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SOUTH EAST THORNLANDS STRUCTURE PLAN

STORMWATER INFRASTRUCTURE CONCEPT PLAN

28 April 2010

M8000_003

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PROJECT M8000_003 - SOUTH EAST THORNLANDS STRUCTURE PLAN

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1. INTRODUCTION

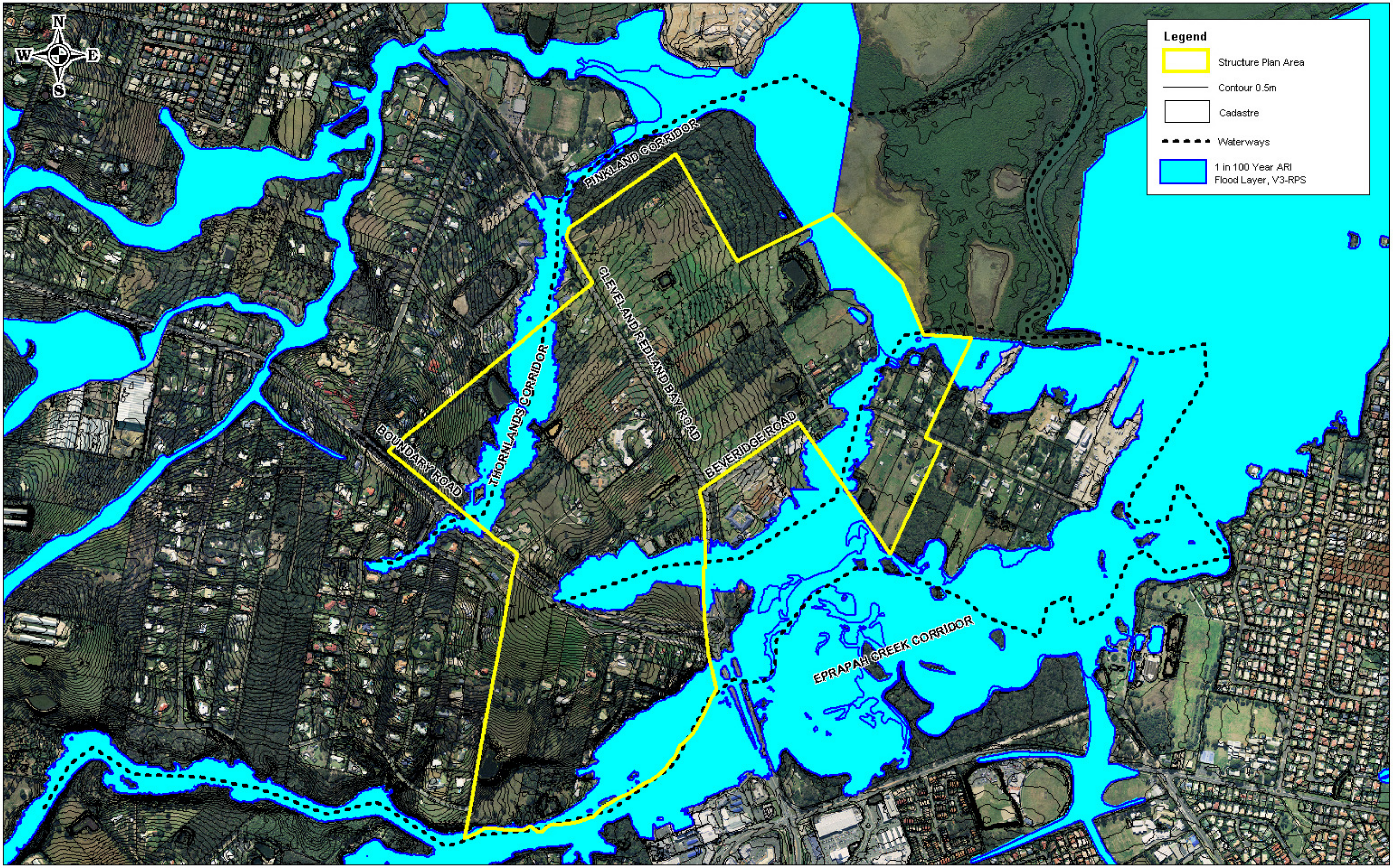
Redland City Council (RCC) has commissioned EnGenY to develop a stormwater infrastructure plan for the proposed South East Thornlands development area. The purpose of this study is to determine the integrated stormwater quantity and quality trunk infrastructure requirements, associated costs and infrastructure charges for the proposed development area. The stormwater infrastructure plan will assist Council in applying appropriate planning and acquisition principles for servicing forecasted demands. Refer to Figure 1.1 which illustrates the extent of the South East Thornlands Structure Plan Area.

The former South East Queensland Regional Plan 2005-2026 included South East Thornlands within the Urban Footprint regional land use category. On 16 June 2006, South East Thornlands was identified as a Major Development Area (MDA) by the regional planning Minister. In accordance with the South East Queensland Regional Plan 2009-2031 (SEQ Regional Plan), land use and infrastructure planning is required to be prepared and adopted prior to any future development taking place within the South East Thornlands Structure Plan Area.

A number of studies previously undertaken to assist in the development of the South East Thornlands Structure Plan have been used by EnGenY to provide background information to this study. The previous studies include:

- South East Thornlands Urban Community Structure Plan, Integrated Urban Water Management Infrastructure Investigation by GHD in November 2006;
- South East Thornlands Urban Community Structure Plan, Flood Mapping by GHD in May 2007;
- Strategic Ecological Review of the Revised South East Thornlands Structure Plan by BAAM in May 2009; and
- Flora and Fauna Assessment – South East Thornlands Community Structure Plan Area by BAAM in March 2006.

The investigation has adopted a design approach consistent with the Queensland Government's Guide to Planning Stormwater Trunk Infrastructure (March, 2010), Statutory Guideline 01/09, Queensland Urban Design Manual (QUDM) and relevant Council policies for stormwater management.



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South East Thornlands Structure Plan

Locality Plan

Figure 1.1

2. SCOPE OF WORKS

The scope of works for this study has included stormwater quantity and quality analysis works, including determination of infrastructure requirements, associated construction costs, infrastructure charges as well as reporting. Specifically, the technical scope of works included the following:

- **Stormwater Quantity**
  - Development of an Existing Case XP-STORM hydrologic and hydraulic model representing the existing land use conditions and existing stormwater infrastructure throughout the study area;
  - Simulate the Existing Case model for the 10 and 100 year ARI design event to determine the existing design flows and flood levels and assess the hydraulic capacity of the existing stormwater infrastructure;
  - Development of an Ultimate Case XP-STORM hydrologic and hydraulic model to represent the proposed development plan which comprises the proposed ultimate land use within the development area;
  - Simulate the Ultimate Case model for the 10 and 100 year ARI design events to determine the ultimate design flows and flood levels for the range of events and assess the hydraulic capacity of the existing stormwater infrastructure (i.e. culvert crossings);
  - Development of a Mitigated Case XP-STORM hydraulic model to determine the trunk stormwater infrastructure requirements to achieve the stormwater quantity objectives and design standards.
  - Concept design of proposed stormwater quantity mitigation measures including estimation of construction costs and infrastructure maps for the proposed trunk infrastructure requirements to cater for the proposed development.

- **Stormwater Quality**
  - Development of a MUSIC Version 3.0 model for the catchment to represent the Ultimate Unmitigated Scenario. This model allows for a quantitative assessment of stormwater runoff quality for the proposed development plan (proposed ultimate land use);
  - Amend the Ultimate Unmitigated MUSIC model to include the appropriate treatment measures required to achieve the prescribed water quality objectives from the catchment. This model represents the Ultimate Mitigated Scenario for the proposed development area and enables the appropriate water quality treatment infrastructure to be defined;
  - Concept design of the proposed stormwater quality mitigation measures including estimation of construction costs for the proposed water quality trunk infrastructure requirements for the proposed development.

3. CATCHMENT DESCRIPTION

The South East Thornlands development area covers one hundred and forty six (146) hectares of land abutting Morton Bay on the east coast of mainland Redland City. It is bounded to the north by Pinklands Sporting reserve, to the east by Morton Bay, to the south by Eprapah Creek and is in close proximity to the Victoria Point Major Centre.

While the majority of the existing land use for the catchment consists of Rural Residential and Open Space with pockets of Community Purpose, the ultimate land uses comprises a mixture of Low to Medium Density Residential, Open Space with pockets of Rural Non-Urban and Local Centre area.

Three main corridors have been identified within the structure plan area which can also be defined as the flood prone area. These three corridors include Eprapah Creek Corridor in south, Pinklands Reserve Corridor in north and north-east, and Thornlands Creek Corridor in north and north-west. Figure 1.1 shows the location of the waterway corridors.

4. TRUNK INFRASTRUCTURE NETWORK COMPONENTS

According to the Department of Infrastructure and Planning's (DIP) Statutory Guidelines 01/09 for Priority Infrastructure Plans and Infrastructure Charges Schedules, trunk infrastructure is defined as 'higher order' development infrastructure planned, funded and provided by local governments and shared between developments. The guidelines also state that local governments should apply proper planning and acquisition principles for servicing forecasted demands rather than imposing development conditions requiring stormwater to be retained and treated on-site. In accordance with Statutory Guidelines, Table 4.1 outlines potential inclusions for trunk infrastructure charges for the South East Thornlands Structure Plan Area.

Table 4.1 Potential Inclusions for Infrastructure Charges

Network	Inclusions
Stormwater Quantity	Pipes, box culverts, manholes, inlets and outlets
	Detention/retention facilities
	Channels and overland flow paths (natural and constructed)
	Bank stabilisation, erosion protection and revegetation (only as direct result in increase in demand)
Stormwater Quality	Riparian corridors
	Wetlands
	Gross Pollutant Traps (GPT's)
	Stormwater quality improvement devises (SQIDS)
	Bio-retention facilities

This study has identified the stormwater quantity and quality trunk infrastructure requirements for the South East Thornlands Structure Plan Area which is outlined in Section 7. It is noted that both the existing (culverts) and proposed trunk stormwater infrastructure meet RCC's desired level of service.

5. STORMWATER QUANTITY ASSESSMENT

5.1 Introduction and Approach

The increase in impervious areas associated with the urban development will lead to increased runoff volumes, reduced infiltration to groundwater and increased rates of runoff and stream flow. Hydrologic and hydraulic modelling has been undertaken to assess the impacts associated with the proposed development. In particular, the road crossings within and downstream of the proposed Structure Plan Area have been assessed for both the existing and ultimate development conditions to determine whether culvert upgrades are required as a result of the increase in flow due to the proposed development. Due to the limited time available to complete this study, EnGenY has not undertaken an impact assessment on the structures in Eprapah Creek under Redland Bay Road as this would require a detailed 1D/2D hydraulic analysis of the regional waterway system. The Flood Mapping project undertaken by GHD (2007) included TUFLOW (1D/2D) modelling which produced flood levels for Eprapah Creek. EnGenY has undertaken a broad assessment of the potential impacts on the structures downstream of the development area in Eprapah Creek. This is discussed further in Section 5.3.

5.2 Hydrologic Analysis

The hydrological impacts from the catchment were determined by estimating peak flows discharging from the catchment. The Laurenson non-linear runoff routing method was utilised within the XP-STORM model for the purposes of undertaking an assessment of the catchment response in terms of design flood discharges. XP-STORM is a non-linear runoff routing program which analyses runoff from a catchment. The hydrological engine within XP-STORM utilises a network analysis with a series of sub-catchment and drainage links to model catchment performance. Hydrographs are produced for the design storm events by routing sub-catchment rainfall runoff through the defined overland and pipe drainage links within the catchment.

The hydrological analysis involved:

- The division of the subject site into a number of discrete sub-catchments (refer to Figures 4.2 and 4.3);
- Derivation of various physical properties for each of the sub-catchments, including:
  - impervious and pervious areas based upon Councils existing and ultimate land use development;
  - sub-catchment slopes;
  - roughness (Pern) values.
- The overall assembly of the sub-catchments and channels into a nodal network that is nested within the hydraulic nodal network model.

Storms with rainfall durations ranging from 15 minutes to 180 minutes were simulated within the XP-STORM models for the 10 and 100 year design storm events in order to identify the critical durations along each of the drainage systems within the catchment. The models were run in a fully dynamic mode to adequately account for routing effects.

