OONOONBA DEVELOPMENT – THE VILLAGE

UPDATED STORMWATER QUALITY MANAGEMENT PLAN

DesignFlow

Prepared for Economic Development Queensland

June 2016

Document Control Sheet

Report Title:	Oonoonba Development – The Village – Updated Stormwater Quality Management Plan
Suggested Reference:	Oonoonba Development – The Village – Updated Stormwater Quality Management Plan (DesignFlow, 2014)
Version:	03
Client:	Economic Development Queensland
Author(s):	Ralph Williams
Reviewed By:	Shaun Leinster
Approved By:	Shaun Leinster
Date:	15/06/2016
File Location:	S:\Projects\4243
Circulation:	Electronic Copies:
	Printed Copies:

Disclaimer

Table of Contents

1 EXECUTIVE SUMMARY

The Oonoonba development is a proposed residential subdivision of approximately 53ha (approximately 900 lots) on a development site of approximately 80ha, located 4 km south of Townsville, on the southern banks of the Ross River. Stages 1 to 6 and 10 have now been built in accordance with the following:

- **Stage 1**: *Stage 1 Operational Works – Detailed Stormwater Quality Management Report – Oonoonba Urban Development, Townsville* (BMT WBM, 2011)
- **Stage 2-6 and 10**: *Oonoonba Development – The Village – Updated Stormwater Quality Management Plan* (DesignFlow, 2014).

This report presents an updated stormwater quality strategy for the Oonoonba development to meet the requirements under the State Planning Policy (DSDIP, 2013). This report supersedes the previously developed site based stormwater management plans for the site namely BMT WBM (2010, 2011) and DesignFlow (2014).

Treatment strategy

Stage 1 - implemented

The treatment strategy for Stage 1 works (completed) is detailed in BMT WBM (2011): *Stage 1 Operational Works – Detailed Stormwater Quality Management Report – Oonoonba Urban Development, Townsville.*

Stage 1 implementation used streetscape raingardens. The original intent of the stormwater management strategy for the site was for mostly streetscape approaches. Experience from Stage 1 has resulted in a re-assessment of the original strategy, with the use of wetlands now the preferred alternative.

Updated strategy

The updated treatment strategy considers an integrated approach using primarily wetlands and waterway upgrades over two main treatment zones. The major portion of development treatment will occur in the main vegetated north-south drainage corridor which discharges to a freshwater treatment wetland (1.0ha) prior to discharge to the Ross River

As part of the treatment strategy, restoration of the main drainage corridor through the site as a natural vegetated freshwater waterway is included to provide treatment, minimise wetland areas required and provide a low maintenance drainage alternative that enhances the development. Existing mangroves at the downstream end of the main drainage corridor will be retained as much as possible and integrated with the treatment strategy. Additional Melaleuca forest/ephemeral wetland zones are proposed to be developed along the eastern drainage corridor, adjacent to the railway.

A bio-retention basin (465m2) is proposed at the north western end of the development, treating development runoff that is not directed to wetlands.

The above strategy provides an integrated best environmental management approach to stormwater quality management that meets the intent of the State Planning Policy (SPP).

2 SITE CHARACTERISTICS

2.1 SITE LOCALITY

The proposed Oonoonba development is located on the southern banks of the Ross River, 4 km south of Townsville. Existing residential areas occur to the south of the site. The North Coast Rail line defines the eastern boundary of the site

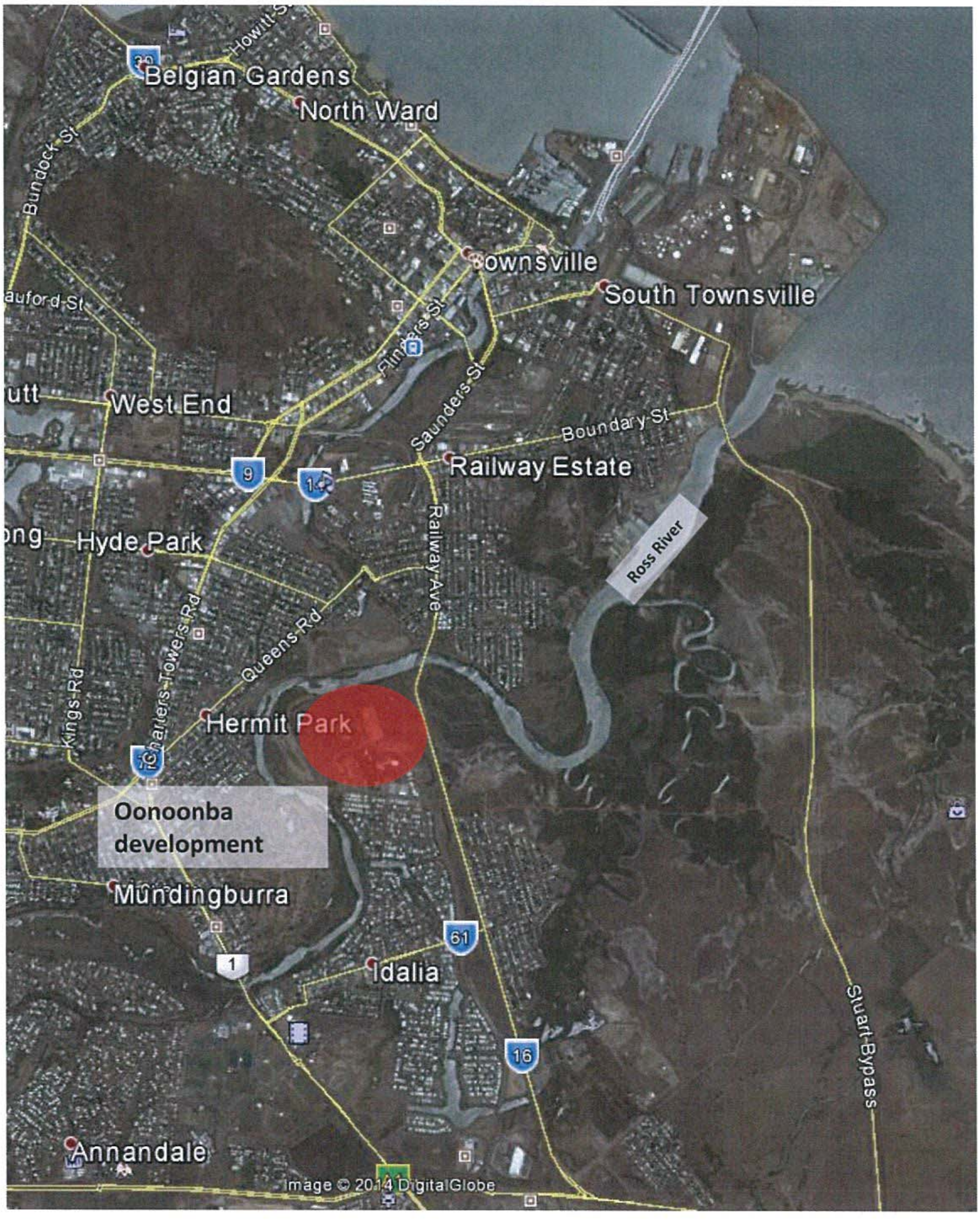

Figure 1: Oonoonba development location

2.2 SITE CHARACTERISTICS

2.2.1 Climate

Oonoonba is located in the dry tropics region of Townsville, which has distinct wet and dry seasons. The average annual rainfall is 1143 mm most of which falls in the four month "wet season" from December to March and on average, there are on average 91 rain days in a year. The variable nature of the tropical lows and thunderstorms of the region the total rainfall and number of rain days can vary significantly from year to year (Bureau of Meteorology website).

Monthly average rainfall for Townsville Airport (Bureau of Meteorology, 2007) and the estimated potential evapotranspiration (PET) for the Townsville Region are shown in Figure 2. The figure clearly indicates the seasonal nature of rainfall and that evapotranspiration is much greater than rainfall for most of the year. Temperatures in the region are moderate to high throughout the year, leading to relatively high evaporation and evapotranspiration in all months.

The seasonal nature of the climate dictates all elements of the natural and urban water cycle. During the wet season vegetation is lush, soils become waterlogged, groundwater recharge fills local aquifers, local waterways/streams flow permanently and there is no need to irrigate landscapes. During the dry season, the region becomes parched with only very hardy vegetation present, local streams cease to flow, groundwater levels drop within aquifers and extensive irrigation is required to sustain green landscapes.

The design of stormwater treatment strategy and public realm landscapes needs to account for this seasonal variability.

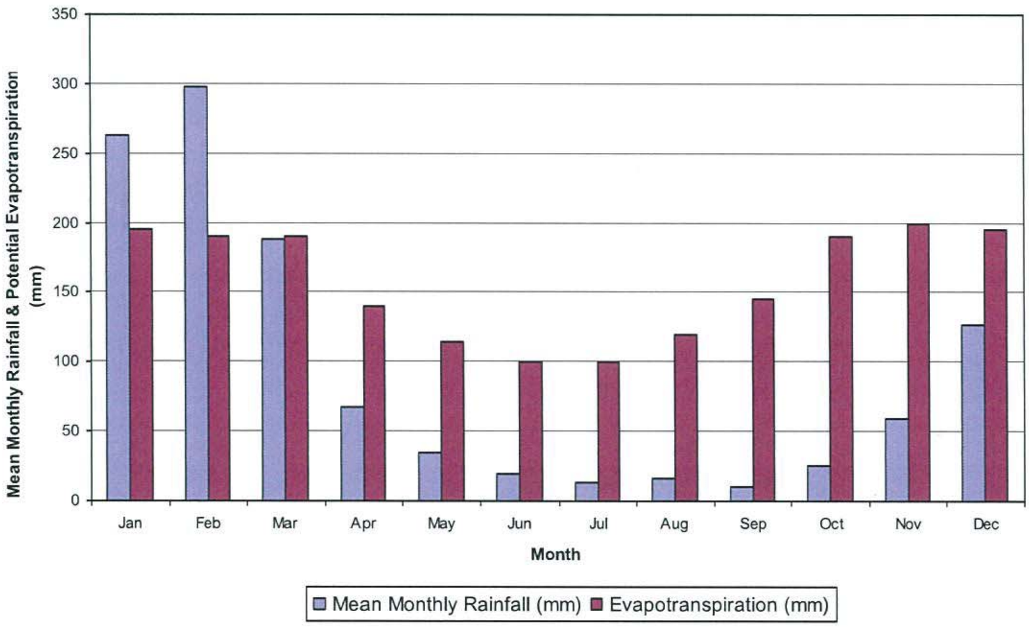

Figure 2: Average climate data for Townsville

2.3 TOPOGRAPHY, CATCHMENTS AND DRAINAGE

The general topography of the Oonoonba development site is very flat with drainage gradients of less than 0.3% typical. Existing ground levels across the site are typically below 5m AHD. A north-south catchment divide through the centre of the site directs drainage to two main drainage zones. West of the catchment divide drainage is directed to a defined drainage channel which discharges northward to the Ross river. East of the divide drainage is less formalised and occurs predominately as overland flow in a north easterly direction. Drainage channels have previously been excavated at the northern boundary of the site to facilitate drainage to the Ross River.

