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WEST HUNTINGWOOD EMPLOYMENT LANDS
DETAILED WSUD STRATEGY

Prepared for Goodman

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1.00 EXECUTIVE SUMMARY

The West Huntingwood Employment Lands site is located within the Blacktown City Council local government area and adjoins the Western Sydney Parkland – Bungarribee Precinct. The Masterplan for the site was a collaboration between Landcom and the NSW Department of Planning. The masterplan for the site is for industrial and commercial users and was approved by the Minister of Planning in 2008. Goodman Pty Ltd proposes to develop the site as per the statement of commitments and conditions of consent agreed upon by the NSW Department of Planning. This report presents the updated WSUD strategy for the development. It has been developed in collaboration with GHD (Civil) and Tract (Landscape) consultants.

The detailed WSUD strategy for the West Huntingwood Employment Lands has been based on the concept design developed by Ecological Engineering in 2006. The WSUD strategy for the site has considered both stormwater generated onsite and from the external 20 hectare industrial catchment, which currently discharges stormwater at the eastern boundary of the site. The site is 56 hectares in area, consisting of three sub-catchments; a northern, central and southern catchment, being 18.5 hectares, 21.3 hectares and 16.2 hectares in area, respectively. The objectives of the strategy have been retained from the concept and consider potable water conservation, stormwater quality improvement and stormwater quantity management. The objectives of the WSUD strategy were informed by relevant state and local planning policies.

The detailed WSUD strategy has made amendments to the concept strategy. The changes include (i) configuring a bioretention system within the northern part of the detention basin (ii) treating the external catchment in the northern bioretention basin rather than in a central median, (iii) locating the central inlet zone within the wetland footprint.

The concept strategy proposed treating stormwater generated from the external catchment through an ‘eco-median’; a bioretention system located in the central median of the main road entering the site. However, difficulties in meeting the required pipe levels for delivering the stormwater to site, as well as ‘daylighting’ the stormwater to the treatment system made a bioretention basin unfeasible. Furthermore, decentralised, streetscape treatment systems were considered vulnerable to damage from activities typical of industrial estates.

The strategy was also modified to manage stormwater in terms of the three sub-catchments (northern, central and southern). The detailed WSUD strategy proposes stormwater treatment through a bioretention system for the northern and external catchment and through a wetland for the central and southern catchment. The original strategy proposed a single constructed wetland.

The location of the central inlet zone has also been modified for a simpler configuration, integrated with the wetland footprint.

The treatment elements comprise:

- A sedimentation basin and subsequent bioretention basin (4,000 m^2) will treat stormwater generated from the northern sub-catchment (18.5 hectares) and stormwater from the external catchment (20 hectares);

- A constructed wetland (16,600 m^2) (with associated inlet zone) will treat stormwater generated from the central catchment (21.3 hectares) and the southern catchment (16.2 ha)
- A sediment basin with connected swales will provide pre-treatment of the flows from the south catchment prior to discharge into the central wetland.

The stormwater quantity management has been accommodated in the design of the above treatment devices. The bioretention basin and wetland have been designed within the footprint of the proposed detention basin at the interface of the site and the neighbouring Western Sydney Parklands. The treatment system has been designed to provide water quality and quantity treatment up to the 1.5 year event without compromising the attenuation of up to 1 in 100 year flood events.
The detailed WSUD strategy retains the potable water conservation targets given in the concept report. That is,

- Dual reticulation will be provided to facilitate the supply of alternative water sources to meet non-potable demands.
- Access to suitable non-potable water sources will be investigated when details of water demands within the site are identified.
- All industrial users of the site will agree to implement a water demand management strategy that requires the installation of water efficient features (for example, toilets and fittings) and ensures equipment such as hoses are maintained to prevent leaks.
- The landscape strategy will include native plants that require little to no irrigation.

2.00 INTRODUCTION

Goodman Pty Ltd propose to develop the land entitled the West Huntingwood Employment Lands for industrial and commercial uses. The site has an area of 56 hectares and is located within the jurisdiction of Blacktown City Council (BCC). The site adjoins the Western Sydney Parklands – Bungarribee Precinct.

EDAW has been commissioned to provide technical input on stormwater management for the West Huntingwood Employment Lands. The stormwater management plan developed has been based on the concept water sensitive urban design (WSUD) strategy developed for the site by Ecological Engineering (2006). A summary of the revised strategy is provided in this report. In particular, the report outlines:

- The key components of the concept WSUD strategy developed for the site and the elements of the strategy that have been made conditions of consent by the Department of Planning.
- The objectives and scope of the WSUD strategy in reference to the concept WSUD strategy and relevant local and state planning policies.
- The detailed WSUD strategy in terms of potable water conservation, stormwater quality management and stormwater quantity management.
- MUSIC modelling of the strategy, including key assumptions, modelling methodology and modelling results. The modelling results will be documented in terms of meeting the required strategy objectives.

3.00 PROJECT BACKGROUND

Landcom and the NSW Department of Planning collaborated in developing a master plan for the West Huntingwood Employment lands site in 2006. The two parties are represented by a technical and design review panel who will oversee the development and ensure the requirements of both parties are satisfied.

A concept WSUD strategy was developed for Landcom in 2006 for submission and approval by the NSW Department of Planning. The Department of Planning approved the development application based on the statement of commitments given by Landcom (the proponent) and certain conditions of consent. The following sections provide a summary of the concept WSUD strategy, the statement of commitments and the conditions of consent as related to stormwater management.

3.01 Concept WSUD Strategy

The concept WSUD strategy for the West Huntingwood Employment Lands was developed to meet relevant state and local policy requirements in terms of potable water conservation, stormwater quality and stormwater quantity management (refer to section 4.02 for details). The strategy considered both the management of stormwater generated from the 56 hectare site and from the neighbouring 20 hectare industrial catchment (east of Brabham Road).

The concept strategy proposed the treatment of stormwater generated from the external catchment in a bioretention basin located within the central median of the main entry road. Stormwater generated onsite was to be treated separately by a constructed wetland. A wetland was considered most appropriate given the aesthetic vision of the precinct and the onsite and flood detention requirements of the development (i.e. the provision of the 1.5 year and 100 year ARI flood detention storage volume). Street tree bioretention systems were also recommended for the site, but were not relied upon to meet the stormwater pollutant load reductions. Street trees are difficult to plan for in industrial sites due to the high likelihood of driveways to industrial lots changing prior to building works.

The concept WSUD strategy detailed the following specifications for the constructed wetland:

1. The constructed wetland will treat stormwater generated from the site, only.

2. All stormwater generated onsite will be pre-treated through gross pollutant traps (GPT) prior to discharge to the constructed wetland. The GPTs are to be located within the West Huntingwood Employment Lands.

3. The wetland is to be constructed at the interface of the West Huntingwood Employment Lands and the adjoining Western Sydney Parklands.

4. The wetland has multiple zones, with the following characteristics:

Wetland Zone	Location	Footprint (ha)	Stormwater Management Function
Ephemeral zone	Parkland	0.6	Primarily flood detention but will also contribute to stormwater quality improvement.
Macrophyte zone	Parkland	1.5	Primarily stormwater quality management, providing a low velocity environment for particles to settle out or adhere to vegetation.
Precinct parks with inlet ponds	Onsite	2.0	Preliminary treatment of stormwater to remove larger, heavier particles. The inlet ponds were configured to provide additional flood attenuation storage.

5. The constructed wetland was sized assuming best practice management of stormwater runoff from industrial sites was adopted at the lot scale. This includes
    - roofing work areas,
    - isolating washdown areas from the stormwater network and directing either to the sewer or onsite storage (to be pumped out and discharged offsite), and
    - controlling activities undertaken in areas connected to the stormwater system.

6. The constructed wetland would provide 54,000 m^3 of flood storage, required to attenuate the 100 year ARI flood event. This storage volume also accommodated the onsite detention requirement for the 1.5 year ARI storm event (which accounted for 34,000 m^3 of the total storage volume).

