REDLAND CITY COUNCIL

Stormwater Infrastructure Plan for Cleveland CBD Catchment






May 2013

M8000_019

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CONTENTS

1. INTRODUCTION 1
2. SCOPE OF WORKS 3
3. CATCHMENT DESCRIPTION 4
4. STORMWATER QUANTITY ASSESSMENT 5
4.1 Catchment Hydrology 5
4.2 Hydrologic Model Validation 6
4.3 Critical Storm Duration 7
4.4 Hydraulic Modelling 9
4.5 Assessment of Existing Drainage Systems 12
4.6 Results Discussion 13
5. STORMWATER QUALITY ANALYSIS 15
5.1 MUSIC Modelling 15
5.2 Typical Treatment Train 16
5.3 Gross Pollutant Traps (GPTs) 18
5.4 Stormwater Quality Management Strategy 19
5.5 Stormwater Quality Results 20
6. PROPOSED TRUNK STORMWATER INFRASTRUCTURE 22
6.1 Stormwater Quantity Infrastructure Requirements 22
6.2 Stormwater Quality Trunk Infrastructure Requirements 22
7. CONSTRUCTION COST ESTIMATES 25
7.1 Stormwater Quantity 25
7.2 Stormwater Quality 25
8. CONCLUSIONS/RECOMMENDATIONS 27
9. QUALIFICATIONS 29
10. REFERENCES 30

Appendices

APPENDIX A FLOOD MAPPING

APPENDIX B WATER QUALITY MAPPING

APPENDIX C STORMWATER QUANTITY CAPITAL COST ESTIMATES

APPENDIX D MUSIC MODEL SCREENSHOTS

List of Tables

Table 4.1 Land Use Impervious Values 6
Table 4.2 Rainfall Loss Parameters 6
Table 4.3 XP-RAFTS and Rational Method 100 Year ARI Comparison 7
Table 4.4 Adopted Roughness Parameters 11
Table 4.5 100 Year ARI Road Hazard Summary 14
Table 5.1 RCC Water Quality Objectives 15
Table 5.2 MUSIC Modelling Results 20
Table 6.1 Details of Stormwater Quantity Treatment Infrastructure 22
Table 6.2 Details of Stormwater Quality Treatment Infrastructure 23
Table 7.1 Stormwater Quantity Infrastructure Cost Estimate 25
Table 7.2 Stormwater Quality Infrastructure Cost Estimate 26
Table 8.1 Stormwater Quantity Infrastructure Cost Estimate 27
Table 8.2 Stormwater Quality Infrastructure Cost Estimate 28

List of Figures

Figure 1.1 Study Area 2
Figure 4.1 Stormwater Quantity Sub-Catchment Layout 8
Figure 4.2 Hydraulic Model Layout 10
Figure 4.3 Hazard Rating Categories (CSIRO, 2000) 13
Figure 5.1 Example of Street Scale Bioretention 17
Figure 5.2 Example of a Constructed Wetland 18
Figure 6.1 Stormwater Infrastructure Requirements 24

1. INTRODUCTION

As part of master planning for the Cleveland CBD, Redland City Council (RCC) requires a trunk stormwater infrastructure plan in order to meet the requirements of local and state planning instruments.

Redland City Council (RCC) has commissioned Engeny to develop a stormwater infrastructure plan for the Cleveland CBD catchment. The purpose of this study is to determine the integrated stormwater quantity and quality trunk infrastructure requirements and associated costs for the proposed infrastructure. The stormwater infrastructure plan will assist Council in applying appropriate planning and acquisition principles for servicing forecasted demands. The study area is located to the south of Raby Bay and it comprises commercial, residential and open space areas. Figure 1.1 illustrates the extent of the study area.

This investigation has adopted a design approach consistent with the Statutory Guideline 01/09 (DIP, 2009), Queensland Urban Design Manual (QUDM, 2007) and the Redland City Council Planning Scheme (RCC, 2013).



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Stormwater Infrastructure Plan for Cleveland CBD Catchment

Study Area

Figure 1.1

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2. SCOPE OF WORKS

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

Stormwater Quantity

- Development of an ultimate case XP-RAFTS hydrologic and TUFLOW hydraulic models representing the ultimate land use conditions and existing stormwater infrastructure throughout the study area;
- Simulate the hydrologic and hydraulic models for the 2, 10, and 100 year ARI design event to determine the ultimate design flows and assess the hydraulic capacity of the existing stormwater infrastructure;
- Review of flood results to identify impacts associated with the proposed ultimate development throughout the study area.

Stormwater Quality

- Development of a MUSIC Version 5.0 model for the catchment to represent the ultimate development scenario. This model allows for a quantitative assessment of stormwater runoff quality for the proposed development plan (proposed ultimate land use);
- Amend the ultimate development MUSIC model to include the appropriate treatment measures required in an attempt to achieve the prescribed water quality objectives for each of the catchments. This model represents the ultimate mitigated scenario for the proposed development area and enables the appropriate water quality treatment infrastructure to be defined;
- Concept layout of the proposed stormwater quality mitigation measures including estimation of construction costs for the proposed water quality trunk infrastructure requirements to address State Planning Policy (SPP) 4/10 (DERM, 2010).

3. CATCHMENT DESCRIPTION

The Cleveland stormwater infrastructure plan catchment is located approximately 25 kilometres east-south-east of Brisbane and bounded by Raby Bay to the north and Moreton Bay to the east, Long Street to the south and Smith Street to the west. The majority of the catchment is fully developed and it is characterised by development ranging from commercial to urban and medium dense residential, there are also number of open space land uses throughout the catchment mainly around Ross Creek and Redland Bay. In general the ultimate land use will be similar to the existing land use.

The study area catchment is approximately 195 hectares with relatively flat topography. The surface runoff mainly is drained via stormwater network to Ross Creek, Raby Bay and Moreton Bay.

4. STORMWATER QUANTITY ASSESSMENT

The increase in impervious areas associated with urban development generally leads to increased runoff volumes, reduced infiltration to groundwater and increased rates of runoff and stream flow. Hydrologic and hydraulic modelling has therefore been undertaken to assess the impacts associated with the proposed development of the Cleveland CBD. In particular, this includes assessment of stormwater infrastructure throughout the study area for ultimate development conditions.

4.1 Catchment Hydrology

Hydrologic modelling of the catchment was undertaken using the XP-RAFTS rainfall-runoff routing model. The XP-RAFTS software is an industry standard rainfall-runoff routing analysis package capable of modelling changes in development for both rural and urban sub-catchments. The hydrologic model calculates flood hydrographs at various locations throughout a catchment for design flood events for input into the hydraulic model.

Flood hydrographs have been determined for a range of design rainfall events including the 2, 10 and 100 year ARI design flood events under ultimate development conditions. These flood hydrographs are used as the key input for the hydraulic model to predict stormwater network and overland flood behaviour.

4.1.1 Model Setup

The XP-RAFTS estimates the runoff hydrograph from individual sub-catchments based on a number of input parameters including rainfall intensity, rainfall losses, fraction impervious, catchment slope, manning's 'n', temporal patterns and catchment area.

4.1.2 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 pervious and impervious area of each sub-catchment for the Ultimate Case was obtained from zoning GIS layer provided by Redland City Council. The proposed future (ultimate) land use consists of a mixture of Urban and Medium Density Residential, Open Space, Community Purpose, Major Centre and Conservation Area. The percentage impervious values have been determined for each land use in accordance with Redland City Council Planning Scheme (2013) - Policy 9 - Stormwater Management.

The ultimate land use for the study area is illustrated in Appendix B - Figure 1. The areas external to the study area was assumed not to change between the Existing and Ultimate Cases. Table 4.1 below outlines the adopted impervious values for each land use type for the existing and ultimate development land use scenarios.

Table 4.1 Land Use Impervious Values

Land Use	Impervious Percentage (%)
Conservation	0
Open Space	0
Urban Residential	50
Medium Density Residential	80
Community Purposes	60
Major Centre	90
Local Centre	100
Road	90

4.1.3 Rainfall Losses and Intensities

Rainfall losses have been represented by an initial loss - continuing loss model. These losses are applied via the associated materials delineation of the study area and are factored according to the percentage imperviousness of the associated land use.

Table 4.2 Rainfall Loss Parameters

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

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 (Engineers Australia, 2001).

4.2 Hydrologic Model Validation

Sub-catchment flows throughout the development area have been validated through the use of the Rational Method. A comparison of three (3) sub-catchments was undertaken to compare the RAFTS 100 year ARI peak flows representing the Ultimate Case and the Rational Method flows. The results are summarized in Table 4.3.

Table 4.3 XP-RAFTS and Rational Method 100 Year ARI Comparison

Rational Method Locations	XP-RAFTS Peak Flow (m^3/sec)	Rational Method Flow (m^3/sec)	Difference
CL16	0.52	0.55	-5.9%
CL48	2.8	2.8	0%
CL96	0.6	0.6	0%

Table 4.3 Shows there is good correlation between the peak flow results calculated using the Rational Method and those estimated from the hydrologic model. The comparative flows are generally within 6 % and as such, it is considered the hydrologic model parameters are suitable for predicting design flood events within the study area.

4.3 Critical Storm Duration

The critical storm duration is defined as the duration of rainfall that will result in the highest peak flood flows at a particular location. In the upper parts of both the northern and southern catchments the 25 minute storm was found to be the dominant duration resulting in the highest peak flows. The 15 minute and 60 minute were also found to dominate in small size and large size catchment. Subsequently all three design storms were adopted for use in the hydraulic model with the maximum level produced by each used for flood mapping purposes.



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Figure 4.1

Subcatchment Layout

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4.4 Hydraulic Modelling

A combined 1D/2D hydraulic analysis has been undertaken to investigate the local flooding characteristics and identify deficiencies in the existing stormwater drainage system.

The hydraulic modelling package chosen for use in this study is the TUFLOW finite difference hydrodynamic flood and tide simulation software. TUFLOW is Australian owned, and is widely used in commercial studies throughout Australia. TUFLOW simulates depth-averaged, two and one-dimensional free-surface flows such as occurs from floods and tides, and uses a combination of 2D and 1D modelling schemes to model complex flooding behaviour.

TUFLOW also allows for the easy production of detailed outputs of flow patterns, flood rise and fall animations, and outputs suitable for direct GIS interfacing. This allows production of accurate depth of flooding, velocity and hazard maps as well as area of influence maps.

