Western Sydney Parklands – Bungarribee Precinct

Huntingwood West WSUD Strategy

Employment Lands

September 2006

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Report for: *Landcom*

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Executive Summary

This report presents the Water Sensitive Urban Design (WSUD) strategy for the 56ha Huntingwood West site, addressing water conservation, pollution control and flow management. This strategy has been developed in collaboration with EDAW and Architectus, the Landscape Architects and Urban Designers for the project, to ensure that the WSUD elements proposed for the site have been designed to be integrated into the open space and built form.

The site is gently undulating to Eastern Creek with two ephemeral depressions draining the site. The site also drains a 20ha industrial development upstream, while the north-east corner of the site drains north across the Great Western Highway.

The industrial precinct will generate stormwater pollution as a result of high percentages of impervious surfaces and traffic volumes, and industrial practices that result in a wide range of pollutants types and concentrations entering the stormwater drainage system. Stormwater washoff from hard paved areas convey typical pollutants including litter, coarse, medium and fine sized suspended solids, nutrients, heavy metals, hydrocarbons, oil and grease. WSUD elements will be used to reduce pollutants carried from the Huntingwood West industrial precinct.

The WSUD strategy has been guided by a series of water management principles for the site derived from the provisions of state and local government planning policies, as well as responding to the site opportunities and constraints. The WSUD Strategy is centred on achieving the following outcomes:

- Potable mains water needs to be reduced through demand management including the installation of water efficient fixtures and using alternative sources of water based on matching water quality to uses on a "fit-for-purpose" basis.
- Stormwater runoff from the development as well as the 20ha catchment to the east of the development which flows through the site, is to current best practice water quality standards.
- Post-development storm discharges to equal pre-development storm discharges for the one and a half year ARI event, so as to minimise the impact of frequent events on the natural waterways and to minimise bed and bank erosion.
- Post-development storm discharges up to the 100 year ARI event need to be contained so as to minimise the impact of flood events on Eastern Creek. These targets can be met in conjunction with the downstream wetland adjacent to the site.

With end users (industry type) and likely water demands currently not known, it is not possible to develop and evaluate potable water conservation strategies. However, guiding principles for potable water conservation based on demand management and provision of alternative non-potable water sources apply.

While the stormwater quality targets could be met through either a series of bioretention systems or a constructed stormwater wetland, only a wetland system allows the site to meet each of the three stormwater related targets outlined above. A bioretention system requires other complementary measures to meet the flood attenuation targets. The proposed wetland improves water quality and also provides flood detention storage. The wetland consists of three zones – precinct parks with inlet ponds, a macrophyte zone, and ephemeral zones.

Hydrologic modelling indicates the total flood detention volume required is approximately 54,000 m^3, of which 34,000 m^3 is required to return the pre-developed 1.5 year ARI peak stormwater discharge. The footprint of the 3.5 ha wetland and associated 0.6 ha of precinct ponds have been configured to provide the required flood detention storage. Flood storage provided at the precinct ponds (wetland inlet zones) and ephemeral zones will be engaged first and this storage should be sufficient to attenuate the majority of events up to the 1.5 year ARI event to pre-development levels. For larger events, flood storage provided above the wetland macrophyte zones will be engaged. The wetland is the preferred stormwater strategy due to it:

- provides the highest flexibility in the final layout of the industrial precinct and thus accommodate other design considerations/requirements by the purchaser.
- overcomes the higher risk of damage to on-site measures (such as street-scale bioretention systems) in an industrial precinct (compared with residential precincts).
- is the most cost effective way to meet flood detention storage requirements.
- provides the potential to treat stormwater from the additional upstream catchment that drains through the site.
- is better integrated to the overall landscape design and provide a suitable interface between the parklands and the industrial precinct.

Incorporating the pre-developed 1.5 year ARI peak stormwater discharge storage into onsite detention (OSD) will reduce the requirement for centralised flood storage provision and thus the size of the wetland system. To contain the 1.5 year ARI peak discharge through OSD at each lot, the storage provision required is 750 m^3/ha impervious area.

The elements of the proposed WSUD Strategy include;

- Gross Pollutant Traps (GPTs) located within the site for initial pollutant reduction,
- A constructed wetland within the parklands as an interface with the Huntingwood West employment lands. The wetland improves water quality and provides flood detention storage. The macrophyte zone is a shallow body of water, heavily vegetated with water plants. The ephemeral zones are planted with species capable of withstanding short term inundation and long term drying.
- Attenuation of storm and flood events is integrated into the storage areas associated with the precinct ponds (within the site), and the macrophyte zone and ephemeral zones of the wetland (within the parklands). This provides geomorphic protection to the waterways downstream, by limiting discharge to pre-development flows for frequent storm events with high erosion potential.
- Bioretention system within the central median of the main entry road to treat stormwater discharged from the upstream catchment
- The option to include street-tree bioretention cells within the streetscape will further increase the capacity of the strategy to achieve stretch targets for stormwater quality treatment.
- Development of building design guidelines to ensure that pollution sourced from work areas does not enter into stormwater drains.
- Guiding principles for potable water conservation initiatives within the precinct

1 Introduction

Ecological Engineering has been engaged by Landcom to develop Water Sensitive Urban Design (WSUD) strategies for the key parcels of the Western Sydney Parklands – Bungarribee Precinct. These areas include the Doonside and Rooty Hill residential sites and the Huntingwood West employment zone.

The WSUD strategy developed for the 56 ha Huntingwood West site is presented in this report. This strategy has been developed in collaboration with EDAW and Architectus, the Landscape Architects and Urban Designers for the development. The WSUD elements proposed for the site have been designed to be integrated into the open space and built form, adding aesthetically and functionally to the design.

This strategy has been further informed by discussions with the Department of Planning, Landcom, Blacktown City Council, the project managers, and other consultants as required. The WSUD strategy is designed to integrate the site specific opportunities with the WSUD principles and objectives to deliver best practice water cycle management.

This report presents a WSUD Strategy for the Huntingwood West site with the aim of ensuring that water cycle management options are optimized for the site. The key sections of this report include:

- water management principles and objectives identified for the parklands through the *Sydney Regional Environmental Plan (SREP) 31 – Regional Parklands* and *Development Control Plan (DCP 1) – Interim Regional Parklands Management*, as well as Landcom's WSUD targets, and the provisions of Blacktown City Council's policies.
- Stormwater quality characteristics in relation to industrial precincts and the opportunity to use building guidelines for pollutant source control at the lot level.
- Water quality treatment measures that are recommended for the site, specifically outlining the function and typical configuration of bioretention central medians, constructed wetlands and street trees
- The details of the WSUD strategy developed for the site, explaining the combination of elements that will deliver the objectives outlined and opportunities identified through the creation of this strategy.
- Preliminary costing of elements proposed for Huntingwood West.
- Flood modelling and the integration of the required flood detention with the site layout and other WSUD elements.
- Potable water conservation measures including demand management and use alternative water sources to meet non potable demands – fit for purpose use of water.

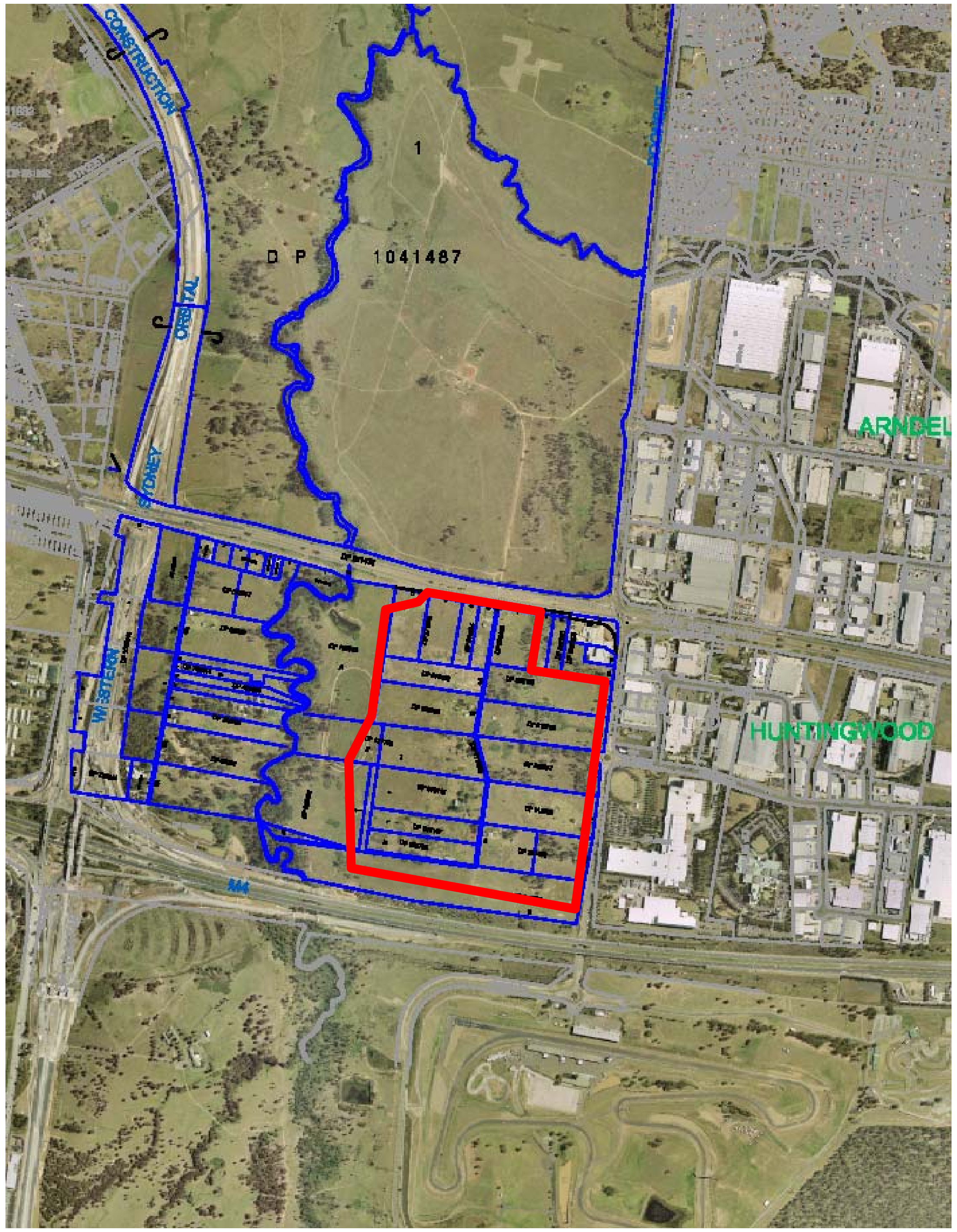

Figure 1.1: Aerial photo showing the Huntingwood West site, at the southern end of the Bungarribee Precinct. The Great Western Highway on the northern boundary, M4 and Eastern Creek International Raceway on the southern side. Whelans ref C607-001A.dwg, 19/9/2005

2 Water Management Principles and Objectives

Water management principles for the site are derived from the provisions of state and local government planning policies, as well as responding to the site opportunities and constraints. The following outlines the principles and objectives that have been established for the development.

