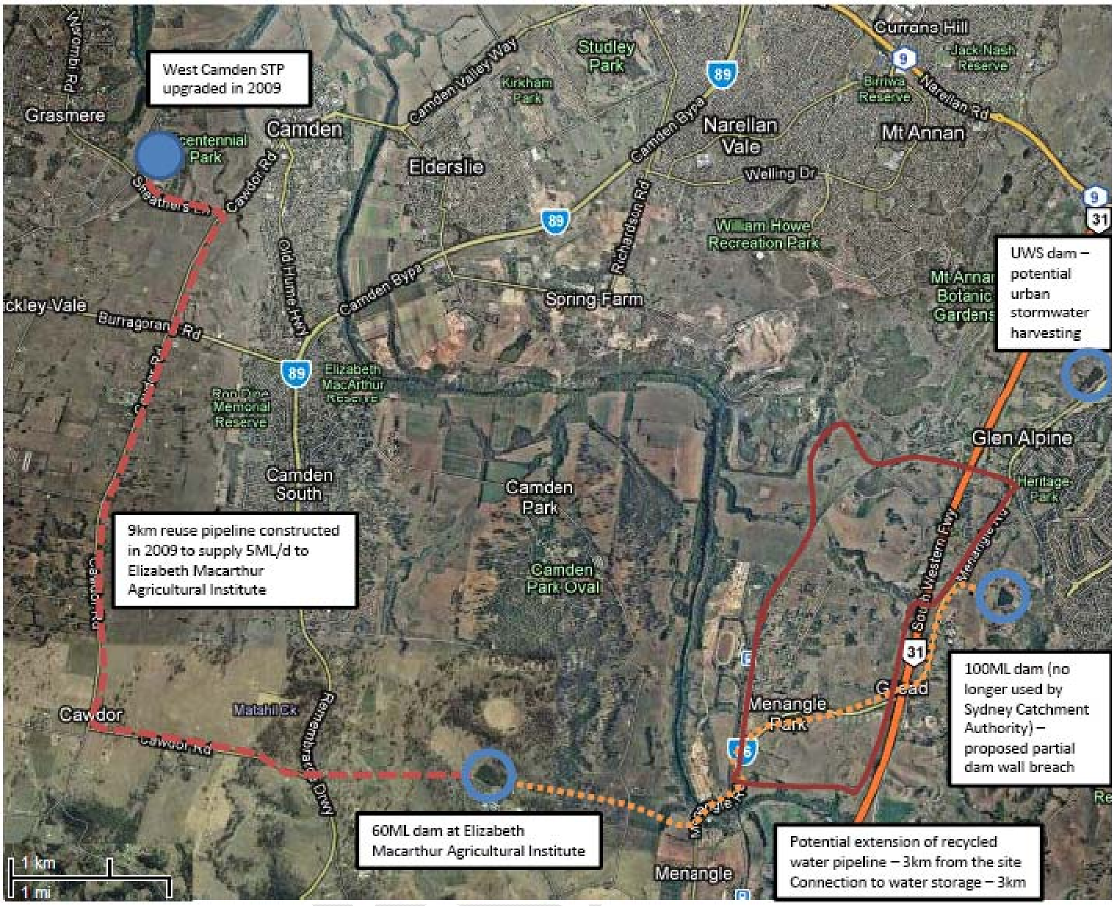

Figure 7.5 Water infrastructure assets near the Menangle Park site

Water Conservation Options

As the planning for the Menangle Park Development proceeds, the range of options available for water conservation should be understood and considered. The options outlined below range from (A) BASIX compliance to (E) an optimum strategy for fit-for-purpose use with dual reticulation, wastewater or stormwater reuse and roof water harvesting for hot water demands.

Figure 7.6 provide a comparison of three of the five options demonstrating the increasing storage volume required to increase potable water savings. Note that the 'Combined storage volume' represents the storage required to get the water savings – regardless of whether this is distributed storage in rainwater tanks for each lot or centralised storage(s) for larger scale stormwater harvesting. Table 7.2 has details and estimated costs for each option, with additional notes following the table.

Option A – BASIX COMPLIANCE

Standard BASIX scenario with 2-3 kL tanks installed on each lot, (equating to 7-10 ML total storage volume across site). This provides water savings of approximately 200-240 ML/yr, resulting in 45-53% non-potable demands being met. This option is the cheapest for developers, as rainwater tank costs are typically incurred by the dwellings residents after sale of the lot. The total cost for this option is high however and it provides the least water savings, and most limited future servicing potential.

This option does not meet the proposed potable water conservation target of a 45% reduction on benchmarked water use. Installing rainwater tanks that are 3.5kL or larger would enable the proposed potable water conservation target to be met, but would not enable stretch targets to be met.

Option B – LARGE RAINWATER TANKS

Large 10 kL rainwater tanks are installed on 90% of the lots, (equating to 30ML total storage vol). The remaining 10% of lots would be serviced by smaller 2-3kL tanks. The collected rainwater is used to supply toilets, laundry, irrigation and hot water demands, resulting in 55-61% of this total demand being met – which is equivalent to meeting 79 – 88% of the non potable demands. This option also has limited future servicing potential, and water savings are likely to reduce with increasing climate variability.

A potable water saving of approximately 58% of benchmark water usage can be achieved with large rainwater tanks. This enables the proposed potable water conservation target to be met – but falls just short of meeting stretch targets for potable water use.

Option C – DUAL RETICULATION AND HARVESTED STORMWATER

A centralised water storage strategy is adopted which results in savings of between 340-410 ML/yr for storage volumes of 20 – 50ML. No rainwater tanks are required on lot areas as a dual reticulation pipe network is provided connecting the central supply of reuse water to each dwelling and to stormwater harvesting basins. This option has excellent future servicing potential enabling a greater proportion of non potable demands to be met when a centralised reuse water supply becomes available. Stormwater harvesting provides a cost effective, interim non potable water supply with additional environmental benefits.

The water savings for these options (A – C) depend on the storage volume available (i.e. large rainwater tanks or central storage volumes result in increasing water saving).

A potable water saving of approximately 62% of benchmark water usage can be achieved with dual reticulation connected to a 50ML stormwater storage. This enables the proposed potable water conservation target to be met, and Landcom's target for areas where dual reticulation is provided – but falls short of meeting Landcom's stretch target of a 70% reduction for potable water use where dual reticulation is provide.

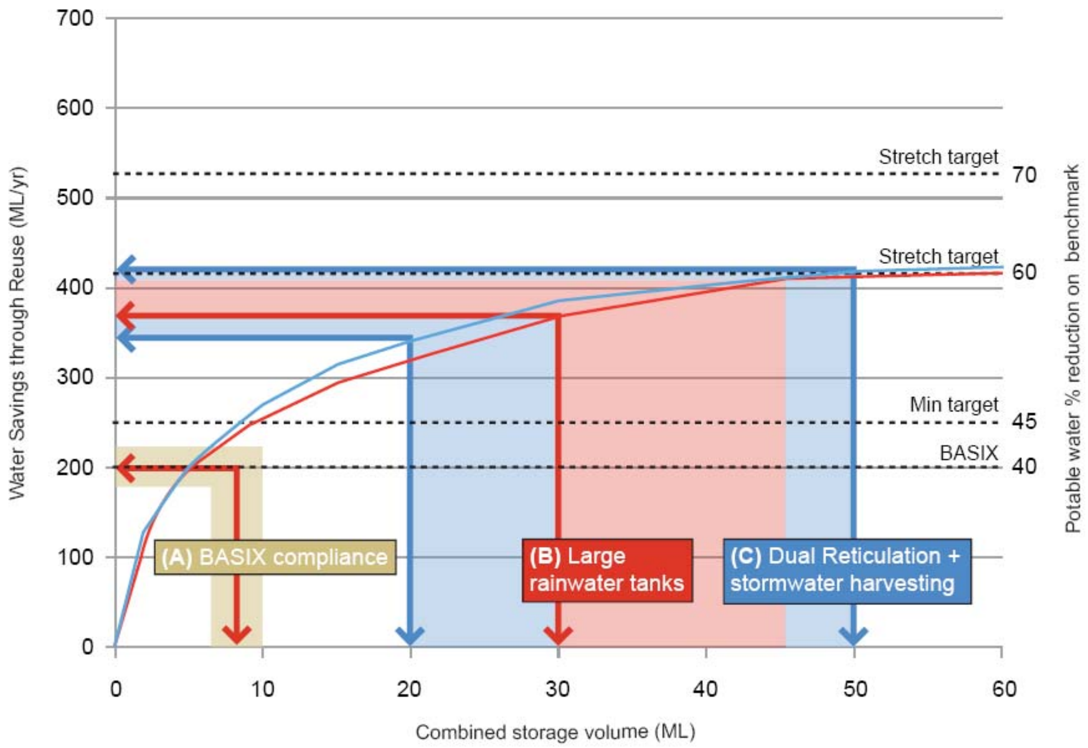

Figure 7.6: Water savings for water conservation options A, B and C

Figure 7.6 shows that

- Option A, BASIX compilance using 2 – 3 kL tanks to supply non potable demands enables water savings of approximately 200-240 ML/yr. Note that 2-3 kL storage per lot equates to a combined storage volume (X axis) for 3,360 dwellings of 7 – 10ML.
- Significantly greater water savings can be achieved with options that go beyond using small rainwater tanks for compliance with BASIX.
- The red shaded area represents option B which uses large rainwater tanks (10 – 15kL per large lot equating to 30 – 45 ML stoarage across the development). With the supply plumbed to both hot water and non potable demands) water savings of 360 ML/yr (10kL tanks) to 400ML/yr (15 kL tanks) are achieved. This is 1.5 to 2 times that achieved with option A - BASIX compliance.
- The blue shaded area representing option C (dual reticulation and stormater harvesting) enables water savings of between 340 and 410 ML/yr, with a central (or distributed) storage volume of 20 – 50 ML.
- For option C, if the available storage volume was 10 kL, water savings of 270 ML/yr are achieved (blue line). Note that this option provides the infrastructure to facilitate additional water savings where a future more reliable storage size is available (e.g. through connection to a treated waste water supply from a Sydney Water Sewage Treatment Plant or a local / nearby sewer mining plant).

There are options that provide even greater water savings, both building on option C, using a dual reticulation network to facilitate fit-for-purpose water use and conservation of potable water supplies. These options (D and E) are presented in Figure 7.7 below, with additional details in Table 7.2.

Option D – DUAL RETICULATION AND TREATED WASTEWATER NON POTABLE SUPPLY

Option D – (yellow label in figure below). A non-potable network with connection to a central supply of recycled water would enable almost all non potable demands to be met (450 ML/yr), without requiring large storage volumes. A non potable reservoir would be requried to buffer demands. There may be a small proportion of the peak irrigation demand in Summer that may not be met subject to design of the non potable supply and irrigation networks.

* A potable water saving of approximately 66% of benchmark water usage can be achieved with dual reticulation connected to a treated wastewater supply. This enables the proposed potable water conservation target to be met, and Landcom's target for areas where dual reticulation is provided – but falls short of meeting Landcom's stretch target of a 70% reduction for potable water use where dual reticulation is provide.

Option E – RAINWATER TANKS (HOT WATER SUPPLY) + DUAL RETICULATION (TREATED WASTEWATER)

Option E – (green label in figure below) builds on option D, adding small rainwater tanks to meet hot water demands, in addition to the dual reticulation network to meet non potable demands. This enables even greater water savings, reducing potable water import to just 22% of the total residential demand. This option is an optimum strategy for fit-for-purpose use with dual reticulation, wastewater reuse and roof water harvesting for hot water demands

* A potable water saving of approximately 77% of benchmark water usage can be achieved with dual reticulation connected to a treated wastewater supply. This enables the proposed potable water conservation target to be met, and Landcom's target for areas where dual reticulation is provided and also meets Landcom's stretch target of a 70% reduction for potable water use where dual reticulation is provide.