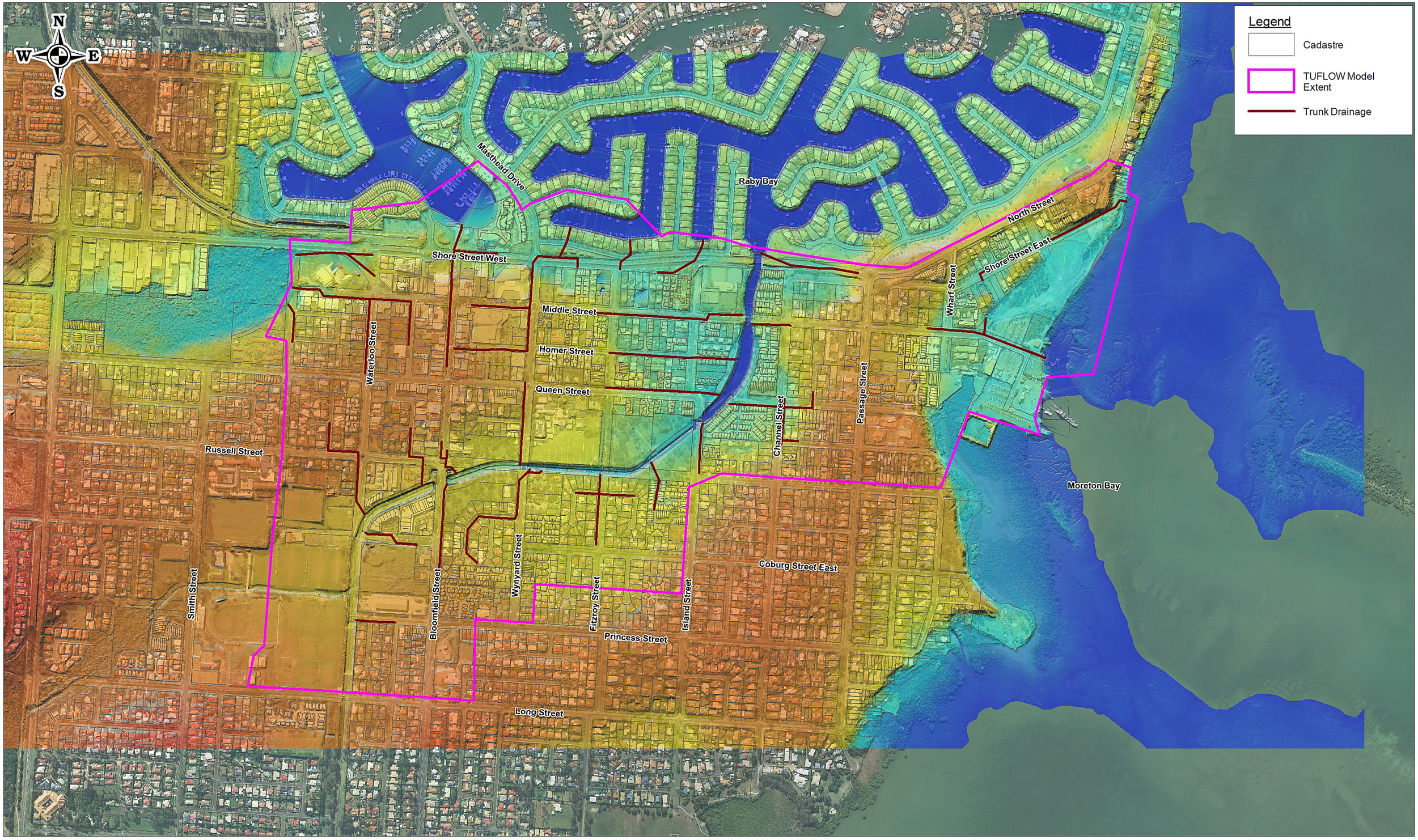
The Tuflow hydraulic model construction consists of the following elements:

- A 2D rectilinear grid representing the topographic levels within the area of interest extracted directly from the 1 m DEM constructed using the supplied RCC LiDAR data;
- Manning's 'n' roughness map covering the area of interest;
- 1D elements representing significant surface and subsurface hydraulic structures within the 2D grid extent;
- A downstream water level boundary applied at the model outlets; and
- Catchment runoff inflow hydrograph boundary conditions.

The hydraulic model layout is shown in Figure 4.2.

4.4.1 2D Topographic Grid

The 2D model topography was derived using the 1 m Digital Elevation Model (DEM) constructed from 2009 topographic LiDAR data as supplied by Council. A balance between the number of computational points, level of modelling detail, density of topographic survey points and model run times was required to deliver suitably accurate outcomes in a timely and efficient manner. The decision on the grid spacing to adopt in the 2D model is a critical one. Based on our review of the catchment and overall study area, it was found that a 2 m cell size provided the detail required for this investigation whilst maintaining realistic model run times.



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Hydraulic Model Layout

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4.4.2 Model Roughness Coefficients

A GIS based floodplain roughness map covering the entire study area was created using ultimate land use scenario Redland Planning Scheme Zoning to accurately define the hydraulic roughness across the study area.

Table 4.4 documents roughness parameters assigned to each land use within the study area.

Table 4.4 Adopted Roughness Parameters

Land Use Type	Manning's 'n' Roughness Value
Roads	0.025
Open Space	0.060
Medium Density Residential	0.200
Urban Residential	0.150
Major Centre	0.250
Local Centre	0.250
Community Purpose	0.150
Dense Vegetation	0.080

4.4.3 Stormwater Pipe System

Hydraulic structures including culverts, stormwater pits and manholes located within the study area were included in the TUFLOW model and have been modelled using the 1D ESTRY element. ESTRY is an explicit finite difference scheme solving the full 1D free surface flow equations. ESTRY has been applied to a wide range of river and urban flood investigations and estuarine tidal studies. Details of the stormwater pipe network including dimensions and invert levels were extracted from the GIS data provided by the RCC. Surface levels for manholes and stormwater pits have been based on the ALS data to prevent model instability arising from possible errors in the ALS levels.

In some instances, trunk drainage infrastructure was shown to have inaccurate invert levels within the GIS database, and as a result interpolation between upstream and downstream pipe invert levels was undertaken in combination with an assumed minimum pipe cover depth.

4.4.4 Model Boundary Conditions

The TUFLOW model boundary types include both variable tailwater conditions for the various design rainfall events as well as inflow boundaries which represent catchment runoff as predicted by the RAFTS model. The following sections summarise the boundary types and their application to the TUFLOW model.

The tailwater boundary condition applied to the model is based on the Semi Diurnal Tide Planes dataset for Redland Bay (MSQ, 2012) Mean High Water Springs (MHWS) of 0.96 was adopted for the design rainfall event simulations.

The local sub-catchment hydrograph results from the RAFTS model were extracted for the 2, 10 and 100 year ARI events. Local sub-catchment hydrographs have then been applied to the TUFLOW model using direct application to the 1D network in the study area or direct application of the representative local catchment hydrograph to the associated sub-catchment. Once the capacity of the 1D network is reached in these areas, surcharging of the flows to the 2D domain occurs.

4.5 Assessment of Existing Drainage Systems

In order to quantify the impacts of stormwater flooding a number of performance criteria have been established and mapped. These performance criteria include standard of service, flood depths and flood hazard. A summary of the flood modelling results against the specified performance criteria is provided in the following Sections.

4.5.1 Standard of Service

The standard of service associated with a stormwater network is based on the major and minor storm concept whereby the major storm which is made up of roadways and open drains provides immunity from flooding for large magnitude events. Typically the 100 year ARI storm event. The minor storm is typically conveyed by a piped drainage system to provide convenience and safety to pedestrians and vehicles. The ARI associated with the minor storm is generally based on the surrounding land use. The standard of service for this study is based on the Redlands Planning Scheme (RCC, 2013) and is summarised below:

- Medium Density Residential – 10 year ARI;
- Commercial – 10 year ARI;
- Low Density Residential – 2 year ARI;
- Major Storm – 100 year ARI (all land uses).

4.5.2 Flood Depths

Flood depth has been used as the key indicator to identify areas of concern that could pose a risk to people or property or even result in nuisance flooding. Flood depths within a private property that are predicted to be typically less than 300 mm without over floor inundation have been classified as prone to nuisance flooding. Whereas over floor inundation in any event up to the 100 year ARI is considered a high risk to property and people. Flood depths within roads that result in overtopping of the crown or kerb are also considered to be high risk, with mitigation options recommended to prevent these situations.

4.5.3 Flood Hazard

Flood hazard is a measure of the ability for a person or vehicle to traverse flood waters. It is measured using a combination of depth and velocity of floodwater. The larger the product of velocity and depth, the greater the risk of people or vehicles being washed away. Flood hazard is a critical factor in determining road closure and evacuation routes.

Flood hazard mapping throughout the study area has been undertaken based on low, medium, high and extreme categories based on SCARM Report 73 (CSIRO, 2000) as summarised below in Figure 4.3 Hazard Rating Categories (CSIRO, 2000) Mitigation options have been identified to reduce the hazard profiles in areas where people or vehicle interaction with flood waters is likely.

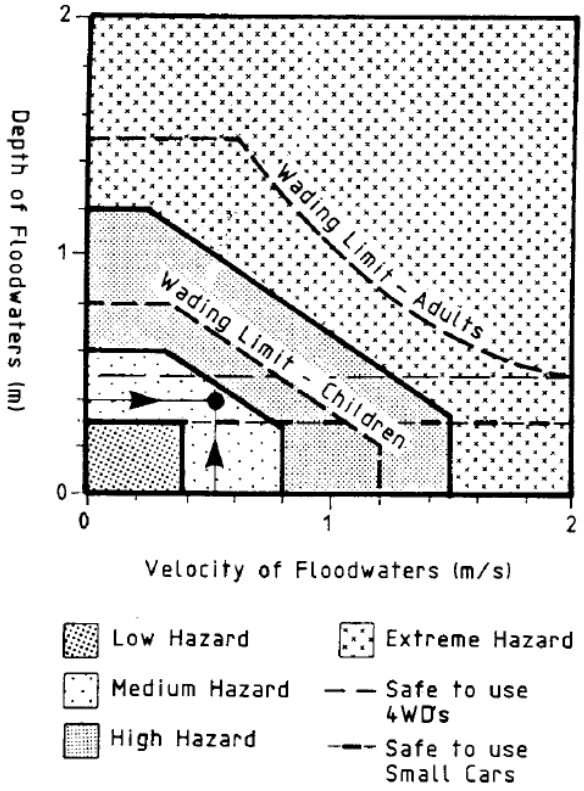


Figure 4.3 Hazard Rating Categories (CSIRO, 2000)

4.6 Results Discussion

Stormwater runoff within study area is conveyed to Ross Creek and Redland Bay via a stormwater drainage network. The results indicate that the majority of the existing pipe network within the study area has capacity to convey flows for the 2 and 10 year ARI events. A number of roads are predicted to experience inundation during the 2, 10 and 100 year ARI events in Cleveland CBD area.

