Bundaberg Regional Council
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Rubyanna Wastewater Treatment Plant

Review of Environmental Factors

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Prepared for

Bundaberg Regional Council

Prepared by

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Reviewed by Michael Puntil

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Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	28-Feb-2012	Final Copy	Michael Puntil Associate Director - Water	Original previously signed
B	10-Apr-2012	Revised Final Copy	Michael Puntil Associate Director - Water	

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Executive Summary

The Bundaberg Regional Council (BRC) has developed a regional wastewater treatment and effluent disposal strategy to service the proposed population growth for the Bundaberg Eastern Coastal regions over the next 30 years. From this strategy, BRC has adopted Option 1A as the preferred option for wastewater treatment and effluent management for the region. Broadly, Option 1A involves the provision of a centralised treatment plant in the eastern outskirts of the city that will service East Bundaberg and the coastal communities with a river outfall retained.

Following adoption of Option 1a by BRC as the preferred treatment and disposal strategy, the project is now referred to as the Rubyanna Wastewater Treatment Plant (WWTP) project. The three proposed components of the Rubyanna WWTP project are:

- A Biological Nutrient Removal (BNR) wastewater treatment plant and effluent irrigation system that will result initially in the decommissioning of the Bundaberg East WWTP;
- A raw sewage rising main from the decommissioned Bundaberg East WWTP to the proposed Rubyanna WWTP; and
- A treated outfall main that discharges treated effluent from the Rubyanna WWTP to the Burnett River.

Additionally, BRC has signed an option contract with Bundaberg Sugar to enable BRC to purchase a proposed site for the Rubyanna WWTP located off Rubyanna Road, Rubyanna within a two year period (until September 2013). It is proposed that ninety hectares (90 ha) of Lot 1 RP57605 will to be leased back to Bundaberg Sugar on a 30 year lease for growing sugar cane that will be irrigated with recycled water from the proposed Rubyanna WWTP. The smaller parcel of land, Lot 6 RP 204880 located to the west of the 108 Ha lot, has been nominated by BRC as the proposed site for the WWTP and associated infrastructure.

The purpose of this Review of Environmental Factors (REF) document is to provide supporting information to the planning and environmental approvals proposed for the project and as identified in the following table:

Approval Type	Infrastructure Component (✓ if Approval is required)		
	Rising Main	Rubyanna WWTP	Outfall Main
Native Title and Cultural Heritage	✓	✓	✓
Interference with overland flow			
Removal of vegetation, fauna habitat and removing or relocating fauna			
Material Change of Use (MCU)		✓	
Reconfiguration of a Lot (RoL)		✓	
Environmentally Relevant Activity (ERA)		✓	
Notifiable activities – storage of petroleum product, and regulated waste handling/disposal		✓	
Resource Entitlement			✓
Queensland Coastal Plan	✓	✓	✓
Prescribed Tidal Works			✓
State Planning Policy's (SPP)		✓	

BRC intends to utilise the Integrated Development Assessment System (IDAS) of the *Sustainable Planning Act 2011*(SPA) for the approval of the following development categories that will be triggered through this project:

1) Material Change of Use (MCU); and

2) Reconfiguration of a lot.

In seeking approval to undertake the above mentioned development types, Council will also seek approvals for the following:

- Native Title and Cultural Heritage;
- Prescribed Tidal Works;
- Queensland Coastal Plan;
- Notifiable Activities; and
- Environmental Relevant Activity (ERA)

BRC, with project partners HWA and AECOM, has undertaken a number of detailed investigations relating to the project and it is acknowledged that there is an increased risk of impacts to the environment of the project, however, these risks will be mitigated by effective design and management of the project infrastructure as follows:

- Development of an Effluent Management Strategy that will limit the amount of Nitrogen load to the Burnett River to levels being currently discharged from the Bundaberg East and North Plants. It is noted that annual monitoring has shown that the existing WWTP does not adversely impact the water quality of the Burnett River;
- Provision of a outfall dispersion system that has been modelled to provide effective dispersion during very conservative ambient conditions;
- Site selection of infrastructure that does not necessitate the removal of protected vegetation or impact on essential habitats of protected fauna;
- Development of Traffic Management strategy to limit impacts to residents during both the construction and operational phase of the project;
- Controls that will be developed during the detailed design process to reduce the impacts of odour and noise from the proposed WWTP; and
- Establishment of a Community Reference Group to provide input during the design, construction and operation phases of the project.

1.0 Introduction

1.1 Project Need

The Bundaberg Regional Council (BRC) has developed a regional wastewater treatment and effluent disposal strategy to service the proposed population growth for the Bundaberg Eastern Coastal regions over the next 30 years. This report titled, The *Bundaberg East & Bargara Coastal Region Wastewater Treatment and Effluent Management Master Plan* (Hunter Water Australia (HWA), September 2009) is presented in Appendix A

Additionally, the location of the Bundaberg and the Bargara coastal communities in proximity to a turtle rookery and the Great Barrier Reef raised environmental concerns that were highlighted in the strategy. Further, the effect on the environment from on-site sewage treatment systems in existing residential areas and the aging WWTP at Bundaberg East were noted as specific issues to be considered by BRC.

The existing Bundaberg East WWTP currently services a population of approximately 30,000 with the treated effluent being discharged into the nearby Burnett River estuary. The Bundaberg East WWTP is subject to requirements of an environmental authority that places annual load limits on the discharge of nitrogen and phosphorus into the river that must be met by the end of 2012. The Bundaberg East WWTP is unable to meet current effluent quality discharge limits and as such needs to be substantially upgraded or replaced by a new STP.

1.2 Regional Treatment Options

The September 2009 Wastewater Master Plan document was based on four broad options developed by BRC following initial scoping and stakeholder consultation. Each of these four options are summarised below. Refer to Appendix A for further details and plans describing each of these options.

- **Option 1A** involves the provision of a centralised treatment plant in the eastern outskirts of the city that will service East Bundaberg and the coastal communities with a river outfall retained.
- **Option 1B** retains the treatment plant in the east of the city to service Bundaberg and the coastal communities closest to Bundaberg City as well as a separate plant inland from Innes Park to service the two communities furthest from the city (Innes Park and Elliott Heads). For this option the Burnett River discharge is maintained and an irrigation scheme spread between the two areas.
- **Option 1C** differs from Option 1B in that the second treatment plant and associated respective irrigation area would be located nearer to Elliott Heads than Innes Park, and a new outfall provided to the Elliott River.
- **Option 2** involves constructing five plants, one on the eastern outskirts of the city and four others at Burnett Head, Elliott Head, Innes Park and Bargara to service the respective coastal communities. New outfalls and irrigation areas would be required for each facility.

BRC has adopted Option 1A as the preferred option for wastewater treatment and effluent management for the region for the following reasons:

- Overall least cost option when compared to the other options;
- Adopting a centralised treatment strategy enables economies of scale in terms of treatment facility and reduces the number of facilities that the Council has to operate, monitor and report on.
- The centralised scheme provides favourable environmental outcomes in that discharges to the Elliott River are avoided and over time the coastal effluent discharges are eliminated.
- The strategy provides flexibility in terms of effluent management options and the new centralised plant is well located to make use of Sunwater's existing irrigation infrastructure.
- This option is most likely to allow the reuse of treated water to substitute surface water allocations. The potential benefits of this substitution include increased environmental flows, increased security for town water supply, or improved water allocations for existing license holders.
- This option is most likely to provide the best option for implementing a number of longer term effluent reuse opportunities such as dual reticulation to new development areas, managed aquifer recharge, or creation of a salt water intrusion barrier at Elliott Heads.

The adopted Option 1A project has been renamed by Council as the Rubyanna Wastewater Treatment Plant (WWTP) project. Details of the infrastructure proposed for this project is presented in Section 2.

We understand that when considering projects of a similar nature, the Department of Environment and Resource Management (DERM) requests a consideration of the "Do Nothing" option. As per the Master Plan report, the "Do Nothing" approach is not feasible from an environmental or social context as the existing treatment plant capacity will be exceeded which would result in large quantities of raw sewage discharging directly to the Burnett River or alternatively Council having to stop development in the region.

1.3 Project Objectives

The objective of the proposed project is to treat sewage from the Bundaberg East and the Bargara coastal communities as the population of the area increases whilst protecting the environment. Additionally, replacing the existing wastewater treatment plants and on-site domestic systems will provide a better long-term outcome for the community and the environment.

The objective of this report is to undertake an assessment of available environmental information in order to provide an overview of potential environmental impacts, possible legislative triggers and outline the proposed mitigation measures.

2.0 Rubyanna WWTP Project Details

2.1 General

BRC has signed an option contract with Bundaberg Sugar to enable BRC to purchase a proposed site for the Rubyanna WWTP located off Rubyanna Road, Rubyanna within a two year period (until September 2013). It is proposed that ninety hectares (90 ha) of Lot 1 RP57605 will to be leased back to Bundaberg Sugar on a 30 year lease for growing sugar cane that will be irrigated with recycled water from the proposed Rubyanna WWTP. The smaller parcel of land, Lot 6 RP 204880 located to the west of the 108 Ha lot, has been nominated by BRC as the proposed site for the WWTP and associated infrastructure.

2.2 Proposed Infrastructure Components

The three proposed components of the Rubyanna WWTP project are:

- A Biological Nutrient Removal (BNR) wastewater treatment plant and effluent irrigation system that will result initially in the decommissioning of the Bundaberg East WWTP;
- A raw sewage rising main from the decommissioned Bundaberg East WWTP to the proposed Rubyanna WWTP;
- A treated outfall main that discharges treated effluent from the Rubyanna WWTP to the Burnett River.

A summary of each of these components are provided below. A more detailed description is presented in the HWA Concept Design Report presented in Appendix B.

2.2.1 Rubyanna WWTP

The project proposes to amalgamate two parcels of land, being approximately 16.7 Ha from Lot 6 RP 204880 and a larger 108 Ha lot, being Lot 1 on RP 57605. The locations of the lots is presented in Appendix C. The Rubyanna WWTP is planned on the lot that is proposed to be subdivided from Lot 6 on RP204880, while the larger lot will potentially be retained for agricultural use, a buffer zone to the plant and for disposal of biosolids and reuse of effluent:

It is envisaged that the WWTP will consist of the following infrastructure:

- A preliminary treatment area with screening, grit removal and odour control facilities;
- BNR bioreactors and clarifiers;
- Chlorine Disinfection;
- Waste activated sludge thickening and aerobic digestion;
- Facility to transfer sludge imported from Millbank WWTP to the aerobic digesters;
- Sludge dewatering;
- A bunded biosolids storage area;
- Effluent storage lagoon; and
- Treated effluent discharge pump stations (effluent irrigation or disposal to Burnett River).

The proposed treatment plant layout is in presented within the HWA Concept Design Report in Appendix B.

2.2.2 Rising Main

The raw sewage rising main will transfer wastewater from a new raw sewage pump station located at the existing Bundaberg East WWTP situated at McGills Road to the proposed Rubyanna WWTP. It is proposed that the rising main will be constructed below ground with 762 mm OD (outside diameter) steel pipe and will be located within existing road reserve and a proposed easement through land owned by Bundaberg Sugar.

A plan of the proposed alignment for the rising main is presented in Appendix C.

2.2.3 Treated Effluent Outfall Main

The route of the treated effluent outfall pipeline, extends from the treatment plant, to Barrons Road. The outfall main will be located within the Barrons Road and Strathdees Road reserves, before discharging into the Burnett River.

The location of this outfall moves the discharge point for Bundaberg's main wastewater treatment plant approximately 10 km further downstream compared to the location of the Bundaberg East WWTP outfall. The outfall will be used to discharge treated effluent that is in excess of the irrigation requirements of the recycled water scheme.

The conceptual design is for the outfall to be on the river bed with effluent discharged to the water column by diffusers.

The alignment of the proposed outfall main and the diffuser concept within the Burnett River is presented in Appendix D.

2.3 Project Staging

BRC intends to construct a 90,000 EP WWTP in two stages. This proposed project forms part of a BRC adopted regional strategy for wastewater treatment areas east of Bundaberg City. The staged construction of the Rubyanna WWTP takes into account the projected increasing population of the region as presented in Table 1.

Table 1 Project population growth in relation to conceptual phasing in of connections to the Rubyanna WWTP

Projected Population (EP) 2011-2055							
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	
Catchment Area	2017	2018	2020	2024	2026	2030	2050
Bundaberg East WWTP	33,000	33,495	34,507	36,625	37,732	40,047	53,938
North WWTP	-	-	2,000	2,081	2,123	2,209	2,696
Bargara WWTP	-	-	-	-	-	10,000	10,000
Coastal Areas	-	3,000	5,308	8,736	15,772	19,879	24,420
Total Load on Rubyanna WWTP	**33,000**	**36,495**	**41,815**	**47,442**	**55,627**	**72,135**	**91,054**

It should be noted that Table 1 is indicative only and will be determinant on development growth within the sewerage catchment.

2.3.1 Stage One

Stage One will accommodate 50,000 EP resulting in the decommissioning of a number of existing treatment plants that are at or near capacity.

The commissioning of Stage One of the Rubyanna WWTP allows for the decommissioning of the Bundaberg East WWTP initially, followed by the decommissioning of the Bundaberg North WWTP in approximately 2020. Raw sewage flows originally treated at the Bundaberg East plant will be transferred via a rising main to the Rubyanna plant. Stage One will provide up to an additional 20000 EP capacity (i.e. additional to the proposed flows at the commissioning of the Rubyanna WWTP) for treatment of wastewater from the future Bundaberg East area and the coastal communities.

2.3.2 Stage Two

By 2025, Stage Two will be commissioned thereby taking the proposed Rubyanna WWTP to the ultimate treatment capacity of 90,000 EP. Stage Two will enable the remaining coastal communities to be brought on line to the Rubyanna WWTP. The proposed Rubyanna WWTP is anticipated to service the Bundaberg and its eastern coastal communities until 2050.

Additionally, part of the regional strategy is the possible diversion of treated effluent from the existing Bargara WWTP to the proposed Rubyanna WWTP for inclusion in the Rubyanna effluent reuse scheme. This would enable the closure of the existing ocean outfall from the Bargara WWTP which is in the vicinity of the Mon Repos turtle rookery site.

2.4 Project Delivery

HWA, on behalf of BRC, has developed a Project Delivery Plan (PDP) for the Rubyanna WWTP project and this plan is presented in Appendix E. The PDP recommends that Council delivers the project through an Early Contractor Involvement (ECI), in which Council involves pre-selected construction contractors in the detailed design process to provide advice on issues such as constructability, innovation, cost reductions, etc.

The timelines for delivery of the project as indicated in the PDP are presented in the following table:

Table 2 Indicative Timings for the Delivery of the Rubyanna WWTP Project

Item	Indicative Timeline
Approval of Development Application for the Scheme	September 2013
Engagement of Design Consultant	October 2013
ECI Contractor Shortlist	January 2014
Construction Contract Award (Construction Commencement)	January 2015
Construction Completion (End of Commissioning)	December 2016

3.0 Review of Planning and Environmental Approvals

3.1 October 2011 Report

An Approvals Planning Report, dated October 2011, provided an assessment of environmental and planning approvals for the proposed work from government agencies. The Approvals Planning Report is presented in Appendix F.

Table 3 summarises the approvals that were identified following a desktop assessment of the existing environment as presented in the Report.

Table 3 Summary of potential approvals from Approvals Planning Report

Approval Type	Infrastructure Component (✓ if Approval is required)		
	Rising Main	Rubyanna WWTP	Outfall Main
Native Title and Cultural Heritage	✓	✓	✓
Interference with overland flow	✓	✓	✓
Removal of vegetation, fauna habitat and removing or relocating fauna	✓	✓	✓
Material Change of Use (MCU)		✓	
Reconfiguration of a Lot (RoL)		✓	
Environmentally Relevant Activity (ERA)		✓	
Notifiable activities – storage of petroleum product, and regulated waste handling/disposal		✓	
Resource Entitlement			✓
Coastal Management District			✓
Prescribed Tidal Works			✓
State Planning Policy's (SPP)			✓

3.2 Approvals Review

3.2.1 Vegetation Clearing

A site inspection was held in November 2011 of the proposed raw sewage rising main and outfall effluent main alignments and the WWTP site and it is noted that generally, all of the infrastructure components are located in highly disturbed areas which will require no removal of protected vegetation or will disturb protected fauna habitats. Photos of the raw rising main alignment, proposed sewage treatment plant site, outfall main alignment and discharge location at the Burnett River is presented in Appendix G.

3.2.2 Coastal Plan

General

The Queensland Coastal Plan (Coastal Plan) was enacted on 3 February 2012 and is the primary statutory instrument under the Coastal Protection and Management Act 1995. The Coastal Plan is made up of two parts being the State Policy for Coastal Management (State Policy) and the State Planning Policy (SPP) 3/11: Coastal

Protection. The State Policy is applicable only to development that is not assessable under SPA while the SPP captures the remaining development .

DERM provides 'trigger maps' that indicate properties that are subject to the coastal policies, this is an imperative step in identifying how the Coastal Plan applies to the proposed project.

It has already been noted in this report that the part of the proposed project is assessable under SPA (Lot 1 RP57605 and Lot 6 RP204880), therefore it follows that the SPP will be applicable to these lots. The construction of the rising main and outfall main within the road reserve is not assessable under SPA and therefore the State Policy will apply to these areas.

The SPP provides a specific planning assessment framework to assess a proposal against, the level of assessment depends on the land use activity and what trigger is activated on the property. The State Policy is more general and applies outcomes that require adhering to.

With regards to the proposed project, the following triggers are applicable:

Triggers	Lot 1 RP57605	Lot 6 RP204880 [1]	McGills Road	Kirby Road	Barron Road	Strathdees Road
Coastal Management District		✓	✓			
Coastal Management Zone	✓		✓		✓	✓
Erosion Prone Area			✓		✓	✓ [3]
Storm Tide Inundation Area		✓ [2]	✓	✓		✓
Strategic Rehabilitation Area	✓	✓		✓	✓	✓
Area of High Ecological Significance	✓		✓	✓	✓	

Notes:

[1] Only the proposed lot that will be subdivided from the larger lot was assessed

[2] It is only a very small area on the south western boundary that is mapped as being impacted by Storm Tide Inundation Area

[3] The erosion prone area will be avoided through the use of directional drilling

Rubyanna WWTP Site – SPP Requirements

The SPP states that there are certain types of development within the Coastal Management District and within the Coastal Management Zone that are assessable development. Due to the nature of the works proposed by the Rubyanna WWTP project, it is likely that the project will be considered assessable development.

Despite the specific policy outcomes and policies outlined in the SPP, there are acceptable circumstances for the project not fully achieving the overall policy outcome when the development:

a) provides an overriding need in the public interest in accordance with the factors outlined at Annex 5 of the SPP; or

b) is a development commitment; or

c) is for a public benefit asset.

Although the proposed WWTP and associated infrastructure falls under Item c), BRC in its Development Application is still required to:

a) achieve the overall policy outcome of the SPP, where relevant, to the maximum extent practicable where this would not significantly change the nature, intensity or scale of the development;

b) provide an environmental offset for any residual adverse impact on an area of high ecological significance; and

c) provide for the natural effect of physical coastal processes to continue outside the development area.

As discussed in Section 3.2.1, the proposed project will not require the removal of native vegetation, hence the impact on areas of high ecological significance will be negligible and offsets will not be required.

Rising Main and Outfall Main – State Policy Requirements

For the provision of community infrastructure, the State Policy indicates that:

- it may be located within erosion prone areas only if there is no other option, there is no disturbance of coastal processes and, structures are designed and managed to ensure the impacts on the coast are avoided or minimised;
- avoids impacts on dunes and vegetation (including areas mapped as having high ecological value) are protected and conserved. Where impacts cannot be avoided management actions are to be taken to minimise impacts and rehabilitate areas, where possible;
- promotes and protects the culture and connection of Traditional Owners with the coast and marine areas;
- maintains public access to the coast and addresses potential future erosion; and
- meets the requirements of the local area coastal management plan (if one has been developed).

Generally, it is considered that the location of the pipeline within the existing road reserve is considered by BRC as the most feasible option for the pipeline alignment, hence it is considered that the construction of the rising main and outfall main meets the requirements of the State Policy.

3.2.3 Wide Bay Burnett Regional Plan

In addition to the above, the Wide Bay Burnett Regional Plan was considered in the planning report in its draft format but has since been formalised as part of the Queensland planning framework. Therefore consideration of the finalised version of the regional plan pertaining to the proposed works is included in this update. The Regional Plan must be addressed in the application for the MCU and Reconfiguration of a Lot as the assessment manager is required under legislation to have regard to the plan. As per the Planning Approvals Report, the proposed works are of benefit to the community, protect the environment and support the future growth areas (mapped in the Regional Plan), and the reconfiguration of a lot meets the required subdivision criteria of the plan. Therefore the proposed works are generally in accordance with the provisions of the Regional Plan.

3.2.4 Overland Flow

Due to the high variability of rainfall during the wet and dry seasons and the relatively short period of wet season, it is likely that the construction will not occur during the wet season. Subsequently, the approval relating to the interference of overland flow during construction is negated. It is noted that the design of the WWTP will consider overland flows during the development of the Stormwater Management Plan for the site and as such overland flows will be diverted and not impeded to coincide with plant operations.

3.2.5 Revised Approval Listing

Based on the above discussion, Table 4 presents the updated list of approvals required for the proposed Rubyanna WWTP project.

Table 4 Revised summary of potential approvals from Approvals Planning Report

Approval Type	Infrastructure Component (✓ if Approval is required)		
	Rising Main	Rubyanna WWTP	Outfall Main
Native Title and Cultural Heritage	✓	✓	✓
Interference with overland flow			

Approval Type	Infrastructure Component (✓ if Approval is required)		
	Rising Main	Rubyanna WWTP	Outfall Main
Removal of vegetation, fauna habitat and removing or relocating fauna			
Material Change of Use (MCU)		✓	
Reconfiguration of a Lot (RoL)		✓	
Environmentally Relevant Activity (ERA)		✓	
Notifiable activities – storage of petroleum product, and regulated waste handling/disposal		✓	
Resource Entitlement			✓
Queensland Coastal Plan	✓	✓	✓
Prescribed Tidal Works			✓
State Planning Policy's (SPP)		✓ [1]	

Notes:

[1] Will be addressed during the MCU process

3.3 Mitigation of Construction Risks

There are a range of mitigation measures that can be specifically designed to reduce the extent of identified potential environmental impacts of the proposed project. Environmental management plans are utilised to reduce the level of risk of the project potentially causing serious environmental harm

Planning Phase Environmental Management Plan

A Planning Phase Environmental Management Plan (PEMP) would be prepared to outline the proposed mitigation strategies and measures that should be adopted by the construction contractor (Contractor) to minimise potential environmental impacts. The strategies and measures recommended in the PEMP will then be incorporated into the Construction Environmental Management Plan.

Construction Phase Environmental Management Plan

Potential impacts identified during the construction phase of the proposed project would be managed through adherence to a Construction Phase Environmental Management Plan (CEMP) that will be developed by the Contractor undertaking the works in consultation with BRC and the relevant government agencies. Environmental controls required to reduce the environmental impacts of this project during construction would include the following:

- minimising the construction footprint;
- minimising disturbance to flora and fauna;
- control of erosion and sedimentation;
- control of declared weed species

3.4 Approvals Approach

BRC intends to utilise the Integrated Development Assessment System (IDAS) of the *Sustainable Planning Act 2011*(SPA) for the approval of the following development categories that will be triggered through this project:

1) Material Change of Use (MCU); and

2) Reconfiguration of a lot.

In seeking approval to undertake the above mentioned development types, Council will also seek approvals for the following:

- Native Title and Cultural Heritage;
- Prescribed Tidal Works;
- Queensland Coastal Plan
- Notifiable Activities; and
- Environmental Relevant Activity (ERA)

The IDAS process is explained in detail in Section 9 of the Approvals Planning Report in Appendix F.

4.0 Potential Environmental Impacts and Management

4.1 Description of Existing Land Use

The Rubyanna WWTP project site is located in the Rubyanna area located and is located centrally to the residential communities of Bundaberg, Burnett Heads and Bargara. The Rubyanna area has been used extensively for farming (mainly sugar cane and cattle production) and as such has been cleared significantly of native vegetation.

As the area is predominately used for sugar cane farming, the harvesting season (typically June to November) contributes to:

- Larger traffic volumes in the area due to the movement of farm machinery;
- Background noise due to cane haulage via rail; and
- Increased dust due to the harvesting methods.

Therefore, when considering the impacts of the Rubyanna WWTP, these impacts should be assessed against the ambient levels experienced in the area during the cane harvesting season.

4.2 Climate

Bundaberg City is situated in the sub-tropical region of Australia where the climate is typified by mild temperatures and low rain fall in the winter months and warmer, decidedly wetter and humid summer months.

The Bundaberg area has the possibility of occurrences of cyclones in the summer months.

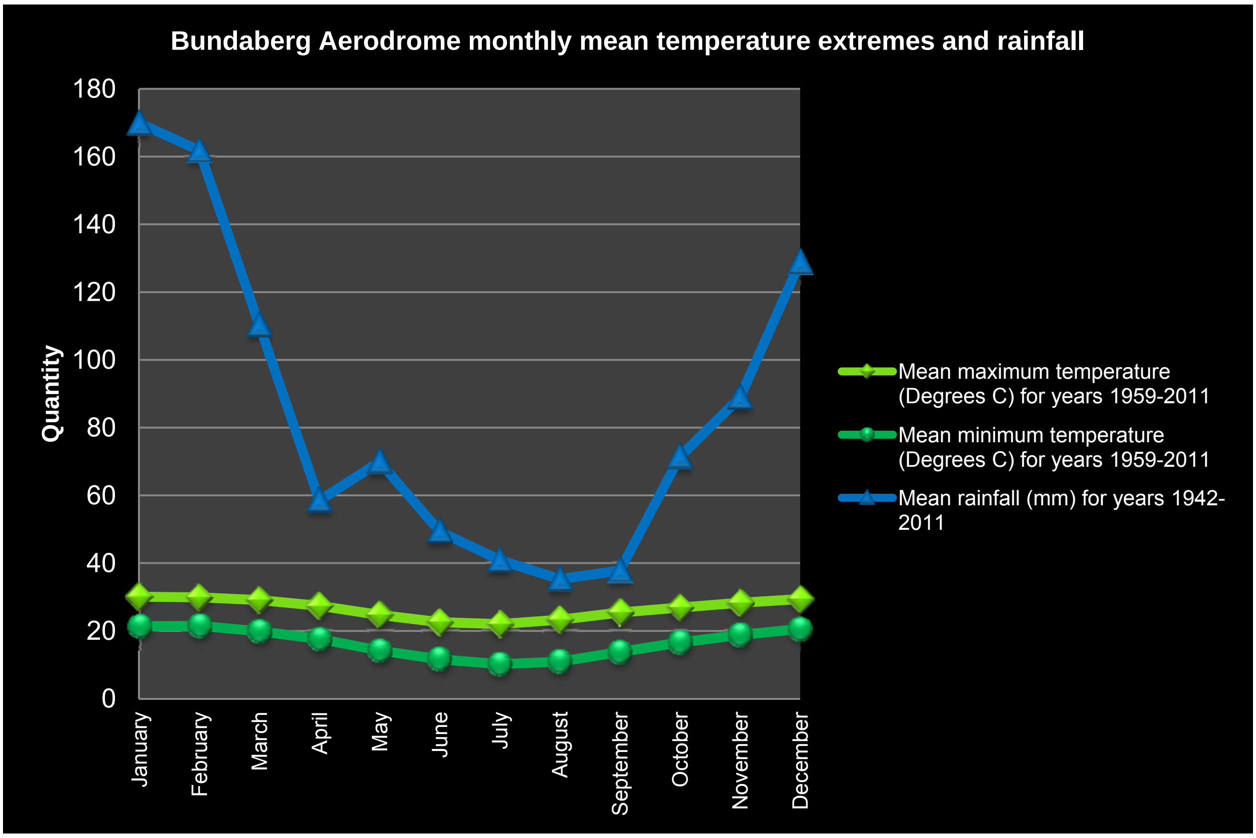

Figure 1 Monthly climate statistics (taken at Bundaberg Aero)

Between December 2011 and February 2011, floods have impacted on Bundaberg, and Queensland in general, prompting the Queensland Government to produce the 'Temporary State Planning Policy 2/11: Planning for stronger more resilient floodplains' (TSPP). The objective of the TSPP is to minimise flooding of urban areas and to protect the wellbeing of people and their communities.

Prior to amalgamation, Council completed a flood study for the city environs, which provides levels for Q50 and Q100 events for the entire Bundaberg region. The Q100 flood levels for the area containing the Rubyanna site is presented in Appendix H. It is noted that Council is undertaking a revised flood study for the area to confirm the Q50 and Q100 levels for the site.

The plan in Appendix H shows that the Q100 encroaches slightly on the proposed Rubyanna WWTP site, however the site is generally free from flooding issues. Additionally, it is general practice that all WWTP structures will be constructed so that they will not be affected by the Q100 flood line and it is envisaged that Council will request the same for the design of the Rubyanna WWTP i.e. top of structure will be above the Q100 flood line.

The prevailing winds in Bundaberg are easterly and south-easterly (ww.msq.qld.gov.au) and this will need to be considered when determining the design of odour and noise attenuation systems for the WWTP (refer to Section 4.6).

4.3 Geology, Geomorphology, Soils and Sediment

4.3.1 General

Bundaberg City was founded on the banks of the Burnett River approximately 15-20 km from the eastern coast of Queensland. The coastal plain in the vicinity of the city is relatively flat and low aside from an extinct volcano known geologically as the "Sloping Hummock" situated approximately 7 km east of the city. The Sloping Hummock, locally known as The Hummock, last erupted around 1 million years ago overlaying a fluvial based landform with olivine basalt. While the olivine basalt covered an area around 200 m, it did not quite meet the present day Burnett River. One recorded instance of the olivine basalt notes that is it 55 m thick at about 1 kilometre from the vent (Johnson, 1989).

The geology under the city proper is comprised of a fluvial deposit of predominantly siltstone and sandstone origin known as the Elliott Formation. The formation is estimated at approximately 20 to 35 million years old and was probably dissected by the Burnett River around 1.5 million years ago. The river has eroded the underlying Elliott Formation and deposited alluvium as it has meandered, flooded and receded over time (Turnbull, 2001). Sediment has also been carried downstream from the upper reaches of the catchment and has over time created sand islands, sand and mud flats.

The Bureau of Sugar Experiment Stations 2003 report (Schroeder *et al*, 2003) on improved nutrient management in the sugar industry reveals that, as part of the study, soils samples were taken in and around Bundaberg including several close to the Rubyanna suburb and nearby coastal places. The samples found the soil ranged from light clay to sandy loam. It would be expected, because of the geology, to potentially see the brown red soils associated with volcanic activity near The Hummock and alluvial soils nearer the Burnett River. There is also potential to come across acid sulphate soils due to the low lying nature of the land near the river, where it is subject to tidal influence, and the coastline.

Mapping of the soils and geological conditions within the Rubyanna Area are presented in Appendix I

4.3.2 Geotechnical Investigations

BRC has undertaken geotechnical investigations at both the Rubyanna WWTP and outfall discharge location at the Burnett River. The Geotechnical Investigations report is in Appendix J.

In summary, the geotechnical investigation report indicated that the general sub-surface conditions are " generally underlain by a surface layer of brown to red-brown medium to high plasticity clay soil, which overlies a grey high plasticity residual clay layer, which in turn overlies the weathered basalt rock layer. The upper levels of the weathered basalt are comprised of a mixed layer of gravel and high plasticity clays. Basalt boulders underlie the residual clay soils and the basalt layer is interspersed with clay and boulders up to 1 metre in size."

At the time of the investigations, no groundwater was encountered during the installation of test pits or bore drilling, however anecdotal advice indicates that groundwater levels are approximately 5-6 m below existing ground level. The relatively shallow ground level will need to be considered during the design of the effluent irrigation scheme and in particular application rates so that the soils do not become super saturated and leach into the groundwater.

4.3.3 Acid Sulphate Soils

Acid Sulphate Soils (ASS) occur naturally in extensively low-lying coastal areas, mostly below 5 m Australian Height Datum (AHD) and cover approximately 2.3 million hectares of land in Queensland. ASS only becomes a problem when it is disturbed and exposed to air, and/or surface or subsurface drainage patterns are altered. When Potential ASS (PASS) are oxidised on exposure, sulphuric acid forms and the soil becomes strongly acidic.

The low elevation of some of the coastal floodplain raises the possibility that PASS may be present. According to the *Bundaberg City Planning Scheme* 2004 McGills Road and certainly part of Kirbys Road fall below 5 metre AHD. The proposed site of the WWTP may partially fall under the 5 metre AHD as would part of the outfall pipework in Barrons Road and also Strathdees Road.

ASS mapping for the area indicates that ASS is not present on the proposed Rubyanna WWTP and generally along the entire alignment of the rising main and effluent outfall main. ASS Mapping is presented in Appendix K.

It is worth noting that further geotechnical assessment for the entire project area will include testing for potential acid sulphate soils and the Contractor will be required to develop an ASS Management Plan as part of their Construction EMP.

4.4 Water

4.4.1 General

During initial community consultation for the project, nearby residents expressed concern that the WWTP may contaminate groundwater. It is understood that groundwater is used extensively in the Rubyanna area for supplementing potable water use.

It is likely that the risk of groundwater contamination due to the Rubyanna WWTP project is expected to be minimal due to the following measures that will be implemented by BRC:

- All structures within the Rubyanna WWTP will be constructed with a minimal freeboard of 500 mm to minimise overtopping events;
- As part of the Site Based Management Plan (SBMP) that will be developed for the site, a spill control procedure will be developed;
- The effluent storage lagoon will be lined with an impervious material (i.e. clay or HDPE) to minimise seepage into the ground water;
- Implementation of a groundwater sampling strategy to monitor the quality of the groundwater in the region; and
- The effluent irrigation system will be designed using the Medli Modelling package and irrigation rates will be determined so as not to impact on the groundwater system.

As the risk of groundwater contamination from the project is expected to be minimal, the following sections on water relates specifically to the discharge of effluent to the Burnett River.

4.4.2 Topography and Drainage

The Burnett River catchment is the third largest on the east coast of Queensland with an area covering 34,500 km^2. The catchment of the Burnett River is formed by the "...Burnett and Dawes Ranges in the north, the Auburn Range to the west, the Great Dividing Range to the southwest and the Cooyar and Brisbane Ranges in the south" (DERM, 2006). The Burnett River has its headwaters over 400 km inland in the Bunya Mountains on the eastern foothills of the Great Dividing Range (Shilton, 2005). The main tributaries of the river are the:

- Auburn River
- Nogo River
- Boyne River
- Stuart River
- Barambah Creek
- Three Moon Creek

The entire project footprint is contained with the lower reaches of the Burnett River sub-catchment, being seaward of the centre of Bundaberg City. The Burnett River and tributaries have been modified over time with dams and weirs being developed within the system. The Ben Anderson Barrage is the nearest structure to the proposed project and is responsible for reducing the estuarine influence on the river from approximately 56 kilometres downstream from the mouth of the river to 25 kilometres (Burnett Mary Regional Group, (unknown publish date).

4.4.3 Burnett River Water Quality

BRC and DERM have undertaken annual water quality testing of the Burnett River for consecutive years from 2005 to 2010. The reports summarising the results of this testing is presented in Appendix L.

The reports cover one annual period (June – July), reflecting at a minimum monthly sampling from 10 points along the Burnett River estuary. The water quality monitoring is undertaken to satisfy the conditions of BRC's existing DERM licence for the discharge of treated sewage wastewater into the Burnett River estuary The results from the sampling are compared with the values from the Queensland Water Quality Guidelines (QWQC) to provide an assessment of the condition of the water in the Burnett River estuary.

The respective reports also include water quality data for the years between 1999 and 2005 period, where DERM had previously undertaken less intensive monitoring, enabling a contextual view of certain components associated with water quality in the estuary over a wider period of time.

To summarise the reports, the impacts from the existing WWTPs are considered relatively minor with the main concern being the levels of chlorophyll a increasing (i.e. an algal bloom). The main contributing factor to chlorophyll a increasing is nutrients (commonly nitrogen and phosphorus) which are introduced from both point source and catchment discharges. The WWTPs introduce both nitrogen and phosphorus, however, phosphorus and nitrogen levels over the 10 years of monitoring by DERM have remained relatively stable decreasing very slightly in later years.

Water quality in the Burnett River estuary is generally good with a 'B' grade being given to the estuary in 2005 under the South East Queensland report card system. Additionally, it is noted that the BMRG, 2009 report indicates that the overall assessment of the health of the Burnett River estuary is considered to be poor when compared to other catchments within the Burnett River.

4.4.4 Environmental Values

Background

The Environmental Protection (Water) Policy 2009 (EPP Water) seeks to achieve the objectives of the Environmental Protection Act 1994 (EP Act) in relation to Queensland waters which is to protect Queensland's waters while allowing for development that is ecologically sustainable. Queensland waters include water in rivers, streams, wetlands, lakes, aquifers, estuaries and coastal areas.

This purpose is achieved within a framework that includes the:

- identification of Environmental Values (EVs) for aquatic ecosystems and for human uses (e.g. water for drinking, farm supply, agriculture, industry and recreational use); and
- determination of water quality guidelines (WQGs) and water quality objectives (WQOs) to enhance or protect the environmental values.

Receiving Environment – Burnett Estuary

The receiving environment for the proposed Rubyanna sewage treatment plant outfall is the Burnett Estuary where the outfall is located approximately 4 km from the mouth of the system. This stretch of water which is bounded by a tidal barrage (25km from the mouth near the city of Bundaberg) holds a number of environmental values that reflect the ecological, social and economic values and uses of the catchment.

The Burnett Estuary is a highly impacted mid- size estuary that is surrounded by urban development (Bundaberg City) and sugar cane areas (BMRG, 2009). The estuary is highly modified with only limited areas of undisturbed riparian vegetation remaining along the river system (BMRG, 2009). Key regional issues that have been identified for the Burnett Estuary are barriers, fishing, litter, catchment pollutant sources, point source pollution, seagrass loss, habitat loss, reduced freshwater inflows and herbicides (BMRG, 2009).

Environmental Values

Processes which are commonly used to identify Environmental Values (EVs) and determine WQGs and WQOs are based on the National Water Quality Management Strategy (NWQMS, 2000), Implementation Guidelines (1998) and are further outlined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000).

A first pass of establishing Environmental Values for the Burnett Estuary were determined using the State of the Estuarine Environment Report for the Burnett Mary NRM Region (2008), analysis of aerial photos and local knowledge of activities undertaken in the region. Table 5 summarises Environmental Values for the receiving environment of the Burnett Estuary.

Table 5 Environmental Values of the receiving environment (adapted from schedule 1 of EPP (Water)).

EV	EV Description	Estuary specifics	Burnett River (lower estuarine)	Burnett Heads (marine)
Aquatic ecosystems	The intrinsic value of aquatic ecosystems, habitat and wildlife in waterways and riparian areas.	Mangroves are located in close proximity to the outfall. A conservation wetland area exists at the mouth of the estuary opposite the Port of Bundaberg. Turtles are known to nest on the open coast.	√	√
Human consumption	Health of humans consuming aquatic foods such as shellfish, crustaceans etc.	The area is a popular fishing spot for a range of activities.	√	√
Primary recreation	Health of humans during recreation that involves direct contact and a high probability of water being swallowed.	Swimming is undertaken in open coastal waters.	-	√
Secondary recreation	Health of humans during recreation that involves indirect contact and low probability of water being swallowed.	Boating and fishing is popular in the area, especially in close proximity to the outfall. An existing public boat ramp is located near the proposed outfall site and sailing club is located seaward.	√	√

EV	EV Description	Estuary specifics	Burnett River (lower estuarine)	Burnett Heads (marine)
Visual recreation	Amenity of waterways for recreation that does not involve any contact with water (e.g. bird watching).	Boating and fishing is popular in the area, especially in close proximity to the outfall. An existing public boat ramp is located near the proposed outfall site and sailing club is located downstream.	√	√
Cultural and spiritual values	Indigenous and non-indigenous cultural heritage	Unknown at this stage.		
Industrial use	Suitability of water supply for industrial use	A number of sewage treatment plants and a sugar mill discharges into the estuary. A Port is located seaward of the proposed outfall site.	√	-
Aquaculture	Health of aquaculture species and humans consuming aquatic foods for commercial ventures.	No known aquaculture site exists near the proposed outfall.	-	-
Drinking water	Suitability of raw drinking water supply	Not suitable	-	-
Irrigation	Suitability of water supply for irrigation	Not suitable	-	-
Stock water	Suitability of water supply for production of healthy livestock	Not suitable	-	-
Farm supply	Suitability of domestic farm water supply, other than drinking water	Not suitable	-	-

Stressor Risks and Condition of assessment categories for the Burnett Estuary

The following condition scores on assessment categories used to provide an indication of estuarine health is provided here to provide context to the first pass environmental values identified.

- Aquatic sediments: very poor condition
- Bacterial Pathogens: good condition
- Biota removal or disturbance: fair condition
- Connectivity: poor condition

- Freshwater flow regime: very poor condition
- Habitat removal or disturbance: very poor condition
- Hydrodynamics: very poor condition
- Litter and rubbish: poor condition
- Nutrients: poor condition
- Organic matter: fair condition
- Pest species (plants and animals): excellent condition
- pH: good condition
- Toxicants: good condition

The stressor risks for these assessment categories for the Burnett Estuary are mostly high to extreme (BMRG 2009) with the exception of moderate for pH.

DERM Advice

The above environmental values were discussed with DERM during a meeting held on 8th September 2011 (a copy of these minutes is presented in Appendix M). At the meeting, DERM indicated that the Burnett River should be considered to be moderately disturbed when assessing the impact from the proposed WWTP.

4.4.5 Effluent Management Strategy

General

HWA, on behalf of BRC, has developed a Effluent Management Strategy for the reuse of effluent from the proposed Rubyanna WWTP. The strategy is presented in Appendix N.

In summary, the development of the strategy has been devised with the objective of limiting the total nitrogen discharge for the Rubyanna WWTP when operating at 90,000 EP capacity to the sum of the existing load limit from the Bundaberg East and North treatment plants. In addition to the strategy, the existing nitrogen limit will be maintained through the production of improved effluent quality produced by the proposed Rubyanna WWTP.

The proposed nitrogen load limit for Rubyanna is shown in Table 6.

Table 6 Total nitrogen mass load limits for Bundaberg WWTP Sites

Site	Total Nitrogen Mass Discharged (kg/yr)
Existing East Wastewater Treatment Plant	28,500 kg/year
Existing North wastewater treatment plant	700 kg/year
Proposed Rubyanna wastewater treatment plant	29,200 kg/year

Nitrogen Loads to Burnett River

Figure 1 shows the forecast increase in total nitrogen discharged to the Burnett River with no water recycling in place. The figures shown assume that the Rubyanna WWTP will be designed to achieve a median concentration of 5 mg/L total nitrogen.

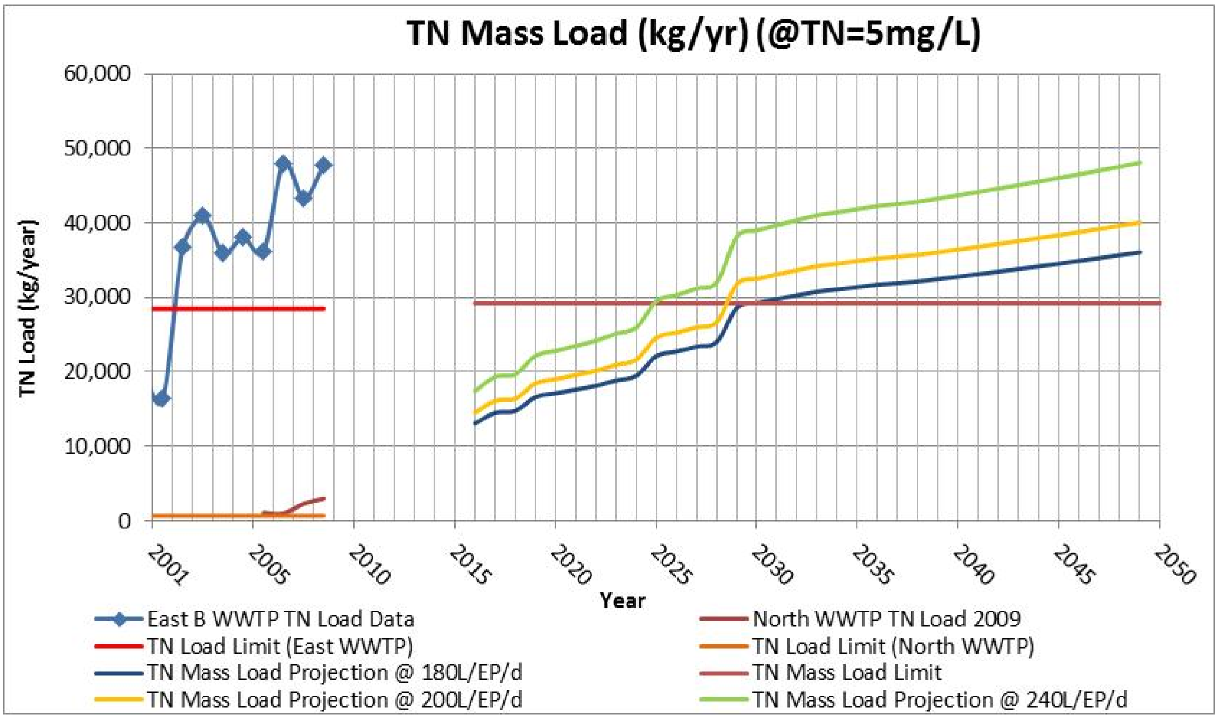

Figure 2 **Projected total nitrogen mass load discharged to the Burnett River from Rubyanna WWTP with no water recycling in place.**

Figure 2 shows the significant benefit provided by the improved total nitrogen effluent quality from Rubyanna WWTP compared to the existing discharge. At a design hydraulic load of 240 L/EP/d, the nitrogen concentration in the effluent discharged by Rubyanna WWTP enables the total nitrogen load from the WWTP to be kept below the existing load limit until 2025.

Beyond 2025, water recycling is required to maintain the total load discharged to the Burnett River to less than the existing load limit. Even at full design capacity with no recycling in place, the projected total nitrogen load from the Rubyanna WWTP is less than the existing loads discharged from the East WWTP.

To ensure that the Nitrogen Loads to the Burnett River are at least equal to the current discharge from the Bundaberg East and North plants, HWA has modelled that an irrigation area of 935 ha is required (assuming discharge of 5 mg/L of total nitrogen and an annual irrigation rate of 4 ML/ha.

Reuse Scheme Development

To achieve the irrigation area of 935 Ha, it is proposed to implement the following staging:

- Stage A (250 ha total) – nominally commenced in 2018 with construction of the first stage of the recycled water storage, pump station and distribution network.
- Stage B (485 Ha total) – commenced prior to effluent load reaching Stage A capacity.
- Stage C (945 Ha Total) – commenced prior to scheme reaching Stage B capacity.

Bundaberg Sugar has indicated a willingness to enter into an agreement with BRC for the provision of effluent for irrigation of land that is owned by Bundaberg Sugar up to the Stage B implementation.

Using the implementation strategy defined above, the anticipated capacity and performance of the recycled water scheme in reducing loads discharged to the Burnett River are summarised in Table 7.

Table 7 Predicted plant capacities, effluent production and required land area for irrigation

Notional year	Units	Implementation Strategy		
		Stage A (2017-2029)	Stage B (2029-2030)	Stage C (2030-2050)
EP		60,000	70,000	90,000
ADWF	(ML/d)	14.40	16.80	18.90
Per Capita Load	(L/EP/d)	240	240	240
Effluent Production	(ML/yr)	5,260	7,889	6,903
Total Irrigation Area	(ha)	250	485	935
Annual Irrigation Rate	(ML/ha)	4	4	4
Recycled Water Irrigated	(ML/yr)	1,000	1,939	3,739
Reuse % (dry weather)	(%)	0-19%	19-28%	28-47%
Discharge to River				
Effluent Discharge	(ML/yr)	5,312	5,424	5,728
Nitrogen Discharge	(kg N/yr)	26,558	27,122	28,641
Phosphorus Discharge	(kg P/yr)	10,623	10,849	11,457

Based on the above table, the projected nitrogen mass load discharged to the Burnett River is presented in the following Figure 3.

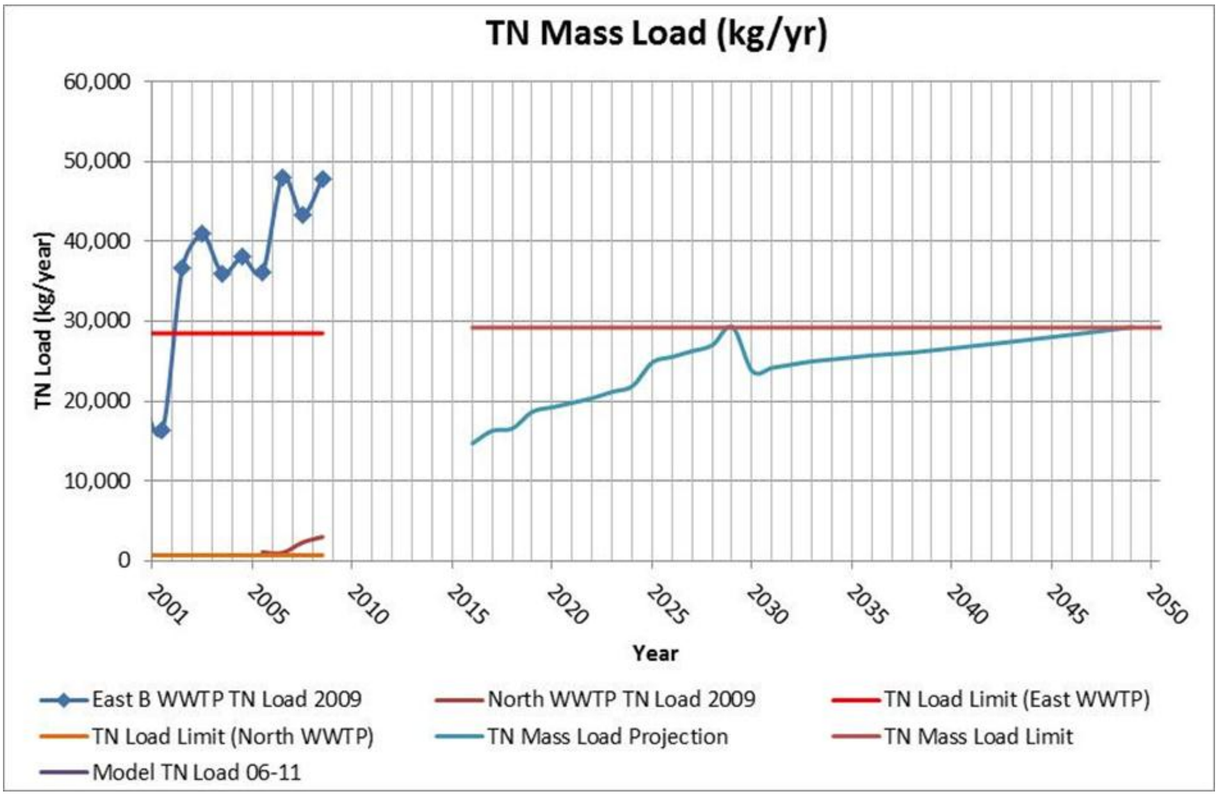

Figure 3 Projected total nitrogen mass load discharged to the Burnett River from Rubyanna WWTP for proposed recycle water scheme

Figure 3 shows that should Council secure 935 Ha of irrigation land, then the nitrogen loads being discharged to the Burnett River will be less than the current discharge from the East and North WWTP.

4.4.6 Near Field Dispersion Modelling

A Near Field Dispersion Model was developed based on the volume of effluent to be disposed to the Burnett River as detailed in the preceding section. The findings of this modelling is presented in Appendix O.

The modelling was undertaken using very conservative conditions i.e. Lowest Astronomical Tide with minimal current in either the downstream and upstream direction. The following summarises the results of the modelling based on these conditions:

- At ADWF a minimum of 120 dilutions are required to dilute the maximum effluent concentrations to guideline levels. This average plume dilution is predicted to be achieved for all density combinations and an ambient current velocity of greater than 0.25 m/s.
- At PWWF a minimum of 100 dilutions are required. This average plume dilution is predicted to be achieved for all density combinations and an ambient current of greater than 0.5 m/s.

It has been reported that the minimum current experienced within the tidal zone within the Burnett River is approximately 1 m/s.

In summary, based on the diffuser design presented in the Concept Design Report (refer to Appendix B), the modelling shows that the effluent is adequately diluted before reaching the surface of the water body.

4.5 Flora and Fauna

4.5.1 Regional Ecosystem, High Value Regrowth Status and Protected Flora

As indicated previously, the project infrastructure components are located within highly disturbed areas including road reserves and previously cleared land for farming purposes. The construction of infrastructure proposed in the project is unlikely to disturb any native vegetation protected though legislation and as such no vegetation clearing approvals are necessary.

4.5.2 Marine Flora

Marine plants are protected from disturbance and removal under the *Fisheries Act* 1994. Mangroves are present in the Burnett River estuary, at least to the point of the Ben Anderson Barrage approximately 25 kilometres upstream from the mouth of the Burnett River.

The outfall site was selected due to the minimal presence of mangroves in the vicinity which is due to the area being utilised as a sugar cane ferry landing and a recreational boat ramp. Photos of the proposed outfall location are presented in Appendix G.

Additionally, it is proposed that the construction of the outfall main will be undertaken using directional boring techniques hence, the extent of mangrove clearing will be significantly reduced. During construction of the outfall main, mangroves will be managed in accordance with proposed Tidal Works Permit and BRC's Mangrove Management Strategy.

4.5.3 Protected Fauna

The EPBC and NCA databases record protected species that may be present within the proposed project footprint. Essential habitat for the Wallum froglet is recorded on the DERM database that recognises regional ecosystems of varying importance. A site inspection of the area mapped as being essential habitat for the Wallum froglet indicated that this essential habitat was not existent over the project foot print.

Photos showing the location where the essential habitat for the Wallum froglet has been mapped (but is not present) is located in Appendix G.

4.5.4 Protected Fauna - *Nature Conservation Act 1992*

No NCA protected fauna was found within a 2.5 kilometre of the proposed WWTP site (where Lot 1 on RP57605 was used as the centre of the search).

4.5.5 Declared Pests

The EPBC search raised the potential for declared pest species to be present within the proposed project footprint. All the weeds listed have the potential to affect the environment and economy of Queensland and Australia. As such, control of listed pest species is required under the *Land Protection (Pest and Stock Route Management) Act* 2002.

As a matter of course, pest species within infested areas should be removed and/or treated prior to commencement of construction to limit the spread of weeds. Suitable erosion and sediment controls should be put in place to stabilise disturbed areas as required. Rehabilitation of any disturbed areas should be undertaken with endemic plants and monitoring undertaken to ensure that invasive species do not re-invade the sites. The CEMP will need to include the previously mentioned requirements along with other necessary measures to ensure that declared weed species are not spread within or introduced to the proposed project area.

Eradication methods will be recommended for each of the main weed species once it can be determined what, if any, of the declared pest species exist within or immediately adjacent to the proposed project footprint.

4.6 Social Issues

4.6.1 General

The administration and enforcement of environmental nuisance laws established under the *Environmental Protection Act* 1994 have been devolved to local government under the *Environmental Protection Regulation* 2008*.* The laws create a number of offences for noise, dust, odour, fumes, ash, light and smoke nuisances. Noise, dust, odour and light nuisances generated by the proposed project should be managed through the Construction EMP during construction.

In general terms, with regards to the WWTP, the detailed design will assess and specify measures to control these issues to acceptable levels.

4.6.2 Noise

It is noted that the *Environmental Protection (Noise) Policy 2008* does not specify a noise criterion with which to assess environmental nuisance from a WWTP. Also, it has been our experience that DERM Development Approvals also do not prescribe a noise criterion but generally stipulates that "*Noise from the activity must not cause an environmental nuisance at any nuisance sensitive or commercial place."*

Subsequently, it is considered that protection of environmental values relating to noise would require:

- Controlling intrusiveness of the noise above existing (background) noise levels, and
- Maintaining noise levels within levels generally accepted for the type of land use, that considers levels appropriate for the protection of health and well-being, the ability to converse and sleep, etc.

It is noted that the background noise levels in the area of the project footprint would be higher than that for a residential area due to the presence of farm machinery, especially during the cane harvesting season (June to November).

The WWTP will be designed with noise attenuation measures to ensure that the background noise criterion for the region will not be impacted by the mechanical equipment proposed.

4.6.3 Odour

Assessment of the predicted pollutant concentrations in and around the proposed WWTP will need to be assessed against the DERM Guideline for Odour Impact Assessment from Developments (2004). The guideline states that the criteria must be compared with the "odour concentrations at the most exposed existing or likely future off-site sensitive receptors".

The relevant impact assessment criteria specified by the DERM Odour guideline that is applicable for the WWTP is presented below.

Table 8 DERM Odour Pollutant Criteria

Pollutant	DERM Criteria	Averaging Period	Percentile
Odour	2.5 Odour Units	1 hour	99.5th

Also, the DERM odour guidelines nominate a buffer distance of at least 400 m from wastewater treatment plants. As reported earlier, the predominate winds in Bundaberg are easterlies and south-easterlies and there are no properties within a 400 m radius from the Rubyanna WWTP that will be affected by these prevailing winds.

Notwithstanding the above, BRC is committed to incorporating odour control systems for the WWTP so that there is minimal impact to residents with regards to odour. Reference should be made to the recently completed

Townsville Wastewater Upgrade Program (TWUP) which has similar control systems proposed for the Rubyanna WWTP and it has received favourable media coverage relating to the minimal odour generated from the upgraded plant.

4.6.4 Traffic

Traffic expected to occur during the construction period will be marginally above what is presently experienced on the local roads. The vehicles numbers to and from the site during the operation of the proposed WWTP at Rubyanna are again not expected to increase far above the present numbers.

In the construction contract, BRC will instruct the construction contractor to utilise roads that will have the least impact to residents. The proposed route for construction traffic is presented in Appendix P. The construction contractor will also be required to prepare a pre-construction record of the proposed road network and it will be a stipulation of the contract that the roads used will be returned to at least the same or better condition prior to the commencement of the project.

It is expected that during the operation of the WWTP, Council will instruct its suppliers and contractors to utilise the road network selected for the construction period.

4.6.5 Visual Amenity

The potential for impacts on visual amenity from the proposed project is related to the visibility of various aspects of the project during the construction phase, and of the finished WWTP structures, which can be assessed in terms of:

- The number of potential viewers (i.e. sensitive receptors); and
- The extent to which the proposed WWTP and associated structures will be visible from surrounding areas.

The proposed project in its entirety has very low numbers of potential viewers due to the relatively short distances covered by the proposed rising main and outfall alignments and the rural setting. The proposed WWTP also has low numbers of potential viewers as it too is within a rural area. Notwithstanding the relatively low numbers of potential viewers of the WWTP, a vegetation buffer is proposed for the site to reduce visual impact to residences.

4.6.6 Recreational Areas

The outfall pipeline will be constructed near the existing Burnett River boat ramp and upstream of the existing Bundaberg Sailing Club. As the outfall diffuser will be located at bed level (approximately 6 metres below LAT), it potentially can be damaged through these activities. The location of the outfall diffuser will be signed on either bank and buoys shall also mark its position. Additionally, Maritime Safety Queensland (MSQ) will be a concurrence agency to the application for tidal works and should be consulted to amend mapping of the river extent to identify the outfall diffuser.

4.6.7 Community Consultation

BRC has commenced extensive community consultation for the project to address the communities concerns regarding the project. Initially, the community consultation will consist of a number of public meetings and the formation of a Community Reference Group (CRG). The CRG will meet on a regular basis and will provide advice to BRC during the design, construction and operating phase of the project.

With the formation of the CRG early in the project delivery phase, it is envisaged that a majority of the community concerns regarding the development can be addressed and mitigated during the detailed design phase.

4.7 Waste Management

The main types of waste most likely generated by the proposed project would be general waste and excess construction waste. It is not expected that regulated waste would be produced by the construction of the proposed project.

All general and building waste generated by the project would be managed with appropriate waste management measures. No waste is to remain on site after project completion. Waste generated during construction would be handled in accordance with the *Waste Management Hierarchy* outlined in the Queensland *Environment Protection (Waste Management) Policy* 2000 (Waste Management Policy).

The Concept Design Report (refer to Appendix B) developed for Rubyanna WWTP prescribes the treatment of wastes that will be generated during the operation of the WWTP, including grit, chemical containers, etc. These measures will form part of the Site Based Management Plan to be developed for the plant.

Stabilised biosolids from the treatment plant are intended to be beneficially reused, for example through spreading on agricultural land. To facilitate reuse, a bunded storage area has been provided that will enable an inventory of biosolids to be stockpiled on site during periods where land-spreading is not desirable due to weather conditions, or the crop cycles of the reuse areas.

4.8 Cultural Heritage

In order to meet the due diligence requirements under section 28 of the *Aboriginal Cultural Heritage Act* 2003 it is recommended that cultural heritage management measures be included in the PEMP and then incorporated into the CEMP. Liaison with Traditional Owners is required throughout the construction phase due to the potential for significant sites in areas such as the creek lines and the Burnett River.

5.0 Conclusion

BRC has adopted a regional strategy for the provision of wastewater treatment to meet the growth predictions of the Bundaberg East and coastal communities. The adopted regional strategy consists of the following infrastructure components:

- A BNR wastewater treatment plant and effluent irrigation system that will be constructed in two stages (Stage 1 – 50,000 EP and Stage 2 – 90,000 EP);
- Initially the decommissioning of the Bundaberg East WWTP with a number of other WWTP being decommissioned as growth increases
- A raw sewage rising main from the decommissioned Bundaberg East WWTP to the proposed Rubyanna WWTP; and
- A treated outfall main that discharges treated effluent from the Rubyanna WWTP to the Burnett River.

The purpose of this REF is to provide supporting information to the planning and environmental approvals proposed for the project and as identified in the following table:

Approval Type	Infrastructure Component (✓ if Approval is required)		
	Rising Main	Rubyanna WWTP	Outfall Main
Native Title and Cultural Heritage	✓	✓	✓
Interference with overland flow			
Removal of vegetation, fauna habitat and removing or relocating fauna			
Material Change of Use (MCU)		✓	
Reconfiguration of a Lot (RoL)		✓	
Environmentally Relevant Activity (ERA)		✓	
Notifiable activities – storage of petroleum product, and regulated waste handling/disposal		✓	
Resource Entitlement			✓
Queensland Coastal Plan	✓	✓	✓
Prescribed Tidal Works			✓
State Planning Policy's (SPP)		✓	

It is noted that the above approvals will be sought through the IDAS process of SPA.

BRC, with project partners HWA and AECOM, has undertaken a number of detailed investigations relating to the project and it is acknowledged that there is an increased risk of impacts to the environment of the project, however, these risks will be mitigated by effective design and management of the project infrastructure as follows:

- Development of an Effluent Management Strategy that will limit the amount of Nitrogen load to the Burnett River to levels being currently discharged from the Bundaberg East and North Plants. It is noted that annual monitoring has shown that the existing WWTP does not adversely impact the water quality of the Burnett River;

- Provision of a outfall dispersion system that has been modelled to provide effective dispersion during very conservative ambient conditions;
- Site selection of infrastructure that does not necessitate the removal of protected vegetation or impact on essential habitats of protected fauna;
- Development of Traffic Management strategy to limit impacts to residents during both the construction and operational phase of the project;
- Controls that will be developed during the detailed design process to reduce the impacts of odour and noise from the proposed WWTP; and
- Establishment of a Community Reference Group to provide input during the design, construction and operation phases of the project.

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Appendix A

Wastewater Master Plan

Bundaberg East & Bargara Coastal Region

Wastewater Treatment and Effluent Management Master Plan

Bundaberg Regional Council

Client Issue

September 2009

Hunter Water Australia

Report Details

Project: **Wastewater Treatment and Effluent Management Master Plan: Bundaberg East & Bargara Coastal Region**

Project No.: **2997**

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Executive Summary

This document, prepared by Hunter Water Australia, represents Bundaberg Regional Council's *Wastewater Treatment and Effluent Management Master Plan* for Bundaberg East and the Bargara coastal region between Burnett Heads and Elliott Heads. Moore Park Beach has also been considered as a separate service area in preparing the plan.

Significant population growth is expected in Bundaberg and the Bargara coastal region. This Master Plan has been developed to identify the wastewater infrastructure required to support population growth in the region over the next 30 years and to improve the level of service provided to the community by programming the installation of sewer connections in backlog-growth areas that are currently served by on-site wastewater treatment systems. A staged approach to providing the infrastructure has been developed based on a logical expansion of the sewer network and the underlying population projections for each area. This staging provides flexibility and allows the costs associated with meeting the plan objectives to be spread over the planning period.

The environmental performance of wastewater treatment operations is a key consideration for Council. The strategies in the Master Plan acknowledge:

- The proximity of the coastal communities to the Mon Repos Turtle Rookery and the Great Barrier Reef Marine Park, and

- Council's commitment under the current EPA licence requirements to consider, where possible, progressively reducing the annual load of contaminants released via the existing East Treatment Plant Burnett River discharge and Bargara ocean outfall.

Beneficial reuse of treated water for sustainable crop irrigation has been identified as the preferred strategy for the region. For the purpose of the Master Plan, it has been assumed that future treatment plants would be designed to produce effluent meeting Class A+ standards. This standard of treatment maximises reuse opportunities by providing treated water that is suitable for a wide range of uses including horticulture and sugar cane irrigation. It is expected that a regional effluent reuse and management strategy will be further developed as part of the planning process.

Following initial scoping and stake-holder consultation, four options were developed for further evaluation. The options are:

Option 1A: Construct a new centralised wastewater treatment plant to service all development areas. The treatment plant would be constructed in the vicinity of Bundaberg East. Beneficial reuse opportunities would initially be explored through Sunwater's existing irrigation area, but the plan would also include the flexibility to utilise alternative reuse opportunities through irrigation in other areas including Council land. The plant would maintain a discharge to the Burnett River.

Option 1B: Construct two treatment plants: a centralised wastewater treatment plant to service Bundaberg East, Burnett Heads and Bargara and a second treatment plant located inland from Innes Park to service Innes Park and Elliott Heads. The centralised plant would pursue reuse opportunities through Sunwater's existing irrigation area and would maintain a discharge to the Burnett River as for Option 1A. The Innes Park treatment plant would pursue beneficial reuse opportunities in the southern area, but would also require a new outfall to the Elliott or Burnett River in order to manage wet weather flows.

Option 1C: This option is identical to Option 1B, except that the southern wastewater treatment plant would be located inland from Elliott Heads. The Elliott Heads treatment plant would make use of beneficial reuse opportunities in the southern area, but would also require a new outfall to the Elliott River.

Option 2: This option is a decentralised strategy that involves the development of a plant to replace Bundaberg East and four coastal plants (Burnett Head, Elliott Head, Innes Park and Bargara). The new plants would require the establishment of land based reuse schemes and new outfalls from each treatment facility.

A scheme for Moore Park was also developed as a separate service area.

Preliminary cost estimates were developed for each option for comparison purposes. The cost estimates included the cost of the treatment plants, sewer network trunk mains and transfer pump stations. For the purpose of the master plan it was assumed that under Options 1B, 1C and 2, Council would acquire 50% of the land required for irrigation and a cost for land acquisition was included. Capital costs for each option were developed based on HWA's proprietary cost curves and supported by recent contract values. The costs developed were considered suitable for comparative purposes but are not intended for budgeting purposes.

Stakeholders were involved in developing key objectives and success criteria for the Master Plan. Options were assessed using a multi-criteria analysis tool developed in consultation with Council to identify the preferred strategy. Results of the cost and non-cost assessment are summarised in the table below.

Option	1A	1B	1C	2
Non-Cost Criteria				
State Government Support	12	9	9	7.5
Irrigation Community Support	10.5	10.5	10.5	7.5
Environmental Sustainability	10.5	9	9	6
Water Cycle Impacts	13.5	10.5	10.5	6
Customer Acceptability	4	7	7	6
Flexible Implementation	4	6.4	6.4	6.4
Affordability	4.8	4	4	5.6
Foreseeable risks	3.5	2.5	2.5	1.5
Impact on Liabilities	3	2	2	1.5
Health and Safety	2.8	2.4	2.4	2
Weighted Non-Cost Score	**68.6**	**63.3**	**63.3**	**50**
Non Cost Rank	1	2	2	3
Cost Comparison				
Discounted Capital Cost	$92.8M	$112.5M	$110.2M	$99.7M
Discounted Operating Cost	$47.5M	$58.3M	$58.3M	$59.9M
Total Discounted Cost	**$140.3M**	**$170.8M**	**$168.5M**	**$159.6M**
Cost Rank	1	4	3	2

Option 1A – the construction of a new centralised treatment plant to service the catchment area was identified as the preferred option.

This option was favourable in terms of the cost comparison and also scored highest in the non-cost criteria, reflecting the key benefits that this strategy offers.

The key benefits of adopting the scheme are:

1. Adopting a centralised treatment strategy enables economies of scale in terms of treatment facility and reduces the number of facilities that the Council has to operate, monitor and report on.
2. The centralised scheme provides favourable environmental outcomes in that discharges to the Elliott River are avoided and over time the coastal effluent discharges are eliminated.
3. The strategy provides flexibility in terms of effluent management options. The new centralised plant is well located to make use of Sunwater's existing irrigation infrastructure. A river discharge is also maintained.
4. This option is most likely to allow the reuse of treated water to substitute surface water allocations. The potential benefits of this substitution include increased environmental flows, increased security for town water supply, or improved water allocations for existing license holders.
5. This option is most likely to provide the best option for implementing a number of longer term effluent reuse opportunities such as dual reticulation to new development areas, managed aquifer recharge, or creation of a salt water intrusion barrier at Elliott Heads.

On this basis, it is recommended that Option 1A is adopted as the basis for future planning. A viable effluent management strategy has also been developed for Moore Park which comprises a single local treatment plant adjacent to a land based effluent management scheme.

As part of the implementation of this master plan strategy is acknowledged that additional work is required to further develop effluent management and reuse opportunities in the region. It is also recommended that ongoing consultation with the community is included in the planning process in order to manage the expectation of both developers and rate payers.

DISCLAIMER:

The Wastewater Treatment and Effluent Management Master Plan (The Master Plan) has been commissioned by Bundaberg Regional Council's Infrastructure Services Department to provide a planning strategy for wastewater treatment and effluent management within the nominated study area. The Master Plan has been prepared for the express use by internal customers of the Bundaberg Regional Council only.

The Master Plan is not intended to be used as supporting land use planning documentation by external customers of Bundaberg Regional Council. Population growth assumptions utilised in the Model are not intended to be referenced or extrapolated in any form for land use planning applications. It is to be noted that population growth assumptions utilised in the Master Plan are not necessarily endorsed by Bundaberg Regional Council and will be subject to natural variations in population trends over time.

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Abbreviations

ADWF	average dry weather flow
ADWG	Australian Drinking Water Guidelines
AEP	annual exceedance probability
BuCC	(former) Bundaberg City Council
BOD	biochemical oxygen demand
BOM	Bureau of Meteorology, Australia
BRC	Bundaberg Regional Council
BuPO	Bundaberg Port Authority
BuS	Bundaberg Sugar
BSC	(former) Burnett Shire Council
CED	common effluent drainage
CMF	continuous microfiltration
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DO	dissolved oxygen
DPW	Queensland Department of Public Works
EIS	Environmental Impact Statement
ENSO	El-Niño Southern Oscillation
EP	equivalent population
EPA	Queensland Environmental Protection Agency
ET	equivalent tenement
GW	Ground water
HRC	Healthy Rivers Commission
HWA	Hunter Water Australia
LGA	local government area
NH3-N	ammonia-N
NRW	Queensland Department of Natural Resources and Water
NWQMS	National Water Quality Management Strategy
p.a.	per annum
PAC	powdered activated carbon
PMF	probable maximum flood
PS	Planning Scheme
QT	Queensland Transport
SPS	sewerage pumping station
SS	suspended solids
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
WSUD	water sensitive urban design
WTP	water treatment plant
WQIP	water quality improvement plan
WQO	water quality objectives
WWPS	Wastewater Pumping Station
WWTP	Wastewater Treatment Plant

1 Introduction

1.1 Scope

Hunter Water Australia (HWA) has been engaged by Bundaberg Regional Council (BRC) to develop a sewerage treatment and effluent management master plan for Bundaberg East and the Bargara coastal region between Burnett Heads and Elliott Heads for the next 30 years. Moore Park Beach has also been considered as a separate service area.

This master plan builds upon the following planning strategies developed for the former Bundaberg City and Burnett Shire Councils:

- GHD (March 2005) *Burnett Coastal Sewerage Strategy*.
- HWA (January 2009) *Planning Strategy for Bundaberg's Wastewater Plants*.

The amalgamation of the two councils in 2008 presents an opportunity to revisit these planning strategies to consider more regional solutions.

1.2 Drivers

This master plan presents a strategy for wastewater treatment and effluent management in a regional context. The drivers for Council are,

- **Need to cater for expected population growth over the next 30 years.**
- **Need to cater for current and future environmental performance requirements from its wastewater treatment facilities.**

Over the next 25 years the Wide Bay - Burnett region is predicted to have the second highest population growth in Queensland. Significant growth is predicted for Bundaberg and the Bargara coastal region with development expected to be most intense along the coastal areas.

The environmental performance of wastewater treatment operations is a key consideration for Council.

Specific issues for the planning area include:

- The proximity of the coastal region to the Mon Repos Turtle Rookery and the southern boundary of the Great Barrier Reef Marine Park.
- The provision of sewer connections and wastewater treatment facilities to areas currently served by on-site treatment systems.
- The largest treatment plant in the study area, Bundaberg East, is aged and is unable to consistently meet effluent discharge requirements. New annual nutrient load limits on the discharge to the Burnett River are to be introduced by 2012.

2 Existing Infrastructure

Wastewater treatment in the master plan study area is currently provided through a combination of centralised sewerage schemes and onsite treatment systems. The existing infrastructure and significant issues facing the study areas are summarised below.

Bundaberg East

The Bundaberg East Treatment Plant is by far the largest wastewater treatment system within the study area, serving a population of approximately 30,000. Treated effluent from the plant is discharged to the Burnett River. While the serviced catchment is not forecast to experience significant population growth, the existing treatment plant is unable to consistently meet effluent discharge requirements as a result of the age, complexity and capacity constraints of the facilities.

In addition to the current constraints, the Integrated Environmental Authority for the plant identifies new annual load limits for the total phosphorous and total nitrogen discharged to the Burnett River. These limits, which must be met by 31 December 2012, cannot be achieved with the existing infrastructure. Previous investigations into Bundaberg East have developed a number of augmentation strategies that combine treatment upgrades with an expansion of treated effluent reuse options.

Burnett Heads

Burnett Heads is currently serviced by onsite domestic treatment systems. These systems perform poorly during wet weather. The basalt derived soils in the Burnett Heads area have low infiltration potential which reportedly results in effluent reaching the surface and entering the stormwater system. Future population growth is expected to exacerbate this problem. This situation could ultimately lead to adverse water quality issues on adjacent beaches. Council operates a small onsite wastewater treatment system at the Burnett Heads Caravan Park which performs poorly during wet weather and peak load periods.

Bargara

Bargara is serviced by a conventional sewerage system with a treatment plant located adjacent to the Pasturage Reserve and Bargara Caravan Park. The Bargara treatment plant was upgraded in 2008 to improve effluent quality and increase capacity to 9,500 EP. Although some treated effluent is used for irrigation on adjacent playing fields, the majority is discharged via an ocean outfall.

Concerns have been raised regarding the proximity of the ocean outfall to the Mon Repos Turtle Rookery Reserve and the southern extremity of the Great Barrier Reef Marine Park. For these reasons Council has been exploring opportunities for increasing the proportion of effluent that can be used for irrigation.

Due to the recent investment in this plant it is assumed that it will remain in operation during the life of the plan. Attention is focused on a phased reduction of effluent discharge to the ocean.

Innes Park

The Innes Park area is currently serviced by onsite domestic wastewater treatment systems.

There is increasing development pressure on this area as it is located between Bargara and Coral Cove. As development spreads along the coastline there is an expectation that sewerage will be expanded to service this area.

Coral Cove

Coral Cove is a recent residential development centred around a golf course. Wastewater treatment is provided by a package treatment plant operated by Council. Treated water from the plant is used to irrigate the adjacent golf course. Council currently has an effluent supply arrangement with the golf course which will be maintained in to the future.

Elliott Heads

Elliott Heads is currently serviced by a mixture of onsite domestic treatment systems and a package WWTP located at the Elliott Heads Golf Course. The township is located on former sand dunes overlying groundwater reserves. The area has high soil permeability and there is some likelihood that nutrients may be being transported to the groundwater reserves. The area faces population growth pressures which will increase any impacts on groundwater reserves in the area.

The Hummock

The Hummock is an established residential area located between Bundaberg and the coast. Whilst not facing significant development pressure, there are concerns with the performance of the existing onsite treatment systems.

Moore Park

Moore Park is a small coastal village located some 15 kilometres north of the mouth of the Burnett River. The area is currently serviced by onsite domestic wastewater treatment systems. Moore Park faces similar issues to Elliott Heads in that the existing onsite treatment systems are located in highly permeable coastal sands adjacent to groundwater reserves. The master plan will explore the provision of suitable wastewater treatment and management solution for the township and residential zoned hinterland.

3 Master Plan Objectives

3.1 Key stakeholders

External stakeholders identified by Council were provided with an issues paper on 30 January 2009 and invited to attend a series of workshops held in Bundaberg during the week of 16 – 20 February 2009. The participating stakeholders are listed in Table 3-1.

Table 3-1: Stakeholders

Stakeholder Listing
Bundaberg Sugar
Growcom – Representing fruit and vegetable growers.
Cane Growers
Burnett Mary Regional Group
Port Marina
Bundaberg Port Authority
Sunwater
Queensland EPA (now DERM)
Queensland Department of Natural Resources (now DERM)

3.2 Objectives

The following objectives for the master plan were developed during the stakeholder consultation process.

Support growth and improve service levels

Parts of the master plan area are currently serviced by onsite treatment systems. In many cases these systems are performing poorly; leading to poor environmental outcomes and public health risks.

In addition to providing the capacity to support population growth, there is an expectation that improvements will be made to levels of service by providing sewer connections to areas that currently rely on onsite treatment facilities.

In developing the plan, it is important to provide capacity in a staged and flexible manner. This approach will assist in mitigating the risks from population growth by allowing future investment to be deferred if growth does not occur as projected.

Protection and enhancement of the environment

The environmental performance of wastewater treatment operations is a key consideration for Council. The operation of wastewater treatment plants and discharges to the environment are licensed by DERM. Increasingly, more stringent conditions are imposed for environmental discharges which over time will lead to an improvement in recognised environmental values and thus enhance the environment.

Government is increasingly looking to improve environmental outcomes where realistically achievable and options which facilitate this outcome are likely to have increased levels of governmental support and manage the risk of tightened regulation in the future.

Compatible with State legislation and policies

The operation of wastewater treatment schemes is regulated by state legislation covering the environmental, health and commercial aspects of their operation. In the area of wastewater treatment, recent policy direction has been towards encouraging beneficial reuse of effluent. Increasingly, the definition of beneficial reuse may be taken to include benefits to the wider water cycle by reducing demand on water sources.

The strategy developed must not only be acceptable in law but must also respond to key policy directions towards beneficial reuse in a way that balances government support with community acceptance. Schemes that respond to policy directions are considered to be more likely to receive government support.

Compatible with the irrigation industry

The master plan study area is within a dynamic and long established irrigation area. The reuse of treated effluent for irrigation within the master plan area must in reality compete or compliment pre-existing water sources.

For an irrigation scheme using treated effluent to be sustainable, the strategy must recognise the reality of the existing irrigation scheme in the district. It is unavoidable that treated effluent will have higher productions costs and more risks than existing water sources. Options which strengthen the business of a broad range of existing users will have more chance of long-term success than options which favour a small selection of groups or individuals.

Minimisation of risks and liabilities

The operation of wastewater treatment infrastructure exposes council to a number of risks and liabilities. Exposure to these can be minimised by adoption of the right strategy.

Consideration of specific risks and liabilities are outlined under the criteria described in Section 5 and developed within the presented options. Developing a strategy which attempts to minimise Council's exposure to risks and liabilities will help to minimise future operating costs

4 Strategy Development

4.1 Population Growth

Both the Queensland Planning Information and Forecasting Unit and the Australian Bureau of Statistics predict that the Bundaberg – Bargara region will experience significant population over the next 30 years. The principal driver of population growth in the area is an increase in the retiree (50+) demographic drawn to the milder climate and more affordable land costs. Actual growth over the last few years has been consistent with these long-term projections.

4.2 Population Projections

The study area was divided up in to logical sub-catchments based on the existing wastewater scheme catchments, planning scheme zones, logical development sequencing and earlier wastewater planning reports. Population growth projections were then developed for each catchment by referring to Planning Information Forecasting Unit reports, Australian Bureau of Statistics data and BRC staff.

The data used in developing the growth projections contained a number of potential growth scenarios. The medium growth projection scenario was adopted for development of the strategy for the following reasons:

- The high growth projection scenario assumed that the major part of growth for the region will occur in the short to medium term. This exposes Council to significant financial risk if development does not proceed as projected.
- As a result of the impact of the recent downturn in economic growth, population growth in the short term is expected to be below the high growth projections. As growth in this region is primarily driven by the demographic fundamentals of a retiring population, it has been assumed that the ultimate projected population will remain unchanged but that the rate of population growth will initially be low before accelerating in the medium to long term.
- Changes in development density due to high rise coastal development will have an impact at the reticulation level but are not likely to increase the ultimate projected population.

Wastewater loadings projections were developed from the adopted population projections by applying a standard wastewater load of 240 litres per person per day. This value is consistent with observed inflow at plants operated by BRC. This wastewater load does not account for future reductions in flow due to demand management or infiltration reduction programs.

Exhibit 1 identifies the various sub catchments identified within the study area and categorises them by catchment type. The adopted growth projections for this study are presented in Table 4-1.

Table 4-1: Adopted Population Growth Projection (EP) by Development Area

Development Area	2006	2011	2016	2021	2026	2036	2056	ULT
Bargara - existing	6,125	8,820	10,423	12,026	13,628	13,628	13,628	13,628
Innes park north			1,057	1,088	1,091	1,091	1,091	1,091
Bargara - area 1			18	27	27	1,987	3,946	3,946
Bargara - area 2						1,376	2,753	2,753
Bargara - area 3			24	36	36	622	1,209	1,209
Bargara - area 4							7,149	7,149
Innes park - existing			1,963	3,864	4,798	6,666	6,666	6,666
Innes park - area 1							653	1,958
Coral cove - existing	1,103	1,258	1,320	1,382	1,444	1,569	1,818	2,191
Elliott heads - existing			1,129	1,924	2,162	2,162	2,162	2,162
Elliott heads - area 1						644	1,932	1,932
Hummock - existing			428	665	691	744	849	849
Burnett heads - existing			3,033	4,957	5,386	6,245	7,964	7,964
Burnett heads - area 1							437	1,093
Rural areas - existing								
Cemex quarry					294	882	2,057	4,408
Total Southern Region:	7,228	10,078	19,395	25,969	29,557	37,616	54,314	58,999
Growth Rates p.a.:		6.87%	13.99%	6.01%	2.62%	2.44%	1.85%	
Moore park - existing			2,084	3,785	4,605	6,816	6,816	6,816
East Bundaberg WWTP	31,967	34,304	36,717	39,029	41,487	43,580	43,580	43,580
Total study area:	39,195	44,965	59,721	71,332	79,863	93,880	97,560	102,246
Growth Rates p.a.:		2.78%	5.84%	3.62%	2.29%	1.63%		

4.3 Service Level Requirements

Issues associated with each catchment were presented in Section 2. The servicing strategy used as the basis for this master plan are presented in Table 4-2.

Table 4-2: Current servicing and future objectives

Catchment	Current Situation	Master Plan Objectives
Bargara - existing	Serviced by Bargara WWTP which has capacity to service growth within this catchment.	Reduce reliance on ocean outfall by increasing beneficial reuse. Assume entire effluent stream to be received by proposed disposal strategy.
Innes Park north	Existing residential area serviced by onsite treatment systems.	Improve service levels by extending sewerage to service existing and future population.
Bargara - area 1	Future Development Area with current Rural Zoning.	To be serviced by reticulated sewerage scheme.
Bargara - area 2	Future Development Area with current Rural Zoning.	To be serviced by reticulated sewerage scheme.
Bargara - area 3	Future Development Area with current Rural Zoning.	To be serviced by reticulated sewerage scheme.
Bargara - area 4	Future Development Area with current Rural Zoning.	To be serviced by reticulated sewerage scheme.
Innes Park - existing	Existing residential area serviced by onsite treatment systems.	Improve service levels by extending sewerage to service existing and future population.
Innes Park - area 1	Future Development Area with current Rural Zoning.	To be serviced by reticulated sewerage scheme.
Coral Cove - existing	Existing Residential area serviced by Package Treatment Plant adjacent to Golf Course.	Abandonment of Ex package plant due to poor operational performance. Assume effluent supply arrangements to be maintained with the Golf Course.
Elliott Heads - existing	Existing residential area serviced by onsite treatment systems.	Improve service levels by extending sewerage to service existing and future population.
Elliott Heads - area 1	Future Development Area with current Rural Zoning.	To be serviced by reticulated sewerage scheme.
Hummock - existing	Existing residential area serviced by onsite treatment systems.	Improve service levels by extending sewerage to service existing and future population.
Burnett Heads - existing	Existing residential and commercial area serviced by onsite treatment systems.	Improve service levels by extending sewerage to service existing and future population.
Burnett Heads - area 1	Speculative development area on Northern Burnett River Mouth.	It is assumed that development will not proceed in this area within a 50 year timeframe.
Rural areas - existing	Rural properties with an existing water connection between the Hummock and Bargara. Currently serviced by onsite treatment systems.	Retain existing onsite treatment systems for these lots. Opportunistic connection of some of these properties can be evaluated during detailed design of transportation strategy.
Cemex quarry	Future Development Area with current Rural Zoning.	To be serviced by reticulated sewerage scheme.
Moore Park - existing	Existing residential area serviced by onsite treatment systems.	Improve service levels by extending sewerage to service existing and future population.
East Bundaberg WWTP	Serviced by Bundaberg East WWTP which has limited capacity to service growth within the catchment.	Augment or replace Bundaberg East WWTP to improve environmental values and license compliance.

4.4 Staging of Development

It has been assumed that development will occur in 4 broad stages. The stages follow a logical sequence of expansion from established schemes into currently un-serviced areas. This order of staging is considered to be the least-cost approach of achieving the strategy objectives.

The year at which each stage is reached has been estimated based on population growth projections. It should be recognised that growth may occur at different rates across the study area resulting in some catchments reaching each stage at different times.

It should also be recognised that other priorities including development pressures for providing new land releases and community pressures for improved service levels in established areas may drive alternative staging scenarios.

The staging adopted in the master plan is considered appropriate for comparative purposes and will also allow the potential cost impacts from adjusting the staging to suit other priorities to be quantified and considered in Council's financial model.

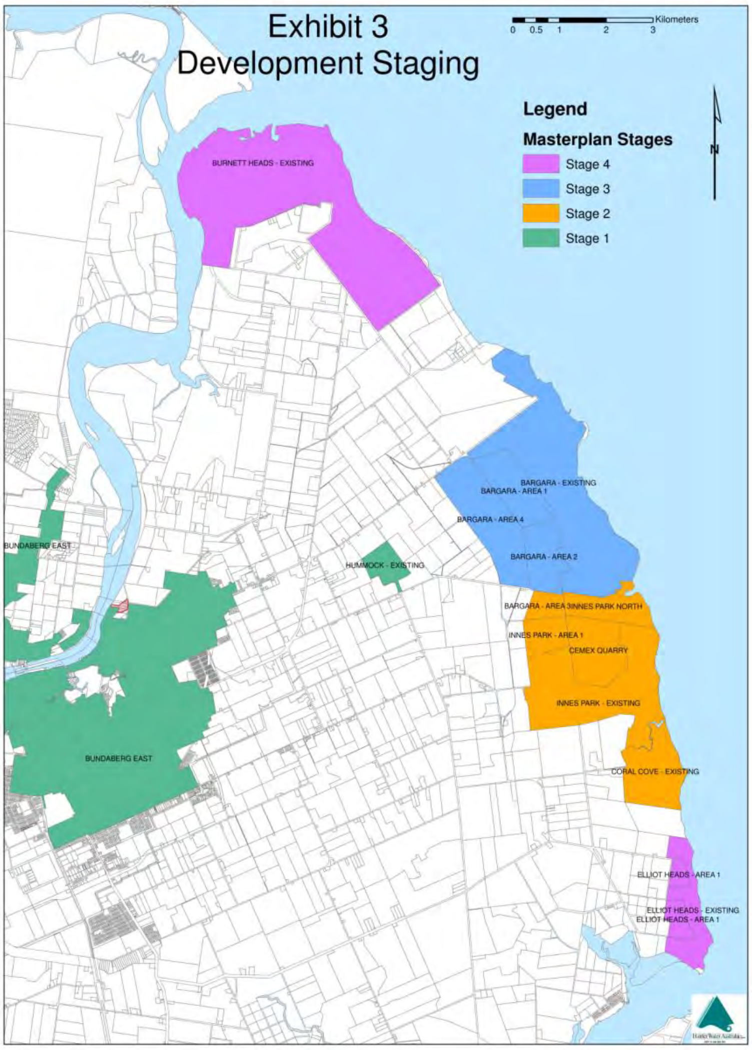


Figure 4-1: Development staging

4.5 Effluent Management Options

Effluent management options for the master plan strategies are discussed below.

River and Ocean discharge

Under current practice, the majority of effluent produced by the Bundaberg East is discharge to the Burnett River and Bargara wastewater treatment plants discharges to ocean via an outfall near Mon Repos.

The Burnett River discharge has been retained as an important feature of the effluent management strategy for the region. Retention of the river discharge is necessary to cater for higher than average rainfall years when the capacity of effluent storage ponds is exceeded and to prevent uncontrolled overtopping of effluent storage ponds during extreme wet weather events.

The long term continuation of the discharge of effluent via the Bargara ocean outfall is not included in later Stages of the plan due to the sensitivity of the receiving waters and the proximity to a protected turtle habitat.

Crop Irrigation

Queensland EPA has developed an operational policy that targets 90% beneficial reuse of effluent in order to reduce the volume of effluent disposed to waters (Environmental Protection Agency, 2005). Council is required under the Integrated Environmental Authority to consider and where appropriate minimise release to waters through the use of water demand management, water quality improvements and reuse of treated water for irrigation.

The irrigation of crops with treated water is generally acknowledged as being the preferred treated water reuse opportunity for the region for the following reasons:

- Reuse for agricultural irrigation is in line with EPA policy and the requirements of the Integrated Authority and is likely to be supported by the regulator and acceptable to the community.

- The master plan study area is within a long established irrigation area and irrigation is expected to remain the major water use in the region over the study period. The pervasiveness of irrigation equipment, knowledge, and the existing distribution infrastructure presents a significant opportunity for wide-scale beneficial reuse of treated water.

- Surface water allocations for irrigation are managed by Sunwater. Sunwater also supplies bulk raw water to the Bundaberg Regional Council for the production of potable water for the community. Although town water allocations are high security, all water users in the community are subject to the same security of supply limitations. The connectivity of water supply in the region offers the subsequent benefit that irrigation demand met from recycling treated water can be deemed to be substituting raw water, thus improving water security in the catchment.

On this basis, the master plan has adopted beneficial reuse of treated effluent for irrigation as the preferred reuse opportunity for the strategies developed.

It is acknowledged that there are barriers to achieving the target of 90% reuse through irrigation, not least of which are readily available sources of irrigation water already within the district. Achieving this aim will require careful negotiation with a broad range of stakeholders over a number of years.

Alternative reuse opportunities

A number of alternative reuse opportunities have been identified for the region. Previous reports discounted these opportunities due to the complexity of gaining the necessary approvals and community consensus. These alternative opportunities are not included in the development of the strategies outlined in this master plan, however consideration has been given to providing sufficient flexibility to allow for the future investigation and implement these more complex reuse opportunities as the effluent management strategy for the region is further developed.

Managed Aquifer Recharge

Artificial recharge (AR) using infiltration basins, vadose zone wells and deep injection wells is a proven water management technique with extensive application in California and the Netherlands. AR has been used for stormwater, effluent and surface water recharge of aquifers with beneficial uses of potable water supply and irrigation. Experience indicates that issues relating to clogging, pathogen attenuation and water quality changes can be overcome through effective planning and management. Water quality improvements during AR due to soil aquifer treatment (SAT) include pathogen attenuation, THM degradation and organic carbon reduction.

A major concern for coastal aquifers is salt water intrusion, the induced flow of salt water into fresh water aquifers caused by groundwater depletion. Many coastal aquifers with hydrologic connections to the sea have been over-drafted for decades, resulting in a reversal of the ground-water gradient. This causes salt water to flow inland, and water in the affected aquifers can become unsuitable for most uses. The key to controlling this problem is to maintain the proper balance between water being pumped from the aquifer and the amount of water recharging it.

Exhibit 2 shows the extent of the Elliott Formation Aquifer that underlays a significant land area to the west of Coral Cove. This aquifer supports existing agricultural uses as well as contributing to the town water supply of Bundaberg. The aquifer and has been suffering from increased salinity due to saltwater intrusion caused by over extraction.

MAR may be an option for reducing stress on the Elliott Formation aquifer through construction of strategically located infiltration ponds, infiltration trenches or injection wells designed to recharge the aquifer and prevent salt water intrusion. Further investigation is required to understand the hydro-geochemical issues and engage stakeholders with regard to planning, permitting and operational monitoring requirements.

Aquifer Storage and Recovery (ASR)

ASR involves storage of available water into aquifers through deep injection wells, with later retrieval from the same wells during dry periods (USGS, 2003) and the term is most often associated with confined aquifer systems where the soil above and below the aquifer is impermeable.

While most ASR systems are designed to store water during the wet season and recover it during the following dry season, some are established for water banking, where recovery may not take place for many years. While ASR does not provide a new source of water, it does provide an effective method of storing large volumes of surface water underground for subsequent use at costs that are much less than the equivalent storage in surface reservoirs.

Whilst ASR undertaken with suitably treated effluent may provide an opportunity cost effectively storage water for irrigation, further work would be required to understand the groundwater hydrology and the impacts of effluent injection on the sustainability of future extractions. Careful community consultation supported by rigorous technical work would also be required to mitigate the potential risk of cross-contamination of the town water supplies from the aquifer.

Managed Wetland Schemes

Managed wetland schemes involve the creation of wetland environments that are sustained by treated effluent flows. Discussions during the stakeholder consultation revealed some support for this type of scheme at two potential sites within the region. These sites were

- the Pasturage Reserve; a 312 Ha cattle grazing and recreation reserve west of Bargara managed by Council, and
- at rehabilitation sites within the strategic port lands.

Both sites would require detailed technical evaluation of the feasibility of creating a managed wetland scheme and careful community consultation before a scheme could be implemented.

Dual Reticulation

Dual reticulation schemes involve the provision of a dedicated reticulation system for recycled water that can be used to substitute potable water demand in residences. Established schemes are generally driven either by the perceived marketing advantage of developing land with an unrestricted outdoor water supply. Dual reticulation is generally only considered viable in new developments with the strong support of the developer.

4.6 Land availability for irrigation

The availability of land for irrigation is of prime importance to the development of options. An analysis of land availability has been carried out and is discussed in three separate categories below. Land availability is shown graphically in Exhibit 2.

Sunwater supplied irrigation district

The northern part of the study area features extensive pipe and channel irrigation infrastructure managed by Sunwater which supplies irrigation water from surface water sources to approximately 3800 Ha of productive irrigation land. This land has been improved over many years and is well equipped with irrigation equipment and supports a thriving agricultural industry.

Groundwater irrigation district

The southern part of the study area is underlain by extensive groundwater aquifers which are intensively harvested to support agriculture on the land above. This groundwater aquifer is known to be stressed and is becoming increasingly affected by saline intrusion. Whilst the increasing salinity levels do not appear to be constraining agriculture at this time the imposition of a groundwater allocation regime in the Burnett Basin – Water Resources Plan (2007), and low announced allocations since, has seen a decrease in agricultural production.

In recent years there have been efforts to develop a scheme to extend the surface water network operated by Sunwater in to this southern area to reduce groundwater extractions. These efforts have been unsuccessful primarily due to costs and the difficulties in gaining agreement from the many irrigators. This precedent, however, provides a potential opportunity in that a need has already been established to reduce pressure on the groundwater resource.

Council owned land

Traditionally, management schemes involving effluent irrigation have involved the purchase of large land areas to ensure the viability of the process over time. This approach requires significant capital outlay which is tied up for long periods, and additionally, the land typically requires improvements and equipment before irrigation can commence.

Other schemes enter agreements with landowners for the supply of effluent on terms which suit both parties. Schemes of this type require lower capital outlay, as land purchase is not required, but present other risks which need careful management. Foremost of these risks is the difficulty of balancing flows over the long run as irrigator's land management priorities change; gaining long term commitment to receive minimum flow volumes is difficult. Council also retain the obligation to ensure the effluent provided does not reduce environmental values; leading to difficulties in monitoring farm management on third party land.

Non residential land within the master plan area is highly productive due to the presence of rich, fertile volcanic soils and is able to support a wide range of profitable agricultural endeavours. This means that the land is more valuable, and hence more expensive, than land on the urban fringes across much of Australia which is typically employed in effluent irrigation schemes.

4.7 Irrigation Modelling

A monthly irrigation model developed by HWA has been used to evaluate various reuse scenarios. For a given land area and crop type, the model uses long-term average climate data to calculate the irrigation and storage requirements.

Irrigation demand

The variation of irrigation demand through the year is caused by the plant's growth cycle and harvesting and planting schedules. Areas with a dominant single crop compound this phenomena due to having similar planting and harvesting times and growth cycles.

Sugar cane growing is the dominant agricultural endeavour in the study area. There are approximately 20,000 Ha of sugar cane harvested annually with indicative crop water demands of 6 ML/Ha/annum.

The last 10 years has seen a doubling in the land used for horticultural production including fruit, vegetable, nut and herb crops. Average crop water use ranges from 1.5 ML/Ha/annum for annuals through to 11 ML/Ha/annum for permanent trees. The horticultural industry typically needs water often in large volumes for short periods to suit the specific growing cycle of the crop. The industry encounters significant commercial risk due to growing seasons typically overlapping water allocation years which can lead to crops being lost or yield reduced if water allocations are reduced.

Estimate of land area

As an initial assessment of the scheme, the irrigation demand model was used to calculate the irrigation area requirements for a centralised disposal scheme receiving the entire effluent stream of the study area. The total land area requirement was calculated for two cases:

- Maximum reuse - where storage is used to ensure that the entire effluent stream is irrigated, and
- Minimum storage - where any effluent not required for irrigation is discharged.

The results from the model are summarised in Table 4-3.

The minimum storage calculations require a significantly smaller irrigable area and minimal balancing storage whilst still achieving in the order of 75% beneficial reuse.

Table 4-3 Irrigation Demand Planning Model Results

Year	Effluent Inflow (ML/a)	Maximum Reuse			Minimum Storage		
		Irrigable Land (Ha)	Irrigation Demand (ML/a)	Storage Volume (ML)	Irrigable Land (Ha)	Irrigation Demand (ML/a)	Discharge Volume (ML/a)
2006	3551	592	3551	340	443	2662	890
2011	4021	726	4021	386	544	3266	1007
2016	5150	858	5150	494	643	3860	1289
2021	6030	1005	6030	580	753	4520	1509
2026	6631	1105	6631	636	828	4971	1660
2036	7715	1285	7715	740	963	5783	1931

It should be noted that the irrigation model is based on average climatic data. Non-average years will affect irrigation demand and storage and discharge calculations, therefore a more detailed model will be needed to confirm the values adopted in the strategy.

The land area calculations assume an average annual irrigation demand of 6.0 ML/Ha/annum which is the original basis for sizing the Bundaberg Irrigation Scheme. Discussions with Irrigators groups during the stakeholder consultation suggested that reliable access to 6.0 ML/Ha/annum of irrigation water would be a sound basis for varied and flexible agriculture in the region.

The irrigation demand model assumes that crop water demand is the long term limiting factor in defining application rates. In reality, nutrient levels in the effluent and the soil profile may lead to applications being limited by long term nutrient build up in the soils. The potential for this to occur can be managed by careful agronomy and soil monitoring. Whilst irrigators are likely to be already carrying out some soil monitoring and engaging with agronomists to ensure efficient use of fertilisers, it is suggested that a broad scale land suitability assessment be carried out in the region to assist in developing sustainable effluent application rates.

The irrigation demand model has also been applied to the detailed options developed for evaluation and used to calculate land area and storage requirements. The results developed are included in the strategy options outlined in this master plan.

4.8 Reused Effluent Quality Requirements

From 1 July 2008, all recycled water providers in Queensland must meet the requirements of the *Water Supply (Safety and Reliability) Act 2008* (the Act). The regulator for the Act is the Office of the Water Supply Regulator (OWSR), which forms part of the Department of Environment and Resource Management.

Health aspects of recycled water use are regulated separately by Queensland Health. The *Public Health Regulation 2005* prescribes the minimum standards for water quality for recycled water used for dual reticulation or the irrigation of minimally processed food crops. The regulation also defines the requirements of the different recycled water classes (A+, A, B, C & D).

Whereas previously, the requirements for recycled water schemes were outlined in guideline documents, the Act and Public Health Regulation 2005 bring these requirements into law. Both the Act and the Public Health Regulation relate to the water quality requirements to protect human health; the requirements to protect the environment remain the responsibility of the EPA.

OWSR may recommend that council prepare a basic Recycled Water Management Plan for the scheme for their use as a management tool. The RWMP could be developed to contain council's obligations on monitoring and reporting, support programs etc in the one place.

Most horticultural crops grown in the region are classified as minimally processed food crops and require wastewater to be treated to a Class A+ standard prior to irrigation. Sugar cane is not classified as a minimally processed food crop and the does not have a disinfection standard specified by the QLD Public Health Regulation.

For sugar cane irrigation there are no prescribed water quality requirements under the *Public Health Regulation 2005*. In this case, BRC are required to prepare a risk assessment of the scheme. The risk assessment is to be used to establish the level of disinfection to be provided by the treatment plant, taking into account the intended uses of recycled water and other control measures that reduce the likelihood of exposure that form part of the scheme (e.g. restrictions on public access during irrigation). Other sugar cane irrigation schemes in Queensland have adopted a Class B effluent standard.

In order to be compatible with the existing irrigation practices and to maximise reuse options, the strategies developed in this master plan are based on providing a Class A+ standard. This standard of effluent is expected to be suitable for both sugar can and irrigation of horticultural crops.

4.9 Cost Estimating Methodology

High level cost estimates have been developed for the master plan for comparative purposes. The costs have been developed using HWA's proprietary cost estimating models, which are supported by recent contract values, to develop high level cost curves for the of infrastructure required. It should be noted that the costs developed are of necessity of a high level and may be significantly different from actual construction costs; this is appropriate given the strategic nature of the master plan where the primary consideration is to compare total option costs on a consistent basis. Detailed discussion of the approach for each infrastructure type is presented below.

Treatment Plants

Capital cost estimates have been developed for the sewage treatment infrastructure required for each of the upgrade options. Capacity indexing has been used to develop the costs from a database of previous recent tenders for similar treatment plants. The costs assume an enhanced biological nutrient removal, activated sludge process capable of producing Class A effluent.

Treatment plant costs include site amenities, inlet works, diffused aeration bioreactor, multiple clarifiers, UV disinfection and sludge digestion and handling. It has been assumed that the plant would be constructed on a green field site, with sufficient grade to avoid the need for intermittent pumping and cut and fill being balanced across the site. It has also been assumed that effluent discharge (if required) will be from the plant boundary and all services (electricity, potable water, telecommunication) are available. The developed costs are designed for indicative budgetary purposes only and are considered accurate to +/- 35%. It will be necessary to revisit cost estimates once the master plan is formulated.

Capital costs estimated for providing tertiary treatment to produce Class A+ effluent have also been developed. These costs have also been produced by capacity indexing recent tenders and assume a membrane tertiary treatment plant located at the STP site. The costs include membranes and associated tanks, chemical systems and any necessary buildings. As with the developed sewage treatment cost estimates, the tertiary treatment costs are for indicative purposes only and must be revisited during later design stages. The budget capital costs are considered accurate to +/- 35%.

Treatment plant operating cost estimates have been established by considering costs for similar activated sludge systems. Operating costs estimates include the following:

- Power usage – including pumping, aeration systems, mixing energy, UV disinfection, general electricity use

- Disposal costs - including screenings and grit land fill costs as well as biosolids disposal costs
- Chemical costs – an allowance has been made for chemical phosphorus removal and polymer dosing (no supplementary carbon or alkalinity correction dosing)
- UV system lamp replacement
- Civil, mechanical and electrical maintenance
- Operations and support staff
- Ground maintenance
- Laboratory analysis.

Operating costs for membrane tertiary treatment have also been developed based on similar systems. The operating cost estimates consider design loads and include the following;

- Power
- Membrane chemicals
- Membrane replacement
- Operations and support staff
- Civil mechanical and electrical maintenance.

It should be noted that operating costs will increase over the design life of the plant (i.e. operating costs will be lower during initial stages of plant operation).

The capital and operating cost estimates have been used to develop indicative Net Present Values (NPVs) for each of the treatment plant options. The NPVs have been developed considering a 30 year design horizon and a discount factor of 7% annually. All developed costs are for indicative planning purposes only and it will be necessary to validate operating costs during later design phases. Further details on the developed costs is available in Appendix A.

Trunkmains and Pumping Stations

The construction costs for each of the pipelines were calculated based on Hunter Water's *Estimating Guidelines for Water Supply and Sewerage Pipe Construction (2008).*

A similar methodology to that used for estimating pipeline construction was used to estimate the pump station costs. Using Hunter Water's *Estimating Guidelines for Water and Sewage Pumping Station Construction (2008).*

Maintenance costs for the pipelines and pump stations were estimated using the following:

Rising Main = $700 + 0.0005D^2$/km.

Sewerage Pumping Station = 4000 + 2000/pump.

The operation costs of the pump stations were calculated using:

$$\$/\text{year} = \frac{0.0098 \times Q \times H \times c \times t}{eff}$$

Where

- Q = pumping rate (l/s)
- H = total pumping head (m)
- c = cost of electricity kWh ($)
- t = operating time (s)
- eff = pump efficiency

Effluent Storage Structures

Effluent storage structures were costed on a first principles basis assuming an impoundment with earth embankments constructed on level ground. The costs are based on mass haulage calculations and rely on the site having material suitable for the construction of earth embankments and sufficient space for disposal of excess material. The estimates provide a reasonable basis for comparison purposes but site specific cost estimates will be required in the preliminary design phase.

Irrigation Land

An indicative cost for the purchase of irrigation land within the district was developed from the purchase prices of three parcels of land recently acquired by Bundaberg Regional Council as shown in the table below.

Table 4-4 Recent purchase prices of land acquired by Bundaberg Council

Land Description	Area (Ha)	Cost ($)	Cost/Ha
295 Hummock Road, Windermere Purchased 05/07/2007	7.5	$361,275	$48,200
Elliott Heads Road, Windermere Purchased 19/07/2007	9.5	$349,000	$36,600
241 Lindemans Road, Moore Park Purchased 27/11/2007.	28.8	$450,000	$15,800

For the purposes of attributing a cost to irrigation land purchases a figure of $30,000/Ha has been adopted for costing the options (1 B-D and 2) in which land ownership is required. It has also been assumed that only 50% of total land area required would need to be directly owned by Council. Further confidence in likely future land costs could be developed by consultation with specialist land valuers familiar with the agricultural real estate market in Bundaberg.

Maintenance and operating costs for land under Council control have not been estimated at this time.

5 Strategy Options

A number of options for location of treatment facilities and associated effluent reuse schemes were developed in consultation with BRC. Three effluent management strategy options were identified as satisfying the objectives of the master plan. These three options were then evaluated against previously determined criteria using a multi criteria analysis (MCA) tool. The three options are

- **Option 1** - centralised treatment and effluent management with three sub-options to reflect potential alternative outcomes following each stage of development.
- **Option 2** - decentralised reuse and considers multiple treatment plants and effluent management schemes to provide maximum flexibility in staging. For comparison purposes Option 2 has been evaluated with the same staging assumptions as Option 1.
- **Option 3** - concerns the servicing of Moore Park in isolation and is assumed to be developed in a single stage.

5.1 Option 1A – Single Centralised Treatment Plant

This option considers a single centralised treatment plant to replace Bundaberg East WWTP servicing all development areas except Moore Park. The effluent management scheme would utilise existing irrigation infrastructure owned by Sunwater. This option represents the maximum possible reuse scenario.

The effluent management strategy would retain the existing Burnett River discharge in perpetuity while land based reuse opportunities are developed and implemented over time. This option is well suited to accessing the established Sunwater Irrigation District providing favourable agreement can be reached with all stakeholders. This option is shown in Exhibit 4 and Figure 5-1. Planning data is summarised in Table 5-1.

Table 5-1: Option 1A Planning Data

Year	2006	2011	2016	2021	2026	2036	2056	ULT
Stage	1	1	2	2	3	4	4	4
EP Projection	33,973	34,304	56,112	64,998	71,044	81,196	90,745	95,430
Effluent Volumes (ML/a)[1]	2976	3005	4915	5694	6223	7113	7949	8360
Discharge Volume (ML/a)[1]	2976	3005	0	0	0	0	0	0
%age Reuse[1]	0%	0%	100%	100%	100%	100%	100%	100%
Storage Requirements (ML)	0	0	472	547	598	683	763	803
Land area Requirements (Ha)	0	0	819	949	1037	1185	1325	1393

1 – For the Average Rainfall Year

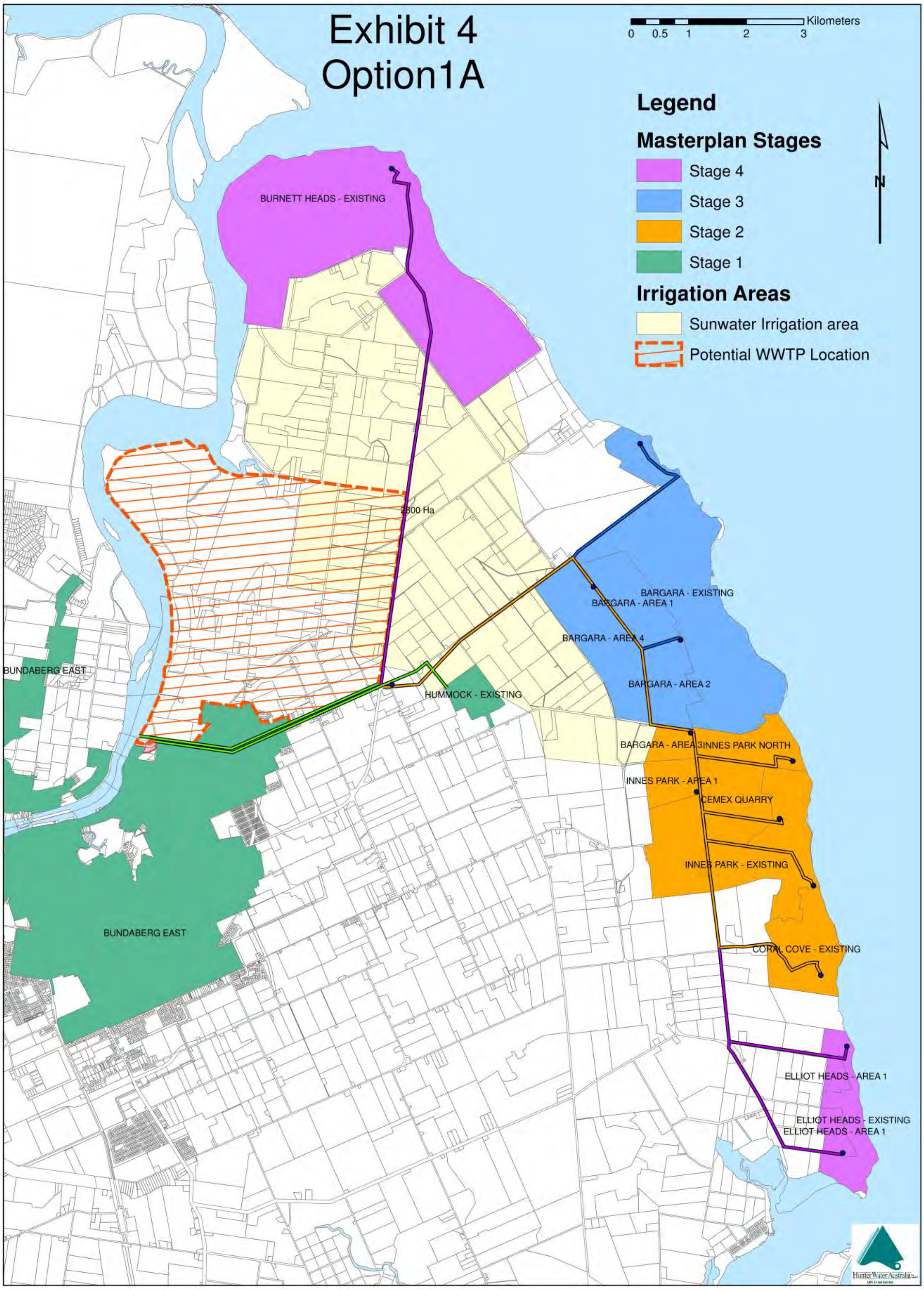


Figure 5-1: Option 1A - Single centralised treatment plant

Stage 1

Stage 1 of this option involves the replacement of the Bundaberg East Plant with a new plant on a new site. This plant will be sized for the projected growth of the Bundaberg East Catchment (45,000 – 50,000EP) and allow for the extension of sewerage to the Hummock. The catchment of the Bargara plant is assumed to be subjected to infill growth only with no expansion of the developable area requiring no augmentation or replacement of the treatment facility during this stage. Effluent management for the Bargara plant during Stage 1 will require a continuation of current efforts to maximise reuse until flows are diverted to the centralised effluent management scheme during Stage 3.

Stage 1 involves discharge of the majority of effluent to the Burnett River from the new plant. The new plant will be designed to meet the effluent quality conditions on the discharge license and the total volumetric discharge will not exceed the current license during the stage.

At projected growth, the Stage 1 will have capacity for up to 10 years. This provides sufficient time for detailed investigation in to defining the requirements for connection to Sunwater's irrigation infrastructure, detailed stakeholder consultation and gaining any necessary approvals. During this time, detailed evaluation of other effluent management opportunities can also be carried out or other forms of effluent irrigation pursued.

Stage 2

Stage 2 comprises the connection of Innes Park and Coral Cove service areas to the centralised treatment system. Projected flows for Stages 1 and 2 will exceed the volumetric limit of the Burnett River discharge requiring the revision of the licence or implementation of additional effluent reuse options before Stage 2 proceeds. Option 1A assumes that negotiations with Sunwater and other stakeholders have been successful and access to land currently serviced by Sunwater infrastructure is available from this time onwards. In the event these negotiations are unsuccessful, Options 1B and 1C present alternatives that can be pursued.

The extent of land available in the Sunwater irrigation district outlined in Exhibit 5 is sufficient to achieve 100% beneficial reuse in the average rainfall year with minimal balancing storage. From Stage 2 onwards the Burnett River discharge would be retained for balancing of storm flows.

Stage 3 and 4

Stage 3 comprises the connection of Bargara service areas to the centralised treatment plant. The Bargara treatment plant would be decommissioned during this stage and flows diverted to the centralised treatment plant. Inflows in excess of the treatment capacity at the Bargara plant would need to be diverted to the regional plant as they occur.

Stage 4 comprises the connection of Burnett Heads service areas to the centralised treatment plant.

Benefits

- Easy access to a large established irrigation district with minimal upfront costs for effluent management.
- Management of irrigation district remains the responsibility of Sunwater. Relationship required with a single stakeholder which may simplify operational decision making.

- Provides some operational flexibility to Sunwater as an alternative water source would be available to irrigators if required for operational reasons.
- Benefits the wider water cycle by substituting surface water irrigation with recycled effluent irrigation. Allows diversion of surface water allocations to alternative uses or environmental flows.
- Effluent reuse could be expanded in future as opportunities (MAR, ASR, dual reticulation) arise.

Risks

- Proximity of irrigation system connection point to Kalkie WTP intake may cause community concern. Risk can be mitigated by careful detailing of connection arrangements to minimise risk of cross connection of sources.
- Effluent reuse occurs under the control and as timed by Sunwater. Outside this arrangement, effluent must be discharged to the Burnett River unless storages are constructed to store effluent during non-irrigation periods.
- Relationship with Sunwater may change over time potentially requiring alternative disposal option to be explored.
- The return on investment will be limited as Sunwater's cost structure is such that there is little opportunity for BRC to charge for effluent supplied to the irrigation district.
- Effluent could be supplied to irrigators out of specification potentially threatening end use of horticultural crops. Can be mitigated by multi barrier treatment and diversion to river discharge if required.
- On farm management becomes more complicated due to presence of nutrients in irrigation water supply.

5.2 Option 1B – Centralised treatment plant with second plant at School Lane Site

This option considers a regionalised treatment plant and effluent management scheme comprising two locations. A larger plant is envisaged to replace Bundaberg East and service areas to the north of Innes Park North. A smaller southern treatment plant is envisaged to service Innes Park, Coral Cove and Elliott Heads. In option 1B, this southern plant is located in the School Lane area.

The effluent management strategy would initially rely on the existing Burnett River discharge connected to the northern plant whilst local reuse opportunities were developed and implemented. The effluent management strategy for this option has been assumed to require a greater proportion of direct land holdings by Council with the remaining land requirements accessed through direct agreement with landholders. This option is also well suited to other effluent management opportunities as discussed below. Option 1B is shown in Exhibit 5 and Figure 5-2. Planning data is summarised in Table 5-2.

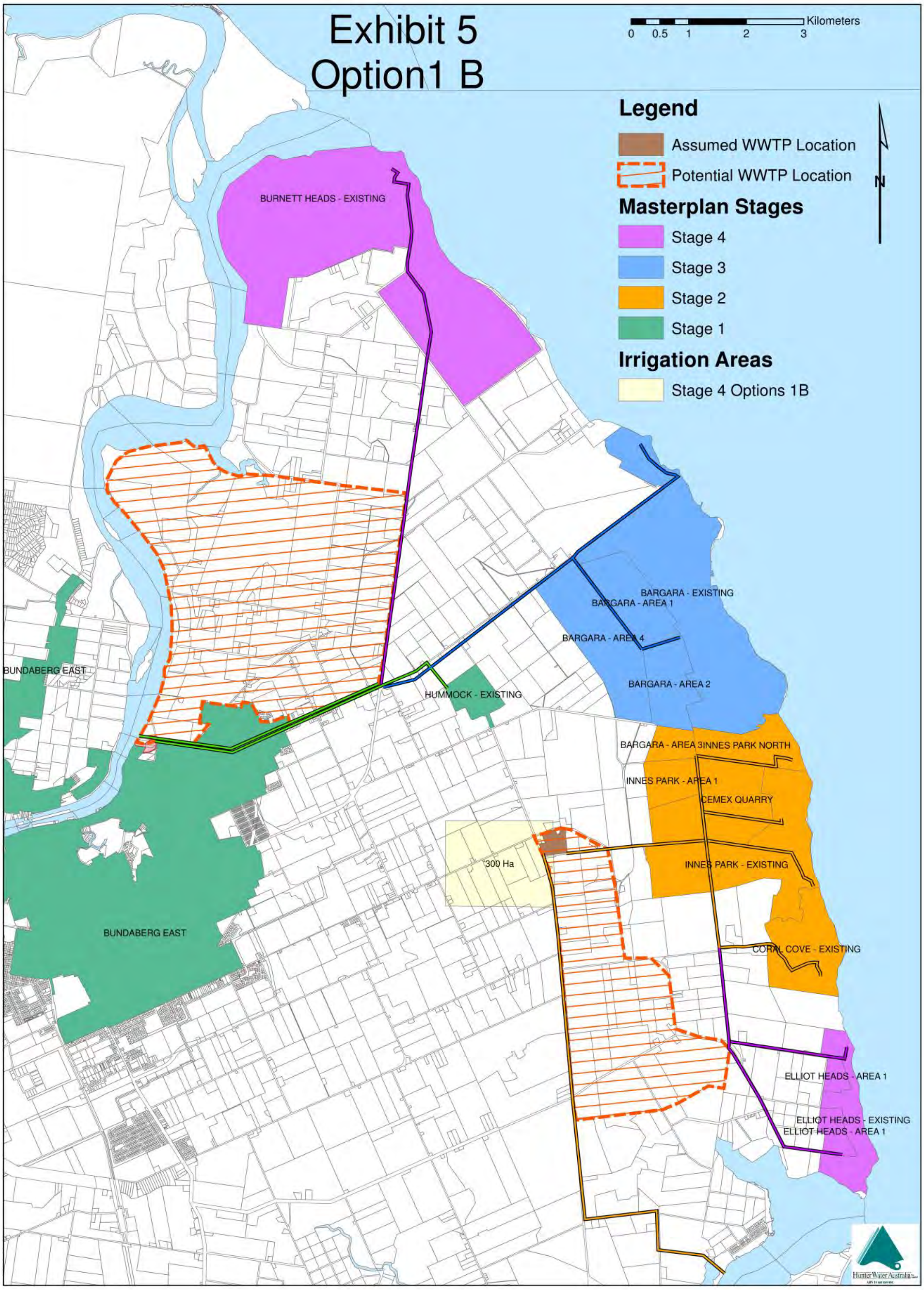


Figure 5-2: Option 1B – Centralised treatment plant with second plant at School Lane

Table 5-2: Option 1B Planning Data

Year	2006	2011	2016	2021	2026	2036	2056	ULT
Stage	1	1	2	2	3	4	4	4
Plant 1 - East Replacement								
EP Projection	33,973	34,304	50,619	56,704	61,219	67,560	73,157	73,813
Effluent Volumes (ML/a)[1]	2976	3005	4434	4967	5363	5918	6409	6466
Discharge Volume (ML/a)[1]	2976	3005	0	0	0	0	0	0
%age Reuse[1]	0%	0%	100%	100%	100%	100%	100%	100%
Storage Requirements (ML)[1]	0	0	426	477	515	568	615	621
Land area Requirements[1]	0	0	739	828	894	986	1068	1078
Plant 2 - Coastal Plant North								
EP Projection			5493	8294	9825	13636	17588	21617
Effluent Volumes (ML/a)[1]			481	727	861	1195	1541	1894
Discharge Volume (ML/a)[1]			0	0	0	0	0	0
%age Reuse[1]			100%	100%	100%	100%	100%	100%
Storage Requirements (ML)[1]			46	70	83	115	148	182
Land area Requirements[1]			80	121	143	199	257	316

1 – For the Average Rainfall Year

Stage 1

Stage 1 of Option 1B is identical to Option 1A.

Stage 2

Stage 2 comprises the construction of a second regional treatment plant in the proximity of School Lane and accessible to the land currently supplied by groundwater sources.

The regional plant delivered in Stage 1 will be retained and service growth within the Bundaberg East and Hummock catchments. River discharge will be retained however Council will need to develop reuse opportunities through direct negotiation with landowners or undertaking effluent irrigation on Council owned land..

Stages 3 & 4

Stage 3 comprises the connection of Stage 3 service areas to the southern treatment plant and the decommissioning of the existing Bargara STP. The irrigation network would be expanded to ensure access to sufficient land area to balance flows.

Stage 4 comprises the connection of the Stage 4 service areas to their respective treatment plant.

Benefits

- Responds to an established need for alternative water sources to relieve pressure on stressed groundwater resource.
- Potentially benefits the wider water cycle by substituting ground water with recycled effluent.
- Opportunity to recover costs through an access pricing regime but this must be balanced with stimulating demand from irrigators.
- Access to established irrigation enterprises.
- Effluent reuse could be expanded in future as opportunities (MAR, ASR, dual reticulation) arise.

Risks

- Council required to manage relationship with a large number of stakeholders.
- Effluent management if operated as a Council owned enterprise would be at risk if sufficient effluent cannot be supplied to meet supply agreements
- The southern treatment plant will need to have a discharge to water to allow for wet weather events or prolonged wet periods. This could be to the Elliott River via a new discharge location or to the Burnett River via the existing discharge.
- Effluent could be supplied to irrigators out of specification potentially threatening end use of horticultural crops. Can be mitigated by multi barrier treatment.
- On farm management becomes more complicated due to increased levels of nutrients in the irrigation water supply.

5.3 Option 1C – Centralised treatment plant with second plant at Elliott Heads

This option considers a regionalised treatment plant and effluent management scheme comprising two locations. A larger plant is envisaged to replace Bundaberg East and service areas to the north of Innes Park North. A smaller southern treatment plant is envisaged to service Innes Park, Coral Cove and Elliott Heads and in option 1C is located west of Elliott Heads.

The effluent management strategy would initially rely on the existing Burnett River discharge connected to the northern plant whilst local reuse opportunities were developed and implemented. The effluent management strategy for this option has been assumed to require a greater proportion of direct land holdings by Council with the remaining land requirements accessed through direct agreement with landholders. This option is also well suited to other effluent management opportunities discussed below. Option 1C is shown in Exhibit 6 and Figure 5-3. Planning data is summarised in Table 5-3.

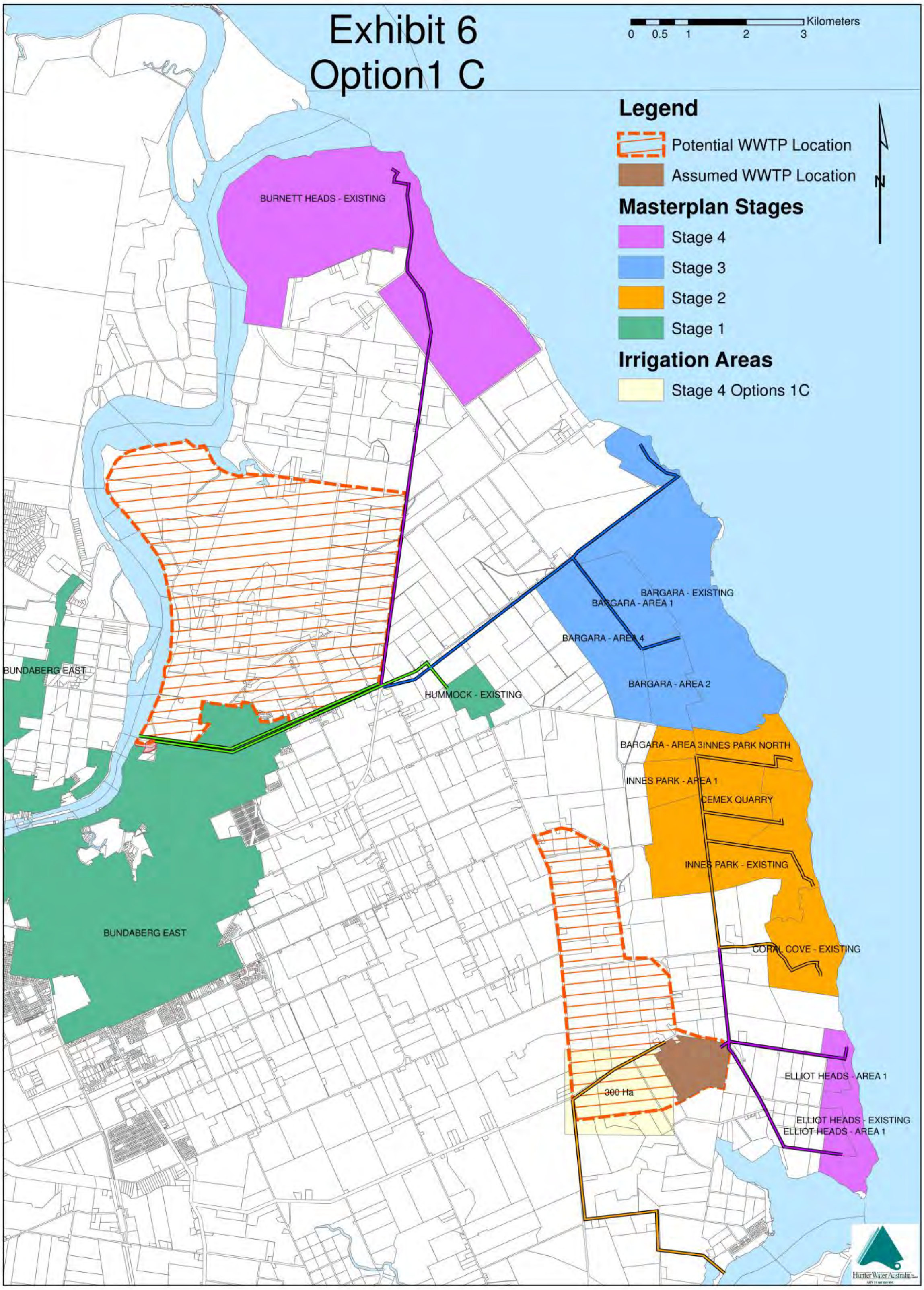


Figure 5-3: Option 1C – Centralised treatment plant with second plant at Elliott Heads

Table 5-3: Option 1C Planning Data

Year	2006	2011	2016	2021	2026	2036	2056	ULT
Stage	1	1	2	2	3	4	4	4
Plant 1 - East Replacement								
EP Projection	33,973	34,304	50,619	56,704	61,219	67,560	73,157	73,813
Effluent Volumes (ML/a)[1]	2976	3005	4434	4967	5363	5918	6409	6466
Discharge Volume (ML/a)[1]	2976	3005	0	0	0	0	0	0
%age Reuse[1]	0%	0%	100%	100%	100%	100%	100%	100%
Storage Requirements (ML)[1]	0	0	426	477	515	568	615	621
Land area Requirements[1]	0	0	739	828	894	986	1068	1078
Plant 2 - Coastal Plant South								
EP Projection			5493	8294	9825	13636	17588	21617
Effluent Volumes (ML/a)[1]			481	727	861	1195	1541	1894
Discharge Volume (ML/a)[1]			0	0	0	0	0	0
%age Reuse[1]			100%	100%	100%	100%	100%	100%
Storage Requirements (ML)[1]			46	70	83	115	148	182
Land area Requirements[1]			80	121	143	199	257	316

1 – For the Average Rainfall Year

Stage 1

Stage 1 of option 1C is identical to Option 1A.

Stage 2

Stage 2 comprises the construction of a second regional treatment plant west of Elliott Heads and accessible to the land currently supplied by groundwater sources.

The regional plant delivered in Stage 1 will be retained and service growth within the Bundaberg East and Hummock catchments. River discharge will be retained however Council will need to develop reuse opportunities through direct negotiation with landowners or undertaking effluent irrigation on Council owned land..

Stages 3 & 4

Stage 3 comprises the connection of Stage 3 service areas to the southern treatment plant and the decommissioning of the existing Bargara STP. The irrigation network would be expanded to ensure access to sufficient land area to balance flows.

Stage 4 comprises the connection of the Stage 4 land to their respective treatment plant locations.

Benefits

- Responds to an established need for alternative water sources to relieve pressure on stressed groundwater resource.
- Provides a high quality effluent stream which could be expanded in to future uses such as MAR, ASR or dual reticulation to new developments as required.
- Potentially benefits the wider water cycle by substituting ground water with recycled effluent.
- Opportunity to recover some costs through an access pricing regime but this must be balanced with significant capital and operating costs and the need to stimulate demand from irrigators.

Risks

- Council required to manage relationship with potentially a large number of stakeholders.
- Effluent management if operated as a Council owned enterprise would be at risk if sufficient effluent cannot be supplied to meet supply agreements
- The southern treatment plant will need to have a discharge to water to allow for wet weather events or prolonged wet periods. This could be to the Elliott River via a new discharge location or to the Burnett River via the existing discharge.
- Effluent could be supplied to irrigators out of specification potentially threatening end use of horticultural crops. Can be mitigated by multi barrier treatment.
- On farm management becomes more complicated due to increased levels of nutrients in the irrigation water supply.

5.4 Option 2 – De-centralised Strategy

This option concerns the development of 5 treatment plants and effluent management schemes comprising;

- One new plant to replace Bundaberg East with the retention of the River discharge and local reuse scheme.
- 3 new coastal plants with land based effluent management schemes (Burnett Head, Elliott Head and Coral Cove/ Innes Park)
- One new plant to replace the existing Bargara Plant and land based effluent management, and

The new plants would require the establishment of land based reuse schemes that would have access to no alternate disposal pathways. It has been assumed that Council would directly acquire 50% of the land area required for these reuse schemes with the remaining land made available through end use agreements with landholders.

This option is shown in Exhibit 7 and Figure 5-4. The sequencing of the development stages is identical for Options 1 and 2. In reality the sequencing of staging in Option 2 is more flexible, due to the independence of each treatment plant, and can be more easily adjusted to suit growth rates and funding priorities. Planning data is summarised in Table 5-4.

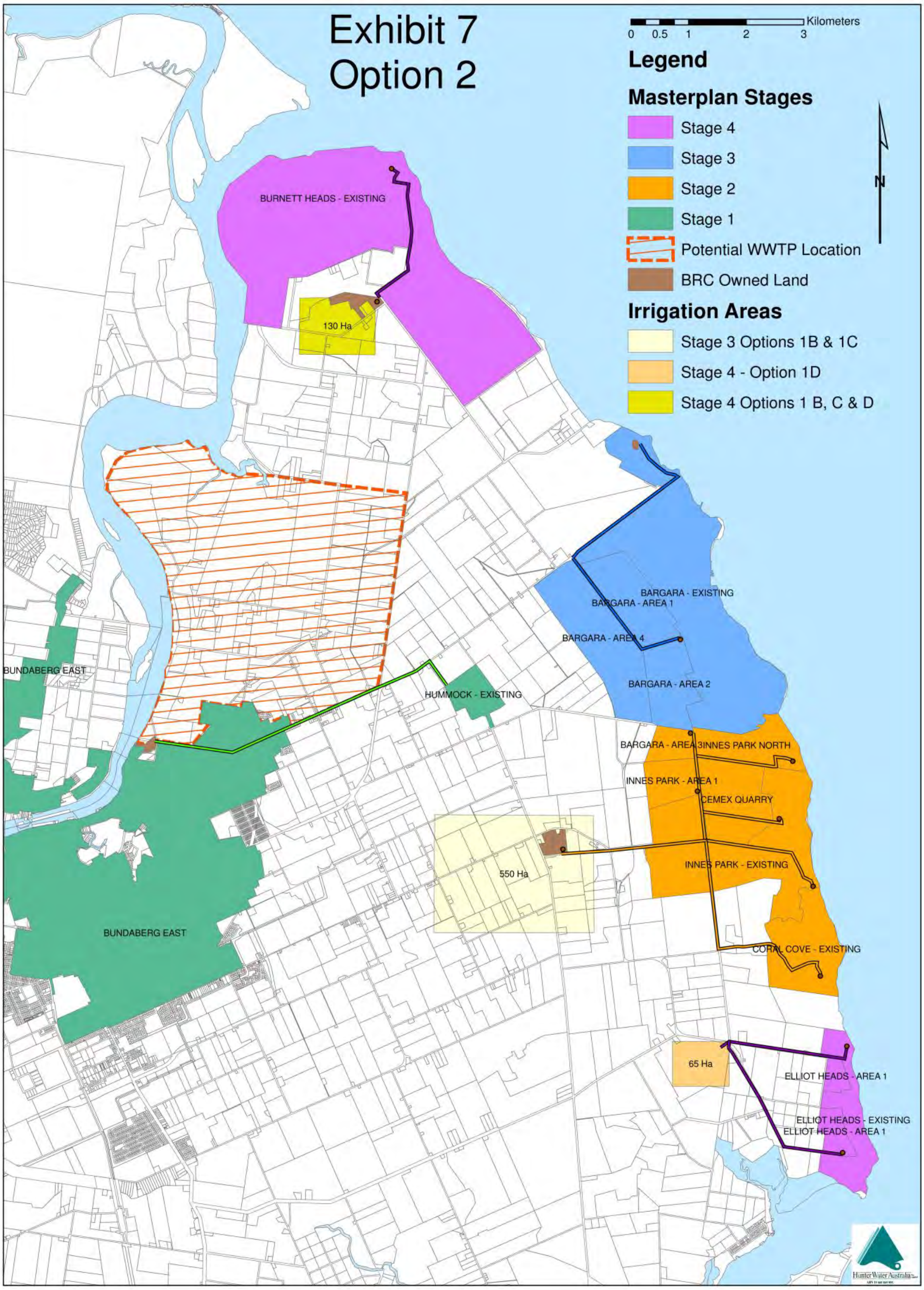


Figure 5-4: Option 2 – Decentralised strategy

Table 5-4: Option 2 Planning Data

Year	2006	2011	2016	2021	2026	2036	2056	ULT
Stage	**1**	**1**	**2**	**2**	**3**	**4**	**4**	**4**
Plant 1 - East Replacement								
EP Projection	33973	34304	37145	39694	42178	44324	44429	44429
Effluent Volumes (ML/a)[1]	2976	3005	3254	3477	3695	3883	3892	3892
Discharge Volume (ML/a)[1]	2976	3005	3254	3293	3293	3293	3293	3293
%age Reuse[1]	0%	0%	0%	5%	11%	15%	15%	15%
Storage Requirements (ML)[1]	0	0	0	18	39	57	58	58
Land area Requirements[1]	0	0	0	31	67	98	100	100
Plant 2 - Coastal Plant								
EP Projection			4364	6370	7663	10830	13494	17523
Effluent Volumes (ML/a)[1]			382	558	671	949	1182	1535
Discharge Volume (ML/a)[1]			0	0	0	0	0	0
%age Reuse[1]			100%	100%	100%	100%	100%	100%
Storage Requirements (ML)[1]			37	54	64	91	114	147
Land area Requirements[1]			64	93	112	158	197	256
Plant 3 - Bargara								
EP Projection			10441	12053	13655	16991	20327	20327
Effluent Volumes (ML/a)[1]			915	1056	1196	1488	1781	1781
Discharge Volume (ML/a)[1]			38	56	0	0	0	0
%age Reuse[1]			96%	95%	100%	100%	100%	100%
Storage Requirements (ML)[1]			84	96	115	143	171	171
Land area Requirements[1]			146	167	199	248	297	297
Plant 4 - Burnett Heads								
EP Projection						2806	4094	4094
Effluent Volumes (ML/a)[1]						246	359	359
Discharge Volume (ML/a)[1]						0	0	0
%age Reuse1						100%	100%	100%
Storage Requirements (ML)[1]						24	34	34
Land area Requirements[1]						41	60	60
Plant 5 - Elliott Heads								
EP Projection						6245	8401	9057
Effluent Volumes (ML/a)[1]						547	736	793

Discharge Volume (ML/a)[1]						0	0	0
%age Reuse[1]						100%	100%	100%
Storage Requirements (ML)[1]						53	71	76
Land area Requirements[1]						91	123	132

1 – For the Average Rainfall Year

Stage 1

Stage 1 comprises the replacement of the existing Bundaberg East treatment plant on a site close to the existing plant. The existing river discharge from Bundaberg East would need to be retained as a significant component of the effluent management strategy whilst local land based reuse opportunities are developed.

Stage 2

Stage 2 comprises a new plant to serve the coastal Stage 2 development area. The plant would require the establishment of a local land based reuse scheme.

Stage 3

Stage 3 comprises a new plant to serve the Stage 3 development areas which comprise the existing Bargara treatment plant catchment. The plant would require the establishment of a local land based reuse scheme.

Stage 4

Stage 4 comprises 2 new plants to serve the Burnett Heads and Elliott Heads development areas. The plant would require the establishment of local land based reuse schemes.

Benefits

- Council retains control over irrigation reuse schemes ensuring compliance with environmental objectives.
- Flexible implementation possible to suit changing funding, growth and development requirements.
- May be possible to use simpler treatment process in line with site specific reuse effluent quality requirements.

Risks

- Greater resources required to administer the effluent management schemes due to multiple locations.
- Difficulty in approving and the environmental discharge mechanism for all areas.
- Council required to manage relationships with a large number of reuse customers.
- More difficult to demonstrate benefits to the wider water cycle.

5.5 Comparative costs

Costs for comparative purposes are provided in Table 5-5.

Table 5-5: Estimate of Likely Present Value of Costs (7% discount rate over 30 years)

Option	Present Value of Capital Costs ($)	Present Value of Operating & Maintenance Costs ($)	Total Option Present Value ($)
1A	$92,762,000	$47,523,000	$140,285,000
1B	$112,474,000	$58,330,000	$170,804,000
1C	$110,247,000	$58,308,000	$168,556,000
2	$99,747,000	$59,896,000	$159,643,000

5.6 Flexibility to Develop Effluent Management Opportunities

Whilst assumptions have been made in defining an effluent management strategy for Options 1A, 1B, and 1C to facilitate comparison, in reality, the implementation of a centralised or regionalised treatment strategy allows a great deal of flexibility in developing effluent management opportunities over time. A key advantage of Options 1A/B/C is the common Stage 1 which is the replacement of the existing plant at Bundaberg East with a regionally located plant better able to meet the current regulated requirements of the EPA. Retaining the existing Burnett River discharge for this plant allows time to investigate, negotiate and implement land based effluent management opportunities which may have wider environmental benefits.