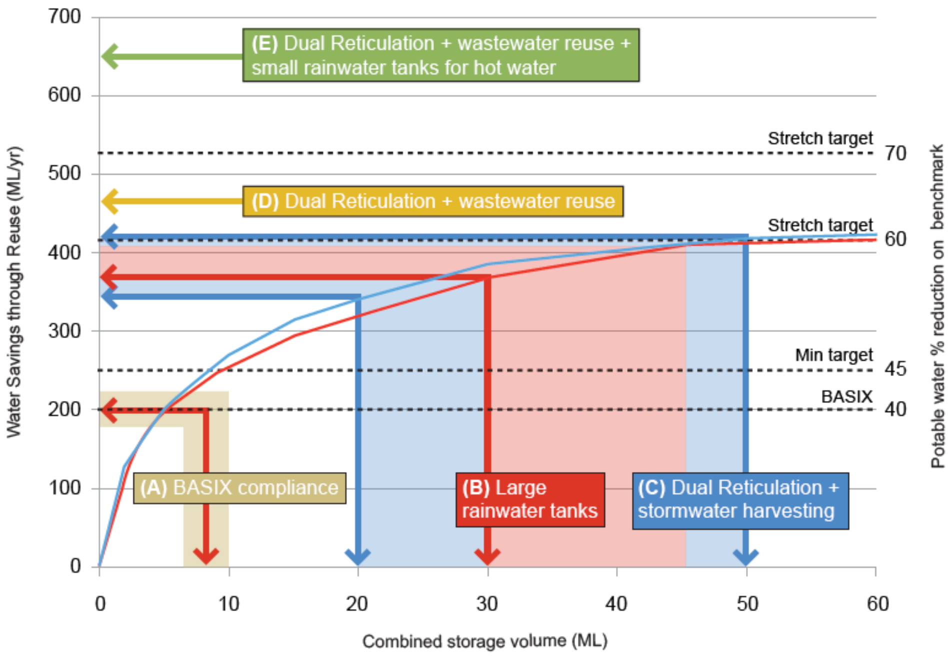

Figure 7.7: Water savings for water conservation options A - E

Figure 7.7 shows that

- Option D, enables water savings of 450 ML/yr, with almost all non potable demands met. This is more than double the savings with small rainwater tanks under the BASIX scenario and can be delivered at cheaper overall cost.
- Option E enables water savings of 620 - 650 ML/yr, with a significant proportion (38 – 66%) of hot water demand met (using rainwater tanks of 3 – 5kL) in addition to supply of treated wastewater to meet non potable demands.

Table 7.2 Water Conservation Options A - E

Option	A	B	C	D	E
	BASIX compliance	Large rainwater tanks on 90% of lots & small tanks on small lots	Dual reticulation & non potable water supply: harvested stormwater	Dual reticulation & non potable water supply: treated wastewater	Dual reticulation (non potable supply D) & rainwater tanks for hot water demands
Rainwater tank size per dwelling (T)	2 – 3 kL	10 – 15 kL	-	-	3 - 5 kL
Centralised water storage volume required (S)	-	-	20 – 50 ML	2 – 5 ML to buffer demands	2 – 5 ML to buffer demands
Equivalent combined total storage volume (T + S)	7 – 10 ML	20 – 30 ML	20 – 50 ML	2 – 5 ML	12 – 22 ML
Water savings	200 - 240 ML/yr	360 – 400 ML/yr	340 - 410 ML/yr	~ 450 ML/yr	620 - 650 ML/yr
Equivalent % reduction on benchmark water use	41% - 44%	56% - 60%	54% - 62%	66%	74% - 81%
Supply reliability to meet non potable demands	45% - 53%	Equivalent to 79 – 88%	75% - 91%	~100 %	137 - 144% (all non potable demand met, + 38-66% hot water demand)
Advantages	Cheapest option for developer	No dual retic. required. Rainwater supply to hot water, toilets, laundry and irrigation, meeting 55% - 61% of demand.	Facilitates optimum future water savings. No rainwater tanks required on lots. Environmental benefits from SW harvesting	Delivers maximum non potable water savings. No rainwater tanks required on lots. Environmental benefits from WW reuse Sydney Water mgt	Delivers optimum total water savings Environmental benefits from rainwater harvesting and WW reuse
Disadvantages	Least water savings, locks out cost-effective future non potable servicing	Large tanks are costly and difficult to fit on mid size lots (<1,000m^2) Climate change likely to reduce water savings	Cost of central storage + pipe network (dual retic and SW harvesting) Need operator / mgt	Upfront cost for pipe network infrastructure: dual retic + reuse supply No SW harvesting	Cost of rainwater tanks and pipe network dual retic + reuse supply
Cost Assumptions	$5k per lot for small tank	$10k per lot for large tank, (some small tanks)	$2k per lot for dual retic, $5 million for storage & filtering/disinfection $1.8 million for pipelines	$2k per lot for dual retic, $2 million for reservoir $3.6 million for reuse supply connection	$6k per lot for small tank $2k per lot for dual retic, $2 million for reservoir $3.6 million for reuse supply connection
Estimated Cost	$16.8 million	$31.9 million	$13.5 million	$12.3 million	$32.5 million
Estimated Cost per lot	$5,000 / lot	$9,500 / lot	$4,000 / lot	$3,700 / lot	$9,700 / lot
Estimated Cost ($) per ML saved	$21 - $25	$24 - $26	$10 - $12	~ $8	$15 - $16
Operational Costs / Savings	For all options there are some cost savings in the unit supply cost of non potable water (pegged at 80% of potable) and rainwater (no unit supply cost) in comparison with use of potable water. The maintenance costs for tanks / pumps and service charges from operating utilities are likely to be comparable in magnitude with the identified savings – thus a more detailed study with sensitivity analysis on critical assumptions is required to provide life cycle costing.				

- Notes for Table 7.2 are provided on the following page

Notes for table 7.2

- Option B: About 10% of lots are small (390 – 450m²). Large tanks would be difficult to configure on small lots. Option B assumes these lots have small tanks for BASIX compliance. This would increase water savings for this option by 20 – 24 ML/yr more than the numbers in the table above. The estimated cost includes the cost for small tanks on 10% of lots.
- Supply reliability of 55 – 61% for both hot water and non potable demands and equates to water savings of 79 – 88% of the non potable demand. No dual reticulation network required, but water savings from rainwater tanks will reduce with increasing climate variability.
- Option C: Cost effective central storage is possible through reconfiguring Sydney Catchment Authority's 100ML Sugarloaf Dam - currently proposed to be partially breached – or by configuring distributed storage in detention basins or other locations. Only minor treatment required (filter and disinfection) for stormwater from bioretention systems. Harvesting pipework & pumping: estimated 6km @ $300/m: $1.8 million). Should this option be pursued an assessment of stormwater storage options would need to be undertaken. Note that large below ground storage costs may reduce within the coming decade through advances in technologies which make assist in feasibility for this option.
- Modelled reuse for water savings: 250 ML/yr for toilet flushing and laundry, 200 ML/yr of irrigation, impervious catchment of 150ha; harvesting from some of the large detention basins in the central part of the site: Basins 4, 2, 12, 7, 8 and 9 with combined impervious catchment 149 ha). A 6km harvesting network required to link basins
- Option D: Non potable supply from Sydney Water's reuse pipeline from West Camden STP. This option for non potable supply is the least complex management arrangement as Sydney Water would construct the required connections and supply the alternative water source with cost of water as set by IPART.
- Option D2: Alternative non potable supply from an onsite sewage treatment plant or sewer mining plant. Management and operator required. Costs likely to be approximately $5,000 per lot. Also possible to integrate stormwater harvesting with sewer mining and operate cost effectively and sell reuse water.
- Option E: Rainwater tanks plumbed to meet hot water demands can deliver an additional 170 – 200 ML/yr in water savings, using a 3 – 5 kL tank / dwelling.

Water Conservation in the public domain

In addition to initiatives to meet residential water demands there are also further opportunities to reduce potable water demands in the Menangle Park development:

- In areas of public open space, use vegetation that does not require irrigation, or where irrigation is necessary, install a drip irrigation system. A list of plant species indigenous to Campbelltown City Council and with low water use requirements can be found at: http://www.basix.nsw.gov.au/pdf/indigenous_species/29.pdf.
- If there are public open spaces requiring irrigation within the development, these could be supplied with treated stormwater collected from treatment systems.
- Sewer mining and wastewater treatment could be undertaken locally with a small treatment plant or plants, to provide a recycled water source for open space irrigation (and supply household non potable demands).

Conclusion

The 45% target can be met with any of options B – E. The stretch target of a 60% reduction in potable water use could be realised for the Menangle Park site with any of the strategies C – E. A stretch target of 70% can be met with option E. The most cost effective solutions are Options C and D which required the construction of a dual reticulation network and a supply of non potable water from either Sydney Water or from harvested stormwater.

7.3 STORMWATER TREATMENT

For Menangle Park section 5 of this WSUD strategy identified a water conservation target of a 45% reduction on the
The pollutant load reduction targets adopted for Menangle Park require an 85% reduction in the TSS load from the developed site, a 70% reduction in the TP load and a 55% reduction in the TN load, as outlined in section 5. The WSUD Strategy outlines how these stormwater quality targets can be met.

This section describes

- WSUD elements - the types of systems proposed to integrate water quality improvement within suitable landscaped areas,
- Treatment area sizing - the required size for these systems based on impervious catchment areas and
- WSUD layout - the design configuration proposed for the site to ensure that the water quality targets are met.

7.3.1 WSUD elements

A range of stormwater treatment elements are available and can be configured as part of the WSUD Strategy for the site to meet the pollution control targets. These systems can be integrated with landscape areas at a range of scales, distributed within the catchment or concentrated in centralised locations. The range of treatment configurations available include:

- In <u>public open space</u> at the downstream areas of the development, regional systems such as wetlands can be constructed. Bioretention systems or wetlands can be configured in the base of detention basins.
- In <u>minor drainage lines</u>, swales or vegetated channels can be used in place of concrete pipes or concrete lined channels.
- In the <u>streetscapes</u>, swales and/or bioretention systems can be incorporated into median strips, road edges, traffic calming features, etc.
- On <u>lots</u> / <u>lot frontage and verge</u> (particularly in the case of rural residential development where lot sizes are relatively large), treatment systems such as bioretention raingardens can be incorporated into the garden areas particularly within the lot frontage (house setback zone) where the ongoing systems functionality can be observed/monitored.

The range of WSUD elements are illustrated through the following images and general description of the design configuration for:

A. bioretention systems within in detention basins,
B. floodplain wetlands, and
C. streetscape bioretention pods
D. on lot / lot frontage bioretention rain gardens

A. Bioretention systems with Detention Basins

Saturated Zone (SZ) bioretention pods are proposed within detention basins for water quality improvement. The bioretention area would typically be less than half of the basin floor area, and be perched above the basin floor, separated from the vegetated open space area of the basin with an embankment. Small flows would enter the bioretention system via a swale or low flow pipe to a coarse sediment forebay (this will concentrate easily removed sediment in an accessible maintenance location). Flows that exceed the capacity of the bioretention system would be directed to the other part of the basin (vegetated open space area), separated from the bioretention system by a bund of 0.5m – 1m. Diversion of high flows from the swale can occur via a side casting weir. Ponding in the open space area will then result in backflow of water to inundate the bioretention system above the extended detention depth. Larger events will result in inundation of the full detention area.