Flood depths for the 2 and 10 year ARI event throughout the majority of the area are predicted to be less than 300 mm. The hydraulic modelling results indicate that properties are predicted not to be affected in 2, 10 and 100 year ARI flood events.

The flood hazard mapping provided in Appendix A indicates there are some areas within Cleveland that are prone to medium, high or extreme hazard. These areas include a number of streets which prevent trafficability along some evacuation routes. A flood hazard summary of the roads that are flood prone in 100 year ARI event has been summarised in Table 4.5.

Table 4.5 100 Year ARI Road Hazard Summary

Road Name	100 Year ARI Hazard Category[1]	100 Year ARI Peak Depth Over Road (mm)
Shore Street West	Medium	370
Shore Street East	Medium	225
Middle Street Police Station	Medium	550
Homer Street	Extreme	550
Wynyard Street Carpark	Medium	280
Yarrow Court	Medium	260
Russell Street Roundabout	Extreme	400
Bloomfield Street (Between Queen Street and Middle Street)	Medium	150
Channel Street	Extreme	450
Fitzroy Street	High	310

5. STORMWATER QUALITY ANALYSIS

5.1 MUSIC Modelling

A quantitative assessment of stormwater runoff quality has been undertaken for the ultimate land use scenario for the Cleveland CBD area. This assessment was undertaken in order to develop a required footprint for water quality treatment devices within the Cleveland study area.

State Planning Policy (SPP) 4/10 provide the development criteria intended to ensure development is carried out in a way that will achieve the relevant water quality objectives of the EP water policy 2009. This policy outlines best practice stormwater quality management to protect the environmental values of receiving waters.

The SPP 4/10 guidelines provide details of the required stormwater management for the study area. These guidelines identify pollutant load reductions for urban stormwater. 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 Cleveland catchment are adopted to ensure "Best Practice" Stormwater Management Standards are achieved. The percentage removal efficiency or the "treatment train effectiveness" requirements are outlined in Table 5.1.

Table 5.1 RCC Water Quality Objectives

Pollutant Type	Objective	Urban Stormwater Quality Planning Guidelines 2010
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%

A quantitative assessment of stormwater runoff quality has been considered for the ultimate land use scenario of the Cleveland Catchment. 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 5.0, released in August 2011, was used in this assessment.

In accordance with State Planning Policy 4/10 MUSIC modelling has been undertaken in accordance with the Water by Design (2009) MUSIC modelling Guidelines for South East Queensland", in conjunction with the Healthy Waterways "Water Sensitive Urban Design Technical Design Guidelines for South East Queensland".

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 1996-2006 rainfall events with six (6) minute timestep.

2. Land uses for the ultimate catchment were derived from GIS information supplied by Redland City Council. Commercial, Industrial and Urban land use were adopted for the MUSIC model with an impervious percentage of 90% adopted for the industrial and commercial while 70% had been used for the residential land use areas. This represents the effective impervious area which differs from the impervious area adopted as part of the hydrological assessment.

3. A treatment train was developed based on available space, existing drainage infrastructure, tide levels, feasibility and target pollutants reductions.

It should be noted that;

- In accordance with the water by design MUSIC modelling guidelines the natural assimilative capacity of any waterway was not represented within the MUSIC model;

- The finished surface of the bioretention filter media must be horizontal (ie. flat) to ensure full engagement of the filter media by stormwater flows and to prevent concentration of stormwater flows within depressions and ruts resulting in potential scour and damage to the filter media;

- Hydraulic modelling has not been undertaken to assess the effects the treatment systems may have on flood levels.

5.2 Typical Treatment Train

Best management practices in Water Sensitive Urban Design (WSUD) techniques are proposed to be implemented throughout the Cleveland CBD. Stormwater runoff will be treated by a range of treatment devices prior to discharge to the receiving waterways. Different WSUD treatment measures are used in different situations to target a variety of pollutants. Examples of typical WSUD treatment measures include:

5.2.1 Bioretention Basins

Bioretention systems act to treat stormwater by accepting stormwater flows into a shallow planted depression where water ponds above a sandy-loam filter planted filter media. This maximises the volume of runoff that passes through the filtration media. Water then

percolates through the filter media at an infiltration rate of approximately 200 mm an hour and out through an underdrainage system where it exits into the receiving drainage system or waterway.

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. There are a limited number of locations within the study area that could be retrofitted with end of pipe bioretention basins which are detailed in Appendix B. Due to the constraints associated with the study area, street scale bioretention basins are recommended to be utilised and considered as part of streetscape planning. An example of a street scale system is provided in Figure 5.1.



Figure 5.1 Example of Street Scale Bioretention

5.2.2 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 course sediment collection area in

order to protect the macrophyte zone. The macrophyte zone is largely vegetated using wetland species which act to remove nutrient from the stormwater. Fluctuating water levels within the wetland mimic natural wetting and drying cycles which is a key in their long-term health. A riser outlet is ideally designed to facilitate this characteristic. A typical layout and cross section for a constructed wetland is included in Figure 5.2.

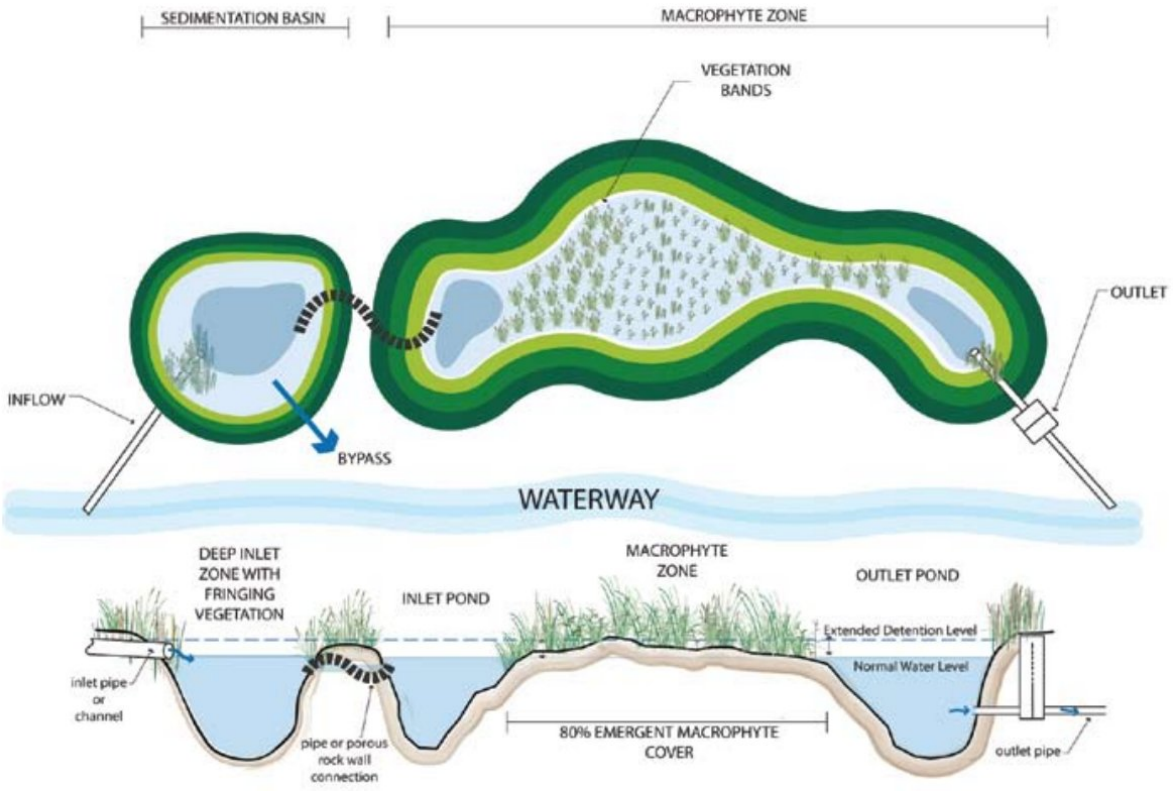


Figure 5.2 Example of a Constructed Wetland

5.3 Gross Pollutant Traps (GPTs)

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. During a site visit it was noted that the majority of gully traps within the Capalaba Central shopping centre had Ecosol litter baskets or similar installed within the gully pits.

GPT's have not been included in the MUSIC modelling for the catchment as it is envisaged that pre-treatment will occur via the use of trash racks or sediment forebays located immediately upstream of the treatment systems where deemed appropriate. It may be feasible to install such devices in specific areas of high litter generation (i.e. shopping centres) where alternative treatment measures are unsuitable however these

areas are often isolated pockets that require specific investigation and are therefore outside the scope of this infrastructure plan.

5.4 Stormwater Quality Management Strategy

The stormwater quality management strategy for the catchment considered site specific constraints for each of the sub-catchments in conjunction with the Master Plan to integrate a range of water sensitive urban design features. Treatment measures have been incorporated to work in conjunction with the existing drainage network to improve stormwater quality discharged to receiving waters.

The vast majority of the study area is fully developed, and as such, retrofitting of water treatment devices is constrained by available council owned open space areas and limitations with the existing drainage network. A break up of the individual sub-catchments and proposed stormwater quality treatment infrastructure is outline below.

5.4.1 Sub-catchment 1 & 3

Runoff from both of these catchments discharges into Ross Creek from a number of outlets via the existing stormwater network. The best method for incorporation of a regional treatment measure for these catchments is a wetland in the existing open space area downstream (William Ross Park). As Ross creek conveys water from a much larger external catchment the wetland would be designed to only capture low flows through a cut out in the bank which would control inflows. A bioretention system was not considered for this site due to issues with tidal ingress into the underdrainage as a result of invert levels. The size of the wetland in this area is limited by space and therefore will not meet water quality objectives.

5.4.2 Sub-catchment 2A and 2B

Stormwater from catchment 2A currently discharges into Ross Creek downstream of William Ross Park. It is possible to discharge flows from the existing pipe network into the William Ross Park at the corner of Russel and Island Streets for treatment through the incorporation of a bioretention system into the parkland. The remainder of flows that inlet the system are unable to be treated and therefore catchment 2B has no stormwater quality treatment.