7. The proposed location of the constructed wetland is within the fringe of the 100 year ARI floodplain.

The potable water conservation concept strategy recommended the site provide dual reticulation for non-potable water supplies, and install water efficient fixtures and features within the development. Further consideration of alternative water supplies was recommended when more detail was available regarding the specific industrial users of the site.

3.02 Conditions of Consent / Statement of Commitments

The West Huntingwood Employment Lands development was approved by the Minister for Planning in 2008. The approval requires the development be in accordance with the plans, documentation and recommendations made in the following:

1. Huntingwood West Environmental Assessment Report prepared by JBA Urban Planning Consultants (Reference No. 08111)
2. Survey plans prepare by David Wallace Fairlie

The concept WSUD strategy was included in the environmental assessment mentioned above. No conditions of consent were given by the Minister in terms of WSUD.

The statement of commitments made by Landcom for the West Huntingwood Employment Lands, and hence approved by the Minister of Planning for WSUD are to implement best practice WSUD measures that comply with Council (BCC) requirements. Particular commitments include:

- Constructing stormwater management controls to ensure that development does not result in any net impact on water quality and quantity of Eastern Creek;
- Ensuring WSUD strategy is in line with best practice;
- Constructing an east west eco-median road that manages stormwater and improves water quality;
- Requiring 1.19 hectares of drainage reserve that are linked to the Western Sydney Parklands and the street network; and
- Requiring landscaped swales and/or bioretention systems to manage stormwater in secondary roads.

Furthermore, landscaping treatments for the development are to conform to WSUD principles imposed.

4.00 WSUD STRATEGY – SCOPE AND OBJECTIVES

4.01 Scope of Development

The West Huntingwood Employment Lands are located in the BCC LGA. The development is bounded by the Great Western Highway on the northern boundary, M4 and Eastern Creek International Raceway on the southern boundary and Brabham Road on the east.

The West Huntingwood Employment Lands have a total site area of 56 hectares. The site in its entirety will be developed for industrial use. The lots will vary in size from 0.79 hectare (Lots 4c and 4d) to 11.268 hectare (Lot 2). The development also provides public access to the Western Sydney Parklands; and hence provisions have been made within the development for non-industrial movements (car and bicycle) and pedestrian traffic.

The West Huntingwood Employment Lands are gently undulating with surface flows draining to Eastern Creek via two ephemeral waterways. Stormwater generated from the existing neighbouring industrial site (east of Brabham Rd) discharges at the central eastern periphery of the proposed development site.

The detailed WSUD strategy has considered both stormwater generated onsite and from the external 20 hectare catchment. The site has been divided into three sub-catchments:

- the northern catchment comprising of lots 5a, 5b, 5c, 5d, 5e, 4a, 4b, 4c, 4d. 6a, and 6b, as well as approximately 3.8 hectares of associated roadways (18.5 hectares in total);
- the central catchment comprising of lots 4e, 4f, 4g, and 6c, a proportion of lots 1, 2 and 3, and approximately 2.9 hectares of associated roads (21.3 hectares in total); and
- the southern catchment comprising of a proportion of lots 1,2 and 3 and approximately 0.3 hectares of associated roadways (16.2 hectares in total).

The delineation of the northern, central and southern catchments for the West Huntingwood Employment Lands is shown schematically in Figure 1.The delineation of the three sub-catchments for the site, although not considered in the previous concept WSUD strategy, does not reflect a change the overall scope of the strategy.

Figure 1: West Huntingwood Industrial Estate – stormwater drainage catchments

4.02 Strategy Objectives

The objectives of the WSUD strategy for the West Huntingwood Employment Lands have been carried forward from the WSUD concept strategy. The water management principles stipulated in the concept strategy were derived from the following state and local government planning policies:

- Sydney Regional Environmental Plan (SREP) 31 – Regional Parklands
- Development Control Plan No.1 – Interim Regional Parklands Management
- Landcom Water Sensitive Urban Design Policy
- Blacktown City Council Stormwater Management Policy (2000)

The corresponding objectives were given as:

- Stormwater runoff from the development as well as the 20 hectare catchment to the east of the development which flows through the site is to meet the following pollution reduction targets:
    - total suspended solids (TSS) – 80 percent reduction in the average annual load from that typically generated from an urban catchment

  - total phosphorous (TP) and total nitrogen (TN) - 45 percent reduction in the average annual load from that typically generated from an urban catchment.
  - litter and gross pollutants will be removed from stormwater leaving the site.
  - Hydrocarbons, oil & grease: 90 percent total annual load, total hydrocarbon discharge < 10 mg/L.

- Post-development storm discharges to equal pre-development storm discharges for the 1.5 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 and laundry.

Since the concept plan was developed, BCC and Landcom have updated their planning policies as related to WSUD. Both documents now require pollutant load reductions of:

- 90 percent pollutant load reduction in gross pollutants and total hydrocarbons;
- 85 percent pollutant load reduction in TSS;
- 65 percent pollutant load reduction in TP; and
- 45 percent pollutant load reduction in TN

Furthermore, the stream erosion index as defined by the NSW Department of Environment and Climate Change (DECC) (2008) has been adopted by BCC and Landcom as an indicator of the erosion potential of a development on the downstream waterway. The stream erosion index has been adopted in addition to matching the pre- and post- development 1.5 year ARI peak flows.

In terms of potable water conservation, the draft Blacktown City Council IWCM DCP is more prescriptive. Dual reticulation must be provided for non-potable water users, and rainwater tanks must be installed to meet 50 percent of non-potable water demands.

The revised objectives for stormwater quality and quantity management and potable water conservation discussed above are not the required targets for the detailed WSUD strategy for the West Huntingwood Employment Lands. They are considered as stretch targets, to be met where possible through the planning and design development.

5.00 WSUD STRATEGY

The WSUD strategy for the West Huntingwood Employment Lands was developed based on the strategy proposed during concept design. The concept WSUD strategy has been summarised in Section 3.01 and has been attached an Appendix to this document. The following sections document how the concept design has been adopted and/or amended in the final design in terms of:

- Potable Water Conservation
- Stormwater Quality Management
- Stormwater Quantity Management

5.01 Water Conservation

The WSUD strategy objectives for potable water conservation proposed in the concept design for the development are:

- 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 and laundry.

The concept WSUD strategy noted the difficulty in developing a potable water conservation strategy for an industrial site. An industrial site will attract a large variety of users, each with different water demand and quality requirements. Consequently, more details on the intended industrial users are required before a potable water conservation strategy can be constructed. When the details of water demands for the site are better understood, the potable water conservation strategy should be revised to ensure opportunities are identified to meet non potable demands with treated wastewater or harvested roofwater / stormwater.

The WSUD strategy recommends conservation of potable water through:

- Provision of dual reticulation to facilitate the supply of an alternative water source to meet non-potable water demands.
- Identifying suitable alternative water sources. Access to treated wastewater may be possible if a recycled water pipeline from Quakers Hill to Parramatta is configured to service the Western Sydney Parklands. Stormwater harvesting can be staged with the development of the site (initially providing water for establishing landscape areas and used to meet non potable demands if a centralised supply of recycled water is not readily available). Collection of roofwater can provide an alternative water source of a higher quality (suitable to meet hot water demands and many industrial uses).
- Ensuring all industrial users of the site agree to implement a water demand management strategy that requires the installation of water efficient features (for example, toilets and fittings) and ensures equipment such as hoses are maintained to prevent leaks.

- Landscape strategy to include native plants, which require little to no irrigation.

The harvesting of rainwater, stormwater or wastewater for non-potable water use has not been investigated at this stage of the development planning and design. Further information regarding the required use of the water are harvestable roof areas is essential in devising a robust harvesting scheme. A harvesting scheme for the development will consider as a minimum meeting 50 percent of non-potable water requirements as per the amended IWCM DCP for BCC.