Tidal influences extend up the main drainage line as a result of previous drainage works. Mangroves have now established along the main drainage line, extending approximately 450m upstream from the Ross River.

The flat nature of the site is a major design constraint when integrating stormwater treatment systems into the development. Typically on such sites wetlands or at surface treatments such as streetscape raingardens are the most applicable.

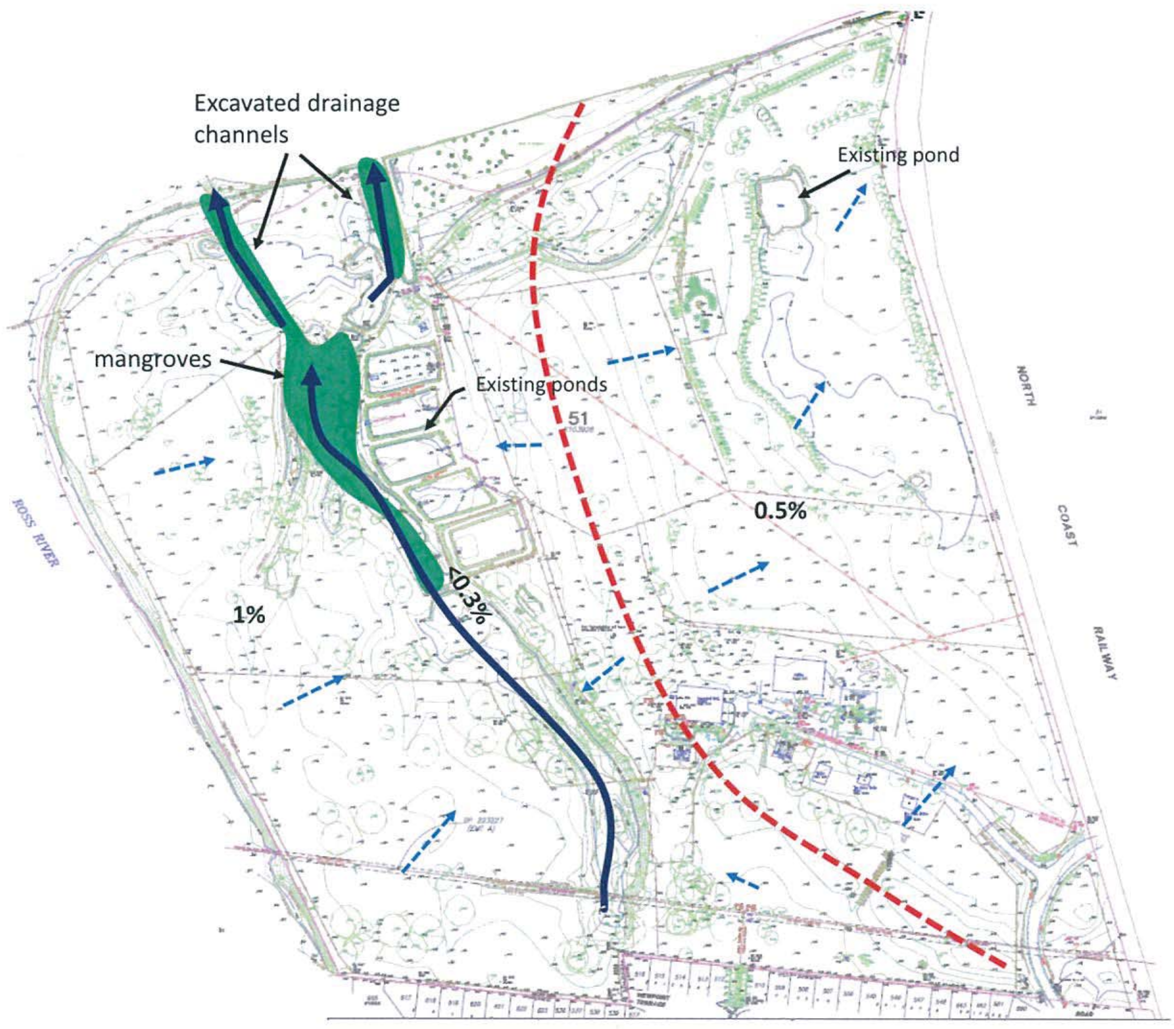

Figure 3 General drainage, catchments and topography

2.4 VEGETATION

The Oonoonba site generally is characterised by mainly open grassed paddocks. Large trees, particularly along the main drainage corridor are noted across the site. At the northern end of the site, mangroves have established as a result of previous drainage works connecting the site to the Ross River. Significant Para grass coverage is noted across the site, including the freshwater zones of the main drainage corridor.

Figure 4 Mangroves (L) and Para grass (R) across the site

2.5 RECEIVING ECOSYSTEMS

There are a number of regionally significant aquatic ecosystems that will ultimately receive stormwater runoff from the site:

- Ross River will accept runoff from the Oonoonba development. This waterway is considered to provide a key riparian corridor within the region and provide important fish and waterbird habitat. The Ross River is considered to be disturbed as a result of changes in catchment land use, however, the local Councils are committed to rectifying the system.
- Halifax Bay and Great Barrier Reef are the ultimate receiving environment for all stormwater discharge from Townsville and Thurwingowa Region. These ecosystems provide recreation resource, significant amenity and underpin economic activity. Importantly the reef represents an aquatic ecosystem that is considered to be regional, nationally and internationally significant and is the focus of numerous management initiatives of the Great Barrier Reef Marine Park Authority. Protection of ecological systems of the Great Barrier Reef from pollutants is recognised as one of the major challenges facing the Authority.

2.6 SITE CONSTRAINTS

Specific design constraints and responses that have influenced the stormwater quality management strategy are summarised in Table 1.

Table 1 Site constraints and design responses

Design constraint	Design response
Flat topography	To avoid excessively deep trunk drainage, adopt open drainage channels with end of line wetlands for treatment, where possible
Intertidal zone	Avoid/minimise impact of stormwater treatment measures on tidal zones, including mangroves, by locating out of and above these areas
Climate variability	Design for extended dry periods • Selection of suitable plant species • Include deep pools for predator refuge in wetlands • Provide saturated zones in bio-retention
Weeds	Freshwater open drainage channels with flat drainage gradients are susceptible to weed infestation. Include dense native vegetation suited to wetted conditions. Provide dense canopy of trees for shade.

2.7 PROPOSED DEVELOPMENT

The Oonoonba development will ultimately cover an area of approximately 53ha of residential development. The site is proposed to be developed into residential allotments (approximately 900 lots) typically varying in size from 100m^2 to +600m^2 lots.

Stages 1 to 6 and 10 of the development has now been built.

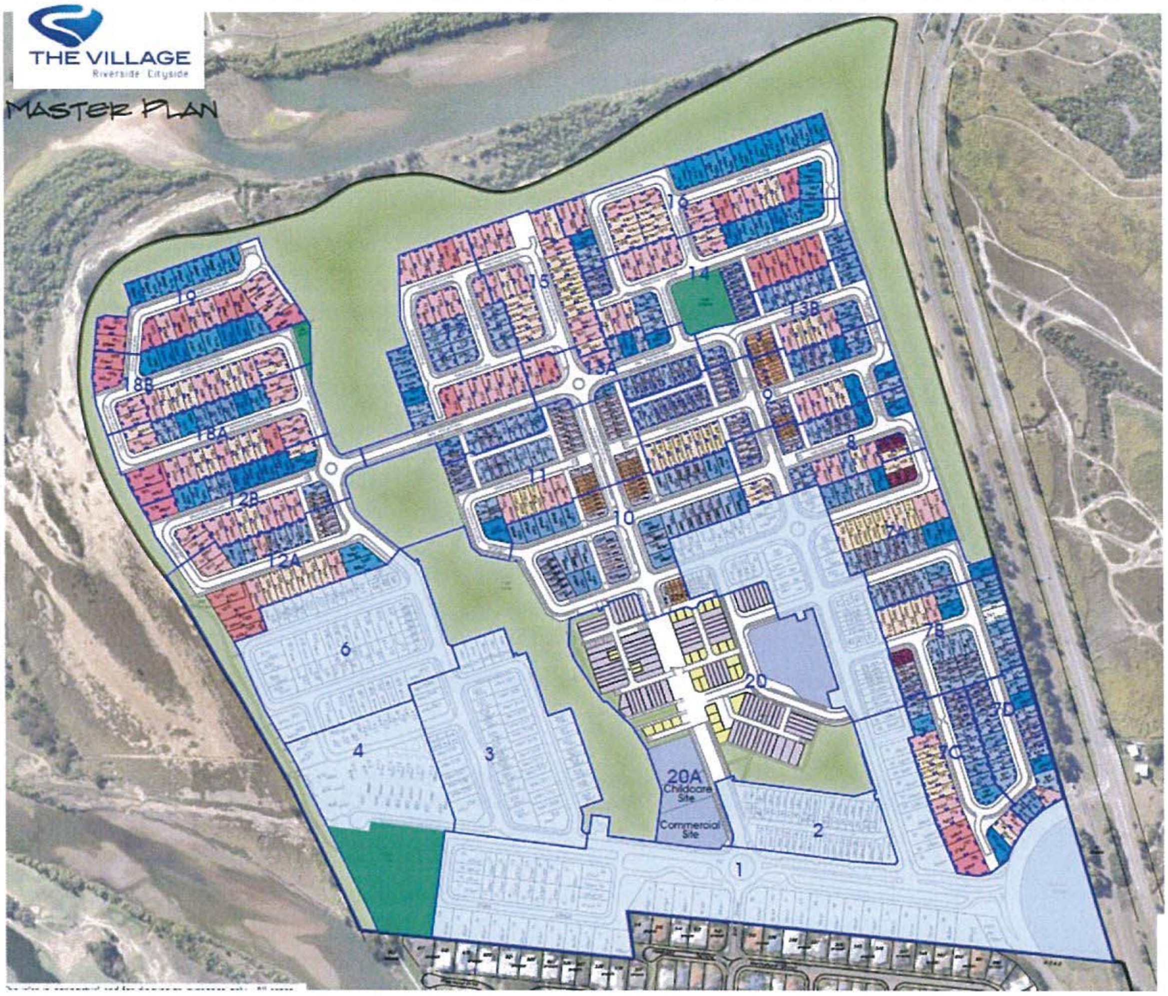

Figure 5 Oonoonba development – The Village

3 DESIGN OBJECTIVES

3.1 CONSTRUCTION PHASE WATER QUALITY

The primary focus of stormwater management during the construction phase is erosion and sediment control. The stormwater management objectives for the construction phase take the form of best-practice concentration-based discharge standards. The performance criteria are limited to those parameters that are directly linked to construction site activities. As the criteria are discharge standards, they apply to runoff events or pumped discharges (during dewatering of siltation basins) from the development site. The design objectives for stormwater discharged from the site during the construction phase are listed in Table 2, reproduced from Table A of the State Planning Policy (DSDIP, 2013)

This document does not propose erosion and sediment control measures for meeting these objectives. These will be developed as part of the operational works design.