Effluent management opportunities are discussed in some detail in Section 5 but, in summary, Options 1A/B/C allow up to 10 years for the detailed evaluation of the following effluent management opportunities, and develop a strategy comprising all or some of the following:

- Continuation of discharge to the Burnett River under a sustainable discharge regime meeting concentration and load based limits of the Environmental Authority.
- Supply of treated effluent though the Sunwater irrigation network for irrigation of cane and horticultural crops.
- Establishment of a Council owned irrigation network in an area not currently serviced by Sunwater infrastructure.
- Separate negotiated agreements with individual landholders for the supply of treated effluent for irrigation of cane or horticultural crops.
- Direct purchase of land by Council and operation of one or more agricultural effluent reuse operation(s).
- Managed Aquifer Recharge or Aquifer Storage and Recovery in the stressed Elliott formation aquifer west of Elliott Heads.
- Creation of a salt water intrusion barrier for the Elliott formation aquifer.

- Dual reticulation could be provided to new developments should community/ developer demand arise and the costs of supply and treatment are in line with consumer price tolerances.

5.7 Moore Park Effluent Management Strategy

A single effluent management strategy has been developed for Moore Park which comprises a single local treatment plant adjacent to a land based effluent management scheme. It is assumed that the servicing of Moore Park will take place in a single stage with the same timing as Stage 2 in Option 1 above. Access to an alternative disposal pathway for Moore Park is considered unlikely to obtain approval given the sensitive nature of the most easily accessed receiving water, placing greater emphasis on land based reuse with significant balancing storages.

This option is shown in Exhibit 13. Planning data is summarised in Table 5-6.

Table 5-6: Moore Park Planning Data

Year	2006	2011	2016	2021	2026	2036	2056	ULT
Stage	1	1	2	2	3	4	4	4
EP Projection			2084	3785	4605	6816	6816	6816
Effluent Volumes (ML/a)[1]			183	332	403	597	597	597
Discharge Volume (ML/a)[1]			0	0	0	0	0	0
%age Reuse[1]	0	0	100%	100%	100%	100%	100%	100%
Storage Requirements (ML)[1]	0	0	18	32	39	57	57	57
Land area Requirements[1]	0	0	30	55	67	100	100	100

1 – For the Average Rainfall Year

Table 5-7: Moore Park Cost Estimate (7% Discount Rate over 30 years)

Option	Present Value of Capital Costs ($)	Present Value of Operating & Maintenance Costs ($)	Total Option present Value ($)
Moore Park	$9,595,000	$3,980,000	$13,576,000

6 Multi Criteria Analysis

6.1 Assessment Criteria

Each option was assessed in terms of:

- Present value analysis of likely capital, operating and maintenance costs over a 30 year period with a 7% discount factor.
- Non-cost criteria as described below.

Multi-criteria analysis was used to identify the preferred strategy. Further details on the scoring methodology are given in Appendix B.

Environmental Sustainability

This refers to an options ability to operate over the long term without an overall adverse impact on the environment. It includes factors such as energy usage, impacts on recognised environmental values, nutrient build up and soil sodicity.

Affordability

This refers to the affordability of the option from the perspective of Council and the rate-paying community. This criterion covers not only the capital and operating costs of the options but also the likelihood of the option attracting external funding.

Water Cycle Impacts

This refers to the impact of the option on the wider water cycle. This criterion was used to score the option on its ability to improve water security in the region, ease pressure on other water sources and substitute raw water supply.

Customer Acceptability

This criterion refers to the likelihood of receiving the community support. Consideration of customer acceptability included an assessment of the customer's exposure to cost through access pricing.

Irrigation Community Support

This criterion was used to gauge the perceived level of support from the irrigation community for the option.

State Government Support

This criterion gauges the perceived level of support from the Queensland Government for the option. This included an assessment of how the option addressed key policy areas regarding water recycling and sustainability.

Minimise Foreseeable Risks

This criterion gauges the ease with which the risks outlined for each option can be mitigated.

Impact on Liabilities

This criterion gauges the ease with which future liabilities for each option could be minimised.

Flexible Implementation

This criterion gauges the level of flexibility that the option provides in terms of infrastructure staging and the ability to respond to changes in population projections and effluent reuse opportunities.

Health and Safety

This criterion allows the options performance against occupational health and safety legislation and risks to be gauged. The scores for this criterion reflect consideration of the health and safety risks of wastewater treatment plant operations and the use of recycled water.

6.2 Option Scores

Table 6-1 presents a summary of the weighted scores developed in consultation with Council. An assessment of the Moore Park scheme is also included.

The assessment indicates that Option 1A is the preferred option.

Table 6-1 Summary of MCA Results and Option Ranks

Option	1A	1B	1C	2	Moore Park
Non-Cost Criteria					
State Government Support	12	9	9	7.5	9
Irrigation Community Support	10.5	10.5	10.5	7.5	10.5
Environmental Sustainability	10.5	9	9	6	10.5
Water Cycle Impacts	13.5	10.5	10.5	6	7.5
Customer Acceptability	4	7	7	6	7
Flexible Implementation	4	6.4	6.4	6.4	8
Affordability	4.8	4	4	5.6	5.6
Foreseeable risks	3.5	2.5	2.5	1.5	3.5
Impact on Liabilities	3	2	2	1.5	3.5
Health and Safety	2.8	2.4	2.4	2	3.2
Weighted Non-Cost Score	**68.6**	**63.3**	**63.3**	**50**	**68.3**
Non Cost Rank	1	2	2	3	-
Cost Comparison					
Discounted Capital Cost	$92.8M	$112.5M	$110.2M	$99.7M	$9.6M
Discounted Operating Cost	$47.5M	$58.3M	$58.3M	$59.9M	$4.0M
Total Discounted Cost	**$140.3M**	**$170.8M**	**$168.5M**	**$159.6M**	**$13.6M**
Cost Rank	1	4	3	2	-

7 Recommendations

7.1 Bundaberg East & Bargara Coastal Region

Option 1A is recommended to be used as the basis for future wastewater treatment and effluent management planning for the region. Under this option a new regional wastewater treatment plant will be constructed to serve both Bundaberg East and the coastal region. Construction of the new plant will enable Bundaberg East STP to be decommissioned and connections to be made in a staged fashion to Innes Park, Bargara, Elliott Heads and Burnett Heads. Reuse opportunities for the treated water for irrigation will be explored initially through the Sunwater irrigation channels, although alternative opportunities will be developed to provide flexibility. The treatment plant will also maintain a discharge to the Burnett River.

Implementation of this strategy will involve:

1. Commence concept design of the new regional/centralised treatment plant.
2. Selection and acquisition of a site for the treatment plant.
3. Preparation of the Environmental Impact Assessment.
4. Further development of the effluent management strategy including initial negotiations with local agribusinesses and Sunwater.
5. Integration of network planning upgrades with this strategy.
6. Negotiation with the EPA regarding licence requirements.
7. Continuation of community and stakeholder communications.

The following additional work is recommended to assist with the implementation of the strategy:

1. The effluent management strategy for the new treatment plant should be further developed as a matter of priority. Development of an effluent management strategy which considers irrigation of effluent, wet weather storage as well as nitrogen and phosphorous removal at treatment facilities should be undertaken as required by the Integrated Authority. The effluent management strategy should include a detailed review of the effluent management requirements for the new site in terms of interim and ultimate target figures for annual effluent reuse and environmental discharge, land area requirements for base-line effluent reuse, storage requirements and operating costs. The effluent management strategy should also consider longer term reuse opportunities including dual reticulation, managed aquifer recharge and salt water intrusion barriers in addition to more traditional options.

   Completion of an effluent management strategy for the new regional wastewater treatment plant will form a useful planning tool for BRC and will greatly assist BRC during negotiation of effluent quality requirements for the new treatment plant.

2. The biosolids management strategy for the region should also be reviewed and revised. Biosolids produced during wastewater treatment are currently beneficially reused by a third party in the production of compost. This contract is soon due for renewal and there is uncertainly about future requirements. It is recommended that BRC develop

and implement a long term, sustainable biosolids management plan.

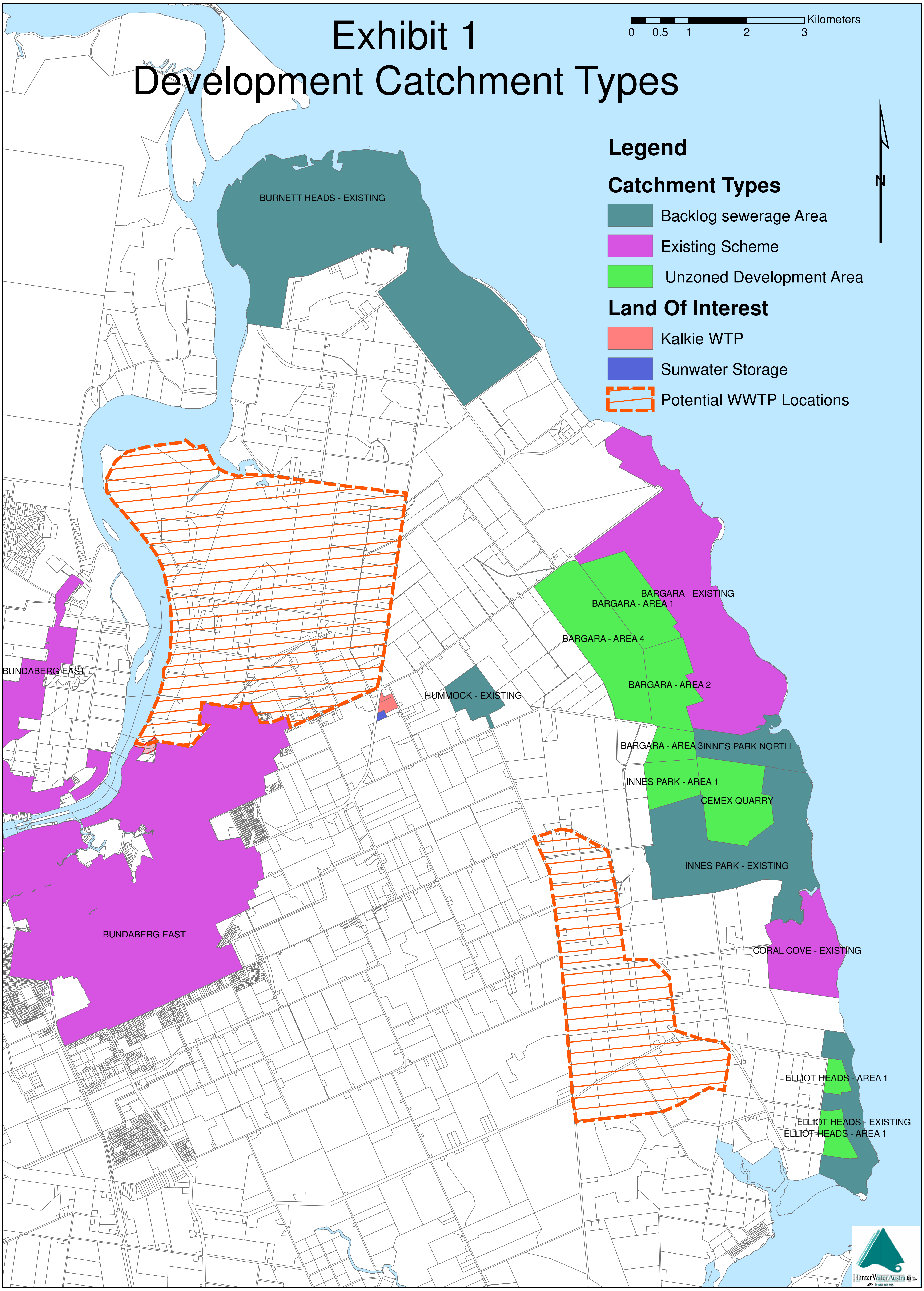
7.2 Moore Park

A viable effluent management strategy has been developed for Moore Park which comprises a single local treatment plant adjacent to a land based effluent management scheme.

Access to an alternative disposal pathway for Moore Park is considered unlikely to obtain approval given the sensitive nature of the most easily accessed receiving water, placing greater emphasis on land based reuse with significant balancing storages.

Exhibits

Exhibit 1
Development Catchment Types



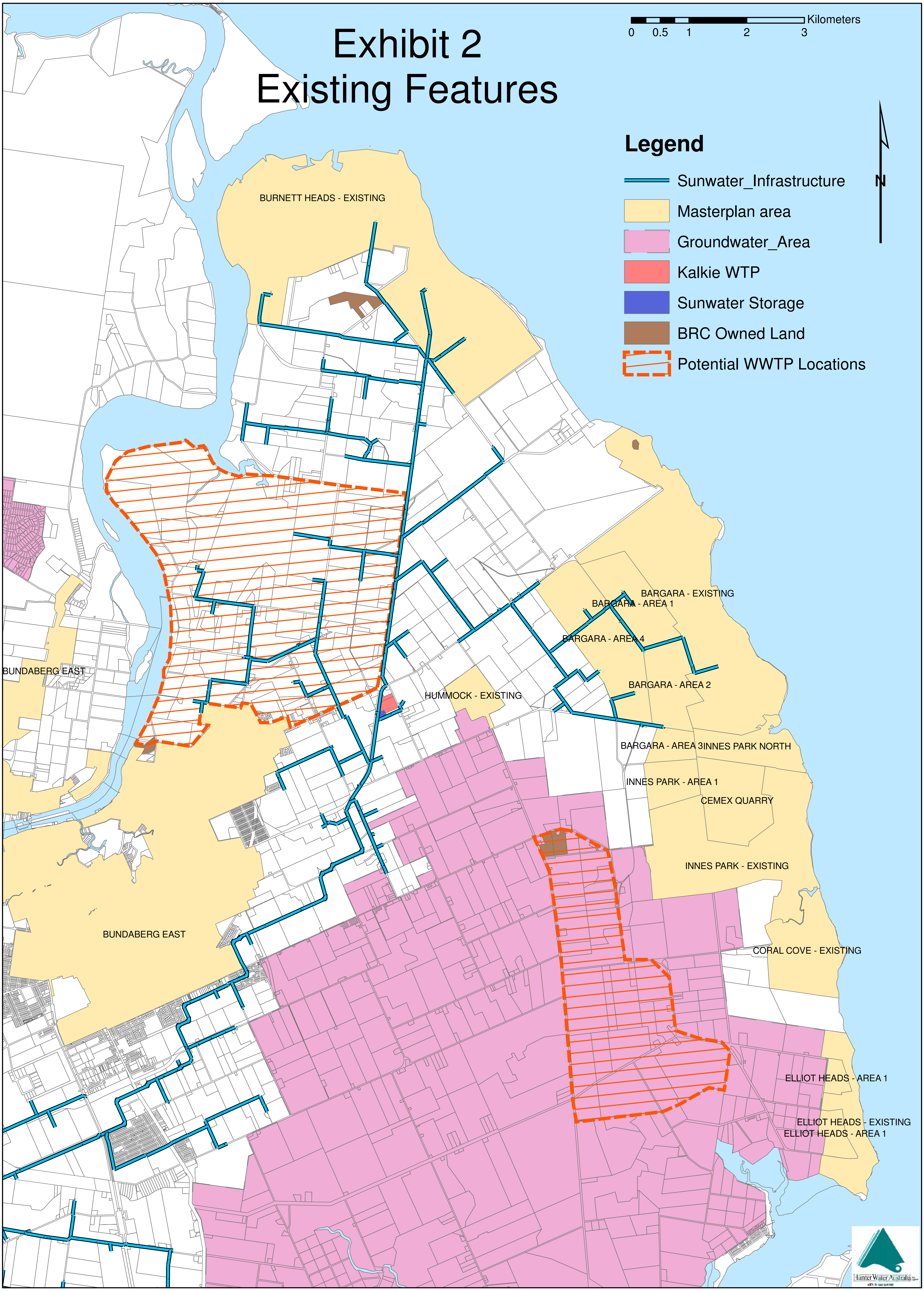


Exhibit 2
Existing Features
0
0.5
1
2
3
Kilometers
Legend
Sunwater_Infrastructure
Masterplan area
Groundwater_Area
Kalkie WTP
Sunwater Storage
BRC Owned Land
Potential WWTP Locations
N
BURNETT HEADS - EXISTING
BARGARA - EXISTING
BARGARA - AREA 1
BARGARA - AREA 4
BARGARA - AREA 2
BUNDABERG EAST
HUMMOCK - EXISTING
BARGARA - AREA 3
INNES PARK NORTH
INNES PARK - AREA 1
CEMEX QUARRY
INNES PARK - EXISTING
BUNDABERG EAST
CORAL COVE - EXISTING
ELLIOT HEADS - AREA 1
ELLIOT HEADS - EXISTING
ELLIOT HEADS - AREA 1
Hunter Water Australia

Exhibit 3
Development Staging

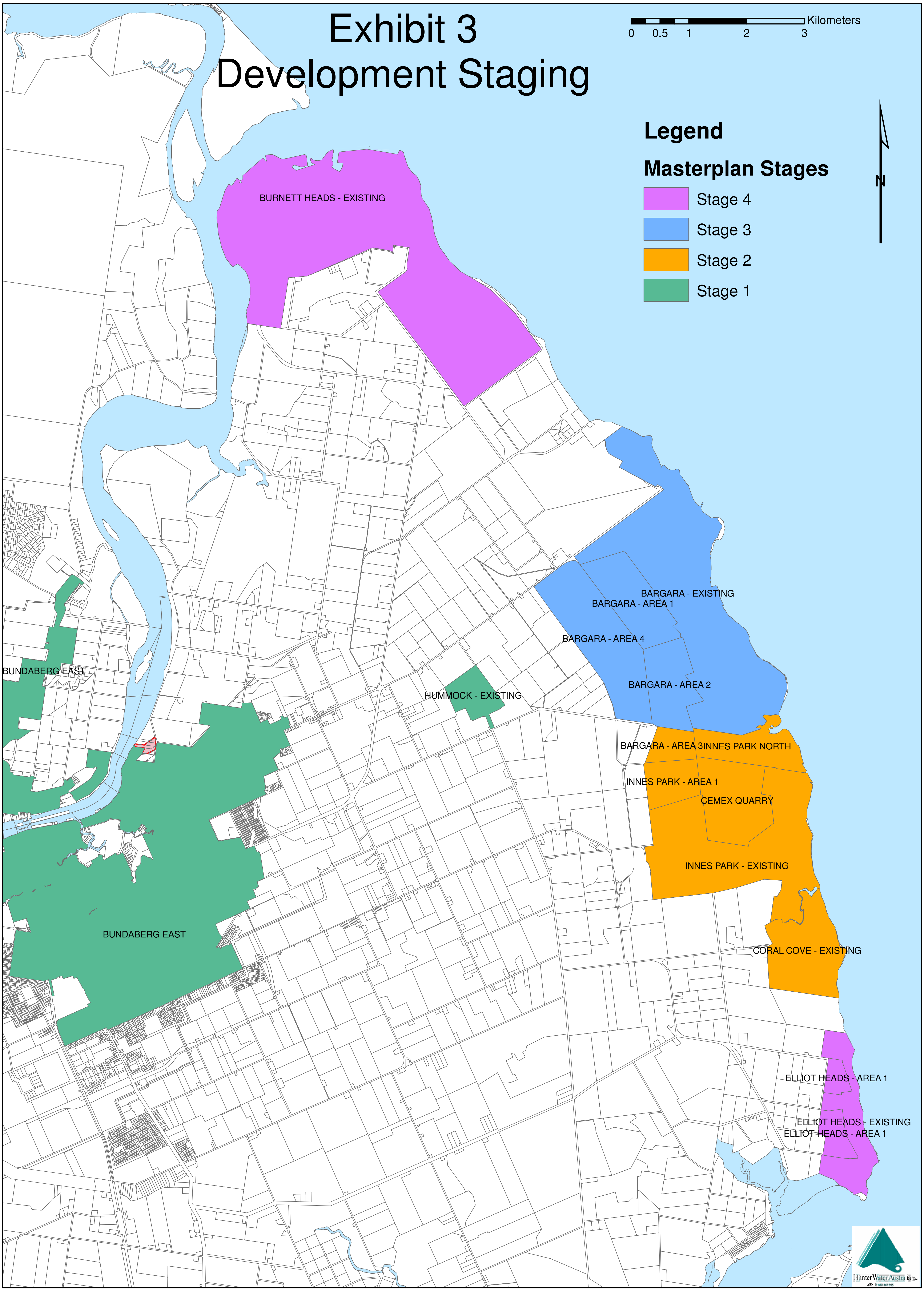
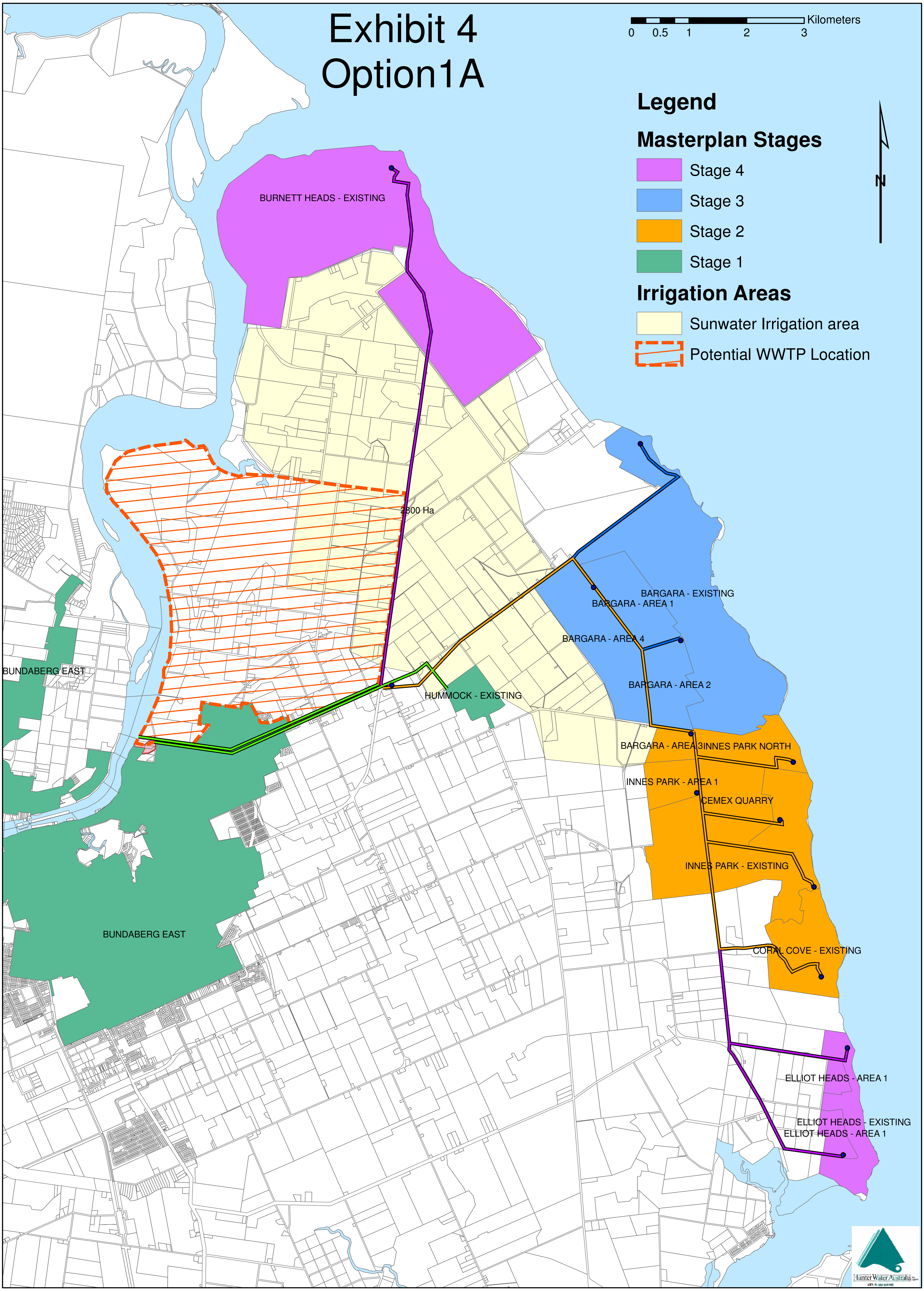


Exhibit 4
Option1A



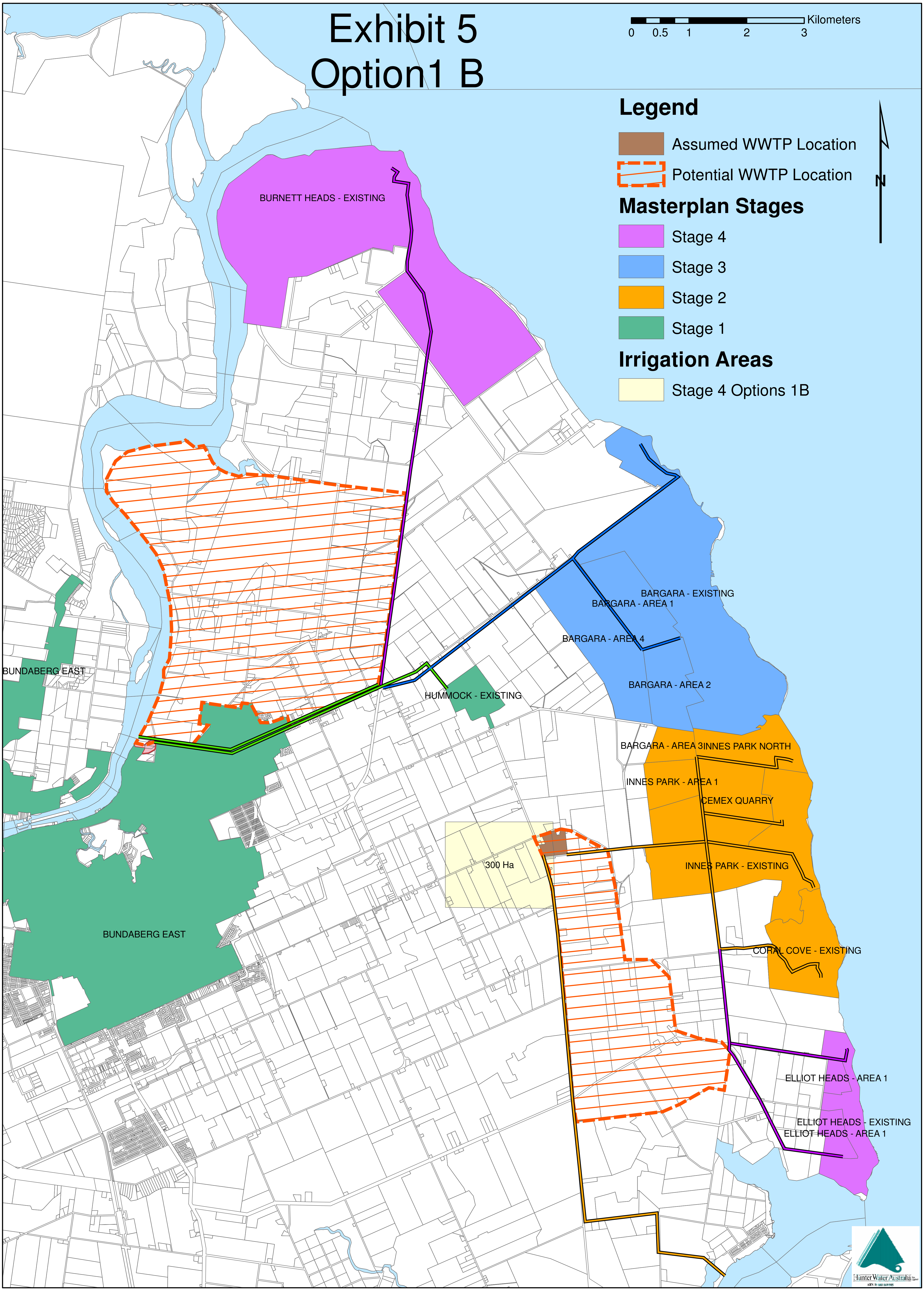


Exhibit 5
Option1 B
Kilometers
0 0.5 1 2 3
Legend
Assumed WWTP Location
Potential WWTP Location
Masterplan Stages
Stage 4
Stage 3
Stage 2
Stage 1
Irrigation Areas
Stage 4 Options 1B
N
BURNETT HEADS - EXISTING
BARGARA - EXISTING
BARGARA - AREA 1
BARGARA - AREA 4
BARGARA - AREA 2
BUNDABERG EAST
HUMMOCK - EXISTING
BARGARA - AREA 3
INNES PARK NORTH
INNES PARK - AREA 1
CEMEX QUARRY
INNES PARK - EXISTING
300 Ha
BUNDABERG EAST
CORAL COVE - EXISTING
ELLIOT HEADS - AREA 1
ELLIOT HEADS - EXISTING
ELLIOT HEADS - AREA 1
Hunter Water Australia

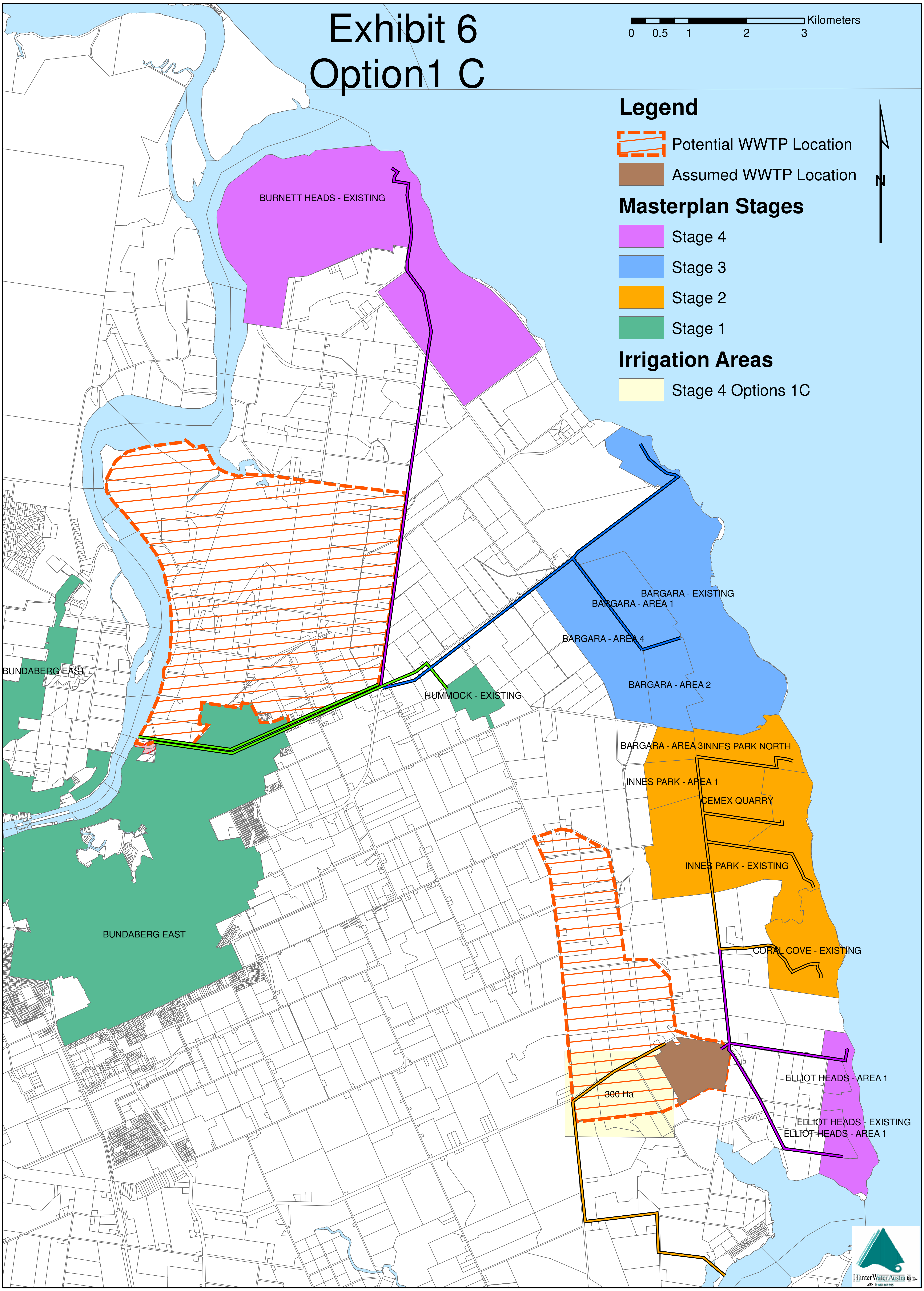


Exhibit 6
Option1 C
Kilometers
0 0.5 1 2 3
Legend
Potential WWTP Location
Assumed WWTP Location
Masterplan Stages
Stage 4
Stage 3
Stage 2
Stage 1
Irrigation Areas
Stage 4 Options 1C
N
BURNETT HEADS - EXISTING
BARGARA - EXISTING
BARGARA - AREA 1
BARGARA - AREA 4
BARGARA - AREA 2
HUMMOCK - EXISTING
BUNDABERG EAST
BARGARA - AREA 3
INNES PARK NORTH
INNES PARK - AREA 1
CEMEX QUARRY
INNES PARK - EXISTING
CORAL COVE - EXISTING
BUNDABERG EAST
300 Ha
ELLIOT HEADS - AREA 1
ELLIOT HEADS - EXISTING
ELLIOT HEADS - AREA 1
Hunter Water Australia

Exhibit 7
Option 2

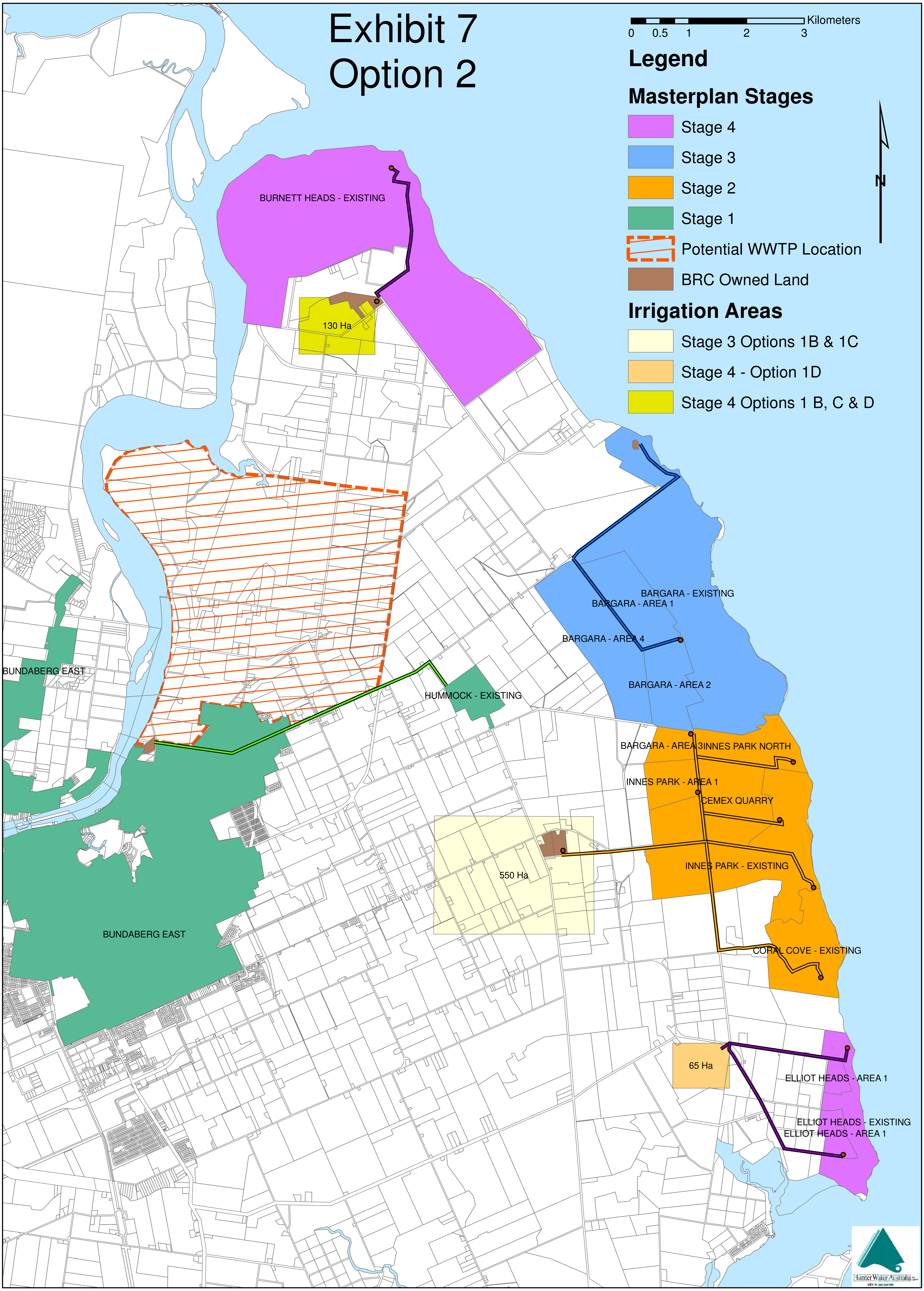
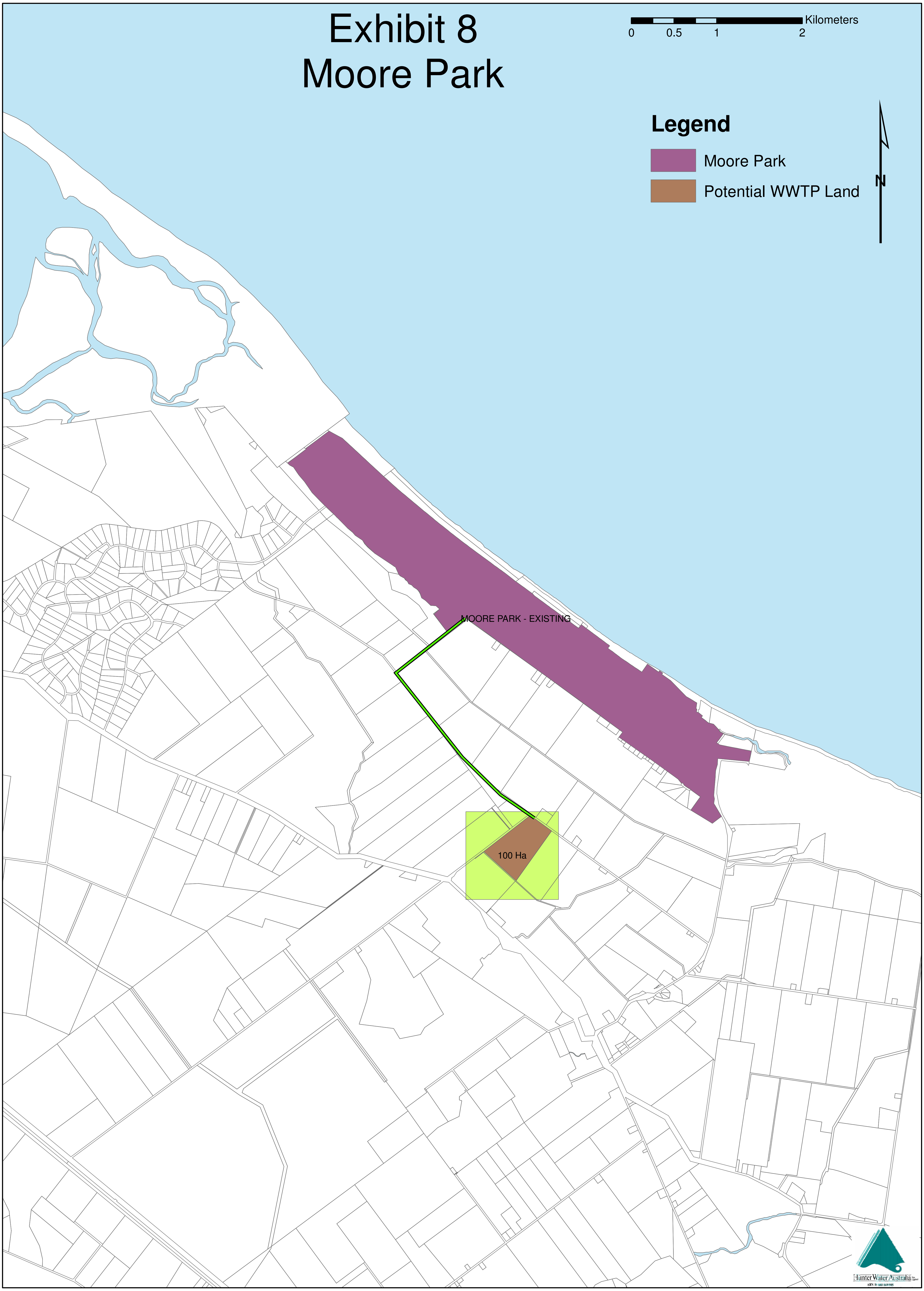


Exhibit 8
Moore Park



Appendix A – Cost Estimates

Option 1A

Year	2006	2011	2016	2021	2026	2036	2056	ULT
Stage	**1**	**1**	**2**	**2**	**3**	**4**	**4**	**4**
Year No	1	6	11	16	21	31	51	60
EP Projection	33,973	34,304	41,509	46,064	63,496	74,951	82,344	86,373
Effluent Volumes (Ml/a)	2976	3005	3636	4035	5562	6566	7213	7566
Discharge Volume (Ml/a)	2976	3005	0	0	0	0	0	0
%age Reuse	0	0	100%	100%	100%	100%	100%	100%
Storage Requirements (Ml)	0	0	349	388	534	631	693	727
Land area Requirements	0	0	606	673	927	1094	1202	1261

ESTIMATED COSTS	2006	2011	2016	2021	2026	2036	2056	ULT
Treatment costs								
Capital	$ 56,000,000				$ 56,000,000			
Transportation Costs								
Pump stations	$ 2,590,000		$ 379,000	$ 379,000	$ 2,262,000	$ 211,000		$ 211,000
Pipelines	$ 14,157,000	$ -	$ 22,222,000	$ -	$ 3,454,000	$ 10,812,000	$ -	$ -
Storage Costs								
Storage Lagoons	$ -	$ -	$ 2,500,000	$ -	$ -	$ -	$ -	$ -
Land Costs								
Nil - sunwater irri district	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Capital Costs	$ 72,747,000	$ -	$ 25,101,000	$ 379,000	$ 61,716,000	$ 11,023,000	$ -	$ 211,000
Disc Rate 7% Discounted Cost	$ 67,987,850	$ -	$ 11,925,304	$ 128,380	$ 14,905,222	$ 1,353,327	$ -	$ 3,641
Cumulative Cost	$ 67,987,850	$ 67,987,850	$ 79,913,155	$ 80,041,535	$ 94,946,757	$ 96,300,084	$ 96,300,084	$ 96,303,725

Capital NPV	**$ 96,303,725**
Operating NPV	**$ 47,528,109**
Total NPV	**$ 143,831,834**

	NPV - Check
Treatment Operating & Maintenance	$ 43,396,065
	$ -
	$ -
PS Op & Maintenance	$ 3,918,890
Pipelines Maintenance	$ 213,154
	$ -
	$ -
	$ -
	$ -
	$ -
	$ -
	$ -
	$ -
	$ -
	$ -
	$ 47,528,109

Option 1B

Year	2006	2011	2016	2021	2026	2036	2056 ULT	
Stage	**1**	**1**	**2**	**2**	**3**	**4**	**4**	**4**
Year No	1	6	11	16	21	31	51	60
Plant 1 - East Replacement								
EP Projection	33973	34304	37145	39694	42178	44324	44429	44429
Effluent Volumes (Ml/a)	2976	3005	3254	3477	3695	3883	3892	3892
Discharge Volume (Ml/a)	2976	3005	3254	3293	3293	3293	3293	3293
%age Reuse	0%	0%	0%	5%	11%	15%	15%	15%
Storage Requirements (Ml)	0	0	0	18	39	57	58	58
Land area Requirements	0	0	0	31	67	98	100	100
Plant 2 - Coastal Plant								
EP Projection			4364	6370	21318	30627	37915	41944
Effluent Volumes (Ml/a)			382	558	1867	2683	3321	3674
Discharge Volume (Ml/a)			0	0	0	0	0	0
%age Reuse			100%	100%	100%	100%	100%	100%
Storage Requirements (Ml)			37	54	179	258	319	353
Land area Requirements			64	93	311	447	554	612
Plant 3 - Burnett heads								
EP Projection						6245	8401	9057
Effluent Volumes (Ml/a)						547	736	793
Discharge Volume (Ml/a)						0	0	0
%age Reuse						100%	100%	100%
Storage Requirements (Ml)						53	71	76
Land area Requirements						91	123	132

D CAPITAL COSTS								
Capital Costs								
Plant 1	$ 56,000,000							
Plant 2			$ 56,000,000					
Plant 3						18200000		
tion Capital Costs								
Pump stations	$ 2,590,000		$ 379,000	$ 379,000	$ 2,262,000	$ 211,000		$ 211,000
Pipelines	$ 14,157,000	$ -	$ 25,533,000	$ -	$ 7,288,000	$ 4,750,000	$ -	$ -
pital Costs								
Storage plant 1								
Storage Plant 2	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Storage plant 3								
	$ 400,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	$ -	$ -	$ 1,400,000		$ -	$ -	$ -	$ -
	$ -	$ -	$ -	$ -	$ -	$ 500,000	$ -	$ -
Total Capital Costs	$ 73,147,000	$ -	$ 83,312,000	$ 379,000	$ 9,550,000	$ 23,661,000	$ -	$ 211,000
Discounted Cost	$ 68,361,682	$ -	$ 39,580,931	$ 128,380	$ 2,306,450	$ 2,904,932	$ -	$ 3,641
Cumulative Cost	$ 68,361,682	$ 68,361,682	$ 107,942,613	$ 108,070,994	$ 110,377,444	$ 113,282,376	$ 113,282,376	$ 113,286,017

	NPV - Check
Operating	$ 40,101,805
	$ 17,626,344
	$ 98,218
	$ 3,768,882
	$ 230,342
	$ -
	$ -
	$ -
	$ -
	$ -
	$ -
	$ -
	$ -
	$ -
	$ -
	$ 61,825,593

Capital NPV	**$ 113,286,017**
Operating NPV	**$ 61,825,593**
Total NPV	**$ 175,111,610**

Option 1B

Year	2006	2011	2016	2021	2026	2036	2056	ULT
Stage	**1**	**1**	**2**	**2**	**3**	**4**	**4**	**4**
Year No	1	6	11	16	21	31	51	60
Plant 1 - East Replacement								
EP Projection	33973	34304	37145	39694	42178	44324	44429	44429
Effluent Volumes (Ml/a)	2976	3005	3254	3477	3695	3883	3892	3892
Discharge Volume (Ml/a)	2976	3005	3254	3293	3293	3293	3293	3293
%age Reuse	0%	0%	0%	5%	11%	15%	15%	15%
Storage Requirements (Ml)	0	0	0	18	39	57	58	58
Land area Requirements	0	0	0	31	67	98	100	100
Plant 2 - Coastal Plant								
EP Projection			4364	6370	21318	30627	37915	41944
Effluent Volumes (Ml/a)			382	558	1867	2683	3321	3674
Discharge Volume (Ml/a)			0	0	0	0	0	0
%age Reuse			100%	100%	100%	100%	100%	100%
Storage Requirements (Ml)			37	54	179	258	319	353
Land area Requirements			64	93	311	447	554	612
Plant 3 - Burnett heads								
EP Projection						6245	8401	9057
Effluent Volumes (Ml/a)						547	736	793
Discharge Volume (Ml/a)						0	0	0
%age Reuse						100%	100%	100%
Storage Requirements (Ml)						53	71	76
Land area Requirements						91	123	132

ESTIMATED CAPITAL COSTS								
Treatment Capital Costs								
Plant 1	$ 56,000,000							
Plant 2			$ 56,000,000					
Plant 3						$ 18,200,000		
Transportation Capital Costs								
Pump stations	$ 2,590,000		$ 379,000	$ 379,000	$ 2,262,000	$ 211,000		$ 211,000
Pipelines	$ 14,157,000	$ -	$ 25,533,000	$ -	$ 7,288,000	$ 4,750,000	$ -	$ -
Storage Capital Costs								
Storage plant 1	$ -	$ -	$ 400,000	$ -	$ -	$ -	$ -	$ -
Storage Plant 2	$ -	$ -	$ 1,400,000		$ -	$ -	$ -	$ -
Storage plant 3	$ -	$ -	$ -	$ -	$ -	$ -	$ 500,000	$ -
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Land Costs								
Capital	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Capital Costs	$ 72,747,000	$ -	$ 83,712,000	$ 379,000	$ 9,550,000	$ 23,161,000	$ 500,000	$ 211,000
7% Discounted Cost	$ 67,987,850	$ -	$ 39,770,968	$ 128,380	$ 2,306,450	$ 2,843,546	$ 15,863	$ 3,641
Cumulative Cost	$ 67,987,850	$ 67,987,850	$ 107,758,819	$ 107,887,199	$ 110,193,649	$ 113,037,195	$ 113,053,058	$ 113,056,699

Capital NPV	**$ 113,056,699**
Operating NPV	**$ 60,305,296**
Total NPV	**$ 173,361,995**

Option 1B

Year	2006	2011	2016	2021	2026	2036	2056	ULT
Stage	**1**	**1**	**2**	**2**	**3**	**4**	**4**	**4**
Year No	1	6	11	16	21	31	51	60
Plant 1 - East Replacement								
EP Projection	33973	34304	37145	39694	42178	44324	44429	44429
Effluent Volumes (Ml/a)	2976	3005	3254	3477	3695	3883	3892	3892
Discharge Volume (Ml/a)	2976	3005	3254	3293	3293	3293	3293	3293
%age Reuse	0%	0%	0%	5%	11%	15%	15%	15%
Storage Requirements (Ml)	0	0	0	18	39	57	58	58
Land area Requirements	0	0	0	31	67	98	100	100
Plant 2 - Coastal Plant								
EP Projection			4364	6370	21318	27821	33821	37850
Effluent Volumes (Ml/a)			382	558	1867	2437	2963	3316
Discharge Volume (Ml/a)			0	0	0	0	0	0
%age Reuse			100%	100%	100%	100%	100%	100%
Storage Requirements (Ml)			37	54	179	234	285	318
Land area Requirements			64	93	311	406	494	553
Plant 3 - Burnett heads								
EP Projection						6245	8401	9057
Effluent Volumes (Ml/a)						547	736	793
Discharge Volume (Ml/a)						0	0	0
%age Reuse						100%	100%	100%
Storage Requirements (Ml)						53	71	76
Land area Requirements						91	123	132
Plant 4 - Elliot Heads								
EP Projection						2806	4094	4094
Effluent Volumes (Ml/a)						246	359	359
Discharge Volume (Ml/a)						0	0	0
%age Reuse						100%	100%	100%
Storage Requirements (Ml)						24	34	34
Land area Requirements						41	60	60

ESTIMATED COSTS

	2006	2011	2016	2021	2026	2036	2056	ULT
Treatment Capital Costs								
Plant 1	$ 56,000,000							
Plant 2			$ 56,000,000					
Plant 3						$ 18,200,000		
Plant 4						$ 10,000,000		
Transportation Capital Costs								
Pump stations	$ 2,590,000		$ 379,000	$ 379,000	$ 2,262,000	$ 211,000		$ 211,000
Pipelines	$ 14,157,000	$ -	$ 25,533,000	$ -	$ 7,288,000	$ 4,750,000	$ -	$ -
Storage Capital Costs								
Storage plant 1	$ -	$ -	$ 400,000	$ -	$ -	$ -	$ -	$ -
Storage Plant 2	$ -	$ -	$ 1,300,000		$ -	$ -	$ -	$ -
Storage plant 3	$ -	$ -	$ 500,000	$ -	$ -	$ -	$ -	$ -
Storage plant 4	$ -	$ -	$ -	$ -	$ -	$ 500,000	$ -	$ -
Storage plant 5	$ -	$ -	$ -	$ -	$ -	$ 500,000	$ -	$ -
Land Costs								
Capital Cost - Assumed 50% land Council Owned	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Capital Costs	$ 72,747,000	$ -	$ 84,112,000	$ 379,000	$ 9,550,000	$ 34,161,000	$ -	$ 211,000
7% Discounted Cost	$ 67,987,850	$ -	$ 39,961,005	$ 128,380	$ 2,306,450	$ 4,194,049	$ -	$ 3,641
Cumulative Cost	$ 67,987,850	$ 67,987,850	$ 107,948,856	$ 108,077,236	$ 110,383,686	$ 114,577,735	$ 114,577,735	$ 114,581,376

Capital NPV	**$ 114,581,376**
Operating NPV	**$ 61,863,504**
Total NPV	**$ 176,444,880**

Option 1B

Year	2006	2011	2016	2021	2026	2036	2056	ULT
Stage	**1**	**1**	**2**	**2**	**3**	**4**	**4**	**4**
Year No	1	6	11	16	21	31	51	60
Plant 1 - East Replacement								
EP Projection	33973	34304	37145	39694	42178	44324	44429	44429
Effluent Volumes (Ml/a)	2976	3005	3254	3477	3695	3883	3892	3892
Discharge Volume (Ml/a)	2976	3005	3254	3293	3293	3293	3293	3293
%age Reuse	0%	0%	0%	5%	11%	15%	15%	15%
Storage Requirements (Ml)	0	0	0	18	39	57	58	58
Land area Requirements	0	0	0	31	67	98	100	100
Plant 2 - Coastal Plant								
EP Projection			4364	6370	7663	10830	13494	17523
Effluent Volumes (Ml/a)			382	558	671	949	1182	1535
Discharge Volume (Ml/a)			0	0	0	0	0	0
%age Reuse			100%	100%	100%	100%	100%	100%
Storage Requirements (Ml)			37	54	64	91	114	147
Land area Requirements			64	93	112	158	197	256
Plant 3 - Bargara								
EP Projection			10441	12053	13655	16991	20327	20327
Effluent Volumes (Ml/a)			915	1056	1196	1488	1781	1781
Discharge Volume (Ml/a)			38	56	0	0	0	0
%age Reuse			96%	95%	100%	100%	100%	100%
Storage Requirements (Ml)			84	96	115	143	171	171
Land area Requirements			146	167	199	248	297	297
Plant 4 - Burnett Heads								
EP Projection						2806	4094	4094
Effluent Volumes (Ml/a)						246	359	359
Discharge Volume (Ml/a)						0	0	0
%age Reuse						100%	100%	100%
Storage Requirements (Ml)						24	34	34
Land area Requirements						41	60	60
Plant 5 - Elliot Heads								
EP Projection						6245	8401	9057
Effluent Volumes (Ml/a)						547	736	793
Discharge Volume (Ml/a)						0	0	0
%age Reuse						100%	100%	100%
Storage Requirements (Ml)						53	71	76
Land area Requirements						91	123	132
Total Land Area	0	0	210	290	378	637	776	844
ESTIMATED COSTS								
Treatment Capital Costs								
Plant 1	$ 56,000,000							
Plant 2			$ 32,300,000					
Plant 3			$ 34,800,000					
Plant 4						$ 10,000,000		
Plant 5						$ 18,200,000		
Transportation Capital Costs								
Pump stations			$ 654,000		$ 183,000	$ 349,000		
Pipelines	$ 1,340,000	$ 1,340,000	$ 4,219,500	$ 4,219,500	$ 3,459,000	$ 1,976,500	$ 1,976,500	$ -
Storage Capital Costs								
Storage plant 1	$ -	$ -	$ 400,000	$ -	$ -	$ -	$ -	$ -
Storage Plant 2	$ -	$ -	$ 760,000		$ -	$ -	$ -	$ -
Storage plant 3	$ -	$ -	$ 800,000	$ -	$ -	$ -	$ -	$ -
Storage plant 4	$ -	$ -	$ -	$ -	$ -	$ 320,000	$ -	$ -
Storage plant 5	$ -	$ -	$ -	$ -	$ -	$ 500,000	$ -	$ -
Land Costs								
Capital Cost - Assumed 50% land Council Owned $ 30,000 50%	$ -	$ -	$ 3,146,777	$ 1,208,843	$ 4,464,281	$ 5,085,143	$ 6,555,512	$ 6,111,158
Total Capital Costs	$ 57,340,000	$ 1,340,000	$ 77,080,277	$ 5,428,343	$ 8,106,281	$ 36,430,643	$ 8,532,012	$ 6,111,158
7% Discounted Cost	$ 53,588,785	$ 892,899	$ 36,620,284	$ 1,838,768	$ 1,957,773	$ 4,472,700	$ 270,694	$ 105,462
Cumulative Cost	$ 53,588,785	$ 54,481,684	$ 91,101,968	$ 92,940,736	$ 94,898,508	$ 99,371,208	$ 99,641,902	$ 99,747,364

Capital NPV	**$ 99,747,364**
Operating NPV	**$ 59,895,606**
Total NPV	**$ 159,642,970**

Option 1A

	2006	2011	2016	2021	2026	2036	2056	ULT
Stage	**1**	**1**	**2**	**2**	**3**	**4**	**4**	**4**
Year No	1	6	11	16	21	31	51	60
EP Projection			2084	3785	4605	6816	6816	6816
Effluent Volumes (Ml/a)			183	332	403	597	597	597
Discharge Volume (Ml/a)	2976	3005	0	0	0	0	0	0
%age Reuse	0	0	100%	100%	100%	100%	100%	100%
Storage Requirements (Ml)	0	0	18	32	39	57	57	57
Land area Requirements	0	0	30	55	67	100	100	100
ESTIMATED COSTS								
Treatment costs								
Capital			$ 14,700,000					
Transportation Costs								
Pump stations			$ 102,000	$ -	$ -	$ -	$ -	$ -
Pipelines		$ -	$ 1,995,000	$ -	$ -	$ -	$ -	$ -
Storage Costs								
Storage Lagoons	$ -	$ -	$ 400,000	$ -	$ -	$ -	$ -	$ -
Land Costs								
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Capital Costs	$ -	$ -	$ 17,197,000	$ -	$ -	$ -	$ -	$ -
7% Discounted Cost	$ -	$ -	$ 8,170,171	$ -	$ -	$ -	$ -	$ -
Cumulative Cost	$ -	$ -	$ 8,170,171	$ 8,170,171	$ 8,170,171	$ 8,170,171	$ 8,170,171	$ 8,170,171

Capital NPV	**$ 8,170,171**
Operating NPV	**$ 3,980,453**
Total NPV	**$ 12,150,624**

Appendix B – Multi-criteria Assessment Methodology

Multi-Criteria Assessment Methodology

Scoring

A numerical scoring system was used in the evaluation which provides for the option to be scored on a scale of 0 to 100 overall. Each of the evaluation criteria has its own weighting within the overall score.

The scoring of the content under each weighted criterion (the total of which adds up to 100) is based on a determination of the degree of achievement of the assessment criteria and objectives established for the project.

A maximum score for a criterion is only be given if the option is outstanding and fully compliant, with no risks and no weaknesses. The score should be reduced proportionate to the extent of non-conformities, discrepancies, errors, omissions, and risks for Council. More detailed guidelines for scoring a proponent's response to a criterion are as outlined below:

9 - 10	Exceptional. Full achievement of the requirements specified in the documentation for that criterion. Demonstrated strengths; no error, risks, weaknesses or omissions.
7 – 9	Superior. Sound achievement of the requirements specified in the documentation for that criterion. Some minor errors, risks, weaknesses, or omissions which may be acceptable as offered.
5 – 7	Good. Reasonable achievement of the requirements specified in the documentation for that criterion. Some errors, risks, weaknesses or omissions which can be corrected/overcome with minimum effort.
3 – 5	Adequate. Minimal achievement of the requirements specified in the documentation for that criterion. Some errors, risks, weaknesses or omissions which are possible to correct/overcome and make acceptable.
1 – 3	Poor to deficient. No achievement of the requirements specified in the documentation for that criterion. Existence of numerous errors, risks, weaknesses or omissions which are difficult to correct/overcome and make acceptable.
0 – 1	Unacceptable. Totally deficient and non-compliant.

The scoring is then multiplied against the maximum of the weighted criteria, and the sums added for each criterion to provide the total overall score of the option.

Criteria Weights

The following weightings were applied to the scores against the criteria for each option considered. This will provide a composite score out of 100 for each option to facilitate comparison and further discussion of the options.

Assessment Criteria	Weighting
State Government Support	15
Irrigation Community Support	15
Environmental Sustainability	15
Water Cycle Impacts	15
Customer Acceptability	10
Flexible Implementation	8
Affordability	8
Foreseeable risks	5
Impact on Liabilities	5
Health and Safety	4

Appendix B

Concept Design Report

Bundaberg Regional Council

Rubyanna WWTP

Concept Design Report

Final

February 2012

Presented by

Hunter Water Australia Pty Limited

ABN 19080869905

Report Details

Report Title	Rubyanna WWTP: Concept Design Report
Project No.	3480
Status	Final
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0	Concept Design Workshop	David Perry			19/10/2011
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Executive Summary

Introduction

In 2009, Bundaberg Regional Council (BRC) prepared the *Wastewater Treatment and Effluent Management Master Plan* for Bundaberg East and the Bargara coastal region between Burnett Heads and Elliott Heads to identify the wastewater infrastructure required to support population growth in the region over the next 30 years.

The Master Plan assumed that future treatment plants would be designed to maximise reuse opportunities by providing treated water that is suitable for a wide range of uses including horticulture and sugar cane irrigation. The construction of a new centralised treatment plant to service the catchment area was identified as favourable in terms of the cost comparison and was selected as the preferred option.

Bundaberg Regional Council (BRC) is planning to construct the centralised wastewater treatment plant (WWTP) at Rubyanna. The WWTP will be constructed in two stages, with Stage One providing capacity for 50,000 EP and Stage Two providing capacity to service 90,000 EP.

Rubyanna WWTP will replace the aging Bundaberg East treatment plant and the North treatment plant; improving the effluent quality discharged to the Burnett River and enabling two existing outfalls to be decommissioned. The plant will also provide wastewater treatment to service population growth in the coastal areas.

Work to be undertaken under as part of the Rubyanna WWTP project includes:

- Installation of a new sewage transfer rising main from Bundaberg East WWTP to Rubyanna WWTP;
- Construction of a new 90,000 EP wastewater treatment plant;
- Installation of an outfall main and new outfall to the Burnett River;
- Subject to suitable agreement with property owners, the construction of recycled water storage and staging of recycled water distribution infrastructure.

This concept design report has been prepared to provide sufficient detail on the intended site activity to support the planning process. Further development of the plant design will occur once planning conditions are known.

Bundaberg East Transfer Rising Main

Wastewater from Bundaberg East and North catchments will be transferred to Rubyanna WWTP. The proposed pipe line for the Bundaberg East Transfer Main is a single main of 762mm OD Sintakote pipe (726mm ID, 6mm WT). The capacity of this rising main enables wet weather flows of up to 5 ADWF from Bundaberg East to be transferred for the projected 2055 population for this catchment.

The rising main route lies within road reserve and agreed easements.

Rubyanna WWTP

A concept design has been developed for the Rubyanna WWTP that includes:

- A preliminary treatment area with screening, grit removal and odour control facilities;
- Biological nutrient removal (BNR) bioreactors and clarifiers;
- Chlorine Disinfection;
- Tertiary filtration and disinfection for reuse;
- Aerobic digestion;
- Biosolids dewatering; and a
- Stabilised biosolids storage area.

The process design has been developed on the available sewage characterisation data and the forecast design flows for 90,000 EP.

The plant has been designed to achieve the following requirements:

- Median effluent concentration of 5 mg/L TN, 2 mg/L TP;
- Disinfected effluent for discharge to the Burnett River (< 1000 FC/100 mL median);
- Class A recycled water suitable for irrigation with unrestricted access for the recycled water scheme; and a
- Biosolids stabilisation Class B.

The construction staging is illustrated on the plant process flow diagram (Appendix C) and site layout (Appendix D). For Stage 1 the inlet works will be constructed along with the bioreactor, clarifiers, chlorine contact tank, sludge digesters and other plant required for a 50,000 EP capacity. Under Stage 2 it is proposed to install a duplicate bioreactor, clarifiers, chlorine contact tank and additional sludge digesters.

Outfall

Rubyanna WWTP requires construction of a new outfall to the Burnett River. The preferred outfall location has been identified as being in the area of the Bundaberg Sugar ferry crossing and public boat ramp off Strathdees Rd.

The proposed outfall route is approximately 3 km in length and lies within road reserve. The existing ground level for the selected Rubyanna WWTP site indicates that there is insufficient hydraulic grade to enable gravity flow to the outfall under high river level conditions. A treated effluent lift pump station is proposed to lift flows during high river level conditions. The same pump station is used to transfer treated effluent to tertiary filtration and disinfection before being transferred to recycled water storage. Subject to further hydraulic design, it is also proposed that the outfall chamber also include a flood relief overflow to enable fully treated effluent to be released to flood waters during flood conditions.

The proposed pipe line for the outfall main is expected to be in the range of DN900 - DN1200 depending on constructability issues and further optimisation of the site hydraulics. This outfall allows for Stage Two flows.

The proposed outfall is a single 1200 mm pipe with 12 discharge ports fitted with duck-bill diffuser valves.

Further Investigation

This concept design has been prepared based on the available sewage characterisation and a hydraulic loading of 240 L/EP/day. It is recommended that BRC undertake further investigation and sampling to confirm the dry weather flow loading and sewage characteristics to inform further treatment plant design. It is also noted that BRC has an appropriate trade waste policy for commercial customers that will be implemented during the development of this project to reduce the risk of trade waste discharges adversely impacting the treatment process.

Contents

Figures

Tables

Appendices

Abbreviations

Outlined below are common terms and acronyms used throughout this report:

ADWF	Average Dry Weather Flow
AHD	Australian Height Datum
BNR	Biological Nutrient Removal
BOD	Biological Oxygen Demand
CFUs	Coliform Faecal Units
COD	Chemical Oxygen Demand
DERM	The Queensland Government department of Environment and Resource Management
DO	Dissolved Oxygen
EP	Equivalent Person
GAO	Glycogen Accumulating Organism
ID	Inner Diameter
MLSS	Mixed Liquor Suspended Solids
OD	Outer Diameter
OTR	Oxygen Transfer Rate
PAOs	Phosphorus Accumulating Organisms
PFTF	Peak Full Treatment Flow
PIF	Peak Instantaneous Flow
PS	Pump Station
PTA	Preliminary Treatment Area
PWWF	Peak Wet Weather Flow
RAS	Recycled Activated Sludge
RE	Recycled Effluent
SCVFA	Short Chain Volatile Fatty Acids
SOTR	Standard Oxygen Transfer Rate
SRT	Solids Retention Time
TKN	Total Kjeldahl Nitrogen
TSS	Total Suspended Solids
TWL	Top Water Level
VSD	Variable Speed Drive
WWTP	Waste Water Treatment Plant

1 Project Development

In 2009, Bundaberg Regional Council (BRC) prepared the *Wastewater Treatment and Effluent Management Master Plan* for Bundaberg East and the Bargara coastal region between Burnett Heads and Elliott Heads.

This Master Plan was developed to identify the wastewater infrastructure required to support population growth in the region over the next 30 years and to improve the level of service provided to the community. A staged approach was developed based on a logical expansion of the sewer network based on population projections for each area to allow the costs associated with meeting the plan objectives to be spread over the planning period.

The strategies in the Master Plan acknowledge:

- The proximity of the coastal communities to the Mon Repos Turtle Rookery and the Great Barrier Reef Marine Park, and
- Council's commitment under the current EPA licence requirements to consider, where possible, progressively reducing the annual load of contaminants released via the existing East Treatment Plant Burnett River discharge and Bargara ocean outfall.

Beneficial reuse of treated water for sustainable crop irrigation was identified as the preferred strategy for the region. The Master Plan assumed that future treatment plants would be designed to maximise reuse opportunities by providing treated water that is suitable for a wide range of uses including horticulture and sugar cane irrigation.

The construction of a new centralised treatment plant to service the catchment area was identified as favourable in terms of the cost comparison and also scored highest in the non-cost criteria, and was selected as the preferred option.

Bundaberg Regional Council (BRC) is planning to construct the new centralised wastewater treatment plant (WWTP) at Rubyanna. Rubyanna WWTP will replace the aging Bundaberg East and North wastewater treatment plants and will provide treatment capacity to service population growth in Bundaberg and the coastal areas. The WWTP will be designed to produce high quality recycled water suitable for agricultural irrigation and will significantly improve the quality of treated effluent discharged to the Burnett River.

Rubyanna WWTP will be constructed in two stages, with Stage 1 providing capacity for 50,000 EP and Stage 2 providing capacity to service 90,000 EP.

BRC has identified a 100 hectare cane farm as the site for the construction of Rubyanna WWTP and has an option to purchase the site from Bundaberg Sugar. The central location of Rubyanna WWTP to agricultural land is designed to facilitate the expansion of recycled water use for irrigation over time. The large site area also offers the potential for significant buffer distances to neighbouring properties.

The majority of the site is to be leased back to Bundaberg Sugar as part of an agreement in which Class A recycled water produced by Rubyanna WWTP will be supplied to Bundaberg Sugar for sugar cane irrigation.

A location plan of the nominated WWTP site is shown in Appendix A.

2 Design Envelope

2.1 Design Population

Rubyanna WWTP will initially service a catchment with a design load of 50,000 Equivalent Persons (EP) as Stage 1. The Stage 2 upgrade will increase the treatment capacity of Rubyanna WWTP to 90,000 EP to allow the WWTP to service a number of coastal communities in addition to Bundaberg.

Rubyanna WWTP will initially be commissioned only with flows transferred from the existing Bundaberg East WWTP. Additional sewerage areas will be connected to the treatment plant in a series of phases. Table 2-1 shows indicative timing of the connection of various catchment areas that has been used for planning purposes; the actual timing of the connection of catchment areas will be determined by population growth.

Table 2-1: Projected growth in the population served by Rubyanna WWTP

Catchment Area	Projected Population (EP) 2011 – 2050						
	Phase 1 2017	Phase 2 2018	Phase 3 2020	Phase 4 2024	Phase 5 2026	Phase 6 2030	- 2050
Bundaberg East WWTP	33,000	33,495	34,507	36,625	37,732	40,047	53,938
North WWTP	-	-	2,000	2,081	2,123	2,209	2,696
Bargara WWTP	-	-	-	-	-	10,000	10,000
Coastal Areas	-	3,000	5,308	8,736	15,772	19,879	24,420
Total Load on Rubyanna WWTP	33,000	36,495	41,815	47,442	55,627	72,135	91,054

On current population projections, Stage 1 will provide sufficient capacity for 2025 predicted loads. The current long-range population projection suggests the Stage 2 upgrade will provide sufficient treatment capacity to cater for expected population growth until 2050.

2.2 Design Flows

The design flows for Rubyanna WWTP are shown in Table 2-2.

Table 2-2: Design flows

Parameter	Units	Stage 1	Stage 2
Design load (EP)	EP	50,000	90,000
Per Capita Loading Rate	L/EP/d	240	240
ADWF	ML/d	11.6	21.2
PDWF (1.8 x ADWF)	ML/h	0.87	1.6
PWWF (5 x ADWF)	ML/d	58	106
PIF	L/s	670	1,230

The design flows are based on the decommissioning of Bundaberg East and Bundaberg North WWTPs and the transfer of these flows to Rubyanna WWTP.

Projected loading on the WWTP are based on an average dry weather flow loading of 240 L/EP/day and a peak dry weather flow of 1.8 times ADWF. All flows to Rubyanna WWTP will be pumped. The peak wet weather flow capacity of Rubyanna WWTP is based on receiving a maximum wet weather flow of 5 ADWF.

It is recommended that more accurate estimates of the hydraulic requirements are obtained by confirming the dry weather flow loading as part of sewage characterisation of the catchment network prior to design.

2.3 Effluent Quality for Discharge

The concept design for the Rubyanna WWTP and recycled water scheme has been developed based on the treated effluent quality limits in Table 2-3 and the mass load limits outlined in Table 2-4.

2.3.1 Release quality limits

The effluent quality targets in Table 2-3 apply to the treated effluent discharged to the Burnett River via the new outfall. The concentrations shown are achievable with the use of a biological nutrient removal (BNR) treatment plant that includes the use of biological phosphorous removal. This high standard of treatment has been selected with consideration to limiting the nutrient load discharged to the Burnett River over the life of the plant and BRC's preference for the use of biological phosphorous removal as part of a strategy to produce a biosolids product that is suited for beneficial reuse for agriculture.

Table 2-3 indicates the water quality parameters and monitoring frequency that is proposed for compliance reporting. Additional parameters will be monitored as part of routine plant operations.

Table 2-3: Contaminant release to waters - Release limits and monitoring points

Monitoring Point	Quality Characteristic	Minimum	50th percentile	80th percentile	Maximum	Proposed Compliance Monitoring Frequency
Treated effluent lift pump station	BOD_5 (mg/L)	N/A	N/A	15	20	Monthly[3]
	Suspended Solids (mg/L)	N/A	N/A	20	30	Weekly[3]
	Total Nitrogen (mg/L)	N/A	5	N/A	15	Weekly[3]
	Ammonia (mg/L)	N/A	1	N/A	3	Weekly[3]
	Total Phosphorus (mg/L)	N/A	2	N/A	5	Weekly[3]
	pH (pH units)	6.5	N/A	N/A	8.5	Weekly
	Dissolved Oxygen (mg/L)	2	N/A	N/A	N/A	Weekly
	Faecal Coliforms (organisms/100mL)	N/A	1,000 cfu/100mL[1]	4,000 cfu/100mL[2]	N/A	Weekly

[1] Assessed weekly against 5 individual grab samples per day collected not less than 30 minutes apart

[2] 4 out of 5 individual grab samples should be less than 4,000 cfu/100mL

[3] Indicates parameters to be analysed using a flow weighted composite sampling method. Flow weighted composite samples are to be weighted to the wastewater flow with the volume of sample changing in proportion to the flow. The flow weighted composite sample is to be obtained over a 24 hour period.

The nutrient concentrations in Table 2-3 are in accordance with the total phosphorus and total nitrogen targets stated in the current Integrated Authority No CM0334 for Bundaberg East and North WWTPs which aims to reduce phosphorous in the effluent discharged to the Burnett River to 2 mg/L (50^{th} percentile) and total nitrogen to 5 mg/L (50^{th} percentile).

The disinfection standard reflects the requirements of the current Integrated Authority No CM0334 and meets the ANZECC disinfection guideline for recreational water quality with secondary contact (e.g. boating) (ANZECC, 2000).

Plume modelling for the proposed outfall based on the figures in Table 2-3 has been undertaken as part of the assessment of the predicted impact of the plant operation on the receiving environment.

2.3.2 Nutrient load limits

The annual load of total nitrogen and total phosphorous discharged from the Rubyanna WWTP outfall will comply with the release limits in Table 2-4. It is assumed that annual loads will be calculated as the yearly mean (Total N or Total P) × total yearly flow.

Table 2-4: Contaminant Release to Waters - Annual Load Limits

Discharge Location	Contaminant	Release Limit	Limit Type
Rubyanna WWTP Outfall	Total Nitrogen	29,200 kg/calendar year	Maximum
	Total Phosphorous	15,476 kg/calendar year	Maximum

The Rubyanna WWTP and recycled water scheme has been devised to minimise potential impacts on the Burnett River by limiting the total annual nitrogen load discharged from the 90,000 EP treatment plant to 29,200 kg/year; the sum of the 2004 release mass load limits for Bundaberg East and North WWTPs that are to be decommissioned as part of the project. The nitrogen load limit is to be achieved through a combination of improved effluent quality and through reducing the volume discharged to the river by producing recycled water for agricultural irrigation. Further details of the development of the nutrient targets are given in the Rubyanna WWTP Effluent Management Strategy.

The annual load limit for total phosphorous is based on ADWF x 365 days x 2 mg/L for 90,000 EP, which is in accordance with the improvement program stated in (C21) of Integrated Authority No CM0334.

The proposed discharge limits for nitrogen and phosphorous is a significant improvement on the recent performance of the aged 30,000 EP Bundaberg East WWTP, which discharged an average of 36,400 kg/year of total nitrogen and 18,700 kg/year of total phosphorous from 2001-2010.

2.4 Recycled Water Quality

Under BRC's agreement with Bundaberg Sugar, Class A recycled water will be supplied from Rubyanna WWTP for use for sugar cane irrigation. The requirements for Class A recycled water as defined in the Public Health Regulation 2005 are summarised in Table 2-5.

Table 2-5: Class A recycled water requirements (Public Health Regulation, 2005)

Monitoring Point	Parameter	Sample Limits	Annual Value	Frequency of sampling
Sample point prior to transfer to Bundaberg Sugar [1]	*E.Coli*	Trigger value for resample > 100 cfu/100 mL Requirement for follow-up sample < 10 cfu/100 mL	95%ile of all samples collected over 12 months < 10 cfu/100 mL	Weekly

[1] The monitoring point will be located as close as practical to the point where the recycled water is transferred to the reuse storage.

Recycled water from Rubyanna WWTP will be supplied to an irrigation storage dam and sugar cane irrigation will take place as per the current practices by using travelling gun irrigators or drip irrigation. While the use of recycled water for irrigation will take place on private property, it is recognised that irrigation can result in spray drift and that irrigation areas are often adjacent to public areas. As such, it is proposed that water recycling facilities at Rubyanna WWTP include advanced treatment designed to provide a high level of disinfection to produce recycled water that is equivalent to the standard required for municipal irrigation with unrestricted access under the Australian Guidelines for Water Recycling 2006 as shown in Table 2-6.

Table 2-6: Log reduction targets for commercial food crop irrigation with unrestricted access (adapted from the Australian Guidelines for Water Recycling 2006)

Log Reduction Targets for Treatment	On-site Preventive Measures	Water Quality Objectives
Virus 5.0 Protozoa 3.5 Bacteria 4.0	Treatment plant design assumes no specific on-site measures are employed to reduce exposure.	To be determined based on technology. May include ▪ Turbidity ▪ Disinfectant Ct ▪ UV transmissivity and dose

The decision to produce Class A recycled water also provides the recycled water scheme with the flexibility to provide recycled water for the irrigation of alternative crops which will allow the use of recycled water for crops other than sugar cane. Suitable uses for Class A recycled water are given in the Public Health Regulation 2005.

The nutrient concentrations in the recycled water are anticipated to be similar to the values outlined in Table 2-3 (i.e. median 5N/2P). It is not intended to produce water with higher nutrient concentrations for reuse.

2.5 Raw Wastewater Quality

The catchment for Rubyanna WWTP is predominantly residential in nature. Raw sewage characterisation was undertaken by Bundaberg City Council in December 2004. The results from this monitoring program are summarised in Table 2-7.

Table 2-7: Raw Sewage characterisation for the Bundaberg area

Parameter[1]	Units	Value	Typical
Chemical Oxygen Demand (COD)	g/EP/d	129	110-145
Biological Oxygen Demand (BOD)	g/EP/d	60	45-72
Total Kjeldahl Nitrogen (TKN)	g/EP/d	9.6	9-14
Total Phosphorus (TP)	g/EP/d	2.2	2-3
Alkalinity[2]	mg $CaCO_3$/L	230	200-300
Ammonia (NH_3)	g/EP/d	7.7	7-11
Total Suspended Solids (TSS)	g/EP/d	60	45-72
Volatile Suspended Solids (VSS)	g/EP/d	50	40-60
Inert Suspended Solids (ISS)	g/EP/d	11	0-20

[1] Raw sewage characteristics values were sourced from report: HWA (2009), '*Planning Strategy for Bundaberg's Wastewater plants*'

[2] This value will change depending on where the raw water has been sourced in the area. Values for alkalinity have been sourced from the report: HWA (2006), '*Capability Review of Bundaberg's Wastewater Treatment Plants*'

The raw sewage characteristics in Table 2-7 have been adopted for this stage of the process design and reactor sizing for Rubyanna WWTP. As the data in Table 2-7 was based on samples mainly collected from Bundaberg East WWTP, it is recommended that BRC undertake a further targeted raw sewage characterisation program in all catchments in the area that will be connected to the new Rubyanna WWTP to inform the design of the treatment process.

The concept design and reactor sizing presented in this report has been developed in the understanding that there are no significant trade waste contributions within the network and that trade waste discharges are limited to those from light industrial and commercial facilities. Wastewater generated from Bundaberg Sugar's operations is currently treated using privately owned treatment facilities and is not discharged to the sewers operated by BRC.

As part of standard management of operating a biological nutrient removal wastewater treatment plant, it is recommended that BRC develop and implement a trade waste policy for commercial customers discharging to the proposed Rubyanna WWTP so as to reduce the likelihood of trade waste discharges disturbing the treatment process.

2.6 Biosolids Quality

The guideline document *Use and Disposal of Biosolids* (NSW EPA, 1997) is currently endorsed by DERM for the classification of biosolids in Queensland. Classification of biosolids takes into account both a biosolids contaminant grade and stabilisation grade. The grade types and requirements can be found in Appendix B.

Rubyanna WWTP will be designed to produce Stabilisation Grade B biosolids as defined by the guideline. This standard reflects the degree of stabilisation that can be achieved without the need to resort to energy intensive thermal stabilisation processes.

The contaminant grade reflects the trace heavy metal and pesticide concentrations in the biosolids. These contaminant concentrations are result of the influent loads of these compounds in the incoming wastewater and are best controlled through an effective trade waste policy. Sample results for biosolids from Bundaberg East WWTP currently satisfy the requirements for Contaminant Grade B due to elevated concentrations of Cu and Zn.

Stabilised biosolids produced at Rubyanna WWTP will be beneficially reused on adjacent agricultural land. (This biosolids use is the subject of a separate ERA application). Biosolids meeting the requirement for Stabilisation Grade B and Contaminant Grade B are suitable for agricultural reuse under the guidelines as summarised in Table 2-8.

Table 2-8: Classification of Biosolids Products (Adapted from EPA NSW (1997))

Biosolids Classification	Allowable Land Application Use	Minimum Quality Grades	
		Contaminant Grade	Stabilisation Grade
Unrestricted Use	Home lawns and gardens Public contact sites Urban landscaping Agriculture Forestry Soil and site rehabilitation Landfill disposal Surface land disposal	A	A
Restricted Use 1	Public contact sites Urban landscaping Agriculture Forestry Soil and site rehabilitation Landfill disposal Surface land disposal	B	A
Restricted Use 2	**Agriculture** Forestry Soil and site rehabilitation Landfill disposal Surface land disposal	**C**	**B**
Restricted Use 3	Forestry Soil and site rehabilitation Landfill disposal Surface land disposal	D	B
Not Suitable For Use	Landfill disposal Surface land disposal	E	C

3 Conceptual WWTP Design

3.1 Overview

The concept design of Rubyanna WWTP is summarised in the process flow diagram in Appendix C. A site plan is provided in Appendix D. Influent wastewater will be transferred to Rubyanna via a series of new rising mains. Wastewater treatment at Rubyanna will include:

1. Preliminary treatment – screening and grit removal and washing;
2. Secondary treatment – activated sludge treatment for biological nutrient removal and clarification including facilities to dose ethanol, alum and caustic as required;
3. Tertiary disinfection – chlorine disinfection to meet river discharge requirements and tertiary filtration and disinfection for recycled water production.

Recycled water produced at Rubyanna WWTP will be transferred to an off-site recycled water storage before being distributed for use in irrigation of sugar cane. Treated effluent flows that exceed the irrigation demand of the recycled water scheme will be discharged to the Burnett River via a new outfall.

Solids produced by the extended aeration treatment process will be thickened and further stabilised using aerobic digestion. The plant includes biosolids dewatering and appropriate facilities are provided for the temporary storage of biosolids in to assist day-to-day management of the beneficial reuse program.

A process schematic of the proposed Rubyanna WWTP is shown in Figure 3-1.

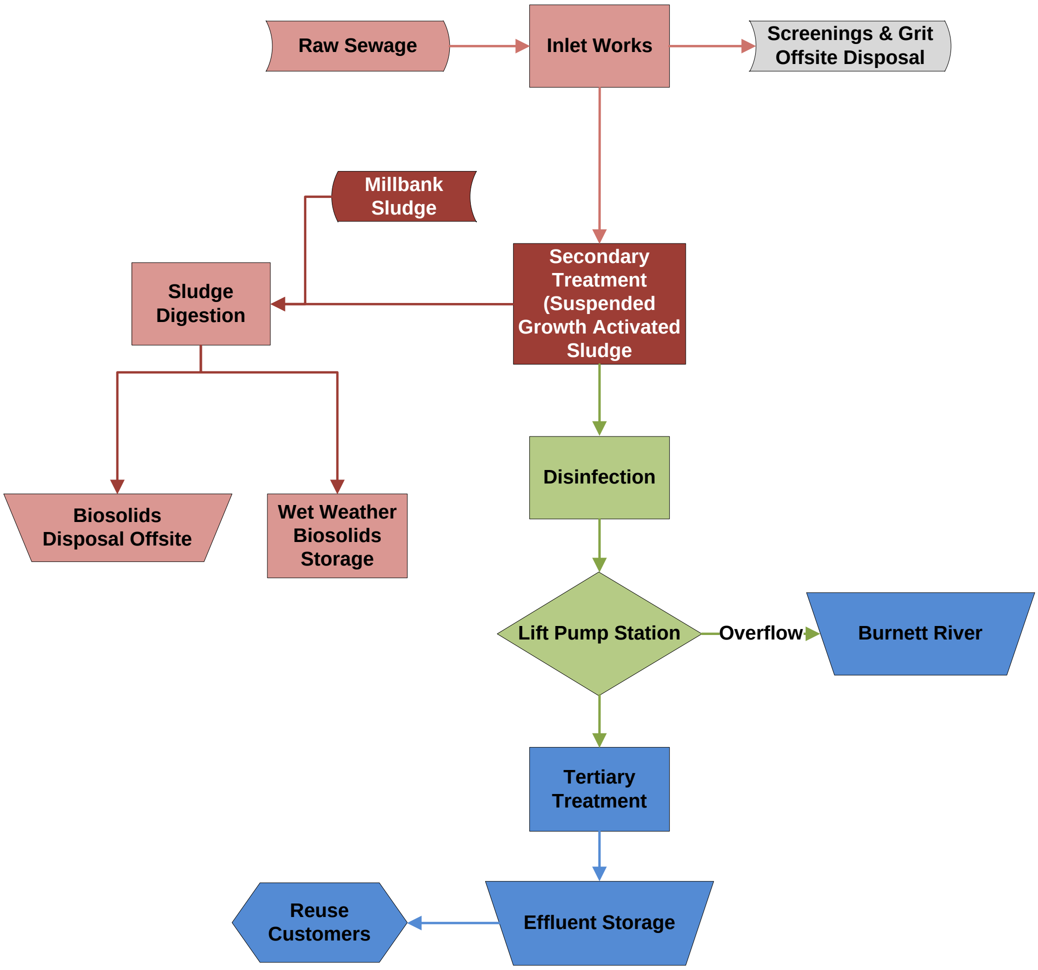

Figure 3-1: Rubyanna WWTP process schematic

A summary of the preliminary design parameters is shown in Table 3-1. As noted in Section 2, the WWTP hydraulic capacity in this conceptual design is based on 240 L/EP/d. Confirmation of the hydraulic loading rate and sewage characteristics should be undertaken prior to further design.

Table 3-1: Rubyanna Key Design Criteria

Item	Quantity / Capacity	Unit	Comment
Preliminary Treatment Area			
Preliminary Treatment Area Hydraulic Capacity	1,230	L/s	Stage 2 PIF
Reception Chamber			Capacity to suit proposed rising mains and inlet works layout.
Automatic screens	670 per Screen	L/s	Band Screens, Full Duty/Standby capacity. Two band screens will be installed in Stage 1. Two additional screens installed for Stage 2.
Aperture of band screen	5	mm	
Manual bypass screen Capacity	1,230	L/s	Sized for the Stage 2 PIF
Aperture of manual bypass screen	20	mm	
Number of wash presses	2		Two units with 100% of Stage design load for Stage 1 Two replacement units with 100% of Stage design load for Stage 2.
No. of grit classifiers	1		One unit with for Stage 1 One replacement unit with 100% of Stage design load for Stage 2.
Secondary Treatment			
No. Bioreactors	2	-	Stage 1 for 50,000EP, Stage 2 for 50,000EP
Total Reactor Volume	16,000	m^3/bioreactor	Reactor depth of 5 m
Bioreactor Aeration system Type			Fine bubble diffused aeration system with positive displacement or turbine blowers
Bioreactor Aeration Capacity (SOTR)	660	Kg O_2/hr	Aeration capacity for Stage 1. Additional aeration capacity to be installed in Stage 2.
Design Sludge Age	21	days	
Bioreactor Scum Removal			A dedicated scum scraper installed in the bioreactor to remove scum to the digester
No. Clarifiers	4		Sized for PWWF when both online, with one operational can handle PDWF. Two clarifiers installed for Stage 1 capacity. Two additional clarifiers installed for Stage 2 capacity. Clarifiers to include Energy Dissipating inlet, Stamford baffles and a log spiral scraper
Diameter	39	m	
Sidewall Depth	4.5	m	
No of scum beaches per clarifier	2		Clarifier scum gravitates to a common pump well for transfer back to the inlet of the bioreactor
Alum Dosing			Aluminium sulphate solution onsite storage of 14 days at maximum usage to be provided for phosphorus removal.
Caustic			Caustic solution onsite storage of 14 days at maximum usage to be provided for alkalinity correction.
Ethanol			Ethanol solution onsite storage of 14 days at maximum usage

			to be provided to assist de-nitrification.
Disinfection & Outfall			
Stage 1 – PWWF Stage 2 – PWWF	58 106	ML/d	The chlorine contact tank to accept flows up to PFTF
Effluent Coliform Concentration	1,000	cfu/100mL	50th percentile
Disinfection Chemical	Cl_2		For large scale chlorination Chlorine gas generally becomes cheaper than hypochlorite.
CT	40	mg.min/L	Calculated based on 3 log removal
Chlorine residual	0.5	mg/L	At outlet from chlorine contact tank (further decay is expected in the outfall prior to discharge)
Stage 1 CCT Volume	4.6	ML	Serpentine flow channels to provide plug flow conditions within CCT. To be increased to 9.2 ML for Stage 2.
Peak Dose Rate	25	kg/h	Dose rate required to achieve a total chlorine concentration at PWWF To be increased to 47 kg/h for Stage 2.
Type of Cylinders	920	kg/h	
Number of cylinders online	4	-	Number of cylinders required to achieve the chlorine dose rate. 7 online cylinders would be required for Stage 2.
Outfall Pump station Stage 1	670	L/s	Provision of duty/standby pumps. Outfall pump station to be sized for Stage 2 flows.
Outfall Pump station Stage 2	1,230	L/s	Stage 2 requires replacement of the Stage 1 pumps with a larger pump set.
Tertiary Treatment			
Tertiary Treatment Feed Pump station Stage 1	400	L/s	Provision of duty/standby pumps. Tertiary Treatment Feed Pump station to be sized for Stage 2 flows.
Tertiary Treatment Feed Pump station Stage 2	740	L/s	Stage 2 requires replacement of the Stage 1 pumps with a larger pump set.
Sludge Digestion and Biosolids Handling			
Total Additional Milbank Sludge to Digester	kg/d	1,680	Based on 240 kg/ML sludge production (2010 Milbank sludge production (IMEMS, Jan 2010)) and a 7 ML/d Forecast ADWF for Millbank in 2036 (HWA, 2009)
Assumed Solids Content	% DS	14%	Based on filter press typical performance
Activated Sludge Wasting Volume	762	kL/d	Volume of WAS taken from each bioreactor per day
No. WAS Pumps	3		2 duty and 1 standby pump for stage 1 and an additional 2 duty pumps for Stage 2
Sludge Thickening	2		2 Gravity Drainage Decks to provide thickening of sludge prior to discharge into the digester.
Aerobic Digester Design HRT	21	Days	Total retention time of sludge over three cells
Aerobic Digester Design	7.6	ML	An additional 7.6 ML of digester volume is required for Stage 2 upgrades
Aerobic Digester Aeration Capacity (SOTR)	300	KgO_2/h	Aeration to be fine bubble diffused aeration or submerged turbine aerators
Sludge Dewatering	2		2 Belt Filter Presses required for dewatering of digested sludge
Total biosolids production rate	24	WT/d	Mass of sludge produced per day from the dewatering system
3 Months Wet Weather Biosolids Storage Volume	2,184	m^3	Volume required for 3 month storage including input from Millbank sludge. Stage 1 sizing only

3.2 Capacity Staging

The concept design has given consideration to the staging of the treatment plant construction including consideration of site space and layout requirements; the plant hydraulics and operational redundancy.

It is proposed that Stage 1 include construction and installation of the following:

- Bundaberg East transfer rising main;
- Inlet works civil components for Stage 2 capacity, mechanical screening and screenings washing for Stage 1, grit removal mechanical equipment sized for Stage 2 and grit washing mechanical equipment sized for Stage 1;
- Bioreactor sized for Stage 1;
- Clarifiers sized for Stage 1;
- Chlorine Contact Tank sized for Stage 1;
- Treated Effluent Lift Pump Station civil components for Stage 2; mechanical equipment to suit Stage 1;
- Treated Effluent Outfall sized for Stage 2;
- Tertiary Treatment filtration and disinfection civil components for Stage 2;
- Recycled water filtration and disinfection processes staged to suit recycled water scheme;
- Aerobic digesters (3) sized for Stage 1;
- Dewatering capacity for Stage 1;
- Pre-thickening lime clarifier sized for Stage 2; and
- Stabilised biosolids storage area.

Stage 2 will consist of construction and installation of the following:

- Additional mechanical screens and screenings processing equipment, modifications to grit removal equipment and increase in grit washing capacity to Stage 2;
- Bioreactor 2 which will mirror the first bioreactor. Flows will be split between the two bioreactors with an ultimate load for each reactor being 45,000 EP;
- Clarifiers 3 and 4 which will mirror the Stage 1 clarifiers;
- Increase capacity of Chlorine Contact Tank capacity to Stage 2;
- Increase Treated Effluent Lift Pump Station mechanical capacity to Stage 2;
- Increase capacity of the tertiary filtration and disinfection train to suit expansion of the recycled water scheme;
- Additional aerobic digesters (3) sized for ultimate capacity; and
- Increase biosolids dewatering capacity to Stage 2.

3.3 Treatment Plant Design Capacity

It is noted that the plant needs to meet some challenging limits. The key limits of concern are the 3 mg/L maximum ammonia and the 80^{th} percentile faecal coliform target of 4,000 cfu/100 mL for effluent discharged to the Burnett River via the new outfall. Meeting these limits for all effluent discharged via the outfall would be challenging during wet weather flow conditions if the plant included a wet weather bypass of secondary treatment for flows greater than 3 ADWF.

On this basis, the plant capacity has been sized to meet the limits in Table 2-3 for all wastewater flows received at the works up to the peak wet weather flow of 5 ADWF. Under this approach all flows receive screening, grit removal, secondary treatment and disinfection. Provision of full treatment to wet weather flow results in slight increases to the capacity of the bioreactors, clarifiers and chlorine contact tank. Treatment of all flows does however allow for a simplified inlet works design and operation.

3.4 Bundaberg East Sewage Transfer Rising Mains

Under Stage 1 of the project, the existing Bundaberg East WWTP will be decommissioned with all flows being transferred to Rubyanna WWTP.

The proposed rising main route to Rubyanna is shown in Appendix E. The proposed transfer main will travel along McGills Rd to the intersection of Kirbys Rd. It will then travel along Kirbys Rd for approximately 1.2 kilometres before following the property boundary to the proposed treatment plant.

Once North WWTP is decommissioned, sewage will also be transferred to Rubyanna. The alignment of the transfer main from North WWTP has not yet been finalised, but it is currently envisaged that flows from this catchment will also be transferred by the Bundaberg East transfer main. The rising main has been sized on this basis.

The proposed pipe line for the Bundaberg East Transfer Main is a single main of 762mm OD Sintakote pipe (726mm ID, 6mm WT). This pipe diameter achieves suitable minimum and maximum velocities for both Stage 1 and Stage 2 flows. Due to the lower flow rates on connection and during Stage 1, the Bundaberg East transfer pump station will need to be operated at maximum flow rate for a short period of time each day to ensure scouring.

Additional rising mains will be required to connect coastal communities to the treatment plant.

3.5 Preliminary Treatment Area

Two Preliminary Treatment Area (PTA) designs were considered for the Rubyanna WWTP:

- An elevated PTA to maintain gravity discharge through the bioreactor and outfall; and
- A PTA set closer to current ground level with a pump station used to lift treated effluent through the tertiary treatment stage or to the outfall.

The selection of the preferred PTA design was based on hydraulic considerations.

The Rubyanna site is relatively flat and offers only a slight grade to drive flows by gravity to the proposed outfall. The existing ground level at Rubyanna provides a maximum elevation of 9.0 m AHD compared with the estimated 1 in 100 year flood level of 5.5 m AHD at the proposed outfall some 3 km away (GHD, 2004).

Preliminary hydraulic calculations indicate that to transfer peak flows by gravity from an elevated PTA to the outfall under flood conditions would require a large outfall diameter and for the PTA to be elevated approximately 6 m above the existing ground level. The bioreactor and other plant structures would also be elevated compared with existing ground levels.

The preferred approach is to install the PTA and plant treatment structures close to ground level as this reduces the need to construct elevated structures. For this option, the PTA is still slightly elevated to allow the contents of the grit chamber to be emptied onto a pad, preventing the need for “super sucker” vacuum tanker if the grit system failed. For this approach, a treated effluent lift pump station is required to lift treated effluent to give it the necessary static head to flow through to the outfall under high river level conditions.

Rubyanna WWTP is designed to provide full treatment to peak wet weather flows. As such the inlet works does not require the need for a wet weather bypass weir, allowing for a PTA with a smaller footprint.

3.5.1 Reception Chamber

A reception chamber at the inlet works is provided to receive the pumped flows from the sewer rising mains. The reception chamber is designed to attenuate flow to ensure a smoothed flow is presented to the screens. The chamber will have a benched floor to minimise grit deposition. Flow measurement on the rising mains will be used to monitor the inlet flow.

3.5.2 Automatic Screening

Typically automatic step screens are utilised for fine screening in Australian plants. However, these screens are only a one dimensional screen and material such as tooth picks and cotton buds can line up and pass through the screens. Poor screening can have negative consequences which include:

- Screenings can accumulate in biosolids which can reduce the attractiveness off the biosolids product for reuse; and
- Screenings debris can accumulate in process units operations and block pumping systems.

To improve screening performance, two dimensional screens such as drum and band screens have been successfully employed to enhance screenings capture. Band screens use a rotating perforated plate and incoming flow is required to change direction through the screen which increases capture efficiency.

The inlet works at Rubyanna WWTP includes use of two band screens for Stage 1 with another two band screens to be installed in Stage 2 to provide two dimensional screening for the peak instantaneous flow.

3.5.3 Screenings Processing

Screenings collected from the band screens are conveyed to a screenings washing system using a water sluice. Recycled effluent is typically used to remove material from the screen which is conveyed down the water sluice to the screenings washing and dewatering units. Recycled effluent is also used for screenings washing.

Screenings washing and dewatering removes the majority of the organic material reducing both the volume and odour potential. High performance systems use separate washing and dewatering zones within a single processing unit. More economical units have combined wash and rinse in the dewatering zone. High performance units are preferred due to the reduced volume, odour potential and vermin attraction they provide. Dry screenings are discharged to a skip bin for disposal by waste contractor.

The following features should be incorporated into the specification for a screenings processing system:

- A single screenings sluice feeds two screenings washing systems;
- Two washing/ dewatering systems should be provided for Stage 1 where each screenings washing system can handle the expected screenings load based on the connected EP (i.e. 2 off 100% Stage 1 capacity);
- Two additional washing/dewatering systems should be provided for Stage 2 where each system can handle the expected screenings load based on the connected EP (i.e. 2 off 100% Stage 2 capacity); and
- Performance criteria should be set for moisture and organic content to ensure a low odour screenings product.

3.5.4 Bypass Screen

In the event of one or both screens being unavailable a bypass screen has been provided.

The bypass screen is a manually raked coarse (20 mm aperture) bar screen. In the event of excessive head loss across the fine screening system raw wastewater will overflow into the bypass screening area.

If the bypass screen does become completely blocked, all flows will overtop the bar screen but still be retained in the inlet works without surcharging.

3.5.5 Grit Removal and Grit Pumping

Grit chambers are designed to remove grit that can consist of sand, gravel, cinders and other heavy solid materials that have subsiding velocities or specific gravities greater than those of organic solids. The three main types of grit chambers include horizontal-flow, aerated and vortex grit chambers.

A vortex grit chamber is proposed for Rubyanna to treat PIF for 90,000 EP. One grit chamber has been designed as the risk of failure of the grit system is not as significant as the screening system. Loss of the grit system will mean some grit accumulation in the downstream process. While the bioreactor process cannot be taken off line some grit deposition is acceptable provided it is not significant. Penstocks are provided to enable the operator to bypass the grit chamber for maintenance.

Grit settles by gravity into the lower section of the grit chamber and can removed using an airlift pump, grit pump or by gravity if the grit chambers are elevated.

3.5.6 Grit Processing

It is proposed that a grit processing system be employed to collect and wash the majority of organic material from the grit. This will reduce both the volume and odour potential of the grit.

Grit produced by the grit removal system will be washed and dewatered and discharged to a skip for disposal by licensed waste contractor. Recycled effluent is typically used for grit washing.

A staged increase in grit processing capacity to provide Stage 1 and Stage 2 capacity when required is proposed.

Expected performance for the grit processing system shall be:

- Solids content > 60%; and
- Volatile solids content < 8%.

3.5.7 Foul Water Pump Station

A Foul Water Pump Station has been provided to collect the waste water from the screenings system, grit system and any runoff from the area where the screenings and grit bins are stored and to return this water to the inlet works for reprocessing.

The Foul Water Pump Station shall be sized to accommodate the peak recycled effluent usage rates from commercially available screenings and grit processing systems. A duty/standby pump configuration has been adopted with the duty pump being able to pass the design flows. The Foul Water Pump discharge is directed to the PTA Reception Chamber.

3.5.8 Septage Waste Pump Station

The inlet works area includes a bay for reception of vacuum tankers delivering waste from domestic septic tank cleaning services. Waste from the tankers will be delivered into a below ground Septage Waste Pump Station. The pump station will have the facility to monitor the waste and record the volume received. The Septage Waste Pump Station discharge is directed to the PTA Reception Chamber.

The waste reception facility is designed to collect domestic septic tank waste only. The facility is not intended for trade waste disposal.

3.5.9 Odour Control

The proposed odour control system is based on standard odour control practice that has been successfully used at other wastewater treatment plants.

Design of the PTA includes a cover system to enable odorous and potentially corrosive gases to be captured and transported by ventilation to an odour control unit. Captured air would be transported to an odour control unit consisting of a combined bio-trickling filter and activated carbon scrubber system in series. To ensure a high level of reliability the design includes the following:

- One bio-trickling filter and a minimum of two activated carbon scrubbers;
- If one activated carbon scrubber is off line and the entire bio-trickling filter system is off line, the remaining activated carbon unit(s) are to be sized to meet the performance requirement; and
- Bypass pipe work is to be provided to enable either the bio-trickling or activated carbon system to be bypassed.

3.6 Secondary Treatment

3.6.1 Overview

A number of process configurations exist however the key driver for the selected process is the need for low effluent discharge nitrogen limits and inclusion of biological phosphorus removal.

To provide a suitable level of detail to inform the planning approval process the design presented here is based around an oxidation ditch.

3.6.2 Bioreactor and Clarifier Sizing

In sizing the bioreactor, many factors are taken into consideration including:

- The minimum Solids Retention Time (SRT) to sustain nitrification. The autotroph bacteria responsible for nitrification (ammonia oxidation to oxidised nitrogen) are the slowest growing of the microorganism in the process and are a key consideration in setting the minimum SRT which has a significant influence on bioreactor size.
- The need to operate above the minimum SRT to allow for down time for maintenance and planned down time when dewatering infrastructure is offline. This design allows for three consecutive days dewatering infrastructure down time to allow for long weekend periods. Failure to do this may mean the minimum SRT is breached.
- For a plant with tight effluent nutrient concentration limits it is often necessary to increase the bioreactor volume to provide more dilution of the diurnal load fluctuations. The bigger bioreactor provides a balance tank effect.
- Mass flux theory. There is a relationship between the bioreactor volume and clarification area. For the treatment of peak flows the required clarifier area is governed by the flux of solids exiting the bioreactor. The flux exiting the bioreactor is influenced by the Mixed Liquor Suspended Solids (MLSS) concentration which in turn is a function of SRT and bioreactor volume.
- Recycle steams associated with the supply of RE for plant services.

The above factors have been taken into consideration in developing the preliminary bioreactor design. It is also noted that the effluent quality limits in Table 2-3 are tighter than typically encountered in Queensland permits, thereby requiring greater bioreactor volume and clarifier area than other designs which are required to meet less stringent effluent nutrient concentration targets.

3.6.3 Biological Nitrogen Removal

There is a minimum SRT which must be met to sustain nitrification (i.e. biological oxidation of ammonia by autotrophic bacteria) to ensure the ammonia limit is met.

The effluent quality limits in Table 2-3 include a median effluent ammonia concentration of less than 1 mg/L.

The factors which influence the minimum SRT to sustain nitrification are:

- Winter temperature. Lower temperatures slow the growth rate of autotrophic bacteria. Data from Bundaberg East suggest minimum water temperatures could reach 20°C.
- Aerobic mass fraction or the fraction of the sludge mass under aerobic conditions. Autotrophs are obligate aerobes and only grow under conditions where DO is present. The SRT needs to increase as the mass fraction is decreased. To achieve the tight nitrogen target it may be necessary to operate with a high un-aerated mass (low aerobic mass fraction) fraction to facilitate denitrification (i.e. nitrate reduction to nitrogen gas).
- Dissolved Oxygen (DO) operational levels. As discussed above autotrophs are obligate aerobes and required DO to grow. However, their growth is suppressed as DO levels reduce. To counter this, the SRT can be increased to provide more time for growth.

Considering the above factors the preliminary bioreactor design to sustain nitrification at the minimum winter temperature is based on an SRT in the order of 20 days.

Due to the low median effluent nitrogen limits, the reactor design should incorporate secondary anoxic and aerobic zones. The secondary anoxic zone provides additional nitrogen removal capacity and in conjunction with carbon dosing provides a higher level of confidence in meeting the effluent discharge requirements.

The secondary aerobic zone provides additional ammonia oxidation, which given the low effluent ammonia concentration limits will be critical to the plant performance.

3.6.4 Biological Phosphorus Removal

Key considerations in the design of the bioreactor for biological phosphorus include:

- The amount of short chain volatile fatty acids (SCVFA) present in the sewage. Currently no data is present on concentrations of SCVFA and it is recommended that this parameter be characterised.
- The anaerobic mass fraction.
- Nitrate and oxygen exclusion from the anaerobic zones.
- The growth of Glycogen Accumulating Organisms (GAOs).

It can be expected for part of the year that elevated temperatures approaching or exceeding 30°C may occur for periods of one to three months each year. Therefore, it is possible that problems may be encountered with biological phosphorus removal due to the growth of GAOs. The following features have been included in the design to limit GAO formation:

- Caustic dosing is provided. This can be used to increase the bioreactor pH to favour the growth of PAOs provided the ratio of acetic acid to propionic acid is in the desired range.
- A full chemical phosphorus removal backup with alum has been provided in the event that biological phosphorous removal cannot be sustained.

The preference for biological phosphorus removal requires the construction on a dedicated anaerobic zone upstream of the main reactor compartments. Additionally, return streams from the dewatering system require lime dosing to prevent high concentrations of phosphorus from being returned to the process.

3.6.5 Chemical Phosphorus Removal (Alum and Caustic)

Alum bulk storage and dosing equipment can be designed to enable the dosing of liquid alum into both bioreactors. A single point dose to the inlet structure is not preferred as it may not be effectively mixed prior to distribution to the bioreactor. It is difficult to provide mixing in the PTA as smooth steady flow paths which are not conducive to mixing of chemicals are present.

As alum is acidic, a caustic soda dosing system has been provided with a dedicated dosing system per bioreactor. Caustic soda dosing may also be used to increase the pH to facilitate biological phosphorus removal.

3.6.6 Supplemental Carbon Dosing (Ethanol)

A below ground bulk ethanol storage facility can be provided and ethanol dosed into each bioreactor. Ethanol can be dosed into both the anaerobic zone and the secondary anoxic zones. The dose to the anaerobic zones increases the soluble COD of the influent sewage if it is not sufficient to provide the organics necessary for nitrogen removal. The other system adds a trimming dose of ethanol to remove nitrate/nitrite which may be present after the oxidation ditch.

It is recommended modelling be undertaken to indicate whether ethanol dosing is required, based on the ratio of biodegradable COD to TKN.

3.6.7 Bioreactor Aeration

Process modelling of preliminary hydraulic and organic load on the aeration system indicates a required peak Standard Oxygen Transfer Rate (SOTR) of approximately 650 kg O_2/h which equates to an installed aeration power of approximately 250 kW.

The aeration system for the bioreactor will be selected at a later stage in the design processes. The aeration system will be selected with consideration to:

- Suitability for the selected bioreactor configuration
- Energy consumption and oxygen transfer efficiency
- Noise and aerosol generation.
- The construction of deep reactors with fine bubble diffused aeration typically provides the most efficient form of aeration with the least power requirement.

The preliminary concept design has allowed space on the site layout for a blower building to serve submerged diffused aeration. Surface aerators may also be considered.

3.6.8 Clarifiers

The clarifier system has been designed with two clarifiers at each stage which can accept flows up to PWWF. As a clarifier has revolving submerged equipment there is a risk that a clarifier will fail and require shut down. With this in mind, it is important that the plant can also treat the dry weather diurnal peak (PDWF) in the event of one clarifier failing.

If one rather than two clarifiers per stage were used, the clarifier diameter required would be much larger. Large clarifiers can suffer from wind action which negatively impacts on the radial flow distribution and can cause effluent quality issues.

To improve effluent and recycled water quality it will be important to have a clarifier design with the following features which assist in effective solids removal:

- An energy dissipating inlet and flocculation well. This is a design features which allows time for flocs which may have been sheared in transport to the clarifier to reform and flocculate prior to entry into the clarifier.
- A Stamford baffle. This is a peripheral baffled which redirect the flow away from the peripheral weir. This avoids the “chimney effect” or region of high velocity near the clarifier wall and creates a lower velocity region conducive to low solids levels near the weir.
- An adequate sidewall depth. There is a relationship between effluent quality and clarifier sidewall depth with greater depths leading to improved quality. The selected clarifier depth is in line with the recommendations in IWA Secondary Settling Tank Scientific & Technical Report No. 6 (1997) and HWA experience to achieve optimal effluent suspended solids.

3.7 Disinfection for Discharge

BRC currently use chlorine disinfection at their water and wastewater treatment plants and operational staff are familiar with this technology.

A chlorine contact tank has been designed to provide effective disinfection for all treated effluent flows prior to discharge to the Burnett River or transfer for tertiary treatment. A serpentine chlorine contact tank has been designed to provide to create a plug flow conditions and suitable contact time to ensure a reliable pathogen log removal. The chlorine contact tank has been sized to accept flows up to PWWF.

3.8 Treated Effluent Lift Pump Station

All flows to Rubyanna WWTW will gravitate from the inlet works, through the secondary treatment process to the treated effluent lift pump station.

During normal operation, treated effluent will be transferred from the treated effluent lift pump station to tertiary treatment for recycled water production. Treated effluent flows that exceed the demand or capacity of the tertiary treatment system gravitate from the treated effluent lift pump station to the outfall.

During peak wet weather flows or during high river conditions when there is an insufficient hydraulic grade to drive flows to the outfall, the water level in the pump station will rise and treated effluent outfall pumps are required to transfer effluent to the outfall.

The treated effluent lift pump station shall be been designed on the basis of provision of separate duty/standby recycled water lift-pumps and duty/standby outfall pumps. The outfall pumps are sized for PIF.

The pump station is sized to enable the installation of additional pump capacity in Stage Two.

3.9 Tertiary Treatment for Recycled Water

The Rubyanna recycled water scheme requires the production of Class A recycled water that is suitable for reuse with unrestricted access and application.

A number of commercially available disinfection processes may be combined to achieve this level of disinfection:

- Filtration may be provided by either dual media filtration or membrane filtration;
- Further disinfection may be provided by ultraviolet (UV) disinfection and/or tertiary chlorine dosing.

It is anticipated that an appropriate tertiary treatment train will be selected as part of a process selection process in the design stage.

The plant layout presented here is based on the use of tertiary filtration and UV disinfection.

3.10 Sludge Treatment and Biosolids Handling

3.10.1 Overview

The sludge treatment and biosolids handling facilities at Rubyanna WWTP include:

- The waste activated sludge (WAS) system for the bioreactor;
- sludge reception facilities to enable the plant to receive sludge from regional treatment plants for further stabilisation;
- aerobic sludge digestion;

- dewatering facilities; and
- stabilised biosolids storage.

The plant sludge handling and biosolids facilities have been located close to each other on the site to limit the length of sludge pumping runs and the extent of plant area impacted by of biosolids vehicle movements.

3.10.2 Waste Activated Sludge

The sludge handling facilities have been sized to enable sludge to be wasted from the bioreactors. The use of hydraulic sludge age control provides operations staff with a reliable and operationally simple process for controlling the operating sludge age.

The waste activated sludge (WAS) system will be configured such that sludge will be directly wasted from the bioreactor to a pre-thickening system prior to aerobic digestion.

The specifics of the pre-treatment system will be detailed later in the design.

3.10.3 Sludge Reception Facilities

Millbank WWTP currently operates without sludge digestion. The waste sludge at Millbank is dewatered directly from the bioreactor and is biologically unstable, which limits BRC's options for beneficial reuse during periods of wet weather.

The sludge treatment and biosolids handling facilities at Rubyanna have been sized to enable further stabilisation of sludge imported from Millbank WWTP, or from other regional treatment plants such as Childers and Gin Gin WWTPs. Imported sludge will be received by tandem truck and will be offloaded into an in-ground pit before being blended with WAS and transferred to the aerobic digesters for further stabilisation. The preliminary basis for sizing sludge import capacity is summarised in Table 3-1.

The reception and transfer of imported sludge will be done as a batch process. The reception facility will be designed to minimise odour release and is expected to include the use of forced ventilation and a dedicated odour control unit.

3.10.4 Aerobic Digestion

Waste activated and imported sludge will be stabilised using aerobic digestion. Stage 1 will be served by a three cell digester. A second three cell digester will be constructed in Stage Two. Each digester has been designed to operate in a series configuration with thickened sludge being fed to Cell 1. Digested sludge is drawn from Cell 3 and dewatered. The aeration system in the digester is expected to be either a submersible aerator mixer or a diffused aeration system.

The aerobic digester should be designed to be intermittently aerated with an operational solids concentration of 1-1.5%. Intermittent aeration is necessary to achieve further nutrient removal and manage pH levels. If aeration is sustained continually the acid produced as a result of nitrification will accumulate leading to pH suppression and potential digestion failure. An aeration off time to develop anoxic conditions is desirable to allow denitrification (removal of nitrate) to occur which adds alkalinity and assists in the prevention of pH suppression. The nitrification and denitrification processes ensure the digester liquor nitrogen returned to the process is low which improves overall plant nitrogen removal.

3.10.5 Sludge Dewatering

Digested sludge will be drawn and pumped from the third aerobic digester cell to a dewatering unit that will separate the digested product into dewatered biosolids and filtrate. The specific method of dewatering will be decided at a later date. Common dewatering methods include:

- Centrifugal dewatering;
- Gravity belt dewatering; or
- Rotary drum dewatering.

The dewatering system will be used to dewater two solids streams:

- Digested sludge from the aerobic digester
- Lime clarifier sludge containing calcium hydroxyapatite and calcium carbonate.

Dewatering of lime and sludge streams will occur simultaneously.

3.10.6 Lime System

If Enhanced Biological Phosphorus Removal is in operation, phosphorus is taken up and stored in high quantities in the Phosphorus Accumulating Organism's (PAO) cell structure. The act of digestion stabilises the sludge by allowing the cells to die. Therefore, as digestion proceeds, phosphorus is released to solution which, if not removed, will be recycled back to the bioreactor via the liquid return from the sludge dewatering process, elevating the effluent phosphorus levels.

To prevent this from occurring, treatment of the liquid return from the sludge dewatering process is required to remove phosphorus. This is most cost effectively achieved using lime for highly concentrated phosphorus streams.

Lime is stored on-site in a bulk silo and prepared as a ~5% slurry. The lime slurry is then either injected directly into the lime clarifier or to the Lime Clarifier Feed Pump Station. To ensure a smooth flow to the clarifier, VSDs should be provided on the Lime Clarifier Feed Pumps.

Lime, when dosed in the filtrate stream, will precipitate as calcium hydroxyapatite provided the pH is sustained at or above 10. Therefore, as lime is consumed to increase the pH, another precipitate (calcium carbonate) will form. The precipitated lime sludge forms a thick sludge which readily settles in the lime clarifier. Positive displacement pumps are used to pump the sludge directly from the base of the clarifier to the dewatering system.

3.10.7 Stabilised Biosolids Storage

Stabilised biosolids from the treatment plant are to be spread on agricultural land as part of BRC's beneficial reuse program for biosolids.

Typically, dewatered biosolids will be directly loaded by a conveyor belt from the dewatering facility into a covered trailer for transport to the reuse area.

During extended wet weather conditions however, it is acknowledged that ground conditions may be unsuitable for spreading biosolids and biosolids will need to be stored on-site. Parties expressing interest in applying biosolids to their agricultural land have also expressed an interest in the ability of receiving larger volumes of biosolids to their properties over a short window of time, which may require stabilised biosolids to be temporarily stored on site until there is a sufficient inventory to meet spreading requirements.

A dedicated stabilised biosolids storage area has been designed to allow for the temporary storage of biosolids on-site to assist in the day to day operation of the biosolids beneficial reuse scheme. The storage area is designed as a bunded concrete pad, divided into four bays. Run-off from the storage area will be diverted to the site storm water (if the area is clean and not in use) or returned to the treatment plant using a return pump station. As a conservative measure for extended wet weather periods, the biosolids storage area provides for a maximum of approximately 3 months of storage.

3.11 Treated Effluent Outfall

3.11.1 Location

The Rubyanna WWTP will require the construction of a new outfall to the Burnett River to discharge treated effluent that is in excess of the requirements of the Rubyanna recycled water scheme. The proposed outfall is within the tidal reach of the Burnett River, approximately 8 km from the river mouth and approximately 10 km downstream from the existing outfall from the Bundaberg East WWTP.

3.11.2 Outfall main

The proposed outfall main route is shown in Appendix F. The outfall route would travel along the property boundary to Barrons Rd, and then continue along the Barrons Rd road reserve to a chamber located in the vicinity of the boat ramp and cable ferry at the end of Strathdees Rd. The outfall route is a total of approximately 3 km.

As discussed in Section 3.8, the available driving head for gravity flows is strongly dependent on the river level. During non-flood conditions, river levels vary from LAT - 1.7 m AHD to HAT 2.0m AHD and there is sufficient gravity head to discharge peak flows using large diameter pipework. During peak flow and flood conditions, a treated effluent lift pump is required.

Selection of the most appropriate outfall main diameter requires consideration of constructability issues and the relative expense of the outfall compared with installing a larger treated effluent pump station. Based on preliminary hydraulic considerations, the outfall main is anticipated to be in the range of DN900 – DN1200.

Subject to further hydraulic design, it is also proposed that the outfall chamber include a flood relief overflow to enable fully treated effluent to be released to flood waters from the outfall chamber during flood conditions.

3.11.3 Preliminary outfall design

A preliminary outfall design has been prepared as shown in Appendix G.

The outfall consists of a DN1200 HDPE pipe with 12 inclined discharge ports fitted with duck-bill diffuser valves. The use of multiple ports assists in providing initial mixing and dispersion of the treated effluent. Preliminary survey information for the local bathymetry indicates that a diffuser depth of – 8.0 m AHD may be achievable for the proposed location (a depth of 6.3m at LAT of -1.7m AHD).

Plume modelling for the proposed outfall has been undertaken to provide further details on the predicted impact of the plant operation on the river water quality.

Based on the preliminary geotechnical information at the outfall site, it is proposed to install the outfall using a horizontal directional drill with flexible pipe string drawn from the river end through to the outfall shaft. Localised open trenching and ballast will be used to install the rigid section of the outfall.

4 Conclusion

Bundaberg Regional Council's *Wastewater Treatment and Effluent Management Master Plan* for Bundaberg East and the Bargara coastal region identified the construction of a new centralised wastewater treatment plant as the preferred approach to provide the wastewater treatment infrastructure required to support population growth in the region and to improve environmental performance.

The construction of Rubyanna WWTP will enable the aging Bundaberg East and Bundaberg North WWTP's to be decommissioned and with an ultimate treatment capacity of 90,000 EP will service population growth in Bundaberg and the coastal region until 2050. The site selected for Rubyanna WWTP is surrounded by agricultural land and offers significant buffer distances to residential areas.

Rubyanna WWTP has been designed to produce Class A recycled water and to significantly improve the quality of treated effluent discharged to the Burnett River compared with current practice. The treatment facilities include biological nutrient removal, tertiary filtration and disinfection processes.

A biological nutrient removal treatment process has been selected to reduce total nitrogen to 5 mg/L and total phosphorous to 2 mg/L (50^{th} percentiles). This improved effluent quality, along with the recycled water agricultural irrigation scheme, is designed to limit the total nitrogen load discharged from Rubyanna to 29,200 kg/year; the sum of the 2004 release mass load limits for the existing Bundaberg East and North WWTPs that are to be decommissioned. This mass load limit is a significant improvement on current performance of the Bundaberg East WWTP.

Rubyanna WWTP has been located in an agricultural area to maximise the potential for use of recycled water for agricultural irrigation. It is proposed that the plant produce Class A recycled water that is suitable for use in agricultural irrigation areas with unrestricted access. As the initial foundation of a recycled water scheme, BRC has an arrangement with Bundaberg Sugar to provide recycled water for irrigation of sugar cane on the Rubyanna farm and adjoining properties. The production of Class A recycled water also provides the recycled water scheme with the flexibility to provide water for the irrigation of alternative crops if required in the future.

Treated effluent that is in excess of the irrigation requirements of the recycled water scheme will be discharged via a new outfall within the tidal reach of the Burnett River, approximately 10 km downstream of the existing outfall from Bundaberg East WWTP. Disinfection will be provided to meet will be disinfected to meet guidelines for recreational water quality with secondary contact. An outfall pump station at Rubyanna WWTP is required to enable peak flows to be discharged during high river level conditions.

This concept design has been prepared based on the available sewage characterisation and a hydraulic loading of 240 L/EP/day. It is recommended that BRC undertake further investigation and sampling to confirm the dry weather flow loading and to confirm sewage characteristics required as part of the design of a biological nutrient removal plant. Further development of the design including process selection and confirmation of plant hydraulics is anticipated once planning requirements are confirmed. In conjunction with the further development of this project, it is recommended that BRC develop an appropriate trade waste policy for commercial customers to reduce the risk of trade waste discharges adversely impacting the treatment process.

5 References

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GHD (2004) Burnett Shire Flood Line, River, Storm Tide and Local Flooding Assessment, GHD Pty Ltd, Report # 41/13462/305219 Rev 4.

HWA (2006) Capability Review of Bundaberg's Wastewater Treatment Plants, Hunter Water Australia Pty Ltd, Report # 2269 Rev 5.

HWA (2009) Planning Strategy for Bundaberg's Wastewater plants, Hunter Water Australia Pty Ltd, Report # 2831 Rev 5.

IWA (1997) Secondary Settling Tanks: Theory, Modelling, Design and Operation; .A. Ekama, J.L. Barnard, F.W. Gunthert, P. Krebs, J.A. McCorquodale, D.S. Parker & E.J. Wahlberg (Eds) IWA Scientific & Technical Report No. 6, ISBN: 9781900222037.

Appendix A: Location Plan

AMENDMENTS

Ver	Date	Description	Drawn
A.00	27.02.2012	DA APPROVAL	MPS

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Drawn	MPS	Checked	
Approved	CC		
RPEQ			
HWA Project Number	3480		

HORIZONTAL
Co-ordinate System
BM Adopted
East North

VERTICAL
Datum
BM Adopted
Reduced Level

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CONCEPT
LOCALITY PLAN

Scale	Document No
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Status	Version
CONCEPT DESIGN	A.00

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Appendix B: Biosolids grading requirements

TABLE 3-1

Contaminant Acceptance Concentration Thresholds*

Contaminant	Grade A[1] (mg/kg)[3]	Grade B[2] (mg/kg)[3]	Grade C (mg/kg)[3]	Grade D (mg/kg)[3]
Arsenic	20	20	20	30
Cadmium	3	5	20	32
Chromium (total)	100	250	500	600
Copper	100	375	2,000	2,000
Lead	150	150	420	500
Mercury	1	4	15	19
Nickel	60	125	270	300
Selenium	5	8	50	90
Zinc	200	700	2,500	3,500
DDT/DDD/DDE	0.5	0.5	1.00	1.00
Aldrin	0.02	0.2	0.5	1.00
Dieldrin	0.02	0.2	0.5	1.00
Chlordane	0.02	0.2	0.5	1.00
Heptachlor	0.02	0.2	0.5	1.00
HCB	0.02	0.2	0.5	1.00
Lindane	0.02	0.2	0.5	1.00
BHC	0.02	0.2	0.5	1.00
PCBs	~~0.3~~ ND[4]	0.3	1.00	1.00

* Contaminant acceptance concentrations are **not** mean values. Refer to Schedule 2.

Notes:

1. The Grade A threshold for cadmium is under review and will be revised in 2 years. Subject to the outcome of this review, the standard for cadmium would be revised and then may become the same as the maximum allowable soil concentration for agricultural land, namely 1 mg/kg.

2. The Grade B threshold levels are under review and will be revised in 2 years.

3. Values are expressed on dry weight basis.

4. No detected PCBs at a limit of detection of 0.2 mgPCB/kg biosolids.

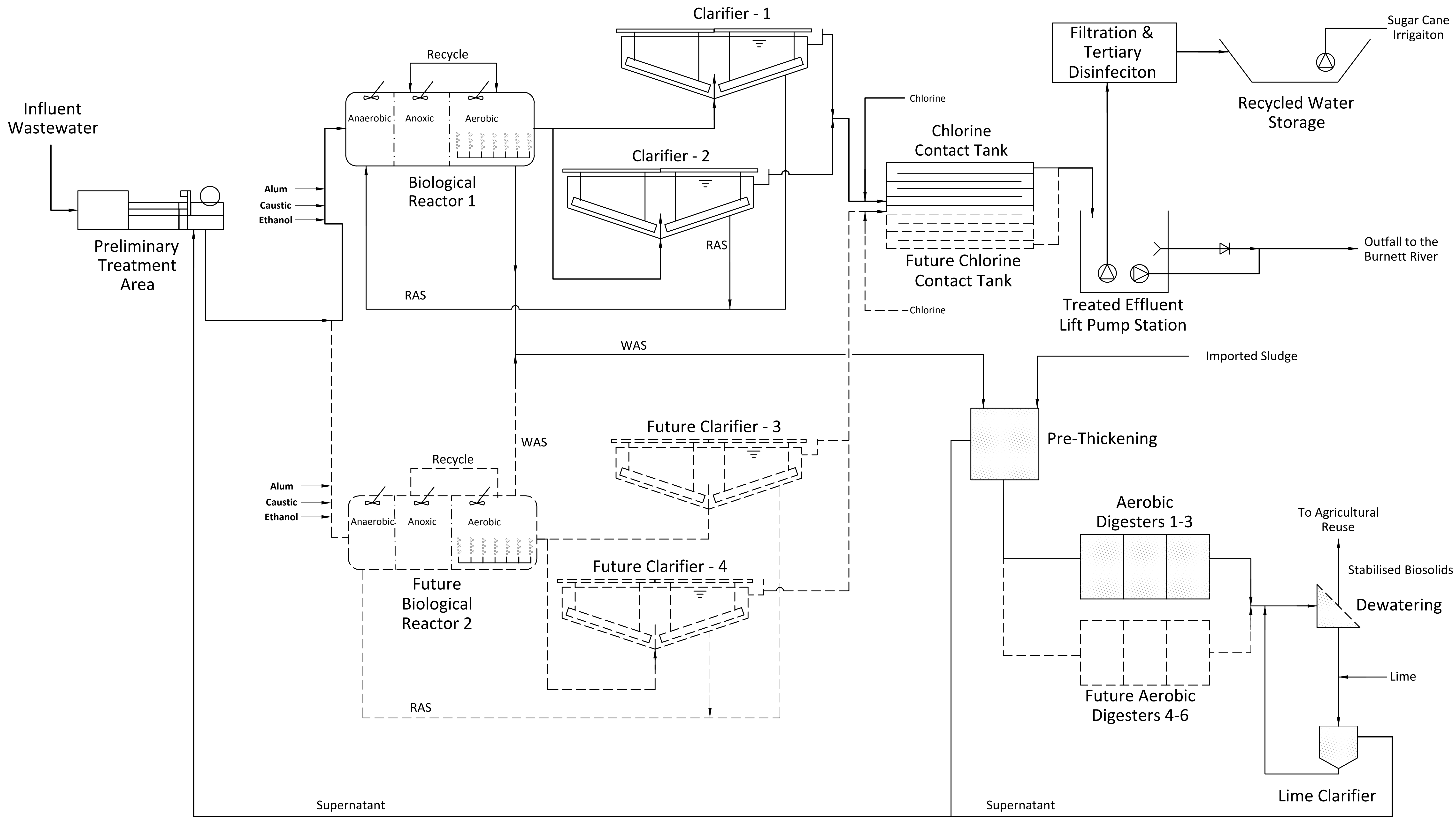
TABLE 3-3

Biosolids Stabilisation Requirements

*A biosolids product must meet at least one **pathogen reduction** requirement and at least one **vector attraction reduction** requirement.*

Pathogen Reduction Process	Vector Attraction Reduction Requirements
Stabilisation Grade A 1. Thermally treated biosolids a) Biosolids > 7% solids with temperature at least 50^0 C. The equation (1) for the time -temperature requirement is: $D = \frac{131,700,000}{10^{0.1400t}}$ where D = time required in days, t = temperature in degrees celcius This option includes pasteurisation at 70^0 C for 30 mins; b) Biosolids > 7% this option includes composting at 55C for 3 consecutive days. c) Biosolids > 7% solids that are small particles heated by contact with either warmed gases or an immiscible liquid. The temperature should be at least 50^0 C for at least 15 seconds using the equation above. This option includes biosolids in contact with a hot gas stream in a rotary drier or biosolids dried in a multiple-effect evaporator system. d) Biosolids < 7% solids and less than 30 minutes contact time. Use equation 1 for contact times > 15 seconds and < 30 minutes. e) Biosolids < 7% solids and > 30 minutes contact time at 50^0 C or higher use equation (2) below: $D = \frac{50,070,000}{10^{0.1400t}}$ This option includes thermophilic aerobic digestion. 2. High pH—high temperature process The pH of the biosolids product is to be raised to greater than or equal to pH 12 and remain above pH 12 for 72 hours. During at least 12 hours of the 72-hour period, temperature of the biosolids product has to be greater than 52^0 C. After 72 hours biosolids product must be air dried to a solids content of more than 50%. 3. Biosolids from unknown processes For biosolids where the history of processing is not known, the product will be subject to a program of testing for the parameters contained in tables 3-4 and 3-5. The testing regime must be accepted by the EPA. This option includes stockpiles of "dewatered" or dried biosolids which have been stored for a minimum of three years.	1. Mass of volatile solids in the biosolids shall be reduced by a minimum of 38%. 2. Anaerobically digested biosolids which do not meet requirement 1. above must have no more than 17% further volatile solids reduction when incubated under anaerobic conditions in a bench scale reactor for an additional 40 days at 30-37^0 C. 3. Aerobically digested biosolids which do not meet requirement 1. above must have no more than 15% further volatile solids reduction when incubated under aerobic conditions in a bench scale reactor for an additional 30 days at 20^0C (typically used for extended aeration processes). 4. Specific oxygen uptake rate for biosolids treated by an aerobic process shall be less than 1.5 mg O_2 /hour/g total solids at 20^0 C. 5. The pH value of the biosolids shall be raised to 12 and without the addition of further alkali shall remain at 12 or higher for two hours and then at 11.5 or higher for an additional 22 hours. 6. For biosolids which contain stabilised solids only, the proportion of dry solids shall be at least 75%. 7. For biosolids which contain unstabilised solids generated in a primary wastewater treatment process the proportion of dry solids shall be at least 90%. 8. Biosolids shall be treated in an aerobic process for at least 14 days. During that time, the temperature of the biosolids shall be >40^0 C and the average temperature >45^0 C. This option relates primarily to composted biosolids.
Stabilisation Grade B 1. Anaerobic digestion 2. Aerobic digestion 3. Air drying 4. Composting 5. Lime stabilisation 6. Extended aeration 7. Other processes accepted by the EPA	One of the vector attraction reduction requirements from Stabilisation A above or one of the following requirements: Process Option (for Stabilisation B only) 1. At least 20 days continuous or intermittent extended aeration including aerobic digestion time followed by six (6) months storage of biosolids in a lagoon or equivalent process. Barrier Options (for Stabilisation B only) 2. Biosolids shall be injected below the surface of the land. 3. Biosolids applied to the land surface must be incorporated within six hours of application on the land.
Stabilisation Grade C Not meeting any of the above requirements	Not meeting any of the above requirements

Appendix C: Process Flow Diagram



A3

AMENDMENTS			
A.01	27.02.2012	DA APPROVAL	MPS
A.00	13.01.2012	Client Review	
Ver	Date	Description	Drawn

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Drawn MPS	Checked DCP
Approved CC	
RPEQ	
HWA Project Number 3480	

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Co-ordinate System
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East North

VERTICAL
Datum
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PROCESS FLOW DIAGRAM

Scale: **NTS** at A3
Document No: **3480-SK-100**
Status: CONCEPT DESIGN
Version: **A.01**

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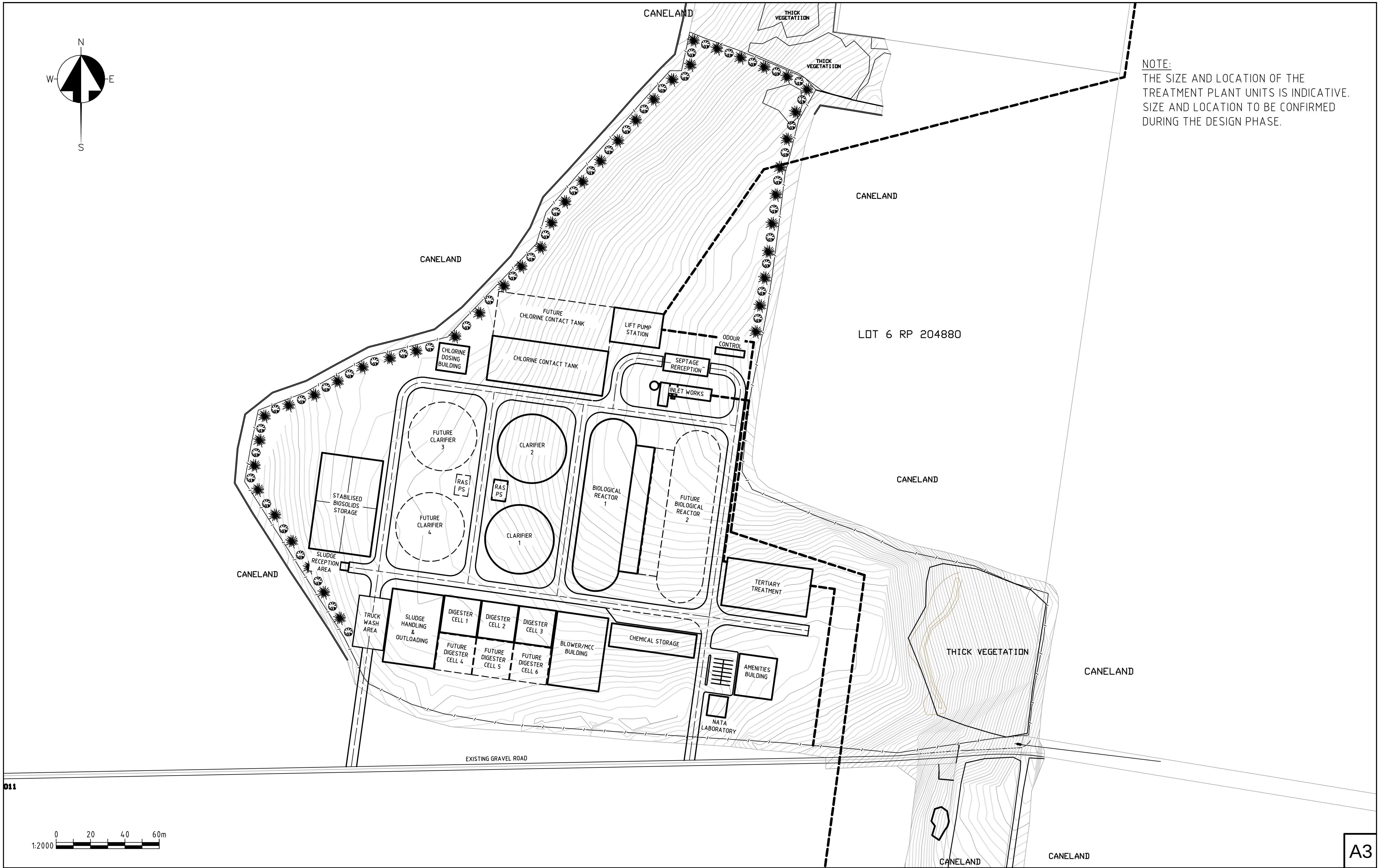
Appendix D: Site Plan



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A.01	24.01.2012	CLIENT REVIEW	MPS
A.00	16.01.2012	DRAFT	MPS
Ver	Date	Description	Drawn

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Drawn MPS	Checked
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East North

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Datum
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Version: A.02

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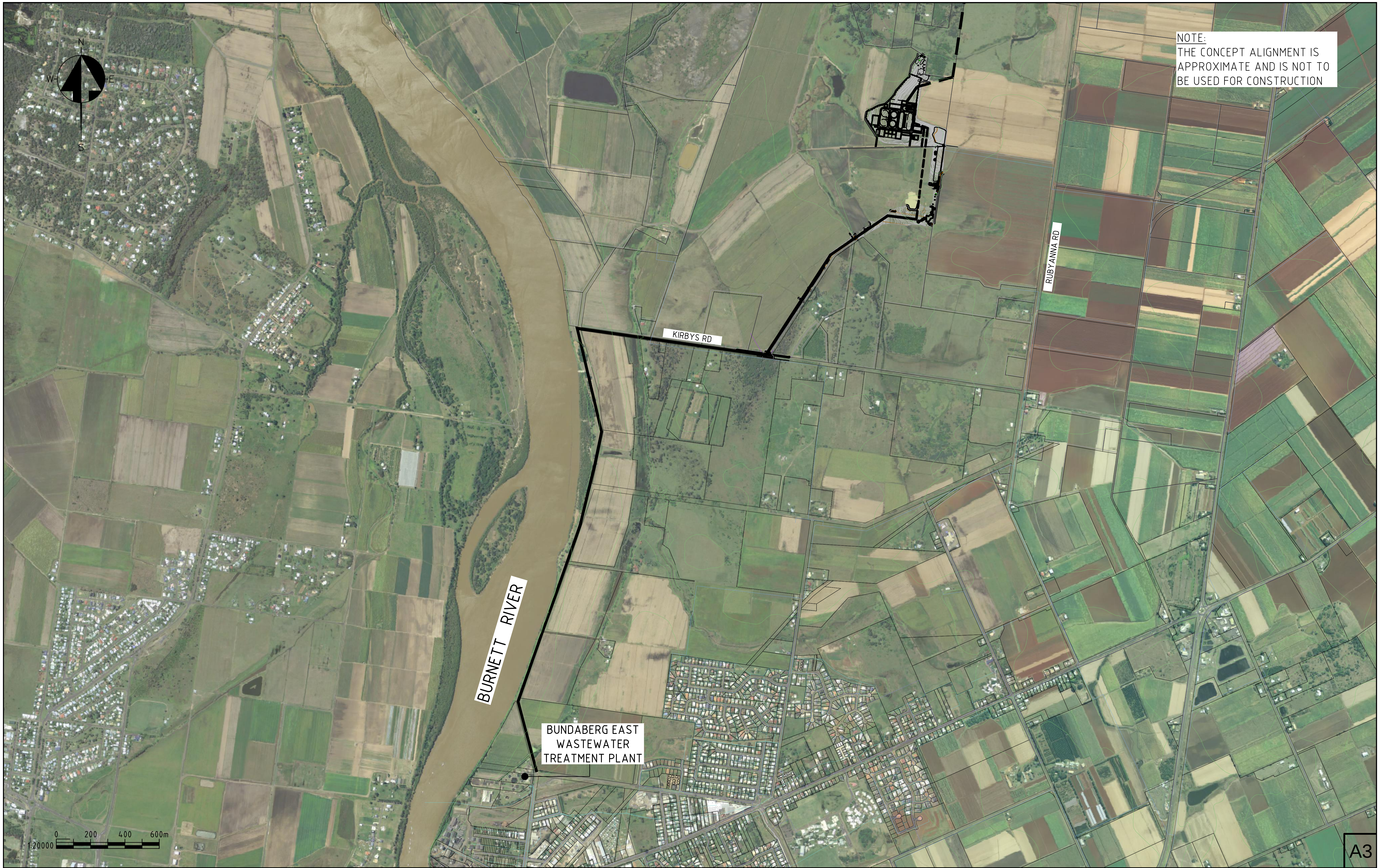
Appendix E: Bundaberg East Rising Main Transfer Route



AMENDMENTS			
A.01	27.02.2012	DA APPROVAL	MPS
A.00	06.02.2012	CLIENT REVIEW	MPS
Ver	Date	Description	Drawn

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Drawn MPS	Checked
Approved CC	
RPEQ	
HWA Project Number 3480	

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Co-ordinate System
BM Adopted
East North

VERTICAL
Datum
BM Adopted
Reduced Level

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CONCEPT
RISING MAIN FROM BUNDABERG EAST

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Version: **A.01**

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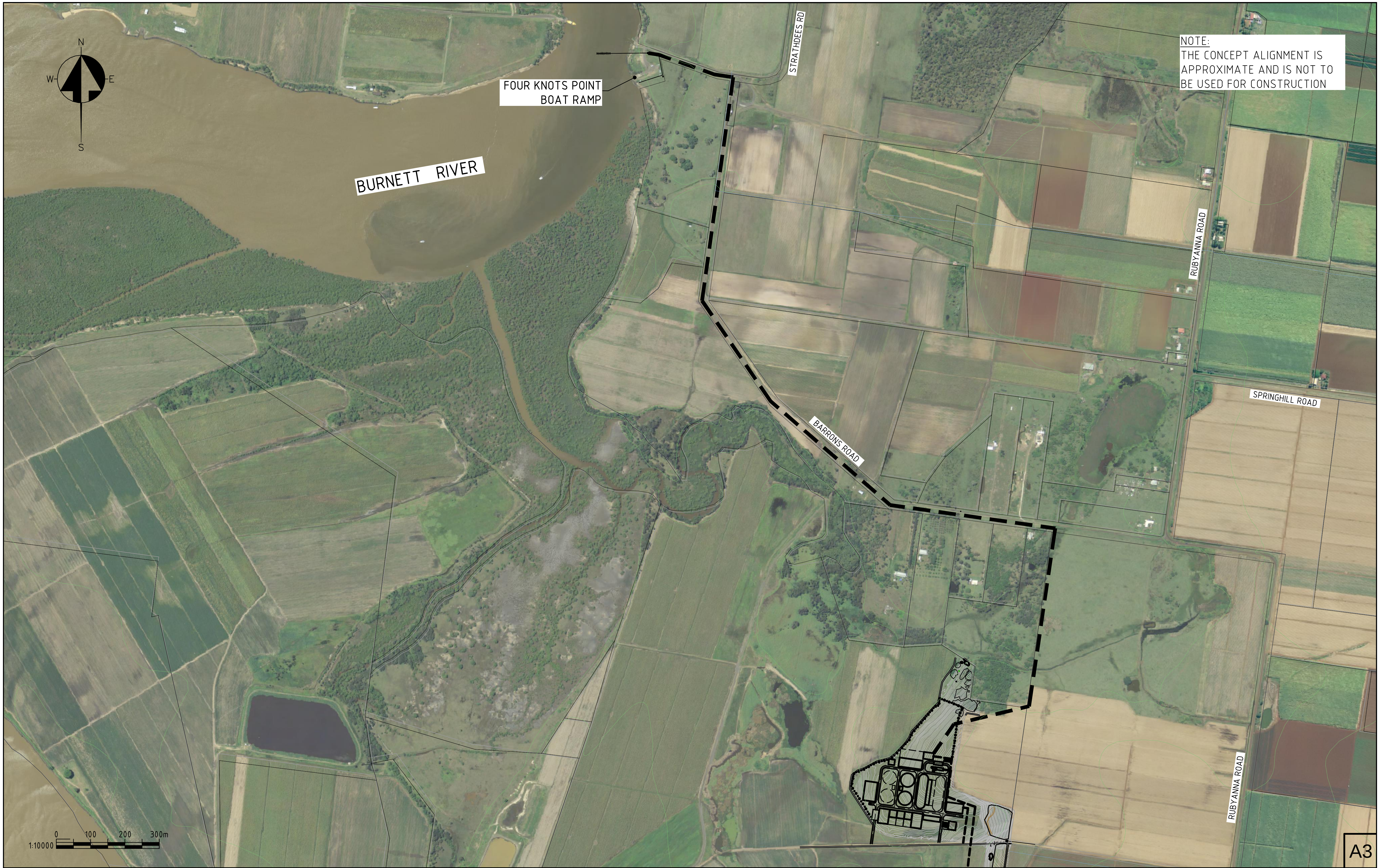
Appendix F: Outfall Main Route



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AMENDMENTS

Ver	Date	Description	Drawn
A.01	27.02.2012	DA APPROVAL	MPS
A.00	06.02.2012	CLIENT REVIEW	MPS

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Designed PG	Checked DCP
Drawn MPS	Checked
Approved CC	
RPEQ	
HWA Project Number 3480	

HORIZONTAL
Co-ordinate System
BM Adopted
East North

VERTICAL
Datum
BM Adopted
Reduced Level

BUNDABERG REGIONAL COUNCIL

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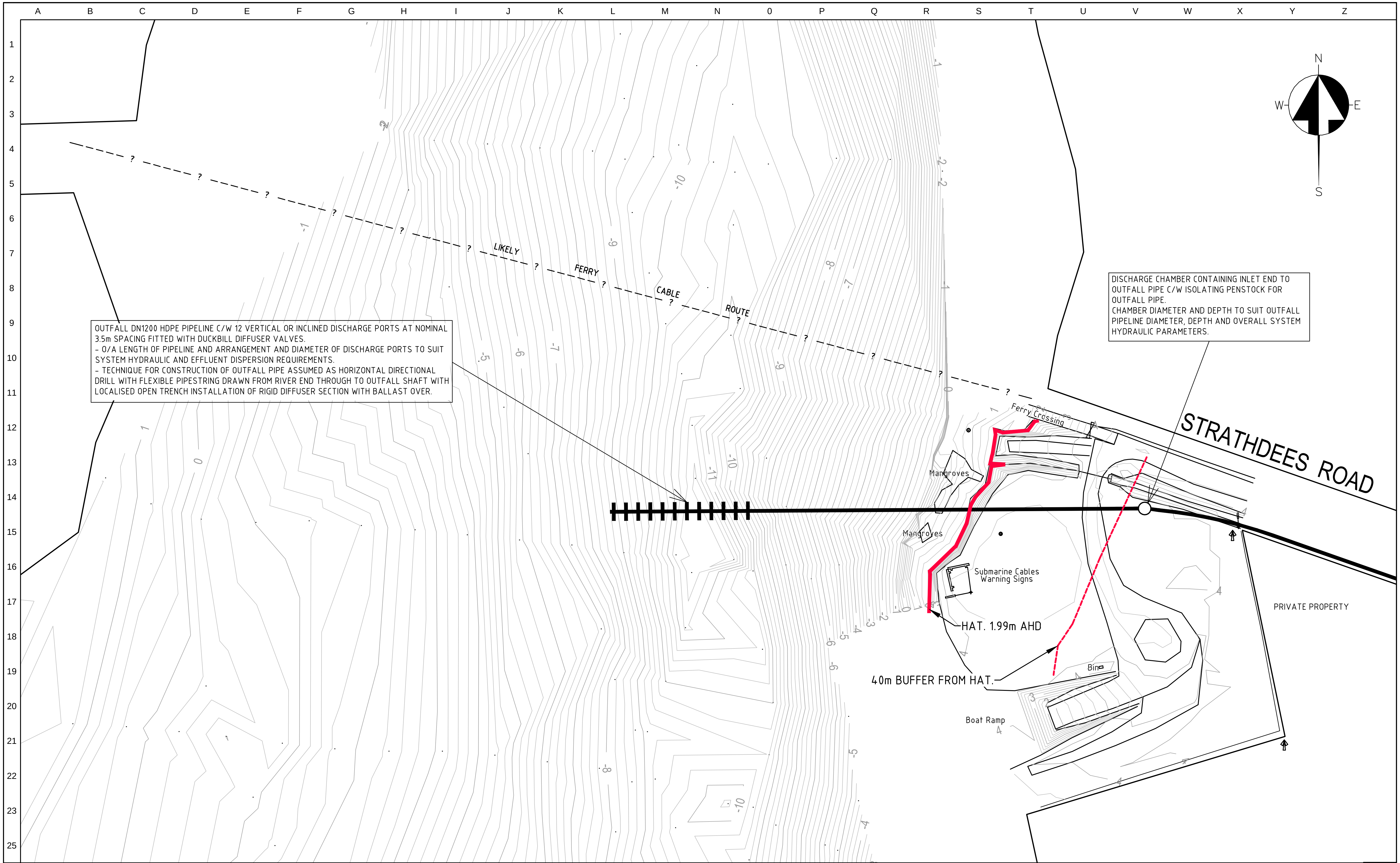
RUBYANNA WWTP
CONCEPT
OUTFALL MAIN FROM RUBYANNA

Scale: **AS SHOWN** at A3
Document No: **3480-SK-003**
Status: CONCEPT DESIGN
Version: **A.01**

Plot Date: 27/02/12 - 14:27 Cad File: \\ho-fs1\Projects\Bundaberg RC\3480 Rubyanna WWTP Concept Design & DA\2Tasks\Task 4B - Concept Design\Plant Layout\Current Working 3840-SK-003 & 000.dwg

Appendix G: Outfall Details



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B.00	17.01.2012	PRELIMINARY ONLY	DJP
A.01	16.01.2012	CARRIER MAIN AMENDED - CONCEPT	DJP
A.00	11.01.2012	CONCEPT	DJP
Ver	Date	Description	Drawn

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Drawn	DJP	Checked	DJC
Approved	DP		
RPEQ			
HWA Project Number	3480		

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PROPOSED OUTFALL PRELIMINARY ARRANGEMENT PLAN

Scale	Document No
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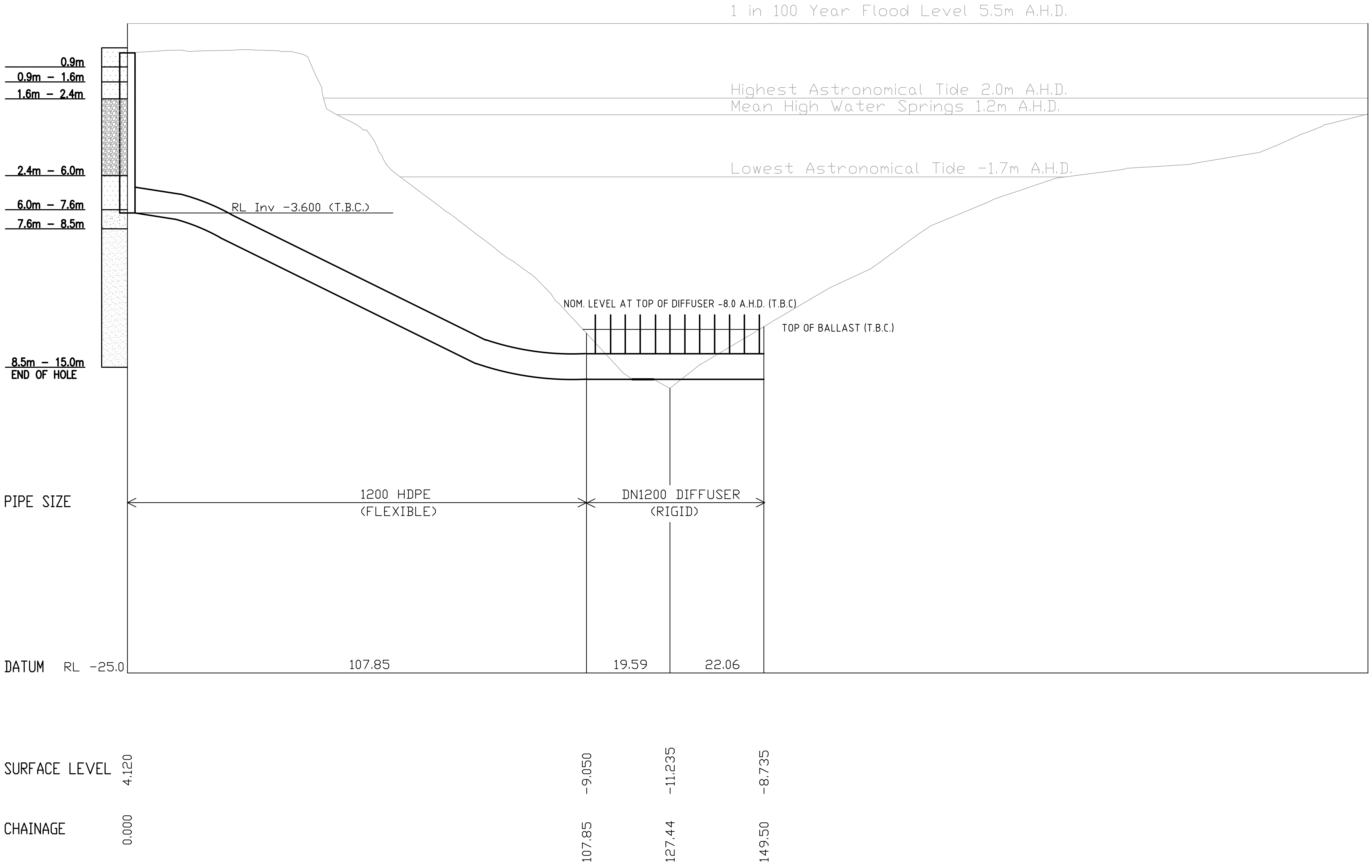
Status	Version
CONCEPT DESIGN	B.02

Plot Date: 27/02/12 - 12:19 Cad File: \\ho-fs1\Projects\Bundaberg RC\3480 Rubyanna WWTP Concept Design & DA\2Tasks\Task 5 - DRAFTING\SURVEY\3480-OUTFALL-01-B.02.dwg

NOTE 1:
TIDE LEVELS EXTRAPOLATED FROM BARGARA AND BURNETT RIVER (TOWN REACH) FIGURES (THE OFFICIAL TIDE TABLES AND BOATING SAFETY GUIDE 2004)

NOTE 2:
1 IN 100 YEAR FLOOD LEVEL FROM BURNETT SHIRE FLOOD LINE, RIVER, STORM TIDE AND LOCAL FLOODING ASSESSMENT (GHD 2004).