There are design options available to ensure that there will be no impact on landtake for the basin as a result of bunding for the bioretention system. The details will be worked through in detailed design. The bunds separating the bioretention systems from the remaining flood detention area would have a very small volume in comparison with the total storage volume provided. The refinement of the basin design and operation through the detailed design phase would ensure that the configuration accommodates the required flow attenuation and also strategies for the protection of the water quality elements.

Figure 7.8 Vegetated bioretention system as part of a detention basin

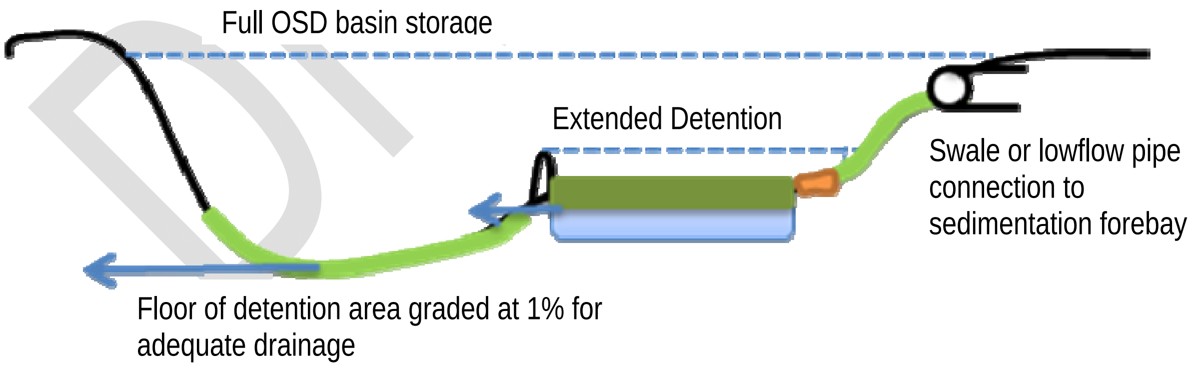

Figure 7.9 Plan (right) and section (above) of detention basin configuration ensuring pre-treatment sedimentation forebay and bypass configuration for high flows

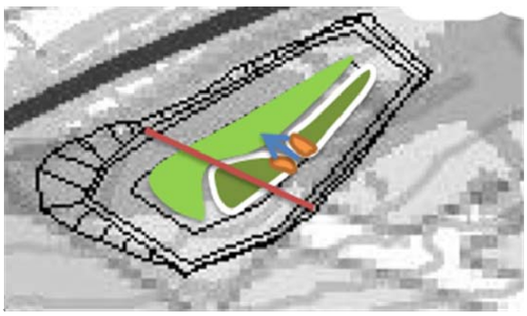

Figure 7.10 Section through detention basin showing a saturated zone bioretention and bund (small) separating it from the larger basin footprint

Figure 7.11 Detention basins may include paths, board walks, wetland pools, varied batter slopes and basin floor elevations and other landscape elements and variety of vegetation types to create interesting public open spaces.

Figure 7.12 Section illustrating path within the detention basin

B. Floodplain Wetlands

Wetlands are proposed within floodplain areas for stormwater quality improvement. These systems are located between the riparian corridor and the development interface. The wetlands are sensitively integrated with existing high quality vegetation and existing topography (requiring limited earthworks primarily for the formation of bunds).

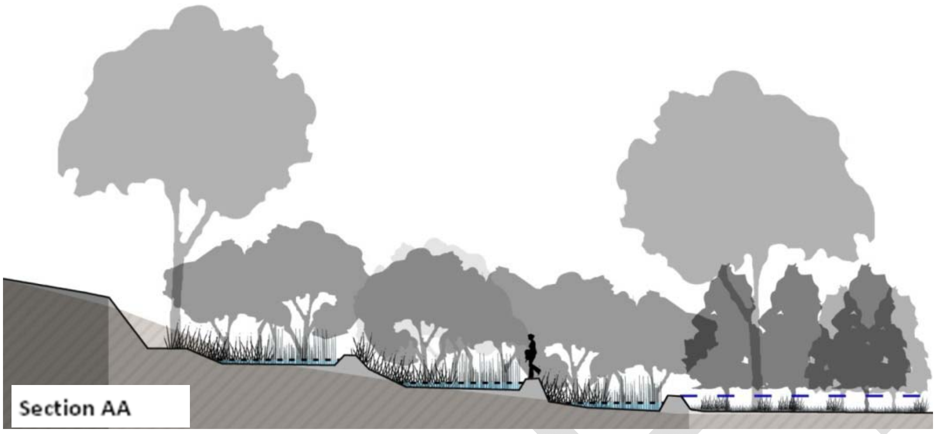

Figure 7.13: Floodplain wetlands (plan – right, section AA- above). Formed creating earth bunds within the floodplain which could be designed as shared paths for recreation opportunities and to control access to valuable vegetation area

Existing Vegetation: The stormwater treatment systems are located outside areas mapped as high quality vegetation to be retain, including areas of Endangered Ecological Communities (e.g. Sydney Freshwater Wetlands). Floodplain wetlands for stormwater treatment are a suitable landscape type adjacent to the Freshwater Wetlands. Establishing wetland areas across the floodplain will increase the habitat value and foraging range for fauna, and is complementary to the habitat types that occur naturally along the waterway in floodplain areas.

Hydrology & floodplain vegetation: Directing urban runoff to floodplain wetland areas (after sediment removal at development interface) will supports the proposed vegetation types (sedges and wetland species), converting pasture lands to floodplain vegetation and sustaining large areas of this vegetation type with runoff from the urban areas. The treatment volume / storage provided in the wetland areas attenuates flows significantly for small storm events. Multiple wetland areas provide distributed discharge of treated runoff to the waterway to minimise erosion of the waterway. Concentration of flows to a small number of drainage discharge locations is likely to impact on the waterway form.

Floodplain engagement: The floodplain wetlands will provide additional attenuation of flows and result in conveyance across a much wider corridor. This will provide protection for existing riparian vegetation and sections of natural geomorphic form. Controls are required to ensure the corridor is well vegetated with tufted grass species and that flows are spread and dispersed to reduce velocity and shear stress.

Bunds: Earthen bunds are proposed to enable attenuation of flow within the wetlands. The bunds would be approximately 7.5m in width including the embankments. There would be no impact on existing trees as the alignment of the bund is flexible. The bunds are best positioned along the contours, providing paths for controlled pedestrian access, reducing the disturbance to the adjacent wetter areas that support wetland species. The bunds can provide clear delineation of wetlands which may mitigate risk of inappropriate community / future land managers

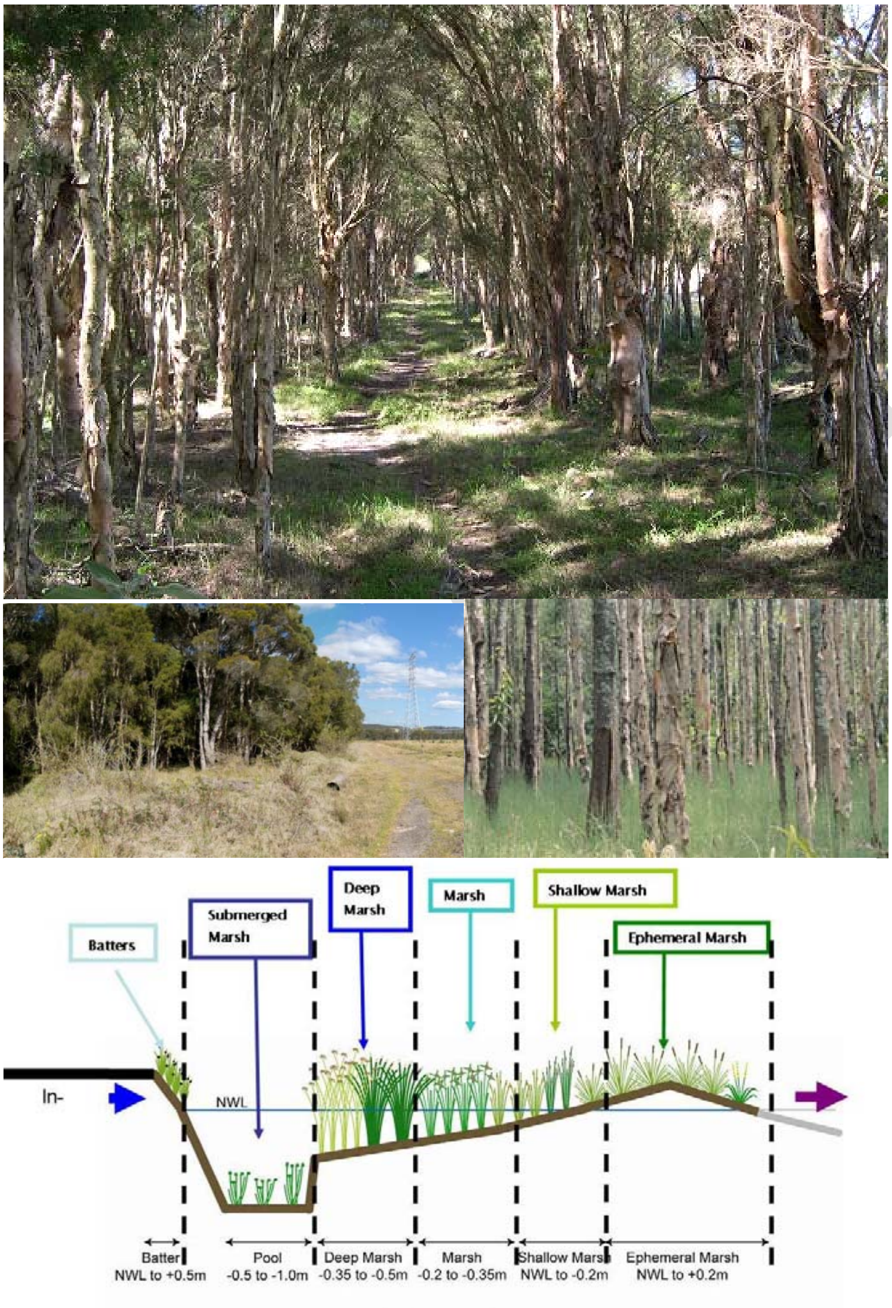

Figure 7.14: Floodplain wetland vegetation - ranging from terrestrial and ephemeral species on the bunded areas to aquatic species within wetland pools.

C. Streetscape Bioretention Systems

At the initial master planning level and rezoning of the site WSUD strategy for Menangle Park will ensure that adequate footprints are reserved for stormwater quality management centrally located bioretention or wetland systems. Streetscape systems do however provide a number of advantages over the larger treatment systems concentrated within the key public open spaces. Streetscape opportunities should be considered as the detail of the drainage and landscaping for the site is developed.

Streetscape systems can be designed to treat runoff from both road surfaces, and from lot areas (downpipe connection to rain garden). The size of streetscape raingardens can vary from small tree pits (2 – 5 m^2) to larger bioretention pods (100 m^2+) extending into large verge areas or adjoining open spaces.