Table 2 - Construction phase stormwater management design objectives (source: DSDIP, 2016)

Issue		Design objectives
Drainage control	Temporary drainage works	1. Design life and design storm for temporary drainage works: • Disturbed area open for <12 months—1 in 2-year ARI event • Disturbed area open for 12–24 months—1 in 5-year ARI event • Disturbed area open for > 24 months—1 in 10-year ARI event 2. Design capacity excludes minimum 150 mm freeboard 3. Temporary culvert crossing—minimum 1 in 1-year ARI hydraulic capacity
Erosion control	Erosion control measures	1. Minimise exposure of disturbed soils at any time 2. Divert water run-off from undisturbed areas around disturbed areas 3. Determine the erosion risk rating using local rainfall erosivity, rainfall depth, soil-loss rate or other acceptable methods 4. Implement erosion control methods corresponding to identified erosion risk rating
Sediment control	Sediment control measures Design storm for sediment control basins Sediment basin dewatering	1. Determine appropriate sediment control measures using: • potential soil loss rate, or • monthly erosivity, or • average monthly rainfall 2. Collect and drain stormwater from disturbed soils to sediment basin for design storm event: • design storm for sediment basin sizing is 80th% five-day event or similar 3. Site discharge during sediment basin dewatering: • TSS < 50 mg/L TSS, and • Turbidity not >10% receiving waters turbidity, and • pH 6.5–8.5
Water quality	Litter and other waste, hydrocarbons and other contaminants	1. Avoid wind-blown litter; remove gross pollutants 2. Ensure there is no visible oil or grease sheen on released waters 3. Dispose of waste containing contaminants at authorised facilities
Waterway stability and flood flow management	Changes to the natural waterway hydraulics and hydrology	1. For peak flow for the 1-year and 100-year ARI event, use constructed sediment basins to attenuate the discharge rate of stormwater from the site

3.2 OPERATIONAL PHASE WATER QUALITY

The stormwater quality management objectives that apply to the operational phase of the Oonoonba development have been established considering the State Planning Policy code – water quality.

Acceptable outcomes with respect to the SPP code is to achieve design objectives as listed in Table 3 below (derived from Table B, DSDIP, 2013 – Dry Tropics Townsville), or current best practice environmental management, reflecting land use constraints.

*The **best practice environmental management** of an activity is the management of the activity to achieve an on-going minimisation of the activity's environmental harm through cost effective measures assessed against the measures currently used nationally and internationally for the activity (Environment Protection Act 1994 Section 21).*

Table 3 - Criteria for stormwater discharged from site

Constituent	Discharge Criteria
TSS	80% reduction in post development mean annual load
TP	65% reduction in post development mean annual load
TN	40% reduction in post development mean annual load
Gross Pollutants	90% reduction in post development mean annual load

4 DESIGN CONSIDERATIONS

Successful water sensitive urban design (WSUD) strategies respond to the specific characteristics and conditions of a site and the local and regional receiving environments. Site specific issues particular to Townsville conditions are described, that have had an influence on the proposed strategy.

4.1 MAINTAINING WATER QUALITY IMPROVEMENTS BASED ON BMP

Achieving the load based objectives (as per Table 3 previously) in Townsville requires relatively large treatment systems, particularly when wetlands are used, compared to other regions in Queensland. For example, achieving load based objectives for a development using wetlands requires wetland sizing of 7-8% of the development and above. This is dictated by the need to achieve the TSS objective of 80%. This significantly impacts on the amount of developable land available, and the cost per dwelling to achieve water quality targets.

The derivation of the objectives adhered to three underpinning principles which called for the objectives to be (Healthy Waterways, 2006):

- Locally relevant - The design objectives must, to the extent possible, be derived using locally relevant information on urban stormwater pollution generation rates and stormwater quality treatment measure performance;

- Practical - The design objectives must be achievable with more than one design solution; and

- Best Practice - The design objectives must result in the adoption of the most effective and efficient forms of contemporary 'best practice' designed stormwater quality treatment infrastructure sized to operate at their respective limit of economic performance (i.e. beyond which any further increase in treatment size will not result in any appreciable increase in treatment performance).

A best management approach aims to provide a treatment strategy suited to the site constraints, that is not an economic burden to the community. State Planning Policy stormwater objectives during the construction and operation phase (refer to Section 3) should be achieved where practical, however strict adherence should not result in excessively large assets for only small gains in treatment. This is a challenge for Townville conditions, where stormwater runoff is concentrated during a few months a year during the wet season.

When developing the stormwater treatment strategy for Oonoonba, an integrated approach using vegetated waterway and wetlands has been considered.

The operation of wetlands must allow sufficient treatment during the wet season, without resulting in excessively large wetland areas to meet State Planning Policy load based objectives (DSDIP, 2013), which potentially impact on available developable land, cost to the community and maintenance cost to Council.

The designs developed have considered wetland notional treatment times of 36 hours to maximise volumes of wetland active storage for treatment during the high rainfall wet season, whilst still providing sufficient detention time to allow treatment processes. The wetland design has also incorporated vegetated waterways upstream of the wetlands where possible, to provide a filtering function of development runoff prior to entering wetlands.

Inclusion of upstream vegetated waterways provides an effective means of managing drainage economically in flat drainage environments as well as providing a treatment function that avoids excessively large wetland areas. This approach reduces required wetland sizes from above 7% to approximately 3-4% of the development area i.e. a 40-50% reduction in size.

4.2 DESIGN FOR FLAT DRAINAGE GRADIENTS

4.2.1 Context

The Oonoonba development site is highly constrained with regards to treatment opportunities due to the flat nature of the site. Typically on such sites wetlands or at surface treatments such as streetscape raingardens are the most applicable. Stage 1 implementation used streetscape raingardens (BMT WBM, 2011). The original intent of the stormwater management strategy for the site was for mostly streetscape approaches. Experiences from Stage 1 has resulted in a re-assessment of the original strategy, with the use of vegetated open waterways and wetlands now the preferred approach.

To avoid expensive, low gradient, large diameter pipe drainage networks, the urban drainage design considered minimising catchment areas, minimising drainage lengths and using surface drainage systems at minimum grade. The surface drainage systems are created as vegetated waterways designed to convey flows up to the major storm event.

An important design consideration for flat gradient drainage channels is the management of trickle and low flows that can result in extended wetted conditions and siltation. Typically such channels have been constructed with hard bases such as concrete. Whist conveying trickle flows and low flows efficiently, these channels provide little treatment function and require on-going maintenance for sediment removal, and maintenance of adjacent planted zones. These channels may also present a potential public slip hazard as a result of algae and slime.

4.2.2 Vegetated waterways

An approach using a densely vegetated low flow channel is proposed for the main drainage corridor for the Oonoonba development, to provide a low maintenance alternative to a hard base invert. This also allows a treatment function, minimising downstream wetland areas.

There are a number of issues that must be considered for successful outcomes using this approach. Most are related to ensuring weeds such as Typha and Para grass do not proliferate, particularly where wetted conditions persist. The main design issues include:

- Careful plant selection suited to the expected operating condition
- Design for shade over the low flow channel
- Provision of suitable access to manage weeds

These issues have been carefully considered in recent work we have completed with Mackay Regional Council, where this approach has now been accepted as a Council standard. The approach has identified a number of species that are best suited to not only provide a good filtering function, but also thrive and out compete weeds species in the wetted conditions.

Low flow channel planting

Two key native grass species have been identified that are common in the local area that would be suited for inclusion in vegetated waterways:

1. Leersia hexandra – suited to more permanent wetted conditions such as the base flow portion of the channel receiving constant trickle flows

2. Imperata cylindrica (blady grass) – suited to zones of the channel that are wetted frequently, but not permanently wet e.g. the low flow portion of the channel above the trickle flow invert

Both species provide dense grass coverage, typically to 0.5m in height. An interesting observation with these species is that weed infestations from species such as Typha are not occurring. The photos below show examples of Leersia hexandra in the lower wetted zone of a bulked out wetland at North Shore (Townsville), as well as an example of Leersia hexandra in an open floodplain zone.

Naturally establishing Leersia hexandra on the lower wetted batter

Leersia hexandra in an open floodplain

Design for shade

The long term success of a vegetated waterway strategy is the establishment of shade across the channel, particularly for the low flow channel section. Species such as Melaleuca are well suited to these types of channels where wetted conditions persist.

A recommended approach is to initially plant out high density (1 per 5-10 m^2) of tubestock in and around the low flow channel section. These can be thinned out if required at a later date once established. Less dense planting of trees (e.g. 1 per 25m^2)

in the floodplain zone above the low flow channel can then occur. A wider palette of species is available in this zone given the less frequent inundation.

Provision for suitable access for weed management

It is important that sufficient access is available for weed management. These tracks do not necessarily require to be of a standard for vehicle access, but rather sufficient to allow maintenance staff to access by foot for weed spraying. Stabilised earthen tracks above the low flow portion of the channel, along the length of the channel would be considered sufficient.

4.3 CLIMATE VARIATION IN THE DRY TROPICS

Design of vegetated treatment systems such as wetlands in Townsville must respond to the challenging climate conditions typical in the dry tropics. This is characterised by a distinct wet season (December to May), where the vast majority of rainfall occurs, followed by an extended period of little to no rain. These climatic conditions result in high water level fluctuations and long periods of wetting and drying in constructed wetlands.