5.2.1 Catchment Characteristics

Model parameters for each sub-catchment have been selected from recommended design values for various categories of land use types based upon the provisions of the Queensland Urban Drainage Manual (QUDM, 2007). The determination of pervious and impervious areas of each sub-catchment for the Existing Case was undertaken using the Council supplied Aerial photography (MainLand_Mosaic_2008) as well as the land use zones provided by Redland Shire Council. The existing land use for the South East Thornlands catchment is illustrated in Figure 4.1

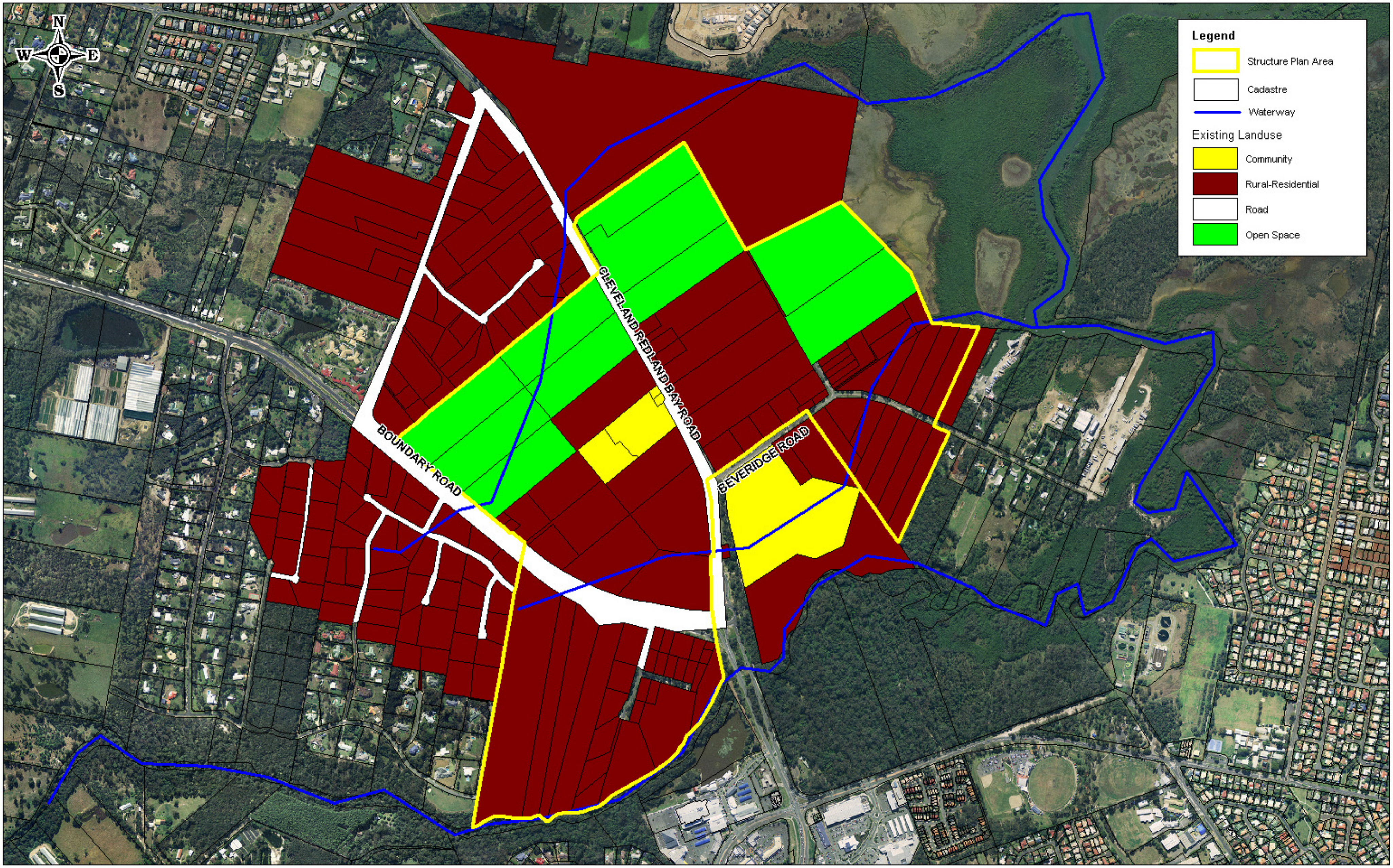
The pervious and impervious area of each sub-catchment for the Ultimate Case was determined from the proposed South East Thornlands land use plan as provided by Council. The proposed future (ultimate) land use consists of a mixture of medium and low density residential with pockets of community purposes, open space, rural residential and rural precincts. The percentage impervious values have been determined for each land use in accordance with Redland City Council Planning Scheme- Policy 9- Stormwater Management and also the South East Thornlands demographic data provided by Redland City Council (i.e. Urban Residential Zone (UR1) is assumed to consist of 15 lots per hectare which equates to 660m^2 lot size and a fraction impervious factor of 0.5 as per Policy 9).

The ultimate land use for the South East Thornlands catchment is illustrated in Figure 4.2. The land use outside the South East Thornlands area was assumed not to change between the Existing and Ultimate Cases. Table 5.1 below outlines the adopted impervious values for each land use type for the existing and ultimate development land use scenarios.

Table 5.1 Land Use Percent Impervious values

Land Use	Percent Impervious (%)
Urban Residential Zone (UR1)	50
Medium Density Residential	80
Rural Residential	20
Non Urban/Rural	10
Local Centre	100
Community	60
Road	90
Public Open Space	0

Existing and Ultimate catchment plans are presented in Figures 5.1 and 5.2.



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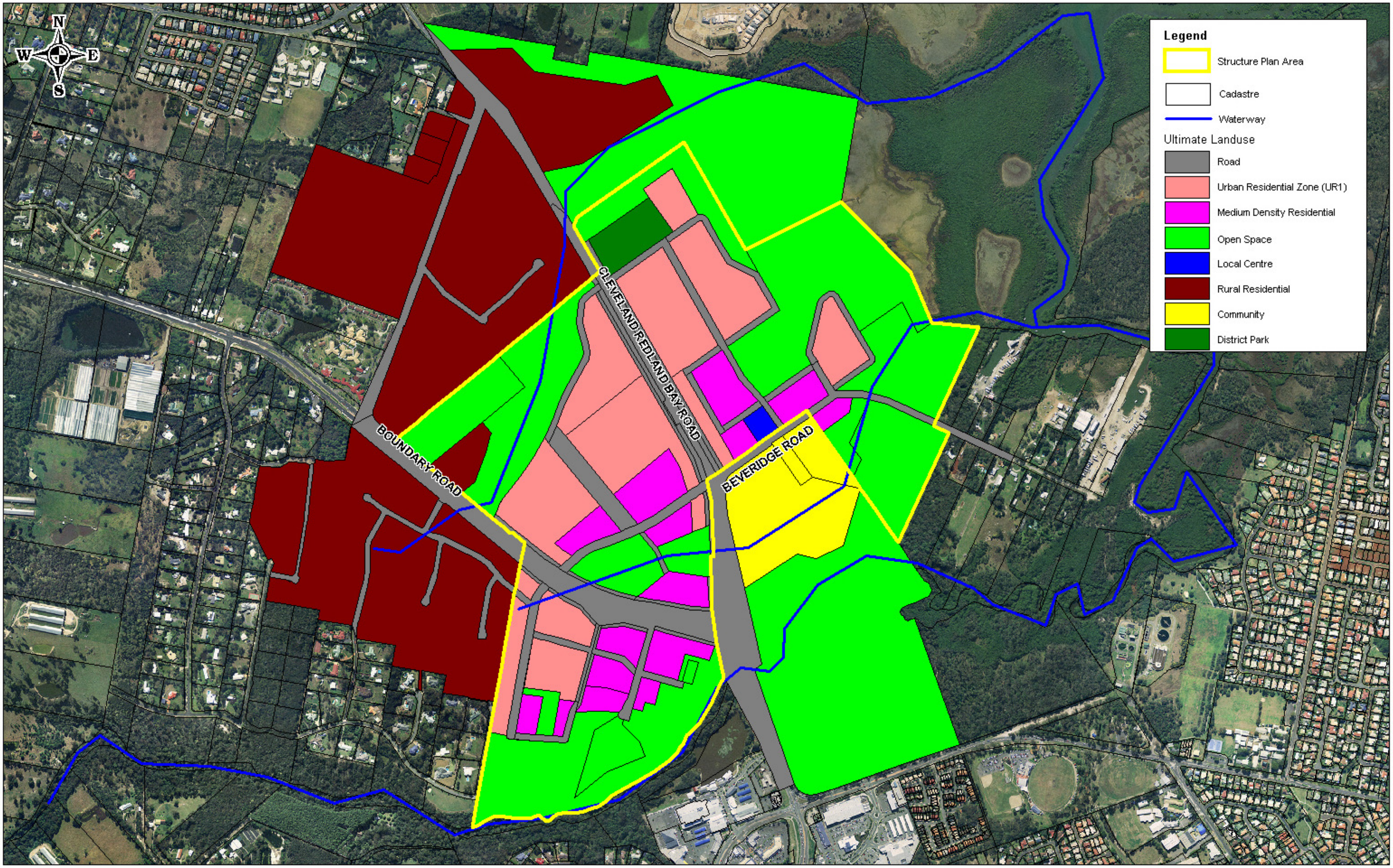
South East Thornlands Structure Plan

Existing Landuse

Figure 5.1



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South East Thornlands Structure Plan

Ultimate Landuse

Figure 5.2

5.2.2 Rainfall Losses and Intensities

Table 5.2 below outlines the rainfall loss parameters used in the XP-STORM model.

Table 5.2 Rainfall Loss Parameters

Surface Condition	Rainfall Losses
Impervious surfaces	Initial Loss 0mm
	Continuing Loss 1mm/hr
Pervious Surfaces	Initial loss 15mm
	Continuing Loss 2.5mm/hr

The adopted Pern value for pervious areas was 0.05 whilst a Pern value of 0.015 was adopted for all impervious surfaces.

The design rainfall Intensity-Frequency Duration (IFD) data for various storm events within the development area were derived based upon the procedures outlined in Book 2 of Australian Rainfall and Runoff (AR&R 2001 edition).

5.2.3 Hydrologic Model Validation

Sub-catchment flows throughout the development area have been independently verified through the use of the Rational Method. A comparison of two (2) sub-catchments was undertaken to compare the XP-STORM 100 year ARI peak flows representing the Existing Case and the Rational Method flows. The results are summarized in Table 5.3.

Table 5.3 Rational and XP-STORM Flow Comparison

Rational Method Locations	Rational Flow (m^3/sec)	XP-STORM Peak Flow (m^3/sec)	Difference (%)
Culvert 1	5.8	5.1	-12.7
Culvert 3	6.3	6.2	-2.7

Figure 4.3 illustrates locations of the flow validation upstream of each culvert. In general, flow comparisons between the XP-STORM model and the Rational Method correlate well (i.e. within 15%).

5.2.4 Hydrologic Results

A comparison of flows for the existing and ultimate development scenarios has been undertaken and are summarised in Table 5.4 below. Refer to Figure 5.1 for reporting locations. The peak flows have been obtained immediately upstream of the respective culvert locations.

Table 5.4 XP-STORM 100 year ARI Flow Comparison

Locations	Existing Peak Flow (m^3/sec)	Ultimate Peak Flow (m^3/sec)	Difference (%)
Culvert 1	4.1	4.81	14.8%
Culvert 2	11.76	11.67	-1%
Culvert 3	4.21	6.32	33%
Culvert 4	7.48	11.93	37%

The comparison of flows demonstrates the hydrologic impacts associated with urban development due to the increase in impervious areas. The marginal decrease in catchment flow immediately upstream of Culvert 2 is due to catchment dynamics and routing effects.

Whilst it has been predicted that local increases in flows may occur as a result of the proposed development, it is likely that downstream flood levels will be dominated by the larger regional flood event and therefore it is unlikely that unmitigated flows would result in adverse impacts from the site. In addition, it is also likely that downstream flows may increase in the event that detention is provided given flow translation and attenuation effects including the likely coincidence of peak flows between the respective flood events. Through discussions with Council and given the location of the proposed development area in relation to the overall Eprapah Creek catchment, there do not appear to be any properties downstream that would be affected. On the basis of the above discussion, the approach considered appropriate for the South East Thornlands Structure Plan Area was to exclude detention basins for flow mitigation.

5.3 Hydraulic Analysis

5.3.1 Model Parameters

The XP-STORM hydraulic model parameters adopted for the various modelling scenarios investigated in this study are summarised briefly below.

5.3.2 Roughness

Hydraulic roughness for the model has been adopted based on a Manning's "n" roughness coefficient which was determined from the 2008 aerial photographs in combination with a site inspection. Typical roughness "n" values ranged from 0.014 for concrete pipes through to 0.08 for vegetated overland flow paths.

5.3.3 Stormwater Pipe System

Existing stormwater pipe data was supplied by Council in a MapInfo spatial GIS format. Any missing data was obtained during a site visit to confirm supplied data and measure stormwater pipes not included within the supplied data from Council. Typically, the pipe information included pipe sizes and spatial locations which assisted in locating stormwater assets throughout the system as well as defining pipe lengths. Culvert invert level information was available for Culvert 2. It was therefore necessary to determine invert levels for trunk stormwater pipe systems not available with Council supplied data. This was done using a variety of techniques including the use of the Digital Elevation Model (DEM) and a site visit. Existing stormwater infrastructure locations are presented in Figure 5.3.

Culvert measurements were obtained under Boundary Road as follows:

- Culvert 1 as 7x750mm RCP
- Culvert 3 as 2x1500mm RCP

Culvert measurements were obtained under Cleveland Redland Bay Road as follows:

- Culvert 2 as 5/1200mmx900mm RCBC
- Culvert 4 a trapezoidal culvert with dimensions of 1500mm height, 1500mm base width and 2250mm top width.

5.3.4 Model Sections

Redland City Council has provided 0.5m Contours and a Digital Elevation Model (DEM) were created using a 1 metre grid size.

All modelling works undertaken for this study have been prepared based on this recent DEM survey information. Specifically, this has included all topographical information for the modelling works comprising cross sections, inverts, weir crest levels, etc. A typical road cross section has been adopted for the overland flow paths on roads.

5.3.5 Hydraulic Model Scenarios

Existing Case Culvert Investigation

This scenario represents the existing catchment flows and existing trunk infrastructure throughout the catchment. The catchment drains by way of three (3) waterway corridors with four (4) culvert crossings influencing the development area.

Some stormwater infrastructure data was provided by Council in GIS format and included stormwater pipes, inlet pits and manholes. From the provided infrastructure data, only four (4) culverts exist within the study area. A site visit was conducted to obtain measurements of the remaining existing culvert data not provided by Council. This scenario allows for the determination of existing design flows for the range of events as well as assessment of the hydraulic capacity of the existing culverts. This scenario identified the target flows and flood levels from which the assessment of infrastructure upgrades could be compared

The XP-STORM model has been utilised to comprehensively assess the hydraulic capacity of existing stormwater infrastructure within the South East Thornlands catchment. XP-STORM hydraulic modelling has been undertaken for the 100 year ARI design event.