SOIL PROFILE LOG – REFER CM TESTING # C99637

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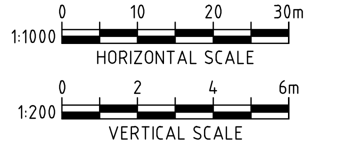
1.6–2.4	SANDY CLAY – MEDIUM PLASTICITY
2.4–6.0	INTERLOCKING BASALT BOULDER LAYER
6.0–7.6	SILTY CLAY – HIGH PLASTICITY
7.6–8.5	CLAYEY SAND – LOW PLASTICITY
8.5–15.0	SAND
15.0	END OF HOLE



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A.01	17.01.2012	100 YEAR FLOOD LEVEL AMENDED - CONCEPT	DJP
A.00	16.01.2012	CONCEPT	DJP

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Designed	HWA	Checked	HWA
Drawn	DJP	Checked	DJC
Approved	DP		
RPEQ			
HWA Project Number	3480		

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RUBYANNA WWTP
PROPOSED OUTFALL
PRELIMINARY ARRANGEMENT
LONG SECTION

Scale: **AS SHOWN** at A3
Document No: **3480-SK-011**
Status: **CONCEPT DESIGN**
Version: **B.02**

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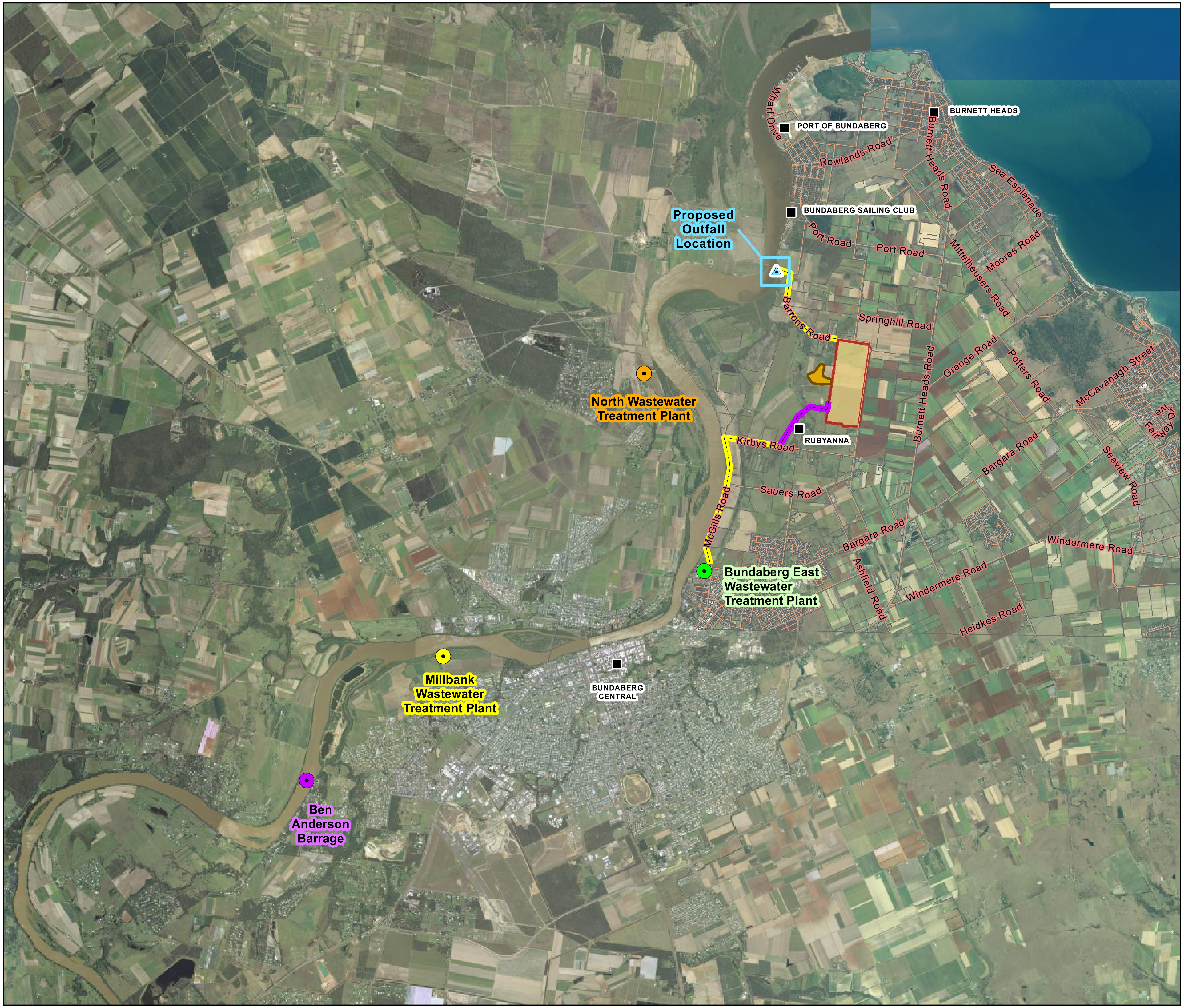
Appendix C

Locality Plans



RUBYANNA WWTP OUTFALL ASSESSMENT

Location Map

Figure 01

Legend

- Proposed Outfall Location
- Ben Anderson Barrage
- Bundaberg East Wastewater Treatment Plant
- Millbank Wastewater treatment Plant
- North Wastewater Treatment Plant
- Roads
- Possible STP Site (approx16.7ha)
- Lot 1 RP57605 (108.6 ha)
- Cadastre

Approximate Alignment : Raw Sewer Rising Main

- Freehold
- Road Reserve

N

Scale: 1:70,000 (when printed at A3)

0 500 1,000 2,000

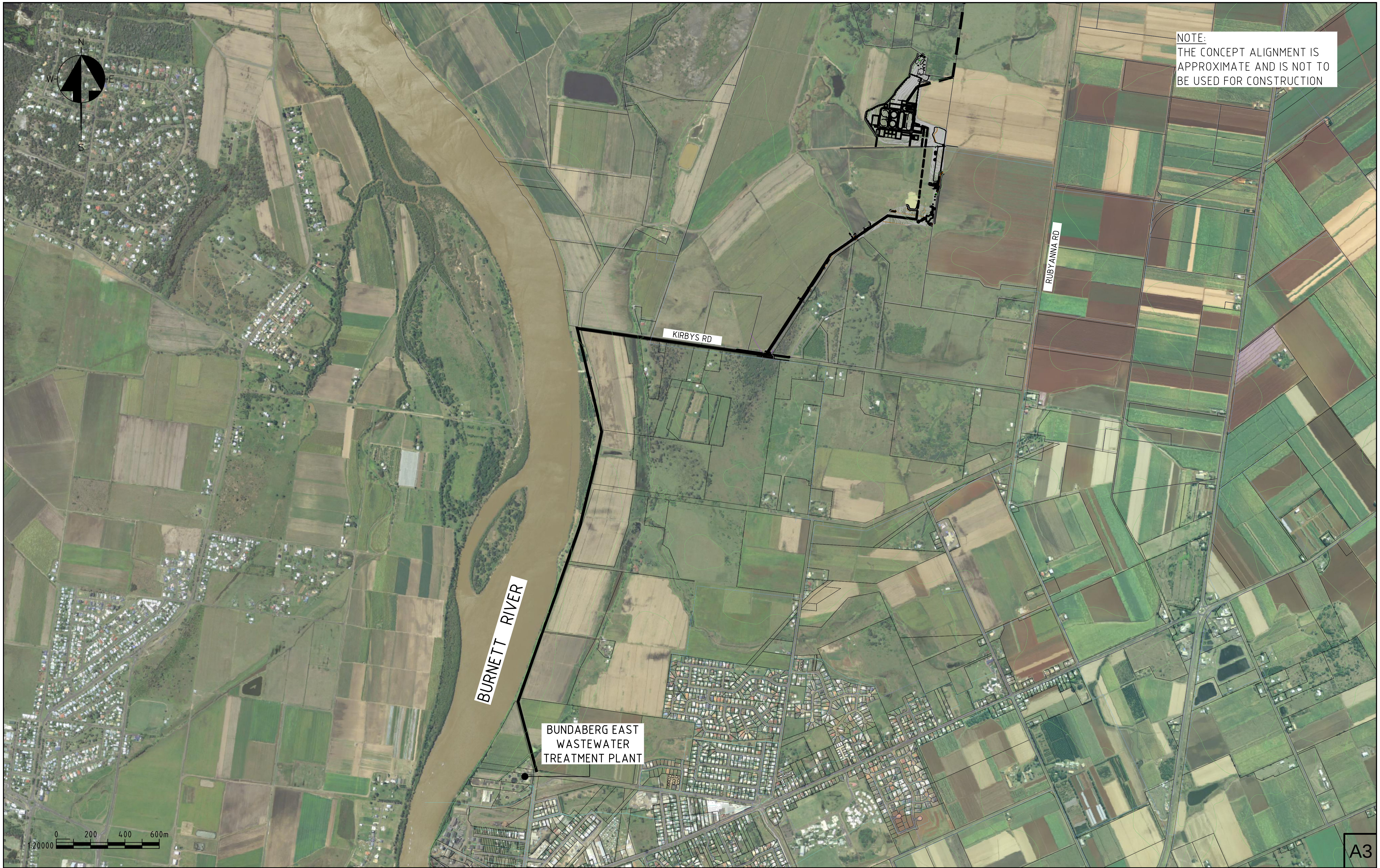
Metres

PROJECT ID 60221597

LAST MODIFIED CFS 17-11-2011

FILE NAME 60221597G_ENV_04

AECOM



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Approved CC
RPEQ
HWA Project Number 3480

HORIZONTAL
Co-ordinate System
BM Adopted
East North
VERTICAL
Datum
BM Adopted
Reduced Level

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RUBYANNA WWTP
CONCEPT
RISING MAIN FROM BUNDABERG EAST

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Status: CONCEPT DESIGN
Version: **A.01**

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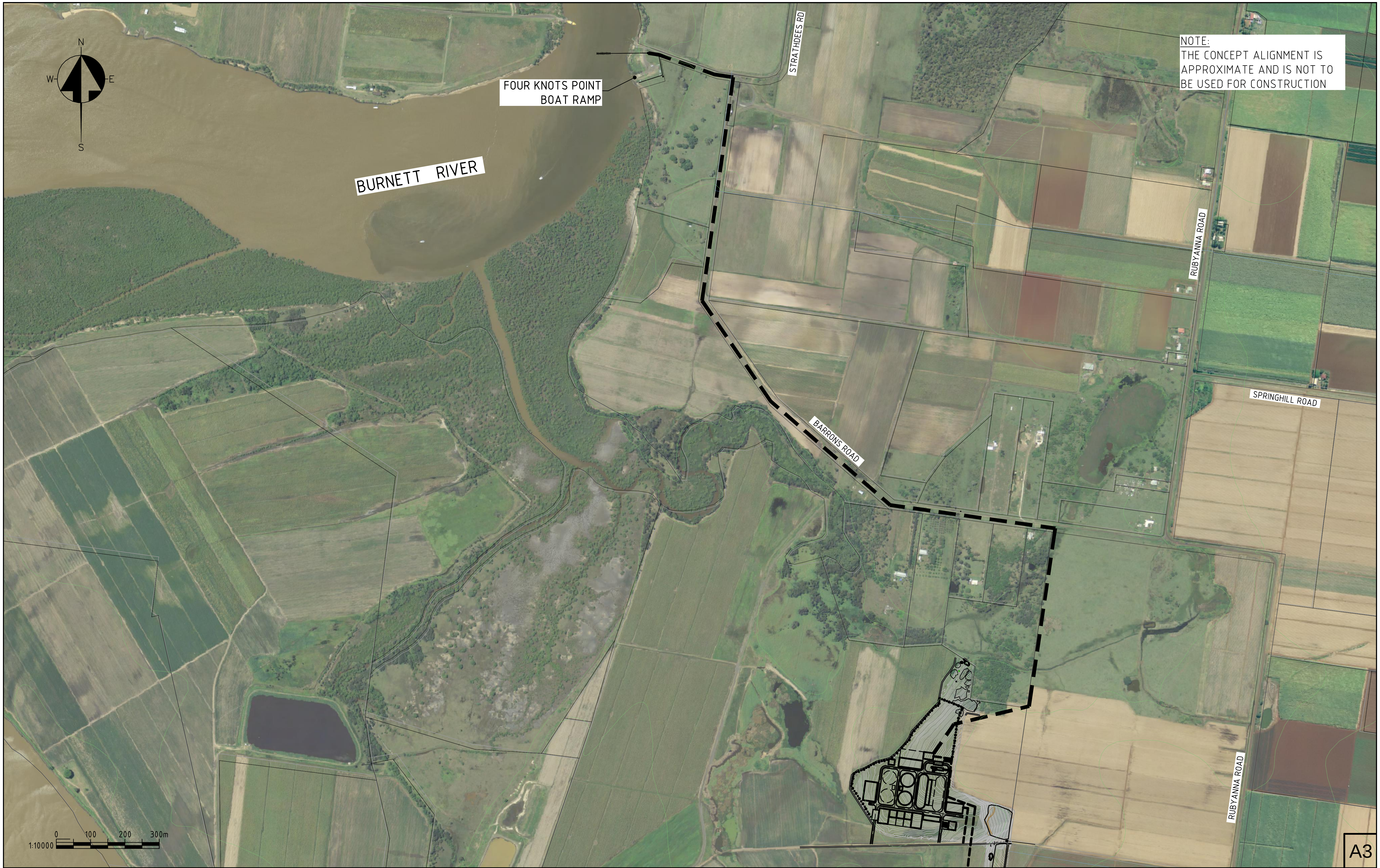
Appendix D

Outfall Layout Plans



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Drawn MPS	Checked
Approved CC	
RPEQ	
HWA Project Number 3480	

HORIZONTAL
Co-ordinate System
BM Adopted
East North

VERTICAL
Datum
BM Adopted
Reduced Level

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CONCEPT
OUTFALL MAIN FROM RUBYANNA

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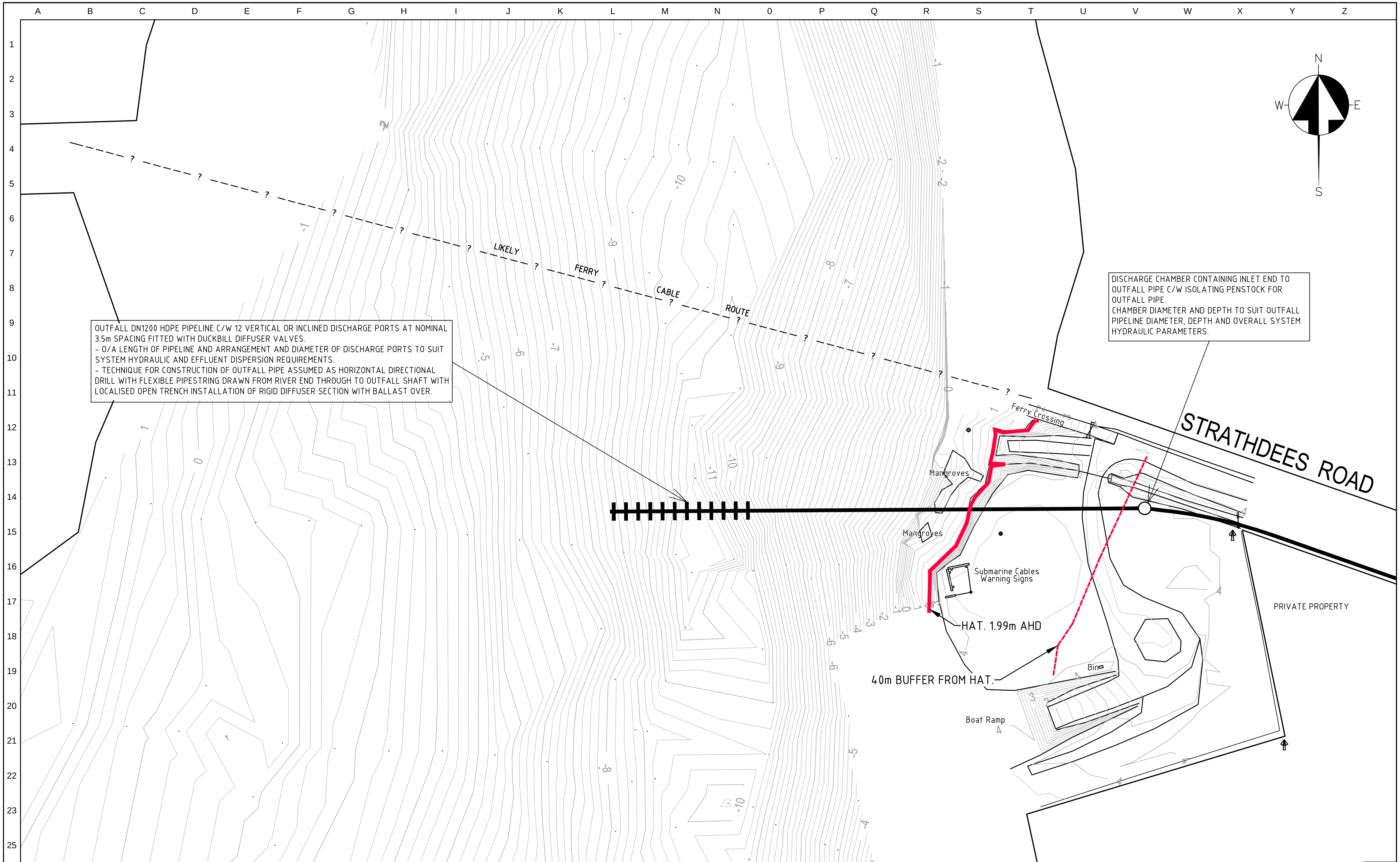

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Designed	HWA	Checked	HWA
Drawn	DJP	Checked	DJC
Approved	DP		
RPEQ			
HWA Project Number	3480		

BUNDABERG REGIONAL COUNCIL

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RUBYANNA WWTP
PROPOSED OUTFALL
PRELIMINARY ARRANGEMENT
PLAN

Scale: 1:1000 at A3
Document No: 3480-SK-010
Status: CONCEPT DESIGN
Version: B.02

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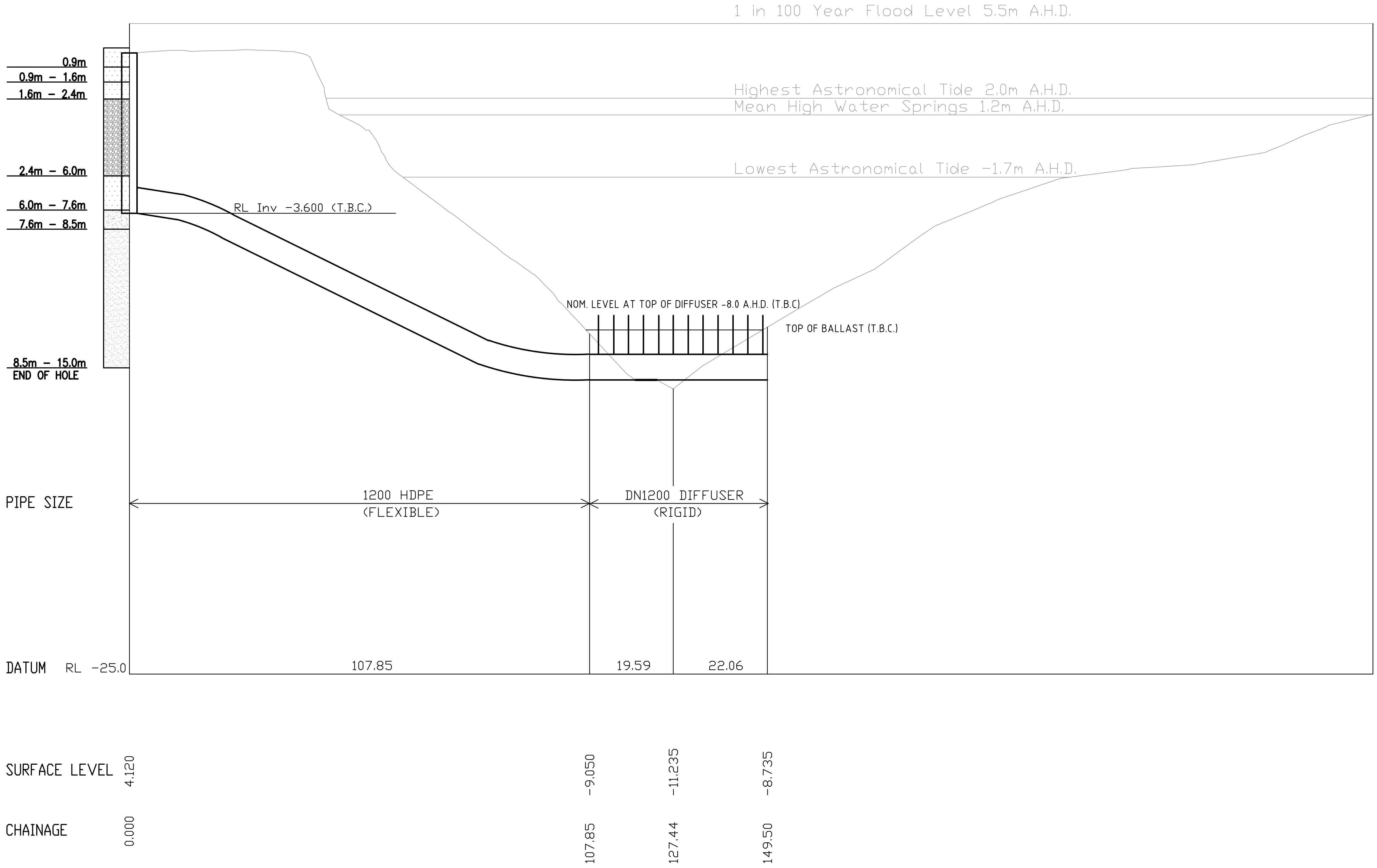

SOIL PROFILE LOG – REFER CM TESTING # C99637	
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0.9–1.6	SANDY CLAY – MEDIUM PLASTICITY
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7.6–8.5	CLAYEY SAND – LOW PLASTICITY
8.5–15.0	SAND
15.0	END OF HOLE

1:1000 HORIZONTAL SCALE (0, 10, 20, 30m)

1:200 VERTICAL SCALE (0, 2, 4, 6m)

A3

AMENDMENTS

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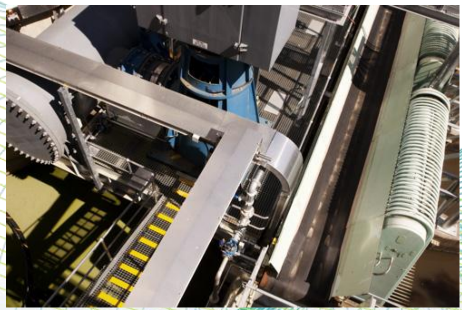
Appendix E

Project Delivery Plan



Hunter Water Australia Pty. Limited

Bundaberg Regional Council

Regional Wastewater Treatment Plant

Project Development Plan

Final

February 2012

Presented by Hunter Water Australia Pty Limited

ABN 19080869905

Report Details

Report Title Regional Wastewater Treatment Plant: Project Development Plan

Project No. 3472

Status Final

Document History and Status

Revision	Report Status	Prepared by	Reviewed by	Approved by	Issue Date
A	Draft	A.Thornton			
B	Revised Draft	A.Thornton	J.Keary		
C	Final	A.Thornton	J.Smith	J.Keary	February 2012

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Executive Summary

This Project Development Plan has been prepared to assist Council make the necessary decisions in a timely way to ensure the new Regional Wastewater Treatment Plant is commissioned by the end of 2016.

This Project Development Plan is a “road map” of the key steps involved with this major project. It also presents Council with the alternatives available for procurement of this project and the rationale for the selected procurement option.

The need for a Regional Wastewater Treatment Plant was identified in a masterplan developed to identify the infrastructure required to support population growth over the next 30 years and to improve the level of service.

Discussions were entered into with Department of Environment and Resource Management with early indications that commissioning of the new plant will be completed by end of 2016. The indicative timeframes shown below are based on this completion date.

The project development plan recommends project delivery by the use of “early contractor involvement” pathway. This process, which involves preselected contractor involvement in the design phase to ensure ease of constructability and encourage innovation, has been successfully used for the Mt St John Wastewater Treatment Plant at Townsville. This process is also being trialled by Council for the upgrades of Gin Gin and Thabeban Wastewater Treatment Plants.

A contract has been signed with Bundaberg Sugar in late 2011 for purchase of the land on which the plant is proposed to be built. The contract will be conditional upon Council being assured of obtaining Development Approval within 2 years of the contract date. This land purchase contract represents the first major decision for Council on this project.

Council decisions required through this project and the indicative timeframes for these decisions are shown in Table 1.

Table 1 Council Decisions

Decision	Indicative Timeframe
Land Purchase for Regional Wastewater Treatment Plant	September 2011
Adoption of this Project Development Plan	June 2012
Approve Development Application for Regional Wastewater Treatment Plant	September 2013
Approve Engagement of Designer	October 2013
Approve Shortlist of Contractors from Expression of Interest	January 2014
Approve Engagement of Contract Projects Manager	January 2014
Approve Calling Tenders for Construction	October 2014
Approve Award of Construction Contract	January 2015

Contents

Figures

Tables

Appendices

1 Introduction

Bundaberg Regional Council (BRC) has identified the need for a Regional Wastewater Treatment Plant in the “Bundaberg East & Bargara Coastal Region Wastewater Treatment and Effluent Management Master Plan” developed to identify the infrastructure required to support population growth over the next 30 years and to improve the level of service.

Discussions have been entered into with Department of Environment and Resource Management with early indications that commissioning of the new plant will be completed by end of 2016. With this requirement in mind a project program has been developed to show how this can be achieved. The project program also identifies the approvals required by Council to enable the project to progress.

This Project Development Plan has been prepared to assist Council in confirming that the necessary decisions are made in advance of the required timeframes needed to ensure the new Regional Wastewater Treatment Plant is commissioned by the end of 2016.

The Project Development Plan is to act as a “road map” to ensure the successful completion of what is for Bundaberg Regional Council (BRC) a major project, and to ensure that the elected Council are aware of the alternatives available for procurement of this project and the rationale for the selected procurement option.

The project development plan recommends project delivery by the use of early contractor involvement pathway. This process, which involves preselected contractor involvement in the design phase to ensure ease of constructability and encourage innovation, has been successfully used for the Mt St John Wastewater Treatment Plant at Townsville. This process is also being trialled at BRC for the upgrades of Gin Gin and Thabeban Wastewater Treatment Plants.

2 Project Background

2.1 The Need for a Regional Wastewater Treatment Works

Significant population growth is expected in Bundaberg Regional Council (BRC) area. A Master Plan has been developed to identify the wastewater infrastructure required to support population growth in the region over the next 30 years and to improve the level of service provided to the customer. A staged approach to providing the infrastructure has been developed based on a logical expansion of the sewer network and the underlying population projections for each area. This staging provides flexibility and allows the costs associated with meeting the plan objectives to be spread over the planning period.

The environmental performance of wastewater treatment operations was recognised as a key consideration for Council. The strategies in the Master Plan acknowledged:

- The proximity of the coastal communities to the Mon Repos Turtle Rookery and the Great Barrier Reef Marine Park, and
- Council's commitment under the current EPA licence requirements to consider, where possible, progressively reducing the annual load of contaminants released via the existing East Treatment Plant Burnett River discharge and Bargara ocean outfall.

Beneficial reuse of treated water for sustainable crop irrigation was identified as one of the preferred strategies for the region. For the purpose of the Master Plan, it was assumed that future treatment plants would be designed to produce effluent meeting Class A standards. This standard of treatment maximises reuse opportunities by providing treated water that is suitable for a wide range of uses including horticulture and sugar cane irrigation. It is expected that an effluent reuse and management strategy will be further developed as part of the planning process.

Construction of a new centralised treatment plant to service the catchment area was identified as the preferred option.

The key benefits of adopting the preferred scheme are:

1. Adopting a centralised treatment strategy enables economies of scale in terms of treatment facility and reduces the number of facilities that the Council has to operate, monitor and report on.
2. The centralised scheme provides favourable environmental outcomes in that discharges to the environment are avoided and over time the coastal effluent discharges are minimised.
3. The strategy provides flexibility in terms of effluent management options.
4. This option is most likely to provide the best option for implementing a number of longer term effluent reuse opportunities.

2.2 Current Status of Regional Wastewater Treatment Works Project

BRC has completed negotiations with Bundaberg Sugar for purchase of the land parcel on which the Regional Wastewater Treatment Plant is proposed to be constructed. A contract has been signed with Bundaberg Sugar as of the end of September 2011 with the contract being conditional upon BRC being assured of obtaining Development Approval within 2 years of the contract date.

A consultant (Hunter Water Australia/Aecom) has been engaged to prepare the supporting documentation for the Development Application for the Regional Wastewater Treatment Plant and lodge the Development Application with Council. The Development Application is to be lodged by end March 2012.

3 Timeline

Discussions have been entered into with the Department of Environment and Resource Management (DERM) with early indications that commissioning of the new plant will be completed by the end of 2016.

A preliminary timeline for the project has been developed that illustrates that this commissioning date is achievable is attached in Appendix A. This identifies the key steps that need to be undertaken to achieve this end result with indicative timeframes and key inter-linkages. Key Council decisions have also been identified in order to achieve this end result.

Having a target commission date by end of 2016 allows BRC a great deal of flexibility in their approach to their delivery of this project. The timeframe is realistic and enables conventional delivery processes to proceed whilst also allowing accelerated timeframes that are achievable with alternate delivery models.

Whilst the timeframe allows for the full range of delivery approaches to be considered, it does not allow huge amounts of float and so the program must be managed well by Council to achieve this end result.

4 Project Financing

Any new project has two cost components, capital cost (which includes investigation, design, construction and project management) and the ongoing operational costs.

The regional plant is proposed to ultimately service an equivalent population (EP) of 90,000.

Bundaberg Regional Council (BRC) currently has the following estimated capital costs associated with this regional plant:

- Stage 1 Plant (50,000 EP), $50M
- Pipelines, pump station, decommissioning East STP, $10M
- Outfall Pipeline, $10M
- Preliminaries, Design, Project Management, Land purchase, $5M
- Stage 2 Plant (40,000EP) – demand driven but after 2018, $25M

Actual operational costs of the new plant will depend greatly on the level of treatment that is required which will be ultimately determined in conjunction with the development application.

Both capital and operating budgets will be refined as the design and specification of the plant proceeds with more certainty. Improvement in cost accuracy will occur once the DA is approved, and once again when designs are finalised and on receipt of tenders.

Funding for the regional plant will be sourced from internal Council funds.

As is normal practice with projects of such significance Council will actively seek funding from both State and Federal Governments to reduce the impact on Council ratepayers.

Regardless of the outcomes of the negotiations with State and Federal Governments regarding funding contributions BRC already has a 10 year forward financial plan approved by Queensland Treasury Corporation which allows for revenue growth due to population increases and reasonable rate increases.

From a total financing point of view, the aim of the project will be to achieve the lowest overall whole of life cost to Council for the new regional wastewater treatment works. This will require the designer to be in a close relationship with Council to ensure that Council's preferred equipment is specified and Council's operational needs and preferences of its operational staff are taken into account in the design process. To achieve certainty in budget estimates the aim of the project should be to minimise variation in contract sums which is normally related to the design quality and the constructability of the final plant design. These issues are discussed in following sections.

5 Land Procurement

Previous investigations culminating in the report titled "Bundaberg East and Bargara Coastal Region Wastewater Treatment and Effluent Management Master Plan" identified a preferred site for the regional wastewater treatment works. The site is owned by Bundaberg Sugar and negotiations for purchase of this land have concluded.

A contract for the purchase of this land has been signed in September 2011 with Council approval for this purchase being obtained. The contract is a 2 year option with completion in September 2013 or earlier when BRC is sure that Development Approval will be achieved.

Land acquisition needs to be completed to enable the consultation process with DERM to be finalised so that certainty on the conditions of the DA can be achieved.

As can be seen on the timeline in Appendix A, at the latest, the land acquisition process needs to be completed by September 2013. Not only is DA certainty linked to the land purchase but commencement of design cannot proceed until both the land purchase is complete and DA certainty has been obtained.

6 Development Application

A Development Application (DA) is required for the Regional Wastewater Treatment Plant. BRC have already commenced the process of collecting background information to prepare the development application.

A consultancy has been awarded to HWA/AECOM to prepare documentation and lodge a development application on behalf of Council for a public utility undertaking (wastewater treatment plant) and related configuration of a lot, environmentally relevant activity and prescribed tidal work. Lodgement of the DA and supporting documentation is to occur by the end of February 2012 and is supplemented by all resource entitlement permissions.

Once the DA is submitted, consultation between the applicant and regulators will be required with the ultimate aim of reaching certainty on the conditions of approval. These negotiations will be conducted by Council staff with the aim of having the development approval conditions agreed to enable approval of the DA by Council by September 2013.

Once the DA is approved, design can commence as the agreed conditions of approval can be specified to the designer.

BRC will be required to process the Development Application as it would any other Development Application with final approval to be by Council.

7 Project Development Plan

The Project Development Plan is to serve as a “road map” for the delivery of the completed Regional Wastewater Treatment Plant. The Project Development Plan will outline the key steps in the delivery of the Regional Wastewater Treatment Plant, the timeline for its completion, outline where alternative options are available, and recommend a preferred option. Most importantly, the plan will spell out the approval processes that are required using BRC’s processes to ensure probity is maintained in the delivery of this project.

The Project Development Plan by its nature should be seen as a document that will outline for all staff the rationale to the decisions that have been made and will provide an outline of the way forward at any point in time. By its nature, it should be seen as a document that will be changed as the project progresses.

It is intended Council approve the Project Development Plan.

8 Procurement Options

8.1 General

Once the DA has been issued, there are a range of different procurement options available to BRC to have the design, construction and commissioning of the new facility carried out. One of the key advantages to BRC in making the decision on the procurement method for design, construction and commissioning is that the required completion of commissioning by end of 2016 is realistic and does not force Council into procurement methods that require meeting tight deadlines. This is not to say that Council does not need to consider these methods but it also still allows Council to consider the more conventional procurement approaches which can take longer time periods.

The main options available for procurement are discussed in the following sections which list some of their key issues, features, advantages and disadvantages.

8.2 Engage Design Consultant, Separate Engagement of Construction Contractor

The sequential design and construction method of delivering projects involves an engineering consultant (or occasionally the client itself) finalising a design before tenders are called for construction. Following construction, operation and maintenance of the facility is carried out by the client. It is sometimes referred to as the 'traditional' delivery approach because it reflects the historical functional separation of engineering disciplines.

8.2.1 Outline of the Delivery Method

The sequential design and construction method starts with the independent selection of the design group. That engineering consultant is generally engaged by the client to manage both the design and the preparation of contract documents for the construction activities. One or more contractors (the work can be separated into several contracts) are then selected in an open tender process to construct the facility. The client has the flexibility to choose which parts of the project will comprise a contract package.

8.2.2 Key Issues

For the sequential design and construction approach to be an effective delivery method it is essential that the design team has broad experience covering relevant process design, mechanical equipment and electrical systems, and construction knowledge. This method involves the largest scope of risk acceptance by the client, and equally the greatest involvement of the client in the day to day delivery of the project.

8.2.3 Key Features

Some of the key advantages and disadvantages of the sequential design and construction approach are as follows:

8.2.3.1 Advantages

- The client maintains a large degree of control over design outcomes, with the ability to change or direct most variables. This may be an important feature if there is uncertainty about the exact nature of works required. Having fully detailed the design before awarding a tender for construction also generates a high potential level of product quality, particularly where the client has specific product specification preferences.

8.2.3.2 Disadvantages

- As the designer, constructor and operator are three different parties there is little incentive for whole of life costs to be considered by the designer or constructor. This can lead to higher operations and maintenance costs. Optimising whole of life costs becomes the responsibility of the client.
- There is a high risk of delays due to the involvement of multiple parties and contract interfaces from start to finish.
- Although alternative technologies can be considered by the designer in conceptual evaluations, the sequential design and construction approach is less effective than all other delivery options in achieving alternative or innovative approaches.
- Innovation in the development and design of a project is limited to some extent by the choice of designer. Once the design has been completed, the subsequent “construction only” contract mechanism makes it very difficult for the contractor to redesign the project to incorporate a more innovative approach.
- The client bears all operations and maintenance risks.

8.3 Engage Design/Construction Contractor

The Design and Construct (D&C) method is a well-developed and practiced delivery approach for new water and sewerage infrastructure, and has been used for projects valued from a few thousand to tens of millions of dollars. However, within the water industry, the absence of clear accountability for ongoing performance and maintenance costs associated with this form of project delivery may lead to an inappropriate focus on lowest upfront capital cost in the tender process.

8.3.1 Outline of the Delivery Method

The client prepares a performance and quality requirement specification, often using standard specifications to ensure minimum quality requirements are met for critical long life components. A single contract is let to prepare the detail design of the facility and to construct the works. The contract is usually lump sum. The client would then operate and maintain the works.

Because all of the works are combined under a single contract, the overall responsibility for commissioning the facility rests with the main contractor. However the risk that the facility continues to function properly lies mainly with the client.

An Expression of Interest process is used to ensure that only competent contractors are invited to tender and to improve competition (recognising the high cost of bidding).

8.3.2 Key Issues

Unless specific, carefully defined performance warranties are used, the D&C method is more likely to be driven by the capacity of the contractor to accept the civil works risks rather than process risk issues. This is because the contractor has no role in the ongoing operations and maintenance of the facility. Such performance warranties are difficult to write for complex projects.

8.3.3 Key Features

The D&C delivery method improves the focus on overall project delivery costs compared to the sequential design and construction approach. As compared to the sequential design and construction approach, the D&C method is more likely to select a more capital efficient plant, and to include more innovation in construction techniques. Whilst more likely to deliver a more capital efficient plant the D&C method can also result in a higher operating cost plant.

Some key advantages and disadvantages of the D&C approach are noted below.

8.3.3.1 Advantages

- If accelerated delivery is required, then the method offers some potential to provide incentives for acceleration of the contract.
- The time delay risk on interfaces between equipment and other suppliers and civil works is placed with a single party, ie the contractor.

8.3.3.2 Disadvantages

- The D&C method can often be a confronting relationship with conflicting priorities. The contractor endeavours to drive costs down whilst the client endeavours to maintain quality and reduce operation and maintenance costs.
- Because the client has little control over the design outcomes after tendering, the client only affects design control where it has well established standard specifications to ensure quality requirements are met for critical long life components.
- Tenders are assessed on predicted life cycle costs, but tenderers tend to focus on lowest capital costs which can lead to higher operations and maintenance costs.
- The client accepts all operations and maintenance risks, apart from specific equipment performance guarantees (which may not be enforceable in all circumstances). Often the contractor subcontracts the process design and hence the commissioning risk. Thus the contractor is focussed on doing what is required to meet practical completion, not the long term performance of the plant.

Example: Trility engagement of BMX/GHD Northern Water Treatment Plant at Townsville.

8.4 Early Contractor Involvement

This method is a modification to the sequential design and construction method of delivering projects (Section 8.2) with the addition of contractor involvement during the design phase to address many of the disadvantages of the normal sequential design construct process. This form of delivering a project relies on relationship building between the client, designer and construction contractors during the design phase.

8.4.1 Outline of the Delivery Method

Early contractor involvement is a similar method of delivering a project to engaging a design consultant with separate engagement of a construction contractor with the added component of selecting several contractors to be involved in the design process. Expressions of interest are called for construction contractors with a short list being developed by the client. The short list is developed on non-price parameters. The short listed contractors are involved in workshops with the designers during the design process. Workshops at which the construction contractors would participate would generally be as follows:

- Introductory Workshop - where the agenda would include relationship management, expectations, project risk register, project progress, design overview and contract form.
- Workshop 2 – the risk workshop where the agenda would include project risks, construction risks and risks versus costs.
- Workshop 3 – safety in design risk assessments and design feedback which would include agenda items, contractors’ feedback from design overview, constructability, operability.
- Workshop 4 – program and costs where the agenda would include construction program, review of project costs.
- Workshop 5 – commercials with the agenda items being commercial risk/opportunity, key result areas, commercial terms and ECI closure.

8.4.2 Key Issues

As for the sequential design and construction approach for early contractor involvement to be an effective delivery method it is essential that the design team has broad experience covering relevant process design, mechanical equipment and electrical systems, and construction knowledge. The selected contractors need to have incentives to ensure that they contribute innovative ideas to the design process that will result in minimising construction risk and costs.

8.4.3 Key Features

ECI delivery method improves the focus on overall project delivery costs compared to the sequential design and construction approach by the involvement of construction contractors during the design process. As compared to the sequential design and construction approach, the ECI method is more likely to select a more capital efficient plant, and to include more innovation in construction techniques.

8.4.3.1 Advantages

- The client maintains a large degree of control over design outcomes, with the ability to change or direct most variables. This may be an important feature if there is uncertainty about the exact nature of works required. Having fully detailed the design before awarding a tender for construction also generates a high potential level of product quality, particularly where the client has specific product specification preferences.
- The contractor has sufficient time to understand the design and project risks outside of the tender period. This understanding leads to more consistent pricing with a lower spread of tender prices between tenderers, as less contingencies are included in the tender price to cater for unknown risks. This improved knowledge of the design can also translate to a reduction in construction variations.
- The discussion and resolution of potential construction issues upfront of the construction phase will result in lower requests for information (RFI) during the tender and construction phase, reducing project management costs.
- The time delay risk on interfaces between equipment and other suppliers and civil works is placed with a single party, ie the contractor.
- Innovation in the development and design of a project is enhanced by the involvement of contractors during the design. Procedures can be developed to encourage innovation by the contractors without the individual contractors feeling that their ideas are going to improve their competitor's position.
- As the designer, constructor and operator are all involved through the ECI process there is still the opportunity for whole of life costs to be considered.

8.4.3.2 Disadvantages

- The client bears all operations and maintenance risks.
- Without clear procedures for innovative ideas to be credited to the contractor who suggests the innovation there is the risk that contractors will not suggest innovations during the design phase.

Example: **Mt St John WWTW. A fact sheet on the ECI process for this plant is attached as Appendix C.**

BRC selected this procurement process for Gin Gin and Thabeban

8.5 Build, Own, Operate, Transfer Contract (BOOT)

Build Own Operate Transfer (BOOT) contracts are of greatest relevance where clients want to transfer the risks of ownership or need to harness private sector capital to finance rapid expansion in the capacity of infrastructure services. They can be thought of as a form of contract where the remuneration for the contractor is not a lump sum paid up front, but a risk bearing compensation scheme spread over a period of time. That is, the construction costs of the facility are paid over time as part of a 'tariff', rather than on completion of construction. This delivery method is also sometimes referred to as Design Build Finance Operate (DBFO).

BOOT projects involve the ownership of the asset(s) transferring back to the client at the end of the contract period (usually 20 to 25 years). They can be structured, however, as Build Own Operate (BOO) contracts, where there is no transfer of ownership involved at the end of the contract period. In these cases the contractual obligations of the client cease at the end of the (20 to 25 year) contract period.

8.5.1 Outline of the Delivery Method

The client prepares a financial, performance and quality based outcomes requirement specification for the design and construction and O&M phases. These are assembled into a single over-riding tender/contract arrangement, with a number of supplementary agreements required to give effect to the long term site use, financial and guarantee arrangements. An Expression of Interest process is used to ensure that only competent contractors are invited to tender and to improve competition (recognising the higher cost of bidding all phases of the project).

The contract involves no payment for the physical design and construction of the facility, only a fixed plus variable payment structure for the operational plant based on facility availability and delivery of the specified product. The client cannot exercise any effective control over the project on a day by day basis, other than for reducing payment to the contractor for non-performance.

Additionally, the complexity of including financing in the tender package significantly increases the cost of the tender process as compared to, say, a DBO contract. The method is therefore only suitable for large projects.

It is considered that the regional wastewater treatment plant is not of sufficient scope to justify the expense of this form of procurement.

8.6 Build, Own, Operate (BOO) Contract

There are now a number of Design Build Operate (DBO) contracts for infrastructure in the water industry in the eastern states of Australia. Within the water industry, the method is starting to gain favour as a means of achieving contractor accountability for both initial capital costs and ongoing performance and maintenance costs without the added financial requirements of a Build Own Operate Transfer (BOOT) process. Design Build Operate contracts tend to display similar advantages and disadvantages to BOOT methods.

8.6.1 Outline of the Delivery Method

The client prepares a performance and quality requirement specification for the design and construction phase of the project and a performance based Operations and Maintenance contract for the operations phase. These are then assembled into a single over-riding outcome driven tender/contract arrangement. The contractor is therefore responsible for the design, construction, operations and maintenance of the facility for a specified period (typically up to 15 years from completion of construction). Ownership of all assets remains with the client. An Expression of Interest process is used to ensure that only competent contractors are invited to tender and to improve competition (recognising the higher cost of bidding all phases of the project).

The contract is usually lump sum for the design and construction phase, and then a fixed fee plus volume based fee structure for the O&M phase, with payments for both phases being dependent on performance. The contract for a treatment plant usually includes an extended testing period to prove its performance.

Because all of the works are combined under a single contract, the overall responsibility for commissioning the integrated facility and ensuring that it continues to function properly for the duration of the contract rests with the contractor.

8.6.2 Key Issues

As compared to the sequential design and construction or the D&C method, the DBO method is more likely to select the facility with the lowest life-cycle cost, and accordingly seeks innovation in both process technology and construction techniques.

8.6.3 Key Features

The key feature of the DBO delivery method is that selection of the contractor by the client is based on a comparison of total life-cycle costs (excluding finance), rather than focussing predominantly on construction costs.

The capital and operating costs (bar inflation based increases) are fixed at the time of contract, and the client bears, effectively, no risk of variation in either of these budgets.

Some key advantages and disadvantages of the DBO approach are noted below.

8.6.3.1 Advantages

- Because alternative treatment process technologies influence all of the capital, operating and maintenance costs, and thus correlate to the life-cycle costing basis on which tenders are called, the DBO method is very effective in achieving lowest overall cost to the client. Achieving the most appropriate design and quality of fittings and finishes is related to the operating term selected, with longer terms approximating the useful life of the facility's major components (typically 15 years) achieving better results.
- The DBO method is, together with the BOOT method, the most directly focused of the delivery alternatives towards achieving the minimum project life cycle cost, provided that there is a sufficiently long operating period in the contract.
- Because all the physical works delivery and operations and maintenance packages are let in a single package, the DBO method (and BOOT) offers more certainty than alternative forms of project delivery that the actual capital costs and O&M costs will not vary from the tendered amounts.

8.6.3.2 Disadvantages

- Completion targets can be established and a payment regime used to ensure timely completion. However as the contract usually involves significant cost risk during the construction phase, the capacity of the client to accelerate the delivery program, once set, is limited.
- If the contractor fails to perform the work adequately, then Council's cost of remedying the situation can be extremely high over a long duration.

Example: Trility contract Townsville

8.7 Alliance Contract

The Alliance Contract method is one of the most recently applied approaches to the delivery of water and sewerage projects. It has been used on several major projects including the Sydney North Side Storage Tunnel, Perth's Woodman Point Sewage Treatment Plant, and the Landers Shute Water Treatment Plant in Queensland.

The principal reason for the development of alliance contracts has been a desire to move toward a co-operative client – contractor approach to achieve the project objectives.

8.7.1 Outline of the Delivery Method

In order to deliver a project, several companies, agencies and/or clients work together. The partners to the alliance in effect form a joint venture company and work together to deliver the project on an agreed fee basis. The partners apportion tasks and the overall profits or losses that accrue. This form of project delivery provides a focused team that combines the owner, designer, builder and operator to deliver the best product.

The client pays the actual costs plus an agreed margin for overheads and profit. The payment mechanism results in bonus payments being made to the contractor if the actual project costs are less than the target cost. Similarly, the contractor loses the profit and overhead payment component if actual costs exceed the target cost. The details of this profit/cost sharing mechanism are written into the contract.

Recently variations to the alliance approach have emerged in the market, whereby each tenderer must provide their target costs at the tender stage. The other variation involves shortlisting two tenderers at EOI stage, and paying each tender to develop the target cost in conjunction with the client.

Queensland Treasury has adopted these variations which effectively mean the alliance approach will only be applicable for extremely large projects and would not be applicable to a project of the scale of the Regional Wastewater Treatment Plant.

Example: SEQ Recycled Water Scheme

8.8 Recommended Procurement Option

BRC's preferred option for procurement of the Regional Wastewater Treatment Plant is Early Contractor Involvement.

This method of procurement is being trialled for the upgrades of the Gin Gin and Thabeban Wastewater Treatment Plants for which design proposals have been invited. Legal clarification of the engagement of contractors in the initial phases of the early contractor involvement process has been obtained to ensure the process is in accordance with the Local Government Finance Standards.

9 Designer Selection

9.1 Design Brief

It is important on a project such as this for the designer to be involved in all phases of the project. This includes the design, throughout the construction phase, and since the design includes wastewater treatment process, it is critical that the designer (including their lead process engineer) be part of the commissioning team. The designer needs to have had previous experience with the early contractor involvement process to ensure the early contractor involvement process works effectively to obtain the best outcomes for BRC. The design brief therefore needs to address these four components.

The design requires the following key inputs:

- Process design
- Civil design
- Mechanical design
- Electrical design
- Plant Control design (PLC/SCADA)

It is important that the design brief spell out the requirements in each of these areas.

The design brief also needs to spell out the requirement for early contractor involvement as this will alert the designer for the need to prepare for and participate in the workshops, and to potentially review/revise their designs based on feedback from the construction contractors. To ensure Council achieves an end result that focusses on the least whole of life cost, the brief needs to clearly spell out Council's requirements with respect to operability and maintainability.

Normally for a project such as this the designer should be able to submit either a Lump Sum Fee or an Upper Fee Limit for the design phase of the project, schedule of rates for design staff required to respond to issues arising from the tender and construction phases, and either a Lump Sum Fee or an Upper Fee Limit for commissioning. From Council's perspective, it is important that the fee process be managed, in particular, the fee component for tender and construction support.

To this end it is suggested a range of KPI's should be developed and included in the brief to measure the performance of consultants on this assignment.

One of the key issues that needs to be spelt out in the design brief is the level of detail that the designer is expected to produce. The design prepared should be in sufficient detail for the contractor to build without having to undertake additional design work. As an example, if steel frame buildings are required the detail should be sufficient for the contractor to issue to a fabricator. There are some designs that are issued where the construction contractor requires further details to be produced prior to issuing to a workshop. This leads to uncertainty on pricing and can contribute to either high initial construction quotes or variation claims during the contract. The design brief should be specific and clear in the level of detail the designer is to produce.

The process designer is one of the critical inputs to this project. The design brief needs to specify a requirement for the design team to commit to specific individuals being guaranteed to work on this project from commencement to handing over the commissioned plant. These individuals will have proven track records on process selection, process design and most importantly process commissioning.

The civil, mechanical, electrical and PLC/SCADA designers will need access to the process engineers to effectively produce their inputs to the final design.

One area that is often not given enough emphasis in design briefs is the area of PLC/SCADA design and is an area that is often sub-contracted by design teams. This is a design area that is critical to the long term efficient and effective operation of a treatment plant and needs to be given careful consideration in the design brief and in the designer selection process to ensure this area of the design is given the priority it requires.

The design brief should also specify a requirement for the designer to design a plant that can be upgraded in the future if required to meet either additional loading or higher standards being required for the effluent quality.

9.2 Designer Selection

Whilst price will undoubtedly be a key component of the designer selection process, it should not be the sole criteria. For a project such as this, a range of consultant qualities should be taken into account in the selection of the designer.

Firstly, process design is critical. A track record of proven performance on treatment plant process selection and design should be key criteria in the selection of the design consultant. A commitment by the designer that their key process designer will be unequivocally involved throughout the design process including the commissioning of the new plant should be an absolute criterion for selection of the designer.

The consultant or consortium of consultants should have the following design experience and track record in the design of wastewater treatment plants:

- Process design
- Civil design
- Mechanical design
- Electrical design
- PLC and SCADA design

Most consultants will have process, civil, mechanical and electrical capability but may not always have the relevant expertise in PLC/SCADA design. From Council's perspective, this is one of the most critical components as it can have a major impact on Council's costs of operating and maintaining the plant. It should be a key component in the selection of the designer.

Since one of the key objectives for Council is to achieve lowest whole of life costs, one other key criteria for selection of the design consultant is their track record on being involved with the operation of plants they have designed. Without operational experience which designers can have achieved through alliance contracts, through relationships with clients and through design build operate contracts it will be difficult for them to prepare designs that take into account the full operational and maintenance requirements of the client. Whilst it could be argued that the brief should spell out these requirements, in reality it is very difficult to specify all these requirements up front and many issues will not be identified until the design is underway.

One other key criterion in the designer selection process is their ability to work in a relationship with both the client and construction contractor. Early contactor involvement relies heavily on relationship building and that relationship building requires client, designer and contractors all working together.

Preparation of the design brief can commence whilst consultation for the development application is occurring. Actual designer selection can also occur prior to DA certainty being achieved with Council approval of the design consultant's engagement occurring following DA approval.

9.3 Council Approval

Council approval will be required for the engagement of the designer in accordance with the Local Government Finance Standards for competitive tendering.

10 Design

10.1 Process Selection

The first step in the design process is the process selection. This cannot commence until the development approval certainty has been obtained as the process selection has to be developed around the required performance standards that the plant must achieve to comply with its development approval.

A range of biological and biological/chemical dosing processes will need to be considered with the final decision being made on the certainty of process performance and operation and maintenance costs. This decision should also be made in conjunction with BRC as it is important that BRC are comfortable with their ability to operate and maintain the final process selected.

10.2 Detail Design/Tender Documentation

Following process selection and process design which would include the preparation of Process and Instrumentation Diagrams (P&ID's) and the selection of the short list of contractors to participate in the early contractor involvement process, the detail design would proceed.

During the design process, workshops would be held with the shortlisted contractors to ensure they have input to the design process and are aware of the client's requirements with respect to the tender process and risk sharing. The intent of the early contractor involvement is to ensure:

- That the final designs are the most efficient from a constructability point of view,
- The contractors have no surprises when the final documents are actually issued as the intent of the documents with respect to risk sharing and requirements of the contractors will have been discussed in the workshops.

It is anticipated that the detail design could take in the order of 12 months. Towards the end of the detail design when detailed specifications have been prepared, contract documents would be drafted for submission to legal advisors for review prior to calling tenders.

Council approval will be required to call tenders for the construction contract.

11 Construction Contractor Selection

11.1 Contractor Selection

In parallel with the process selection and process design, Expressions of Interest would be called for interested contractors to register for the construction phase of this project. Selection of contractors would be based on non-price parameters such as previous experience in building plants of this nature, their record of commissioning wastewater treatment plants, proven record in relationship building with clients and designers as well as safety and environmental performance.

From the Expression of Interest three (3) contractors would be selected to participate in the early contractor involvement process.

Council approval is required for the engagement of the selected contractors.

11.2 Early Contractor Involvement

The selected contractors would be required to actively participate in the design process to ensure the construction phase of the project proceeds with minimal variations as most constructability issues should have been addressed as part of the early contractor involvement process. An independent facilitator is normally utilised to facilitate the workshops with an assessment made as to the participation of the contractors selected being part of the final contractor selection process. (For the Gin Gin and Thabeban plants BRC have engaged an independent facilitator.)

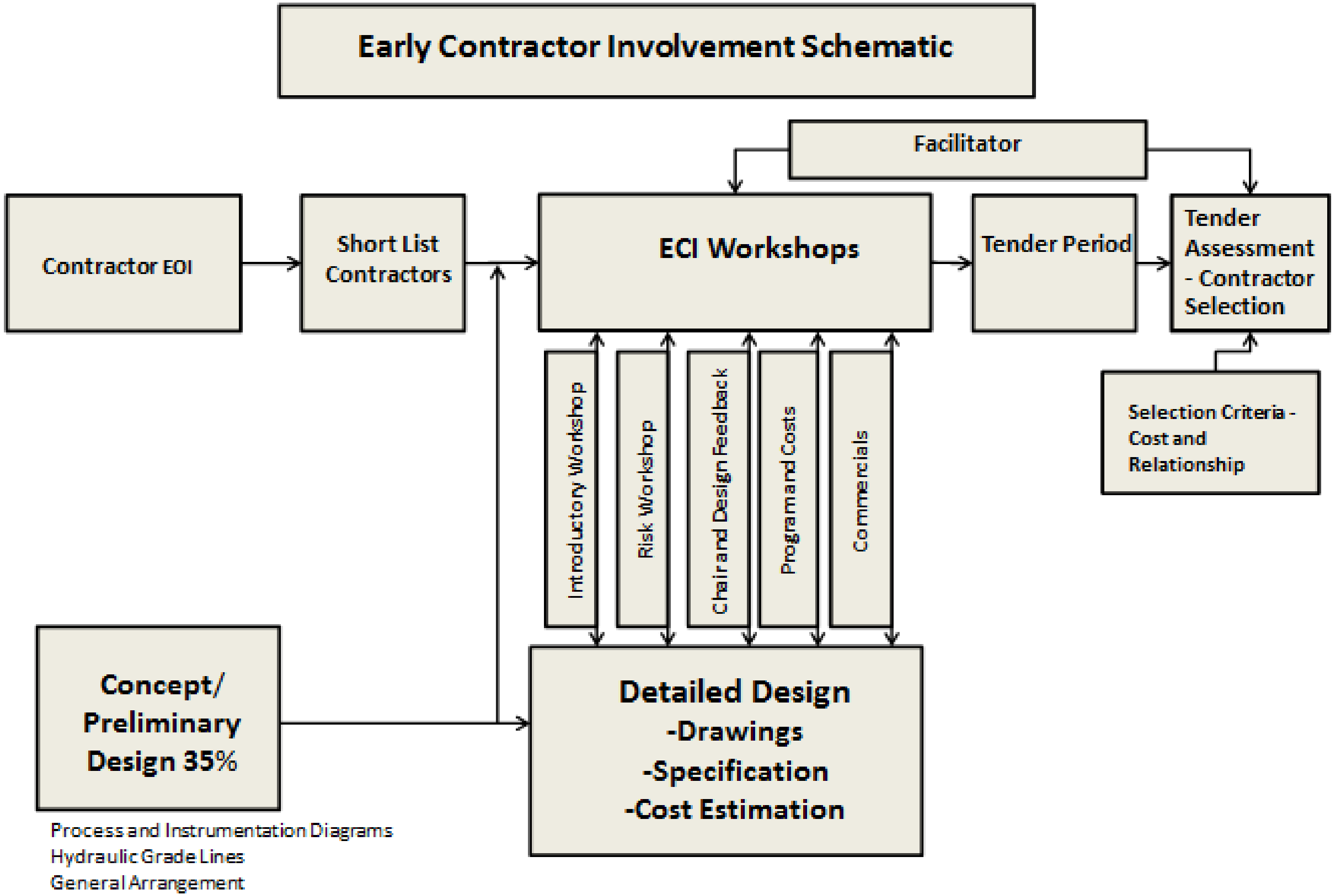
As a minimum the contractors will be required to participate in the following workshops:

- Introductory Workshop - where the agenda would include relationship management, expectations, design risk register program, project progress, design overview and contract form.
- Workshop 2 – the risk workshop where the agenda would include project risks, construction risks and risks versus costs.
- Workshop 3 – chair 2, 3 and design feedback which would include agenda items, contractors feedback from design overview, constructability, operability.
- Workshop 4 – program and costs where the agenda would include construction program, review of project costs.
- Workshop 5 – commercials with the agenda items being commercial risk/opportunity, key result areas, commercial terms and BCI closure.

A flow chart showing this process diagrammatically is shown in Figure 1.

To facilitate the early contractor involvement process the selected contractors would normally be paid a nominal amount for their participation. BRC have obtained legal advice from King & Co regarding this payment. Their opinion is that the shortlisted contractors can be treated as 'sole supplier' as they have been selected from the expression of interest process. Any payments can be made under the sole supplier provisions of the Local Government Act.

Figure 1 Early Contractor Involvement Schematic



To facilitate the early contractor involvement process the selected contractors would normally be paid a nominal amount for their participation. BRC have obtained legal advice from King & Co regarding this payment. Their opinion is that the shortlisted contractors can be treated as 'sole supplier' as they have been selected from the expression of interest process. Any payments can be made under the sole supplier provisions of the Local Government Act.

11.3 Award of Construction Contract

Tenders would only be called for construction from the contractors who had been selected to participate in the early contractor involvement process. An invitation to tender will only be made to those contractors that actively participated in the ECI process. This requirement should be an incentive to actively participate and will be scored by the Tender Assessment Panel.

Once tenders are submitted, selection of the preferred contractor should be relatively straight forward as one of the key considerations will be price. Having gone through a pre-selection process it would be difficult to eliminate a shortlisted contractor on other than price unless they had not actively participated in the workshops and provided feedback during the design and tender operation phases.

As such selection of the preferred tender will be based on price, quality and the relationship assessment as determined by the early contractor involvement process.

Council approval will required to award the construction contract.

12 Construction Contract Management

There are two main options available to Council to manage the construction contract:

- engage specialist construction project managers, eg consultants, or
- Council directly engage experienced construction project managers to manage the construction project.

12.1 Engage Specialist Construction Project Manager

A range of firms offer services in the field of construction project management. For this option, Council would need to prepare a brief detailing Council's requirements for project management of the construction project and then invite proposals from suitably qualified consultants. Proposals could be invited on an Upper Fee Limit basis and could include all staff necessary to be supplied by the consultant to project manage the construction contractor. Invited firms should be able to price these services based on their experience in this type of contract, knowing the likely duration of the contract term and knowing the type and number of experienced personnel that would be required in different phases of the project to include in their bid.

One advantage of this process is that Council has a defined fee for this part of the works. Council with this method of procurement would also have certainty that appropriate resources are being applied to the contract management task to ensure that the outcomes from Council's perspective are achieved.

The disadvantage to Council of this option is that it is another contractor working for Council that needs to be managed. In addition, Council would have to ensure that the project manager's brief clearly spells out Council's requirements otherwise the project manager may not actually deliver the outcomes that are in line with Council's long term objectives.

12.2 Council Staff Project Manage Construction Contractor

Rather than engage an external consultant, Council may consider hiring specialist construction project managers (on short term contracts) to manage the construction contract. This would be one way of having close alignment between Council and the construction project management.

If an external party is undertaking the construction project management it is important for BRC to embed council staff in this team particularly in the "Clerk of Works" role. That way there is an incentive for them to ensure a quality product (not just getting through to Practical Completion as quick as possible)

It may be possible that a combination of both methods are used by Council whereby a specialist contract project manager is engaged by Council with the project manager engaging other specialist staff through consultants to make up the full team that is required.

12.3 Recommended Method of Construction Project Management

A final decision on the method of construction project management is not required until the design process commences. Ideally the construction project manager should participate in the early contractor involvement process so that they are already part of the relationship building process and there is continuity of intent from the ECI process.

Based on the timeline in Appendix A this decision can be delayed until the same time as the decision on the Early Contractor Involvement shortlist which is to be completed by January 2014.

13 Council Project Management

Bundaberg Regional Wastewater Treatment Works is a major project for Council. It is important that the project is managed by Council throughout the entire process.

It is therefore important that Council appoint a project manager for the delivery of this project.

The project manager's role is to manage the process that has already commenced including engagement of consultants, managing timelines and ensuring Council's probity requirements and decision making rules are followed at all required steps during this project. Failure to appoint a project manager will inevitably result in delays to the project and could result in steps being overlooked leading to ultimate delays.

Council's project manager would also be responsible for managing communication issues related to this which is discussed in the next section.

The project manager would not be able to personally undertake all the tasks or have the time to manage all the different components of this work on their own but should have the ability to utilise other resources to undertake certain components of this overall program. The key objective would be to have an experienced project manager who can manage budgets, timelines, Council processes, community consultation and negotiations with a range of both regulators and consultants undertaking tasks for Council related to this project.

BRC intend to employ a project manager to undertake this key role. The advantages to BRC in employing the project manager include:

- Keeping control of the project in the local community,
- Ensuring that the treatment process selected is capable of being operated by BRC,
- Ensuring BRC's operational staff are fully involved throughout the design and procurement stages of the project to ensure their operability and preferred equipment issues are addressed.

14 Probity

Council already has in place procedures to ensure probity in its operations. Procedures exist in relation to engagement of contractors, consultants and gaining necessary Council approvals for these engagements. One of the roles of the project manager appointed by Council to manage this project would be to ensure that Council's probity procedures are in place for each step of this project. If Council's rules and procedures are followed then it would follow that probity issues will have been addressed throughout this project.

To ensure that probity issues are fully addressed for the procurement of the upgrades of the Gin Gin and Thabeban plants BRC have, in addition to their normal processes, utilised their External Auditor to ensure BRC's procedures are being followed.

If similar processes are put in place for the Regional Wastewater Treatment Plant procurement BRC consider that this will be sufficient to ensure that probity issues are appropriately addressed on this project.

15 Communication Plan

As the Regional Wastewater Treatment Works will be a major project for Council, there will be substantial interest in the project from the Council, community, local media and regulators on the progress and delivery of this project. A range of stakeholders will have an interest in this project and the stakeholders will change as the project progresses.

It is important that a communication plan is developed to ensure that timely and meaningful information is made available to the stakeholders. This would be a task that should be managed by the Council's project manager with support from experienced personnel as required.

The communication plan will be a live document that will evolve as the project develops. Relevant stakeholders will change as the project progresses as will the information that is required to be distributed to those stakeholders.

BRC have a Communication/Media officer who has already commenced preparation of a communications plan for this project. The draft communications plan is attached as Appendix B.

16 Required Council Decisions and Approvals

This project will require BRC's elected Council to formally approve a number of resolution type decisions and approval decisions throughout the life of the Project. Whilst these have been referenced within the main document this section summarises the decisions that the elected Council will be required to make with an indication as to when the decisions will be required;

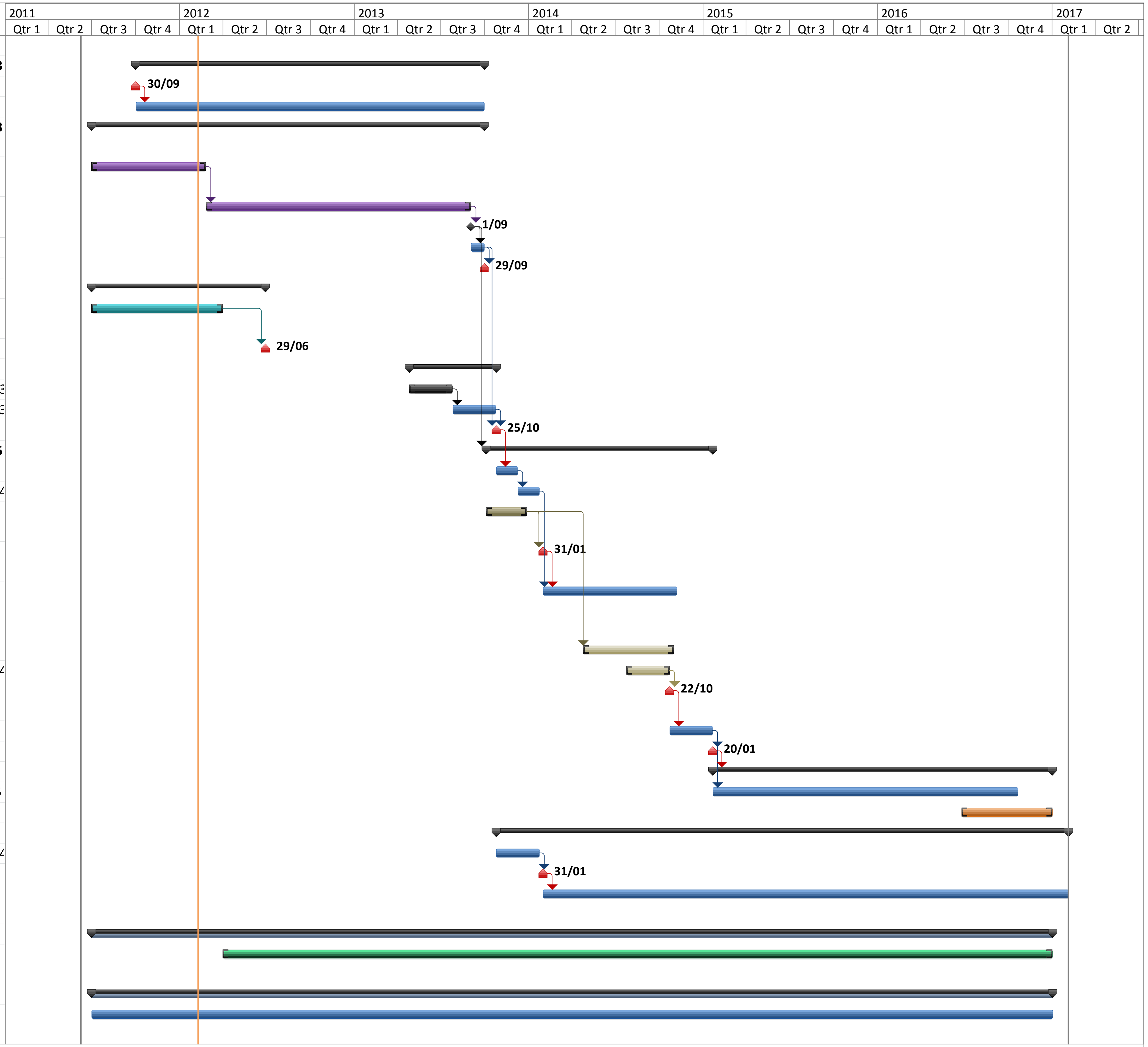
Table 2 Required Council Decisions and Approvals

Decision	Indicative Timeframe
Land Purchase for Regional Wastewater Treatment Plant	September 2011
Adoption of this Project Development Plan	June 2012
Approve Development Application for Regional Wastewater Treatment Plant	September 2013
Approve Engagement of Designer	October 2013
Approve Shortlist of Contractors from Expression of Interest	January 2014
Approve Engagement of Contract Projects Manager	January 2014
Approve Calling Tenders for Construction	October 2014
Approve Award of Construction Contract	January 2015

Note: These timeframes are indicative based on the target for Regional Wastewater Treatment Plant being constructed and commissioned by the end of 2016.

Appendix A – Procument Program

ID		Task Mode	Task Name	Duration	Start	Finish
1						
2			**Land Procurement**	**730 days**	**Fri 30/09/11**	**Sun 29/09/13**
3			Council Approval	0 days	Fri 30/09/11	Fri 30/09/11
4			Land Acquisition	730 days	Sat 1/10/11	Sun 29/09/13
5			**Development Application**	**822 days**	**Fri 1/07/11**	**Sun 29/09/13**
6			DA Application Preparation to DERM	239 days	Fri 1/07/11	Fri 24/02/12
7			DA Consultation	555 days	Sat 25/02/12	Sun 1/09/13
8			DA Certainty	0 days	Sun 1/09/13	Sun 1/09/13
9			DA Final Approval	28 days	Mon 2/09/13	Sun 29/09/13
10			Council Approval	0 days	Sun 29/09/13	Sun 29/09/13
11			**PDP**	**364 days**	**Fri 1/07/11**	**Fri 29/06/12**
12			Project Delivery Plan Prep	274 days	Fri 1/07/11	Fri 30/03/12
13			Council Approval	0 days	Fri 29/06/12	Fri 29/06/12
14			**Designer Selection**	**182 days**	**Fri 26/04/13**	**Fri 25/10/13**
15			Designer Brief	90 days	Fri 26/04/13	Wed 24/07/13
16			Designer Selection	90 days	Fri 26/07/13	Wed 23/10/13
17			Council Approval	0 days	Fri 25/10/13	Fri 25/10/13
18			**Design**	**474 days**	**Fri 4/10/13**	**Tue 20/01/15**
19			Process Selection	45 days	Fri 25/10/13	Sun 8/12/13
20			Process Design	45 days	Mon 9/12/13	Wed 22/01/14
21			ECI Contractor Shortlist	85 days	Fri 4/10/13	Fri 27/12/13
22			Council Approval of Contractors	0 days	Fri 31/01/14	Fri 31/01/14
23			ECI Detailed Design/Document Prep	280 days	Fri 31/01/14	Thu 6/11/14
24			Legal input	190 days	Fri 25/04/14	Fri 31/10/14
25			Tender Prep	90 days	Fri 25/07/14	Wed 22/10/14
26			Council Approval to call	0 days	Wed 22/10/14	Wed 22/10/14
27			Tender Award	90 days	Thu 23/10/14	Tue 20/01/15
28			Council Approval	0 days	Tue 20/01/15	Tue 20/01/15
29			**Construction**	**711 days**	**Wed 21/01/1**	**Sat 31/12/16**
30			Construction	639 days	Wed 21/01/1	Thu 20/10/16
31			Commissioning	190 days	Sat 25/06/16	Sat 31/12/16
32			**Contract PM**	**1198 days**	**Fri 25/10/13**	Fri 3/02/17
33			Selection	90 days	Fri 25/10/13	Wed 22/01/14
34			Council Approval	0 days	Fri 31/01/14	Fri 31/01/14
35			Contract Project Management	1100 days	Fri 31/01/14	Fri 3/02/17
36			**Overall Project PM**	**2012 days**	**Fri 1/07/11**	**Sun 1/01/17**
37			Project Manager / Facilitator	1738 days	Sat 31/03/12	Sun 1/01/17
38			**Communication Plan**	**2012 days**	**Fri 1/07/11**	**Sun 1/01/17**
39			Communication/Med Officer	2012 days	Fri 1/07/11	Sun 1/01/17



Project: Bundaberg PDP Timeline
Date: Thu 9/02/12

Task		Summary		External Milestone		Inactive Summary		Manual Summary Rollup		Finish-only
Split		Project Summary		Inactive Task		Manual Task		Manual Summary		Deadline
Milestone		External Tasks		Inactive Milestone		Duration-only		Start-only		Progress

Appendix B – Communication Plan

Communications Plan – Wastewater Treatment Plant

Event: Bundaberg Regional Council's new Wastewater Treatment Plant will cater for growth in the Bundaberg and coastal areas for the next 50 years. While Council has only committed to build the regional plant now, it will be large enough by Stage 2 to receive sewerage from the coast.

Objectives – Step 1 – Document signed by Bundaberg Sugar

1. To allay fears of nearby residents regarding smell, visual aspect and wind direction.

2. To outline the benefits of the new Plant for the region as "good news for all".

3. To clarify to coastal residents that this is the first stage of a long-term Strategy that may provide for sewerage in their areas in the future

Task	Objective	Action	Contact Person	Desired Outcome	Date
Contract of Sale/Council Report	Confirmation of project going ahead	To be voted on at Council Meeting Signing of contract	Andrew Fulton Tom McLaughlin David Gill Peter Byrne	Adopted at Council Meeting	Completed – 5 September Completed 0 6 September
Fact Sheet	To inform nearby residents and general public of project Q & A to be included	To be produced ready to be posted to residents and handed out at Media Conference, Council Centres etc. To be included on double sided sheet	Trish Mears David Gill Trish Mears	Fact Sheet to be posted to households, available at Service Centres and on website Review Fact Sheet and see what is required.	Completed. Completed
Community Engagement – Announcement of project	Ensure residents are included/engaged – provide information – explain benefits	Personalised letter to nearby residents. Invitation to meet with residents.	Tom McLaughlin David Gill Trish Mears	Residents have all the facts and a contact person they can liaise with	Completed
Media Coverage on the day	Positive coverage – opportunity to explain the benefits	Media alert to go out Thursday 8 Sept Media release handed to all media on the day and emailed to those who couldn't attend.	Trish to send out Media Alert and follow up media Trish	Positive publicity in all media about progressive nature of project Full information to media and therefore public	Completed.
Website	Full information to go on website	Fact Sheet, Map and Media release featured	Trish Mears Helen Ricciardi	Public fully informed	Completed

		in special section: Rubyanna Regional Wastewater Treatment Plant			
Council Centres	Public to easily receive information	Fact Sheet to be printed out and sent to all Centres	Lenore Hanks	Public fully informed	Completed
Community Consultation	Allay public's fears	Councillors to attend RM Public Meeting 23/9. Fact Sheet and Q & A to be available for people	 Trish Mears	 Correct information to be available	Completed
State and Federal Member Briefing	State and Federal Members to be fully briefed	Meeting – 10am Friday 30/9 in Committee Room All information prepared for them to look at.	Trish Mears Andrew, Tom, David, Mayor etc	Members supportive	Trish emailed all members 20/9 – completed. Completed
Information Sessions	Public to be fully aware	Tentative dates: 7pm – 9pm Thursday 13/10 9am – 12 noon Saturday 15/10 Kalkie School Hall (tbc)	Cr Batt to source contact for School	Public fully informed	Completed
Consultative Committee	Stakeholders to meet and form group	Submissions called and members selected and notified			Completed
Community Reference Group		Chair appointed (Angela Williams)	David Gill Trish Mears		First meeting to be held 13.2.12

Appendix C – Mt St John Fact Sheet

Mount St John Water Purification Plant (Townsville)

The Mount St John Water Purification Plant (WPP) is a good example of a fast tracked design. It took just over twelve months to deliver the design from strategy finalisation through to completion of detail design. HWA in conjunction with AECOM was commissioned by Townsville City Council (TCC) to undertake detailed investigations and design for the $189 million Townsville Wastewater Upgrade Program (WUP).

The project was required to be delivered in a tight time frame to meet Council's commitment to high growth of the catchment and DERM's requirements. With the amalgamation of Townsville and Thuringowa Councils there was a need to review each Council's individual wastewater upgrade strategies with a view to providing an integrated vision for the future. A centralised strategy was adopted which reduced the number of plants from five to two representing a saving of $70 million to TCC.

A key component in the timely and successful delivery of the design was the incorporation of an Early Contractor Involvement (ECI) or Early Tenderer Involvement (ETI) phase prior to the issue of the tender documents. The objectives of this phase were to:

- Provide prospective contractors with a comprehensive overview of the design, contract documentation and site specific issues that would have a bearing on their ability to accurately price the project.
- Establish and foster relationship building between the owners, designers and contractors.
- Provide feedback from the contractors to the designer on constructability issues with the design and examine opportunities for innovation.
- Examine the risks associated with the construction and allocate these accordingly.
- Identify early works that could proceed to minimise the impacts of the wet season.

The process involved calling Expressions of Interest (EOI) and shortlisting three contractors/consortiums to participate in the ECI phase. The phase was broken into 5 discrete workshops:

1. Introductory Workshop (2 days) – The first day consisted of an overview of the design, contract documentation, cost estimate, program and proposed early works. The second day focussed on relationship management fundamentals.
2. Risk Workshop – This workshop focussed on discussing and allocating project risks, construction risks, and determining guidelines for assessing the cost impacts of the risks.
3. Constructability and Operability Review Workshop – This workshop focussed on obtaining contractors' feedback on the design and undertaking a NSW Workcover CHAIR 2/3 (Construction Hazards Assessment and Implication Review) assessment of constructability and operability/maintainability issues.
4. Program and Cost Review Workshop – This workshop consisted of investigating innovative ways of meeting the program through construction staging and early works.
5. Commercial Workshop – This workshop was held with individual contractors to allow confidential discussion on the costing of risk, key result areas (KRAs) and any issues with commercial terms prior to the tender phase.

Outcomes

The project was delivered significantly under the budget and after allowing for the delays due to Cyclone Yasi, on schedule.

Significant contributions from all ECI participants were observed throughout the process, with general endorsement of the process by all parties.

Confirmation of the success in communicating the design to all parties was evident in the low spread of final tender prices which were far lower than the pre-tender estimate.

Practical Completion was achieved by the date specified in the contract.

The construction firm, Baulderstones, adopted the “relationship and quality” philosophy to contracting very well and achieved an outstanding result on workforce safety with 1 million hours of construction work done without a lost time injury.

Variations under the contract were just over 5% of the contract sum.

Commissioning of the completed plant proceeded smoothly with the required effluent quality being produced earlier than anticipated.

Appendix F

Approvals Planning Report

Bundaberg Regional Council
10 April 2012
Document No. 60221597

Rubyanna Wastewater Treatment Plant

Approvals Planning Report

Rubyanna Wastewater Treatment Plant

Approvals Planning Report

Prepared for

Bundaberg Regional Council

Prepared by

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ABN 20 093 846 925

10 April 2012

60221597

AECOM in Australia and New Zealand is certified to the latest version of ISO9001 and ISO14001.

Quality Information

Document Rubyanna Wastewater Treatment Plant

Ref 60221597

Date 10 April 2012

Prepared by Kylie Grusning

Reviewed by Sonya Bryce

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	22-Sep-2011	Final Copy	Michael Puntil Principal Engineer	Original previously signed
B	31-Oct-2011	Revised Final Copy	Michael Puntil Principal Engineer	Original previously signed
C	10-Apr-2012	2nd Revised Final Copy	Michael Puntil Principal Engineer	

Table of Contents

1.0 Introduction

Bundaberg Regional Council (BRC) is proposing to construct a 90,000 EP Wastewater Treatment Plant (WWTP) at Rubyanna. The joint team of Hunter Water Australia Pty Ltd (HWA) and AECOM Australia Pty Ltd (AECOM) were engaged by BRC to assist Council with the preparation of supporting and developmental approval documentation for the project.

The purpose of this draft approvals planning report is undertake a desktop assessment to determine environmental and planning constraints and opportunities for the development of a new Wastewater Treatment Plant. This approvals strategy outlines the following:

- which approvals may need to be obtained for which components of proposed work; and
- a strategy for obtaining approval and identification of agencies that will be involved.

1.1 Background

BRC intends to sign an option contract with Bundaberg Sugar to enable BRC to purchase a proposed site for the Rubyanna WWTP located off Rubyanna Road, Rubyanna within a two year period. The site being considered is Lot 1 RP57605 and is 100 hectares (Ha) in size with 90 Ha to be leased back to Bundaberg Sugar on a 30 year lease for growing sugar cane that will be irrigated with recycled water. The contract with Bundaberg Sugar includes the option to purchase an additional smaller parcel of land, Part Lot 6 RP 204880, located to the west of the 100 Ha lot, which has also been identified by BRC as a possible site for WWTP infrastructure. A map of the aforementioned lots can be found in **Appendix A** of this report. The lots are currently zoned as rural with the larger lot extensively cultivated under cane with a bitumen road access. Access to the smaller lot will need to be gained most likely through an easement over the larger lot connecting to Barrons Road / Rubyanna Road.

BRC intends to construct a 90,000 Equivalent Persons (EP) Wastewater Treatment Plant (WWTP) in two stages. Stage 1 will accommodate a 50,000 EP with Stage 2 increasing capacity to 90,000 EP, which will result in the decommissioning of a number of existing treatment plants that are at capacity. This project forms part of a recently adopted Regional Strategy for wastewater treatment areas east of Bundaberg City. The objectives of this strategy will be to remove the existing outfall discharge to the Burnett River from the Bundaberg East plant and from the Bundaberg North plant which do not have sufficient capacity to handle the expected growth in the region and are unable to meet current effluent quality discharge limits.

In addition to supporting the urban growth of Bundaberg, the regional plant at Rubyanna will also support population growth in the coastal areas of Bargara Beach, Coral Cove and Elliot Heads which are currently served by treatment plants that discharge into the ocean or by household septic tanks. The current regional strategy proposes that sewage from these areas that cannot be treated by the existing coastal treatment plants will be sent to the proposed regional treatment plant at Rubyanna.

Elements associated with establishment of the new centralised Rubyanna WWTP are:

- construction of a new Regional Wastewater Treatment in two stages;
- close the current 30,000 EP plant at East Bundaberg;
- divert sewage from East Bundaberg via an underground rising main to the first stage (50,000 EP) of the regional plant;
- close the current outfall to the Burnett River from the eastern plant;
- establish a new underground outfall to the Burnett River for the new regional plant (see **Appendix B**); and
- undertake initial consultation with interest groups and adjoining property owners.

It should be noted that this planning approvals advice for the project covers the Rubyanna WWTP site location, new outfall pipeline to Burnett River and raw sewage rising main from East Bundaberg WWTP only (refer to **Appendix A** and **B**). It does not include an assessment of the decommissioning of any existing WWTP's nor any required pump stations outside of the proposed Rubyanna site.

2.0 Planning Considerations

The proposed project footprint is covered by two planning schemes namely the Burnett Shire Planning Scheme and Bundaberg City Plan.

2.1 Burnett Shire Planning Scheme 2006 (Local)

The Burnett Shire Planning Scheme 2006 sets out the land use constraints for development for this project. The purpose of the Planning Scheme is to identify impact assessment, assessable, self-assessable and exempt development and the outcomes sought to be achieved in the area as a context for assessing development.

Zoning under the Planning Scheme

Under the Planning Scheme the proposed Rubyanna WWTP location, raw sewage rising main and outfall pipeline routes pass through land that is zoned as 'Rural'. Construction of the WWTP, raw sewage rising main and outfall pipeline would require a planning approval for material change of use (MCU). The undertaking of an environmentally relevant activity (ERA) will also trigger a MCU.

Under Part 4 – Division 2 of the Planning Scheme, a wastewater treatment plant is defined as a public utility. The Rubyanna area is in the Burnett Shire Planning Scheme – Rural Planning Areas 8 & 9 and under the assessment code for the rural areas, a public utility undertaking is considered to be impact assessable. All of these rural planning areas are in a declared catchment area. Subject to the final location of the actual plant infrastructure there may be implications from Planning Scheme overlays relating to dominant wetlands, flood storm tide and coastal storm tide risk, potential salinity and acid sulphate soils on the Burnett River side of Rubyanna. An impact assessable application under the Planning Scheme will follow the path of the IDAS flowchart shown in **Appendix C** of this report and include a public notification stage. As the proposed project triggers an impact assessment, the assessment manager can apply the entire Planning Scheme in their assessment.

Schedule 6 of the SPA Regulations implies that because a MCU is triggered under the Planning Scheme, the assessment manager will be Council for both the Planning Scheme MCU and the environmentally relevant activity (ERA) MCU. The MCU under the Planning Scheme and the MCU for the ERA will be components of a single application.

Reconfiguration of a lot may be triggered by this project. For reconfiguration of a lot, under Part 4 – Division 2 – Table 4.4 of the Burnett Planning Scheme, reconfiguration of a lot can be code assessable, impact assessable or exempt depending on whether the project involves realigning a boundary, creating an access easement and the number of lots configured. Reconfiguration of Part Lot 6 RP204880 would be required for the project if this land is required. The reconfiguration of a lot does require assessment of access to the lot from a road. If Part Lot 6 does not intend to or is unable to secure its own access as part of the subdivision, easements will need to be secured if it is intended that access to Part Lot 6 RP204880 will be through the larger lot (Lot 1 RP57605).

There is an exemption under SPA regulation Schedule 4 Table 4 for operational works by or on behalf of a public sector entity that cannot be declared to be a development of a particular type (i.e. exempt, self assessable , code etc) by a planning scheme, temporary local planning instrument, master plan etc. Therefore any operational works undertaken by Council would be exempt from assessment against the planning schemes.

Overlays of the Planning Scheme

Under the Burnett Planning Scheme, in terms of interpreting the level of assessment required as a result of the zone and overlay provisions, the highest level of assessment will apply. Given that the rural zone already requires an impact assessable process for a MCU for a public utility, the various overlay codes requirements as well as all aspects of the Planning Scheme as relevant will need to be addressed in the design and subsequent development application, but will not alter the level of assessment (refer to Table 1).

Table 1 Assessment of the Burnett Shire Planning Scheme Overlays

<table>
<tr><th>Overlay</th><th>Trigger for Project Area</th><th>Comment</th></tr>
<tr><td>Soil Resources and Extractive Resources</td><td>Good quality agricultural land – A and good quality agricultural land – B</td><td>This overlay seeks to retain Class A and B land for cropping by ensuring that other uses do not reduce the productive capacity of the land, or do not conflict with surrounding land uses unless there is an overriding public benefit.</td></tr>
<tr><td>Water Resources and Biodiversity (WRB 1.8 to 1.9)</td><td>Declared groundwater area</td><td>This overlay seeks to protect land condition by preventing inappropriate land uses and managing impacts of development to ensure there are no significant adverse influences on groundwater quality.</td></tr>
<tr><td>Natural Hazard Areas: Bushfire Prone Areas</td><td>Low bushfire risk</td><td>The overlay provides a range of probable solutions to mitigate bush fire risk in medium and high bushfire hazard areas.</td></tr>
<tr><td>Natural Hazard Areas: Flood Storm Tide Risk Area</td><td>Left boundary of Lot 1 on RP 57605 (possible effluent storage lagoons) are located in a flood area between 0.25 – 2.00 m depth. The respective raw sewage rising main and outfall pipeline traverse a flood prone area of between 0.75 and >5.00 m deep.</td><td rowspan="2">These overlays seek to ensure that:
- development maintains the safety of people on premises from all floods up to the defined flood event (DFE) and storm tide events;
- access to premises is maintained during the DFE or storm tide event;
- development complies with the Planning Scheme’s stormwater management policy;
- development does not result in adverse impacts on people’s safety or the capacity to use land for its intended purpose within the flood/storm tide area;
- proposed works do not reduce any on site flood capacity or flood characteristics of the property
- development minimises the potential damage from flood or storm tide to the property;
- public safety and the environment are not adversely affected by detrimental impacts of floodwater or storm tide on hazardous materials manufactured or stored in bulk.</td></tr>
<tr><td>Natural Hazard Areas: Coastal Storm Tide Risk Area</td><td>The northern boundary of the proposed WWTP site (Lot 6 on RP204880) is located within a storm tide risk area of between 2.5 m and 5.0 m AHD. The respective raw sewage rising main and outfall pipeline will traverse a portion of land ((buried at depth) designated as a storm tide risk area between 0.0 m and 5.0 m AHD.</td></tr>
</table>

Overlay	Trigger for Project Area	Comment
Natural Hazard Areas: Potential Salinity, Landslide Hazard and Acid Sulfate Areas	The raw sewage rising main will traverse soils in certain areas at 5 m Australian Height Datum (AHD). The same location is also mapped as a potential salinity hazard area. The outfall pipeline crosses several places mapped at 5 m AHD.	There is potential for acid sulphate soils (PASS) within this area. The adoption of appropriate management strategies during construction of the raw sewage rising main will negate this risk and it is not considered a constraint for the siting of the rising main.

2.2 Bundaberg City Plan

The *Sustainable Planning Regulations 2009*, Schedule 4 provides that operational works undertaken by or on behalf of a public sector entity is "Development that cannot be declared to be development of a particular type" and therefore is not assessable development.

The connection of the proposed rising main to the existing WWTP is considered to be part of the land use activity currently being undertaken onsite, not increasing scale and intensity, and therefore does not require approval.

2.3 Draft Wide Bay Burnett State Planning Regulatory Provisions 2010 and the Draft Wide Bay Burnett Regional Plan

The draft regulatory provisions and regional plan were publicly notified on 1 October 2010 with a potential completion date of mid-2011, however the documents have not commenced at the time of writing this report. The Bundaberg office of the Department of Local Government and Planning has advised that the finalised regional plan is due out this year. Section 317(1) of the *Sustainable Planning Act 2009* states that an assessment manager may give weight to a planning regulatory document that was enacted after a development application was received. In this regard, the draft regional plan is addressed below.

The *Draft Wide Bay Burnett State Planning Regulatory Provisions 2010* is a statutory document that is applied in addition to the applicable planning scheme(s) and supports the regional plan (regardless of whether draft or enacted). Section 16(2) of the *Sustainable Planning Act* 2009 (SPA) provides that "A *State planning regulatory provision* includes a draft State planning regulatory provision that under section 73 has effect as a State planning regulatory provision."

The regional plan and regulatory provisions classify the land in the region into three categories and apply strategies and preferred outcomes accordingly. The proposed development is situated on land defined in the documents as Regional Landscape and Rural Production Area (RLRPA).

The proposed development consists of infrastructure that will benefit the local community. The proposed infrastructure will support the growth of Bundaberg and ultimately the nearby coastal towns by enabling the decommissioning of ineffective wastewater treatment plants and household septic tanks. The proposed infrastructure will support the preferred settlement pattern shown in the *Wide Bay Burnett regulatory map, August 2010, Map WBB RP 8*, being situated between the eastern outskirts of the city of Bundaberg and the coastline.

The proposed development will see a reduction in the current concentrations of nitrogen and phosphorous released to the Burnett River, a decrease in the number of outfalls and decommissioning of household septic tanks in coastal areas. Water recycled from the proposed development will be used to irrigate sugar cane grown on the property when conditions are conducive. The development supports the draft regional plan's efforts to improve and protect the environment and natural resources.

The proposed development will trigger only 'Division 3 – Subdivision' of the regulatory provisions. Table 3A within Division 3 supplies the criteria for subdivisions in the RLRPA, by meeting any of the criteria in the table a subdivision will meet the land use intent for the RLRPA. Criteria 6(b) of Table 3A states that a subdivision of one additional lot for the purposes of accommodating a water cycle management facility is applicable criteria. SPA provides in its definition of 'development infrastructure' that water cycle management infrastructure includes providing infrastructure for sewage. This does not negate approvals that are required at a local and potentially State or Federal level.

2.4 *Sustainable Planning Act* 2009 (State)

The *Sustainable Planning Act* 2009 (SPA) is the main piece of State legislation that provides the framework for planning and development assessment.

For the proposed development under SPA, BRC has the option of applying for a designation of community infrastructure, a planning scheme amendment (to rezone the land) or development approvals to legitimise the proposed Rubyanna project. There are short term and long term benefits and disbenefits to the respective options which are discussed in section 10 of this report.

SPA also provides for the creation of state planning policies which prescribe the type of development appropriate in areas at the local, regional and state scale, respectively. Relevant State Planning Policies for the project are outlined below:

State Planning Policy 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide

The purpose of this State Planning Policy (SPP) is to ensure that certain development considers the three natural hazards to enable the protection of life, property, the economy and the environment. This SPP will apply to the project as it is partially located within an area potentially affected by flood waters (please see Table 1 above).

State Planning Policy 1/92: Development and the Conservation of Agricultural Land

This SPP addresses the conservation of good quality agricultural land and provides guidance to local authorities on how this matter should be addressed. This SPP is likely to apply to the project given the overlays in the area.

State Planning Policy 2/02: Planning and Managing Development Involving Acid Sulphate Soils

SPP 2/02 Planning and Managing Development Involving Acid Sulfate Soils is triggered if the works are assessable under the SPA and will involve excavation of 100 m^3 or more of soil or sediment and/or will involve placement of more than 500 m^3 of spoil at an average depth of 0.5 m or greater. Acid sulphate soil has been mapped as occurring in the rising main alignment and is likely to apply to execution activities.

Draft State Planning Policy: Protecting Queensland's Strategic Cropping Land

When enacted, this SPP will operate together with SPP 1/92 (see above 'SPP 1/92: Development and the Conservation of Agricultural Land') to promote the sustainable use of agricultural lands. This policy will apply as the project is located on good quality agricultural land and development will be required to achieve the policy outcome.

2.5 *Environmental Protection Act* 1994 (State)

Under the *Environment Protection Act 1994* certain activities are identified as environmentally relevant activities (ERAs) and must be undertaken in accordance with a licence issued by an assessment authority through the integrated development assessment system (IDAS). The responsible entity for assessing applications for licences under IDAS is determined in the *Sustainable Planning Regulation 2009*. Table 2 provides a list of ERAs that are or may be applicable to the project site.

Table 2 Identified ERA Relevant to the Project Site

Environmentally Relevant Activities	Permit / Application Trigger	Approval Required/Comments
55 – Regulated waste recycling or reprocessing	Regulated waste recycling or reprocessing consists of operating a facility for receiving, and recycling or reprocessing, regulated waste to produce saleable products	Possibly. The proposed biosolids handling on-site could trigger this ERA.
63 – Sewage treatment	Sewage treatment consists of— (a) operating 1 or more sewage treatment works at a site that have a total daily peak design capacity of at least 21EP; or (b) operating a sewage pumping station with a total design	Yes

Environmentally Relevant Activities	Permit / Application Trigger	Approval Required/Comments
	capacity of more than 40KL in an hour, if the operation of the pumping station is not an essential part of the operation of sewage treatment works to which paragraph (a) applies.	

Contaminated Land

These are activities that have been identified as being likely to cause contamination and are listed as notifiable activities in Schedule 3 of the *Environmental Protection Act 1994* (EPA). Table 3 identifies two notifiable activities as potentially occurring on the project site once operational.

Table 3 Potential Notifiable Activities for the Project

Notifiable Activities	Permit / Application Trigger	Approval Required/Comments
29. Petroleum product or oil storage-storing petroleum products or oil- (a) in underground tanks with more than 200L capacity; or (b) in aboveground tanks- (i) for petroleum products or oil in class 3 in packaging groups 1 and 2 of the dangerous goods code-more than 2500L capacity; or (ii) for petroleum products or oil in class 3 in packaging groups 3 of the dangerous goods code-more than 5000L capacity; or (iii) for petroleum products that are combustible liquids in class C1 or C2 in Australian Standard AS 1940, 'The storage and handling of flammable and combustible liquids' published by Standards Australia-more than 25 000L capacity.	This will depend on the amount of petroleum utilised and storage requirements onsite.	Yes. Ethanol will be stored in underground tanks consisting of ~ $10m^3$ or ~20kL. Diesel in the region of 4kL will also be contained on site.
37. Waste storage, treatment or disposal-storing, treating, reprocessing or disposing of regulated waste (other than at the place it is generated), including operating a nightsoil disposal site or sewage treatment plant where the site or plant has a design capacity that is more than the equivalent of 50 000 persons having sludge drying beds or on-site disposal facilities.	The WWTP would be designated as a centralised facility to receive biosolids from BRC's existing WWTPs.	Yes. Initially the proposed WWTP will cater to 50,000EP and ultimately 90,000EP.

Under the Environmental Protection Act, landowners and local government must inform the Department of Environment and Resource Management that land has been or is being used for a notifiable activity. Land that has been or is being used for a notifiable activity is recorded on the Environmental Management Register, which is maintained by the Department. Searches of the register for the lots in the proposed project footprint will be undertaken for the impact assessment phase.

3.0 Flora and Fauna Matters in the Project Area

Both the Commonwealth and Queensland Governments seek to regulate activities that have, or are likely to have, an impact on threatened species and communities, including species habitat. Desktop searches provided in **Appendix D** were undertaken of both Commonwealth and Queensland listings of protected species for the project area.

3.1 *Environment Protection and Biodiversity Conservation Act* 1999 (Commonwealth)

The *Environment Protection and Biodiversity Conservation Act 1999*) (EPBC) is one of the key Commonwealth pieces of legislation for protection of the environment. A search of the EPBC Protected Matters Search Tool of the project area including a buffer area of 1 km revealed the potential for the following species or their habitat that are recognised as matters of national environmental significance (NES) to occur within the area.

Table 4 Threatened Species Potentially Occurring Within the Project Area

Species Name	Common Name	EPBC Status	Migratory
Botaurus poiciloptilus	Australasian Bittern	Endangered	-
Erythrotriorchis radiatus	Red Goshawk	Vulnerable	-
Rostratula australis	Australian Painted Snipe	Vulnerable	-
Turnix melanogaster	Black-breasted Button-quail	Vulnerable	-
Neoceratodus forsteri	Australian lungfish	Vulnerable	-
Chalinolobus dwyeri	Large-eared Pied Bat, Large Pied Bat	Vulnerable	-
Nyctophilus timoriensis (South-eastern form)	Greater Long-eared Bat, South-eastern Long-eared bat	Vulnerable	-
Pteropus poliocephalus	Grey-headed Flying fox	Vulnerable	-
Xeromys myoides	Water Mouse, False Water Rat	Vulnerable	-
Caretta caretta	Loggerhead Turtle	Endangered	Migratory
Chelonia mydas	Green Turtle	Vulnerable	Migratory
Delma torquate	Collared Delma	Vulnerable	-
Dermochelys coriacea	Leatherback Turtle, Leathery Turtle, Luth	Endangered	Migratory
Egernia rugosa	Yakka Skink	Vulnerable	-
Eretmochelys imbricata	Hawksbill Turtle	Vulnerable	Migratory
Furina dunmali	Dunmall's Snake	Vulnerable	-
Lepidochelys olivacea	Olive Ridley Turtle, Pacific Ridley Turtle	Endangered	Migratory
Natator depressus	Flatback Turtle	Vulnerable	Migratory
Cycas megacarpa	-	Endangered	-
Cupaniopsis shirleyana	Wedge-leaf Tuckeroo	Vulnerable	-
Phebalium distans	Mt Berryman Phebalium	Critically Endangered	-
Taeniophyllum meulleri	Minute Orchid, Ribbon-root Orchid	Vulnerable	-

Species Name	Common Name	EPBC Status	Migratory
Apus pacificus	Fork-tailed Swift	-	Migratory
Ardea Alba	Great Egret, White Egret	-	Migratory
Ardea Ibis	Cattle Egret	-	Migratory
Lamna nasus	Porbeagle, Mackerel Shark	-	Migratory
Haliaeetus leucogaster	White-bellied Sea-Eagle	-	Migratory
Hirundapus caudacutus	White-throated Needletail	-	Migratory
Hirundo rustica	Barn Swallow	-	Migratory
Merops ornatus	Rainbow Bee-eater	-	Migratory
Monarcha melanopsis	Black-faced Monarch	-	Migratory
Monarcha trivirgatus	Spectacled Monarch	-	Migratory
Myiagra cyanoleuca	Satin Flycatcher	-	Migratory
Rhipidura rufifrons	Rufous Fantail	-	Migratory
Gallinago hardwickii	Latham's Snipe, Japanese Snipe	-	Migratory
Nettapus coromandelianus albipennis	Australian Cotton-Pygmy-goose	-	Migratory
Rostratula benghalensis s. lat	Painted Snipe	Vulnerable	Migratory

The majority of the project area footprint is under cane and is mapped by the Queensland Government as containing non-remnant vegetation (see **Appendix D** – Environmental Searches). The outfall pipeline is contained entirely within an existing road reserve, as is a large amount of the proposed raw sewage rising main.

Where the proposed raw sewage rising main is on private land it traverses two watercourses. These watercourses are ephemeral and meander through cane fields where there is very limited riparian vegetation.

The outfall pipeline terminates at the Burnett River noted as containing EPBC listed species e.g. Australian lungfish. The Burnett catchment is also known to provide habitat for the Black-breasted button quail.

Confirmation of the likelihood of the presence of listed threatened species and ecological communities will be verified by a field survey and an assessment of any proposed impacts will be undertaken.

3.2 *Nature Conservation Act* 1992 (State)

The *Nature Conservation Act 1992* (NCA) is administered by the Queensland Parks and Wildlife Service, a division of the Department of the Environment and Resource Management (DERM). The Act includes the management of protected areas, protected declared wildlife (plants and animals) and wildlife habitat; and regulates the taking and use of wildlife. The Act and associated subordinate legislation provide legislative protection of all native species and in particular those considered to be endangered, vulnerable, near threatened or least concern.

A search of the DERM's Wildlife Online from the centre point of the WWTP site including a 2.5 km buffer revealed one plant species as near threatened (ie. *Actephila sessilifolia* - hillslope vine thicket). Essential habitat for *Crinia tinnula* (Wallum froglet) identified as vulnerable under the NCA, was mapped outside of the project footprint but in a nearby watercourse which would be traversed by the proposed sewage rising main.

Table 5 Threatened Species under the NCA Potentially Occurring within the Rubyanna WWTP Site

Species Name	Common Name	NCA Status
Actephila sessilifolia	Hillslope vine thicket	Near Threatened
Crinia tinnula	Wallum froglet	Vulnerable (essential habitat only)

A further search was conducted from the point of the outfall with a buffer of 5.0 km to identify any marine species in the vicinity. Several species were mapped within 5 km of the point the outfall pipeline terminates and are identified in Table 6 below. A single plant species was identified as potentially occurring within 5km of the outfall point, the remaining eight species are birds including several migratory species.

Table 6 Threatened Species under the NCA Potentially Occurring in the vicinity of the outfall

Species Name	Common Name	NCA Status
Accipiter novaehollandiae	Grey goshawk	Near Threatened
Actephila sessilifolia	Hillslope vine thicket	Near Threatened
Ephippiorhynchus asiaticus	Black-necked stork	Near Threatened
Esacus magnirostris	Beach stone-curlew	Vulnerable
Haematopus fuliginosus	Sooty oystercatcher	Near Threatened
Lophoictinia isura	Square-tailed kite	Near Threatened
Numenius madagascariensis	Eastern curlew	Near Threatened
Sternula albifrons	Little tern	Endangered
Tadorna radjah	Radjah shelduck	Near Threatened

There are three activities under the NCA which may potentially occur as a result of the proposed project.

1. The taking or interfering with protected native plants and animals – this is triggered for clearing native plants on land owned by the State. In this case, this would only apply to road reserves and Lot boundary watercourse crossings. An initial desktop assessment of aerial photos suggests that there is a low risk that native plants will be impacted by proposed rising main and WWTP infrastructure, but this will be confirmed following a field survey. Should clearing be required, then a clearing permit under NCA would need to be approved. Conditions on clearing permits tend to require applicants to replant areas of native plants post work completion.

2. Removing or relocating wildlife– if protected wildlife is found within a project area or in vegetation that will be cleared, it will need to be captured and relocated safely. Whilst the likelihood of needing to relocate species is low, this could occur anywhere in the project location and at any stage of the works, with access to the site during construction. An assessment of fauna habitat will be undertaken during the flora survey, which includes habitat for the Wallum froglet.

3. Tampering with an animal breeding place – interference with an animal's breeding place will trigger this permit approval. While this is not likely to be an issue from a desktop assessment, this approval requirement will be confirmed following a fauna survey.

There are 12 listed introduced species that may potentially occur in the project area. Both *Asparagus africanus* and *Celtis sinesis* (Chinese elm/Chinese celtis) are declared as a class 3 pest under the *Land Protection (Pest and Stock Route Management) Regulation 2003*. The 'Declared plant of Queensland' Fact Sheet (produced by the Department of Employment, Economic Development and Innovation) determines that a "Declared A Class 3 pest is one that is commonly established in parts of Queensland but its control by landowners is not deemed to be warranted unless the plant is impacting, or has the potential to impact, on a nearby 'environmentally significant area' (e.g. a national park)."

There are no Weeds of National Significance (WoNS) listed as potentially occurring in the project area.

3.3 *Vegetation Management Act* 1999 (State)

Regional Ecosystem's (RE) have been mapped as occurring within and adjacent to the project area (see **Appendix D**). The RE's relevant to this project are found in the vicinity of:

- the road reserve where the raw sewage rising main is to be installed along the eastern bank of the Burnett River, and
- to the west of the site of the proposed WWTP and outfall pipeline (ie. Lot 1 RP 57605).

Construction of the WWTP and raw sewage rising main may require the removal of vegetation which is controlled under the *Vegetation Management Act 1999* (VMA). Under the VMA, remnant vegetation is protected and across the State has been mapped as belonging to a specific type of RE which has different conservation status.

Table 7 Mapped Regional Ecosystem that potentially occurs within and adjacent to the Project Area

Regional Ecosystem Type	Occurrence	VM Act Status	Biodiversity Status	Where
12.1.3 Estuarine wetlands (e.g. mangroves). Mangrove shrubland to low closed forest on marine clay plains and estuaries (N.B. marine plants are regulated by the *Fisheries Act 1994*)	Occurs on Quaternary estuarine deposits.	Least Concern	No Concern at present	To west of WWTP site and outfall route.
12.8.13 Complex notophyll vine forest	Occurs on Cainozoic igneous rocks, especially basalt<600m altitude.	Least Concern	No Concern at present	Adjacent to western boundary of Lot RP57605 and to the south west of Lot RP57605 on watercourse.

The raw sewage rising main traverses land designated as both freehold and road reserve (i.e. local roads). Under the SPA, clearing of native vegetation on freehold, indigenous land, or a road is code assessable. The only clearing of mapped vegetation, which may be required as part of this project, is in road reserve. An exemption for the clearing of native vegetation exists that is pertinent to the road reserve. The SPA Regulation 2009 in Schedule 24, part 2, 5(1)(ii) states that native vegetation in the road reserve can be removed if it is in an urban area and is shown on the regional ecosystem map or remnant map as a least concern regional ecosystem. **Appendix D** contains a regional ecosystem map that shows the RE's in question for this project as a least concern regional ecosystem.

Any clearance permits and offset provisions under the VMA for the WWTP, outfall pipeline and raw sewage rising main are considered unlikely as any clearance of vegetation would occur within the road reserve. It should be noted however, that some of the lots outside the project area has essential habitat designations for Wallum's froglet in the least concern RE.

Any proposed clearing of mapped REs would need to be ground-truthed to ensure that it is correctly mapped as remnant and therefore assessable under the VMA. RE mapping across the State has largely been undertaken using aerial photography.

Should any environmental permitting associated with the need to obtain a vegetation clearing permit under the existing legislation be required, a two stage process applies that may take between 3 and 6 months to obtain and does not include any time that may be needed to acquire any offsets. This is not foreseen as occurring for the project at this stage.

4.0 Water Considerations

Parts of the project area are located in the flood plain of the Burnett River. The proposed raw sewage rising main route traverses two mapped watercourses. Disturbance to the beds and banks of watercourses and interference with flows are regulated through the *Water Act 2000* and creating waterway barriers through the *Fisheries Act 1994*.

4.1 *Water Act* 2000 (State)

Construction of any works associated with the wastewater treatment plant that are for the purpose of interfering with overland flow are declared under the *Water Regulations 2002* to be assessable as the proposed project is situated within the Burnett Basin Catchment Area.

The proposed project at this stage will not require the diversion or infilling of any watercourses, nor will there be a requirement to redirect overland flow.

For works undertaken in a watercourse which require removal of vegetation and/or the placement and excavation of fill, a guideline for activities in a watercourse, lake, or spring carried out by an entity must be abided to otherwise a riverine protection permit under the Water Act 2000 will be required.

4.2 *Water Regulation* 2002 (State)

The Rubyanna area is in an overland flow moratorium area. Works that interfere with but are not built with the intention of capturing overland flow water (such as fences, roads and flood mitigation structures) may be applicable.

4.3 *Water Resource (Burnett Basin) Plan* 2000

The water resource plan seeks to ensure the sustainable management and use (taking) of surface waters and groundwater is included where a groundwater management area is declared. The project area is included within the Coastal Burnett Groundwater Management Area. As this proposed project does not require the taking of ground or surface water, assessment against this water resource plan is not required.

4.4 Water Quality Improvement Plans (Burnett / Baffle)

The Burnett-Baffle Water Quality Improvement Plan (WQIP) has an overall aim to manage the reduction of pollutant loads entering waterways within the Burnett-Baffle area and to guide the achievement of water quality objectives required to protect the environmental values for these resources. The proposed project will assist in improving water quality in the Burnett River as it will require the decommissioning of older, lesser performing WWTPs, reuse recycled water (where possible) as irrigation, and any discharge to the river will be of a higher quality.

4.5 Recommendations

- All construction works should seek to minimise interference with the banks and beds of watercourses and to minimise disturbance to watercourses where possible.
- Construction works should be undertaken during the dry season to minimise impacts.

5.0 Cultural Heritage and Native Title

5.1 Indigenous and European Cultural Heritage

A search of the Queensland Heritage Register and Burnett Shire Planning Scheme did not reveal sites within the project area. For indigenous cultural heritage much of the proposed WWTP location and raw sewage rising main alignment has been disturbed by sugar cane farming however a number of sites may exist that are significant to the Port Curtis Coral Coast traditional owners in the project footprint area. Traditional Owners are to be consulted on cultural heritage matters on confirmation of the disturbance footprint.

5.2 Native Title

The *Native Title Act 2003* stipulates the notification requirements for traditional owner representatives for works occurring on land where native title has not been extinguished. Native title may apply to the following areas within the project area footprint, road reserves and other state land such as where the outfall pipeline terminates as well as boundary watercourses.

6.0 *Coastal Protection and Management Act* 1995 (State)

Works within a coastal management district, as defined under the *Coastal Protection and Management Act 1995* (Coastal Act), are assessable as operational work under the SPA. The Coastal Act also establishes the State Coastal Management Plan (2002), which then establishes the framework for regional coastal management plans.

The State Coastal Management Plan (2002) and the Regional Coastal Management Plan establish policies with which development in the coastal management district, triggering assessment under the SPA must comply. There is no Regional Coastal Management Plan applicable to the project area. The provisions of the repealed *Beach Protection Act 1968* regarding erosion prone areas and coastal management control districts that were previously designated are therefore taken to be the transitional or interim coastal management district.

A review of the 2002 State Coastal Management Plan has been undertaken by the Queensland Government and a new Queensland Coastal Plan is due for release at the end of October 2011. The new Queensland Coastal Plan includes a State Planning Policy (SPP) Coastal Protection which aims to protect the coastal resources of the coastal zone by setting out criteria for land use planning, coastal activities and development assessment. The new Queensland Coastal Plan will supersede regional coastal management plans and the existing State Coastal Management Plan.

The new Queensland Coastal Plan mapping associated with the draft Plan places Lot 1 on RP57605 (100 Ha lot) within the Coastal Zone but not the Coastal Management District (the Coastal Management District CMD). A final CMD must be made by a regulation upon commencement of the new Queensland Coastal Plan and therefore these maps are to be treated as being indicative at this stage.

The smaller lot that BRC has the option of purchasing, being Part Lot 6 on RP204880, is within both the Coastal Zone and the CMD. Both lots are outside the Indicative Erosion Prone Area. Any development within the Coastal Zone, the CMD or the Erosion Prone Area requires assessment against the SPP Coastal Protection to ensure it is consistent with the SPP's principles, policies and code unless the proposed development is a public benefit asset. A public benefit asset includes a sewage treatment plant. A public benefit asset is considered under the SPP to be "Acceptable circumstances for not fully achieving the policy". Nevertheless the public benefit asset is expected to be able to achieve the outcomes of the SPP to the fullest extent practicable.

Under section 109 of the Coastal Act "…a development application for reconfiguration of a lot situated completely or partly within a coastal management district" may attract a condition of approval that requires surrender of part of the land (that is proposed for reconfiguration). Section 110 of the Coastal Act provides that the surrender may be required only if:

(a) the chief executive is satisfied the land should be surrendered for coastal management; and

(b) the land is—

  (i) in an erosion prone area; or

  (ii) within 40 m of the foreshore; and

(c) the Minister approves the inclusion of the land surrender condition.

The proposed project will also trigger an application for Prescribed Tidal Works under the Coastal Act as the proposed outfall will discharge into the Burnett River which is tidal at that point.

7.0 *Land Act* 1994 (State) – Resource Entitlement

This Act applies to any structure or activity occurring over State owned land, including land below the high water mark. Confirmation is being sought of land tenure for the land that the proposed outfall pipeline crosses (at the boat ramp off Strathdees Road) just prior to the point of discharge into the Burnett River. The point of discharge in the Burnett River is likely to be State land and would trigger a requirement for resource entitlement from DERM. The assessment period for resource entitlement is approximately 90 days and not statutory. Resource entitlements would also be required for lot boundary watercourses and works in road reserves.

8.0 Existing Services Considerations in the Project Area

Major services that occur in the area include Sunwater channels and electrical distribution network infrastructure. Consultation should be undertaken with Ergon Energy regarding the location of future power poles and the capacity needs of the WWTP so that electrical infrastructure can be timely provided.

9.0 Proposed Approvals Strategy

Benefits and disbenefits of the approvals path options for the project are presented below.

Table 8 Benefits and disbenefits of proposed approvals pathways

	Benefit	Disbenefit
Community Infrastructure Designation (CID)	- The CID process exempts community infrastructure development from assessment against the local planning scheme. ie. Under section 203 of SPA: *Development under a designation is exempt development, to the extent the development is either, or both, of the following—* *(a) self-assessable development, development requiring compliance assessment or assessable development under a planning scheme;* *(b) reconfiguring a lot.* - Greater certainty in approval outcome using CID guideline for assessment and consultation process. - Preferred process when multiple planning schemes are traversed by the proposed infrastructure. - Appeals to the 'designation of land' decision have a low chance of succeeding in court.	- A lengthy approvals process (12-18 months minimum) to gain designation over the land required through ministerial sign off. - The Minister must be satisfied that an adequate environmental assessment and public consutlation in carrying out the environmental assessment has taken place before deciding on a designation. SPA, section 207(3) details the mechanisms to ensure that these requirements are fulfilled (see section 9.1 below). - An Environmentally Relevant Activity permit and other state approvals will still be required through the IDAS process.
Development Approvals (Material Change of Use, Reconfiguration of a Lot, Environmentally Relevant Activity, Prescribed Tidal Works)	- In comparison to the other two options, incurs the shortest timeframe (especially if all approval applications are lodged at the same time and no appeals made). - Preferred process if relatively straightforward project with support from agencies, stakeholders, landholders and community ie. no expected major opposition to the project.	- Objections may be obtained from the community during the processing of the development application (public notification stage) creating time delays. - A decision notice (the outcome of the development application processing) can be appealed which can hold up or even derail the project. - Compliance issues may be highest for this option during life of operation (ie. community concerns will call up the conditions of the approval for scrutiny). - Not recommended if expecting substantial opposition to project.

	Benefit	Disbenefit
Planning Scheme amendment (to rezone the land for a public utility)	- Council could rezone the land to make the public utility land use activity an 'as of right activity'.	- A major planning scheme amendment can take years to enact. It will also be dependent on support from the State Government as to whether they would allow an amendment to an existing scheme if a new planning scheme is going to be developed in the near future. - An Environmentally Relevant Activity permit will still be required and other State approvals may be required.

A further option exists for Council that is a combination of the options tabled above. Under SPA, Local Government authorities must update their planning schemes "...to reflect the new Queensland Planning Provisions when their scheduled review becomes due" (Department of Local Government and Planning website). BRC can opt to reflect the land use activity approved by the MCU in the new Planning Scheme, thereby securing the land use rights in the long term and making future development assessments simpler and faster. Preparing a new Planning Scheme will take 3+ years once a Local Government decides to commence the process.

Alternatively, the existing Planning Scheme can be amended under SPA to rezone the land to reflect the MCU approval. If there has been adequate State and public consultation a minor amendment could be sought which takes approximately 3 – 12 months to have enacted (this includes Council preparation and State Government involvement). In order to enable a minor amendment to proceed there must be a current development approval and the Minister must be satisfied that adequate public and State consultation has been undertaken. The proposed development subject to this report triggers an impact assessable development application which necessitates public consultation. Consultation with the State is required through approvals and licences required for this development to proceed, however it is not known at this stage whether the State agencies required for approval and licences will be those required to be consulted for an amendment. If Council or the Minister believe that the consultation is inadequate a major amendment could be requested which can take upwards of a year.

9.1 Community Infrastructure Designation Process

Land to be designated must pass a public benefit test to ensure the designation is justified. For example, the designating minister or local government must be satisfied that the community infrastructure will contribute to environmental protection or ecological sustainability, or satisfy community expectations for the efficient and timely supply of infrastructure.

A minister, before designating land must also be satisfied that for development, there has been adequate environmental assessment, including adequate public consultation, and also adequate account of issues raised in the public consultation. One way in which the requirements for adequate environmental assessment and public consultation may be met is for the assessment of the proposed development to be carried out in accordance with Guidelines provided by the Department of Local Government and Planning (under section 760 of SPA). The community infrastructure designation flowchart of the process based on these Guidelines is shown in Appendix C. The guidelines provides a number of steps to ensure key issues are addressed during project planning and involves producing reports and undertaking consultation with stakeholders and the wider community.

These steps are:

1. Preparation of an Initial Assessment Report (IAR)

   The IAR is a detailed study of the entire proposed project footprint investigating environmental, social, economic and technical aspects of the project.

2. Initial consultation with stakeholders

   The IAR is released for consultation during which time appropriately made submissions are made commenting on the IAR. The period within which a properly made submission can be made is a minimum of

15 days. The guideline states that the IAR should be at a minimum provided to the relevant local government, public sector entities and other parties that are identified as in step 1 of this process as concerned parties.

3. Preparation of a Final IAR

   The IAR will be updated to account for issues raised in the first round of consultation - any changes made to the proposed project footprint will be outlined in this report.

4. Second consultation with stakeholders

   The Final IAR will be released for a second round of public consultation; appropriately made submissions can be made commenting on the Final IAR. This step requires notification in a newspaper, as well as notice to the land owners and other parties identified in step 2, with a submission period for a minimum of 15 days.

5. Preparation of a Final Assessment Report (FAR)

   The Final Assessment Report - which forms the basis for the request for Community Infrastructure Designation – will need to include a copy of all submissions received.

   Incorporate any changes arising from public consultation, a summary of submissions made, public sector and local government views and a statement of any matters to be included in the designation.

6. Final Assessment Report (FAR) submitted to the Minister

   The FAR is submitted for consideration under the Sustainable Planning Act 2009. The Minister will identify:

   - matters for consideration prior to designation;
   - if the designation is to occur, will provide notice to the land owner, local government and the chief executive;
   - if designation is not to proceed, will provide notice the parties identified above.

A designation ceases after six years if it has not been acted upon, for example, if construction of the community infrastructure has not started, or a notice of intention to resume the land has not been given, etc. Notwithstanding, a minister may give a local government written notice reconfirming a ministerial designation.

9.2 IDAS Process

SPA establishes the Integrated Development Assessment System (IDAS) (**Appendix C** contains an IDAS flowchart) which provides a framework for the assessment of proposed development in Queensland. The act classifies development into four categories:

1) Material Change of Use (MCU);
2) Reconfiguration of a lot;
3) Building work;
4) Operational work.

For the Wastewater Treatment Plant both an MCU and reconfiguration of a lot will be required:

Table 9 IDAS Activities Applicable to the Project

IDAS Activity	Permit/Application Trigger	Approval Required
Material Change of Use (MCU)	This approval is required under the Burnett Shire Planning Scheme and is the lead approval.	Yes. Impact assessable.
Reconfiguration of a Lot (RoL)	Under the Burnett Planning Scheme, reconfiguration of a lot can be code or impact assessable depending on the access, site boundaries and number of lots configured. This will be required for Lot 6 on RP 204880.	Yes. Impact assessable.

IDAS Activity	Permit/Application Trigger	Approval Required
Environmentally Relevant Activity (ERA)	See section 2.5 of this report.	Yes. The application for an ERA is submitted with the MCU and RoL applications.
Prescribed Tidal Works	See section 6.0 of this report.	Yes. Works within the tidally influenced portion of the Burnett River.
State Planning Policy's (SPP)	Various SPP apply to this proposed project, further information can be found in section 2.4 and section 6.0 of this report.	Dependent on the SPP. It is likely all the SPP in section 2.4 and section 6.0 will be applicable, however several of the SPP are draft at present and timing of the development application will be the deciding factor.
Interference with overland flow	*Water Regulation 2002* (see section 4.2 of this report).	It is not expected the proposed project will interfere with overland flow, but is possible if works are undertaken in the wet season.

The impact assessable application should address the actual and potential requirement for further permits placed on the proposed project from other pieces of legislation such as:

Table 10 Requirements for further approvals

Activity	Permit/Application Trigger	Approval Required
Notifiable activities – storage of petroleum product, and regulated waste handling/disposal	Under the *Environmental Protection Act 1994*, Schedule 3 (see section 2.5 of this report).	No approval as such but DERM must be informed of notifiable activities occurring on a site.
Removal of vegetation, fauna habitat and removing or relocating fauna	*Environmental Protection and Biodiversity Conservation Act 1999*, *Vegetation Management Act 1999*, *Water Act 2000* and *Nature Conservation Act 1992.*	Potentially. Further investigation is required, however the proposed project will avoid native vegetation wherever possible.
Native Title	*Native Title Act 2003.*	Notification requirements under this Act may be required.
Resource Entitlement	*Land Act 1994*	Yes, wherever the proposed project is required to cross over State land.

The IDAS process has four stages applicable for an impact assessable application. Time periods for the approval strategy will be in accordance with SPA. For an application involving public notification, request of information and IDAS referral agencies, these stages include the:

1) Application stage;
2) Information and referral stage;
3) Notification stage;
4) Decision stage.

In the information and referral stage, an applicant responds to concurrence agencies as soon as all requests for information (RFI's) have been responded to and copies produced to the assessment manager. In the notification stage, notification can start if there are no RFI's from concurrence agencies at the end of the last notification period from the information and referral stage.

When an application is lodged, the assessment manager will determine whether the application is properly made. Supporting documentation such as evidence of resource entitlement should be in place before lodgement, otherwise the application may not be considered properly made. This will cause delays in assessment of the application. It is therefore the intent that the application for resource entitlement be lodged to DERM as soon as possible.

The IDAS timeline for assessment of a properly made impact assessable application is up to thirty eight weeks (this does not cover response by the applicant to RFI's or any agreement by either party to extend the timeframe). **Appendix C** contains an IDAS flowchart which details the time requirements for each stage of the process.

Closure of offices over the holiday period of December and January needs to be factored in to any timeframes, the IDAS specifically mentions that public notification is not to occur between 20 December and 5 January (inclusive of both days).

A spreadsheet is attached in **Appendix C** that provides indicative timeframes for both the designation and IDAS processes. This enables a comparison of the expected time each process takes.

