Appendix C

Stormwater Quality Management Plan

OONOONBA DEVELOPMENT – THE VILLAGE

UPDATED STORMWATER QUALITY MANAGEMENT PLAN

DesignFlow

Prepared for Economic Development Queensland

May 2026

Document Control Sheet

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Author(s):	Ralph Williams
Reviewed By:	Shaun Leinster
Approved By:	Shaun Leinster
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1 EXECUTIVE SUMMARY

The Oonoonba development (the Village) is a proposed residential subdivision of approximately 41ha on a development site of approximately 70ha, located 4 km south of Townsville, on the southern banks of the Ross River. Development across the site has been occurring for over a decade.

Economic Development Queensland (EDQ) are in the process of planning for future development zones across Oonoonba and require a review of the previously developed stormwater treatment strategy. This report presents an updated stormwater quality management strategy for the Oonoonba development to meet the requirements under the State Planning Policy (DILGP, 2017). This report supersedes the previously developed site-based stormwater management plans for the site namely BMT WBM (2010, 2011) and DesignFlow (2014, 2016 and 2025).

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 resulted in a re-assessment of the original strategy, with the use of waterways and wetlands now the preferred alternative.

2016 strategy

An updated treatment strategy was developed in 2016 focussing on an integrated approach using freshwater wetlands and waterway upgrades (DesignFlow, 2016). The strategy focussed on two main treatment zones:

- Central drainage corridor discharging to a freshwater wetland (1ha)
- Eastern rail corridor linear wetland system

The strategy was based on freshwater treatment systems.

Construction and establishment of the central drainage corridor has been in progress for over a decade and has been generally completed to the tidal interface. A treatment swale at the southwestern corner of the site has also been operational since 2014. No other treatment systems previously identified in the 2016 strategy have been constructed.

Updated strategy

Following site visits and discussions with EDQ and the design team an updated stormwater treatment strategy has now been developed for the site. The overall development extent has now been reduced from ~55ha to ~41ha, with areas previously identified for development at the northern end of the site now removed. The updated treatment strategy now reflects to reduced development extent for the site.

The fundamental change to the treatment stargey since 2016 is the inclusion of a tidal wetland system connecting the central drainage corridor to the Ross River. This replaces the freshwater wetland previously proposed. The tidal wetland system is now preferred for a number of reasons:

- Site observations along the central drainage corridor where the freshwater section of the drainage corridor was observed to be poorly draining and weedy, whilst the mangrove area at the downstream end of the corridor was observed to have a good vegetation structure, weed free and low maintenance.
- Expanded mangrove/salt marsh communities in the zone between the development edge and the Ross River enhancing local ecology and habitat
- Potential increase in fish habitat
- Lower long-term maintenance, particularly weed management (e.g. Typha).
- Lower operating levels increasing flood storage potential.

Tidal mangrove wetland system restoration and rehabilitation projects are increasingly being acknowledged as playing an important role in climate change due to their very high carbon sequestration rates (UNSW, 2023).

As part of the treatment strategy, downstream sections of the central drainage corridor that currently operate as fresh are proposed be converted to tidal systems. A tidal barrier will be included along the drainage corridor to retain freshwater conditions in the upstream sections which are currently free draining and generally performing as intended.

The previously proposed linear wetland system along the eastern rail corridor is retained and re-configured to suit the new development extent.

The above strategy provides an integrated best environmental management approach to stormwater quality management that compliments the local environment and 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.

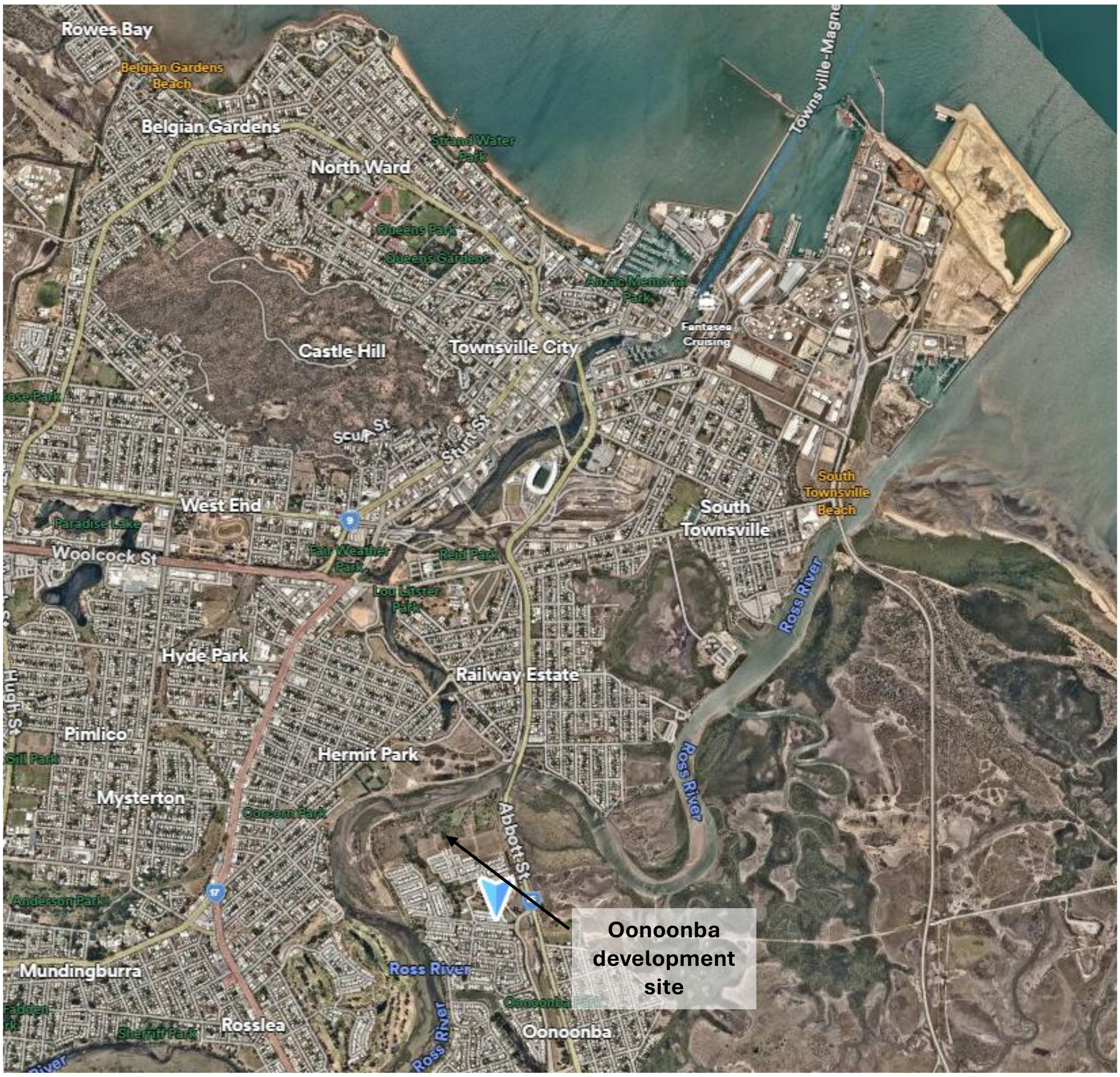


Figure 1: Oonoonba development location (source: nearmap)

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.

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.

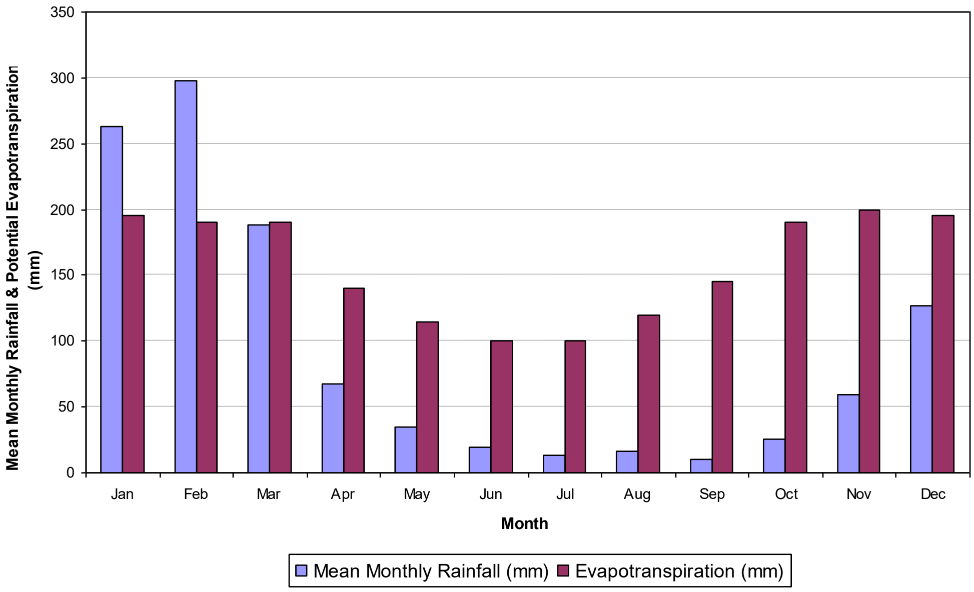


Figure 2: Average climate data for Townsville

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 an easterly direction before discharging eastward via culverts under the rail corridor.

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.