5.4.3 Sub-catchment 4

Due to the lack of available space for regional treatment infrastructure it is proposed that street scape bioretention systems be incorporated into sub-catchment 4. This is in line with the concepts within the Master Plan. Due to the layout of the drainage network and the fact that parking space is at a premium within the centre of Cleveland it has been determined that treatment systems can only treat approximately 15% of the overall catchment area. This proportion of the site has been modelled as WQ4A in the music model layout figure. The remaining 85% of the catchment would discharge to Ross Creek

and Redland Bay via stormwater network without treatment. This area has been modelled as WQ4B in the music model layout figure.

5.4.4 Sub-catchment 5

Sub-catchment 5 is fully developed catchment with flows discharging into Ross Creek via existing pit and pipe networks and surface runoff. As there is no available space for regional stormwater quality infrastructure and the catchment is outside the main master plan area it is unlikely that any significant number of street scape systems are likely to be retrofitted. Therefore no stormwater quality devices have been incorporated into this catchment.

5.4.5 Sub-catchment 6

Sub-catchment 6 like sub-catchment 5 has no stormwater quality infrastructure incorporated the stormwater runoff from catchment WQ6 flows to the Redland Bay via existing stormwater network. The area has been constrained by lack of land and dense vegetation.

5.4.6 Sub-catchment 7

The runoff from catchment 7 discharges to Redland Bay via a combination of overland flow and a piped stormwater network. Due to the low levels of the site a wetland has been incorporated to treat runoff in this catchment.

5.5 Stormwater Quality Results

Results shown is Table 5.2 demonstrate that the load based objectives are not met for all sub-catchments and therefore the proposed treatment measures are unable to meet water quality objectives for the total Cleveland catchment. However a number of individual sub-catchments are able to achieve the objectives.

The details of the proposed treatment measures are outlined in Section 6.2.

Table 5.2 MUSIC Modelling Results

Location	Pollutants	Unmitigated	Mitigated	Reduction (%)	Target	Target Achieved
Receiving Node (total catchment)	TSS (kg/yr)	327000.0	212000.0	35.3	80	x
	TP (kg/yr)	693.0	500.0	27.8	60	x
	TN (kg/yr)	3460.0	2960.0	14.5	45	x
	GP (kg/yr)	38800.0	17600.0	54.6	90	x
Catchment WQ1 and WQ3 Combined	TSS (kg/yr)	136000.0	55300.0	59.3	80	x
	TP (kg/yr)	283.0	144.0	49.2	60	x
	TN (kg/yr)	1400.0	1090.0	22.3	45	x

Location	Pollutants	Unmitigated	Mitigated	Reduction (%)	Target	Target Achieved
	GP (kg/yr)	15900.0	0.0	100.0	90	✓
Catchment WQ2_A	TSS (kg/yr)	14900.0	2380.0	84.0	80	✓
	TP (kg/yr)	29.1	11.6	60.3	60	✓
	TN (kg/yr)	138.0	68.3	50.5	45	✓
	GP (kg/yr)	1750.0	0.0	100.0	90	✓
Catchment WQ2_B	TSS (kg/yr)	1500.0	1500.0	0.0	80	x
	TP (kg/yr)	3.0	3.0	0.0	60	x
	TN (kg/yr)	14.1	14.1	0.0	45	x
	GP (kg/yr)	179.0	179.0	0.0	90	x
Catchment WQ4A_Urban	TSS (kg/yr)	9930.0	1660.0	83.2	80	✓
	TP (kg/yr)	19.4	7.6	60.7	60	✓
	TN (kg/yr)	93.0	45.8	50.7	45	✓
	GP (kg/yr)	1180.0	0.0	100.0	90	✓
Catchment WQ4A_Commercial	TSS (kg/yr)	4690.0	902.0	80.8	80	✓
	TP (kg/yr)	12.3	4.7	61.5	60	✓
	TN (kg/yr)	70.5	36.2	48.6	45	✓
	GP (kg/yr)	527.0	0.0	100.0	90	✓
Catchment WQ4B	TSS (kg/yr)	82000.0	82000.0	0.0	80	x
	TP (kg/yr)	182.0	182.0	0.0	60	x
	TN (kg/yr)	941.0	941.0	0.0	45	x
	GP (kg/yr)	9670.0	9670.0	0.0	90	x
Catchment WQ5	TSS (kg/yr)	47400.0	47400.0	0.0	80	x
	TP (kg/yr)	96.5	96.5	0.0	60	x
	TN (kg/yr)	469.0	469.0	0.0	45	x
	GP (kg/yr)	5650.0	5650.0	0.0	90	x
Catchment WQ6	TSS (kg/yr)	15100.0	15100.0	0.0	80	x
	TP (kg/yr)	33.6	33.6	0.0	60	x
	TN (kg/yr)	183.0	183.0	0.0	45	x
	GP (kg/yr)	2130.0	2130.0	0.0	90	x
Catchment WQ7	TSS (kg/yr)	15500.0	5250.0	66.2	80	x
	TP (kg/yr)	30.4	13.9	54.3	60	x
	TN (kg/yr)	149.0	112.0	24.7	45	x
	GP (kg/yr)	1860.0	0.0	100.0	90	✓

6. PROPOSED TRUNK STORMWATER INFRASTRUCTURE

6.1 Stormwater Quantity Infrastructure Requirements

Mitigation options investigated as part of this assessment included trunk stormwater infrastructure upgrades such as pipes, open channels and kerb and channel. A number of options were considered for each problem area, however the preferred option was identified based on its practicality, cost and associated benefits.

It should be noted that the options identified and assessed at this stage are preliminary only and will require further detailed design prior to construction. The concept design and finalising of mitigation options should consider all possible constraints such as existing services, land ownership, site specific survey information and directly impacted residents. The infrastructure upgrades required are summarised in Table 6.1 and a map showing indicative requirements is provided in Figure 6.1.

Table 6.1 Details of Stormwater Quantity Treatment Infrastructure

Location	Upgrade Requirement
Channel Street	Pipe Duplication
Fitzroy Street	Pipe Duplication
Ross Court	Pipe Duplication
Russell Street and Lexen Street	Pipe Upgrade/Replacement
Waterloo Street	Pipe Upgrade/Replacement
Russell Street (east)	Pipe Duplication and Upgrade/Replacement
Middle Street (Police Station)	Pipe Duplication
Yarrow Court	Pipe Duplication
Shore Street East	Kerb & Channel and Drainage Improvement[1]
Middle Street (Wharf Street Intersection)	Pipe Duplication
Shore Street West	Pipe Duplication

1. Clearing and minor excavation of existing open drain.

6.2 Stormwater Quality Trunk Infrastructure Requirements

The stormwater quality treatment train includes a large wetland system that will treat low flows form the existing concrete lined channel that conveys water from three (3) bioretention and two wetland systems. Table 6.2 outlines the details of the stormwater quality treatment infrastructure and the locations are summarised in Figure 6.1.

Table 6.2 Details of Stormwater Quality Treatment Infrastructure

Catchment	Treatment Device	Filter Area(m^2)	Surface Area(m^2)	Filter Depth(m)	Extended Depth(m)
WQ1 and WQ3	Wetland	NA	13000	NA	0.5
WQ2A	Bioretention	750	900	0.4	0.4
WQ4A_Urban	Bioretention	500	650	0.5	0.4
WQ4A_Commercial	Bioretention	220	250	0.5	0.4
WQ7	Wetland	NA	2000	NA	0.5

6.2.1 Consideration of Treatment Options and Locations

In all cases, it has been considered to minimize disturbance to the natural environment, minimise both construction and maintenance costs and add to the feel of the areas there incorporated into. All the treatment devices have been placed with consideration of site access for construction and maintenance.



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Stormwater Infrastructure Plan for Cleveland CBD Catchment

Stormwater Infrastructure Requirements

Figure 6.1

Job Number: M8000_019
Revision: A
Drawn: JNA
Date: 3 May 2013

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7. CONSTRUCTION COST ESTIMATES

7.1 Stormwater Quantity

The cost estimates of the proposed stormwater quantity infrastructure upgrades have been prepared based on the preliminary design arrangements, diameters and lengths of upgrades. The base date for these estimates is 1 January 2013 and has been escalated from actual civil contactor rates for works within Redlands. A summary of these cost estimates is provided in Table 7.1 and the detailed estimates are provided in Appendix C.

Table 7.1 Stormwater Quantity Infrastructure Cost Estimate

Upgrade Location	Capital Cost($)[1]
Channel Street	148,254
Fitzroy Street	157,076
Ross Court	41,714
Russell Street and Lexen Street	142,407
Waterloo Street	25,279
Russell Street (east)	106,842
Middle Street (Police Station)	54,628
Yarrow Court	84,035
Shore Street East	68,758
Middle Street (Wharf Street Intersection)	134,233
Shore Street West	107,863
Total Cost($)	$1,071,089

1. Excludes costs associated with land acquisition.

For stormwater quantity infrastructure costs, a contingency of 20% has been added to each estimate to allow for additional costs including survey and design of each option.

7.2 Stormwater Quality

Costing for the bioretention basins and wetlands was obtained from the costing module of MUSIC using the upper acquisition cost. It should be noted that the connection from the outlet of each catchment to the bioretention basins has not been included in the cost estimation as this should be undertaken at the detailed design stage. The summary of the stormwater quality infrastructure costs is outlined in Table 7.2. It is noted that this is an upper acquisition cost and does not include land acquisition, annual maintenance, annual renewal, annual establishment or decommissioning costs.

Individual cost estimates in the form of screenshots from MUSIC are provided in Appendix D.

Table 7.2 Stormwater Quality Infrastructure Cost Estimate

Treatment Device	Total Acquisition Cost($)
Bioretention A	$ 176,849
Bioretention B	$132,349
Bioretention C	$78,051
Wetland A	$1,600,257
Wetland B	$497,934
Total Cost($)	$2,485,440

It should be noted that the land acquisition costs have not been included in the above cost estimates. The drainage pipes which convey the Q3 month to the bioretention basins have also been excluded from the proposed trunk infrastructure system.

8. CONCLUSIONS/RECOMMENDATIONS

This study has been prepared for the purposes of quantifying stormwater quantity and quality aspects of the Cleveland Stormwater Infrastructure Plan Area.

The study has quantified stormwater infrastructure requirements relating to stormwater quantity and 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 stormwater quantity and water quality for the development.

The hydraulic modelling results indicate that properties in the Cleveland CBD area are predicted not to be affected in 2, 10 and 100 year ARI flood events. A number of roads were identified as not being trafficable subject to inundation during the 100 year ARI event. Consequently stormwater mitigation measures have been identified for these areas.