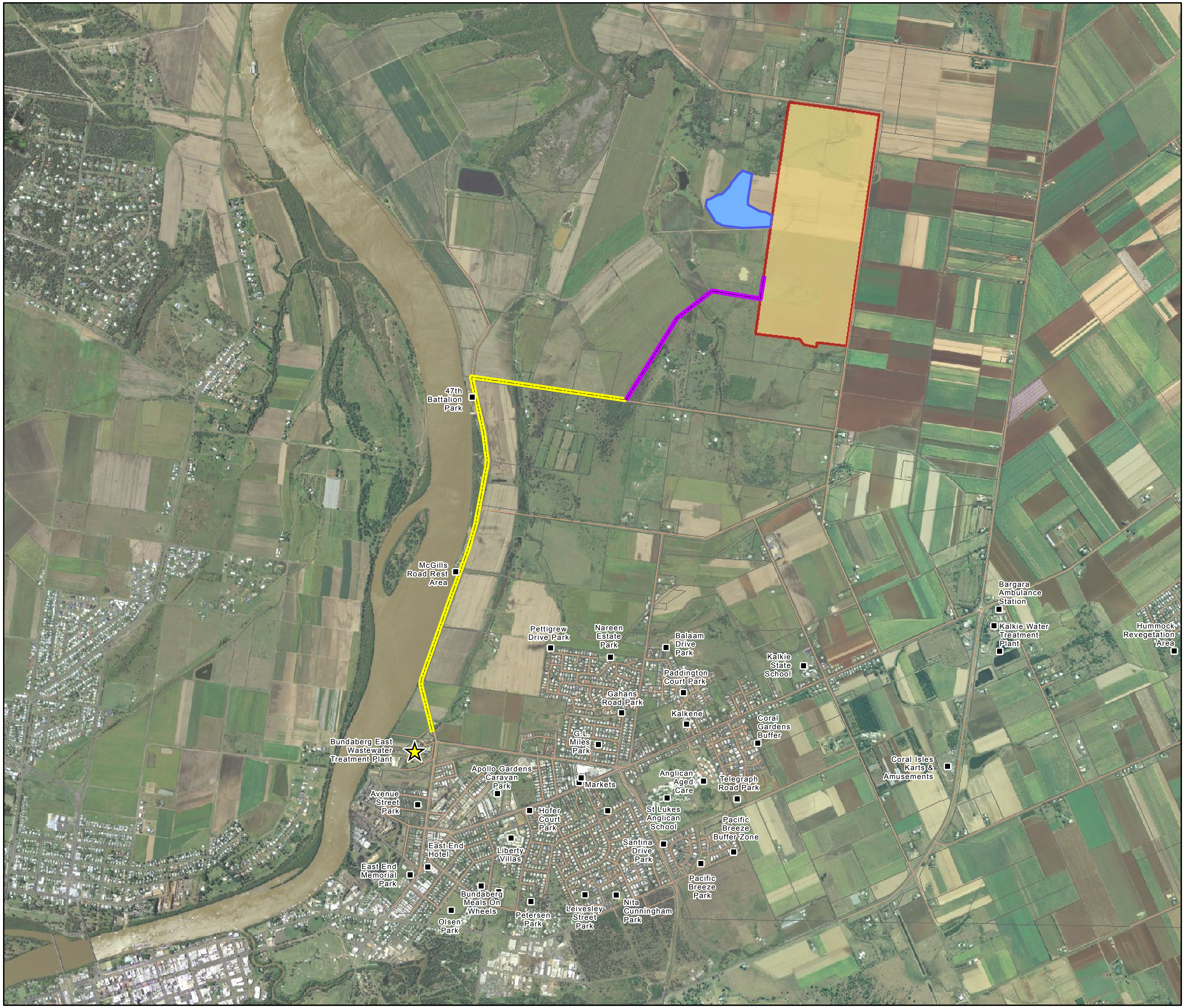
10.0 Next Steps

The following steps are recommended as a path forward for the proposed wastewater treatment plant in terms of environmental and planning considerations:

1) confirm and sign off of the approvals pathway with Council;
2) continue liaison with the approval agencies, including DERM, on project status and findings;
3) undertake scoping of the impact assessment work to support the approvals documentation as soon as possible. Environmental Impact Study completed by end of December 2011;
4) Resource Entitlements sought as soon as possible (submission of REs to DERM by end of October 2011);
5) Approvals application lodged with BRC by end of January 2012.

Appendix A

Map showing the proposed STP location and Rising Main from Bundaberg East



RUBYANNA STP DEVELOPMENT APPROVALS

Proposed Rising Main from Bundaberg East

Figure 01

Legend

- Localities
- Bundaberg East Wastewater Treatment Plant
- Roads
- Possible STP Site (approx16.7ha)
- Lot 1 RP57605 (108.6 ha)
- Cadastre

Approximate Alignment : Raw Sewer Rising Main

- Freehold
- Road Reserve

N

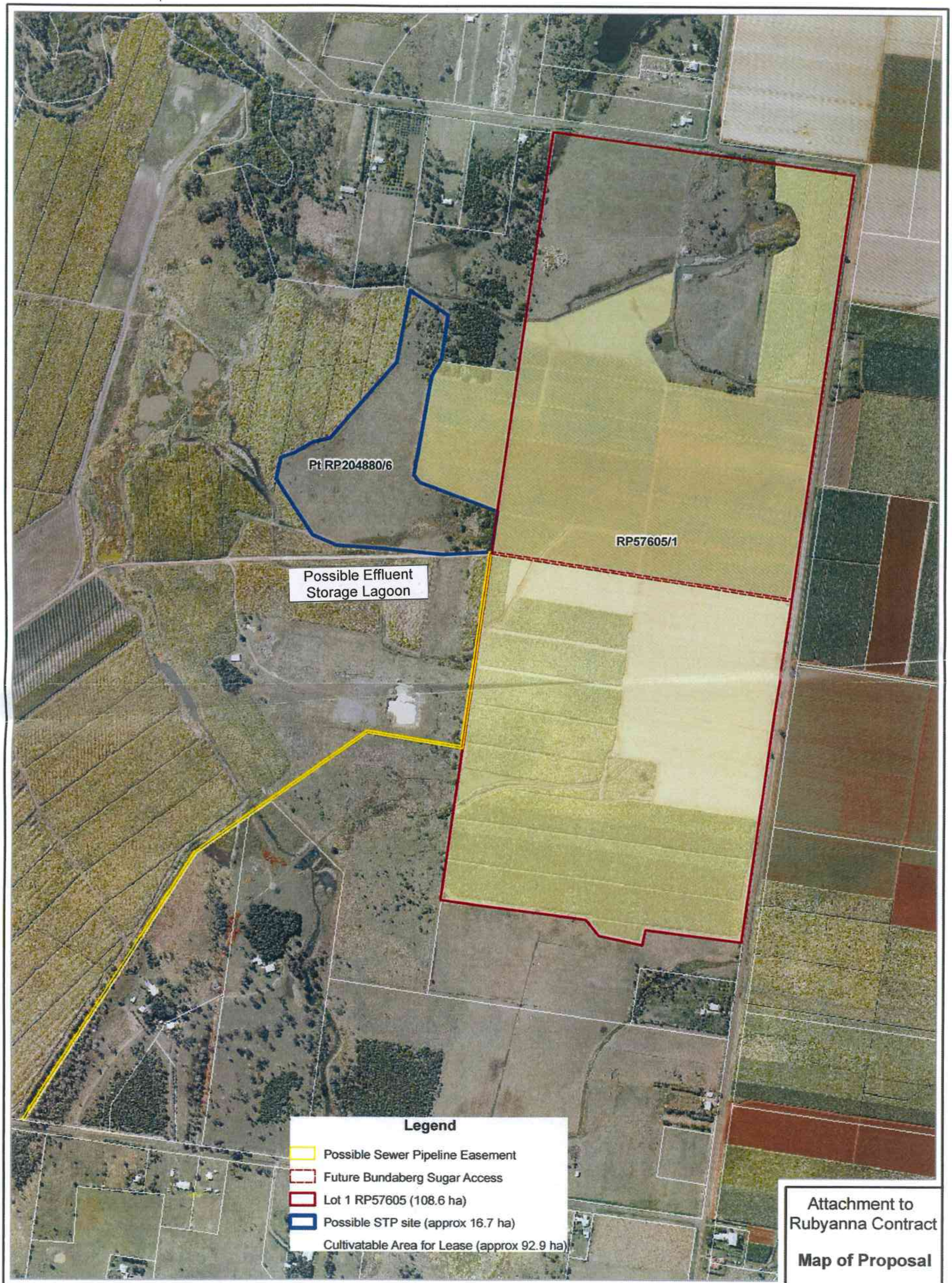
Scale: 1:25,000 (when printed at A3)

0 250 500 1,000
Metres

PROJECT ID 60221597
LAST MODIFIED CFS 23-Aug-2011
FILE NAME 60221597_ENV_001

Data Supplied by Bundaberg Regional Council 2011.
Approximate Alignment - Sewer Pipeline was determined from aerial. This alignment should not be used for construction.
Possible STP site and Lot Lot 1 RP57605 (108.6 ha), were derived from supplied .pdfs from Bundaberg Regional Council 2011

Recieved by hand. David Gill 4/8/2011



N

Scale 1:7,500 on A3 Sheet

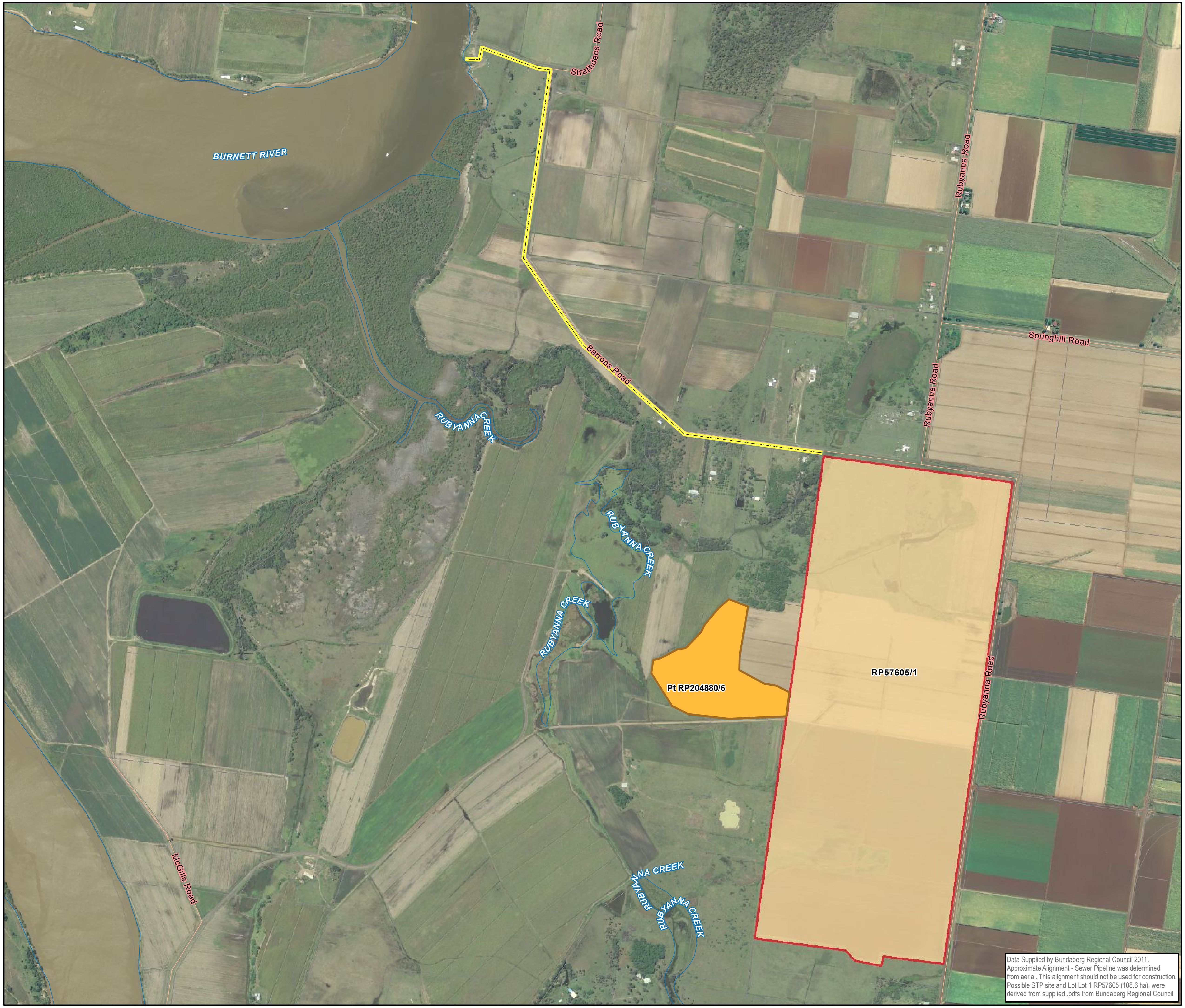
BUNDABERG REGIONAL COUNCIL

Appendix B

Map showing Outfall Main from Rubyanna Sewage Treatment Plant

RUBYANNA STP DEVELOPMENT APPROVALS

Outfall Main from Rubyanna STP



Legend

- Possible STP Site (approx16.7ha)
- Lot 1 RP57605 (108.6 ha)

Approximate Alignment : Raw Sewer Rising Main

- Road Reserve

N

Scale: 1:12,000 (when printed at A3)

0 110 220 440

Metres

PROJECT ID 60221597

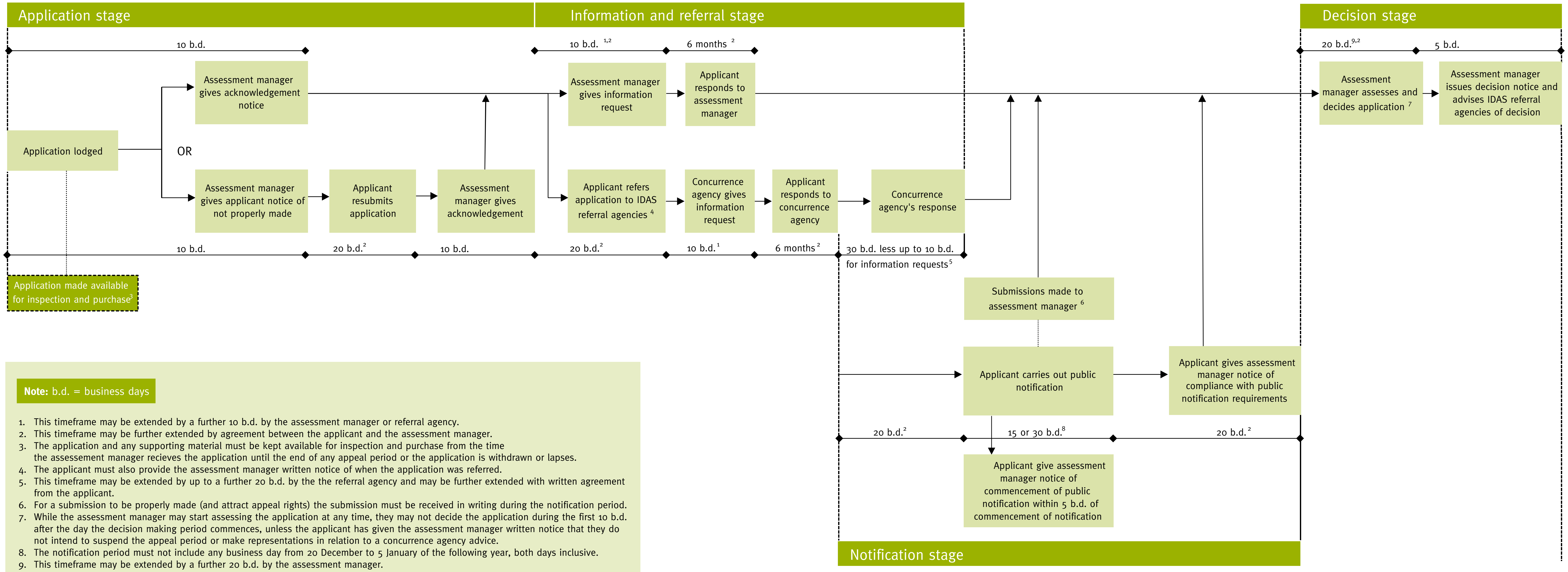
LAST MODIFIED dxe 07-SEPT-2011

FILE NAME 60221597G_ENV_02

Appendix C

IDAS Flowchart, Community Infrastructure Designation Flowchart and Indicative Timeframes Spreadsheet

For application involving: public notification, information request, IDAS referral agencies



Note: b.d. = business days

1. This timeframe may be extended by a further 10 b.d. by the assessment manager or referral agency.
2. This timeframe may be further extended by agreement between the applicant and the assessment manager.
3. The application and any supporting material must be kept available for inspection and purchase from the time the assessment manager recieves the application until the end of any appeal period or the application is withdrawn or lapses.
4. The applicant must also provide the assessment manager written notice of when the application was referred.
5. This timeframe may be extended by up to a further 20 b.d. by the the referral agency and may be further extended with written agreement from the applicant.
6. For a submission to be properly made (and attract appeal rights) the submission must be received in writing during the notification period.
7. While the assessment manager may start assessing the application at any time, they may not decide the application during the first 10 b.d. after the day the decision making period commences, unless the applicant has given the assessment manager written notice that they do not intend to suspend the appeal period or make representations in relation to a concurrence agency advice.
8. The notification period must not include any business day from 20 December to 5 January of the following year, both days inclusive.
9. This timeframe may be extended by a further 20 b.d. by the assessment manager.

Qplan

FLOWCHART SUMMARISING STEPS FOR ENVIRONMENTAL ASSESSMENT AND CONSULTATION

Step 1: Initial assessment report

Description–
of site attributes;
existing use;
adjoining uses;
socio-economic characteristics;
nature, scale, intensity of each proposed use; location plan;
existing transport networks;
relevant planning scheme provisions; consistency with SPP provisions, SEQ regional plan, and any other relevant regional plan.

Assessment and management–
of environmental effects including short-, long-term and cumulative, from use and works, on and off-site.

Refer to schedule 2 for matters to consider and sources of information and advice.

Identify matters of concern–
to other identified parties.

Identify assessment requirements–
under State and Commonwealth legislation.

Step 2: Initial Consultation

Initial assessment report to–
relevant local governments and public sector entities;
other parties identified in step 1.

Submissions–
within at least 15 business days.

Step 3: Finalise initial assessment report

Including–
identification of parties consulted; a summary of submissions; account of submissions.

Description–
of any further assessment of environmental effects and additional management strategies; any designation requirements under the IPA, s 2.6.4.

Step 4: Public notification and second consultation

Notice–
in newspaper describing proposal,
providing contact and submission details, and advising that the assessment report is available.
Copy of notice to land owner and other parties given a report or identified in step 2.

Submissions–
within at least 15 business days.

Step 5: Prepare final assessment report

Advice–
to any public sector entity likely to be affected by changes arising from consultation.

Incorporation of–
any changes arising from consultation;
a copy of all submissions; a summary of submissions and account of issues raised;
statement of the views of relevant public sector entities and local governments; statement of any matters proposed to be included in the designation under the IPA, s 2.6.4.

Step 6: Forward final assessment report to Minister

IPA–
s 2.6.7 identifies matters for consideration prior to designation;
s 2.6.8 states actions if designation is to occur;
s 2.6.9 states actions if the decision is not to designate.
If proceeding, a summary of submissions and account of issues raised is sent to each principal submitter.

AECOM

SIMPLIFIED TIMELINE	This is an indicative timeline as information requests and processing of public submission requirements cannot be foreseen PLEASE NOTE: There are three tables below: 1) Resource Entitlement, 2) DA, 3) Designation

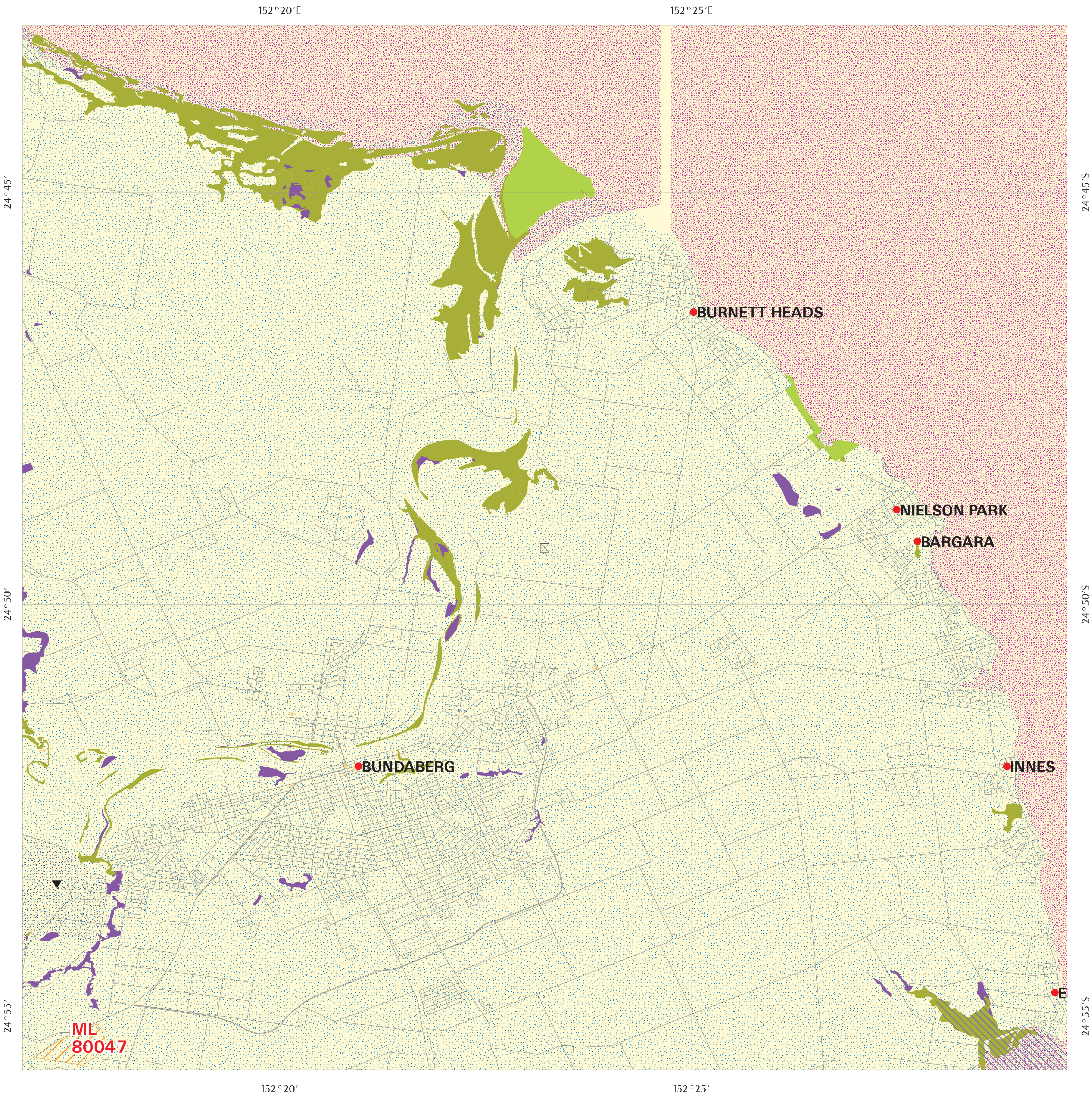
Resource Entitlement	Oct `11	Nov `11	Dec `11	Jan `12	Feb `12
Prepare and submit					
Processing by DERM					
Receive Resource Entitlement					

Development Approval (IDAS)	Oct `11	Nov `11	Dec `11	Jan `12	Feb `12	Mar `12	Apr `12	May `12	Jun `12	Jul `12	Aug `12	Sep `12	Oct `12	Nov `12	Dec `12	....
Studies/investigations/ preliminary consultation																
Prepare environmental impact study (assumes all studies required are started by beginning of November 2011)																
Prepare application (ERA/MCU/PTW)																
Application reviewed by Bundaberg Regional Council																
Submit application																
Assessment period (including public notification but not response to information requests - outside of the scope of works for AECOM)															Minimum expectation for approval by Dec `12	**Could take longer dependent on number of requests for information, from whom and the time required to respond (must be less than 6 months under SPA). Once public notification is undertaken, the timeframes can be impacted by the number and complexity of public submissions received.**
Notify DERM of the notifiable activity																

Designation	Oct `11	Nov `11	Dec `11	Jan `12	Feb `12	Mar `12	Apr `12	May `12	Jun `12	Jul `12	Aug `12	Sep `12	Oct `12	Nov `12	Dec `12	Jan `13	....
Consultation with stakeholders	This period will need to continue for as long as it takes to identify matters of concern and assessment requirements																
Studies/investigations																	
Environmental impact study																	
Prepare initial assessment report																	
Notification period (for previously consulted stakeholders)																	
Finalise initial impact assessment report						This timeframe is impacted on by the number and complexity of submissions received											
Public notification (newspaper etc) and second consultation with stakeholders																	
Prepare final assessment report (and advice to public sector entity likely to be affected)									This timeframe is impacted on by the number and complexity of submissions received								
Forward final assessment report to Minister plus summary of submissions and account of issues raised sent to each submitter												**There are no timeframes that the Minister must abide by to process the application therefore this is an unknown. The Minister has the discretion to decide whether the consultation has been adequate and that all environmental factors have been considered appropriately (this period typically takes 4 - 6 months).**					
Notify DERM of the notifiable activity																	
Prepare IDAS approval applications (prescribed tidal works, Environmentally Relevant Activity etc)				**This process can take place at any stage along this line.**													

Appendix D

Environmental Searches



ENVIRONMENTALLY SENSITIVE AREAS - Mining Activities

Requested By: RYAN.OLEARY@AECOM.COM
Date: 30 Aug 11 Time: 13.16.07

Centered on point position:
Latitude: -24.821864 Longitude: 152.38706
(decimal degrees)

Legend

- Mining Leases

CATEGORY A
- National Parks
- Conservation Parks
- Forest Reserves
- Wet Tropics World Heritage Area
- Great Barrier Reef Marine Park Region
- Marine Parks other than General Use Zones

CATEGORY B
- World Heritage Areas
- Queensland Heritage Register Places
- Ramsar Sites
- Cultural Heritage Registered Areas and DLA's other than Stanbroke
- Special Forestry Areas
- Fish Habitat Areas
- Koala Plan
- Coordinated Conservation Areas
- Endangered Regional Ecosystems (Biodiversity Status)
- General Use Zones of Marine Parks
- Marine Plants

CATEGORY C
- Nature Refuges
- Resources Reserves
- Declared Catchment Areas
- Declared Irrigation Areas
- Drainage Areas
- River Improvement Areas
- Stanbroke DLA
- State Forests
- Timber Reserves
- Coastal Management Control Districts
- Dams and Weirs

OTHERS
- Roads
  © MapInfo Australia Pty Ltd 2010
- Towns
- Wild River Nominated Waterways
- Wild River High Preservation Areas
- Wild River Preservation Areas
- Mahogany Glider Habitat
- Directory of Important Wetlands
- Queensland

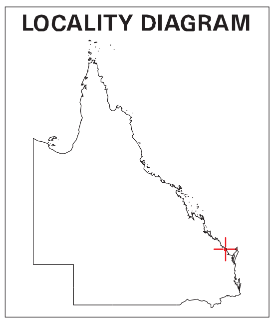
Queensland Government

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, MapInfo Australia and the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

External contributors (non-government parties) of the data for this product are:
Great Barrier Reef Marine Park Authority
MapInfo Australia Pty Ltd

LOCALITY DIAGRAM



NOTE TO USER: Themes presented in this map are indicative only. Field survey may be required to verify the 'true' spatial extent and value. Not all environmentally sensitive areas are presented in this map. A user should refer to the particular circumstances relevant to their situation to assess the 'completeness' of themes provided.

The user should note that some boundaries and indicated values are ambient and may change over time (e.g. regional ecosystem boundaries and conservation status, watercourse mapping etc).

The user should be aware that due to multiple overlapping themes/ layers present, some themes/layers may be obscured by others. Ordering in the Legend does not accurately reflect the order by which themes/layers are displayed.

0 1000 2000 3000 4000 5000 m

This scale bar is approximate only
Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)
This product is unprojected and is not suitable for measuring distances

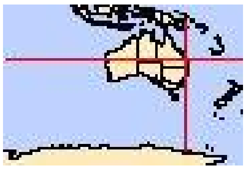
EPBC Act Protected Matters Report: Coordinates

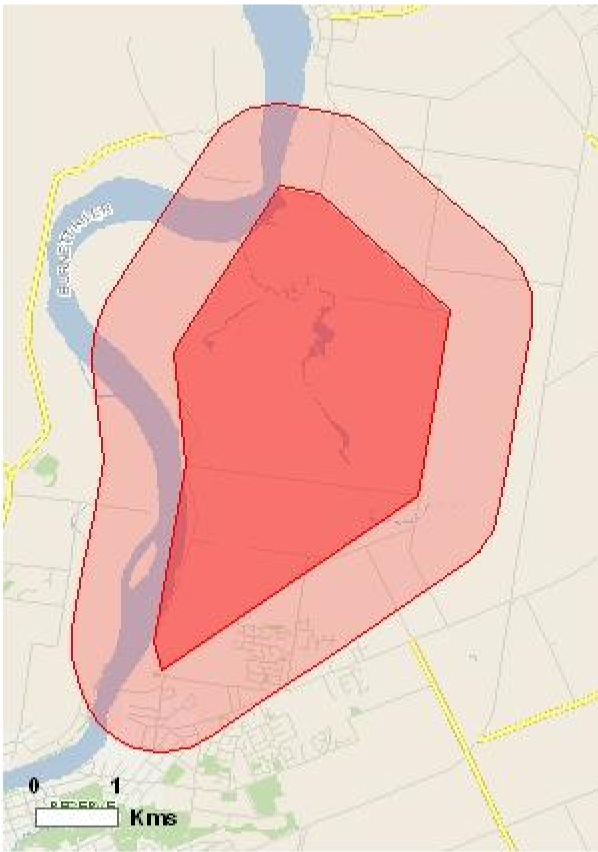
This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

Report created: 30/08/11 14:08:37





This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 1.0Km

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance (Ramsar Wetlands):	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Threatened Ecological Communitites:	None
Threatened Species:	24
Migratory Species:	23

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	21
Whales and Other Cetaceans:	None

Critical Habitats:	None
Commonwealth Reserves:	None

Report Summary for Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	None
State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	11
Nationally Important Wetlands:	None

Details

Matters of National Environmental Significance

Threatened Species [Resource Information]

Name	Status	Type of Presence
BIRDS		
Botaurus poiciloptilus		
Australasian Bittern [1001]	Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus		
Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Vulnerable	Species or species habitat may occur within area
Turnix melanogaster		
Black-breasted Button-quail [923]	Vulnerable	Species or species habitat likely to occur within area
FISH		
Neoceratodus forsteri		
Australian Lungfish, Queensland Lungfish [67620]	Vulnerable	Species or species habitat likely to occur within area
MAMMALS		
Chalinolobus dwyeri		
Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus		
Northern Quoll [331]	Endangered	Species or species habitat may occur within area
Nyctophilus timoriensis (South-eastern form)		
Greater Long-eared Bat, South-eastern Long-eared Bat [66888]	Vulnerable	Species or species habitat may occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Xeromys myoides		
Water Mouse, False Water Rat	Vulnerable	Species or species habitat likely to occur within area

[66]

OTHER		
Cycas megacarpa [55794]	Endangered	Species or species habitat may occur within area
Cycas ophiolitica [55797]	Endangered	Species or species habitat may occur within area
PLANTS		
Cupaniopsis shirleyana Wedge-leaf Tuckeroo [3205]	Vulnerable	Species or species habitat likely to occur within area
Phebalium distans Mt Berryman Phebalium [81869]	Critically Endangered	Species or species habitat may occur within area
Taeniophyllum muelleri Minute Orchid, Ribbon-root Orchid [10771]	Vulnerable	Species or species habitat may occur within area
REPTILES		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Delma torquata Collared Delma [1656]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Egernia rugosa Yakka Skink [1420]	Vulnerable	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Furina dunmalli Dunmall's Snake [59254]	Vulnerable	Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area

Migratory Species [Resource Information]

Name	Status	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		

Cattle Egret [59542]		Species or species habitat may occur within area
Migratory Marine Species		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Lamna nasus		
Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Lepidochelys olivacea		
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat may occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat may occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Species or species habitat may occur within area
Monarcha trivirgatus		
Spectacled Monarch [610]		Breeding likely to occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat likely to occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Breeding may occur within area
Migratory Wetlands Species		
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Nettapus coromandelianus albipennis		
Australian Cotton Pygmy-goose [25979]		Species or species habitat may occur within area

Rostratula benghalensis s. lat.		
Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anseranas semipalmata		
Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat may occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Species or species habitat may occur within area
Monarcha trivirgatus		
Spectacled Monarch [610]		Breeding likely to occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat likely to occur within area
Nettapus coromandelianus albipennis		
Australian Cotton Pygmy-goose [25979]		Species or species habitat may occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Breeding may occur within area
Rostratula benghalensis s. lat.		
Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area
Reptiles		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata		

Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area

Extra Information

Invasive Species		**[Resource Information]**
Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.		
Name	Status	Type of Presence
Frogs		
Bufo marinus Cane Toad [1772]		Species or species habitat likely to occur within area
Mammals		
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area

Parthenium hysterophorus

Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]	Species or species habitat likely to occur within area

Salvinia molesta

Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]	Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:
- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:
- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:
- non-threatened seabirds which have only been mapped for recorded breeding sites;
- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-24.80987 152.40216,-24.8195 152.40046,-24.83051 152.3985,-24.84955 152.37028,-24.84658

152.3694,-24.82691 152.37302,-24.81485 152.37173,-24.81362 152.37203,-24.7963 152.38326,-24.79717 152.38784,-24.80987 152.40216

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- -Department of Environment, Climate Change and Water, New South Wales
- -Department of Sustainability and Environment, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment and Natural Resources, South Australia
- -Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
- -Environmental and Resource Management, Queensland
- -Department of Environment and Conservation, Western Australia
- -Department of the Environment, Climate Change, Energy and Water
- -Birds Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -SA Museum
- -Queensland Museum
- -Online Zoological Collections of Australian Museums
- -Queensland Herbarium
- -National Herbarium of NSW
- -Royal Botanic Gardens and National Herbarium of Victoria
- -Tasmanian Herbarium
- -State Herbarium of South Australia
- -Northern Territory Herbarium
- -Western Australian Herbarium
- -Australian National Herbarium, Atherton and Canberra
- -University of New England
- -Ocean Biogeographic Information System
- -Australian Government, Department of Defence
- -State Forests of NSW
- -Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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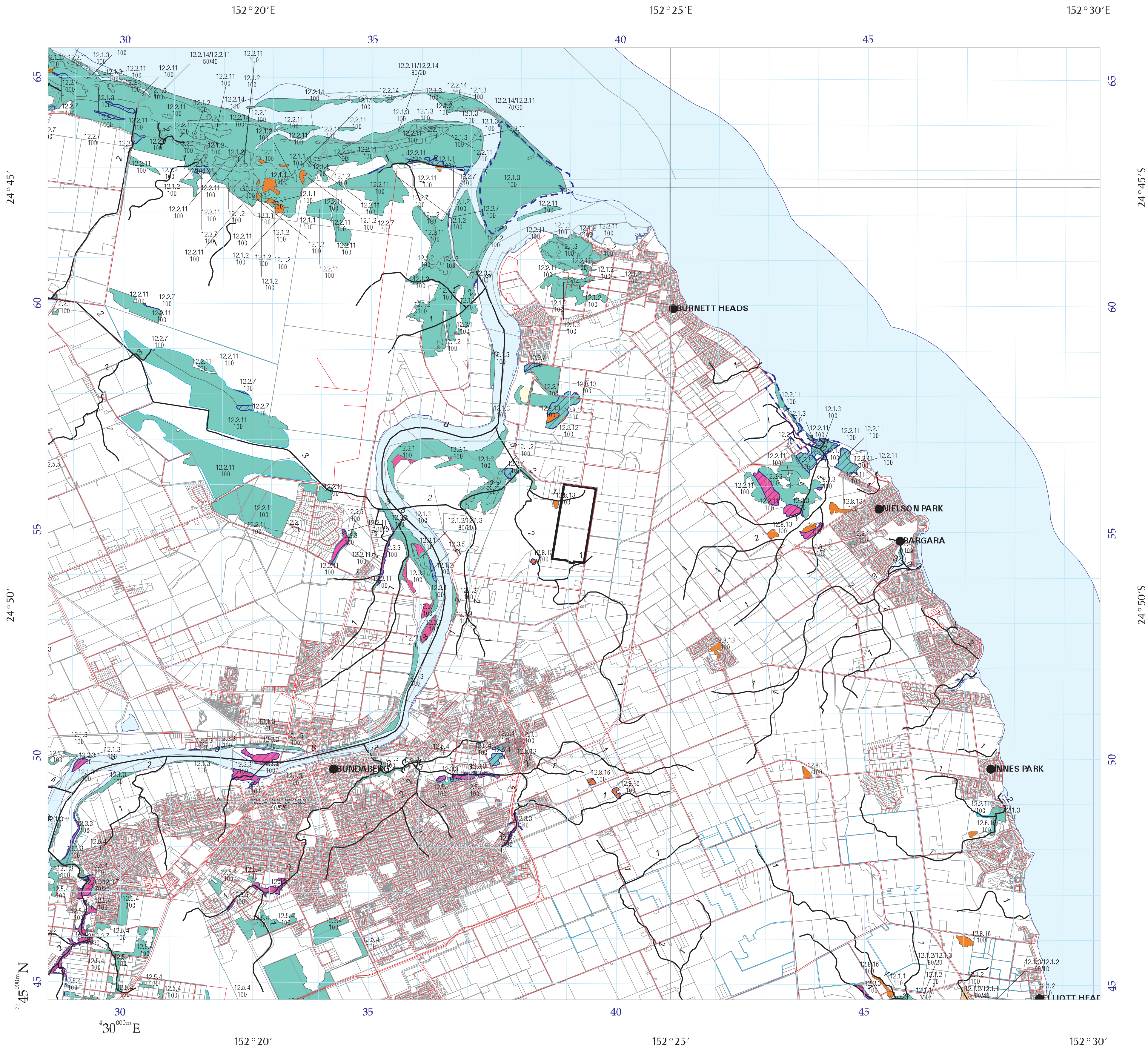


Vegetation Management Act Regional Ecosystem and Remnant Map-Version 6

Based on 2006 Landsat TM imagery

Requested By: RYAN.OLEARY@AECOM.COM
Date: 29 Aug 11 Time: 16.50.36

Centered on Lot on Plan:
1 RP57605

Bioregion: Southeast Queensland

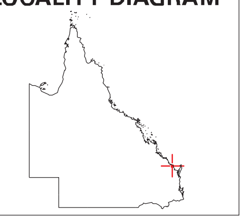
Remnant vegetation containing endangered regional ecosystems
- Dominant
- Sub-dominant

Remnant vegetation containing of concern regional ecosystems
- Dominant
- Sub-dominant

- Remnant vegetation that is a least concern regional ecosystem
- Remnant vegetation under Section 20AH of the VMA
- Non-remnant
- Plantation Forest
- Dam or Reservoir
- Remnant Vegetation
- PMAV Category X area
- Great Barrier Reef Wetlands
- Vegetation Management Act Essential Habitat
  For further information on VMA Essential Habitat, please see the attached VMA Essential Habitat map.
- Subject Lot
- Watercourse (Stream order shown as black number against stream where available)
- Bioregion boundary
- Roads © MapInfo Australia Pty Ltd 2009
- National Park, Conservation Area State Forest and other reserves
- Cadastral line
  Property boundaries shown are provided as a locational aid only.
- Towns

Queensland Government

LOCALITY DIAGRAM



2000 0 2000 m

Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)

A remnant map covers areas not covered by a regional ecosystem map.

Defined map areas are labelled with the regional ecosystem (RE) code along with the percentage breakdown if more than one RE occurs within the area. Detailed definitions of regional ecosystems are available from www.derm.qld.gov.au/REDD. Defined map areas smaller than 5ha may not be labelled.

Regional ecosystem linework has been compiled at a scale of 1:100 000, except in designated areas where a compilation scale of 1:50 000 is available. Linework should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100 000 is +/-100 metres. The extent of remnant regional ecosystems as of 2006, depicted on this map is based on rectified 2006 Landsat TM imagery (supplied by the Statewide Landcover and Trees Study (SLATS), Department of Environment and Resource Management (DERM)).

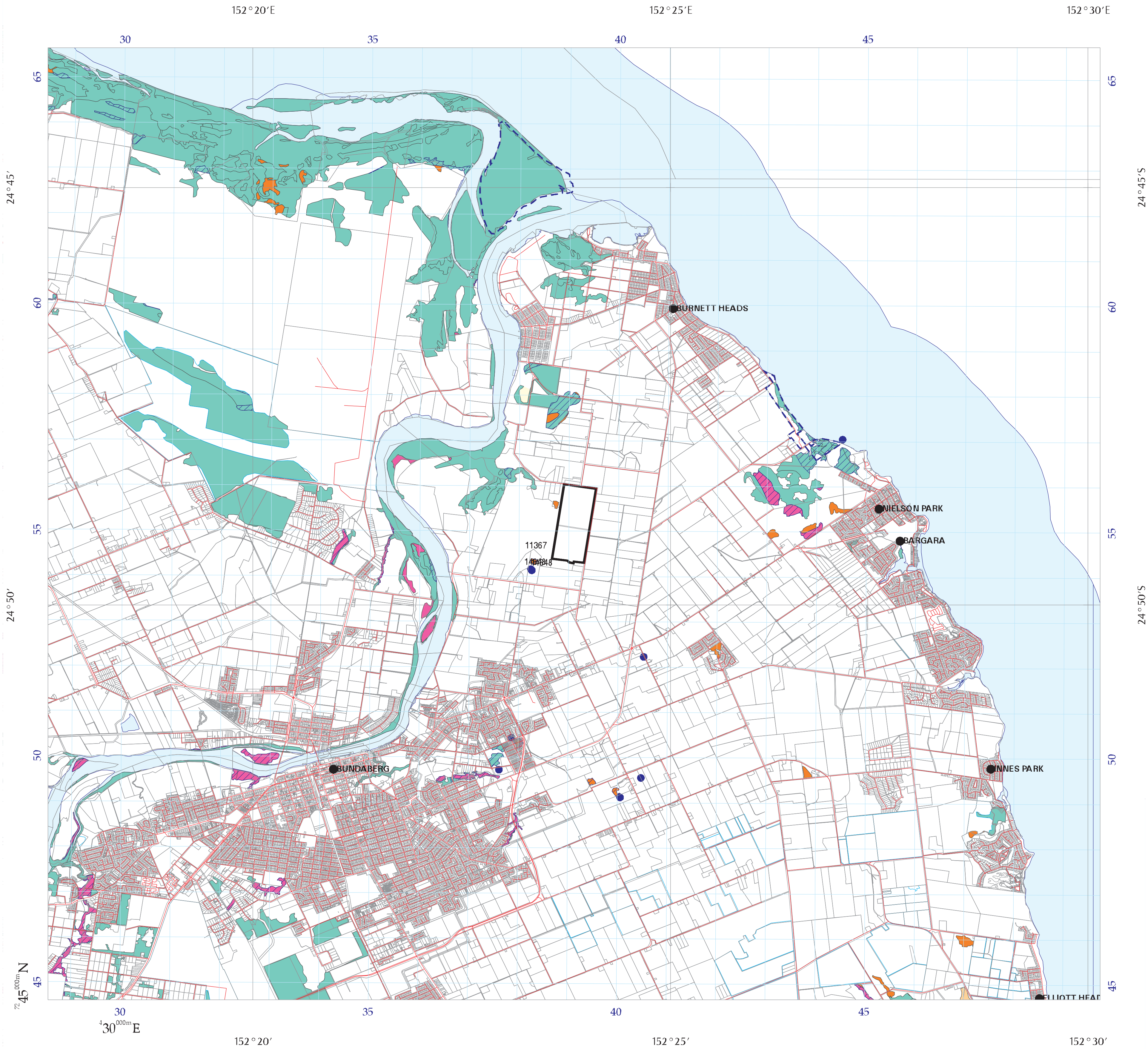
Some watercourse lines are derived from GeoScience Australia 1:250 000 mapping.

Disclaimer:
While every care is taken to ensure the accuracy of this product, the Department of Environment and Resource Management and MapInfo Australia Pty Ltd, makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.

All datasets are updated as they become available to provide the most current information as of the date shown on this map.

Additional information is required for the purposes of land clearing or assessment of a regional ecosystem map or PMAV applications. For further information go to the web site: www.derm.qld.gov.au/vegetation or contact the Department of Environment and Resource Management.

Digital regional ecosystem data is available in shapefile format, for Lot on Plans from www.derm.qld.gov.au/REDATA or from DERM for larger areas.



Vegetation Management Act Essential Habitat Map Version 3.0

Remnant vegetation containing endangered regional ecosystems

- Dominant
- Sub-dominant

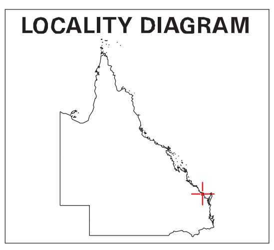
Remnant vegetation containing of concern regional ecosystems

- Dominant
- Sub-dominant
- Remnant vegetation that is a least concern regional ecosystem
- Remnant vegetation under Section 20AH of the VMA
- Non-remnant
- Plantation Forest
- Dam or Reservoir
- Remnant Vegetation
- PMAV Category X area
- Vegetation Management Act Essential Habitat
- Vegetation Management Act Essential Habitat Species Records
- Subject Lot
- Roads © MapInfo Australia Pty Ltd 2009
- National Park, Conservation Area State Forest and other reserves
- Cadastral line
  Property boundaries shown are provided as a locational aid only.
- Towns

Requested By: RYAN.OLEARY@AECOM.COM
Date: 29 Aug 11 Time: 16.50.42

Centered on Lot on Plan:
1 RP57605

Queensland Government



2000 0 2000 m

Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)

Labels for the Vegetation Management Act Essential Habitat are centred on the subject lot (1.1km surrounding and including a Lot on Plan). Labels correlate to the label field in the attached essential habitat database.

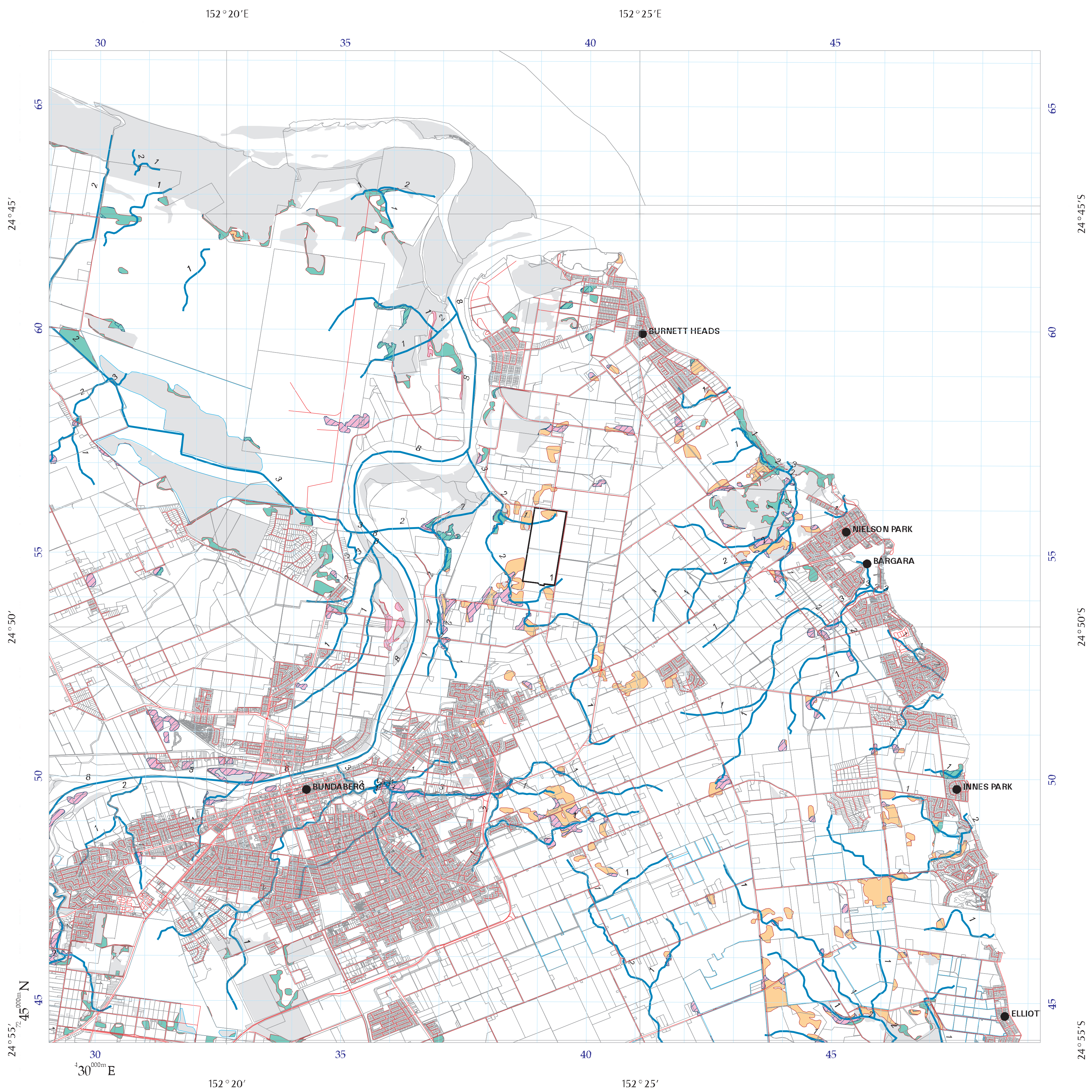
Regional ecosystem linework has been compiled at a scale of 1:100 000, except in designated areas where a compilation scale of 1:50 000 is available. Linework should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100 000 is +/-100 metres. The extent of remnant regional ecosystems as of 2006, depicted on this map is based on rectified 2006 Landsat TM imagery (supplied by SLATS, Department of Environment and Resource Management).

Disclaimer:
While every care is taken to ensure the accuracy of this product, the Department of Environment and Resource Management and MapInfo Australia Pty Ltd, makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.

All datasets are updated as they become available to provide the most current information as of the date shown on this map.

Additional information is required for the purposes of land clearing or assessment of a regional ecosystem map or PMAV applications. For further information go to the web site: www.derm.qld.gov.au/vegetation or contact the Department of Environment and Resource Management.

Digital regional ecosystem data is available in shapefile format, for Lot on Plans from www.derm.qld.gov.au/REDATA or from DERM for larger areas.



REGROWTH VEGETATION MAP - Version 2.0

1087 Vegetation Management Act Essential Regrowth Habitat with example label number

Great Barrier Reef Wetland Protection Area

High value regrowth vegetation containing Endangered regional ecosystems

High value regrowth vegetation containing Of Concern regional ecosystems

High value regrowth vegetation that is a Least Concern regional ecosystem

Remnant Vegetation
(Refer to the Vegetation Management Act Regional Ecosystem and Remnant Map also available from the Department of Environment and Resource Management website for further information on these areas)

Non-remnant

PMAV Category X area

Regrowth watercourse (Stream order shown as black number against stream)

Other watercourse(Stream order shown as black number against stream where available)

Subject Lot

Roads
© MapInfo Australia Pty Ltd 2009

Cadastral line
Property boundaries shown are provided as a locational aid only.

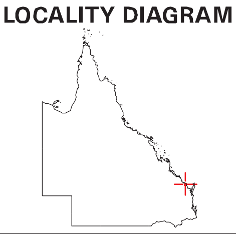
Towns

Requested By: RYAN.OLEARY@AECOM.COM
Date: 29 Aug 11 Time: 16.51.28

Centered on Lot on Plan:
1 RP57605

Queensland Government

LOCALITY DIAGRAM



Labels for Vegetation Management Act Essential Regrowth Habitat are centred on the subject lot.
Labels correlate to the label field in the attached essential regrowth habitat database.

The high value regrowth, regrowth watercourse, other watercourse, Great Barrier Reef wetland protection area and essential regrowth habitat data shown on this map are representations of the preliminary data.

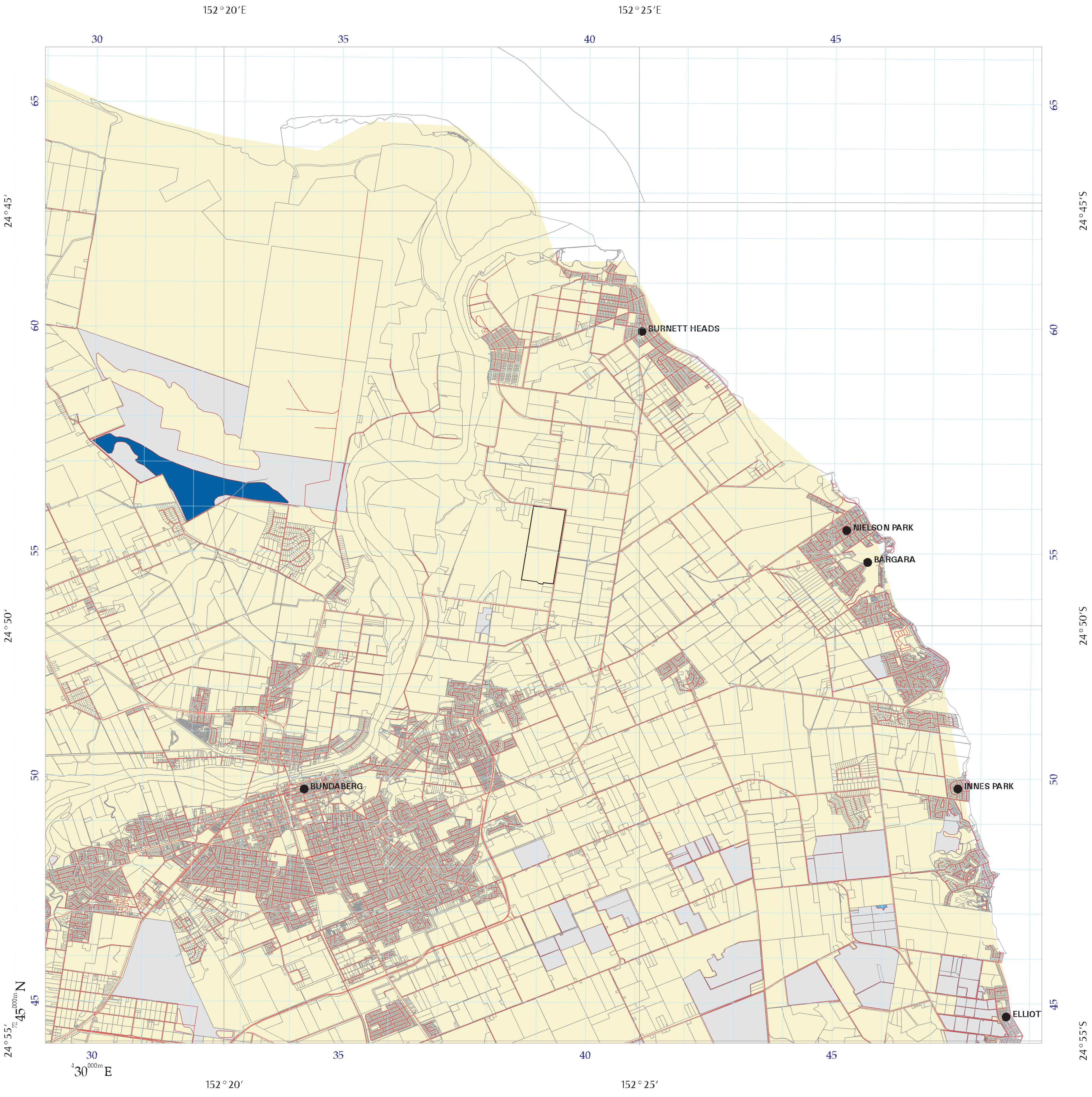
Some watercourse lines are derived from GeoScience Australia 1:250 000 mapping.

For further information go to the website:
http://www.derm.qld.gov.au or contact Vegetation Management, Department of Environment and Resource Management.

Areas covered by a Property Map of Assessable Vegetation (PMAV) are represented on the map attached as Page 2 to this Regrowth Vegetation Map and provided with it.

2000 0 2000 m

Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)



Property Maps of Assessable Vegetation (PMAVs)

Requested By: RYAN.OLEARY@AECOM.COM
Date: 29 Aug 11 Time: 16.51.32

Centered on Lot on Plan:
1 RP57605

The PMAV data shown on this map are a representation of the data used to create certified PMAVs. Variations may occur between PMAV boundaries and cadastral boundaries. PMAV data incorporates cadastral boundary data as at the time of certification of the PMAV. The cadastral boundaries shown on this map may have shifted relative to the PMAV boundaries as more accurate cadastral boundary data have become available.

All datasets are updated as they become available to provide the most current information as of the date shown on this map.

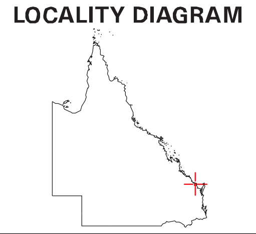
For further information go to the website:
http://www.derm.qld.gov.au/vegetation/index.html
or contact Vegetation Management, Department of Environment and Resource Management.

Property Map of Assessable Vegetation Vegetation Category Area

- Category A area
- Category B area
- Category C area
- Category X area
- Area that is subject to other PMAVs or, if no PMAV exists, a regional ecosystem map, remnant map or regrowth vegetation map
- Subject Lot
- Roads
  © MapInfo Australia Pty Ltd 2009
- Cadastral line
  Property boundaries shown are provided as a locational aid only.
- Towns

Queensland Government

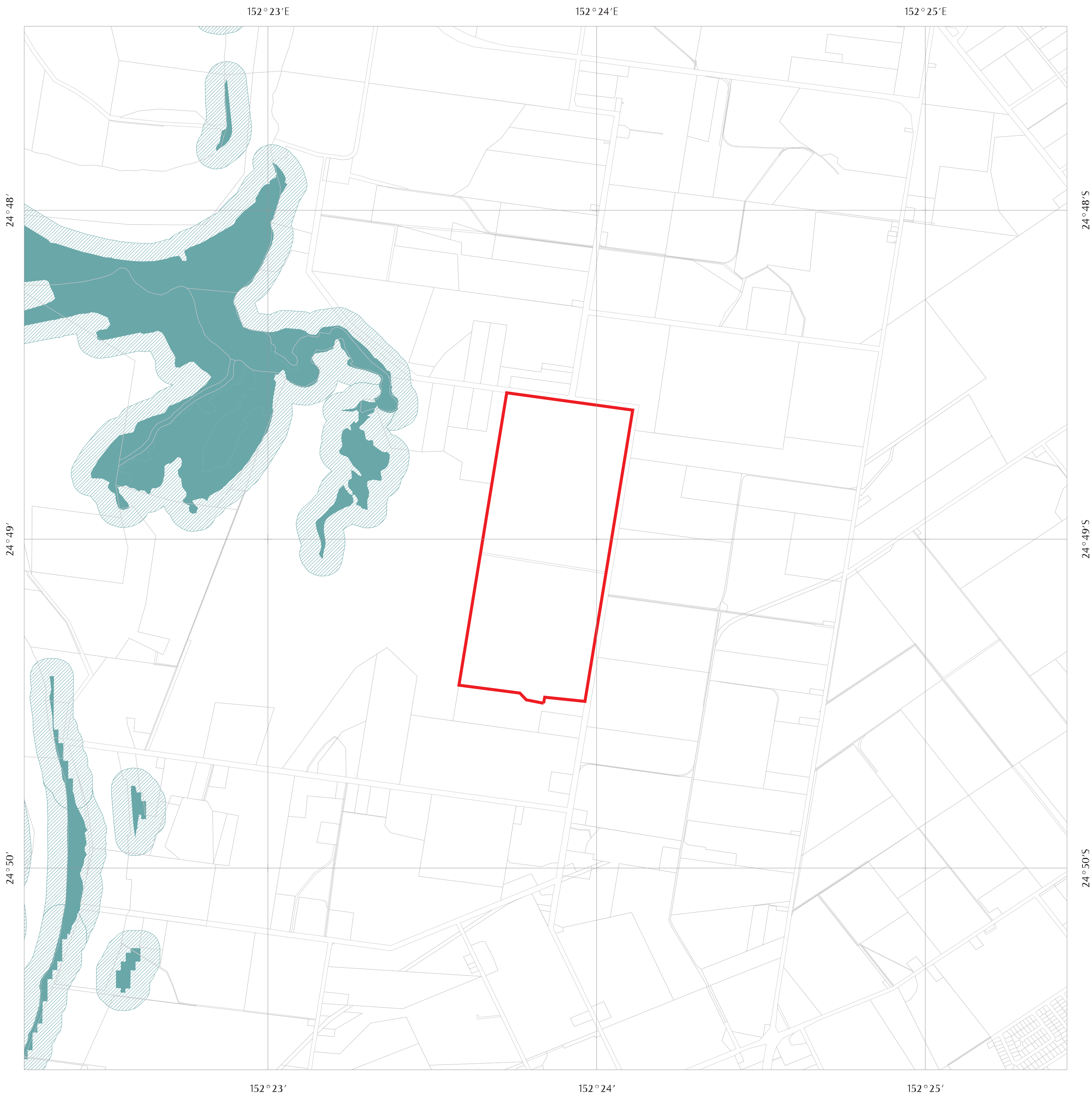
LOCALITY DIAGRAM



N

2000 0 2000 m

Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)



Map of Referable Wetlands

Requested By: RYAN.OLEARY@AECOM.COM
Date: 29 Aug 11 Time: 16.41.33

Centered on Lot on Plan:
1 RP57605

Legend

Selected Land Parcel
Property Boundary

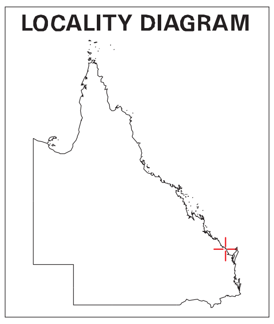
GBR Wetland Protection Area

Wetland
Trigger Area

Wetland Management Area

Wetland
Trigger Area

Queensland Government



0 200 400 600 800 1000m

This scale bar is approximate only
Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)
This product is unprojected and is not suitable for measuring distances

This map should only be used to apply policies outlined in the Temporary State Planning Policy: Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments (SPP for GBR Wetlands).

Information shown on the map includes multiple spatial datasets that define policies stated in the Temporary State Planning Policy: Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments (SPP for GBR Wetlands). Datasets include wetlands, roads, rail lines and cadastral boundaries.

All datasets are current as at 30 April 2010.

The maps are produced at a scale relevant to the size of the lot on plan identified and should be printed as A4 size in portrait orientation. Consideration of the effects of mapped scale is necessary when interpreting data at a large scale i.e. property level. For property assessment, digital linework should be used as a guide only.

The Wetlands Regulatory Map is A4 portrait and should be printed at this size.

For further information or assistance with interpretation of this product, please contact the Department of Environment and Resource Management at planning.support@derm.qld.gov.au

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: All
Status: All
Records: All
Date: All
Latitude: 24.8219
Longitude: 152.3871
Distance: 2.5
Email: Ryan.OLeary@aecom.com
Date submitted: Tuesday 30 Aug 2011 13:18:41
Date extracted: Tuesday 30 Aug 2011 13:31:02

The number of records retrieved = 100

Disclaimer

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	ferns	Marsileaceae	*Marsilea hirsuta*	hairy nardoo		C		1/1
plants	ferns	Polypodiaceae	*Pyrrosia confluens*			C		1
plants	higher dicots	Acanthaceae	*Pseuderanthemum variabile*	pastel flower		C		1
plants	higher dicots	Anacardiaceae	*Pleiogynium timorense*	Burdekin plum		C		1
plants	higher dicots	Apocynaceae	*Hoya australis*			C		1
plants	higher dicots	Apocynaceae	*Secamone elliptica*			C		1/1
plants	higher dicots	Apocynaceae	*Alyxia ruscifolia*			C		1
plants	higher dicots	Apocynaceae	*Marsdenia pleiadenia*			C		2/1
plants	higher dicots	Araliaceae	*Polyscias elegans*	celery wood		C		1
plants	higher dicots	Capparaceae	*Capparis arborea*	brush caper berry		C		1
plants	higher dicots	Casuarinaceae	*Casuarina glauca*	swamp she-oak		C		1/1
plants	higher dicots	Celastraceae	*Maytenus disperma*	orange boxwood		C		1
plants	higher dicots	Celastraceae	*Hippocratea barbata*	knotvine		C		1
plants	higher dicots	Celastraceae	*Elaeodendron melanocarpum*			C		1/1
plants	higher dicots	Ebenaceae	*Diospyros geminata*	scaly ebony		C		3/1
plants	higher dicots	Euphorbiaceae	*Croton phebalioides*	narrow-leaved croton		C		2/1
plants	higher dicots	Euphorbiaceae	*Alchornea ilicifolia*	native holly		C		1
plants	higher dicots	Euphorbiaceae	*Croton acronychioides*	thick-leaved croton		C		1
plants	higher dicots	Euphorbiaceae	*Macaranga tanarius*	macaranga		C		1
plants	higher dicots	Euphorbiaceae	*Mallotus discolor*	white kamala		C		1
plants	higher dicots	Euphorbiaceae	*Acalypha eremorum*	soft acalypha		C		1
plants	higher dicots	Euphorbiaceae	*Mallotus philippensis*	red kamala		C		1
plants	higher dicots	Fabaceae	*Lablab purpureus*	lablab	Y			1/1
plants	higher dicots	Fabaceae	*Austrosteenisia blackii*	bloodvine		C		1
plants	higher dicots	Fabaceae	*Crotalaria pallida var. obovata*		Y			1/1
plants	higher dicots	Flacourtiaceae	*Casearia multinervosa*	casearia		C		1/1
plants	higher dicots	Lamiaceae	*Clerodendrum floribundum*			C		1/1
plants	higher dicots	Lecythidaceae	*Planchonia careya*	cockatoo apple		C		1/1
plants	higher dicots	Meliaceae	*Owenia venosa*	crow's apple		C		1/1
plants	higher dicots	Meliaceae	*Dysoxylum gaudichaudianum*	ivory mahogany		C		1
plants	higher dicots	Meliaceae	*Melia azedarach*	white cedar		C		2/1
plants	higher dicots	Mimosaceae	*Acacia fasciculifera*	scaly bark		C		1
plants	higher dicots	Mimosaceae	*Acacia aulacocarpa*			C		1
plants	higher dicots	Moraceae	*Ficus opposita*			C		1
plants	higher dicots	Moraceae	*Trophis scandens*			C		2
plants	higher dicots	Moraceae	*Maclura cochinchinensis*	cockspur thorn		C		1
plants	higher dicots	Moraceae	*Streblus brunonianus*	whalebone tree		C		2
plants	higher dicots	Myrsinaceae	*Embelia australiana*	embelia		C		1
plants	higher dicots	Myrtaceae	*Psidium guajava*	guava	Y			1
plants	higher dicots	Myrtaceae	*Eugenia uniflora*	Brazilian cherry tree	Y			1
plants	higher dicots	Myrtaceae	*Melaleuca dealbata*	swamp tea-tree		C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus tereticornis*			C		1
plants	higher dicots	Myrtaceae	*Gossia bidwillii*			C		2/1
plants	higher dicots	Ochnaceae	*Ochna serrulata*	ochna	Y			1
plants	higher dicots	Oleaceae	*Notelaea longifolia*			C		1
plants	higher dicots	Oleaceae	*Jasminum didymum subsp. racemosum*			C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Passifloraceae	*Passiflora suberosa*	corky passion flower	Y			1
plants	higher dicots	Phyllanthaceae	*Actephila lindleyi*	actephila		C		1/1
plants	higher dicots	Phyllanthaceae	*Breynia oblongifolia*			C		1
plants	higher dicots	Phyllanthaceae	*Actephila sessilifolia*			NT		1/1
plants	higher dicots	Phyllanthaceae	*Phyllanthus microcladus*			C		1
plants	higher dicots	Phyllanthaceae	*Bridelia leichhardtii*			C		1
plants	higher dicots	Pittosporaceae	*Bursaria incana*			C		1/1
plants	higher dicots	Putranjivaceae	*Drypetes deplanchei*	grey boxwood		C		1
plants	higher dicots	Rhamnaceae	*Alphitonia excelsa*	soap tree		C		1
plants	higher dicots	Rubiaceae	*Triflorensia ixoroides*			C		1/1
plants	higher dicots	Rubiaceae	*Everistia vacciniifolia var. nervosa*			C		1
plants	higher dicots	Rubiaceae	*Cyclophyllum coprosmoides*			C		1
plants	higher dicots	Rutaceae	*Acronychia laevis*	glossy acronychia		C		1
plants	higher dicots	Rutaceae	*Dinosperma erythrococcum*			C		1/1
plants	higher dicots	Rutaceae	*Coatesia paniculata*			C		1/1
plants	higher dicots	Rutaceae	*Flindersia australis*	crow's ash		C		1
plants	higher dicots	Rutaceae	*Glycosmis trifoliata*			C		1/1
plants	higher dicots	Rutaceae	*Murraya ovatifoliolata*			C		1
plants	higher dicots	Rutaceae	*Geijera salicifolia*	brush wilga		C		1/1
plants	higher dicots	Sapindaceae	*Jagera pseudorhus*			C		1
plants	higher dicots	Sapindaceae	*Arytera microphylla*			C		2/1
plants	higher dicots	Sapindaceae	*Cupaniopsis sp. (Watalgan A.R.Bean 8611)*			C		3/3
plants	higher dicots	Sapindaceae	*Cupaniopsis anacardioides*	tuckeroo		C		1
plants	higher dicots	Sapindaceae	*Cupaniopsis wadsworthii*			C		1
plants	higher dicots	Sapindaceae	*Elattostachys nervosa*	green tamarind		C		1
plants	higher dicots	Sapindaceae	*Alectryon subdentatus*			C		1
plants	higher dicots	Sapindaceae	*Alectryon tomentosus*			C		1
plants	higher dicots	Sapindaceae	*Atalaya salicifolia*			C		1
plants	higher dicots	Sapindaceae	*Arytera divaricata*	coogera		C		1
plants	higher dicots	Sapotaceae	*Planchonella pubescens*			C		1
plants	higher dicots	Sapotaceae	*Planchonella cotinifolia*			C		2/1
plants	higher dicots	Solanaceae	*Solanum stelligerum*	devil's needles		C		1
plants	higher dicots	Solanaceae	*Solanum seaforthianum*	Brazilian nightshade	Y			1
plants	higher dicots	Sparrmanniaceae	*Triumfetta rhomboidea*	chinese burr	Y			1
plants	higher dicots	Sterculiaceae	*Sterculia quadrifida*	peanut tree		C		2
plants	higher dicots	Ulmaceae	*Celtis sinensis*	Chinese elm	Y			1
plants	higher dicots	Ulmaceae	*Aphananthe philippinensis*			C		1
plants	higher dicots	Vitaceae	*Clematicissus opaca*			C		1
plants	lower dicots	Annonaceae	*Melodorum leichhardtii*			C		1
plants	lower dicots	Lauraceae	*Cryptocarya triplinervis*			C		1
plants	lower dicots	Menispermaceae	*Pachygone ovata*			C		1
plants	lower dicots	Menispermaceae	*Tinospora smilacina*	snakevine		C		1
plants	monocots	Arecaceae	*Livistona decora*			C		1
plants	monocots	Asparagaceae	*Asparagus africanus*		Y			1
plants	monocots	Bromeliaceae	*Tillandsia usneoides*		Y			1/1
plants	monocots	Cyperaceae	*Cyperus enervis*			C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	monocots	Hemerocallidaceae	*Geitonoplesium cymosum*	scrambling lily		C		1
plants	monocots	Orchidaceae	*Dockrillia schoenina*	pencil orchid		C		1
plants	monocots	Orchidaceae	*Saccolabiopsis armitii*			C		1/1
plants	monocots	Orchidaceae	*Geodorum densiflorum*	pink nodding orchid		C		1/1
plants	monocots	Poaceae	*Panicum pygmaeum*	dwarf panic		C		1
plants	monocots	Poaceae	*Oplismenus imbecillis*			C		1
plants	monocots	Poaceae	*Stenotaphrum secundatum*	buffalo grass	Y			1/1
plants	monocots	Smilacaceae	*Smilax australis*	barbed-wire vine		C		1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Appendix G

Project Photos

Appendix G - Photos

Photo 1
Rising main location along McGills Road

Photo 2
Rising main location along McGills Road adjacent Burnett River

Photo 3
Rising main location along Kirbys Road

Photo 4
Rising main along proposed easement

Photo 5
Rising main location at Rubyanna Creek (mapped as Wallum Froglet habitat but not found during site visit)

Photo 6
Rising main location through cleared grazing land

Photo 7
Rising main location through cleared grazing land

Photo 8
Proposed STP site looking south

Photo 9
Proposed STP site looking north

Photo 10
Outfall main location along Rubyanna Road

Photo 11
Outfall main location along Rubyanna Road

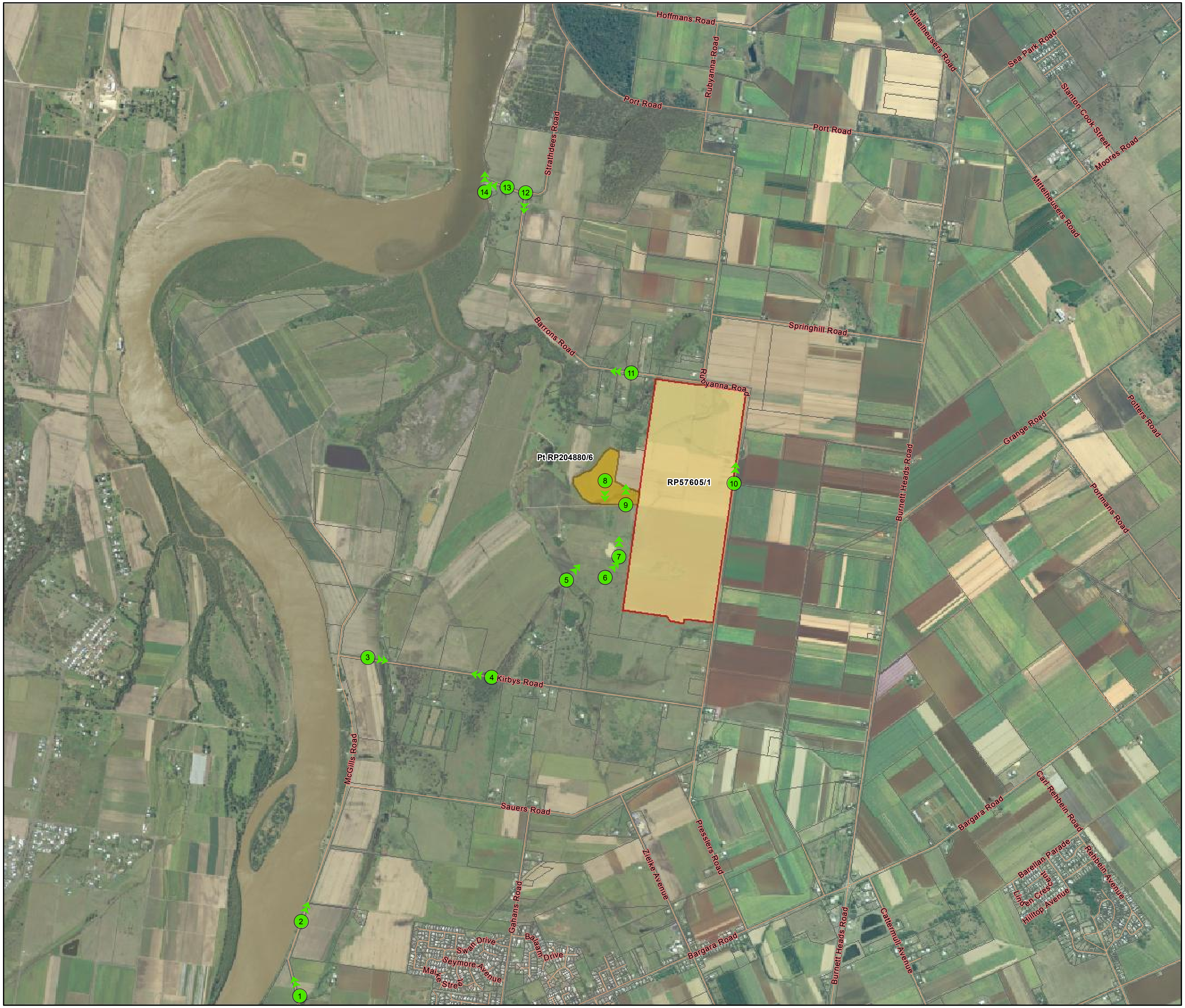
Photo 12
Outfall main location along Barrons Road Easement

Photo 13
Outfall main location along Strathdees Road

Photo 14
Outfall main location at Burnett River

RUBYANNA STP DEVELOPMENT APPROVALS

Site Photo Index



Legend

- Photo Location and Direction
- Possible STP Site (approx16.7ha)
- Lot 1 RP57605 (108.6 ha)

N

Scale: 1:25,000 (when printed at A3)

0 235 470 940

Metres

PROJECT ID 60221597

LAST MODIFIED CFS 28-Feb-2012

FILE NAME 60221597G_ENV_09

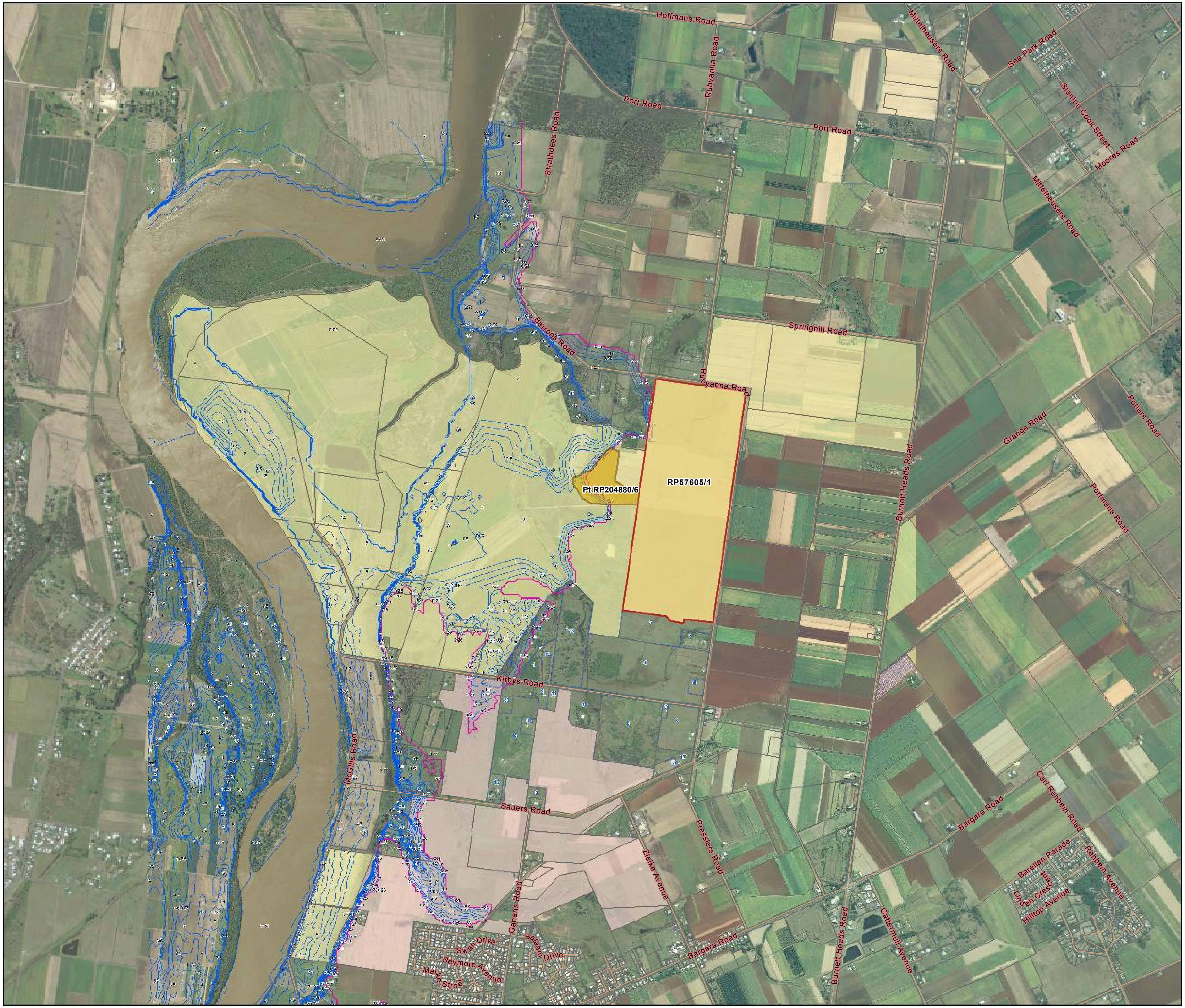
AECOM

Appendix H

Q100 Flood Levels

RUBYANNA STP DEVELOPMENT APPROVALS

Flood Extent



Legend

- Possible STP Site (approx16.7ha)
- Lot 1 RP57605 (108.6 ha)
- 100 Yr Flood Depth
- 100 Yr Flood Extent

N

Scale: 1:25,000 (when printed at A3)

0 235 470 940

Metres

PROJECT ID 60221597

LAST MODIFIED CFS 28-Feb-2012

FILE NAME 60221597G_ENV_08

AECOM

Appendix I

Soil Mapping

Map Code supplied by DERM

No Codes on fact sheets Aldershot, Bauple, Booyal & Boyne

DUPLICATE MAP CODES

Craignish map code is Cr only in BAB (Shown as Cr_BAB)

Rubyanna map code is Ra only in BAB project (Fact Sheet shows code as Rb)

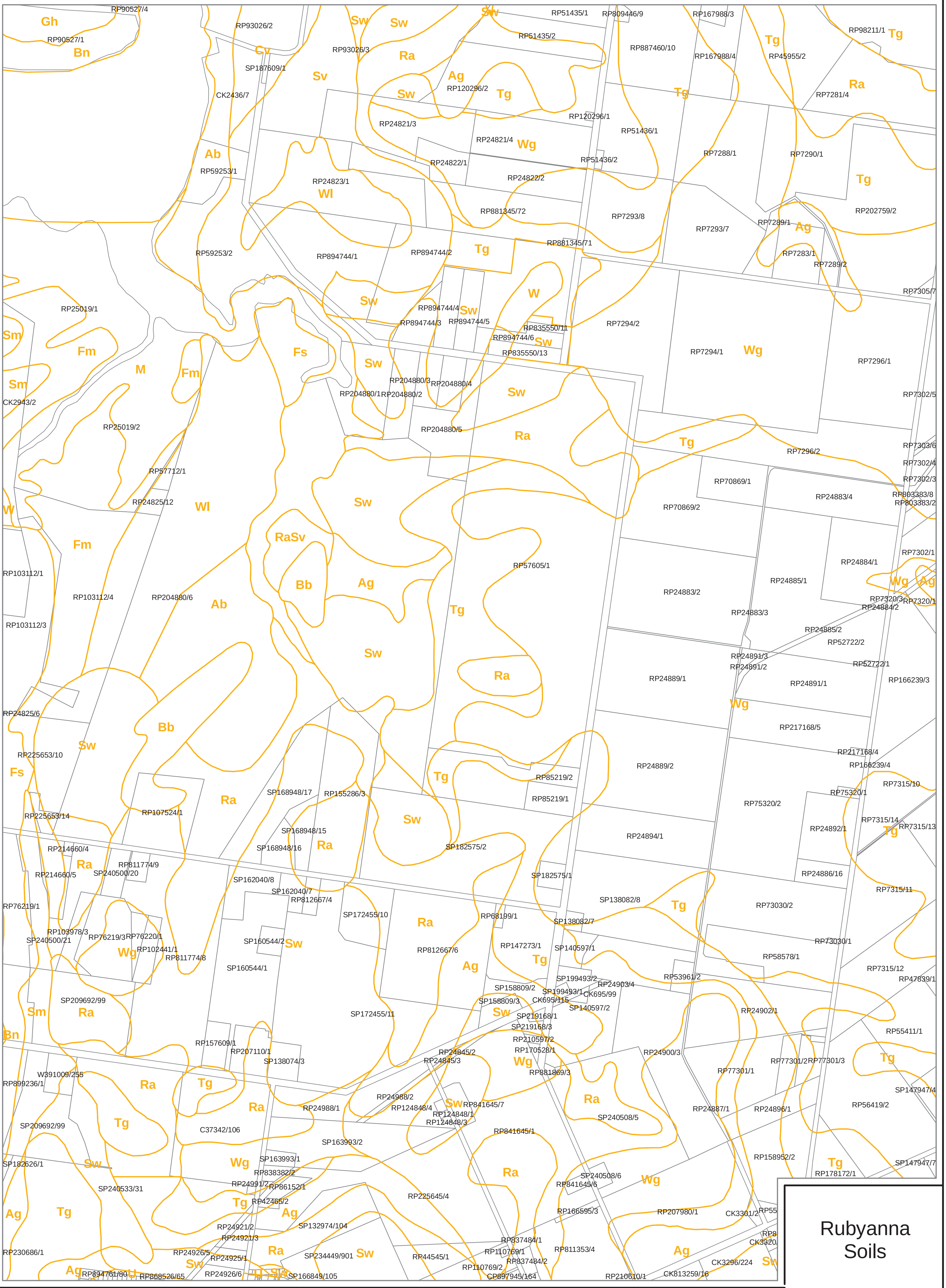
Woodgate (Wg) map code is only found in CBW project (Shown as Wg_CBW)

Woongarra (Wg) map code is only found in BAB project (Shown as Wg)

- Ab = Auburn
- Ag = Ashgrove
- Al = Alloway
- Av = Avondale
- Aldershot = Aldershot
- Bb = Barubbra
- Ba = Baddow
- Bauple = Bauple
- Bv = Bever
- Bi = Beelbi
- Be = Berren
- Bd = Bidwill
- Br = Bingera
- Bo = Booloongie
- Booyal = Booyal
- Bh = Botherm
- Boyne = Boyne
- Bw = Brooweena
- Bc = Bucca
- Bg = Bungadoo
- Bn = Burnett
- Bn = Burnett
- Bt = Butcher
- Cv = Calavos
- Cr = Cedars
- Cd = Childers
- Ch = Chin
- Cl = Clayton
- Cv = Colvin
- Cn = Coonar
- Co = Copenhagen
- Cf = Corfield
- Cr_BAB = Craignish-BAB

- Cg = Crossing
- Dw = Dawes
- Dm = Diamond
- Db = Doolbi
- Do = Doongul
- Dn = Drinan
- Dg = Duingal
- Dr = Dundowran
- Fd = Fairydale
- Fm = Fairymead
- Ff = Farnsfield
- Fs = Flagstone
- Gh = gahan
- Gl = Gall
- Gs = Gibson
- Gn = Gigoon
- Gi = Gillen
- Gv = Givelda
- Gb = Gooburrum
- Gr = Granville
- Gy = Gutchy
- Gu = Guyra
- He = Hillend
- Hs = Howes
- Hm = Hummock
- Hx = Huxley
- Is = Isis
- Jr = Jaro
- Jp = Jumpo
- Kh = Kalah
- Kp = Kepnock
- Kn = Kinkuna
- Ko = Kolan
- Kl = Kolbore
- Kr = Kooringa
- Kb = Kowbi
- Lt = Littabella
- Mh = Mahogany
- Mm = Maroom
- Mr = Maroondan
- My = Mary
- Md = Meadowvale
- Mp = Moore Park
- Ml = Moorland
- Mg = Mungar
- Nb = Netherby
- Nb = Netherby
- Nv = Norville
- Ok = Oakwood
- Ot = Otoo

- Ow = Owanyilla
- Pp = Peep
- Pe = Pelion
- Pk = Pocket
- Qr = Quart
- Qb = Qunaba
- Rd = Redbank
- Rb = Robur
- Rt = Rothchild
- Ra = Rubyanna
- Sw = Seaview
- Sp = Springs
- Sm = Sugarmill
- Sv = Summerville
- Tk = Takoko
- Tn = Tandora
- Tt = Tantitha
- Td = Teddington
- Tg = Telegraph
- Th = Theodolite
- Ta = Tiaro
- Tb = Timbrell
- Ti = Tinana
- Tr = Tirroan
- To = Toogum
- Tp = Turpin
- Wk = Walker
- Wl = Wallla
- Wm = Wallum
- Wt = Watalgan
- Wh = Weithew
- Wy = Whymere
- Wi = Windemere
- Wf = Winfield
- Wo = Woko
- Wb = Woober
- Wg_CBW = Woodgate
- Wr = Woolmer
- Wg = Woongarra



Rubyanna Soils

N

Scale 1:15,000 on A3 Sheet

BUNDABERG REGIONAL COUNCIL

BRC Plan No.40143

Appendix J

Geotechnical Investigations Report

BUNDABERG REGIONAL COUNCIL

PROPOSED SEWERAGE TREATMENT PLANT

Rubyanna Road - Rubyanna

SITE INVESTIGATION REPORT

Prepared by:

C M Testing Service
A.C.N. 103 228 726
2 Turner Street
West Bundaberg QLD 4670

BC10737 - 16 October 2011

INTRODUCTION

At the request of Mr David Gill of the Bundaberg Regional Council, CM Testing Service has undertaken a geotechnical investigation and prepared this geotechnical assessment report for the site of the proposed Rubyanna sewerage treatment plant.

Council proposes to design a sewerage treatment plant, which will be sited based on the findings of this preliminary geotechnical assessment. The main components of the proposed sewerage treatment plant include:

- sewerage plant requiring excavation to depths up to 3 metres for concrete structures (Part of RP204880/6);
- sewer pipeline easement (refer yellow easement line on location plan);
- sewer outfall from the proposed plant to the river;
- effluent storage lagoons;
- effluent irrigation area on the surrounding cane cultivation (RP57605/1).

A location map was provided with the brief, which showed the property descriptions and indicated approximately the locations of the proposed works.

The aims of the investigations were to determine the following:

- the nature and characteristics of the subsurface strata;
- groundwater and current use in the area
- appropriate foundation types and founding conditions;
- excavation and construction conditions for structures and lagoons;
- infiltration characteristics of soils in the effluent disposal areas.

This report presents the findings of the geotechnical investigation that have been undertaken and includes the laboratory testing and discussion of the findings. Note that this is a preliminary assessment for the feasibility of construction of the proposed sewerage treatment plant. The investigations were undertaken following agreement between the Council and the land holder on the procedure to undertake the investigations and the locations of the investigation sites. Detailed investigations for final design and construction will be undertaken when the location of the plant is finalised.

SITE CONDITIONS

The proposed Rubyanna sewerage treatment plant is located approximately 7km east of Bundaberg on the western side of the Rubyanna Road. The area under assessment is a privately owned working cane farm. The natural ground is gently undulating and generally falls to the drainage line at the northern end of the area, which leads to a creek which flows to the Burnett River to the northwest.

The proposed treatment plant will be located in the western parts of the nominated area for the assessment. The effluent disposal areas are proposed to be in the cane cultivation areas along Rubyanna Road, and the effluent lagoons are proposed in the northern areas of the assessment.

The geology at the site is residual clay soils overlying Tertiary Basalt rock. The basalt in the Bargara area is comprised of basalt flow lava, which at the surface manifests as large boulders, underlain by more massive rock. The basalt is found to be up to 10 to 20 metres in thickness and overlies the Tertiary Elliott Formation. This underlying sedimentary formation is comprised of sandstone, siltstone and minor conglomerate, mudstone and shale.

The weather conditions were fine at the time of the investigation and the area.

INVESTIGATIONS

Sixteen (16) boreholes were drilled using a trailer mounted Gemco HP4 hydraulically powered auger drilling rig, equipped with 100 mm augers and a tungsten carbide drill bit, to determine the subsurface conditions and to obtain disturbed and undisturbed samples.

The boreholes were drilled to refusal on the basalt boulders and rock that underlie the site and varied from 0.9 up to 3.6 metres in depth.

Seven (7) test pits were excavated in the areas of the proposed structure and effluent lagoons and were terminated at refusal on the basalt boulders. The test pits varied from 1.6 up to 5.4 metres in depth. The test pits were used to determine the subsurface profiles in the areas where rock had been encountered and to sample the soils for laboratory testing.

The following table indicates the specific locations of the investigations of each test site.

Test Location	Easting	Northing	Site Description
Hole 1	439300	7254473	Irrigation
Hole 2	439001	7254601	Irrigation
Hole 3	438701	7254470	Irrigation
Hole 4	438875	7255117	Irrigation
Hole 5	439093	7255078	Irrigation
Hole 6	439415	7255044	Irrigation

Test Location	Easting	Northing	Site Description
Hole 7	439533	7255836	Irrigation
Hole 8	439193	7255493	Irrigation
Hole 9	438720	7255396	Irrigation
Hole 10	438534	7254743	Pipeline
Hole 11	438313	7254637	Pipeline
Hole 12	438045	7254372	Pipeline
Hole 13	437760	7253945	Pipeline
Hole 14	438815	7256058	Pipeline
Hole 15	438478	7256107	Pipeline
Hole 16	438302	7256197	Pipeline
Pit 1	439197	7255975	Lagoons
Pit 2	438971	7255821	Lagoons
Pit 3	439318	7255693	Lagoons
Pit 4	439008	7255601	Irrigation
Pit 5	438584	7255463	Treatment Plant
Pit 6	438383	7255230	Treatment Plant
Pit 7	438605	7255274	Treatment Plant

The logs of the test pits and boreholes are included in this report and the investigation locations are shown on the Investigation Location plan.

SUBSURFACE CONDITIONS

The investigations have shown that the site is generally underlain by a surface layer of brown to red-brown medium to high plasticity clay soil, which overlies a grey high plasticity residual clay layer, which in turn overlies the weathered basalt rock layer. The upper levels of the weathered basalt are comprised of a mixed layer of gravel and high plasticity clays.

The surface brown and red-brown clay soils are generally 1 to 1.5 metres thick but increase up to 2.7 metres thick. The deeper grey residual silty clay if of high plasticity and highly reactive to moisture change and overlies the basalt rock. Interlocking basalt boulders underlie the residual clay soils.

The deeper basalt layer is interspersed with clay and boulders up to 1 metre in size. The interface between the overlying clay and the basalt is poorly defined, with abrupt undulations in the surface caused by the extreme weathering. Clay is present in some areas, whilst high strength boulders are present at the top of the interface in other areas.

The surface level of the rock has been found to vary by several metres in approximately the same distance in plan. This results from differential weathering of the surface of the basalt, which is controlled by the fracturing in the rock.

Deep boreholes in the vicinity of this site have shown that the basalt layer is approximately 10 to 20 metres thick.

The following table summarises the investigation findings and the approximate thickness of the subsurface strata and depth to rock:

Test Location	Hole 1	Hole 2	Hole 3	Hole 4	Hole 5	Hole 6	Hole 7	Hole 8
Clay thickness	1.65	0.6	3.6	1.8	2.7	3.0	3.0	0.95
Top of Boulders	1.65	0.6	-	1.8	-	-	-	0.95
Refusal	2.45	0.85	3.6	2.6	3.0	3.0	3.0	1.7

Test Location	Hole 9	Hole 10	Hole 11	Hole 12	Hole 13	Hole 14	Hole 15	Hole 16
Clay thickness	2.4	0.5	1.0	2.4	2.65	1.0	2.0	0.8
Top of Boulders	2.4	0.5	1.0	2.4	-	1.0	-	0.8
Refusal	3.8	0.9	1.65	3.6	2.65	1.35	-	1.0

Test Location	Pit 1	Pit 2	Pit 3	Pit 4	Pit 5	Pit 6	Pit 7
Clay thickness	2.0	0.7	1.3	1.4	1.5	1.5	2.0
Top of Boulders	2.7	0.7	2.0	2.3	2.3	1.9	2.6
Refusal	5.4	1.6	3.0	2.8	3.0	3.2	3.4

No groundwater was recorded during the current investigation. However, very moist conditions were encountered in the deeper high plasticity clay soils. Deeper moist layers were also encountered and excavations in the basalt rock have been seen to make water if left open.

DERM groundwater monitoring boreholes and licensed bores in the area show that the regional groundwater is at approximately 5 to 6 metres depth.

LABORATORY TESTING

Samples of the natural soils were taken for testing to determine the soil classification. The following tables summarise the test results:

Sample	**Hole 1 1.0m**	**Hole 7 1.0m**	**Hole 11 0.5 to 1.0m**	**Hole 13 1.0m**	**Pit 1 1.0m**	**Pit 1 1.8m**	**Pit 4 1.0m**	**Pit 5 1.0m**	**Pit 6 1.0m**	**Pit 7 1.5m**
Classification	Silty CLAY (CH)	Silty CLAY (CH)	Silty CLAY (CH)	Silty CLAY (CH)	Sandy CLAY (CH-SC)	Silty CLAY (CH)	Silty CLAY (CH)	Silty CLAY (CH)	Sandy CLAY (SC)	Silty CLAY (CH)
Max. particle size	9.5	4.75	2.36	2.36	26.5	9.5	9.5	9.5	9.5	9.5
% < 2.36 mm	96	99	100	100	65	93	92	93	96	95
% < 0.425 mm	85	87	93	98	59	85	81	88	77	91
% < 75 mm	74	71	86	85	56	82	78	84	54	89
Liquid Limit	45	46	58	55	61	92	17	106	68	111
Plasticity Index	19	26	48	39	41	73	89	91	56	87
Linear Shrinkage	12.0	12.0	20.5	21.0	18.0	22.0	26.0	27.5	21.5	27.5
Moisture Content	23.0	15.0	21.0	25.8	20.2	30.0	29.0	40.6	19.9	40.8
Emerson Class	5	6	-	-	6	6	6	-	-	-

The following table summarises the results of the in situ percolation tests:

Location	Hole 1	Hole 2	Hole 3	Hole 4	Hole 5	Hole 6	Hole 7	Hole 8	Hole 9
Classification	Silty CLAY (CH)	Silty CLAY (CH)	Silty CLAY (CH)	Silty CLAY (CH)	Silty CLAY (CH)	Silty CLAY (CH)	Silty CLAY (CH)	Silty CLAY (CH)	Silty CLAY (CH)
Percolation Rate (m/d)	0.061	0.07	0.08	0.07	0.078	0.08	0.064	0.06	0.068
Soil Class (AS1547)	6	6	6	6	6	6	6	6	6

The following table summarises the results of the shrink swell index test:

Location	Pit 1 1.0m	Pit 5 1.0m
Classification	Silty CLAY (CH)	Silty CLAY (CH)
Natural moisture content (%)	21.7	34.3
Pocket penetrometer (kPa)	80	70
Shrink / Swell Index	3.94	5.61

The following table summarises the results of the CBR testing:

Location	**Hole 11 0.5 to 1.0m**	**Pit 6 1.0m**
Classification	Silty CLAY (CH)	Sandy CLAY (SC)
Optimum moisture content (%)	18.6	24.4
Max. Dry Density (t/m^3)	1.68	1.54
CBR	1.0	1.0

The test certificates are included with this report.

DISCUSSION

General

The investigations have shown that the site is generally underlain by a surface layer of brown to red-brown medium to high plasticity clay soil, which overlies a grey high plasticity residual clay layer, which in turn overlies the weathered basalt rock layer. The upper levels of the weathered basalt are comprised of a mixed layer of gravel and high plasticity clays. Basalt boulders underlie the residual clay soils and the basalt layer is interspersed with clay and boulders up to 1 metre in size.

A soils map is included in this report, which shows the surface soil types that cover the area of the assessment. The red-brown clays are frequently observed on the higher topography, whilst the grey-black clay is observed along the drainage lines. Areas of mixed basalt boulders and clay have also been shown on the map.

No groundwater was recorded during the current investigation. However, very moist conditions were encountered in the deeper high plasticity clay soils and seepage is frequently observed in excavations in the basalt rock.

DERM groundwater monitoring boreholes and licensed bores in the area show that the regional groundwater is at approximately 5 to 6 metres depth.

Treatment Plant Area

The proposed area for the treatment plant structures is located in an area with shallow grey-black clays and boulders and rock at shallow depth.

The clay is highly reactive to moisture change. The clays are very moist from 0.5 to approximately 1.5 metres depth and the testing shows it to be of firm to stiff consistency. The bearing capacity in firm clay would be less than 100 kPa and long term settlements would be expected.

However, the foundations may possibly be constructed on earthworks platforms constructed of crushed fill. Compaction of the crushed rock platform fill should be to a dry density ratio of 95% of modified compaction. The platform should be filled in uniform layers with a constant thickness of compacted fill, placed over uniform founding conditions to minimise differential settlement across the structure.

Prior to placing and compacting the filling, the stripped surface should be proof rolled in accordance with AS3798 and the filling also placed in accordance with that Standard.

A sump or temporary de-watering system may be required to cater for any seepage and drainage of the site and gravel drainage layers may be required to facilitate adequate drainage.

Where external ground slabs are required, the slabs should be designed to tolerate the likely ground movement by adopting isolation joints and by having joints dowelled or keyed to prevent differential movement. This would also apply to the joints with the surrounding pavements and at the doors and access ways to the building. Slab edge thickenings should also be used at the doors and access ways.

Shallow footings for lightly loaded minor facilities may be designed for an allowable bearing capacity of 150 kPa when founded in the crushed rock platform fill.

Stiffened Raft Footings

Alternatively heavily stiffened raft foundation systems may be adopted. For the design of shallow foundations, the site would be classified as Class E with respect to AS2870, based on a shrink/swell index of 5 to 6% in the high plasticity residual clay soils.

Again it is recommended that a layer of good quality crushed rock fill be used to cap the natural clays. Prior to placing the capping layer, the surface should be proof rolled to identify any soft areas, which should be removed and replaced.

The allowable bearing pressure for the design of stiffened raft foundation constructed on the compacted capping layer would be taken 100 kPa.

The construction of the building platform may require drainage of the soils and replacement of excessively moist or softened material and replacement with compacted good quality crushed rock fill. The platform should be filled in uniform layers with a constant thickness of compacted fill over uniform founding conditions to minimize differential settlement across the structure. Compaction of the backfill should be to a dry density ratio of 95% of modified compaction.

Bored Pile Footings

Deep footings may be adopted for individual or heavily loaded structures founded on the rock. The excavations for the footings will expose variably weathered basalt. In some areas, the basalt boulders will be in a matrix of weathered clay and rock. The weathered clay should be removed so that basalt boulders cover the majority of the footing base and mass concrete used to replace the removed clay and to backfill undulations in the rock up to the underside of the footing.

The base of the pile excavations should be thoroughly cleaned of loose material prior to pouring the concrete and inspected and certified that the foundation conditions agree with the conditions assumed from the borehole investigations. The fill material at the surface may require lining to prevent collapse during excavation.

Ground Slabs

Ground slabs should be cast on a layer of compacted gravel placed upon the compacted natural surface soils. If the soils become saturated due to rainfall, the surface sandy soils would have poor trafficability characteristics and it will be necessary to remove this material. Placement of a capping layer over the natural soils will improve the trafficability particularly if the material was to become moist or saturated.

Prior to placing and compacting the filling, the stripped surface should be proof rolled in accordance with AS3798 and the filling also placed in accordance with that Standard. If the soils were to become saturated, it is recommended that the sands be removed and replaced with the capping layer fill.

The gravel fill material below pavements and ground slabs should typically be crushed rock filling of CBR 45 or greater material (ref. DOT MRS 11.05 Type 2 Unbound base course material). In the design of the pavements and ground slabs, it is recommended that a CBR of 1 to 2 be used for the natural clay subgrade and this should be tested to confirm the actual design values.

Surface footings and ground slabs should be designed to tolerate up to 100 mm of movement of the foundations. All slabs and pavements should be designed to tolerate the expected ground movements. Slab edge thickenings should be used at doors and access ways. Isolation joints should be provided between columns and floor slabs to allow for differential movement. Ground slabs should be dowelled to prevent differential movement at the joints due to movement of the soils.

Pavements

The current CBR testing indicates that the clay subgrade has a low CBR value of 1.

Therefore where the surface high plasticity clay is at the subgrade level, it is recommended that the clay should be removed and a lower sub-base be laid to replace the low CBR clay. It is recommended that the subgrade be proof rolled and tested prior to pavement construction. If soft or saturated areas are encountered these will require removal.

Subsoil drainage should be provided around all paved areas and along all buried pipes and adjacent to the structures.

Concrete pavements should be dowelled to prevent differential movement due to seasonal movement of the soils.

Excavation and Retaining Walls

Excavations may be undertaken using medium sized excavators and conventional earthmoving equipment.

Shallow excavations in the surface clays may be excavated to a maximum depth of 1 metre vertically, with the overlying loose soil trimmed above the clays. It is recommended that the excavations be benched at that level and the deeper stiff to very stiff clays be excavated with 1 metre vertical cuts and 1.5 metre wide benches.

Deeper excavations should be supported during construction and the support designed based on a lateral pressure coefficient of 0.5, which should be used in the calculation of the horizontal loads on permanent retaining walls. The active lateral pressure coefficient for free draining granular backfill would be 0.25.

Where services and adjacent structures are in close proximity to the excavation or inside a line of 1 in 3 from the base of the excavation, it is recommended that temporary retaining walls be used.

Effluent Disposal Areas

The investigation findings indicate that the soil profile is similar in the proposed effluent disposal areas, with a surface layer of red-brown and grey, high plasticity silty clay covering mst of the area of the assessment.

No ground water was observed during the site investigations.

The testing indicates that the clayey soils have a very low permeability of approximately 0.06 to 0.08 metres per day.

Surface runoff and shallow infiltration will follow the northerly slopes and drain towards the streams and drainage lines located to the north of the disposal area and thereafter towards the northwest in the low swales and drainage lines that drain towards the river.

Flows would be generally in the direction of the drainage lines and generally in an north westerly direction with the topography and underlying geological formation. Deeper permanent groundwater flows would be expected to mimic the surface drainage direction.

Construction

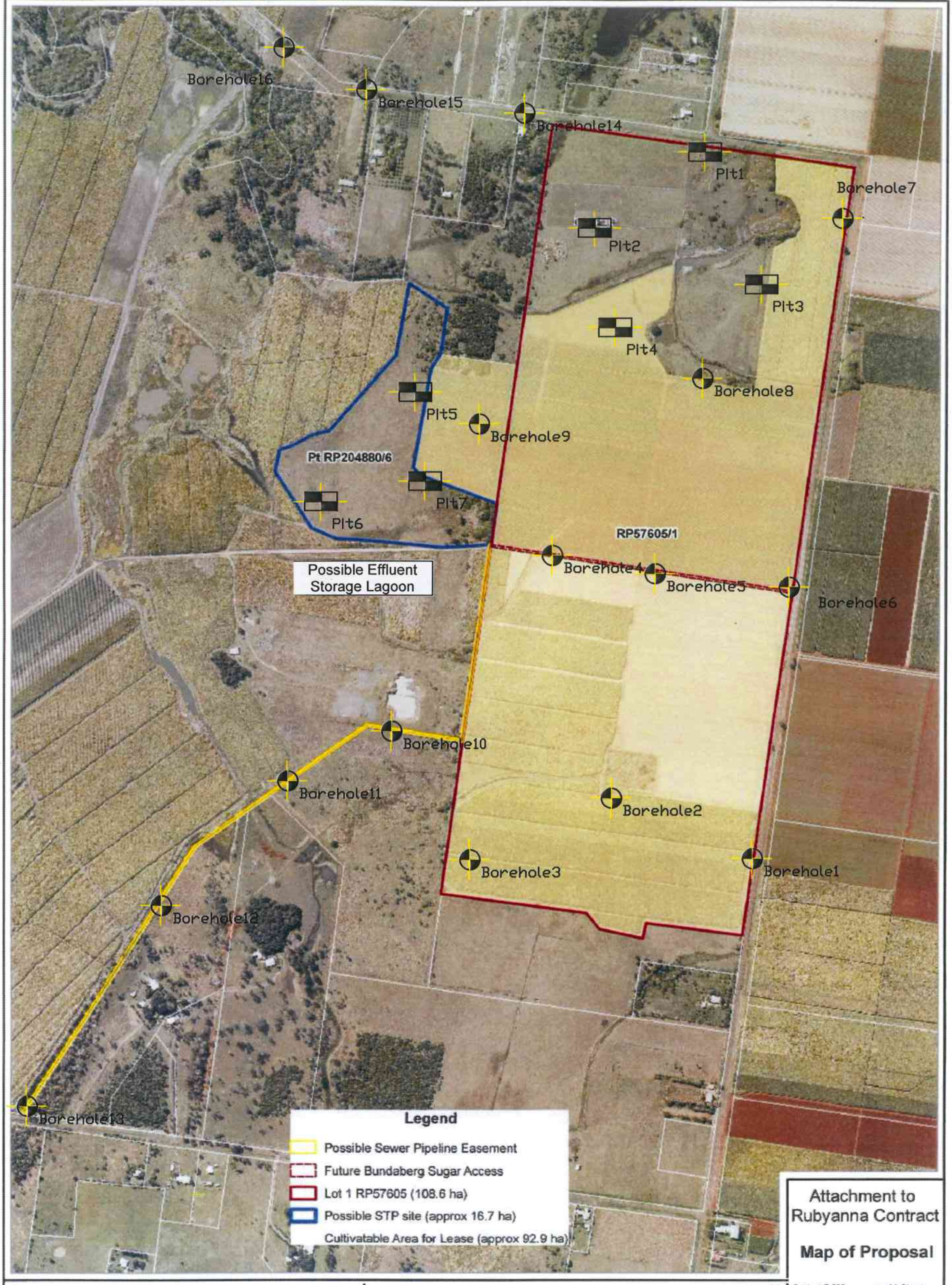
As stated above the surface clayey soils become saturated following rain periods and become untrafficable. This material should be capped to minimise construction difficulties in the areas surrounding the structures.

Deep excavations should allow for the possibility of water ingress. The excavations should be left open for a minimum time following excavation to allow inspection only, and then be poured immediately to avoid softening of the sides and base.

Drainage will need to be provided in the base of the excavation into the basalt rock. During construction, drainage sumps should be provided to remove any seepage that collects in the footing excavations.

The excavations into the weathered basalt will expose areas of basalt boulders encapsulated in highly plastic clay. Saturated conditions will be present, which will cause the foundation base to soften during excavation. The construction should be undertaken to cater for seepage entering the excavations and appropriate drainage measures should be provided to collect seepage entering the excavations during construction. The clay should be removed to expose the basalt boulders over at least 80% of the area of the footing base, where founded on the rock. Some dental type excavation of the clay and smaller boulders will be required and should be allowed for in the construction.

Investigation Locations



Attachment to Rubyanna Contract

Map of Proposal

Scale 1:7,500 on A3 Sheet

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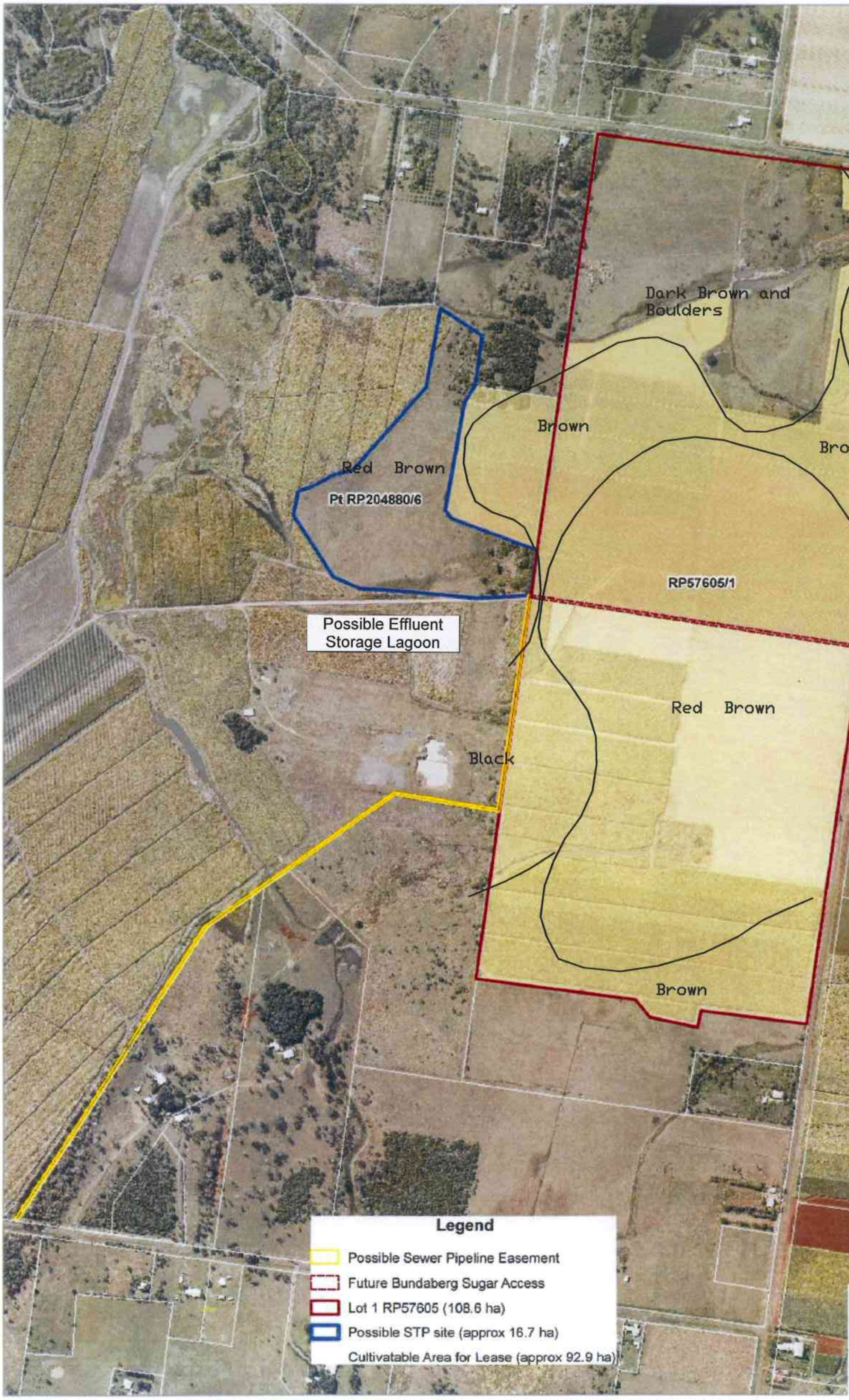
BUNDABERG REGIONAL COUNCIL

Soils Mapping



Attachment to Rubyanna Contract

Map of Proposal

Scale 1:7,500 on A3 Sheet

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Logs and Test Certificates

Attachment to Rubyanna Contract

Map of Proposal

Scale 1:7,500 on A3 Sheet

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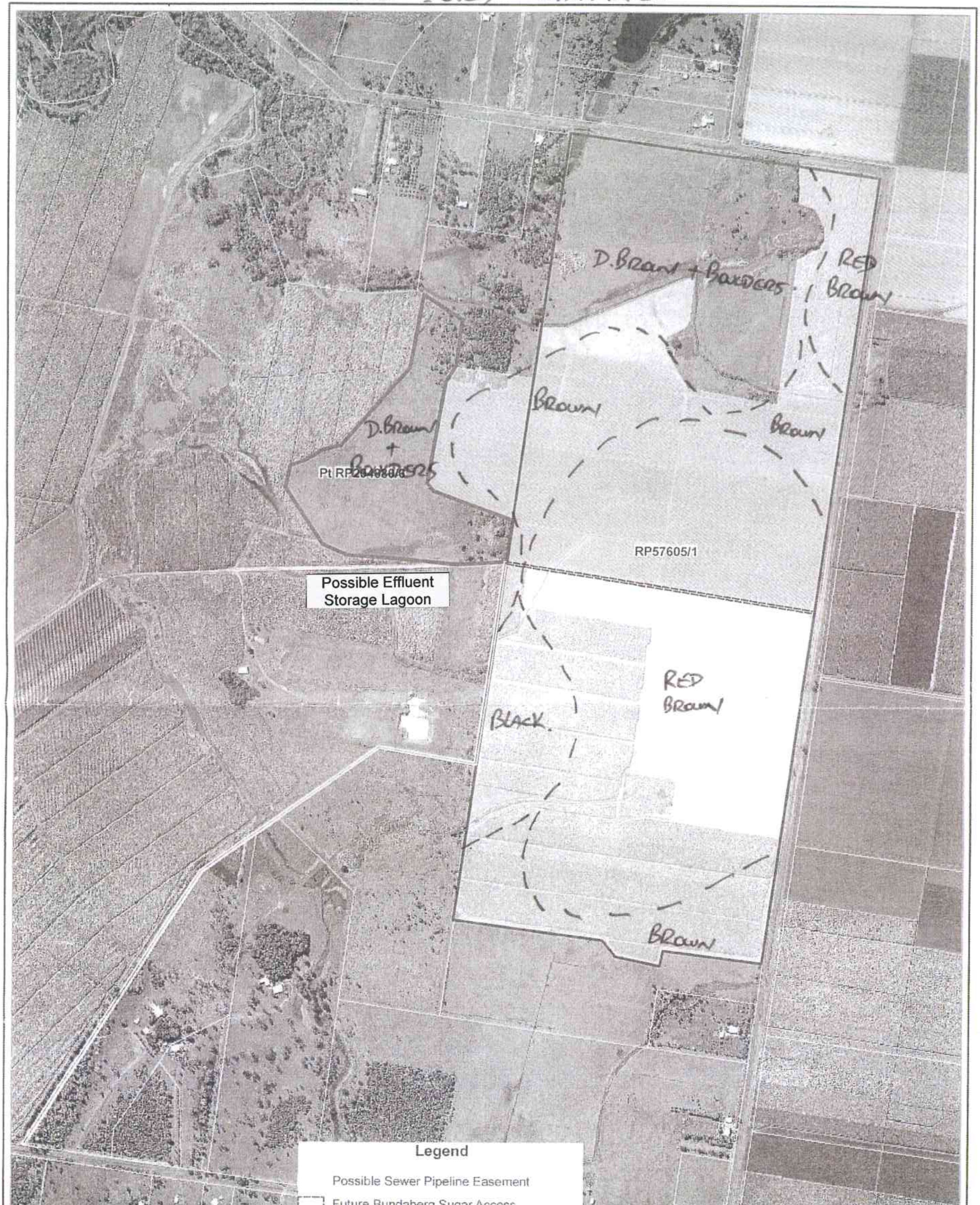
SURFACE SOILS MAPPING.



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BUNDABERG REGIONAL COUNCIL

ROHD FOUR PTY LTD ACN:103228726 ABN:34103228726 t/a

C. M. Testing Service

PO Box 5421 West Bundaberg QLD 4670
Ph (07) 41527644 Fax (07) 41521405

2 Turner St Bundaberg Qld 4670
Email: mark@cmtesting.com.au

12th September 2011

"SAMPLE LIST"

RE: BC10737 – RUBYANNA SEWERAGE PLANT

3.0 Kg Bags

Hole 1	1.0m
Hole 5	0.5-1.5m
Hole 7	1.0m
Hole 11	0.5-1.0m
Hole 13	1.0m

Pit 1	1.0m
Pit 1	1.8m
Pit 4	1.0m
Pit 5	1.0m
Pit 6	1.0m
Pit 7	1.5m

ROHD FOUR PTY LTD ACN:103228726 ABN:34103228726 t/a

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2 Turner St Bundaberg Qld 4670
Email: mark@cmtesting.com.au

12th September 2011

RE: RUBYANNA SEWERAGE PLANT

HOLE NO.	GPS CO-ORDINATES
Pit 1	0439197 – 7255975
Pit 2	0438971 – 7255821
Pit 3	0439318 – 7255693
Pit 4	0439008 – 7255601
Pit 5	0438584 – 7255463
Pit 6	0438383 – 7255230
Pit 7	0438605 – 7255274
Borehole 1	0439300 – 7254473
Borehole 2	0439001 – 7254601
Borehole 3	0438701 – 7254470
Borehole 4	0438875 – 7255117
Borehole 5	0439093 – 7255078
Borehole 6	0439415 – 7255044
Borehole 7	0439533 – 7255836
Borehole 8	0439193 – 7255493
Borehole 9	0438720 – 7255396
Borehole 10	0438534 – 7254743
Borehole 11	0438313 – 7254637
Borehole 12	0438045 – 7254372
Borehole 13	0437760 – 7253945
Borehole 14	0438815 – 7256058
Borehole 15	0438478 – 7256107
Borehole 16	0438302 – 7256197

ROHD FOUR PTY LTD ACN 103228726 ABN 34103228726 T/A

C.M. Testing Service

MATERIALS TESTING LABORATORY

PO Box 5421 West Bundaberg Qld 4670 2 Turner St Bundaberg Qld 4670 Ph 07 4152 7644 Fax 07 4152 1405 Email: mark@cmtesting.com.au

SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG
PROJECT: RUBYANNA SEWERAGE PLANT
LOCATION: 0439197-7255975
METHOD: 20T EXCAVATOR

CERTIFICATE NUMBER: C98859
JOB NUMBER: BC10737
HOLE NO.: PIT 1
DATE LOGGED: 12/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
				M	ST	CH	SILTY CLAY Brown High Plasticity	Trace Basalt Boulders To 100-500mm
0.7				M	ST	CH	SILTY CLAY Red Orange High Plasticity	Trace Basalt Boulders To 100-500mm
1.4				M	ST	CH	SILTY CLAY Olive Grey High Plasticity	
2.0				M	ST	CH	GRAVELLY CLAY & BASALT BOULDERS TO 300mm Pale Grey Mottled Orange High Plasticity MPS to 100mm	
2.7				M	MD	GP	CLAYEY GRAVEL & BASALT BOULDERS TO 400mm Pale Grey Mottled Orange High Plasticity MPS to 100/200mm	
5.4							END OF HOLE 5.4m – REFUSAL ROCK BASALT BOULDER LAYER UNABLE TO PENETRATE	

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

ROHD FOUR PTY LTD ACN 103228726 ABN 34103228726 T/A

C.M. Testing Service

MATERIALS TESTING LABORATORY

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG	**CERTIFICATE NUMBER:** C98860
PROJECT: RUBYANNA SEWERAGE PLANT	**JOB NUMBER:** BC10737
LOCATION: 0438971-7255821	**HOLE NO.:** PIT 2
METHOD: 20T EXCAVATOR	**DATE LOGGED:** 12/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
				M	ST	CH	SILTY CLAY Brown High Plasticity	Trace Basalt Boulders To 200-400mm
0.7				--	--	--	INTERLOCKING BASALT BOULDERS TO 100-500mm Grey	
1.6							END OF HOLE 1.6m – REFUSAL ROCK BASALT BOULDER LAYER UNABLE TO PENETRATE	

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG	**CERTIFICATE NUMBER:** C98861
PROJECT: RUBYANNA SEWERAGE PLANT	**JOB NUMBER:** BC10737
LOCATION: 0439318-7255693	**HOLE NO.:** PIT 3
METHOD: 20T EXCAVATOR	**DATE LOGGED:** 12/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
				M	ST	CH	SILTY CLAY Brown High Plasticity	Trace Basalt Boulders To 300mm
0.6				M	ST	CH	SILTY CLAY Olive Grey High Plasticity	
1.3				M	MD	GP	CLAYEY GRAVEL & BASALT BOULDERS TO 600mm Grey Brown High Plasticity MPS to 10mm	
2.0				--	--	--	INTERLOCKING BASALT BOULDERS TO 100-500mm Grey Brown	
3.0							END OF HOLE 3.0m – REFUSAL ROCK BASALT BOULDER LAYER UNABLE TO PENETRATE	

Sample:	Moisture:	Consistency Cohesive:	Consistency Noncohesive:	Density:	Soils:
H – hand	D – dry	VS – very soft	VL - very loose	VL – very loose	G - gravel
Test:	SM – slightly moist	S – soft	L - loose	L – loose	C - clay
V – shear vane	M – moist	F – firm	MD – medium dense	MD – medium dense	S - sand
HP – penetrometer	VM – very moist	St – stiff	D - dense	D – dense	M - silt
UCS – 50mm tube	S - saturated	VSt – very stiff	VD – very dense	VD – very dense	XW, DW, SW, FR, (ROCK)
	W – free water	H - hard			

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG
CERTIFICATE NUMBER: C98862
PROJECT: RUBYANNA SEWERAGE PLANT
JOB NUMBER: BC10737
LOCATION: 0439008-7255601
HOLE NO.: PIT 4
METHOD: 20T EXCAVATOR
DATE LOGGED: 12/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
				M	ST	CH	SILTY CLAY Dark Brown High Plasticity	
0.5				M	ST	CH	SILTY CLAY Brown High Plasticity	
0.8				M	ST	CH	SILTY CLAY Grey Brown High Plasticity	
1.4				M	MD	GP	CLAYEY GRAVEL & BASALT BOULDERS TO 200mm Grey Brown High Plasticity MPS to 150mm	
2.3				--	--	--	INTERLOCKING BASALT BOULDERS TO 100-500mm Grey Brown	
2.8							END OF HOLE 2.8m – REFUSAL ROCK BASALT BOULDER LAYER UNABLE TO PENETRATE	

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG	**CERTIFICATE NUMBER:** C98863
PROJECT: RUBYANNA SEWERAGE PLANT	**JOB NUMBER:** BC10737
LOCATION: 0438584-7255463	**HOLE NO.:** PIT 5
METHOD: 20T EXCAVATOR	**DATE LOGGED:** 12/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
				M	ST	CH	SILTY CLAY Brown High Plasticity	Trace Basalt Boulders To 500mm
0.5				M	ST	CH	SILTY CLAY Orange Brown High Plasticity	
0.8				VM	ST	CH	SILTY CLAY Pale Grey Mottled Red High Plasticity	
1.5				M	ST	CH	GRAVELLY CLAY & BASALT BOULDERS TO 300-500mm Grey Brown High Plasticity MPS to 150mm	
2.3				--	--	--	INTERLOCKING BASALT BOULDERS TO 500mm Grey Brown	
3.0							END OF HOLE 3.0m – REFUSAL ROCK BASALT BOULDER LAYER UNABLE TO PENETRATE	

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG
CERTIFICATE NUMBER: C98864
PROJECT: RUBYANNA SEWERAGE PLANT
JOB NUMBER: BC10737
LOCATION: 0438383-7255230
HOLE NO.: PIT 6
METHOD: 20T EXCAVATOR
DATE LOGGED: 12/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description		Comments
				M	ST	CH	SILTY CLAY High Plasticity	Dark Brown	Trace Basalt Boulders To 100-500mm
0.6				M	ST	CH	SILTY CLAY High Plasticity	Orange Brown	
0.9				M	ST	CH	SANDY CLAY High Plasticity	Red Orange Mottled Grey Fine to Medium Particles	
1.5				M	MD	GP	CLAYEY GRAVEL High Plasticity	Grey Brown MPS to 150mm	
1.9				--	--	--	INTERLOCKING BASALT BOULDERS TO 100-500mm	Grey Brown	
3.2							END OF HOLE 3.2m – REFUSAL ROCK BASALT BOULDER LAYER UNABLE TO PENETRATE		

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG	**CERTIFICATE NUMBER:** C98865
PROJECT: RUBYANNA SEWERAGE PLANT	**JOB NUMBER:** BC10737
LOCATION: 0438605-7255274	**HOLE NO.:** PIT 7
METHOD: 20T EXCAVATOR	**DATE LOGGED:** 12/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
0.0–0.5				M	ST	CH	SILTY CLAY Dark Brown High Plasticity	Trace Basalt Boulders To 500mm
0.5–2.0				M	ST	CH	SILTY CLAY Pale Grey Mottled Orange High Plasticity	Trace Basalt Boulders To 200-500mm
2.0–2.6				M	MD	GP	CLAYEY GRAVEL & BASALT BOULDERS Grey High Plasticity MPS to 100mm	
2.6–3.4				--	--	--	INTERLOCKING BASALT BOULDERS TO 500mm Grey	
3.4							END OF HOLE 3.4m – REFUSAL ROCK BASALT BOULDER LAYER UNABLE TO PENETRATE	

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG	**CERTIFICATE NUMBER:** C98866
PROJECT: RUBYANNA SEWERAGE PLANT	**JOB NUMBER:** BC10737
LOCATION: 0439300-7254473	**HOLE NO.:** BOREHOLE 1
METHOD: GEMCO HP4	**DATE LOGGED:** 01/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
				M	ST	CH	SILTY CLAY Dark Brown High Plasticity	
0.4				M	ST	CH	SILTY CLAY Brown High Plasticity	
1.0				M	ST	CH	SILTY CLAY Brown High Plasticity	Trace Ironstone Gravel To 10mm
1.65				M	MD	GP	CLAYEY GRAVEL Grey Brown Medium Plasticity MPS to 40mm	Extremely Weathered Basalt
2.45							END OF HOLE 2.45m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE	

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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AS1547 EFFLUENT DISPOSAL CERTIFICATE

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG		**CERTIFICATE NUMBER**: C98867
PROJECT: RUBYANNA SEWERAGE PLANT		**JOB NUMBER**: BC10737
LOCATION: BOREHOLE 1	**DATE ISSUED:** 13/09/11	**DATE ASSESSED:** 01/09/11

SLOPE:	1m IN 50m		
SLOPE DIRECTION:	SOUTH		
SLOPE SHAPE:	PLANAR		
SITE EXPOSURE:	EXCELLENT EXPOSURE TO WIND AND SUN		
PREVIOUS/CURRENT USAGE:	CANE FIELD		
EROSION POTENTIAL:	LOW SHEET		
GEOLOGY:	BASALT		
ROCK EXPOSURE:	NO EXPOSURE		
SITE DRAINAGE:	GOOD		
SOIL DRAINAGE:	POOR		
SITE DRAINS TO:	GULLY	APPROX. 150m TO THE SOUTH	
FLOOD POTENTIAL:	NIL		
WATER BORES:	NO		
GROUNDWATER:	NOT ENCOUNTERED ABOVE 2m		
PERCHED WATER TABLE:	NOT DETECTED		
CURRENT MOISTURE:	MOIST		
CRACKING:	NIL		
CLAY DISPERSION:	NO DISPERSION OBSERVED, EMERSON 6		
AS1547 SOIL CLASS:	HEAVY CLAY		**CLASS No.**: 6
SOIL STRUCTURE:	STRONG		

Authorised Signatory: Mark Rohdmann

PERCOLATION TEST: AS1547 APPENDIX 4.1F (CONSTANT HEAD)
DEPTH OF AUGER HOLE: 0.6m
RADIUS OF AUGER HOLE: 100mm
DEPTH OF WATER MAINTAINED IN AUGER HOLE: 250mm

PERCOLATION RATE = 0.061 m/DAY

SITE SKETCH (not to scale)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG
PROJECT: RUBYANNA SEWERAGE PLANT
LOCATION: 0439001-7254601
METHOD: GEMCO HP4

CERTIFICATE NUMBER: C98868
JOB NUMBER: BC10737
HOLE NO.: BOREHOLE 2
DATE LOGGED: 01/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
				M	ST	CH	SILTY CLAY Dark Brown High Plasticity	Trace Basalt Boulders To 300-400mm
0.6				M	MD	GP	CLAYEY GRAVEL Grey Brown High Plasticity MPS to 40mm	Extremely Weathered Basalt
0.85							END OF HOLE 0.85m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE BEST OF 3 ATTEMPTS	

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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AS1547 EFFLUENT DISPOSAL CERTIFICATE

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG		**CERTIFICATE NUMBER**: C98869
PROJECT: RUBYANNA SEWERAGE PLANT		**JOB NUMBER**: BC10737
LOCATION: BOREHOLE 2	**DATE ISSUED:** 13/09/11	**DATE ASSESSED:** 01/09/11

SLOPE: 1m IN 100m
SLOPE DIRECTION: STH WEST
SLOPE SHAPE: PLANAR
SITE EXPOSURE: EXCELLENT EXPOSURE TO WIND AND SUN
PREVIOUS/CURRENT USAGE: VACANT PASTURE
EROSION POTENTIAL: LOW SHEET
GEOLOGY: BASALT
ROCK EXPOSURE: SHALLOW ROCK
SITE DRAINAGE: GOOD
SOIL DRAINAGE: POOR
SITE DRAINS TO: GULLY APPROX. 80m TO THE STH WEST
FLOOD POTENTIAL: NIL
WATER BORES: NO
GROUNDWATER: NOT ENCOUNTERED ABOVE 2m
PERCHED WATER TABLE: NOT DETECTED
CURRENT MOISTURE: MOIST
CRACKING: NIL
CLAY DISPERSION: NO DISPERSION OBSERVED, EMERSON 6
AS1547 SOIL CLASS: HEAVY CLAY **CLASS No.**: 6
SOIL STRUCTURE: STRONG

Authorised Signatory: Mark Rohdmann

PERCOLATION TEST: AS1547 APPENDIX 4.1F (CONSTANT HEAD)
DEPTH OF AUGER HOLE: 0.6m
RADIUS OF AUGER HOLE: 100mm
DEPTH OF WATER MAINTAINED IN AUGER HOLE: 250mm

PERCOLATION RATE = 0.07 m/DAY

SITE SKETCH (not to scale)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG
PROJECT: RUBYANNA SEWERAGE PLANT
LOCATION: 0438701-7254470
METHOD: GEMCO HP4

CERTIFICATE NUMBER: C98870
JOB NUMBER: BC10737
HOLE NO.: BOREHOLE 3
DATE LOGGED: 01/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description		Comments
				M	ST	CH	SILTY CLAY High Plasticity	Dark Brown	
0.5				M	ST	CH	SILTY CLAY High Plasticity	Brown	
0.8				M	ST	CH	SILTY CLAY High Plasticity	Brown	Trace Ironstone Gravel To 10mm
1.4				M	ST	CH	SILTY CLAY High Plasticity	Red Mottled Grey	
2.3				VM	ST	CH	SILTY CLAY Very High Plasticity	Pale Grey Mottled Red	
3.6							END OF HOLE 3.6m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE		

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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AS1547 EFFLUENT DISPOSAL CERTIFICATE

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG		**CERTIFICATE NUMBER**: C98871
PROJECT: RUBYANNA SEWERAGE PLANT		**JOB NUMBER**: BC10737
LOCATION: BOREHOLE 3	**DATE ISSUED:** 13/09/11	**DATE ASSESSED:** 01/09/11

SLOPE:	1m IN 100m
SLOPE DIRECTION:	WEST
SLOPE SHAPE:	PLANAR
SITE EXPOSURE:	EXCELLENT EXPOSURE TO WIND AND SUN
PREVIOUS/CURRENT USAGE:	CANE FIELD
EROSION POTENTIAL:	LOW SHEET
GEOLOGY:	BASALT
ROCK EXPOSURE:	NO EXPOSURE
SITE DRAINAGE:	GOOD
SOIL DRAINAGE:	VERY POOR
SITE DRAINS TO:	GULLY APPROX. 300m TO THE STH WEST
FLOOD POTENTIAL:	NIL
WATER BORES:	NO
GROUNDWATER:	NOT ENCOUNTERED ABOVE 2m
PERCHED WATER TABLE:	NOT DETECTED
CURRENT MOISTURE:	MOIST
CRACKING:	NIL
CLAY DISPERSION:	NO DISPERSION OBSERVED, EMERSON 6
AS1547 SOIL CLASS:	HEAVY CLAY **CLASS No.**: 6
SOIL STRUCTURE:	STRONG

Authorised Signatory: Mark Rohdmann

PERCOLATION TEST: AS1547 APPENDIX 4.1F (CONSTANT HEAD)
DEPTH OF AUGER HOLE: 0.6m
RADIUS OF AUGER HOLE: 100mm
DEPTH OF WATER MAINTAINED IN AUGER HOLE: 250mm

PERCOLATION RATE = 0.08 m/DAY

SITE SKETCH (not to scale)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG	**CERTIFICATE NUMBER:** C98872
PROJECT: RUBYANNA SEWERAGE PLANT	**JOB NUMBER:** BC10737
LOCATION: 0438875-7255117	**HOLE NO.:** BOREHOLE 4
METHOD: GEMCO HP4	**DATE LOGGED:** 01/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description		Comments
0 – 0.5				M	ST	CI	SILTY CLAY Medium Plasticity	Red Brown	
0.5 – 1.0				M	ST	CH	SILTY CLAY High Plasticity	Brown	
1.0 – 1.8				M	ST	CH	GRAVELLY CLAY High Plasticity	Orange Brown MPS to 40mm	
1.8 – 2.6				M	MD	GP	CLAYEY GRAVEL Medium Plasticity	Grey Brown	Extremely Weathered Basalt
2.6							END OF HOLE 2.6m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE		

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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AS1547 EFFLUENT DISPOSAL CERTIFICATE

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG		**CERTIFICATE NUMBER**: C98873
PROJECT: RUBYANNA SEWERAGE PLANT		**JOB NUMBER**: BC10737
LOCATION: BOREHOLE 4	**DATE ISSUED:** 13/09/11	**DATE ASSESSED:** 01/09/11

SLOPE: 1m IN 100m
SLOPE DIRECTION: WEST
SLOPE SHAPE: PLANAR
SITE EXPOSURE: EXCELLENT EXPOSURE TO WIND AND SUN
PREVIOUS/CURRENT USAGE: CANE FIELD
EROSION POTENTIAL: LOW SHEET
GEOLOGY: BASALT
ROCK EXPOSURE: NO EXPOSURE
SITE DRAINAGE: GOOD
SOIL DRAINAGE: VERY POOR
SITE DRAINS TO: GULLY APPROX. 80m TO THE STH WEST
FLOOD POTENTIAL: NIL
WATER BORES: NO
GROUNDWATER: NOT ENCOUNTERED ABOVE 2m
PERCHED WATER TABLE: NOT DETECTED
CURRENT MOISTURE: MOIST
CRACKING: NIL
CLAY DISPERSION: NO DISPERSION OBSERVED, EMERSON 6
AS1547 SOIL CLASS: HEAVY CLAY **CLASS No.**: 6
SOIL STRUCTURE: STRONG

Authorised Signatory: Mark Rohdmann

PERCOLATION TEST: AS1547 APPENDIX 4.1F (CONSTANT HEAD)
DEPTH OF AUGER HOLE: 0.6m
RADIUS OF AUGER HOLE: 100mm
DEPTH OF WATER MAINTAINED IN AUGER HOLE: 250mm

PERCOLATION RATE = 0.07 m/DAY

SITE SKETCH (not to scale)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG
CERTIFICATE NUMBER: C98874
PROJECT: RUBYANNA SEWERAGE PLANT
JOB NUMBER: BC10737
LOCATION: 0439093-7255078
HOLE NO.: BOREHOLE 5
METHOD: GEMCO HP4
DATE LOGGED: 01/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
0.0–0.6				M	ST	CI	SILTY CLAY, Red Brown, Medium Plasticity	
0.6–2.0				M	ST	CH	SILTY CLAY, Red Brown, High Plasticity	
2.0–2.7				M	VST	CH	SILTY CLAY, Red Brown, High Plasticity	
2.7–3.0				M	VST	CI	SILTY CLAY, Red Orange, Medium Plasticity	
3.0							END OF HOLE 3.0m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE	

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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AS1547 EFFLUENT DISPOSAL CERTIFICATE

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG		**CERTIFICATE NUMBER**: C98875
PROJECT: RUBYANNA SEWERAGE PLANT		**JOB NUMBER**: BC10737
LOCATION: BOREHOLE 5	**DATE ISSUED:** 13/09/11	**DATE ASSESSED:** 01/09/11

SLOPE:	FLAT
SLOPE DIRECTION:	NOT APPLICABLE
SLOPE SHAPE:	PLANAR
SITE EXPOSURE:	EXCELLENT EXPOSURE TO WIND AND SUN
PREVIOUS/CURRENT USAGE:	CANE FIELD
EROSION POTENTIAL:	LOW SHEET
GEOLOGY:	BASALT
ROCK EXPOSURE:	NO EXPOSURE
SITE DRAINAGE:	GOOD
SOIL DRAINAGE:	VERY POOR
SITE DRAINS TO:	GULLY APPROX. 250m TO THE STH WEST
FLOOD POTENTIAL:	NIL
WATER BORES:	NO
GROUNDWATER:	NOT ENCOUNTERED ABOVE 2m
PERCHED WATER TABLE:	NOT DETECTED
CURRENT MOISTURE:	MOIST
CRACKING:	NIL
CLAY DISPERSION:	NO DISPERSION OBSERVED, EMERSON 6
AS1547 SOIL CLASS:	HEAVY CLAY **CLASS No.**: 6
SOIL STRUCTURE:	STRONG

Authorised Signatory: Mark Rohdmann

PERCOLATION TEST: AS1547 APPENDIX 4.1F (CONSTANT HEAD)
DEPTH OF AUGER HOLE: 0.6m
RADIUS OF AUGER HOLE: 100mm
DEPTH OF WATER MAINTAINED IN AUGER HOLE: 250mm

PERCOLATION RATE = 0.078 m/DAY

SITE SKETCH (not to scale)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG	**CERTIFICATE NUMBER:** C98876
PROJECT: RUBYANNA SEWERAGE PLANT	**JOB NUMBER:** BC10737
LOCATION: 0439415-7255044	**HOLE NO.:** BOREHOLE 6
METHOD: GEMCO HP4	**DATE LOGGED:** 01/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
0.0–0.5				M	ST	CI	SILTY CLAY Red Brown Medium Plasticity	
0.5–1.8				M	ST	CH	SILTY CLAY Red Brown High Plasticity	
1.8–2.4				M	VST	CH	SILTY CLAY Red Brown High Plasticity	
2.4–3.0				M	VST	CI	SILTY CLAY Red Orange Medium Plasticity	
3.0							END OF HOLE 3.0m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE	

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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AS1547 EFFLUENT DISPOSAL CERTIFICATE

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG		**CERTIFICATE NUMBER**: C98877
PROJECT: RUBYANNA SEWERAGE PLANT		**JOB NUMBER**: BC10737
LOCATION: BOREHOLE 6	**DATE ISSUED:** 13/09/11	**DATE ASSESSED:** 01/09/11

SLOPE: FLAT
SLOPE DIRECTION: NOT APPLICABLE
SLOPE SHAPE: PLANAR
SITE EXPOSURE: EXCELLENT EXPOSURE TO WIND AND SUN
PREVIOUS/CURRENT USAGE: CANE FIELD
EROSION POTENTIAL: LOW SHEET
GEOLOGY: BASALT
ROCK EXPOSURE: NO EXPOSURE
SITE DRAINAGE: GOOD
SOIL DRAINAGE: VERY POOR
SITE DRAINS TO: ROAD APPROX. 50m TO THE EAST
FLOOD POTENTIAL: NIL
WATER BORES: NO
GROUNDWATER: NOT ENCOUNTERED ABOVE 2m
PERCHED WATER TABLE: NOT DETECTED
CURRENT MOISTURE: MOIST
CRACKING: NIL
CLAY DISPERSION: NO DISPERSION OBSERVED, EMERSON 6
AS1547 SOIL CLASS: HEAVY CLAY **CLASS No.**: 6
SOIL STRUCTURE: STRONG

Authorised Signatory: Mark Rohdmann

PERCOLATION TEST: AS1547 APPENDIX 4.1F (CONSTANT HEAD)
DEPTH OF AUGER HOLE: 0.6m
RADIUS OF AUGER HOLE: 100mm
DEPTH OF WATER MAINTAINED IN AUGER HOLE: 250mm

PERCOLATION RATE = 0.08 m/DAY

SITE SKETCH (not to scale)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG	**CERTIFICATE NUMBER:** C98878
PROJECT: RUBYANNA SEWERAGE PLANT	**JOB NUMBER:** BC10737
LOCATION: 0439533-7255836	**HOLE NO.:** BOREHOLE 7
METHOD: GEMCO HP4	**DATE LOGGED:** 02/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
				M	ST	CH	SILTY CLAY Red Brown High Plasticity	
2.5				M	ST	CI	SILTY CLAY Red Brown Medium Plasticity	
3.0							END OF HOLE 3.0m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE	

Sample:	Moisture:	Consistency Cohesive:	Consistency Noncohesive:	Density:	Soils:
H – hand	D – dry	VS – very soft	VL - very loose	VL – very loose	G - gravel
Test:	SM – slightly moist	S – soft	L - loose	L – loose	C - clay
V – shear vane	M – moist	F – firm	MD – medium dense	MD – medium dense	S - sand
HP – penetrometer	VM – very moist	St – stiff	D - dense	D – dense	M - silt
UCS – 50mm tube	S - saturated	VSt – very stiff	VD – very dense	VD – very dense	XW, DW, SW, FR, (ROCK)
	W – free water	H - hard			

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AS1547 EFFLUENT DISPOSAL CERTIFICATE

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG		**CERTIFICATE NUMBER**: C98879
PROJECT: RUBYANNA SEWERAGE PLANT		**JOB NUMBER**: BC10737
LOCATION: BOREHOLE 7	**DATE ISSUED:** 13/09/11	**DATE ASSESSED:** 02/09/11

SLOPE: 1m IN 100m
SLOPE DIRECTION: SOUTH
SLOPE SHAPE: PLANAR
SITE EXPOSURE: EXCELLENT EXPOSURE TO WIND AND SUN
PREVIOUS/CURRENT USAGE: CANE FIELD
EROSION POTENTIAL: LOW SHEET
GEOLOGY: BASALT
ROCK EXPOSURE: NO EXPOSURE
SITE DRAINAGE: GOOD
SOIL DRAINAGE: POOR
SITE DRAINS TO: GULLY APPROX. 100m TO THE SOUTH
FLOOD POTENTIAL: NIL
WATER BORES: NO
GROUNDWATER: NOT ENCOUNTERED ABOVE 2m
PERCHED WATER TABLE: NOT DETECTED
CURRENT MOISTURE: MOIST
CRACKING: NIL
CLAY DISPERSION: NO DISPERSION OBSERVED, EMERSON 6
AS1547 SOIL CLASS: HEAVY CLAY **CLASS No.**: 6
SOIL STRUCTURE: STRONG

Authorised Signatory: Mark Rohdmann

PERCOLATION TEST: AS1547 APPENDIX 4.1F (CONSTANT HEAD)
DEPTH OF AUGER HOLE: 0.6m
RADIUS OF AUGER HOLE: 100mm
DEPTH OF WATER MAINTAINED IN AUGER HOLE: 250mm

PERCOLATION RATE = 0.064 m/DAY

SITE SKETCH (not to scale)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG	**CERTIFICATE NUMBER:** C98880
PROJECT: RUBYANNA SEWERAGE PLANT	**JOB NUMBER:** BC10737
LOCATION: 0439193-7255493	**HOLE NO.:** BOREHOLE 8
METHOD: GEMCO HP4	**DATE LOGGED:** 02/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description		Comments
0 – 0.7				M	ST	CH	SILTY CLAY High Plasticity	Brown	
0.7 – 0.95				M	ST	CH	SILTY CLAY High Plasticity	Grey Brown	
0.95 – 1.7				M	MD	GP	CLAYEY GRAVEL High Plasticity	Grey Brown MPS to 40mm	Extremely Weathered Basalt
1.7							END OF HOLE 1.7m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE		

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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AS1547 EFFLUENT DISPOSAL CERTIFICATE

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG		**CERTIFICATE NUMBER**: C98881
PROJECT: RUBYANNA SEWERAGE PLANT		**JOB NUMBER**: BC10737
LOCATION: BOREHOLE 8	**DATE ISSUED:** 13/09/11	**DATE ASSESSED:** 02/09/11

SLOPE:	1m IN 50m		
SLOPE DIRECTION:	WEST		
SLOPE SHAPE:	CONVEX		
SITE EXPOSURE:	EXCELLENT EXPOSURE TO WIND AND SUN		
PREVIOUS/CURRENT USAGE:	CANE FIELD		
EROSION POTENTIAL:	LOW SHEET		
GEOLOGY:	BASALT		
ROCK EXPOSURE:	SHALLOW ROCK		
SITE DRAINAGE:	GOOD		
SOIL DRAINAGE:	POOR		
SITE DRAINS TO:	GULLY	APPROX. 100m TO THE STH WEST	
FLOOD POTENTIAL:	NIL		
WATER BORES:	NO		
GROUNDWATER:	NOT ENCOUNTERED ABOVE 2m		
PERCHED WATER TABLE:	NOT DETECTED		
CURRENT MOISTURE:	MOIST		
CRACKING:	NIL		
CLAY DISPERSION:	NO DISPERSION OBSERVED, EMERSON 6		
AS1547 SOIL CLASS:	HEAVY CLAY	**CLASS No.**:	6
SOIL STRUCTURE:	STRONG		

Authorised Signatory: Mark Rohdmann

PERCOLATION TEST: AS1547 APPENDIX 4.1F (CONSTANT HEAD)
DEPTH OF AUGER HOLE: 0.6m
RADIUS OF AUGER HOLE: 100mm
DEPTH OF WATER MAINTAINED IN AUGER HOLE: 250mm

PERCOLATION RATE = 0.06 m/DAY

SITE SKETCH (not to scale)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG
PROJECT: RUBYANNA SEWERAGE PLANT
LOCATION: 0438720-7255396
METHOD: GEMCO HP4

CERTIFICATE NUMBER: C98882
JOB NUMBER: BC10737
HOLE NO.: BOREHOLE 9
DATE LOGGED: 02/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description		Comments
				M	ST	CH	SILTY CLAY High Plasticity	Brown	
0.7				M	ST	CH	SILTY CLAY High Plasticity	Red Brown	
1.6				M	ST	CH	SILTY CLAY High Plasticity	Red Orange	
2.4				M	ST	CI	GRAVELLY CLAY Medium Plasticity	Red Orange MPS to 20mm	
3.8							END OF HOLE 3.8m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE		

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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AS1547 EFFLUENT DISPOSAL CERTIFICATE

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG		**CERTIFICATE NUMBER**: C98883
PROJECT: RUBYANNA SEWERAGE PLANT		**JOB NUMBER**: BC10737
LOCATION: BOREHOLE 9	**DATE ISSUED:** 13/09/11	**DATE ASSESSED:** 02/09/11

SLOPE: FLAT
SLOPE DIRECTION: NOT APPLICABLE
SLOPE SHAPE: PLANAR
SITE EXPOSURE: EXCELLENT EXPOSURE TO WIND AND SUN
PREVIOUS/CURRENT USAGE: CANE FIELD
EROSION POTENTIAL: LOW SHEET
GEOLOGY: BASALT
ROCK EXPOSURE: NO EXPOSURE
SITE DRAINAGE: GOOD
SOIL DRAINAGE: POOR
SITE DRAINS TO: GULLY APPROX. 300m TO THE NTH
FLOOD POTENTIAL: NIL
WATER BORES: NO
GROUNDWATER: NOT ENCOUNTERED ABOVE 2m
PERCHED WATER TABLE: NOT DETECTED
CURRENT MOISTURE: MOIST
CRACKING: NIL
CLAY DISPERSION: NO DISPERSION OBSERVED, EMERSON 6
AS1547 SOIL CLASS: HEAVY CLAY **CLASS No.**: 6
SOIL STRUCTURE: STRONG

Authorised Signatory: Mark Rohdmann

PERCOLATION TEST: AS1547 APPENDIX 4.1F (CONSTANT HEAD)
DEPTH OF AUGER HOLE: 0.6m
RADIUS OF AUGER HOLE: 100mm
DEPTH OF WATER MAINTAINED IN AUGER HOLE: 250mm

PERCOLATION RATE = 0.068 m/DAY

SITE SKETCH (not to scale)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG	**CERTIFICATE NUMBER:** C98884
PROJECT: RUBYANNA SEWERAGE PLANT	**JOB NUMBER:** BC10737
LOCATION: 0438534-7254743	**HOLE NO.:** BOREHOLE 10
METHOD: GEMCO HP4	**DATE LOGGED:** 02/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
				M	ST	CH	SILTY CLAY & BASALT BOULDERS TO 300-400mm Dark Brown High Plasticity	
0.5				--	--	--	INTERLOCKING BASALT BOULDERS TO 100-300mm Grey Brown	
0.9							END OF HOLE 0.9m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE BEST OF MANY ATTEMPTS INSPECTION OF ADJACENT OLD QUARRY SITE	

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG
CERTIFICATE NUMBER: C98885
PROJECT: RUBYANNA SEWERAGE PLANT
JOB NUMBER: BC10737
LOCATION: 0438313-7254637
HOLE NO.: BOREHOLE 11
METHOD: GEMCO HP4
DATE LOGGED: 02/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
0.0–0.45				M	ST	CH	SILTY CLAY Black High Plasticity	
0.45–1.0				M	ST	CH	SILTY CLAY Pale Grey Brown High Plasticity	
1.0–1.65				M	MD	GP	CLAYEY GRAVEL Grey Brown Medium Plasticity MPS to 40mm	
1.65							END OF HOLE 1.65m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE	

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG
PROJECT: RUBYANNA SEWERAGE PLANT
LOCATION: 0438045-7254372
METHOD: GEMCO HP4

CERTIFICATE NUMBER: C98886
JOB NUMBER: BC10737
HOLE NO.: BOREHOLE 12
DATE LOGGED: 02/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description		Comments
				M	ST	CH	SILTY CLAY High Plasticity	Dark Brown	
0.5				VM	ST	CH	SILTY CLAY High Plasticity	Olive Grey	
2.4				M	ST	CH	GRAVELLY CLAY High Plasticity	Grey Brown MPS to 20mm	
3.6							END OF HOLE 3.6m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE		

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H - hard

Consistency Noncohesive:
VL - very loose
L - loose
MD – medium dense
D - dense
VD – very dense

Density:
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

Soils:
G - gravel
C - clay
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

ROHD FOUR PTY LTD ACN 103228726 ABN 34103228726 T/A

C.M. Testing Service

MATERIALS TESTING LABORATORY

PO Box 5421 West Bundaberg Qld 4670 2 Turner St Bundaberg Qld 4670 Ph 07 4152 7644 Fax 07 4152 1405 Email: mark@cmtesting.com.au

SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG
PROJECT: RUBYANNA SEWERAGE PLANT
LOCATION: 0437760-7253945
METHOD: GEMCO HP4

CERTIFICATE NUMBER: C98887
JOB NUMBER: BC10737
HOLE NO.: BOREHOLE 13
DATE LOGGED: 02/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description	Comments
				M	ST	CH	SILTY CLAY Dark Brown High Plasticity	
0.6				M	ST	CH	SILTY CLAY Grey Brown High Plasticity	
2.65							END OF HOLE 2.65m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE	

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
VS – very soft
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St – stiff
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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG
PROJECT: RUBYANNA SEWERAGE PLANT
LOCATION: 0438815-7256058
METHOD: GEMCO HP4

CERTIFICATE NUMBER: C98911
JOB NUMBER: BC10737
HOLE NO.: 14
DATE LOGGED: 15/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description		Comments
0.0–0.4				M	ST	CH	SILTY CLAY High Plasticity	Dark Brown	Trace Basalt Boulders To 200mm
0.4–0.7				M	ST	CH	SILTY CLAY High Plasticity	Grey Brown	
0.7–1.0				M	ST	CH	GRAVELLY CLAY High Plasticity	Grey Brown MPS to 10mm	
1.0–1.35				M	MD	GP	CLAYEY GRAVEL High Plasticity	Grey Brown MPS to 100mm	
1.35							END OF HOLE 1.35m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE		

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
W – free water

Consistency Cohesive:
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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG
PROJECT: RUBYANNA SEWERAGE PLANT
LOCATION: 0438478-7256107
METHOD: GEMCO HP4

CERTIFICATE NUMBER: C98912
JOB NUMBER: BC10737
HOLE NO.: 15
DATE LOGGED: 15/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description		Comments
0.0–0.5				M	MD	SC	CLAYEY SAND Low Plasticity	Dark Brown Fine Particles	
0.5–0.8				M	ST	CI	SANDY CLAY Medium Plasticity	Dark Brown Fine to Medium Particles	
0.8–1.4				M	ST	CI	SANDY CLAY Medium Plasticity	Red Mottled Grey Fine to Medium Particles	
1.4–2.0				M	ST	CI	SANDY CLAY Medium Plasticity	Grey Mottled Red Orange Fine to Medium Particles	
2.0							END OF HOLE 2.0m		

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
D – dry
SM – slightly moist
M – moist
VM – very moist
S - saturated
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Consistency Cohesive:
VS – very soft
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ROHD FOUR PTY LTD ACN 103228726 ABN 34103228726 T/A

C.M. Testing Service

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SOIL PROFILE LOG

CLIENT: BUNDABERG REGIONAL COUNCIL - BUNDABERG
PROJECT: RUBYANNA SEWERAGE PLANT
LOCATION: 0438302-7256197
METHOD: GEMCO HP4

CERTIFICATE NUMBER: C98913
JOB NUMBER: BC10737
HOLE NO.: 16
DATE LOGGED: 15/09/11

Depth (m)	Sample	Test	Graphic Log	Moisture	Consistency	Symbol	Materials Description		Comments
0.0–0.4				M	ST	CI	SANDY CLAY Medium Plasticity	Brown Fine Particles	Trace Basalt Boulders To 500mm
0.4–0.8				M	ST	CI	GRAVELLY CLAY Medium Plasticity	Grey Brown MPS to 80mm	
0.8–1.0				M	MD	GP	GRAVEL	Grey Brown MPS to 80mm	
1.0							END OF HOLE 1.0m – REFUSAL ROCK BASALT BOULDERS UNABLE TO PENETRATE		

Sample:
H – hand

Test:
V – shear vane
HP – penetrometer
UCS – 50mm tube

Moisture:
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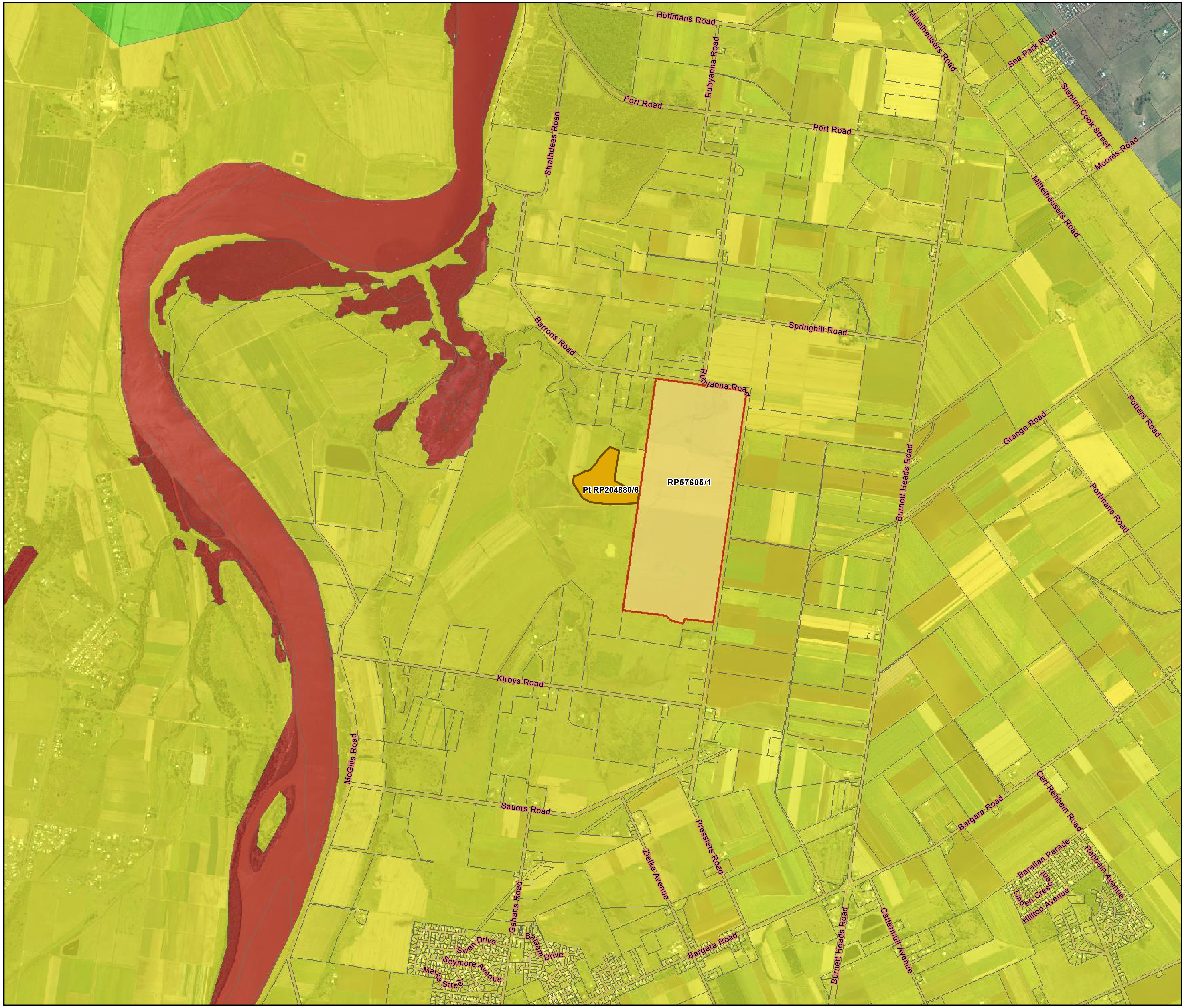
S - sand
M - silt
XW, DW, SW, FR, (ROCK)

Appendix K

ASS Mapping



RUBYANNA STP
DEVELOPMENT APPROVALS

Acid Sulphate Soils

Legend

Possible STP Site (approx16.7ha)

Lot 1 RP57605 (108.6 ha)

Acid Sulphate Soils

High Probability of occurrence

Low Probability of occurrence

Extremely low probability of occurrence

N

Scale: 1:25,000 (when printed at A3)

0 235 470 940

Metres

PROJECT ID 60221597

LAST MODIFIED CFS 28-Feb-2012

FILE NAME 60221597G_ENV_07

AECOM

Appendix L

Burnett River Water Quality Testing

Report to the Bundaberg City Council on the results of monitoring water quality in the Burnett River estuary for the period 2005 to 2006

Queensland EPA 2006

Contents

1. Introduction

Bundaberg City Council (BCC), under a licence from the Environmental Protection Agency (EPA), discharges treated sewage wastewater to the Burnett River estuary from three separate locations – see Figure 1. One condition of the licence is that BCC should undertake monitoring of the impacts of this wastewater on the receiving environment i.e. the Burnett River estuary. To meet this condition, BCC had the options of either undertaking an independent program of its own or entering into a joint program with the EPA, which already undertakes some routine monitoring in the estuary. In November 2004, BCC advised the EPA that it would pursue the latter option and agreed to provide an annual sum of $10,000 to support the EPA program. This amount is consistent with the pro rata support provided by local authorities in SE Queensland to the Healthy Waterways monitoring program in that region.