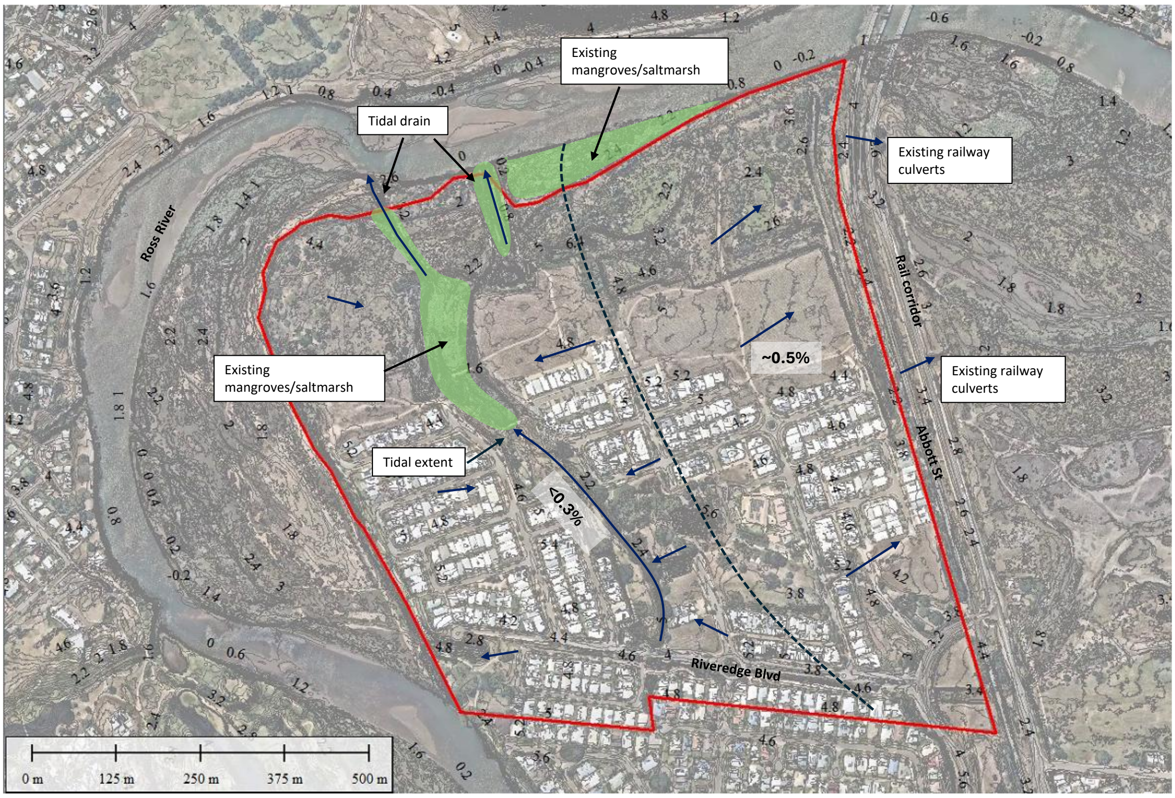


Figure 3 General drainage, catchments and topography

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	Protect existing mangrove species and enhance where opportunities are available
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 area (the Village) covers an area of ~70ha and will ultimately include approximately 41ha of residential development. The site is proposed to be developed into residential allotments typically varying in size from 100m² to +600m² lots.

Development has been occurring across the site with ~470 lots now already constructed.

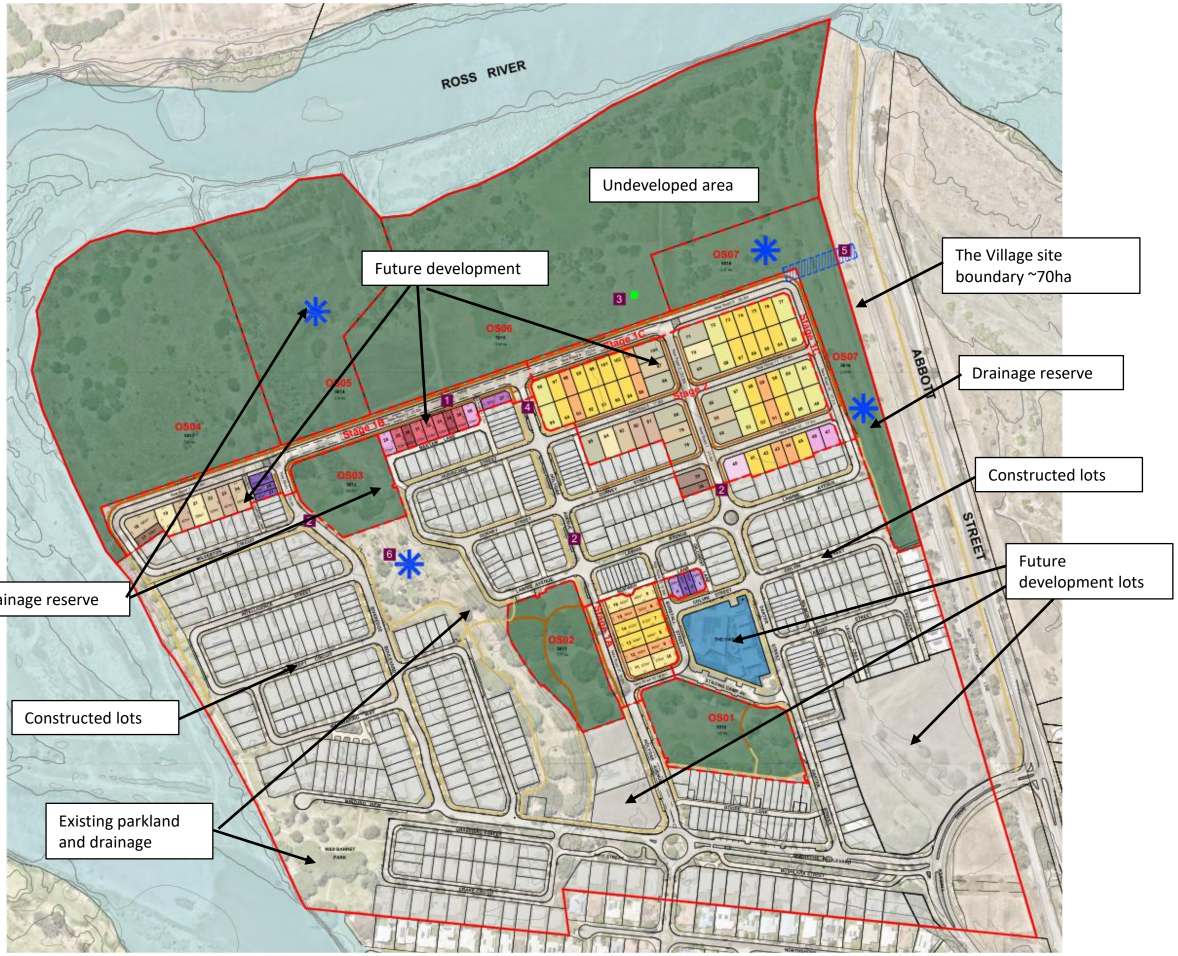


Figure 5 Oonoonba development

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 Appendix 2 – Table A of the Stage Planning Policy (DILGP, 2017). 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: DILGP, 2017)

Issue	Desired outcomes
Drainage control	1. Manage stormwater flows around or through areas of exposed soil to avoid contamination. 2. Manage sheet flows in order to avoid or minimise the generation of rill or gully erosion. 3. Provide stable concentrated flow paths to achieve the construction phase stormwater management design objectives for temporary drainage works (part 2). 4. Provide emergency spillways for sediment basins to achieve the construction phase stormwater management design objectives for emergency spillways on temporary sediment basins (part 3).
Erosion control	1. Stage clearing and construction works to minimise the area of exposed soil at any one time. 2. Effectively cover or stabilise exposed soils prior to predicted rainfall. 3. Prior to completion of works for the development, and prior to removal of sediment controls, all site surfaces must be effectively stabilised[13] using methods which will achieve effective short-term stabilisation.
Sediment control	1. Direct runoff from exposed site soils to sediment controls that are appropriate to the extent of disturbance and level of erosion risk. 2. All exposed areas greater than 2500 metres^2 must be provided with sediment controls which are designed, implemented and maintained to a standard which would achieve at least 80% of the average annual runoff volume of the contributing catchment treated (i.e. 80% hydrological effectiveness) to 50mg/L Total Suspended Solids (TSS) or less, and pH in the range (6.5–8.5).
Litter, hydrocarbons and other contaminants	1. Remove gross pollutants and litter. 2. Avoid the release of oil or visible sheen to released waters. 3. Dispose of waste containing contaminants at authorised facilities.
Waterway stability and flood flow management	1. Where measures are required to meet post-construction waterway stability objectives (specified in table B), these are either installed prior to land disturbance and are integrated with erosion and sediment controls, or equivalent alternative measures are implemented during construction. 2. Earthworks and the implementation of erosion and sediment controls are undertaken in ways which ensure flooding characteristics (including stormwater quantity characteristics) external to the development site are not worsened during construction for all events up to and including the 1 in 100 year ARI (1% AEP).

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 load based objectives (DILGP, 2017)

Load based stormwater quality objectives applicable to climatic conditions in Townsville (Dry Tropics) are outlined in Table 3.

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 Townsville 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 inclusion of a tidal wetland system as part of the strategy responds to the site conditions and enhances local mangrove communities within the site area.

Inclusion of vegetated waterways and a linear wetland provides an effective means of managing drainage economically in flat drainage environments as well as providing a treatment function.

4.2 DESIGN FOR FLAT DRAINAGE GRADIENTS

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 resulted in a re-assessment of the original strategy, with the use of vegetated open waterways and end of line 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.

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.

The strategy has incorporated tidal wetlands which retain wetting and drying cycles throughout the year based on tidal exchanges. Where freshwater wetlands occur plant selection is key to support the extended wet and dry periods that occur throughout the year.

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

Use of tidal wetland systems in the stargey also will play an important role in managing weeds across the site.

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 2.36mAHD, 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. Incorporating tidal wetlands into the strategy will support and enhance existing mangrove communities across the site.