Constructed wetland systems are still in their infancy in the dry tropics, and the best operating configuration is still to be tested. DesignFlow, together with Greening Australia are currently undertaking planting trials at the two wetland sites at the North Shore development (Townsville) that have been bulked out to provide sediment management for construction activities. Each wetland is designed with a different operating regime:

- Shallow ephemeral type wetland that is designed to operate in seasonal wetting and drying cycles
- A deeper wetland system that retains water throughout the whole year

Our current experience on the North Shore site suggests that the shallower type system will provide successful outcomes, allowing for a diverse range of plants. Further monitoring of seasonal variations in the coming years will confirm the preferred approach.

4.4 WEEDS

The long term success of vegetated stormwater systems in the Townsville region will often be dictated by the resilience to weed infestation. Careful design is required to avoid conditions that will be preferred by species such as Typha and Para grass. Observations at the Oonoonba site indicate that management of Para grass will be critical to the success of vegetated systems.

Careful plant design plays an important role in the management of weeds. Key aspects to consider include:

- Dense planting of native species suitable for the operating and climatic conditions

- Tree plantings to establish longer term shade canopy
- Establish batter plantings early to provide a weed barrier to aquatic plantings
- Choose species that allow easy identification of weeds for removal
- Suitable access around vegetated assets to allow weed management

Where weeds are present prior to the construction and establishment of vegetated assets, a weed management regime of spraying should occur to minimise the incidence of future weeds outbreaks. Any topsoils used should also be weed free.

4.5 TIDAL CONSTRAINTS

Design of vegetated treatment systems must consider the possible impact on tidal ingress. Tidal ranges in Townsville can be expected to approximately 2.25mAHD, corresponding to the highest astronomical tide (HAT). Freshwater treatment systems must be protected from tidal influences that could potentially have detrimental impacts of aquatic vegetation. This will typically require operating levels of the treatment systems at or above the HAT level, or appropriate measures to minimise the impact of any tidal influences (e.g. outlet configuration to restrict tidal backflow).

Existing mangroves that have established within the development site as a result of previous drainage works connecting to the Ross River will be protected as far as possible, and integrated with the treatment strategy. Development low flows are proposed to pass through freshwater treatment systems prior to any discharge to these areas.

5 STORMWATER TREATMENT STRATEGY

The stormwater treatment strategy for the Oonoonba development considers an integrated approach considering the whole development. This avoids numerous treatment elements that could occur as varying stages of the development are released. This simplifies and minimises on-going maintenance for Council.

The overall stormwater treatment strategy developed has occurred in collaboration with urban and landscape designers to ensure strategies developed do not conflict with current masterplan designs, and retain minimum flood storage volumes.

The proposed Oonoonba development will cover an area of approximately 55ha. Two main drainage discharge zones are proposed, and correspond to the location of the main treatment elements. The proposed drainage for the development will consist of a piped minor drainage system to 2 year average recurrence interval (ARI), with overland flows managed within road reserves and drainage corridors.

The flat nature of the site has required careful consideration of urban drainage and stormwater treatment solutions. From an urban design perspective a preference was for the main treatment zones to be located within and at the end of the major open drainage corridors. The main treatment elements considered in the strategy are wetlands and vegetated waterways due to the flat drainage gradients.

The treatment strategy proposed aims to create a naturalised environment, with dense planting of trees and native vegetation along drainage corridors and wetland zones. These areas will be integrated with the overall landscape enhancements (e.g. paths etc) to allow public interaction. Retaining and enhancing mangroves across the site will offer varied ecological environments. Table 4 and Figure 6 details the stormwater treatment strategy for the Oonoonba development.

Table 4 Stormwater treatment elements

Catchment		Treatment	
ID	Development Area (ha)	Treatment	Area/length
A (Stage 1)	3.29	Stage 1 Biopods	305 m^2
B	1.80	Swale S3	100m
C	2.56	Swale S1 Wetland W1 Swale S2	500 m 10,000 m^2 125 m
D	4.54		
E	2.93		
F	2.94		
G	6.16		
H	7.78		
I	4.87	Bioretention B1	465 m^2
J	10.09	Ephemeral Wetland EW1	5,500 m^2
K	0.74		
L	7.33	Ephemeral Wetland EW2	4,500 m^2
Total	55.94		

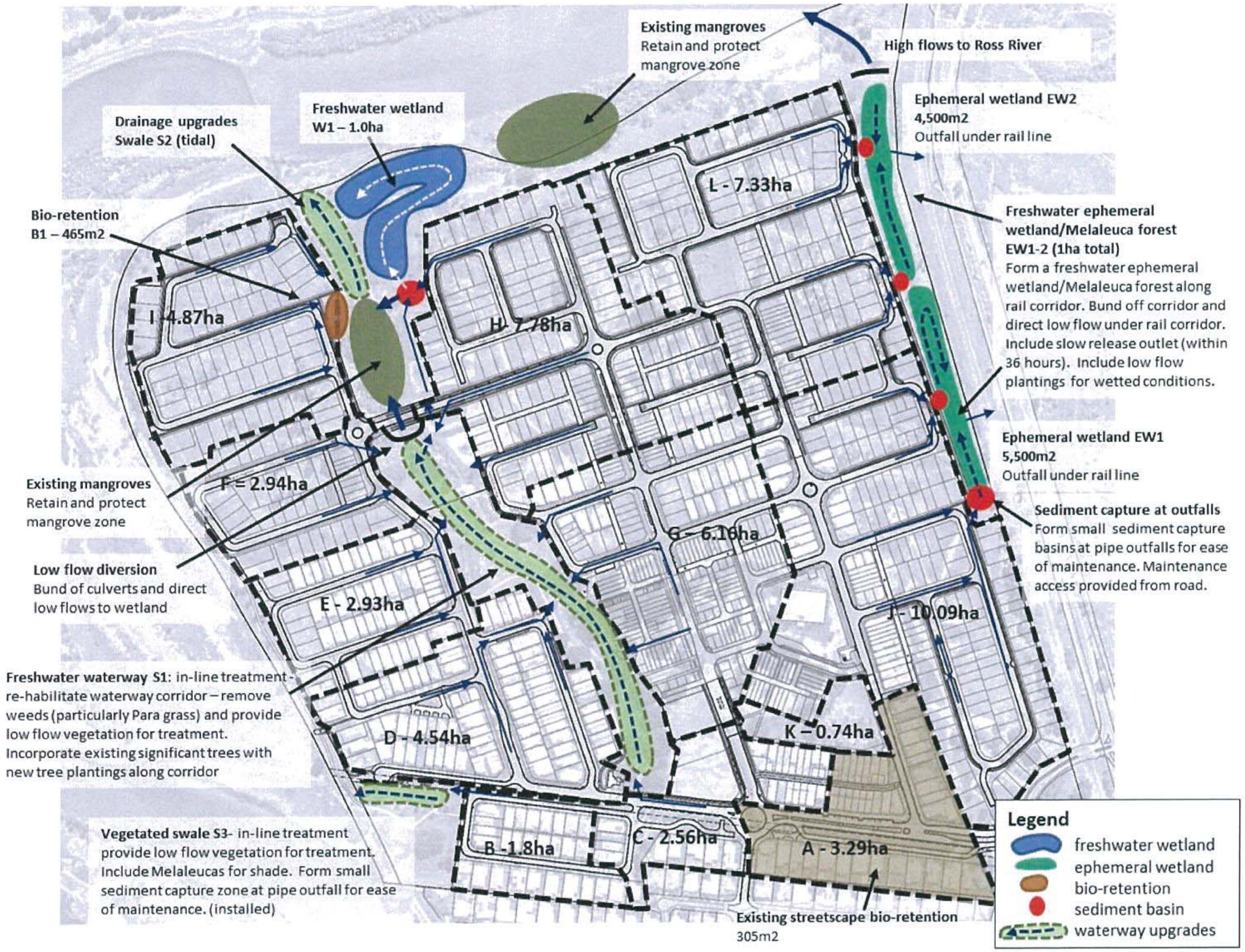

Figure 6 Oonoonba stormwater treatment strategy

Central drainage corridor

This represents the main treatment zone for the development, representing approximately 60% of the development. Restoration of the main drainage corridor (S1) upstream of the road crossing connecting Stage 12 and 13 forms an important part of the strategy, providing a treatment function and minimising the size of the downstream wetland proposed.

This drainage corridor upstream of the road crossing will be configured as a freshwater waterway, which will provide a filtering treatment function for discharged development runoff prior to diversion to the downstream wetland.

Downstream of the road crossing low flows will be diverted to a freshwater wetland (W1-1.0ha) for treatment. The operating levels of the upstream waterway and wetland must be chosen to avoid tidal influences (Highest Astronomical Tide level corresponds to 2.25mAHD, Mean High Water Spring 1.25mAHD).

Downstream of the road crossing the existing mangrove zone will be retained. This will receive high flows and overflows not treated by the wetland. Whilst this area does not form part of the formal stormwater quality management strategy presented in this report, retention of this zone is important from an ecological perspective and will provide an additional treatment buffer prior to discharge to the Ross River.

Note: development discharge from Stage 18/19 (4.75ha) is proposed to be treated by a bio-retention basin (B1 – 465 m^2). Diversion to the main treatment wetland is not practical from this stage of the development. Treatment via bio-retention will be feasible in this location given an approximate 2.5 m elevation difference will be available from finished development level to the drainage invert. This basin can be easily accommodated within the masterplan layout.

Eastern drainage corridor

A 50 m wide drainage corridor is available along the eastern boundary of the site. This area is proposed to be converted to a Melaleuca forest combined with freshwater ephemeral wetlands. At the downstream end of the drainage corridor a bund will be built to retain freshwater conditions. Treated low flows are proposed to be directed under the rail line using existing culverts. High flows will continue down the channel over the downstream bund to the Ross River.

Sediment capture zones at each pipe outfall are proposed to be incorporated for maintenance purposes.

South west drainage

A small catchment at the south west corner of the development is directed to a swale (S3) prior to discharge to the Ross River. This area has recently been completed with native grass along the wetted low flow channel and extensive plantings of Melaleucas along the low flow swale to allow a shaded canopy to establish in time.

5.1 STORMWATER TREATMENT ELEMENTS

The following provides details on stormwater treatment elements proposed in the water quality strategy.

5.1.1 Vegetated waterways

Within the very flat topography of the Oonoonba development a surface drainage strategy using vegetated drainage corridors is adopted to minimise the requirements for large pipe drainage systems and provide a treatment function.

The existing main drainage corridor across the site is degraded and is infested with weeds. There exists an excellent opportunity to rehabilitate the main open drainage corridor back to a naturalised waterway with dense native plantings of grasses and trees which will significantly increase the ecological value. As well as increasing ecological value, this would increase landscape amenity, minimise maintenance weed issues by getting shade into the waterways and improve water quality treatment.