5.02 Stormwater Quality

The stormwater pollutant load reduction objectives stipulated in Section 4.02 for the West Huntingwood Employment Lands development will be met through a centralised treatment system. The treatment system has been split into three sections as per the catchment delineations discussed in Section 4.01 (i.e. northern, central and southern catchments):

1. Stormwater generated from the northern catchment will be piped to a bioretention basin (with an inlet sediment basin). Primary treatment will be provided by a gross pollutant trap located onsite. Overflows and treated flows from the bioretention basin are discharged to Eastern Creek. The northern bioretention basin will also treat stormwater from the external 20 hectare catchment. The stormwater will be piped from the existing headwall along the boundary of lots 6c and 6a, then down the road to the northern inlet and bioretention basin. The bioretention basin will be constructed within the proposed detention basin at the interface of the site and the Parklands.
2. Stormwater generated from the central catchment will be treated through a constructed wetland. The wetland will be constructed adjacent to the northern bioretention basin within the proposed detention basin at the interface between the Parklands and the West Huntingwood Employment Lands. The constructed wetland will consist of an inlet zone, a macrophyte zone and a small pool of open water. A gross pollutant trap will be included upstream of the inlet zone to provide primary treatment. Overflows from the wetland inundate the northern bioretention basin to meet flood detention requirements (refer to section 5.03). Treated flows will discharge to Eastern Creek.
3. Stormwater generated from the southern catchment will also be treated in the same constructed wetland as for the central catchment. Stormwater will be discharged to the wetland through a vegetated swale with a sediment basin upstream.

These key components of the stormwater treatment strategy for the site are illustrated in Figure 2. The detailed drawings (plan and sections) for these elements are included as an Appendix to this report and form part of the infrastructure documentation set provided by GHD.

Figure 2: Catchments and stormwater treatment areas

5.02.01 Amendments to Concept Stormwater Quality Management Strategy

The concept WSUD strategy documented in the Appendix to this report included the following:

- A treatment train of a gross pollutant trap and constructed wetland was proposed for treating all stormwater generated from the 56 hectare site.
- A bioretention basin within the median of the central road of the development was proposed to treat stormwater generated from the external 20 hectare catchment.

The concept WSUD strategy also discussed including street tree bioretention systems within road reserves. The strategy though did not depend on bioretention street trees to meet the required pollutant load reductions. Driveway locations for industrial lots are likely to change prior to building construction, which makes planning and design of street trees difficult.

The central median bioretention system (eco-median) was not carried forward through the functional design phase primarily due to difficulties with the pipe levels required to
a) direct flows to the central median from the existing discharge location,
b) 'daylight' pipes within the eco-median, and
c) accommodate road crossings.

Stormwater treatment systems incorporated into the streetscape are also considered vulnerable to damage from vehicular traffic within the development. Consequently, the treatment performance of the bioretention basin could not be ensured.

The constructed wetland has been retained in the detailed design, treating stormwater generated from the central and southern catchments. Stormwater generated from the northern catchment is to be treated separately through a bioretention basin. The northern bioretention basin has also been sized to treat stormwater from the external 20 hectare industrial catchment.

The treatment strategy was augmented to treat stormwater from the external catchment. The strategy has utilised the dry area either side of the constructed wetland proposed in the concept design and the existing embankment.

A summary of the main amendments to the WSUD strategy from the concept strategy are summarised in Table 1.

Table 1: Summary of the modifications made from the concept WSUD strategy.

Concept Stormwater Quality Management Component	Amendments to concept for detailed strategy	Justification for amendment
Eco-median - Bioretention system in central median to treat stormwater generated from the external industrial catchment.	Stormwater generated from the external industrial catchment to be piped for treatment in the northern bioretention basin (the northern bioretention basin also accepts flows from the northern sub-catchment of the site). The stormwater pipe from the external catchment will follow the northern periphery of the development to the northern inlet zone.	Difficulties arose with the pipe levels required for: a) directing flows to the central median; b) 'Daylighting' flows into the central median; and c) Accommodating road crossings Streetscape treatment systems were also considered vulnerable to vehicular traffic within the site, and hence the performance of the treatment system could not be guaranteed.
Treatment of all stormwater generated from the site in a constructed wetland.	The treatment strategy has been divided based on the three internal catchments identified for the site. The constructed wetland will treat stormwater generated from the central and southern catchment.	The configuration proposed optimises the pollutant removal in the available treatment area, integrating a bioretention system within the northern part of the detention basin and a suitably configured wetland within the remaining area.
Central inlet zone located within the industrial site	The central catchment is directed to a GPT and then an inlet zone which is located within the wetland (western side of the road at the Parkland / industrial site boundary)	The design outcome is preferable with the inlet zone integrated within the wetland footprint. The configuration for drainage and piped connections is simpler and the less visually appealing aspects of the inlet zone can be more easily screened with vegetation.

5.02.02 Lot Scale Management of Stormwater Quality

The WSUD strategy proposed for the site is a centralised approach to stormwater quality management rather than using multiple, distributed lot scale treatment devices. Lot scale treatment is considered vulnerable to changes in pollutant characteristics generated from the site and difficult to monitor and maintain as numerous access points are required. The use of a centralised on-site detention and stormwater treatment location was considered the preferred approach by the stakeholders during the development of the concept strategy as it provided the desired landscape outcome (wetland adjoining the Parklands) and the opportunity to provide best practice water quality improvement for the existing external catchment in addition to the site.

It is acknowledged that it is important to control the source of pollutants discharged to the treatment system. Source control of pollutants can be achieved through the following building design practices as recommended in the concept strategy:

- Roofing work areas;
- Directing wash-down to storage, which is subsequently pumped out as an industrial waste, or to the sewer system; and
- Controlling activities undertaken in areas connected to the sites stormwater system.

The above lot controls have been carried forward to the detailed WSUD strategy. Implementation of these site controls is important in ensuring the integrity of the centralised treatment system.

5.03 Stormwater Quantity Management

The stormwater quantity management system developed for detailed design has been designed as per the Landcom and BCC requirements stipulated in the concept WSUD strategy:

- Return peak discharge from the developed catchment in a 1.5 year event back to pre-development 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 BCC stormwater policy; and
- Ensure no adverse interaction between the 100 year ARI hydrograph from the site and the Eastern Creek flood hydrograph.

As stated previously, the WSUD strategy has been designed to provide flood attenuation and hence meet the above stormwater quantity management requirements. Hydrologic modelling was undertaken to determine the required storage capacity for the 1.5 year and 100 year ARI storm events. The results from the hydrologic model indicated a detention volume of 34,000 m^3 and 54,000 m^3 would be required to attenuate the 1.5 year ARI and the combined 1.5 and 100 year ARI storm event, respectively.

Both onsite detention and the 100 year ARI flood detention storage requirements have been designed for within the proposed detention basin. The footprint of the proposed detention basin has been utilised for the northern bioretention basin and the constructed

wetland. Consequently, both the northern bioretention basin and constructed wetland will be inundated during the 100 year ARI storm event.

Flow between the treatment elements has been designed to ensure overflow is discharged to the constructed wetland and northern bioretention basin. The flow distribution system is as follows:

- Overflow from the constructed wetland is discharged to the northern bioretention basin via a weir.
- During storm events up to the 1 in 100 year event, detained water will back up from the northern end and ultimately inundate the entire footprint of the bioretention system, wetland and remaining dry basin area. The ultimate water level in the 100 year event will be blow the crest of the eastern embankment.

6.00 SIZING OF WSUD ELEMENTS

A MUSIC model has been developed to represent the West Huntingwood Employment Lands site and the proposed Water Quality Treatment Strategy. The strategy consists of a centralised detention basin with integrated water quality treatment systems located at the western boundary of the proposed development (as an interface with the Western Sydney Parklands). These systems comprise a 4,000m^2 bioretention system in the northern part of the detention basin and a 16,600 m^2 wetland immediately south of this bioretention basin. Both elements will be constructed in the base of the proposed flood detention basin which extends along the western boundary of the site. The bioretention system and wetland will treat stormwater runoff during typical rainfall events. During extreme events the flood detention basin will engage and the bioretention system and wetland will be submerged. Discharge from the treatment elements will be to Eastern Creek and downstream receiving waters.

The following sections document the model assumptions, methodology and results.