4.6 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.
- Drainage runnels included in tidal wetland zones to avoid isolated pools forming during spring tides
- Access tracks along wetlands to facilitate spraying
- Creating sparsely vegetated zones and breezeways between wetland areas and residential lots
- Stocking open water bodies with lavivorous fish
- 2 monthly inspections of vegetated stormwater assets for mosquito breeding and larval abundance

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 41ha. 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 (fresh and tidal) 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

ID	Treatment		Development area	Comment
	Type	Area/length	ha	
S1	Swale	S1A = 150m S1B=100m	4.96 (S1A=2.6 S1B=S1A+2.36 parkland)	Central freshwater drainage channel discharging to tidal wetlands
S2	Swale	100m	1.85	Swale treating SW development area. This is now operational.
S3	Tidal swale	225m	S1 +12.4	Tidal swale connecting freshwater swale S1 to downstream tidal wetland TW1
TW1	Tidal wetland	0.75ha	S3 + 5.05	Tidal wetland discharging north to Ross River
S4	Tidal swale	115m	TW1	Tidal overflow channel discharging to Ross River
FW1	Freshwater wetland	1.235ha	13.55	Freshwater wetland discharging east via rail corridor culverts
Stage 1	Bioretention	305m²	3.2	At surface bio pods installed in Stage 1 development
		TOTAL	**41.0**	

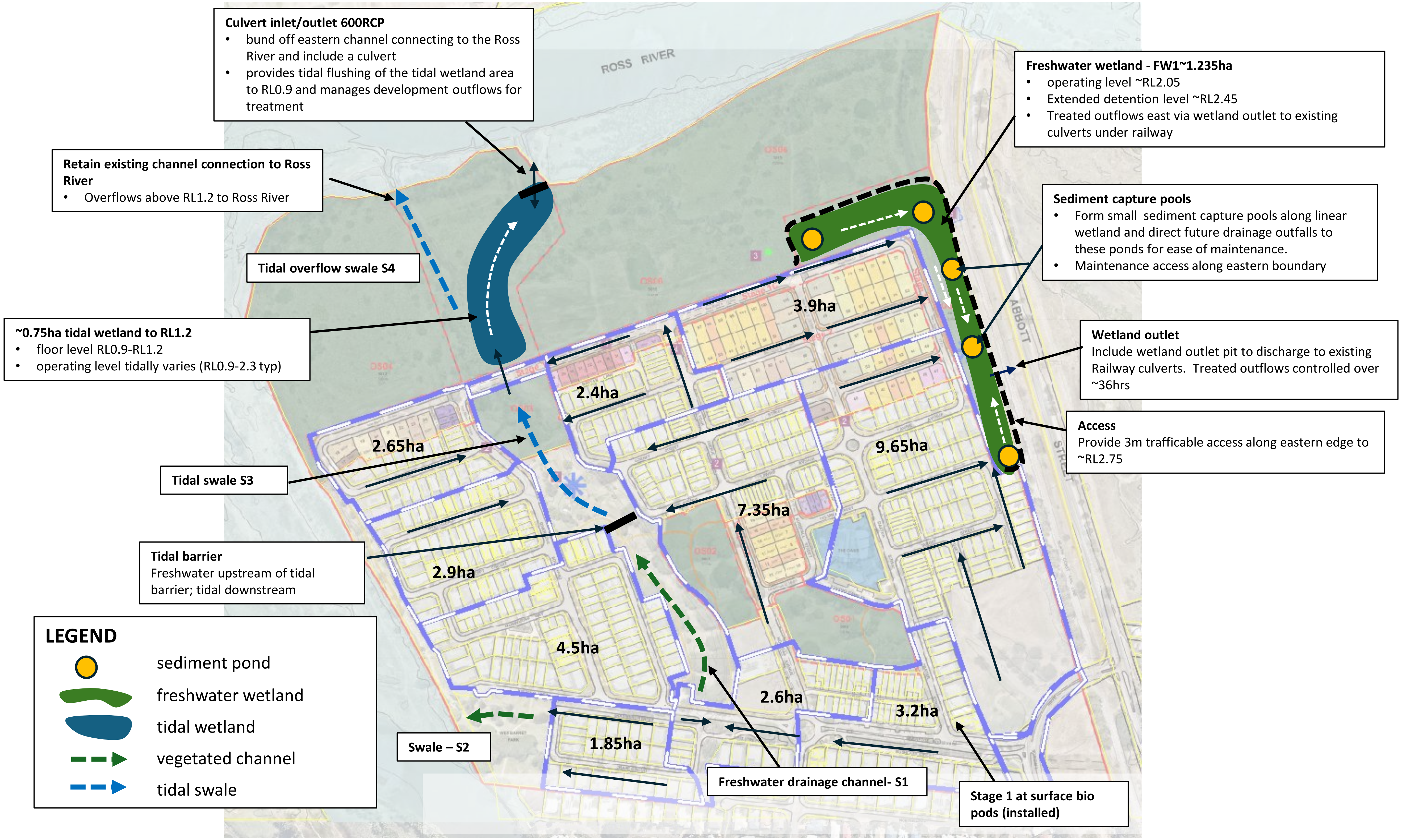


Figure 6 Oonoonba stormwater treatment strategy

Central drainage corridor

Construction of the central drainage corridor has occurred as part of the development with ~400m length of channel now completed. The initial 150m of channel is generally in good condition and appears to be functioning as intended. Further downstream the channel is observed to become weedy and poorly drained. This has resulted in Typha and Para grass to establish.

Mangroves have established at the northern end of the drainage corridor, extending ~425m into the site.

The current condition and performance of drainage corridor has informed the preferred treatment strategy that integrates with the site constraints and minimises on-going maintenance.

The preferred strategy is to expand the existing mangrove zone to create a larger tidal wetland area. This updates the previous strategy that diverted development flows to an offline freshwater wetland. The works will involve earthworks to expand the tidal interaction zone, formalising a tidal outlet across an existing drainage channel connecting to Ross River by bunding off channel and installing a culvert to allow tidal interaction.

A tidal barrier is also included ~500m upstream of the outlet to maintain a freshwater channel in the upstream portions of the central drainage corridor. Figure 7 illustrates how the tidal wetland can be configured.

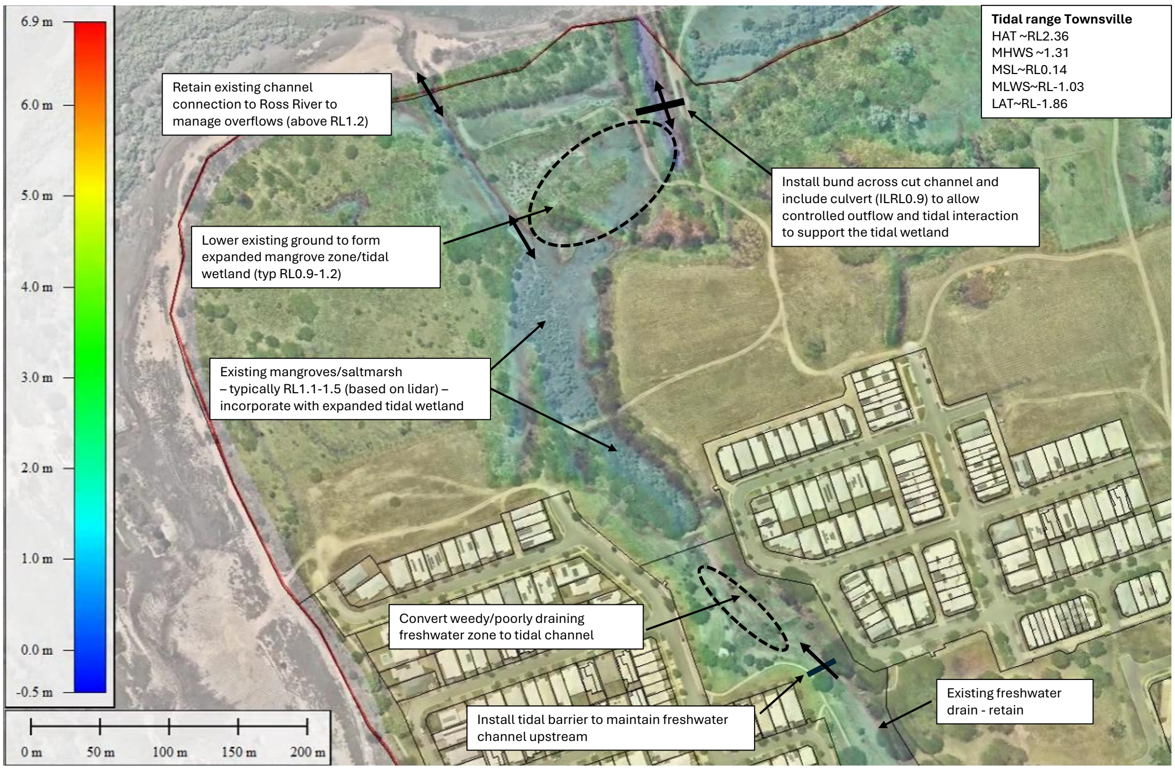


Figure 7 Tidal wetland works

This strategy enhances the extent of mangroves across the site, converts the weedy and poorly draining freshwater section of channel into low maintenance tidal wetland areas and retains the established and good performing freshwater channel in the upstream sections of the corridor. The tidal wetland area also supports improved storage volumes for flood management purposes by allowing lower operating levels than the previous freshwater wetland system (~1m lower operating level).

Eastern drainage corridor

An ~30-50 m wide drainage corridor is available along the eastern boundary of the site. This area is proposed to include a linear freshwater wetland. The wetland will also extend along the boundary of the future development edge. Treated low flows are proposed to be directed under the rail line using existing culverts. A wetland outlet will be included upstream of the railway culverts to manage wetland outflows for treatment.

Sediment pools are located along the length of the linear wetland, where existing and future development drainage outfalls can be directed for maintenance purposes.

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.

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 be 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 8 provides a typical sectional detail for the proposed waterway sections.