Water quality results indicate that the proposed treatment devices are unable to meet water quality objectives for the total Cleveland catchment due to the lack of available land throughout the Cleveland study area.

The total estimated cost for construction of stormwater quality infrastructure is $2.5M and quantity infrastructure is $1.1M. 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. The cost estimates for stormwater quantity and quality infrastructure are provided in Table's 8.1 and 8.2 respectively.

It should be noted that the total acquisition costs for stormwater quality infrastructure have been determined within the MUSIC model and does not include land acquisition, annual maintenance, annual renewal, annual establishment or decommissioning costs.

Table 8.1 Stormwater Quantity Infrastructure Cost Estimate

Upgrade Location	Upgrade Requirement	Capital Cost($)
Channel Street	Pipe Duplication	148,254
Fitzroy Street	Pipe Duplication	157,076
Ross Court	Pipe Duplication	41,714
Russell Street and Lexen Street	Pipe Upgrade/Replacement	142,407
Waterloo Street	Pipe Upgrade/Replacement	25,279
Russell Street (east)	Pipe Duplication and Upgrade/Replacement	106,842
Middle Street (Police Station)	Pipe Duplication	54,628
Yarrow Court	Pipe Duplication	84,035

Shore Street East	Kerb & Channel and Drainage Improvement	68,758
Middle Street (Wharf Street Intersection)	Pipe Duplication	134,233
Shore Street West	Pipe Duplication	107,863
Total Cost($)		$1,071,089

Table 8.2 Stormwater Quality Infrastructure Cost Estimate

Treatment Device	Total Acquisition Cost($)
Bioretention A	$ 176,849
Bioretention B	$132,349
Bioretention C	$78,051
Wetland A	$1,600,257
Wetland B	$497,934
Total Cost($)	$2,485,440

It should be noted that the stormwater infrastructure requirements identified and assessed in this study are preliminary only and will require further concept and detailed design prior to construction. The concept design and finalising of mitigation options should consider all possible constraints such as existing services, land ownership, site specific survey information and directly impacted residents.

It is recommended that the locations and types of stormwater quality treatment devices are reviewed when additional planning is undertaken for the proposed Cleveland CBD redevelopment. The stormwater infrastructure construction cost estimates are preliminary estimates and should also be reviewed once additional planning and design has been undertaken.

9. QUALIFICATIONS

a. In preparing this document, including all relevant calculation and modelling, Engeny Management Pty Ltd (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

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10. REFERENCES

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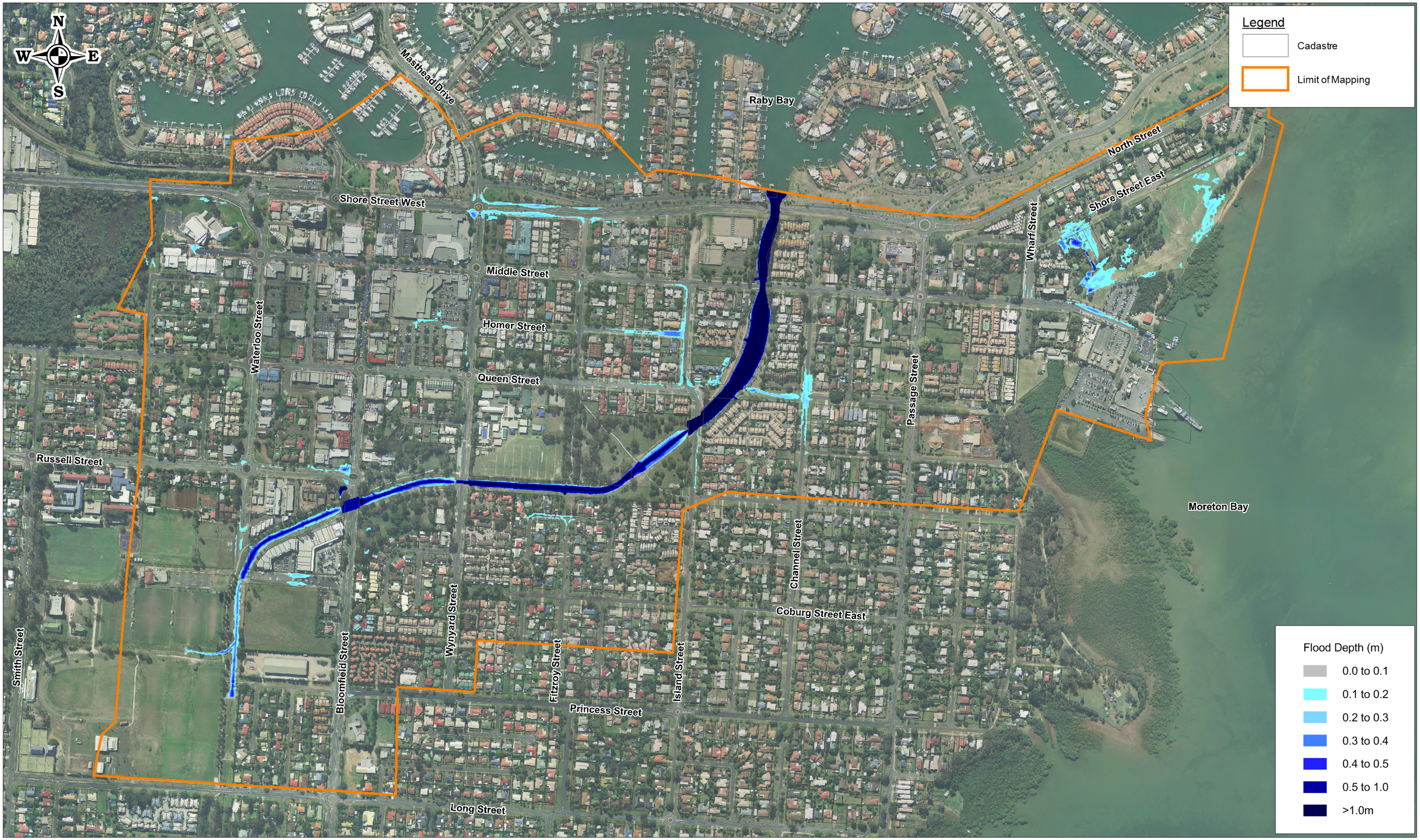
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APPENDIX A

Flood Mapping



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Map Projection: Transverse Mercator
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Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

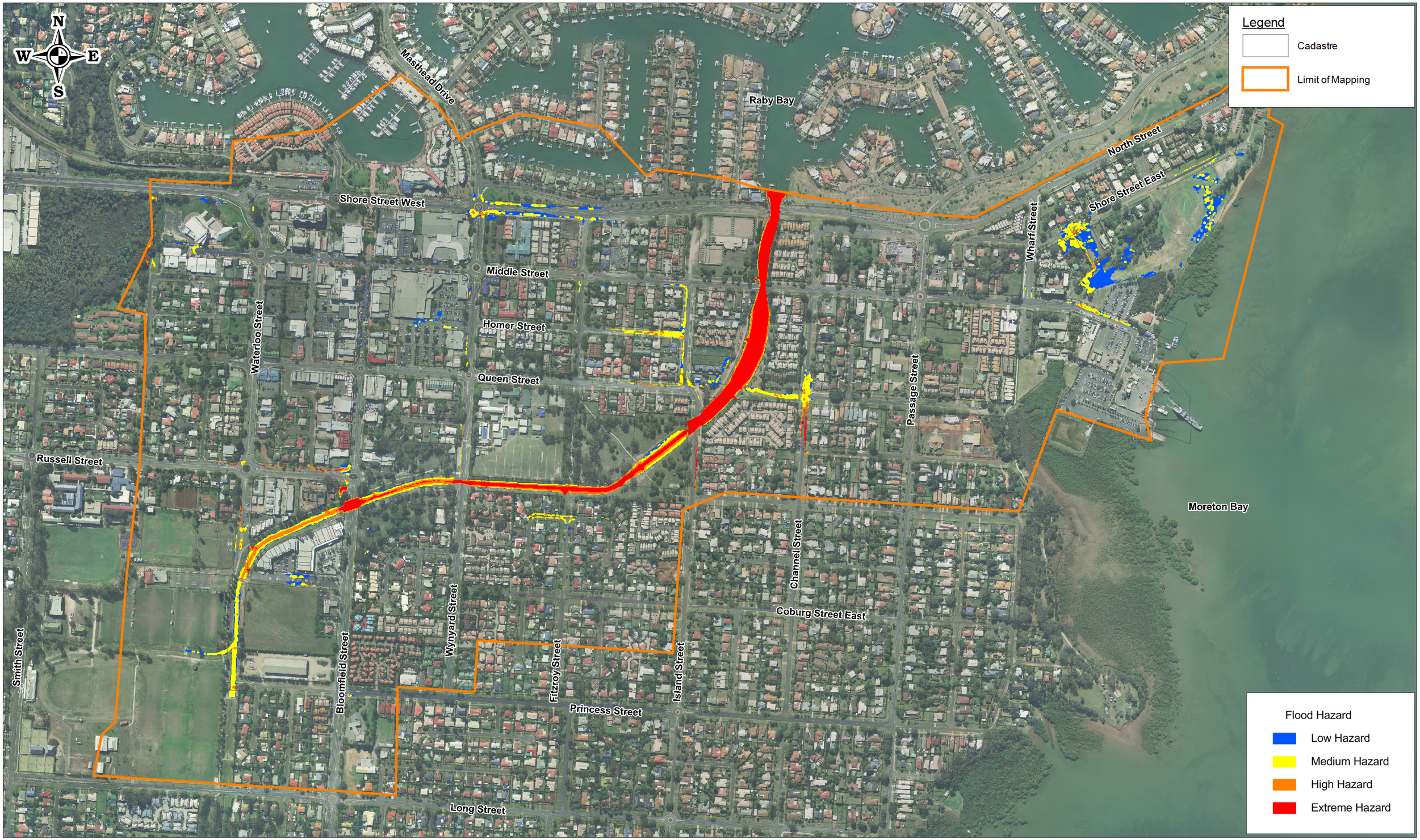
Stormwater Infrastructure Plan for Cleveland CBD Catchment