Under the agreement between BCC and EPA, the EPA undertook to provide an annual report on the outcomes of the monitoring program. This report is the first of its kind and covers the first year of monitoring (2005-2006) under the agreement. It describes the program and the results of the monitoring and then provides an assessment of the condition of the estuary with regard to water quality. The report includes some results from previous years of EPA monitoring in the estuary which enables the recent results to be put into a proper historical context.

2. Description of the Burnett River estuary

The Burnett River estuary extends approximately 25km from its mouth at Burnett Heads up to the Ben Anderson Barrage, which is now the upstream limit of tidal influence. The original tidal limit was just above the location of Bingera weir which is 42.1 km from the river mouth. The main land uses adjacent to the estuary are agriculture (mostly sugar cane) and the urban areas of the city of Bundaberg, see Figure 1.

The National Land and Water Resources Audit national assessment of estuaries carried out in 2002 (for detailed information see www.**ozestuaries**.org) describes the Burnett estuary as being extensively modified from its pre-European condition. It has ongoing dredging at the mouth and most of its riparian vegetation has been removed. There has also been significant loss of mangroves. Freshwater inflows to the estuary are highly modified (i.e. reduced) due the extensive system of weirs and associated agricultural water use within the Burnett catchment.

The main sources of pollutants entering the estuary are:

- Diffuse pollutant loads entering from the catchment during infrequent flood events
- Urban stormwater from Bundaberg City
- Point discharges

This report is principally concerned with point discharges and their associated impacts. In the 1970's, point discharges caused significant water quality problems in the Burnett estuary, including a number of fish kills. Since that time, discharges have been either diverted to land disposal or have received considerable upgrades in treatment, and water quality has greatly improved. The main existing point discharges to the estuary are the BCC treated sewage discharges. There are no other significant point discharges. The BCC discharges comprise:

- BCC North WWTP (Waste Water Treatment Plant)
- BCC East WWTP
- BCC Millbank WWTP

Discharge locations are shown in figure 1. Annual loads from these plants are given in Table 2.1 below. The most significant discharge is the East WWTP.

Table 2.1 Annual pollutant loads from discharges to the Burnett River estuary

Source	Annual pollutant loads (tonnes)			
	TN	**TP**	**BOD**	**TSS**
North WWTP	1.0	0.9	1.3	1.1
East WWTP	38.6	20.5	49.8	42.2
Millbank WWTP	4.6	8.6	8.1	6.3

Table 2.2 below shows annual loads from the East and Millbank WWTPs since 2000, which is useful for comparing with water quality trends.

Table 2.2 Historical records of annual nutrient loads from treatment plants

	East WWTP		Millbank WWTP	
Year (Jul/Jun)	**Total Nitrogen (Kg)**	**Total Phosphorus (Kg)**	**Total Nitrogen (Kg)**	**Total Phosphorus (Kg)**
99/00	32900	17900	16400	8760
00/01	20800	16100	8050	8400
01/02	16400	16600	6360	11400
02/03	36700	19200	7940	11100
03/04	40900	19600	11900	11000
04/05	36000	22200	9870	10800
05/06	38000	20400	4590	8590

3. Scope of Monitoring Program

3.1. *Routine monthly monitoring*

The main component of the EPA monitoring program consists of routine monthly monitoring at 10 sites in the Burnett River estuary. The program aims to provide a general assessment of water quality in the estuary and also, in the longer term, to pick up any trends in quality. The indicators sampled at each site are detailed in Table 3.1. These indicators and their purpose are described individually in more detail in Section 8. Not all indicators are sampled at all sites but the program provides sufficient data to provide a clear picture of water quality throughout the estuary.

The monitoring is undertaken by experienced EPA field staff who routinely undertake this type of activity in estuaries in other parts of Queensland. On a number of occasions in the past 12 months, officers of BCC have also accompanied EPA on these surveys and have been provided with training in the sampling techniques. Apart from familiarising BCC with the surveys, this training is also aimed at enabling BCC staff to undertake sampling during a flood event, as described in the next section.

Table 3.1 Burnett River estuary monitoring program: Indicators and Sites

SITE (km)	**INDICATORS**							
	DO	Temp	pH	Conduct -ivity	Turbid -ity	Chl a	N	P
0.0	✓	✓	✓	✓	✓			
4.8	✓	✓	✓	✓	✓	✓		
6.0	✓	✓	✓	✓	✓			
8.5	✓	✓	✓	✓	✓	✓	✓	✓
11.4	✓	✓	✓	✓	✓		✓	✓
14.7	✓	✓	✓	✓	✓	✓	✓	✓
17.4	✓	✓	✓	✓	✓	✓		
18.7	✓	✓	✓	✓	✓	✓	✓	✓
20.3	✓	✓	✓	✓	✓	✓	✓	✓
23.5	✓	✓	✓	✓	✓	✓		

3.2. *Flood event monitoring*

Under dry weather conditions, inflow of freshwater to the Burnett River estuary from the catchment is minimal and this is the normal condition for over 90% of the time. Water quality in the estuary under these conditions is therefore largely controlled by internal estuarine processes and by the impacts of any local point discharges. Under these conditions, water quality is relatively stable with no large variations. Major flood inflows of freshwater occur infrequently and usually last only a few days.

During such events, large volumes of water from the catchment enter the estuary. Under these conditions, the quality of water in the estuary is completely changed from its normal dry weather pattern and is largely determined by the quality of the water entering from the catchment. In the absence of further inflows, water quality in the estuary normally reverts to dry weather conditions within a few weeks.

The aim of this component of the program is therefore to assess water quality in the weeks immediately after a significant flood event. This would allow an assessment of the impacts of catchment inflows on the estuary. While BCC is not responsible for quality of water from the catchment, it is of interest to compare quality during dry periods when point sources are the main impact with quality during wet weather when catchment pollutant sources dominate.

3.3. Temporally intensive monitoring

The routine monthly monitoring program provides a good overall assessment of water quality in the estuary. However, it does not provide a measure of short term – hours or days – fluctuations in water quality. Such fluctuations can be important, particularly for indicators such as dissolved oxygen which exhibit large diurnal cycles. Large temporal variations in water quality also occur during and in the weeks after flood events. These can be very significant and are also missed by routine monthly sampling. A particular aim of this monitoring was to assess the impacts of catchment flood waters on the Burnett River estuary. No events of this nature have occurred since the intensive monitoring began (in February) but the intensive program will continue until at least one such event is recorded.

In order to obtain the temporally intensive data, an automated monitoring trailer has been located adjacent to the estuary on a jetty at the old TAFE Marine College. This is close to site 17.4 in the estuary. This is the first time such a trailer has been used by the EPA. The trailer was put in place in February 2006. It takes measurements every half an hour and these are saved on a data storage unit. The data can be downloaded remotely by a mobile phone link. So far the unit has worked well although there have been a few minor teething problems. Sufficient data has been obtained to give a reasonable picture of daily and weekly variations in water quality. As noted above, no flood events have yet been recorded.

3.4. Metals in sediments

It was agreed that a once off assessment of the levels of heavy metals in the sediments in the Burnett River estuary would be undertaken as part of the monitoring program. Unfortunately, due to a miscommunication with the field team this has not yet happened. However, this has now been programmed for the month of August 2006 and the results will be reported on later as an addendum to this report.

4. Methods for assessing water quality

4.1. Condition

The basic approach to condition assessment is to compare monitoring data with guideline values. The guidelines used in this report are taken from the recently published Queensland Water Quality Guidelines (QWQG). These provide guideline values for all the indicators measured in this program.

Water quality in estuaries varies naturally from the mouth up to the tidal limit. To allow for this natural variation, the QWQG provides separate guidelines for different reaches of estuaries. These reaches are defined as follows:

1. <u>Lower estuary</u> – the reaches near the estuary mouth that experience frequent exchange with coastal waters
2. <u>Mid estuary</u> – the main body of the estuary
3. <u>Upper estuary</u> – the upper 15% of the length of the estuary – these reaches are poorly flushed and have naturally poorer water quality than the main body of the estuary

Table 4.1 below shows the guideline values for each indicator for each of these segments. It also shows which sites in the Burnett fall into each category.

Table 4.1 Guideline values for each reach of the Burnett River estuary

REACH	GUIDELINE VALUES FOR KEY INDICATORS							
	DO	pH	Secchi	Turb-idity	Total N	Total P	Chl a	
	%sat		(m)	NTU	μg/L	μg/L	μg/L	
Lower estuary Sites 0.0	105-95	8.0-8.4	1.5	6	200	20	2	
Mid estuary Sites 4.8, 6.0, 8.5, 11.4, 14.7, 17.4, 18.5	105-85	7.0-8.4	1.0	8	300	25	4	
Upper estuary Sites 20.3, 23.5	100-80	7.0-8.4	0.5	25	450	30	8	

These guideline values are designed to be compared with the median of a series of values rather than every individual value from a test site. Thus, the graphical presentation in the results show the guidelines compared with the median values for the last 12 months for each indicator.

As well as assessing the median value, the results also need to be checked for extreme values. Such values (e.g. very low DO levels) have the potential to be very harmful even though median values comply with the guideline value.

The indicators assessed for condition include:

Dissolved oxygen
pH
Turbidity
Secchi depth (clarity)
Total N
Total P
Chlorophyll a

4.2. Trend

The more intensive monitoring of the Burnett River estuary only started in 2005 and so there is insufficient data to comprehensively assess trends throughout the estuary. However, EPA data is available for a longer time period for two sites. This is briefly assessed using simple regression techniques to provide an indication of improvements or declines in water quality over the past few years. This information can give an indication of what issues are likely to arise in the future.

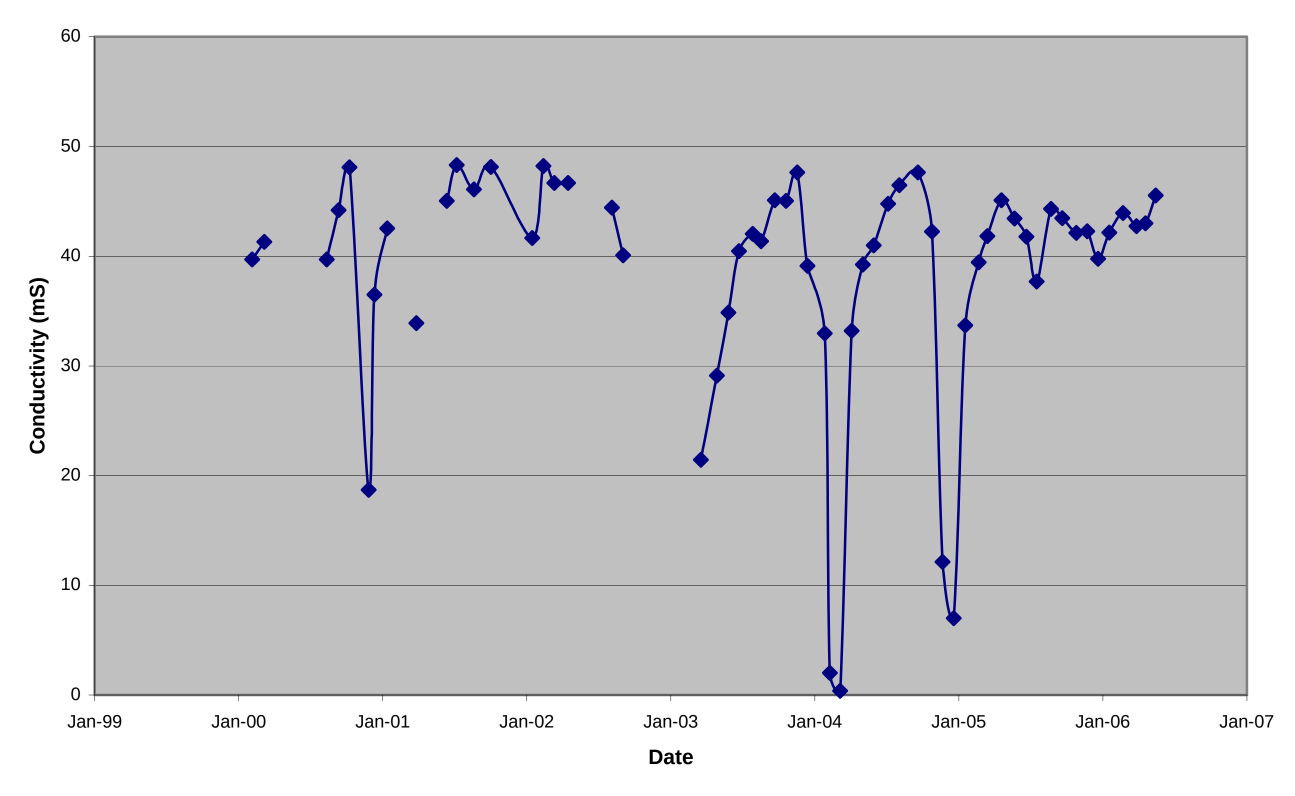
5. Overview of estuary conditions during 2005 - 2006

Water quality in estuaries can be broadly separated into (i) flow event and immediate post flow event conditions and (ii) dry weather conditions. Flow events carry large volumes of freshwater and catchment sourced pollutants into estuaries and have considerable but short term impacts on water quality. During dry weather, water quality is more stable and largely controlled by internal processes and any point discharges. On average, most estuaries experience dry weather conditions (i.e. minimal inflow from the catchment) for >90% of the time.

Figure 5.1 shows conductivity at a site in the upper reaches of the Burnett estuary. For much of the time conductivity is in the range 40 - 50 mS/cm which is indicative of dry weather conditions. Sudden reductions below 40 mS/cm indicate recent freshwater inflows, the larger the reduction the larger the inflow. The graph shows a number of major dips in conductivity over the 7 year period but it can be seen that the past 12 months were a particularly dry period with only a couple of very minor inflows.

From the point of view of this report, this is quite useful in that there would have been very few impacts on water quality from the catchment during that time. This means that the data collected in that period will be better reflect the impacts of point sources and not be confounded by other influences.

Figure 5.1 Conductivity at site 18.7



6. Results

6.1. Condition assessment

Figures A1 to A6 in Appendix A show median values for each indictor plotted against distance upstream in the estuary. The plot also shows the relevant guideline values for each reach of the estuary. Where median values comply with guideline values they are coloured in black and where they do not comply they are coloured in red. These plots provide a broad overview of water quality in the estuary.

It could be expected that the presence treated sewage discharges would result in reductions in dissolved oxygen levels, elevated levels of nitrogen and phosphorus and consequent increases in chlorophyll a. In fact dissolved oxygen values are generally within the guideline range and total N values largely comply with guidelines, with one small exceedance. Chlorophyll a values exceed guideline values at two sites but not to a major extent. The only indicator which clearly indicates the presence of treated sewage is total P which exhibits significant exceedances of the guideline value at all sites.

The other indicators, pH (not shown), turbidity and Secchi disc clarity all largely comply with the guidelines at all sites.

Overall, the results indicate that the treated sewage discharges are not currently having major impacts on the estuary. Partial tertiary treatment of the effluent has reduced BOD and N loads to the point where the discharges are not causing large reductions in dissolved oxygen levels or large increases in N levels in the receiving water. The treatment plants do not remove P and therefore there are significant increases in P levels in the estuary compared to background levels. However, the high P levels do not appear to result in large increases in chlorophyll a. This may be due to the fact that phytoplankton growth is limited by N rather than P although there is no unequivocal proof of this.

6.2. Trends in water quality

The trend results are based on data collected by the EPA at two sites (8.5 & 18.7) since January 2000. Graphs for each of the selected indicators are given in Figures B1 to B12 in Appendix B.

The most clear cut trend is the significant increase in total P which occurred at both sites. This is most likely a reflection of an increase in overall P load from the WWTP discharges although Table 2.2 indicates that these increases during the period 2000 to 2006 were relatively modest and only occurred in the Millbank plant.

At site 8.5 there was a slight improvement in clarity (Secchi depth). There was also a small statistical increase in total N but this is thought to be related to the wetter period during 2004 to early 2005 when significant loads of N from catchment sources would have entered the estuary.

At site 18.7, DO values show an increase and in particular an increase in the level of supersaturation (i.e. values greater than 100% saturation) This is indicative of increased phytoplankton activity. This inference is backed up by the significant increase in chlorophyll a values that was also recorded at this site. It would appear therefore that the upper part of the estuary is becoming more eutrophic, although no algal blooms (i.e. chlorophyll a values >25ug/L) were recorded at any time. The cause of the increase in phytoplankton activity is unclear. Total N values remained relatively static over this period so this unlikely to be the cause. Total P values showed a significant increase so this may be a factor. However, P levels in estuaries are generally considered to be less likely than N to be a factor limiting phytoplankton growth.

6.3. Temporally intensive monitoring

The temporally intensive data was acquired from the trailer located near site 17.4. The trailer recorded surface (0.2m) readings for the following indicators; DO, pH, conductivity, turbidity, temperature and chlorophyll a (fluorescence reading). Figures

C1 to C3 in Appendix C show data for three indicators, dissolved oxygen, turbidity and chlorophyll a.

Dissolved oxygen (Figure C1) shows typical diurnal fluctuations that are related to daytime phytoplankton primary production. Highest DO levels occur in mid afternoon while minimums occur around dawn. The day night range is larger than in some estuaries indicating that significant phytoplankton activity is occurring in the Burnett.

Turbidity values (Figure C2) cover a month of data and illustrate the variations in turbidity that occur over the lunar tidal cycle. During dry weather, turbidity in estuaries is largely controlled by resuspension of fine particulates by tidal currents. Thus, highest turbidities occur during spring tides when tidal velocities are at a maximum. Conversely, lowest turbidities occur during neap tides. This spring/neap cycle variation in turbidity is clearly visible in Figure C2. There are also much shorter term variations in turbidity over daily tidal cycles. These are related to the daily variations in tidal current velocities associated with the ebb and flood tides. The cyclic variation in turbidity in the Burnett is typical of most estuaries in this region.

Chlorophyll a values (Figure C3) show regular cycles. These are mainly related to tidal movement of water past the sampling point. Thus, peak values tend to occur at low tide when the probe is sampling water from further up the estuary which generally has higher chlorophyll a levels. Conversely, minimum values occur at low tides when cleaner water from downstream is adjacent to the probe.

Overall, the data showed daily and weekly fluctuations of a nature similar to those in other estuaries.

While the temporal variation in various indicators is of interest, one of the main purposes of the trailer is to measure the impacts of a flood event. Such an event has not occurred in the past twelve months but it is hoped that one will occur in the next twelve months.

7. Conclusions

Overall, water quality in the Burnett River estuary was reasonably good. Most indicators complied with the guidelines at most sites although there were some small exceedances of chlorophyll a guidelines. The main exception was total P which significantly exceeded the guidelines at all sites. However, this does not appear to be having major impacts on phytoplankton growth in the estuary.

As a comparison, water quality in the Burnett River estuary is similar to water quality in estuaries in SE Queensland that score a B under the SE Queensland report card system (score range of A-F). ‘B’ is considered to be a good score. The full report card system also includes an assessment of factors other than water quality e.g. habitat integrity, and on this count the extensively disturbed Burnett estuary would probably score poorly. However, this issue is not related to the Bundaberg City WWTP discharges.

An assessment of trends in water quality showed evidence of increasing total P levels and algal activity in the upper reaches of the estuary. This has not reached a level to be of major concern but ongoing surveillance is desirable.

The temporally intensive monitoring indicates that daily and weekly variations in water quality in the Burnett River estuary are similar to other estuaries. The temporally intensive monitoring system was also designed to provide detailed measurements of the impact of flood events on the estuary. However, there were no significant flood events during 2005/2006 so it has not been possible to assess such impacts. It is hoped that a significant event will occur during the next wet season.

8. Explanation of Indicators

Dissolved oxygen	The amount of oxygen dissolved in the water. Oxygen is essential for the life processes of most aquatic organisms, and lack of oxygen can cause suffocation of aquatic organisms. Low concentrations are often a symptom of pollution by organic matter, and are a by product of the rapid breakdown of the organic matter by bacteria. High concentrations (i.e. values > 110% saturation) are indicative excessive plant productivity. In estuaries this is due to phytoplankton growth.
pH	A measure of the acidity or alkalinity of the water. Extremes of pH (acidity less than 6.5 or alkalinity greater than 9) can be toxic to aquatic organisms. Estuarine waters are usually in the range 7-8.4
Conductivity	Conductivity is used as a measure of salinity. Seawater has a conductivity of about 51 mS/cm which is equivalent to a salinity of around 35g/L.
Turbidity	Turbidity is an indirect measure of the concentration of fine particulate matter in the water column. The higher the concentration of particles, the higher the turbidity. High levels of turbidity are indicative of excessive inputs of fine particles from the catchment or from urban stormwater. In estuaries, turbidity is also affected by the spring neap tidal cycle, with highest turbidities occurring during spring tides when tidal currents are at a maximum.
Secchi depth	An indicator of water clarity. The depth to which a secchi disc lowered into the water can be clearly seen from the surface. Secchi depth and turbidity are strongly correlated.
Nitrogen & Phosphorus	The major nutrients (nitrogen and phosphorus) are essential for plant growth. Measurements of nutrient concentrations in waters provide an indication of the potential for excessive plant and algal growth.
Chlorophyll-a	Chlorophyll-a, the green pigment found in all plants. In

	estuaries, the concentration of chlorophyll a in a sample it is used as an indicator of the phytoplankton biomass. High levels of algae (algal blooms) can have adverse effects on water quality.

Report to the Bundaberg City Council on the results of monitoring water quality in the Burnett River estuary for the period 2006 to 2007

Queensland EPA 2007

Contents

1. Introduction

Bundaberg City Council (BCC), under a licence from the Environmental Protection Agency (EPA), discharges treated sewage wastewater to the Burnett River estuary from three separate locations – see Figure 1. To address the receiving water quality monitoring requirements of this licence, the EPA, through agreement with the BCC, undertakes regular monitoring of the Burnett River estuary.

Under the agreement between BCC and EPA, the EPA undertakes to provide an annual report on the outcomes of the monitoring program. This is the second such report and covers the year 2006-2007. It describes the program and the results of the monitoring and provides an assessment of the condition of the estuary with regard to water quality. The report includes some results from previous years of EPA monitoring in the estuary which enables the recent results to be put into a historical context and allows an assessment of trends in water quality.

2. Description of the Burnett River estuary

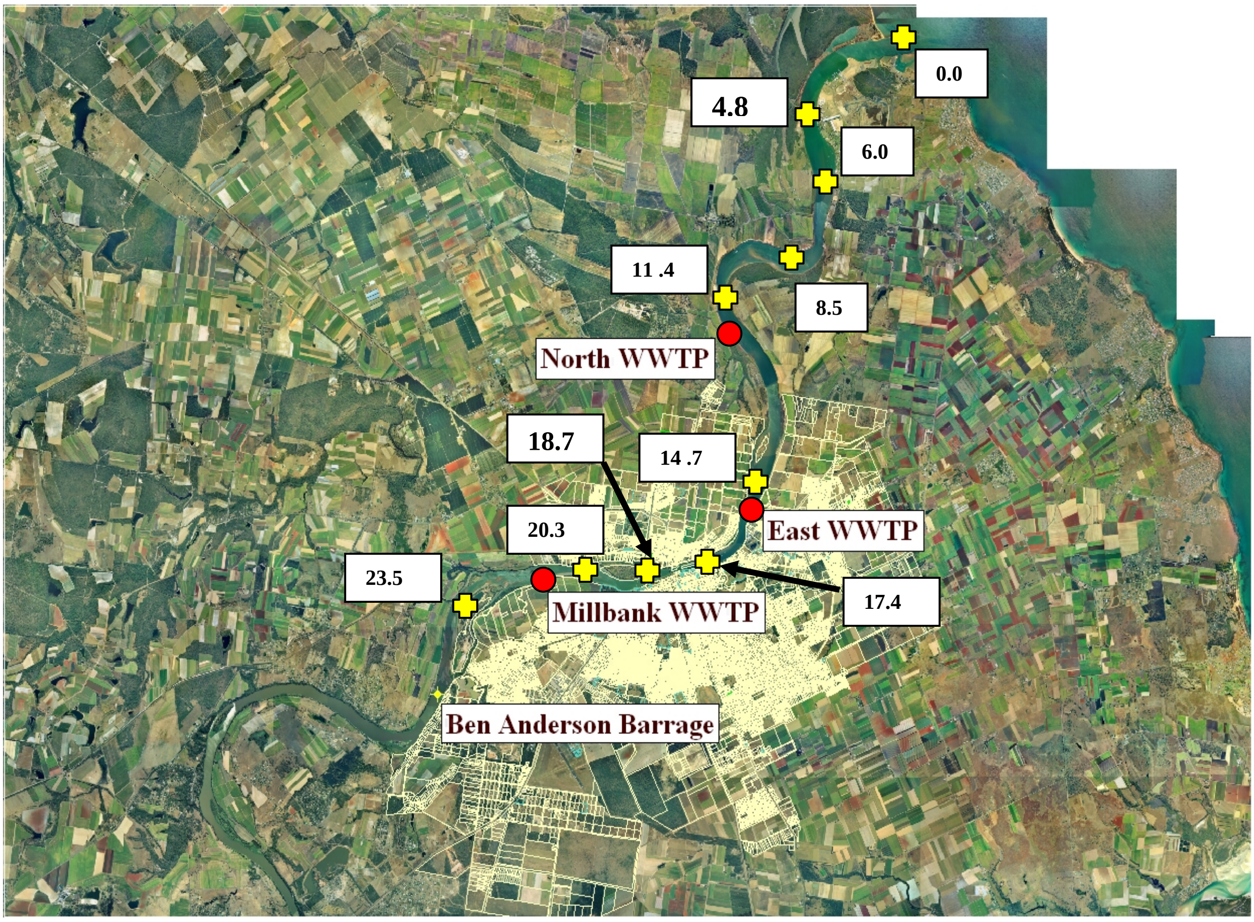
The Burnett River estuary extends approximately 25km from its mouth at Burnett Heads up to the Ben Anderson Barrage, which is now the upstream limit of tidal influence. Prior to construction of the barrage, the natural tidal limit was just above the current location of Bingera Weir which is 42.1 km from the river mouth. The main land uses adjacent to the estuary are agriculture (mostly sugar cane) and the urban areas of the city of Bundaberg, see Figure 1.

The National Land and Water Resources Audit national assessment of estuaries carried out in 2002 (for detailed information see www.**ozestuaries**.org) describes the Burnett estuary as being extensively modified from its pre-European condition. It has ongoing dredging at the mouth and much of its riparian vegetation has been removed. There has also been significant loss of mangroves. Freshwater inflows to the estuary have been reduced very significantly from their natural state due the extensive system of weirs and associated agricultural water use within the Burnett catchment.

The main sources of pollutants entering the estuary are:

- Diffuse pollutant loads entering from the catchment during infrequent flood events
- Urban stormwater from Bundaberg City
- Point discharges

Figure 1: Burnett River estuary showing sampling sites and discharge points



This report is principally concerned with the point discharges and their associated impacts. The main existing point discharges to the estuary are the BCC treated sewage discharges. There are no other significant point discharges. The BCC discharges comprise:

- BCC North WWTP (Waste Water Treatment Plant)
- BCC East WWTP
- BCC Millbank WWTP

Discharge locations are shown in Figure 1. Annual loads from these plants are given in Table 2.1 below. The most significant discharge is the East WWTP.

Table 2.1 Annual pollutant loads from discharges to the Burnett River estuary during 2006 - 2007

Source	Annual pollutant loads (tonnes)			
	TN	TP	BOD	TSS
North WWTP	1.1	1.0	1.6	1.7
East WWTP	36.1	22.3	45.4	54.9
Millbank WWTP	7.0	9.2	10.0	9.7

Table 2.2 below shows annual loads from the East and Millbank WWTPs since 2000, which is useful for comparing with water quality trends.

Table 2.2 Historical records of annual nutrient loads from treatment plants

	East WWTP		Millbank WWTP	
Year (Jul/Jun)	Total Nitrogen (Tonnes)	Total Phosphorus (Tonnes)	Total Nitrogen (Tonnes)	Total Phosphorus (Tonnes)
99/00	32.9	17.9	16.4	8.8
00/01	20.8	16.1	8.1	8.4
01/02	16.4	16.6	6.4	11.4
02/03	36.7	19.2	7.9	11.1
03/04	40.9	19.6	11.9	11.0
04/05	36.0	22.2	9.9	10.8
05/06	38.0	20.4	4.6	8.6
06/07	36.1	22.3	7.0	9.2

3. Scope of Monitoring Program

3.1. Routine monthly monitoring

The main component of the EPA monitoring program consists of routine monthly monitoring at 10 sites in the Burnett River estuary. The program aims to provide a general assessment of water quality in the estuary and also, in the longer term, to pick up any trends in quality. The indicators sampled at each site are detailed in Table 3.1. These indicators and their purpose are described in more detail in Appendix D. Not all indicators are sampled at all sites but the program provides sufficient data to provide a good general assessment of water quality throughout the estuary.

The monitoring is undertaken by experienced EPA field staff, who routinely undertake this type of activity in estuaries in other parts of Queensland.

Table 3.1 Burnett River estuary monitoring program: Indicators and Sites

SITE (km)	INDICATORS							
	DO	Temp	pH	Conductivity	Turbidity	Chl a	N	P
0.0	✓	✓	✓	✓	✓			
4.8	✓	✓	✓	✓	✓	✓		
6.0	✓	✓	✓	✓	✓			
8.5	✓	✓	✓	✓	✓	✓	✓	✓
11.4	✓	✓	✓	✓	✓		✓	✓
14.7	✓	✓	✓	✓	✓	✓	✓	✓
17.4	✓	✓	✓	✓	✓			
18.7	✓	✓	✓	✓	✓	✓	✓	✓
20.3	✓	✓	✓	✓	✓	✓	✓	✓
23.5	✓	✓	✓	✓	✓	✓		

3.2. *Temporally intensive monitoring*

The temporally intensive data was acquired from an instrument array contained in a purpose designed trailer. Up to October 2006, this was located on a jetty close to site 17.4. In October this had to be moved and it is currently located further upstream on a jetty close to site 18.7. The trailer records surface (0.2m) readings every half hour for the following indicators; DO, pH, conductivity, turbidity, temperature and chlorophyll a (fluorescence reading).

Routine monthly monitoring program provides a good overall assessment of water quality in the estuary. However, it does not provide a measure of short term – hours or days – fluctuations in water quality. Such fluctuations can be important, particularly for indicators such as dissolved oxygen which exhibit large diurnal cycles. Large temporal variations in water quality also occur during and shortly after flood events. These can be very significant and are often missed by routine monthly sampling. A particular aim of this monitoring was to assess the impacts of catchment flood waters on the Burnett River estuary. There were no events of this nature in 2005/06 and similarly no significant events have occurred in 2006/07. It is still intended to continue this monitoring until at least one major inflow event to the Burnett River estuary has been captured.

3.3. *Metals in sediments*

It was agreed that a once-off assessment of the levels of heavy metals in the sediments in the Burnett River estuary would be undertaken as part of the monitoring program. This has been completed and the results are described in this report. Metals were monitored at all of the sites used in the monthly water quality monitoring program.

The method used was to collect three sediment samples across the width of the estuary at each site. These were then combined to make a single well mixed composite sample and a sub-sample of this was used for analysis. Use of composite samples provides a better estimate of the average concentration of metals at a site than using a single sample.

4. Methods for assessing water quality

4.1. Condition

The basic approach to condition assessment is to compare monitoring data with guideline values. The guidelines used in this report are taken from the Queensland Water Quality Guidelines (QWQG). These provide guideline values for all the indicators measured in the routine monthly program.

Water quality in estuaries varies naturally from the mouth up to the tidal limit. To allow for this natural variation, the QWQG provides separate guidelines for different reaches of estuaries. These reaches are defined as follows:

1. Lower estuary – the reaches near the estuary mouth that experience frequent exchange with coastal waters
2. Mid estuary – the main body of the estuary
3. Upper estuary – the upper 15% of the length of the estuary – these reaches are poorly flushed and have naturally poorer water quality than the main body of the estuary

Table 4.1 below shows the guideline values for each indicator for each of these segments. It also shows which sites in the Burnett fall into each category.

Table 4.1 Guideline values for each reach of the Burnett River estuary

REACH	**GUIDELINE VALUES FOR KEY INDICATORS**							
	DO	pH	Secchi	Turb-idity	Total N	Total P	Chl a	
	%sat		(m)	NTU	µg/L	µg/L	µg/L	
Lower estuary Sites 0.0	105-95	8.0-8.4	1.5	6	200	20	2	
Mid estuary Sites 4.8, 6.0, 8.5, 11.4, 14.7, 17.4, 18.5	105-85	7.0-8.4	1.0	8	300	25	4	
Upper estuary Sites 20.3, 23.5	100-80	7.0-8.4	0.5	25	450	30	8	

These guideline values are designed to be compared with the median of a series of values rather than every individual value from a test site. Thus, the graphical presentations of the results show the guidelines compared with the median values for the last 12 months for each indicator at each site.

As well as assessing the median value, the results also need to be checked for extreme values. Such values (e.g. very low DO levels) have the potential to be very harmful even though median values comply with the guideline value.

The indicators assessed for condition include:

Dissolved oxygen
pH
Turbidity
Secchi depth (clarity)
Nitrate N
Total P
Chlorophyll a

Condition assessment for the levels of metals in sediment was undertaken by comparing the results with the ANZECC 2000 Guidelines values.

4.2. Trend

The more intensive monitoring of the Burnett River estuary only started in 2005 and so there is insufficient data to comprehensively assess trends throughout the estuary. However, EPA data is available for a longer time period for two sites (8.5 and 18.7). Data from these sites is assessed using simple regression techniques to provide an indication of improvements or declines in water quality over the past few years. This information can give an indication of improvements in water quality or of what issues are likely to arise in the future.

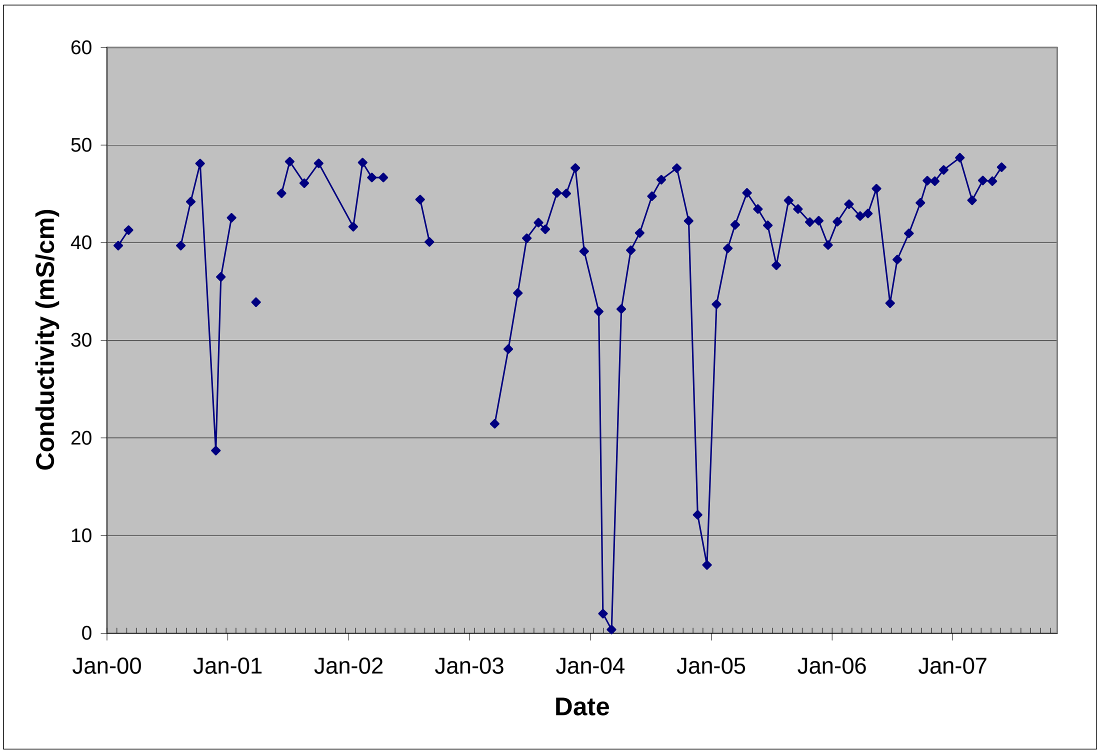
5. Overview of Burnett estuary conditions during the period 2006 - 2007

Water quality condition in estuaries can be broadly separated into (i) flow event and immediate post flow event conditions and (ii) dry weather conditions. Flow events carry large volumes of freshwater and catchment sourced pollutants into estuaries. These have considerable but usually short term impacts on water quality. During dry weather, water quality is more stable and is largely controlled by internal processes and any point discharges. Most sub-tropical Queensland estuaries experience dry weather conditions (i.e. minimal inflow from the catchment) for >90% of the time.

Figure 5.1 shows conductivity at a site in the upper reaches of the Burnett estuary over the period 1999 to 2007. For much of the time conductivity is in the range 40 - 50 mS/cm which is indicative of dry weather conditions. Sudden reductions below 40 mS/cm indicate recent freshwater inflows, the larger the reduction the larger the inflow. The graph shows a number of major dips in conductivity over the 8 year period but it can be seen that the very dry period that started in 2005 has continued throughout 2006/07 except for a small event prior to the sampling in June 2006.

This means that there would have been very few impacts on water quality from the catchment during 2006 - 2007. Thus, the data collected in that period will largely reflect the impacts of point sources and not be confounded by other influences.

Figure 5.1 Conductivity at site 18.7



6. Results

6.1. Condition assessment

6.1.1. General water quality

Figures A1 to A6 in Appendix A show median values for each of the six selected indictors plotted against distance upstream in the estuary. The plots also show the relevant guideline values for each reach of the estuary. Where median values comply with guideline values they are coloured in black and where they do not comply they are coloured in red. These plots provide a broad overview of water quality in the estuary.

The main pollutants associated with treated sewage discharges are organic matter and nutrients (nitrogen and phosphorus). The expected impacts on estuary water quality would include reductions in dissolved oxygen levels, elevated levels of nitrogen and phosphorus and consequent increases in phytoplankton (measured as chlorophyll a).

The results in Figure A1 show that dissolved oxygen complies with guidelines at all sites except the most upstream site where there is an indication of persistent supersaturation due to algal activity. The temporally intensive monitoring similarly showed frequent occurrence of levels of supersaturation up to 120% during the daytime. This indicates a level of algal activity higher than in pristine estuaries but is not indicative of a high level of eutrophication. Minimum DO levels (at night) were usually > 60% saturation but there were a few periods when they fell to around 55% saturation. This latter is slightly outside the range for pristine estuaries, but is not excessively low.

Nitrate N values (Figure A4) exceed guidelines at many sites but in most cases these exceedances are relatively minor. Total P values (Fig A5) significantly exceed guideline values at most sites.

Median chlorophyll a values (Fig A6) met guideline values at all except one site. The monthly data also showed that there were no major algal blooms at any site during 2006/07. The temporally intensive monitoring showed that chlorophyll a levels were nearly always <30ug/L, which is the normal range for estuaries.

The other indicators, turbidity (Fig A2), Secchi disc clarity (Fig A3), all comply with the guidelines at all sites. The low levels of turbidity are not unexpected as there has been almost no catchment run-off into the estuary this year. The temporally intensive monitoring showed the typical estuarine variation in turbidity that is associated with the neap-spring tidal cycle, but there were no abnormal values.

Values of pH in estuaries are generally buffered in the range of 7.0 to 8.4 by the presence of salt water. However, major catchment run-off events can reduce levels due to the presence of freshwater and in some locations acid sulphate run-off can reduce levels very significantly for short periods. During 2006 – 2007, pH values recorded during the monthly surveys in the Burnett estuary remained within the range of 7.5 to 8.2 at all sites throughout the year. The pH range recorded by the continuous monitoring trailer (6.7 to 8.2) was a little wider but this was due to the much greater sampling frequency but still lies within the normal range. As with turbidity, the absence of any low pH values during the year is not unexpected given the absence of significant run-off.

As in 2005 – 2006, the results indicate that the treated sewage discharges are not having major impacts on the estuary. The partial tertiary treatment of the effluent has reduced BOD and N loads to the point where the discharges are not causing large reductions in dissolved oxygen levels or large increases in N levels in the receiving water. The treatment plants do not currently remove P to tertiary levels and therefore there are significant increases in P levels in the estuary compared to natural levels. However, the high P and slightly elevated N levels do not appear to have resulted in large increases in chlorophyll a.

6.1.2. Metals in sediments

Results for the levels of metals in sediment are shown in Figures B1 to B6 in Appendix B. These show the levels of metals in sediments at sites along the length of the estuary. The graphs also show the ANZECC 2000 Guideline values for comparison. In brief, the results show that levels of all metals at all sites were well within the ANZECC Guideline values. It might have been expected that there would be some impact on levels of copper, lead and zinc caused by urban run-off from the Bundaberg city area. This would be normal for waters adjacent to urban areas. However, any such impacts appear to be limited. The only indication of this effect is at site 17.4, which is in the middle of the city reach. Here there are noticeably elevated levels of copper (Fig B2) and slightly elevated levels of lead (Fig B5) but in both cases, levels remain well within guideline values.

6.2. Trends in water quality

The trend results are based on data collected by the EPA at two sites (8.5 & 18.7) since January 2000. Graphs for each of the selected indicators are given in Figures C1 to C6 (Site 8.5) and C7 to C12 (Site 18.7) in Appendix C.

Given that there is only one extra year of data, the trend results are not very different to those in the 2005/06 report. With the ongoing dry weather, water clarity in the mid-lower estuary continued to improve slightly and conversely turbidity continued to fall. This is not apparent in the upper estuary.

Dissolved oxygen values in 2006/07 were similar to those in 2005/06 with site 18.7 continuing to exhibit supersaturation on many occasions, due to phytoplankton activity.

With regard to nutrients, the increase in total P that occurred at both sites during the period 2000 to 2005 appears to have levelled out with no increases in subsequent years. This is consistent with P loads discharged from the treatment plants. Nitrate N levels remained about the same as previous years.

Chlorophyll a values in the mid-lower estuary continued to decrease slightly while at the upper estuary site they remained about the same as the previous year.

6.3. Catchment impacts on water quality

One of the main purposes of the continuous monitoring trailer is to measure the impacts of a flood event. However, as was the case in 2005/06, no significant inflow events occurred during 2006/07, and so these impacts could not be assessed. It is intended to leave the trailer in place for at least another year in the hope of capturing an event.

7. Conclusions

Overall, water quality in the Burnett River estuary was reasonably good. Clarity, turbidity, dissolved oxygen and pH meet or very nearly meet guidelines at all sites.

Nitrogen shows small exceedances of guidelines but phosphorus significantly exceeds guidelines at most sites. However, the elevated nutrients do not appear to be having major impacts on phytoplankton growth, with chlorophyll a levels complying with guidelines at all but one site.

An assessment of trends in water quality showed continuing decreases in turbidity in the mid-lower estuary, probably related to the continuing dry weather. Turbidity levels can be expected to increase considerably if the estuary receives significant inflows in the next 12 month monitoring period. Total P levels showed some increases during 2000 – 2005 but there is no evidence of further increases in total P levels since then. Algal activity in the estuary is about the same as last year.

Levels of heavy metals in the estuary sediments were well within guideline values at all sites with no major impacts from urban run-off from the city area.

No significant flood events occurred during 2006/07 so it has not been possible to assess such impacts. It is hoped that a significant event will occur during the next wet season.

Acknowledgements

Thanks to John Ferris and the EPA field staff for undertaking surveys efficiently and on schedule and for the high level of QA that is maintained.

Thanks to Jeff Rohdman of Bundaberg City Council for always providing a full and rapid response to requests for data and for any other assistance requested.

APPENDIX A: Water quality compared to guidelines

Figure A1

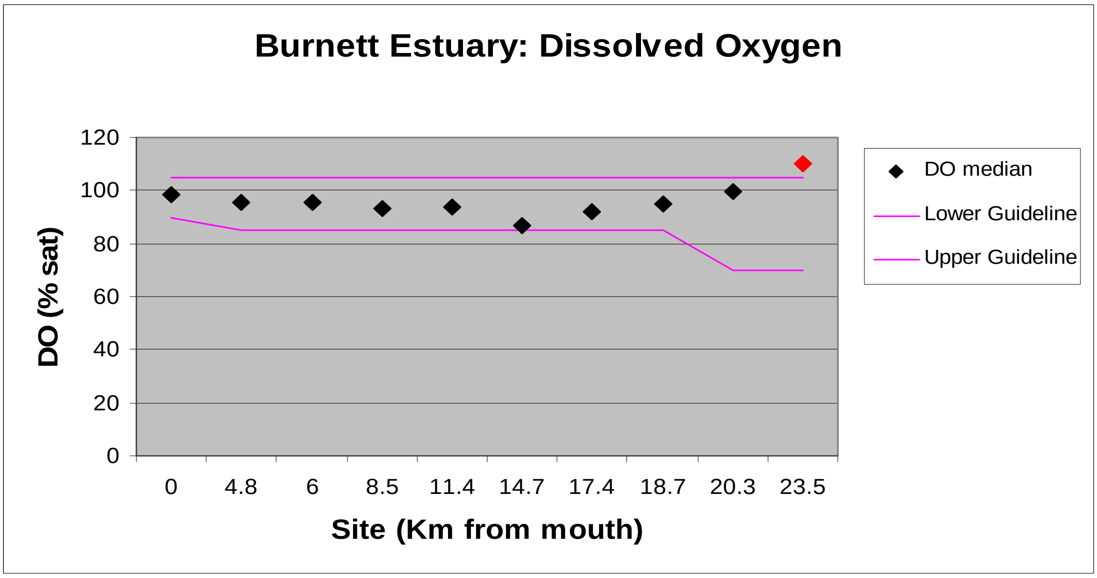
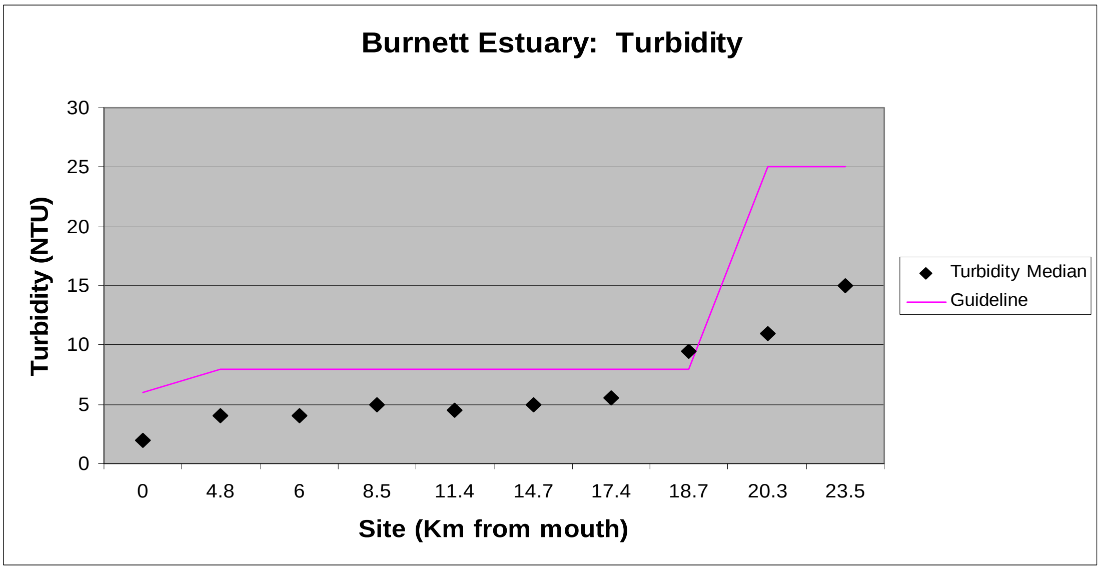


Figure A2



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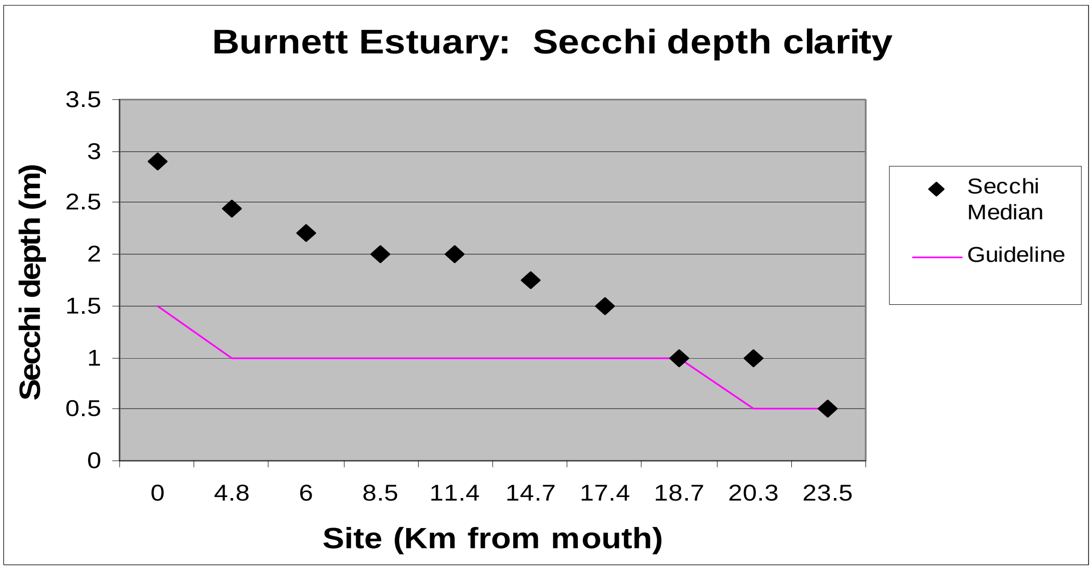
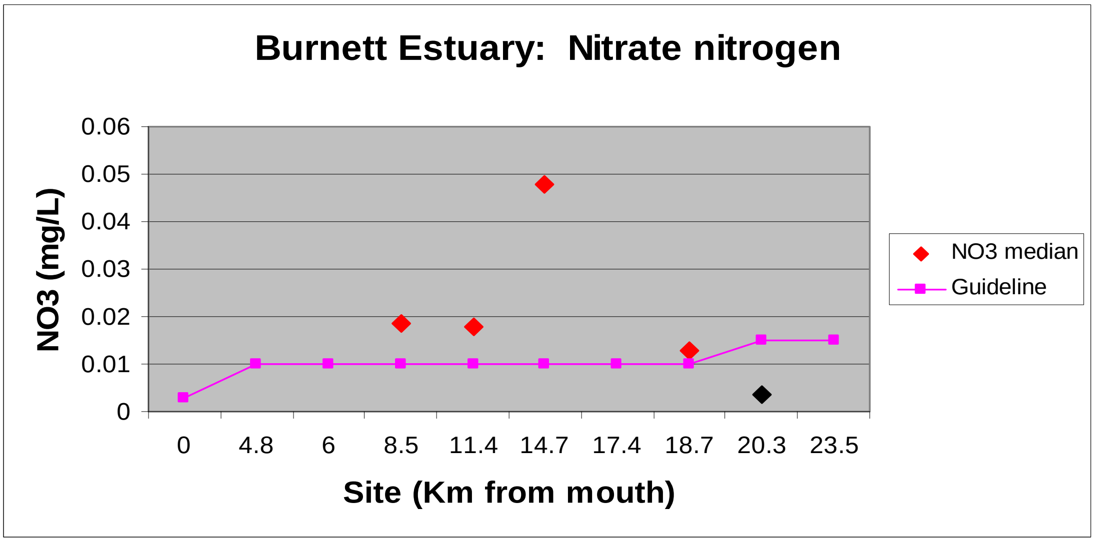


Figure A4



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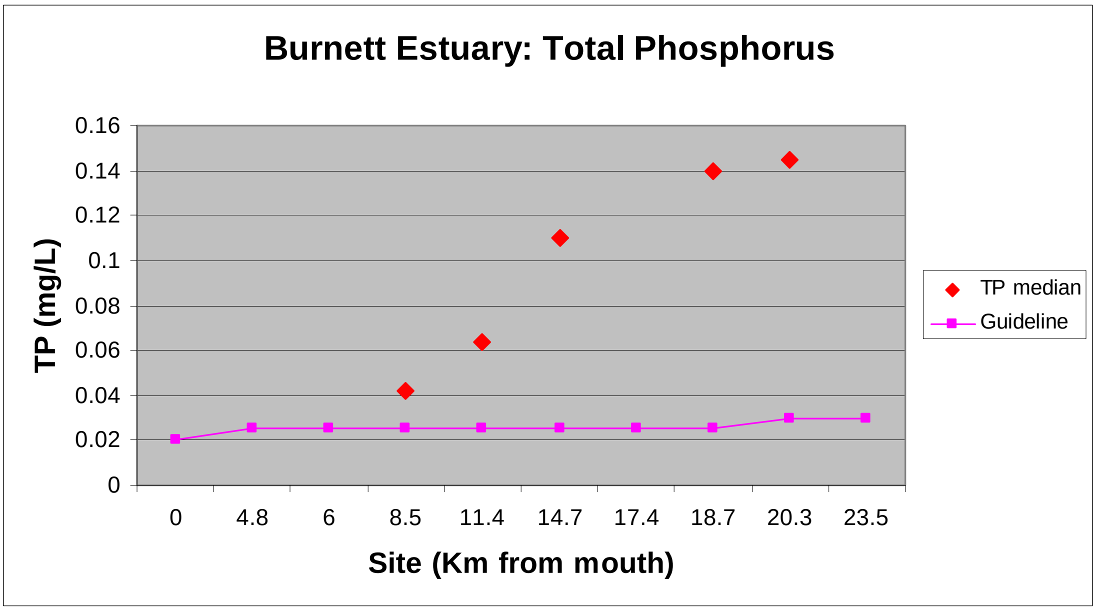
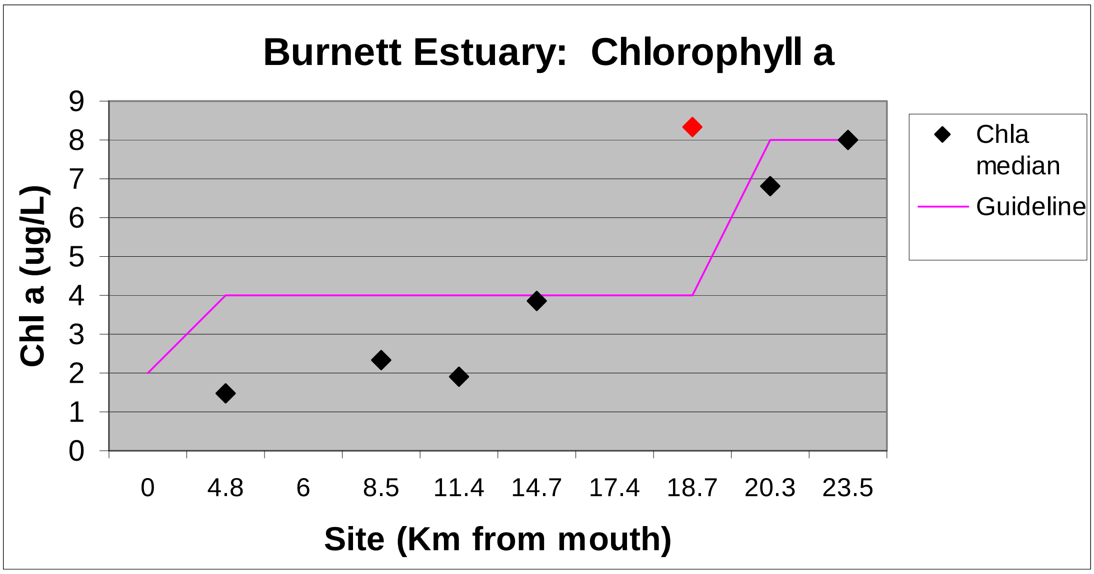


Figure A6



APPENDIX B: Levels of metals in sediments compared to guidelines

Figure B1

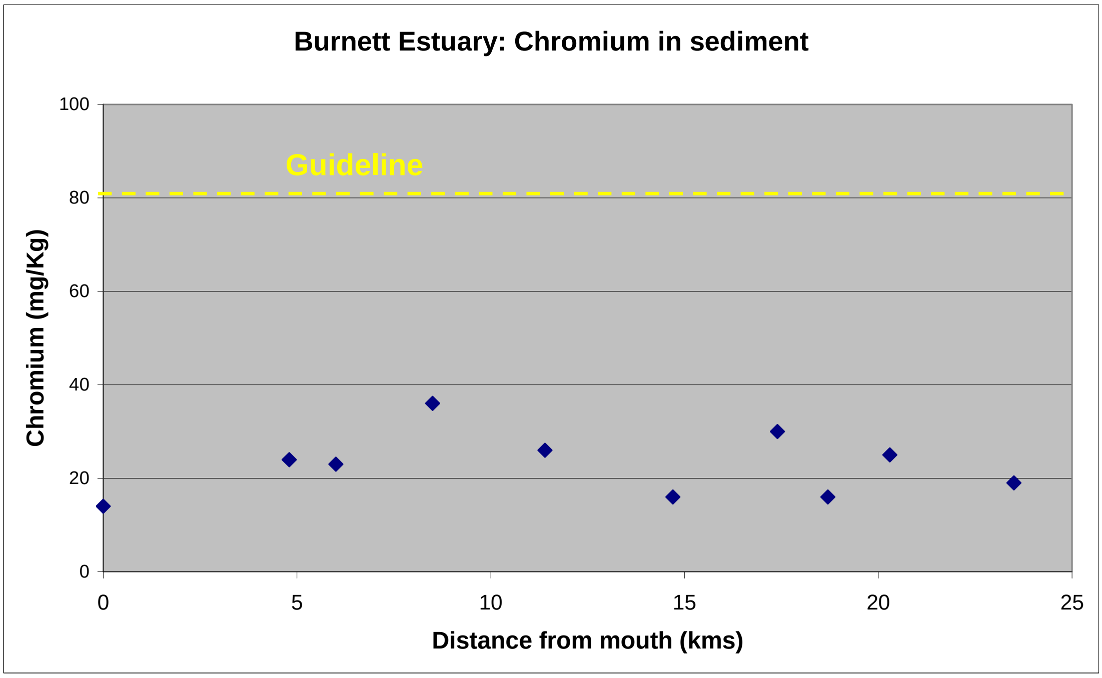
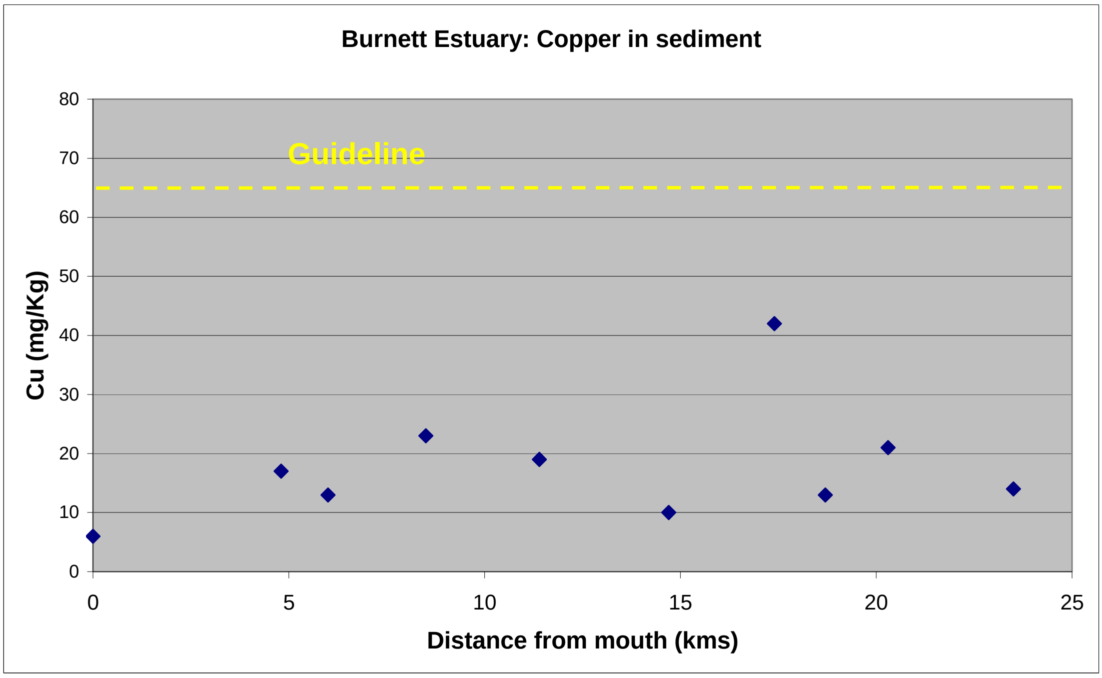


Figure B2



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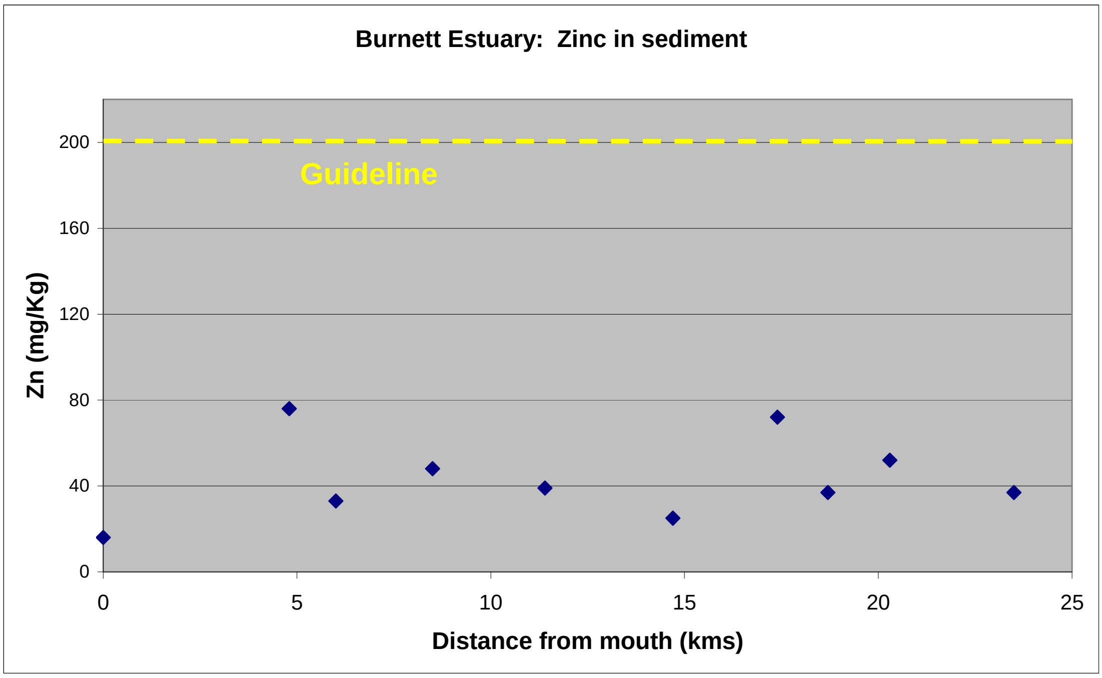


Figure B4

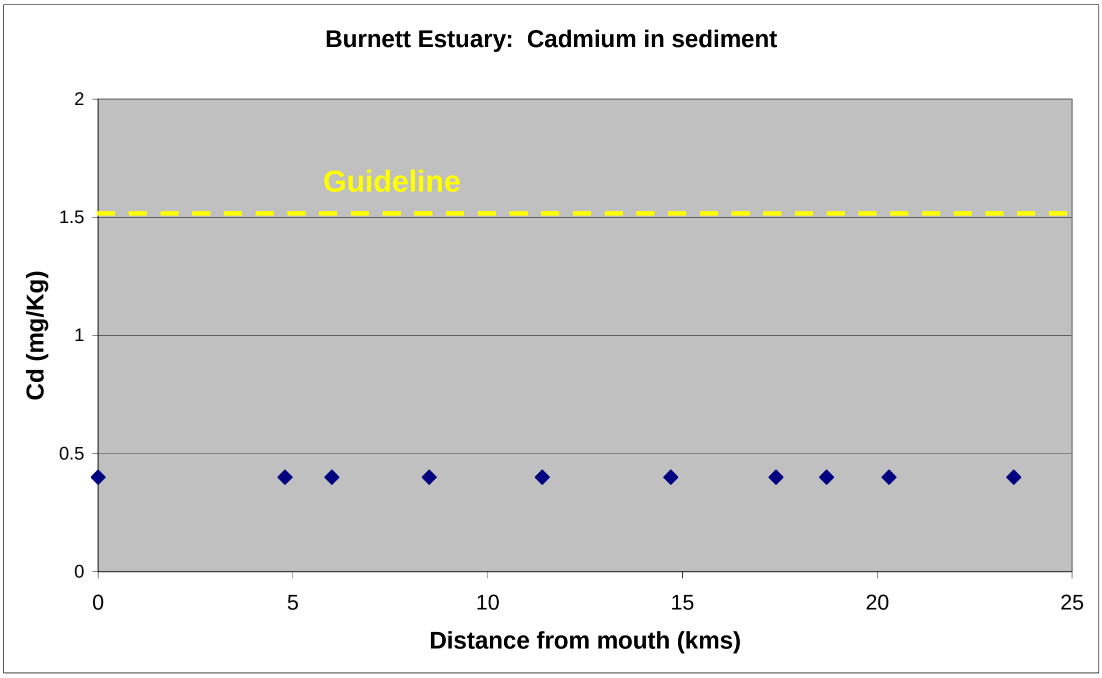


Figure B5

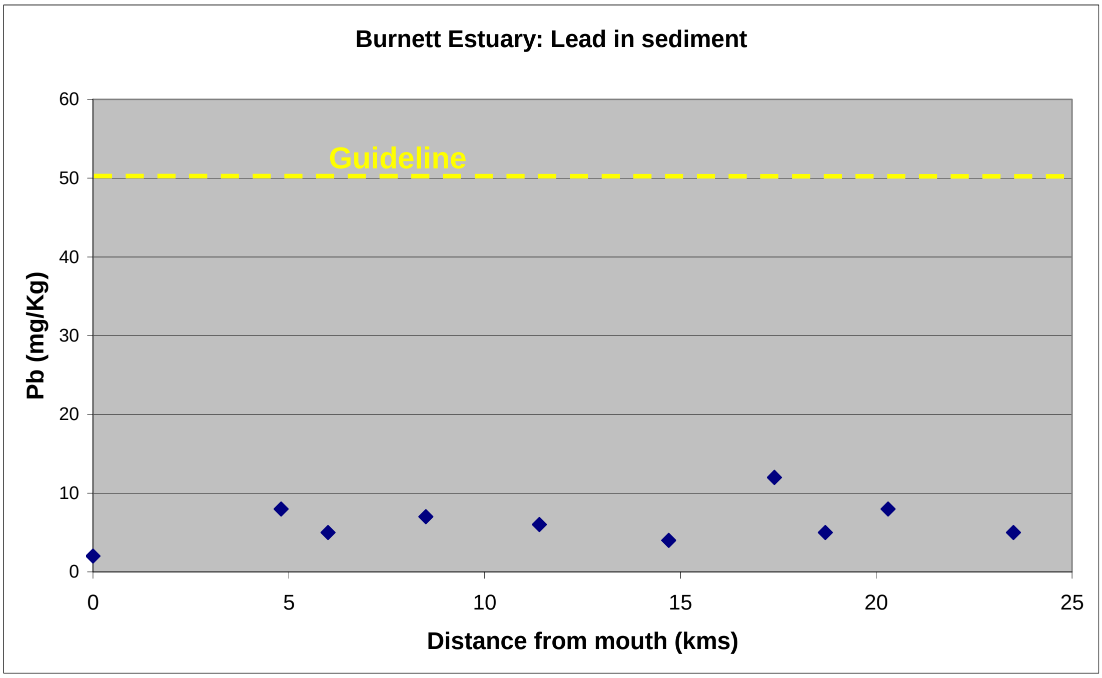
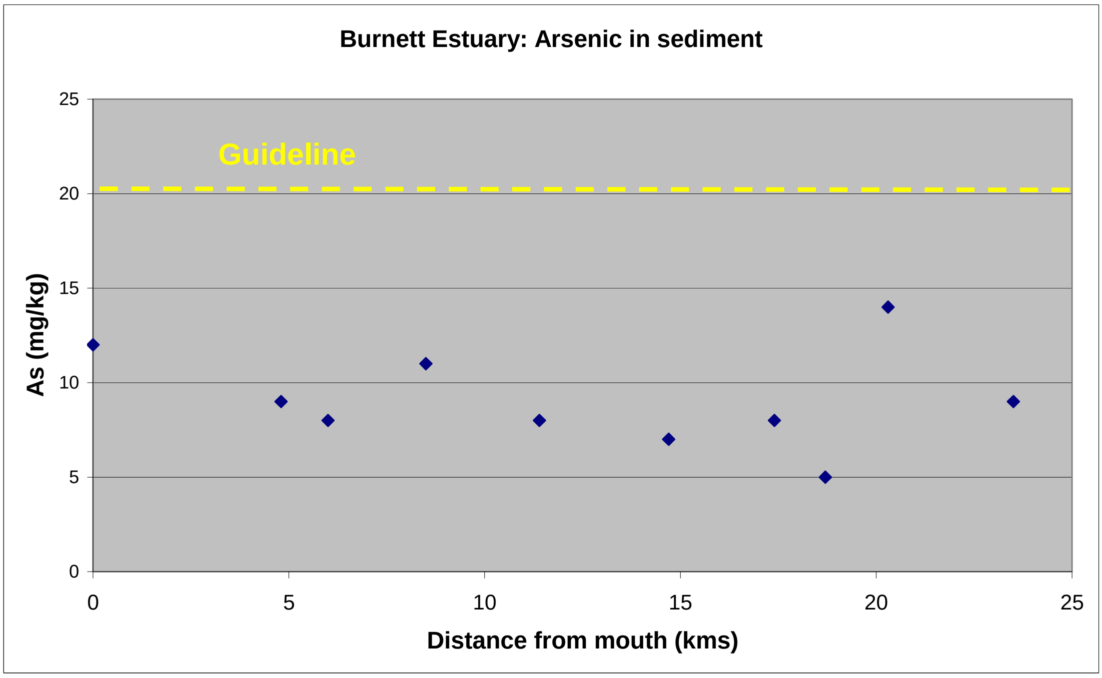


Figure B6



APPENDIX C: Trends in water quality

Figure C1

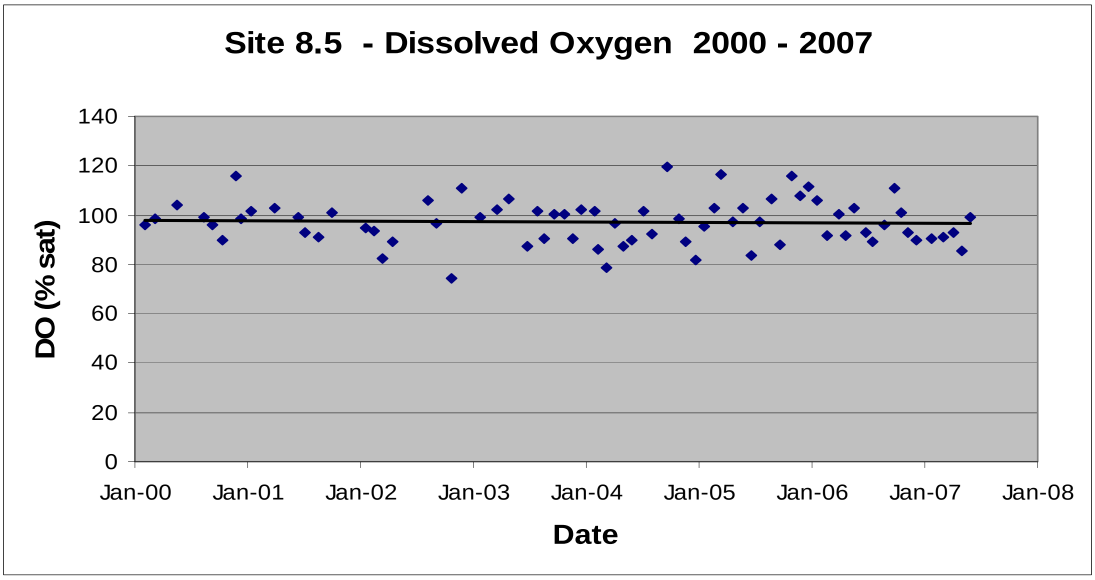
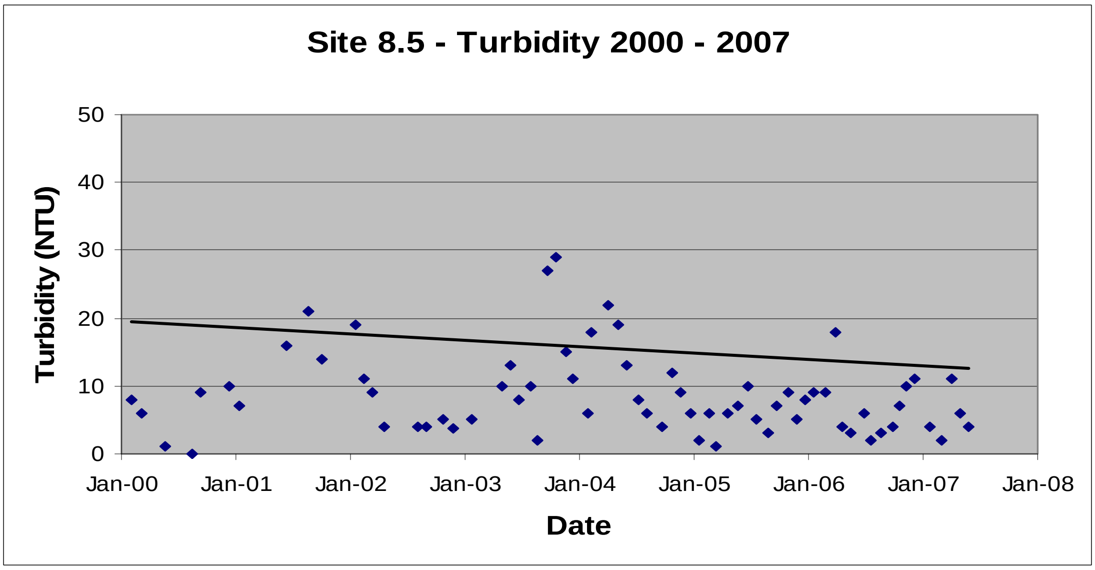


Figure C2



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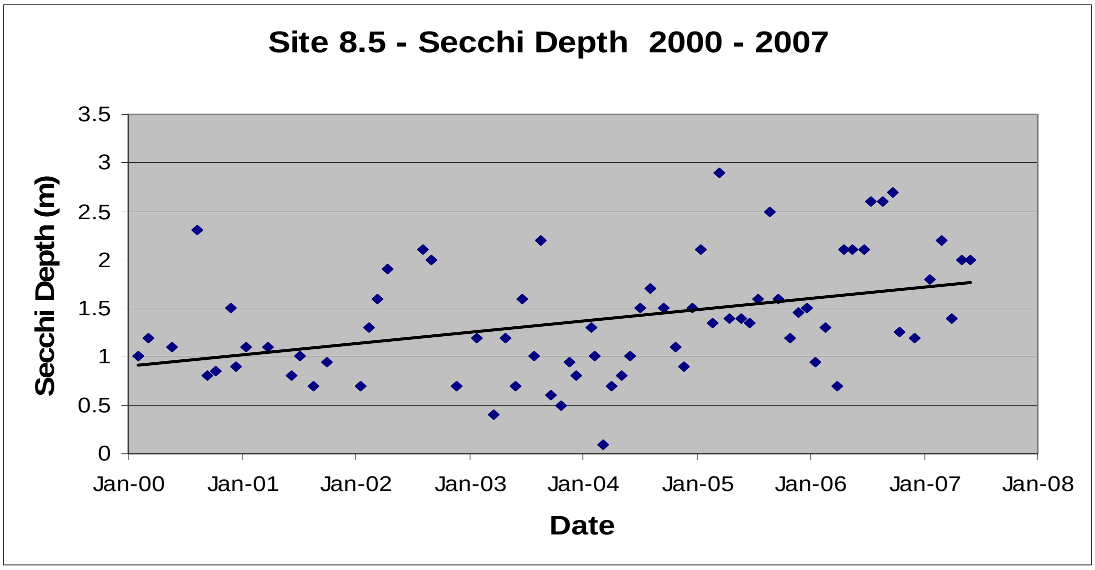


Figure C4

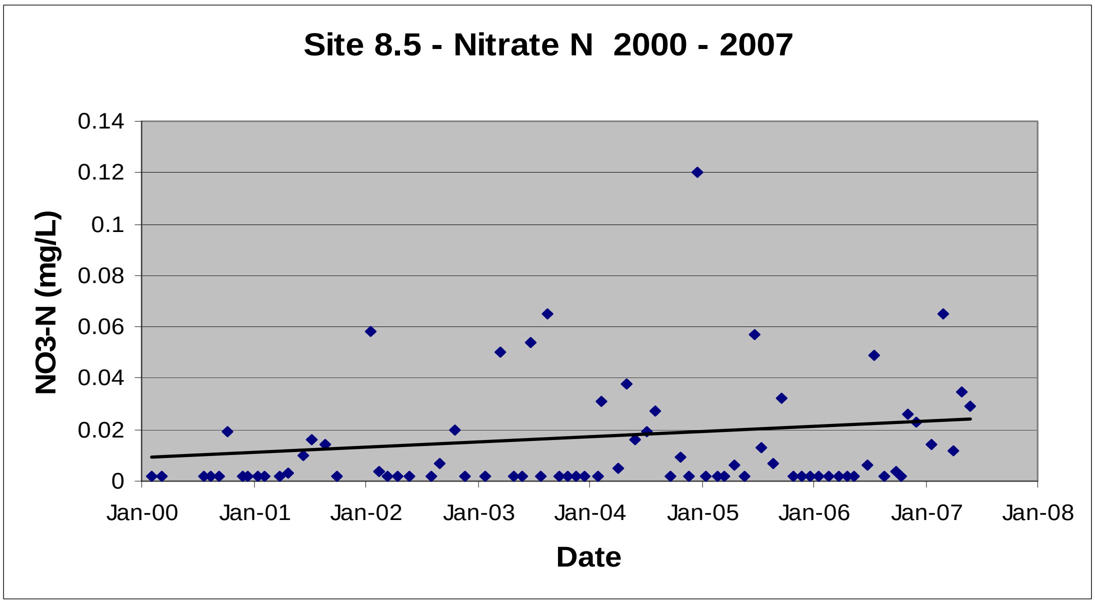


Figure C5

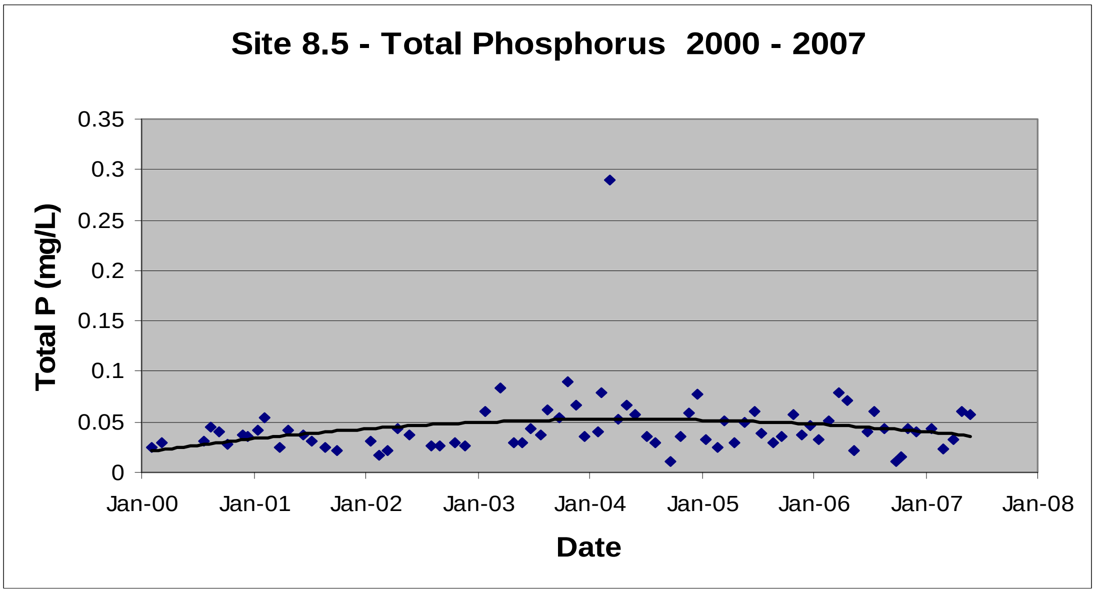
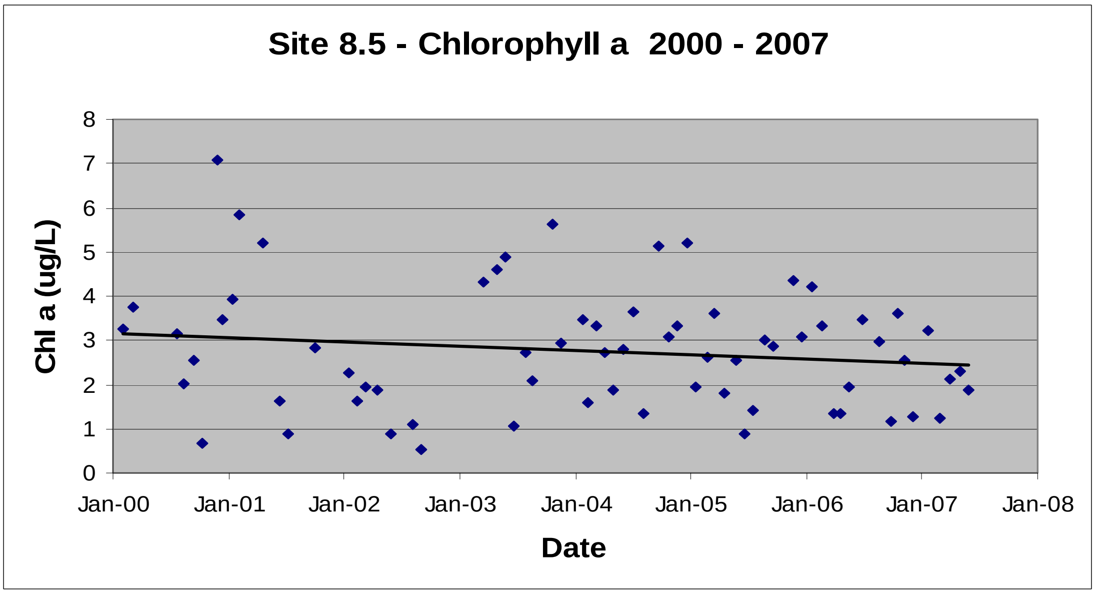


Figure C6



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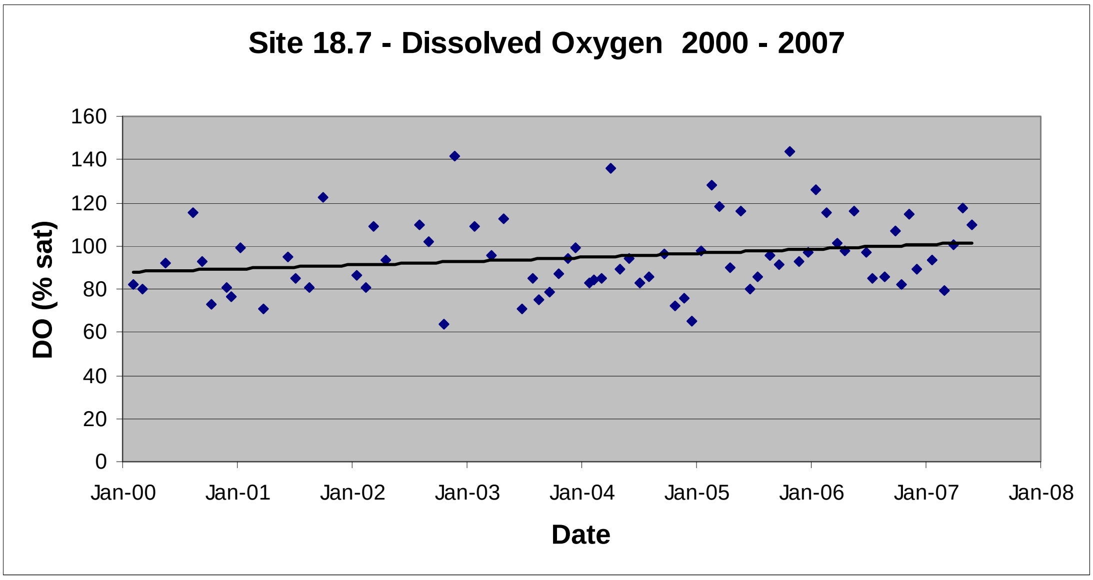


Figure C8

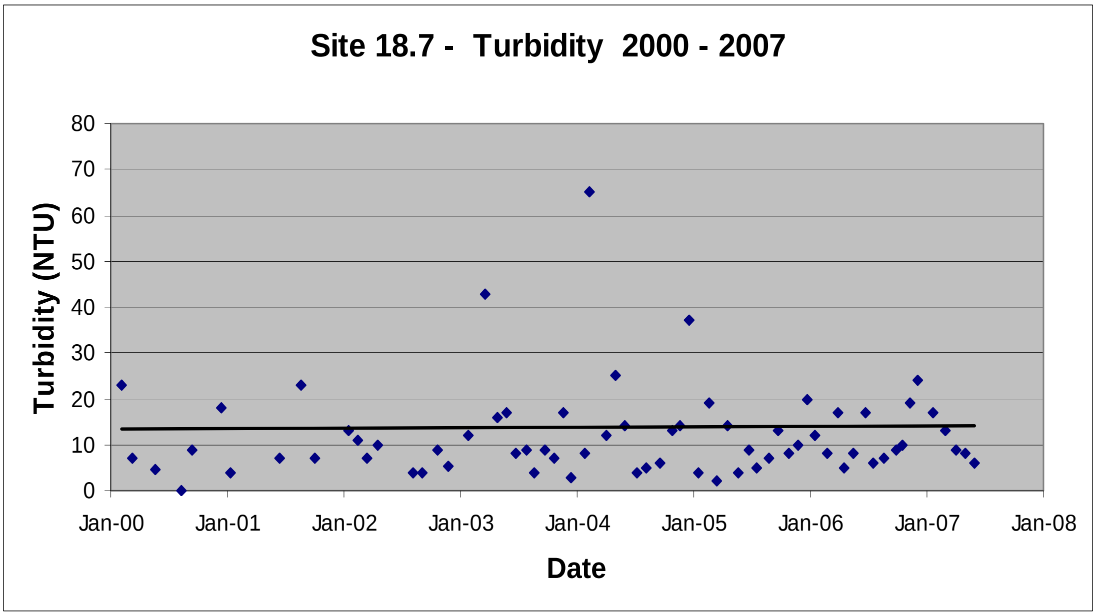


Figure C9

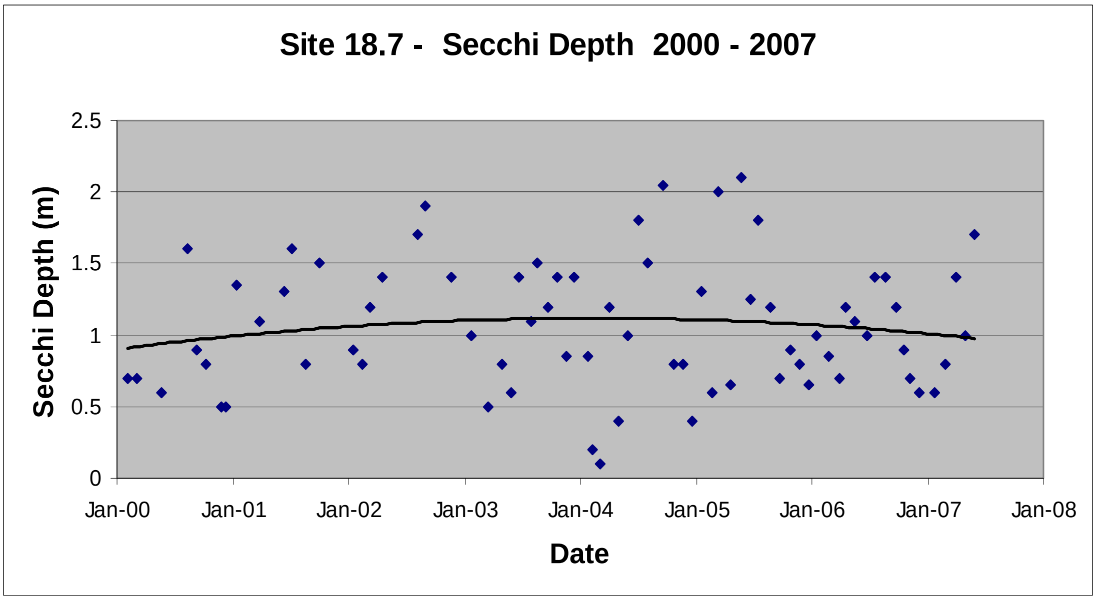


Figure C10

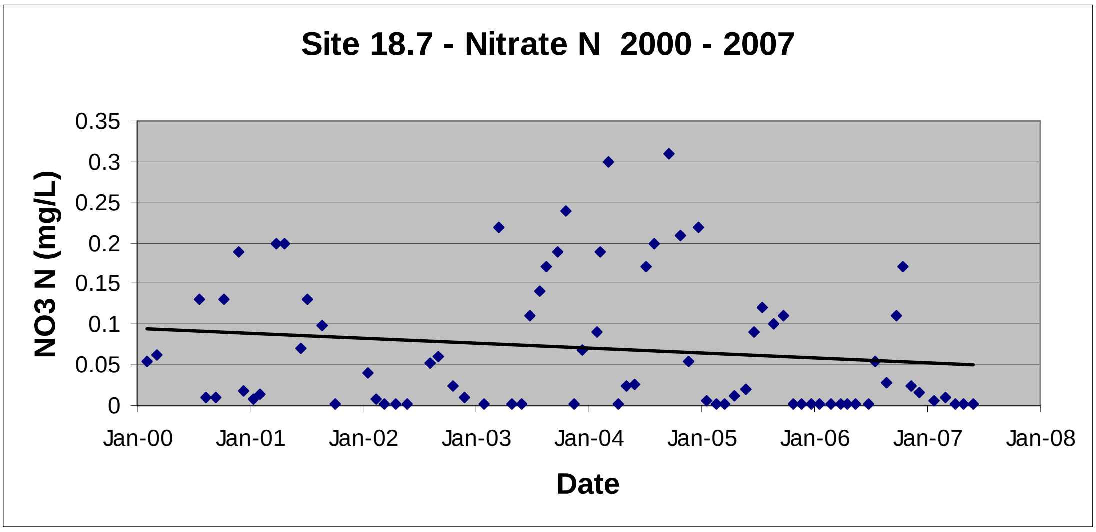


Figure C11

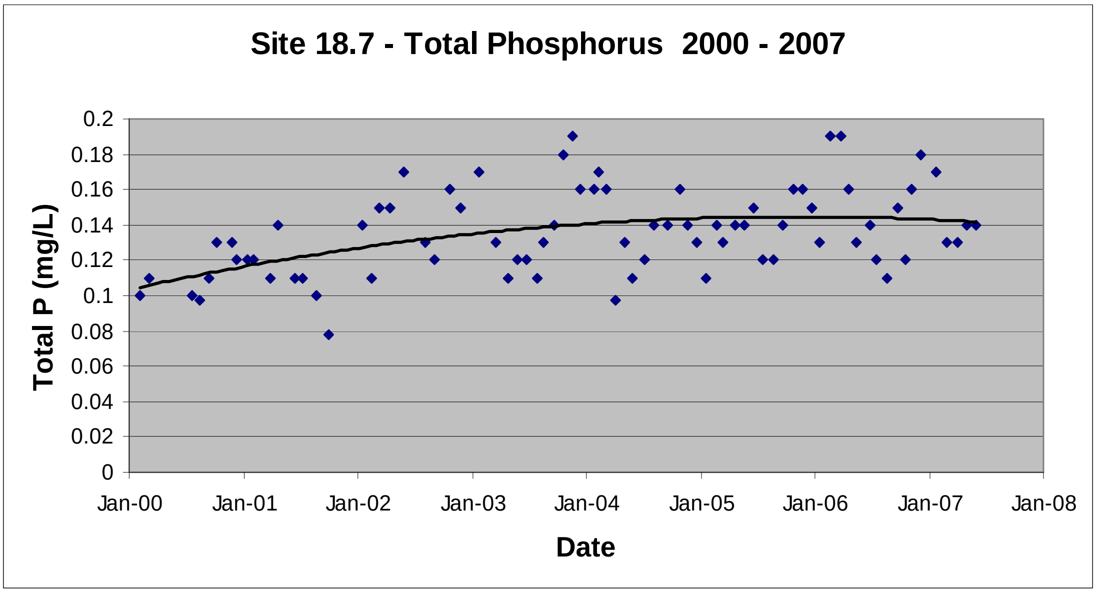
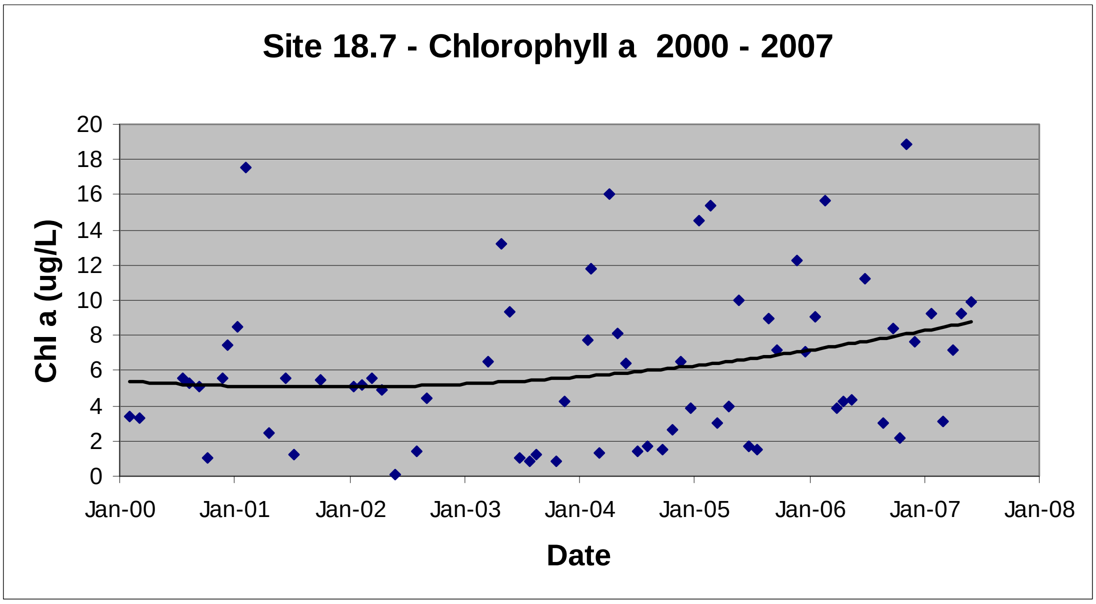


Figure C12



APPENDIX D – Explanation of indicators

Dissolved oxygen	The amount of oxygen dissolved in the water. Oxygen is essential for the life processes of most aquatic organisms, and lack of oxygen can cause suffocation of aquatic organisms. Low concentrations are often a symptom of pollution by organic matter, and are a by product of the rapid breakdown of the organic matter by bacteria. High concentrations (i.e. values > 110% saturation) are indicative excessive plant productivity. In estuaries this is due to phytoplankton growth.
pH	A measure of the acidity or alkalinity of the water. Extremes of pH (acidity less than 6.0 or alkalinity greater than 9) can be toxic to aquatic organisms. Estuarine waters are usually in the range 7-8.4
Conductivity	Conductivity is used as a measure of salinity. Seawater has a conductivity of about 51 mS/cm which is equivalent to a salinity of around 35g/L.
Turbidity	Turbidity is an indirect measure of the concentration of fine particulate matter in the water column. The higher the concentration of particles, the higher the turbidity. High levels of turbidity are indicative of excessive inputs of fine particles from the catchment or from urban stormwater. In estuaries, turbidity is also affected by the spring neap tidal cycle, with highest turbidities occurring during spring tides when tidal currents are at a maximum.
Secchi depth	An indicator of water clarity. The depth to which a secchi disc lowered into the water can be clearly seen from the surface. Secchi depth and turbidity are strongly correlated.
Nitrogen & Phosphorus	The major nutrients (nitrogen and phosphorus) are essential for plant growth. Measurements of nutrient concentrations in waters provide an indication of the potential for excessive plant and algal growth.
Chlorophyll-a	Chlorophyll-a, the green pigment found in all plants. In estuaries, the concentration of chlorophyll a in a sample it is used as an indicator of the phytoplankton biomass. High levels of algae (algal blooms) can have adverse effects on water quality.

PLEASE RETURN TO
RECORDS WHEN COMPLETED

Queensland Government

Environmental Protection Agency
Incorporating the
Queensland Parks and Wildlife Service

Enquiries Andrew Moss
Telephone (07) 3896 9245
Your reference
Our reference

9 October 2008

Chief Executive Officer,
Bundaberg City Council,
PO Box 538,
Bundaberg
Qld 4670

Attention Tom McLaughlin

Dear Sir,

Burnett River Estuary Water Quality Monitoring Program Report 2007-2008

Please find attached the 2007-2008 report on the joint EPA/Bundaberg City Council water quality monitoring program in the Burnett River estuary. The findings were similar to the previous year in that the report concludes that although the discharges of treated sewage to the estuary do have measurable effects, the majority of indicators at most sites within the estuary comply with guideline values.

Yours Sincerely

Julia Playford

Julia Playford
Director, Freshwater and Marine Sciences,
Queensland EPA

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Queensland 4068 Australia
PO Box 155 Brisbane Albert Street
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Report to the Bundaberg City Council on the results of monitoring water quality in the Burnett River estuary for the period 2007 to 2008

Queensland EPA 2008

Contents

1. Introduction

Bundaberg City Council (BCC), under a licence from the Environmental Protection Agency (EPA), discharges treated sewage wastewater to the Burnett River estuary from three separate locations – see Figure 1. To address the receiving water quality monitoring requirements of this licence, the EPA, through agreement with the BCC, undertakes regular monitoring of the Burnett River estuary.

Under the agreement between BCC and EPA, the EPA undertakes to provide an annual report on the outcomes of the monitoring program. This is the third such report and covers the year 2007-2008. It describes the program and the results of the monitoring and provides an assessment of the condition of the estuary with regard to water quality. The report includes some results from previous years of EPA monitoring in the estuary which enables the recent results to be put into a historical context and allows an assessment of trends in water quality.

2. Description of the Burnett River estuary

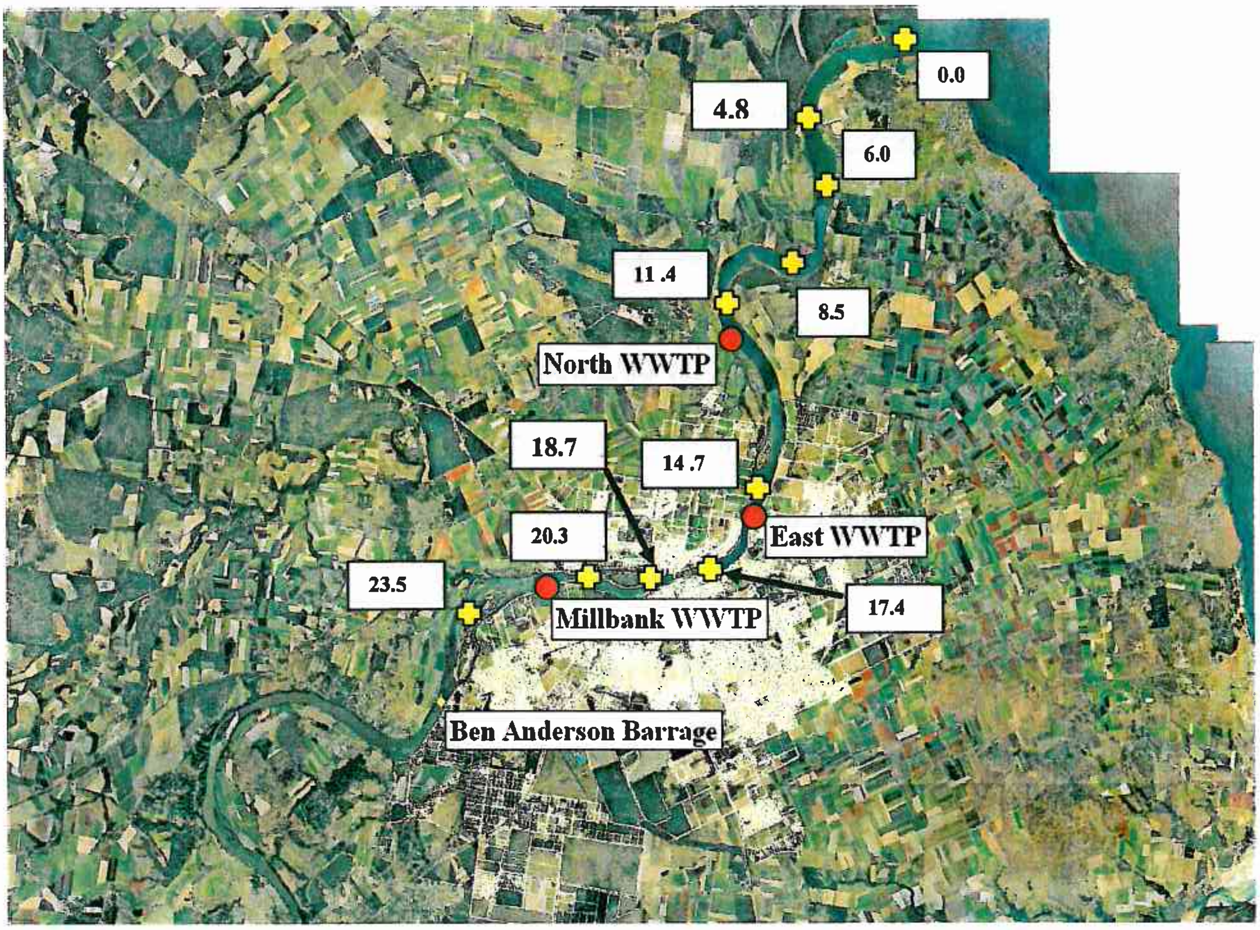
The Burnett River estuary extends approximately 25km from its mouth at Burnett Heads up to the Ben Anderson Barrage, which is now the upstream limit of tidal influence. Prior to construction of the barrage, the natural tidal limit was just above the current location of Bingera Weir which is 42.1 km from the river mouth. The main land uses adjacent to the estuary are agriculture (mostly sugar cane) and the urban areas of the city of Bundaberg, see Figure 1.

The National Land and Water Resources Audit national assessment of estuaries carried out in 2002 (for detailed information see www.ozestuaries.org) describes the Burnett estuary as being extensively modified from its pre-European condition. It has ongoing dredging at the mouth and much of its riparian vegetation has been removed. There has also been significant loss of mangroves. Freshwater inflows to the estuary have been reduced very significantly from their natural state due the extensive system of weirs and associated agricultural water use within the Burnett catchment.

The main sources of pollutants entering the estuary are:

- Diffuse pollutant loads entering from the catchment during infrequent flood events
- Urban stormwater from Bundaberg City
- Point discharges

Figure 1: Burnett River estuary showing sampling sites and discharge points



Monitoring site

Discharge location

This report is principally concerned with the point discharges and their associated impacts on water quality. The main existing point discharges to the estuary are the BCC treated sewage discharges. There are no other significant point discharges. The BCC discharges comprise:

- BCC North WWTP (Waste Water Treatment Plant)
- BCC East WWTP
- BCC Millbank WWTP.

Discharge locations are shown in Figure 1. Information on discharge loads from these plants is given in Tables 2.1 and 2.2 below. The most significant discharge is the East WWTP. Total N loads from this plant appear to have increased this year.

Table 2.1 Annual pollutant loads from discharges to the Burnett River estuary during 2007 - 2008

Source	Annual pollutant loads (tonnes)			
	TN	TP	BOD	TSS
North WWTP	1.0	0.7	1.7	2.5
East WWTP	9.0	20.1	47.3	43.5
Millbank WWTP	4.9	5.3	6.5	6.0

Table 2.2 below shows annual loads from the East and Millbank WWTPs since 2000, which is useful for comparing with water quality trends.

Table 2.2 Historical records of annual nutrient loads from treatment plants

	East WWTP		Millbank WWTP	
Year (Jul/Jun)	Total Nitrogen (Tonnes)	Total Phosphorus (Tonnes)	Total Nitrogen (Tonnes)	Total Phosphorus (Tonnes)
99/00	32.9	17.9	16.4	8.8
00/01	20.8	16.1	8.1	8.4
01/02	16.4	16.6	6.4	11.4
02/03	36.7	19.2	7.9	11.1
03/04	40.9	19.6	11.9	11.0
04/05	36.0	22.2	9.9	10.8
05/06	38.0	20.4	4.6	8.6
06/07	36.1	22.3	7.0	9.2
07/08	48.0	20.1	4.9	5.3

3. Scope of Water Quality Monitoring Program

3.1. Routine monthly monitoring

The main component of the EPA monitoring program consists of routine monthly monitoring at 10 sites in the Burnett River estuary. The program aims to provide a general assessment of water quality in the estuary and also, in the longer term, to pick up any trends in quality. The indicators sampled at each site are detailed in Table 3.1. These indicators and their purpose are described in more detail in Appendix C. Not all indicators are sampled at all sites but the program provides sufficient data to provide a good general assessment of water quality throughout the estuary.

The monitoring is undertaken by experienced EPA field staff, who routinely undertake this type of activity in many Queensland estuaries.

Table 3.1 Burnett River estuary monitoring program: Indicators and Sites

SITE (km)	INDICATORS							
	DO	Temp	pH	Conductivity	Turbidity	Chl a	N	P
0.0	✓	✓	✓	✓	✓			
4.8	✓	✓	✓	✓	✓	✓		
6.0	✓	✓	✓	✓	✓			
8.5	✓	✓	✓	✓	✓	✓	✓	✓
11.4	✓	✓	✓	✓	✓		✓	✓
14.7	✓	✓	✓	✓	✓	✓	✓	✓
17.4	✓	✓	✓	✓	✓			
18.7	✓	✓	✓	✓	✓	✓	✓	✓
20.3	✓	✓	✓	✓	✓	✓	✓	✓
23.5	✓	✓	✓	✓	✓	✓		

3.2. *Temporally intensive monitoring*

The temporally intensive data was acquired from an instrument array contained in a purpose designed trailer. Up to October 2006, this was located on a jetty close to site 17.4. In October this had to be moved and it is currently located further upstream on a jetty close to site 18.7. The trailer records surface (0.2m) readings every half hour for the following indicators; DO, pH, conductivity, turbidity, temperature and chlorophyll a (fluorescence reading).

While the routine monthly monitoring program provides an overall assessment of water quality in the estuary, it does not provide a measure of short term – hours or days – fluctuations in water quality. Such fluctuations can be important, particularly for indicators such as dissolved oxygen which exhibit large diurnal cycles. Large temporal variations in water quality also occur during and shortly after flood events. These can be very significant and are often missed by routine monthly sampling. A particular aim of this monitoring was to assess the impacts of catchment inflows to the Burnett River estuary. While the years 2005/06 and 2006/07 were unusually dry, in 2007/08 there were two significant inflow events. The effects of these were captured by the continuous monitoring trailer.

3.3. *Additional data from other monitoring programs*

During 2007/08 some monitoring in a number of estuaries in the Mary Burnett region, including the Burnett estuary, was undertaken as part of a joint Burnett/Mary

Regional NRM and Queensland EPA program. Some faecal coliform data from this program has been incorporated into this report

.

4. Methods for assessing water quality

4.1. Condition – core indicators

The basic approach to condition assessment is to compare monitoring data with guideline values. The guidelines used in this report are taken from the Queensland Water Quality Guidelines (QWQG). These provide guideline values for all the indicators measured in the routine monthly program.

Water quality in estuaries varies naturally from the mouth up to the tidal limit. To allow for this natural variation, the QWQG provides separate guidelines for different reaches of estuaries. These reaches are defined as follows:

1. Lower estuary – the reaches near the estuary mouth that experience frequent exchange with coastal waters
2. Mid estuary – the main body of the estuary
3. Upper estuary – the upper 15% of the length of the estuary – these reaches are poorly flushed and have naturally poorer water quality than the main body of the estuary

Table 4.1 below shows the guideline values for each indicator for each of these segments. It also shows which sites in the Burnett fall into each category.

Table 4.1 Guideline values for each reach of the Burnett River estuary

REACH	GUIDELINE VALUES FOR KEY INDICATORS							
	DO	pH	Secchi	Turb-idity	Total N	Total P	Chl a	
	%sat		(m)	NTU	µg/L	µg/L	µg/L	
Lower estuary Sites 0.0	105-95	8.0-8.4	1.5	6	200	20	2	
Mid estuary Sites 4.8, 6.0, 8.5, 11.4, 14.7, 17.4, 18.5	105-85	7.0-8.4	1.0	8	300	25	4	
Upper estuary Sites 20.3, 23.5	105-80	7.0-8.4	0.5	25	450	30	8	

These guideline values are designed to be compared with the median of a series of values rather than every individual value from a test site. Thus, the graphical presentations of the results show the guidelines compared with the median values for the last 12 months for each indicator at each site.

As well as assessing the median value, the results also need to be checked for extreme values. Such values (e.g. very low DO levels) have the potential to be very harmful even though median values comply with the guideline value.

The indicators assessed for condition include:

Dissolved oxygen
pH
Turbidity
Secchi depth (clarity)
Nitrate N
Total P
Chlorophyll a

4.2. Condition – additional indicators

The data for faecal coliforms and pesticides were assessed against the ANZECC 2000 guideline values.

4.3. Trend

The more intensive monitoring of the Burnett River estuary only started in 2005 and so there is insufficient data to comprehensively assess trends throughout the estuary. However, EPA data is available for a much longer time period for two sites (8.5 and 18.7). Data from these sites is assessed using simple regression techniques to provide an indication of improvements or declines in water quality over the past few years. This information can give an indication of improvements in water quality or of what issues are likely to arise in the future.

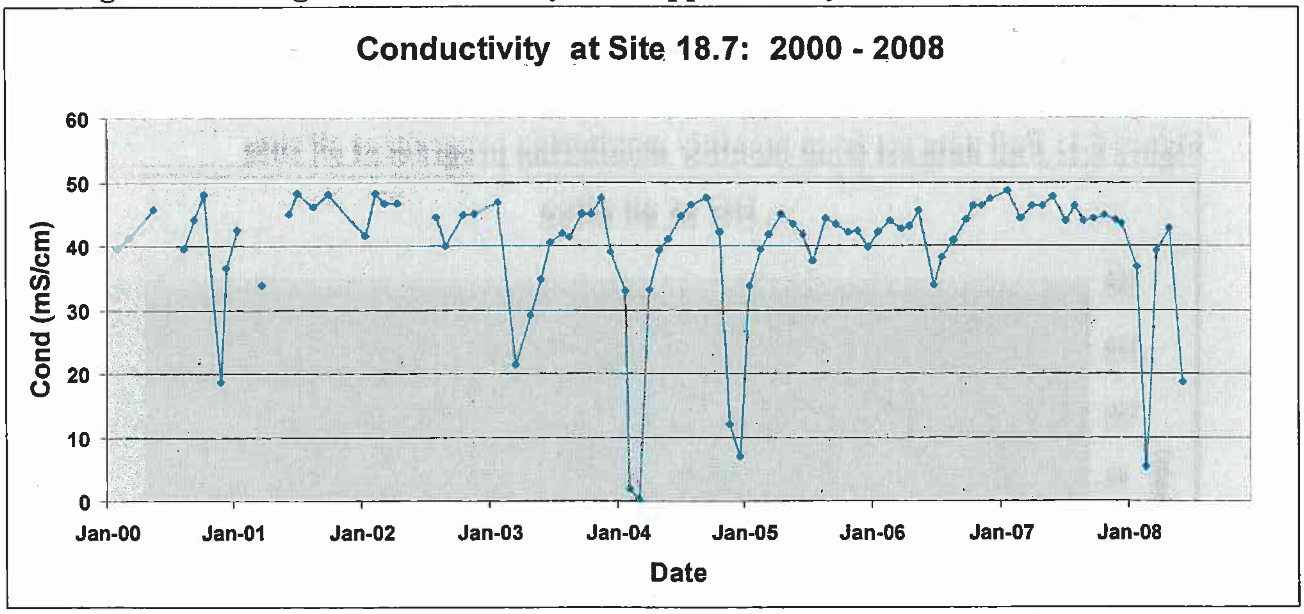
5. Overview of Burnett estuary conditions during the period 2006 - 2007

Water quality condition in estuaries can be broadly separated into (i) flow event and immediate post flow event conditions and (ii) dry weather conditions. Flow events carry large volumes of freshwater and catchment sourced pollutants into estuaries. These have considerable but usually short term impacts on water quality. During dry weather, water quality in estuaries is more stable and is largely controlled by internal processes and any point discharges. Most sub-tropical Queensland estuaries experience dry weather conditions (i.e. minimal inflow from the catchment) for >90% of the time.

Figure 5.1 shows conductivity at a site in the mid/upper reaches of the Burnett estuary over the period 1999 to 2008. For much of the time conductivity is in the range 40 - 50 mS/cm which is indicative of dry weather conditions. Sudden reductions below 40 mS/cm indicate recent freshwater inflows, the larger the reduction the larger the inflow. The graph shows a number of major dips in conductivity over the 8 year period. There was a very dry period in 2006 and 2007 which coincided with the first two years of these more intensive surveys. However, 2007/8 was a more normal wet season and two significant falls in salinity can be seen, the most recent in May.

This means that in 2007/08 there may have been some catchment related impacts on water quality in the estuary whereas in the previous two years, catchment impacts would have been minimal.

Figure 5.1: Long-term conductivity at an upper estuary site



6. Results

6.1. Data presentation

Figures A1 to A6 in Appendix A show median values for each of the six selected core indictors plotted against distance upstream in the estuary. The plots also show the relevant guideline values for each reach of the estuary. Where median values comply with guideline values they are coloured in **black** and where they do not comply they are coloured in **red**. These plots provide a broad overview of water quality in the estuary.

Trends in water quality are shown in figures B1 to B12. These show trends in water quality for the six selected core indicators at two sites, 8.5 and 18.7 over the period 2000 to 2008.

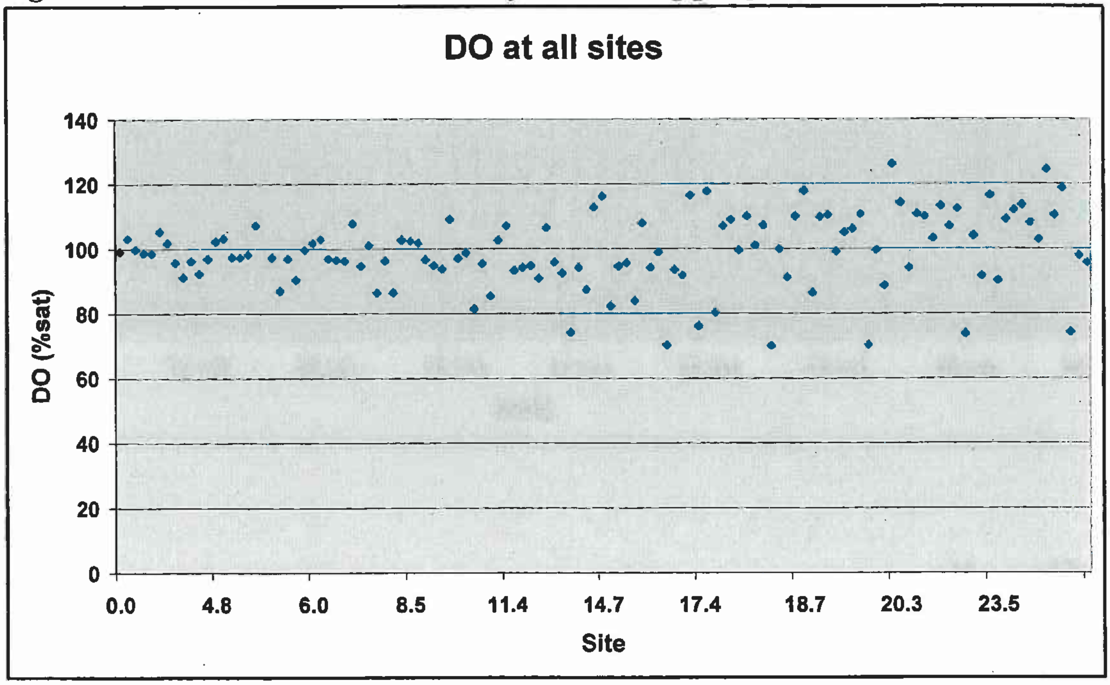
For some core indicators, some additional graphical data is presented to illustrate specific points.

Information for the additional indicators, faecal coliforms and pesticides, is provided within their respective sections.

6.2. *Dissolved Oxygen*

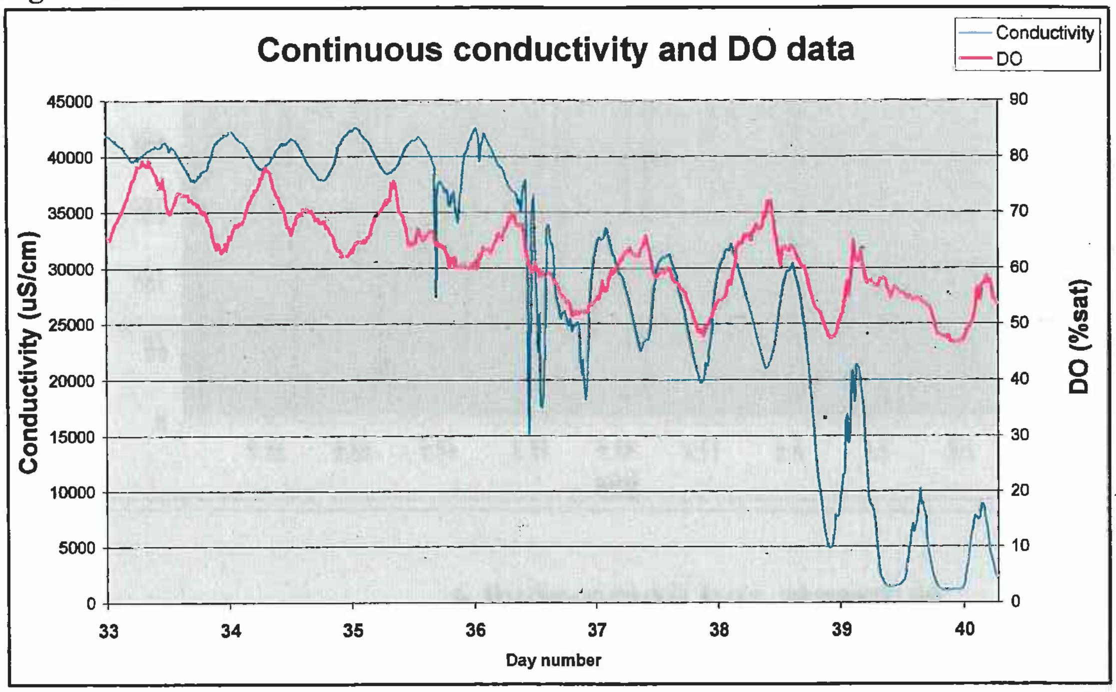
The results in Figure A1 show that dissolved oxygen complies with guidelines at all sites except the most upstream site where there is an indication of persistent supersaturation due to algal activity. Figure 6.1 shows the full monthly data set at each site along the estuary. It can be seen that the minimum value recorded at any site during the entire 12 months was 70% saturation. The absence of low values indicates that the BOD load from the WWTPs is not having a significant impact on the estuary.

Figure 6.1: Full data set from monthly monitoring program at all sites



The temporally intensive DO monitoring showed that night time minimum DO values often fell to around 60% saturation which is normal for most estuaries. The lowest DO values recorded by the intensive monitoring station (around 45-50% sat) occurred following an inflow event and were presumably related to the influx of catchment sourced organic loads. The effect of this inflow on DO is illustrated in Figure 6.2. This shows day night cycles of DO and conductivity over approximately a 7 day period. In the first 3 days minimum DO values are around 60% saturation. On the fourth day, the sudden fall in conductivity is indicative of a significant inflow. Following this inflow, there is a fall in minimum DO levels to 50% saturation and below, caused by catchment sourced organic matter.