Figure 7.15: Bioretention in the street verge within residential estate (Photo A.Cook, AECOM)

Figure 7.16: Bioretention in the street verge, clusteded at the entry to a local access street
(Image from SEQ HWP, 2009, Concept Design Guidelines for WSUD)

A range of drainage configurations can be used to direct stormwater runoff to appropriate streetscape locations. The diagrams below illustrate options for a range of scenarios:

1. lot runoff from the high side of the street to verge area
2. road runoff to the verge on the low side of the street
3. back of lot drainage to end of block verge
4. street drainage to planted areas at intersections
5. street drainage to planted areas in the middle of the block
6. street trees for drainage on steeper slopes
7. street drainage to adjacent open space areas
8. street drainage to planter beds between car parking bays

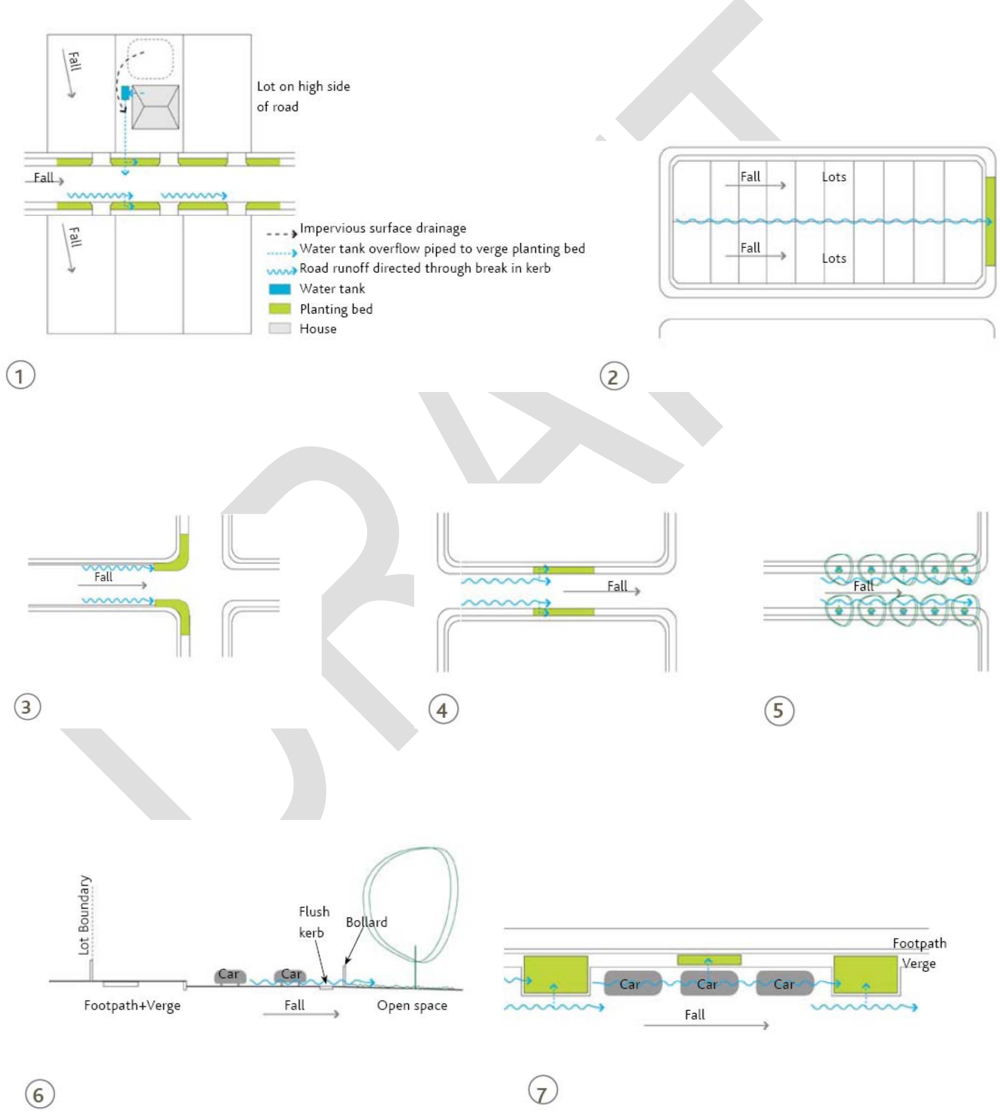

Figure 7.17: Options for integrating WSUD elements in streetscape areas – passive irrigation and/or bioretention pods

The indicative sections below show possible configurations of bioretention systems within the streetscape. Within the available road corridor widths, there are constraints on integrating footpaths, required set backs, service allocations and landscaped areas / WSUD treatment landscape areas. Joint trenching may be required to combine services to enable sufficient space for WSUD or other landscape elements.

The Guide to Codes and Practices for Streets Opening, (NSW Street Opening Conference) provides useful information on space allocations for foot paths, shared trenching, tree selection, and various construction issues. Landcom's Street Design Guidelines provide design principles and guidelines for good practice in street design to enhance urban design outcomes. The design principles for streets include the integration of WSUD.

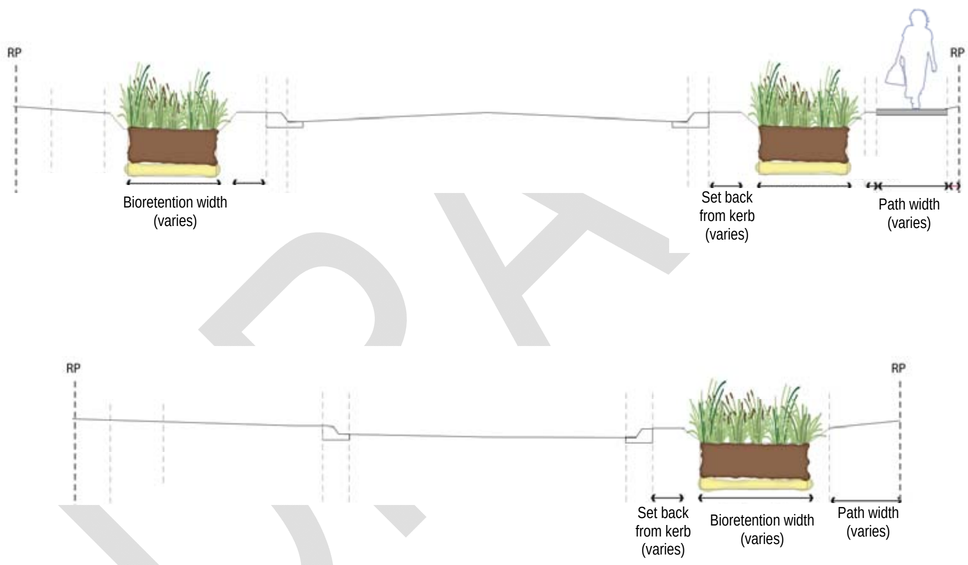

Figure 7.18: Indicative Streetscape Sections illustrating Bioretention Systems within Verge areas

D. Bioretention Systems within Lot Frontages

Bioretention systems can be integrated within lot areas. This area could be in the lot frontage (where observations could be made of these distributed systems to ensure their continuing effective operation as vegetated filtration systems). For a 1000 – 1500 m^2 lot and associated road area, with an assumed impervious area of 60%, a bioretention raingarden of approximately 20m^2 can provide the required water quality improvement (2% impervious area, normal bioretention system with 0.3m ponding depth)

Designing systems with a shallower ponding depth following rain may be desirable to reduce the need for noticeable batters to the set down bioretention surface. The footprint required will then increase to approximately 30m^2 (up to 3% of impervious catchment area). A saturated zone system could be used, requiring a slightly smaller footprint.

Bioretention systems within lots have many benefits:

- reduce the size of treatment systems needed downstream (this reduces the constraints on design of detention basins etc)
- reduce water use by residents for irrigation as bioretention systems are passively irrigated by stormwater runoff
- investment in visible and attractive garden areas that are sustained by appropriate hydrology, enhances aesthetic values and habitat with native , lush planting.
- Council or a developer could construct these systems in partnership with the community, providing an opportunity to engage with the community in awareness of stormwater issues, understanding of the local catchment and waterways and appreciation of native vegetation and material of local provenance. Opportunities to communicate about these issues may result in enhanced environmental outcomes and dialogue with Council.
- residents are likely to take on the ownership, management and maintenance of systems planted within or adjacent to their property. This may reduce the requirement for Council to maintain larger centralised systems downstream.

Council has noted concerns about the long term management of these systems which would need to be addressed for these systems to be adopted.

Figure 7.19a: Bioretention Systems within lots (front setback to house).Photos S.Boer (AECOM)

Figure 7.19b: Bioretention Systems within lots (front setback to house).Photos S.Boer (AECOM)

7.3.2 WSUD treatment area sizing

The impervious area within drainage catchments across the site has been estimated. MUSIC modelling has been used to determine the size of wetlands and bioretention systems required to reduce the pollutant loads. A strategy has been developed to integrate appropriately sized WSUD elements suitably within the site – responding to the constraints and opportunities discussed in section 6 of this report.

IMPERVIOUS AREAS

Campbelltown City Council has provided estimates of the average impervious area associated with particular land use categories (based on lot size) as tabulated below (Table 7.3). Road areas are included in these land use categories. These assumptions enable the likely impervious areas for each catchment to be calculated. The treatment area required is based on the impervious area for each catchment, as pervious runoff is likely to occur when the treatment capacity of a bio retention system or wetland is exceeded (ie bypass occurs).

Table 7.3 Impervious areas for various landuses (based on lot size) (Campbelltown Council)

Land use category based on lot size	Estimated impervious fraction (%)
350-390sqm lots	90%
540-700sqm lots	75%
1000-1500sqm lots	60%
2000+sqm lots	30%

The estimated impervious fraction for rural lands is highly variable. The required area for water quality treatment will be based on the impervious areas for a given rural site and is assumed to be able to be accommodated within the rural lands in association with drainage easements.

MUSIC MODELLING

The MUSIC modelling demonstrates that the following treatment areas are able to meet the water quality targets:

- Floodplain wetland areas corresponding to 6% of the impervious catchment area (including sedimentation control).
- Saturated zone bioretention filter media area corresponding to 1% of the impervious catchment area (with 0.3m extended detention).
- Streetscape bioretention systems (with as little as 0.1m extended detention) with a footprint of 2-3% of the impervious catchment area.

Note that sedimentation control is required upstream of the bioretention systems. This may include GPTs (in some areas), sediment forebays and pre-treatment swales. The footprint to provide for 0.3m extended detention is larger than the filter media area. The final footprint is dependent on the shape and configuration of the system.The documentation of the MUSIC modelling for the site is included as Appendix B to this report.

The SZ bioretention sizing through MUSIC is based on modelling using algorithms derived from the CRC for Catchments Hydrology and the Facility for Advancing Water Biofiltration. This technology represents current best practice with a significantly more efficient treatment foot print in comparison with that for constructed wetlands. Wetlands have been selected in floodplain areas due to the habitat, revegetation flow management and amenity values that are complementary with location within the riparian corridor.

As more research and monitoring of the SZ systems become available, the sizing and configuration can be refined. This would occur through the detailed design phase where drainage catchments will also be confirmed.

7.3.3 WSUD Layout

The strategy is illustrated in Figures 20 and 21 with the wetland and bioretention areas proposed. The expected drainage subcatchments are illustrated on Figure 20. The proposed elements are also overlaid on an aerial photo of the site (Figure 21) which shows areas of existing vegetation.

Where possible, wetlands have been used within floodplains to enhance the habitat value of the riparian corridors that will be revegetated as part of the development works.

Saturated zone bioretention systems are proposed within most of the detention basins as their efficient treatment footprint enables the stringent water quality targets to be met within the limited basin floor area available.

Streetscape systems are also recommended, and the use of these systems will reduce the constraints on design of the centralised treatment locations proposed. A range of streetscape opportunities exist (as presented Figure 7.17). The details of the optimum configuration for street trees and raingardens would need to be developed in the next phase of planning for the site – in association with the landscape masterplanning and detailed drainage design for the site. Streetscape systems would be particularly suitable:

- along the existing wide streets of the Menangle Park township (illustrated in Figure 7.21)
- in sub-catchments 18 and 19 (illustrated in Figure 7.20) which include areas that are likely to be difficult to drain to basins 7 and 8 respectively.
- along the drainage corridor between sub-catchments 24 and 26, where the sandy soils may be suitable to configure elements that allow infiltration of treated stormwater.

Tables 7.4 – 7.6 provide the details for each of the minor subcatchment areas:

- Catchment area
- Impervious area
- Proposed WSUD treatment element
- Notes, discussion and alternative WSUD options.