2.1 Bungarribee Precinct Water Management Targets

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

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

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

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

2.2 Landcom Water Management Targets

Landcom's WSUD Policy includes objectives for water conservation, pollution control and mitigation of the effect of increased flow as a result of catchment urbanisation. The implementation of the WSUD policy aims to achieve the protection of aquatic ecosystems and water resources. The policy has been developed to provide Landcom development staff, its consultants and private sector partners with an overview of WSUD guiding principles and practices together with selection guidelines of suitable and appropriate WSUD practices. The specific WSUD targets within the policy are listed in Table 2.1.

Table 2.1 – Landcom's WSUD Targets

Objective	Performance Measure and Target
1. WSUD Strategy	(a) 100% of projects to have project-specific WSUD strategies.
2. Water Conservation	(a) Combination of water efficiency and reuse options, 40% reduction on base case.
3. Pollution Control	(a) 45% reduction in the mean annual load of Total Nitrogen (TN).
	(b) 45% reduction in the mean annual load of Total Phosphorus (TP).
	(c) 80% reduction in the mean annual load of Total Suspended Solids (TSS).
4. Flow Management	(a) Post-development storm discharges = pre-development storm discharges for one and a half years ARI event. The purpose of this is to minimise the impact of frequent events on the natural waterways and to minimise bed and bank erosion.

To complement the WSUD targets, Landcom's mandatory WSUD requirements are:

- All Landcom projects must have a project specific WSUD strategy developed appropriate to the size, scale and complexity of the project. The WSUD strategies must meet Landcom WSUD targets (related to objective 1).
- Priority must be given to the use of non-potable water sources for public domain irrigation within all Landcom projects (related to objective 2).
- Where reticulated recycled water is available from the local water utility, it must be used for appropriately matched uses such as toilet flushing, garden watering etc. (related to objective 2).

2.3 Blacktown Council DCP Water Management Targets

Blacktown City Councils (2000a and 2000b) Policies "Stormwater Quality Control" and "Stormwater Quality Control Policy Background Information and Guidelines for Application" are aimed at implementing the council's objectives for new development as listed in the Stormwater Management Plans for the area. The Policy applies to commercial areas, residential developments, and industrial developments greater than 1000m^2.

The policy sets both quantitative and qualitative objectives, and establishes a priority hierarchy for prioritising pollutants (hydrocarbons, litter, coarse sediments, fine sediments, and nutrients) based on the different types of development (industrial, commercial, residential etc). The policy establishes treatable flow volumes, requires modelling for larger catchments, and promotes a treatment train approach where critical pollutants are targeted for removal with a combination of appropriate treatment measures. For sites greater then 5 ha, other then residential developments, the policy requires the development of Stormwater Management Plan to be submitted as part of the development application.

Appropriate targets for the site include:

- Gross pollutants: 90% total annual load
- Coarse sediment: 80% total annual load
- Fine sediment: 50% total annual load
- Nutrients: 45% total annual load
- Hydrocarbons, oil & grease: 90% total annual load, total hydrocarbons < 10 mg/L

In addition to the pollution retention criteria listed above, there are qualitative operational objectives for new developments that have been adapted from the WSUD-Technical Guidelines for Western Sydney, 2004 and include:

- Limiting the direct connection between impervious areas and the stormwater drainage system and using vegetated flow paths where possible
- Maximising reuse of stormwater for non potable demands
- Infiltrating stormwater 'at source' where soil types allow
- Protecting natural wetlands, watercourses and riparian corridors and protecting drainage channels with base flow, defined bed or banks, or native riparian vegetation.
- Maintaining natural flow paths, discharge points and runoff volumes. The frequency of the bank-full flows should not increase as a result of development. Generally, no increase in the 2 year and 100 year ARI peak flows.
- Compatible multiple use of stormwater facilities
- No adverse impacts from stormwater discharging to urban bushland areas.

2.4 DCP Controls for Huntingwood West

Based on the objectives identified in the above planning controls the following DCP provisions are recommended to be adopted for the Huntingwood West development.

2.4.1 Objectives

- Stormwater runoff from the development as well as the 20ha catchment to the east of the development which flows through the site, is to meet the following pollution reduction targets which can be met in conjunction with the proposed downstream wetland adjacent to the site.
  a. total suspended solids – 80% reduction in the average annual load from that typically generated from an urban catchment
  b. total phosphorous (TP) and total nitrogen (TN) – 45% reduction in the average annual load from that typically generated from an urban catchment.
  c. litter and gross pollutants will be removed from stormwater leaving the site.
  d. Hydrocarbons, oil & grease: 90% total annual load, total hydrocarbon discharge < 10 mg/L
- Post-development storm discharges to equal pre-development storm discharges for the one and a half year ARI event, so as to minimise the impact of frequent events on the natural waterways and to minimise bed and bank erosion.
- Post-development storm discharges up to the 100 year ARI event need to be contained so as to minimise the impact of flood events on Eastern Creek. These targets can be met in conjunction with the downstream wetland adjacent to the site.
- Potable mains water needs to be reduced through demand management including the installation of water efficient fixtures and using alternative sources of water based on matching water quality to uses on a "fit-for-purpose" basis.
- Investigate the potential of using alternative water sources including wastewater and stormwater to meet non potable demands on the site.
- Where reticulated recycled water is available from the local water utility, it must be used for appropriately matched uses such as toilet flushing, garden watering etc.
- Avoid adverse impacts due to soil salinity.

2.4.2 Source controls

a. Stormwater quality controls to meet the development objectives can include gross pollutant traps, bioretention systems, rain gardens and wetlands. These systems can be located as discrete individual elements, as larger regional elements, or a combination therein. Modelling at the detailed design stage should determine appropriate size and location in conjunction with the downstream wetland. All WSUD elements should minimise any potential impact on sodic soils.

b. Pollution sourced from work areas is to be prevented from entering the stormwater system and thereby the downstream environment by roofing work areas, directing wash-down to storage (which is subsequently pumped out as industrial waste) or sewer and controlling activities undertaken in areas connected to stormwater drains.

2.4.3 Downstream controls

a. The precinct ponds (within the site), and the wetland (within the parklands) will provide sufficient flood storage so that the one and a half year ARI event equals the pre-development one and a half year ARI event. For the wetland storage is provided in both the ephemeral wetland zones and the extended detention of the macrophyte zone

b. A wetland adjacent to the development can be used to assist the development attaining stormwater quality objectives and retardation of the flows up to the 100 year ARI event. If this wetland is not constructed, the objectives need to be met within the development.

2.4.4 Minor and major drainage controls

The drainage system is to consist of the following components:

a. Minor drainage system – Pipe and street system able to convey runoff safely through the development up to the 20 year ARI storm.

b. Major drainage system – Overland flow paths must be designed to convey the 100 year ARI flows.

c. Combined detention / wetlands to provide necessary quantity/quality controls whilst being able to cope with 100 year ARI flows.

2.4.5 Potable water controls

a. A water balance should be undertaken to ascertain water consumption and stormwater harvesting potential within the development.

b. Where feasible, the development should use collected rainwater for toilet flushing.

c. Priority shall be given to the use of non-potable water sources for public domain irrigation

d. Developments that consume high volumes of water in their operation shall incorporate recycling initiatives in the plant's operation to reduce the demand on water.

e. The following water saving devices are to be installed through the development:
   - 6/3 litre dual flush toilets, waterless urinals, at least AAA water efficiency ratings for all staff amenity appliances and aerators fitted to hot and cold water taps over basins and sinks in staff amenity areas.

The WSUD strategy for Huntingwood West is guided by the objectives outlined above.

3 Stormwater Management Strategy for Huntingwood West

Improving stormwater quality prior to discharge into Eastern Creek is an essential stormwater management objective. Stormwater pollution in industrial precincts is associated with typically high percentages of impervious surfaces and traffic volumes, and industrial practices that result in a wide range of pollutants types and concentrations entering the stormwater drainage system. Stormwater washoff from hard paved areas convey typical pollutants including litter, coarse, medium and fine sized suspended solids, nutrients, heavy metals, hydrocarbons, oil and grease. WSUD elements can be used to reduce pollutants carried from the Huntingwood West industrial precinct.

Stormwater treatment elements include gross pollutant traps, bioretention systems, swales and wetlands. These systems can be located as discrete individual elements, as larger regional elements, or a combination therein. These stormwater management features can be readily incorporated into the landscape and streetscape design of the industrial precinct and the adjoining parkland. The optimal configuration of WSUD elements is typically a combination of these alternatives, with the detail of a strategy for a particular site determined in collaboration with the landscape and urban design teams.

Stormwater modelling was undertaken using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC), to determine the approximate size of the treatment elements. The model used eleven years (1967 – 1977) of 6 minute rainfall data from the Liverpool Bureau of Meteorology station which has a mean annual rainfall of 857 mm/yr and mean annual potential evapo-transpiration of 1496mm/yr. This station has rainfall comparable with the daily data available from the Prospect Dam Bureau of Meteorology station which has a mean annual rainfall of 866 mm/yr (120 year record from 1887).

3.1 Preferred Stormwater Management Strategy

The preferred stormwater management strategy for the Huntingwood West Industrial Precinct is centred on achieving the following outcomes:

- Stormwater runoff from the development as well as the 20ha catchment to the east of the development which flows through the site, is to current best practice water quality standards.
- Post-development storm discharges to equal pre-development storm discharges for the one and a half year ARI event, so as to minimise the impact of frequent events on the natural waterways and to minimise bed and bank erosion.
- Post-development storm discharges up to the 100 year ARI event need to be contained so as to minimise the impact of flood events on Eastern Creek. These targets can be met in conjunction with the downstream wetland adjacent to the site.

While the stormwater quality targets could be met through either a series of bioretention systems or a constructed stormwater wetland, only a wetland system allows the site to meet each of the three outcomes outlined above. A bioretention system requires other complementary measures to meet the flood attenuation targets.

The wetland is the preferred stormwater strategy due to the following reasons:

- provides the highest flexibility in the final layout of the industrial precinct and thus accommodate other design considerations/requirements by the purchaser;
- overcomes the higher risk of damage to on-site measures (such as street-scale bioretention systems) in an industrial precinct (compared with residential precincts);
- is the most cost effective way to meet flood detention storage requirements (see further discussion below).
- provides the potential to treat stormwater from the additional up stream catchment that drains through the site.
- is better integrated to the overall landscape design and provides a suitable interface between the parklands and the industrial precinct.

The elements of the preferred wetland strategy are shown in Figure 3.1 and include;

- Gross Pollutant Traps (GPTs) for initial pollutant reduction (located underground, adjacent to precinct pond)
- a constructed wetland as an interface between the parklands and the Huntingwood West employment lands. The wetland improves water quality and provides flood detention storage. The wetland consists of three zones – precinct parks with inlet ponds, a macrophyte zone, and ephemeral zones. The macrophyte and ephemeral zones are located within the parkland.
- bioretention system within the central median to treat stormwater discharged from the upstream catchment
- the option to include street-tree bioretention cells within the streetscape will further increase the capacity of the strategy to achieve stretch targets for stormwater quality treatment.

Flood storage provided at the precinct ponds (wetland inlet zones) and ephemeral zones will be engaged first and this storage should be sufficient to attenuate the majority of events up to the 1.5 year ARI event to pre-development levels. For larger events, flood storage provided above the wetland macrophyte zones will be engaged. Careful design is required to protect the structural integrity of the various wetland elements.