Culverts details used in the existing investigation of stormwater infrastructure are presented below in Table 5.5. Culvert locations are shown in Figure 5.3.

Table 5.5 Existing Culvert Details

Culvert Name	Culvert Details
Culvert 1	7 No. 750mm RCP
Culvert 2	5 No. 1200mmx900mm RCBC
Culvert 3	2 No. 1500mm RCP
Culvert 4	Trapezoidal culvert (1.5m base, 1.5m height, 1 in 0.25m side slopes)

EnGenY has also undertaken a broad assessment of the potential impacts on the structures downstream of the development area in Eprapah Creek. Upstream of the Cleveland Redland Bay Road structures in Eprapah Creek, the peak for the 100 year ARI flow (24 hour storm duration) occurs after approximately 4.5 hours. Based on the XP-STORM modelling that has been undertaken for the South East Thornlands Structure Plan Area, the peak 100 year ARI flow occurred after approximately 60 minutes.

Although the proposed development area results in an increase in the impervious percentage of the local catchment, there is unlikely to be an appreciable increase in flows at the Cleveland Redland Bay Road structure in Eprapah Creek. This is due to the catchment dynamics and routing effects and more specifically the location of the proposed Structure Plan Area in the lower reaches of the larger Eprapah Creek catchment.

Ultimate Case Culvert Investigation

This scenario represents the ultimate catchment flows and existing trunk infrastructure throughout the development area. Analysis of this scenario has been undertaken to ensure that adequate flow conveyance exists in the trunk drainage system to cater for the proposed ultimate development of the area and to ensure roads are trafficable in accordance with QUDM maximum requirements of maximum 250mm depth and 0.6 depth velocity product.

Investigation of Trunk Drainage Infrastructure

This scenario assesses the trunk infrastructure requirements to service the proposed development area exclusive of the existing culverts under Cleveland Redland Bay Road and Boundary Road. XP-STORM hydraulic modelling has been undertaken for the 10 and 100 year ARI design events in order to size the trunk infrastructure pipes which service the development area. The development area was divided into three (3) sub-areas which are presented in Figure 4.4. The trunk infrastructure was designed to convey the 10 year ARI event for the development. The location of required trunk stormwater infrastructure was based on the location of the stormwater quality treatment devices proposed for the development in order for the Q_{3month} to be treated prior to discharge.

5.3.6 Hydraulic Results

Culvert Investigation Results

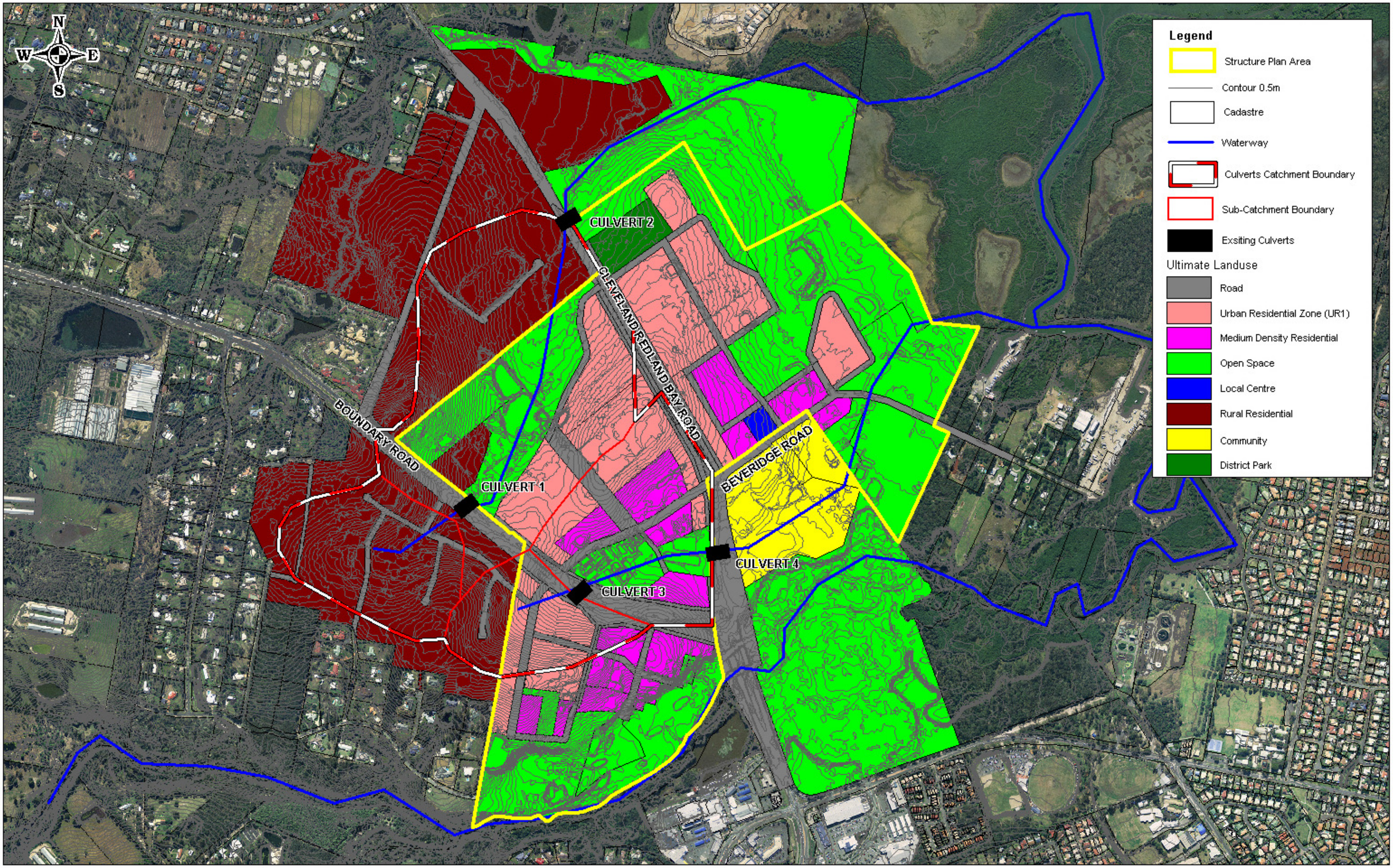
The culvert upgrades have been assessed using XP-STORM in order to ensure that adequate flow conveyance exists in the trunk drainage system to cater for the proposed ultimate development of the area and to ensure roads are trafficable in accordance with QUDM maximum requirements of maximum 250mm depth and 0.6 depth velocity product. Major culvert upgrades are not required as it has been determined that the existing stormwater infrastructure has capacity to accommodate the increase in flow due to the proposed development.

A broad assessment of the potential impacts on the structures downstream of the development area in Eprapah Creek was also undertaken. Upstream of the Cleveland Redland Bay Road structures in Eprapah Creek, the peak for the 100 year ARI flow for the 24 hour storm duration occurs after approximately 4.5 hours. Based on the XP-STORM modelling that has been undertaken for the South East Thornlands Structure Plan Area, the peak 100 year ARI flow generally occurred after approximately 60 minutes. It is therefore assumed that the flow from the development area would pass under Cleveland Redland Bay Road well before the dominant regional flow peaked at the same location.

Trunk Drainage Infrastructure

Findings on this scenario predict that trunk stormwater infrastructure is required to service Catchment A of the development area for the 10 year ARI design event. The identified trunk drainage is located within the proposed Beveridge Road reserve. Beveridge Road is being considered as a trunk road and therefore the proposed trunk stormwater drainage will be included in the infrastructure charge calculations for the trunk road network.

Figure 7.1 shows the location and size of proposed trunk stormwater infrastructure required to service Catchment A the development. Due to the topography and proposed road layout of Catchment's B and C, it is anticipated that only internal stormwater connectors will be required to convey flows to the receiving waterway.



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South East Thornlands Structure Plan
Culvert Locations

Figure 5.3

6. STORMWATER QUALITY ANALYSIS

6.1 MUSIC Modelling

A quantitative assessment of stormwater runoff quality has been undertaken for the ultimate land use scenario for the South East Thornlands Structure Plan Area. This assessment was undertaken in order to develop a required footprint for regional water quality treatment devices within the South East Thornlands Structure Plan Area.

In completing the water quality modelling for the South East Thornlands catchments, the load based objectives identified within the South East Queensland Regional Plan as well as those adopted by the Healthy Waterways Partnership have been used. Load based objectives compare loads produced by an unmitigated developed catchment to the loads coming from the developed catchment where Water Sensitive Urban Design has been implemented. It is recommended that these objectives for urbanised areas within the South East Thornlands catchment are adopted to ensure “Best Practice” Stormwater Management Standards are achieved. The percentage removal efficiency or the “treatment train effectiveness” required to be achieved are outlined in Table 6.1.

Load based targets stipulated in the South East Queensland Regional Plan 2005-2026 Implementation Guideline No. 7 were adopted for discharge targets from urban areas as outlined in Table 6.1 below.

Table 6.1 RCC Water Quality Objectives

Pollutant Type	Objective	South East Queensland Regional Plan Load Based Reduction Targets
Total Suspended Solid	Reduction in average annual load of pollutants leaving the developed unmitigated scenario compared to the developed mitigated scenario	80 %
Total Phosphorous	Reduction in average annual load of pollutants leaving the developed unmitigated scenario compared to the developed mitigated scenario	60%
Total Nitrogen	Reduction in average annual load of pollutants leaving the developed unmitigated scenario compared to the developed mitigated scenario	45%
Gross Pollutant	Reduction in average annual load of pollutants leaving the developed unmitigated scenario compared to the developed mitigated scenario	90%

The MUSIC model was established for the ultimate catchment scenario. Climate data for the catchment was sourced from the Bureau of Meteorology (BOM). Rainfall data is from the Redlands BOM station (40265), and uses the 1996-2001 rainfall events with 6 minute rainfall duration.

A quantitative assessment of stormwater runoff quality has been considered for the ultimate land use scenario of the South East Thornlands catchments. The pollutant export loads from the catchment were assessed using the Cooperative Research Centre for Catchment Hydrology's (CRCCH) Model for Urban Stormwater Improvement Conceptualisation (MUSIC). MUSIC is a decision support tool, used to plan and design appropriate urban stormwater management systems at the conceptual level. MUSIC Version 3.0, released in June 2005, was used in this assessment.

As Redland City Council does not have specific guidelines on MUSIC modelling, the Brisbane City Council (BCC) "Pollutant Export Modelling Guidelines" and Gold Coast City Council's (GCCC) "MUSIC Modelling Guidelines 2006" was used, in conjunction with the Healthy Waterways "Water Sensitive Urban Design Technical Design Guidelines for South East Queensland". The stormwater quality treatment devices incorporated into the catchment model have been setup based on the design parameters recommended by the GCCC and Healthy Waterways Guidelines.

The MUSIC model was established for the ultimate unmitigated and ultimate mitigated scenarios. This involved the following steps:

1. Climate data for the catchment was sourced from the Bureau of Meteorology (BOM). Rainfall data is from the Redlands BOM station (40265), and uses the 1996-2001 rainfall events with six (6) minute rainfall duration.
2. Land uses for the ultimate catchment were derived from GIS information supplied by Redland City Council. The representation of each zoning within MUSIC has been defined in Table 6.2.
3. The natural assimilative capacity of any waterway was not able to be represented within the MUSIC model as it presently does not have the capability to perform in-stream treatment effectiveness assessment.
4. A breakdown of the MUSIC land uses within each sub-catchment is detailed in Table 6.2.

Table 6.2 Land Uses adopted in MUSIC

Land Use Type	Description	MUSIC Land Use
1	Residential	Urban Residential
2	Local Centre	Commercial
3	Open Space	Agricultural
4	Park and Non-Urban Area	Urban Residential

It should be noted that rainwater tanks have not been considered for the purpose of identifying trunk stormwater infrastructure and the requirements for rainwater tanks are managed separately under the Queensland Development Code.

6.1.1 Typical Treatment Train

Best management practices in Water Sensitive Urban Design (WSUD) techniques are proposed to be implemented throughout the South East Thornlands Structure Plan Area. Stormwater runoff will be treated by a range of treatment devices prior to discharge to the receiving waterways. Certain techniques of WSUD target varying aspects with regard to pollutant reduction and water re-use. Examples of typical WSUD treatment measures include:

- ***Gross Pollutant Traps (GPT's)***

GPT's trap coarse sediment, trash and debris carried in stormwater flows. Most GPT's act by passing a design storm flow collected from the pipe networks through a screen. This screen captures gross pollutants down to a certain diameter. The GPT's are generally designed so that flows above the design event by-pass the trash screens so that re-suspension of captured material does not occur. Regardless of the type of gross pollutant trap incorporated into the treatment train, these mechanical separators play an important role in reducing the gross pollutant load on the waterways. GPT's were only recommended in area identified as being high litter generation areas. These land uses have been identified as being School, Business and Town Centre. The GPT's have been proposed at the pipe outlet immediately upstream of the bio-retention basins.

- ***Constructed Wetlands***

Constructed Wetlands are designed to primarily remove stormwater pollutants, associated with fine to colloidal particles and dissolved contaminants. Because of these properties wetlands are effective in reducing loads associated with TN and TP as well as TSS. The wetland is setup with an inlet zone, which acts as a sedimentation basin to protect the macrophyte zone. The macrophyte zone is largely vegetated using wetland species and is the main process for nutrient removal. Fluctuating water levels within the wetland to mimic wetting and drying cycle is a key in their long-term health. A riser outlet is ideally designed to facilitate this characteristic.

- ***Bio-Retention Basins***

Bio-retention basins use ponding above a bio-retention surface to maximise the volume of runoff through the filtration media. Their operation for treatment is in a similar manner as for a bio-retention swale, but typically they convey flows above the design event through overflow pits.