2 Year ARI Peak Flood Depth

Appendix A
Figure 1

Job Number: M8000_019
Revision: A
Drawn: JNA
Date: 4 Apr 2013

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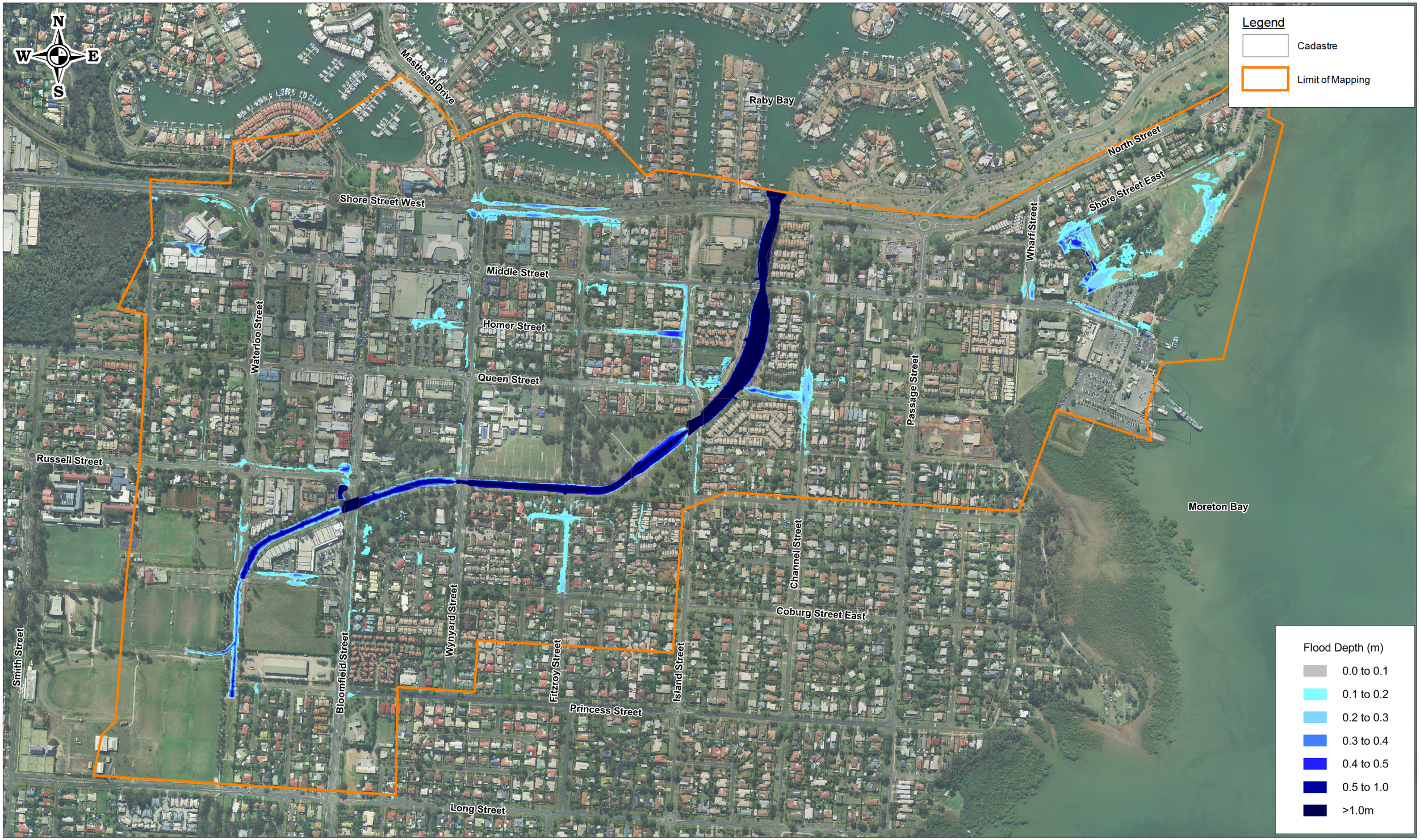
Stormwater Infrastructure Plan for Cleveland CBD Catchment

2 Year ARI Peak Flood Hazard

Appendix A
Figure 2

Job Number: M8000_019
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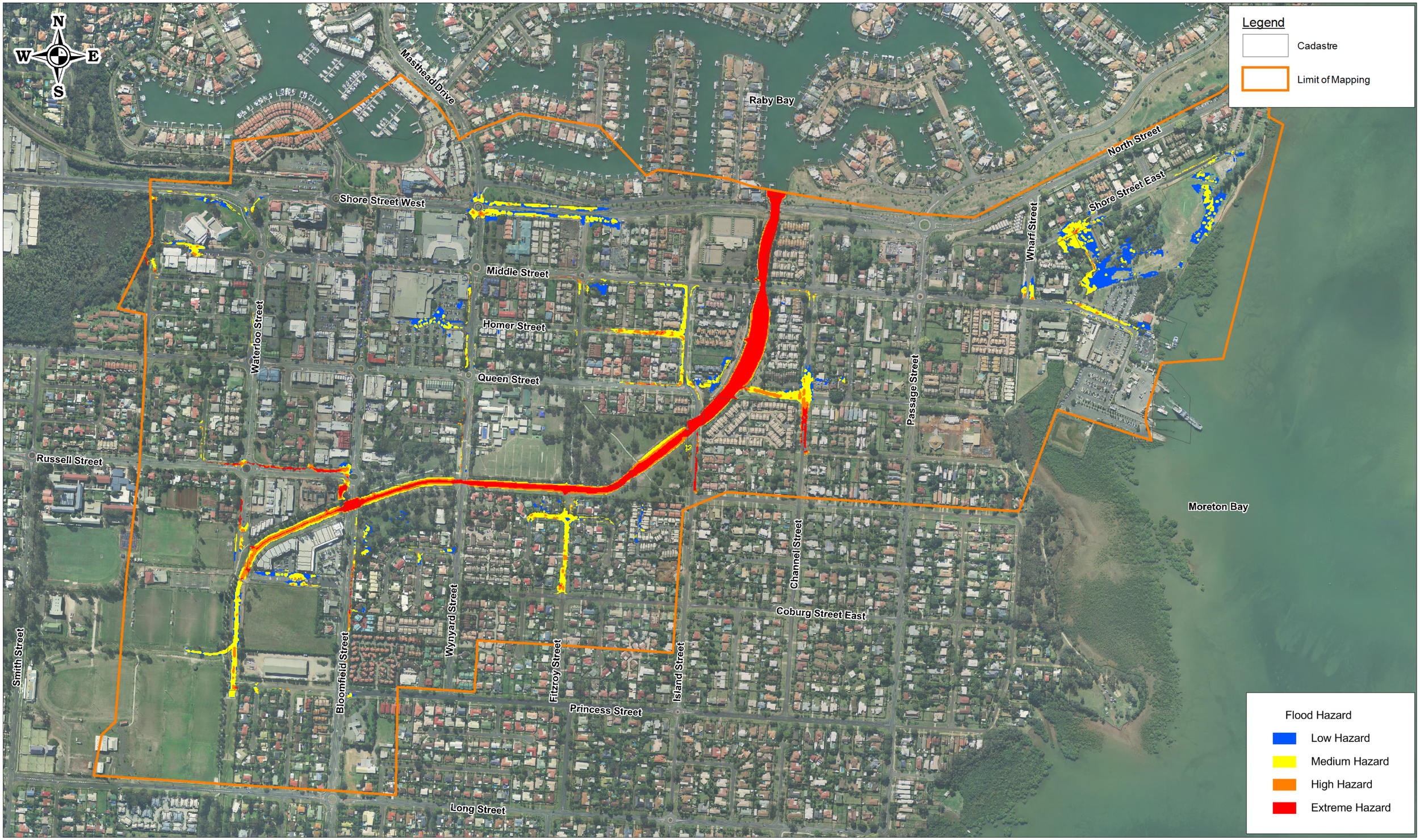
Stormwater Infrastructure Plan for Cleveland CBD Catchment

10 Year ARI Peak Flood Depth

Appendix A
Figure 3

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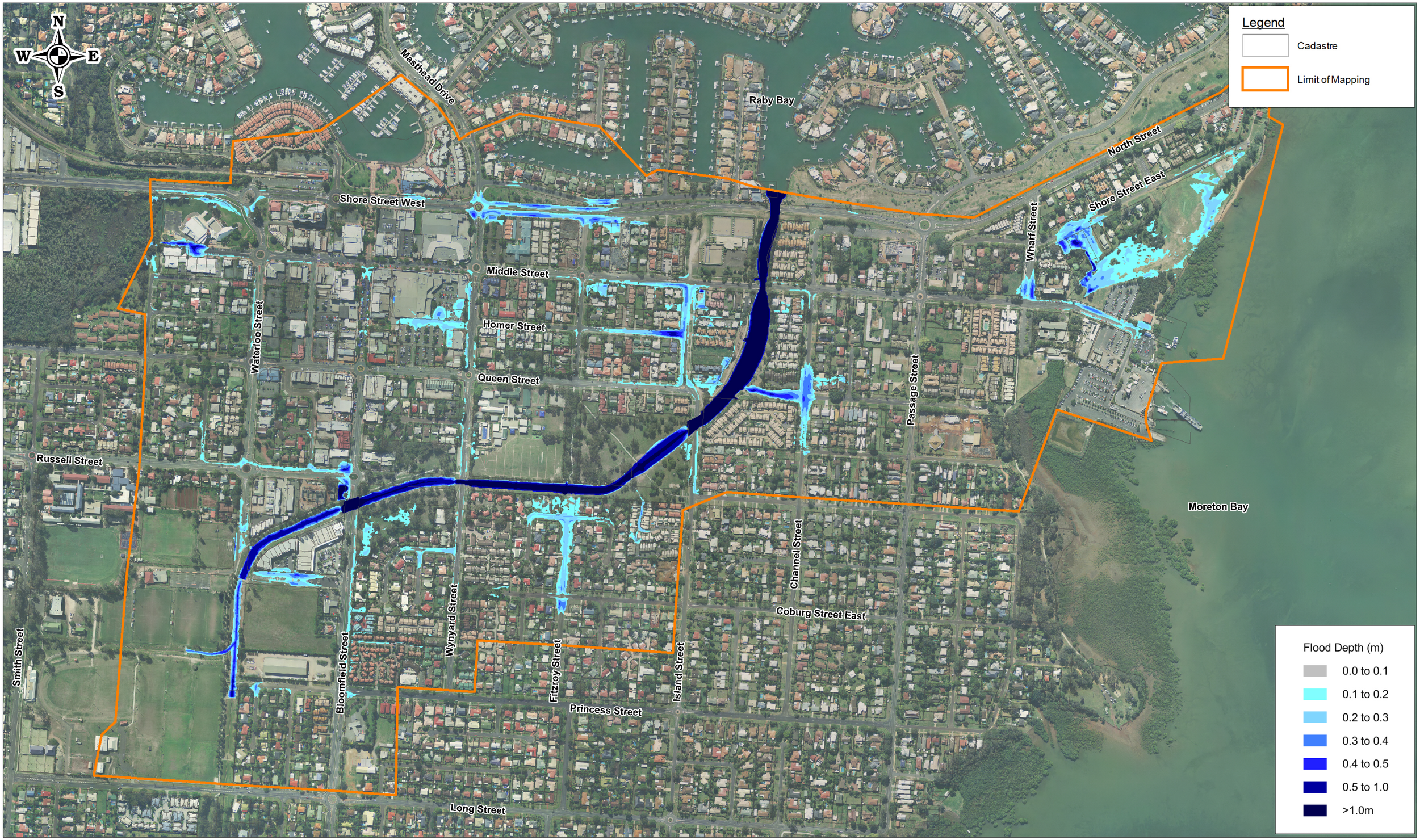
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10 Year ARI Peak Flood Hazard