Hydrologic modelling indicates the total flood detention volume required is approximately 54,000 m^3, of which 34,000 m^3 is required to return the pre-developed 1.5 year ARI peak stormwater discharge. The proposed footprint of the wetland has been configured to provide the required flood detention storage, with the component required for events up to the 2 year ARI being provided at the precinct ponds/inlet zones and the ephemeral zones of the wetland.

Incorporating the pre-developed 1.5 year ARI peak stormwater discharge storage into onsite detention (OSD) will reduce the flood storage provision and thus the size of the wetland system. This would require an OSD provision for each lot with the current notional OSD requirement being 750 m^3/ha impervious area. Further details are given in Section 5.

Figure 3.1 –
WSUD elements for Huntingwood West, overall site layout

- the wetland (marcophyte and ephemeral zones) as an interface between the parklands and the Huntingwood West Employment lands,
- the central median which will be used to treat stormwater from the upstream industrial catchment and
- the precinct ponds which incorporate inlet zones for the wetland and detention for geomorphic protection

3.2 Constructed Wetlands

The preferred stormwater management strategy for the 56 ha Huntingwood West industrial precinct is a treatment train consisting of gross pollutant traps (GPTs) and a constructed wetland. The GPTs would be effective in reducing the suspended solids load by 70% and phosphorus by approximately 35%. Downstream of the GPTs the wetland has been sized to meet best practice water quality targets as well as flood attenuation requirements. The precinct ponds/ inlet zones are located within the site. The wetland is located in the parklands and comprises three zones;

1. precinct ponds / inlet zone (0.6 ha) – where heavier sediments (> 0.125 mm) are removed from the water column prior to the stormwater entering the wetland macrophyte zone.
2. macrophyte (marsh) zone (1.5ha) – to provide a low velocity environment where the smaller suspended particles settle out of suspension or adhere to the vegetation. Soluble pollutants such as nutrients may be adsorbed onto the surfaces of suspended solids and entrained within the wetland sediments, or biologically absorbed by the epiphytic biofilms present upon the macrophytes or by the macrophytes themselves.
3. ephemeral zone (2.0 ha) – primarily used for flood detention but will also contribute to the treatment of stormwater quality

The configuration of a wetland can vary however the preferred ratio of length to width is between 1:4 and 1:10. Where wetland cells have irregular shapes it is suggested that the flow direction and conditions in the wetlands are regulated by berms placed in the wetland.

The configuration of the precinct ponds/inlet zones has been designed to balance flood detention requirements, sustainable wetland function and developable area. These are located within the industrial precinct and are connected to both the macrophyte and ephemeral zones. The stormwater network for the site will discharge collected water to a GPT and then into the precinct ponds. Stormwater inflow to this inlet zone is preferentially directed into the macrophyte zone for water quality treatment for normal storm events, and into the ephemeral zone when the macrophyte zone reaches its extended detention depth. This mode of operation prioritises water quality treatment before excess flow is diverted for further flood detention to limit flows to predevelopment levels for up to the two year ARI storm. This operation is considered essential in protect the water quality and waterway geomorphic form of Eastern Creek. For the 100 year ARI, the wetland will be submerged, and the entire footprint used for flood storage.

The macrophyte (marsh) zone is designed with a permanent pool with an average depth of 0.3m, with provision for extended detention of 0.5m and a notional detention period of 72 hours. Figure 3.2 illustrates the macrophyte zone of the wetland and the adjacent precinct pond/inlet zones and ephemeral zones at the northern and southern sections of the proposed wetland.

Stormwater diverted into the macrophyte zone will pass through a sequence of densely vegetated areas of varying depth before being discharged to Eastern Creek. The macrophyte zone of the wetland will have 0.5 m extended detention (the water quality detention depth) and drain via a riser over 72 hours.

Stormwater will spill into the ephemeral zones via bypass weirs when the depth of inundation in the macrophyte zone is at its design water quality treatment detention depth. The ephemeral zones will drain via pipes to Eastern Creek at such a rate as to preserve the predevelopment 1.5 year ARI discharge from the site and catchment.

The peak inundation level in the inlet zone and ephemeral zone for the 1.5 year ARI event is estimated to be the same as the top of the extended detention level in the macrophyte zone. Storm events larger than the 1.5 year ARI event and up to the 100 year event will fully engage the wetland as a single detention storage unit. For the 100 year event, the maximum depth of inundation above the permanent pool level of the wetland is estimated to be one metre. The wetland storage will drain via a number of pits that will maintain the peak 100 year ARI 36 hour discharge from the existing catchment. The duration of inundation at these levels will be short (hours) with the pits rapidly draining the wetland storage to minimise inundation beyond the water quality detention depth.

Images of wetlands in both urban environments and more natural parkland areas are shown in Figure 3.5.

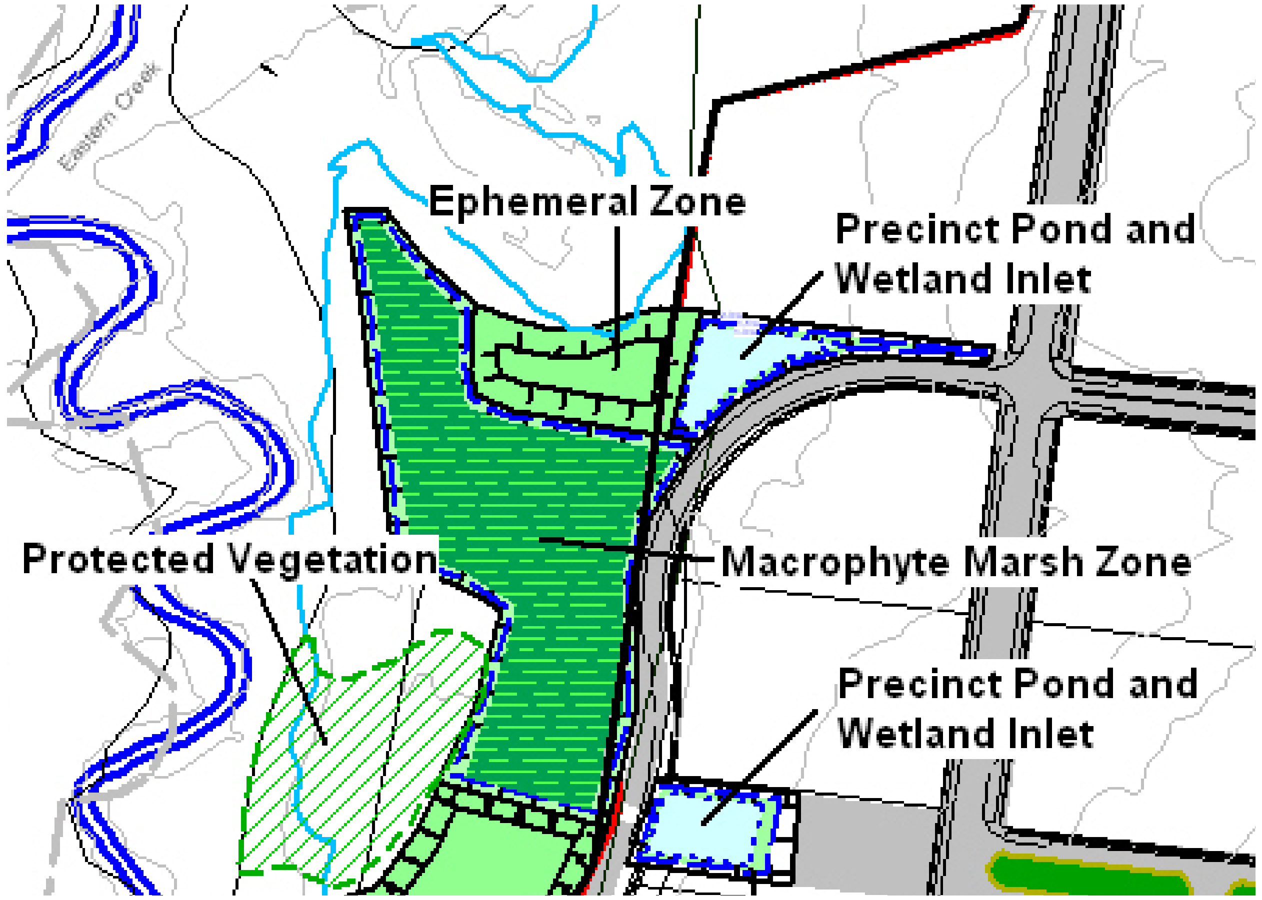

Figure 3.2: Wetland and precinct areas. Operational details are discussed in section 4.

3.2.1 Wetland Vegetation for Huntingwood West

The full details of the plant species to be planted in the various wetland zones are provided in Appendix A, Table 2. Figures 3.3 and 3.4 gives an overview of suitable plants for each of the wetland zones. The selection of plant species is based upon Shale-Plains Woodland and Alluvial Woodland ecological communities as present within the Bungarribee Precinct.

The inlet zone will be planted with a range of ephemeral marsh and low profile terrestrial plant species to provide protection from erosion.

The macrophyte zone is a shallow body of water that will be heavily vegetated with emergent and submerged macrophytes (water plants). The macrophytes will be planted in a series of bands corresponding to the depth profiles of the shallow marsh, marsh, deep marsh and submerged marsh zones (Figure 3.4). This will ensure that uniform flow conditions across the wetland are achieved. The macrophyte species have been purpose selected for the stormwater treatment wetland, with consideration given to the hydrologic conditions expected within the wetland.

The ephemeral zones will be planted as a lateral Melaleuca wetland with a range of plant species that are capable of withstanding short term inundation and long term drying. The species selected for this zone are typically found growing in riparian zones within Alluvial Woodland ecological communities.

Figure 3.3: Examples of planting species and wetland areas.