The treatment system operates by firstly filtering surface flows through surface vegetation and then percolating runoff through prescribed filtration media that provides treatment through fine filtration, extended detention and some biological uptake. They also provide flow retardation for smaller events and are particularly efficient in removing nutrients. The

MUSIC modelling undertaken has shown that the surface area of a bio-retention system is required to be approximately 2.5% of the contributing developable area.

6.2 Stormwater Quality Results

A MUSIC model was developed for the South East Thornlands Structure Plan Area. The water quality sub-catchments have been illustrated in Figure 7.2 whilst the MUSIC model layout for the South East Thornlands Structure Plan Area is provided in Figure 6.1. Outlined in Table 6.3 is the MUSIC modelling results which demonstrate that the load based objectives for the catchment have been achieved using five(5) GPT's, six (6) bio-retention basins and two (2) wetlands. The details of the proposed treatment measures are outlined in Section 7.2.

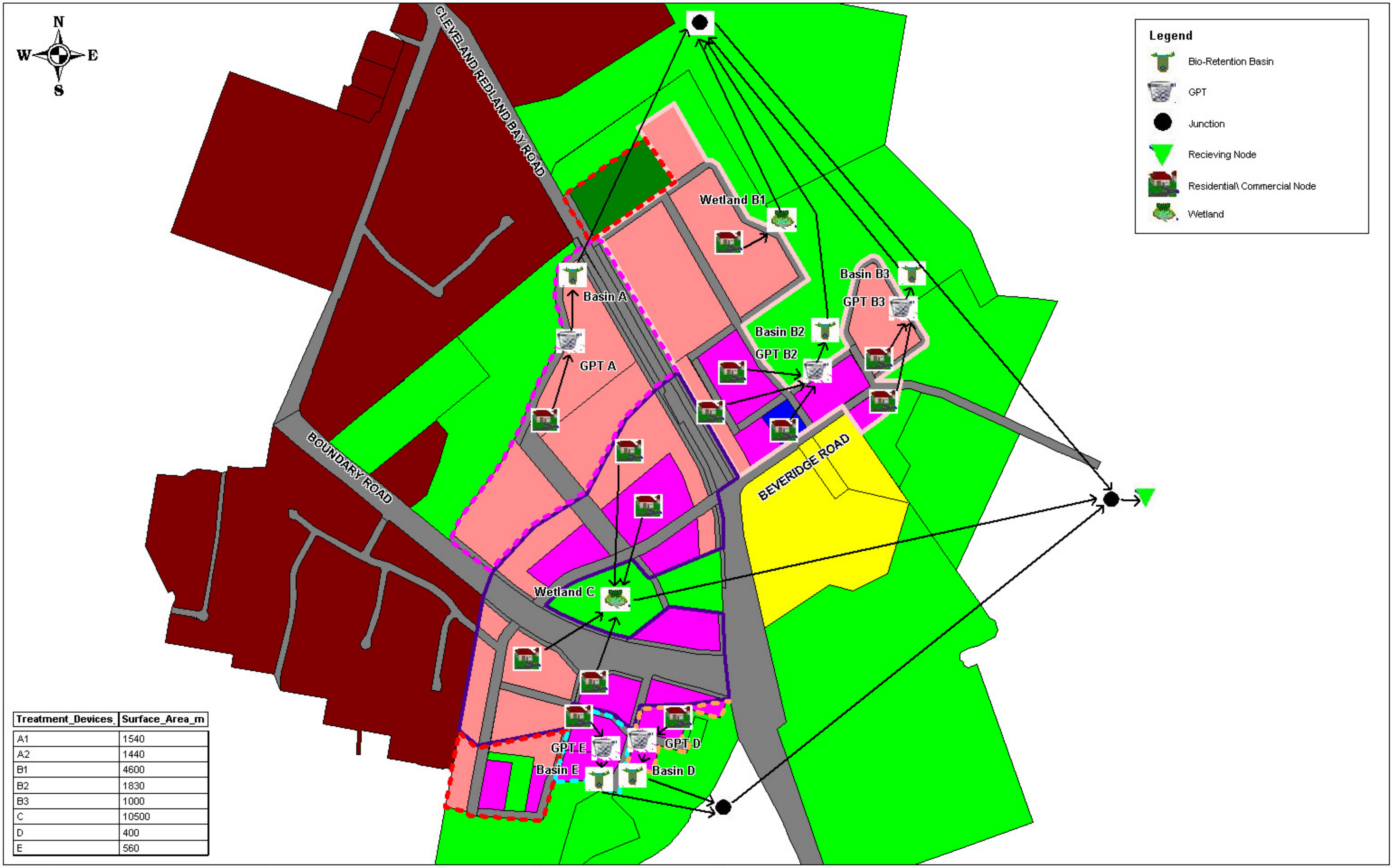
Table 6.3 MUSIC Modelling Results

Location	Pollutants	Unmitigated	Mitigated	Reduction (%)	Target	Target Achieved
Receiving Node	**TSS (kg/yr)**	**56.7E3**	**7.79E3**	**86.3**	**80**	✓
	TP (kg/yr)	**112**	**31.7**	**71.8**	**60**	✓
	TN (kg/yr)	**557**	**305**	**45.2**	**45**	✓
	GP (kg/yr)	**7.04E3**	**16.5**	**99.8**	**90**	✓
Basin A	TSS (kg/yr)	10.4E3	520	95	80	✓
	TP (kg/yr)	20.6	5.26	74.5	60	✓
	TN (kg/yr)	104	56.5	45.4	45	✓
	GP (kg/yr)	1.26E3	0.0	100	90	✓
Wetland B1	TSS (kg/yr)	10.1E3	2.0E3	80.1	80	✓
	TP (kg/yr)	19.9	5.97	70	60	✓
	TN (kg/yr)	96.4	53	45.1	45	✓
	GP (kg/yr)	1.16E3	5.25	99.5	90	✓
Basin B2	TSS (kg/yr)	6.67E3	311	95.3	80	✓
	TP (kg/yr)	13.3	3.5	73.7	60	✓
	TN (kg/yr)	69.1	37.9	45.1	45	✓

Location	Pollutants	Unmitigated	Mitigated	Reduction (%)	Target	Target Achieved
	GP (kg/yr)	856	0.0	100	90	✓
Basin B3	TSS (kg/yr)	3.12E3	173	94.4	80	✓
	TP (kg/yr)	6.24	1.64	73.8	60	✓
	TN (kg/yr)	31.5	17.2	45.4	45	✓
	GP (kg/yr)	400	0.0	100	90	✓
Wetland C	TSS (kg/yr)	22.9E3	4.58E3	80	80	✓
	TP (kg/yr)	45	13.4	70.1	60	✓
	TN (kg/yr)	221	121	45.1	45	✓
	GP (kg/yr)	2.87E3	11.3	99.6	90	✓
Basin D	TSS (kg/yr)	1.41E3	76	94.6	80	✓
	TP (kg/yr)	2.84	0.715	74.8	60	✓
	TN (kg/yr)	14	7.64	45.3	45	✓
	GP (kg/yr)	197	0.0	100	90	✓
Basin E	TSS (kg/yr)	2.17E3	122	94.4	80	✓
	TP (kg/yr)	4.32	1.13	73.8	60	✓
	TN (kg/yr)	21.5	11.7	45.5	45	✓
	GP (kg/yr)	295	0.0	100	90	✓

In recommending appropriate treatment devices for this catchment, an assessment was undertaken for each sub-catchment and its relative topography. Wetlands require a larger area per hectare of developable land and are therefore generally placed where the topography is flatter and there are limitations in grade for bio-retention systems. Bio-retention basins are generally located where the land is more constrained or where achieving an effective outlet is possible due to an increasing grade over the treatment area. It is for these reasons that six (6) bio-retention basins and two (2) wetlands have been proposed to achieve the prescribed water quality objectives. The stormwater quality improvement devices have been designed for sub-catchment scale treatment and are therefore relatively large in size. A major benefit of sub-catchment scale treatment as opposed to development or on-site treatment is the reduction in the number of treatment devices. A stormwater quality infrastructure conceptual plan for the South East Thornlands Structure Plan Area has been provided in Figure 7.2.

It should be noted that two sub-catchments at the most southern and northern extent of the Structure Plan Area have not been included in this structure plan and will therefore require on-site stormwater quality treatment. This is due to the topography of the sub-catchment area as well as isolation from other catchment areas which are able to drain through sub-catchment scale treatment devices. The sub-catchments requiring on-site treatment are shown in Figure 7.2 and will need to be managed by Council through the development assessment process.



Treatment_Devices_	Surface_Area_m
A1	1540
A2	1440
B1	4600
B2	1830
B3	1000
C	10500
D	400
E	560

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N.T.S.

South East Thornlands Structure Plan
MUSIC Model Layout

Figure 6.1

7. PROPOSED TRUNK STORMWATER INFRASTRUCTURE

7.1 Stormwater Quantity Trunk Infrastructure Requirements

All mitigation works have been determined based on the detailed XP-STORM modelling works undertaken as part of this study. The mitigation works have been devised to ensure that adequate flow conveyance exists in the trunk drainage system to service the proposed development in accordance with current stormwater drainage standards.

It should be noted that rainwater tanks have not been considered for the purpose of identifying trunk stormwater infrastructure and the requirements for rainwater tanks are managed under the Queensland Development Code.

The identification of trunk stormwater infrastructure is consistent with Queensland Government's Guide to Planning Stormwater Trunk Infrastructure (March, 2010) as well as Statutory Guideline 01/09 (2009).

7.1.1 Trunk Drainage Infrastructure Summary

The proposed trunk infrastructure has been determined based on ultimate flood modelling results in order to ensure that adequate flow conveyance exists in the trunk drainage system to cater for the proposed ultimate development of the area. Section 5.3 outlines the philosophy behind the modelling works undertaken. Details of the proposed trunk stormwater infrastructure required to service Catchment A are shown in Figure 7.1. Due to the topography and nature of Catchment B and C, it is anticipated that flows will be conveyed to the open space corridors via a local stormwater drainage network. Table 7.1 provides a summary of the trunk drainage infrastructure required to service the proposed development area.

Table 7.1 Proposed Trunk Drainage Infrastructure

Pipe Section	Pipe Dimensions (mm)	Length (m)
A	2/1200mm dia. RCP	62
B	2/1050mm dia. RCP	129
C	1050mm dia. RCP	172

The trunk drainage infrastructure also includes scour protection at the system outlet. The scour protection is required to ensure that the flows discharging to the receiving waterways do not result in soil erosion due the discharging velocity. Only scour protection infrastructure costs will be included in the infrastructure charges calculations for stormwater as the proposed drainage system is within the Beveridge Road reserve, which is included in the trunk road network and will therefore be included in calculation for the road infrastructure charges.

The major overland flow path (Q100) represented by the latest Flood Layer, Version 3 of the Redland City Planning Scheme (RPS) is also considered to be trunk infrastructure for the South East Thornlands development area due to the fact that the overland flow paths provide flood conveyance for the entire South East Thornlands catchment area. It is also recommended that the overland flow path upstream of Boundary Road be maintained to provide an outlet and legal point of discharge for the local catchment upstream of Boundary Road.

The costs for acquisition of waterways within the South East Thornlands Structure Plan Area have been determined for infrastructure charging purposes and are outlined in Section 9.

7.2 Stormwater Quality Trunk Infrastructure Requirements

As seen in Figure 6.1, the stormwater quality treatment train includes five (5) GPT'S, six (6) bio-retention systems and two (2) wetlands. Table's 7.2 and 7.3 outline the details of the bio-retention basins and wetland systems.

Table 7.2 Details of Bio-retention Basins

Bio-retention	Filter Area(m^2)	Surface Area(m^2)	Filter Depth(m)	Extended Depth(m)
Bio-retention A1	1320	1540	0.6	0.3
Bio-retention A2	1230	1440	0.6	0.3
Bio-retention B2	1500	1830	0.6	0.3
Bio-retention B3	750	1000	0.6	0.3
Bio-retention D	255	400	0.6	0.3
Bio-retention E	380	560	0.6	0.3

Table 7.3 Details of Wetland

Wetland	Inlet Pond Volume(m^3)	Storage Surface Area(m^2)	Extended Depth(m)
Wetland B1	3200	4600	0.5
Wetland C	4000	10500	0.5

The various treatment measures and locations that have been considered are discussed below.

7.2.1 Consideration of Treatment Options and Locations

The selection of treatment devices and locations was undertaken based on the Redland City Planning Scheme as well as the requirements of various Council stakeholders including Infrastructure Planning, Environmental Management, Development & Community Standards, etc. The recommended treatment measures and locations are summarised below and are based on the following considerations:

Bio-retention Basin A1 and A2

- In order to minimize disturbance to the natural environment and the neighbouring urban koala habitat as well as maximize the amount of available land for development, it is recommended that two (2) bio-retention basins are used to achieve the water quality objectives for the sub-catchment.
- Bio-retention basin A1 has been sized according to the amount of cleared vegetation present in the Thornlands Corridor. The intention was to avoid tree canopies and therefore the need for tree removal.
- Bio-retention basin A2 has been sized to treat the portion of the sub-catchment not being treated by A1.
- The option for a single basin located within developable land was not favoured by some Council stakeholders.
- Basins have been positioned at the downstream boundary of the sub-catchment along the natural drainage line with consideration of site access for construction and maintenance.
- A GPT is also proposed upstream of the bio-retention basins.

Wetland B1, Bio-retention Basin's B2 and B3

- In order to maximise the amount of developable land, it is recommended that treatment devices are located within the Open Space corridor without impacting the natural environment.
- Due to the flat topography and availability of the land in the north-west of the Structure Plan Area, it is recommended that Wetland B1 be located within the open space area to service the west and north-west of the structure plan area. Flow from the wetland could either be discharged to the existing dam for polishing or alternatively the open space area west of the existing dam.
- Bio-retention Basin's B2 and B3 have been sized to treat the eastern portion of the Structure Plan Area that cannot be serviced by Wetland B1 due to topography.