Figure 6.2: Effects of catchment inflow on DO levels

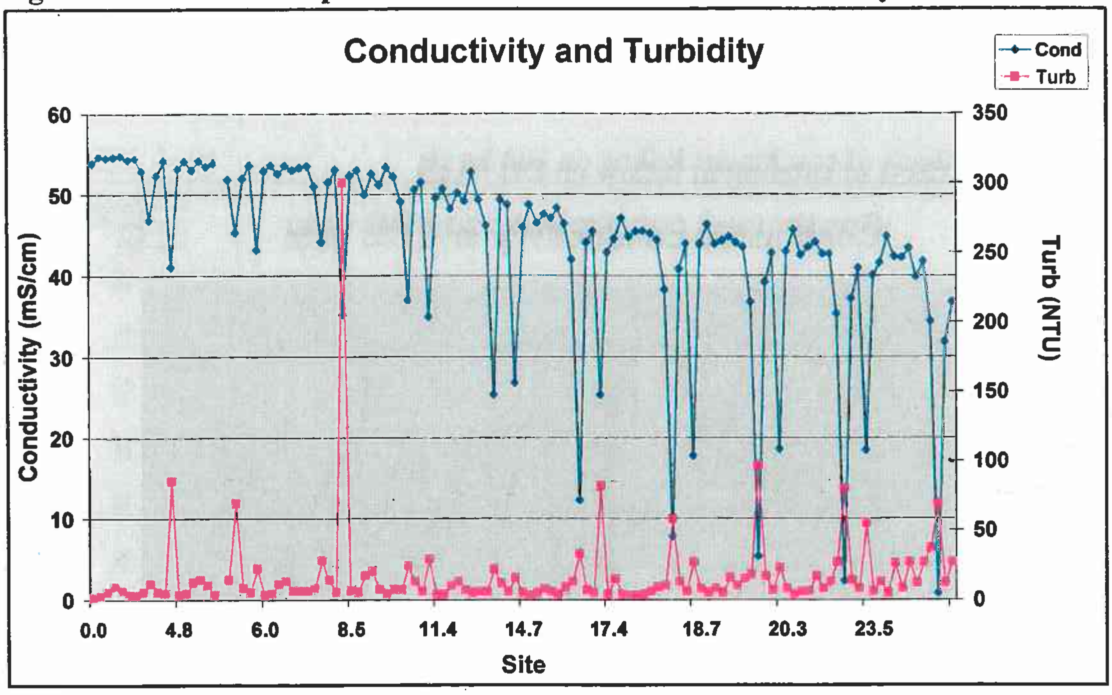


Both the monthly monitoring and the temporally intensive monitoring showed that in the daytime, supersaturated levels of DO of between 100% and 120% were the norm. This indicates a level of algal activity higher than in pristine estuaries.

6.3. Turbidity and Clarity

Levels of turbidity (Fig A2), Secchi disc clarity (Fig A3) complied with the guidelines at most sites, but there were some exceedances. In the previous year (06/07) there were no exceedances but that was a much drier year. Figure 6.3 below shows the complete monthly turbidity data set at all sites. It also shows corresponding conductivity values at each site. What can be seen is that all the high turbidity values are associated with falls in conductivity, which are indicative of catchment inflows. During dry weather, turbidity values are much lower. It is thus clear that turbidity in the estuary is strongly related to turbid catchment inflows, which is what would be expected.

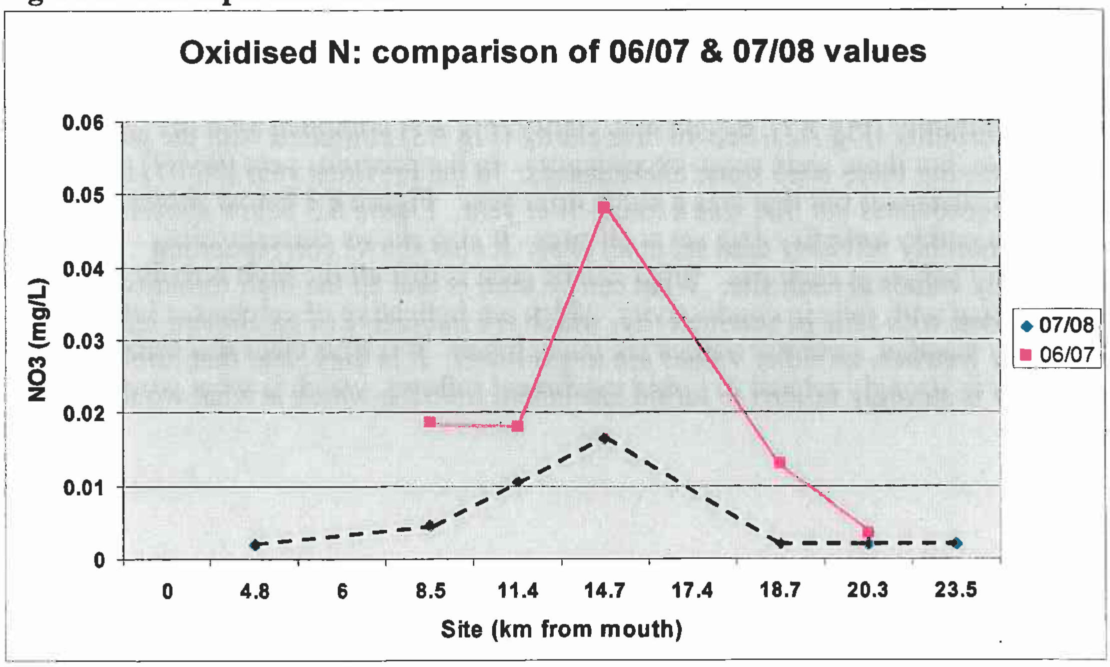
Figure 6.3: Relationship between catchment inflow and turbidity



6.4. *Nutrients and Chlorophyll a*

Oxidised N (NO2+NO3) values (Figure A4) exceed guidelines at one site (14.7). Values are lower than in 06/07 – see Figure 6.4. The cause of this is not known and it will be interesting to see if these lower levels persist into the next 12 months. Total P values (Fig A5) in 07/08 significantly exceed guideline values at most sites. There has been no significant change in P loads from WWTPs and, as a result, total P concentrations are similar to those in 06/07.

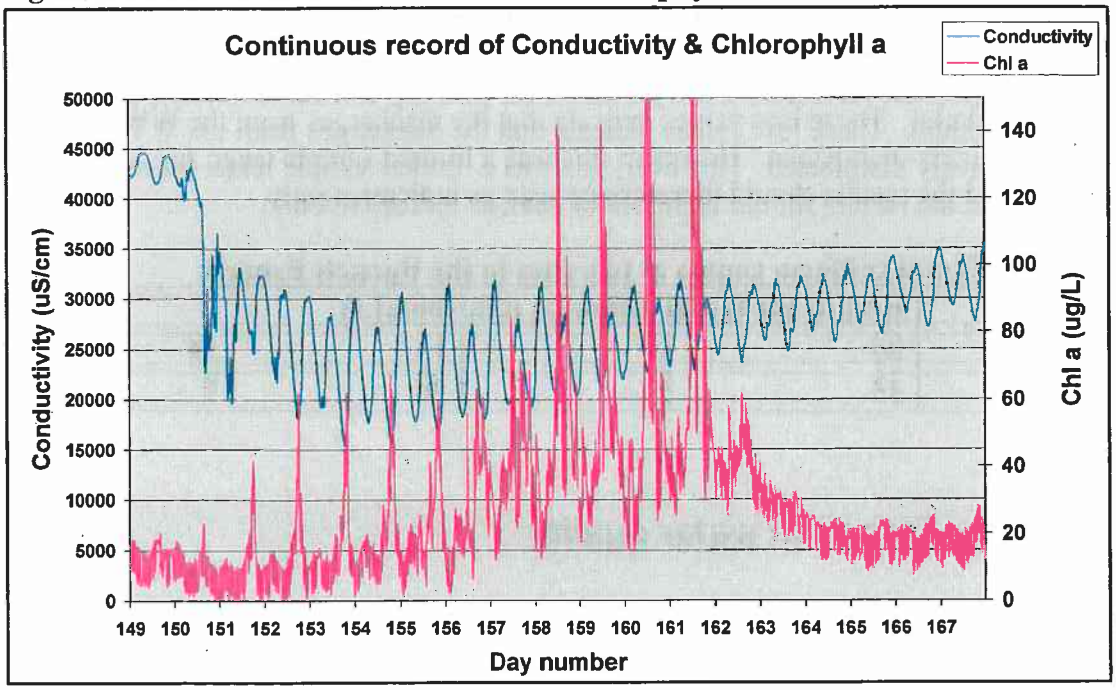
Figure 6.4: Comparison of median oxidised N values in 06/07 and 07/08



Median chlorophyll a values (Fig A6) met guideline values at most sites but there are significant exceedances in the mid estuary region (sites 14.7 and 18.7). This is the main zone of influence of the WWTP discharges and these are clearly still having an impact on phytoplankton production in the estuary. However, the maximum chlorophyll a levels recorded at any site in the monthly monitoring program were all below 30µg/L which indicates that the estuary is not highly eutrophic.

The highest chlorophyll a levels recorded during 07/08 were recorded by the continuous monitoring trailer. These high values occurred following a significant inflow event and were almost certainly associated with catchment nutrient loads. This is illustrated in figure 6.5 shows conductivity and chlorophyll a values over an18 day period. The conductivity record shows there was a significant freshwater inflow into the estuary late on the second day. Over the next 13 days this resulted in a significant phytoplankton production response. Chlorophyll a levels reached values over 100ug/L for short periods. However, after about two weeks the catchment sourced nutrients were exhausted and chlorophyll a levels returned to near pre-event levels.

Figure 6.5: Effect of catchment inflow on chlorophyll a levels



This type of event occurs naturally in all estuaries. However, catchment development and associated increases in diffuse source loads result in larger estuary responses. Ultimately, management of estuary water quality requires that point sources of nutrients – which impact dry weather chlorophyll a levels - and diffuse catchment sources of nutrients – which cause short lived blooms – both need to be reduced as far as possible.

6.5. pH

Values of pH in estuaries are generally buffered in the range of 7.0 to 8.4 by the presence of salt water. However, major catchment run-off events can reduce levels due to the presence of freshwater and in some locations acid sulphate run-off can reduce levels very significantly for short periods. During 2007 – 2008, pH values recorded during the monthly surveys in the Burnett estuary remained within the range of 6.9 to 8.2 at all sites throughout the year. Major inflows appeared not to have any major impact on pH. However, the fact that these readings were only at monthly intervals means that much lower values may have occurred but not been recorded. A wider range of values was recorded at the continuous monitoring site but the lowest value was 5.9. Overall therefore, neither data gives any indication of significant acid run-off. However, this does not mean that acid inflows did not occur in localised areas of the estuary.

6.6. Faecal coliforms

As part of a different program, faecal coliform samples were collected at two sites in the estuary on 4 dates. Results are shown in Table 6.1. All values were <100 cfu/100mls. While there were not enough samples to comply with the ANZECC 2000 sampling protocol (this requires 5 samples at weekly intervals), the numbers are low and would meet the ANZECC 2000 guideline for primary contact recreation (median <150cfu/100mls). These low values indicate that the discharges from the WWTPs are being effectively disinfected. However, this was a limited sample taken for other purposes and the results should therefore be seen as indicative only.

Table 6.1: Faecal coliform counts at two sites in the Burnett Estuary

	Results for faecal coliforms (cfu/100mLs)			
Site 1	62	17	13	48
Site 2	35	5	26	9

6.7. Trends in water quality

The trend results are based on data collected by the EPA at two sites (8.5 & 18.7) since January 2000. Graphs for each of the selected indicators are given in Figures B1 to B12 Appendix B.

Dissolved oxygen values in 2007/08 were similar to those in 2006/07. At site 8.5, DO levels have remained relatively stable over time (Fig B1). At site 18.7 (Fig B2) there is an overall increasing trend, due mainly to an increase in the frequency of supersaturated values, which indicates increased algal activity. However, there didn't appear to be any further increase between 06/07 and 07/08.

Both turbidity and clarity show overall improving trends at site 8.5 (Figs B3 & B4). However, due to the inflow events, values in 07/08 were generally poorer than the previous dry year. At site 18.7, turbidity has been relatively stable over the past five years but clarity has been declining in the last 3 years (Figs B5 & B6)

With regard to nutrients, the increase in total P (Figs B9 & B10) that occurred at both sites during the period 2000 to 2005 appears to have levelled out with no increases in subsequent years. This is consistent with P loads discharged from the treatment plants. Nitrate N levels remained about the same as previous years at site 8.5 (Fig B7) but at site 18.7, nitrate levels sharply declined. Again, the reason for this is not known.

Chlorophyll a values at site 8.5 (Fig B11) in the mid-lower estuary have remained relatively stable over the study period. However, levels at site 18.7 (Fig B12) in the upper estuary are continuing to increase. This may in part be due to the impact of the increased catchment inflows in 07/08.

7. Conclusions

Water quality in the Burnett estuary is impacted to a limited degree by both point and diffuse sources of pollutants.

Turbidity and clarity are strongly related to diffuse catchment sources of fine particulates. As a result, quality of these indicators in the year 07/08 was poorer than in the much drier 06/07 year. However, values mostly complied with guidelines.

Dissolved oxygen can be impacted by both diffuse and point sources. In the Burnett, point sources appeared to have little impact on this indicator while diffuse inputs had some relatively limited impacts. Overall, there was a high level of compliance with guidelines.

Nutrient levels in the Burnett estuary are measurably impacted by the WWTP discharges, particularly with respect to phosphorus which exceeds guidelines at most sites. N levels exceed guidelines at only one site. The elevated nutrients are clearly having an impact on dry weather chlorophyll a levels in the mid/upper estuary but do not cause significant blooms. Diffuse source nutrient inflows to the estuary also impact chlorophyll a levels.

Limited measurements of faecal coliforms indicate that the WWTP discharges are not having a significant impact on levels in the estuary.

Overall, while water quality in the Burnett estuary is measurably impacted by the WWTP discharges, these impacts can be described as relatively moderate. The only concern is the apparent increase in chlorophyll a levels in the upper estuary. Future monitoring will indicate if this is a medium term effect or part of a long term change in water quality.

8. References

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000).

EPA (2006) Queensland Water Quality Guidelines. www.epa.qld.gov.au/environmental_management/water/queensland_water_quality_guidelines

9. Acknowledgements

Thanks to John Ferris and the EPA field staff for undertaking surveys efficiently and on schedule and for the high level of QA that is maintained.

Thanks to Jeff Rohdman of Bundaberg City Council for providing a full and rapid response to requests for data and for any other assistance requested.

APPENDIX A: Water quality compared to guidelines

Figure A1

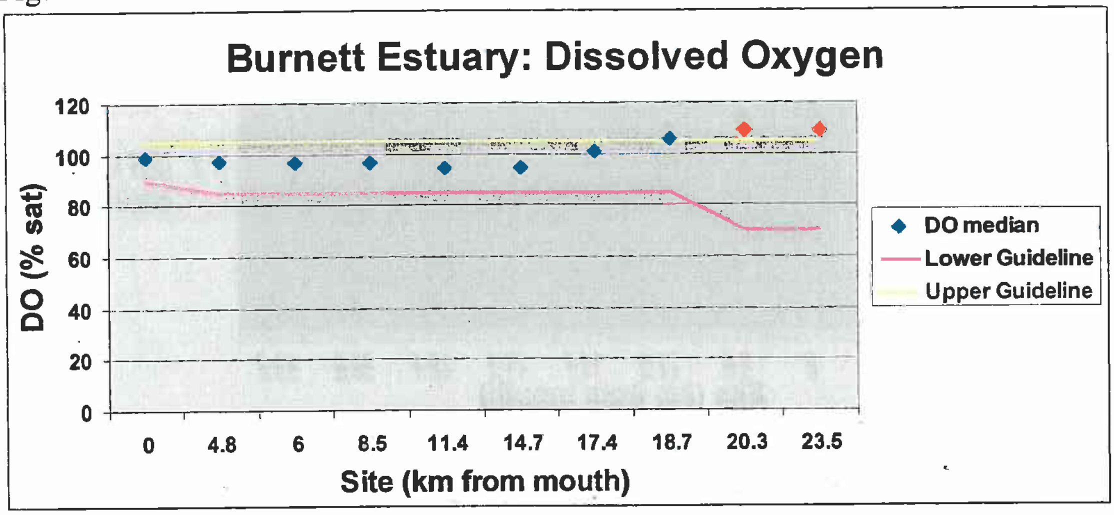


Figure A2

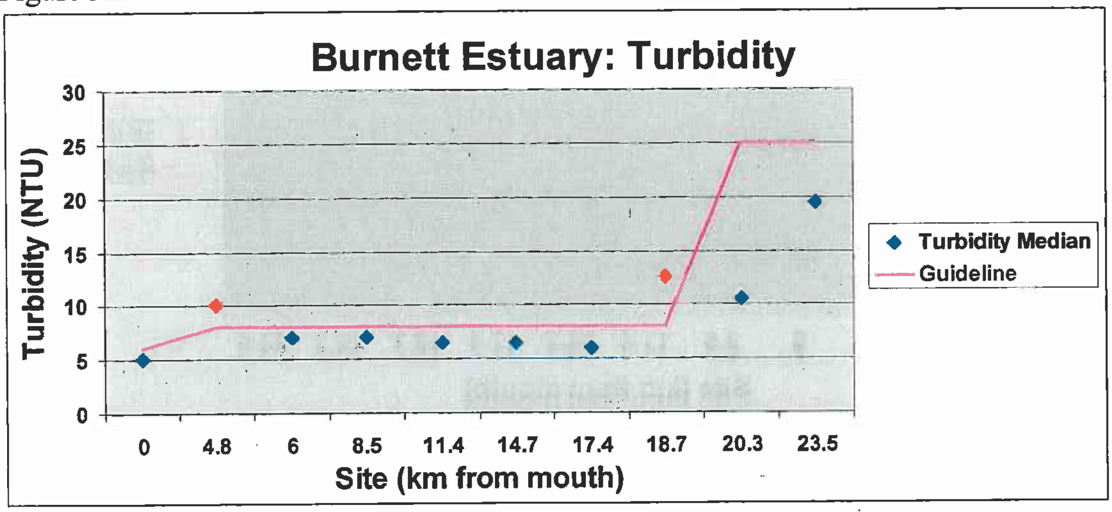


Figure A3

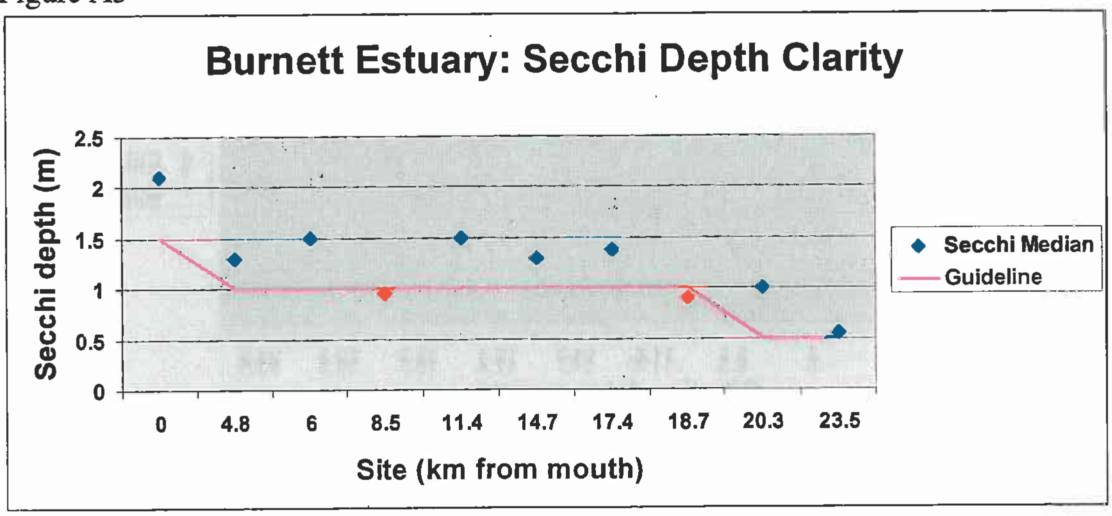


Figure A4

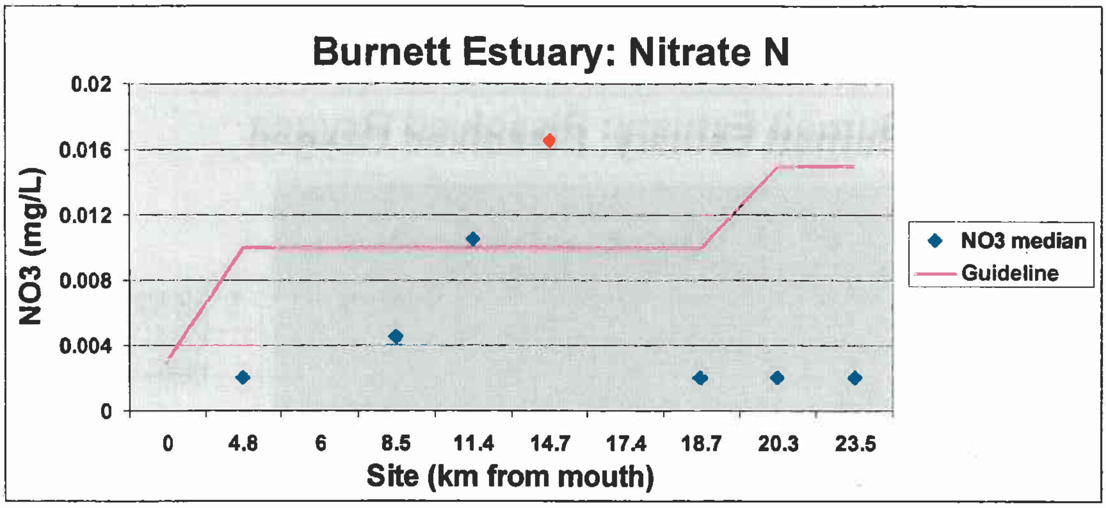


Figure A5

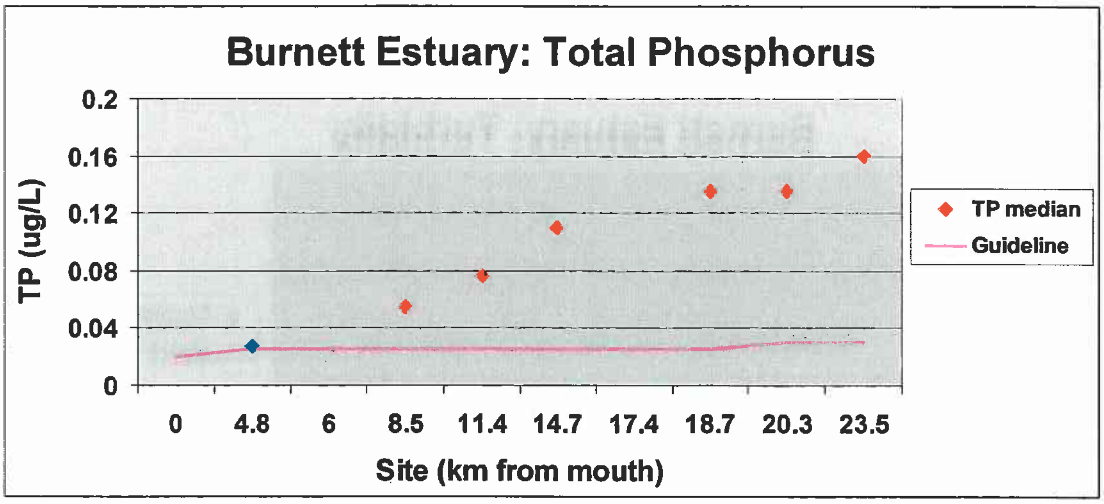
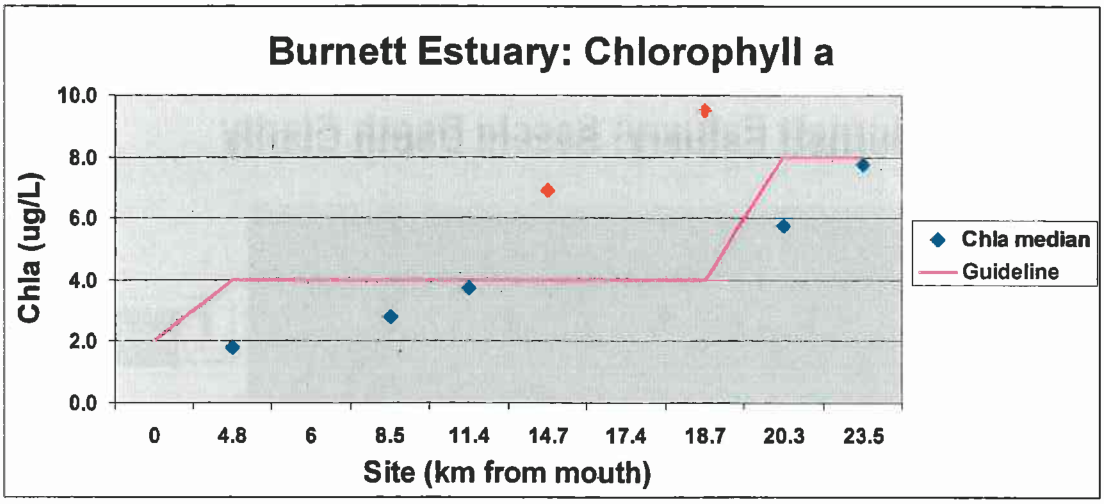


Figure A6



APPENDIX B: Trends in water quality

Figure B1

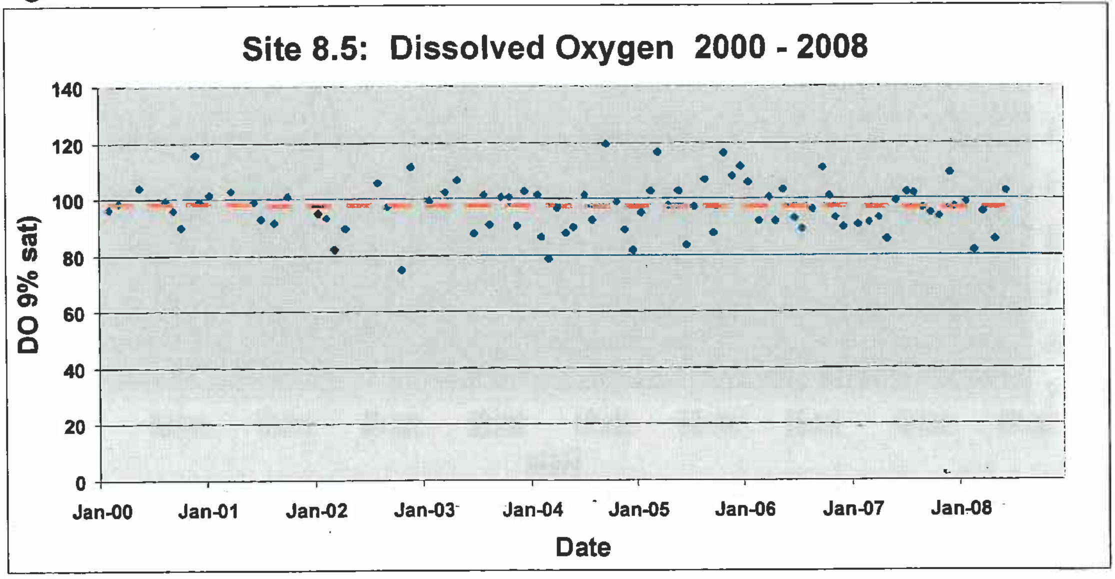


Figure B2

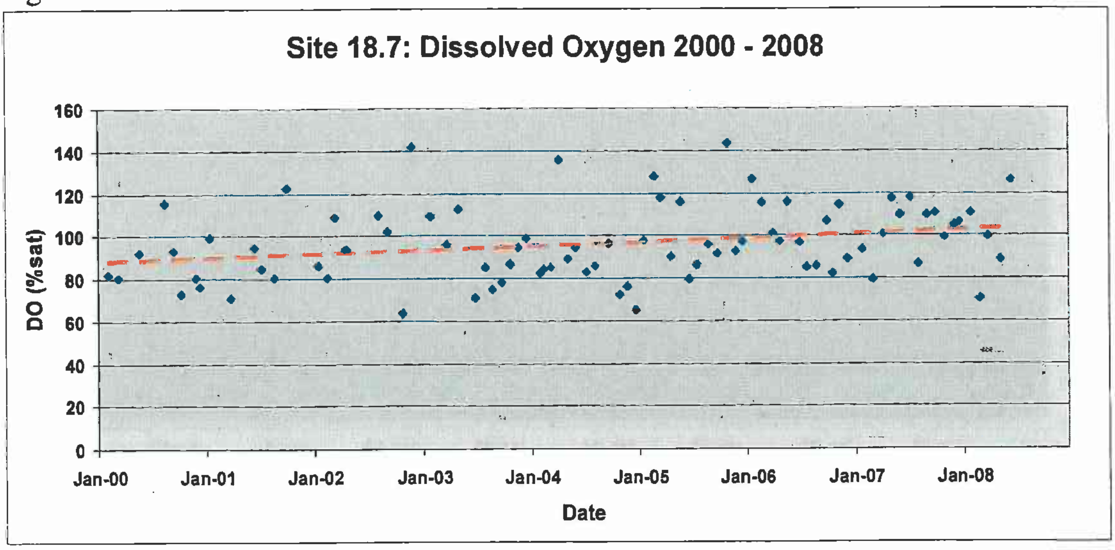


Figure B3

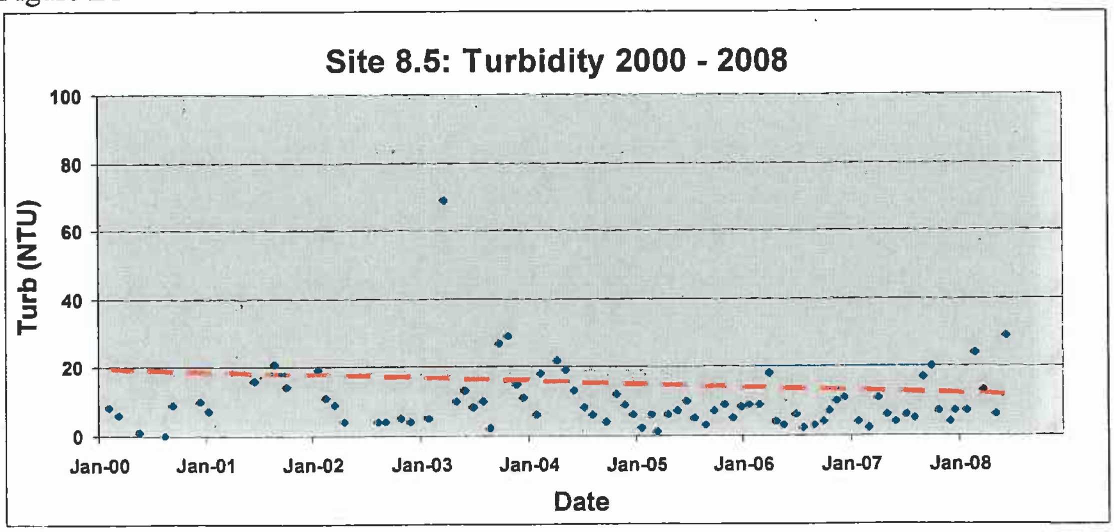


Figure B5

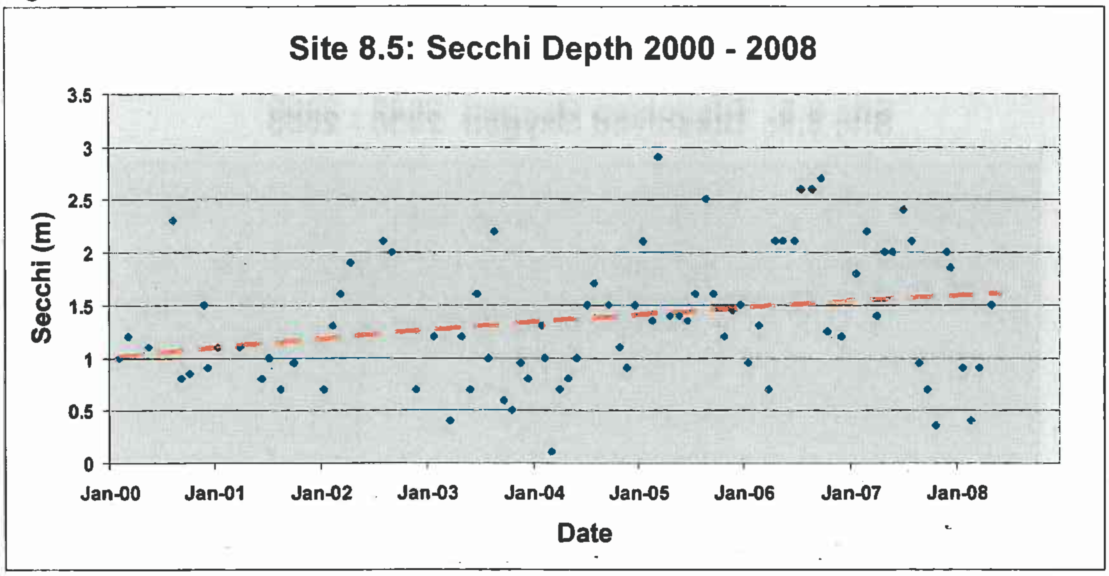


Figure B4

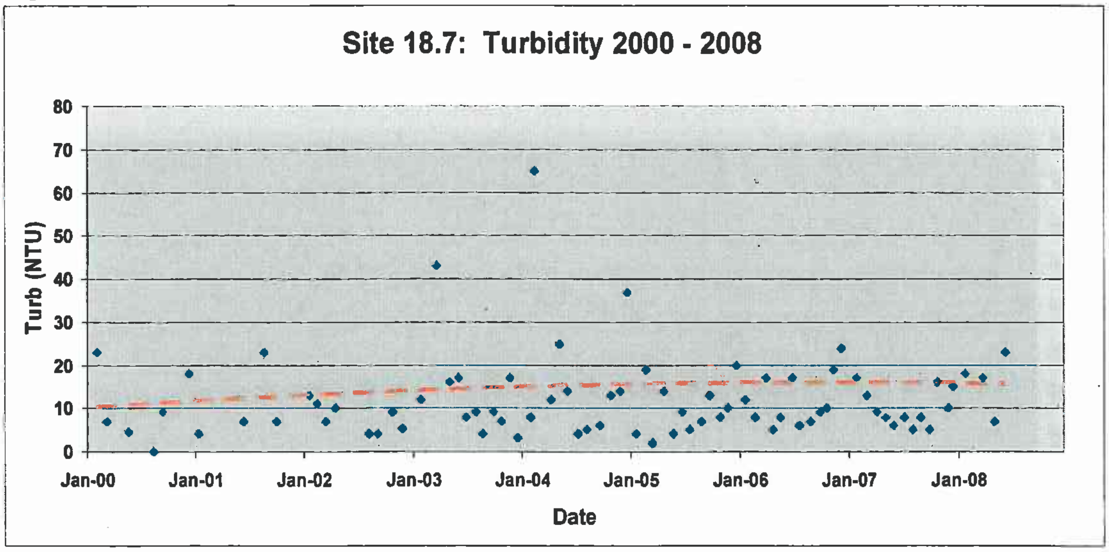
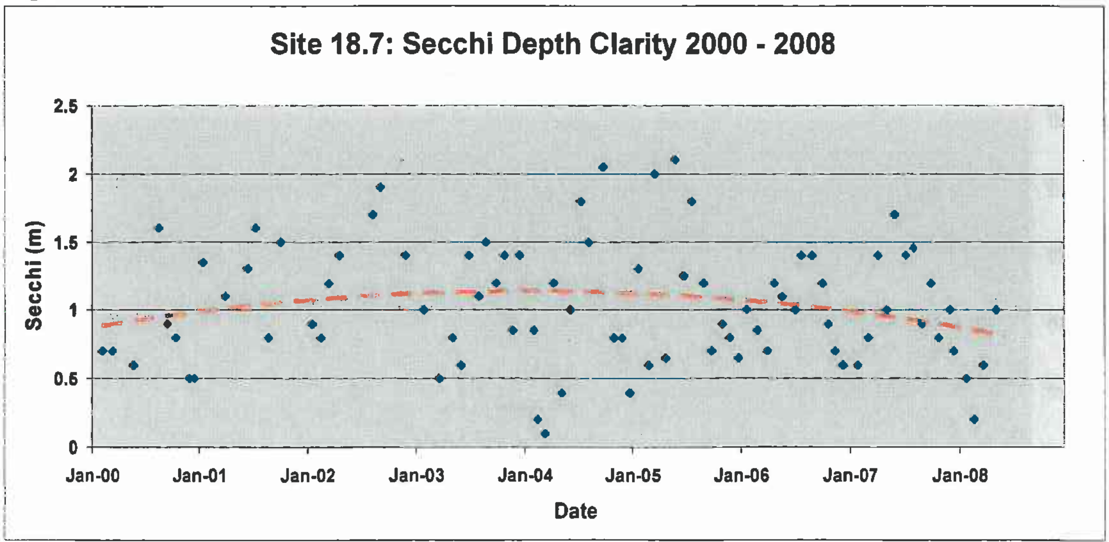


Figure B6



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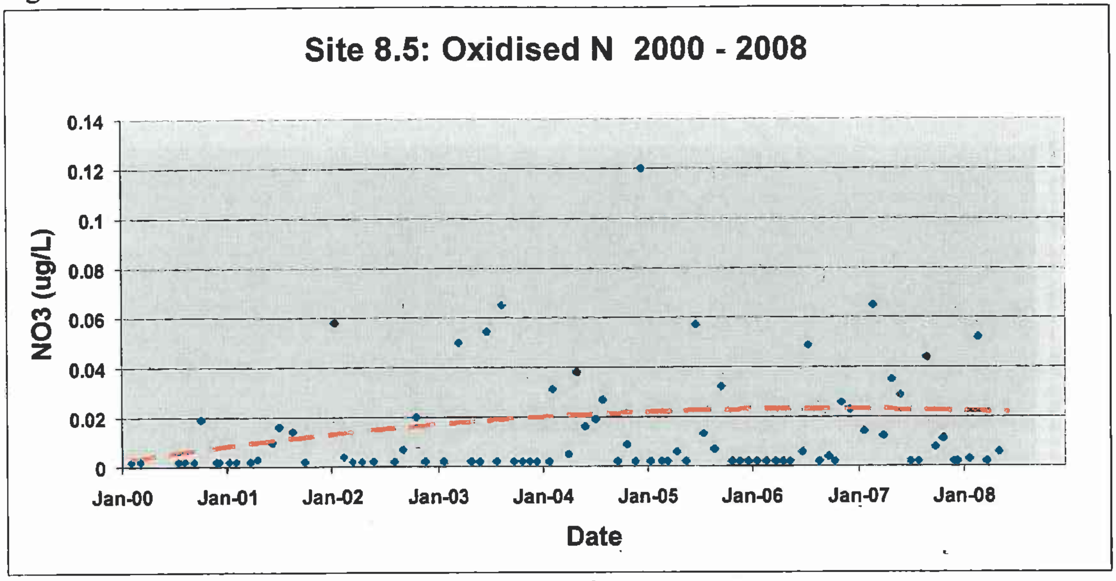

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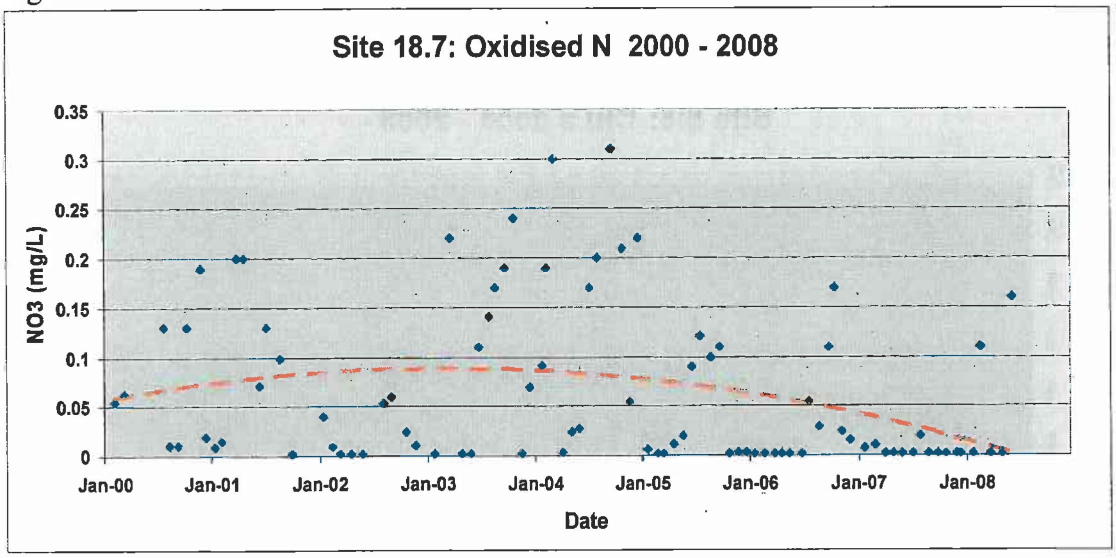

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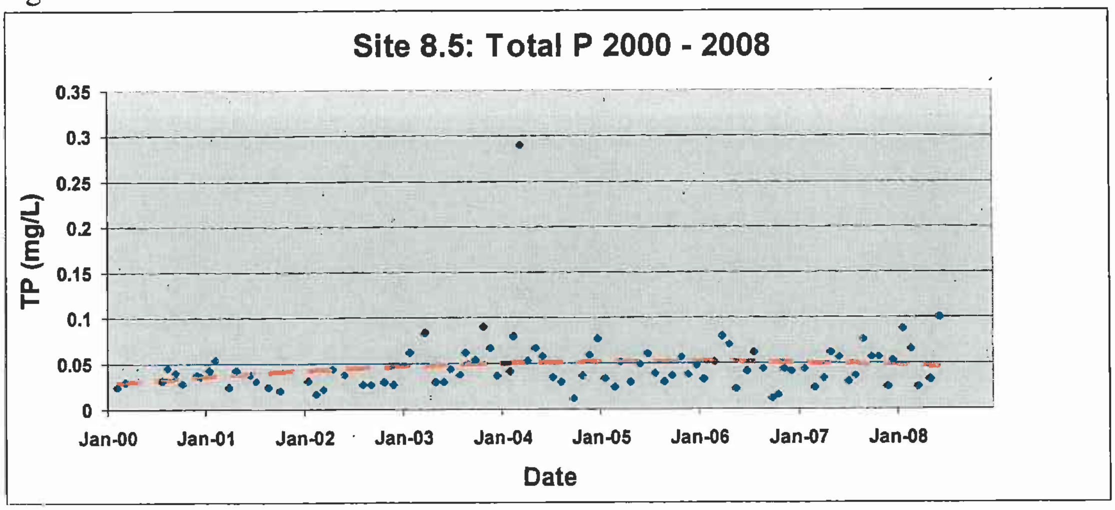

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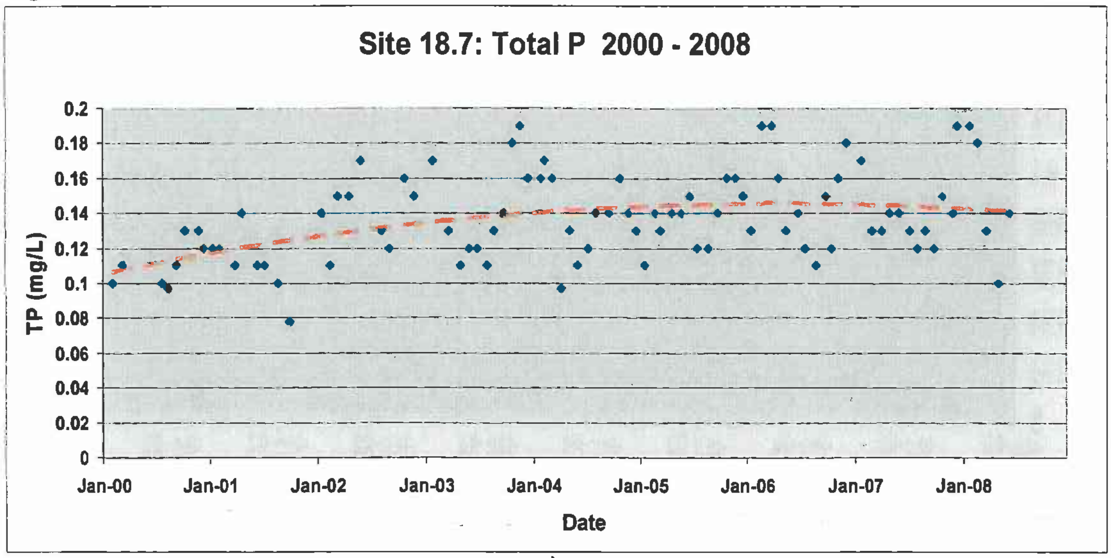

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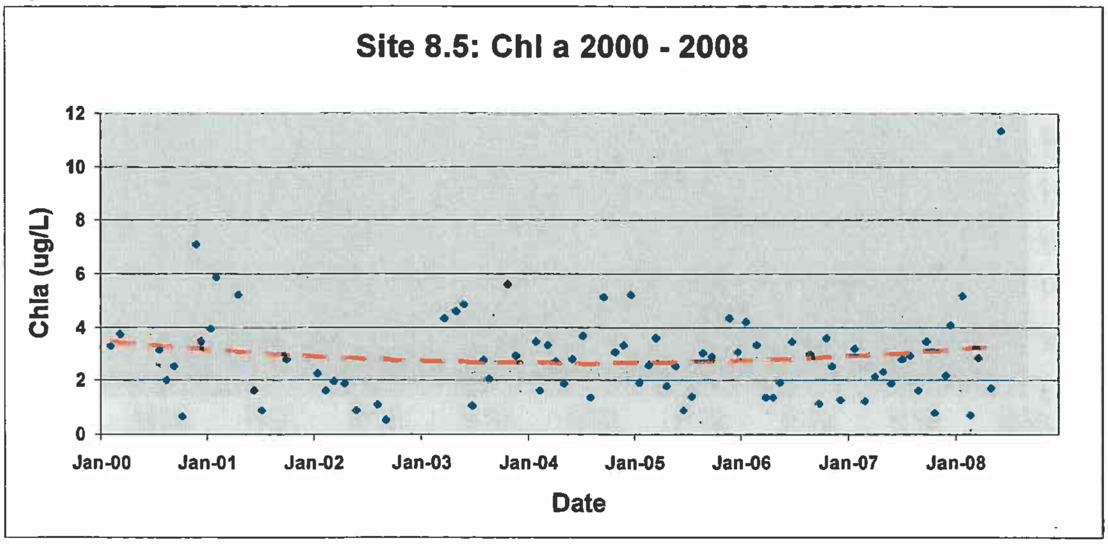
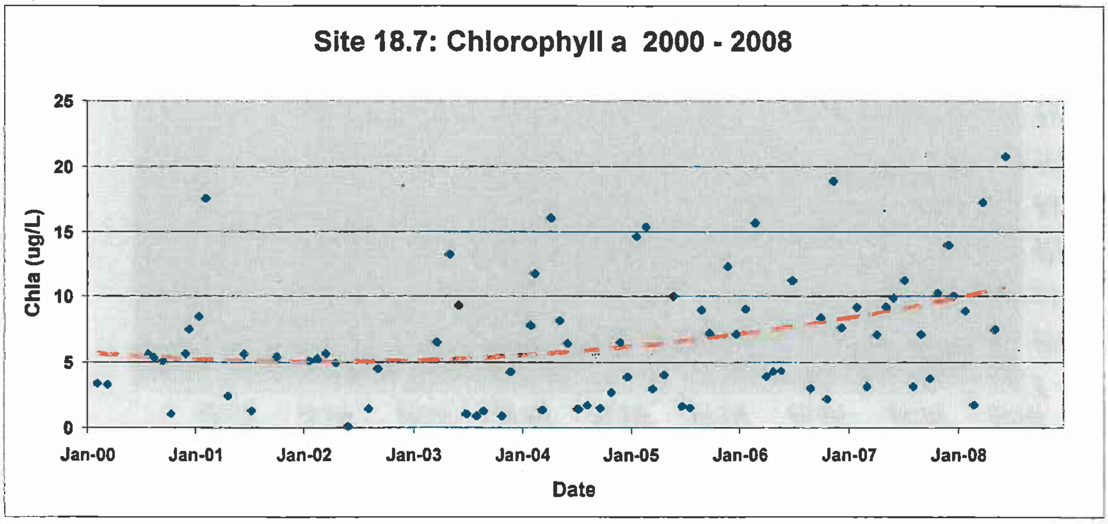


Figure B12



APPENDIX C – Explanation of indicators

Dissolved oxygen	The amount of oxygen dissolved in the water. Oxygen is essential for the life processes of most aquatic organisms, and lack of oxygen can cause suffocation of aquatic organisms. Low concentrations are often a symptom of pollution by organic matter, and are a by product of the rapid breakdown of the organic matter by bacteria. High concentrations (i.e. values > 110% saturation) are indicative excessive plant productivity. In estuaries this is due to phytoplankton growth.
pH	A measure of the acidity or alkalinity of the water. Extremes of pH (acidity less than 6.0 or alkalinity greater than 9) can be toxic to aquatic organisms. Estuarine waters are usually in the range 7-8.4
Conductivity	Conductivity is used as a measure of salinity. Seawater has a conductivity of about 51 mS/cm which is equivalent to a salinity of around 35g/L.
Turbidity	Turbidity is an indirect measure of the concentration of fine particulate matter in the water column. The higher the concentration of particles, the higher the turbidity. High levels of turbidity are indicative of excessive inputs of fine particles from the catchment or from urban stormwater. In estuaries, turbidity is also affected by the spring neap tidal cycle, with highest turbidities occurring during spring tides when tidal currents are at a maximum.
Secchi depth	An indicator of water clarity. The depth to which a secchi disc lowered into the water can be clearly seen from the surface. Secchi depth and turbidity are strongly correlated.
Nitrogen & Phosphorus	The major nutrients (nitrogen and phosphorus) are essential for plant growth. Measurements of nutrient concentrations in waters provide an indication of the potential for excessive plant and algal growth.
Chlorophyll-a	Chlorophyll-a, the green pigment found in all plants. In estuaries, the concentration of chlorophyll a in a sample it is used as an indicator of the phytoplankton biomass. High levels of algae (algal blooms) can have adverse effects on water quality.

Report to the Bundaberg Regional Council on the results of monitoring water quality in the Burnett River estuary for the period 2008 to 2009

Queensland Department of Environment and Resource Management 2009

Contents

1. Introduction

Bundaberg Regional Council (BRC), under a licence from the Department of Environment and Resource Management (DERM), discharges treated sewage wastewater to the Burnett River estuary from three separate locations – see Figure 1. To address the receiving water quality monitoring requirements of this licence, DERM, through agreement with the BCC, undertakes regular monitoring of the Burnett River estuary.

Under the agreement between BRC and DERM, the Department of Environment and Resource Management undertakes to provide an annual report on the outcomes of the monitoring program. This is the fourth such report and covers the year 2008-2009. It describes the program and the results of the monitoring and provides an assessment of the condition of the estuary with regard to water quality. The report includes some results from previous years of DERM monitoring in the estuary which enables the recent results to be put into a historical context and allows an assessment of trends in water quality.

2. Description of the Burnett River estuary

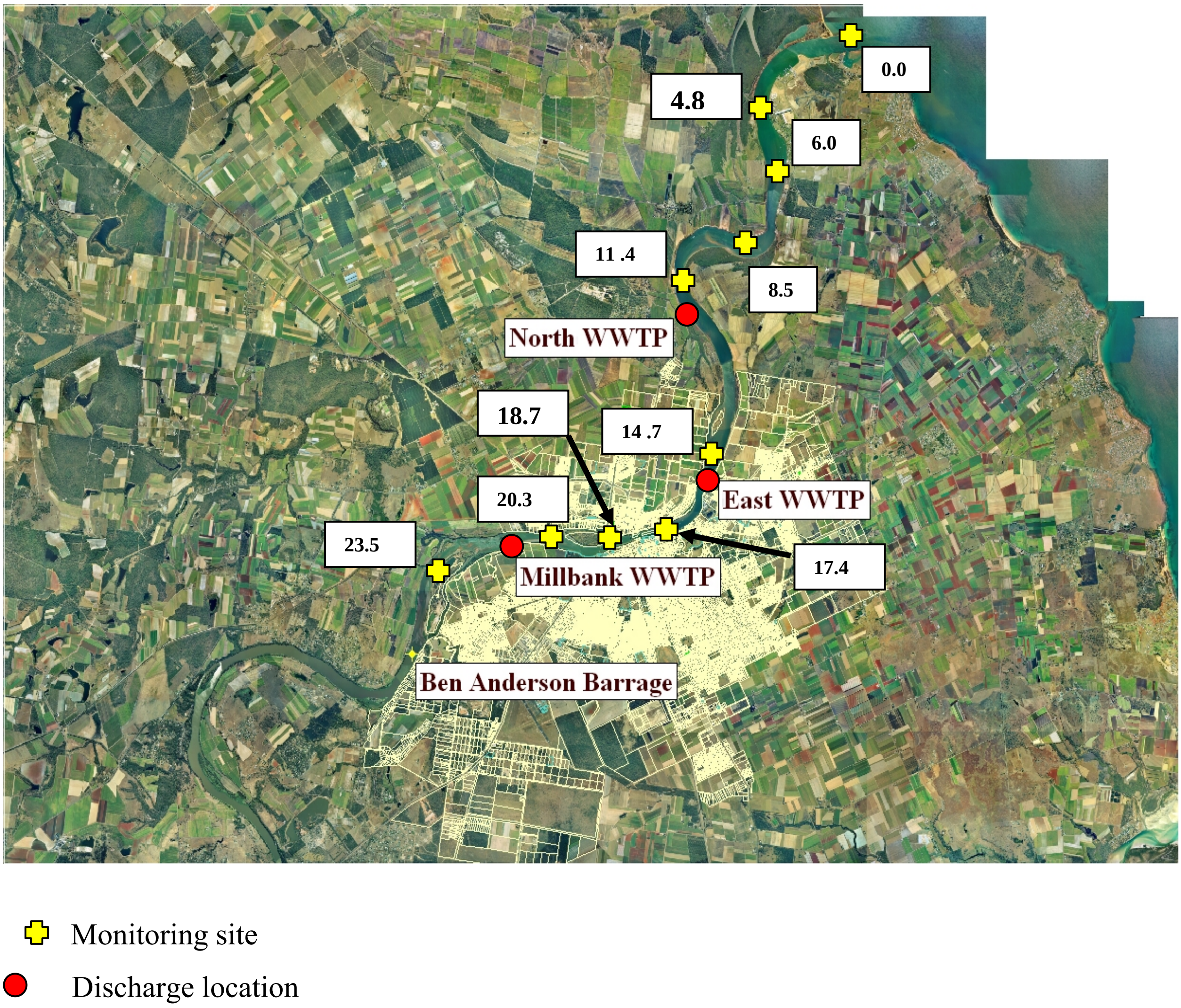
The Burnett River estuary extends approximately 25km from its mouth at Burnett Heads up to the Ben Anderson Barrage, which is now the upstream limit of tidal influence. Prior to construction of the barrage, the natural tidal limit was just above the current location of Bingera Weir which is 42.1 km from the river mouth. The main land uses adjacent to the estuary are agriculture (mostly sugar cane) and the urban areas of the city of Bundaberg, see Figure 1.

The National Land and Water Resources Audit national assessment of estuaries carried out in 2002 (for detailed information see www.**ozestuaries**.org) describes the Burnett estuary as being extensively modified from its pre-European condition. It has ongoing dredging at the mouth and much of its riparian vegetation has been removed. There has also been significant loss of mangroves. Freshwater inflows to the estuary have been reduced very significantly from their natural state due the extensive system of weirs and associated agricultural water use within the Burnett catchment.

The main sources of pollutants entering the estuary are:

- Diffuse pollutant loads entering from the catchment during infrequent flood events
- Urban stormwater from Bundaberg City
- Point discharges

Figure 1: Burnett River estuary showing sampling sites and discharge points



This report is principally concerned with the point discharges and their associated impacts on water quality. The main existing point discharges to the estuary are the BRC treated sewage discharges. There are no other significant point discharges. The BRC discharges comprise:

- BRC North WWTP (Waste Water Treatment Plant)
- BRC East WWTP
- BRC Millbank WWTP

Discharge locations are shown in Figure 1. Information on discharge loads from these plants is given in Tables 2.1 and 2.2 below. By far the most significant discharge is the East WWTP which showed a small decrease in N and P loads in 2008/09 compared to the previous year.

Table 2.1 Annual pollutant loads from discharges to the Burnett River estuary during 2008 - 2009

Source	Annual pollutant loads (tonnes)			
	TN	TP	BOD	TSS
North WWTP	2.3	0.6	1.3	5.6
East WWTP	43.3	16.8	51	37.2
Millbank WWTP	5.0	5.5	6.9	5.0

Table 2.2 below shows annual loads from the East and Millbank WWTPs since 2000, which is useful for comparing with water quality trends.

Table 2.2 Historical records of annual nutrient loads from treatment plants

	East WWTP		Millbank WWTP	
Year (Jul/Jun)	Total Nitrogen (Tonnes)	Total Phosphorus (Tonnes)	Total Nitrogen (Tonnes)	Total Phosphorus (Tonnes)
99/00	32.9	17.9	16.4	8.8
00/01	20.8	16.1	8.1	8.4
01/02	16.4	16.6	6.4	11.4
02/03	36.7	19.2	7.9	11.1
03/04	40.9	19.6	11.9	11.0
04/05	36.0	22.2	9.9	10.8
05/06	38.0	20.4	4.6	8.6
06/07	36.1	22.3	7.0	9.2
07/08	48.0	20.1	4.9	5.3
08/09	43.3	16.8	3.5	5.5

3. Scope of Water Quality Monitoring Program

3.1. Routine monthly monitoring

The main component of the DERM monitoring program consists of routine monthly monitoring at 10 sites in the Burnett River estuary. The program aims to provide a general assessment of water quality in the estuary and also, in the longer term, to pick up any trends in quality. The indicators sampled at each site are detailed in Table 3.1. These indicators and their purpose are described in more detail in Appendix C. Not all indicators are sampled at all sites but the program provides sufficient data to provide a good general assessment of water quality throughout the estuary.

The monitoring is undertaken by experienced DERM field staff, who routinely undertake this type of activity in many Queensland estuaries.

Table 3.1 Burnett River estuary monitoring program: Indicators and Sites

SITE (km)	INDICATORS							
	DO	Temp	pH	Conductivity	Turbidity	Chl a	N	P
0.0	✓	✓	✓	✓	✓			
4.8	✓	✓	✓	✓	✓	✓		
6.0	✓	✓	✓	✓	✓			
8.5	✓	✓	✓	✓	✓	✓	✓	✓
11.4	✓	✓	✓	✓	✓		✓	✓
14.7	✓	✓	✓	✓	✓	✓	✓	✓
17.4	✓	✓	✓	✓	✓			
18.7	✓	✓	✓	✓	✓	✓	✓	✓
20.3	✓	✓	✓	✓	✓	✓	✓	✓
23.5	✓	✓	✓	✓	✓	✓		

3.2. Temporally intensive monitoring

Temporally intensive data is acquired from an instrument array contained in a purpose designed trailer located adjacent to the railway bridge. In 2008/09 data from this trailer suffered some significant interruptions due to vandalism, technical faults and the need to relocate the trailer. Only a very limited amount of data was collected and therefore this data is not reported on this year.

In 2009, thanks to the Bundaberg Regional Council, a more permanent location was provided for the trailer at one of the riverside boardwalks. The trailer is now operating normally and we expect to report on this data next year.

4. Methods for assessing water quality

4.1. Condition

The basic approach to condition assessment is to compare monitoring data with guideline values. The guidelines used in this report are taken from the Queensland Water Quality Guidelines (QWQG). These provide guideline values for all the indicators measured in the routine monthly program.

Water quality in estuaries varies naturally from the mouth up to the tidal limit. To allow for this natural variation, the QWQG provides separate guidelines for different reaches of estuaries. These reaches are defined as follows:

1. Lower estuary – the reaches near the estuary mouth that experience frequent exchange with coastal waters
2. Mid estuary – the main body of the estuary
3. Upper estuary – the upper 15% of the length of the estuary – these reaches are poorly flushed and have naturally poorer water quality than the main body of the estuary

Table 4.1 below shows the guideline values for each indicator for each of these segments. It also shows which sites in the Burnett fall into each category.

Table 4.1 Guideline values for each reach of the Burnett River estuary

REACH	GUIDELINE VALUES FOR KEY INDICATORS							
	DO	pH	Secchi	Turb-idity	Total N	Total P	Chl a	
	%sat		(m)	NTU	µg/L	µg/L	µg/L	
Lower estuary Sites 0.0	105-95	8.0-8.4	1.5	6	200	20	2	
Mid estuary Sites 4.8, 6.0, 8.5, 11.4, 14.7, 17.4, 18.5	105-85	7.0-8.4	1.0	8	300	25	4	
Upper estuary Sites 20.3, 23.5	105-80	7.0-8.4	0.5	25	450	30	8	

These guideline values are designed to be compared with the median of a series of values rather than every individual value from a test site. Thus, the graphical presentations of the results show the guidelines compared with the median values for the last 12 months for each indicator at each site.

As well as assessing the median value, the results also need to be checked for extreme values. Such values (e.g. very low DO levels) have the potential to be very harmful even though median values comply with the guideline value.

The indicators assessed for condition include:

Dissolved oxygen
pH
Turbidity
Secchi depth (clarity)
Nitrate N
Total P
Chlorophyll a

4.2. Trend

The more intensive monitoring of the Burnett River estuary only started in 2005/06 and so there is insufficient data to comprehensively assess trends throughout the estuary. However, DERM data is available for a much longer time period for two sites (8.5 and 18.7). Data from these sites is assessed using simple regression techniques to provide an indication of improvements or declines in water quality over the past few years. This information can give an indication of improvements in water quality or of what issues are likely to arise in the future.

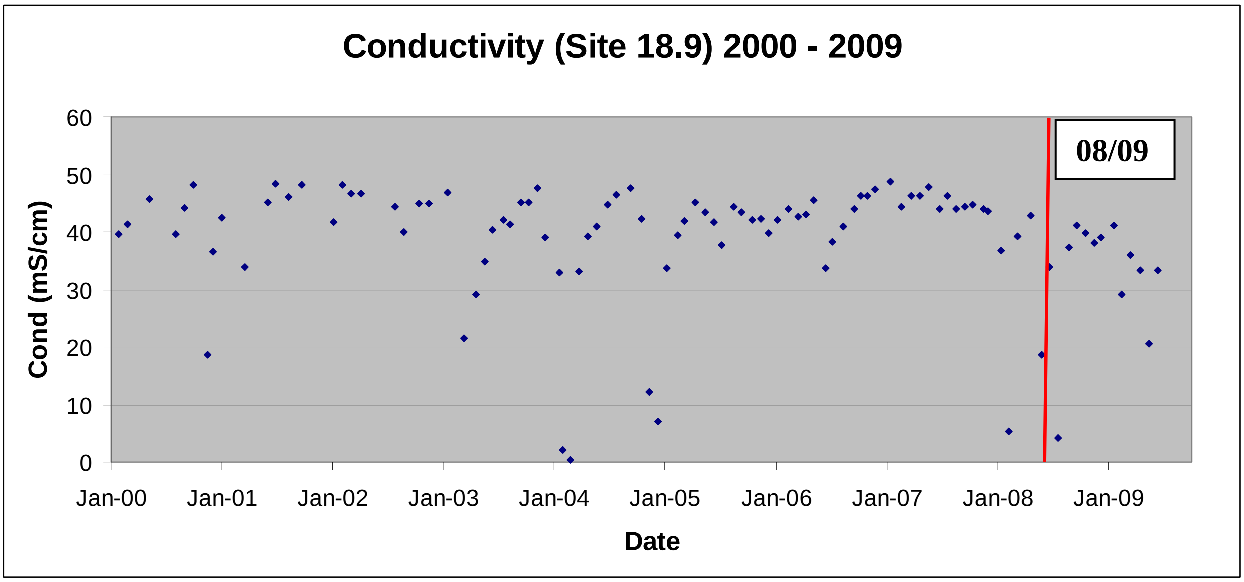
5. Overview of Burnett estuary conditions during the period 2008 - 2009

Water quality condition in estuaries can be broadly separated into (i) flow event and immediate post flow event conditions and (ii) dry weather conditions. Flow events carry large volumes of freshwater and catchment sourced pollutants into estuaries. These have considerable but usually short term impacts on water quality. During dry weather, water quality in estuaries is more stable and is largely controlled by internal processes and any point discharges. Most sub-tropical Queensland estuaries experience dry weather conditions (i.e. minimal inflow from the catchment) for >90% of the time.

Figure 5.1 shows conductivity at a site in the mid/upper reaches of the Burnett estuary over the period 1999 to 2009. For much of the time conductivity is in the range 40 - 50 mS/cm which is indicative of dry weather conditions. Sudden reductions below 40 mS/cm indicate recent freshwater inflows, the larger the reduction the larger the inflow.

The graph shows significant variation between years. There was a very dry period in 2005/06 and 2006/07 which coincided with the first two years of these more intensive surveys. 2007/8 was a slightly wetter year while 2008/9 appears to have been one of the wettest years for some time, with very few values exceeding 40 mS/cm. This means that catchment impacts on water quality in the estuary are likely to have been more significant this year than in previous years. There is some indication of this in the data.

Figure 5.1: Long-term conductivity at an upper estuary site



6. Results

6.1. Data presentation

Figures A1 to A6 in Appendix A show median values for each of the six selected core indictors plotted against distance upstream in the estuary. The plots also show the relevant guideline values for each reach of the estuary. Where median values comply with guideline values they are coloured in **black** and where they do not comply they are coloured in **red**. These plots provide a broad overview of water quality in the estuary.

Trends in water quality are shown in figures B1 to B12. These show trends in water quality for the six selected core indicators at two sites, 8.5 and 18.7 over the period 2000 to 2008.

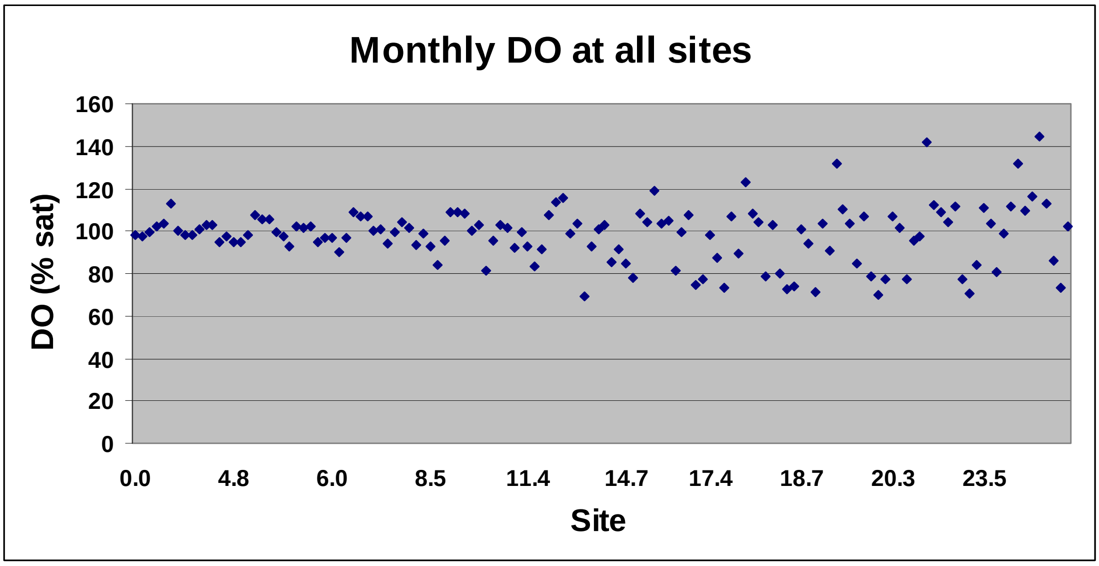
For some core indicators, some additional graphical data is presented to illustrate specific points.

6.2. Dissolved Oxygen

The results in Figure A1 show that during 2008/09 dissolved oxygen complied with guidelines at all sites except the most upstream site where there is an indication of persistent supersaturation due to algal activity. Figure 6.1 shows the full monthly data set at each site along the estuary. It can be seen that the minimum value recorded at any site during the entire 12 months was around 70% saturation. The absence of low values indicates that the BOD load from the WWTPs is not having a significant impact on the estuary.

However, all the more upstream sites show evidence of significant supersaturation which is indicative of increased algal activity promoted by the WWTP discharges.

Figure 6.1: Full DO data set from monthly monitoring at all sites



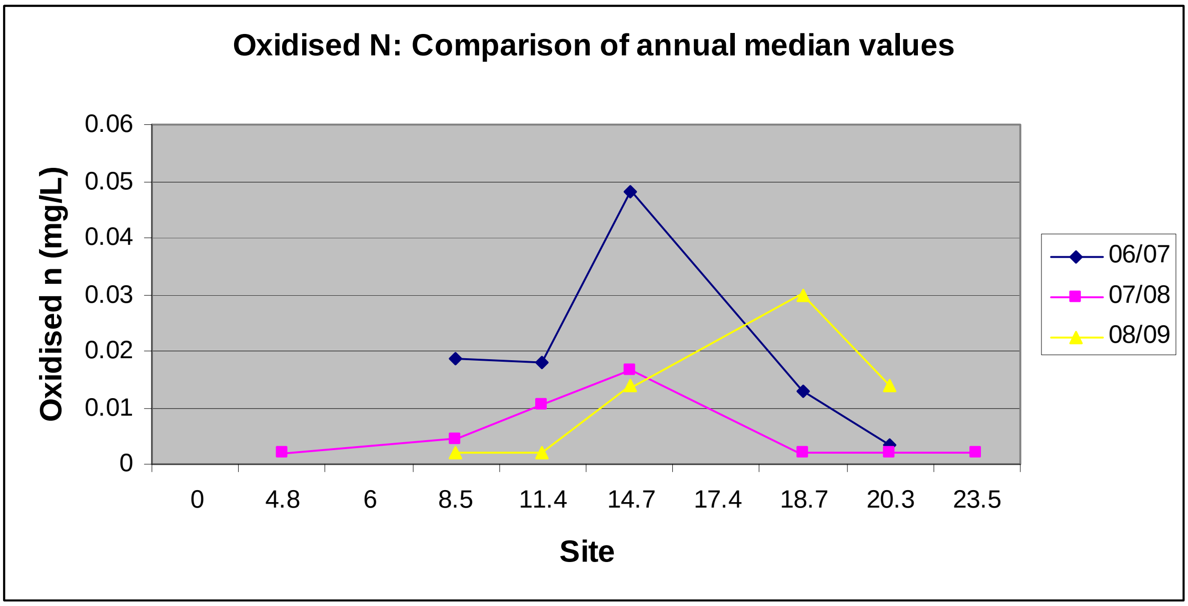
6.3. Turbidity and Clarity

Levels of turbidity (Fig A2) and Secchi disc clarity (Fig A3) complied with the guidelines at nearly all sites, the only exception being very minor exceedances at site 18.7.

6.4. Nutrients and Chlorophyll a

Oxidised N (NO2+NO3) values (Figure A4) exceed guidelines at site 14.7 by a small margin and at site 18.7 by a larger margin. Figure 6.2 is a comparison of oxidised N values over the past three years and it shows that while 2008/09 levels in the mid estuary are similar to or lower than previous years, levels at more upstream sites are higher. The largest discharge to the estuary (East STP) discharges in the mid estuary, but the results indicate that this is not having any increased impact compared to previous years. The higher levels in the upper estuary could be due to the Millbank STP discharge but loads from that plant in 2008/09 were actually lower than in 2007/08. The most likely explanation of the higher values is therefore the increased inflows from the catchment.

Figure 6.2: Comparison of median oxidised N values in 06/07, 07/08 & 08/09

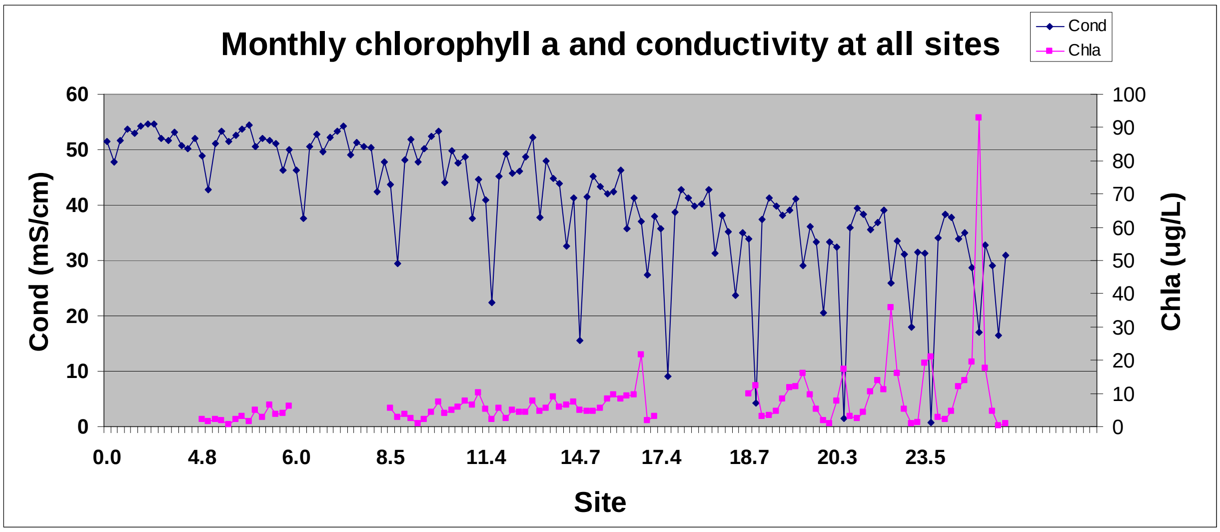


Due to the STP discharges, total P values (Fig A5) significantly exceed guideline values at most sites. There was a small reduction in total P loads in 2008/09 compared to 2007/08 but the total P concentrations in the estuary remained very close to those in 2007/08.

Median chlorophyll a values (Fig A6) exceeded guideline values at most sites although these exceedances were not large in the mid estuary region. The mid estuary exceedances are probably related to the STP discharges in this region. However, chlorophyll a levels in this part of the estuary rarely exceeded 10µg/L (see figure 6.3) so it is not experiencing significant eutrophication problems.

Further upstream, there were slightly larger exceedances. These higher chlorophyll a values are in part associated with catchment inflows - Figure 6.3 shows clearly how peak chlorophyll a levels usually coincide with falls in conductivity (i.e. freshwater inflows). However, although catchment inflows are a primary cause of these chlorophyll a peaks, the point nutrient discharges to the estuary still contribute to some degree. The reason for this is that although catchment inflows contain significant amounts of the major nutrients N and P, they also contain a wide array of important micronutrients e.g. Fe. These often seem to be a growth limiting factor in dry weather rather than N or P. Thus, an influx of these micronutrients allows the phytoplankton to make increased use of N and P contributed by the point sources which in turn contributes to the increased chlorophyll a levels. However, the relative importance of this effect is difficult to quantify and probably the catchment N and P fluxes are at least equally important.

Figure 6.3: Effect of catchment inflows on chlorophyll a levels



6.5. pH

Values of pH in estuaries are generally buffered in the range of 7.0 to 8.4 by the presence of varying concentrations of salt. However, major catchment run-off events can reduce levels due to the presence of freshwater and in some locations acid sulphate run-off can reduce levels very significantly for short periods. During 2008/09, pH values recorded during the monthly surveys in the Burnett estuary remained within the range of 7.3 to 8.3 at all sites throughout the year. Major inflows did not cause any large reductions in pH levels although the fact that these readings were only at monthly intervals means that much lower values may have occurred but not been recorded. However, in previous years the continuous water quality monitoring data has not shown any evidence of this.

6.6. Trends in water quality

The trend results are based on data collected by DERM at two sites (8.5 & 18.7) since January 2000. Graphs for each of the selected indicators are given in Figures B1 to B12 in Appendix B. Trend lines are not linear trends but rather are polynomial lines that provide a best fit to trends that vary over time.

Dissolved oxygen values (Figs B1 & B2) at both sites in 2008/09 were similar to those over the past three years which indicates that there has been little change in organic loading to the estuary in this time.

Secchi depth clarity (Figs B5 & B6) shows a decrease at both sites in 2008/09 while turbidity shows a parallel increase at site 8.5 although little change at 18.7. The reduced water clarity in this year is related to the increased catchment inflows and their associated loads of fine particulates.

Nitrogen levels (Oxidised N) levels (Figs B7 & B8) do not exhibit any large trends. Examination of the individual data points suggest that during dry weather levels are quite low while higher values occur following catchment inflows.

Total P levels (Figs B9 & B10) have also remained relatively stable over the past few years, as would be expected given that STP loads have not changed much since about 2003.

Chlorophyll a values at site 8.5 (Fig B11) in the mid-lower estuary exhibited a marked increase in 2008/09 compared to the previous year. This is thought to be due to the increased catchment inflows this year. Chlorophyll a levels at site 18.7 (Fig B12) in the upper estuary were similar to the previous year but there still seems to be a small long-term increase in levels at this site. are continuing to increase. This year this may in part be due to the impact of the increased catchment inflows.

7. Conclusions

Turbidity and clarity are strongly related to diffuse catchment sources of fine particulates. Values in 2008/09 were a little poorer than the previous year due to the increase in catchment inflows. However, values mostly complied with guidelines.

Dissolved oxygen levels in the estuary meet guideline values at nearly all sites indicating that levels are not significantly impacted by the BOD loads in the WWTP discharges. The upper guideline value is exceeded at the most upstream site due to supersaturation caused by phytoplankton activity. Moderate levels of supersaturation occur at a number of sites and this is indicative of increased algal production caused in part by the STP discharges.

Nutrient levels in the Burnett estuary are measurably impacted by the WWTP discharges, particularly with respect to phosphorus which exceeds guidelines at most sites. N levels exceed guidelines at some sites but this is thought to be partly related to the increased catchment inflows in 2008/09. The elevated nutrients are clearly having some impact on dry weather chlorophyll a levels in the middle estuary but do not cause significant blooms. However, the combination of point discharges and inflows of diffuse source pollutants from the catchment occasionally resulted in high chlorophyll a levels in the upper estuary.

Overall, while water quality in the Burnett estuary is measurably impacted by the WWTP discharges, these impacts can be described as relatively moderate. The increased catchment inflows in 2008/09 caused some limited impacts on water quality but again these impacts were relatively moderate.

8. References

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000).

DERM (2009) Queensland Water Quality Guidelines. www.derm.qld.gov.au

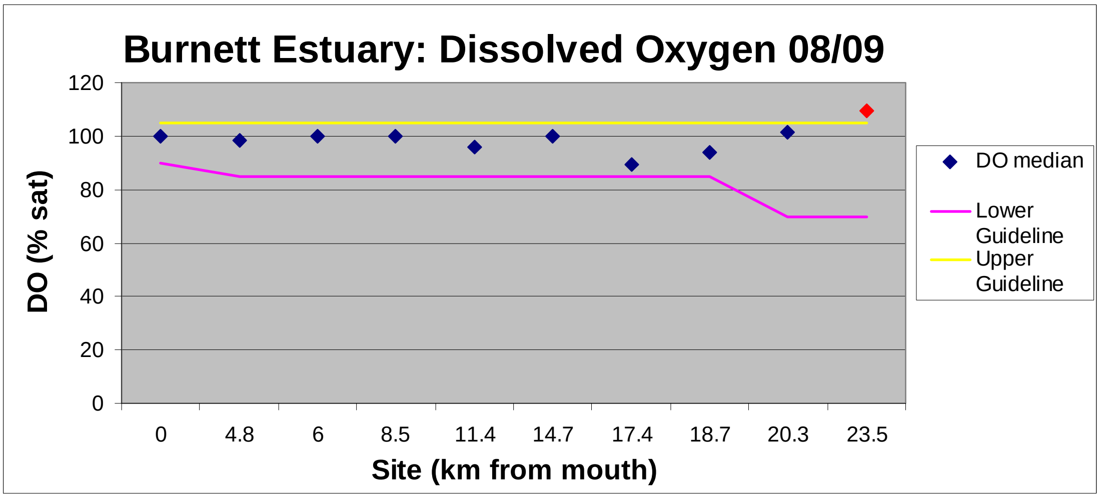
9. Acknowledgements

Thanks to John Ferris and the DERM field staff for undertaking surveys efficiently and on schedule and for the high level of QA that is maintained.

Thanks to Jeff Rohdman of Bundaberg Regional Council for providing a full and rapid response to requests for data and for any other assistance requested.

APPENDIX A: Water quality compared to guidelines

Figure A1



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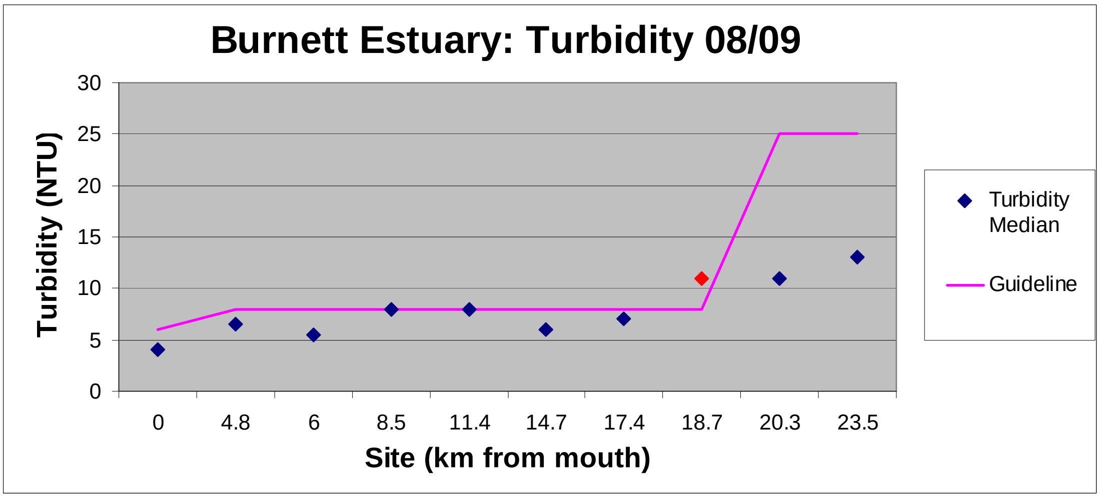

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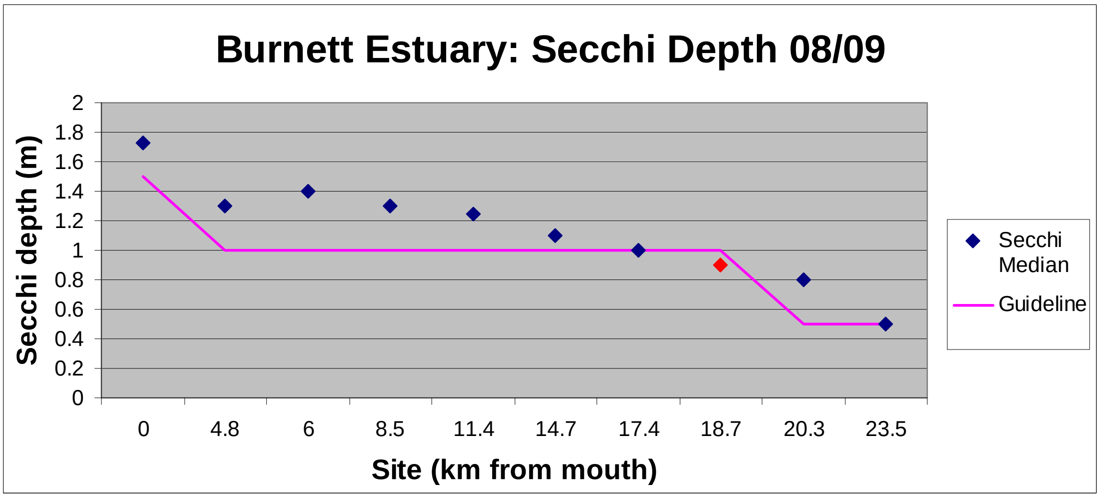

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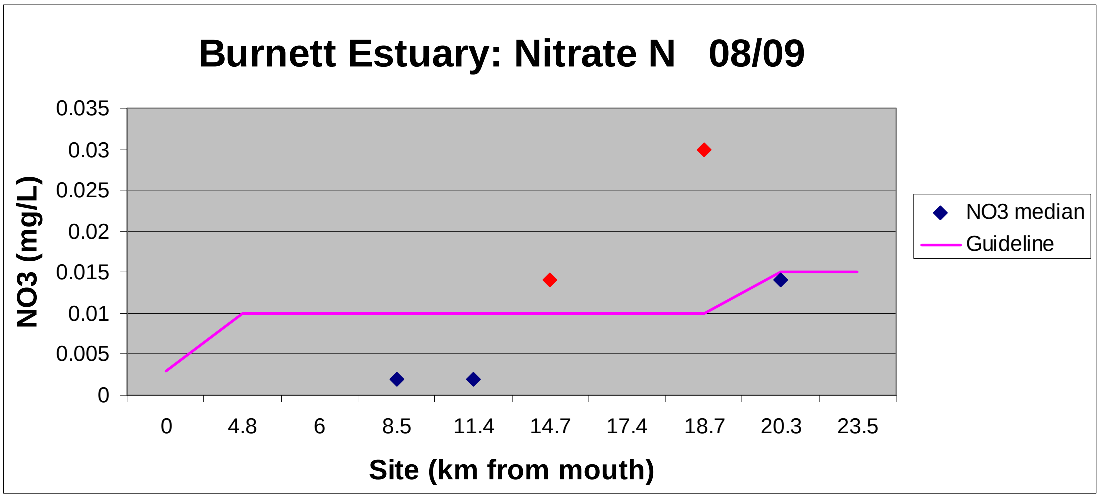

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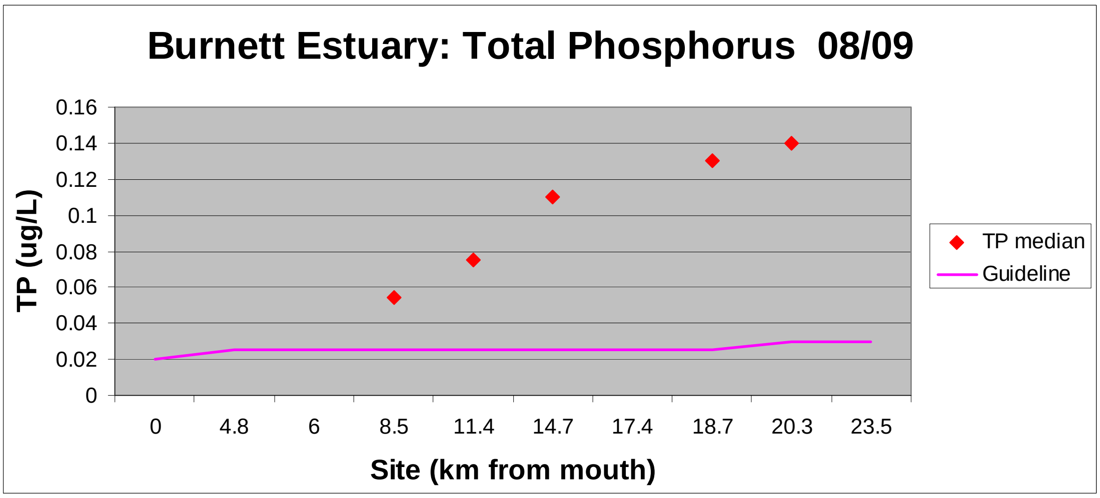

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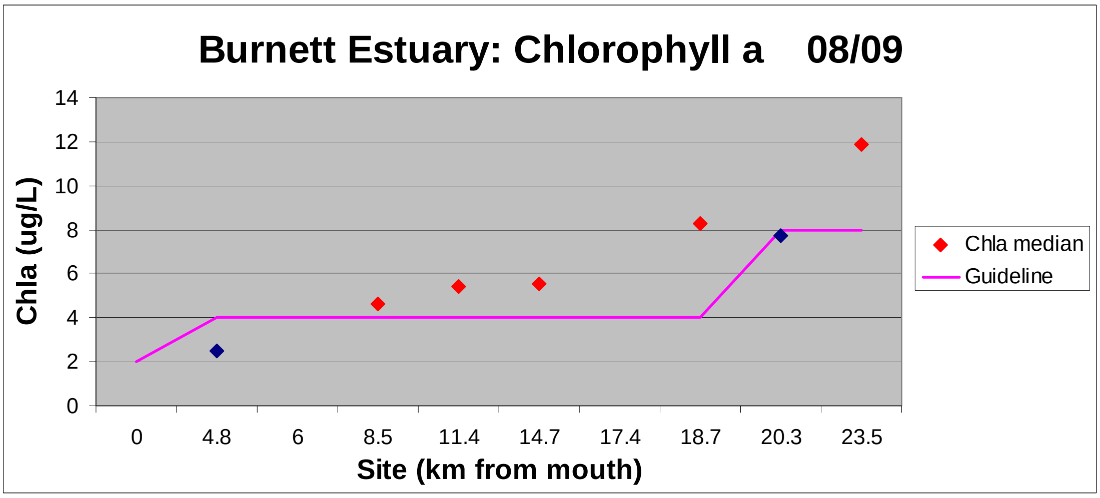
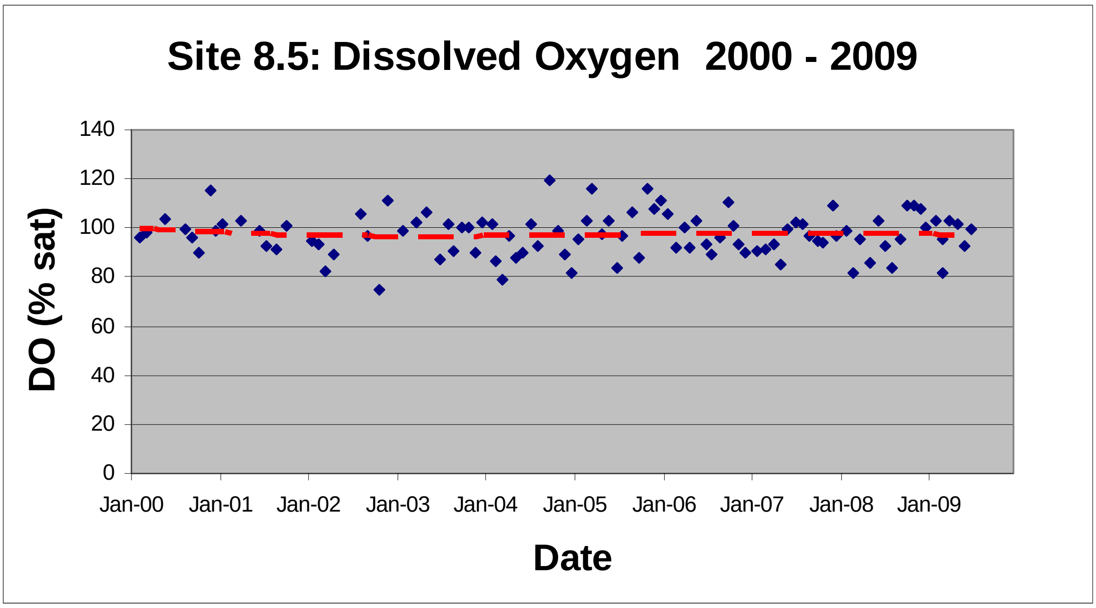


APPENDIX B: Trends in water quality

Figure B1



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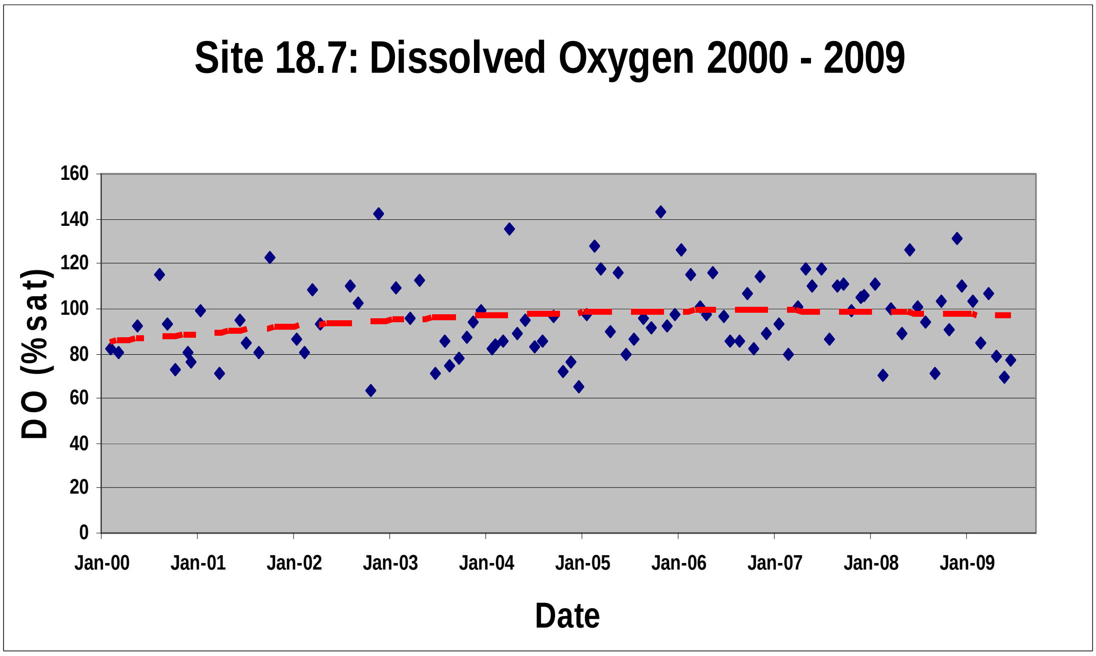

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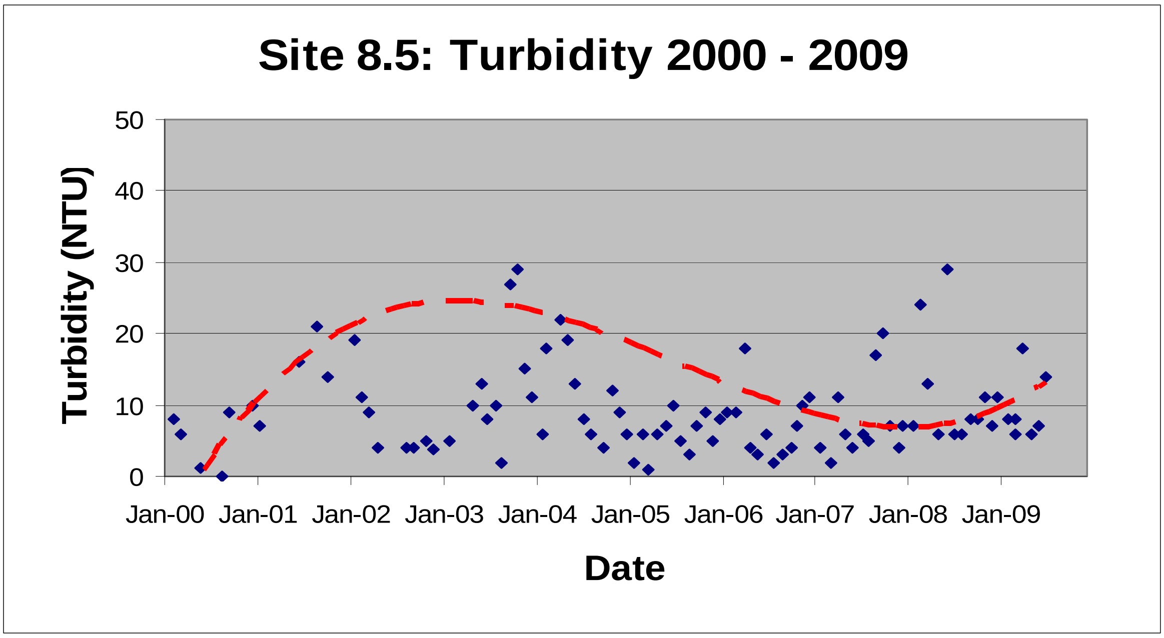

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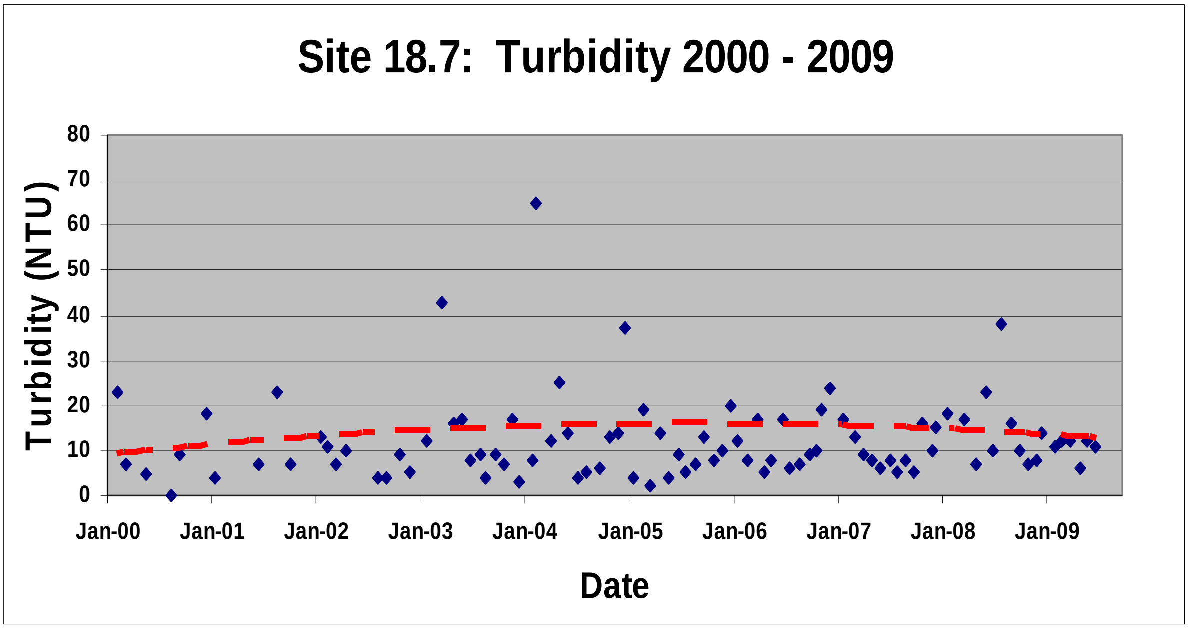

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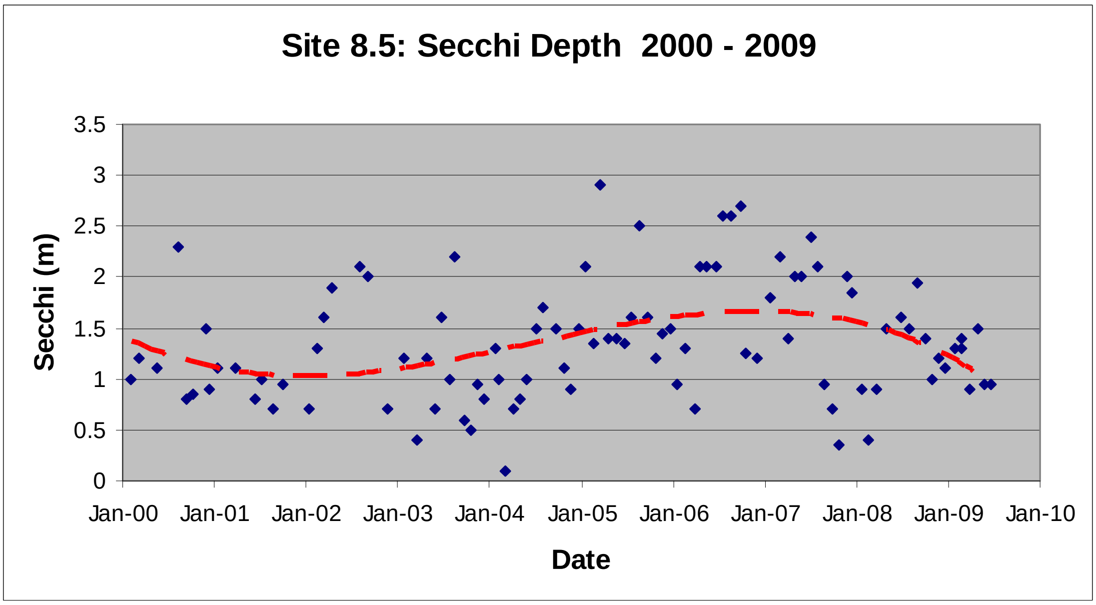

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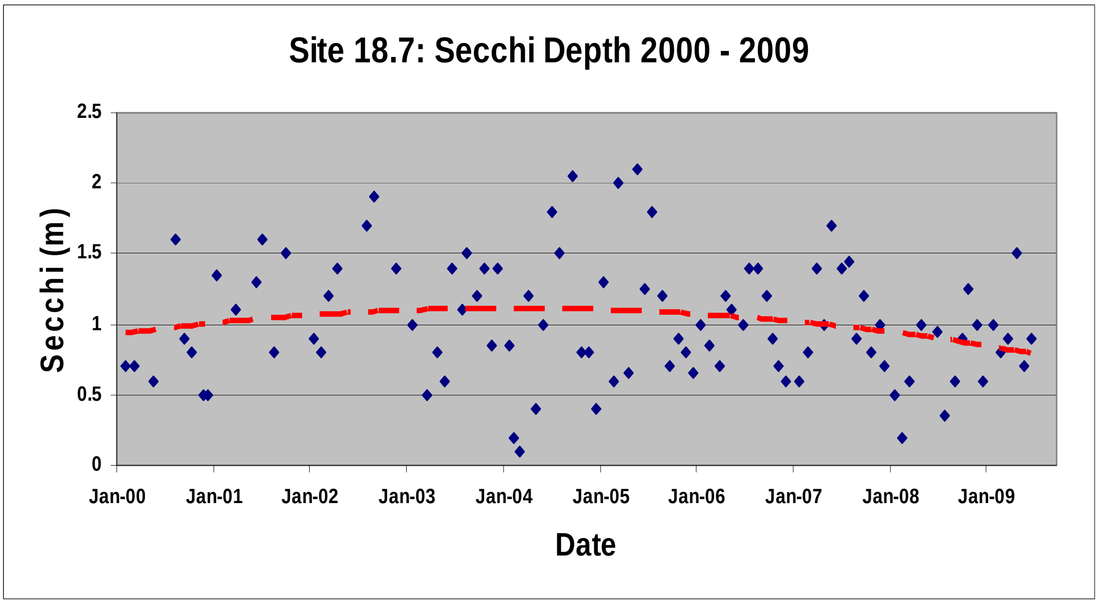

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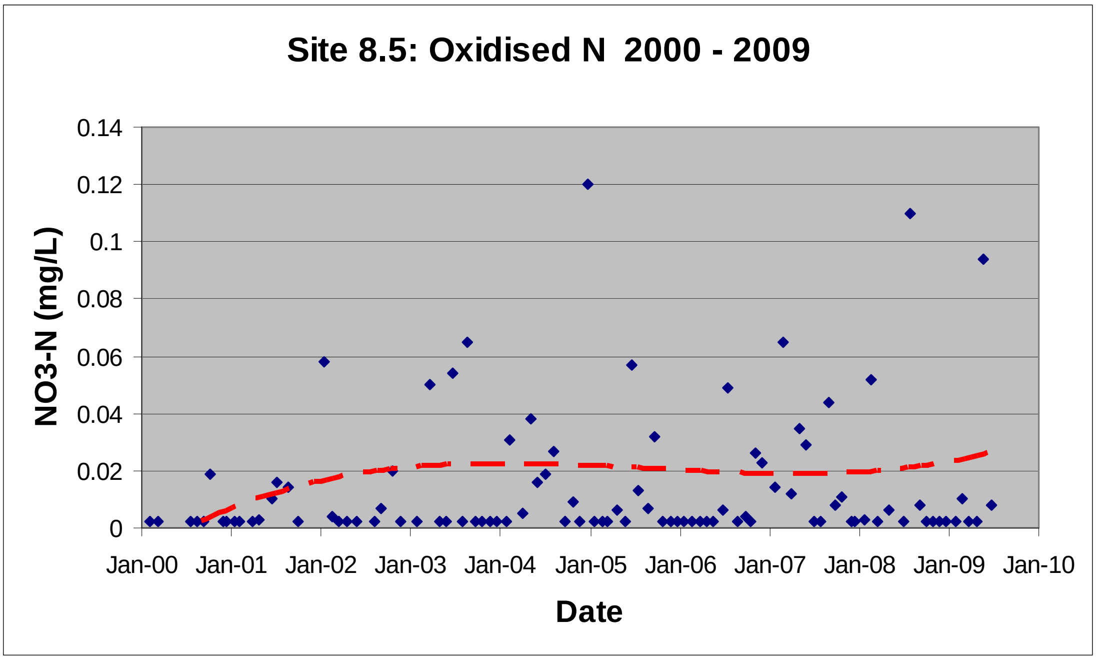
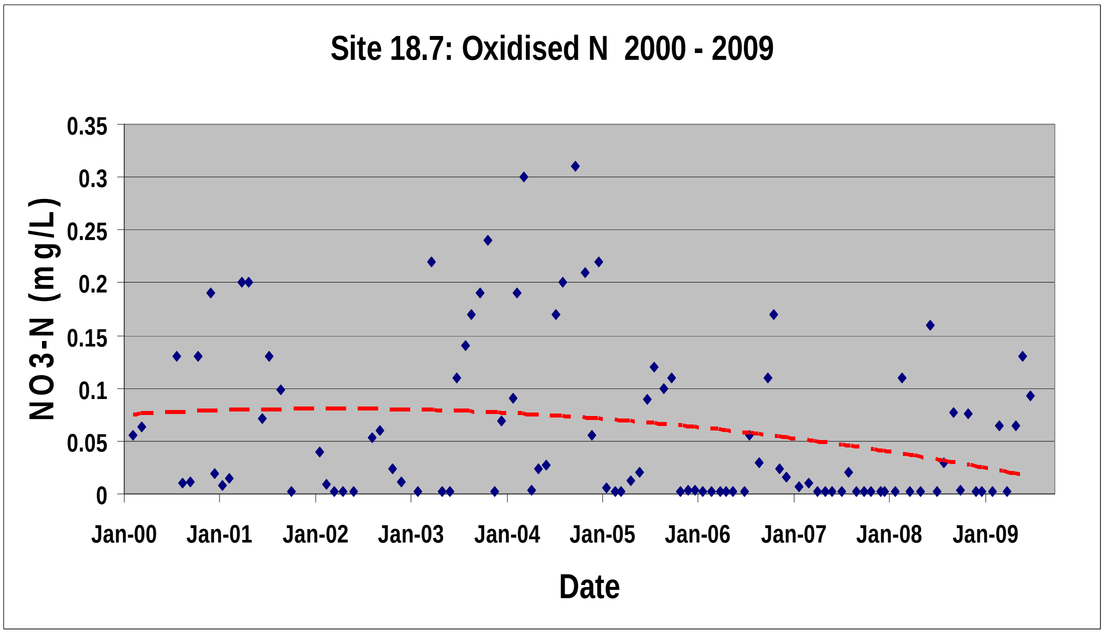


Figure B8



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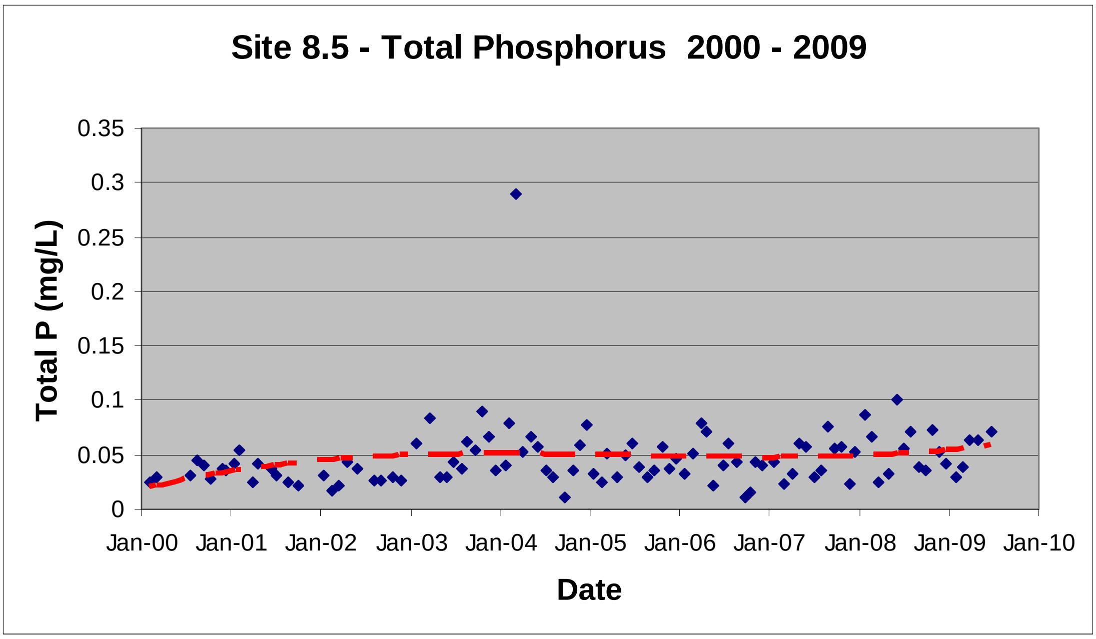

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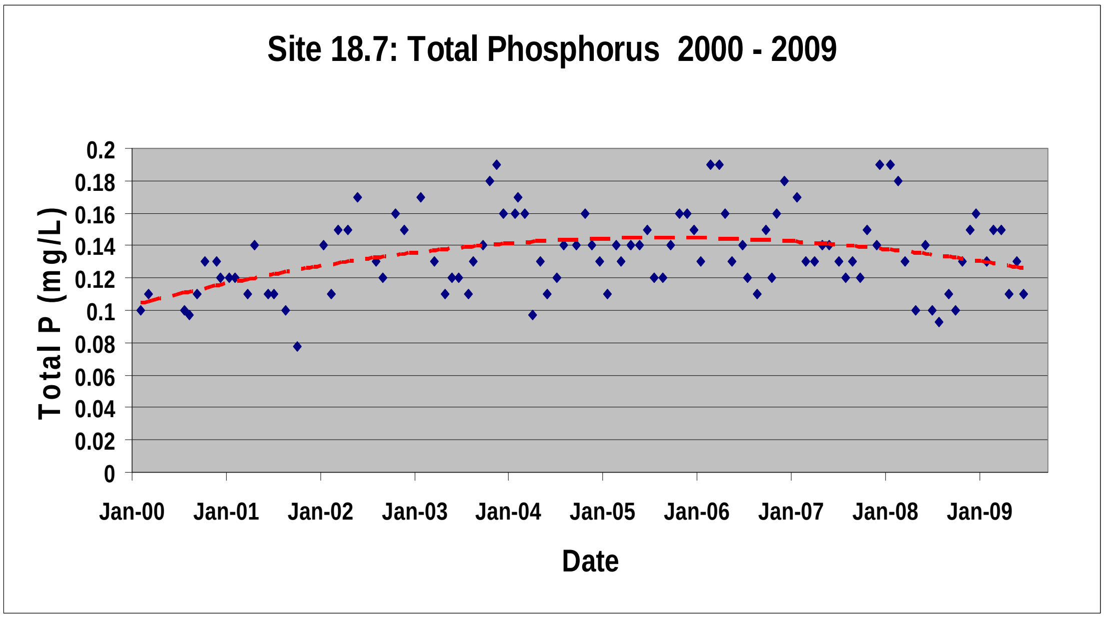


Figure B11

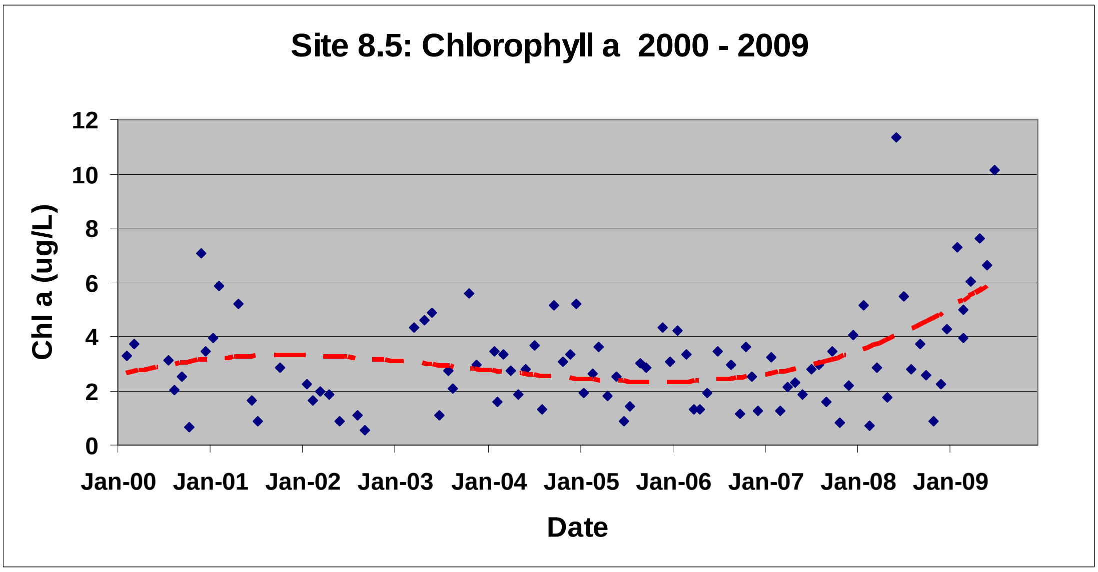
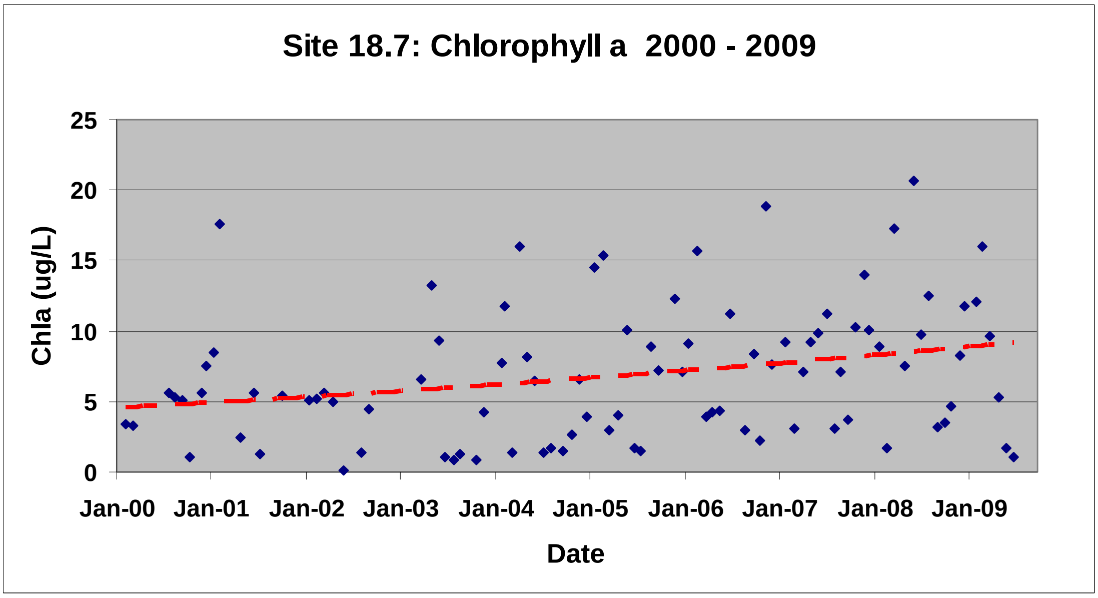


Figure B12



APPENDIX C – Explanation of indicators

Dissolved oxygen	The amount of oxygen dissolved in the water. Oxygen is essential for the life processes of most aquatic organisms, and lack of oxygen can cause suffocation of aquatic organisms. Low concentrations are often a symptom of pollution by organic matter, and are a by product of the rapid breakdown of the organic matter by bacteria. High concentrations (i.e. values > 110% saturation) are indicative excessive plant productivity. In estuaries this is due to phytoplankton growth.
pH	A measure of the acidity or alkalinity of the water. Extremes of pH (acidity less than 6.0 or alkalinity greater than 9) can be toxic to aquatic organisms. Estuarine waters are usually in the

	range 7-8.4
Conductivity	Conductivity is used as a measure of salinity. Seawater has a conductivity of about 51 mS/cm which is equivalent to a salinity of around 35g/L.
Turbidity	Turbidity is an indirect measure of the concentration of fine particulate matter in the water column. The higher the concentration of particles, the higher the turbidity. High levels of turbidity are indicative of excessive inputs of fine particles from the catchment or from urban stormwater. In estuaries, turbidity is also affected by the spring neap tidal cycle, with highest turbidities occurring during spring tides when tidal currents are at a maximum.
Secchi depth	An indicator of water clarity. The depth to which a secchi disc lowered into the water can be clearly seen from the surface. Secchi depth and turbidity are strongly correlated.
Nitrogen & Phosphorus	The major nutrients (nitrogen and phosphorus) are essential for plant growth. Measurements of nutrient concentrations in waters provide an indication of the potential for excessive plant and algal growth.
Chlorophyll-a	Chlorophyll-a, the green pigment found in all plants. In estuaries, the concentration of chlorophyll a in a sample it is used as an indicator of the phytoplankton biomass. High levels of algae (algal blooms) can have adverse effects on water quality.

Report to the Bundaberg Regional Council on the results of monitoring water quality in the Burnett River estuary for the period 2009 to 2010

Queensland Department of Environment and Resource Management 2011

Contents

1. Introduction

Bundaberg Regional Council (BRC), under a licence from the Department of Environment and Resource Management (DERM), discharges treated sewage wastewater to the Burnett River estuary from three separate locations – see Figure 1. To address the receiving water quality monitoring requirements of this licence, DERM, through agreement with the BRC, undertakes regular monitoring of the Burnett River estuary.

Under the agreement between BRC and DERM, the Department of Environment and Resource Management undertakes to provide an annual report on the outcomes of the monitoring program. This is the fifth such report and covers the 12 month period from July 2009 to June 2010. It describes the program and the results of the monitoring and provides an assessment of the condition of the estuary with regard to water quality. The report includes some results from previous years of DERM monitoring in the estuary which enables the recent results to be put into a historical context and allows an assessment of trends in water quality.

2. Description of the Burnett River estuary

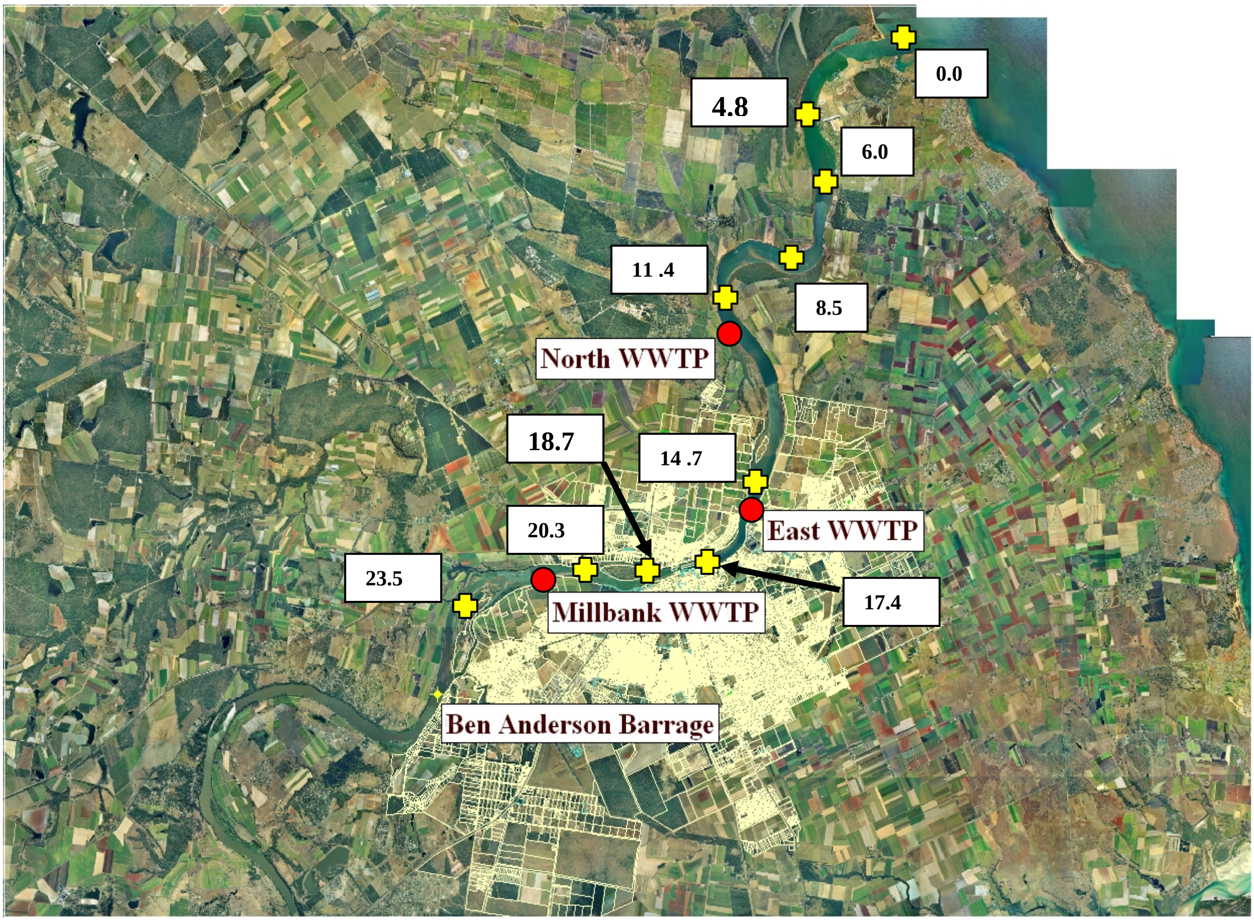
The Burnett River estuary extends approximately 25km from its mouth at Burnett Heads up to the Ben Anderson Barrage, which is now the upstream limit of tidal influence. Prior to construction of the barrage, the natural tidal limit was just above the current location of Bingera Weir which is 42.1 km from the river mouth. The main land uses adjacent to the estuary are agriculture (mostly sugar cane) and the urban areas of the city of Bundaberg, see Figure 1.

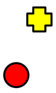
The National Land and Water Resources Audit national assessment of estuaries carried out in 2002 (for detailed information see www.**ozestuaries**.org) describes the Burnett estuary as being extensively modified from its pre-European condition. It has ongoing dredging at the mouth and much of its riparian vegetation has been removed. There has also been significant loss of mangroves. Freshwater inflows to the estuary have been reduced very significantly from their natural state due the extensive system of weirs and associated agricultural water use within the Burnett catchment.

The main sources of pollutants entering the estuary are:

- Diffuse pollutant loads entering from the catchment during infrequent flood events
- Urban stormwater from Bundaberg City
- Point discharges

Figure 1: Burnett River estuary showing sampling sites and discharge points





This report is principally concerned with the point discharges and their associated impacts on water quality. The main existing point discharges to the estuary are the BRC treated sewage discharges. There are no other significant point discharges. The BRC discharges comprise:

- BRC North WWTP (Waste Water Treatment Plant)
- BRC East WWTP
- BRC Millbank WWTP

Discharge locations are shown in Figure 1. Information on discharge loads from these plants is given in Tables 1 and 2 below. By far the most significant discharge is the East WWTP.

Table 1 Annual pollutant loads from discharges to the Burnett River estuary during 2009 - 2010

Source	Annual pollutant loads (tonnes)			
	TN	TP	BOD	TSS
North WWTP	3.0	0.7	3.8	3.0
East WWTP	47.8	13.3	50.3	34.5
Millbank WWTP	2.0	4.4	8.0	8.5

Table 2 below shows annual loads from the East and Millbank WWTPs since 2000, which is useful for comparing with water quality trends.

Table 2 Historical records of annual nutrient loads from treatment plants

	East WWTP		Millbank WWTP	
Year (Jul/Jun)	Total Nitrogen (Tonnes)	Total Phosphorus (Tonnes)	Total Nitrogen (Tonnes)	Total Phosphorus (Tonnes)
99/00	32.9	17.9	16.4	8.8
00/01	20.8	16.1	8.1	8.4
01/02	16.4	16.6	6.4	11.4
02/03	36.7	19.2	7.9	11.1
03/04	40.9	19.6	11.9	11.0
04/05	36.0	22.2	9.9	10.8
05/06	38.0	20.4	4.6	8.6
06/07	36.1	22.3	7.0	9.2
07/08	48.0	20.1	4.9	5.3
08/09	43.3	16.8	3.5	5.5
09/10	47.8	13.3	2.0	4.4

3. Scope of Water Quality Monitoring Program

The main component of the DERM monitoring program consists of routine monthly monitoring at 10 sites in the Burnett River estuary. The program aims to provide a general assessment of water quality in the estuary and also, in the longer term, to pick up any trends in quality. The indicators sampled at each site are detailed in Table 3. These indicators and their purpose are described in more detail in Appendix C. Not all indicators are sampled at all sites but the program provides sufficient data to provide a good general assessment of water quality throughout the estuary.

The monitoring is undertaken by experienced DERM field staff, who routinely undertake this type of activity in many Queensland estuaries.

Table 3 Burnett River estuary monitoring program: Indicators and Sites

SITE (km)	**INDICATORS**							
	DO	Temp	pH	Conductivity	Turbidity	Chl a	N	P
0.0	✓	✓	✓	✓	✓			
4.8	✓	✓	✓	✓	✓	✓	✓	✓
6.0	✓	✓	✓	✓	✓			
8.5	✓	✓	✓	✓	✓	✓	✓	✓
11.4	✓	✓	✓	✓	✓	✓	✓	✓
14.7	✓	✓	✓	✓	✓	✓	✓	✓
17.4	✓	✓	✓	✓	✓			
18.7	✓	✓	✓	✓	✓	✓	✓	✓
20.3	✓	✓	✓	✓	✓	✓	✓	✓
23.5	✓	✓	✓	✓	✓	✓	✓	✓

4. Methods for assessing water quality

4.1. Condition

The basic approach to condition assessment is to compare monitoring data with guideline values. The guidelines used in this report are taken from the Queensland Water Quality Guidelines (QWQG). These provide guideline values for all the indicators measured in the routine monthly program.

Water quality in estuaries varies naturally from the mouth up to the tidal limit. To allow for this natural variation, the QWQG provides separate guidelines for different reaches of estuaries. These reaches are defined as follows:

1. Lower estuary – the reaches near the estuary mouth that experience frequent exchange with coastal waters
2. Mid estuary – the main body of the estuary
3. Upper estuary – the upper 15% of the length of the estuary – these reaches are poorly flushed and have naturally poorer water quality than the main body of the estuary

Table 4 below shows the guideline values for each indicator for each of these segments. It also shows which sites in the Burnett fall into each category.

Table 4 Guideline values for each reach of the Burnett River estuary

REACH	GUIDELINE VALUES FOR KEY INDICATORS							
	DO	pH	Secchi	Turb-idity	Total N	Total P	Chl a	
	%sat		(m)	NTU	µg/L	µg/L	µg/L	
Lower estuary Sites 0.0	105-95	8.0-8.4	1.5	6	200	20	2	
Mid estuary Sites 4.8, 6.0, 8.5, 11.4, 14.7, 17.4, 18.5	105-85	7.0-8.4	1.0	8	300	25	4	
Upper estuary Sites 20.3, 23.5	105-80	7.0-8.4	0.5	25	450	30	8	

These guideline values are designed to be compared with the median of a series of values rather than every individual value from a test site. Thus, the graphical presentations of the results show the guidelines compared with the median values for the last 12 months for each indicator at each site.

As well as assessing the median value, the results also need to be checked for extreme values. Such values (e.g. very low DO levels) have the potential to be very harmful even though median values comply with the guideline value.

The indicators assessed for condition include:

- Dissolved oxygen
- pH
- Turbidity
- Secchi depth (clarity)
- Nitrate N
- Total P
- Chlorophyll a

4.2. Trend

The more intensive monitoring of the Burnett River estuary only started in 2005/06 and so there is insufficient data to comprehensively assess trends throughout the estuary. However, DERM data is available for a much longer time period for two sites (8.5 and 18.7). Data from these sites is assessed using simple regression techniques to provide an indication of improvements or declines in water quality over the past few years. This information can give an indication of improvements in water quality or of what issues are likely to arise in the future.

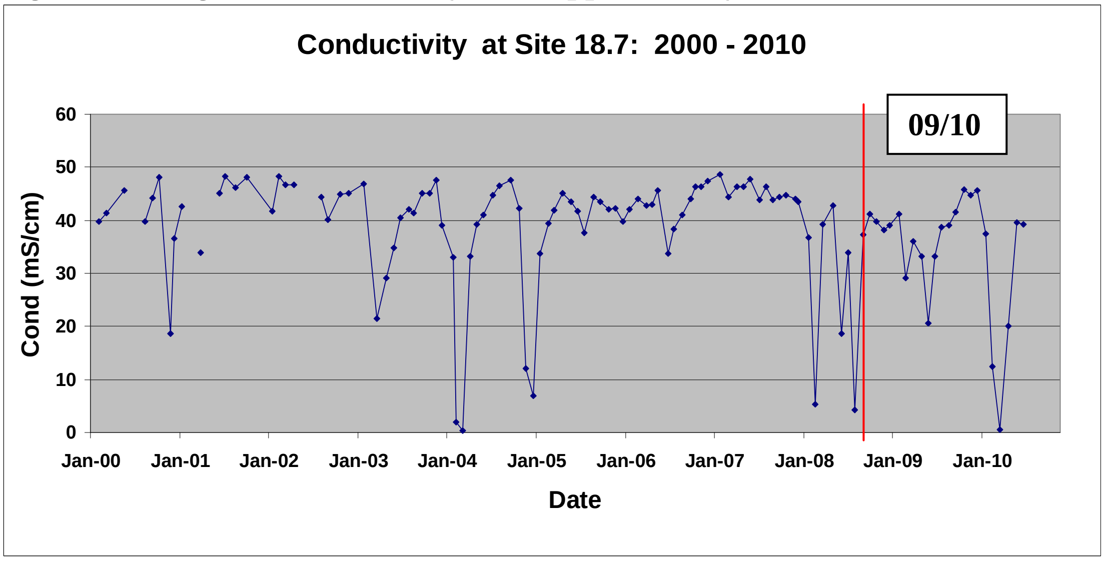
5. Overview of Burnett estuary conditions during the period 2009 - 2010

Water quality condition in estuaries can be broadly separated into (i) flow event and immediate post flow event conditions and (ii) dry weather conditions. Flow events carry large volumes of freshwater and catchment sourced pollutants into estuaries. These have considerable but usually short term impacts on water quality. During dry weather, water quality in estuaries is more stable and is largely controlled by internal processes and any point discharges. Most sub-tropical Queensland estuaries experience dry weather conditions (i.e. minimal inflow from the catchment) for >80% of the time.

Figure 2 shows conductivity at site 18.7 in the mid/upper reaches of the Burnett estuary during the period 1999 to 2010. For much of this time conductivity lies in the range 40 - 50 mS/cm which is indicative of dry weather conditions. Sudden reductions below 40 mS/cm are indicative of recent freshwater inflows, the larger the reduction the larger the inflow.

The graph shows significant variation between years. There was a very dry period in 2005/06 and 2006/07 which coincided with the first two years of these more intensive surveys. 2007/8 was a slightly wetter year while 2008/9 appears to have been one of the wettest years for some time, with very few values exceeding 40 mS/cm. The year 09/10 exhibited a more normal seasonal pattern with a dry period during winter and spring and significant freshwater inflows in January, February and March. During this wet period, catchment pollutants rather than point discharges would be the main factor impacting on estuary water quality.

Figure 2: Long-term conductivity at an upper estuary site



6. Results

6.1. Data presentation

Figures A1 to A6 in Appendix A show median values for each of the six selected core indictors plotted against distance upstream in the estuary. The plots also show the relevant guideline values for each reach of the estuary. Where median values comply with guideline values they are coloured in **blue** and where they do not comply they are coloured in **red**. These plots provide a broad overview of water quality in the estuary.

Trends in water quality are shown in figures B1 to B12. These show trends in water quality for the six selected core indicators at two sites, 8.5 and 18.7 over the period 2000 to 2008.

For some core indicators, some additional graphical data is presented to illustrate specific points.

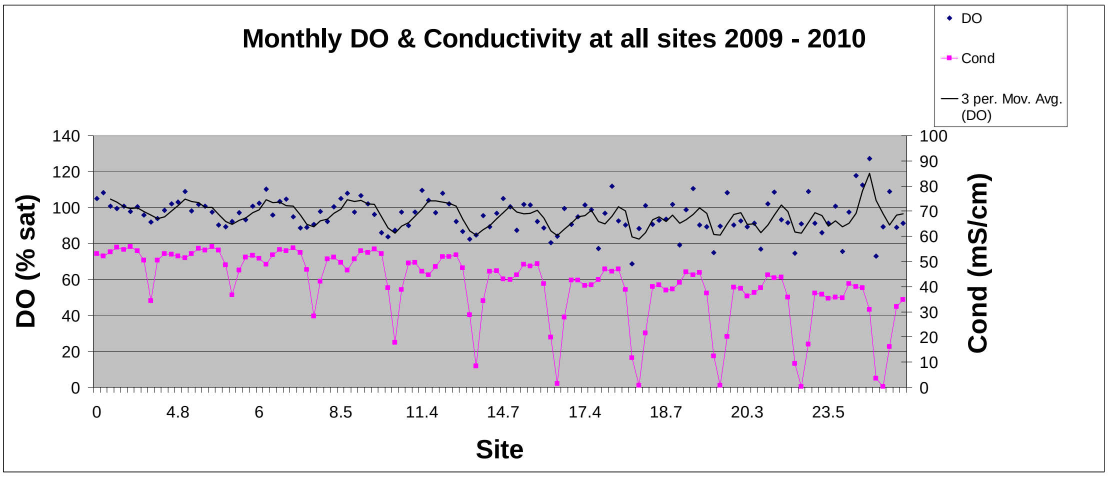
6.2. Dissolved Oxygen

The results in Figure A1 show that during 2009/10 median dissolved oxygen complied with guidelines at all sites. Figure 3 shows the full monthly DO data set at each site along the estuary together with the full set of conductivity values. It can be seen that the minimum DO value recorded at any site during the entire 12 months was around 70% saturation. The absence of low values indicates that the BOD load from the WWTPs is not having a significant impact on the estuary.

The DO data is overlaid with a moving average line which shows a clear cyclical variation in DO values. Comparison with conductivity shows that this DO cycle is strongly associated with low conductivity values i.e. freshwater inflows. This indicates that the lowest DO values are very largely related to catchment sources of organic matter rather than to organic matter in the treated sewage discharges.

Supersaturated DO values occur on occasions at most sites, which is indicative of algal activity. However, the supersaturated values are not unusually high and the chlorophyll a data (Fig 6.3) shows no evidence of any significant algal blooms in the estuary.

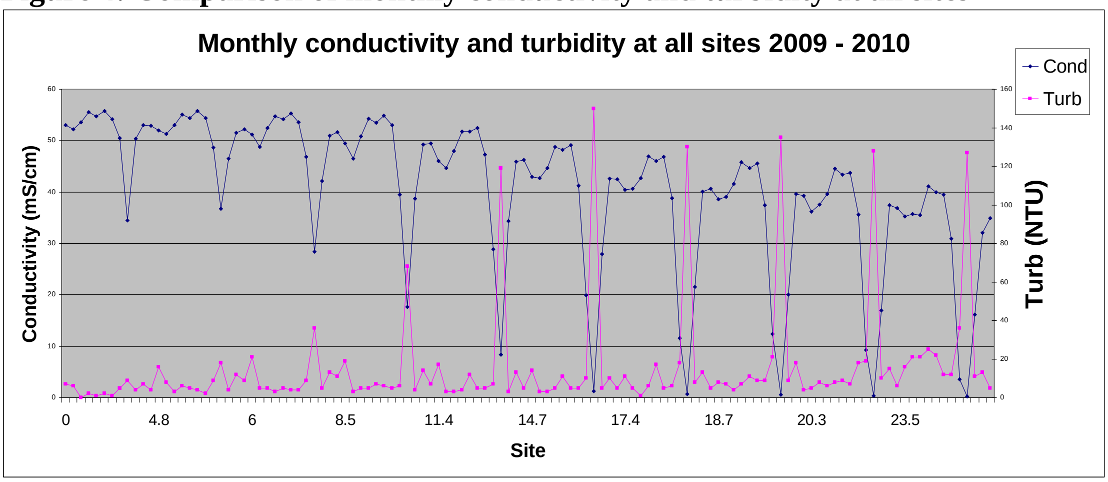
Figure 3: DO & conductivity data set from monthly monitoring at all sites



6.3. *Turbidity and Clarity*

Levels of turbidity (Fig A2) and Secchi disc clarity (Fig A3) complied with the guidelines at nearly all sites, the only exception being very minor exceedances at site 18.7. High values of turbidity are strongly associated with freshwater inflows as is illustrated in Figure 4 below which shows turbidity peaks correlating with low conductivity.

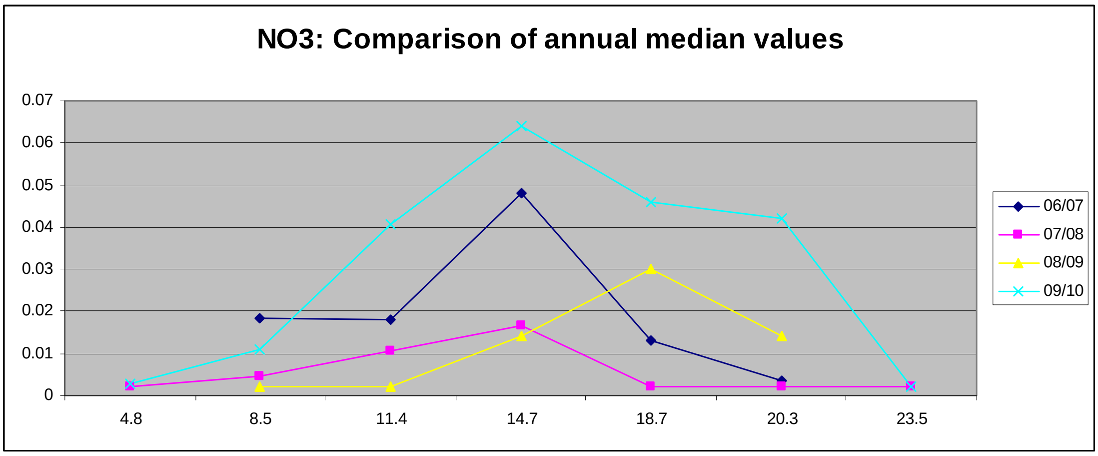
Figure 4: Comparison of monthly conductivity and turbidity at all sites



6.4. Nutrients and Chlorophyll a

Oxidised N (NO2+NO3) values (Figure A4) exceed guidelines at most sites although levels are not excessively high. Figure 5 is a comparison of oxidised N values over the past four years and it shows that 2009/10 levels in the mid estuary were a little higher than in previous years. This may be related to small increases in total N loads discharged from the East WWTP compared to 08/09 (see Table 3). However WWTP total N loads in 07/08 were just as high while oxidised N levels at that time were lower. It therefore seems most likely that the small increase is related to both catchment and point source effects.

Figure 5: Comparison of median oxidised N values in 06/07, 07/08 & 08/09

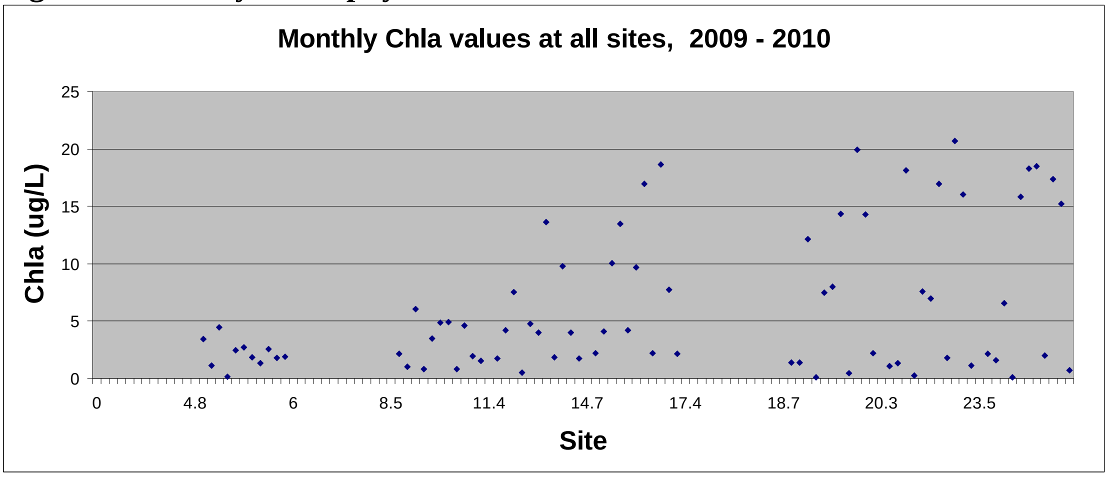


Due to the STP discharges, total P values (Fig A5) significantly exceed guideline values at most sites. There was a reduction in total P loads in 2009/10 compared to 2008/09 but the total P concentrations in the estuary remained very close to those in 2008/09.

Median chlorophyll a values (Fig A6) exceed guideline values at two mid-estuary sites. These mid estuary exceedances are very likely related to the WWTP discharges in this region.

Chlorophyll a values of up to 20µg/L occur in the mid and upper estuary (Fig 6.3). However no values higher than this were recorded at any site and there is no evidence of any significant algal blooms (i.e. levels of >30-40µg/L). Thus currently, the estuary does not appear to be experiencing serious eutrophication problems, even though it is nutrient enriched to a limited degree.