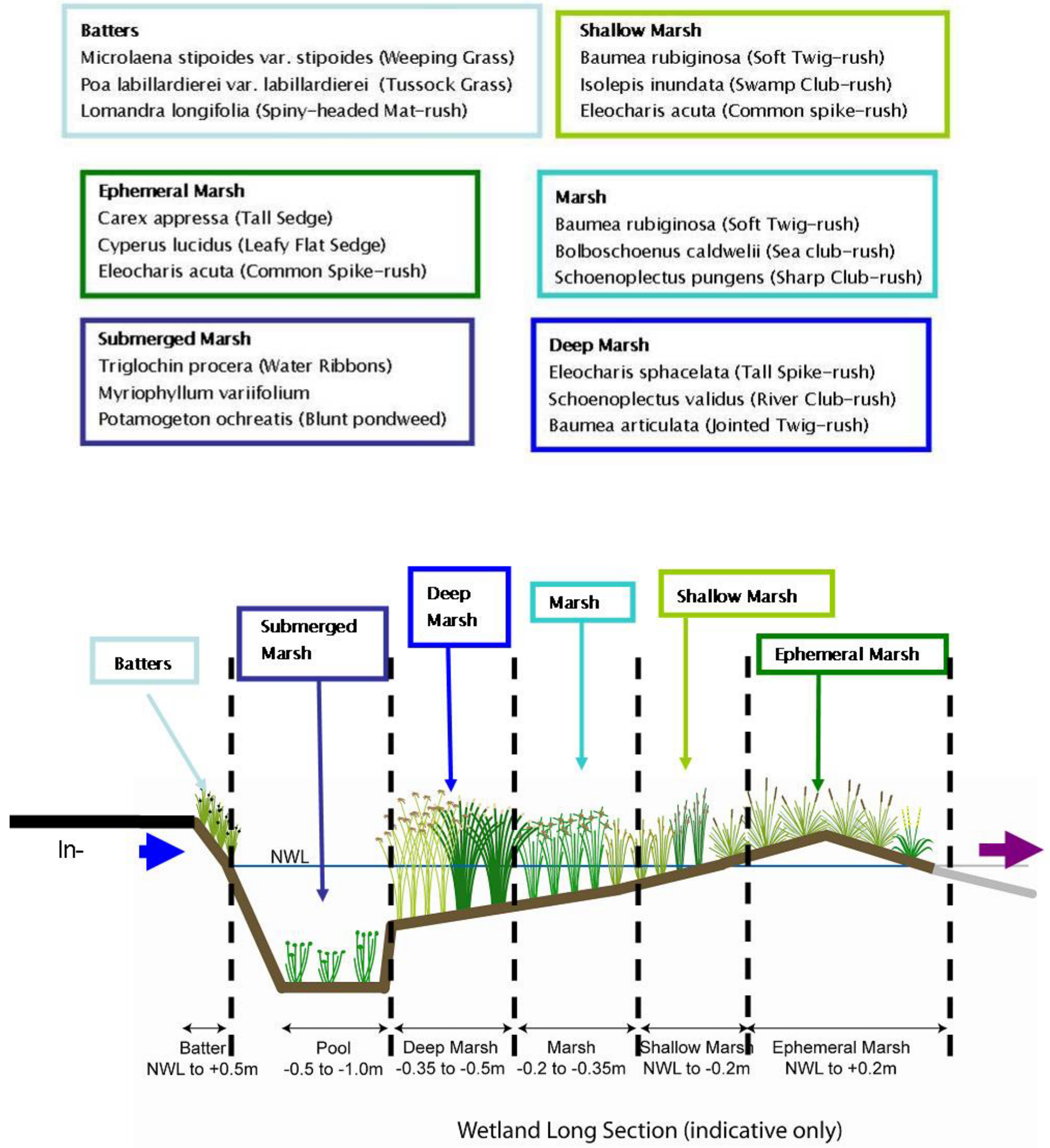

Figure 3.4: Indicative species planting for macrophyte zone of the wetland.

3.2.2 Costing of wetland and precinct parks

Cost estimates for the wetland are based on similar projects and from the MUSIC User Manual (Taylor 2005). The estimated costs for the wetland, GPTs and precinct ponds are shown in Table 3.6. More detailed costing can be done in association with detailed design of the wetland.

The costing below is itemised for:

- 1.5 ha macrophyte wetland area providing best practice water quality for stormwater runoff from the site
- 2.0 ha ephemeral wetland area essential for detention of small storm events to provide geomorphic protection as well as flood storage for extreme events
- 0.6 ha in total of the two precinct ponds which act as inlet ponds for the wetland and integrate with the ephemeral wetland detention storages
- gross pollutant traps for additional stormwater quality and litter control.

Table 3.1 – Costing of stormwater quality wetland and flood detention storage elements

Wetland Area: 1.5 ha	Estimated Cost	Cost range (Low – High Estimate)
Total Acquisition Cost [1]	$825,000	$600,000 – $1,500,000
Annual Maintenance Costs [2]	$17,000	$6,000 – $50,000
Annualised Life Cycle Cost [3]	$23,000	
Ephemeral Wetland Area: 2.0 ha		
Total Acquisition Cost	$880,000	$600,000 – $1,850,000
Annual Maintenance Costs	$30,000	$8,000 – $70,000
Annualised Life Cycle Cost	$30,000	
Precinct Ponds/inlet zones [4]: 0.6 ha		
Total Acquisition Cost	$750,000	$500,000 – $1,000,000
Annual Maintenance Costs	$15,000	$10,000 – $25,000
Annualised Life Cycle Cost	$25,000	
Gross Pollutant Traps [5]		
Total Acquisition Cost	$120,000	$30,000 – $150,000
Annual Maintenance Costs	$15,000	$5,000 – $30,000
Annualised Life Cycle Cost	$8,000	
TOTAL		
Total Acquisition Cost	$2.6 million	
Annual Maintenance Costs	$77,000	
Annualised Life Cycle Cost	$86,000	

Note[1]: The total acquisition cost includes preliminary feasibility studies, design costs, construction and overhead costs. GST is not included.

Note[2]: Annual maintenance costs are typically 2% of design and construction costs for first few years, then 1%. Corrective maintenance every 10 years: ~5% of construction cost. The cost of vegetation establishment over the first two years is estimated at $10,000/ha/yr. Ongoing maintenance of the plants is estimated at $4,000/ha/yr

Note[3]: 50 yr analysis, real discount rate of 5.5% and annual inflation rate of 2%.

Note[4]: The precinct ponds/parks are designed to provide flood detention for up to the two year ARI for geomorphic protection. The cost is particularly depended on the cost of engineering structures for inlet and outlet flow control, landscape design and vegetation selection that will be confirmed through detailed design. The maintenance and renewal costs are particularly difficult to estimate, given the range of values reported for various sites.

Note[5]: GPTs are required, to address runoff from the catchment. Replacement required after approximately 25 yrs.

The cost components within the development and within the parkland are tabulated below. The cost of the bioretention central median is also located within the Huntingwood West site and is detailed in section 3.3, Table 3.3.

Table 3.2 – Costing of stormwater quality wetland and flood detention storage elements

	Estimated Costs within Parkland	Estimated Costs within Huntingwood West Development
Wetland Area: 1.5 ha	$825,000	
Ephemeral Wetland Area: 2.0 ha	$880,000	
Precinct Ponds/Parks : 0.6 ha		$750,000
3 x Gross Pollutant Traps		$120,000
Total Acquisition Cost	**$1,705,000**	**$870,000**
Total Annual Maintenance Costs	$47,000	$30,000
Annualised Life Cycle Cost	$53,000	$33,000

Figure 3.5a: Wetland at Woolworths Industrial estate Wyong (Industrial / Forest edge)
NB photo is shortly after planting

Figure 3.5c: Wetland at Coomera Waters Brisbane (Parkland edge)

Figure 3.5b: Wetland at Melbourne Docklands (Urban edge)

Figure 3.5d: Wetland at Waitangi Park NZ (Urban edge)

3.3 Bioretention Systems

Bioretention systems can be designed as street trees, rain gardens or linear bioretention systems to integrate with the landscape design. A schematic cross section of a bioretention system is illustrated in Figure 3.6, in which stormwater is designed to pond to a depth of approximately 0.2m, then filter through the soil media to a sandy drainage layer where it is collected in perforated pipes and can be directed to a storage tank or discharged to the stormwater system and downstream environment.

Bioretention systems provide water quality treatment by filtering stormwater through vegetated soil media. Ponding above the bioretention system enables a larger proportion of the stormwater volume to be treated. The bioretention area is defined as the area of the base of the bioretention system and does not include the batter slopes which are required to provide the extended detention depth. A central median bioretention system, from Landcom's Victoria Park development, is illustrated in Figure 3.7b.

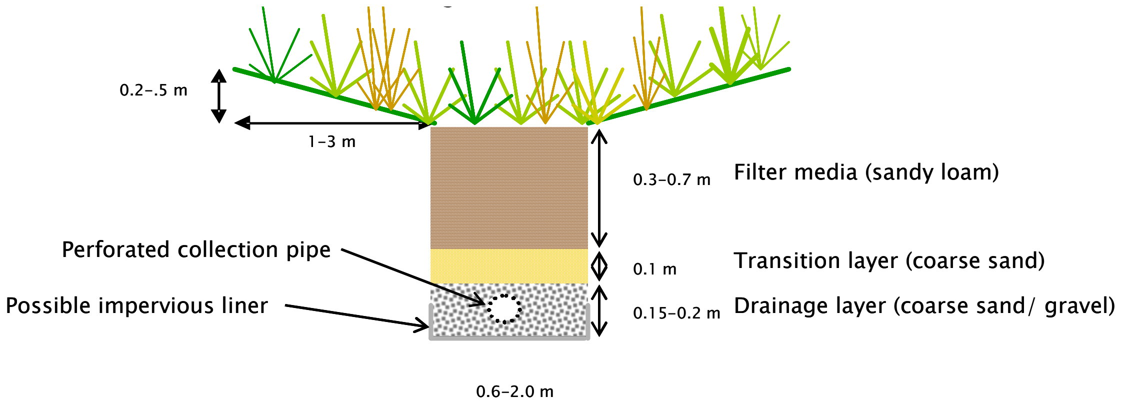

Figure 3.6 – Cross section of a bioretention system

For Huntingwood West, a central median bioretention system is proposed to treat stormwater from the upstream external 20ha industrial area. The modelling shows that a bioretention system area of 2,000m^2, with a detention depth of 0.2 m, will deliver the required water quality treatment. The soil filter depth is 0.6m, and the soil filter has a mean particle size 0.5mm (sandy loam filter media), and a saturated hydraulic conductivity 100 mm/hr. Where the extended detention is limited to 0.1m, the area required is 2,300m^2. Figure 3.7a shows the integration of the bioretention median with the landscape design for the major entrance road to the Huntingwood West site. The bioretention elements are alternated with landscaping vegetation for visual effect. A cross section of the central median is shown in Figure 3.8.

The bioretention elements that are to be contained within the central median have a combined area of 2000m^2. The planted area covers approximately 7000m^2 (including the bioretention area) as the length of the central median is approximately 450m and proposed width 15m. The total length including road intersections is 600m. The costing is particularly dependent on the landscape selection and vegetation costs.

Cost estimates for the proposed bioretention system are provided in Table 3.3 for the system based on a bioretention area of 2000m^2 using a combination of the cost/size relationships available through the life cycle costing module of MUSIC and a preliminary assessment of specific structures that may be required. A more refined cost estimate will be developed as part of the detailed design of the project and should be informed by the proposed road layout, the location of the stormwater drainage network, connections between bioretention cells and the designed road cross fall.

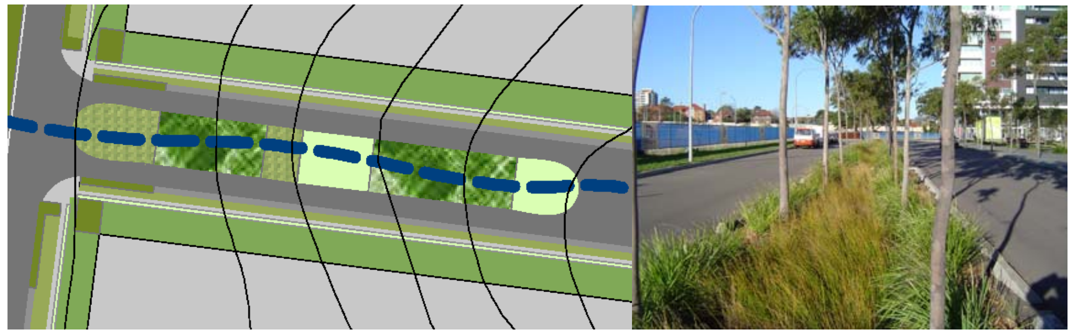

Figure 3.7a Bioretention elements and alternate vegetation / turf for the central median providing water quality treatment of the upstream external catchment.