- Basin B2 has been positioned north of Beveridge Road in the Open Space area where a small dam currently exists. It is recommended that the existing dam will be retained and converted into the proposed bio-retention basin as this will reduce the amount of earthworks required for construction.
- Basin B3 has been positioned at the downstream boundary of the sub-catchment along the natural drainage line with consideration of site access for construction and maintenance.
- Two (2) GPT's are also proposed upstream of each bio-retention basin.

Wetland C:

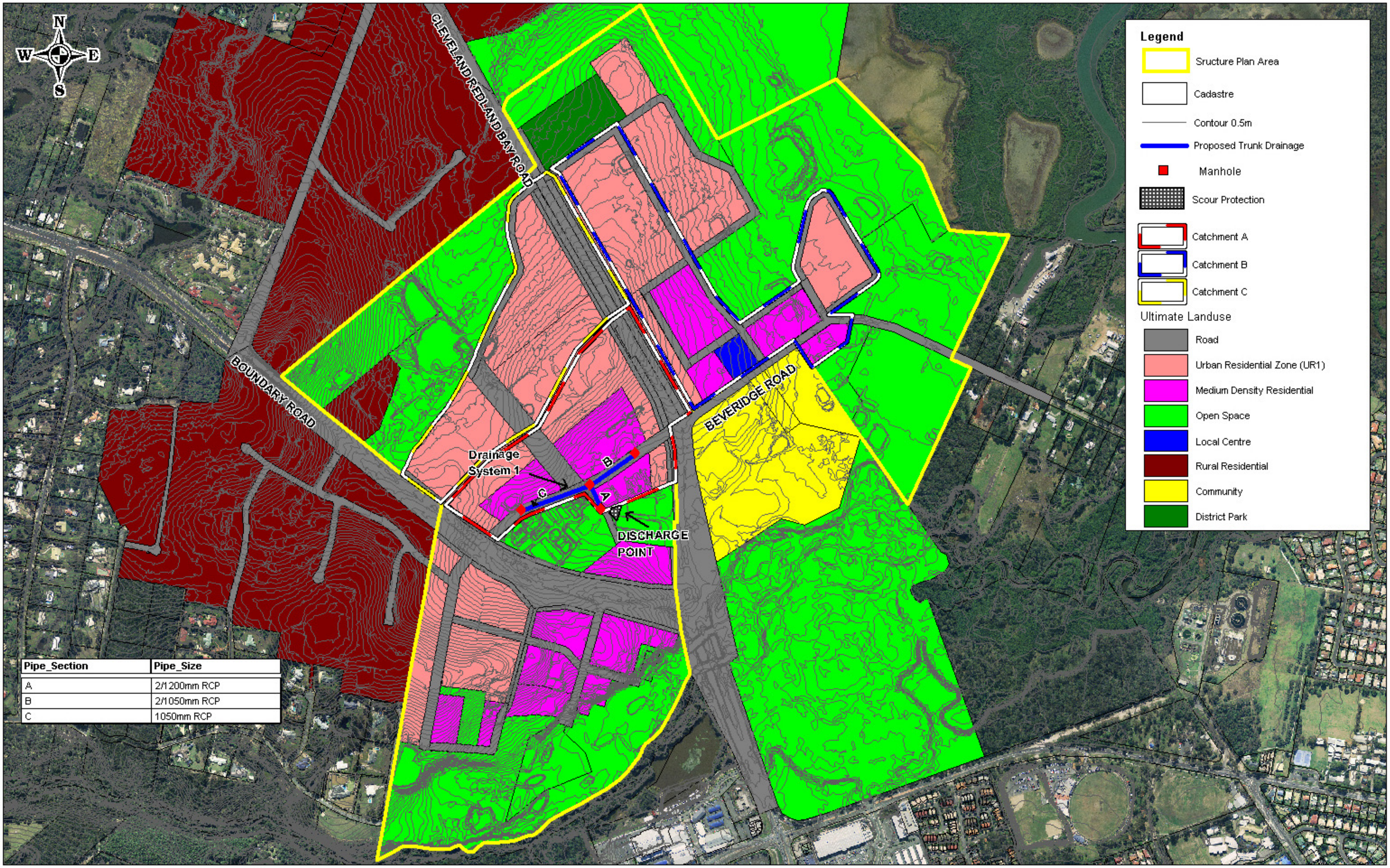
- Bio-retention basins located on either side of the Open Space corridor and immediately upstream of Cleveland Redland Bay Road were considered; however the catchment dynamics, potential challenges in directing flow to these basins and achieving an effective outlet, resulted in this option being less favoured.
- The option of placing bio-retention basins on the banks of the Open Space corridor was also considered, however a hydraulic assessment using the GHD (2007) TUFLOW model predicted an average increase in the 100 year flood level of 100mm. The accuracy of this result is questionable due to the 10m cell size of the TUFLOW 2D domain and therefore a more detailed model would be required to provide greater certainty of results. The increase in flood levels also resulted in a breakout of flow into the developable area.
- In order to improve the condition of the existing waterway corridor and maximise the amount of land available for development, it is recommended that a wetland be used to achieve the water quality objectives for the sub-catchment.
- As seen in the aerial photo below, the existing waterway immediately downstream of Boundary Road would benefit significantly from the construction of an engineered natural wetland which would enhance the visual amenity and environmental value of the area. It is recommended that the existing dams within the proposed wetland area be filled and converted.
- The wetland has been positioned with consideration of site access for construction and maintenance.

Aerial photo of proposed location for wetland C

Bio-retention Basin D and E

- In order to minimize disturbance to the natural environment and the neighbouring urban koala habitat, it is recommended that two (2) bio-retention basins are used to achieve the water quality objectives for the sub-catchments located to the east and west of Abeya Street.
- The Bio-retention Basin E has been positioned in the Open Space corridor along the natural drainage line to maximise the amount of developable land, however it is considered impracticable for Bio-retention Basin D to be located within Open Space due to the 100 year ARI flood extent (Eprapah Creek), cross sectional gradient of the waterway banks and not being able to achieve an effective outlet due to the flat longitudinal gradient of the waterway.
- Bio-retention Basin E remains unaffected during the regional flood events.
- Bio-retention Basin D has been positioned to allow for access to the rear of the lot. Consideration has also been given to the site access for construction and maintenance for Basin E.
- A GPT is also proposed upstream of each bio-retention basin.

It should be noted that the viability of incorporating treatment devices within the proposed boulevard of Beveridge Road (east of Boundary Road) was considered (bio-retention swale within effective treatment area), however due to the nature of the catchment and the road gradient (topography), this option was deemed unsuitable.



Pipe_Section	Pipe_Size
A	2/1200mm RCP
B	2/1050mm RCP
C	1050mm RCP

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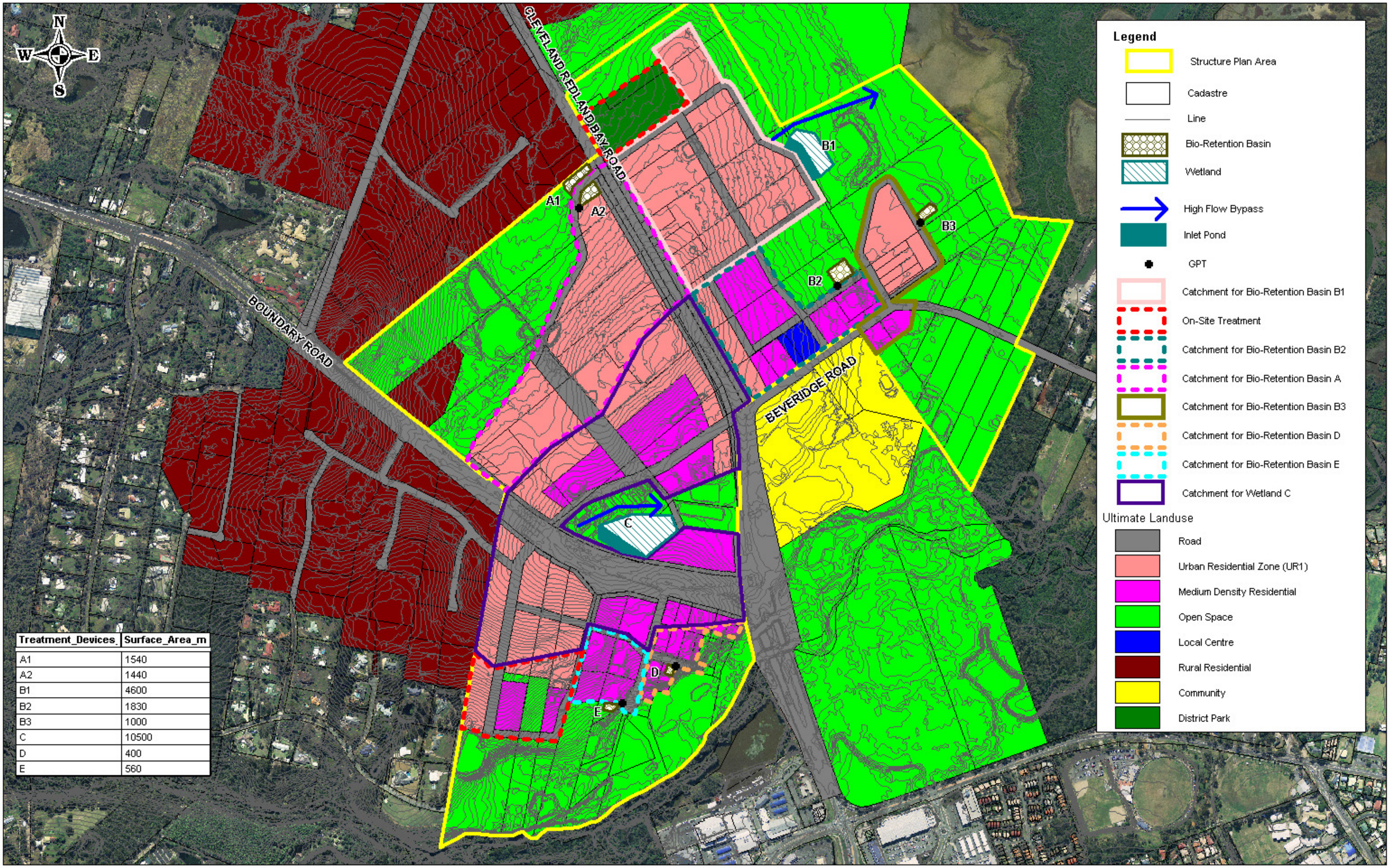
Scale 1:8,000

South East Thornlands Structure Plan
Stormwater Quantity Infrastructure Concept Plan

Figure 7.1



Treatment_Devices	Surface_Area_m
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A2	1440
B1	4600
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Scale 1:8,000

South East Thornlands Structure Plan

Water Quality Infrastructure Concept Plan

Figure 7.2

8. CONSTRUCTION COST ESTIMATES

8.1 Stormwater Quantity

Construction cost estimates have been prepared for the various drainage upgrade works identified as part of this study. The cost estimates have been prepared based on a standard cost estimating spreadsheet and incorporates various allowances and assumptions made for the works. A detailed summary of the estimated costs against each work element as based on Council's standard cost estimating spreadsheet are also included in Appendix A. It should be noted that the costs for providing scour protection at the outlet into waterways have been included in the trunk drainage infrastructure costs. The resulting construction cost estimates for the drainage upgrade works identified as part of this study are summarised in Table 8.1 below.

Table 8.1 Stormwater Quantity Infrastructure Cost Estimate

Infrastructure Upgrade Item	Estimated Construction Cost ($)
Drainage System 1 (Including Pipes, Manholes, Pits and Earthworks)	$680,000
Scour Protection Works	$11,500
Total	**$691,500**

The construction cost estimates prepared as part of this study are based upon standard construction rates and unit prices as detailed in Council's standard cost estimating spreadsheet. The resulting costs should therefore be considered as approximate budget estimates only based on conceptual modelling works and in the absence of any preliminary or detailed design. It will be necessary to undertake more detailed design works for the respective measures in order to obtain a more accurate cost estimate for the various work items. As such, construction cost estimates should be revised and updated following further design works where more detailed information including detailed survey and service relocation requirements are accurately known.

8.2 Stormwater Quality

Costing for the bio-retention basins, GPT's and wetland was obtained from the life cycle costing module of MUSIC. It should be noted that the connection from the outlet of each catchment to the bio-retention basins has not been included in the cost estimation as this should be undertaken at the detailed design stage. Cost estimates as outlined from MUSIC are found in Appendix B. The summary of the stormwater quality infrastructure life cycle cost (excluding land acquisition) is outlined in Table 8.2.

Table 8.2 Stormwater Quality Infrastructure Cost Estimate

Treatment Device	Cost ($)
Bio-retention A1 & A2	$258,148
Bio-retention B2	$180,016
Bio-retention B3	$153,845
Bio-retention D	$107,738
Bio-retention E	$121,792
Wetland B1	$173,769
Wetland C	$342,238
GPT A	$16,109
GPT B2	$11,931
GPT B3	$7,152
GPT D	$4,195
GPT E	$5,608
Total Cost	**$1,382,541**

It should be noted that the land acquisition costs has not been included in the above cost estimates. The drainage pipes which convey the Q_{3month} to the bio-retention basins have also been excluded from the proposed trunk infrastructure system.

9. STORMWATER INFRASTRUCTURE CHARGES

As part of this study, stormwater infrastructure charges have been calculated for the South East Thornlands Structure Plan Area. This was undertaken to enable the establishment costs of trunk infrastructure to be recovered through the fair apportionment of these costs amongst network users. A summary of infrastructure charge calculations is provided in Appendix C. Appendix C includes a number of tables outlining information used to calculate infrastructure charges for South East Thornlands.