6.01 Site Characteristics and Land Areas

In modelling the expected site runoff, sub catchments have been identified and the relative impervious areas of these sub-catchments have been defined. In doing this a number of assumptions were made, these are summarised as follows;

- An external catchment of 20 hectare located east of Brabham Drive will be included in the overall treatment strategy for the site. Runoff from this catchment will be piped beneath the site and directed to the northern bioretention. The area has existing industrial development with an assumed impervious land cover of 80 percent. Of this, 60 percent (9.56 hectare) consists of roof areas with 40 percent (6.37 hectare) being roads, parking and other hardstand areas. The remaining 3.98 hectare consists of garden areas and other pervious land cover.
- The West Huntingwood Employment Lands have a total area of 56 hectare.
- The northern bioretention will receive runoff from 18.5 hectares (90 percent impervious) plus the 20 hectare external catchment detailed above.
- The central wetland will receive runoff from the northern catchment (21.3 hectare and 90 percent impervious) and the southern catchment (16.2 ha and 90 percent impervious)

- Impervious fractions are assumed to comprise 60% roof area with remaining 40% being roads and other hardstand areas
- Modelling parameters used have been based on the BCC MUSIC modelling guidelines

Table 2 summarises the land areas contributing flow to the respective treatment systems used in the modelling of the site.

Table 2: Areas used in MUSIC model of the West Huntingwood sub-catchments

	North Bioretention Basin	Central Wetland
External Catchment	20	n/a
Internal Roads/hardstand (ha)	6.7	13.5
Internal Roofs (ha)	10	20.3
Internal Pervious (gardens) (ha)	1.9	3.8

6.02 Stormwater Characteristics and Modelling Assumptions

The stormwater quality modelling has been completed for the three internal catchments and external industrial catchment described in section 4.01.

The treatment systems have been modelled to meet the required stormwater quality objectives for the site in terms of TSS (80 percent reduction), TP (45 percent reduction) and TN (45 percent reduction). Treatment measures designed to target these pollutants will also remove a high proportion of other pollutants such as heavy metals, hydrocarbons and gross pollutants that may be present in runoff. By meeting the required TSS and TP load reductions it is reasonable to assume the required load reductions in hydrocarbons and litter have also been satisfied.

The modelling has assumed that at source pollution abatement measures recommended in section 4.02 have been adopted onsite. Consequently, site catchments and associated pollutant loadings have been modelled as if an urban development.

6.03 Water Quality Treatment System Modelling

As mentioned previously, the footprint of the proposed flood attenuation basin has been utilised to provide treatment of regular rainfall events from the West Huntingwood Employment Lands site, as well as the external industrial catchment. The constructed wetland and the northern bioretention basin will operate independently during typical events; however, during large flood events, both systems will become inundated.

A MUSIC model has been developed for the site and the external catchment to optimise the pollutant removal efficiencies of the proposed treatment strategy. The modelling considers the treatment performance of individual elements only and does not model the flood attenuation process. A copy of the MUSIC model has been provided and Figure 3 shows the MUSIC model developed to represent the treatment elements for the site.

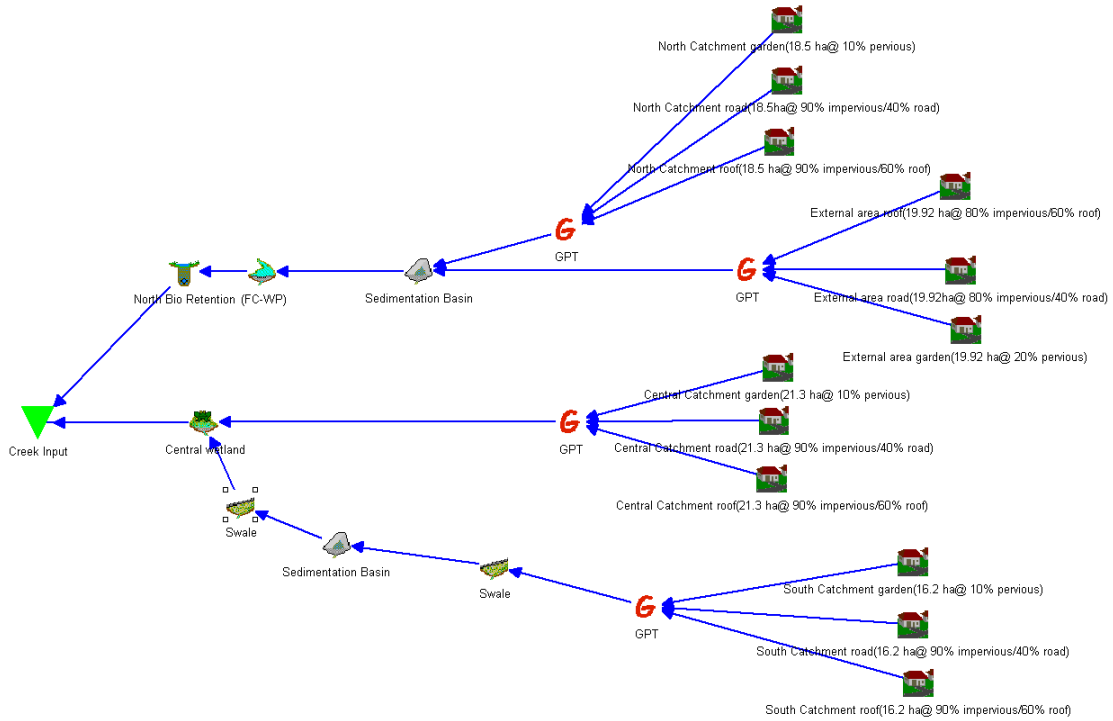


Figure 3: MUSIC model representing West Huntingwood Employment Lands (090721 Final WestHuntingwood_Liverpool Rainfall 67-77.SQZ)

Table 3 provides the relative sizes of the key treatment elements within the strategy. Areas at extended detention are based on a 1V:3H batter slope from the operating filter level up to the full potential extended detention depth.

Table 3: Modelled treatment areas

	North Bioretention Basin	Central Wetland
Filter surface area (m^2)	4,000	n/a
Area when extended detention at capacity (m^2)	4,250	16,600

The MUSIC model was run over a 10 year time period (01/01/1967 – 01/01/1977) with 6 minute precipitation data from the Liverpool (Whitlam Centre) rainfall gauge (067035).

Critical components of the treatment strategy are described in the following section, with details of the MUSIC results in section 6.04.

Gross pollutant traps (GPT's)

Stormwater is collected and conveyed to GPT's upstream of the main treatment elements to remove a proportion of the readily removable Total Suspended Solids (TSS) and Total Phosphorus (TP). For TSS, negligible removal is expected for concentrations up to 75 mg/L with an overall treatment efficiency of 70 percent for concentrations above this. For TP there is negligible removal for concentrations up to 0.5 mg/L with overall treatment efficiency of 30 percent for concentrations above this. There is negligible removal of total nitrogen (TN) within typical GPT systems.

Sedimentation basins

Sedimentation basins have been modelled for flows prior to discharge to the bioretention basin and wetland. Separate nodes have been included upstream of the bioretention basin with the sediment basin incorporated into the wetland node as the 'inlet pond'. These elements are designed to remove the larger fraction of the particulate loading (typically particles up to 0.125 mm). These will be lined with either an impermeable liner or heavy clay (assumed 0.36 mm/hr seepage loss).

Bioretention systems

A bioretention basin is proposed to treat stormwater generated from the northern catchment. The bioretention basin has a filter surface area of 4,000 m^2. The system will be constructed below the floor level of the flood detention basin to prevent any impact on the ultimate flood capacity. A pond node is used to represent the depletion of soil moisture due to evapo-transpiration in the bioretention soils. This is done by creating a permanent pond volume equivalent to 18 percent (sandy loam) of the bioretention systems filter volume (filter surface area times filter depth).

For the modelling of the site, the depth of the filtration media is 600 mm, the saturated hydraulic conductivity is 100 mm/hr, the seepage loss is 3.6 mm/hr and the extended detention depth is 300 mm (1V:3H batter slope above filter surface). Planting densities and specifications are not included in this report.