Appendix A
Figure 4

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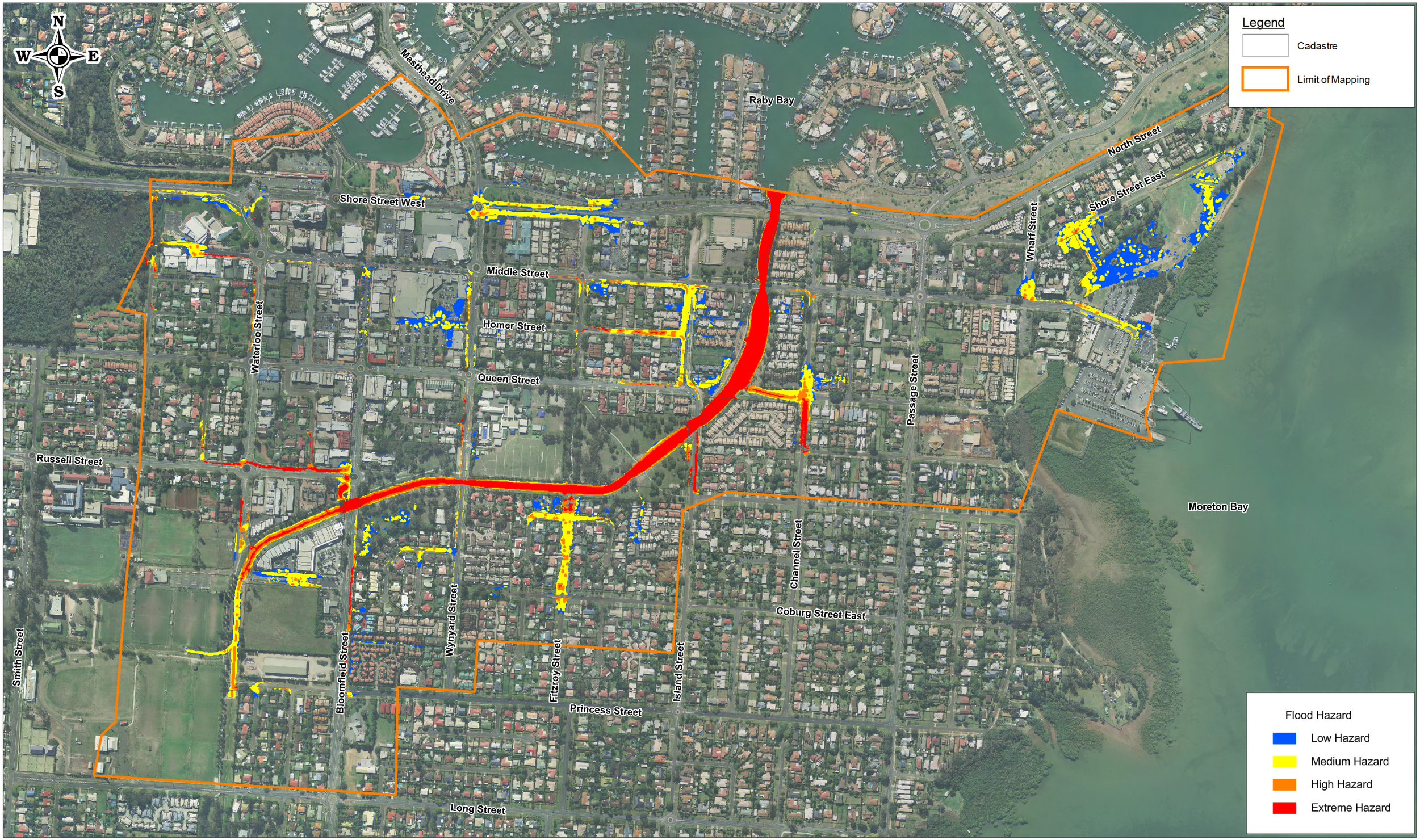
Stormwater Infrastructure Plan for Cleveland CBD Catchment

100 Year ARI Peak Flood Depth

Appendix A
Figure 5

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Stormwater Infrastructure Plan for Cleveland CBD Catchment

100 Year ARI Peak Flood Hazard

Appendix A
Figure 6

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APPENDIX B

Water Quality Mapping



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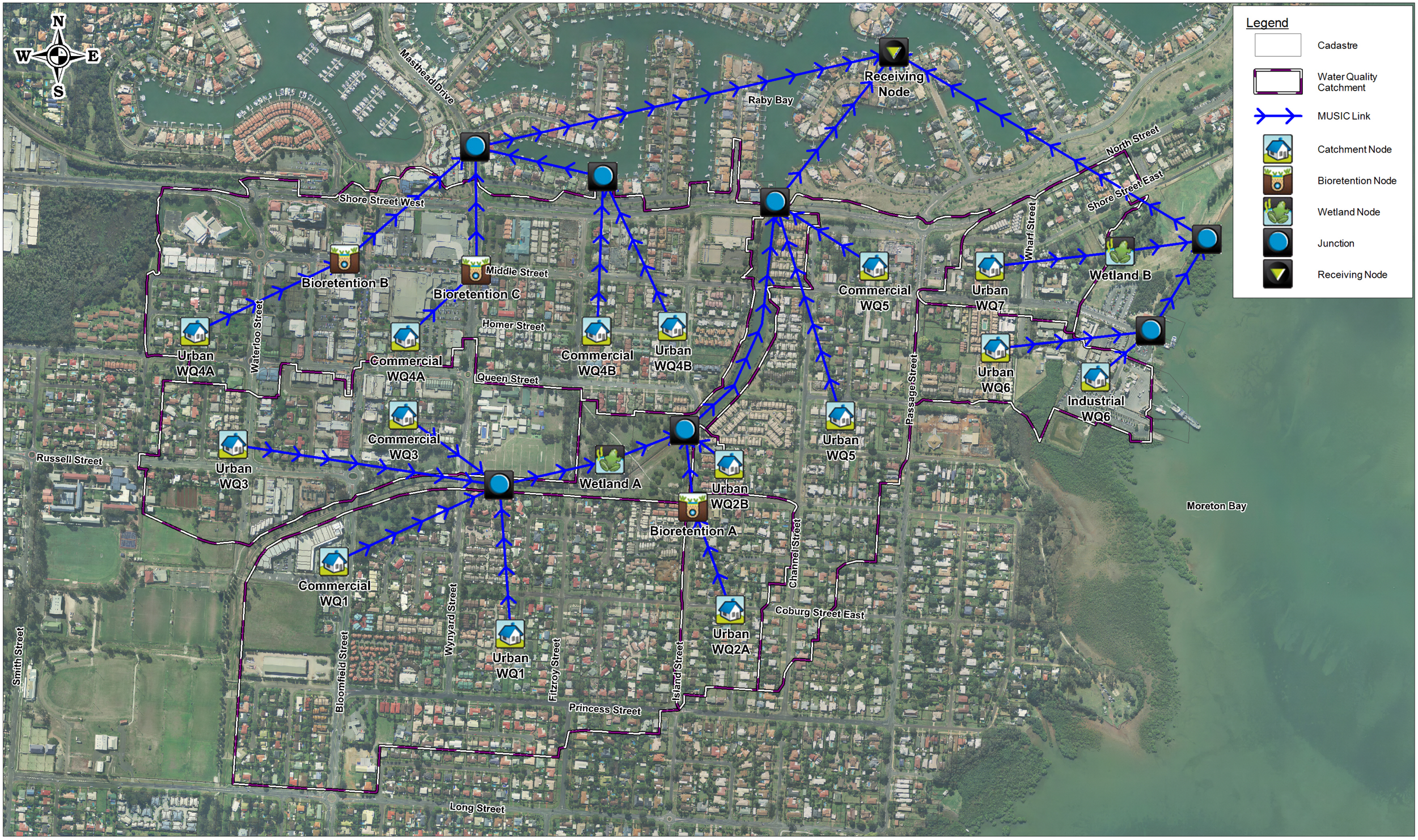
Stormwater Infrastructure Plan for Cleveland CBD Catchment

Water Quality Catchment Layout with Ultimate Landuse

Appendix B
Figure 1

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Stormwater Infrastructure Plan for Cleveland CBD Catchment

MUSIC Model Layout

Appendix B
Figure 2

Job Number: M8000_019
Revision: A
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Date: 4 Apr 2013

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APPENDIX C

Stormwater Quantity Capital Cost Estimates

Cleveland Stormwater Infrastructure Plan Costing Sheet

Description: Channel Street

Item	Description	Unit	Quantity	Rate	Amount
Preliminary Items					
1	Site Establishment and disestablishment	Each	1	$ 10,000.00	$ 10,000.00
2	Traffic Control (Minimum two people + truck)	Each	1	$ 20,000.00	$ 20,000.00
Pipe Construction					
3	1650 RCP including supply, transport, excavation, backfilling, compaction of trenches, disposal of spoil, sand bedding, laying and jointing and blanking off temporary ends	m	150	$ 450.00	$ 67,500.00
4	Stormwater manholes 2100 mm complete in place including excavations, weepholes, step irons, frames, covers, gates and concrete benching	No.	2	$ 4,500.00	$ 9,000.00
5	Supply and installation of headwall including scour protection	Each	1	$ 6,000.00	$ 6,000.00
6	Pavement cutting and disposal	m^2	40	$ 50.00	$ 2,000.00
7	Road pavement including, laying sub-base, base coarse, compaction plus AC supply and lay	m^2	40	$ 110.00	$ 4,400.00
8	Seeding and watering of disturbed areas	m^2	260	$ 0.60	$ 156.00
Miscellaneous					
Sub-Total					$ 119,056.00
Project On costs					
Construction Supervision		%	1	4	$ 4,762.24
Portable Long Service Levy		%	1	0.525	$ 625.04
Contingency		%	1	20	$ 23,811.20
Total					**$ 148,254.48**

Notes:
Total price based on the assumption that earthworks will go to spoil, material may be required for subdivision works in Bassett Lane.