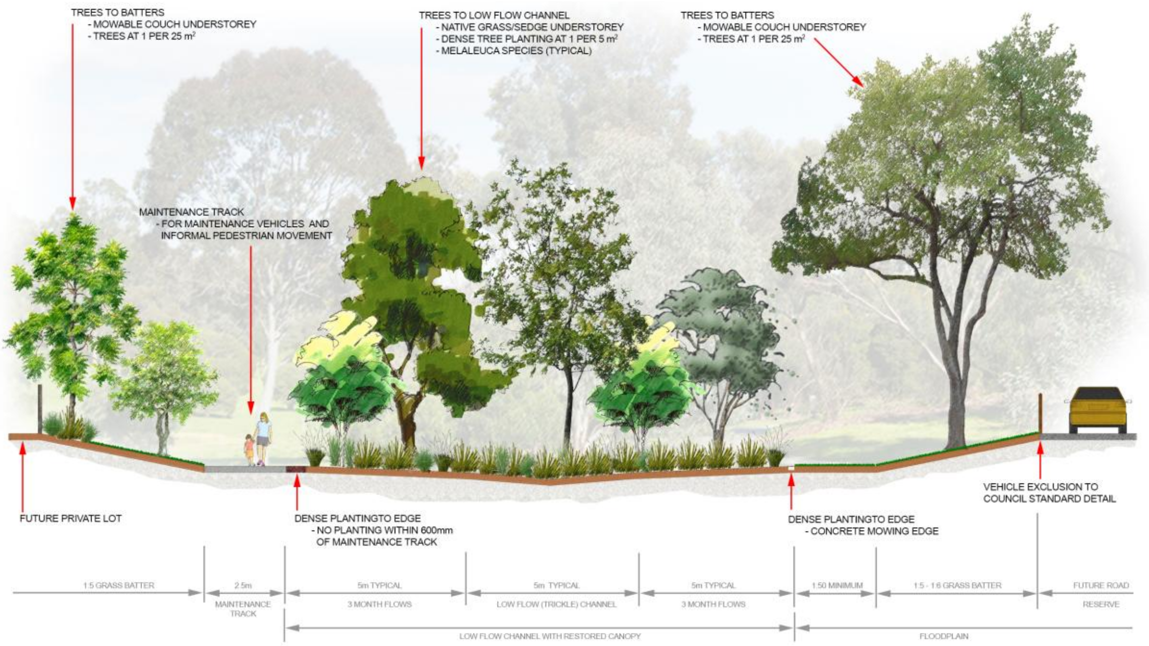


Figure 8 Typical section of a naturalised waterway

5.1.2 Wetlands

Tidal and freshwater wetland systems are proposed as part of the overall stormwater treatment strategy.

Tidal wetlands

Tidal wetlands are configured to ensure the wetland bathymetry supports the expected tidal range. Tidal wetlands proposed will consist of mangroves, salt marsh and sedges. The tidal wetland predominately operates as a saline to brackish system. During periods of rain, freshwater inflows will discharge via the tidal wetland system.

The outlet from the tidal wetland must ensure sufficient tidal interaction with the Ross River to allow tidal (estuarine) flushing, but also be configured to manage daily water levels variations within a range that will support the proposed tidal wetland vegetation. The outlet also restricts outflows to allow necessary treatment of development runoff.

Continuous water level and salinity monitoring of the Ross River over a 3-month period has been completed at the northern end of the site to inform the design of the tidal wetland system. This information is used to review wetland performance and size wetland outlets and wetland bathymetry to support the tidal vegetation communities. Typically, tidal vegetation communities require the following regime:

- Marine sedges – water available for the majority of the time
- Mangroves – daily wetting and drying cycles required – typically 15-70% of the time inundated
- Salt marsh – occasional inundation – typically up to 15% of the time inundated

Figure 7 shows an example of a constructed tidal wetland system.

Figure 9 Constructed tidal wetland

Freshwater constructed wetlands

The Oonoonba freshwater wetlands are located along the eastern drainage corridor of the site and will extend along the northern boundary of the future development edge. Within the ~30-50m wide eastern drainage corridor a linear wetland will be formed within the drainage corridor. The treatment component of the linear wetland will typically occur at the base of the drainage corridor, typically spanning ~15-20m. The invert zone will include a 300mm deep zone (typically 5m width) for aquatic plants and a floodplain zone for riparian vegetation. At each drainage outfall to the linear wetland a deep pool up to ~1.5m deep will be included to provide a sediment capture function. These pools will be provided with maintenance access and provide a refuge for fish during the dry season.

Outflows from the linear wetland will discharge via the existing culverts under the railway to the east. A wetland outlet will be provided immediately upstream of the railway culverts to allow controlled outflows over ~36hrs from the wetland.

Key to the success of the wetland system is to establish dense plantings of aquatic and riparian vegetation, including dense planting of trees. This minimises potential for weed ingress. A dense planting of trees (typ. Melaleuca spp.) across the linear wetland floodplain zone together with plantings of native grass species such as Leersia hexandra and Imperata cylindrica have been found to be effective to minimise the ingress of weeds such as Typha.

Access will be provided along the eastern and northern edge of the wetland for maintenance.

Figure 10 shows a typical section of a linear wetland within a drainage corridor, whilst Figure 11 and Figure 12 shows a case study of a linear wetland constructed within a drainage corridor (Isle of Newport Development, Morton Bay). The case study demonstrates rapid establishment of vegetation within 12 months and successful establishment 3 years after construction. The wetland has demonstrated to be resilient to weeds and has been performing well in terms of treatment function. The system has also added significant ecological and habitat value to the development.