Due to the large area of the basin and the variable flow rates, it will be critical to specify a distribution system which delivers water relatively uniformly across the surface. This is required to prevent potential short circuiting of flows, detrimental dry spells for areas of vegetation and general reductions in treatment efficiencies.

Treatment wetland

The design of the wetland responds to the relatively small size of the wetland in proportion to the catchment and the resultant associated wet hydrologic conditions. The inundation regime would frequently flood the wetland making it unfavourable to typical ephemeral species. If ephemeral zones at the centre of a wetland (i.e. where the wetland bottom contour rises out of the water to 0.2m above Normal Water Level (NWL)) are flooded too often, such zones are likely to then be less densely vegetated, less effective in pollutant reduction and vulnerable to weed infestation and erosion.

This wetland has not been designed with an ephemeral zone. The proposed wetland bathymetry consists of deep marsh zones with average depth of 0.5m, a shallow marsh zone of 0.2m depth and a small open water zone within a deeper pool (1.5 m depth at NWL) near the overflow weir that discharges to Eastern Creek.

A nominal and functional wetland bathymetry is indicated in the designs for the wetland (Appendix 1). The bioretention and wetland elements are nested in the base of the retarding basin. Drawings showing both the overall plan view of the treatment systems and sections are included in Appendix 1. These drawings show the important relative level differences features of the treatment systems and the finishing detail required to achieve the intended treatment results. Required soil/filtration profiles are shown on the cross sections.

Wetland vegetation specification
Species nominated in the concept strategy for the relevant wetland zones have been adopted in the current landscape master plan (Tract, 2009). To complement this, lists of aquatic macrophytes, appropriate for specific depths and suitable for planting in the stormwater treatment wetland are provided in Appendix 2. The planting lists for relevant zones include deep marsh (- 0.5m to -0.35m), marsh (-0.35 m to -0.2 m), shallow marsh (-0.2 to NWL) and ephemeral (NWL to 0.2m for batter slopes). Ephemeral zone species are to be used for planting on the batters at the relevant levels.

Wetland modelling parameters
A single cell central treatment wetland with a 16,600 m^2 surface area has been modelled. The wetland has been modelled with an extended detention depth of 350 mm, an average permanent pool depth of 400 mm, a seepage loss of 0.36 mm/hr (heavy clay liner) and a notional detention time of 72 hrs.

Swales

Two lengths of grassed swale, with a combined lengthy of 470m, have been included in the model to treat the runoff from the southern catchment prior to discharge into the constructed wetland.

6.04 MUSIC Results

MUSIC modelling was undertaken to ensure that the defined water quality targets will be met by the treatment elements. The model was run with both the inclusion and exclusion of the 20 hectare external catchment to analyse the sensitivity to this increased loading.

The proposed treatment system is expected to reduce more than 45 percent of the total nitrogen load and more than 85 percent and 65 percent of the TSS and TP loads before delivering stormwater to Eastern Creek. Table 4 summarises the pollutant reductions achieved (including the external catchment) and represents this as an equivalent reduction based on pollutants generated solely within the site boundary.

Table 4: Water quality treatment efficiency based on bioretention basins

Pollutant	Total Site (including external catchment)	Equivalent reduction on basis of pollutants generated within site boundary
TSS	89 percent	118 percent
TP	71 percent	94 percent
TN	48 percent	61 percent

From these results it is evident that the treatment elements proposed are able to meet the required water quality targets (80:45:45 reduction in TSS:TP:TN respectively). The

proposed treatment elements are also adequate in meeting the stretch target (BCC current WSUD targets, 85:65:45 reduction in TSS:TP:TN respectively).
In providing stormwater treatment for the external catchment, the removal of total pollutants exceeds the loads generated within the site for TSS and far exceeds the defined targets for TP and TN.

Figure 4 below gives a graphical representation of the performance of the system and compares the achieved results with the treatment targets and the pollutants resultant from the site without treatment.

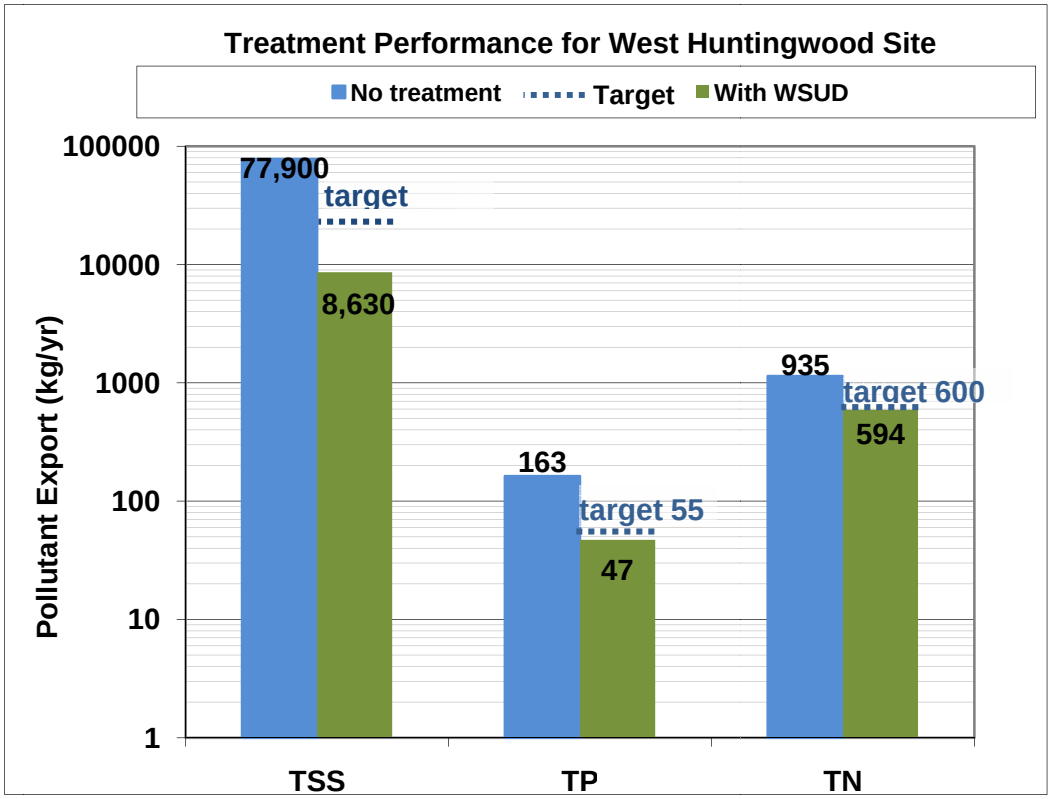


Figure 4: Performance of treatment and non-treatment options against the stormwater quality objectives for TSS, TP and TN.

7.00 STAGED CONSTRUCTION OF WSUD STRATEGY

The construction of WSUD elements should be coordinated with other construction activities within the catchment. Construction activities will generate greater loads of coarse sediment and gross pollutants, for which the WSUD treatment element is unlikely to be designed for. High loadings of coarse sediment and gross pollutants can be particularly detrimental during plant establishment for a vegetated system, smothering infant vegetation and changing the bathymetry of the element (which in turns affects the hydraulic function and the distribution of flow within the treatment element).

Staged construction of WSUD elements is recommended to minimise the impact of construction activities on the functional elements of a WSUD strategy. The staged construction of WSUD elements generally occurs as follows:

Stage 1: Civil construction (or functional installation)
Stage 1 requires the construction of the functional elements for the WSUD element.

Stage 2: Building phase protection (or sediment and erosion control)
Stage 2 involves the construction of temporary measures to protect the functional elements of the system.

Stage 3: Operational establishment (civil and/or landscaping)
Stage 3 involves reconnecting the functional elements of the WSUD element to meet design specifications. In general, this involves decommissioning erosion and sediment control protection devices and replanting of landscape areas.

The staged construction of the constructed wetland and bioretention basin will reference guidance material provided in the draft Landcom Maintenance and Operation Booklet.