Figure 3.7b Central median bioretention system, Victoria Park, Sydney

Table 3.3– Life Cycle Costing of bioretention/landscaped central median

Bioretention Area: 2,000m^2	Estimated Cost
Total Acquisition Cost [1]	$260,000
Annual Maintenance Costs [2]	$9,000
Annualised Life Cycle Cost [3]	$8,500
Other vegetation: 5,000m^2	
Total Acquisition Cost	$170,000
Annual Maintenance Costs	$5,000
Annualised Life Cycle Cost	$5,000
TOTAL	
Total Acquisition Cost	$430,000
Annual Maintenance Costs	$14,000
Annualised Life Cycle Cost	$13,000

Note[1]: The total acquisition cost includes preliminary feasibility studies, design costs, construction and overhead costs. GST is not included. The estimated range of acquisition cost for a bioretention system of this size is between $60,000 and $350,000 as per life cycle costing element of MUSIC, collating available costing information from Australia in 2003-04.

Note[2]: Annual maintenance costs for particular systems are highly dependent on available budget and management practices. The cost of replanting approximately 50% of the system every 5 years: $25,000 for landscaped vegetation, $10,000 for bioretention vegetation.

Note[3]: 50 yr analysis, real discount rate of 5.5% and annual inflation rate of 2%.

3.3.1 Bioretention Vegetation for Huntingwood West

Ecological communities present within the Bungarribee Precinct include Shale-Plains Woodland and Alluvial Woodland. The plant species selected for the bioretention system are primarily based upon the Alluvial Woodland (Sydney Coastal River Flat Forest). The vegetation prevents erosion and maintains the porosity of the system by continuously breaking up the filter media through plant growth. The root systems also provide sites for biofilms (fungi and bacteria) that absorb and transform pollutants.

A list of indicative plant species that are suitable for planting in the bioretention system is provided in Table 3.4. Several of the shrub species recommended for planting along the wetland batters would also be suitable for the bioretention system (See Appendix 1, Table 2 for the recommended wetland planting).

Table 3.4 – Recommended plant species for bioretention systems at Huntingwood West.

Austrostipa verticillata	Slender bamboo grass
Carex appressa	Tall sedge
Dianella longifolia	
Dianella revoluta	Blue flax-lily
Lomandra longifolia	Spiny-headed matt rush
Lomandra multiflora	Many-flowered matt-rush
Poa labillardierei	Tussock grass
Themeda australis	Kangaroo grass

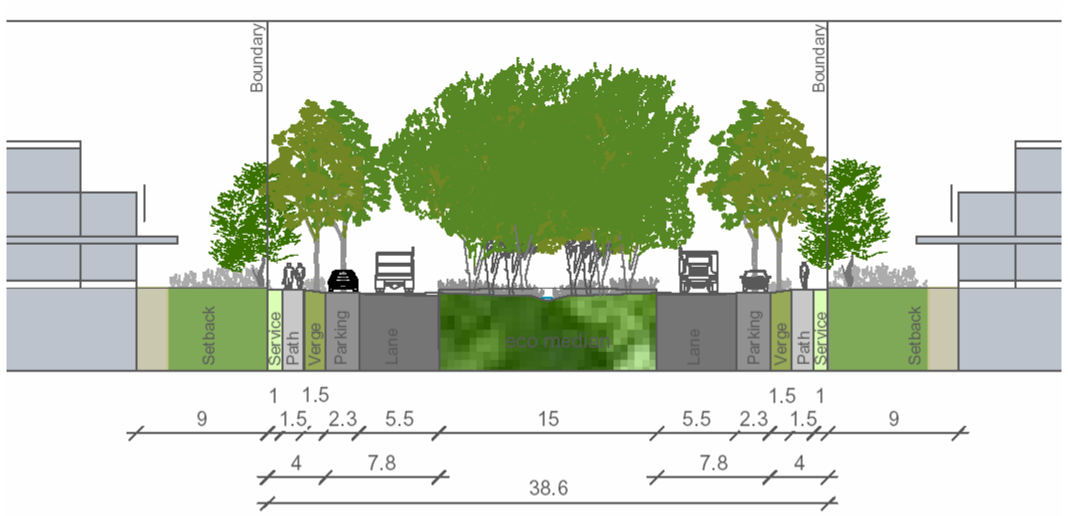

Figure 3.8 – Cross section of the entrance road with central median bioretention system

3.3.2 Street tree bioretention systems

Where street trees are desired within the road reserves of the industrial precinct, stormwater quality treatment functionality can be incorporated into the landscape design. Bioretention street trees are commonly used to treat road runoff with stormwater diverted from the gutter to a street tree pit that is either flush with or lower than the road (Figure 3.9).

The integration of street trees in industrial precincts can be difficult to plan and design for as the layout of lot entrances can change prior to the building construction with driveways and suitable locations for trees conflicting. The spacing between street trees and the size of the filter area provided for each tree is bioretention street trees is related to the road area or impervious area directed to the tree.

The WSUD strategy proposed to meet best practice stormwater quality objectives for the Huntingwood West site does not rely upon the construction of street trees. Where these systems are constructed, the stormwater quality will be improved further, bringing additional benefits to the downstream environment.

Street trees at Docklands in Melbourne

Construction of a planter tree in Sydney (Kings Cross)

Figure 3.9: Street tree pits in built up urban areas in Melbourne and Sydney (Ecological Engineering).

3.3.3 Road side bioretention systems / swale

Where road side bioretention systems or swales are desired, stormwater quality treatment functionality can be incorporated into the landscape design. Speccifically, the opportunity exists for a 'bio-swale' or other road side treatment adjacent to the park edge road. Through the detailed design process further opportunities may be identified to integrate treatment requirements with the proposed landscape design. The location and connections for a swale are also dependent on the configuration of stormwater infrastructure and requirements for particular edge treatments.

The WSUD strategy proposed to meet best practice stormwater quality objectives for the Huntingwood West site does not rely upon the construction of road side bioretention systems or swales. The integration of such measures, in line with the landscape vision, should be considered through detailed design to compliment or supplement the treatment achieved through the proposed stormwater wetland.

4 Stormwater Quantity Management at Huntingwood West

With increased impervious areas associated with the proposed development, the volume and rate of stormwater runoff will increase. Provision of stormwater drainage infrastructure will include an underground stormwater pipe system to cater for frequent storms and overland flow paths for conveyance of large events up to, and including, the 100 year Average Recurrence Interval (ARI) event. Attenuation of increased flows is required to protect the geomorphic form of the low flow channel of Eastern Creek, and prevent worsened downstream flooding.

Based on Landcom and Council requirements for stormwater flow management, storages must be sized and configured to:

- Return peak discharge from the developed catchment in a 1.5 year event back to predevelopment peak flow from the catchment in accordance with Landcom's WSUD objectives.
- Ensure no increase in the frequency of bank full flows in Eastern Creek, generally the 2 year and 100 year ARI peak flows from the site in accordance with Blacktown City Council's stormwater policy.
- Ensure no adverse interaction between the 100 year ARI hydrograph from the site and the Eastern Creek flood hydrograph.

To meet these conditions, stormwater can be managed within a regional facility, or in combination with on site detention (OSD) within each of the allotments.

The regional facility will comprise precinct ponds, ephemeral zones and macrophyte zones to restore predevelopment 1.5 year flows, as demonstrated by design 1 and 2 year ARI events flows. Additional flood detention within the proposed wetland will provide storage to ensure no adverse interaction between the 100 year ARI hydrograph from the site and the Eastern Creek flood hydrograph. At present the wetland footprint has been selected to maintain the existing peak 100 year ARI discharge in Eastern Creek and thus provide an upper estimate of the required storage. This requirement can be further refined during the design phase of the project.

Alternatively, OSD could provide the required storage up to the 1 and 2 year event, with exceeding flows up to the 100 year event being managed through the regional wetland.

4.1 Existing Catchment and Proposed Development

The proposed development will replace approximately 56 ha of rural lands with an industrial employment precinct. The landuse on the site is presently agricultural and drains to Eastern Creek. The natural predevelopment flow paths of the catchment have been altered by an underground drainage network and intersecting roads.

Approximately 20 ha of industrial lands external to the site, drain through the site via minor drainage networks. Some part of the external catchment is controlled by a retarding basin. Some overland flow from the upstream catchment will also enter the site via the entrance road into the site off Brabham Drive. At present, other areas of the catchment now drain away from the site along Brabham Drive. The entrance road appears to be the most logical pathway for overland flow from the external catchments east of the site and Council has suggested that modification of the vertical alignment of Brahham Drive may enable overland flow from a larger proportion of the external catchment to be directed towards this road. In the design of the entrance road, it will be necessary to ensure adequate provision is made to convey the 20 ha external catchment to the east of the site.

The proposed development will feature pipe networks, overland flow paths along roads, flood detention storages and stormwater quality treatment facilities. The major entrance to the site (off Brabham Drive) runs west along a minor ridge. This entrance road will feature a bioretention swale and will convey runoff from the upstream catchment during frequent storms events.

Detention storage will be required prior to discharge to Eastern Creek as discussed in section 4.4. Subject to detailed assessment, it is desirable that the capacity of detention storage provided include provision for the external catchment.

Preliminary hydrologic modeling has been undertaken to size the stormwater detention structures and is discussed in the following section.

4.2 Hydrologic Model Set Up

Hydrologic modelling was undertaken to size stormwater detention structures using the flood estimation software RORB. RORB is a runoff and routing program developed at Monash University, Australia to calculate flood hydrographs from design rainfall patterns, loss and run-off processes, catchment storage and channel network routing, and has been developed in line with Australian Rainfall and Runoff for applications across Australia. The model can also be used to investigate storage and discharge configurations to design retarding basins.

RORB models were developed for the following development conditions:

- the pre developed catchment, which assumes the entire catchment is in a relatively natural condition with drainage paths following the natural surface contours,
- the existing catchment with the subject site in a rural condition and industrial development in the catchment east of Brabham Drive; and
- the developed catchment incorporating the proposed Huntingwood West development.

4.2.1 Catchment Delineation and RORB Model Structure

Discretisation of the catchment into sub-catchments and slope calculations were performed using Council's 2 metre interval contour set. The model structure was determined referring to feature survey of the site, the existing and proposed road network and Council's underground pipe network.

The structure of the three models differs, reflecting the changes to site topography and drainage under the three development conditions. The pre developed and existing catchment RORB model layout is presented in Figure 4.1 and the developed RORB model layout is presented in Figure 4.2.

Areas of the predevelopment catchment that now drain away from the site were identified.

Under the existing development condition, the industrial catchment to the west of the proposed development drains onto the site via culverts and a low point in Brabham Drive. It is anticipated that flows within the culverts will be drained through the site, but overland flows will be directed north along Brabham Drive and then east via a reserve adjacent to the Great Western Highway.

Flows draining to Eastern Creek, were routed north to the Great Western Highway, which was selected as the coincident location to compare flows rates from the catchment under the different development conditions.