It should be noted that the land acquisition costs for stormwater quality treatment devices located in the Open Space has been included in the infrastructure charge calculations.

The scour protection infrastructure costs have also been included in the stormwater infrastructure charge calculations as the identified trunk drainage system is within the Beveridge Road reserve, which is included in the trunk road network and will therefore be included in calculation for the road infrastructure charges.

The 100 year ARI flood extent (Flood Layer, V3 of the RPS) is also considered to be trunk infrastructure; however it is understood that this land will remain in private ownership as a dedication and therefore no land acquisition is required for the waterway corridors within the Structure Plan Area.

The costs for land acquisition have been determined for infrastructure charging purposes and are outlined in Table 9.1.

Table 9.1 Land Acquisition Costs

Item Description	Land Area (m^2)	Ultimate Land Use Type	Rate ($/$m^2$) (2006)	Cost ($) (2006)
Bio Retention Basin A1	1,540	Open Space	Advised by RCC* $104/$m^2$	160,160
Bio Retention Basin A2	1,440	Urban Residential (UR1)	Advised by RCC* $343/$m^2$	493,920
Wetland B1 (Including Inlet Pond)	6,600	Open Space	Advised by RCC* $104/$m^2$	686,400
Bio Retention Basin B2	1,830	Open Space	Advised by RCC* $104/$m^2$	190,320
Bio Retention Basin B3	1,000	Park Residential	Advised by RCC* $343/$m^2$	343,000
Bio Retention Basin D	400	Medium Density Residential	Advised by RCC* $343/$m^2$	137,200
Bio Retention Basin E	560	Open Space	Advised by RCC* $104/$m^2$	58,240
Total Cost$_{2006}$ ($)				**2,069,240**
Total Cost$_{2010}$ ($) (Total Cost for 2006 converted to 2010 Total Land Acquisition Cost by applying factor of 1.35 as per Appendix C, Table 1)				**2,796,270**

**Refer to Appendix C, Table 3 for 2006 Land Values as provided by RCC.*

The acquisition of land for stormwater quality treatment devices has been determined using the land values for the Thornlands area as provided and advised by RCC. It should be noted that the land acquisition costs do not include Wetland C as the land is below the 100 year ARI flood level and is therefore within the dedicated waterway corridor. It should also be noted that acquisition of land for GPT's has not been included as it is anticipated that the devices will be located within drainage reserves or easements.

Table 9.2 provides an outline of the calculated infrastructure charges (2006 and 2010) for the South East Thornlands Structure Plan.

Table 9.2 Summary of Infrastructure Charges for South East Thornlands

Item Description	2010 Charge ($/Ha)	2006 Charge ($/Ha)
Base Stormwater Quantity Infrastructure Charge	362	267.85
Base Stormwater Quality Infrastructure Charge	131,525	97,328.47
Base Total Stormwater Infrastructure Charge	131,887	97,596.32

The total cost (present value term for 2010) for all trunk stormwater infrastructure (excluding trunk drainage system) is $1.39 Million for constructions costs and $2.79 Million for land acquisition. The Base Infrastructure Charge (2010) for the South East Thornlands Structure Plan Area is $131,887/ha. Appendix C provides a summary of infrastructure charge calculations and assumptions used for the calculations.

The Base Infrastructure Charge (2010) for Stormwater Quantity is $362/ha and only includes the scour protection at outlet (Catchment A). The Base Infrastructure Charge for Stormwater Quality is $131,525/ha and includes the following:

- Treatment devices
- Land acquisition for treatment devices

Once the sequencing of development has been established, the base infrastructure charge can be adjusted accordingly.

10. ENVIRONMENTAL CONSTRAINTS AND CONSIDERATIONS

The South East Thornlands catchment area contains a number of environmental constraints which include the following:

- Habitat protection and enhancement; and
- Fauna movement and corridors.

The Fauna and Flora Assessment undertaken for the South East Thornlands area by BAAM (2006) recommended that wetlands (dams, water impoundment structures) and associated aquatic vegetation remain in undevelopable areas as they will serve as fauna habitat and as sediment and nutrient removal devices. Whilst this would be a favorable environmental outcome, consideration must be given to public safety (i.e. drowning) and nuisance (i.e. mosquitoes etc.) given that this will become a fully urbanized catchment.

The study also recommended that the fauna habitat/movement corridors designed for the Structure Plan Area should incorporate recreated habitats, including linked bushland, open native and exotic grasslands and dams/freshwater wetlands. From a stormwater a flooding perspective, it is agreed that the existing dams/ wetlands provide a water quality benefit; however consideration must be given to public safety. The stormwater infrastructure plan has aimed to minimize the impact on the natural environment and as such the majority of the proposed infrastructure has been located outside of the Open Space and Environmental Protection areas (i.e. within developable area).

It is noted that Moreton Bay is a Ramsar listed wetland. The foreshore area, marine flats and waters present within and adjacent to the north eastern boundary of the Structure Plan Area are therefore subject to assessment by the Commonwealth Government under the EPBC Act where threatening processes are identified. The incorporation of a buffer to this area is required. BAAM recommended a buffer of at least 200m between the foreshore and residential development in the Structure Plan Area.

The BAAM report also states that stormwater management systems must be designed to ensure that nutrient and sediments loads reaching marine environments and Eprapah Creek are no greater than currently occur and, in preference, are improved. The Stormwater Infrastructure Plan has identified bio-retention basins, a wetland and a swale which are designed to ensure that the water quality objectives are achieved and the impacts associated with the proposed development are reduced.

11. CONCLUSIONS/RECOMMENDATIONS

This study has been prepared for the purposes of quantifying stormwater quantity and quality aspects of the South East Thornlands catchment as a result of the proposed development of the South East Thornlands area. The study has quantified stormwater infrastructure requirements relating to water quantity and water quality measures for the catchment. These measures have been defined in order to ensure that the proposed development can be undertaken without resulting in adverse stormwater management outcomes and to address Council's Codes and Policies relating to both water quantity and water quality for the development.

This study has included a comprehensive assessment of both stormwater flooding and water quality under a range of scenarios to assist in determining infrastructure upgrade works to appropriately manage and address any impacts resulting from the planned development works. Trunk stormwater infrastructure has been identified in this report and these include measures to address stormwater drainage in addition to water quality measures. It is noted that an evaluation of the potential for water reuse should be undertaken for development sites where dams are to be retained or alternative water supply sources are available.

The infrastructure upgrade works have been discussed and presented as part of this report and construction cost estimates have also been prepared and are documented in this study for the respective upgrade measures that have been determined. The construction cost estimates represent budget cost allocations based upon conceptual infrastructure sizing and should be updated as part of the future detailed design of the infrastructure works. Stormwater infrastructure charges schedules have been calculated using the identified trunk infrastructure and associated infrastructure construction cost estimates.

The total cost (present value term-2010) for all required stormwater infrastructure is $1.39 Million for constructions costs and $2.79 Million for land acquisition. The Stormwater Infrastructure Contribution (2010) for the South East Thornlands Structure Plan Area is $131,887/ha impervious area.

It is therefore recommended that Council adopt the outcomes from this report for the purposes of guiding the future direction of the planned South East Thornlands Development Area as this relates to stormwater quantity and quality elements of the development.

12. QUALIFICATIONS

1. In preparing this report and estimate of costs, EnGenY has exercised the degree of skill and care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering design principles.

2. EnGenY has used all reasonable endeavours to inform itself of the parameters and requirements of the project and has taken all reasonable steps to ensure that the report and costs estimate is as accurate and comprehensive as possible given the information upon which it is based.

3. It is not intended that this report and costs estimate represent a final assessment of the feasibility of the project.

4. EnGenY reserves the right to review and amend all calculations, cost estimates and/or opinions included or referred to in the report if:

   (a) additional sources of information not presently available (for whatever reason) are provided or become known to EnGenY; or

   (b) EnGenY considers it prudent to revise the estimate in light of any information which becomes known to it after the date of submission.

5. If any warranty would be implied whether by law, custom or otherwise, that warranty is to the full extent permitted by law excluded.

6. This report and cost estimate is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this report and cost estimate.

13. REFERENCES

1. “South East Thornlands Urban Community Structure Plan- Flood Mapping – Final Report”, GHD, May 2007;

2. Redland City Council Digital Data (0.5m Contour, Rectified Aerial Photography, Land Use Information, Stormwater Pipe Data, etc);

3. “Australian Rainfall and Runoff (ARR2000)” The Institution of Engineers Australia.

4. “Flora & Fauna Assessment SE Thornlands Urban Community Structure Plan Area”, BAAM, 2006.

5. Statutory Guideline 01/09, Priority Infrastructure Plans and Infrastructure Charges Schedule, Department of Infrastructure and Planning, 2009.

Appendix A

Stormwater Quantity Infrastructure Construction Cost Estimates

Redland CITY COUNCIL

DESIGN ESTIMATE

PROJECT DELIVERY GROUF

DESIGN SEVICES

Project:	M8000, South East Thornlands Structure Plan - Southern Location- System 1
Description of Works:	Tunk Infrastructure

Works Program:	Residential Street	**Prepared By:**	-
Client:	Infrastructure Planning	**Estimate Date:**	25/03/2010
Program Year:	09/10	**Revision:**	P1 - Preliminary Issue
Allocation / Budget:	$0	**Construction:**	External

Cap/Op - C if working on capital job i.e. install = Capital, repair/maintain = Operational

Line No	Task	C/O	Asset Definition	Description	Units	Qty	Rate	Total
				Preliminary Items				
	6303	C	Disperse	Site Establishment & Disestablishment Including Final Site Specific Safety Plan	Item	1	10000	$10,000.00
	6010	C	Disperse	Traffic Control & Public Safety Including Final Site Specific Traffic Management Plan	Item	1	5000	$5,000.00
				Pipes, Culvert, Pits & Headwalls				
	6423	C	Stormwater Pipes	Pipe supply & lay ø1050mm RCP	m	430	735	$316,050.00
	6424	C	Stormwater Pipes	Pipe supply & lay ø1200mm RCP	m	124	855	$106,020.00
		C	Headwalls	Headwall including wingwalls etc.	No.	1	7500	$7,500.00
		C	Headwalls	Scour Protection adjacent to headwalls	m²	100	115	$11,500.00
				Manholes				
	6420	C	Manholes	Supply & Install Manhole -- 1500ø	No.	1	2545	$2,545.00
		C	Manholes	Manholes Special in place	No.	2	8000	$16,000.00
				Subtotal:				**$474,615.00**
				Project Construction On Costs				
	6441	C	Disperse	Sediment & Erosion Control	%		2%	$9,492.30
	6329	C	Disperse	Contingencies	%		15%	$71,192.25
	6300	C	Disperse	RCC Operations & Maintenance	%		0%	$0.00
	6300	C	Disperse	Construction On Costs - External Construction	%		11%	$52,207.65
	6039	C	Disperse	Survey Setout - External Construction	%		2.7%	$12,814.61
				Subtotal:				**$620,321.81**
				Project Delivery Group Oncosts				
	6300	C	Disperse	Project Delivery Group / Corporate Overhead	%		11%	$68,235.40
	6033	C	Disperse	External Design	Item			$0.00
				Subtotal:				**$688,557.20**
	6330	C	Disperse	Portable Long Service Leave Levy	%		0.425%	$2,926.37
				Subtotal:				**$691,483.57**

	Operational Value	09/10		$0.00
	Capital Value	09/10		$691,483.57
	Add Risk	%	5%	$34,574.18
	Add Escalation	%	10%	$69,148.36
Grand Total Construct:		**10/11**		**$795,206.11**
	Operational Value	10/11		$0.00
	Capital Value	10/11		$795,206.11
	Add Risk	%	5%	$39,760.31
	Add Escalation	%	10%	$79,520.61
Grand Total Construct:		**11/12**		**$914,487.02**
	Operational Value	11/12		$0.00
	Capital Value	11/12		$914,487.02
	Add Risk	%	5%	$45,724.35
	Add Escalation	%	10%	$91,448.70
Grand Total Construct:		**12/13**		**$1,051,660.08**

Appendix B

Stormwater Quality Infrastructure Construction Cost Estimates

Bio-Retention A

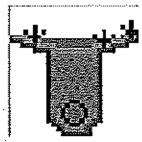
Basin A - Life Cycle Cost Results

Summary | Relative Distribution | Temporal Distribution | Sensitivity to Real Discount Rate |

Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$249,913	Real Discount Rate (%)	7.79
Acquisition Cost	$454,746	Renewal Period (yrs)	25	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$17,201	Decommissioning Cost	$199,880	Base Year for Costing	2010

Costing Results



Life Cycle Cost of Basin A ($2010)	$712,894
Equivalent Annual Payment Cost of the Asset ($2010/annum)	$14,258
Equivalent Annual Payment/kg Total Suspended Solids/annum	$3.04
Equivalent Annual Payment/kg Total Phosphorus/annum	$927.23
Equivalent Annual Payment/kg Total Nitrogen/annum	$303.28
Equivalent Annual Payment/kg Gross Pollutant/annum	$11.30

Wetland B1

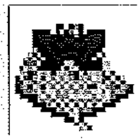
Wetland B1 - Life Cycle Cost Results

Summary | Relative Distribution | Temporal Distribution | Sensitivity to Real Discount Rate |

Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$90,590	Real Discount Rate (%)	7.79
Acquisition Cost	$779,927	Renewal Period (yrs)	20	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$11,182	Decommissioning Cost	$372,234	Base Year for Costing	2010