Figure 6: Monthly chlorophyll a levels at all sites



6.5. pH

Values of pH in estuaries are generally buffered in the range of 7.0 to 8.4 by the presence of varying concentrations of salt. In some estuaries, acid sulphate contaminated run-off can reduce pH levels very significantly for short periods. During 2009/10, pH values recorded during the monthly surveys in the Burnett estuary remained within the range of 7.1 to 8.4 at all sites throughout the year. Major inflows did not cause any large reductions in pH levels so there is no evidence of acid run-off, although the fact that these readings were only at monthly intervals means that much lower values may have occurred but not been recorded. However, water quality monitoring data in previous years has not shown any evidence of this.

6.6. Trends in water quality

The trend results are based on data collected by DERM at two sites (8.5 & 18.7) since January 2000. Graphs for each of the selected indicators are given in Figures B1 to B12 in Appendix B. Trend lines are not linear trends but rather are polynomial lines that provide a best fit to trends that vary over time.

Dissolved oxygen values (Figs B1 & B2) at both sites in 2009/10 were similar to those over the past three years which indicates that there has been little change in organic loading to the estuary in this time.

Turbidity (Figs B3 & B4) shows a decreasing trend at site 8.5 while levels at site 18.7 it remained fairly stable during 2009/2010. Secchi depth clarity (Figs B5 & B6) showed little change at either site. As noted in section 6.3 above, turbidity/clarity during a particular year is largely related to the sediment loads entering from the catchment during freshwater inflow periods.

Median nitrogen levels (Oxidised N) levels appeared to be higher in 2010 than in previous years (see Figure 6.2). The long-term trend graphs (Figs B7 & B8) show little change at site 18.7 but there was an increase at site 8.5. As noted in section 6.4, the exact reason for the increase is not known but it is probably related to both diffuse and point source inputs

Total P levels (Figs B9 & B10) remained stable at site 8.5 but there is evidence of a decrease at site 18.7. This trend could be related to a 20% decrease in total P loads discharged from the main WWTP's this year but given the variability in total P levels over the year this must remain a tentative conclusion.

Chlorophyll a values at site 8.5 (Fig B11) in the mid-lower estuary increased between 2007/08 and 2008/09. However, there is no evidence of any further increase in 2009/10 and in fact peak values were lower than in 2008/09. Chlorophyll a levels at site 18.7 (Fig B12) in the upper estuary were similar to the previous year but there still seems to be a small long-term increase in levels at this site. Given that combined WWTP loads of total N have not changed greatly since 02/03 while total P loads have decreased in the same period, it is not clear what the cause of this increase is.

7. Conclusions

Water quality in the Burnett estuary is consistent with a limited impact due to discharges from a number of WWTP's. Organic loads from the discharges appear to be having no measureable impact on dissolved oxygen levels in the estuary. Nutrient loads in the discharges have a measureable impact on nutrient levels in the water column at both mid and upper estuary sites. The elevated nutrient levels are causing some increase in chlorophyll a levels at some sites but there have been no significant algal blooms in the estuary.

As well as point discharges, water quality in the estuary is impacted by inflows from the catchment. These have a much larger impact than point sources on turbidity levels in the estuary and also have a greater impact on dissolved oxygen levels. They also impact on nutrient and chlorophyll a levels for limited periods following the inflows.

There is no evidence of any acid sulphate inflows into the estuary although monthly monitoring of pH is not an ideal approach to detecting these ephemeral types of effects.

8. References

DERM (2009) Queensland Water Quality Guidelines. www.derm.qld.gov.au

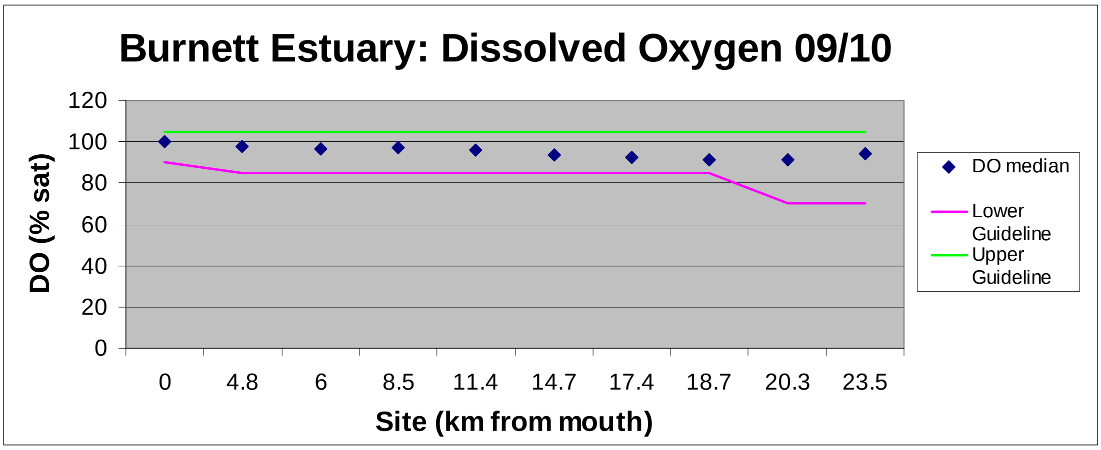
9. Acknowledgements

Thanks to John Ferris and the DERM field staff for undertaking surveys efficiently and on schedule and for the high level of QA that is maintained.

Thanks to Jeff Rohdman of Bundaberg Regional Council for providing a full and rapid response to requests for data and for any other assistance requested.

APPENDIX A: Water quality compared to guidelines

Figure A1



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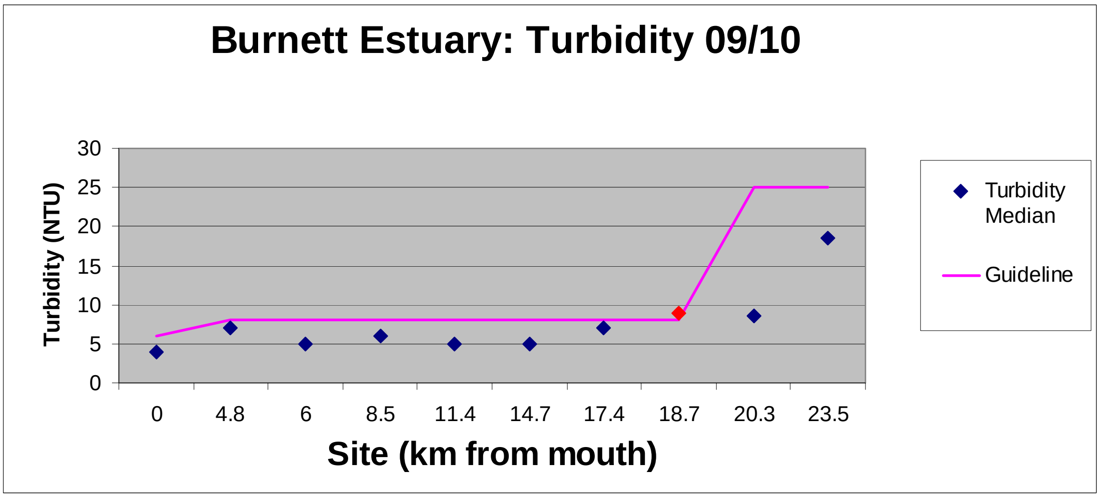


Figure A3

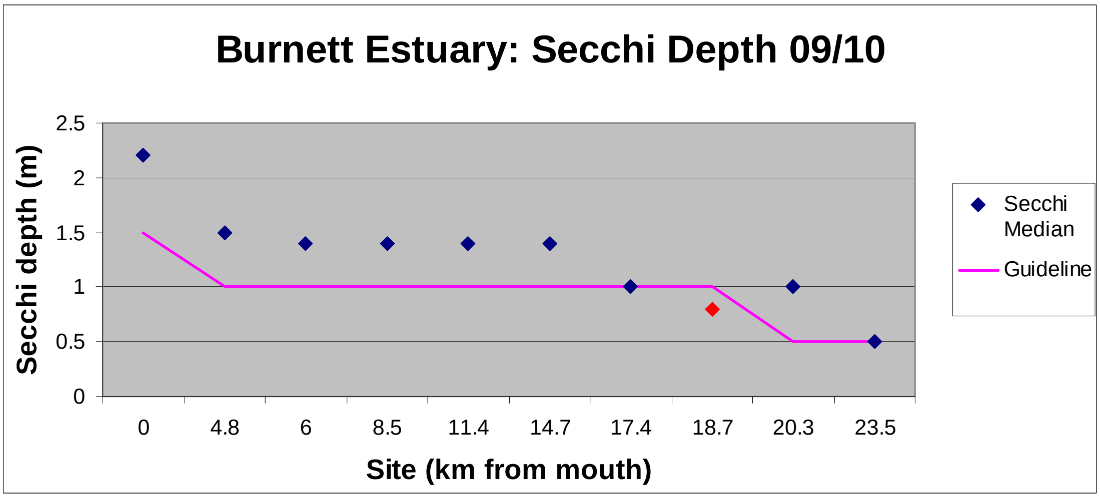
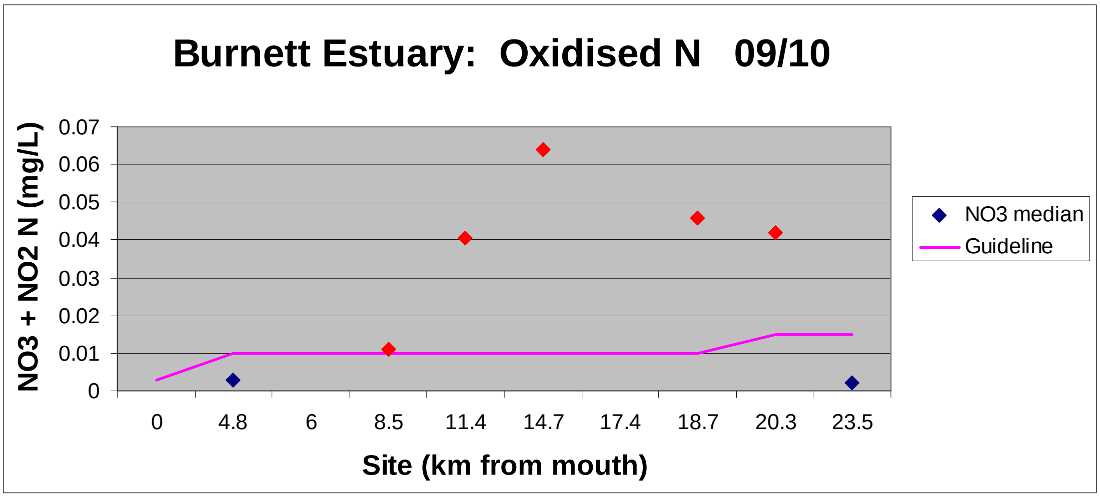


Figure A4



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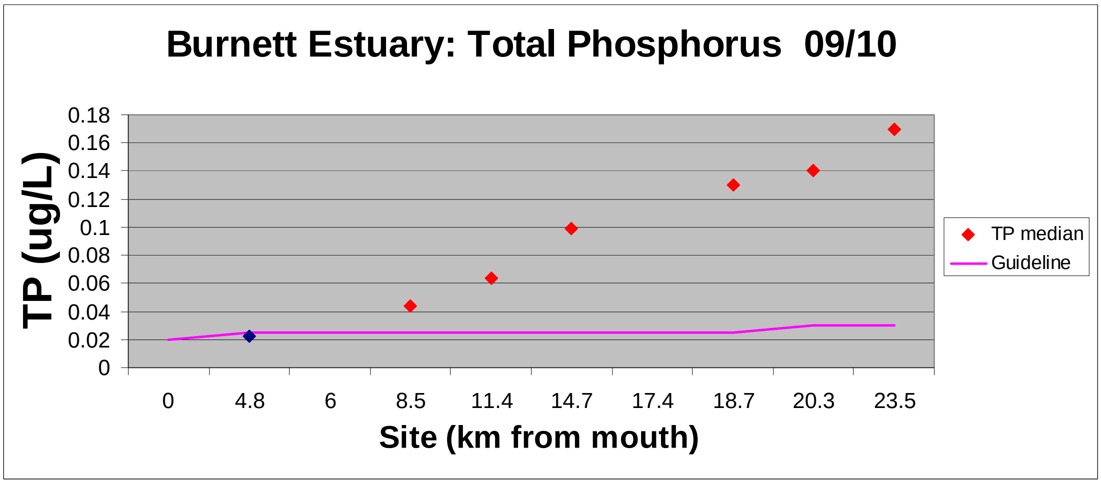

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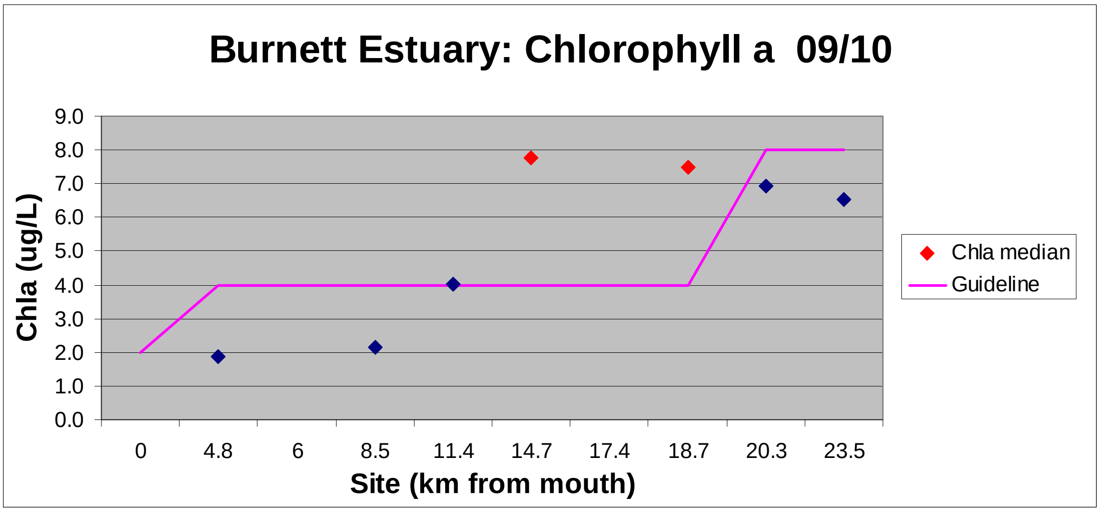


APPENDIX B: Trends in water quality

Figure B1

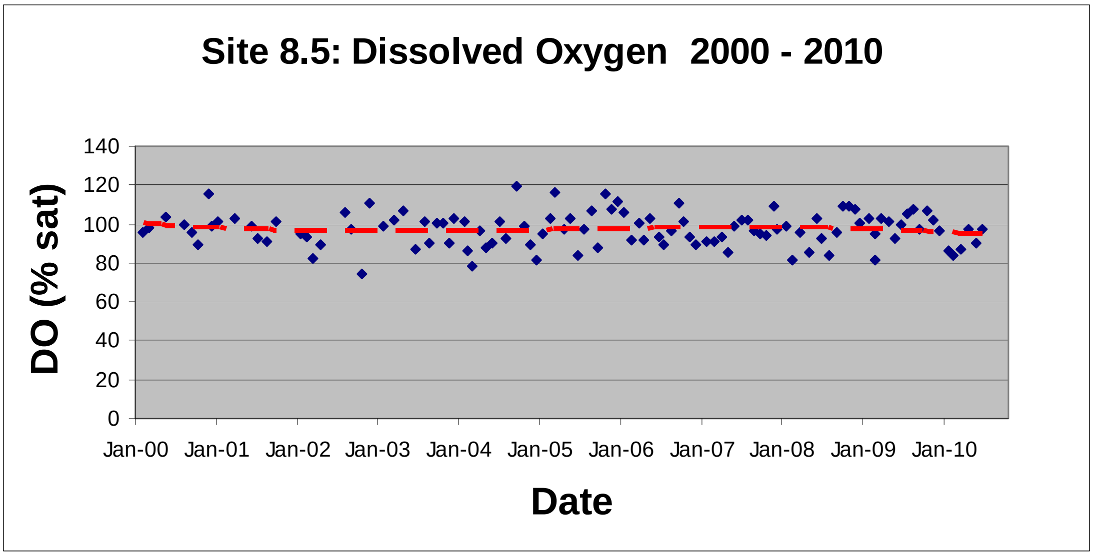
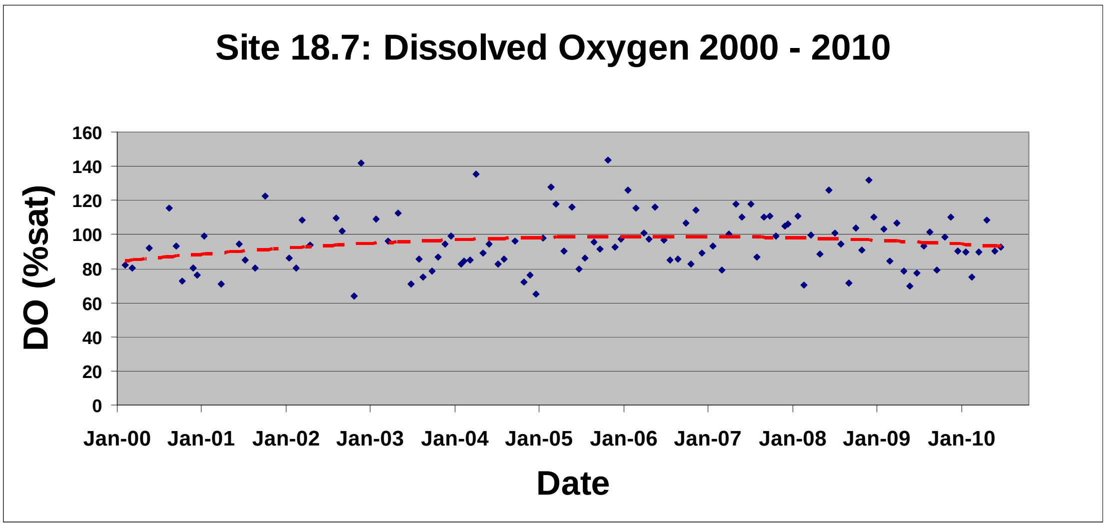


Figure B2



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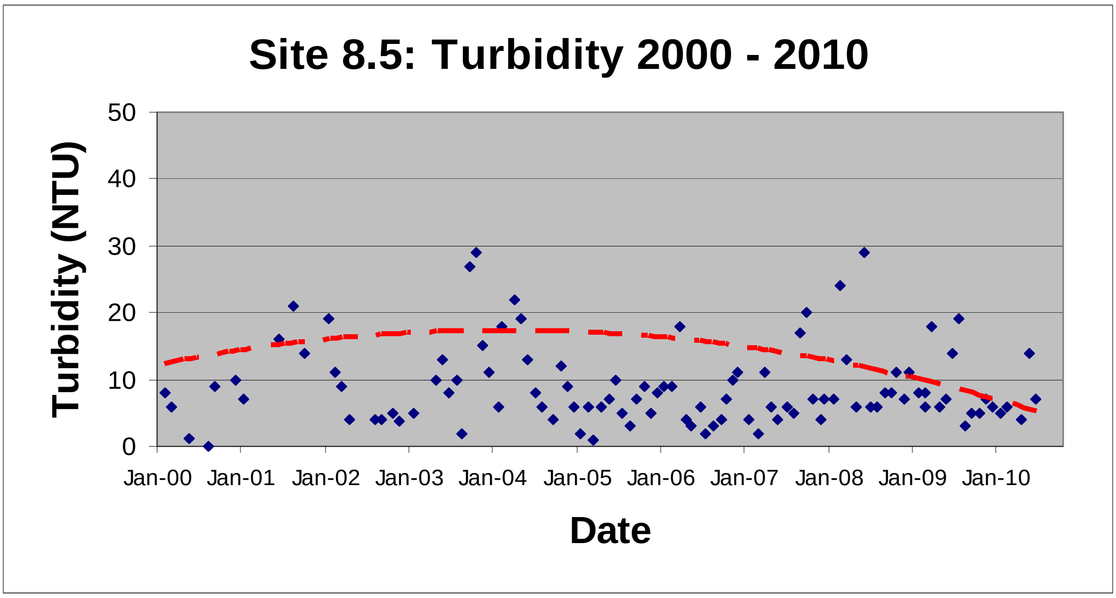

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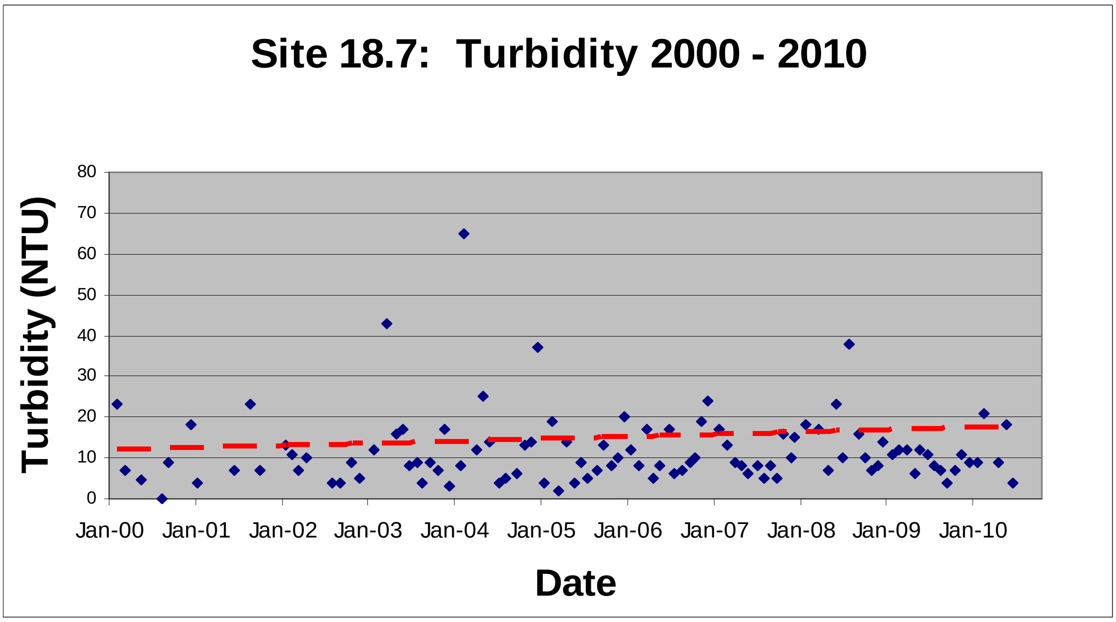

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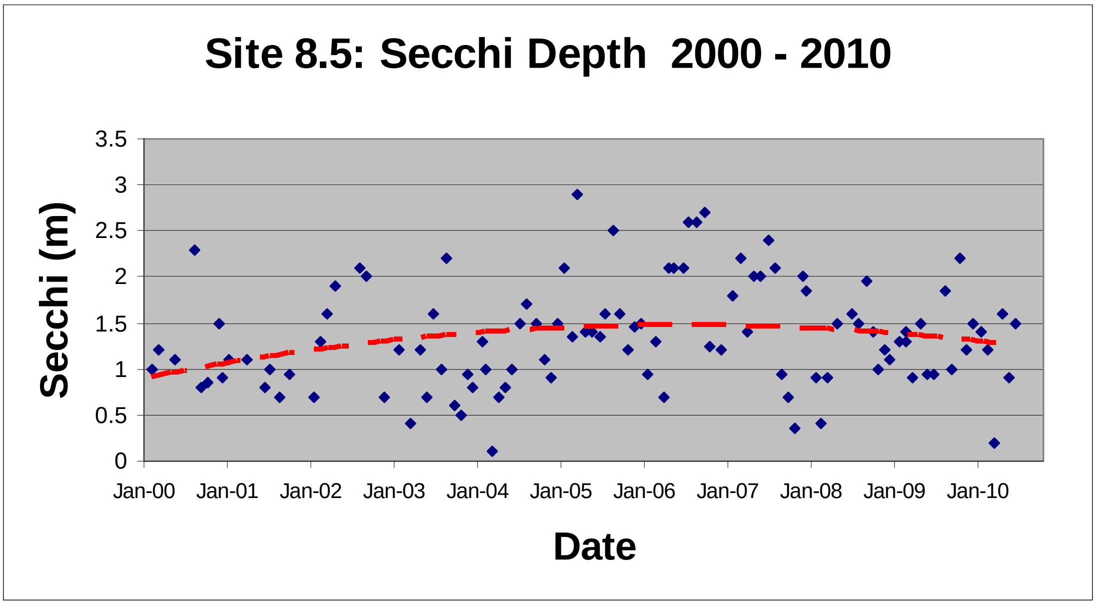

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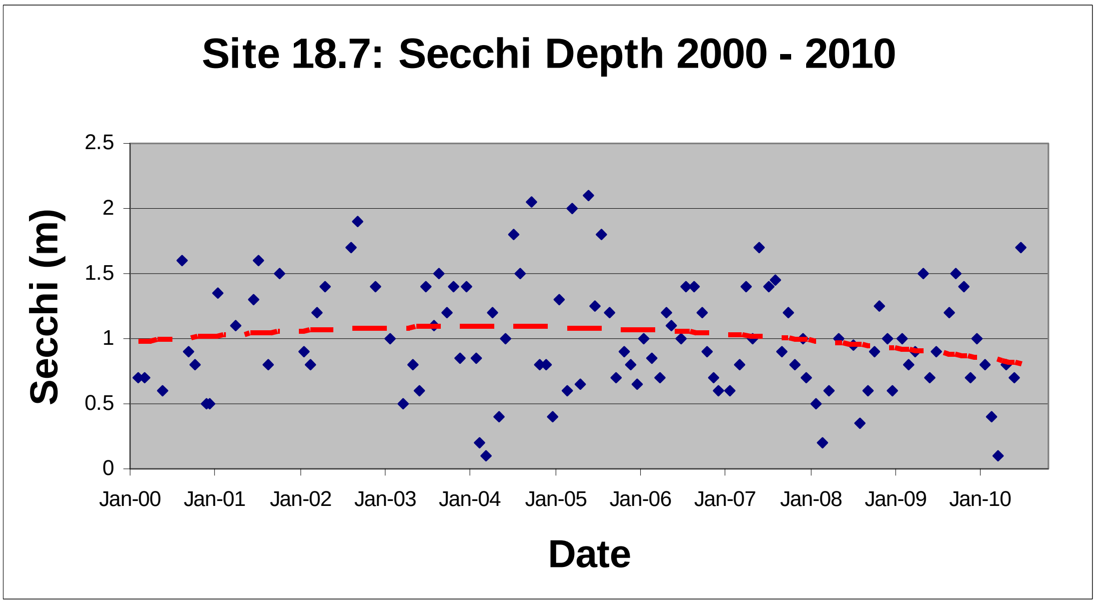

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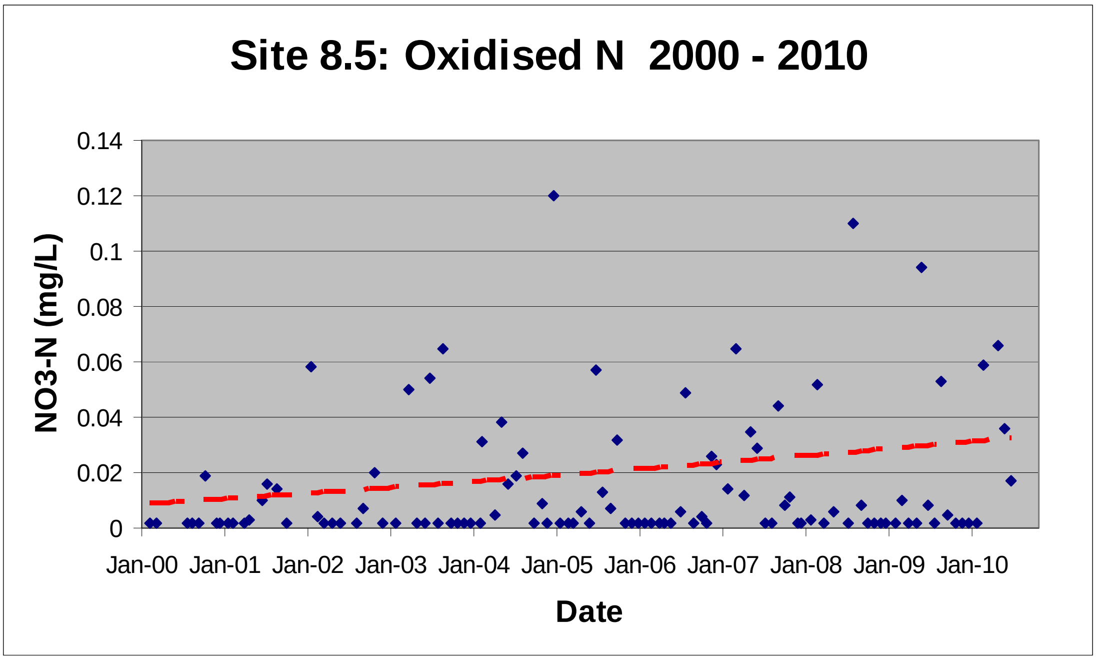

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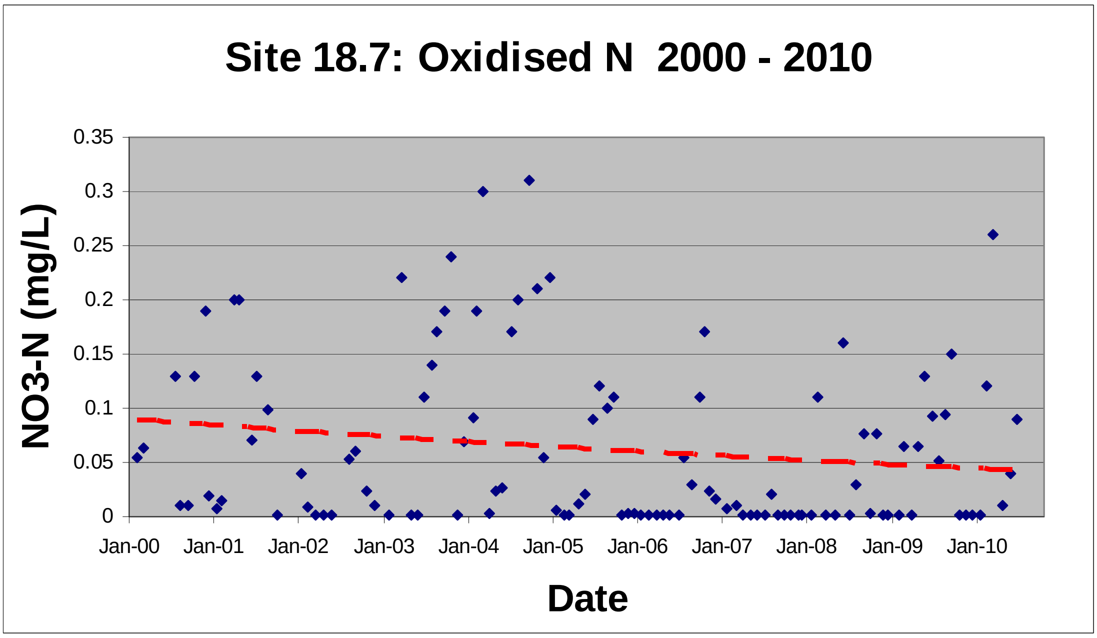

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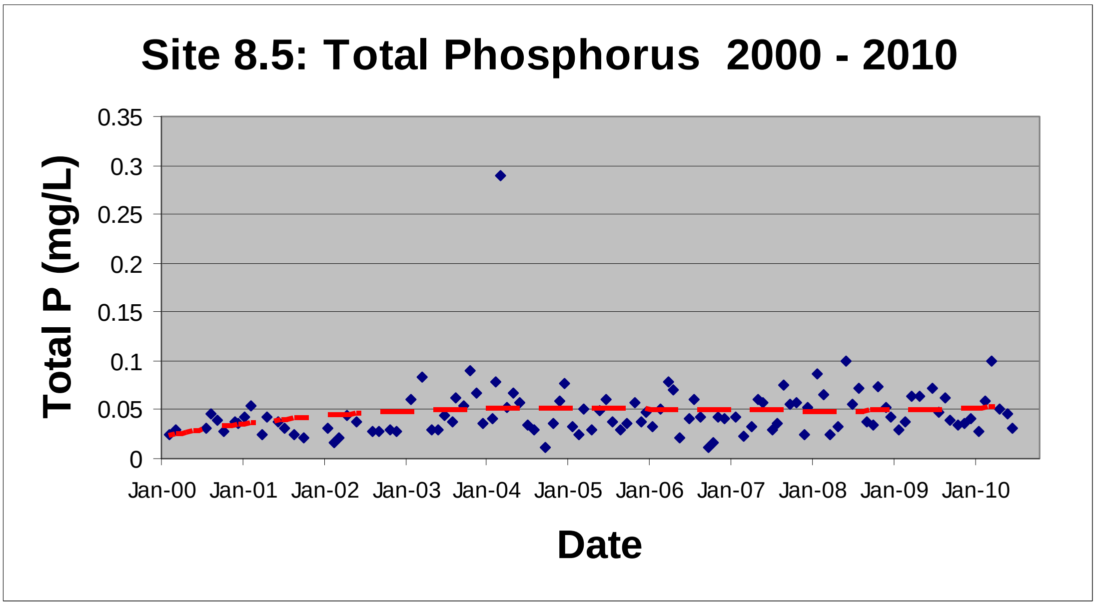


Figure B10

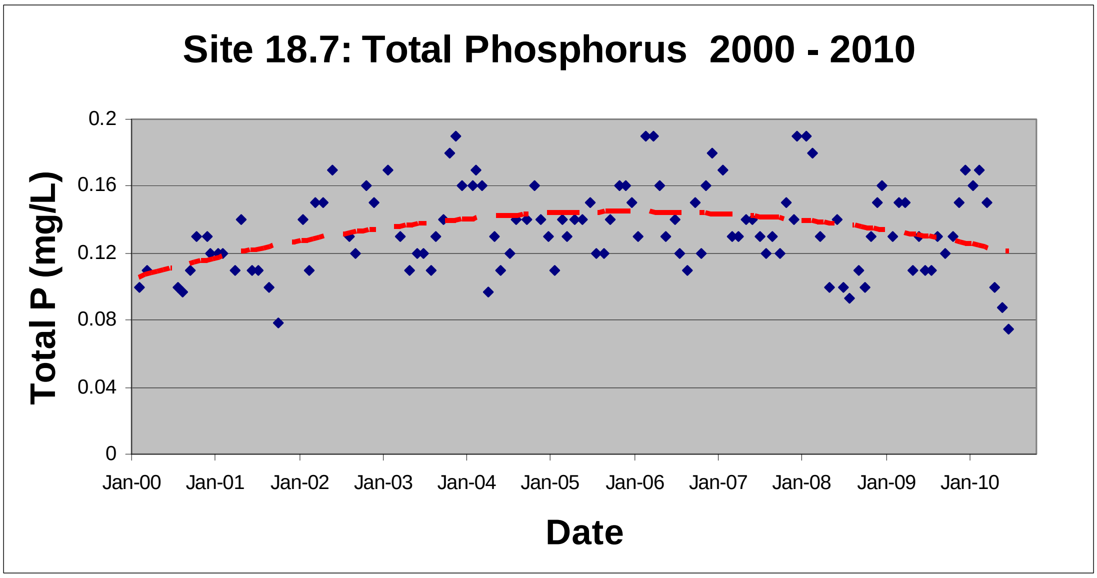


Figure B11

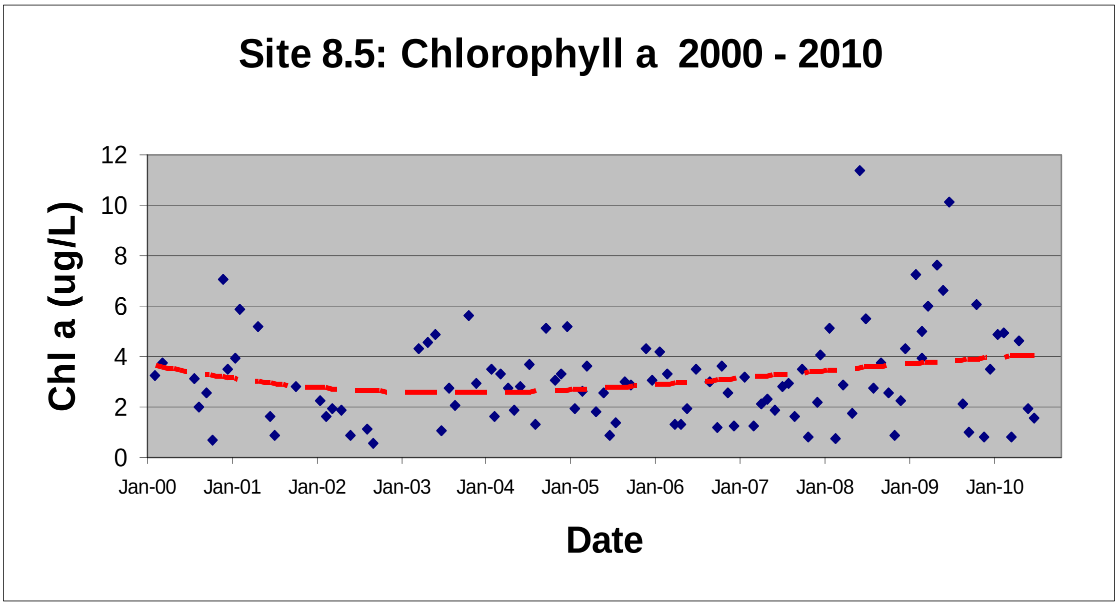
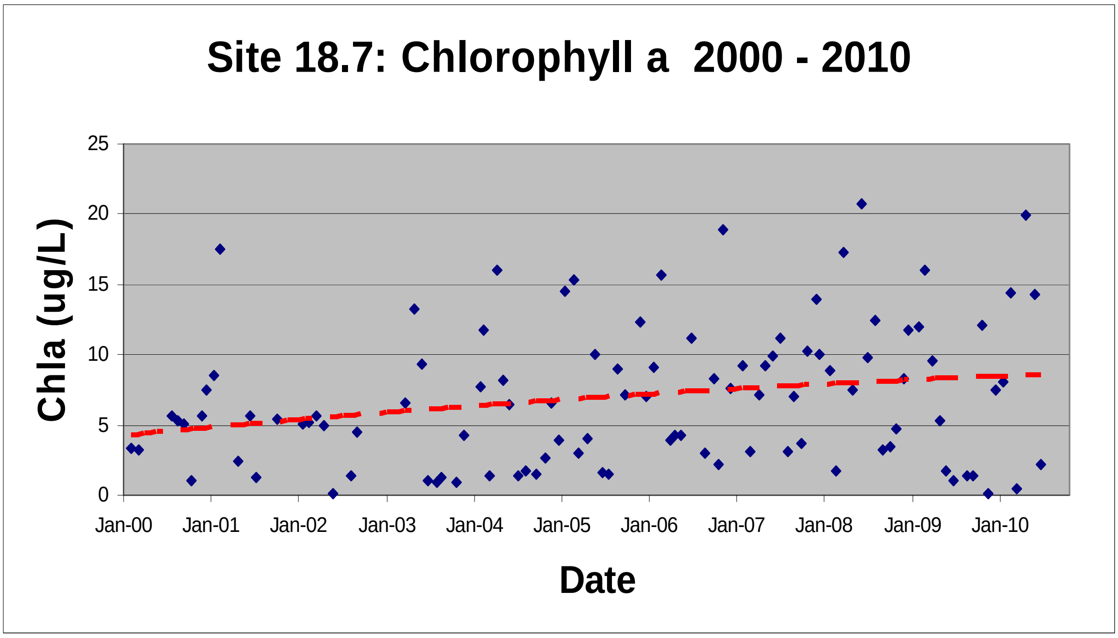


Figure B12



APPENDIX C – Explanation of indicators

Dissolved oxygen	The amount of oxygen dissolved in the water. Oxygen is essential for the life processes of most aquatic organisms, and lack of oxygen can cause suffocation of aquatic organisms. Low concentrations are often a symptom of pollution by organic matter, and are a by product of the rapid breakdown of the organic matter by bacteria. High concentrations (i.e. values > 110% saturation) are indicative excessive plant productivity. In estuaries this is due to phytoplankton growth.
pH	A measure of the acidity or alkalinity of the water. Extremes of pH (acidity less than 6.0 or alkalinity greater than 9) can be toxic to aquatic organisms. Estuarine waters are usually in the range 7-8.4
Conductivity	Conductivity is used as a measure of salinity. Seawater has a conductivity of about 51 mS/cm which is equivalent to a salinity of around 35g/L.
Turbidity	Turbidity is an indirect measure of the concentration of fine particulate matter in the water column. The higher the concentration of particles, the higher the turbidity. High levels of turbidity are indicative of excessive inputs of fine particles from the catchment or from urban stormwater. In estuaries, turbidity is also affected by the spring neap tidal cycle, with highest turbidities occurring during spring tides when tidal currents are at a maximum.
Secchi depth	An indicator of water clarity. The depth to which a secchi disc lowered into the water can be clearly seen from the surface. Secchi depth and turbidity are strongly correlated.
Nitrogen & Phosphorus	The major nutrients (nitrogen and phosphorus) are essential for plant growth. Measurements of nutrient concentrations in waters provide an indication of the potential for excessive plant and algal growth.
Chlorophyll-a	Chlorophyll-a, the green pigment found in all plants. In estuaries, the concentration of chlorophyll a in a sample it is used as an indicator of the phytoplankton biomass. High levels of algae (algal blooms) can have adverse effects on water quality.

Appendix M

DERM Minutes

MEETING MINUTES

PROJECT: 3480 – Rubyanna WWTW
DERM Project Update Briefing

VENUE: Department of Environment and Resource Management (DERM)
41 Boggo Road Dutton Park

DATE: Thu 8th September 2011 **TIME:** 1:45 – 3:30 PM

PARTICIPANTS:

Bundaberg Regional Council (BRC) – David Gill, Tom McLaughlin (by teleconference)

Hunter Water Australia (HWA) – David Perry, Chris Conway

AECOM – Michael Puntil

DERM - Dr Ian Ramsay, Nicole Christiansen (Brisbane); Matt Karle (by teleconference)

	Points of discussion	*Action By*	*Date*
1.	**Introductions** David Gil – Project Manager (DG) Tom McLaughlin – Group Manager-Water & Wastewater Infrastructure Services(TM) Dr David Perry – Project Manager (DP) Chris Conway – Principal Process Engineer (CC) Michael Puntil – Project Manager (MP) Dr Ian Ramsay (IR) Nicole Christiansen (NC) Matt Karle (MK)		
2	**Project Background (DP)** ▪ Strategic overview - Rubyanna WWTP to be constructed in two stages. Stage 1 50,000 EP expected in 2017; Stage 2 90,000 EP. - Scheme will enable decommissioning of the existing Bundaberg East WWTP (30,000 EP) and North plant (2,000 EP). - Scheme also provides capacity to service the coastal communities while avoiding the need for new outfalls to the coastal waters. ▪ Current project status - Hunter Water Australia (HWA) and AECOM have been engaged to prepare supporting documents for lodgement of a development application - Bundaberg Regional Council have signed an option contract to enable them to purchase the selected site within a two year period. The contract includes an agreement from Bundaberg Sugar to take recycled water for irrigation. - HWA have undertaken an initial assessment of the projected mass loads for		

	Points of discussion	Action By	Date
	the proposed treatment plant for a range of effluent quality and reuse scenarios.		
3	**Review of load discharge model (DP)** (Copy of the presentation is attached –3480 - Rubyanna WWTP - DERM brief-20110908.pdf)		
3.1	Objectives of the model - To quantify how discharge loads will increase for the projected increase in population serviced - To enable projected discharge loads to the river to be quantified compared to the existing discharge condition to identify whether a net-benefit to the river can be demonstrated - Enables a range of scenarios for different nitrogen effluent quality limits and reuse scenarios to be considered		
3.2	Projected population - The projected population prepared based on BRC's best estimates for population growth and the intended staging of connections of new service areas was presented. - Note that population and staging has been updated since the briefing the new timeframes differ slightly, however overall population growth is broadly in-line with the earlier figures. - The initial population at 2017 was 33,000 EP - Stage 1 of Rubyanna WWTP is to cover 50,000 EP capacity. The Stage 2 upgrade of Rubyanna WWTP to 90,000 EP is currently anticipated as being required by 2026. Actual timing of this upgrade will depend on actual population growth. - The planning horizon for Rubyanna WWTP is 2055. - [MK] At inception meeting (4 Aug 2011) it had been recommended that the planning application be submitted for the full 90,000 EP treatment plant to avoid the need to reapply for approval for the stage 2 upgrade.		
3.3	Projected flows - Projected flows to Rubyanna were presented for 3 per capita flow rates: 180, 200 and 240 L/EP/d - The variation in per capita flow rates is significant for the model results, particularly at the ultimate timeframe of 2055. - While BRC recognise the benefits of reducing wastewater flows as a conservative approach, the initial modelling results as presented has been based on 240 L/EP/d.		

3.4	Model objectives
	
	- Modelling has been undertaken to investigate what median nitrogen concentration should be targeted and what level of reuse is required for the scheme to deliver a net-benefit to the river when compared with the existing discharge
	- Modelling was undertaken for 3 different median nitrogen concentrations based on the expected concentrations from different treatment technologies
	    o 19.5 mg/L median –existing performance at East
	    o 8 mg/L median – expected performance from an intermittent style		

	Points of discussion	Action By	Date
	activated sludge plant o 5 mg/L median – expected performance from an advanced biological nutrient removal (BNR) plant - Modelling was then undertaken for various % reuse to quantify the impact on the discharge loads - Investigation to date has focused on nitrogen as this will determine the type of treatment plant required. Phosphorous limits can be met through a combination of biological removal and chemical dosing. - [IR] For regional treatment plants, it may be appropriate to consider other aspects as part of process slection: o Greenhouse gas generation associated with higher energy use o Phosphorous removal becomes an operational cost o The holding capacity of the reuse area also needs to be considered o It may be beneficial to the scheme to consider a polishing treatment system, such as a wetland. This may be particularly beneficial to reduce nutrient concentrations during seasonal periods of high discharge due to no reuse.		
3.4	Net benefit target - As an initial target for demonstrating net-benefit to the river, the scheme aims to maintain the total annual nitrogen load from Rubyanna WWTP below the sum of the existing release mass load limits for the two treatment plants that are to be decommissioned (East and North) - [MK] Are the target values were based on the existing integrated authority figures, or the figures proposed in the TEP for East? - (Post meeting confirmation) The target TN mass load limit of 29,200 kg/y is the sum of the load limits from the existing integrated authority being W1 North (700 kg/y) and W3 East (28,500 kg/y). (The TEP for East states a release limit of 41,000 kg/y for effluent quality between January 2012 and September 2012). - Historical results for East show the plant has failed to meet the existing limit since 2002. Annual loads are 36,000 – 48,000 kg/y. Loads are showing a trend of increasing. - (Post meeting confirmation) Historical results from North also indicate limits are not being met and are increasing. Annual loads are 1,000 – 3,000 kg/y compared with a limit of 700 kg/y. - [IR] The aim of the scheme should be to demonstrate no increased risk to the receiving environment. - [MK] It was discussed at the inception meeting that the project should also consider the effluent quality values of the receiving water and work back to an target effluent concentration.		
3.4	Model results with no recycling - Scenario 1 – TN 19.5 mg/L median. Loads continue to increase with population well in excess of limit - Scenario 2 – TN 8 mg/L median. Loads exceed the target in the period 2019-2025 (depending on flow loading) - Scenario 3 – TN 5 mg/L median. Loads exceed the target in the period 2029 – 2040. - These scenarios clearly demonstrate that effluent reuse will need to be included in the scheme in order to meet the targets.		

	Points of discussion	Action By	Date
3.5	Model results with recycling - Scenario 4 – For TN 8 mg/L median near 90% reuse is required with approximately 900 ha. - Staged increases to the reuse scheme are recommended as the plant will be able to supply larger irrigation areas as flows increase. - However given that sugar cane is the predominant agricultural crop in the area the climate and irrigation requirements for this crop make it unlikely that 90% reuse is feasible. Sugar cane is not irrigated for a 3 month period. The achievable % reuse is likely to be closer to 60%. - For 60% reuse the TN load profile with a TN of 8 mg/L exceeds the target in 2029.		
3.6	Discussion of reliance on an effluent reuse scheme - [MK] As the scheme relies on reuse, what assurances can be provided in the application that the reuse area will be available, particularly at the long design horizon? - [DP] Assurance across the life of the scheme is difficult given the long planning horizon. BRC are providing a high level of assurance in the near term through the reuse agreement with Bundaberg Sugar. The options contract with Bundaberg Sugar provides a commitment to reuse even before the concept design has been commenced. - [MK] The application should clearly define the degree of assurance (or lack of assurance) for reuse to support the scheme - [MK] The licence may require the scheme to ensure that 3rd party reuse contracts are set up in advance of being required. - [DG] The agreement with Bundaberg Sugar provides for initial reuse for sugar cane irrigation on the Rubyanna site, but also a connection point to service a second property. Additional assurance may be provided by seeking a long-term reuse contract with Bundaberg Sugar. - [MK] There is a risk of developing a scheme that is reliant on a single user, as local agriculture and land use may change - [DG] The Rubyanna site is located surrounded by flood-prone agricultural land that is not zoned for development. - [IR] It may be prudent for the scheme to identify a back-up plan and to state this in the application. This may include for example diversifying reuse through alternative crops, or through the use of wetland system to minimise nutrient release during discharge periods. - [IR] 3 month discharge as a result of no irrigation during the drying out phase of sugar cane is not ideal from a policy perspective. Policy changes in the future may not regard this as a suitable practice.		

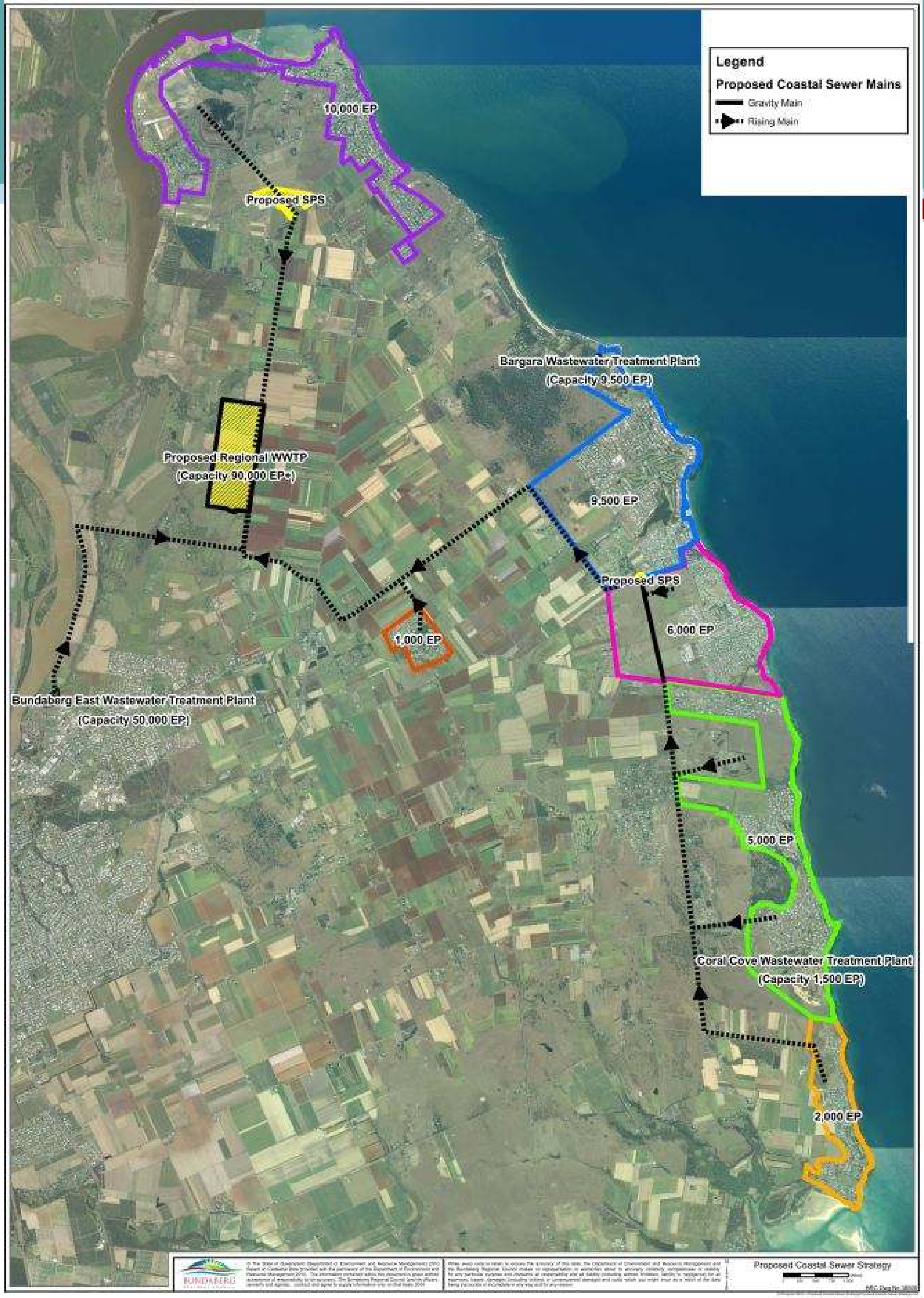
3.7	Activated sludge treatment standards
	- Scenario 5 - Construction of a 8 mg/L TN activated sludge plant with future BNR
	    o Assumes an activated sludge treatment plant with TN 8 mg/L median is constructed initially with a BNR plant of equal capacity being constructed in 2030.
	    o Results indicate that the nitrogen target is exceeded around 2038.		

	Points of discussion	Action By	Date
	- Scenario 6 - Construction of a BNR plant (5 mg/L TN) o Initial construction of a BNR plant shows TN target can be met with 52% reuse o Scheme meets TN target without relying on reuse until 2028		
3.8	Summary of findings - Incorporation of water recycling is essential - There are practical limitations to the about of reuse that can be achieved through sugar cane irrigation. - It is proposed that the scheme be developed base on initial irrigation scheme of 100 ha, increasing to an ultimate of 540 ha. - It is recommended that the treatment plant be designed as an advanced BNR plant to achieve TN median of 5 mg/L.		
3.9	Discussion of findings & suggested refinements - [IR] Findings are very positive when viewed from a total annual load perspective. Consideration also needs to be given to the potential impact on the receiving environment during the 3 month period of continuous discharge. Discharges may have an impact during this period. - [CC] Effect of wet weather bypasses and the impacts of wet weather flows also needs to be considered further. - [IR] Disinfection needs to be considered. Note DERM now considers total chlorine concentrations in discharges to waterways. - [CC] Prefers not to use chlorine disinfection when ammonia is present. May form chloroamines which are more toxic than free chlorine. - [IR] Total phosphorous also needs consideration. - [IR] Decision to adopt BNR has additional treatment benefits. Long sludge age processes provide higher removal rates of toxicity compounds.		
4	**Proposed Outfall (MP)**		
4.1	Selection of preferred outfall location - AECOM has given consideration to 4 alternative outfall locations and a desk-top review has been completed - Locations that discharged to Rubyanna Ck raised concerns relating to the need to clear mangrove vegetation and also that introduction of effluent to this tidal water way may result in changes to the ecosystem - Location 3 – an outfall adjacent to the existing boat ramp was agreed as the preferred option - Outfall location is in deep water and this location is anticipated to provide good mixing and dispersion. - It is noted that this location presents stakeholder issues as a result of the proximity of the outfall to the public boat ramp and sailing club. BRC intend to engage with stakeholders to address these concerns.		
4.2	Discussion of outfall - [IR] Disinfection will need to be considered based on the existing recreational use. - [IR] A second release point may be required from the effluent storage lagoons at the treatment plant. It is often impractical to pump storm flows.		

	Points of discussion	Action By	Date
	- [MK] Some aspects of resource entitlements have now been incorporated into IDAS. The resource entitlement for the outfall has not been incorporated and so a separate resource entitlement will be needed. Sufficient information will need to be presented with the resource entitlement application to demonstrate that the outfall location is suitable. - *(MK to confirm with Julie Murdoch if a separate resource entitlement for the outfall is required)* - [MP] Land ownership at the outfall location thought to be state road reserve however this needs to be confirmed as information is not clear from the available data. - [MK] Tony Ferguson from SLAMS group may be able to assist (4121 1770). - *(MP to follow up with Tony Ferguson to confirm land tenure)* - [IR] The fact that the outfall has been located downstream of the existing outfall locations is a positive feature and should be mentioned in the application.	MK MP	30/9/11 30/9/11
5	**General feed-back and discussion**		
5.1	Further investigation into impact of outfall discharge [IR]. - The key environmental value to be considered is "Aquatic Ecosystems" and in particular nutrient levels. - It is acceptable to use default values and ground truth them against the available data - Need to determine what impact the discharge may have on these values - Suggest use the existing discharge and Burnett River monitoring data to establish if the existing outfalls are having an impact. What is the assimilative capacity of the river at this point. - Assume that river is moderately disturbed in order to determine water quality objectives. - Some modelling is required to determine acceptability. - A box model has been typically used. - EWater have also been developing a water quality analyser software which may be suitable. To be released at the upcoming river conference. - Information is to be sent through to DERM's River Quality group for review prior to formal submission		
5.2	General Notes: - The concept design should look to minimise "dry weather release" to the river. - The concept design needs to consider the nutrient requirements for irrigation purposes that may be different to the river discharge. - The concept design needs to consider the strategy in going from the nominal 100Ha to 540Ha for irrigation and how will these land packages be assured into the future. - The irrigation strategy needs to account for river flows during the two key seasonal periods – 3 months dry weather when irrigation is limited as the cane id dried & 3 months during the traditional dry season. How will this impact on the discharge mass loads? - Where will over flow release from the irrigation storage lagoons go to? - It was generally accepted that a point of discharge as close to the river mouth would be preferred.		

Rubyanna WWTP
DERM Briefing

Hunter Water Australia



Overview

Overview of Regional Strategy

- Rubyanna WWTP to be constructed in two stages 50,000 EP in 2017 expanding to 90,000 EP
- Wastewater diverted from the existing Bundaberg East and Bundaberg North plants
- Treatment capacity provided for coastal communities growth avoiding new coastal discharges
- Central location provides accessibility for recycled water scheme.
- A new outfall to the Burnett River

Hunter Water Australia

General Locality Plan

Current Project Status

- Hunter Water Australia (HWA) and AECOM have been engaged to prepare supporting documents for lodgment of a development application
- Bundaberg Regional Council have signed an option contract to enable them to purchase the selected site within a two year period
- Following the project inception meeting with Matt Karle, HWA have undertaken an initial assessment of the projected mass loads for the proposed treatment plant for a range of effluent quality and reuse scenarios.

Hunter Water Australia

Objective of The Model

- Shows how the loads on the plant will increase with
  - Population growth in the service areas
  - Staged connections as new service areas are directed to Rubyanna WWTP.

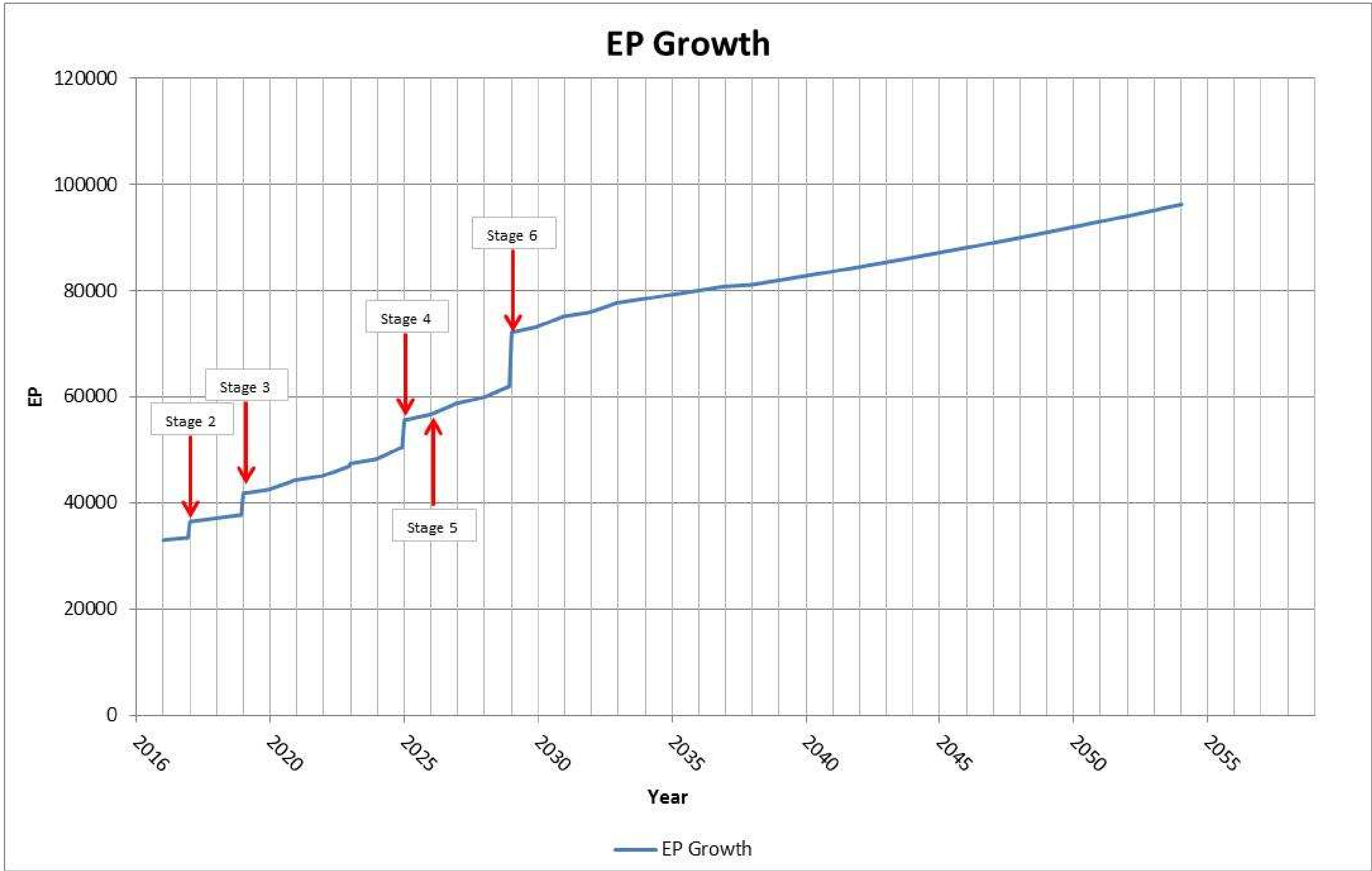
- The model investigates how annual mass loads of TN (kg/yr) and TP (kg/yr) will change with the above growth.

- To reduce TN discharge loads irrigation can be employed – this model looks at what % of reuse is required to provide a TN discharge load that complies with the yearly mass load.

- The model provides the following outputs:
  - How TN Load increase over time
  - % of Flow Irrigated to Maintain a Load Limit
  - Required Irrigable Area Over Time

Hunter Water Australia

Growth and Staging



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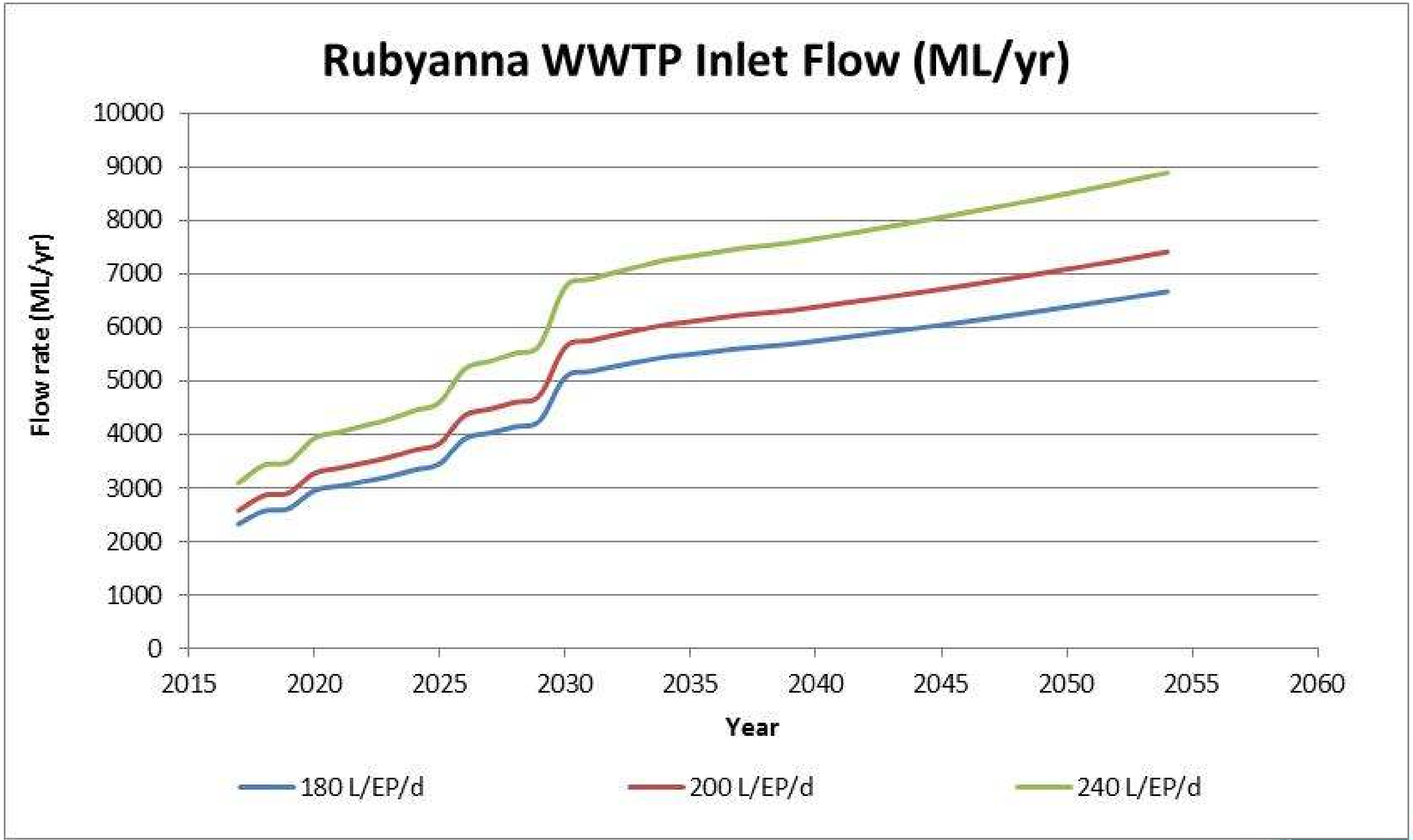
Projected Flow Rates



Model Scenarios

- A number of scenarios were undertaken to see how the variation of different inputs affects mass loads discharged and irrigation requirements. These include:
  1. Performance of the current WWTP with a TN effluent concentration of 19.5mg/L (median) at three different flow rates.
  2. Performance of an activated sludge WWTP with a TN effluent concentration of 8mg/L (median) at three different flow rates.
  3. Performance of an advanced BNR WWTP with a TN effluent concentration of 5mg/L (median) at three different flow rates.
  4. Variation of Reuse % for an activated sludge WWTP with a TN effluent concentration of 8 mg/L
  5. Variation of Reuse % for an activated sludge WWTP (TN=8mg/L) with an advanced BNR WWTP (TN=5mg/L) brought online at 2030 with inlet flows split between the two.
  6. Variation of Reuse % for an advanced BNR WWTP with a TN effluent concentration of 5 mg/L

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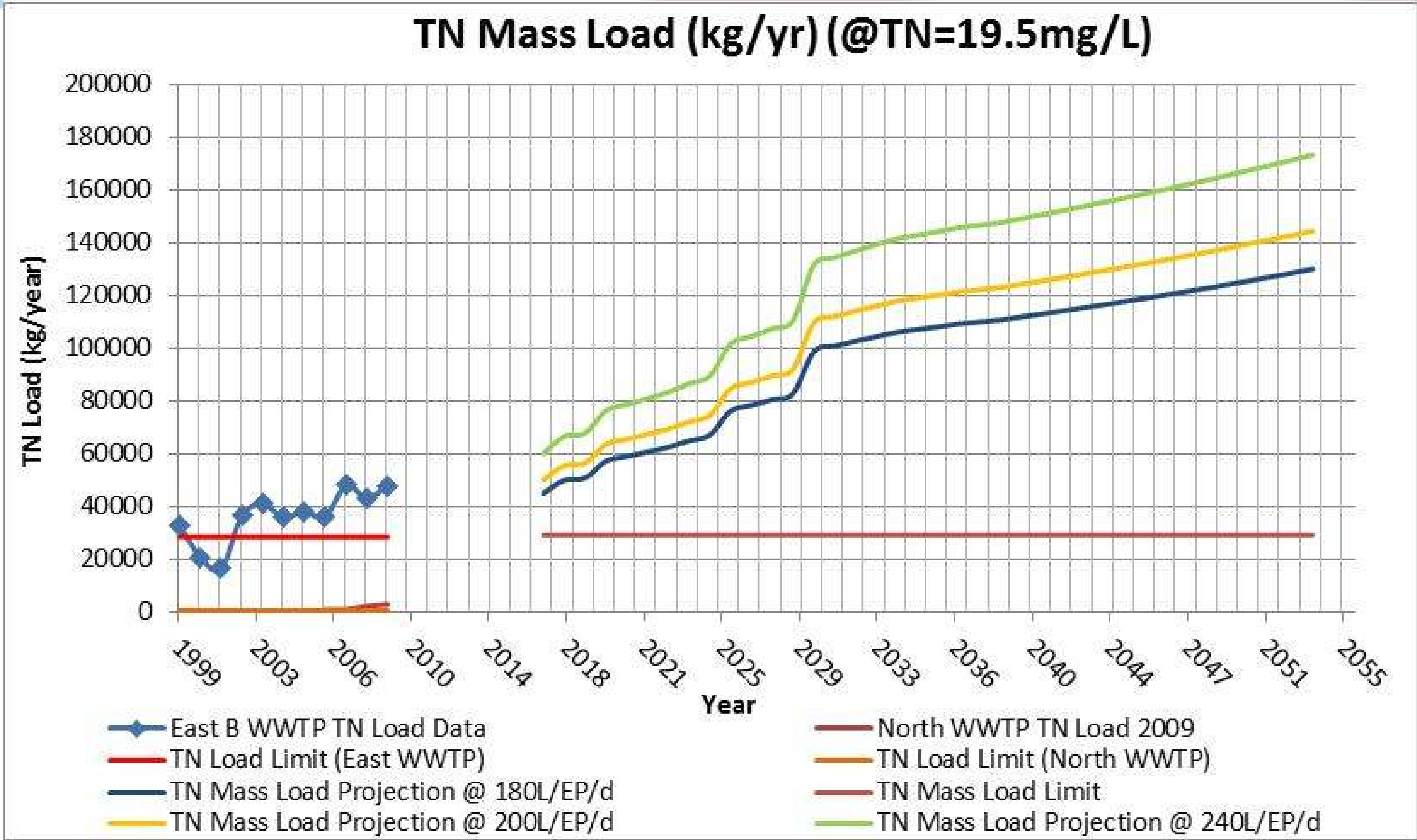
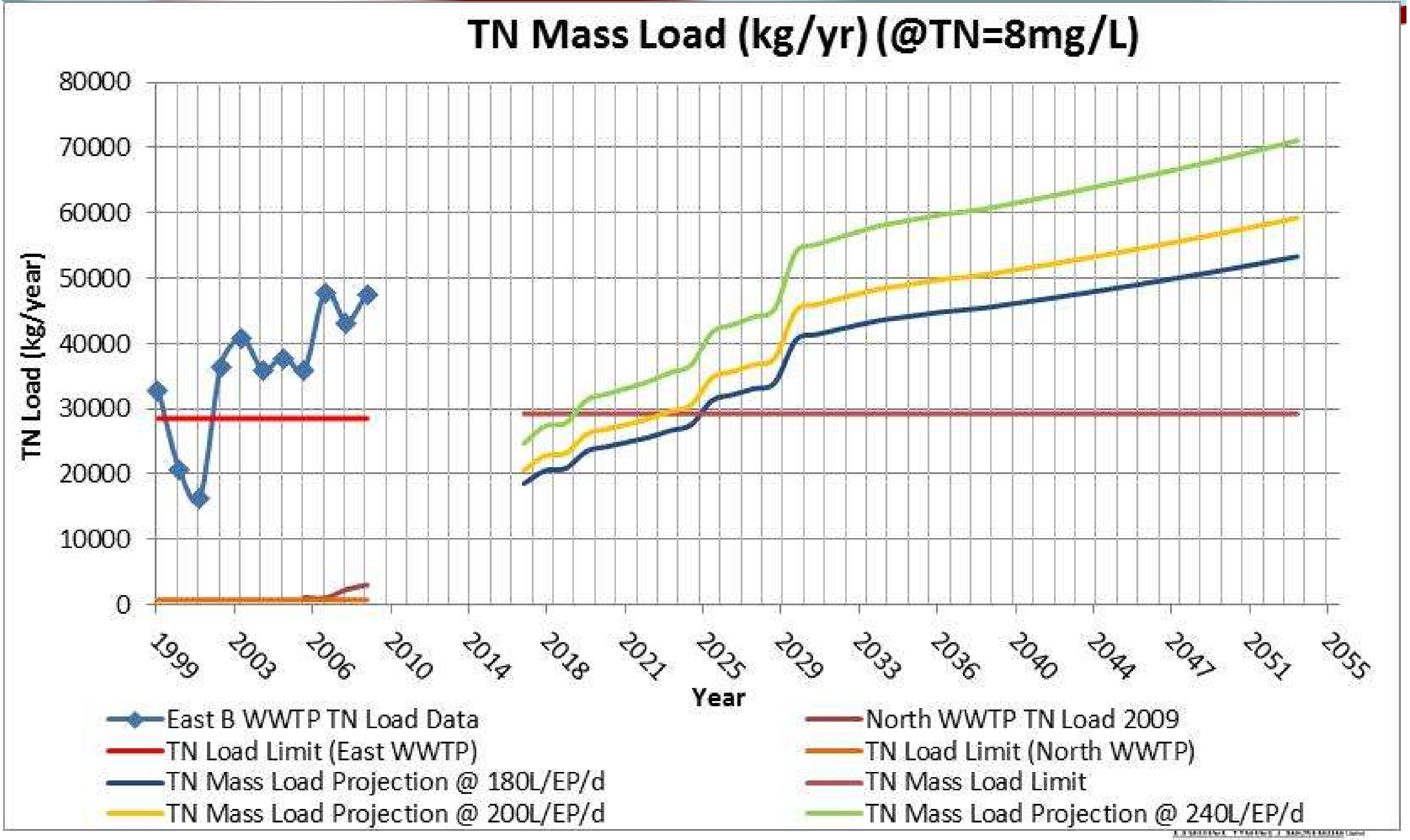
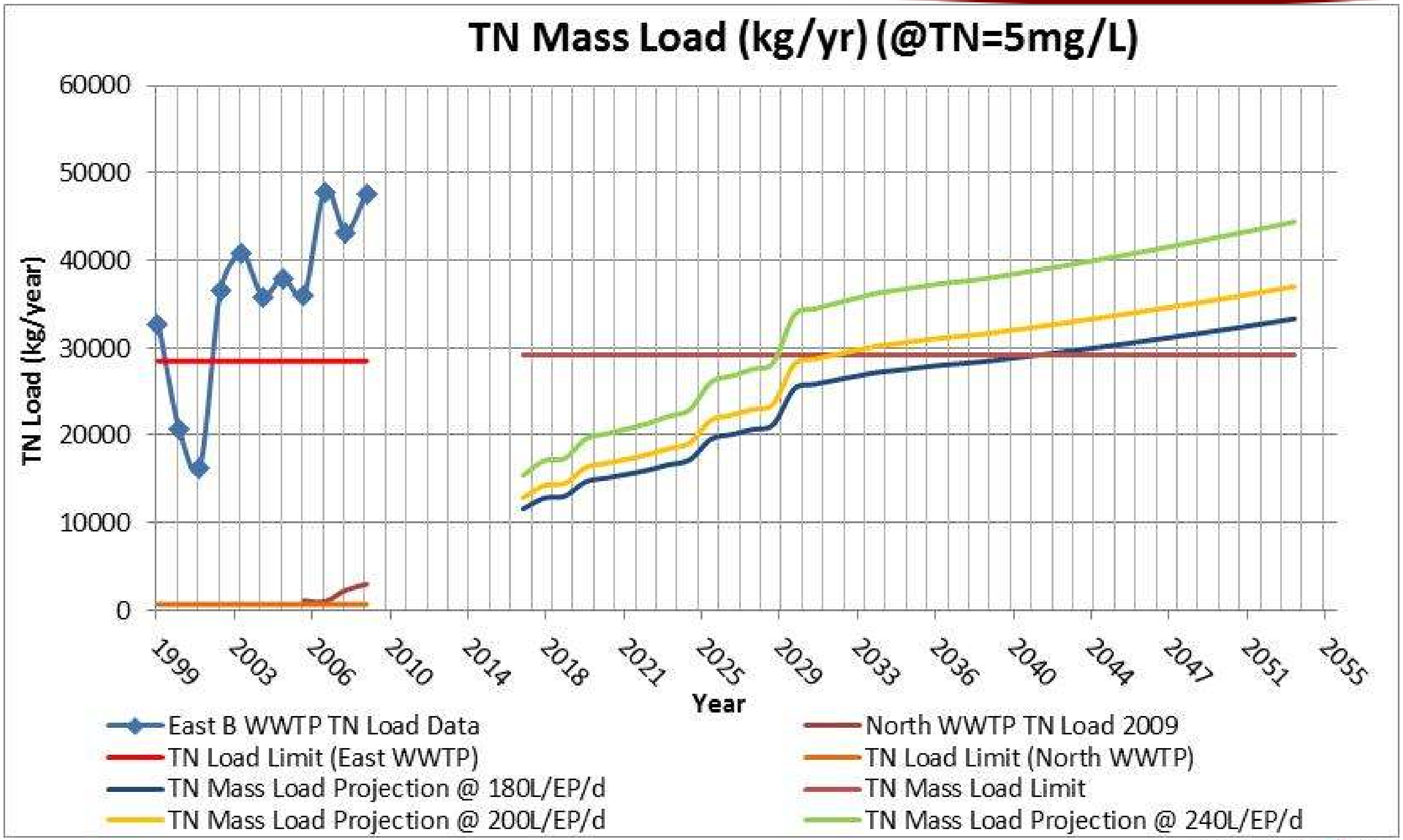
Scenario 1 – TN Mass Load (kg/yr) at TN=19.5mg/L



Scenario 2 – TN Mass Load (kg/yr) at TN=8mg/L



Scenario 3 – TN Mass Load (kg/yr) at TN=5mg/L



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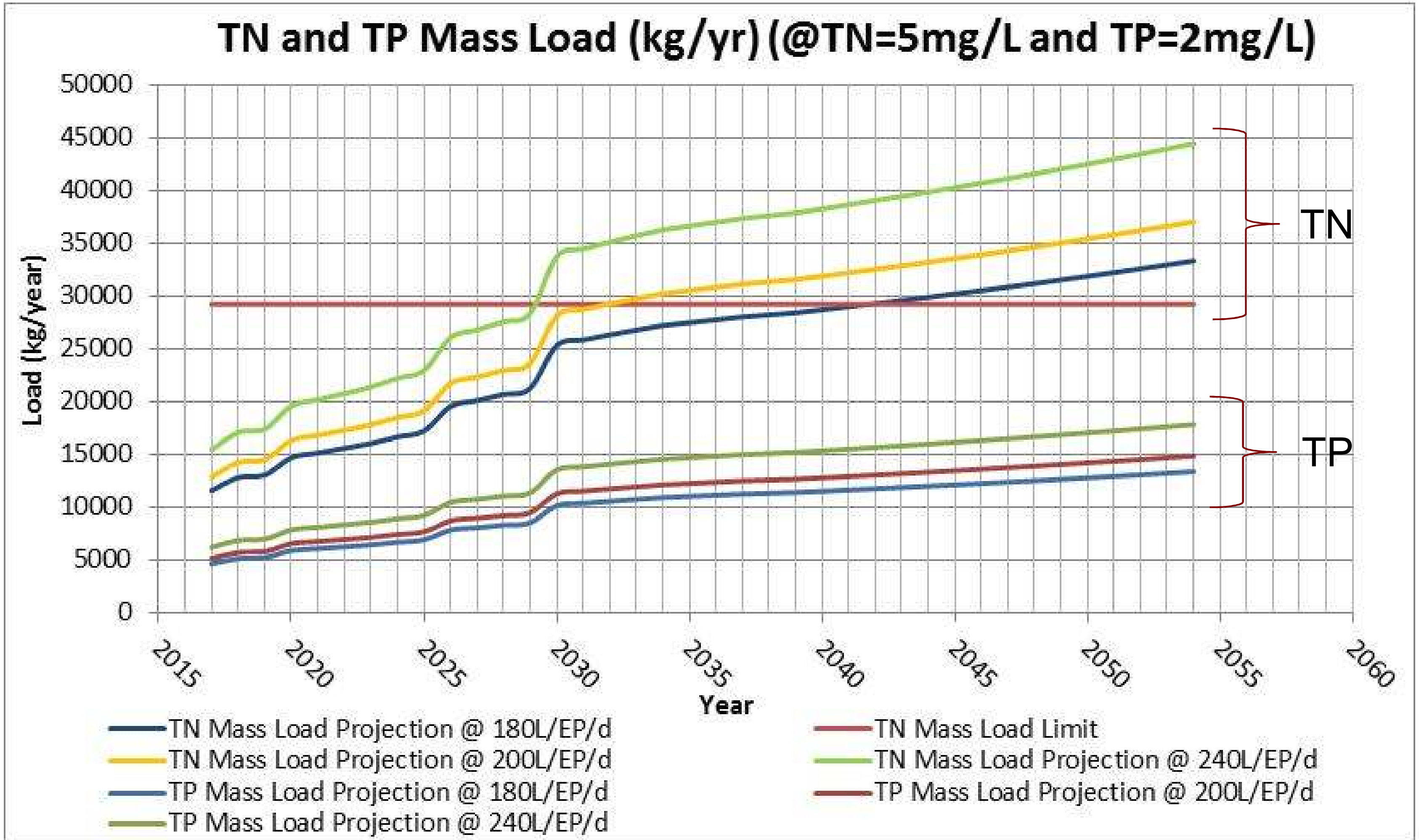
Scenario 3 – TN and TP Mass Load (kg/yr) at TN=5mg/L and TP=2mg/L



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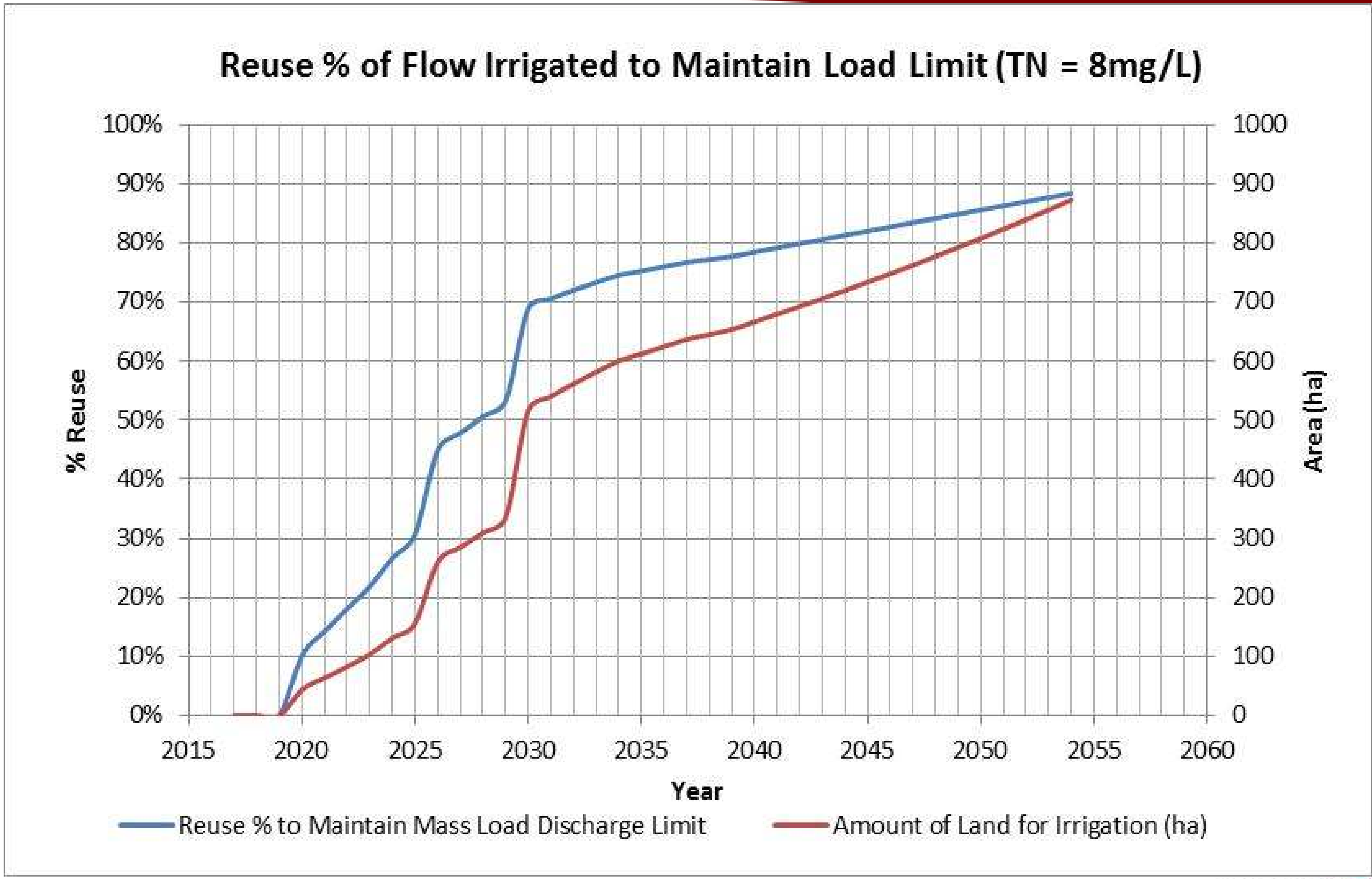
Scenario 4 - Variation of Reuse % TN = 8mg/L



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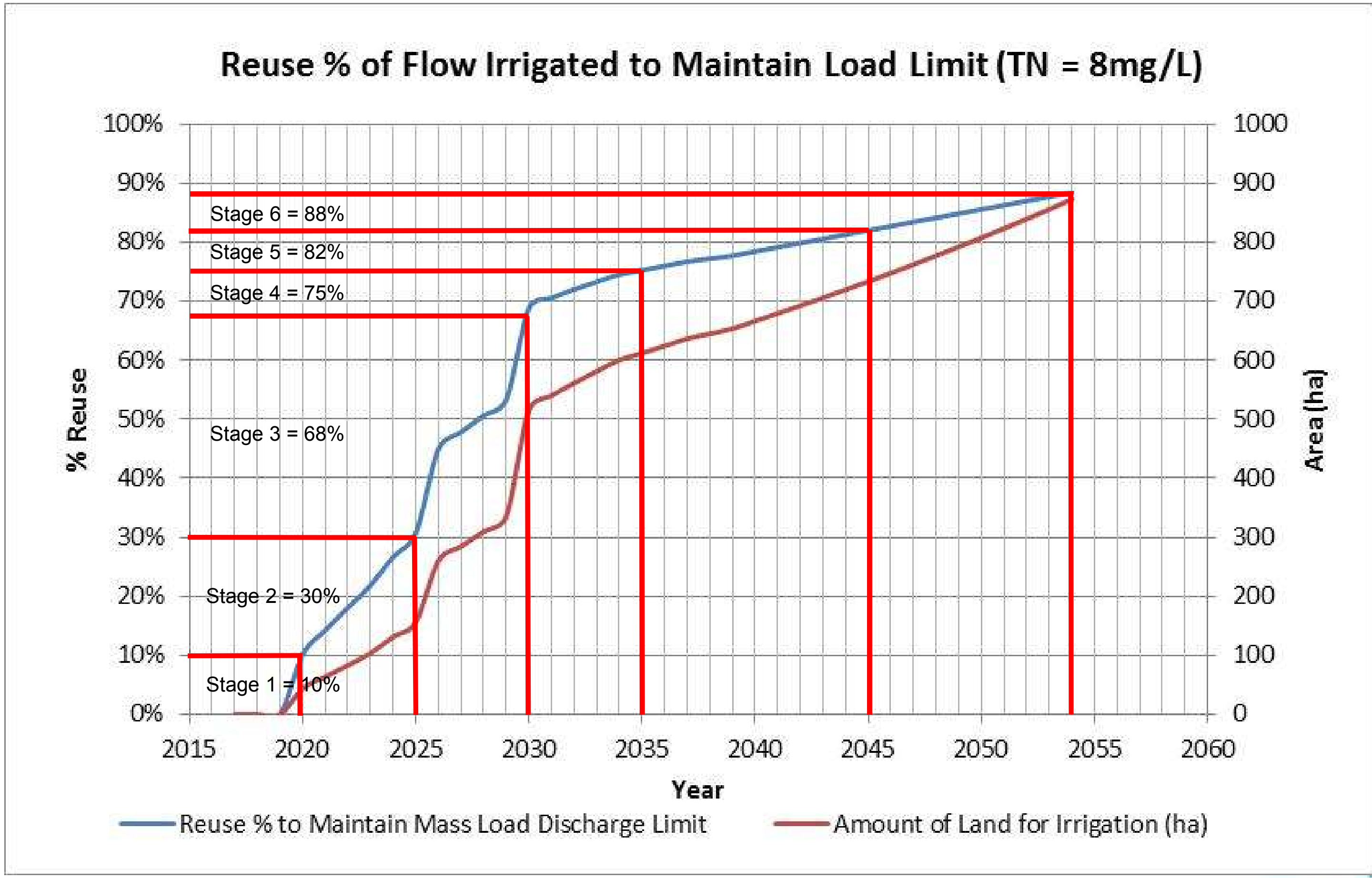
Scenario 4 - Variation of Reuse % TN = 8mg/L

Rather than incrementally increasing the reuse % a staged approach is more realistic, as a sufficient amount of land would be secured to maintain irrigating volumes for 5 to 10 years into the future. Difficulties may arise for a reuse % above 60%. This means by the year 2030 other options to reduce the TN Mass Load may be required.



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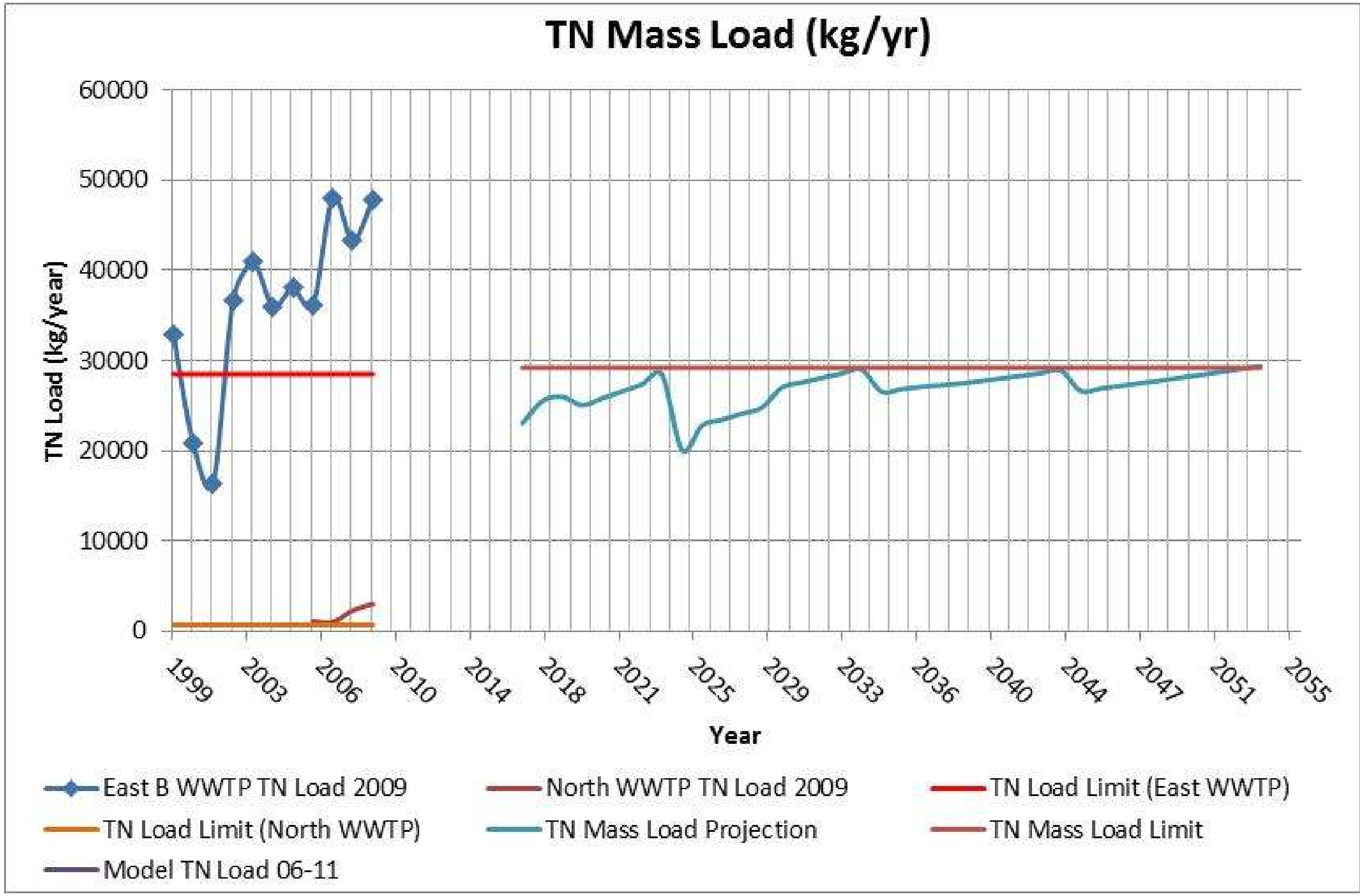
Scenario 4 - Variation of Reuse % TN = 8mg/L

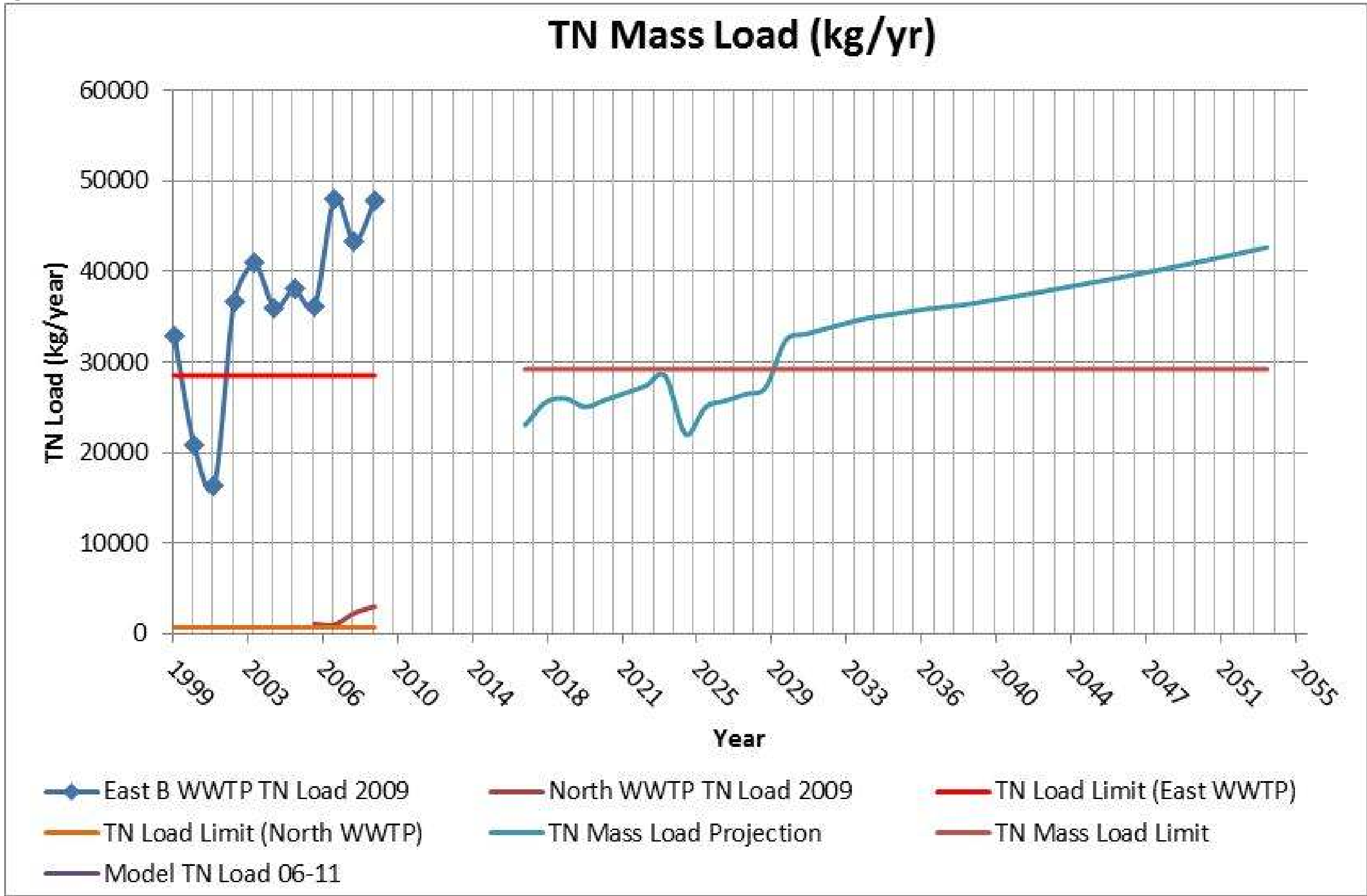
The implementation of the staged irrigation approach into the model develops the following TN Mass Load profile.



Water Australia

Scenario 4 - Variation of Reuse % TN = 8mg/L

If the maximum possible reuse is actually 60% then the TN Mass Load profile will look like this:



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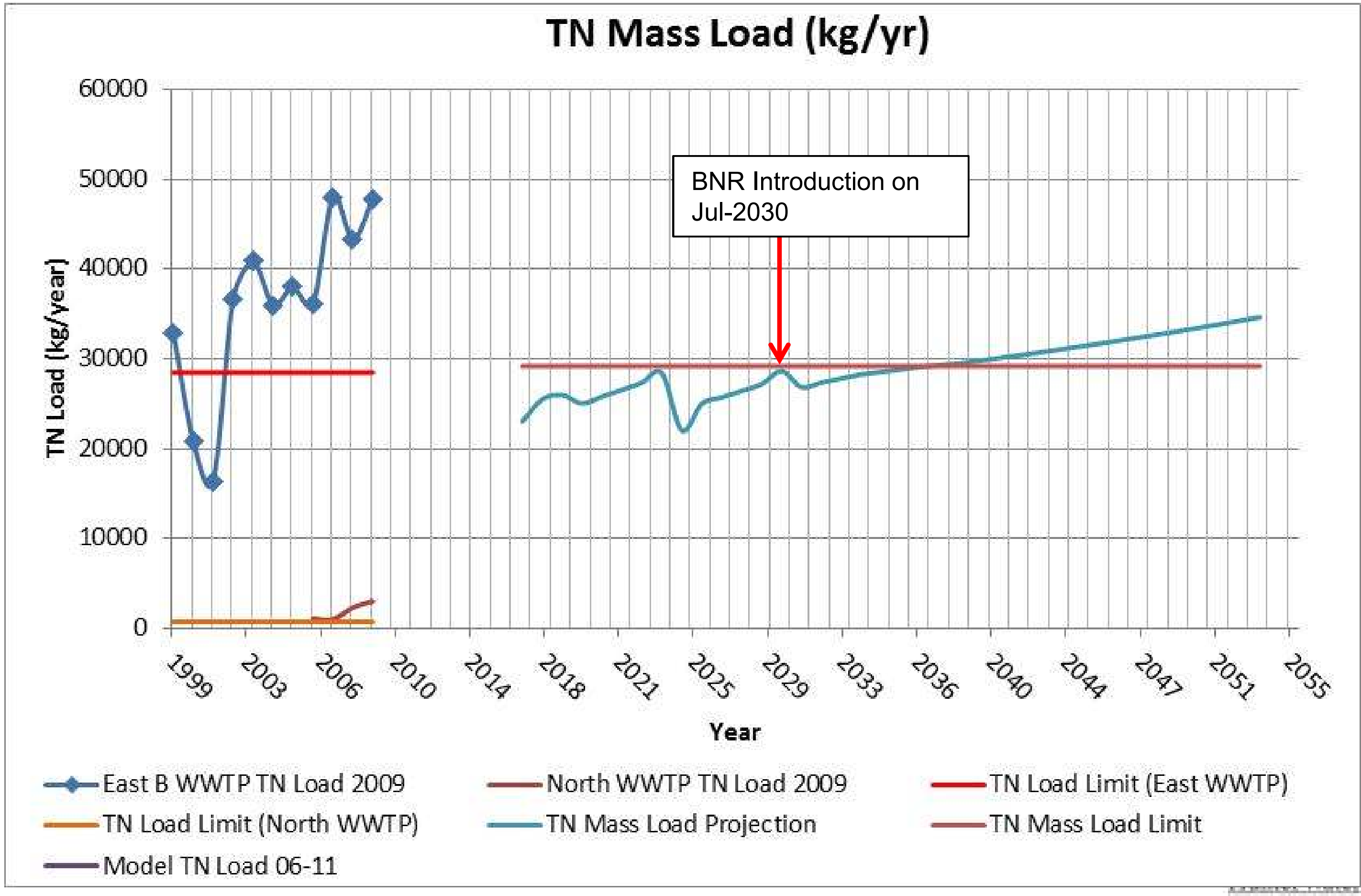
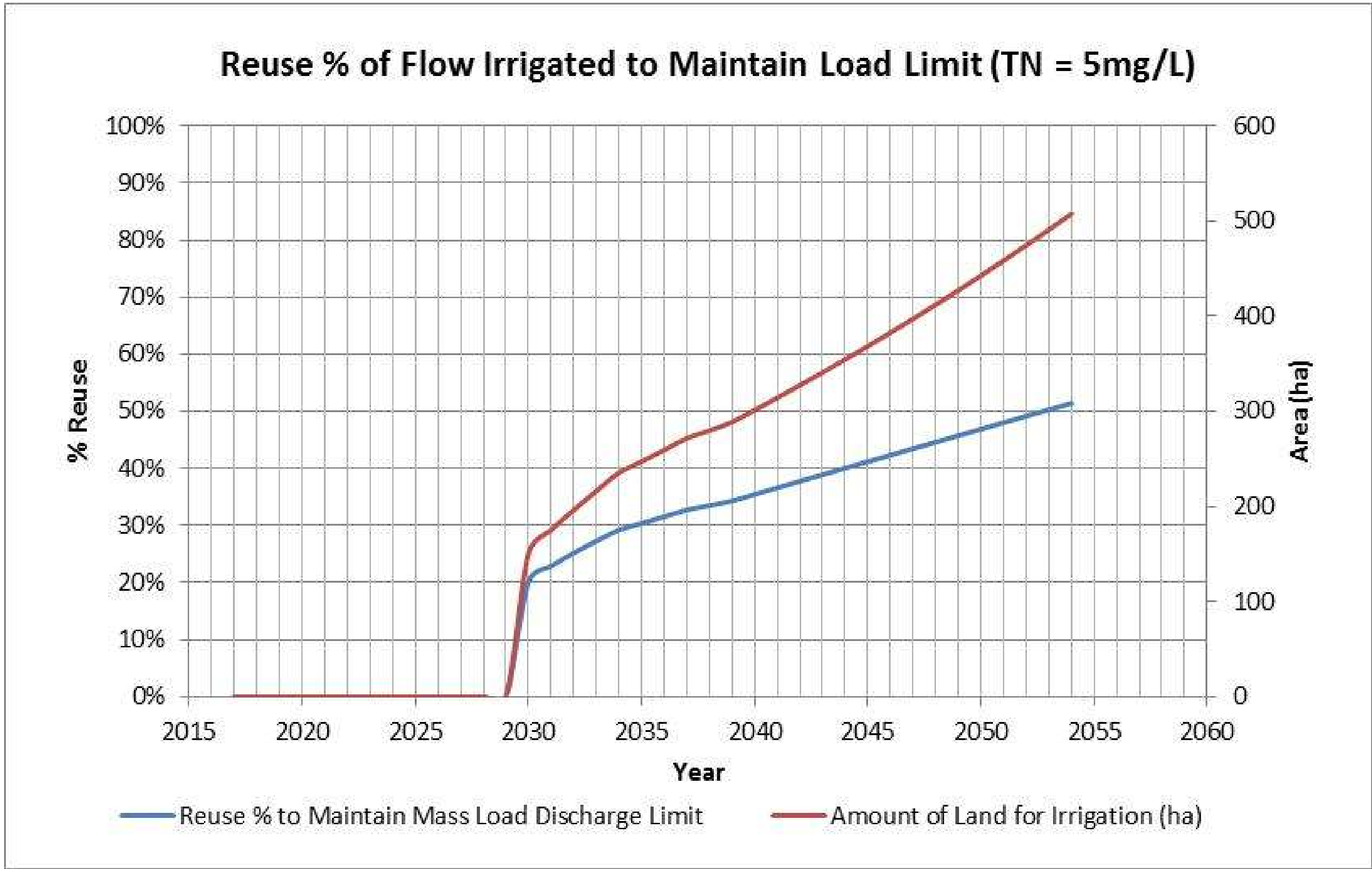
Scenario 5 - Variation of Reuse % TN = 8mg/L & TN = 5mg/L

- Is it possible to use the activated sludge plant with a TN = 8mg/L concentration until 2030 then bring a BNR plant online producing TN = 5mg/L splitting the flows equally between the two?



Scenario 6 – Variation of Reuse % TN = 5mg/L

- What about using a BNR plant from the beginning – and using a irrigation schedule ramping up to 60%?



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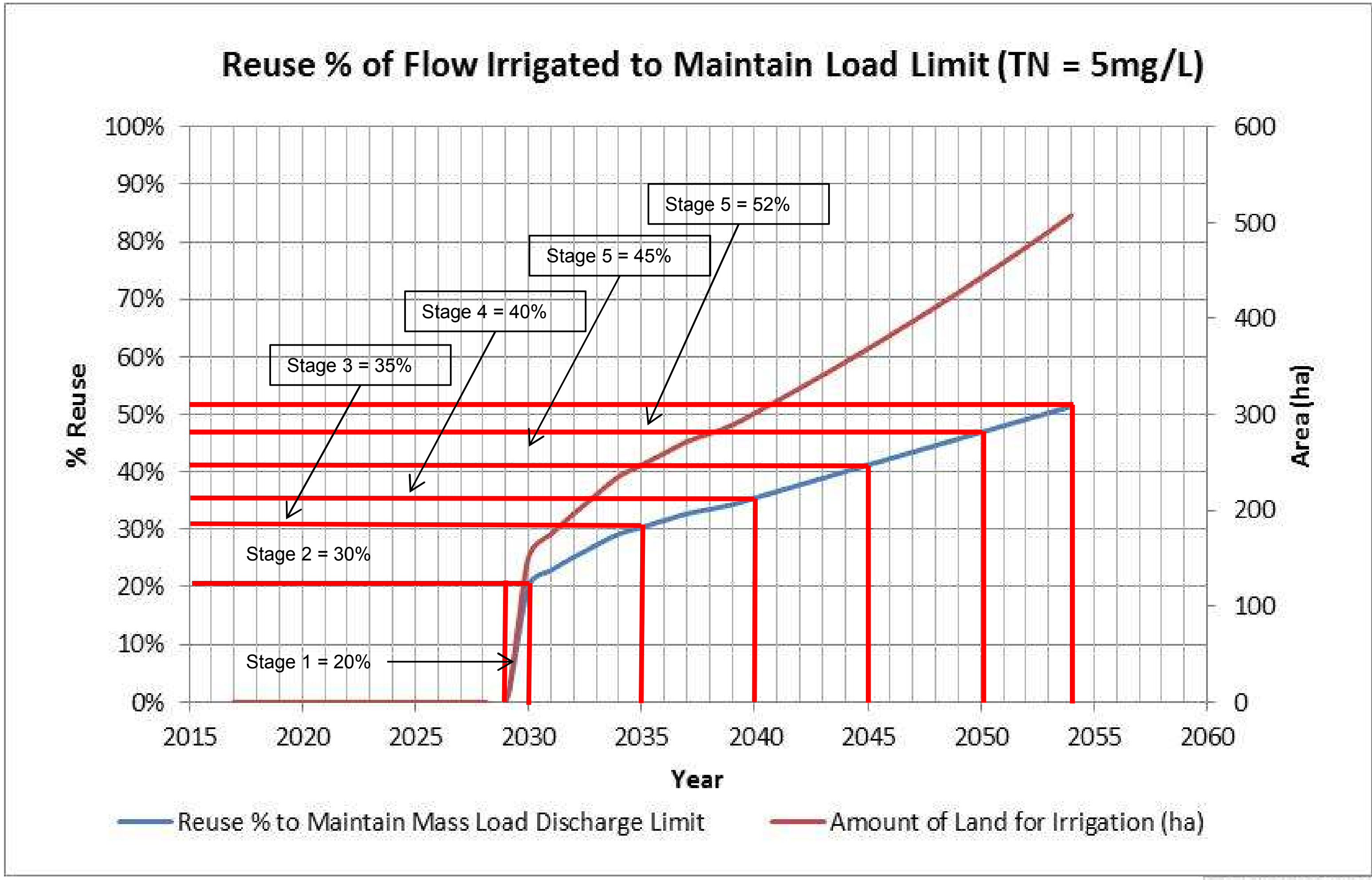
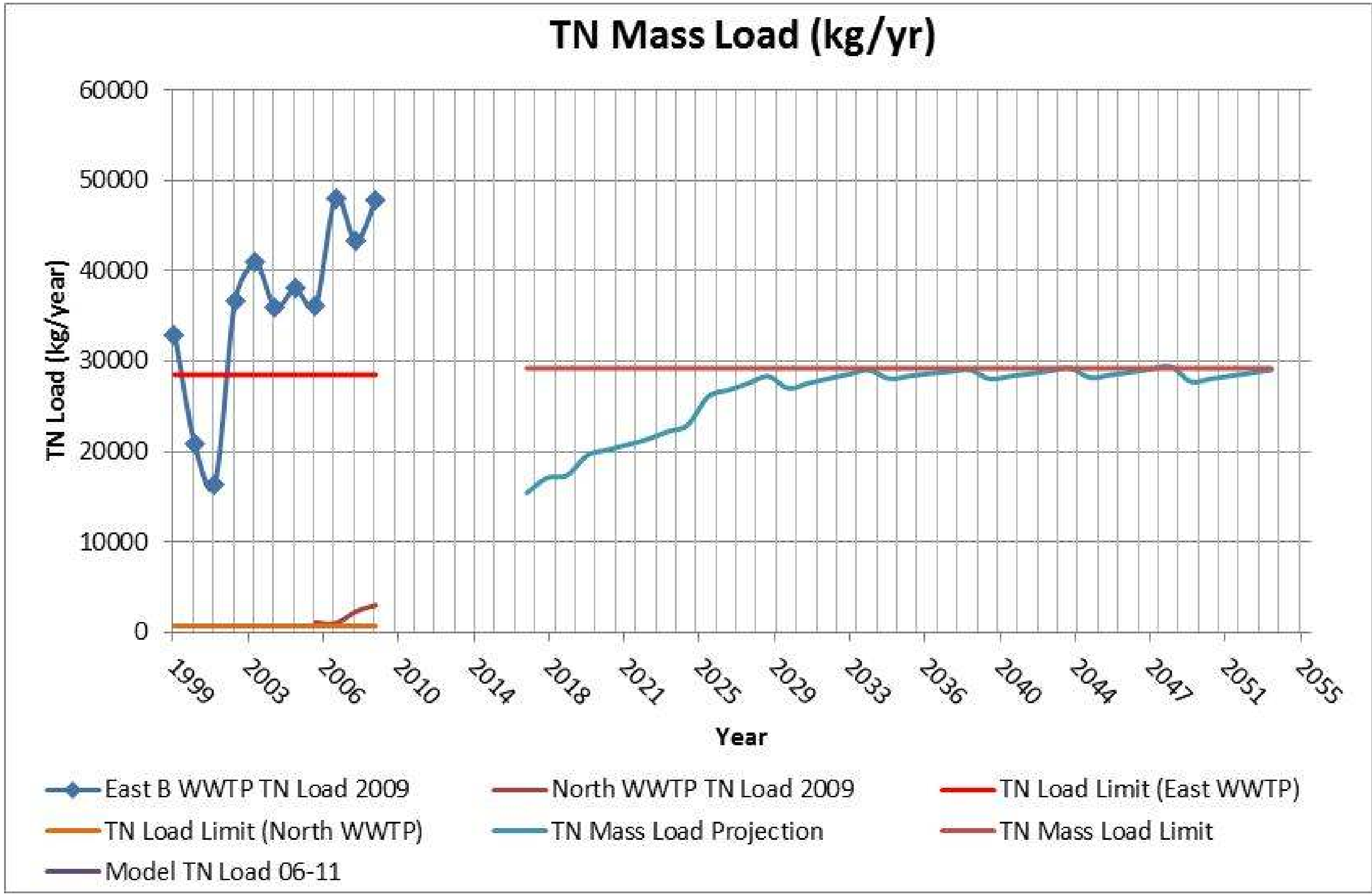
Scenario 6 – Variation of Reuse % TN = 5mg/L

- What about using a BNR plant from the beginning – and using a irrigation schedule ramping up to 60%?



Scenario 6 – Variation of Reuse % TN = 5mg/L

- Using a BNR plant means that no irrigation is required till 2028, as the capacity grows irrigation can be introduced and ramped until 2056.



Summary of Model Outcomes

- Incorporation of water recycling is essential to maintaining total nitrogen loads below the existing mass load limit
- The location of the treatment plant supports reuse for local sugar cane. However there are practical limits to how much recycling can be achieved due to climate and irrigation scheduling.
- It is proposed that the current scheme be developed to target an initial irrigation scheme of 100 ha, increasing to an ultimate 540 ha.
- Based on the load assessment it is recommended that the treatment plant be design as an advanced BNR treatment plant to achieve a TN median of 5 mg/L

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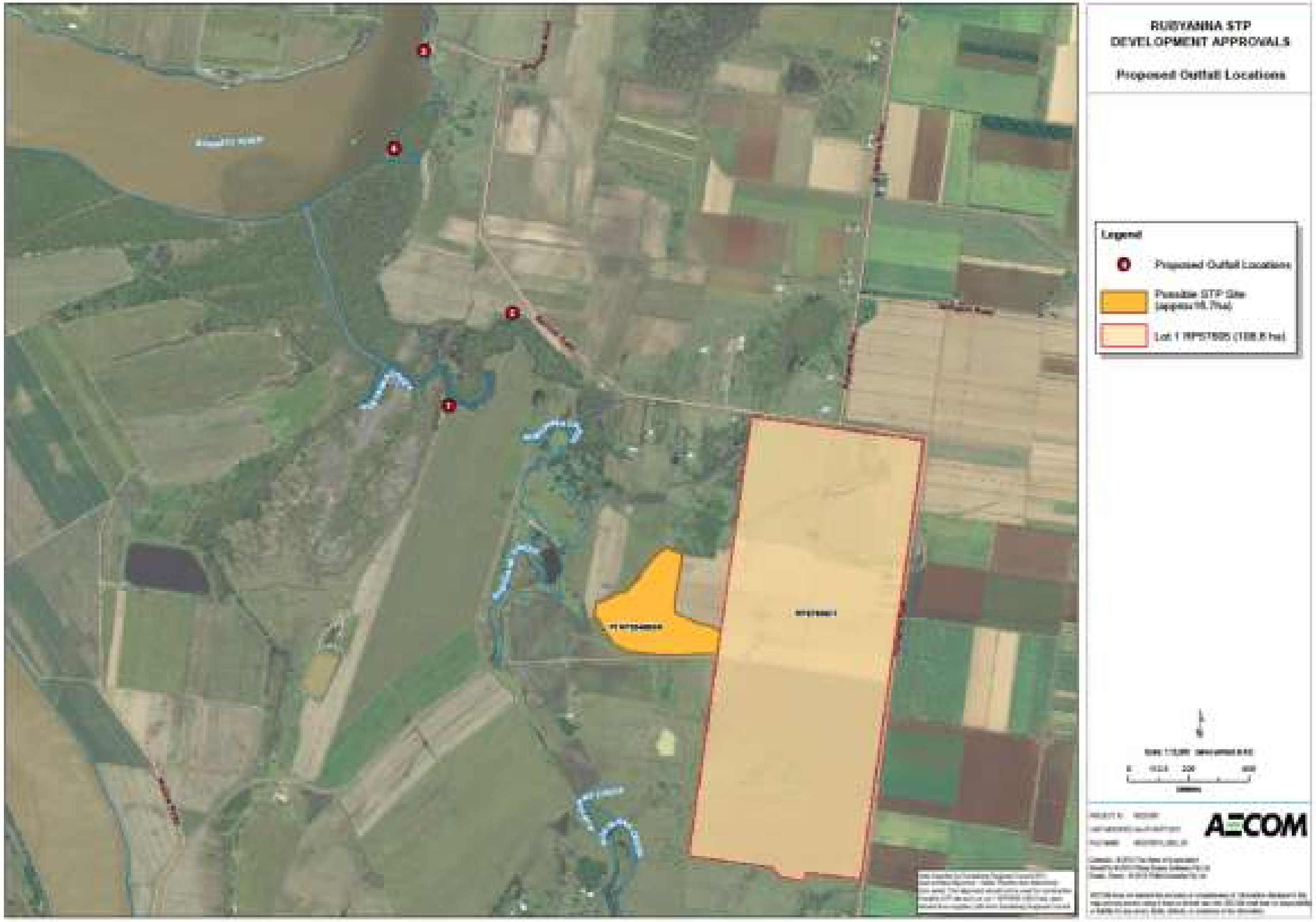
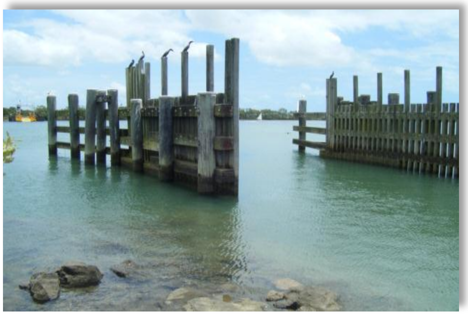
Assessment of Outfall Locations



Appendix N

Effluent Management Strategy



Bundaberg Regional Council

Rubyanna WWTP

Effluent Management Strategy

Final

April 2012

Presented by

Hunter Water Australia Pty Limited

ABN 19080869905

Report Details

Report Title	Rubyanna WWTP Effluent Management Strategy
Project No.	3480-006
Status	Final
File Location	\\ho-fs1\Projects\Bundaberg RC\3480 Rubyanna WWTP Concept Design & DA\2Tasks\Task 6 - Effluent Reuse Strategy\3480 Rubyanna WWTP-Effluent Management Strategy-Rev F.docx

Document History and Status

Revision	Report Status	Prepared by	Reviewed by	Approved by	Issue Date
A	Draft for Client Review	Mark Dawson	David Perry	Draft	15 February 2012
B	Draft 2	Mark Dawson	David Gill (BRC)	Draft 2	23 February 2012
C	Final	Mark Dawson	David Gill (BRC)	Steve Blanshard	27 February 2012
D	Final	David Perry	David Gill (BRC)	Steve Blanshard	23 March 2012
E	Final	David Perry	Tom McLaughlin (BRC)	Mark Dawson	02 April 2012
F	Final	David Perry	Tom McLaughlin (BRC)	Mark Dawson	04 April 2012

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Executive Summary

Introduction

Bundaberg Regional Council (BRC) proposes to construct a new centralised wastewater treatment plant (WWTP) at Rubyanna to replace the ageing infrastructure and provide treatment capacity to service population growth in Bundaberg and the coastal areas. The WWTP will be designed to produce high quality recycled water suitable for agricultural irrigation and will significantly improve the quality of treated effluent discharged to the Burnett River.

The effluent management strategy is to limit the total nitrogen discharge to less than the existing load limit from the Bundaberg East and North treatment plants by expansion of a recycled water sugar cane and crop irrigation scheme in line with increasing load on the WWTP.

Location

BRC has identified a site for the construction of Rubyanna WWTP and has signed an option contract to enable them to purchase the selected site within a two year period subject to approvals and investigations. The location of the site facilitates the expansion of recycled water irrigation over time as well as providing significant buffer distances to neighbouring properties.

Recycled Water Quality

Under BRC's agreement with Bundaberg Sugar, Class A recycled water will be supplied from Rubyanna WWTP for use for sugar cane irrigation. Recycled water will be transfer to Bundaberg Sugar irrigation sites with irrigation taking place as per the current practices.

Class A recycled water provides irrigators with high quality recycled water that does not require restrictive site controls which is viewed as an important issue in positioning recycled water as a similar or superior product to normal irrigation water. This will be a key factor in maximising the irrigator acceptance that will be necessary to achieve high levels of recycled water uptake over time.

Staging

The significant improvement in total nitrogen effluent quality from Rubyanna WWTP compared to the existing WWTPs at East and North Bundaberg enables the average annual nitrogen discharge to be kept below the existing load limit of 29,200 kg/yr until at least 2025. Beyond 2025, water recycling is required.

Three stages of scheme development are:

- Stage A - An area of 250 ha should be secured for a design population of 60,000 EP.
- Stage B - An additional 235 ha should be secured for a design population of 70,000 EP.
- Stage C - An additional area of up to 450 ha will be required to maintain discharge loads below the targets for a design population of 90,000 EP.

The total scheme area required is sensitive to a number of factors.

A 100 ML recycled water storage will be constructed during Stage A of the scheme.

Scheme Overview

Preliminary details of the scheme are outlined below.

- Secondary treatment with disinfection to a standard suitable for discharge to the Burnett River will be the first stage of treatment. The WWTP will include biological nutrient removal, phosphorous removal and disinfection.
- Recycled water will be treated by filtration and further disinfection to meet the requirements for Class A recycled water.
- Recycled water will initially be supplied to land adjacent to the WWTP.

- To maintain nutrient discharge in the average rainfall year to less than the target over the planning horizon will require expansion of the irrigation area over time. Recycled water will be in competition with readily available sources of irrigation water provided by Sunwater.
- A preliminary design of the reticulation scheme has been developed by BRC to facilitate discussion with Bundaberg Sugar and stakeholders.
- A new effluent outfall to Burnett River will be located approximately 8 km from the mouth of the river and approximately 10 km further downstream compared to the location of the existing Bundaberg East WWTP outfall. Plume modelling has been undertaken to provide details on the predicted impact of discharges on water quality.

A schematic of the WWTP and Effluent Management Strategy is shown in Figure E-1

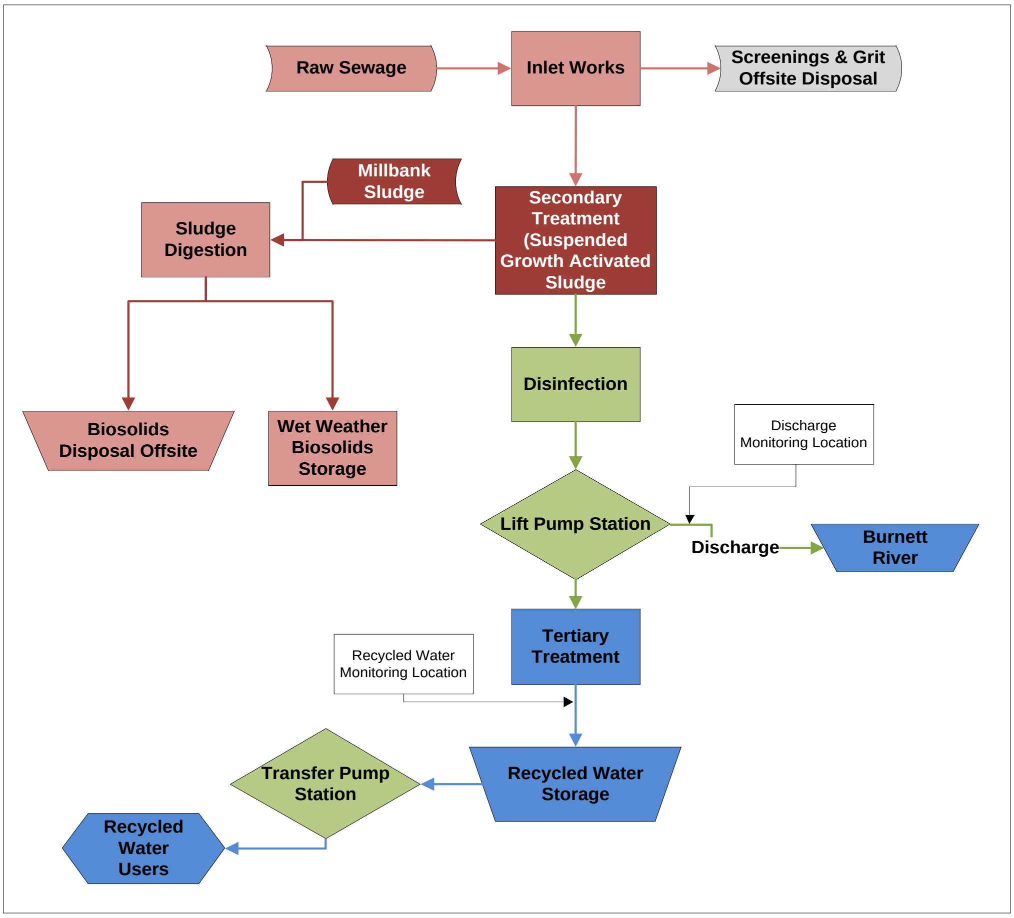

Figure E-1: Rubyanna WWTP -Treatment and Effluent Management Schematic

Risk

There is considerable risk relating to planning for a recycled water scheme with a 40 year planning horizon. This Effluent Management Strategy addresses a number of risks in the following way:

- Even with no recycling in place, average annual nitrogen loads discharged to the Burnett River are projected to be below the loads currently discharged.
- Rubyanna WWTP has been deliberately located in an agricultural zoned area to maximise access to irrigation areas.
- Surrounding sugar cane irrigation areas owned by Bundaberg Sugar provide sufficient area at the current irrigation practice to maintain discharge loads to the Burnett River below the existing limit for a capacity of up to 70,000 EP in an average rainfall year.
- The high quality of effluent from the new WWTP will increase the potential for use on alternative crops.

A formal risk management plan will be developed for the Recycled Water Scheme.

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1 Introduction

1.1 Background

In 2009, Bundaberg Regional Council (BRC) prepared the *Wastewater Treatment and Effluent Management Master Plan* for Bundaberg East and the Bargara coastal region between Burnett Heads and Elliott Heads.

This Master Plan was developed to identify the wastewater infrastructure required to support population growth in the region over the next thirty years and to improve the level of service provided to the community. A staged approach was proposed based on a logical expansion of the sewer network based on population projections for each area to allow the costs associated with meeting the plan objectives to be spread over the planning period.

Bundaberg Regional Council (BRC) proposes to construct a new centralised wastewater treatment plant (WWTP) at Rubyanna to replace the ageing Bundaberg East and North wastewater treatment plants and provide treatment capacity to service population growth in Bundaberg and the coastal areas. The WWTP will be designed to produce high quality recycled water suitable for agricultural irrigation and will significantly improve the quality of treated effluent discharged to the Burnett River.

Rubyanna WWTP will be constructed in two stages, with Stage 1 providing capacity for 50,000 EP and Stage 2 providing capacity to service 90,000 EP.

BRC has identified a 100 hectare cane farm as the site for the construction of Rubyanna WWTP and has an option to purchase the site from Bundaberg Sugar. The central location of Rubyanna WWTP to agricultural land is designed to facilitate the expansion of recycled water use for irrigation over time. The large site area also offers the potential for significant buffer distances to neighbouring properties.

1.2 Location

Bundaberg is a major centre the Wide Bay-Burnett region of Queensland. The city lies on the Burnett River, approximately 385 kilometres north of Brisbane and 15 kilometres inland from the coast.

Rubyanna WWTP and Recycled Water Scheme will be developed approximately ten kilometres north-northeast of Bundaberg as shown in Figure 1-1.

The scheme is located in the irrigation district bounded by the Pacific Ocean and the Burnett River. Irrigated crops in the area include sugar cane, tomatoes, rockmelons, watermelons, capsicum, zucchini, beans, macadamia nuts and avocados (Queensland Competition Authority, 2011).

Figure 1-1: Locality Map

1.3 Climate

Climate statistics for Bundaberg Aerodrome which are representative of the region are shown in Table 1-1.

Table 1-1: Climate Statistics for Bundaberg Aerodrome - Stn 039128

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean Rainfall	169.9	161.8	110.3	58.5	69.9	49.4	40.9	35.3	37.8	71.4	88.9	128.9	1018.9
Median Rainfall	149.1	136.5	83.1	40.7	52.8	29.8	25.2	23.4	34.8	53.4	78.5	99.2	980.3
Mean Max Temp	30.1	29.9	29.1	27.4	24.7	22.6	22	23.3	25.4	26.9	28.3	29.4	26.6
Mean Daily evap	7.1	6.4	6	4.6	3.6	2.9	3.2	4.1	5.2	6.1	6.7	7.1	5.3

Bureau of Meteorology (BOM) data was compared to the input data for the daily water balance model (MEDLI) which was used for reuse scheme modelling as supplied by DERM for the 60 year period 1950-2010 from the SILO database.

Good agreement was observed between the BOM climate records for the sites at Bundaberg Airport (1942- current) and Bundaberg Post Office (1885-1990) and the synthetically derived 60 year duration daily dataset provided by the SILO data drill.

Significant climate parameters in relation to reuse for the Rubyanna scheme are mean rainfall and evaporation as shown in the following figures.

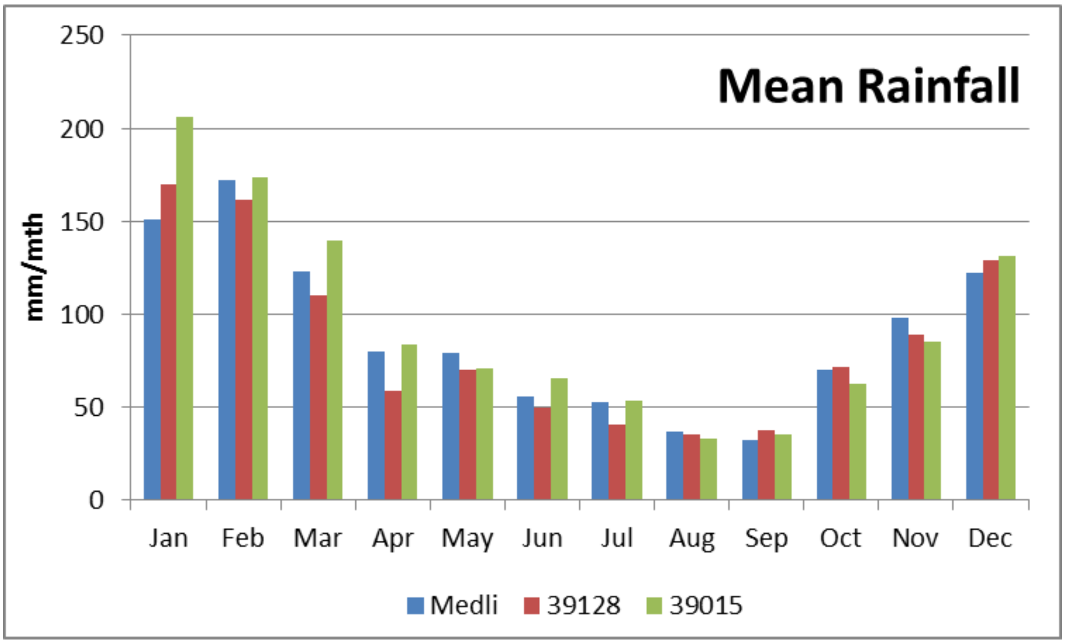

Figure 1-2: Mean Rainfall

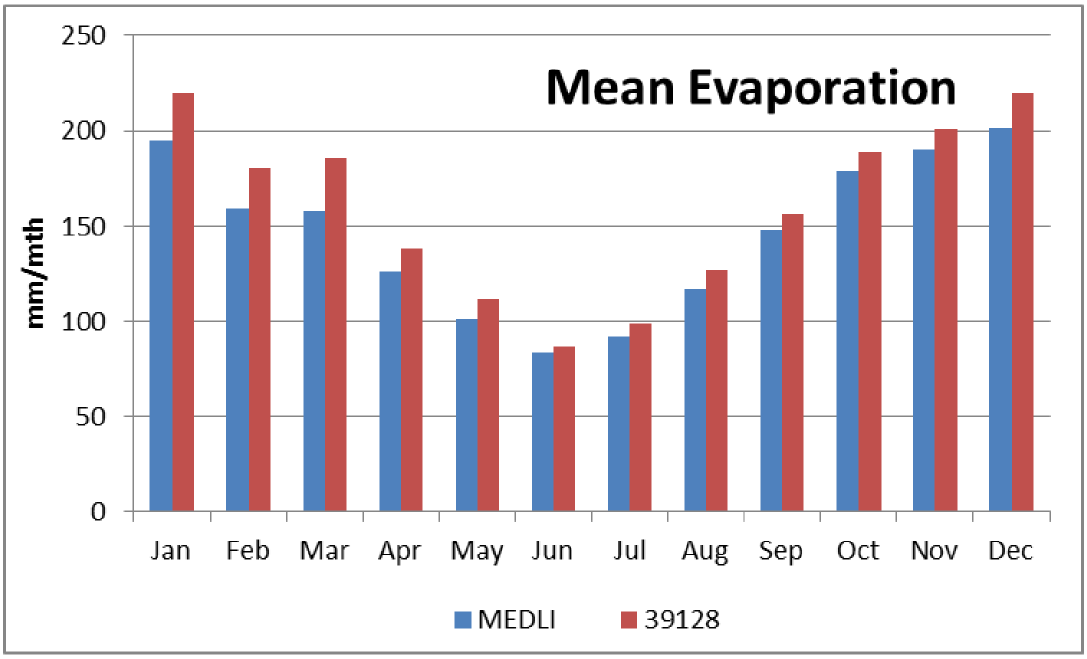

Figure 1-3: Mean monthly pan evaporation

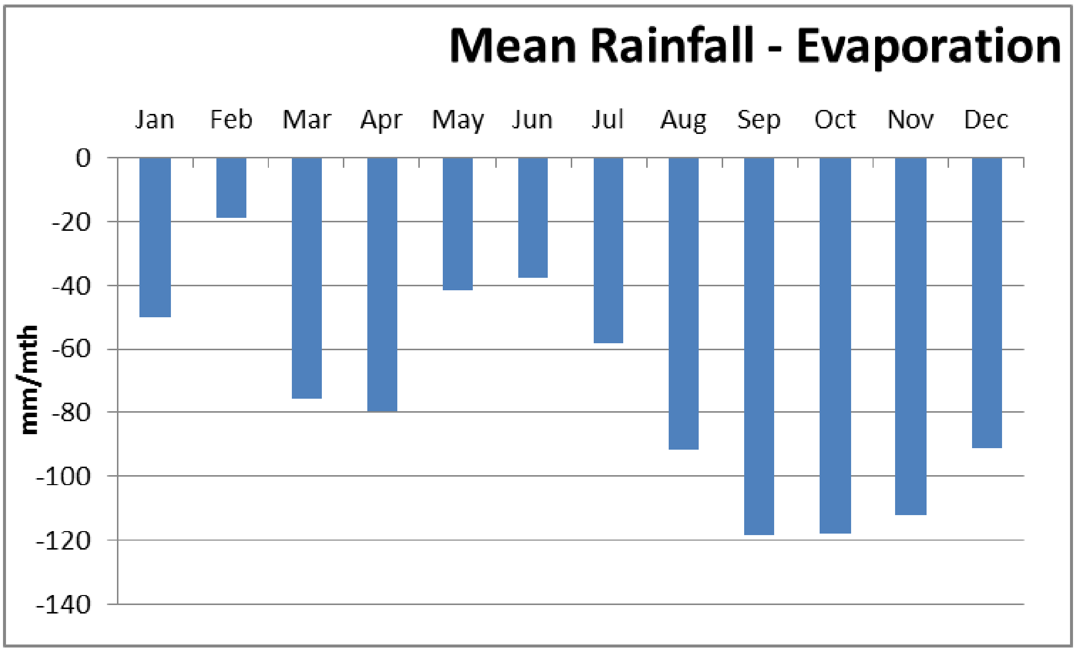

Figure 1-4: Water deficit mean rainfall less mean evaporation for BoM Stn 39128.

1.4 Catchment

Table 1-2 shows indicative timing of the connection of various catchment areas that has been used for planning purposes; the actual timing of the connection of catchment areas will be determined by population growth.

Table 1-2: Projected growth in the population to be served by Rubyanna WWTP

Catchment	Projected Population (EP) 2011 – 2050						
	Stage 1				Stage 2		
	~2017	~2018	~2020	~2024	~2026	~2030	~2050
Bundaberg East WWTP	33,000	33,495	34,507	36,625	37,732	40,047	53,938
North WWTP	-	-	2,000	2,081	2,123	2,209	2,696
Bargara WWTP	-	-	-	-	-	10,000	10,000
Coastal Areas	-	3,000	5,308	8,736	15,772	19,879	24,420
Total Load	33,000	36,495	41,815	47,442	55,627	72,135	91,054

Rubyanna WWTP will service a catchment with a design load of 50,000 Equivalent Persons (EP) at Stage 1. The Stage 2 upgrade will increase the treatment capacity of Rubyanna WWTP to 90,000 EP.

The design flows for Rubyanna WWTP are shown in Table 1-3.

Table 1-3: Design flows

Parameter	Units	Stage 1	Stage 2
Design load (EP)	EP	50,000	90,000
Per Capita Loading Rate	L/EP/d	240	240
ADWF	ML/d	11.6	21.2
PDWF (1.8 x ADWF)	ML/h	0.87	1.6
PWWF (5 x ADWF)	ML/d	58	106
PIF	L/s	670	1,230

1.5 Sewage Characterisation

Recycled water will be produced from sewage sourced from BRC's sewer network. The catchment for Rubyanna WWTP is predominantly residential in nature. Raw sewage characterisation undertaken by Bundaberg City Council in December 2004 is summarised in Table 1-4.

Table 1-4: Raw Sewage characterisation for the Bundaberg area

Parameter[1]	Units	Value	Typical
Chemical Oxygen Demand (COD)	g/EP/d	129	110-145
Biological Oxygen Demand (BOD)	g/EP/d	60	45-72
Total Kjeldahl Nitrogen (TKN)	g/EP/d	9.6	9-14
Total Phosphorus (TP)	g/EP/d	2.2	2-3
Alkalinity[2]	mg $CaCO_3$/L	230	200-300
Ammonia (NH_3)	g/EP/d	7.7	7-11
Total Suspended Solids (TSS)	g/EP/d	60	45-72
Volatile Suspended Solids (VSS)	g/EP/d	50	40-60
Inert Suspended Solids (ISS)	g/EP/d	11	0-20

1 Raw sewage characteristics values were sourced from report: HWA (2009), '*Planning Strategy for Bundaberg's Wastewater plants*'

2 This value will change depending on where the raw water has been sourced in the area. Values for alkalinity have been sourced from the report: HWA (2006), '*Capability Review of Bundaberg's Wastewater Treatment Plants*'

The WWTP design has been developed on the understanding that there are no significant trade waste contributions within the network and that trade waste discharges are limited to those from light industrial and commercial facilities. Wastewater generated from Bundaberg Sugar operations is currently treated using privately owned treatment facilities and is not discharged to sewer.

It is noted that BRC has an appropriate trade waste policy for commercial customers that will be implemented to reduce the risk of trade waste discharges adversely impacting the treatment process.

2 Effluent Management Strategy

2.1 Nutrient Discharge Management

Rubyanna WWTP will be designed to produce high quality recycled water suitable for agricultural irrigation and will significantly improve the quality of treated effluent discharged to the Burnett River.

The recycled water scheme has been devised with the objective of limiting the total nitrogen discharge for the Rubyanna WWTP when operating at 90,000 EP capacity to less than the existing load limit from the Bundaberg East and North treatment plants. The proposed nitrogen load limit for Rubyanna is 29,200 kg/yr.

Figure 2-1 shows the projected total nitrogen that would be discharged to the Burnett River if no water recycling were to occur. The figures shown assume that the Rubyanna WWTP will achieve a median concentration of 5 mg/L total nitrogen consistent with a Biological Nitrogen Removal (BNR) treatment process configuration as proposed in the Concept Design Report. The historic total nitrogen mass discharged from East and North WWTPs is shown as well as the proposed annual total nitrogen load limit for Rubyanna WWTP.