Inclusion of naturalised (vegetated) waterways into the overall strategy is critical in minimising the requirements for wetland areas. These waterways provide treatment, principally of suspended sediment, prior to discharge to wetlands for final treatment. Wetland areas to meet SPP requirements have been found to be reduced by approximately 40-50% with the inclusion of vegetated waterways that provides a water quality treatment function.

Vegetated waterways will be formed considering a trickle/low flow channel (to 3 month flows) with a flood plain zone to manage less frequent flood flows. Careful selection of plants is required to minimise the instance of weed infestations. A dense planting of trees across the low flow section (typ. Melaleuca spp.) and planting with native grass species such as Leersia hexandra and Imperata cylindrica in more frequently wetted low flow channel have been found to be effective to minimise the ingress of weeds such as Typha.

The dense canopy of trees provides a shading function that minimises the incidence of Typha growth, whilst planting such as Leersia hexandra have been found to be very resistant to weed infestation.

Adjacent floodplain zones can grassed and treed, with a maintenance access track provided above the low flow channel section for maintenance. The floodplain zone can include park areas and specific landscape treatments.

Figure 7 provides a typical sectional detail for the proposed waterway sections. Figure 8 provides some photo examples of naturalised waterways.

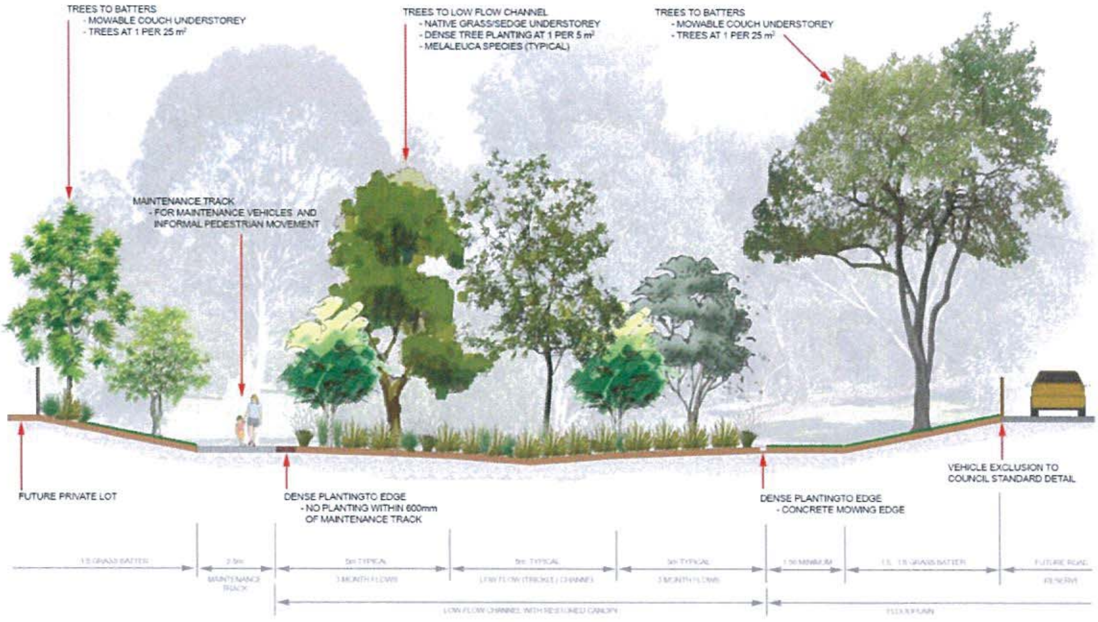

Figure 7 Typical section of a naturalised waterway

Figure 8 Example naturalised waterways

5.1.2 Constructed wetlands

Constructed wetland systems are densely vegetated water bodies that use enhanced sedimentation, fine filtration and biological uptake processes to remove pollutants from stormwater. Water levels rise during rainfall events and outlets are configured to slowly release flows, typically over two to three days, back to dry weather water levels. In addition to treating stormwater, constructed wetlands can also provide habitat, passive recreation and improved landscape amenity.

Constructed wetlands typically consist of an inlet zone (sediment management), a macrophyte zone (a shallow heavily vegetated area to remove fine particulates and uptake soluble pollutants) and a high flow by pass to protect the macrophyte from scour. Figure 9 shows the key elements of constructed wetland systems.

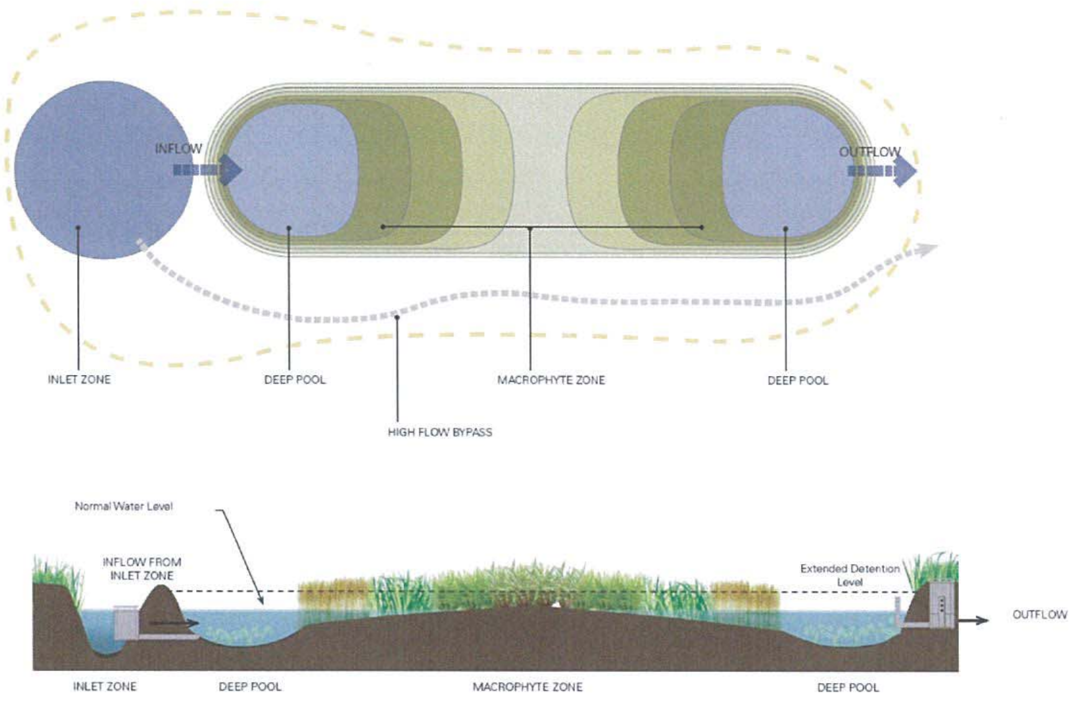

Figure 9 Typical constructed wetland details (source: Water by Design)

<u>Design considerations in the Dry Tropics</u>

In the context of the dry tropics, constructed wetlands will not fill and drain regularly like wetlands in temperate zones. The large and consistent rainfall during the wet months will ensure that wetlands remain charged during the wet. During the dry months the absence of rainfall will result in wetlands drying out, due to high evaporative losses and no top up from stormwater runoff.

<u>Ephemeral vs Permanent water wetlands</u>

Wetlands in the dry tropics may need to persist for four to seven months with very little input of water.

To account for extended dry periods wetland configurations for dry tropics can consider either an ephemeral system, designed with shallow planted zones that will dry out for up to 6 months per year, or wetlands consisting of mostly deep marsh (0.5 to 0.7 m deep) and open pool areas (to 2 m deep) that maintain a permanent pool of water over the majority of the wetland throughout the dry season. Careful plant selections are required for each type of wetland.

Wetlands for the Oonoonba development are proposed to be freshwater ephemeral wetlands. Experience from recent work around Townsville (e.g. NorthShore development where the two wetland systems are currently being trialled) indicates that this type of wetland will allow greater diversity of plant species and retain water for a reasonable duration during the dry season.

Design considerations - ephemeral wetland

An ephemeral wetland for the dry tropic regions considers shallow vegetated zones (0.1 to 0.5 m deep) over the majority of the wetland (85-90%) with open pool areas (to 2 m deep). The performance of the wetland is expected to result in the majority of the wetland drying out for 2-3 months per year. Shallower zones can be expected to be dry for up to 6 months per year. The main design issues for an ephemeral wetland are described below:

- The wetland deep pool areas are lined with a relatively impervious clay layer. This is suggested to maximise the retention of water throughout the dry season to allow permanent pools to be maintained. Clay lining of the shallow wetland floors is most likely not required as plants will be selected to survive for extended dry periods.
- Topsoil would need to be included over the wetland floor; a minimum of 200 mm is required for plant growth.
- The majority of the wetland (85-90%) shall consist of shallow vegetated zones, typically 0.1 to 0.5 m deep, with open pool areas to 2 m.
- An extended detention depth of 0.5m would be adopted for the wetland with a notional detention time of 36 hours.
- It will be beneficial to retain a deep water zone (~10-15% of wetland area), to create a habitat for mosquito larvae predators, to improve landscape aesthetics and to provide habitat and refuge zone for submerged aquatic and macrophytes during the dry. This refuge will then assist the vegetation to rapidly colonise at the beginning of the wet season.

This deep water zone should have a large section of open water, which would be designed to retain water for the whole dry season. To achieve this, the deep open pool zones are considered to 1.5-2m depths. Initial water balance modelling and observations from open water bodies around Townsville indicates water level variation due to evapotranspiration is 0.8 - 1m.

Oonoonba wetlands

Wetlands proposed for the Oonoonba development will be located at discharge points from either pipe drainage outfalls or from stormwater diverted from vegetated swales. Drainage discharges are then directed to the wetland inlet sediment capture zones to manage coarse sediment inputs. From here stormwater runoff will be directed to each wetland in a controlled manner, with high flows by-passing the wetlands.

The open waterways upstream of wetlands will be designed to convey flows at very flat grade. They will be created as a natural vegetated waterway and will provide some level of sedimentation and filtration of stormwater.

Wetland W1 (1.0ha), which manages approximately 60% of the development, will be built and planted when approximately 80-90% of the contributing development catchment has been built out. This sequencing protects the wetland from high sediment laden runoff from construction activities, which can potentially smother establishing wetland vegetation. In this case, use of construction sediment measures such as temporary sediment basins will be required to protect downstream waterways.