Linear wetland/vegetated waterway corridor

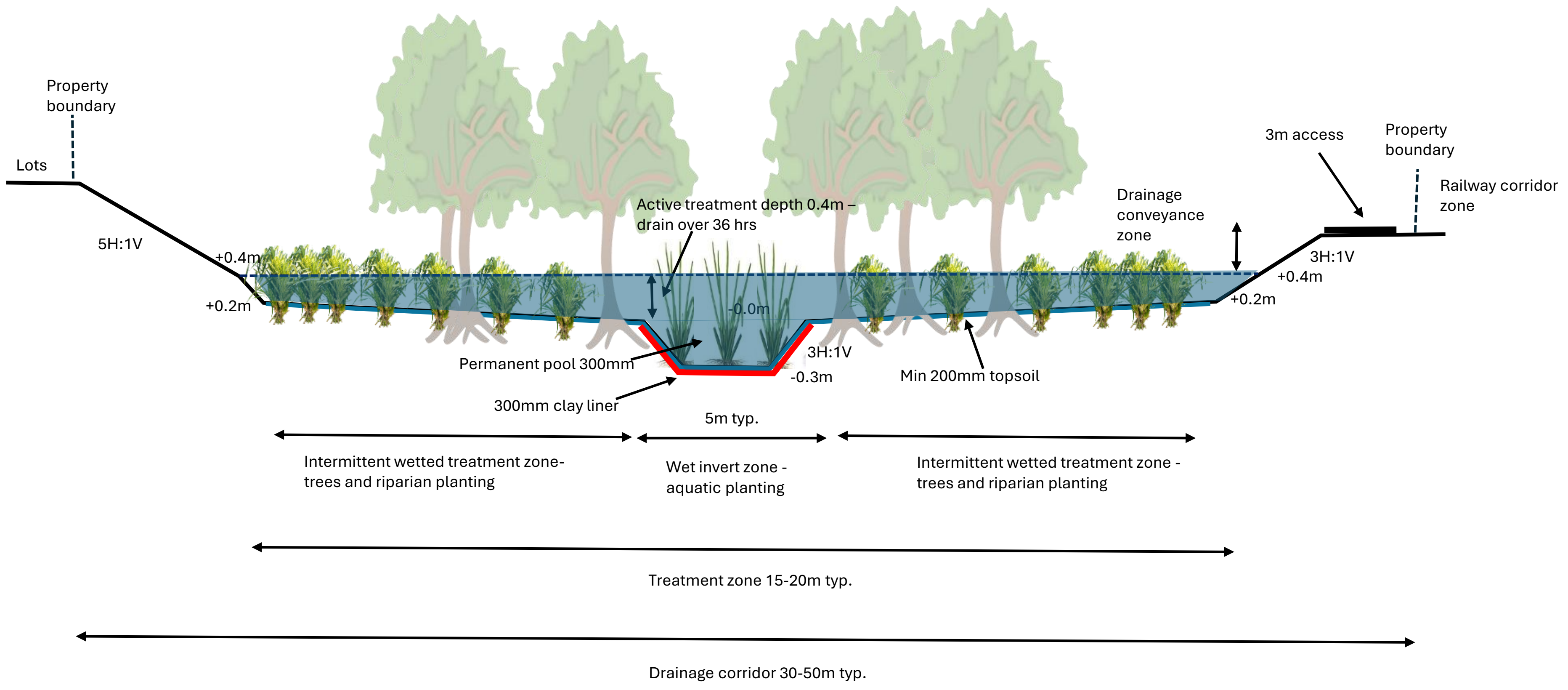


Figure 10 Typical section - linear wetland/drainage corridor

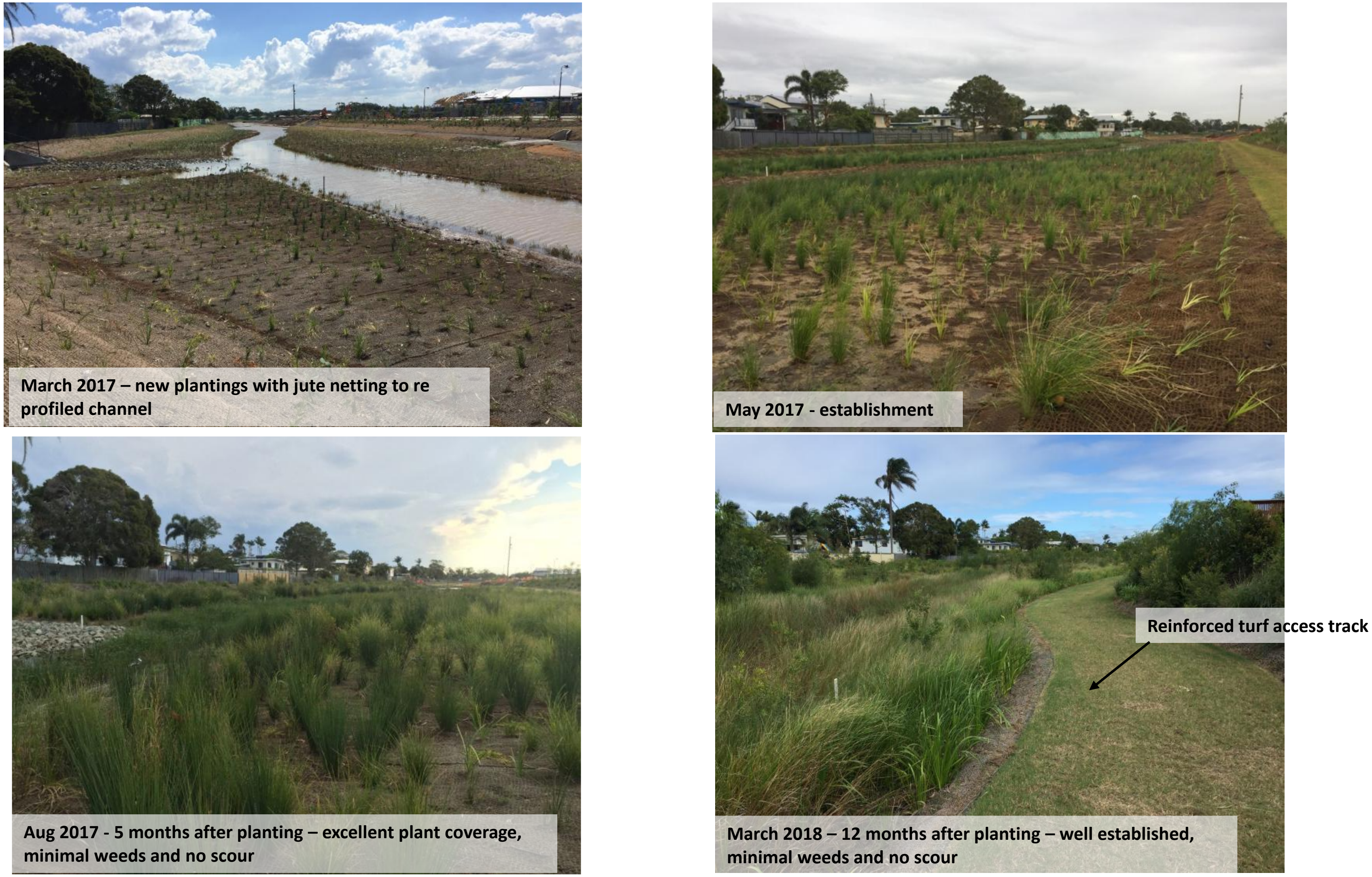


Figure 11 linear wetland case study - Isle of Newport - establishment phase

Jan 2020- note reinforced turf track still in good condition

Jan 2020 – open water areas at discharge points well integrated and healthy

Figure 12 case study - Isle of Newport linear wetland - fully established

5.1.3 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. Typical species are provided below. Detailed planting lists will be developed as the design progresses:

Tidal wetland planting

Mangroves

- ✓ *Aegiceras corniculatum (river mangrove)*
- ✓ *Aegialitis annulata (club mangrove)*
- ✓ *Avicennia marina (grey mangrove)*
- ✓ *Bruguiera gymnorrhiza (large leaf orange mangrove)*
- ✓ *Ceriops tagal (yellow mangrove)*
- ✓ *Exoecaria agallocha (blind you eye mangrove)*
- ✓ *Lumnitzera spp (Black mangrove)*
- ✓ *Rhizophora stylosa (red mangrove)*

Saltmarsh

- ✓ *Fimbristylis polytrichoides (rusty sedge)*
- ✓ *Fimbristylis ferrugineab (rusty sedge)*
- ✓ *Sesuvium portulacastrum (sea purslane)*
- ✓ *Sporobolus virginicus (salt couch)*

Freshwater wetland aquatic planting

- ✓ *Actinoscirpus grossus*
- ✓ *Baumea articulata*
- ✓ *Cyperus alopecuroides*
- ✓ *Cyperus polystachyos*
- ✓ *Eleocharis dulcis*
- ✓ *Eloacharis sphacelta*
- ✓ *Leersia hexandra (edges)*
- ✓ *Lepironia articulata*
- ✓ *Marsilea mutica*
- ✓ *Oryza australiensis*
- ✓ *Persicaria strigosa*
- ✓ *Schleria poiformis*
- ✓ *Schoenoplectus subulatus*

Wetland floodplain/batter planting

- ✓ *Acacia holosericia*
- ✓ *Allotreopsis semialata*

- ✓ *Corymbia clarksonii*
- ✓ *Cynodon dactylon*
- ✓ *Chrysopogon fallax*
- ✓ *Eucalyptus tereticornis*
- ✓ *Ghania aspera*
- ✓ *Imperata cylindrica*
- ✓ *Isachne globosa*
- ✓ *Leersia hexandra*
- ✓ *Leptochloa neesii*
- ✓ *Lomandra hystrix*
- ✓ *Lomandra longifolia*
- ✓ *Melaleuca dealbata*
- ✓ *Melaleuca leucadendra*
- ✓ *Melaleuca viridiflora*
- ✓ *Nauclea orientalis*
- ✓ *Oryza austriensis*
- ✓ *Pandanas cookii*
- ✓ *Persicaria srtrigosa*
- ✓ *Themada triandra*

6 STORMWATER TREATMENT PERFORMANCE ASSESSMENT

MUSIC modelling was conducted to quantitatively assess the stormwater treatment performance of the proposed stormwater strategy. MUSIC version 6.3 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 13 with the general data upon which the model is based provided in Table 5.

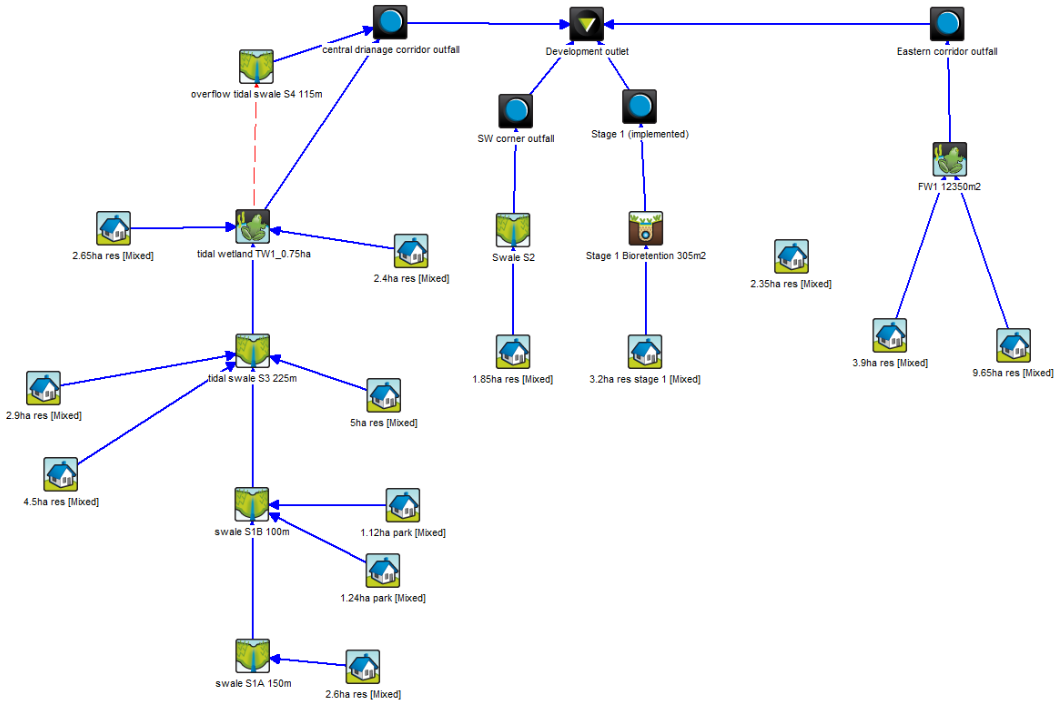


Figure 13: MUSIC catchment and model layout

Table 5 MUSIC model data summary

Treatment element	Key modelling assumption
Source data	
Rainfall data set	32040 Townsville; 1970-1984
Model time step	6 minute
Mean annual rainfall 1980-1989	1165 mm (for the period used)
Mean annual evapotranspiration	1856mm
Soil properties (runoff generation parameters)	Upland soils (Table 7 Mackay MUSIC modelling guidelines)
Pollutant concentrations (base and storm flow concentration parameters)	Urban Residential (Table 9 Mackay MUSIC modelling guidelines)
Catchment area	Refer to Table 4
Percent impervious	75% (residential landuse); 10% (park)
Treatment elements	
Swales S1 to S4	Length: S1A=150m; S1B=100m;S2=100m;S3=225m;S4=115m Bed slope S1, S3, S4= 0.1%;S2=1% Base width S1= 5m; S2=1m, S3=0.1m Top width = S1, S3=15m; S2=5.6m; S4=10m Depth =S1-3=0.5m; S4=1m Vegetation height = S1, S3, S4=0.3m; S2=0.05m Infiltration = 0mm/hr
Wetland TW1 and FW1	Inlet pond volume=TW1 = 0m^3; FW1=1200m^3 Surface area: TW1=7,565m^2;FW1=12,350m^2 Extended detention depth: TW1=0.3m refer to note 1; FW1=0.4m Permanent pool: TW1=50m^3; FW1=1,315m^3 Exfiltration rate: TW1=3.6mm/hr; FW1=0mm/hr Evaporation loss: 125% of PET Notional detention time FW1: 36hr; TW1 refer note 1 TN k=200m/yr; TN C*=0.75mg/L
Stage 1 bioretention (installed)	Filter area: 305m^2 Surface area: 305m2 Extended detention depth:0.2m Saturated hydraulic conductivity: 180mm/hr Filter depth: 0.3m TN content: 400mg/kg^1 OP content: 30mg/kg^1 Exfiltration rate: 0mm/hr

Note: 1. The tidal wetland has been modelled with a custom outlet based on the preliminary wetland outlet configuration and bathymetry detailed in Section 7.1.2.

6.1.1 Results

The results of the MUSIC modelling for the proposed development are shown in Table 6. Whilst individual treatment elements may not necessarily meet load-based objectives, the combined effect of all treatments when considered for the combined development discharge is within the water quality objectives to meet SPP requirements.

Table 6: MUSIC model results – stormwater quality

ID	Pollutant	Inflows (kg/yr)	Outflows (kg/yr)	Reduction achieved (%)	Water Quality Objective (%)
central drainage corridor (S1, S3,S4,TW1)	TSS	40300	6060	84.9	Water quality objective applies to combined site discharge
	TP	78.7	22.1	72.0	
	TN	380	233	38.7	
eastern corridor (FW1)	TSS	26600	5310	80.0	
	TP	51.4	14.7	71.4	
	TN	246	125	49.1	
SW outlet (S2)	TSS	3680	1080	70.6	
	TP	6.9	3.48	49.5	
	TN	33.6	31.1	7.4	
Stage 1 bioretention	TSS	6250	1,470	76.5	
	TP	12.0	3.94	67.2	
	TN	58.0	34.7	40.1	
TOTAL	**TSS**	**76800**	**13900**	**81.9**	**80**
	TP	**149**	**44.2**	**70.4**	**65**
	TN	**718**	**424**	**40.9**	**40**

7 TIDAL WETLAND MODELLING

Tidal modelling has been completed to inform the overall design of the tidal wetland. The following summarises the performance assessments completed and the expected tidal wetland performance.