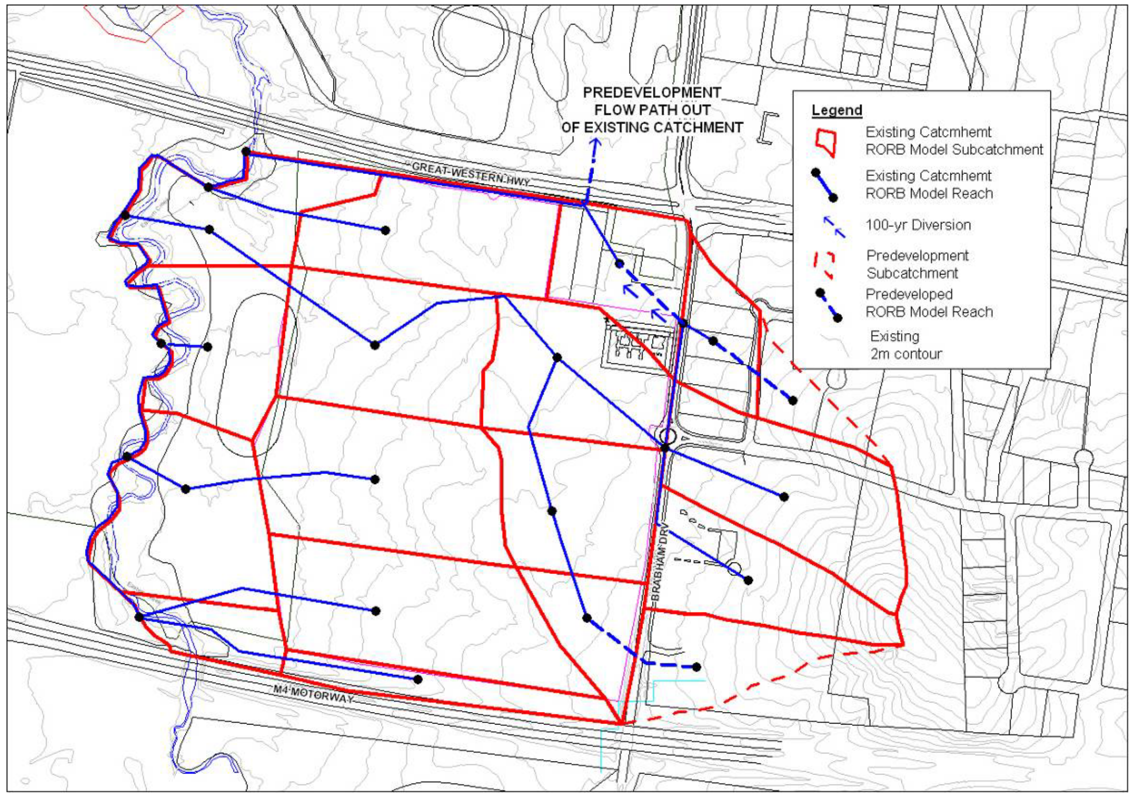

Figure 4.1: Pre development and existing catchment RORB model structures

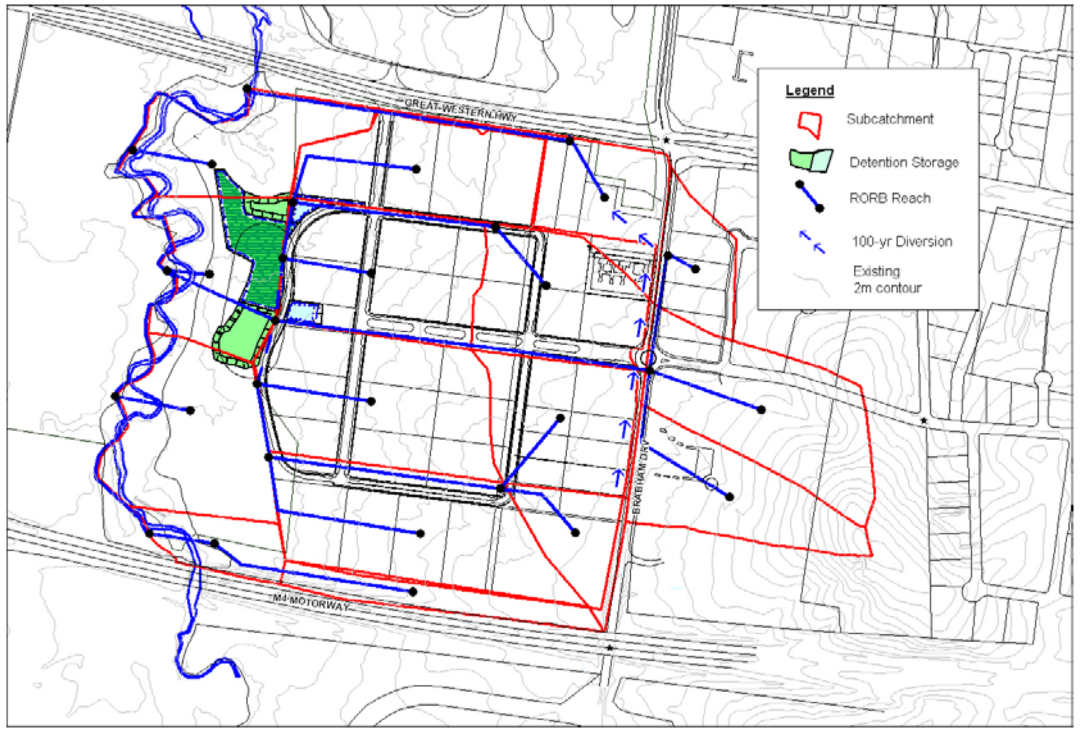

Figure 4.2: Developed catchment RORB model structure

4.2.2 Catchment and RORB Parameter Selection

Rainfall intensity, frequency and duration parameters applicable for the site were obtained from Blacktown City Council. Fraction impervious values of 0.8 and 0.02 were adopted for industrial land use and rural / pre development areas respectively. Values were selected with reference to site inspections and aerial photography.

RORB reach type parameters were selected to represent routing as either overland sheet flow, concentrated flow in natural/rural depressions and, flow along underground pipes and street gutters.

An initial loss of 20 mm and volumetric runoff coefficients of 0.6, 0.21 and 0.2 were selected for the 100, 2 and 1 year ARI events respectively.

A default value of 0.8 was adopted for RORB parameter “m”. A “kc” parameter of 3.3 was adopted and verified by comparing the undiverted results of the developed model to the flow rate derived by applying the Rational Method, calculated using the methodology described in Australian Rainfall and Runoff Volume 1. For the pre development and existing catchment modelling, a kc value of 3.0 was adopted to ensure the ratio of average flow path length to “kc” was preserved.

The results of hydrologic modelling are presented in Section 4.3.

4.3 Hydrologic Modeling Results

Flood simulations were undertaken for a range of storm duration. A summary of peak flows for different ARIs under different development conditions is presented in Table 4.1.

Table 4.1 –Peak Stormwater Discharges to Eastern Creek

ARI	Modeled Discharge to Eastern Creek at the Great Western Hwy (m^3/s)
Pre Developed Catchment	
1 –year	0.5
2 –year	0.7
Existing Catchment	
2 year	0.9
100 year	6.2 (9 hour) 5.0 (36 hour)*
Developed Catchment Without Attenuation	
1 year	2.0
2 year	2.7
100 year	7.5 (9 hour) and 5.8 (36 hour)

* Critical for 100 year downstream flooding in Eastern Creek

Due to the distributed flow paths across the site, routing of flows was performed in Eastern Creek to ensure flows were compared at a coincidental point at the Great Western Highway. Routing flows within Eastern Creek has an extenuative effect on peak flows and hence Table 4.1 reports a more pronounced increased discharge from the developed catchment that is in fact the case.

4.4 Onsite Detention and Flood Detention Storage Design

Provision of flood detention can be provided by a stand-alone regional wetland facility within adjacent parklands or through a combination of OSD and a regional wetland facility with a reduced associated park land-take.

A stand alone flood detention storage were designed to restore peak flows from the developed catchment back to predevelopment flows for the 1.5 ARI event, with additional flood detention storage provided to maintain the existing peak 100 year discharge from the catchment.

Consideration was also given to the arrival of the 100 year flood hydrograph in Eastern Creek to ensure that interaction of flood hydrographs does not worsen downstream flooding.

4.4.1 Regional Wetland Storage Facility

A system of interacting wetland inlet zones, ephemeral zones, wetland extended detention storage and wetland flood storage have been designed that balance flood detention requirements, sustainable wetland function and developable area. The results of modelling the wetland facility in RORB indicate that approximately 25,000 and 34,000 m^3 of storage will be required to return the peak pre development 1 and 2 year ARI flows respectively. The peak 100 year volume within the wetland storage required is 51,000 m^3

The operation of the wetland system is described in Section 3.2.

4.4.2 Combined OSD and Regional Wetland Storage Facility

With OSD provided throughout the development the wetland storage could be designed to operate in only rare events, and the footprint could be reduced.

OSD could be provided at a rate of 560 and 750 m^3/hectare of impervious development (within the site and excluding roads) to return the peak predevelopment 1 and 2 year ARI flows respectively from the entire catchment.

4.5 Results of Modelling Wetland Storages in RORB

A summary of peak flow rates from RORB modelling is presented in Table 4.3.

Table 4.3 –Flood Detention Storage Details

ARI	Modeled Discharge to Eastern Creek (m^3/s)
Target Discharges	
1 year (pre developed catchment)	0.5
2 year (pre developed catchment)	0.7
100 year (existing catchment)	6.2 (9 hour); 5.0 (36 hour)*
Developed Catchment with Precinct Park Storage and Wetland Flood Detention Storage	
1 year	0.5
2 year	0.6
100 year	4.4 (9 hour); 4.9 (36 hour); 5.1 (48 hour)

* Critical for 100 year downstream flooding in Eastern Creek

Table 4.3 shows that the proposed stormwater detention and wetland system will maintain frequent peak discharges at pre development levels. A comparison of hydrographs is presented in Figure 4.3.

To prevent adverse impacts to downstream flooding, it is critical to ensure the run off hydrograph from the site and catchment does not interact with the peak 100-yr 36 hour flood hydrograph from the entire Eastern Creek catchment. Modelling shows that the wetland system will attenuate the developed 100 year ARI peak flows to the effect of no net increase in peak flow in the Eastern Creek flood hydrograph. This is illustrated by the reductions in peak 100 year ARI 9 hour and 36 hour duration storm events shown in Table 4.3 and Figure 4.4.

It is evident from Table 4.3 and Figure 4.4 that the estimated peak discharge for a 48 hour 100 year ARI storm is 5.1 m^3/s. This is slightly higher than the 5.0 m^3/s peak discharge corresponding to the critical storm duration of 36 hours under existing conditions. This higher flow under post-development conditions is not expected to increase the 1% AEP flood levels in Eastern Creek and thus will comply with Council's requirement that to ensure no adverse interaction between the 100 year ARI hydrograph from the site and the Eastern Creek flood hydrograph. A 48 hour storm

duration would have resulted in a lower peak discharge in Eastern Creek (compared to that from the critical 36 hour storm). Thus the increased flow from the site during a 48 hour storm would have coincided with a lower peak discharge in Eastern Creek resulting in an overall lower combined peak discharge in Eastern Creek compared to the discharge for a 36 hour event.

Figure 4.5 shows the attenuation effect and timing effect of the wetland storage system and therefore this will satisfy the criteria that the frequency of bank full flows is not increased and downstream flooding is not exacerbated.

Further optimisation of the basin system and confirmation of timing can be addressed at the detailed design stage.