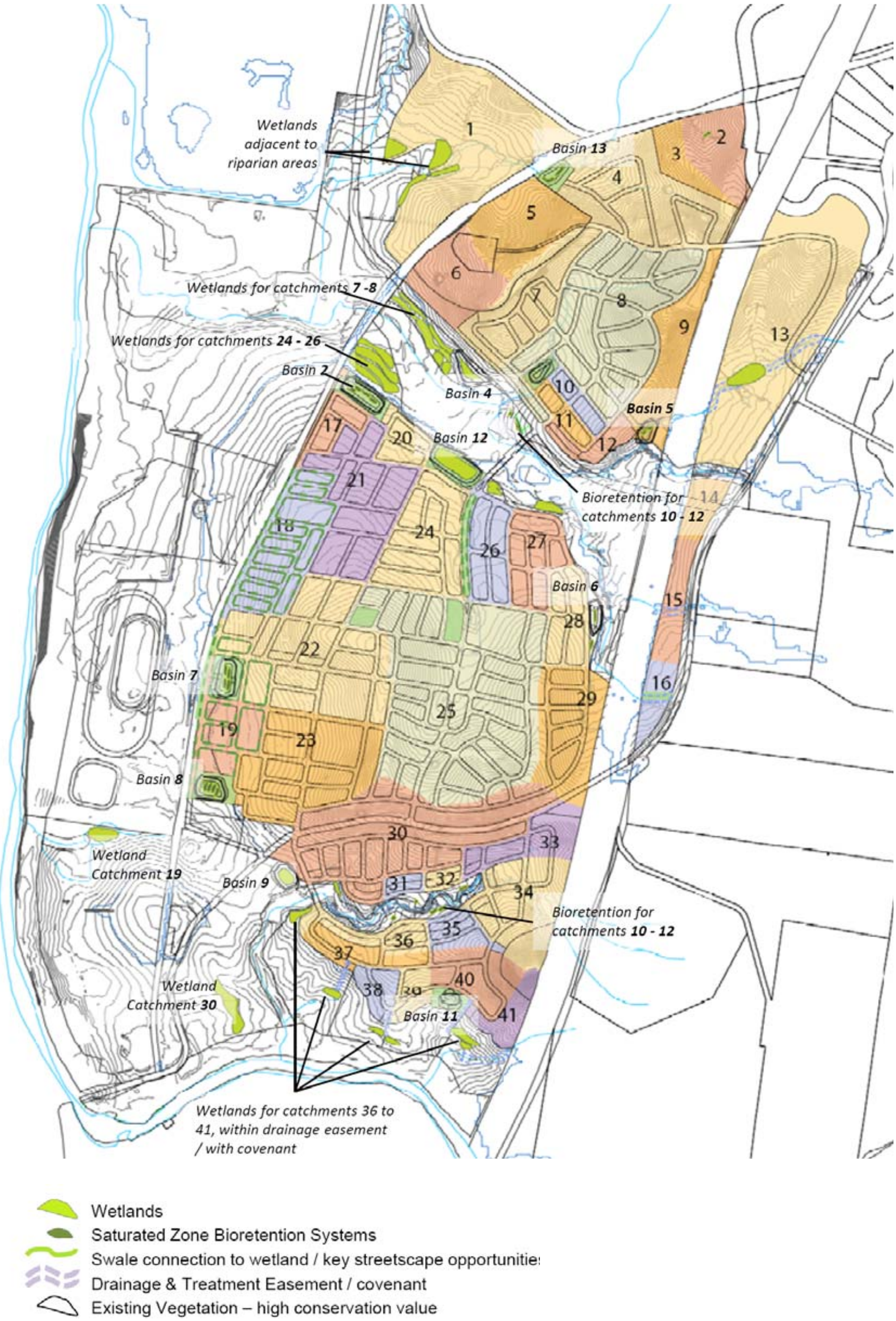

Figure 7.20: Drainage subcatchments and WSUD elements for managing stormwater quality

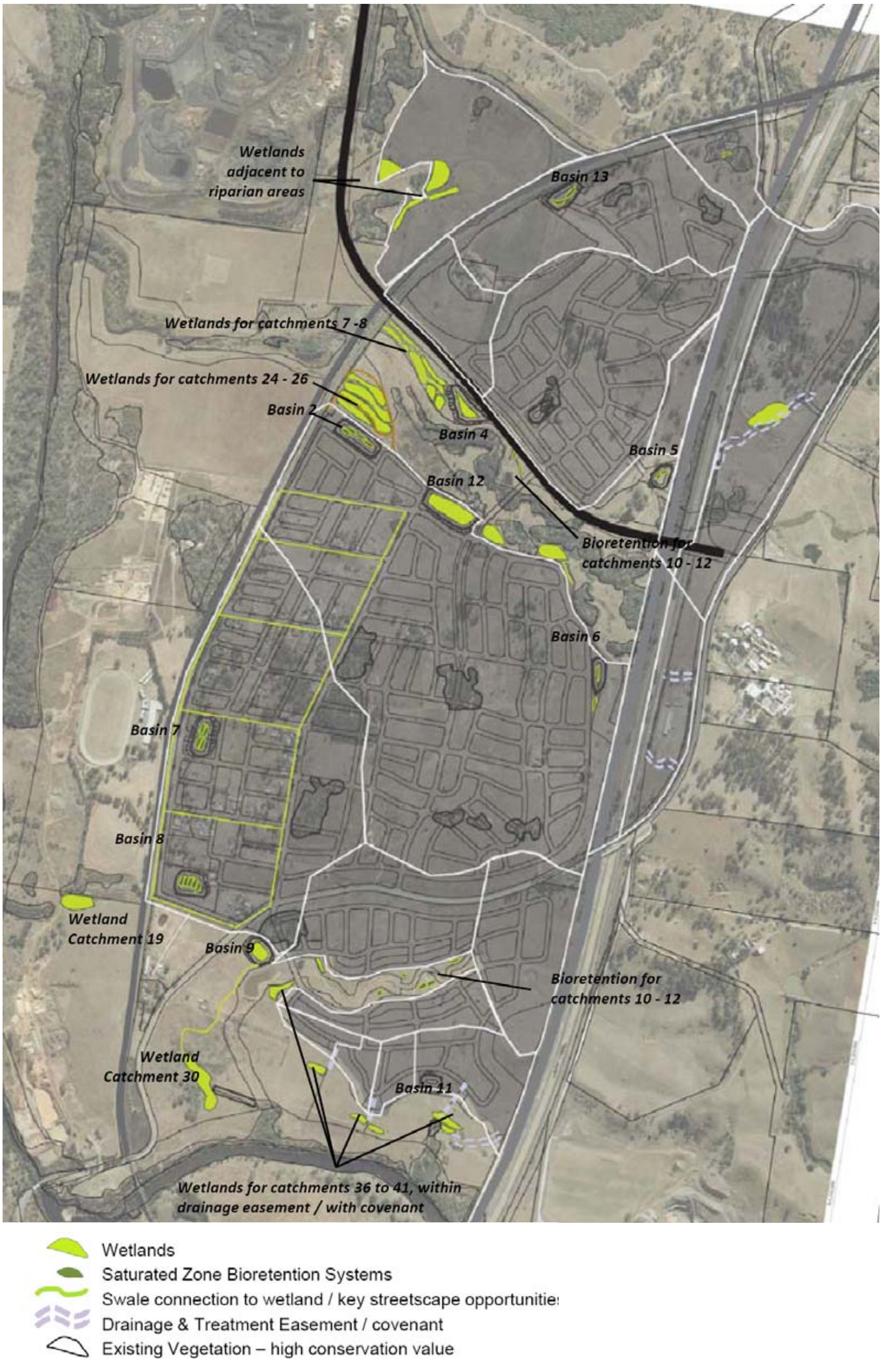

Figure 7.21: Wetland and Bioretention areas for managing stormwater quality

Table 7.4 - Northern and Eastern Catchments – WSUD elements

Ref no.	Catchment Area (m^2)	Description	Impervious %	Impervious Area (m^2)	WSUD treatment element	Notes / Alternatives
1	280,217	Employment lands	90%	252,195	Wetland cells for each minor catchment (total footprint 15,100m^2): 2,700+2,200+6,150+4,050	To be integrated with future masterplanning. Where constrained, can use smaller footprint SZ bioretention (2,520m^2 filter area). Wetland provides a good buffer to the downstream riparian corridor
2 & 3	101,316	Transgrid site	20%	20,263	Water quality management on Transgrid site (bioretention 200 - 400m^2)	
4	192,478	catchment to Basin 13	60%	115,487	2 x 575m^2 SZ bio in Basin 13 (44% of basin base area)	
5	99,740	Glenlee (northern side)	1%	997	Water quality management within Glenlee site	
6	84,470	Glenlee (southern side)	1%	845		
7 & 8	391,250	Full catchment including parks / large pervious areas (breakdown below for lot and road areas)				
	362,329	lot & road areas	68%	246,472	Wetland cells in Basin 4 and floodplain (total 14,800m^2); Basin 2,500 + 6 floodplain cells each approx 2,000m^2	SZ bioretention (2,470m^2 filter area) at edge of floodplain
9	90,322	large lot area adj freeway	60%	54,193	540m^2 SZ bio (2 x 270m^2) in Basin 5	
10 - 12	79,750	lot & road areas	70%	55,703	560m^2 SZ bio (2 x 280m^2) at riparian / development interface	
13	326,115	lot & road areas	39%	128,539	7,700m^2 wetland integrated with drainage easement/bypass	Streetscape / allotment SZ bio (1,235 – 2,570m^2) Note: steep grades
14 - 16	101,172	rural land	*~ 10%*	10,117	On site water quality management, allotment systems	

Table 7.5 – Central Catchments – WSUD elements

Ref no.	Catchment Area (m²)	Description	Impervious %	Impervious Area (m²)	WSUD treatment element	Notes / Alternatives
19	69,900	To 'polishing wetland' West of rail line	75%	52,470	5,250m² wetland in existing pond along the drainage corridor at the southern boundary with the Harness racing track	Reduce size with streetscape WSUD, Note difficulty to drain to Basin 8
17, 20, 21	219,527	To basin 2	75%	164,645	1,640m² SZ bio (4 cells x 410m²), 40% Basin 2 floor area	Reduce size with streetscape WSUD
18 & 22	259,203	Catchment 22 and as much as possible of 18 to Basin 7	76%	306,616	3,000m² SZ bio (6 cells x 500m²), 80% Basin 7 floor area	Use streetscape elements (and potentially treatment within rail corridor / Harness Racing land) to reduce the catchment treated in Basin 7. Note difficulty to get some areas to Basin 7 and potential to direct some piped flow to Basin 8 – thus the Basin 7 catchment may be slightly reduced when drainage catchments are confirmed.
23	180,985	To basin 8	52%	145,214	1,500m² SZ bio (3 cells x 500m²), 35% Basin 8 floor area	Reduce size with streetscape WSUD
24,25, 26	652,828	To basin 12	Full catchment including parks / large pervious areas (breakdown below for lot and road areas)			
	626,662	lot & road areas	75%	469,997	Wetland in Basin 12 and floodplain wetlands: total 28,200m², (8,220 in basin + 4 floodplain cells (8,200+5,224+3,700+3,420))	Size may be reduced with streetscape WSUD (including in drainage channel)
27 & 28	129,240		75%	96,930	Floodplain wetland cells 5,800m² (3,100 + 2,700) as interface between road and riparian	SZ system where constrained
29	110,945		70%	77,539	775m² SZ Bio (2 cells: 400 in Basin 6 and 375 cell to the south)	

Table 7.6 – Southern Catchments – WSUD elements

Ref no.	Catchment Area (m²)	Description	Impervious %	Impervious Area (m²)	Preferred WSUD treatment element	Notes / Alternatives
30	271,450	Full catchment including parks / large pervious areas (breakdown below for lot and road areas)				
	261,098	lot & road areas	68%	177,828	10,700 m² wetland (2,700m² in Basin 9 and swale connection to 8,000m² in floodplain)	
31	11,813		83%	9,746	600m² perched wetland	Small catchments 31 - 35 treated in bioretention or wetlands in landscape buffer to riparian corridor. Bioretention systems preferred where more dense planting / screening is desired and where space constraints arise due to road batter.
32	20,119		78%	15,625	160m² SZ bio	
33	45,578		65%	29,521	300m² SZ bio	
34	112,927		70%	78,884	790m² SZ bio (2 x 400m² cells)	
35	29,105		79%	23,102	230m² SZ bio	
36	40,485		83%	33,696	2,020m² wetland, southern side of watercourse	340m² SZ bio
37	37,210		75%	27,908	1,670m² wetland, draining to minor watercourse	280m² SZ bio
38	26,719		67%	17,923	1,080 m² wetland	180m² SZ bio
39	24,681		68%	16,880	1,010 m² wetland	170m² SZ bio
40	66,378	Full catchment including parks / large pervious areas (breakdown below for lot and road areas)				
	59,738	lot & road areas	64%	42,497	2,550m² wetland downstream of Basin 11 as protective buffer to stand of existing high quality vegetation	420m² SZ bio in Basin11, 70% of the basin floor area
41	30,782	Full catchment including parks / large pervious areas (breakdown below for lot and road areas)				
	24,751	1000 – 1500m² lots	60%	14,851	900 m² wetland associated with drainage pathway for external catchment / waterway corridor (not classified riparian zone)	Bioretention within allotments or within drainage corridor.