At the eastern boundary of the site ephemeral wetlands EW1 and EW2 are proposed within the main drainage corridor. This area will be combined with a Melaleuca forest, providing a dense canopy of shade to minimise weed ingress. The drainage corridor will be planted with a range of grasses, sedges and rushes suited to the expected wetted conditions. During storm event the drainage corridor will pond with water and be slowly released over 36 hours. High flows will still continue down the channel to the outfall to Ross River.

Vegetation

Wetland plants that occur naturally in the freshwater lagoons, floodplains and wetlands of the Townsville Region are likely to be appropriate for stormwater treatment wetlands. These local plants are able to tolerate the high water level fluctuations and long periods of wetting and drying. DesignFlow, in consultation with local industry, have developed an extensive palette of plants suited to Townsville conditions over the last few years whilst working on the North Shore development.

A wetland planting trial is currently underway with Greening Australia at the North Shore wetland sites on a range of wetland plants. A number of species are being trialled from shallow to deep marsh species to review the overall performance during the wet and dry season. The outcomes of this trial will help inform future plant selections for constructed wetlands in Townsville.

Plant communities such as Eleocharis sedgelands, Oryza, Pseudoraphis, Leersia hexandra and Hymenachne grasslands, Melaleuca forests are likely to be key components of the design.

Mosquitoes

Mosquitoes are responsible for the transmission of a number of arboviral diseases the most common in northern Australia are Ross River fever, and malaria (DHCS, 2001). The government actively controls mosquitoes, especially when outbreaks of arboviral diseases occur. Wetlands create standing water bodies which are potential breeding grounds for mosquitoes. In particular, wetland drying presents the risk of mosquito breeding, as it can lead to isolated stagnant pools as a wetland dries out.

Mosquito control is an important consideration in the design of any wetland type in the dry tropics region. The design needs to carefully consider issues such as the likelihood of the design to create disconnected shallow pools, promotion of mosquito larvae predators, vegetation type and edge type. Key management measures include:

- Permanent pools to support mosquito predators – e.g. small native freshwater fish

- Waterbodies edged with "sloped" banks to prevent the formation of isolated stagnant pools
- Diversity of aquatic species to support macroinvertabrates. Macroinvertabrates serve an important function in the management of mosquito numbers.

5.1.3 Bio-retention

Although the vast majority of stormwater treatment proposed for the Oonoonba development is associated with wetlands and vegetated waterways, bio-retention is proposed to treat Stage 18 and 19 at the north western end of the development.

Function

Bio-retention systems are vegetated areas where runoff is filtered through a filter media layer (e.g. sandy loam) as it percolates downwards. Vegetation plays a key role in bio-retention systems. The surface is densely planted with ground level grasses and rushes and may also contain selected tree and shrub species. The agitation of the surface of the bio-retention basin caused by movement of the vegetation and the growth and die off of root systems prevents accreted sediments clogging the filtration media. Beneath the surface, vegetation provides a substrate for biofilm growth within the upper layer of the filter media. Vegetation facilitates the transport of oxygen to the soil and enhances soil microbial communities which enhance biological transformation of pollutants.

In a bio-retention system, treatment of the stormwater occurs both on the surface amongst the vegetation and within the filter media. When larger storm inflows cause temporary ponding on the surface of the basin, pollutants are removed from the stormwater through sedimentation and particulate adhesion onto the stems and leaves of the vegetation. As stormwater percolates through the filter media, fine particulates and some soluble pollutants are removed through processes such as adhesion on to the surface of the filter media particles, biological transformation of pollutants by biofilms growing on the surface of the filter media particles, and biomass uptake of nutrients and metals through the root systems of the vegetation growing in the system.

Bio-retention basins typically use temporary ponding of 0.2–0.4 m depth above the filter media surface to increase the volume of runoff treated through the filter media. Flows above the design flow are conveyed through overflow pits or bypass paths so the filter media surface is protected from high velocities that can dislodge collected pollutants or scour vegetation.

There is a reasonable amount of flexibility regarding the size, shape and location of the systems. As such, there are opportunities to integrate bio-retention systems as landscape features throughout the urban environment as described in the following sections.

The photos below provide examples of bio-retention basins integrated into public realm, parkland spaces and streetscapes.

Figure 10 Examples of bio-retention basins in urban areas

Design considerations in the Dry Tropics

The nature of the climate in Townsville means bio-retention basin must include a saturated zone in the base. Experimental trials conducted by the Facility for Advancing Water Biofiltration (FAWB) show benefits for plants and for removing nitrogen. By using a saturated zone soil moisture can be maintained during the long dry season to sustain vegetation for a number of months without rainfall or stormwater inflow. Figure 11 shows that saturated zones are a relatively simple modification to standard bio-retention designs by:

- incorporating an impervious liner to ensure the basin holds water
- amending the hydraulic structures at the outlet to allow 400–500 mm ponding in the base
- using coarse gravel the base of the saturated zone to support the removal of nitrogen
- ensuring the base of the basin is flat.

Top-up of the saturated zone of the bio-retention basin during the dry season may be required to ensure there is enough water in the zone to sustain plants.

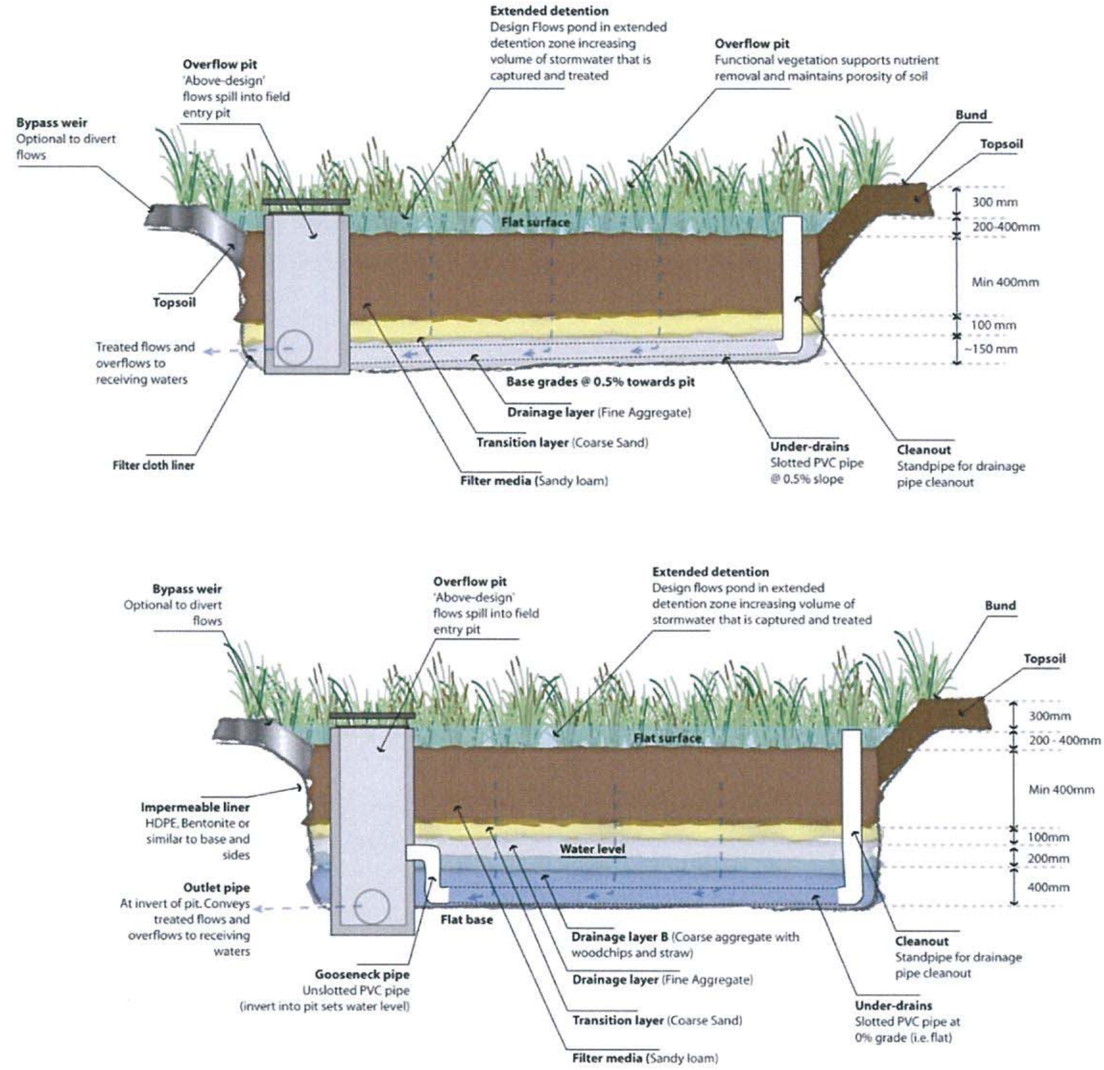

Figure 11: Typical section through bio-retention basin with a saturated zone

Vegetation selection

Due to the wet and dry seasons in the Townsville region, bio-retention systems will operate substantially differently to those in temperate regions. During the wet season, the bio-retention systems will receive large volumes of consistent rainfall while during the dry season the bio-retention are likely to remain dry if no irrigation is used.

Bio-retention systems are typically constructed using free draining soils and so, unlike wetlands, they drain completely after the cessation of rainfall. A typical hydraulic conductivity of bio-retention systems is 100 to 200 mm/hr; therefore bio-retention systems can drain within hours after a storm event.

During the dry season, bio-retention systems will dry out relatively quickly due to the nature of the free draining soils. Therefore, vegetation selection must be carefully considered to ensure the bio-retention vegetation can be sustained during long periods of little or no rainfall. It is expected that without irrigation, the majority of the bio-retention vegetation will die back during the dry season, but should be capable of re-establishment at the start of the next wet season.

Establishment of trees within and around the bio-retention basins have also been found to be an effective way to manage weeds and thus reducing general maintenance. They also provide additional amenity function. Filter depths of 0.7 m minimum are preferred (where drainage permits) in such cases to provide sufficient media for potential tree plantings within the basins.

Typical plant species considered appropriate for bio-retention in Townsville include:

Acacia holosericea	*Silver leaf wattle*
Alloteropsis semialata	*Cockatoo grass*
Carex appressa	
Lomandra hystrix	
Ghania aspera	
Isachne globosa	
Imperata cylindrical	*Blady grass*
Chrysopogon fallax	*Golden beard grass*
Leptochloa neesii	*Umbrella canegrass*
Melaleuca leucadendra	
Melaleuca nervosa	*Fibrebark*
Melaleuca viridiflora	*Broad leaved tea tree*
Oryza austaliensis	*Australian wild rice*
Pandanus cookii	*Screw pine*

6 STORMWATER TREATMENT PERFORMANCE ASSESSMENT

MUSIC modelling was conducted to quantitatively assess the stormwater treatment performance of the proposed stormwater strategy. MUSIC version 6.0 was used for the assessment and model the parameters have been adapted from the Mackay MUSIC Guidelines (MRC, 2008). These are considered the most applicable modelling guidelines applicable to Townsville.