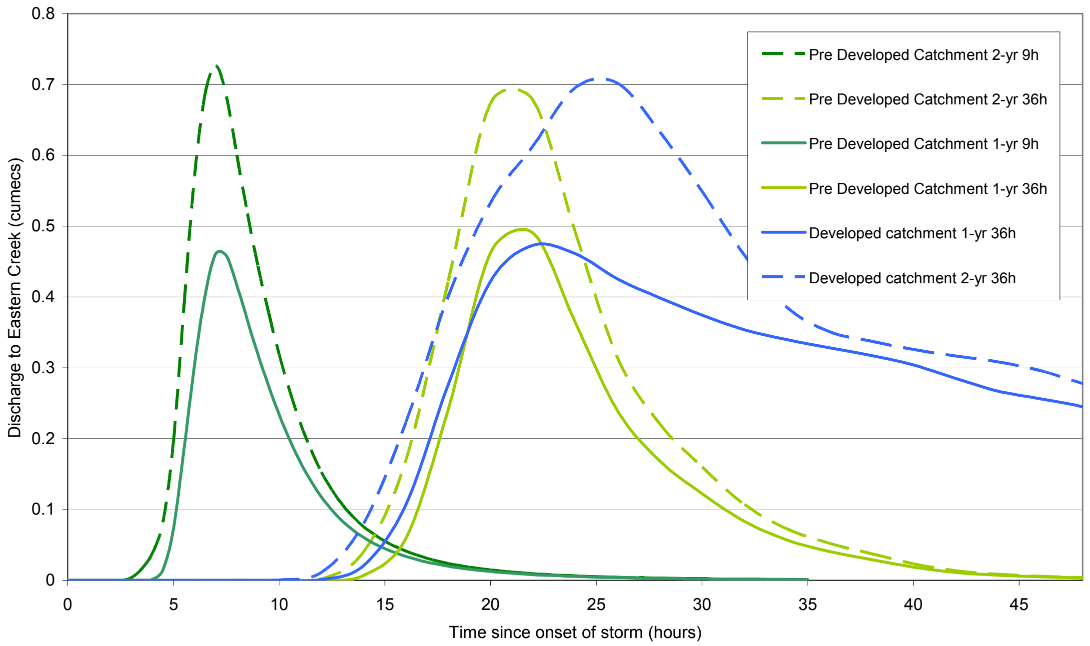

Figure 4.3: 1 and 2 year ARI discharge hydrographs to Eastern Creek for existing catchment and developed catchment with proposed stormwater detention in place.

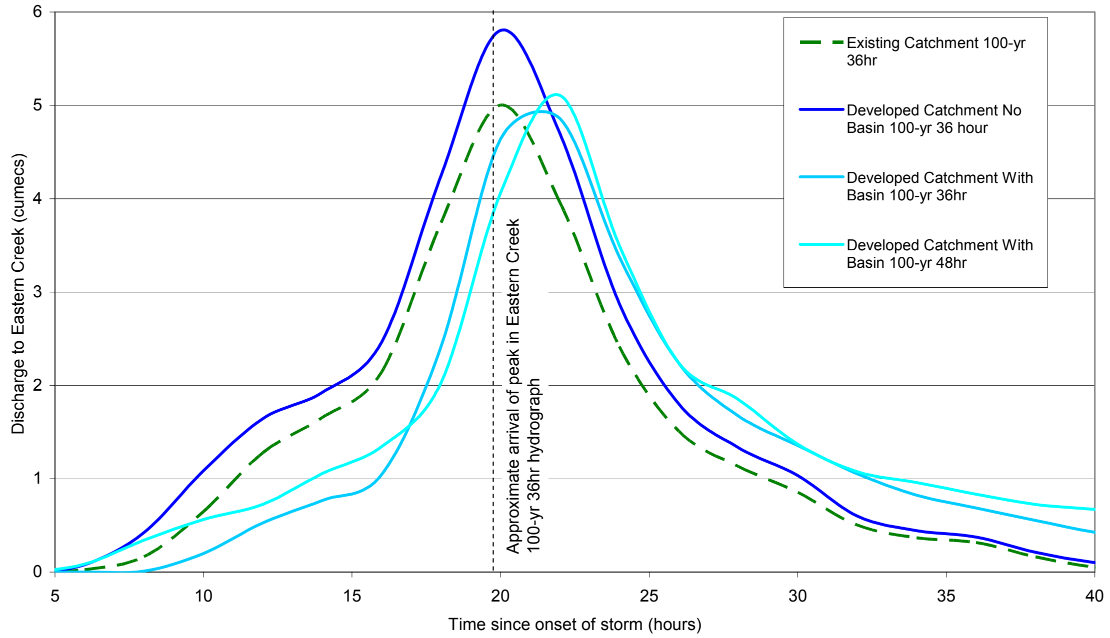

Figure 4.4: 100 year ARI discharge hydrographs to Eastern Creek for existing catchment and developed catchment with proposed stormwater detention in place.

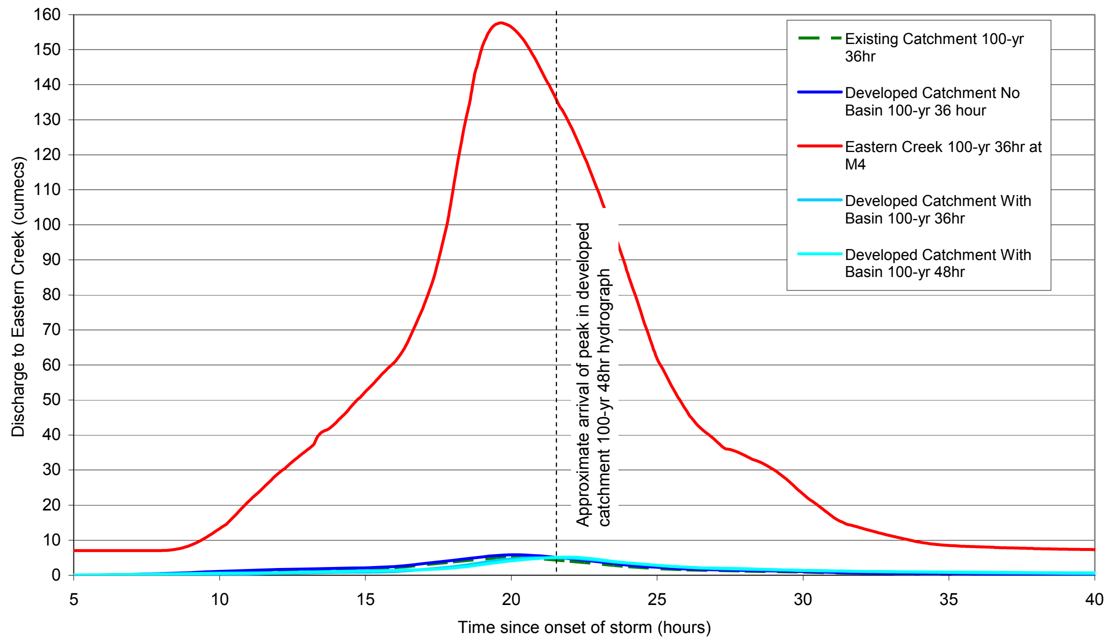

Figure 4.5: Timing of peak hydrograph from the site and the Eastern Creek

4.6 Conclusions

Hydrologic modelling of the pre developed, existing and developed catchment has been undertaken using RORB to assess the impact of the proposed development on the hydrology of the catchment and determine the requirement for stormwater detention. Modelling shows that the proposed development will increase the magnitude of peak discharges to Eastern Creek and stormwater detention is required. Stormwater storages can be provided by regional wetland or in combination with OSD.

Stormwater detention facilitates have been sized to meet the following criteria:

- to restore the 1.5 year ARI discharge from the developed catchment;
- to ensure the discharge from the developed catchment does not increase the frequency of 100 year ARI discharge in Eastern Creek; and
- to ensure the discharge from the developed catchment does not exacerbated downstream flooding.

A stand alone regional wetland facility with total storage of 54,000 m^3 can be designed to meet the above requirements.

Alternatively 34,000 m^3 of OSD can be provided throughout the development at a rate of between 560 m^3 and 750 m^3/hectare of impervious development to meet 1.5 year ARI detention requirements. In this case a wetland storage can be designated to attenuate flows larger than the 2 year ARI event and up to the 100 year event. Adopting OSD throughout the development will significantly reduce the volume and footprint of the wetland facility.

Optimisation of wetland performance and configuration can be carried out at detailed design.

5 Potable Water Conservation and Dual Reticulation

As the end users and likely potable and non potable water demands are not known at present, it is not possible to develop potable water conservation strategies and assess the feasibility of stormwater harvesting or wastewater reuse. It is recommended that the following water balance calculations are done once information is available:

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

5.1 Demand Management

Demand management through the use of water efficient fixtures and appliances is a critical and effective way to reduce potable water use. The most cost effective strategy to reduce potable water consumption is to ensure the widespread adoption of demand management measures including water efficient toilets, fixtures and fitting as well as hoses for wash down areas and irrigation infrastructure for landscaped areas. Building guidelines can address appropriate metering, monitoring and management practices to ensure conservation of potable water.

5.2 Alternative Water Sources

Alternative water sources include wastewater, stormwater and groundwater which can be used to meet non potable demands. "Fit for purpose use" is where alternative water sources are used for demands which do not require potable water, including toilet flushing and air conditioning systems reliant on evaporative cooling. Building design guidelines can be used to ensure that non-potable water is appropriately connected to meet appropriate demands.

Stormwater runoff should be managed as a resource with consideration given to harvesting either from large roof surfaces for reuse within buildings or at a precinct scale with runoff pumped from the proposed detention basins to storage areas and plumbed to meet significant non potable demands through the development.

The Quakers Hill Sewage Treatment Plant is located 7km from the site. The reticulation for the development should be designed to integrate with a possible reuse pipeline. Where dual reticulation is provided, initially harvested stormwater (supplemented with mains water) can be used as the alternative water source. Plumbing design should be configured to adapt to future opportunities, specifically centralised provision of non potable water. Non potable water may also be used to meet irrigation demands of the adjacent parklands - active recreation areas.

The substitution of potable water with alternative water sources where available would result in a significant reduction in potable water consumption. Consideration should be given to providing dual reticulation for the development, even where a non potable water source may not be immediately available. The plumbing design should be resilient to future opportunities, with connection points suitably located to integrate with a centrally reticulated non potable water source.

5.3 Microclimate Control

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

5.4 Water Supply and Sewerage

As identified in the Civil Infrastructure Masterplan Report (YSCO Geomatics), potable water will be supplied through the Brabham Drive main from the Prospect Hill elevated system with minor main amplifications at an estimated cost of $200,000. Sewage from the site would be transported to the Quaker's Hill Sewage Treatment plant, with works totalling approximately $800,000 for extension of the sewer main and a horizontal bore beneath the Great Western Highway, linking to the north western part of the site.

6 Building Design Guidelines for Huntingwood West

Stormwater pollution in industrial precincts has two risk profiles, one associated with its typically high percentage of impervious surfaces and traffic volumes, and the other related to industrial practices that result in pollution entering the stormwater drainage system. It is the latter that differentiate stormwater pollution characteristics in industrial precincts from that of a typical high density urban environment. Inappropriate drainage of works areas and inappropriate work practices are largely responsible for a wider range of pollutants types and concentrations experienced in industrial precincts and are the main causes of stormwater pollution during dry-weather conditions. Difficulties will arise in the long term if stormwater treatment devices are tailored to known pollutants from a particular business activity as businesses will change premises and devices tailored to the needs of one business are unlikely to suit subsequent businesses.