7.4 FLOW MANAGEMENT

Detention basins are used to meet the flood management targets for the site. The basin locations and sizing is summarised in Figure 7.22. Further details are provided in GHD's Flood Study for the site (GHD, 2010).

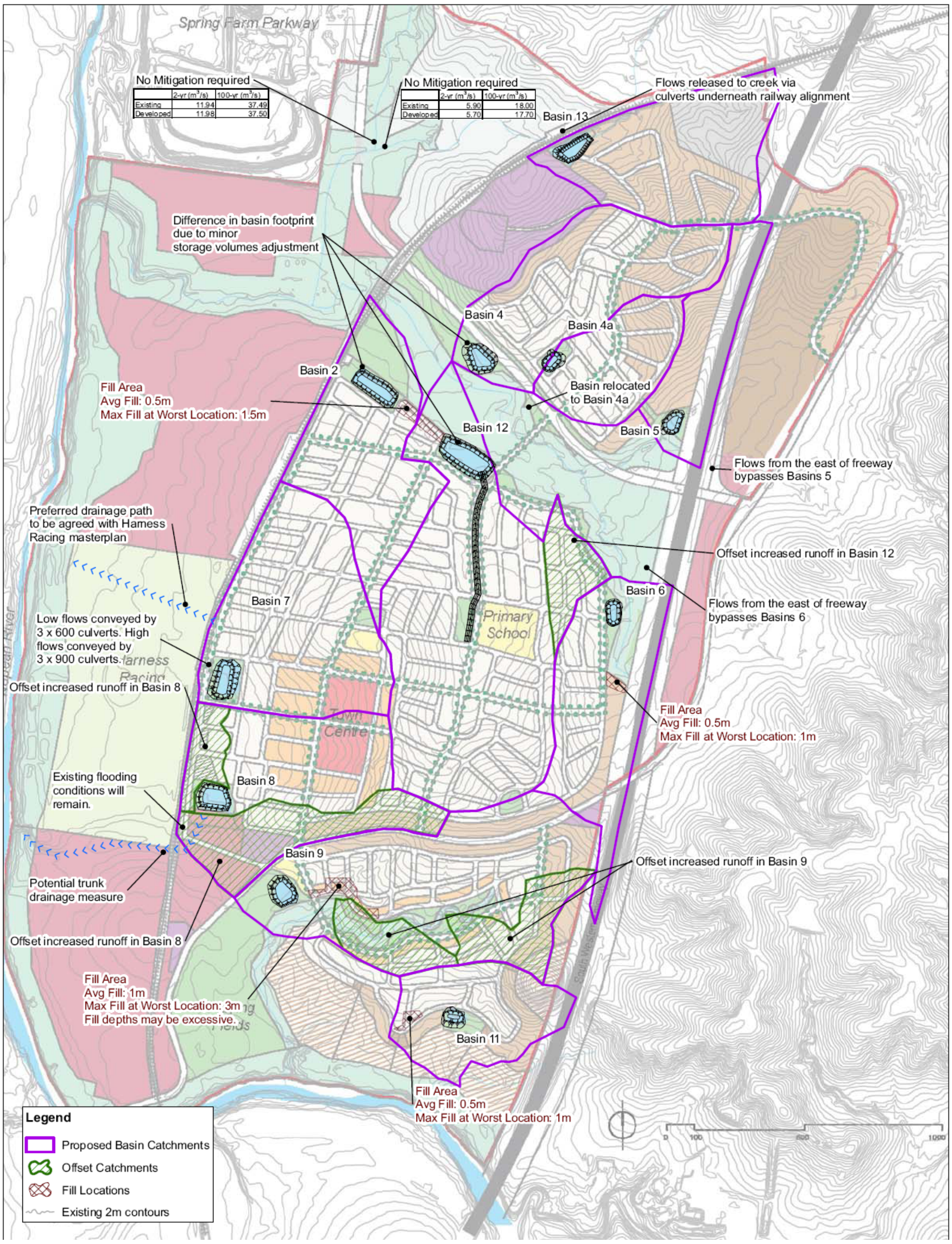

Figure 7.22: Detention Basin locations and sizing (GHD).

GHD has commented that Council's DCP parameters (including Mannings coefficient) result in higher than usual predevelopment flows and smaller than expected detention requirements. Council has noted the catchment time of concentration characteristics as a possible reason for the small detention requirements.

The assumptions and outcomes of the flood study are supported by Council's own flood studies, and the flood models have been endorsed by Council.

As a result of the small detention basin footprints saturated zone bioretention systems rather than wetlands have been configured within most of the detention basins as they have a more efficient treatment footprint.

Along Howells Creek (Waterway M), floodplain wetlands have been proposed which can be configured to provide additional attenuation and protection of the remaining geomorphic attributes of the waterway (Figure 7.23). These wetlands can be configured to enable more distributed discharge of flow to the waterway, rather than concentrated point source discharge locations from a small number of detention basins. The resulting engagement of the floodplain will provide enhanced waterway protection.

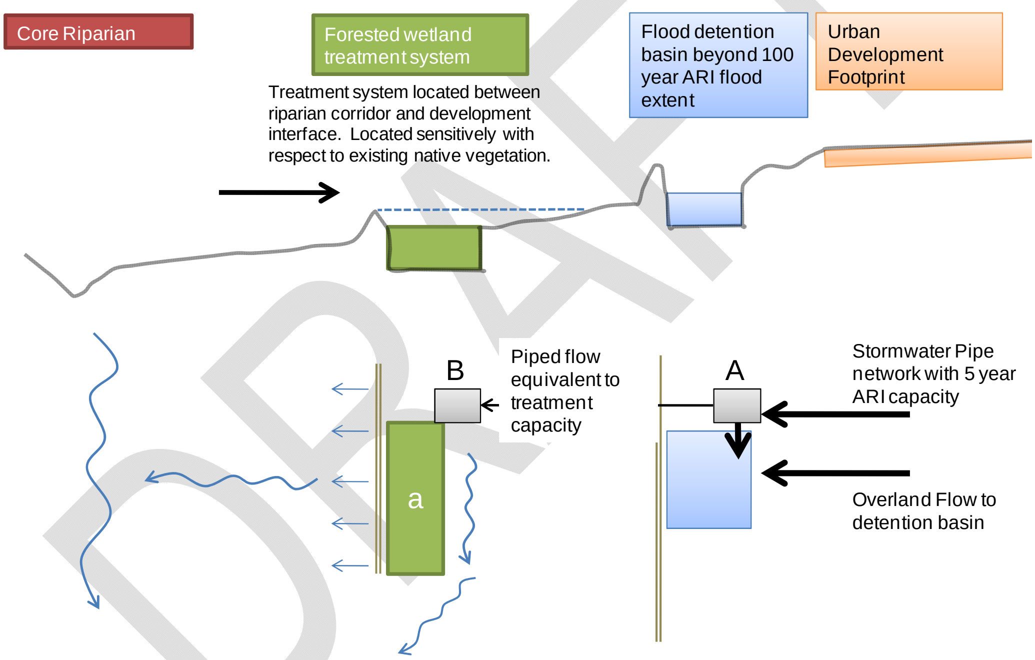

Figure 7.23 Schematic (section and plan) of the operation of the floodplain wetland treatment system

7.5 RIPARIAN CORRIDOR MANAGEMENT

The rehabilitation of the riparian corridors within the Menangle Park site presents a significant opportunity for an enhanced ecological outcome. Most of the waterways are in a degraded condition with little or no riparian vegetation and significant erosion of the bed and banks due to impacts from agricultural land use.

The riparian corridor categorisation outlines the environmental objectives for the waterways on the site. The aesthetic, recreational and microclimate benefits for the development associated with rehabilitation of the riparian corridors provides additional drivers for planning the rehabilitation of waterways and investing in the revegetation of these corridors and in the water management elements that protect and can sustain the riparian vegetation.

The key areas to be address include:

- Waterway stability – works will be required to address existing erosion of the watercourses prior to the urbanisation of the catchment and resulting increase in stormwater runoff. Detention basin configurations should ensure optimum flow control to maintain pre-development storm discharges for the 1.5 year ARI event (objective for waterway protection).
- There are a number of large headcuts along the southern watercourses – particularly in the lower reaches as the tributaries meet the Nepean River. A waterway rehabilitation approach is required that addresses the need for any bed and bank control structures as a priority. Revegetation of the waterway corridor can be strategically planned, with early establishment of canopy vegetation to shade out weeds and a longer term, staged and adaptive approach to in channel works and increasing the diversity in ground cover planting.
- Water quality – the construction of the WSUD elements proposed will ensure the water quality targets for the site can be met. Through construction, it is critical that adequate sedimentation control is provided and monitored to ensure its effective function.
- Habitat – the revegetation works within the corridor and within the waterway channel will result in a significant enhancement of the terrestrial and aquatic habitat value on the site. The floodplain wetlands proposed for water quality improvement will create important refugia for flora and fauna. There are significant areas of pastoral land supporting mostly exotic species. Once these areas are replaced with native vegetation, they will substantially augment the provision of riparian habitat.
- Environmental corridors – A substantial corridor width has been provided for the category 1 water courses in the northern part of the site. These corridors provide biodiversity linkages by maintaining connectivity for aquatic and terrestrial fauna and flora. Where effective works are delivered for waterway rehabilitation, flow control, revegetation and water quality management, enhanced outcomes will be realised; with less erosion in healthy and functioning streams, corridors of habitat supporting a diverse range of species and improved water quality.

The Biodiversity offset strategy (GHD, 2010) requires revegetation of large areas of pastoral land, particularly along the waterway corridors. This will enhance the ecology of the site considerably.

7.6 WASTEWWATER POLLUTION CONTROL

Given the sensitive receiving environment, limiting sewage discharge to the Nepean River is important.

SEWERAGE NETWORK DESIGN

To minimise leakage from the sewage network in dry weather, small bore sewers and other advanced sewerage design options should be considered. This will also assist in minimising infiltration during wet weather and subsequent wet weather overflows. Design of sewage pumping stations should accommodate adequate storage volumes to ensure that back up pumps could be brought in following a breakdown or power failure without discharge of sewage to the environment.