7.1 MODELLING ASSUMPTIONS

A hydraulic model of the tidal wetland has been developed using XP-SMWW software to size an appropriate outlet configuration and define expected wetland operating levels and frequency of tidal inundation to inform wetland floor bathymetry and marine planting zones.

7.1.1 Tidal variation

The tidal tailwater level data adopted has been based on 3 months of continuous monitored data adjacent to the site (10-minute continuous monitoring May 14-Aug 20, 2025). Figure 14 shows the tidal variation for the modelled period. Tidal ranges modelled vary from ~RL2.1 to RL-1.5.

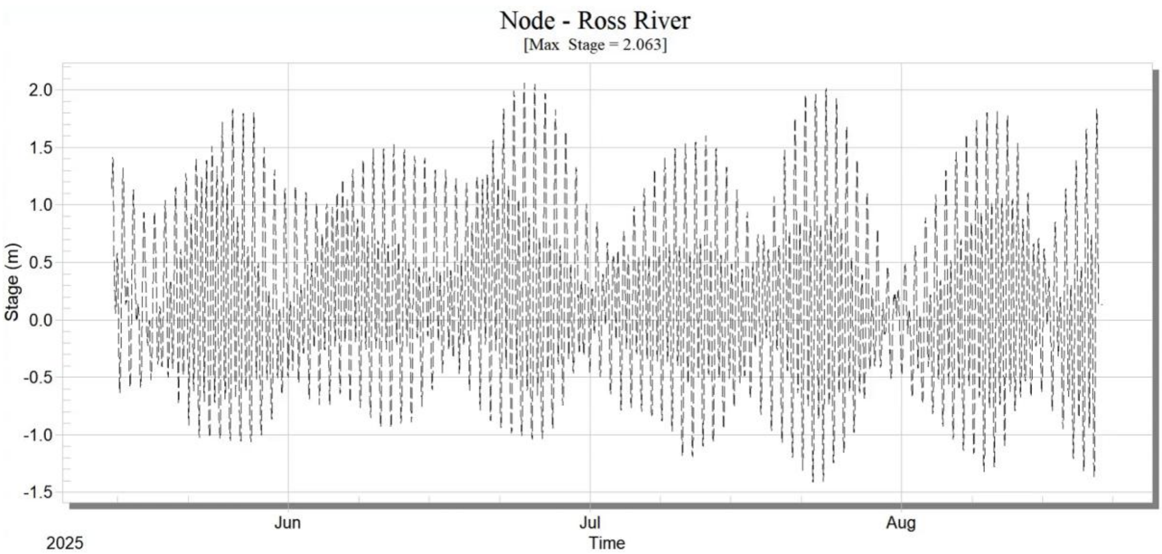


Figure 14 Tidal variation (mAHD) – May-Aug 2025

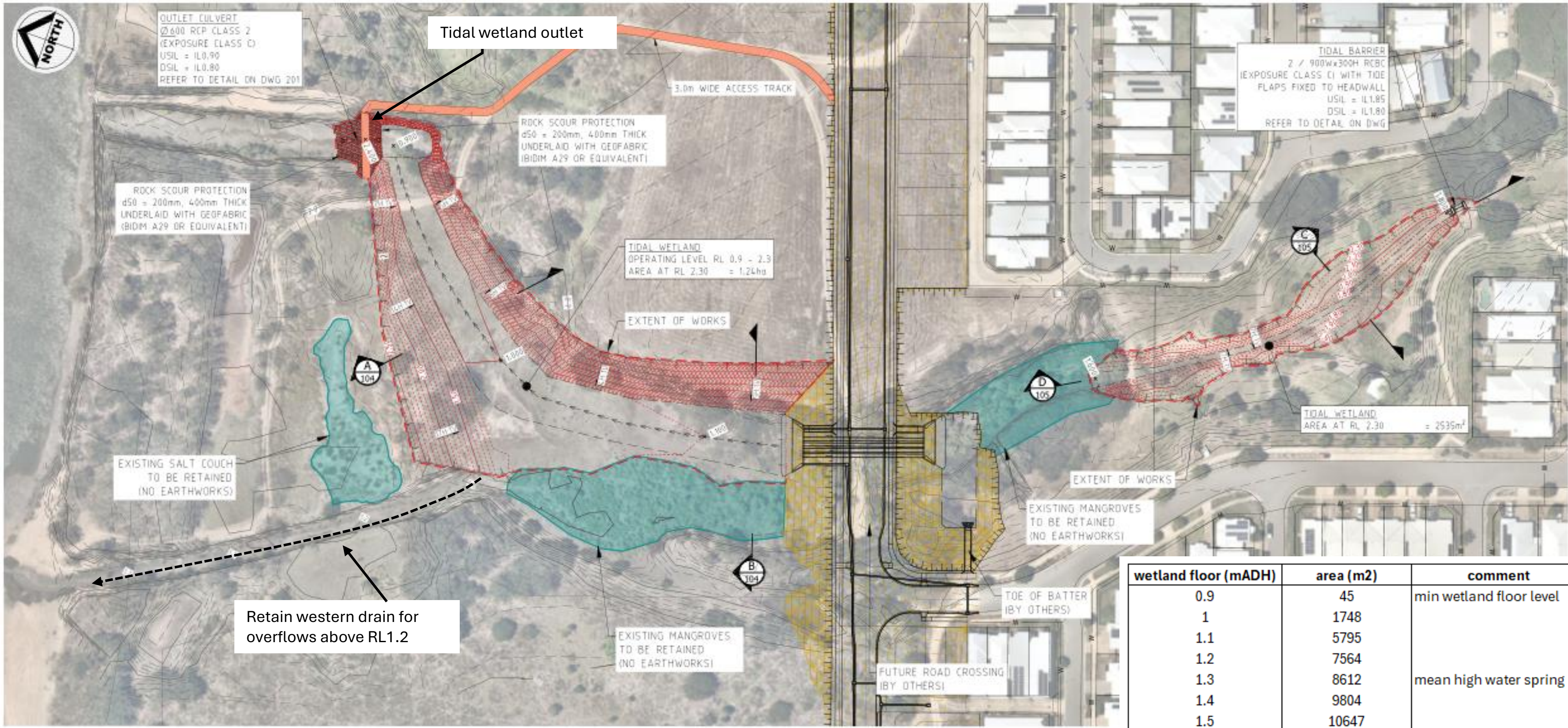
<u>Note:</u> The following tidal planes for Townsville (source: BOM)

- Highest astronomical tide (HAT): RL2.36
- Mean high water spring (MHWS): RL1.31
- Mean sea level (MSL): RL0.14
- Mean low water spring (MLWS): RL-1.03
- Lowest astronomical tide (LAT): RL-1.86

7.1.2 Wetland bathymetry and outlets

A wetland bathymetry has been modelled to support tidal vegetation communities. Recent survey has helped informed the proposed wetland bathymetry to review tidal interactions and frequency of tidal inundation. This include levels of existing mangroves and expected drainage levels that can be achieved at the connections to the Ross River. Figure 15 shows the proposed wetland bathymetry together with the stage/area relation. Minimum wetland floor level corresponds to RL0.9.

The tidal wetland proposes a new drainage outfall at the northern boundary of the site connecting the tidal wetland to the Ross River. A range of outlet configurations were tested to determine a preferred outlet configuration. The outlet must ensure sufficient tidal interaction and manage daily water level variations within a range that will support the proposed marine vegetation communities (mangroves and salt marsh). Figure 15 summarises the outlets modelled. A new 600mm dia RCP (IL RL0.9) will define the tidal wetland outlet, whilst overflows will be conveyed via the existing western drain which operates above RL1.2.



wetland floor (mADH)	area (m2)	comment
0.9	45	min wetland floor level
1	1748	
1.1	5795	
1.2	7564	
1.3	8612	mean high water spring
1.4	9804	
1.5	10647	
1.6	11538	
1.7	12706	
1.8	14032	
1.9	15595	
2	18873	
2.1	22169	
2.2	25089	
2.3	27174	HAT

Figure 15 Proposed tidal wetland configuration

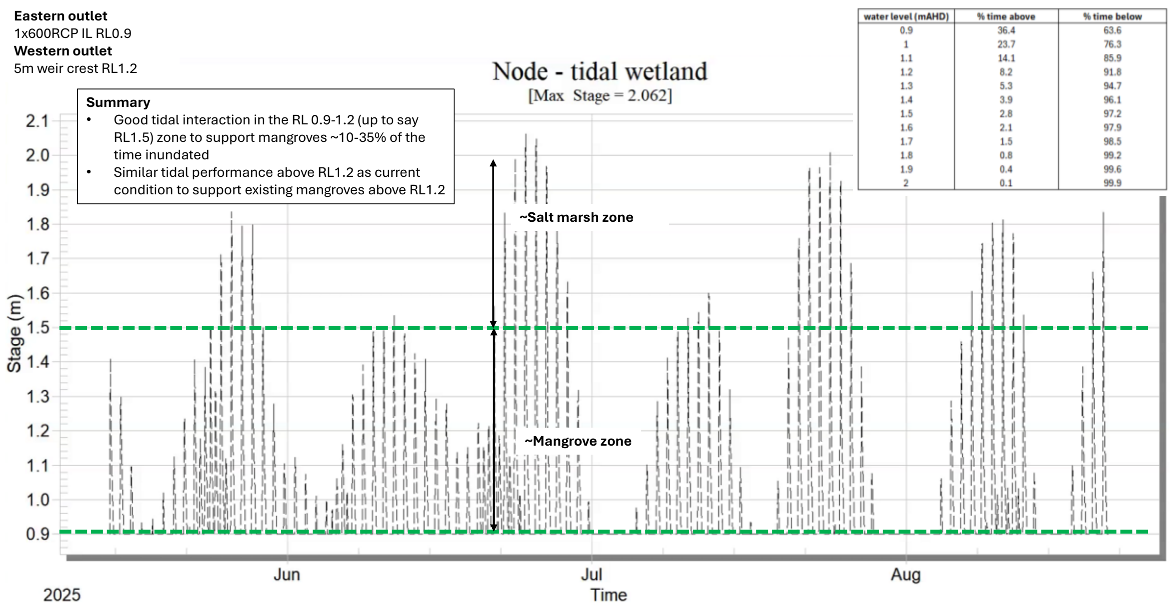
7.2 RESULTS

The following summarises the expected tidal wetland performance based on the modelled assumptions. The results are based on tidal influences only.