Building design guidelines can be developed to ensure that pollution sourced from work areas does not enter into stormwater drains and thence to the downstream environment. This is the most effective method in implementing WSUD in industrial precincts in a sustainable manner and can be achieved by:

- roofing work areas,
- directing wash-down to storage (which is subsequently pumped out as industrial waste) or directing wash-down to sewer and
- controlling activities undertaken in areas connected to stormwater drains.

It is important to isolate the work areas with a higher pollutant risk profile to ensure that standard WSUD treatment measures designed to treat stormwater from typical urban environments are not compromised with the wider range of pollutants types and concentrations experienced in industrial precincts. Conventional WSUD practices for the management of stormwater runoff from impervious surfaces other than work areas can be implemented along the same basis as other urban environments.

Programs to promote good environmental practice in businesses in industrial precincts are seen as an essential part in helping sites meet water quality objectives. Programs may specifically promote good environmental practices in the operation of individual businesses, with structural measures physically separating work areas from stormwater runoff into the drainage system. Other programs aim to raise awareness and responsibility for appropriate environmental protection behaviour of individuals working in industrial precincts.

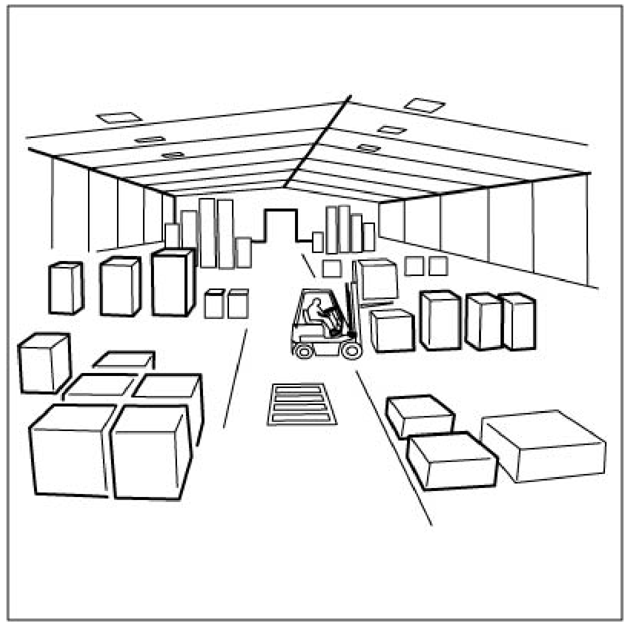

Figure 6.1: Pollution source control, with roofed work areas and interception of pollutant that would otherwise be discharged to the stormwater network from work areas.

Further details regarding appropriate controls for industrial sites can be found in ‘Water sensitive urban design for industrial sites and precincts’, available under the *Papers and Publications* page on the Ecological Engineering website; www.ecoeng.com.au

7 Huntingwood West WSUD Strategy

The proposed WSUD Strategy for the Huntingwood West employment zone addresses pollution control and flow management.

With end users (industry type) and likely water demands currently not known, it is not possible to develop and evaluate potable water conservation strategies. However, guiding principles for potable water conservation based on demand management and provision of alternative non-potable water sources apply. Water demand management measures include water efficient toilets, fixtures and fittings as well as efficient hoses for wash down areas and irrigation infrastructure for landscaped areas. Building guidelines can address appropriate metering, monitoring and management practices to ensure conservation of potable water.

Consideration should be given to installing infrastructure that would provide the industrial precincts resilience to future opportunities. Providing dual reticulation for the development, even where a non potable water source may not be immediately available is one such initiative. The plumbing design of buildings should be adaptive to future alternative sources of non-potable water with connection points suitably located to integrate with a centrally reticulated non potable water source.

Source control is important for industrial precincts. Building design guidelines can be developed to ensure that pollution sourced from work areas does not enter into stormwater drains. The key structural measures include roofing work areas, directing wash-down to storage (which is subsequently pumped out as industrial waste) or to sewer and controlling activities undertaken in areas connected to stormwater drains. Additionally programs can be introduced to encourage good environmental practices for both businesses and individuals.

Pollution control would be achieved with WSUD elements for the management of stormwater runoff from impervious surfaces other than work areas. The strategy proposed uses a wetland to treat stormwater runoff from the site to best practice and bioretention elements within the central median of the main entry road to improve the water quality of stormwater passing through the site from the upstream catchment. Attenuation of storm and flood events is integrated into the storage areas associated with the precinct parks, the macrophyte zone and lateral Melaleuca ephemeral zone. This provides geomorphic protection to the waterways downstream, by limiting discharge to pre-development flows for frequent storm events with high erosion potential.

The pollution control and flow management targets are met for both the Huntingwood West site and stormwater draining from the upstream catchment. The bioretention central median and the wetland have been integrated with the urban design and provide the required functionality.

The stormwater management measures identified to meet the desired outcomes in terms of water quality and flood attenuation also provide a suitable interface between the parklands and the industrial precinct. The desired landscape vision for the parklands precinct includes a large wetland area with open water and wetland vegetation.

The stormwater management strategy for the Huntingwood West Industrial Precinct is centred on achieving the following outcomes:-

- Stormwater runoff from the development as well as the 20ha catchment to the east of the development which flows through the site, is to current best practice water quality standards.

- Post-development storm discharges to equal pre-development storm discharges for the one and a half year ARI event, so as to minimise the impact of frequent events on the natural waterways and to minimise bed and bank erosion.

- Post-development storm discharges up to the 100 year ARI event need to be contained so as to minimise the impact of flood events on Eastern Creek. These targets can be met in conjunction with the downstream wetland adjacent to the site.

While the stormwater quality targets could be met through either a series of bioretention systems or a constructed stormwater wetland, only a wetland system allows the site to meet each of the three targets outlined above. A bioretention system requires other complementary measures to meet the flood attenuation targets.

The elements of the preferred WSUD strategy include;

- building guidelines for pollutant source control at the lot level; specifically addressing the need to roof work areas, direct wash-down water to storage (for subsequent pumped out or discharge to sewer) and control of other activities undertaken in areas connected to stormwater drains.
- Gross Pollutant Traps (GPTs) for initial pollutant reduction
- a constructed wetland as an interface between the parklands and the Huntingwood West Employment lands. The wetland improves water quality and limits stormwater discharge to pre-development flows for frequent storm events. The wetland consists of three zones - precinct parks with inlet ponds, a macrophyte zone, and the ephemeral zone.
- flood detention storage for extreme event integrated within the bunded wetland footprint.
- the option to include street-tree bioretention cells within the streetscape will further increase the capacity of the strategy to achieve stretch targets for stormwater quality treatment.
- Potable water conservation measures including demand management and use alternative water sources to meet non potable demands - fit for purpose use of water.

The WSUD Strategy presented for the Huntingwood West site will ensure that water cycle management opportunities are optimised for the site and that the environmental objectives are met, delivering best practice water cycle management.

Appendix 1 – Wetland and bioretention vegetation

The Huntingwood West site lies within the Blacktown LGA of the Cumberland Plains. Ecological communities present within the immediate vicinity of the site include Shale-Plains Woodland and Alluvial Woodland, and are listed as endangered ecological communities under the Threatened Species Conservation Act 1995.

The plant species selected for the bioretention system and the stormwater treatment wetland are primarily based upon the Sydney Coastal River Flat Forest - Alluvial Woodland ecological communities.

A list of the plant species that are suitable for planting in the bioretention system is provided in Table 1. Several of the shrub species recommended for planting along the wetland batters would also be suitable for the bioretention system (Table 2).

The details of the plant species to be planted in the various wetland zones are provided in Table 2. The selection of plant species has been guided by the Shale-Plains Woodland and Alluvial Woodland ecological communities present within the Blacktown LGA of the Cumberland Plains.

The macrophyte species have been purpose selected for the stormwater treatment wetland, with consideration given to the hydrologic conditions expected within the wetland. The planting location and species mixes are designed to ensure that optimal stormwater treatment performance is achieved based on the specifications of the wetland. In particular, macrophyte species have been chosen that suit the frequency of inundation, depth of permanent pools and the depth of extended detention.

The lateral Melaleuca wetlands will provide temporary flood storage and also contribute to the treatment of stormwater quality. This wetland zone will be planted with a range of plant species that are capable of withstanding short term inundation. The species selected for this zone are typically found growing in riparian zones within Alluvial Woodland ecological communities.

Table 1 Recommended plant species for the central median bioretention system.

Austrostipa verticillata	Slender bamboo grass
Carex appressa	Tall sedge
Dianella longifolia	
Dianella revoluta	Blue flax-lily
Lomandra longifolia	Spiny-headed matt rush
Lomandra multiflora	Many-flowered matt-rush
Poa labillardierei	Tussock grass
Themeda australis	Kangaroo grass

Table 2 - Recommended plant species for the Huntingwood West stormwater treatment wetland

Wetland zone Littoral/ephemeral marsh (NWL to +0.2m)	Alisma plantago-aquatica	Water plantain
	Carex appressa	Tall sedge
	Carex gaudichadiana	Tufted sedge
	Carex polyantha	
	Cyperus lucidus	Leafy flat sedge
	Cyperus sphaeroideus	
	Eleocharis acuta	Common spike-rush
	Juncus subsecundus	Finger rush
	Juncus usitatus	
	Lythrum salicaria	Purple loosestrife
	Microlaena stipoides	Weeping grass
	Persicaria decipiens	Slender knotweed
	Persicaria prostrata	
Shallow marsh (NWL to - 0.2m)	Baumea rubiginosa	Soft twig-rush
	Isolepis inundata	Swamp club-rush
	Eleocharis acuta	Common spike-rush
Marsh (-0.2m to -0.35m)	Baumea rubiginosa	Soft twig-rush
	Bolboshoenus caldwellii	Sea club rush
	Schoenoplectus mucronatus	
	Schoenoplectus pungens	Sharp club-rush
Deep marsh (-0.35m to -0.5m)	Baumea articulata	Jointed twig-rush
	Eleocharis sphacelata	
	Schoenoplectus validus	River club rush
Submerged marsh (-0.5m to 1m)	Myriophyllum variifolium	
	Potamogeton ochreatis	Blunt pondweed
	Potamotgeton tricarinatus	Floating pondweed
	Triglochin procera	
Ephemeral Zone Lateral Melaleuca wetland	Bursaria spinosa	Sweet bursaria
	Casuarina glauca	Swamp oak
	Hymenanthera dentata	
	Imperata cylindrica	Blady grass
	Melaleuca linariifolia	Flax leaved paperbark
	Microlaena stipoides	Weeping grass
	Poa labillardierei	Tussock grass
Batters	Austrostipa ramosissima	Stout bamboo grass
	Austrostipa verticillata	Slender bamboo grass
	Bursaria spinosa	Sweet bursaria
	Cassinia arcuata	Chinese scrub
	Daviesia ulicifolia	Gorse bitter pea
	Dianella longifolia	
	Dianella longifolia	
	Dillwynia sieberi	
	Einadia hastata	Berry saltbush
	Gahnia filifolia	
	Imperata cylindrica	Blady grass
	Lomandra filiformis	Wattle matt-rush
	Lomandra longifolia	Spiny-headed matt rush
	Microlaena stipoides	Weeping grass
	Poa labillardierei	Tussock grass
	Themeda australia	Kangaroo grass

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