Ideally, lots within the Huntingwood West Employment Lands would be developed on a sub-catchment basis. For example, lots within the northern sub-catchment would be developed before any construction work was scheduled in the southern catchments. This would allow either the constructed wetland or bioretention basin to be brought online prior to construction work being completed onsite.

Goodman has already purchased a range of lots from all three sub-catchments within the site. Consequently, neither the bioretention basin nor constructed wetland will be brought online until the majority of construction work onsite is complete.

To protect the functional elements of the bioretention basin and constructed wetland, it is recommended that the functional elements of both the constructed wetland and bioretention basin are isolated from their respective inlets. To isolate the functional elements, a temporary by-pass will be connected from the inlet basins, which will redirect flows into Eastern Creek. By isolating the functional elements of both systems, the constructed wetland and bioretention basin can be planted as per the design without the risk of stormwater with high sediment loading clogging the vegetated systems. Aesthetically, this is preferential to the overall “look” of the development.

The bioretention basin and constructed wetland will be brought online (that is, commence Stage 3 works) when 90 percent of construction work in all three sub-catchments is completed.

8.00 LIFE CYCLE COSTING

Preliminary costings have been estimated based on the MUSIC life cycle cost analysis. These costs are based on typical unit costs associated with construction and ongoing maintenance weighted by applicable inflation/depreciation rates. The design life cycle for the treatment elements is taken as 50 years although it is likely that re-setting of the bioretention system will required within this time frame (typically 10-25 years depending on load characteristics).

The results of the life cycle cost analysis are summarised in table 5 below.

Table 5 Life cycle cost analysis

	North bioretention	***Central wetland***	***Combined sedimentation basins***	***Combined swales***
Acquisition Cost	$233,978	$1,028,171	$217,800	$182,330
Annual Maintenance Cost	$11,854	$31,299	$8,107	$15,643
Annual Renewal-Adaptation Cost	$4,752	$5,516	$3,150	$3,703
Life Cycle Cost (50 years)	$519,689	$1,679,200	$413,005	$512,530

The life cycle cost analysis does not include costs associated with the retarding basin or general maintenance of surrounding open spaces.

9.00 MONITORING AND MAINTENANCE

Monitoring water quality performance for stormwater treatment systems can be costly, requiring extensive auto sampling through many storm events and subsequent laboratory analysis of contaminant concentrations. There are cost effective and simple methods to monitor the hydrologic and hydraulic performance of treatment systems. These surrogate methods can be as effective as costly water quality sampling in evaluating the adequacies of the operation, and thus the performance, of the treatment system. The implicit assumption with surrogate methods is the premise that if the WSUD elements operate in accordance with the design hydrologic and hydraulic characteristics, it follows that these systems can be reasonably expected to deliver the pollutant reduction as determined from laboratory and field experiments.

Key hydrologic and hydraulic operation characteristics define the detention time of WSUD elements. Monitoring of the following operation of bioretention systems, wetlands and ponds, can provide important insights on the likely performance of these WSUD elements:

- Flow pattern (most relevant to wetlands and ponds), to identify the presences of short-circuiting that may inhibit the uniform distribution of inflow across systems. Short circuiting will reduce the contact exposure with biofilms and may result in flow conditions that act to strip the plant matter of the biofilms critical for treatment processes.

- Duration of inundation (most relevant to wetlands and bioretention systems) to assess the operating detention time of these systems and to highlight potential clogging of soil media (bioretention systems) or the outlet structure (wetlands) that would have a direct impact on its performance in water treatment. Duration of inundation may also be indicated by monitoring of plant health. Excessively wet or dry conditions will typically be reflected in plant health and may be indicative of variance to the hydraulics of the system.

- Turbidity of inflow and outflow which are good surrogates for suspended solids which are generally associated with particulate metal pollutants.

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

- Structures, such as overflow weirs, bypass structures and inlets/outlets should be checked for blockages, damage (including vandalism) or obvious signs of unexpected flow conditions
- Erosion of the side batter slopes, areas of channelised flow (swales), surface of bioretention filtration media, internal wetland embankments and areas subjected to high energy flows such as slopes adjacent to the outlets and constrictions.
- Sediment build-up in the base of the sediment basins, invert of the swales and in the region around the inlet into the bioretention cell.
- Establishment of invasive weed species either within the treatment elements or on the adjacent batter slopes
- Algal blooms, this will be of particular importance during prolonged periods with little or no inflows and elevated temperatures. Algal blooms will typically establish in areas of open water (wetlands and sediment basins)
- Litter (anthropogenic and non-anthropogenic) in and around the systems. Litter can potentially clog both the outlets and the surface of the filtration media reducing the treatment performance.
- Any evidence of oil slicks and/or inflows of industrial pollutants

10.00 CONCLUSION

A detailed WSUD strategy has been proposed for the West Huntingwood Employment Lands Landcom development. The strategy has been based on the original concept strategy developed by Ecological Engineering (2006) and the statement of commitments agreed upon by the NSW Department of Planning.

The detailed WSUD strategy has made amendments to the original concept strategy. The amendments were made to account for a centralised system as opposed to a distributed treatment system as per the concept design. A distributed treatment system was disregarded due primarily to issues relating to pipe levels in delivering the stormwater to site and the treatment system, as well as accommodating road crossings. A distributed system was also considered vulnerable to damage from activities common to an industrial / commercial estate.

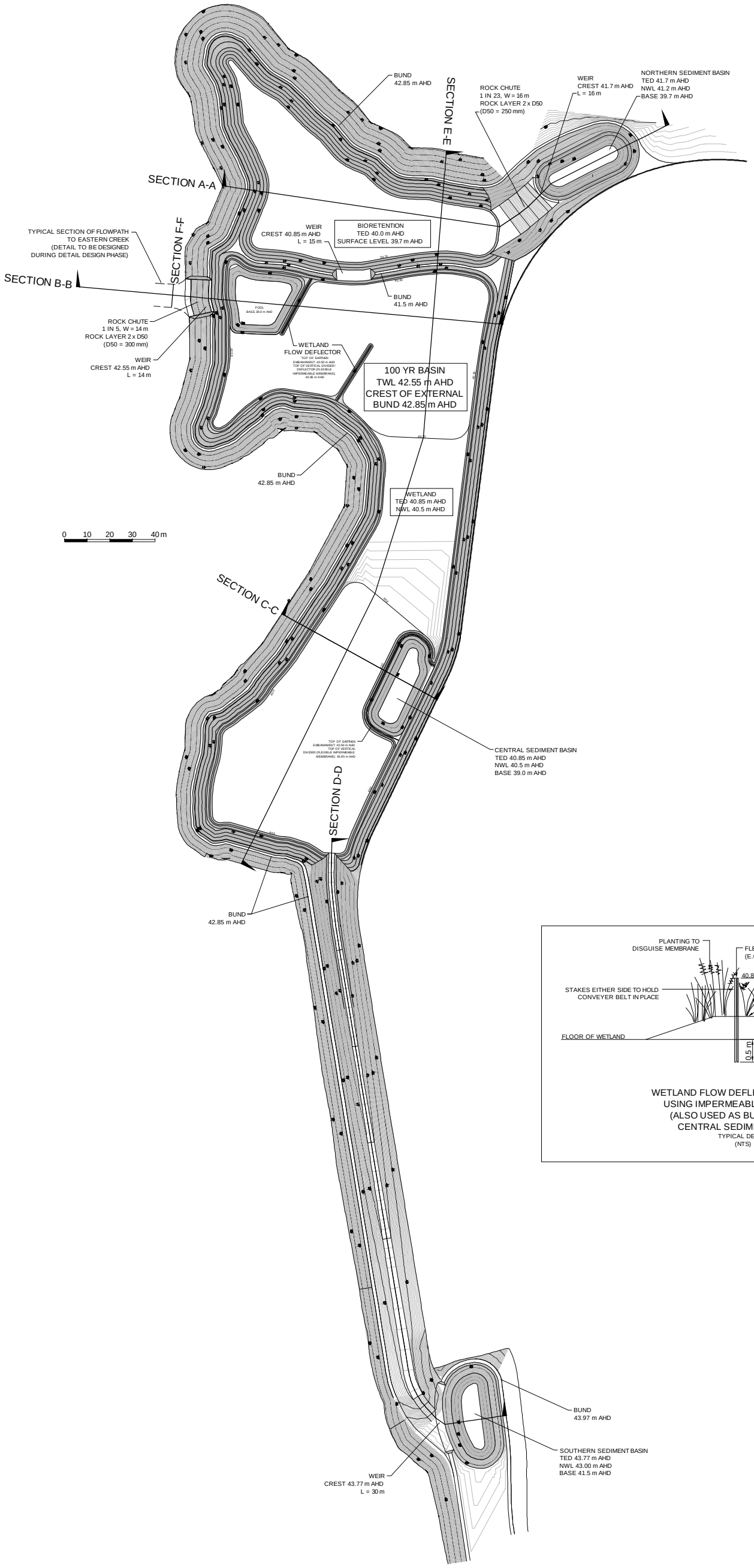
The key aspects and main amendments to the concept WSUD strategy for detailed design are:

- The detailed WSUD strategy considers the site as having three sub-catchments; a northern catchment (18.5 hectares), a central catchment (21.3 hectares) and a southern catchment (16.2 hectares).
- Stormwater generated from the external 20 hectare industrial catchment will no longer be treated through an eco-median (bioretention system located in the central median of the main access road to the site). Rather, the stormwater will be piped along the periphery of the site for treatment through the northern bioretention basin.
- The constructed wetland, although located as per the concept design, will treat stormwater from the central and southern catchments, only. The constructed wetland will have a footprint of 16,600 m^2.
- The central sedimentation basin has been relocated, now integrated with the wetland area.
- Stormwater generated from the northern catchment will be treated through a dedicated bioretention basin. The footprint of the basin is 4,000 m^2.
- The constructed wetland and bioretention basin will be located within the proposed detention basin. The detention basin footprint lies in part within the fringe of the 100 year ARI floodplain, as per the concept strategy.
- The constructed wetland alone will not provide attenuation of the 100 year ARI flood event. The northern bioretention basin and constructed wetland have been connected such that the 100 year ARI flood storage volume is available.
- The constructed wetland will meet Council's OSD requirements of attenuating the 1.5 year ARI storm event.

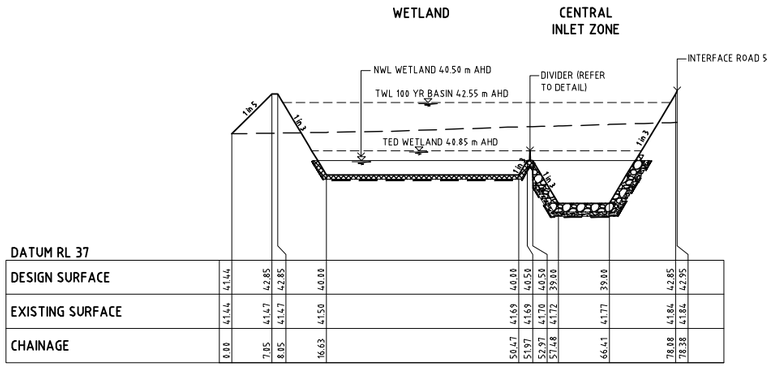
The detailed WSUD strategy retains the potable water conservation targets given in the concept report.

APPENDIX 1: TREATMENT STRATEGY DRAWINGS

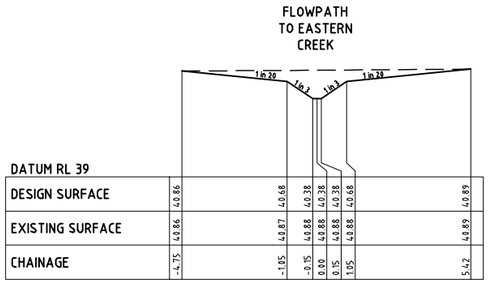
- System overview (plan)
- Typical sections
- Long sections



WETLAND FLOW DEFLECTOR / DIVIDER
USING IMPERMEABLE MEMBRANE
(ALSO USED AS BUND AROUND
CENTRAL SEDIMENT BASIN)
TYPICAL DETAIL
(NTS)



SECTION C-C



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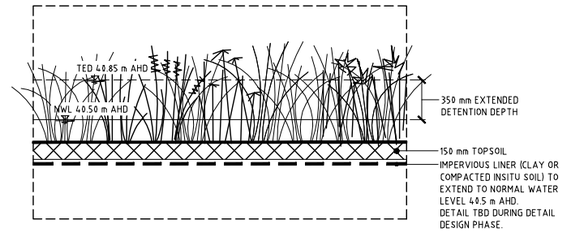
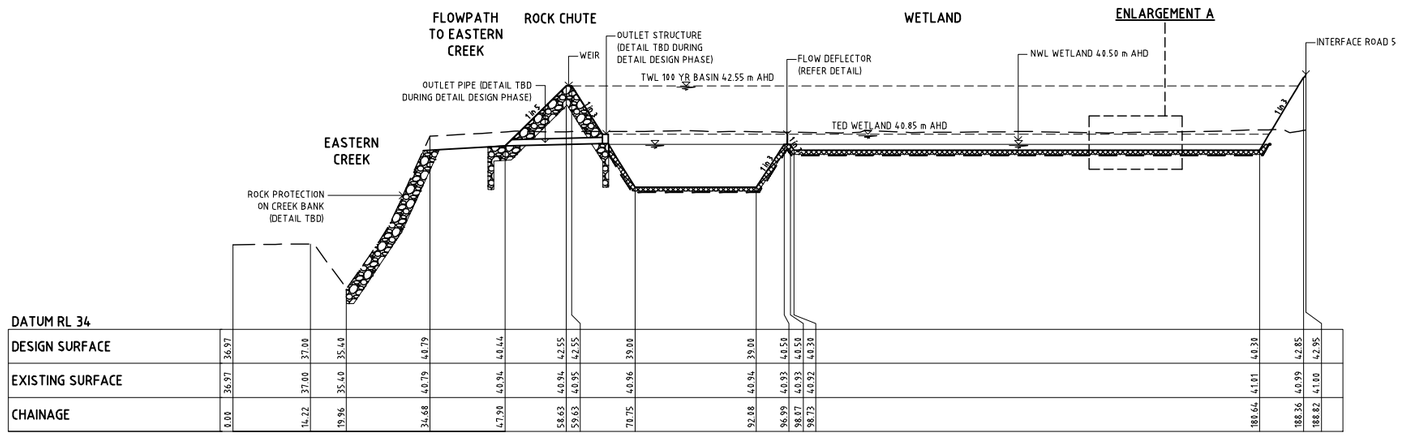
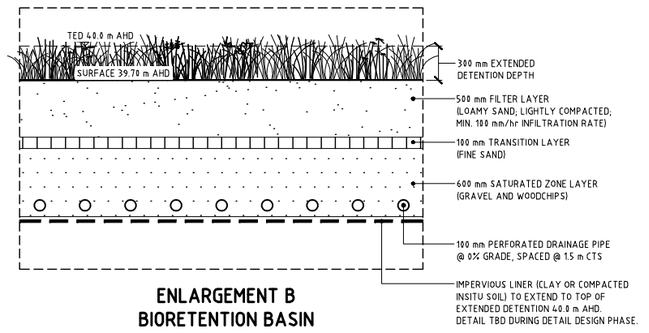