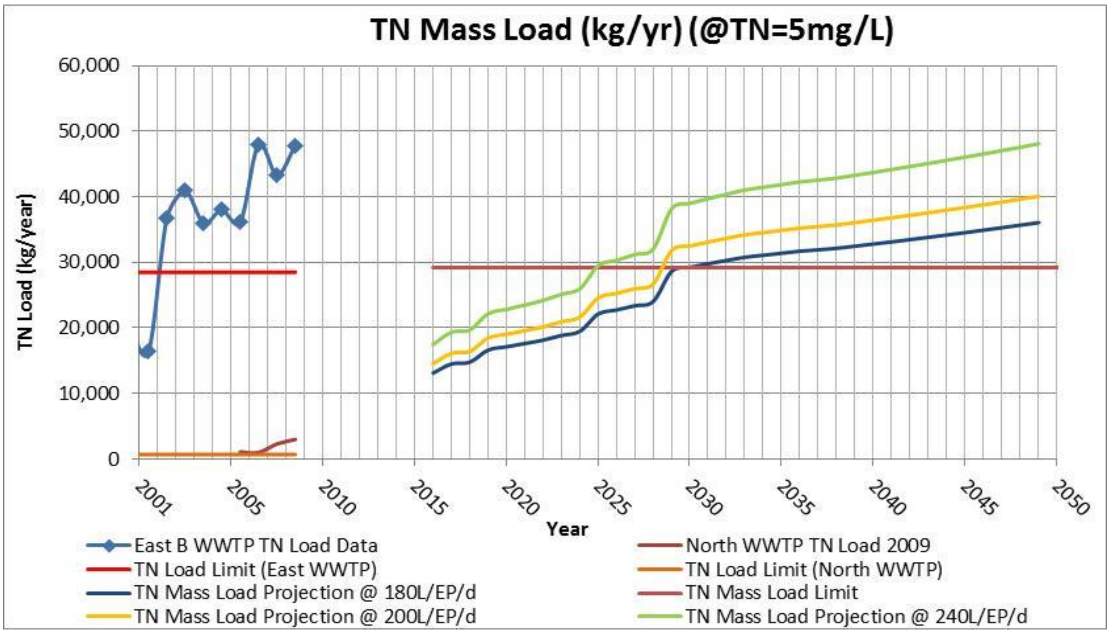

Figure 2-1: Projected total nitrogen mass load discharged to the Burnett River from Rubyanna WWTP with no water recycling in place.

Figure 2-1 shows that the significant improvement in total nitrogen effluent quality from Rubyanna WWTP compared to the existing WWTPs at East and North Bundaberg enables the average annual nitrogen discharge to be kept below the existing load limit of 29,200 kg/yr until at least 2025. Beyond 2025, water recycling is required.

2.2 Recycling Opportunities

BRC is required under the Integrated Environmental Authority to consider and where appropriate minimise release to waters through the use of water demand management, water quality improvements and reuse of treated water for irrigation. The irrigation of crops with recycled water was generally acknowledged in the 2009 Master Plan as being the preferred recycled water reuse opportunity for the region for the following reasons:

- Reuse for agricultural irrigation is in line with DERM policy and the requirements of the

Integrated Authority and is likely to be supported by the regulator and acceptable to the community.

- The proposed WWTP site is within a long established irrigation area and irrigation is expected to remain the major water use in the region. The pervasiveness of irrigation equipment, knowledge, and the existing infrastructure presents a significant opportunity for wide-scale beneficial reuse of treated water.

On this basis, the master plan adopted beneficial reuse of recycled water for irrigation as the preferred reuse opportunity for the strategies developed.

It is acknowledged that there are barriers to achieving the DERM policy target of 90% reuse through irrigation, not least of which are readily available sources of irrigation water already within the district from the Sunwater operated Bundaberg Water Supply Scheme.

Bundaberg Water Supply Scheme is unique in Queensland in that it is the only large-scale irrigation area designed to serve existing farming enterprises. Over 600 kilometers of channel and pipeline distribute irrigation water to over 1,000 properties connected to the surface water scheme.

The Bundaberg Water Supply Scheme (Channel) operates as an on-demand water supply with no water ordering system in place. Distribution of water during times of peak demand, roster periods or restrictions may be required in accordance with the Access Conditions (Sunwater, 2012).

2.2.1 Alternative reuse opportunities

A number of alternative reuse opportunities were identified but discounted due to the complexity of gaining the necessary approvals and community consensus. These alternative opportunities are not included in the development of the strategy but include:

- Managed Aquifer Recharge
- Aquifer Storage and Recovery (ASR)
- Managed Wetland Schemes
- Dual Reticulation

2.2.2 Bundaberg Sugar Sites

Bundaberg Sugar is a grower, miller, refiner, and marketer of sugar and related products in Australia. The company is Queensland's largest cane grower and owns and operates sugar mills in Queensland.

BRC has identified a 100 hectare cane farm as the site for the construction of Rubyanna WWTP and has an option to purchase the site from Bundaberg Sugar. Bundaberg Regional Council has signed an option contract to enable them to purchase the selected site within a two year period subject to approvals and investigations. The contract includes an agreement from Bundaberg Sugar to take recycled water for irrigation. The location of the site with respect to agricultural land is designed to facilitate the expansion of recycled water use for irrigation over time. The large site area also offers the potential for significant buffer distances to neighbouring properties.

Bundaberg Sugar operates existing irrigation schemes on a number of cane farms surrounding the proposed Rubyanna WWTP site. A number of Bundaberg Sugar properties close to the WWTP site were determined as being not suitable or not available due to either prior commitment or proximity to environmentally sensitive areas.

For any site, the available irrigation area is limited to 75-80% of total area due to site roads and fallow fields. The total of the available area of the Bundaberg Sugar sites for irrigation with recycled water is detailed in Table 2-1. The location of the suitable sites is shown in Figure 2-2.

Table 2-1: Bundaberg Sugar properties and area available for recycled water use

Site Number	Site Name	Site Area (ha)	Effective Area (ha)
8301	Barron	130	105
9953	Rubyanna	80	65
9769	Spring Hill	95	80
9304	Qunaba	133	100
9355	Bull Paddock	40	30
9785	Grange	140	105
Total			485

Figure 2-2: Bundaberg Sugar Irrigation Areas

2.3 Area required to meet Recycled Water Production

In Bundaberg, the average annual crop water requirement of sugar cane is some 1360 mm with 580 mm normally supplied by effective rainfall and 780 mm (7.8 ML/ha) required by irrigation (Holden, 1998).

As a comparison, effluent reuse modelling was carried out using the daily time-step effluent reuse model MEDLI. Medli modelling predicts an average annual irrigation demand of 4 to 6 ML/ha/yr for sugar cane in the Bundaberg area with variability due to soil characteristics and irrigation scheduling. Results of Medli modelling are contained in Appendix C. Note that the connected EP, areas and storage volumes shown for Medli modelling do not strictly align with the Staging described in Section 2.5.1 and care must be used when comparing Medli results to the results below.

Bundaberg Sugar has advised (*Simon Doyle, Bundaberg Sugar. pers. comm. 8 Sept 2011*) that an application rate of 4 ML/ha/yr should be adopted for recycled water irrigation of their sites. This rate is somewhat lower that the theoretical maximum application rate however this conservatism serves to ensure that risk of hydraulic or nutrient overloading of the irrigation site is avoided. Subsequent calculations are based on this limitation. Details of calculations are contained in Appendix B.

Figure 2-3 shows the required reuse % (expressed as a % of dry weather flows) and the irrigation land area required to maintain total nitrogen discharges to the less than the current limit for the average rainfall year. The calculations assume an effluent mean total nitrogen of 5 mg/L and an annual recycled water irrigation rate of 4 ML/ha.

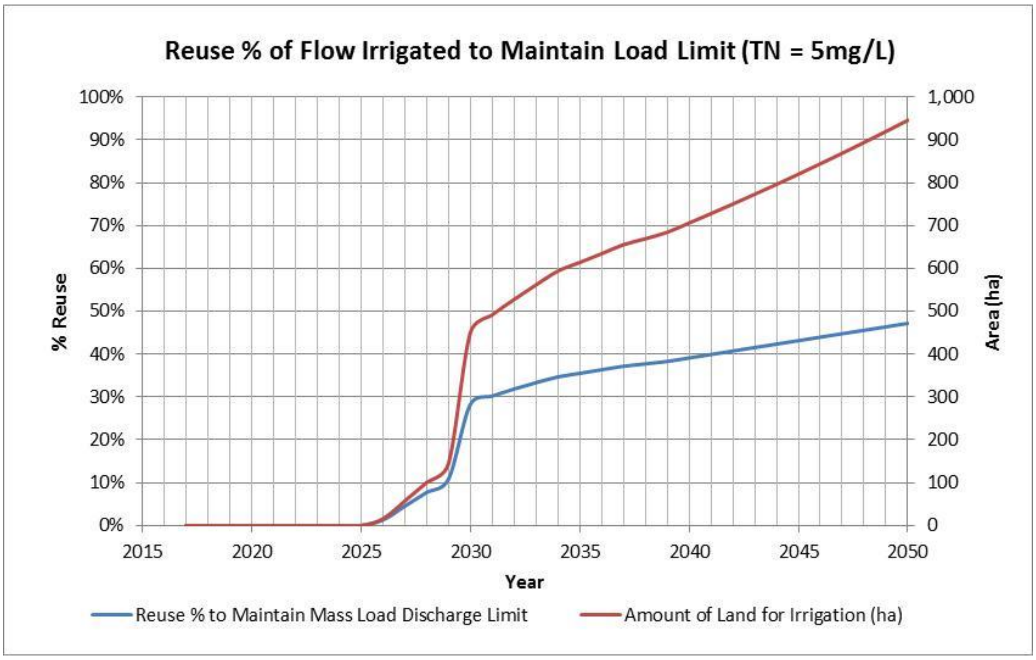

Figure 2-3: Required reuse % and irrigation land area to maintain nitrogen discharge below the proposed nitrogen mass limit for Rubyanna WWTP.

2.4 Recycled Water Quality

2.4.1 Recycled Water Quality Guidelines

From 1 July 2008, all recycled water providers in Queensland are to meet the requirements of the *Water Supply (Safety and Reliability) Act 2008* (the Act). The regulator for the Act is the Office of the Water Supply Regulator (OWSR), which forms part of the Department of Environment and Resource Management.

Health aspects of recycled water use are regulated separately by Queensland Health. The *Public Health Regulation 2005* prescribes the minimum standards for water quality for recycled water used for dual reticulation or the irrigation of minimally processed food crops. The regulation also defines the requirements of the different recycled water classes (A+, A, B, C & D).

Whereas previously, the requirements for recycled water schemes were outlined in guideline documents, the Act and Public Health Regulation 2005 bring these requirements into law. Both the Act and the Public Health Regulation relate to the water quality requirements to protect human health; the requirements to protect the environment remain the responsibility of DERM (the former EPA).

OWSR may recommend that BRC prepare a basic Recycled Water Management Plan for the scheme for their use as a management tool. The RWMP could be developed to contain Council's obligations on monitoring and reporting, support programs etc. in the one place.

Chapter 3 of the Australian Guidelines for Water Recycling – Phase 1 (2006) describes treatment processes and on-site controls for designated uses of recycled water. Table 3.8 AGWR provides guidance on the likely treatment requirements.

Many horticultural crops grown in the region are classified as minimally processed food crops and require wastewater to be treated to a Class A or A+ standard. Sugar cane is not classified as a minimally processed food crop and the does not have a disinfection standard under the *Public Health Regulation 2005*. In this case, BRC are required to prepare a risk assessment of the scheme. The risk assessment is to be used to establish the level of disinfection to be provided by the treatment plant, taking into account the intended uses of recycled water and other control measures that reduce the likelihood of exposure that form part of the scheme (e.g. restrictions on public access during irrigation). Other sugar cane irrigation schemes in Queensland have adopted a Class B effluent standard.

2.4.2 Why Adopt Class A Recycled Water?

Under BRC's agreement with Bundaberg Sugar, Class A recycled water will be supplied from Rubyanna WWTP for use for sugar cane irrigation.

The current proposal is for recycled water from Rubyanna WWTP to be transferred to irrigation sites with sugar cane irrigation taking place as per the current practices by using travelling gun irrigators or drip irrigation.

While the use of recycled water for irrigation will take place on private property, it is recognised that irrigation can result in spray drift and that irrigation areas are often adjacent to public areas. As such, it is proposed that water recycling facilities at Rubyanna WWTP include tertiary treatment designed to provide a high level of disinfection that is equivalent to the standard required for municipal irrigation with unrestricted access under the Australian Guidelines for Water Recycling 2006 as shown in Table 2-2.

Table 2-2: Log reduction targets for commercial food crop irrigation with unrestricted access (adapted from the Australian Guidelines for Water Recycling 2006)

Log Reduction Targets for Treatment	On-site Preventive Measures	Water Quality Objectives
Virus 5.0 Protozoa 3.5 Bacteria 4.0	Treatment plant design assumes no specific on-site measures are employed to reduce exposure.	To be determined based on technology. May include ▪ Turbidity ▪ Disinfectant Ct ▪ UV transmissivity and dose

Class A with the tertiary treatment standard in Table 2-2 provides irrigators with high quality recycled water that does not require additional site controls such as:

- Restriction on public access during irrigation;
- Minimum 25–30 m buffer to nearest point of public access; or
- Spray drift control; for example, through low-throw sprinklers (180° inward throw), vegetation screening, or anemometer switching

This avoidance of restrictive site controls is viewed as an important issue in positioning recycled water as a similar or superior product to normal irrigation water and is seen as a key factor in maximising the irrigator acceptance that will be necessary to achieve high levels of recycled water uptake over time.

The requirements for Class A recycled water as defined in the Public Health Regulation 2005 are summarised in Table 2-3.

Table 2-3: Class A recycled water requirements (Schedule 3D Public Health Regulation, 2005)

Monitoring Point	Parameter	Sample Limits	Annual Value	Frequency of sampling
Sample point prior to transfer to Bundaberg Sugar [1]	*E.Coli*	Trigger value for resample > 100 cfu/100 mL Requirement for follow-up sample < 10 cfu/100 mL	< 10 cfu/100 mL in 95% of the samples collected over 12 months	Weekly

[1] The monitoring point will be located as close as practical to the point where the recycled water is transferred to the reuse storage.

The decision to produce Class A recycled water also provides the recycled water scheme with the flexibility to provide recycled water for the irrigation of crops other than sugar cane. Classes for horticultural crops reported grown in the region are shown in Table 2-4.

Table 2-4: Recycled Water Class for minimally processed food crops (Schedule 3E Public Health Regulation 2005)

Crop	Drip Irrigation	Spray Irrigation	Subsurface Irrigation
Sugar cane	B	B	B
Tomatoes	A+	A+	C
Rockmelons	C	B	C
Watermelons	A+	A+	C
Capsicum	A	A+	C
Zucchini	A	A+	C
Beans	A	A+	C
Macadamia nuts	C	B	C
Avocados	C	B	C

The nutrient concentrations in the recycled water are anticipated to be similar to the values outlined in Table 2-6 (i.e. median 5N/2P). It is not intended to produce water with higher nutrient concentrations for reuse.

2.5 Scheme Overview

Bundaberg Regional Council has entered into an arrangement with Bundaberg Sugar to provide a portion of the effluent as Class A recycled water for beneficial reuse for sugar cane irrigation. This effluent will also be available to other irrigators.

The details of the recycled water scheme will need to be developed in consultation with irrigators. Details of the storage volume and reticulation network are still being developed, but preliminary details of a possible scheme are outlined below.

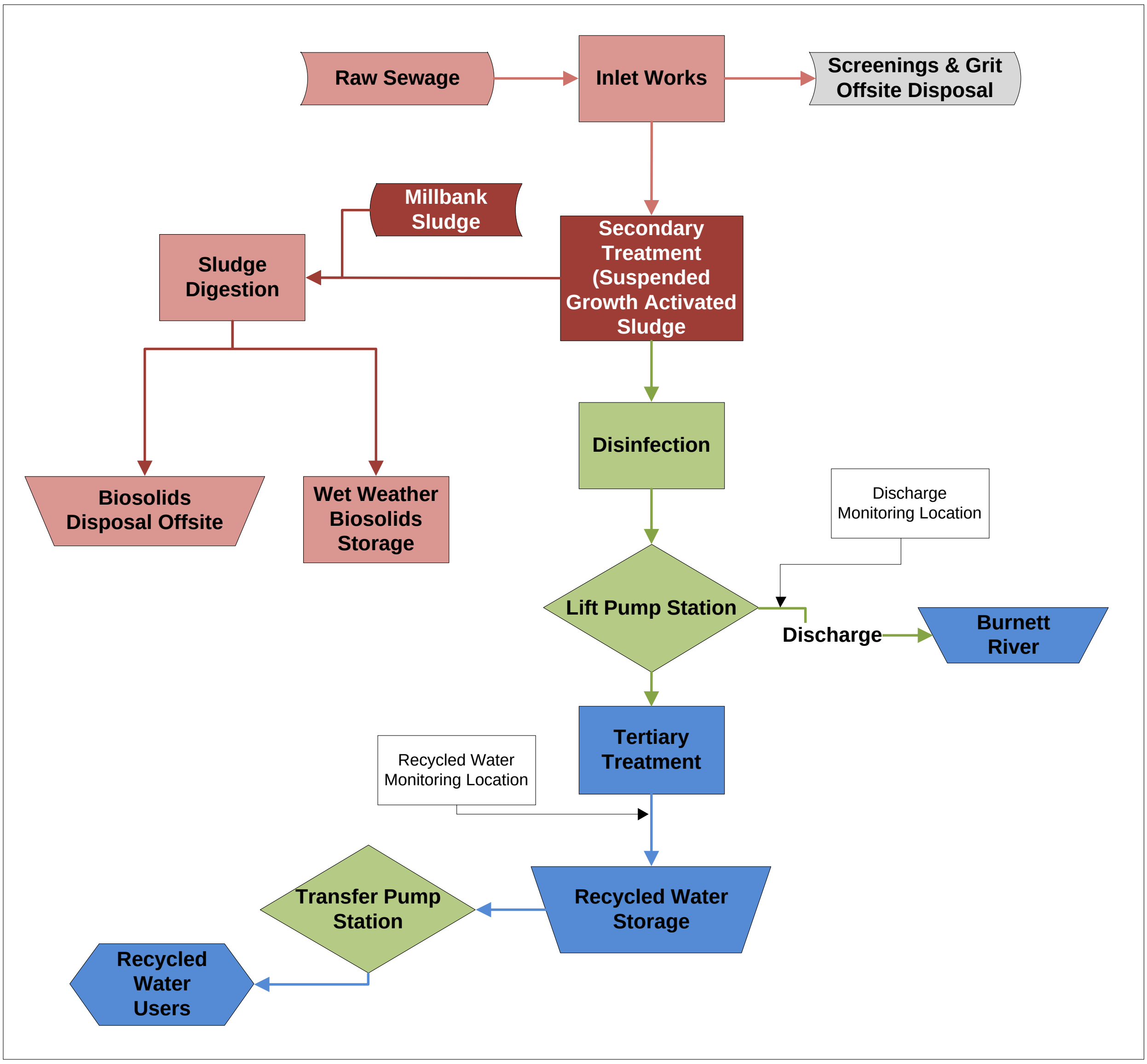

Figure 2-4: Rubyanna WWTP -Treatment and Effluent Management Schematic

2.5.1 Staging

Due to the significant reduction in effluent nutrient concentrations with the new process, the average annual mass of nitrogen discharged from Rubyanna WWTP will not exceed the current licence limit until the connected population reaches approximately 56,000 EP.

It is intended to implement expansion in recycling scheme capacity slightly in advance of actual growth in the catchment to ensure that the total nitrogen mass load discharged to the river for the average rainfall year is below the target. Three stages of scheme development are:

- Stage A - An area of 250 ha should be secured for a design population of 60,000 EP.
- Stage B - An additional 235 ha should be secured for a design population of 70,000 EP.
- Stage C - An additional area of up to 450 ha will be required to maintain discharge loads below the targets for a design population of 90,000 EP.

There is considerable uncertainty relating to planning for a recycled water scheme with a 40 year planning horizon.

The total scheme area of 935 ha required to maintain discharge loads below the target level at a 90,000 EP load are based on future flows calculated based on a hydraulic loading of 240 L/EP/day and an annual irrigation rate based on current practice reported by Bundaberg Sugar. The predicted area is sensitive to a number of factors including:

1. The required irrigation area is sensitive to WWTP hydraulic loading. If the actual hydraulic loading reduces over time to less than 200 L/EP/day (*c.f.* 240 L/EP/d), the existing area provided by Bundaberg Sugar in Stage B of 485 ha is sufficient for the life of the scheme at the proposed irrigation rate of 4 ML/ha/year.
2. The predicted area is also significantly sensitive to the irrigation rate. While current practice is to apply an annual irrigation rate of 4 ML/ha/year, climate conditions at Bundaberg suggest that higher irrigation rates could be employed. Studies in the literature report increasing yield for sugar cane in the Bundaberg area for irrigation rates up to 7.8 ML/ha. Changes in current practice in response to the improved security of supply provided by the recycled water scheme may therefore result in a reduced area requirement.
3. The predicted additional area of 450 ha is calculated on the irrigation rate nominated by Bundaberg Sugar for their sites. New users growing crops with different irrigation demands would result in a greater or lesser required irrigation area.

2.5.2 Design Capacity

Staging of the implementation of the Rubyanna recycled water scheme have broadly been assessed as follows:

- Stage A – Commences after construction of the WWTP with construction of the tertiary treatment plant, and a recycled water distribution network. Recycled water supplied to adjacent Bundaberg Sugar properties of Rubyanna, Springhill and Barron (250 ha total), and other adjacent properties if available, once the connected population reaches 50,000EP.
- Stage B – Prior to effluent load on the WWTP exceeding Stage A capacity, the recycled water scheme will be extended to include identified Bundaberg Sugar properties (485 ha total) to cater for a connected population of 70,000EP.
- Stage C – Commenced prior to connection of remaining catchment. Recycled water sites extended to include additional 450 ha of sugar cane/ horticultural properties within a reasonable distance (nominally 2-4km to the east or south east of the WWTW) that can be supplied with recycled water for a connected population of 90,000EP.

The anticipated capacity and performance of the recycled water scheme in reducing loads discharged to the Burnett River are summarised in Table 2-5.

Table 2-5: Predicted plant capacities, effluent production and required land area for irrigation

Parameters	Units	A	B	C
EP		60,000	70,000	90,000
Per Capita Load	(L/EP/d)	240	240	240
ADWF	(ML/d)	14.40	16.80	18.90
Effluent Production	(ML/yr)	5,260	6,136	7,889
Bundaberg Sugar Irr. Area	(ha)	250	485	485
Other Irrigation Area	(ha)	0	0	450
Total Irrigation Area	(ha)	250	485	935
Annual Irrigation Rate	(ML/ha)	4	4	4
Recycled Water Irrigated	(ML/yr)	1,000	1,939	3,739
Reuse % (dry weather)	(%)	19%	32%	47%
Discharge to River				
Effluent Discharge	(ML/yr)	5,312	5,424	5,728
Nitrogen Discharge	(kg N/yr)	**26,558**	**27,122**	**28,641**
Phosphorus Discharge	(kg P/yr)	10,623	10,849	11,457

The predicted reuse percentage predicted in Table 2-5 will vary in line with the timing of connections to WWTP and the connection of irrigation area to the Recycled Water Scheme. Relationship between the two parameters is shown in Figure 2-5.

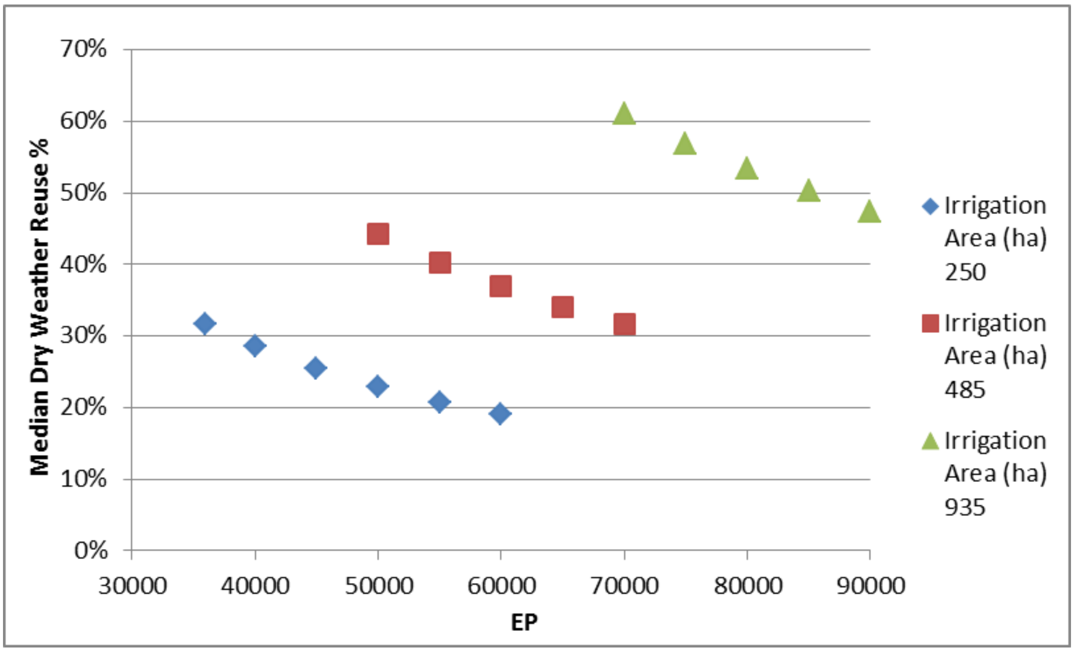

Figure 2-5: Dry weather reuse (%) achieved in response to area and population

While the arrangement with Bundaberg Sugar is anticipated to provide sufficient area to maintain the total nitrogen discharge to the Burnett River until the connected population reaches 60,000EP, further expansion of the scheme in Stage C will require identification and connection of the scheme to additional irrigation users. Properties to the east and south east of the WWTP are currently engaged in irrigation of cane and other horticultural crops and it is expected that reuse agreements will be entered into as and when required. Due to the number of discrete smaller properties compared to the substantial single owner arrangement with Bundaberg Sugar, it is expected that achievement of up to an additional 450 ha of irrigation area ultimately required will be a challenging objective in terms of the number of separate agreements, supply arrangements and physical connections that must be made.

The proposed site for Rubyanna WWTP has been selected to provide good access to surrounding irrigation sites. As shown in Figure 2-6, a total area of at approximately 1300 ha exists within some 4 km of the WWTP. Allowing for connection of Bundaberg Sugar sites during Stage 1 and Stage 2 with an area of 313ha (excluding Barron), approximately 1000 ha could be available for scheme expansion in Stage 3.

The total area of 1000 ha must be reduced as discussed in Section 2.2.2 to allow for roads, services, fallow field and unsuitable areas. Sunwater has indicated that only 75-80% of the area can be considered as available for irrigation. It is therefore considered feasible that BRC can enter into agreements with surrounding landowners over time to bring the required 49% of the area shown in Figure 2-6 into the Scheme to achieve the total irrigated area for Stage 3.

Figure 2-6: Potential Recycled Water Irrigation Areas

2.5.3 Nutrient Application Rates

Applying the nitrogen and phosphorus effluent quality concentrations stated in Table 2-6 and an irrigation rate of 4 ML/ha/yr, the resultant application rates for the average rainfall year are

- Median Nitrogen Loading Rate 20 kg N/ha
- Median Phosphorus Loading Rate 8 kg P/ha

These results compare favourably with predicted sugar cane uptake rates of 50-60 kg N/ha/yr and 6-7 kg P/ha/yr.

Ongoing monitoring of soil phosphorus and salinity must be undertaken over the life of the scheme in accordance with the Recycled Water Management Plan.

2.5.4 Effluent Discharge

Rubyanna WWTP will have a new outfall to Burnett River located approximately 8 km from the mouth of the river. The location of this outfall moves the discharge point for Bundaberg's main wastewater treatment plant approximately 10 km further downstream compared to the location of the Bundaberg East WWTP outfall. The outfall will be used to discharge treated effluent that is in excess of the requirements of the recycled water scheme.

Discharge Quality

The secondary effluent quality targets in Table 2-6 are assumed to apply to the treated effluent discharged to the Burnett River. The concentrations shown are consistent with a new biological nutrient removal (BNR) treatment plant that includes the use of biological phosphorous removal. This high standard of treatment has been selected with consideration to limiting the nutrient load discharged to the Burnett River over the life of the plant and BRC's preference, when possible, for the use of biological phosphorous removal as part of a strategy to produce a biosolids product that is suited for beneficial reuse for agriculture.

Table 2-6: Contaminant release to waters - Release limits and monitoring points

Monitoring Point	Quality Characteristic	Minimum	50th percentile	80th percentile	Maximum	Proposed Compliance Monitoring Frequency
Treated effluent lift pump station	BOD_5 (mg/L)	N/A	N/A	15	20	Monthly[3]
	Suspended Solids (mg/L)	N/A	N/A	20	30	Weekly[3]
	Total Nitrogen (mg/L)	N/A	5	N/A	15	Weekly[3]
	Ammonia (mg/L)	N/A	1	N/A	3	Weekly[3]
	Total Phosphorus (mg/L)	N/A	2	N/A	5	Weekly[3]
	pH (pH units)	6.5	N/A	N/A	8.5	Weekly
	Dissolved Oxygen (mg/L)	2	N/A	N/A	N/A	Weekly
	Faecal Coliforms (organisms/100mL)	N/A	1,000 cfu/100mL[1]	4,000 cfu/100mL[2]	N/A	Weekly

[1] Assessed weekly against 5 individual grab samples per day collected not less than 30 minutes apart

[2] 4 out of 5 individual grab samples should be less than 4,000 cfu/100mL

[3] Indicates parameters to be analysed using a flow weighted composite sampling method. Flow weighted composite samples are to be weighted to the wastewater flow with the volume of sample changing in proportion to the flow. The flow weighted composite sample is to be obtained over a 24 hour period.

Disinfection

The conceptual design allows for chlorine disinfection for all secondary treated effluent prior to either transfer for tertiary treatment or discharge to the Burnett River. A serpentine chlorine contact tank has been designed to provide to create a plug flow conditions and suitable contact time to ensure a reliable pathogen log removal. The chlorine contact tank has been sized to accept flows up to PWWF.

The disinfection standard reflects the requirements of the current Integrated Authority No CM0334 and meets the ANZECC disinfection guideline for recreational water quality with secondary contact (e.g. boating) (ANZECC, 2000).

Outfall Route

The preliminary outfall route travels along the property boundary to Barrons Rd, and continues along the Barrons Rd road reserve to a chamber located in the vicinity of the boat ramp and cable ferry at the end of Strathdees Rd. The outfall route is a total of approximately 3 km.

The available driving head for gravity flows is strongly dependent on the river level. During non-flood conditions there is sufficient gravity head to discharge peak flows using large diameter pipework. During peak flow and flood conditions, a treated effluent lift pump will provide the necessary energy to discharge storm flows at high river levels.

Plume modelling for the proposed outfall has been undertaken to provide further details on the predicted impact of the plant operation on the river water quality.

Nutrient Concentration

The nutrient concentrations in Table 2-6 are in accordance with the total phosphorus and total nitrogen targets stated in the current Integrated Authority No CM0334 for Bundaberg East and North WWTPs which aims to reduce phosphorous in the effluent discharged to the Burnett River to 2 mg/L (50th percentile) and total nitrogen to 5 mg/L (50th percentile).

Consideration was given to the use of a wetland to further reduce effluent concentrations beyond what is capable with a BNR process especially for the above average rainfall years and during annual periods of prolonged discharge associated with non-irrigation of cane prior to harvest. Site limitations preclude the use of a wetland and it is proposed that chemical phosphorus removal with metal salts be implemented during prolonged non-irrigation periods. Effluent nitrogen concentration will be unaffected.

2.5.5 Tertiary Treatment

The Rubyanna recycled water scheme requires the production of Class A recycled water that is suitable for application with unrestricted site access.

Secondary treatment with disinfection to a standard suitable for discharge to the Burnett River will be the first stage of treatment. Recycled water will be treated by filtration and further disinfection to meet the requirements for Class A recycled water.

A number of commercially available solids separation and disinfection processes may be applied to achieve this level of disinfection:

- Filtration may be provided by either:
  - a Coagulation and dual media filtration or
  - b Membrane filtration.
- Disinfection will be provided by either:
  - a Ultraviolet (UV) disinfection and/or
  - b Chlorine dosing.

It is anticipated that an appropriate tertiary treatment train will be selected as part of a process selection process in the design stage.

2.5.6 Recycled Water Storage

Location

A recycled water storage will be located on Bundaberg Sugar land to the south of the WWTP. The storage will store Class A recycled water prior to distribution to the reuse sites. The general area in which the centralised recycled water storage is to be located is shown in Figure 2-7. Note that the new rising main from East Bundaberg WWTP is along the eastern boundary of the storage area. The exact location of these assets will be determined during subsequent design stages.

Figure 2-7: Recycled water storage location

Volume

The effluent management strategy for Rubyanna WWTP allows for staged implementation of irrigation of surrounding cane fields to keep the mass of nitrogen discharged to the Burnett River below current licence limits.

The proposed mode of operation is to provide sufficient storage to allow balancing of flows and store approximately 15 day's irrigation demand at the Bundaberg Sugar advised irrigation rates of ~28 L/s per site for 20 hours a day (peak irrigation period).

BRC plan to construct a 100 ML centralised recycled water storage during Stage A of the effluent management scheme. The design of the storage volume is to be considered and finalised during subsequent design stages in consideration of the agreed reticulation design and recycled water supply details.

Table 2-7: Calculated storage volume for 15 day's irrigation demand

Stage	ADWF (ML/d)	Storage Volume (ML)	Depth (m)	Approximate Area (ha)	HRT (days) at ADWF
A	12	91	3.6	2.5	7.6
B	16.8	167	3.6	4.7	10.0
C	21.6	302	3.6	8.4	14.0

Overflow

The maximum level in the recycled water storage must include a freeboard allowance to cater for the design storm. Consideration must be given to the location of any overflow to cater for extended wet weather or exceeding of the design storm during subsequent design stages.

Delivery to Third Parties

A preliminary design of the reticulation scheme has been developed by BRC to facilitate discussion with Bundaberg Sugar and other irrigators. Many issues are still to be agreed including:

- Staging and pipeline route;
- Maximum daily demand per site;
- Maximum instantaneous demand per site;
- Maximum supply pressure;
- Sharing rules; and
- Reliability indices.

Further development will occur as the scheme design develops.

The preliminary arrangement including first pass assessment of pipeline routes, diameters, volumetric requirements and supply pressures is contained in Appendix A.

2.5.7 Third Party Risks

It cannot be guaranteed that all contracted recycled water users will be available throughout the life of the scheme. BRC recognise this uncertainty and have made planning decisions for the Rubyanna WWTP and recycled water scheme to maximise the likelihood of achieving an ongoing successful recycled water operation that will minimise nutrient loads discharged to the Burnett River:

1. The Rubyanna WWTP has adopted biological nutrient removal which is a significant improvement in the quality of effluent discharged compared with the current performance of Bundaberg East. Even with no recycling in place, average annual nitrogen loads discharged to the Burnett River are projected to be below the loads currently discharged.
2. Rubyanna WWTP has been deliberately located in an agricultural zoned area to maximise access to irrigation areas. Significant areas surrounding Rubyanna are flood prone and are therefore unlikely to be zoned for residential development in the future.
3. BRC will enter into a reuse agreement with Bundaberg Sugar prior to the construction of the treatment plant. Surrounding sugar cane irrigation areas owned by Bundaberg Sugar provide sufficient area at the current irrigation practice to maintain discharge loads to the Burnett River below the existing limit for a capacity of up to 70,000 EP in an average rainfall year.
4. The Rubyanna WWTP has adopted production of Class A effluent. This high quality of effluent increases the potential for use on alternative crops should the surrounding land use move away from cane production.

3 Recycled Water Management Plan

For schemes commencing supply after 1 July 2009 supplying irrigation water for heavily processed food crops, an approved Recycled Water Management Plan (RWMP) (or exemption) must be in place within 1 year of the day that the supply of recycled water commences.

A RWMP is a documented risk based system for managing production and supply of recycled water. The steps involved in preparation of a RWMP are:

1. Assemble Risk Assessment Team;
2. Document description the treatment system (including source water), uses, recycled water quality and levels of exposure;
3. Identify hazards and assess risks;
4. Determine Critical Control Points, Quality Control Points and control measures;
5. Establish critical limits for each control measure;
6. Establish monitoring, validation and verification programs; and
7. Prepare management procedures and corrective actions.

3.1 Risk Management Plan

Steps 1-5 will take a Hazard Analysis and Critical Control Points (HACCP) approach to the management of risks and will be undertaken during the detailed planning and design of the scheme.

A Risk Management Plan will be prepared by BRC to document foreseeable risks, estimate the impact of certain foreseeable events occurring and to create a response plan to mitigate the impact of risk.

BRC's risk management process utilises the principles of AS/NZS 4360:1999 *Risk Management* and the risk management process will be documented and retained in BRC's Integrated Management System (IMS).

All members of BRC's risk management team will receive training relating to the processes and procedures which will be implemented at the Rubyanna WWTP. This training detailed the responsibilities of each member of the risk management team and the role they play in the correct management of the Rubyanna Recycled Water Scheme.

3.2 Validation and Verification

Validation and verification of the Recycled Water scheme in accordance with the requirements of the "*Recycled water management plan and validation guidelines*" (DNRW, 2008) will need further discussion and liaison with DERM to determine the specific requirements for each scheme depending on the selected tertiary treatment processes.

3.3 Management Procedures

BRC operates the Childers WWTP Recycled Water Scheme which provides for the irrigation of food crops in accordance with the BRC Recycled Water Policy Statement. This experience with irrigation of food crops has resulted in the development of systems for management of Recycled Water Schemes including procedures for:

- Incident and Emergency Response Procedure for a Recycled Water Scheme
- Exceedance of Escherichia Coli Level (>100 org/mL)
- Childers Recycled Water Management Plan Annual Review Procedure (PD-7-249).

It is anticipated that project specific procedures will be developed prior to commencement of the Rubyanna Scheme.

4 Conclusions

An Effluent Management Strategy has been developed as part of the approvals package for Rubyanna WWTP and to guide development of the Recycled Water Scheme. Scheme design will be completed once approvals conditions are known.

Key findings of the Effluent Management Strategy are detailed below.

1. The implementation of regional treatment plant at Rubyanna is part of regional strategy to provide cost effective centralised sewage services and avoid need for effluent discharges to high value coastal waters.
2. The WWTP will include a biological nutrient removal (BNR), biological phosphorous removal with chemical phosphorus removal backup and disinfection.
3. There is a significant reduction in effluent nutrient concentrations with the new BNR process and the average annual mass of nitrogen discharged from Rubyanna WWTP will not exceed the current licence limit for East and North WWTPs until the connected population reaches 56,000 EP. The initial load at commissioning is forecast at 36,000EP.
4. Irrigation of recycled water to limit the mass of nitrogen discharge to the Burnett River below the current licenced limit is not forecast to be required until 2025 as detailed in Figure 2-1.
5. The selected WWTP site is located in an irrigation area to facilitate recycled water use for irrigation of sugar cane and horticultural crops.
6. BRC are proactively seeking a recycled water supply agreement with a major irrigator prior to the construction and commissioning of the treatment plant and recycled water scheme.
7. Recycled water will initially be supplied to land adjacent to the WWTP. Based on conservative hydraulic loading and irrigation rates, Bundaberg Sugar land covered by the agreement provides sufficient irrigation area to maintain nutrient discharges to Burnett River to less than existing target until the connected load reaches 70,000EP.
8. To maintain nutrient discharge in the average rainfall year to less than the target over the planning horizon will require expansion of irrigation area to 935 ha. There are uncertainties surrounding the ultimate area required due to the long planning horizon and the fact that recycled water will be in competition with readily available sources of irrigation water already within the district from the Sunwater Water Supply Scheme.
9. Risks to the scheme from having one large and many smaller 3rd parties have been identified with the following responses:
   i. Even with no recycling in place, average annual nitrogen loads discharged to the Burnett River are projected to be below the loads currently discharged.
   ii. Rubyanna WWTP has been deliberately located in an agricultural zoned area to maximise access to irrigation areas.
   iii. Surrounding sugar cane irrigation areas owned by Bundaberg Sugar provide sufficient area at the current irrigation practice to maintain discharge loads to the Burnett River below the existing limit for a capacity of up to 70,000 EP in an average rainfall year.
   iv. The high quality of effluent from the new WWTP will increase the potential for use on alternative crops.
10. A new effluent outfall to Burnett River will be located approximately 8 km from the mouth of the river and approximately 10 km further downstream compared to the location of the existing Bundaberg East WWTP outfall. Plume modelling has been undertaken to provide details on the predicted impact of discharges on water quality.

5 References

Sunwater, 2010-*Water Supply Arrangements and Service Targets - BUNDABERG WATER SUPPLY SCHEME*. On line at http://www.sunwater.com.au/__data/assets/pdf_file/0010/3124/Bundaberg_rules_targets.pdf. Accessed 19 January 2012.

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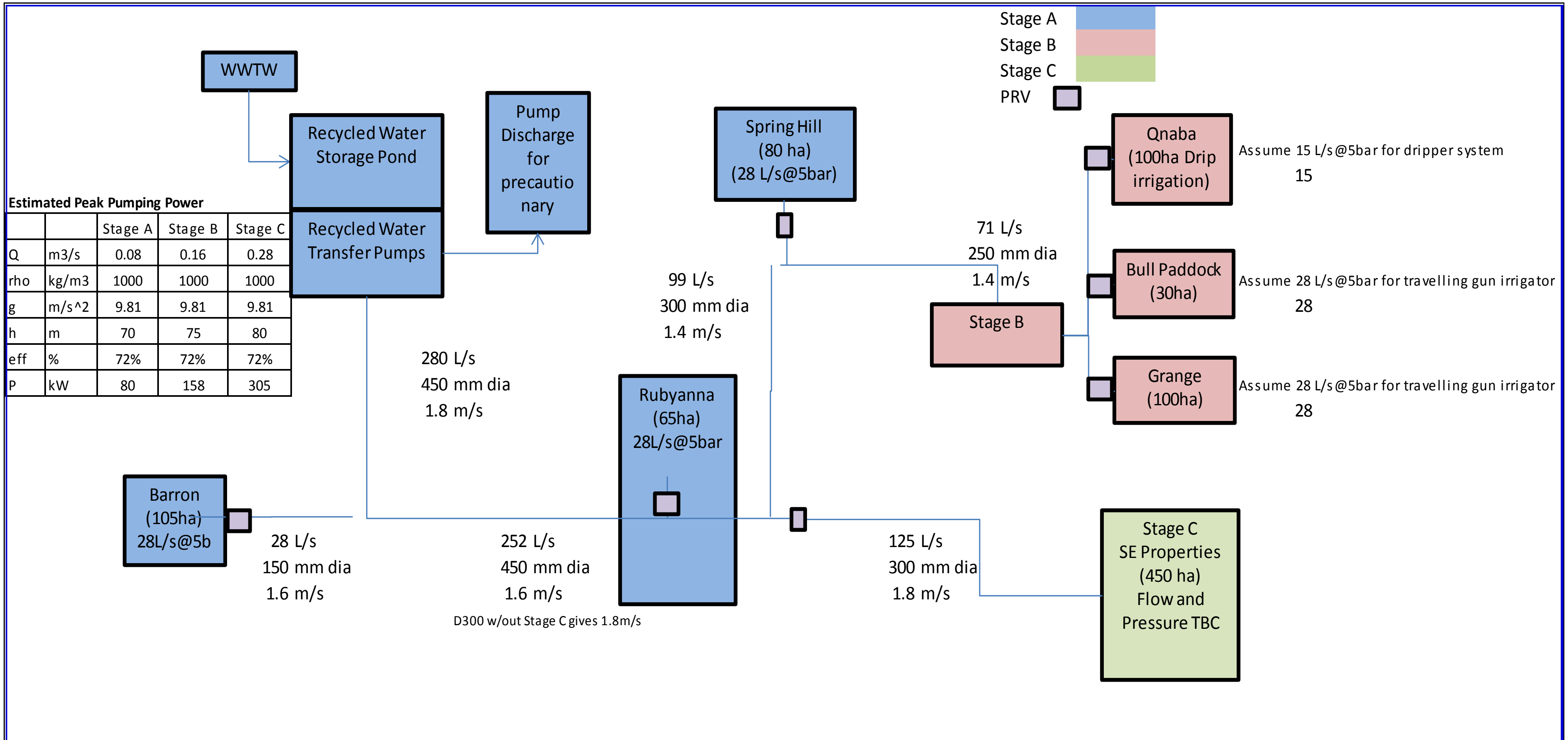
Appendix A – Reticulation Schematic



Estimated Peak Pumping Power

		Stage A	Stage B	Stage C
Q	m3/s	0.08	0.16	0.28
rho	kg/m3	1000	1000	1000
g	m/s^2	9.81	9.81	9.81
h	m	70	75	80
eff	%	72%	72%	72%
P	kW	80	158	305

Rubyanna WWTW - Recycled Water Reticulation Schematic

Date: 18-Jan-12

Appendix B – Calculations

Rubyanna Reuse Areas (BRC Plan 37115)

Site Number	Site Name	Site Area (ha)	Connected (y/n)	Eff Area (ha)
9582	River	146.2	n	0.0
30197	River- Rehbein's	78.82	n	0.0
8301	**Barron**	130	**y**	**105.0**
9953	**Rubyanna**	80	**y**	**65.0**
9769	**Spring Hill**	95	**y**	**80.0**
9304	Qunaba	133	n	0.0
9451	Pines	168	n	0.0
9355	Bull Paddock	40	n	0.0
9785	Grange	140	n	0.0
All Bundaberg Sugar				250
Independents	Individual Lots (Irrigation Area)	400	n	0.0
Total Area				250

A

Load

60,000	EP
240	L/EP/d

AF/ADWF	1.2

Eff TN (median)	5
Eff TP (median)	2

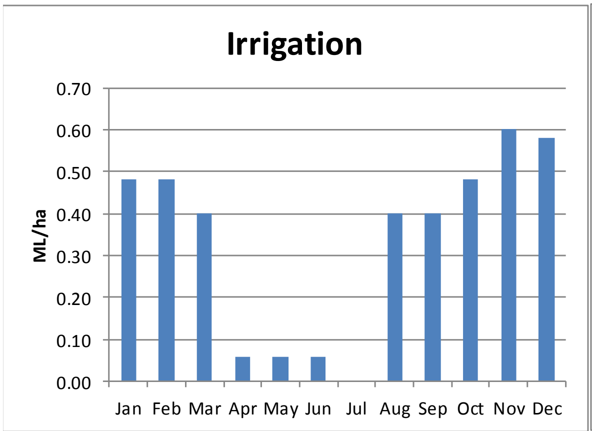
Reuse Estimate

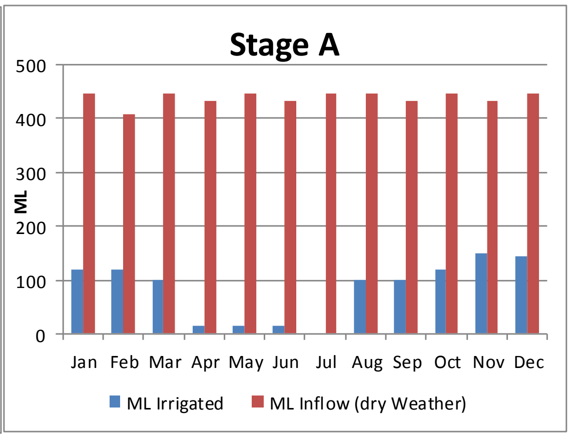
Area	ha	**250.0**	
Nominal Irrigation rate	ML/ha/yr	4	Simon Doyle, Bundy Sugar. 8 Sept 2011
Average Annual Demand	ML/yr	1000.0	
Dry Weather Supply	ML/yr	5259.6	
Median Annual Reuse	% dry weather f	19%	16% Total Flow
Discharge	ML/yr	5312	
	kg N/yr	26558	
	kg P/yr	10623	

Irrigation Profile

	% of annual	ML/ha
Jan	12.0%	0.48
Feb	12.0%	0.48
Mar	10.0%	0.40
Apr	1.5%	0.06
May	1.5%	0.06
Jun	1.5%	0.06
Jul	0.0%	0.00
Aug	10.0%	0.40
Sep	10.0%	0.40
Oct	12.0%	0.48
Nov	15.0%	0.60
Dec	14.5%	0.58
Annual	100.0%	4.00

	ML Irrigated	ML Inflow (dry Weather)
Jan	120	446
Feb	120	407
Mar	100	446
Apr	15	432
May	15	446
Jun	15	432
Jul	0	446
Aug	100	446
Sep	100	432
Oct	120	446
Nov	150	432
Dec	145	446
Annual	1000	5259.6





Rubyanna Reuse Areas (BRC Plan 37115)

Site Number	Site Name	Site Area (ha)	Connected (y/n)	Eff Area (ha)
9582	River	146.2	n	0.0
30197	River- Rehbein's	78.82	n	0.0
8301	**Barron**	**130**	**y**	105.0
9953	**Rubyanna**	**80**	**y**	65.0
9769	**Spring Hill**	**95**	**y**	80.0
9304	**Qunaba**	**133**	**y**	99.8
9451	Pines	168	n	0.0
9355	**Bull Paddock**	**40**	**y**	30.0
9785	**Grange**	**140**	**y**	105.0
All Bundaberg Sugar				485
Independents	Individual Lots (Irrigation Area)	450	n	0.0
Total Area				485

B

Load

70,000	EP
240	L/EP/d

AF/ADWF	1.2

	Eff TN (median)	5
25% of Qn	Eff TP (median)	2

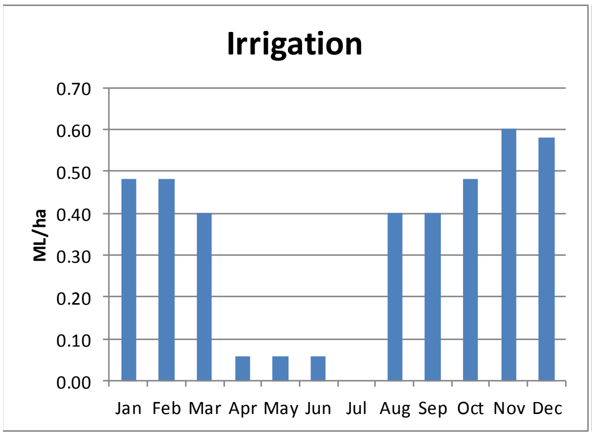
Reuse Estimate

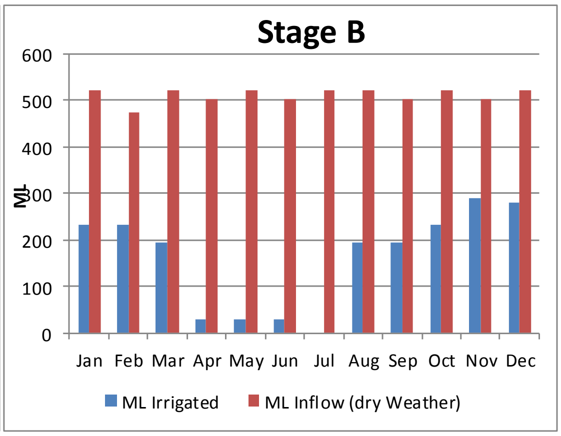
Area	ha	**484.8**		
Nominal Irrigation rate	ML/ha/yr	4	Simon Doyle, Bundy Sugar. 8 Sept 2011	
Average Annual Demand	ML/yr	1939		
Dry Weather Supply	ML/yr	6136		
Median Annual Reuse	% dry weather f	32%	26%	Total Flow
Discharge	ML/yr	5424		
	kg N/yr	27122		
	kg P/yr	10849		

Irrigation Profile

	% of annual	ML/ha
Jan	12.0%	0.48
Feb	12.0%	0.48
Mar	10.0%	0.40
Apr	1.5%	0.06
May	1.5%	0.06
Jun	1.5%	0.06
Jul	0.0%	0.00
Aug	10.0%	0.40
Sep	10.0%	0.40
Oct	12.0%	0.48
Nov	15.0%	0.60
Dec	14.5%	0.58
Annual	100.0%	4.00

	ML Irrigated	ML Inflow (dry Weather)
Jan	233	521
Feb	233	475
Mar	194	521
Apr	29	504
May	29	521
Jun	29	504
Jul	0	521
Aug	194	521
Sep	194	504
Oct	233	521
Nov	291	504
Dec	281	521
Annual	1939	6136.2





Rubyanna Reuse Areas (BRC Plan 37115)

Site Number	Site Name	Site Area (ha)	Connected (y/n)	Eff Area (ha)
9582	River	146.2	n	0.0
30197	River- Rehbein's	78.82	n	0.0
8301	**Barron**	**130**	**y**	105.0
9953	**Rubyanna**	**80**	**y**	65.0
9769	**Spring Hill**	**95**	**y**	80.0
9304	**Qunaba**	**133**	**y**	99.8
9451	Pines	168	n	0.0
9355	**Bull Paddock**	**40**	**y**	30.0
9785	**Grange**	**140**	**y**	105.0
All Bundaberg Sugar				485
Independents	Individual Lots (Irrigation Area)	450	y	450
Total Area				935

C
Load

90,000	EP
240	L/EP/d

AF/ADWF	1.2

	Eff TN (median)	5
75% of Q	Eff TP (median)	2

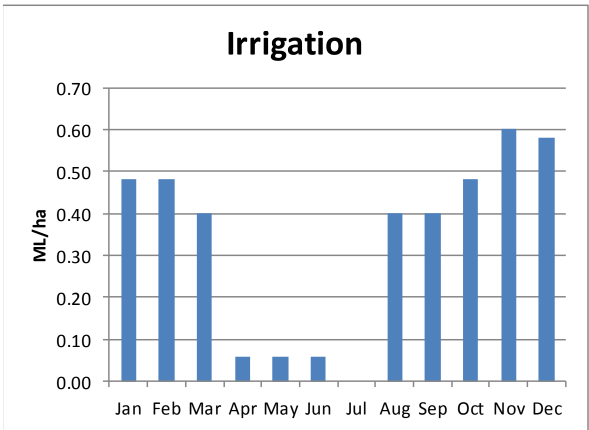
Reuse Estimate

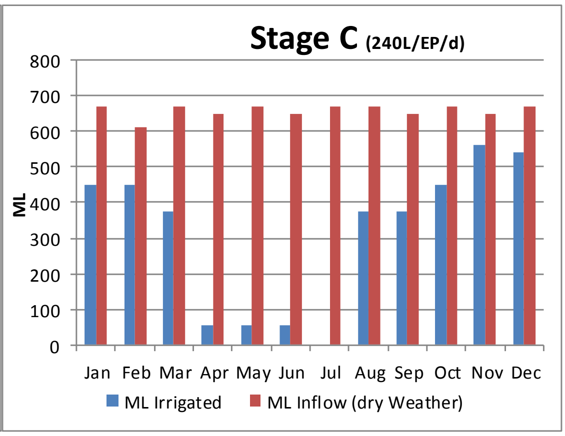
Area	ha	**934.8**	
Nominal Irrigation rate	ML/ha/yr	4	Simon Doyle, Bundy Sugar. 8 Sept 2011
Average Annual Demand	ML/yr	3739.0	
Dry Weather Supply	ML/yr	7889.4	
Median Annual Reuse	% dry weather f	47%	39% Total Flow
Discharge	ML/yr	5728	
	kg N/yr	28641	
	kg P/yr	11457	

Irrigation Profile

	% of annual	ML/ha
Jan	12.0%	0.48
Feb	12.0%	0.48
Mar	10.0%	0.40
Apr	1.5%	0.06
May	1.5%	0.06
Jun	1.5%	0.06
Jul	0.0%	0.00
Aug	10.0%	0.40
Sep	10.0%	0.40
Oct	12.0%	0.48
Nov	15.0%	0.60
Dec	14.5%	0.58
Annual	100.0%	4.00

	ML Irrigated	ML Inflow (dry Weather)
Jan	449	670
Feb	449	610
Mar	374	670
Apr	56	648
May	56	670
Jun	56	648
Jul	0	670
Aug	374	670
Sep	374	648
Oct	449	670
Nov	561	648
Dec	542	670
Annual	3739	7889.4





Appendix C – MEDLI Run Summaries

Rubyanna Reuse

Medli Runs

Effluent Nutrient Concentrations	
N	5 mg/L
P	2 mg/L

	ADWF (ML/d)
Stage A	8.7
Stage B	13.3
Stage C	23.0

MEDLI Number		Crop	Pan Coefficient	Soil Type	EP	Irrigation Area (ha)	Storage Volume (ML)	Inflow to Pond System (ML)	rain added to pond (ML)	Evap from Pond (ML)	Irrigation From Pond (ML)	Volume of Overtopping (ML)	% Reuse	Average Irrigation rate (ML/ha/yr)	Drainage (mm)	N application (kg/ha/yr)	P application (kg/ha/yr)	N Discharge (kg/yr)	P discharge (kg/yr)
Stage A	**Averages**				**36500**	**295**	**200**	**3919**	**63**	**70**	**1600**	**2306**	**41%**	**5.42**	**479**	**27**	**11**	**11532**	**4613**
0017	Ruby_1	Tropical Crop	0.8	Hi Permeability Red Brown Earth	36500	295	200	3918.9	62.8	69.8	1758.3	2148.4	45%	5.96	470.8	29.8	11.92	10742	4297
0018	Ruby_2	Tropical Crop	0.8	Krasnozem	36500	295	200	3918.9	62.8	69.9	1603.6	2303	41%	5.43	450.7	27.15	10.86	11515	4606
0019	Ruby_3	Tropical Crop	0.8	Red Earth	36500	295	200	3918.9	62.8	69.9	1438.6	2467.5	37%	4.87	516.3	24.35	9.74	12338	4935
Stage B	Average				**55600**	**600**	**300**	**5970**	**90**	**101**	**2824**	**3127**	**47%**	**4.71**	**410**	**24**	**9**	**15634**	**6253**
0020	Ruby_3 2026	Tropical Crop	0.8	Red Earth	55600	600	300	5969.6	90.3	100.8	2650.7	3300	45%	4.42	467.9	22.1	8.84	16500	6600
0021	Ruby_2 2026	Tropical Crop	0.8	Krasnozem	55600	600	300	5969.6	90.3	100.8	2806.5	3145.2	47%	4.68	379.8	23.4	9.36	15726	6290
0023	Ruby_1 2026	Tropical Crop	0.8	Hi Permeability Red Brown Earth	55600	600	300	5969.6	90.3	100.8	3015.9	2935	51%	5.02	380.9	25.1	10.04	14675	5870
Stage C	Average				**96300**	**1500**	**700**	**10340**	**199**	**224**	**6690**	**3607**	**65%**	**4.46**	**385**	**22**	**9**	**18033**	**7213**
0022	Ruby_1 2055	Tropical Crop	0.8	Hi Permeability Red Brown Earth	96300	1500	700	10339.5	199.3	223.9	7092.2	3204.3	69%	4.73	349	23.65	9.46	16022	6409
0024	Ruby_2 2055	Tropical Crop	0.8	Krasnozem	96300	1500	700	10339.5	199.3	224.1	6695.5	3600.8	65%	4.46	357.6	22.3	8.92	18004	7202
0025	Ruby_3 2055	Tropical Crop	0.8	Red Earth	96300	1500	700	10339.5	199.3	224.2	6281.4	4014.8	61%	4.18	449.8	20.9	8.36	20074	8030

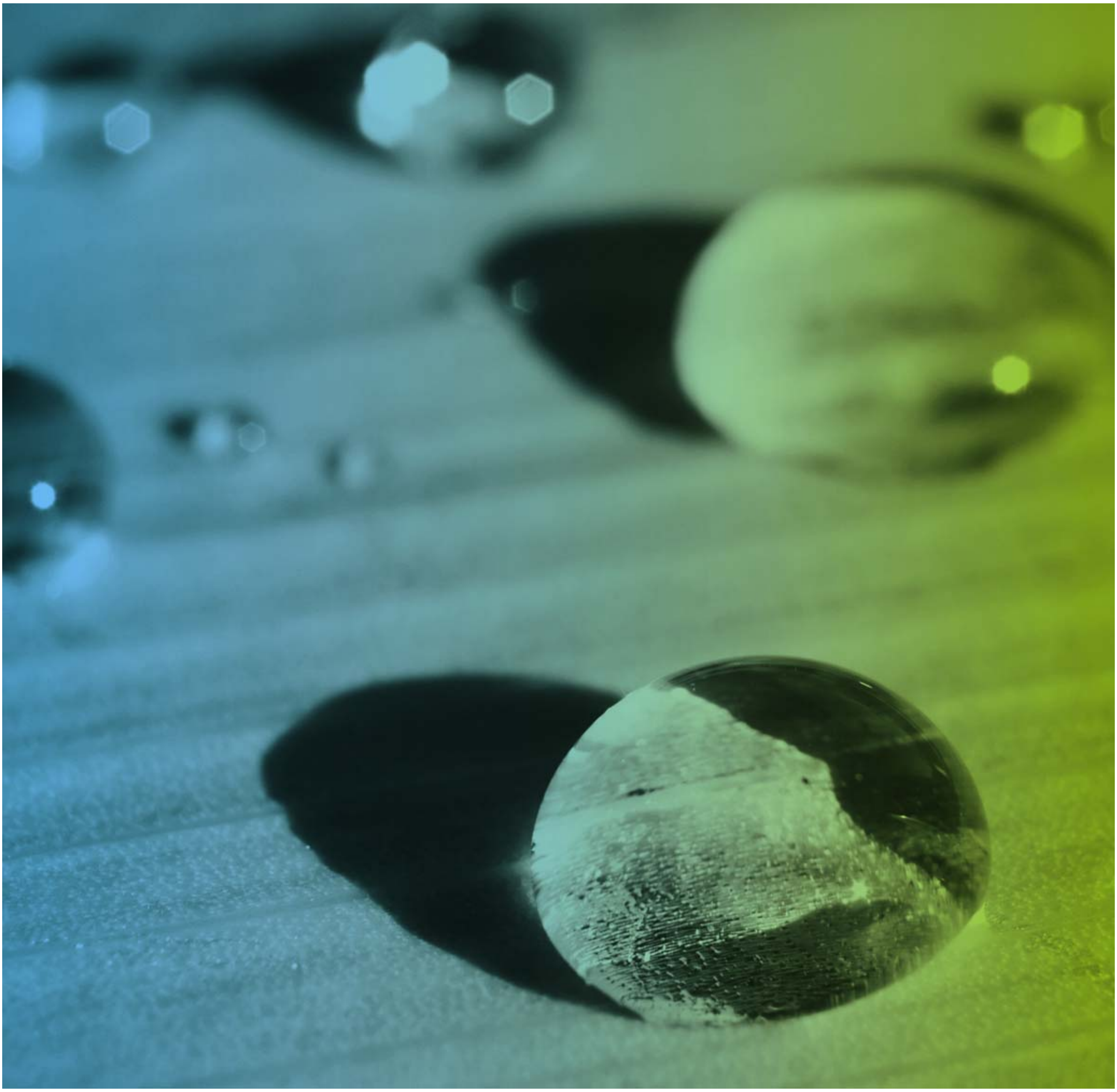
Appendix O

Near Field Dispersion Modelling Report

Rubyanna WWTP Outfall Assessment
Bundaberg Regional Council
28 February 2012
Document No. 60221597

Rubyanna WWTP Discharge Plume Modelling

Report



Rubyanna WWTP Discharge Plume Modelling

Report

Prepared for

Bundaberg Regional Council

Prepared by

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Quality Information

Document Rubyanna WWTP Discharge Plume Modelling

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Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
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Executive Summary

Bundaberg Regional Council (BRC) is proposing to construct a new regional wastewater treatment plant (WWTP) with ultimate capacity to service 90,000 Equivalent Persons (EP). A concept design for an advanced Biological Nutrient Removal (BNR) process has been developed and a preferred site at Rubyanna has been selected.

Rubyanna WWTP will facilitate the projected population growth along the Bundaberg coastal development corridor and will replace Bundaberg East and Bundaberg North treatment plants. These plants do not have sufficient capacity to cater for the projected population growth and are unable to meet the current effluent quality discharge limits.

A preferred new outfall location has been identified in the tidal reach of the Burnett River. This report details numerical modelling of the near-field effluent discharge plume for flows relating to a 90,000EP plant and provides a baseline for the impact assessment of the proposed new outfall.

Modelling results indicate during Average Dry Weather Flow (ADWF) and at Lowest Astronomical Tide (LAT) water levels, a background current of 0.25m/s or greater is sufficient to ensure mixing of average effluent concentrations to water quality guideline levels prior to the water surface being reached. For ADWF a minimum of 120 dilutions are required to reduce the maximum effluent concentrations to guideline levels. On average this is achieved prior to the water surface being reached when ambient current speeds are greater than 0.5 m/s.

1.0 Introduction

1.1 Project Description

Bundaberg Regional Council (BRC) is proposing to construct a new regional wastewater treatment plant (WWTP) at Rubyanna, Bundaberg.

The proposed WWTP will facilitate population growth and replace the Bundaberg East and Bundaberg North treatment plants, enabling two existing outfalls to the Burnett River to be decommissioned. The improvements in effluent quality will provide opportunities for water recycling, as well as limiting impacts to receiving waters.

A concept design has been developed for the Rubyanna WWTP with an ultimate capacity of 90,000 Equivalent Persons (EP).

A preferred location for a new outfall has been identified on the Burnett River approximately 8 km Adopted Middle Thread Distance (AMTD) from the river mouth at Burnett Heads (Figure 1).

1.2 Purpose and scope

This report gives details of numerical modelling carried out in order to predict the near-field effluent discharge plume from the proposed Rubyanna WWTP.

Based on concept design discharges for an ultimate plant capacity of 90,000 EP, the objectives of this study are:

- To indicate the number of dilutions required such that nutrient concentrations do not exceed background levels when the buoyant plume reaches the water surface;
- To describe plume dispersion characteristics under varying ambient scenarios;
- To minimise the environmental impact of the discharge plume by providing recommendations regarding the diffuser design;
- To provide the hydrodynamic baseline necessary for detailed assessment of the impacts of the discharge.

1.3 Outline

Important site specific background information regarding the proposed outfall location and the background water quality of the Burnett estuary is given in Section 2. Aspects of the concept design which will influence the nature of the proposed discharge are summarised in Section 3.

Section 4 presents the methodology and assumptions behind the evaluation of the near-field characteristics of the concept design discharge. In this section the likely dilution and spatial extent of the plume under varying ambient conditions is considered.

A summary of the likely near-field characteristics of the effluent discharge from the proposed Rubyanna WWTP is given in Section 5.

2.0 Physical Environment

2.1 Outfall Location

A preferred location for the proposed Rubyanna WWTP outfall has been identified in the Long Reach of the Burnett River.

As shown in Figure 1, the proposed outfall location is approximately 8 km Adopted Middle Thread Distance (AMTD) from the river mouth at Burnett Heads, 3.5 km AMTD upstream of the Port of Bundaberg and 11 km AMTD downstream of Bundaberg city. The outfall site is located within the tidal reach of the Burnett River, which is now bounded by the Ben Anderson barrage approximately 25 km AMTD from Burnett Heads. The proposed site is downstream of the existing Bundaberg North and Bundaberg East WWTP outfalls and approximately 450m upstream from Bundaberg Sailing Club.

Figure 2 is a large scale view the outfall location area highlighted in Figure 1 showing the proposed outfall location in relation to the Fairymead Cable-Ferry Crossing and the public boat ramp off Strathdees Road. The river channel is approximately 200m wide at this location.

2.2 Bathymetry

Hydrographic survey of the Burnett River undertaken by Gladstone Ports Corporation (GPC) and Maritime Safety Queensland (MSQ) following the January 2011 flood event was provided to HWA/AECOM.

The maximum post flood channel depth at the proposed outfall location was 13.6m below Lowest Astronomical Tide (LAT). A minimum available water depth of 10m below LAT existed for approximately 50m of the 200m channel width. Figure 3 shows a cross section of the river channel at the proposed outfall location.

2.3 Water Levels

Table 1 shows predicted astronomical tide levels for the Burnett River relative to LAT. It is noted that the tidal planes for standard and secondary ports in Queensland were revised in July 2009. The values quoted below are the new values which are based on the current tidal datum epoch of 1992 to 2011 (Ref: TMR, 2011).

Table 1 Tidal Levels for Burnett River relative to LAT [Ref: TMR, 2011]

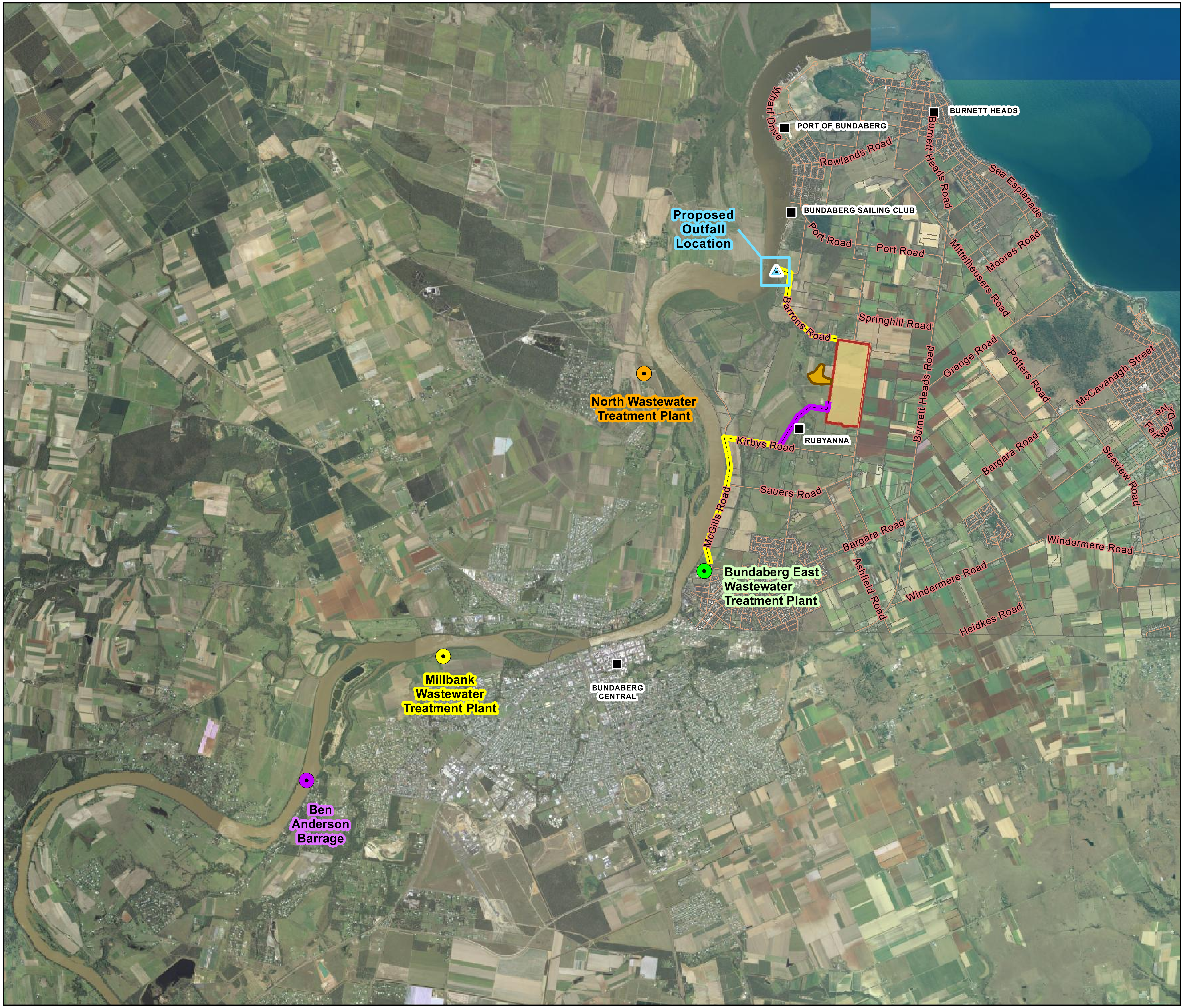
	MHWS	MHWN	MLWN	MLWS	AHD	MSL	HAT
Burnett Heads	2.88	2.30	1.14	0.56	1.69	1.72	3.67
Burnett River (Town Reach)	3.17	2.53	1.25	0.62	1.79	1.83	4.04

Meteorological variations to these predicted tide levels will not be considered in this study, however it is recommended that the likely impacts of flood and storm surge events are taken into account during the detailed design of significant infrastructure.

RUBYANNA WWTP OUTFALL ASSESSMENT

Location Map

Figure 01



Legend

- Proposed Outfall Location
- Ben Anderson Barrage
- Bundaberg East Wastewater Treatment Plant
- Millbank Wastewater treatment Plant
- North Wastewater Treatment Plant
- Roads
- Possible STP Site (approx16.7ha)
- Lot 1 RP57605 (108.6 ha)
- Cadastre

Approximate Alignment : Raw Sewer Rising Main

- Freehold
- Road Reserve

N

Scale: 1:70,000 (when printed at A3)

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Metres

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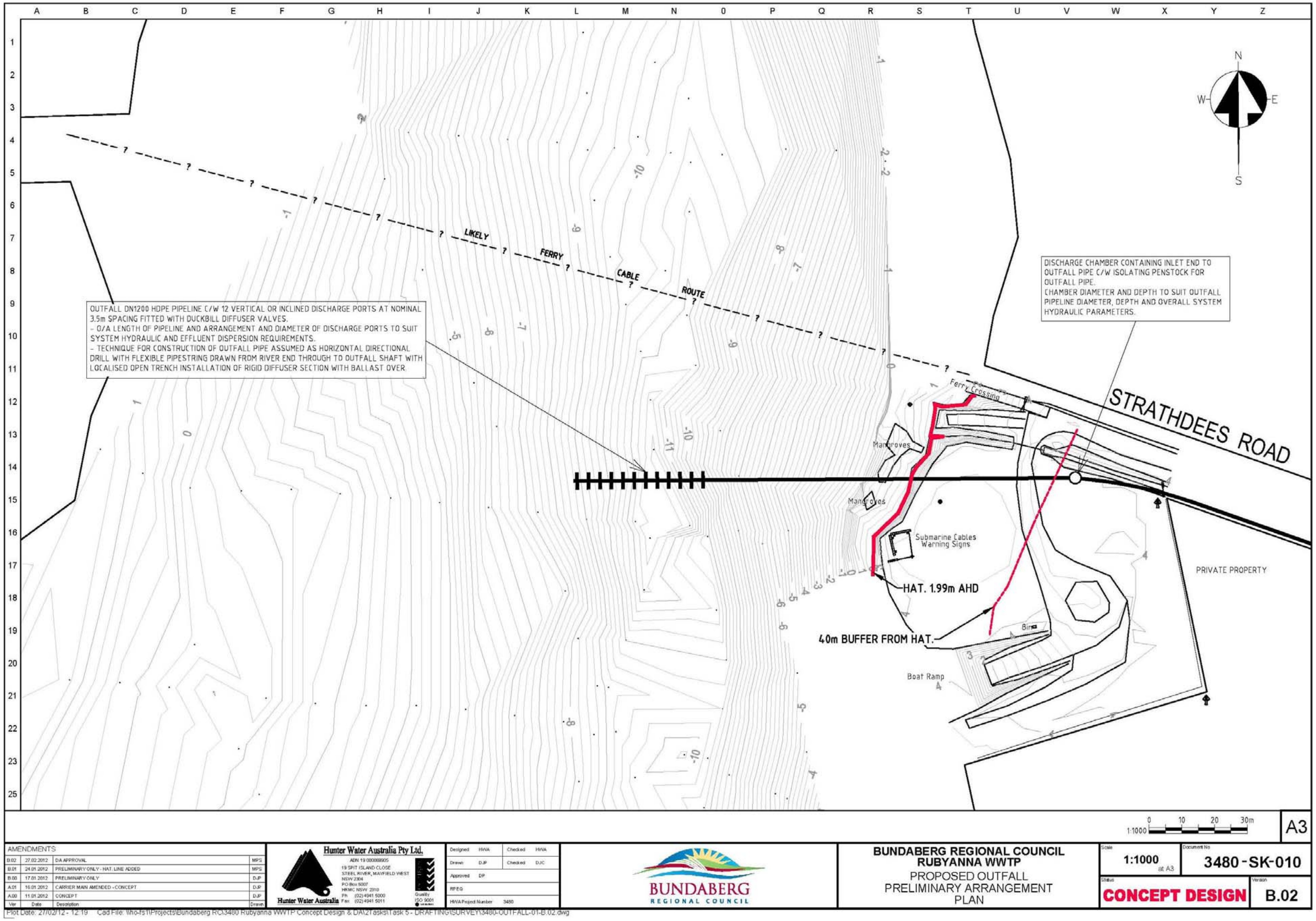

Figure 2 **Close up of the outfall location [Ref: *HWA*, 2011]**

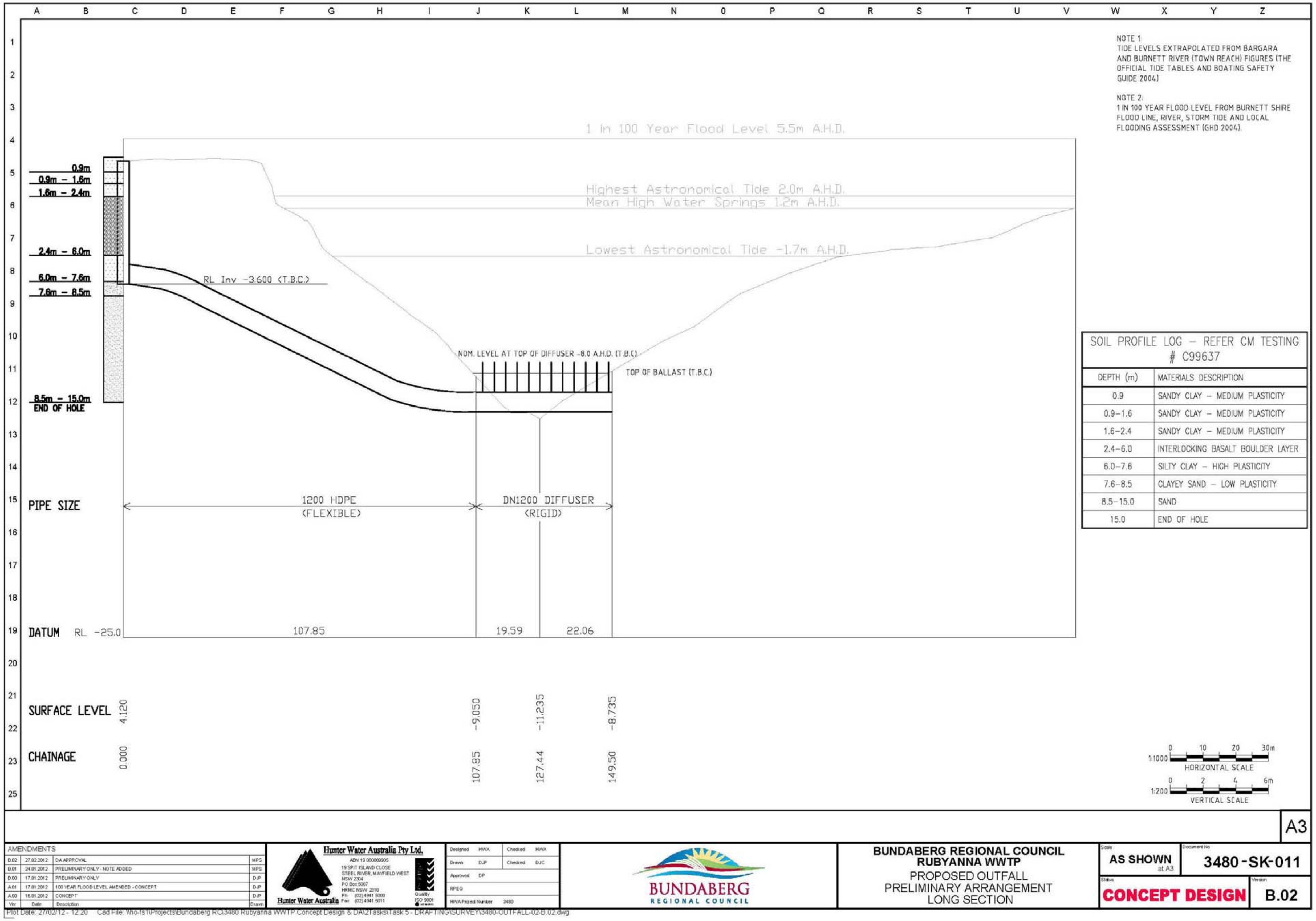

Figure 3 Cross Section of the River Channel at the proposed Outfall Location and Sketch of the Concept Diffuser Design [Ref: *HWA*, 2011]

2.4 Baseline Characteristics of Receiving Waters

2.4.1 Pollutant Sources

Water quality in the Burnett River can be typically categorised according to dry and wet weather conditions.

During dry weather, pollutant loads are generally governed by point source discharges of treated effluent from Bundaberg North, Bundaberg East and Millbank WWTPs (see Figure 1 for locations) [Ref: DERM 2006-2011]. There are no other known significant point source inflows.

During wet weather conditions catchment inflows have a considerable but relatively short term impact on water quality in the Burnett Estuary. With the exception of the urban area of Bundaberg city, the principal land use adjacent to the Burnett estuary is agriculture (predominantly sugar cane farming).

Most sub-tropical Queensland estuaries experience minimal inflow from the catchment for over 80% of the year [Ref: DERM 2011].

2.4.2 Ambient water quality

The proposed outfall location is located within the mid-estuary reach of the Burnett Estuary. Table 2 shows the applicable Queensland and ANZECC ambient water quality guideline trigger values.

Table 2 Applicable water quality guideline values [Ref: ANZECC(2000), DERM (2009)].

Parameters	Guideline Value	Reference
Total Nitrogen (TN)	300 µg/L	QWQG 2009, Section 3.2.1 (QLD Central Coast mid-estuarine waters).
Total Phosphorus (TP)	25 µg/L	QWQG 2009, Section 3.2.1 (QLD Central Coast mid-estuarine waters).
Total Suspended Solids (TSS)	20 mg/L	QWQG 2009, Section 3.2.1 (QLD Central Coast mid-estuarine waters).
Faecal Coliforms (FC)	1000 CFU/100mL	ANZECC 2000, Section 5.2.3.1 (recreational water, secondary contact).

Since 2006 DERM has undertaken regular monitoring and reporting of water quality indicators at 10 sites in the Burnett River estuary. Nutrient levels have generally exceeded water quality guideline values at the mid and upper estuary monitoring sites, indicating that discharges from the Bundaberg North, Bundaberg East and Millbank WWTPs are having a measurable impact on water quality in the Burnett Estuary [Ref: DERM 2006-2011].

2.4.3 Physical characteristics

No existing measurements of the current speed, water temperature and salinity profiles have been found for the proposed outfall location. Values which are considered representative of a sub-tropical estuarine environment will be assumed for the purpose of this assessment. It is recommended that measurements are made to confirm the physical characteristics of the receiving waters prior to the detailed plant design.

3.0 Rubyanna WWTP Concept Design

3.1 Diffuser Design

A concept diffuser design has been developed to satisfy a range of design constraints including:

- Predicted flows;
- Near-field mixing efficiency;
- Minimisation of hydraulic head losses;
- Prevention of sediment and saline intrusion;
- Outfall purging.

As shown in Figure 3, the preliminary design consists of a single outfall with twelve risers spaced approximately 3.5m apart. The use of multiple submerged ports will improve the initial mixing and dilution by increasing the total plume area available for jet entrainment. Each riser will have a single 0.3m diameter port orientated at approximately 30° from vertical and discharging downstream.

Non-return duckbill valves will be fitted to the end of each discharge port. The duckbill valve has a variable orifice size, with effective diameter and discharge velocity varying non-linearly with flow rate. In addition to maintaining long-term hydraulic capacity by preventing sediment and saline intrusion, duckbill valves improve dilution efficiency by forcing higher jet velocities and a more even flow distribution across ports relative to circular ports.

3.2 Characteristics of Proposed Discharge

3.2.1 Flows

Design flows for the ultimate plant capacity of 90,000 EP are given in Table 3 [Ref: HWA (2011)]. The Average Dry Weather Flow (ADWF) is predicted to be 21.2 ML/d and the Peak Wet Weather Flow (PWWF) is predicted as 5xADWF.

Table 3 Concept Daily Design Flows for 90,000 EP design load [Ref: *HWA,* 2011].

Parameter	Value	Units
Average Dry Weather Flow (ADWF)	21.2	ML/d
Peak Wet Weather Flow (PWWF)	106	ML/d

Refined estimates of the hydraulic requirement may be obtained using catchment network modelling prior to the detailed design phase.

3.2.2 Effluent quality

For all flows up to the Peak Full Treatment Flow the advanced Biological Nutrient Removal process will be designed to meet the average (50^{th} percentile) and maximum concentrations shown in Table 4. The predicted effluent concentrations for a PWWF of 106 ML/day are also shown in Table 4. These figures reflect the nutrient design targets discussed with DERM at a preconference meeting in September 2011.

The number of effective dilutions required to reduce effluent concentrations to the water quality guideline concentrations shown in Table 2 are also given in Table 4.

Table 4 Effluent concentrations and required effective dilutions for different operating scenarios (Ref: *HWA*,2011).

	ADWF = 21.2 ML/d				PWWF = 106 ML/d	
	Average Concentration	Average Required Dilution	Maximum Concentration	Maximum Required Dilution	Average Concentration	Required Dilution
TSS	9 mg/L	-	30 mg/L	2	20 mg/L	-
TN	5 mg/L	17	15 mg/L	50	7 mg/L	24
TP	2 mg/L	80	3 mg/L	120	2 mg/L	80
FC	1000 cfu/100mL	-	10 000 cfu/100mL	10	1000 cfu/100mL	-

4.0 Effluent Plume Modelling

4.1 Background to Near-Field Mixing

Near-field mixing is the initial dilution of a discharge which is predominantly momentum and buoyancy driven. Far-field mixing occurs once ambient hydrodynamics become the primary control on dispersion and takes place over greater spatial and time scales. Significantly more dilution generally takes place in the near-field mixing zone.

From a regulatory perspective, the near-field mixing zone is often defined as an explicit area adjacent to a discharge source in which environmental values are not protected. Water quality concentrations are sometimes regulated at the edge of a predicted mixing zone.

When effluent is discharged from an outfall, ambient water becomes entrained at the plume boundary and dilutes the effluent whilst also increasing the plume width. The spatial extent and dilution of the plume is a function of the diffuser design as well as the physical characteristics of the discharge and the receiving waters.

For a given effluent flow and concentration the amount of initial dilution can be maximised through engineering design of the diffuser for particular ambient conditions, however the actual degree to which dilution occurs will vary with the discharge and ambient flow conditions.

4.2 Modelling Approach

The US EPA's Visual Plumes mixing zone modelling package was used to predict the extent of the effluent plume from the proposed Rubyanna WWTP under varying ambient conditions.

The three-dimensional Lagrangian plume transport model UM3 was selected as most applicable to the present case. The UM3 model predicts the dimensions and the dilution of the plume using a detailed near field projected-area-entrainment theory, which is applicable to multiport submerged discharges. Detailed verification of the performance of this model is available [Ref: Frick, 2003].

The aim of the near field modelling is to understand variance in the spatial extent of the mixing zone and the extent of the dilution of key contaminants for the range of operating conditions and under varying ambient conditions.

4.3 Model Setup for Concept Design Case

The concept outfall design parameters for the preliminary model setup are based on the values given previously in Sections 2.4 and Section 3.2. The preliminary model setup is summarised in Table 5.

The base case design concept model assumes Average Dry Weather Flow (ADWF) conditions with average (50^{th} percentile) effluent concentrations. Ambient river concentrations are assumed as being at the water quality guideline values given in Table 2.

It is assumed that at the design flow rate the duckbill valve approaches a circular shape with effective diameter equivalent to the port diameter of 0.3m. For an ADWF of 21.2ML/d this results in a discharge velocity of approximately 0.29 m/s. This conservative approximation has previously been demonstrated as acceptable (Tate, 2004).

Due to the lack of measured values for ambient parameters it was assumed that treated effluent discharges into ambient water flowing downstream at 0.01 m/s. This is a conservative assumption since the river will rarely be stationery and higher velocities will enhance dilution. Physically, such a low ambient flow may occur at the turn of the tide, or possibly if tidal and other forcings are opposing and cancel each other out.

The density of water in the Burnett River at the point of discharge will vary according to tidal and meteorological conditions. DERM measurements indicate that conductivity levels are in the range of 40-50mS/cm at sites close to the point of discharge during dry weather conditions. A water density of 1020 kg/m^3 (at 25˚C this equates to a salinity of approximately 30 PSU) was assumed for the base case model. A density of 1000 kg/m^3 was assumed for the treated effluent discharge.

A water depth of approximately 10m at the diffuser location was assumed. Each port is assumed to discharge at a height of 6.5m below the water surface. This is assumed to approximately represent Lowest Astronomical Tidal conditions.

Table 5 Concept design model setup [Ref: *HWA*, 2011]

Outfall Design Parameters	Value
Number of ports	12
Port Spacing	3.5 m
Port elevation	3.5 m
Port diameter	0.3 m
Vertical discharge angle	60° from horizontal
Horizontal discharge angle	0° from downstream
Discharge Parameters	
Effluent Flow Rate (ADWF)	21.2 ML/d
Effluent density	1000 kg/m^3
TSS	9 mg/L
Total Nitrogen	5 mg/L
Total Phosphorus	2 mg/L
Faecal Coliforms	1000 cfu/100mL
Ambient Parameters	
Current Speed	0.01 m/s
Water Density	1020 kg/m^3
Water Depth	10 m
TSS	13 mg/L
Total Nitrogen	0.3 mg/L
Total Phosphorus	0.025 mg/L
Faecal Coliforms	1000 cfu/100mL

Conservative pollutant decay rates were assumed for each contaminant of interest, as shown in Table 6. The effect of pollutant decay is only of significance over long times scales, such as when tidal buildup is considered.

Table 6 Assumed pollutant decay rates (Metcalf and Eddy, 2004).

Pollutant	Decay Rate
Faecal Coliform (FC)	2.87 cfu/mg /day
Total Nitrogen (TN)	0.05 mg/l /day
Total Phosphorus (TP)	0 mg/l day
Total Suspended Solids (TSS)	0 mg/l day

Model results for the base case will be discussed in the following section. The sensitivity of these results to plant operating parameters and variations in ambient receiving water characteristics is then discussed in Section 4.5.

4.4 Model Results for Concept Design

The concept design case outlined in Table 5 was modelled with Visual Plumes. The results for the plume elevation with horizontal distance downstream from the outfall are shown in Figure 4 and the corresponding plume dilution is shown in Figure 5.

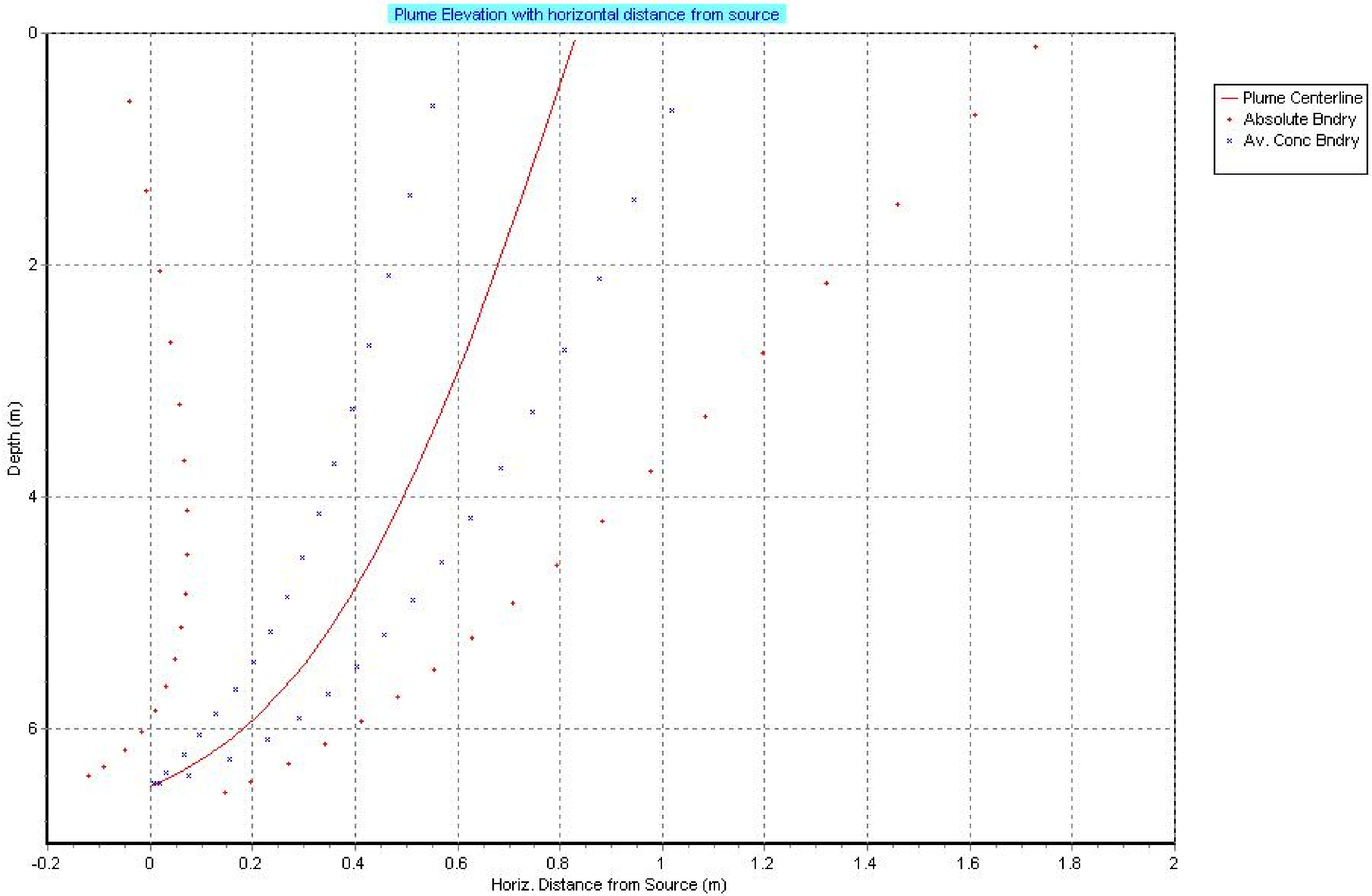

Figure 4 **Plume elevation with horizontal distance downstream from outfall**

In Figure 4 the plume centreline elevation is shown as a red solid line and the absolute plume boundary as a red dotted line. Also shown in Figure 4 is an internal boundary corresponding to the average plume dilution, which is marked with blue crosses. The corresponding average and centreline dilutions will be used in the following sections to determine average and minimum concentrations of important plume constituents.

Under the low ambient current velocity of 0.01 m/s it was found that the spatial extent of the plume was less than 2m from the outfall. It was found that a horizontal spacing of 3.5m between ports is sufficient to prevent merging of the individual plumes when the prevailing ambient current is directed downstream. This improves dilution by maximising the surface area over which ambient water can cross the plume surface.

The centreline and averaged plume volumetric dilutions are shown in Figure 5. An average of 26 dilutions are achieved by the time the plume reaches the water surface. The minimum number of dilutions achieved before the plume centreline reaches the surface is 16.

The effective dilution of individual contaminants will vary slightly from the volumetric dilution shown in Figure 5 with the presence of background ambient concentrations and the effects of decay.

The concentrations of each effluent constituent can be calculated from the effective dilution of the plume and the discharge concentration. For example, based on a discharge concentration of 15mg/L, where the modelling indicates that 50 effective dilutions occur, the concentration would be 15/50=0.3mg/L.

The average and centreline effective dilutions for total nitrogen (red) and total phosphorus (green) under ADWF conditions are shown in Figure 6 when ambient concentrations are assumed as equal to guideline values. It is observed that in this case the effective dilution is similar to the volumetric dilution.

An average of 26 effective dilutions and a minimum centreline effective dilution of 19 are achieved for total nitrogen by the time the plume reaches the water surface. The average and centreline effective dilutions of total phosphorus are 26 and 17 respectively by the time the plume reaches the water surface.

To reduce concentrations of total nitrogen and total phosphorus to water quality guideline levels 17 and 80 dilutions are required respectively. Therefore, for Average Dry Weather Flow at low tide with an assumed ambient current of 0.01m/s scenario sufficient dilution of total nitrogen takes place before the plume reaches the water surface however the plume reaches the surface before phosphorus concentrations are diluted to guideline levels.

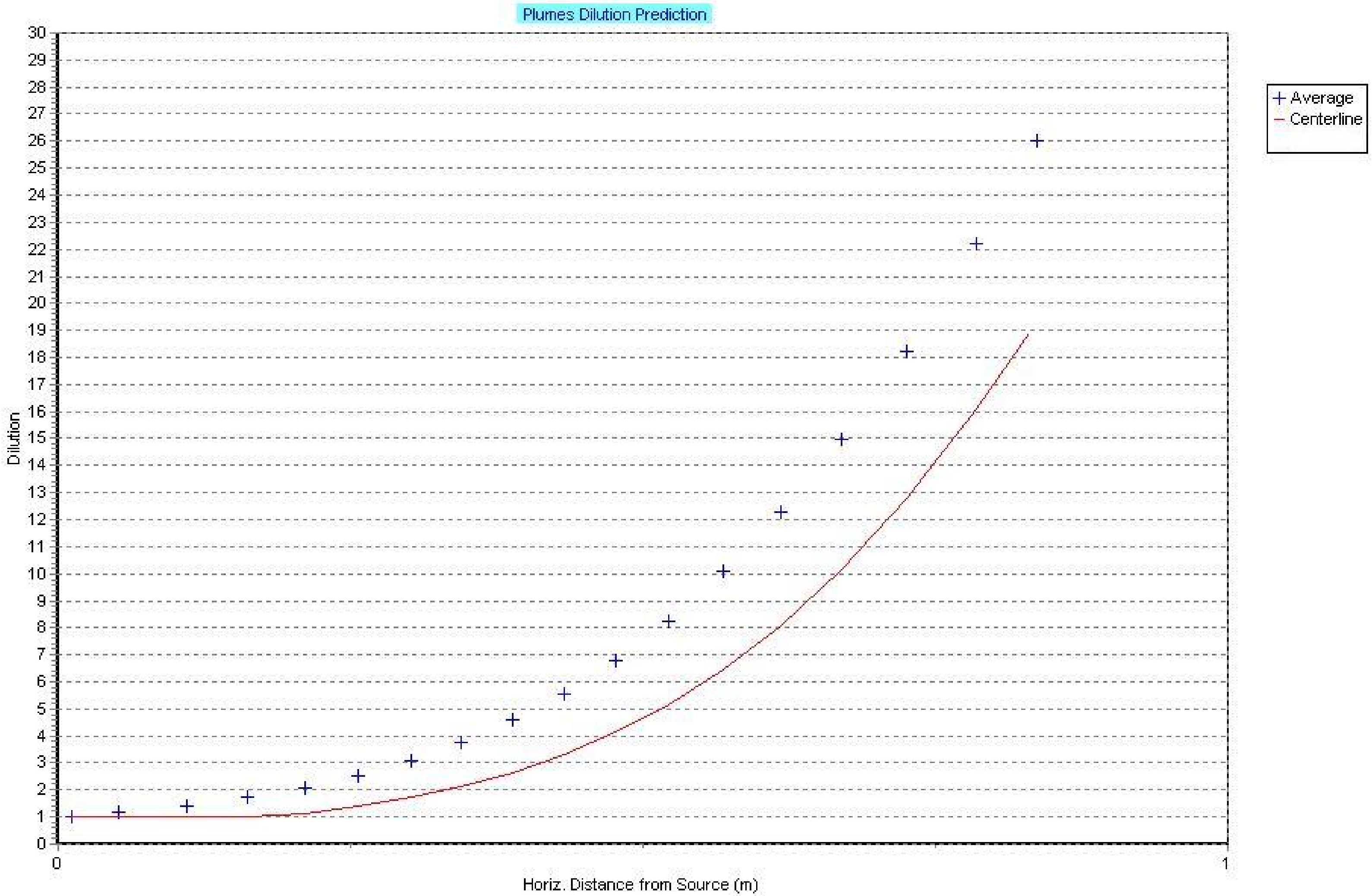

Figure 5 Volumetric plume dilutions with distance along the plume centreline from outfall

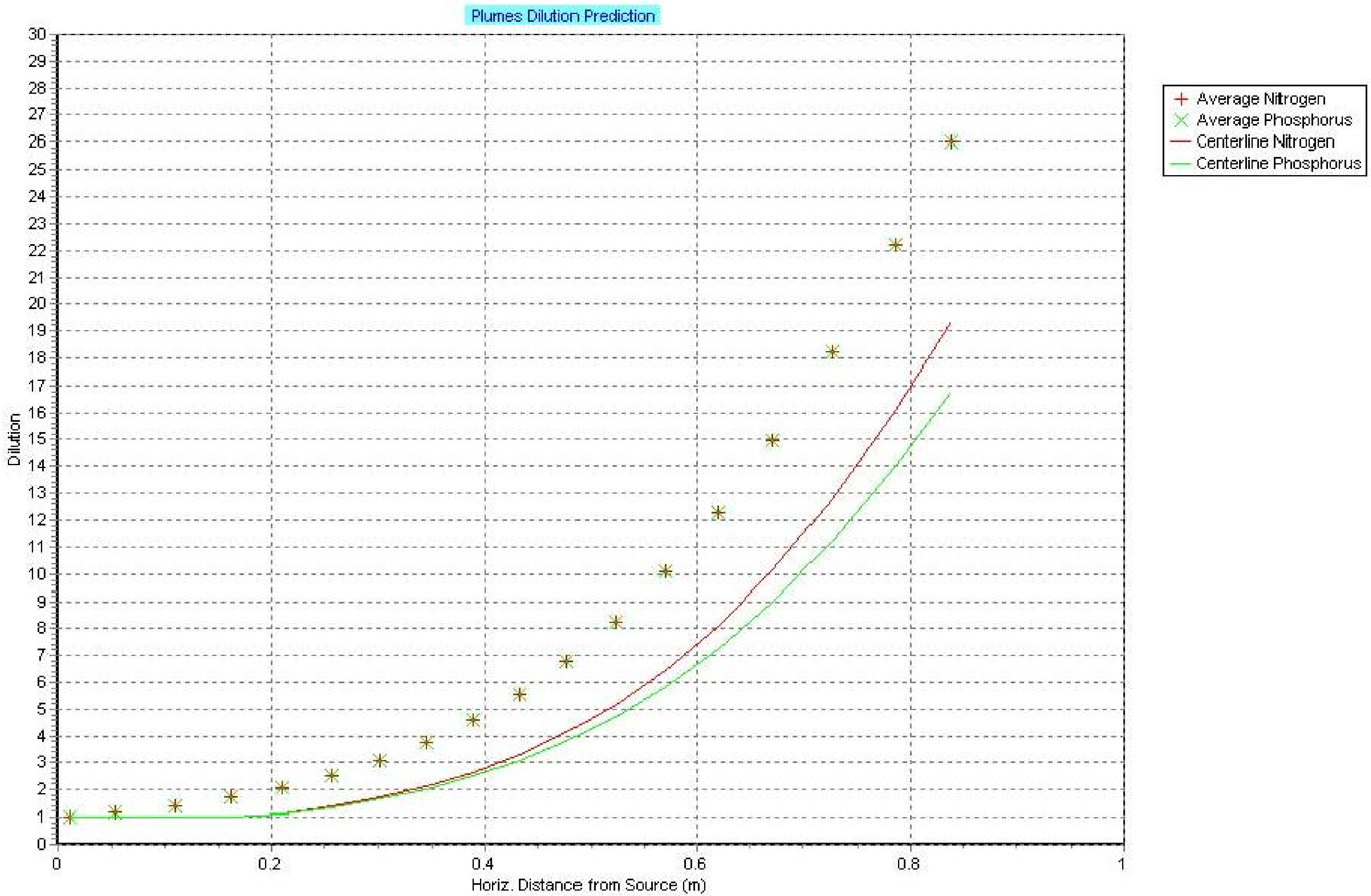

Figure 6 Average (dashed line) and centreline (solid line) effective dilution of total nitrogen (red) and total phosphorus (green) with distance from outfall

4.5 Sensitivity Analysis

For a given effluent flow and concentration the amount of initial dilution can be maximised through engineering design of the diffuser for particular ambient conditions, however the actual degree to which dilution occurs will vary with the plant operation and ambient flow conditions.

In this section the sensitivity of the predicted plume dilution is studied with respect to the diffuser design and the WWTP plant operating envelope. The influence of varying ambient conditions is then considered.

4.5.1 Ambient Current

A very low ambient current speed was assumed in the base case model since a low (not necessarily zero) velocity generally provides the worst case mixing performance. High current speeds deliver more ambient fluid to the surface of the plume and act to increase shear between the plume and its receiving waters, this contributes to the production of turbulence which directly affects dilution.

The sensitivity of the discharge plume to current speed was assessed using current speeds between 0.1 m/s and 0.5 m/s inclusive. The current speed and direction remained constant with respect to time and depth.

Figure 7 shows the results of the current speed sensitivity test on the trajectory of the plume centreline and absolute plume boundary and Figure 8 shows the corresponding dilutions. Both Figure 7 and Figure 8 demonstrate that the ambient current speed has a significant impact on mixing once the initial discharge momentum has reduced.

It was found that under ADWF conditions and assuming a river depth corresponding to LAT, a background current of 0.4m/s or greater is sufficient to ensure at 120 dilutions at the plume centreline prior to plume reaching the water surface. An ambient current of at least 0.25m/s is required to ensure an average plume dilution of 120 prior to plume reaching the water surface.

4.5.2 Unsteady Tidal Effects

The tidal cycle alters both the depth of the outfall below the surface as well as the velocity of the water past the end of the outfall.

The depth of water above the discharge port has a significant impact on the number of dilutions achieved before the plume reaches the water surface. Assuming a port depth of 10.5m (based on the estimated Highest Astronomical Tide Level at the outfall location) the number of dilutions at the water surface for ADWF and a low ambient current of 0.01m/s increases from an average of 26 to 52.

A synthetic timeseries was generated assuming that the tidal velocity varies between 0.01-0.75m/s and changes direction at slack tide, as shown in Figure 9. In this figure each ‘case number’ represents a half hour time period. The depth of water above the port was assumed to vary between the estimated Mean High Water Springs and Mean Low Water Springs levels at the outfall location. It is noted that due to the lack of measured data the extent of tidal influence at the point of discharge it is presently unclear. The results presented here are for planning purposes and should not be seen as a substitute for actual, measured data.

Figure 10 shows the predicted tidal effect on the effective dilution corresponding to the daily ebb and flood tides in addition to the monthly spring and neap tides shown in Figure 9. The predicted nearfield dilutions and mixing zone dilutions are shown. The ‘nearfield’ dilution is the average number of dilutions achieved by the time the plume hits the water surface. The ‘mixing zone’ dilution represents the average number of dilutions in the water column at a nominal distance of 10m from the outfall. An increase in effective dilution can be observed during the transition to spring tides.

The inset of Figure 10 show the first few days of the simulation, when the effective dilution shows a regular pattern of high dilutions during times of maximum currents and relatively low dilution during times of low currents.

Tidal reversals may also reduce the effective dilution of the discharge by re-entraining the plume remaining from the previous cycle. Assuming that the river is approximately one dimensional with low freshwater inflow an estimate of the buildup of background concentration due to repeated passage of given fetch of water past the discharge can be obtained. No effect of pollutant buildup over the month for the assumed current and depth profile is apparent in Figure 10. It is recommended that current velocity measurements are made to confirm the actual likelihood of pollutant buildup at the outfall location.

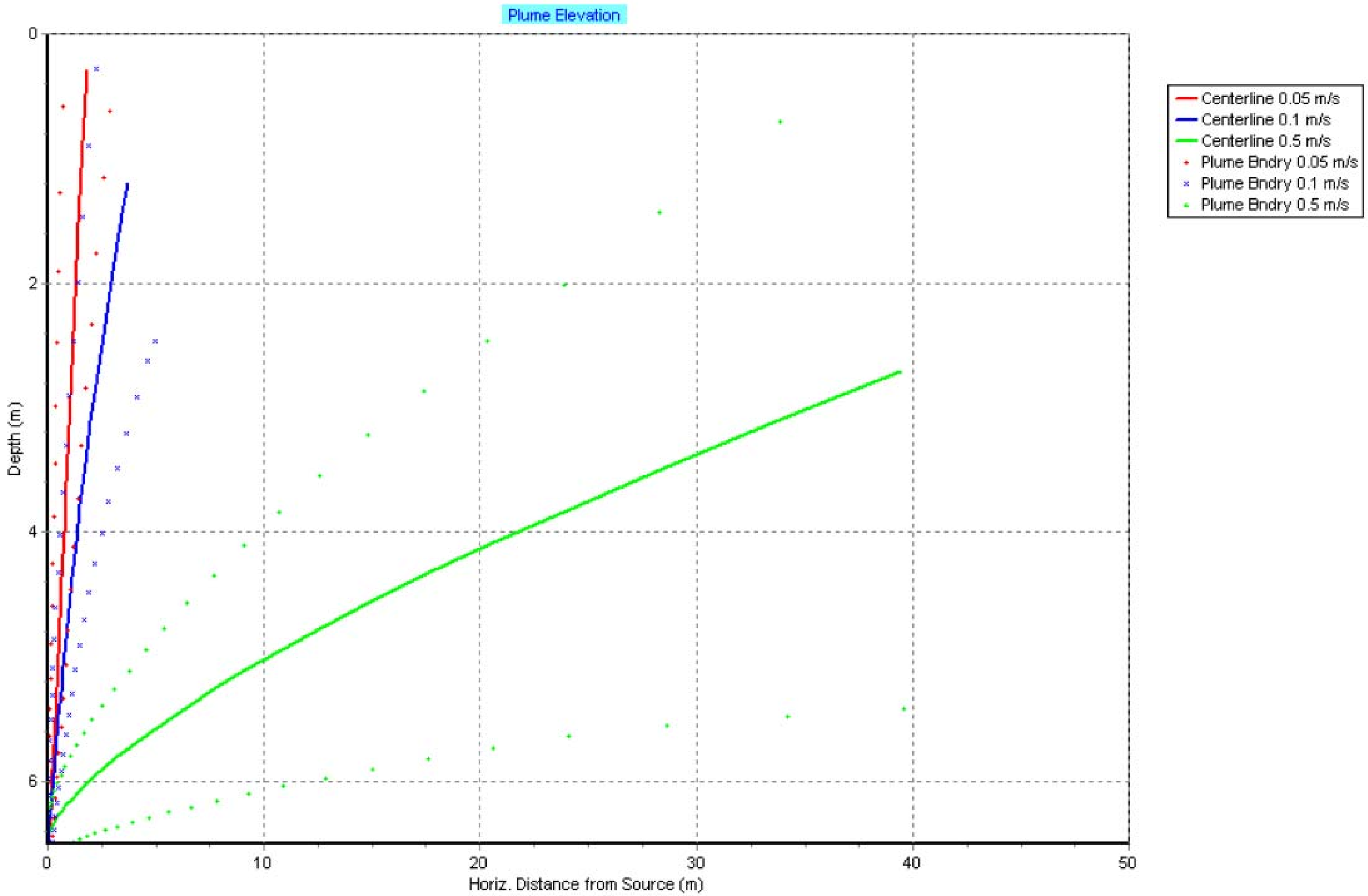

Figure 7 **Variation in plume trajectory with ambient current speed (Red=0.05 m/s, Blue=0.1 m/s, Green=0.5 m/s)**

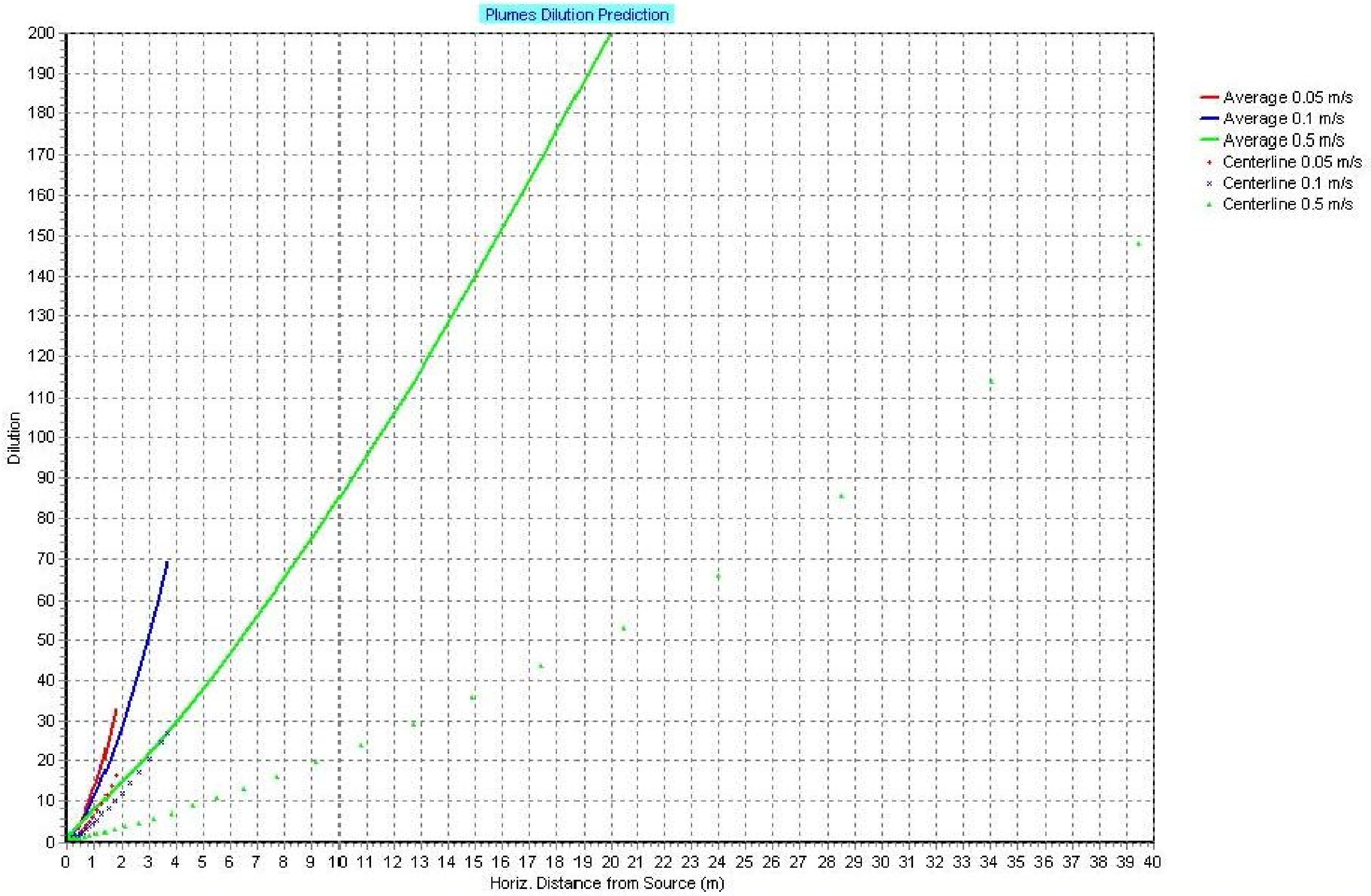

Figure 8 **Variation in average (solid lines) and minimum centreline (dotted lines) dilution with ambient current speed (Red=0.05 m/s, Blue=0.1 m/s, Green=0.5 m/s)**

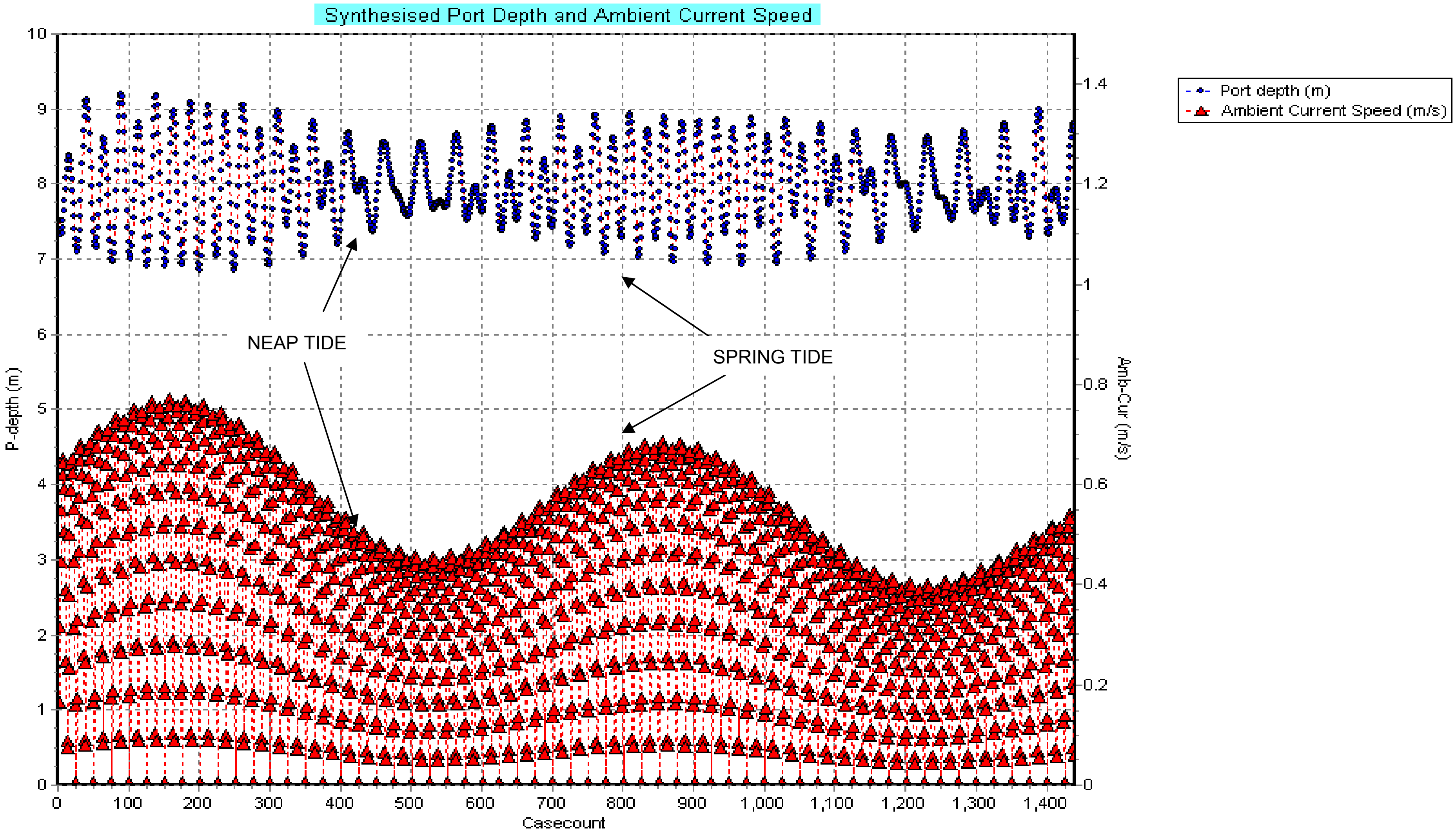

Figure 9 **Month long record of synthesised tidal current speed (m/s) and port depth (m) at the outfall location.**

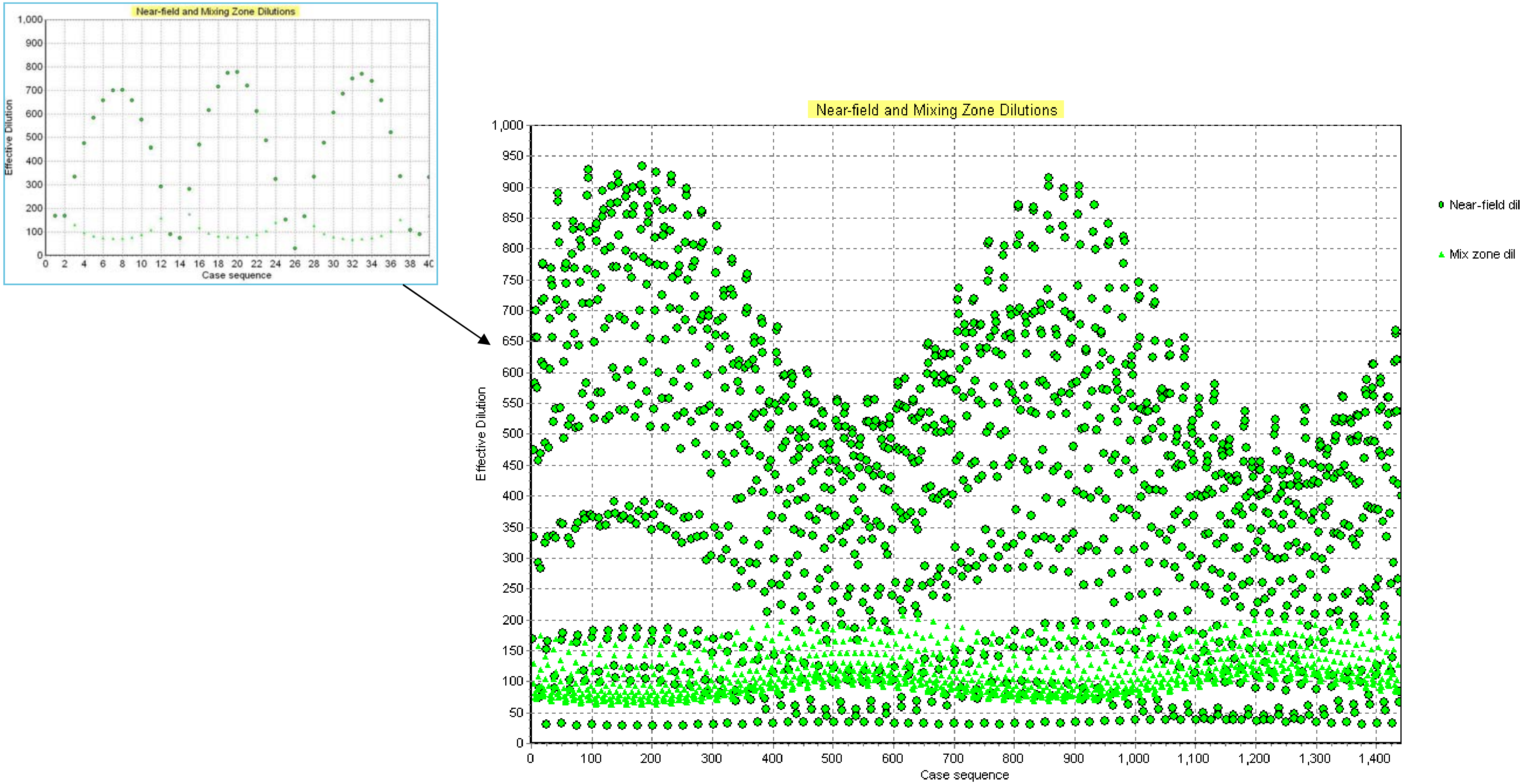

Figure 10 Month long simulation showing the effect of tidal recirculation and background pollution buildup on effective dilution

4.5.3 Plume Buoyancy

An effluent density of 1000 kg/m^3 was assumed for the base case model. A water density of 1020 kg/m^3 was assumed to represent the Burnett River estuary water density at the point of discharge.

The salinity of the effluent discharge is expected to be minimal and the effluent temperature will vary seasonally, as will the ambient Burnett River temperature. However, sudden reductions in the salinity (and hence water density) of the Burnett River occur during relatively short periods of significant freshwater inflow.

The density of the receiving water and discharged effluent was sensitivity tested and over the range of expected values. Figure 11 shows the variation in the plume trajectory when the density of the effluent density relative to the river density is varied between 0.97 and 1. A low relative density of 0.97 would correspond to a freshwater effluent density of 998kg/m^3 combined with a river water density of approximately 1030 kg/m^3. A relative density of greater than 0.99 would occur during periods of significant freshwater river flow.

The corresponding average dilutions achieved when the plume reaches the water surface are given in Table 7.

4.5.4 Diffuser design

Design influences on mixing include the angle of discharge, the port diameter, port spacing, and number of ports. In general, these parameters influence effluent discharge velocity (and hence momentum) and an increase in one or all may be associated with slightly higher hydraulic head requirement.

The port diameter affects the effluent velocity and the surface to volume ratio of an individual plume. The use of multiple submerged ports improves the initial mixing and dilution by increasing the total plume area available for jet entrainment. Similarly, the larger the spacing between ports, the greater the path over which plumes do not interact.

The initial results described in the previous section indicate that for ADWF the plume half width is expected to be less than 2.5m for a parallel (downstream) orientated current, so a 3.5m riser spacing is adequate in minimising the chance of plume interaction.

Sensitivity analysis indicates that plume merging is likely to occur for very low effluent flows which have minimal horizontal momentum, however the use of duckbill valves will improve initial dilution during low flow, relative to a circular orifice.

The orientation of the discharge port relative to the ambient flow modifies the plume trajectory which may enhance plume dilution by lengthening the travel distance. Figure 12 shows that the vertical discharge angle has a small effect on the initial plume dilution. The corresponding dilution at the water surface increases slightly from 16 to 17 dilutions.

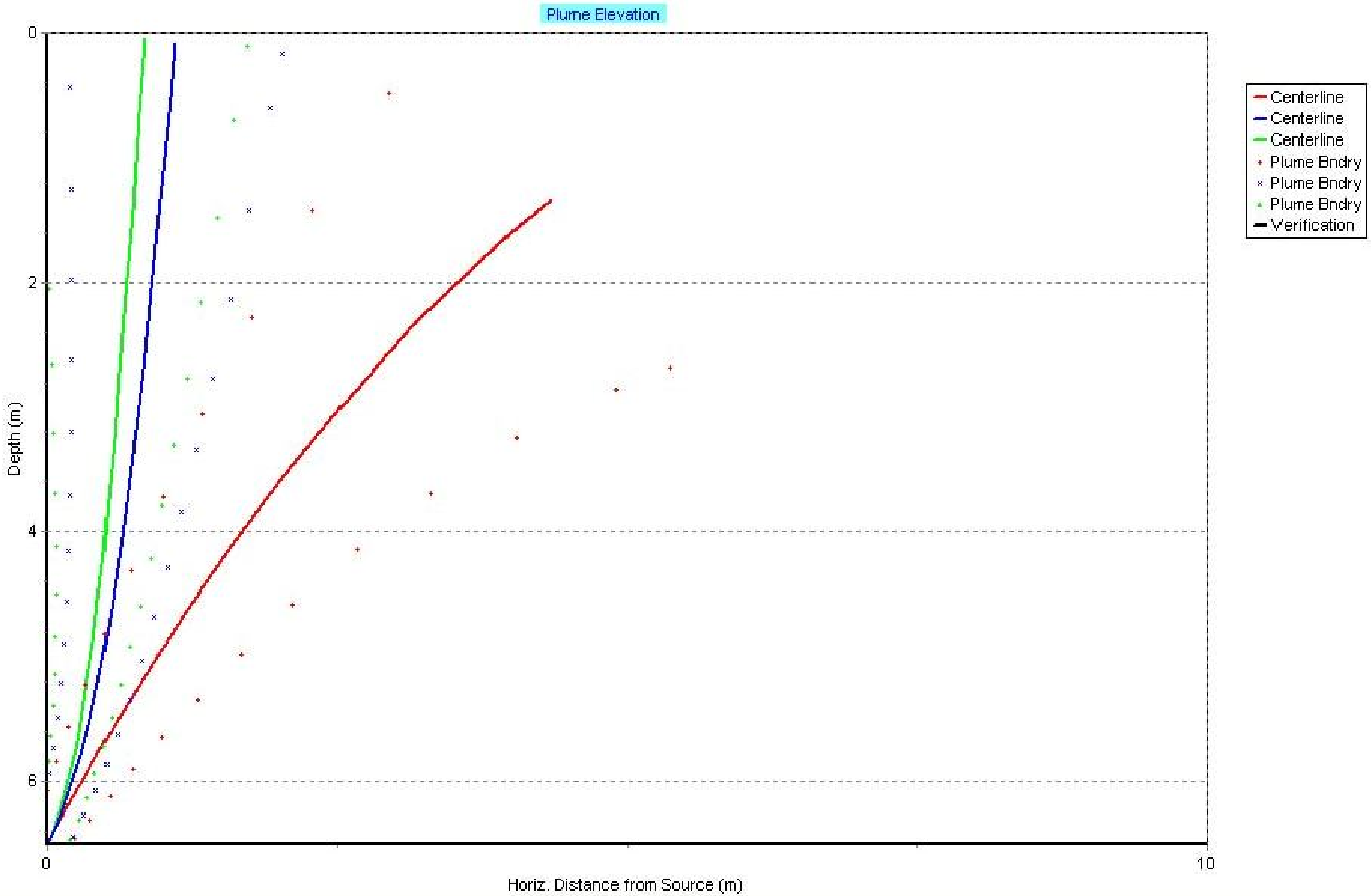

Figure 11 Variation in plume trajectory with relative density (0.97=green, 0.98=blue, 0.99=red)

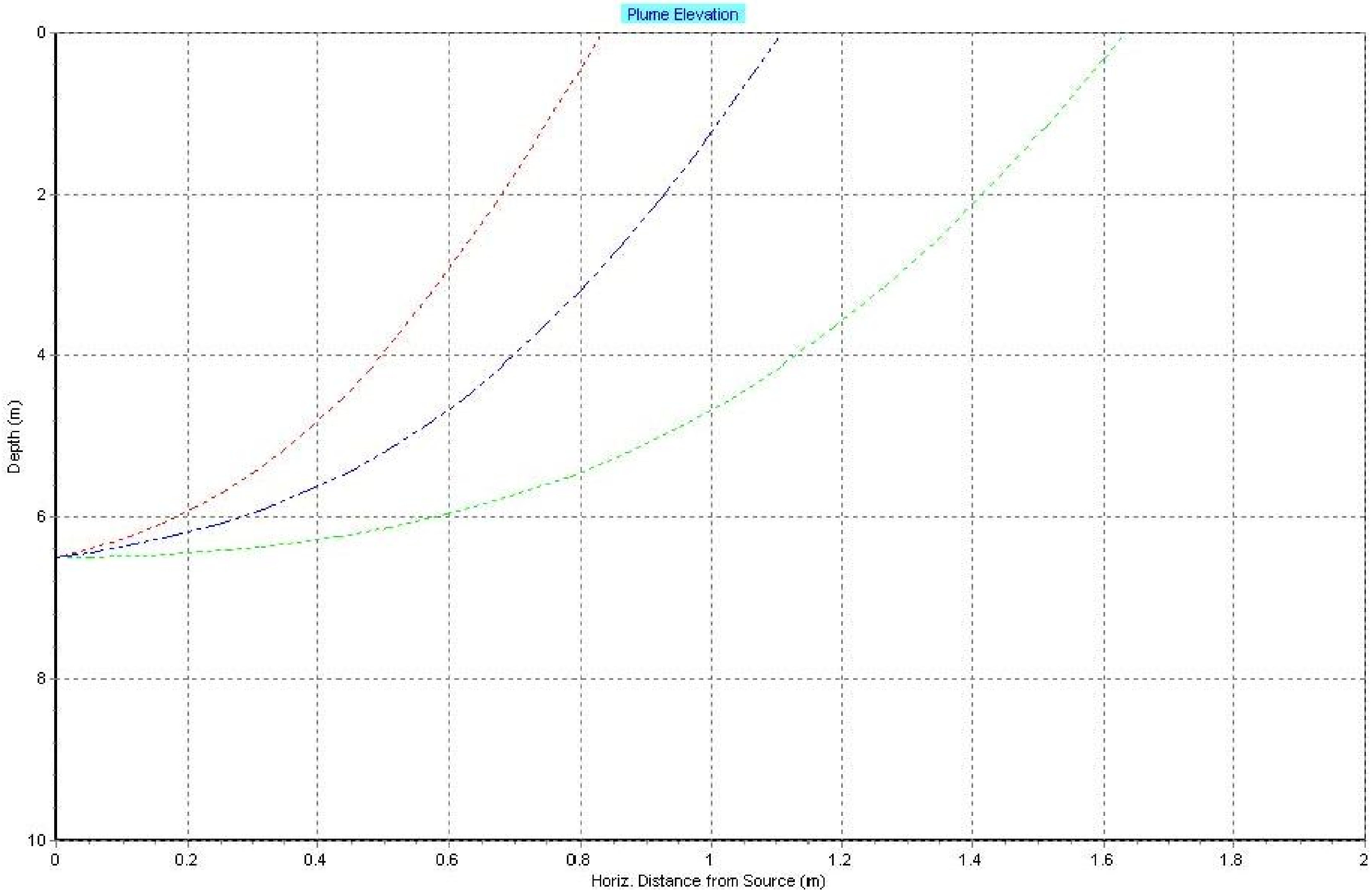

Figure 12 Variation in plume centreline trajectory with vertical discharge angle: 0°(green) 30° (blue) and 60° (red) from horizontal

4.5.5 Summary

The Visual Plumes model was run for ADWF and PWWF scenarios with varying ambient current speeds of 0.01-1 m/s and relative water density from 0.97 to 1. A summary of the average number of dilutions achieved by the time the plume reaches the water surface is given in Table 7.

Table 7 Summary of predicted average plume dilution at the water surface for ADWF and PWWF at LAT with varying ambient current and relative density

	ADWF = 21.2 ML/d		PWWF = 106 ML/d	
	Relative density		Relative density	
Current Speed (m/s)	0.97	1	0.97	1
0.01	26	13	14	10
0.1	82	128	18	21
0.25	297	330	49	60
0.5	612	714	121	128
1	n/a	n/a	245	257

n/a=plume does not reach water surface prior to an average dilution of 1000.

At PWWF the outlet velocity is increased from 0.29m/s to1.45m/s. For PWWF and a low ambient current an average of 10 dilutions are achieved before the plume reaches the water surface rather than 13 for ADWF.

At PWWF a minimum of 80 dilutions are required (Table 4). On average this is predicted to be achieved for all density combinations and an ambient current speed of greater than 0.5 m/s. It is noted that during PWWF conditions the river is likely to have elevated water levels and peak current speeds due to the significant freshwater inflow.

At ADWF a minimum of 120 dilutions are required to dilute the maximum effluent concentrations. This plume dilution (average and centreline) is predicted to be achieved for all density combinations and a current speed of greater than 0.25 m/s.

5.0 Summary

The Burnett Estuary has dynamic characteristics that are determined by the interactions of tidal exchanges and and river flow. The objective of the outfall design is to discharge treated effluent such that detrimental effects to the Burnett River are minimal.

Modelling has been carried out to determine the number of dilutions of key contaminants by the time the discharge plume reaches the water surface. The US EPA's Visual Plumes software was used to predict the plume trajectory and dilution.

All modelling and calculations have been performed using conservative methodologies. It is therefore anticipated that the results presented in this report provide a conservative estimate of actual system performance. A sensitivity analysis was also undertaken to determine that dilution targets are achieved under a variety of ambient conditions.

In order to calculate the average dilution achievable a statistical basis both for the discharge and ambient currents would need to be applied. However, for the purpose of conceptual design, the median dilution based on the predicted ADWF (21.2ML/d) and an assumed current should give an indication of the expected average performance of the outfall.

At ADWF a minimum of 120 dilutions are required to dilute the maximum effluent concentrations to guideline levels (Table 4). This average plume dilution is predicted to be achieved for all density combinations and an ambient current velocity of greater than 0.25 m/s. At PWWF a minimum of 80 dilutions are required (Table 4). This average plume dilution is predicted to be achieved for all density combinations and an ambient current of greater than 0.5 m/s.

Lowest initial dilutions occur when the discharge is reduced to almost zero river current at low tide. The lowest initial average plume dilution of 10 occurs when the outfall is releasing the highest possible discharge (PWWF) combined with lowest astronomical tide and river level and an almost zero ambient current. In practice, elevated river levels and current speeds would be expected under PWWF conditions.

Under ADWF and LAT a background current of 0.25m/s or greater is sufficient to ensure mixing of average effluent concentrations to guideline levels prior to the water surface being reached.

While this desktop study has utilised state of the art modelling techniques, their limitations must be recognised. Near-field models only give an approximation of expected initial dilutions and the accuracy of the model predictions must be incorporated into final design considerations. If a final design is selected that only just meets the design criteria, field monitoring and physical modelling are recommended in order to accurately determine background conditions and to more accurately assess the final design.

5.1 Recommendations

To allow for maximum dispersion it is recommended to:

- Locate the outlet discharge as deep as practicable to enhance mixing and prevent problems to navigation;
- Locate the outlet discharge as far downstream as practicable to enhance mixing due to natural estuarine processes;
- Orientate to face the direction of the tidal current, facing downstream;
- Regularly monitor outfall headloss to anticipate diffuser maintenance;
- Ebb tide release will minimise impact of discharge.

It is further recommended that a field measurement campaign is undertaken at the proposed point of discharge in order to understand the ambient physical characteristics. Due to the lack of measured data the extent of tidal influence at the point of discharge it is presently unclear.

6.0 References

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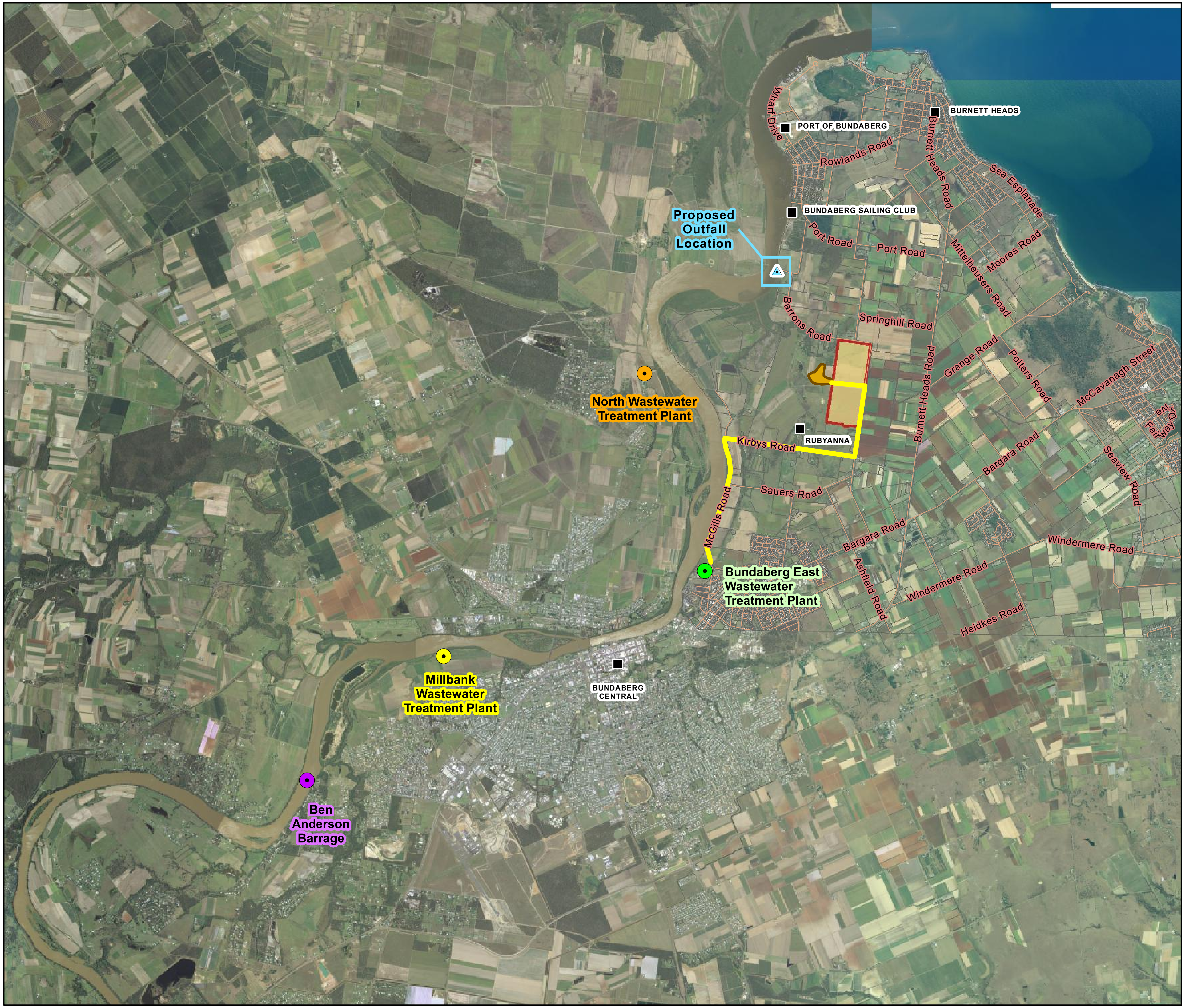
Appendix P

Traffic Route Plan

RUBYANNA WWTP

Traffic Management Plan



Legend

- Proposed Outfall Location
- Ben Anderson Barrage
- Bundaberg East Wastewater Treatment Plant
- Millbank Wastewater treatment Plant
- North Wastewater Treatment Plant
- Roads
- Proposed Construction Traffic Route
- Possible STP Site (approx16.7ha)
- Lot 1 RP57605 (108.6 ha)
- Cadastre

N

Scale: 1:70,000 (when printed at A3)

0 500 1,000 2,000

Metres

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