Overflow points from the sewage system should be configured to discharge into WSUD elements (bioretention or wetland areas via the stormwater network) rather than directly to waterways to provide some treatment in the event of an overflow, particularly those that may occur in dry weather due to blockages etc.

Whilst a dry weather overflow directed to a WSUD element may result in significant odour, resident complaints and some mess that is inconvenient for Council, it is likely that the problem would be identified, reported and resolved. Discharges directly to the Nepean may not be noticed, reported, and resolved for extended periods.

WSUD elements would typically be operating above designed capacity during wet weather flow conditions where wet weather sewer overflows may occur. However, without establishing dedicated sewer overflow detention structure, it is recommended that stormwater treatment systems remains the 'first line of defence' against discharge of sewage to the receiving water.

SEWAGE TREATMENT

At present there is no centralised sewage infrastructure servicing the Menangle Park site.

The most likely option for sewage treatment is construction of a pipeline connecting to the recently upgraded West Camden sewage treatment plant located about 10 km from the site. With suitable sewerage network design, centralised wastewater treatment provides economic and effective wastewater management, with all operational issues managed by Sydney Water.
Wastewater reuse pipelines have been constructed from this plant (to within 3km of the Menangle Park site), allowing for some beneficial reuse for agricultural irrigation. The remainder of sewage treated at the plant is discharged to the Nepean River. An extension of the reuse pipeline to the site could provide a non potable water source.

Onsite sewage treatment is feasible, and should be considered as planning for the site proceeds. It is acknowledged that a suitable location would need to be identified for an onsite sewage plant and options resolved for management and operations. There is a significant upfront cost for the design, construction and coordination of onsite sewage treatment plants.
An onsite sewage treatment plant would also provide a source of non potable water for reuse. It may be possible for an effective water manager to provide a comparable service to Sydney Water, with the potential for cost savings if the operational costs for a localised scheme are less than Sydney Water's increasing operational costs for regional scale systems.

8 MAINTENANCE CONSIDERATIONS

8.1 INSPECTION AND MAINTENANCE

WSUD infrastructure such as sedimentation basins, constructed wetlands and bioretention systems, require ongoing inspection and maintenance to ensure that they establish and operate in accordance with the design intent. Potential problems associated with WSUD infrastructure as a result of poor maintenance include:

- Decreased aesthetic amenity;
- Reduced functional performance;
- Public health and safety risks; and
- Decreased habitat diversity (dominance of exotic weeds).

Importantly, the most intensive period of maintenance is during the plant establishment period (initial one to two years) when weed removal and some replanting may be required. The designs of the WSUD elements seek to minimise maintenance requirements during this period by incorporating a provision to isolate the majority of the 'vegetated' areas of the WSUD systems from inflows during the 'Allotment Building' phases. This greatly reduces the risk of plants becoming smothered by sediments resulting from construction activity (a common cause of early plant mortality and filter media clogging for bioretention systems) and importantly also reduces the seed load being deposited during the period when the plants are establishing and least able to compete with (shade out) weed species. Therefore, it is expected that the vegetation in the WSUD systems will become well established prior to bringing them online – which will occur at the end of 'on maintenance' period (2 years after construction).

After establishment, WSUD elements should be inspected every three months, with particular reference to:

- Structures, such as overflow weirs, bypass and inlets
- Erosion
- Sediment build-up
- Weeds
- Algal blooms
- Litter (anthropogenic and non-anthropogenic)
- Oil slicks

Inspections are also recommended following large storm events to check for flow distribution, ponding, scour and any other damage.

It is recommended that the personnel who are to undertake the operation and maintenance of the stormwater treatment elements be briefed and trained on procedures and protocols prior to commencement. Vegetated WSUD elements should be monitored by personnel with bush regeneration qualifications (as approved by Australian Association of Bush Regenerators). Bush regenerators are well equipped at identifying evasive species within a native landscape typical of vegetated WSUD systems. Keeping and maintaining records on the condition of the systems and all maintenance works required will be important to inform and schedule future maintenance works.

The following sections provide details of the maintenance requirements of the sedimentation basins, constructed wetlands and bioretention basins, during both the 'on maintenance' period and 'operational' phase. Additionally, construction/establishment and asset handover checklists can be found in Landcom (2009) to assist in 'on maintenance' period and 'off maintenance' period inspections.

8.2 SEDIMENTATION BASINS AND GROSS POLLUTANT TRAPS (GPTS)

Sedimentation basins are stormwater detention systems that promote the settling of coarse sediment (defined as particles greater than 125 microns in diameter). GPTs are effective in the removal of litter, gross pollutants and (to varying degrees depending on GPT design) will also remove sediment.

Due to the operation of a sedimentation basin, regular clean out and removal of accumulated sediment is required. Sedimentation basins are generally designed for a clean out frequency of five years, which equates to a volume half that of the permanent pool (defined by the invert of the outlet structure). Accumulated sediments must also be removed when sediment accumulates to half the sediment basin depth to ensure that the sediment trapping performance of this system is sustained.

The majority of maintenance associated with sedimentation basins concerns the inlet zone (and GPT if installed). Inlets can be prone to scour and build up of litter. Litter removal and potential replanting may be required as part of maintaining an inlet zone. Inspections should be undertaken monthly and after storm events as the frequency of litter and debris removal may be high. Debris, if not removed, can block inlets or outlets, and can be unsightly if located in a visible location. Inspection for accumulated sediments and debris should be done regularly and debris should be removed whenever it is observed. Weed removal and replanting of edge vegetation will also be required intermittently.

More details on the monitoring requirements for sediment basins can be found in Table 5 of Landcom's *DRAFT Water Sensitive Urban Design, Book 4: Maintenance*.

8.3 CONSTRUCTED WETLANDS

Constructed wetlands use enhanced sedimentation, fine filtration and biological uptake processes to remove pollutants from stormwater. The wetland processes are engaged by slowly passing runoff through heavily vegetated areas where plants filter sediments and pollutants from the water. Biofilms that grow on the plants can absorb nutrients and other associated contaminants.

Maintenance requirements

To ensure the functionality of the system, routine monitoring and maintenance of constructed wetlands will require:

- Checking flow paths in and out of the system are unobstructed
- Ensuring vegetation is healthy and is sufficiently dense
- Preventing undesired vegetation from taking over the desirable vegetation
- Removal of noxious plants or weeds
- Re-establishment of plants that die
- Removal of accumulated sediments
- Litter and debris removal

More details on the monitoring requirements for constructed wetlands can be found in Table 4 of Landcom's *DRAFT Water Sensitive Urban Design, Book 4: Maintenance*.

Of the above items, debris removal should be the only action requiring ongoing attention. Debris, if not removed, can block inlets or outlets, and can be unsightly if located in a visible location. Inspection and removal of debris should be done regularly, but debris should be removed whenever it is observed.

8.4 BIORETENTION SYSTEMS

Bioretention systems are vegetated filter systems designed to allow water to pool temporarily before percolating through the filter media. Critical to the performance of a bioretention system is maintaining the permeability of the filter media and the health of the vegetation. In comparison with a sedimentation basin or wetland inlet zone, the maintenance requirements for a bioretention system are perhaps more frequent but involve less heavy machinery for removal of sediment and for access. Maintenance of bioretention systems will involve:

- Routine monthly inspection of the bioretention system profile to identify any areas of obvious increased sediment deposition, scouring from storm flows, rill erosion of the batters from lateral inflows, damage to the profile from vehicles and clogging of the bioretention system (evident by a 'boggy' filter media surface).
- Routine monthly inspection of inflows systems, overflow pits and under-drains to identify and clean any areas of scour, litter build up and blockages.
- Removal of sediment where it is smothering the bioretention system vegetation.
- Removal of accumulated sediment from the coarse sediment forebay.
- Repairing any damage to the profile resulting from scour, rill erosion or vehicle damage by replacement of appropriate fill (to match onsite soils) and revegetating.
- Tilling of the bioretention system surface, or removal of the surface layer, if there is evidence of clogging.
- Regular watering / irrigation of vegetation until plants are established and actively growing.
- Removal and management of invasive weeds (herbicides should not be used).
- Removal of plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule.
- Pruning to remove dead or diseased vegetation material and to stimulate growth.
- Vegetation pest monitoring and control.

Maintenance should only occur after a reasonably rain free period when the soil in the bioretention system is dry. Inspections are also recommended following large storm events to check for scour and other damage.

Resetting (i.e. complete reconstruction) of bioretention elements will be required if the available flow area of the overlying basin is reduced by 25 percent (due to accumulation of sediment) or if the bioretention trench fails to drain adequately after tilling of the surface. Current experience with systems operating for approximately 10 years (Victoria Park) and modelling suggests that this would only be required after 20 - 25 years.

More details on the monitoring requirements for bioretention basins can be found in Table 3 of Landcom's *DRAFT Water Sensitive Urban Design, Book 4: Maintenance*.

8.5 MINIMISING MAINTENANCE THROUGH DESIGN

Good design can reduce maintenance costs, and poor design can result in systems that are a significant cost burden for Council. There are a number of recommended strategies that assist in designing for low maintenance, for example

- Using landscape edge treatments to define a management edge
- Plant selection to reduce areas requiring mowing
- Plant selection appropriate to the hydrology to ensure self sustaining and healthy landscapes
- Designing for ease of access for sediment removal
- Designing sedimentation areas that are screened visually and can assimilate some sediment

9 COSTING

9.1 MENANGLE PARK WSUD – PRELIMINARY CAPITAL COST ESTIMATES

A preliminary costing has been completed for the proposed water sensitive elements (bioretention basins and constructed wetlands). The costing is based on previous experience in the construction and establishment of these systems in similar Greenfield developments. The costing includes only those items that are unique to the construction of either bioretention basin or constructed wetlands. Infrastructure costs and site specific costs have not been included as these items have been addressed in the GHD preliminary schedule of costs for the basins in which these systems will be constructed.

A summary of the cost for each water sensitive urban design element proposed is given in Table 9.1.

The items included in the costing are described in Table 9.2 (a 500 m^2 saturated zone bioretention cell) and Table 9.3 (a 1000 m^2 constructed wetland cell).

The itemised costing includes the following assumptions:

<u>Bioretention basin</u>

- Filter depth (transition sand layer) = 550 mm
- Filter (SZ) = 440 mm
- Drainage layer = 200 mm
- Flow distribution = 150 mm half pipe with an equivalent length equal to the perimeter of the basin
- Costs associated with basin construction, inlet and outlet structures and site preliminaries and management excluded (these costs have been included in the GHD costing).
- NO contingency (as the GHD contingency is considered high at 30 percent)

ITEM COST FOR BIORETENTION CELLS IS APPROXIMAETLY $300 / 500 m^2 (see table 9.2)

<u>Constructed wetland within floodplain areas</u>

- The cost of earthworks is assumes bund length of 100m for a 1000m^2 cell (the other side bunded by adjoining cells).
- The bund configuration (0.5m height, 2m top width/path, 1 in 6 side slope)
- Geotextile may be required to ensure wetland operation in sandy floodplain
- A simple inlet and outlet structure is required – estimated at $10,000 each

ITEM COST FOR CONSTRUCTED WETLANDS APPROXIMAETLY $50 / m^2 (see table 9.3)

The total cost of the proposed WSUD measures given below DOES NOT include site wide waterway rehabilitation work. A cost for this work cannot be determined until a waterway rehabilitation strategy is developed for the site.