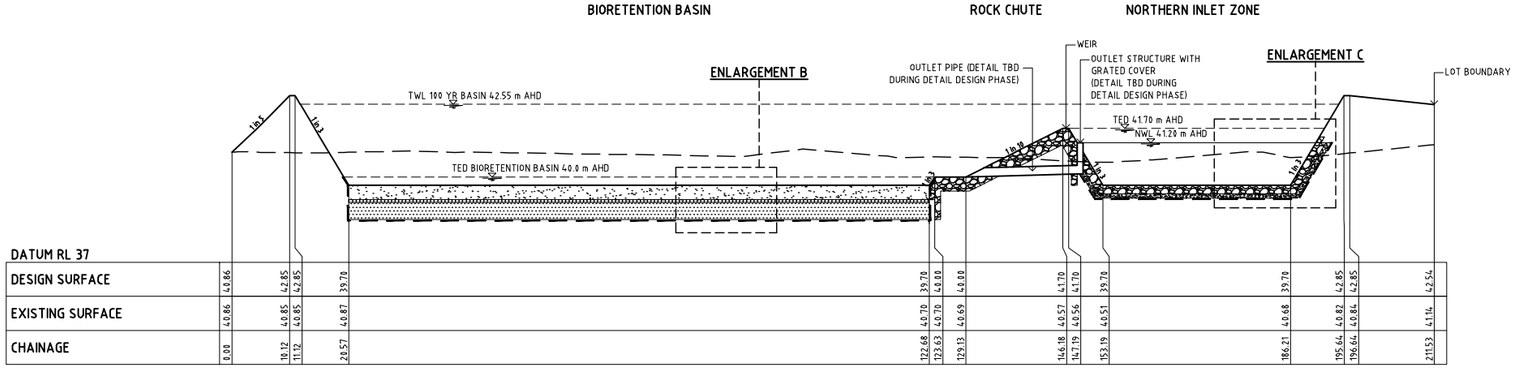
ENLARGEMENT A
WETLAND
TYPICAL DETAIL
N.T.S.



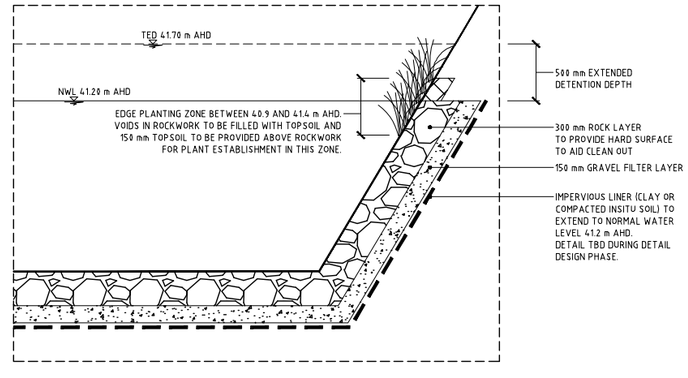
SECTION B-B



ENLARGEMENT B
BIORETENTION BASIN
TYPICAL DETAIL
N.T.S.



SECTION A-A

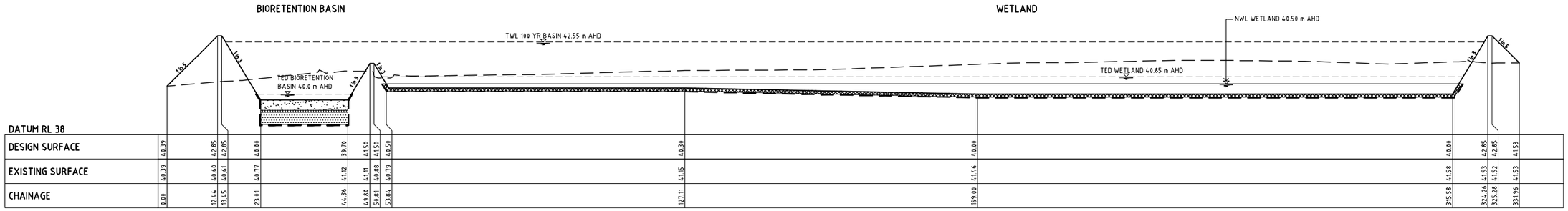


ENLARGEMENT C
INLET ZONE
TYPICAL DETAIL
N.T.S.

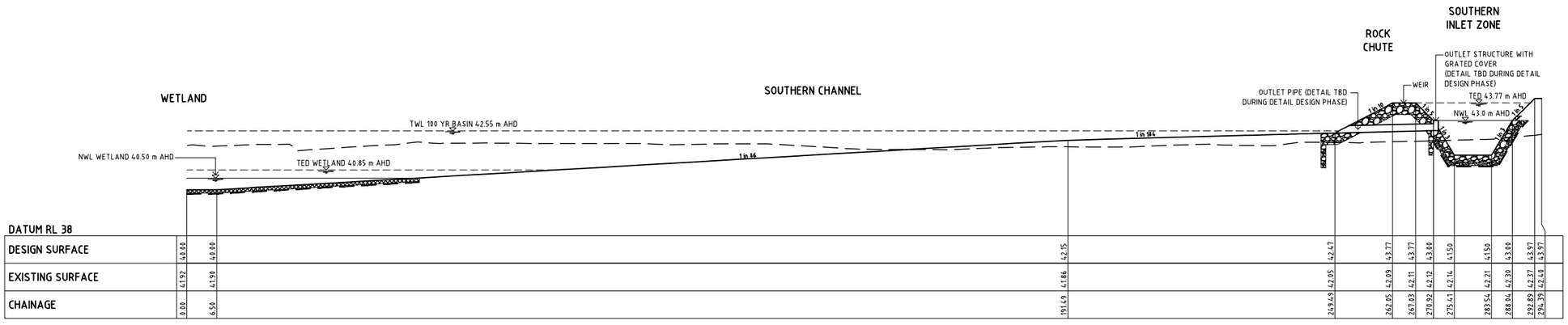
West Huntingwood
CROSS SECTIONS

VER SCALE 1:100 (0 1 2 3 4 m)
HOR SCALE 1:500 (0 5 10 15 20 m)

12d Model
Horizontal Scale 1:500
Vertical Scale 1:100
Tue Jun 30 11:53:16 2009



SECTION E-E



SECTION D-D

West Huntingwood
CROSS SECTIONS

0 1 2 3 4 m
VER SCALE 1:100

0 5 10 15 20 m
HOR SCALE 1:500

12d Model
Horizontal Scale 1:500
Vertical Scale 1:100
Tue Jun 30 11:53:16 2009

APPENDIX 2: RECOMMENDED PLANT LIST FOR CONSTRUCTED WETLAND

Wetland, Bioretention and Inlet Zone Planting		
Grasses/sedges/marcophytes		
Littoral/ephemeral marsh	*Alisma plantago-aquatica*	Water plantain
(NWL to +0.2m)	Carex appressa	Tall sedge
	Carex gaudichadiana	Tufted sedge
	Carex polyantha	
	Cyperus lucicus	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	Baumea rubiginosa	Soft twig-rush
(NWL to – 0.2m)	Isolepis inundata	Swamp club-rush
	Eleocharis acuta	Common spike-rush
Marsh	Baumea rubiginosa	Soft twig-rush
(-0.2m to -0.35m)	Bolboshoenus caldwellii	Sea club rush
	Schoenoplectus mucronatus	
	Schoenoplectus pungens	Sharp club-rush
Deep marsh	Baumea articulata	Jointed twig-rush
(-0.35m to -0.5m)	Eleocharis sphacelata	
	Schoenoplectus validus	River club rush
Submerged marsh (-0.5m to 1m)	Myriophyllum variifolium Potamogeton ochreatis	 Blunt pondweed
	Potamolgeton tricarinatus	Floating pondweed
	Triglochin procera	
Ephemeral Zone	Bursaria spinosa	Sweet bursaria
Lateral Melaleuca wetland	Casuarina glauca	Swamp oak
	Hymenanthera dentata	
	Imperata cylindrica	Blady grass
	Melaleuca linariifolia Microlaena stipoides	Flax leaved paperbark 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 mat-rush
	Lomandra longifolia	Spiny-headed matt rush
	Microlaena stipoides	Weeping grass
	Poa labillardierei	Tussock grass
	Themeda australia	Kangaroo grass
Trees	*Allocasuarina glauca*	She-Oak

APPENDIX 3: CONCEPT WSUD STRATEGY FOR THE WEST HUNTINGWOOD EMPLOYMENT LANDS (ECOLOGICAL ENGINEERING, 2006)