7.2.1 Tidal wetland water levels

Figure 16 shows the modelled tidal wetland water level variation. The frequency of inundation is included for reference. Based on the modelled tidal wetland water level regime the following vegetation zones would be anticipated to establish:

- RL0.9-1.2 (up to say 1.5) – mangroves – typically allows daily wetting and drying cycles – frequency of inundation ~10-35% of the time
- RL above say 1.5 – salt marsh – infrequent wetting (typically levels exceeded ~7-10 days per month)



water level (mAHD)	% time above	% time below
0.9	36.4	63.6
1	23.7	76.3
1.1	14.1	85.9
1.2	8.2	91.8
1.3	5.3	94.7
1.4	3.9	96.1
1.5	2.8	97.2
1.6	2.1	97.9
1.7	1.5	98.5
1.8	0.8	99.2
1.9	0.4	99.6
2	0.1	99.9

Figure 16 Modelled tidal wetland water level variation (mAHD)

7.3 TIDAL EXCHANGE

Figure 17 shows the modelled flows and velocities through the wetland outlet. The average daily tidal wetland inflow/outflow is ~3.2ML (each way). The modelled output illustrates the variations in flows and velocities between high and low tide periods. The western outlet overflow has less tidal engagement given this outlet sits at a higher level than the eastern outlet (RL1.2 compared to RL0.9).

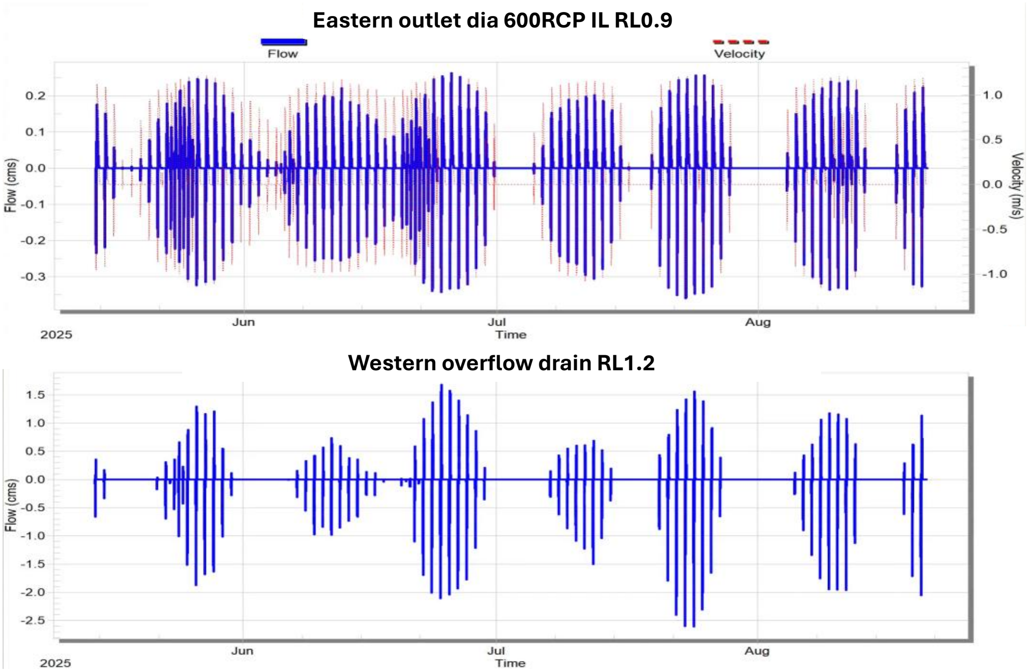


Figure 17 Inflow/outflow through wetland outlets

8 FUNCTIONAL DESIGNS

Functional designs have been developed for the two wetlands proposed to demonstrate how the wetlands will integrate and operate with the development constraints. Figure 18 and Figure 19 provides overall layout plans for each wetland site. Full wetland designs will be developed as part of the Operation Works application.

Eastern wetland

The main functional items to note include:

- Wetland normal operating level RL2.05 with an extended detention level of RL2.45
- Wetland area at extended detention depth = 1.45ha, with an average area of 1.235ha between RL2.05 and RL2.45
- 1.2m deep pools are provided every ~100-150m to allow connection with existing and future drainage outfalls
- Low flow channel connects deep pool zone with inverts varying from RL1.95 to 1.75 – channels are graded back to pools
- Minimum 2% cross fall provided across the wetland flood plain zone for drainage back to the central low flow channel
- 3m wide access track (minimum level RL2.75) provided along the full length of the wetland. 3m wide ramps also provided to each deep pool zone
- Wetland outlet pit controls wetland outflows and discharges to existing culverts under the railway (existing culverts 640x1220 RCBC invert level RL1.815).

Tidal wetland

- Earthworks completed to connect to and create additional mangrove zones. Minimum earthworks level RL0.9. Earthworks graded to provide free drainage
- Existing mangrove communities retained and connected with new mangrove areas
- New wetland outlet created by bunding off northeastern drainage channel and installing a 600 dia RCP pipe at RL0.9
- Existing drain at western side retained to retain overflow capacity
- Tidal barrier included at southern end of wetland to prevent tidal egress into existing freshwater drain

Further refinement of the functional designs for each treatment will occur as part of future Operational Works applications.