Table 9.1: Summary of costs for proposed WSUD elements

Catchment	Basin no.	Catchment no.	WSUD treatment	Area (m^2)	Cost
Employment Zone		1	Wetland cells integrated into each minor catchment	15,100	$ 755,000
		2&3	Trans grid - on site mgt - not included		-
Northern	13	4	Bioretention	1,150	$ 345,000
		5&6	Glenlee - not included		-
Central	4	7&8	Wetland (within basin and floodplain)	14,800	$ 740,000
	5	9	Bioretention	540	$ 162,000
		10 - 12	Bioretention adjacent to riparian	560	$ 168,000
		13	Wetland on drainage easement	7,700	$ 385,000
		14 - 16	Rural - on site mgt - not included		-
		27, 28	Wetland floodplain	5,800	$ 290,000
	6	29	Bioretention (partly in basin)	775	$ 232,500
	12	24 -26	Wetland (within basin and floodplain)	28,200	$ 1,410,000
	2	17,20,21	Bioretention	1,640	$ 492,000
Village	7	18, 22	Bioretention	3,000	$ 900,000
		19	Wetland near S3 waterway	5,250	$ 262,500
	8	23	Bioretention	1,500	$ 450,000
Southern	9	30	Wetland downstream of basin	10,700	$ 2,675,000
		31	Wetland	600	$ 30,000
		32 - 35	Bioretention along riparian	1,480	$ 444,000
		36 - 39	Wetland floodplain	5,960	$ 298,000
		41	Wetland floodplain	900	$ 45,000
	11	40	Wetland downstream of basin	2,550	$ 127,500
TOTAL					$ 10,211,500
Sub total constructed wetlands – including substantial revegetation within the floodplain / riparian corridor				91,760	$ 6,728,000
Sub total bioretention				10,645	$ 3,193,500

NOTE: Waterway rehabilitation strategy required to assess the rehabilitation approach, extent of works and stabilisation structures required. A costing cannot be given until this strategy is developed.

Table 9.2: Itemised costing for a typical 500m2 saturated zone bioretention cell

SECTION 1: 500m² BIORETENTION CELL COSTING					
Pay Item	Brief Description	Unit	Qty	Unit Rate ($ excl GST)	Price ($ excl GST) (Quantity x Unit Rate)
1.01	Slotted under-drainage pipes including supply and install (a) 100 mm diameter	m	157	$20.00	$ 3,140.00
	(b) 150 mm diameter	m	7	$40.00	$ 1,000.00
1.02	Cleanout points for slotted pipes (a) 100 mm diameter	No.	11	$41.00	$ 451.00
	(b) 150 mm diameter	No.	1	$76.00	$ 76.00
1.03	Geofabric to base and walls	m²	110	$2.25	$ 247.50
1.04	200 mm gravel drainage layer (a) Supply and delivery	m³	100	$60.00	$ 6,000.00
	(b) Install	m³	100	$15.00	$ 1,500.00
1.95	Hardwood woodchips (a) Supply and delivery	m³	70	$28.60	$ 2,002.00
	(b) Install to transition sand layer as directed	m³	70	$15.00	$ 1,050.00
1.06	550 mm sand transition layer (a) Supply and delivery	m³	275	$115.60	$ 31,790.00
	(b) Install	m³	275	$15.00	$ 4,125.00
1.07	Filter material 400 mm deep (a) Supply and delivery	m³	180	$120.50	$ 21,690.00
	(b) Install	m³	180	$15.00	$ 2,700.00
1.08	Rock energy dissipation (a) rock placed at inlet	m	25	$35.00	$ 875.00
1.09	Inflow distribution (150 mm half pipe)	M	45	$40.00	$ 1,800.00
SECTION 2: BIORETENTION BASINS PLANTING OF BIORETENTION BASIN					
2.01	PA2 - Planting area including 150 mm subsoil cultivation, 200 mm topsoil, 75 mm mulch	m²	500	$12.00	$ 6,000.00
2.02	Planting Type 1 - pot size 140 mm 4/m²	no.	2000	$7.00	$ 14,000.00
2.03	Planting Type 3a - tube stock 8/m²	no.	4000	$3.00	$ 12,000.00
2.04	Planting Type 3b - 140 mm 6/m²	no.	3000	$7.00	$ 21,000.00
2.05	Planting Type 5 - tube stock 6/m²	no.	3000	$3.00	$ 9,000.00
2.06	Water truck hire - excluding cost of water	hour	80	$100.00	$ 8,000.00
Sub-total Amount for bioretention cell including planting (excl GST)					$ 148,446.50 (~$300/m²)

Table 9.3: Itemised cost for constructed wetlands (outside basin)

SECTION 4: WETLAND COSTING (1,000m² cell)					
Pay Item	Brief Description	Unit	Unit Rate ($ excl GST)	Qty	Price ($ excl GST)
4.01	Earthworks	m^3	$ 20.00	300	$ 6,000.00
4.02	Bunding (including placement of removed soil)	m^3	$ 10.00	400	$ 4,000.00
4.03	Planting	m^2	$ 20.00	1000	$ 20,000.00
4.04	Inlet structures	item	$10,000.00	1	$ 10,000.00
4.05	Outlet structures	item	$10,000.00	1	$ 10,000.00
Sub-total amount for wetland (excl GST)					$ 50,000.00 (~$50 / m²)

Annualised maintenance costs

Annualised maintenance costs for these treatment systems have also been calculated. Like construction costs, maintenance also becomes less costly as the size of the system increases.

The range of maintenance costs for bioretention basins and constructed wetlands given in the Landcom WSUD maintenance booklet (Book 4) is:

- Bioretention systems = $2 to $4 per m²
- Constructed wetland systems = $3 to $5 per m²

Maintenance costs will typically include general maintenance of public areas, litter control, weed control (especially during establishment phase) and inspection (with occasional repairs) of hydraulic structures (pipes/pits/weirs etc).

10 CONCLUSIONS

The WSUD Strategy Report documents preliminary WSUD Options for the Menangle Park release area.

The report describes the nature of the site (Section 4); identifies opportunities and constraints (Section 6); outlines WSUD strategy targets (Section 5); presents components of the WSUD strategy (Section 7); and provides discussion of costing (Sections 8 & 9).

The site is largely degraded as a result of historical clearing and grazing practices. The catchments and waterways are illustrated in Figure 4.2. The development of Menangle Park release area and associated waterway rehabilitation and revegetation works has the potential to enhance the habitat and amenity of the waterway and riparian areas.

WSUD Strategy objectives are listed in Table 5.1. These include:

- Water conservation target
  - 45% reduction on base case water consumption (exceeding minimum BASIX target for a 40% reduction on base case)
  - Stretch target of 60% if a reticulated non-potable (recycled) water supply is not available
  - Further stretch target of a 70+% reduction on the benchmarked water use is proposed if a reticulated non-potable (recycled) water supply is available for the site.
- Stormwater pollution control targets for
  - 55% reduction in mean annual load of Total Nitrogen,
  - 70% reduction in mean annual load of Total Phosphorus and
  - 85% reduction in mean annual load of Total Suspended Solids
- Flow management targets
  - Maintain 1.5 year ARI peak discharge to pre-development magnitude.
  - Stream Erosion Index [4] (SEI) of 2.
  - *Stretch target:* Stream Erosion Index target of 1 (limit the erosion potential of urban waterways to the pre-development erosion potential).

Flood Protection target

- Maintain 5 and 100 year ARI peak discharge to pre-development magnitude.

Riparian Corridor Management

- Provision of riparian corridors to meet the NSW Office of Water's requirements.

Wastewater Pollution Control Targets

- No dry weather sewer overflows
- Restrict wet weather sewer overflows to a maximum of 10 overflows each 10 years

Section 6 provides a detailed description of the site and outlines the proposed treatment elements and approach for both the WSUD strategy and waterway rehabilitation.

Section 7 outlines the components of the WSUD Strategy needed to meet the identified objectives. Potable water conservation options are discussed and their ability to meet the proposed potable water conservation targets and stretch targets is described. The provision of large rainwater tanks or a dual reticulation network (supplied with either treated waste water or harvested stormwater) can ensure the potable water target is met. The stretch target for potable water conservation where a dual reticulation network is provided can be achieved with the use of rainwater tanks for hot water demands – in addition to a non potable supply for toile flushing, irrigation and cold water for clothes washing.

The WSUD Strategy integrates stormwater treatment elements with the opportunities identified on the site, particularly in response to topography, catchment and waterway condition and existing vegetation. Rehabilitation works along the central Category 1 watercourse ('M') are to incorporate floodplain wetlands, improving stormwater quality, while providing riparian restoration. Bioretention areas are integrated with the stormwater detention basin design for multi-functional open spaces. The design of these basins can ensure that stormwater quality and flood mitigation targets are met in addition to creating interesting open spaces with high amenity value for the community.
Options for streetscape bioretention systems are described. These systems can be configured further improve water quality or to reduce the size of the treatment elements proposed in central basins and floodplain locations.

The flow management targets are achieved through the use of detention basins to maintain predevelopment peak flows for the 1 in 2 year – 1 in 100 year ARI storm events in addition to the use of WSUD elements that ensure post development peak flows are attenuated for smaller storm events (wetlands and bioretention systems with a capacity for approximately the 1 in 3 month ARI).

A separate flood study (GHD, May 2010) provides detail of the detention basin configuration to mitigate flooding risks.

The Menangle Park: Offsetting Strategy (GHD, May 2010) provides details of the NSW Office of Water's requirements in relation to riparian corridors for the site. The opportunities to enhance waterway condition are identified for each watercourse in Section 6. The WSUD strategy has aimed to integrate opportunities for stormwater management using vegetated systems with the objectives for revegetating the riparian corridors and enhancing the ecological and social values of these areas.

A discussion of maintenance costs and preliminary capital cost estimates for the WSUD elements proposed are discussed in Sections 8 & 9. These costs are intended to inform this phase of the development process and ensure that adequate funds are reserved for the implementation of the elements proposed in this strategy.

11 REFERENCES

Bio-Analysis, 2003 “Menangle Park Master Planning Project Aquatic Ecological Assessment” Prepared for Ecological Australia on behalf of Campbelltown City Council, October 2003.

Civitas Partnership, 2005 “Menangle Park Development Concept Background Report” prepared for Campbelltown City Council, April 2005.

Douglas Partners, 2004 “Report on Land Capability Study – the Menangle Park Urban Release Area” prepared for Campbelltown City Council and Landcom, August 2004.

Douglas Partners, 2009 “Review of Land Capability Study - Menangle Park Urban Release”. Letter report to Owen Burnie of APP Corporation dated 8 December 2009.

Ecological Engineering, 2002 “Menangle Park Release Area Water Cycle Management Options Report” prepared for Landcom and Campbelltown City Council, August 2002.

GHD, 2004 “Menangle Park Master Planning Project – Local Flood and Drainage Analysis: Q03/33 – Existing Drainage Environment Report” prepared for Campbelltown City Council, July 2004.

GHD, 2010, Menangle Park - Offsetting Strategy, May 2010

GHD, 2010, Menangle Park - Local Flooding and Stormwater Quantity Management (Detention), May 2010

HNCMA, 2006 “Hawkesbury-Nepean Catchment Action Plan 2007-2016” Hawkesbury-Nepean Catchment Management Authority, October 2006.

MG Planning, 2004 “Menangle Park Preliminary LES” prepared for the Menangle Park Project Control Group, September 2004.

Brookes and Wong, 2009 WSUD09 conference Paper – title:

DWE (2000). Water Management Act 2000. Guidelines for controlled activities. Riparian corridors. Department of Water and Energy

Harvest Scientific Services, 2010 “Mineral Resources of the Menangle Park Development Site - Review”, prepared for Landcom and Campbelltown City Council, January 2010

Healthy Rivers Commission, 2001. Statement of Joint Intent.

Heather Nesbitt Planning, 2010, ‘Menangle Park Social Assessment Report’

Landcom (2009 draft, 2010 draft final). Water Sensitive Urban Design (Books 1 – 4).