Costing Results



Life Cycle Cost of Wetland B1 ($2010)	$953,696
Equivalent Annual Payment Cost of the Asset ($2010/annum)	$19,074
Equivalent Annual Payment/kg Total Suspended Solids/annum	$2.37
Equivalent Annual Payment/kg Total Phosphorus/annum	$1,371.00
Equivalent Annual Payment/kg Total Nitrogen/annum	$439.02
Equivalent Annual Payment/kg Gross Pollutant/annum	$16.49

Bio-Retention B2

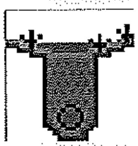
Basin B2 - Life Cycle Cost Results

Summary | Relative Distribution | Temporal Distribution | Sensitivity to Real Discount Rate |

Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$159,020	Real Discount Rate (%)	7.79
Acquisition Cost	$287,536	Renewal Period (yrs)	25	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$14,052	Decommissioning Cost	$126,384	Base Year for Costing	2010

Costing Results



Life Cycle Cost of Basin B2 ($2010)	$490,426
Equivalent Annual Payment Cost of the Asset ($2010/annum)	$9,809
Equivalent Annual Payment/kg Total Suspended Solids/annum	$3.25
Equivalent Annual Payment/kg Total Phosphorus/annum	$998.37
Equivalent Annual Payment/kg Total Nitrogen/annum	$314.34
Equivalent Annual Payment/kg Gross Pollutant/annum	$11.45

Bio-Retention B3

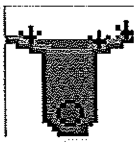
Basin B3 - Life Cycle Cost Results

Summary | Relative Distribution | Temporal Distribution | Sensitivity to Real Discount Rate |

Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$91,585	Real Discount Rate (%)	7.79
Acquisition Cost	$166,649	Renewal Period (yrs)	25	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$11,048	Decommissioning Cost	$73,249	Base Year for Costing	2010

Costing Results



Life Cycle Cost of Basin B3 ($2010)	$320,494
Equivalent Annual Payment Cost of the Asset ($2010/annum)	$6,410
Equivalent Annual Payment/kg Total Suspended Solids/annum	$4.63
Equivalent Annual Payment/kg Total Phosphorus/annum	$1,391.95
Equivalent Annual Payment/kg Total Nitrogen/annum	$448.91
Equivalent Annual Payment/kg Gross Pollutant/annum	$16.01

Wetland C

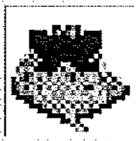
Wetland C - Life Cycle Cost Results

Summary | Relative Distribution | Temporal Distribution | Sensitivity to Real Discount Rate |

Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$152,579	Real Discount Rate (%)	7.79
Acquisition Cost	$1,313,608	Renewal Period (yrs)	20	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$22,803	Decommissioning Cost	$626,943	Base Year for Costing	2010

Costing Results



Life Cycle Cost of Wetland C ($2010)	$1,655,846
Equivalent Annual Payment Cost of the Asset ($2010/annum)	$33,117
Equivalent Annual Payment/kg Total Suspended Solids/annum	$1.81
Equivalent Annual Payment/kg Total Phosphorus/annum	$1,050.75
Equivalent Annual Payment/kg Total Nitrogen/annum	$332.61
Equivalent Annual Payment/kg Gross Pollutant/annum	$11.58

Bio-Retention D

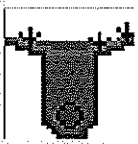
Basin D - Life Cycle Cost Results

Summary | Relative Distribution | Temporal Distribution | Sensitivity to Real Discount Rate |

Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$44,220	Real Discount Rate (%)	7.79
Acquisition Cost	$80,464	Renewal Period (yrs)	25	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$8,014	Decommissioning Cost	$35,367	Base Year for Costing	2010

Costing Results



Life Cycle Cost of Basin D ($2010)	$188,202
Equivalent Annual Payment Cost of the Asset ($2010/annum)	$3,764
Equivalent Annual Payment/kg Total Suspended Solids/annum	$5.98
Equivalent Annual Payment/kg Total Phosphorus/annum	$1,773.69
Equivalent Annual Payment/kg Total Nitrogen/annum	$594.69
Equivalent Annual Payment/kg Gross Pollutant/annum	$19.15

Bio-Retention E

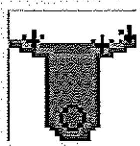
Basin E - Life Cycle Cost Results

Summary | Relative Distribution | Temporal Distribution | Sensitivity to Real Discount Rate

Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$56,983	Real Discount Rate (%)	7.79
Acquisition Cost	$103,687	Renewal Period (yrs)	25	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$8,962	Decommissioning Cost	$45,575	Base Year for Costing	2010

Costing Results



Life Cycle Cost of Basin E ($2010)	$225,479
Equivalent Annual Payment Cost of the Asset ($2010/annum)	$4,510
Equivalent Annual Payment/kg Total Suspended Solids/annum	$4.68
Equivalent Annual Payment/kg Total Phosphorus/annum	$1,413.13
Equivalent Annual Payment/kg Total Nitrogen/annum	$461.02
Equivalent Annual Payment/kg Gross Pollutant/annum	$15.29

GPT A

GPT A - Life Cycle Cost Results

Summary | Relative Distribution | Temporal Distribution | Sensitivity to Real Discount Rate

Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$0	Real Discount Rate (%)	7.79
Acquisition Cost	$0	Renewal Period (yrs)	15	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$1,290	Decommissioning Cost	$0	Base Year for Costing	2010

Costing Results

Life Cycle Cost of GPT A ($2010)	$16,109
Equivalent Annual Payment Cost of the Asset ($2010/annum)	$322
Equivalent Annual Payment/kg Total Suspended Solids/annum	$0.06
Equivalent Annual Payment/kg Total Phosphorus/annum	invalid
Equivalent Annual Payment/kg Total Nitrogen/annum	invalid
Equivalent Annual Payment/kg Gross Pollutant/annum	invalid

GPT B2

GPT B2 - Life Cycle Cost Results

Summary | Relative Distribution | Temporal Distribution | Sensitivity to Real Discount Rate

Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$0	Real Discount Rate (%)	7.79
Acquisition Cost	$0	Renewal Period (yrs)	15	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$356	Decommissioning Cost	$0	Base Year for Costing	2010

Costing Results

Life Cycle Cost of GPT B2 ($2010)	$11,931
Equivalent Annual Payment Cost of the Asset ($2010/annum)	$239
Equivalent Annual Payment/kg Total Suspended Solids/annum	$0.07
Equivalent Annual Payment/kg Total Phosphorus/annum	invalid
Equivalent Annual Payment/kg Total Nitrogen/annum	invalid
Equivalent Annual Payment/kg Gross Pollutant/annum	invalid

GPT B3

GPT B3 - Life Cycle Cost Results

Summary | Relative Distribution | Temporal Distribution | Sensitivity to Real Discount Rate

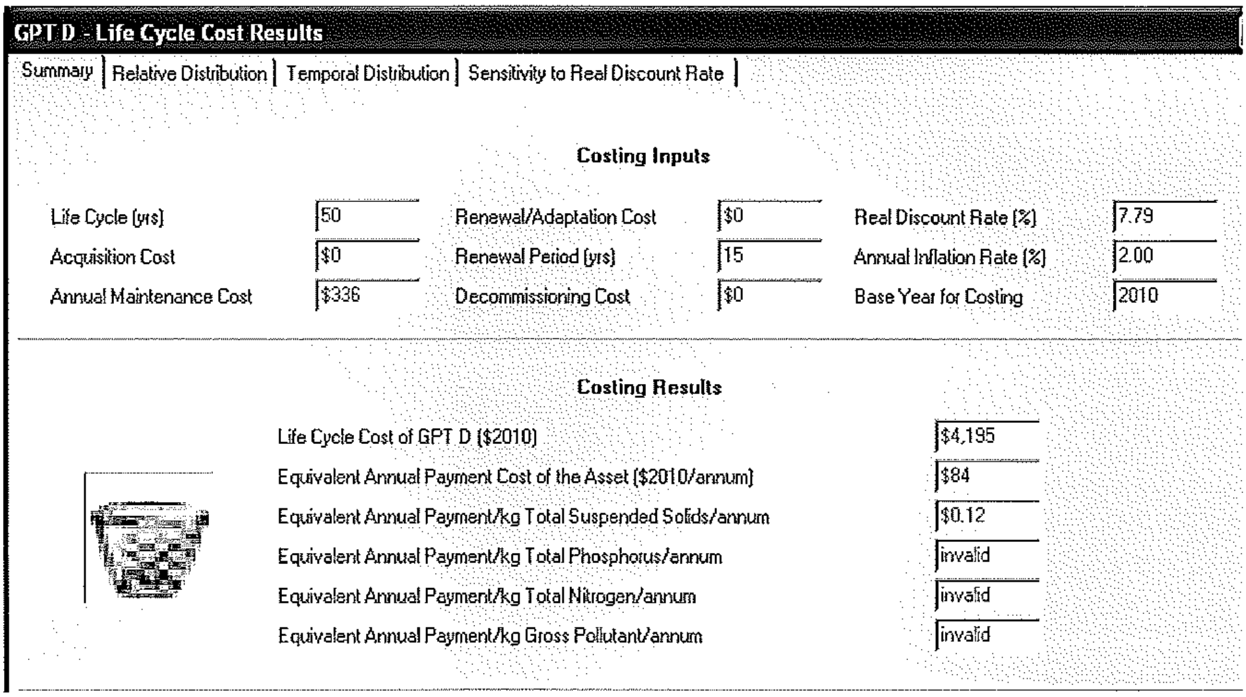
Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$0	Real Discount Rate (%)	7.79
Acquisition Cost	$0	Renewal Period (yrs)	15	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$573	Decommissioning Cost	$0	Base Year for Costing	2010

Costing Results

Life Cycle Cost of GPT B3 ($2010)	$7,152
Equivalent Annual Payment Cost of the Asset ($2010/annum)	$143
Equivalent Annual Payment/kg Total Suspended Solids/annum	$0.09
Equivalent Annual Payment/kg Total Phosphorus/annum	invalid
Equivalent Annual Payment/kg Total Nitrogen/annum	invalid
Equivalent Annual Payment/kg Gross Pollutant/annum	invalid

GPT D



GPT D - Life Cycle Cost Results

Summary | Relative Distribution | Temporal Distribution | Sensitivity to Real Discount Rate

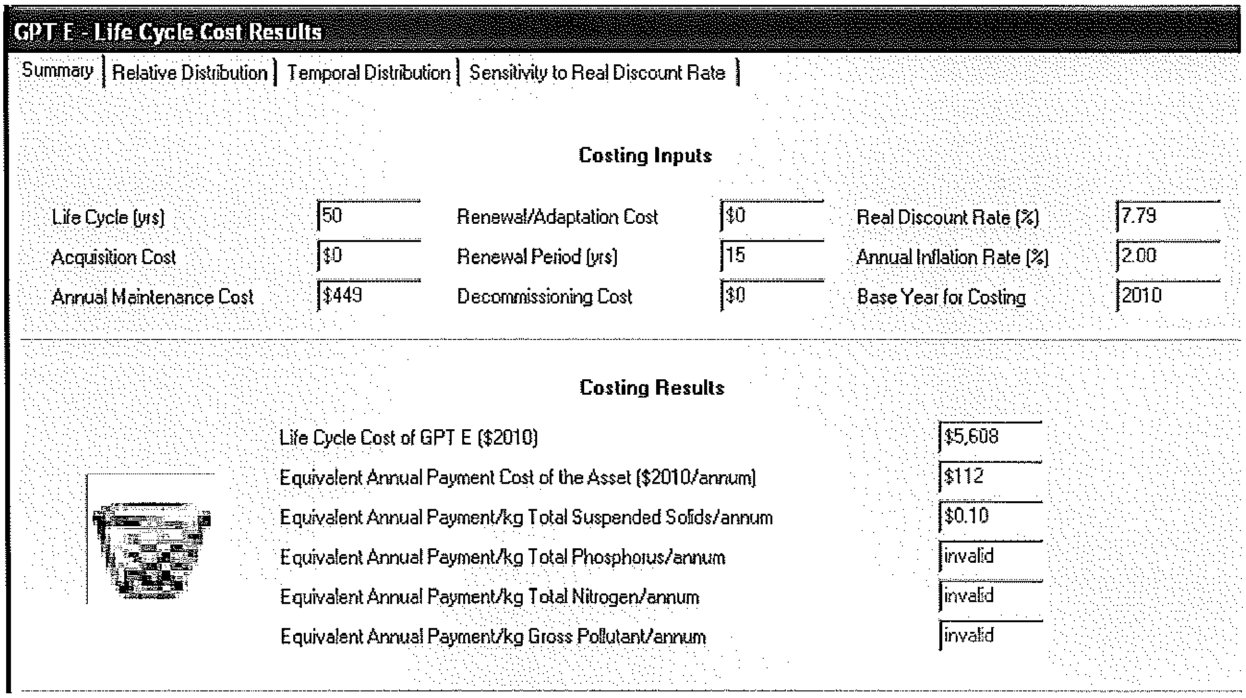
Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$0	Real Discount Rate (%)	7.79
Acquisition Cost	$0	Renewal Period (yrs)	15	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$336	Decommissioning Cost	$0	Base Year for Costing	2010

Costing Results

Life Cycle Cost of GPT D ($2010)	$4,195
Equivalent Annual Payment Cost of the Asset ($2010/annum)	$84
Equivalent Annual Payment/kg Total Suspended Solids/annum	$0.12
Equivalent Annual Payment/kg Total Phosphorus/annum	invalid
Equivalent Annual Payment/kg Total Nitrogen/annum	invalid
Equivalent Annual Payment/kg Gross Pollutant/annum	invalid

GPT E



GPT E - Life Cycle Cost Results

Summary | Relative Distribution | Temporal Distribution | Sensitivity to Real Discount Rate

Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$0	Real Discount Rate (%)	7.79
Acquisition Cost	$0	Renewal Period (yrs)	15	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$449	Decommissioning Cost	$0	Base Year for Costing	2010

Costing Results

Life Cycle Cost of GPT E ($2010)	$5,608
Equivalent Annual Payment Cost of the Asset ($2010/annum)	$112
Equivalent Annual Payment/kg Total Suspended Solids/annum	$0.10
Equivalent Annual Payment/kg Total Phosphorus/annum	invalid
Equivalent Annual Payment/kg Total Nitrogen/annum	invalid
Equivalent Annual Payment/kg Gross Pollutant/annum	invalid

Appendix C

Infrastructure Charge Calculations

INFRASTRUCTURE CHARGE CALCULATIONS

Assumptions:

Table 1: RCC Supplied Discounting Factors

7.79% Nominal pre-tax WACC

Year	Time Since 2006	Discounting Factor
2006	0	1.0000
2007	1	0.9277
2008	2	0.8607
2009	3	0.7985
2010	***4***	***0.7408***
2011	5	0.6872
2012	6	0.6376
2013	7	0.5915
2014	8	0.5487
2015	9	0.5091
2016	10	0.4723
2017	11	0.4382
2018	12	0.4065
2019	13	0.3771
2020	14	0.3499
2021	15	0.3246
2022	16	0.3011
2023	17	0.2794
2024	18	0.2592

Table 2: Land Acquisition Costs

Item Description	Report Reference	Land Area (m^2)	Ultimate Land Use Type	Rate ($/$m^2$) 2006	Cost ($) 2006
Bio Retention Basin A1	Figure 7.2	1,540	Open Space	Advised by RCC* $104/$m^2$	160,160
Bio Retention Basin A2	Figure 7.2	1,440	Urban Residential (UR1)	Advised by RCC* $343/$m^2$	493,920
Wetland B1 (Including Inlet Pond)	Figure 7.2	6,600	Open Space	Advised by RCC* $104/$m^2$	686,400
Bio Retention Basin B2	Figure 7.2	1,830	Open Space	Advised by RCC* $104/$m^2$	190,320
Bio Retention Basin B3	Figure 7.2	1,000	Park Residential	Advised by RCC* $343/$m^2$	343,000
Bio Retention Basin D	Figure 7.2	400	Medium Density Residential	Advised by RCC* $343/$m^2$	137,200
Bio Retention Basin E	Figure 7.2	560	Open Space	Advised by RCC* $104/$m^2$	58,240
Total Cost ($)-2006					**2,069,240**
Total Cost ($)-2010 (Total Cost for 2006 converted to 2010 Total Land Acquisition Cost by applying factor of 1.35 as per Table 1, Appendix C)					**2,796,270**

**Refer to Table 3 for land values*

Table 3: Land Value for Each Community of Interest

Community Of Interest	Market Land Value $/$m^2$	Englobo Land Values $/$m^2$
Alexandra Hills	392.00	100.00
Birkdale	375.43	100.00
Capalaba	309.69	90.00
Cleveland	349.94	115.00
Ormiston	*432.21*	*125.00*
Redland Bay	306.70	90.00
Sheldon-Mt Cotton	239.73	80.00
Thorneside	543.48	110.00
Thornlands	**329.20***	**100.00***
Victoria Point	316.90	100.00
Wellington Point	470.76	125.00

**4.2% has been assumed as factor for escalation of land resumption cost to current date*

Table 4: Stormwater Infrastructure Construction Costs

Item Description	Category	Report Reference	Cost ($) (2010)
Scour Protection Works	Water Quantity	Section 8.1	11,500
Treatment Devices	Water Quality	Section 8.2	1,382,541
Total Cost ($)			**1,394,041**

Stormwater Quantity Infrastructure Charges

Table 5.1: Stormwater Quantity Infrastructure Charge per Land Use

Ultimate Land Use *[A]*	Area* (Ha) *[B]*	Impervious Percentage (%) *[C]*	Impervious Area (Ha) *[D]*	Stormwater Quantity Apportioned Infrastructure Charge ($) (Present Day Value$_{2010}$) *[E]*	Stormwater Quantity Infrastructure Charge per Land Use$_{2010}$ ($/Ha) *[F]*
District Park	0.00	5	0.00	*$0.00*	*$18/Ha*
Local Centre	0.62	100	0.62	*$224*	*$362/Ha*
Medium Density Residential	16.13	80	12.90	*$4,671*	*$290/Ha*
Open Space	0.00	0	0.00	*$0.00*	*$0.00/Ha*
Urban Residential 1	36.50	50	18.25	*$6,606*	*$181/Ha*

** excluding area acquired for treatment devices*

Table 5.2: Total Stormwater Quantity Infrastructure Charge

TOTAL EQUIVALENT IMPERVIOUS AREA (HA) *[G]*	**31.77 Ha**
TOTAL COST OF STORMWATER QUANTITY INFRASTRUCTURE - 2010 PRICE ($) *[H]*	**$11,500**
BASE INFRASTRUCTURE CHARGE FOR <u>2010</u> ($/HA) *[I]*	**$362/Ha**
BASE INFRASTRUCTURE CHARGE FOR <u>2006</u> ($/HA) (Applying 0.74 Discounting Rate as per Table 1) *[J]*	**$267.85/Ha**
BASE INFRASTRUCTURE CHARGE FOR AVERAGE 600m^2 LOT FOR <u>2010</u> ($/LOT) *[K]*	**$12.07/Lot**
BASE INFRASTRUCTURE CHARGE FOR AVERAGE 600m^2 LOT FOR <u>2006</u> ($/LOT) (Applying 0.74 Discounting Rate as per Table 1) *[L]*	**$8.93/Lot**

Calculations & Description

[A] – Ultimate land use type for South East Thornlands
[B] – Total area for each proposed land use type within developable area (Ha) excluding land acquired for treatment devices.
[C] – Impervious percentage (%) for each land use as per RPS & ultimate land use information provided by RCC.
[D] – Total impervious area for each land use type (Ha) = *[B] x ([C]*
[E] – Apportioned infrastructure charge for present day value (2010) ($)
= *[D] x [I]*
[F] – Infrastructure charge per land use type ($/Ha)
= *[I] x ([C]/100)*
[G] – Total impervious area (Ha)
= *Sum ([D])*
[H] – Total cost of stormwater quantity infrastructure including construction costs and land acquisition (2010) ($)
[I] – Base infrastructure charge for 2010 ($/Ha)
= *[H]/[G]*
[J] – Base infrastructure charge for 2006 converted by applying 0.74 discounting rate (26% reduction) to 2010 base charge
= *[I] – ([I] x 0.26)*
[K] – Base infrastructure charge for 2010 for an average 600m^2 lot ($/Lot)
= $Infrastructure charge for Urban Residential 1/ Total area for Urban Residential 1(Ha)/15 (No. of lots per hectare for Urban Residential 1 as advised by RCC)
[L] – Base infrastructure charge for 2006 for an average 600m^2 lot ($/Lot) converted by applying 0.74 discounting rate (26% reduction) to 2010 base charge
= *[K] – ([K] x 0.26)*

Stormwater Quality Infrastructure Charges

Table 6.1: Stormwater Quality Infrastructure Charge per Land Use

Ultimate Land Use *[A]*	Area* (Ha) *[B]*	Impervious Percentage (%) *[C]*	Impervious Area (Ha) *[D]*	Stormwater Quality Apportioned Infrastructure Charge ($) (Present Day $Value_{2010}$) *[E]*	Stormwater Quality Infrastructure Charge per Land Use_{2010} ($/Ha) *[F]*
District Park	0.00	5	0.00	*$0*	*$6,576/Ha*
Local Centre	0.62	100	0.62	*$81,282*	*$131,525/Ha*
Medium Density Residential	16.13	80	12.90	*$1,697,198*	*$105,220/Ha*
Open Space	0.00	0	0.00	*$0*	*$0.00/Ha*
Urban Residential 1	36.50	50	18.25	*$2,400,331*	*$65,762/Ha*

* excluding area acquired for treatment devices

Table 6.2: Total Stormwater Quality Infrastructure Charge

TOTAL EQUIVALENT IMPERVIOUS AREA (HA) *[G]*	**31.77Ha**
TOTAL COST OF STORMWATER QUALITY INFRASTRUCTURE - 2010 PRICE ($) *[H]*	**$4,178,811**
BASE INFRASTRUCTURE CHARGE FOR <u>2010</u> ($/HA) *[I]*	**$131,525/Ha**
BASE INFRASTRUCTURE CHARGE FOR <u>2006</u> ($/HA) (Applying 0.74 Discounting Rate as per Table 1) *[J]*	**$97,328.47/Ha**
BASE INFRASTRUCTURE CHARGE FOR AVERAGE 600m^2 LOT FOR <u>2010</u> ($/LOT) *[K]*	**$4,384.17/Lot**
BASE INFRASTRUCTURE CHARGE FOR AVERAGE 600m^2 LOT FOR <u>2006</u> ($/LOT) (Applying 0.74 Discounting Rate as per Table 1) *[L]*	**$3,244.28/Lot**

Calculations & Description

[A] – Ultimate land use type for South East Thornlands
[B] – Total area for each proposed land use type within developable area (Ha) excluding land acquired for treatment devices.
[C] – Impervious percentage (%) for each land use as per RPS & ultimate land use information provided by RCC.
[D] – Total impervious area for each land use type (Ha) = *[B] x ([C]*
[E] – Apportioned infrastructure charge for present day value (2010) ($)
= *[D] x [I]*
[F] – Infrastructure charge per land use type ($/Ha)
= *[I] x ([C]/100)*
[G] – Total impervious area (Ha)

= Sum ([D])
[H] – Total cost of stormwater quality infrastructure including construction costs and land acquisition (2010) ($)
[I] – Base infrastructure charge for 2010 ($/Ha)
= [H]/[G]
[J] – Base infrastructure charge for 2006 converted by applying 0.74 discounting rate (26% reduction) to 2010 base charge
= [I] – ([I] x 0.26)
[K] – Base infrastructure charge for 2010 for an average 600m^2 lot ($/Lot)
= $Infrastructure charge for Urban Residential 1/ Total area for Urban Residential 1(Ha)/15 (No. of lots per hectare for Urban Residential 1 as advised by RCC)
[L] – Base infrastructure charge for 2006 for an average 600m^2 lot ($/Lot) converted by applying 0.74 discounting rate (26% reduction) to 2010 base charge
= [K] – ([K] x 0.26)

Total Stormwater Infrastructure Charges

Table 7.1: Total Stormwater Infrastructure Charge per Land Use

Ultimate Land Use *[A]*	Area* (Ha) *[B]*	Impervious Percentage (%) *[C]*	Impervious Area (Ha) *[D]*	Total Stormwater Apportioned Infrastructure Charge ($) (Present Day Value$_{2010}$) *[E]*	Total Stormwater Infrastructure Charge per Land Use$_{2010}$ ($/Ha) *[F]*
District Park	0.00	5	0.00	*$0.00*	*$6,594/Ha*
Local Centre	0.62	100	0.62	*$81,506*	*$131,887/Ha*
Medium Density Residential	16.13	80	12.90	*$1,701,869*	*$105,510/Ha*
Open Space	0.00	0	0.00	*$0.00*	*$0.00/Ha*
Urban Residential 1	36.50	50	18.25	*$2,406,936*	*$65,943/Ha*

* excluding area acquired for treatment devices

Table 7.2: Total Stormwater Infrastructure Charge

TOTAL EQUIVALENT IMPERVIOUS AREA (HA) *[G]*	31.77 Ha
TOTAL COST OF STORMWATER INFRASTRUCTURE - 2010 PRICE ($) *[H]*	$4,190,311
BASE INFRASTRUCTURE CHARGE FOR 2010 ($/HA) *[I]*	$131,887/Ha
BASE INFRASTRUCTURE CHARGE FOR 2006 ($/HA) (Applying 0.74 Discounting Rate as per Table 1) *[J]*	$97,596.32/Ha
BASE INFRASTRUCTURE CHARGE FOR AVERAGE 600m^2 LOT FOR 2010 ($/LOT) *[K]*	$4,396.23/Lot
BASE INFRASTRUCTURE CHARGE FOR AVERAGE 600m^2 LOT FOR 2006 ($/LOT) (Applying 0.74 Discounting Rate as per Table 1) *[L]*	$3,253.21/Lot

Calculations & Description

[A] – Ultimate land use type for South East Thornlands
[B] – Total area for each proposed land use type within developable area (Ha) excluding land acquired for treatment devices.
[C] – Impervious percentage (%) for each land use as per RPS & ultimate land use information provided by RCC.
[D] – Total impervious area for each land use type (Ha) = *[B] x ([C]*
[E] – Apportioned infrastructure charge for present day value (2010) ($)
= *[D] x [I]*
[F] – Infrastructure charge per land use type ($/Ha)
= *[I] x ([C]/100)*
[G] – Total impervious area (Ha)
= *Sum ([D])*
[H] – Total cost of infrastructure including construction costs and land acquisition (2010) ($)
[I] – Base infrastructure charge for 2010 ($/Ha)
= *[H]/[G]*
[J] – Base infrastructure charge for 2006 converted by applying 0.74 discounting rate (26% reduction) to 2010 base charge
= *[I] – ([I] x 0.26)*
[K] – Base infrastructure charge for 2010 for an average 600m^2 lot ($/Lot)
= $Infrastructure charge for Urban Residential 1/ Total area for Urban Residential 1(Ha)/15 (No. of lots per hectare for Urban Residential 1 as advised by RCC)
[L] – Base infrastructure charge for 2006 for an average 600m^2 lot ($/Lot) converted by applying 0.74 discounting rate (26% reduction) to 2010 base charge
= *[K] – ([K] x 0.26)*