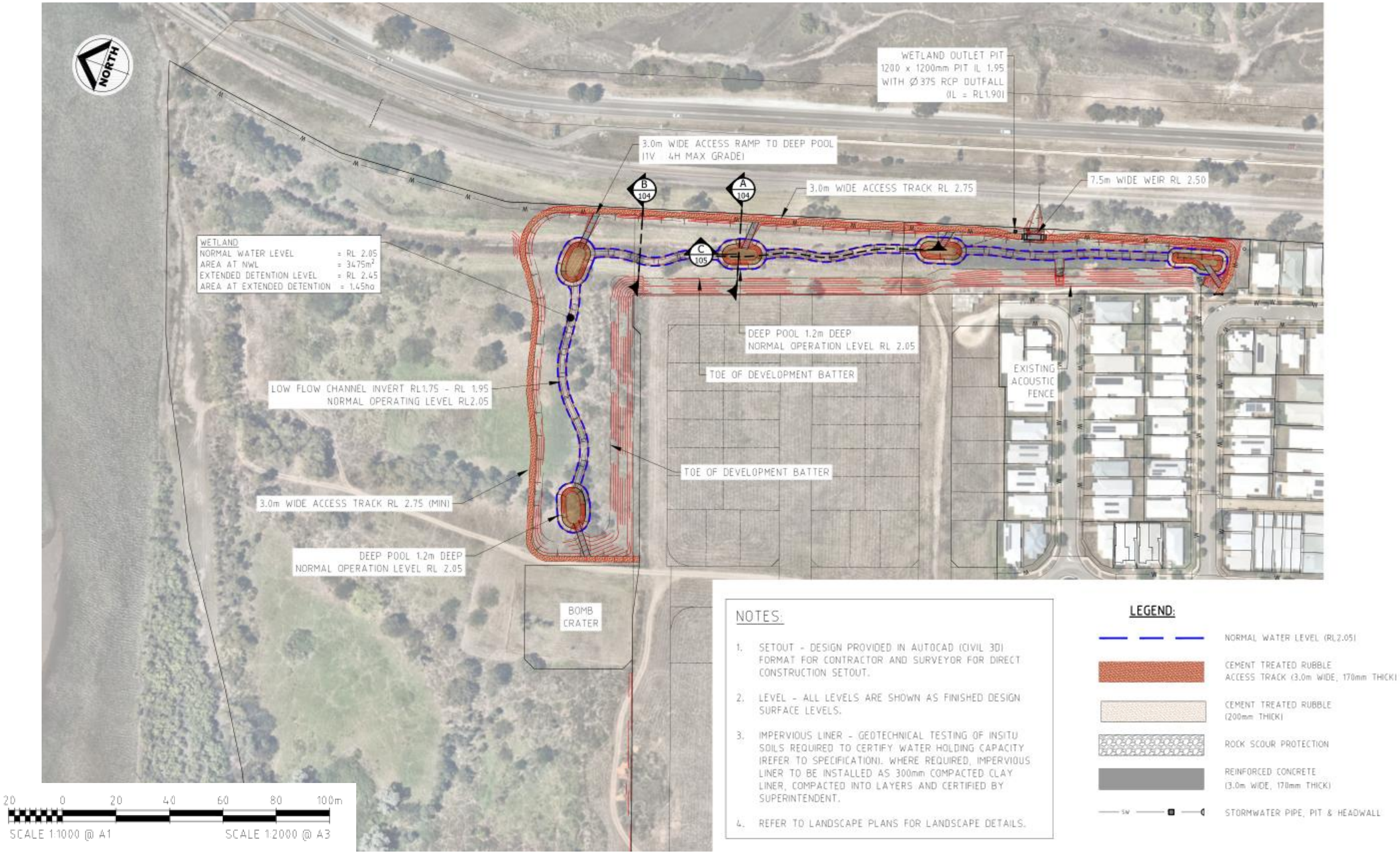


Figure 18 Eastern wetland overall layout plan

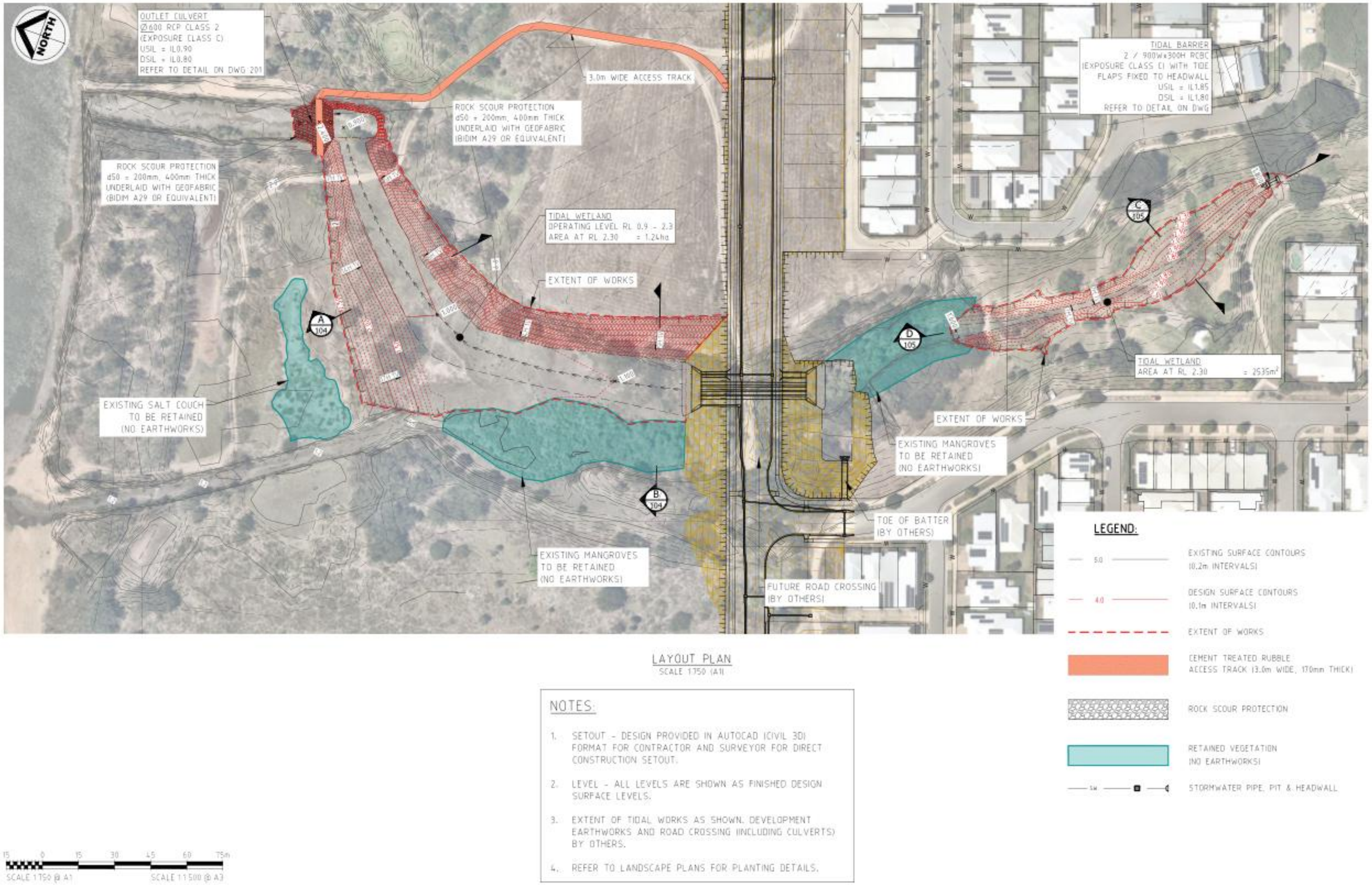


Figure 19 Tidal wetland overall layout plan

9 CONSTRUCTION STAGING

It is important that WSUD systems are protected from large sediment loads during the building phase and certain measures are available to treatment 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 online. 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.

- Bulk out the wetlands as use them as temporary High Efficiency Sediment (HES) basins. This can provide an effective means of protecting downstream receiving water from construction sediment loads. This option does not allow planting of the wetland to commence, although wetland batter zones can be planted. At near completion of the building phase (say 90%) the bulked-out wetlands can be de-silted and completed as per the design intent.

- Treat construction runoff via HES basins prior to discharge to the treatment zones

Detailed soil erosion and sediment management plans will need to be developed as part of future operation works submissions for each development stage.

The majority of new development is associated with areas draining to the eastern wetland site. This offers a good opportunity to partially complete this wetland and bulk out the remaining area and configure as a HES basin. The HES basin can then be decommissioned and the wetland completed once construction activities are nearing completion. An example of how a construction stage could be managed is illustrated in Figure 20.

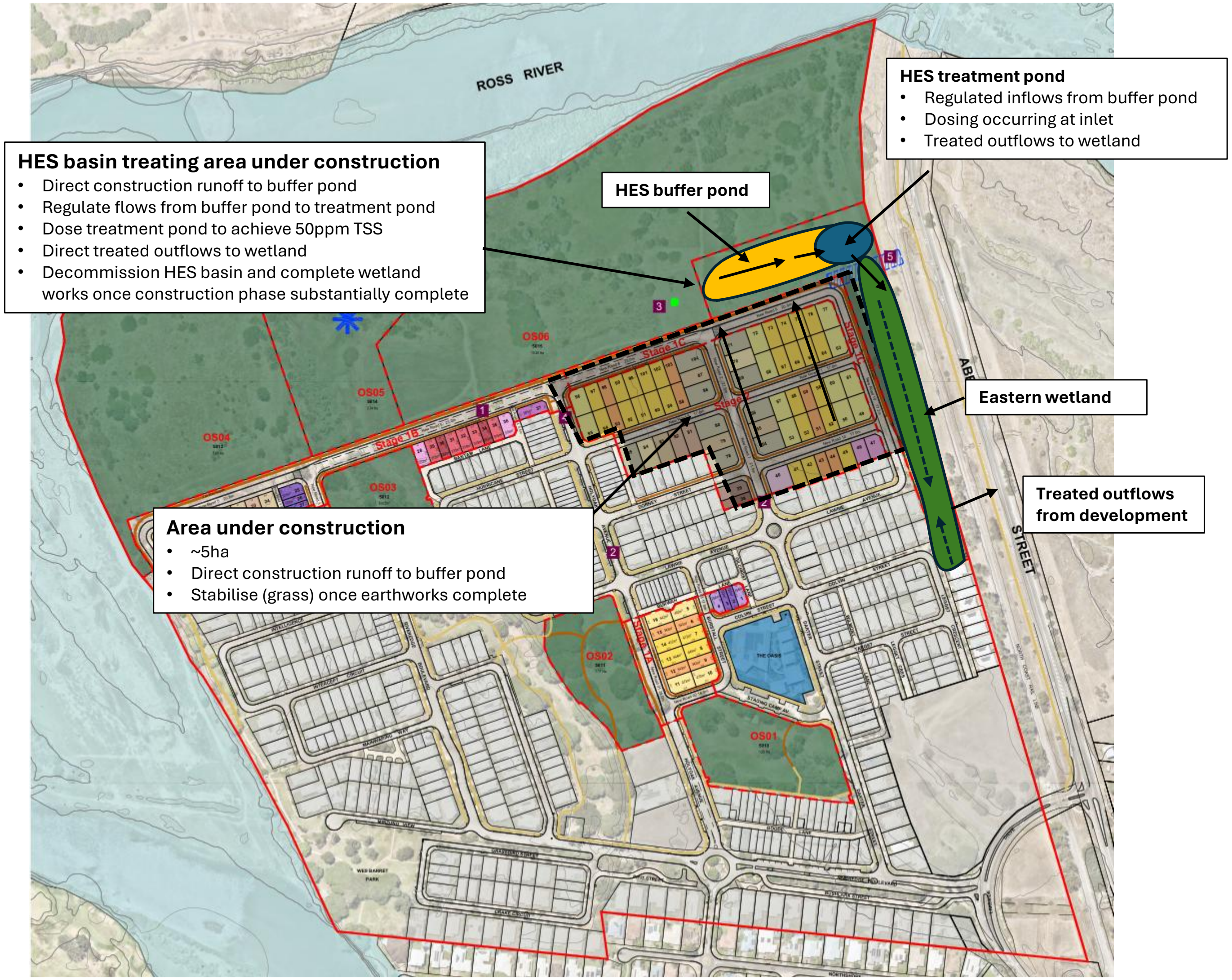


Figure 20 Example construction sediment management

10 MAINTENANCE

WSUD infrastructure such as constructed wetlands, bioretention basins and vegetated waterways 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, bioretention basins and vegetated swales. Detailed operation and maintenance plans 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.

10.1 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 every 2 months.

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.

10.2 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

10.3 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.

11 CONCLUDING REMARKS

An updated stormwater quality management strategy has been developed for the Oonoonba development to meet the requirements of the State Planning Policy (DLIGP, 2017). The overall development extent has now reduced from ~55ha to ~41ha, with the removal of development areas at the northern end of the site. The updated treatment strategy now reflects the reduced scope of development.

The overall treatment strategy considers an integrated approach using primarily vegetated waterways and wetlands. Site observations have helped inform the preferred strategy, particularly the areas of the site where tidal inundation occurs.

Existing mangroves at the downstream end of the main drainage corridor will be retained and expanded to create the new tidal wetland system at the northern boundary of the site. This is the fundamental change in the treatment strategy from the previously approved strategy (DesignFlow, 2016).

The tidal wetland system can be readily configured using existing drainage connections to the Ross River and will result in expanded mangrove/salt marsh communities in the zone between the development edge and the Ross River enhancing local ecology and habitat. The current observations of the existing mangrove community that has established at the downstream end of the central drainage corridor indicate this will result in a low maintenance treatment system, particularly weed management (e.g. Typha).

Inclusion of the tidal wetland is considered the best outcome for the site, where the opportunity to restore and increase mangroves exists. This provides a treatment buffer not only for development flows, but provides additional tidal interaction with the Ross River and can provide an important role in carbon sequestration, where mangrove wetland systems have been acknowledged as playing an important role in managing climate change due to their very high carbon sequestration rates (UNSW, 2023)

At the eastern boundary of the site the linear freshwater wetland is retained and reconfigured to suit the new development extent. Treated outflows will discharge via existing culverts under the rail corridor.

The updated treatment 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.

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