Details of the modelling assumptions, parameters and results are presented in the following sections.

6.1 MODEL STRUCTURE

The structure of the MUSIC model is shown in Figure 12 with the general data upon which the model is based provided in Table 5.

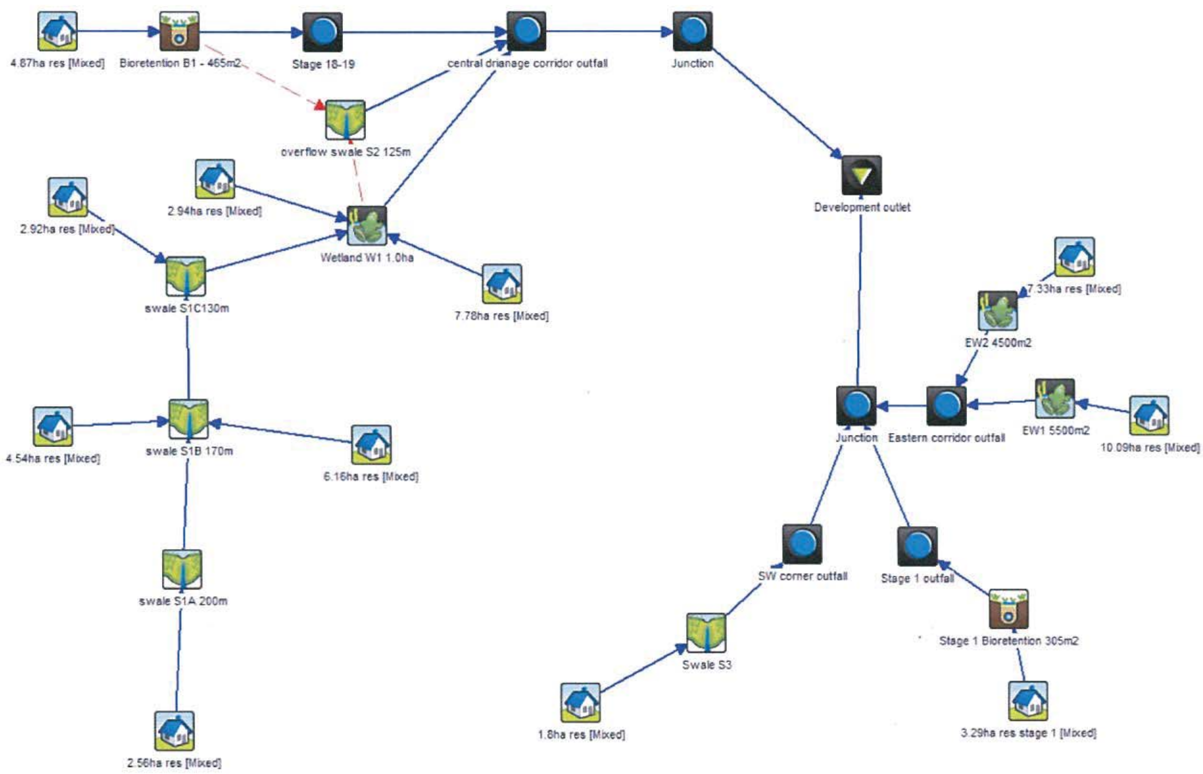

Figure 12: MUSIC catchment and model layout

Table 5: MUSIC model data summary

Input	Data used in modelling
Rainfall station	32040 Townsville
Time step	6 minute
Modelling period	1970-1984
Mean annual rainfall	1165 mm (for the period used)
Mean annual evapotranspiration	1856 mm
Rainfall runoff parameters	Upland soils (Table 7 Mackay MUSIC modelling guidelines)
Pollutant export parameters	Urban Residential (Table 9 Mackay MUSIC modelling guidelines)

6.1.1 Catchment data

Catchment areas draining to each treatment system have been derived from proposed master plan layout for the development, considering the pipe drainage system that would apply. The model adopts the lumped catchment approach with an overall percent impervious value assigned depending on the landuse.

Table 6 Land use assumptions

Land use	Percent impervious
Urban residential	60 %
Community facility and park	30 %

The main catchment areas draining to each treatment zone are shown previously in Figure 6. For the purposes of sizing treatment systems, open space and drainage reserves have been excluded from the catchment areas as these areas will provide a treatment function.

6.1.2 Wetland reporting table

The model parameters adopted for each wetland are shown in Table 7. The main treatment wetland (W1) is proposed to be configured with an inlet pond. Smaller eastern corridor wetlands (EW1-2) will be provided with small sediment basins at pipe outfalls prior to diversion to each wetland.

Table 7 Wetland node reporting table

Parameter	W1	EW1	EW2
Catchment area (ha)	26.9	10.83	7.33
Inlet pond volume (m3)	1,000	500	300
Macrophyte surface area (m2)	10,000	5,500	4,500
Proportion contributory catchment area %	3.7%	5.1%	6.1%
Has surface area been calculated correctly	Y	Y	Y
Extended detention depth (m)	0.5	0.5	0.5
Permanent pool volume (m3)	3,000	0	0
Exfiltration rate (mm/hr)	0	0	0
Evaporation loss as % PET	125	125	125
Equivalent pipe dia (mm)	153	113	103
Overflow weir length (m)	20	20	20
Notional detention time (hrs)	48	36	36
Number CSTR cells	5	5	5

6.1.3 Swale reporting table

The model parameters adopted for each swale are indicated in Table 8. Freshwater swales (S1 and s3) will be planted with native grass species such as Leersia hexandra and Imperata cylindrical across the low flow portion of the channel. These species typically grow to over 0.5 m in height. Swale S2 will provide treatment to wetland overflows. This drainage corridor will be tidal and salt water species such as Sporobolous (salt couch) are more appropriate. A maximum vegetation height of 100mm is considered in this case.

The swale width and height consider only the low flow portion of the channel, where the majority of treatment will occur. Swale gradients are taken at 0.1% reflecting the generally flat gradients available. Swale lengths represent the minimum length of treatment each sub-catchment can expect to have, based on the current masterplan.

Modelled parameters are considered a conservative representation of actual conditions.

Table 8 Swale reporting table

Parameter	S1A-C	S2	S3
Length (m)	500	125	100
Bed slope (%)	0.1	0.1	1.0
Base width (m)	5	5	1
Top width (m)	15	15	5.6
Depth (m)	0.5	1.0	0.4
Vegetation height (mm)	0.5	0.1	0.25
Exfiltration (mm/hr)	0	0	0

6.1.4 Bioretention reporting table

The model parameters used for each bio-retention cell are shown in Table 9. The bioretention systems were modelled using minimum 30 mg/kg Orthophosphate (OP) minimum 400 mg/kg Total Nitrogen (TN) in accordance with the recent advice issued by Healthy Waterways Partnership.

(http://healthywaterways.org/initiatives/waterbydesign/stormwater)

Table 9 Bio-retention reporting table

Parameter	Bio-retention basin ID	
	B1	Stage 1 (existing)
Catchment Area (ha)	4.87	3.29
Surface Area (m2)	465	305
Has the surface area been calculated appropriately?	Y	Y
Extended detention depth (m)	0.3	0.2
Filter area (m2)	465	305
Proportion contributing catchment area (%)	1.0	0.9
Hydraulic conductivity (mm/hr)	150	150
Filter depth (m)	0.6	0.3
Overflow weir width (m)	5	5
Seepage loss (mm/hr)	0	0

6.1.5 Results

The results of the MUSIC modelling for the proposed development are shown in Table 10. Results are provided for the whole site.

Whilst individual treatment elements may not necessarily meet load based objectives, the combined effect of all treatments when considered at the catchment outlet applies when considering the water quality objectives to meet SPP requirements.

Table 10: MUSIC model results – stormwater quality

ID	Pollutant	Inflows (kg/yr)	Outflows (kg/yr)	Reduction achieved (%)	Water Quality Objective (%)
TOTAL	TSS	95,000	18,900	80.1%	80 %
	TP	189	61	67.6%	65 %
	TN	931	590	36.6%	40 %

The above results indicate that water quality objectives are met for both TSS and TP, but fall below the TN objective. As explained in Sections 3.2 and 4.1 previously, given the constrained nature of the site due to flat drainage gradients, practically achieving the TN objective will require considerably larger treatments for only a minor reduction in nitrogen load.

Given the water quality strategy considers an integrated approach using vegetated waterways and wetlands and retains and enhances existing mangrove zones across the development, the approach is considered best practice environmental management with significant ecological benefits, complying with the intent of the SPP (refer to Section 3.2 previously).

7 PRELIMINARY EARTHWORKS

The main wetland zone (W1 – 1.0ha) has been fully designed and in readiness for construction. The earthworks of the shown in Figure 13.

The wetland layout was selected to avoid impact on the existing mangroves and fit within the constraints of the current masterplan layout. Operating levels have been selected based on requirements to allow low flow diversions to the wetland and avoid tidal influences into the wetland. For the purposes of preliminary design a 3 m wide access track is included around the perimeter of the wetland and wetland batters are taken at 4H:1V.

The preliminary earthworks indicate that it is possible to develop a total wetland area of 1.0 ha in the downstream open drainage zone within the site constraints. The final form of the wetland layout will likely alter as detail design progresses, however the overall intent indicated in this preliminary earthworks model will be maintained.

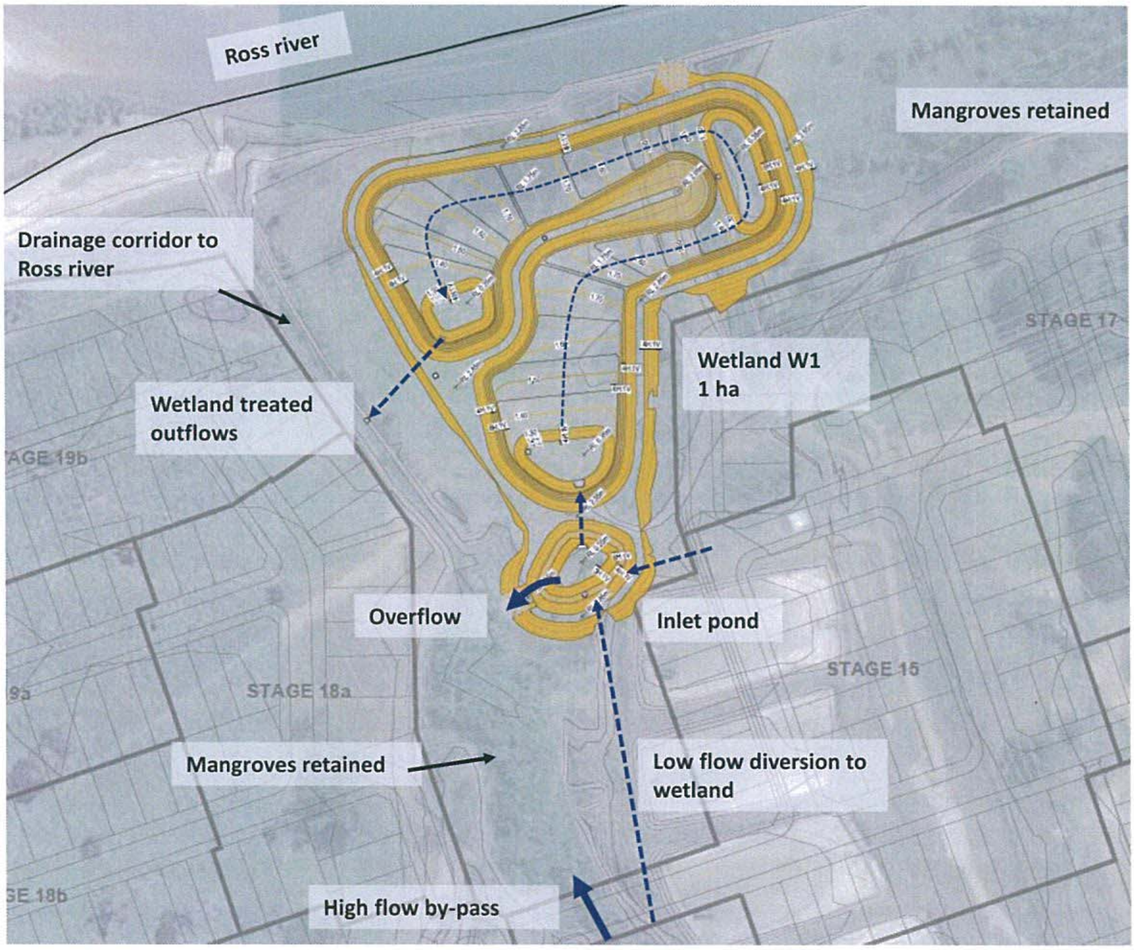

Figure 13 Preliminary earthworks model - wetland W1

8 CONSTRUCTION STAGING

It is important that WSUD systems are protected from large sediment loads during the building phase and certain measures are available to protect both wetlands and bio-retention systems. These include:

- Isolate WSUD systems from inflows during the allotment building phase to protect vegetated zones from sediment smothering. This can allow systems to become well established before coming on line. Irrigation will most likely be required to maintain plant health. Construction sediment management via temporary sediment basins etc will be required to protect downstream waterways.

- In the case of bio-retention systems provide a temporary protective layer over the filter media, such as turf. This then removed and planted as designed toward the end of the allotment building phase.

- Bulk out the wetlands and bio-retention basins as use them as temporary sediment basins. This can provide an effective means of protecting downstream receiving water from construction sediment loads. This option does not allow planting to commence and will not provide any aesthetic value during the allotment development phase. At near completion of the building phase (say 90%) the wetlands and bio-retention basins can be de-silted and completed as per the design intent.

The recommended approach for the Oonoonba development is to isolate treatment systems from construction sediment loads and sequence construction of each once the build out phase of the development reaches approximately 80%. As an example, wetland 1 (1.0ha) would be required to be built at the completion of Stage 12. The contributory catchment at this stage will be nearing 80%. Construction of the road connecting Stage 12 to 15 will then occur, together with necessary diversion structures to direct drainage to the wetland.

Further detailed advice in relation to construction and establishment of the stormwater treatment system will be provided during Operational Works as each treatment site detailed further.

9 MAINTENANCE

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

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

The following sections summarise the maintenance requirements of the constructed wetlands, bio-retention basins and vegetated swales. Detailed operation and maintenance schedules will be provided prior to handover of assets.

It is recommended that the personnel who are to undertake the operation and maintenance of the vegetated assets be briefed and trained on procedures and protocols prior to commencement. Keeping and maintaining records on the condition of the systems and all maintenance works required will be important to inform and schedule future maintenance works.

9.1 CONSTRUCTED WETLANDS

Maintaining healthy vegetation and adequate flow conditions in a wetland are the key maintenance considerations. Weeding, planting, mowing and debris removal are the dominant tasks (but should not include the use of herbicides as this affects water quality). In addition, wetlands need to be protected from high loads of sediment and debris and the inlet zone needs to be maintained in the same way as sedimentation basins. Routine maintenance of wetlands should be carried out once a month.

The most intensive period of maintenance is during the plant establishment period (first two years) when weed removal and replanting may be required. It is also the time when large loads of sediments could impact on plant growth, particularly in developing catchments with poor building controls. Debris removal is an ongoing maintenance function. If not removed, debris can block inlets or outlets, and can be unsightly if in a visible location. Inspection and removal of debris should be done regularly. Additional inspections are recommended following large storm events to check for scour and damage.

Typical maintenance of constructed wetlands will involve:

- De-silting the inlet zone following the construction/ building period

- routine inspection of the wetland to identify any damage to vegetation, scouring, formation of isolated pools, litter and debris build up or excessive mosquitoes
- routine inspection of inlet and outlet points to identify any areas of scour, litter build up and blockages
- removal of litter and debris
- removal and management of invasive weeds
- repair to wetland profile to prevent the formation of isolated pools
- periodic (usually every 5 years) draining and de-silting of the inlet pond
- regular watering of littoral vegetation during plant establishment
- water level control during wetland plant establishment
- replacement of plants that have died (from any cause) with plants of equivalent size and species as detailed in the planting schedule
- vegetation pest monitoring and control.

9.2 VEGETATED WATERWAYS

The establishment of vegetated waterways (as per the suggested design approach) is expected to reduce on-going maintenance in the long term. This includes:

- Reduced weed management
- Reduced removal of accumulated silts
- Lower risk of mosquito breeding

Densely vegetated waterways will filter out sediments, with the trapped sediment supporting vegetation growth. The visual amenity of the waterways will be significantly improved and provide a habitat for macro invertebrates for mosquito control.

The main maintenance activities that will be required include:

- Removal of weeds – spot spraying as required
- Repair of any erosion to batters and culvert locations (minimal)
- Removal of litter/debris (as required)

- Removal of excessive accumulated sediment (where smothering of vegetation occurs)

- Repair to access tracks – e.g. rutting - as required

9.3 BIO-RETENTION SYSTEMS

Typical maintenance of bio-retention systems during operation will involve:

- Routine inspection of the bio-retention system profile to identify any areas of obvious increased sediment deposition, scouring from storm flows, rill erosion of the batters from lateral inflows, damage to the profile from vehicles and clogging of the bio-retention system (evident by a 'boggy' filter media surface).

- Routine inspection of inflows systems, overflow pits and under-drains to identify and clean any areas of scour, litter build up and blockages.

- Removal of sediment where it is smothering the bio-retention system vegetation.

- Where a sediment forebay is adopted, removal of accumulated sediment.

- Repairing any damage to the profile resulting from scour, rill erosion or vehicle damage by replacement of appropriate fill (to match onsite soils) and revegetating.

- Tilling of the bio-retention system surface, or removal of the surface layer, if there is evidence of clogging.

- Regular watering/ irrigation of vegetation until plants are established and actively growing.

- Removal and management of invasive weeds (herbicides should not be used).

- Removal of plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule.

- Pruning to remove dead or diseased vegetation material and to stimulate growth.

- Vegetation pest monitoring and control.

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

10 CONCLUDING REMARKS

An updated stormwater quality management strategy has been developed for the Oonoonba development to meet the requirements of the State Planning Policy (DSDIP, 2013). The overall treatment strategy considers an integrated approach using primarily vegetated waterways and wetlands.

The major portion of development treatment will occur in the main north-south vegetated drainage corridor which discharges to freshwater treatment wetland (1.0ha) prior to discharge to the Ross River. At the eastern boundary of the site a Melaleuca forest/ephemeral wetland system will be included along the drainage corridor adjacent to the rail line.

As part of the treatment strategy, restoration of the main drainage corridor through the site as a naturalised freshwater waterway is included to minimise wetland areas required and provide a low maintenance drainage alternative that enhances the development.

Existing mangroves at the downstream end of the main drainage corridor will be retained as much as possible and integrated with the treatment strategy.

The above strategy provides an integrated best environmental management approach to stormwater quality management that meets the intent of the State Planning Policy (SPP), thereby affording appropriate protection to the Ross River, Halifax Bay and the Great Barrier Reef.

11 REFERENCES

AECOM (2011), *Water Sensitive Urban Design for the Coastal Dry Tropics (Townsville) – Technical Design Guidelines for Stormwater Management.* Prepared for Townsville City Council.

AECOM + McGarry and Eadie (2011), *Water Sensitive Urban Design for the Coastal Dry Tropics (Townsville): Design Objectives for Stormwater Management.* Prepared for Townsville City Council.

BMT WBM (2010), *Site Based Stormwater Management Plan – Oonoonba Urban Development, Townsville.* Prepared for Urban Land Development Authority.

BMT WBM (2011), *Stage 1 Operational Works – Detailed Stormwater Quality Management Report – Oonoonba Urban Development, Townsville.* Prepared for Urban Land Development Authority.

DILGP (2016). *State Planning Policy* Department of Infrastructure, Local Government and Planning

EDAW Ecological Engineering (2008) *WSUD Design Objectives for the Dry Tropics –* Discussion Paper for Creek to Coral

FAWB (2009) *Guidelines for Filter media in Biofiltration Systems (Version 3.01),* Facility for Advancing Water Biofiltration, Monash University, June 2009. (http://www.monash.edu.au/fawb/products/index.html)

Mackay Regional Council (2008) *Mackay Regional Council MUSIC Guidelines.* Version 1.1

Water by Design (2006), *Water Sensitive Urban Design Technical Design Guidelines for South East Queensland Version 1.* Moreton Bay and Waterways Catchments Partnership. Brisbane, Queensland.

Water by Design (2010), *MUSIC Modelling Guidelines.* Water by Design - SEQ Healthy Waterways Partnership. Brisbane, Queensland.