Cleveland Stormwater Infrastructure Plan Costing Sheet

Description: Ross Court

Item	Description	Unit	Quantity	Rate	Amount
Preliminary Items					
1	Site Establishment and disestablishment	Each	1	$ 10,000.00	$ 10,000.00
Pipe Construction					
3	525 RCP including supply, transport, excavation, backfilling, compaction of trenches, disposal of spoil, sand bedding, laying and jointing and blanking off temporary ends	m	100	$ 170.00	$ 17,000.00
4	Stormwater manholes 1050 mm complete in place including excavations, weepholes, step irons, frames, covers, gates and concrete benching	No.	1	$ 2,520.00	$ 2,520.00
5	Supply and installation of headwall including scour protection	Each	1	$ 4,000.00	$ 4,000.00
6	Seeding and watering of disturbed areas	m^2	200	$ 0.60	$ 120.00
Miscellaneous					
Sub-Total					$ 33,640.00
Project On costs					
Construction Supervision		%	1	4	$ 1,345.60
Portable Long Service Levy		%	1	0.525	$ -
Contingency		%	1	20	$ 6,728.00
Total					**$ 41,713.60**

Notes:
Total price based on the assumption that earthworks will go to spoil, material may be required for subdivision works in Bassett Lane.

Cleveland Stormwater Infrastructure Plan Costing Sheet

Description: Russell Street and Lexlen Court

Item	Description	Unit	Quantity	Rate	Amount
Preliminary Items					
1	Site Establishment and disestablishment	Each	1	$ 10,000.00	$ 10,000.00
2	Traffic Control (Minimum two people + truck)	Each	1	$ 20,000.00	$ 20,000.00
Pipe Construction					
3	800 RCP including supply, transport, excavation, backfilling, compaction of trenches, disposal of spoil, sand bedding, laying and jointing and blanking off temporary ends	m	170	$ 270.00	$ 45,900.00
4	Pavement cutting and disposal	m^2	240	$ 50.00	$ 12,000.00
5	Road pavement including base coarse and AC supply, surfacing, laying and compacting	m^2	240	$ 110.00	$ 26,400.00
6	Seeding and watering of disturbed areas	m^2	100	$ 0.60	$ 60.00
Miscellaneous					
Sub-Total					$ 114,360.00
Project On costs					
Construction Supervision		%	1	4	$ 4,574.40
Portable Long Service Levy		%	1	0.525	$ 600.39
Contingency		%	1	20	$ 22,872.00
Total					**$ 142,406.79**

Notes:
Total price based on the assumption that earthworks will go to spoil, material may be required for subdivision works in Bassett Lane.

Cleveland Stormwater Infrastructure Plan Costing Sheet

Description: Waterloo Street

Item	Description	Unit	Quantity	Rate	Amount
Preliminary Items					
1	Site Establishment and disestablishment	Each	1	$ 10,000.00	$ 10,000.00
Pipe Construction					
2	750 RCP including supply, transport, excavation, backfilling, compaction of trenches, disposal of spoil, sand bedding, laying and jointing and blanking off temporary ends	m	35	$ 250.00	$ 8,750.00
3	Pavement cutting and disposal	m^2	10	$ 50.00	$ 500.00
4	Road pavement including base coarse and AC supply, surfacing, laying and compacting	m^2	10	$ 110.00	$ 1,100.00
5	Seeding and watering of disturbed areas	m^2	60	$ 0.60	$ 36.00
Miscellaneous					
Sub-Total					$ 20,386.00
Project On costs					
Construction Supervision		%	1	4	$ 815.44
Portable Long Service Levy		%	1	0.525	$ -
Contingency		%	1	20	$ 4,077.20
Total					**$ 25,278.64**

Notes:
Total price based on the assumption that earthworks will go to spoil, material may be required for subdivision works in Bassett Lane.

Cleveland Stormwater Infrastructure Plan Costing Sheet

Description: Russell Street (east)

Item	Description	Unit	Quantity	Rate	Amount
Preliminary Items					
1	Site Establishment and disestablishment	Each	1	$ 10,000.00	$ 10,000.00
2	Traffic Control (Minimum two people + truck)	Each	1	$ 20,000.00	$ 20,000.00
Pipe Construction					
3	900 RCP including supply, transport, excavation, backfilling, compaction of trenches, disposal of spoil, sand bedding, laying and jointing and blanking off temporary ends	m	90	$ 300.00	$ 27,000.00
4	Pavement cutting and disposal	m^2	180	$ 50.00	$ 9,000.00
5	Road pavement including base coarse and AC supply, surfacing, laying and compacting	m^2	180	$ 110.00	$ 19,800.00
Miscellaneous					
Sub-Total					$ 85,800.00
Project On costs					
Construction Supervision		%	1	4	$ 3,432.00
Portable Long Service Levy		%	1	0.525	$ 450.45
Contingency		%	1	20	$ 17,160.00
Total					**$ 106,842.45**

Notes:
Total price based on the assumption that earthworks will go to spoil, material may be required for subdivision works in Bassett Lane.

Cleveland Stormwater Infrastructure Plan Costing Sheet

Description: Middle Street (Police Station)

Item	Description	Unit	Quantity	Rate	Amount
Preliminary Items					
1	Site Establishment and disestablishment	Each	1	$ 10,000.00	$ 10,000.00
Pipe Construction					
2	600 RCP including supply, transport, excavation, backfilling, compaction of trenches, disposal of spoil, sand bedding, laying and jointing and blanking off temporary ends	m	95	$ 195.00	$ 18,525.00
3	Stormwater manholes 1050 mm complete in place including excavations, weepholes, step irons, frames, covers, gates and concrete benching	No.	2	$ 2,520.00	$ 5,040.00
4	Supply and installation of headwall including scour protection	Each	1	$ 4,000.00	$ 4,000.00
5	Pavement cutting and disposal	m^2	40	$ 50.00	$ 2,000.00
6	Road pavement including base coarse and AC supply, surfacing, laying and compacting	m^2	40	$ 110.00	$ 4,400.00
7	Seeding and watering of disturbed areas	m^2	150	$ 0.60	$ 90.00
Miscellaneous					
Sub-Total					$ 44,055.00
Project On costs					
Construction Supervision		%	1	4	$ 1,762.20
Portable Long Service Levy		%	1	0.525	$ -
Contingency		%	1	20	$ 8,811.00
Total					**$ 54,628.20**

Notes:
Total price based on the assumption that earthworks will go to spoil, material may be required for subdivision works in Bassett Lane.

Cleveland Stormwater Infrastructure Plan Costing Sheet

Description: Yarrow Court

Item	Description	Unit	Quantity	Rate	Amount
Preliminary Items					
1	Site Establishment and disestablishment	Each	1	$ 10,000.00	$ 10,000.00
2	Traffic Control (Minimum two people + truck)	Each	1	$ 20,000.00	$ 20,000.00
Pipe Construction					
3	450 RCP including supply, transport, excavation, backfilling, compaction of trenches, disposal of spoil, sand bedding, laying and jointing and blanking off temporary ends	m	75	$ 150.00	$ 11,250.00
4	Stormwater manholes 1050 mm complete in place including excavations, weepholes, step irons, frames, covers, gates and concrete benching	No.	1	$ 2,520.00	$ 2,520.00
5	Pavement cutting and disposal	m^2	150	$ 50.00	$ 7,500.00
6	Road pavement including base coarse and AC supply, surfacing, laying and compacting	m^2	150	$ 110.00	$ 16,500.00
Miscellaneous					
Sub-Total					$ 67,770.00
Project On costs					
Construction Supervision		%	1	4	$ 2,710.80
Portable Long Service Levy		%	1	0.525	$ -
Contingency		%	1	20	$ 13,554.00
Total					**$ 84,034.80**

Notes:
Total price based on the assumption that earthworks will go to spoil, material may be required for subdivision works in Bassett Lane.

Cleveland Stormwater Infrastructure Plan Costing Sheet

Description: Shore Street East

Item	Description	Unit	Quantity	Rate	Amount
Preliminary Items					
1	Site Establishment and disestablishment	Each	1	$ 10,000.00	$ 10,000.00
2	Traffic Control (Minimum two people + truck)	Each	1	$ 20,000.00	$ 20,000.00
Drainage Works					
3	Excavations and drainage improvement downstream of outlet	Each	1	$ 15,000.00	$ 15,000.00
4	Pavement cutting and disposal	m^2	110	$ 50.00	$ 5,500.00
5	Concrete kerb and channel complete in place including transitions	m	110	$ 45.00	$ 4,950.00
Miscellaneous					
Sub-Total					$ 55,450.00
Project On costs					
Construction Supervision		%	1	4	$ 2,218.00
Portable Long Service Levy		%	1	0.525	$ -
Contingency		%	1	20	$ 11,090.00
Total					**$ 68,758.00**

Notes:
Total price based on the assumption that earthworks will go to spoil, material may be required for subdivision works in Bassett Lane.

Cleveland Stormwater Infrastructure Plan Costing Sheet

Description: Shore Street West

Item	Description	Unit	Quantity	Rate	Amount
Preliminary Items					
1	Site Establishment and disestablishment	Each	1	$ 10,000.00	$ 10,000.00
2	Traffic Control (Minimum two people + truck)	Each	1	$ 20,000.00	$ 20,000.00
Pipe Construction					
3	450 RCP including supply, transport, excavation, backfilling, compaction of trenches, disposal of spoil, sand bedding, laying and jointing and blanking off temporary ends	m	175	$ 150.00	$ 26,250.00
4	Stormwater manholes 1500 mm complete in place including excavations, weepholes, step irons, frames, covers, gates and concrete benching	No.	2	$ 3,600.00	$ 7,200.00
5	Pavement cutting and disposal	m^2	144	$ 50.00	$ 7,200.00
6	Road pavement including base coarse and AC supply, surfacing, laying and compacting	m^2	144	$ 110.00	$ 15,840.00
7	Seeding and watering of disturbed areas	m^2	216	$ 0.60	$ 129.60
Miscellaneous					
Sub-Total					$ 86,619.60
Project On costs					
Construction Supervision		%	1	4	$ 3,464.78
Portable Long Service Levy		%	1	0.525	$ 454.75
Contingency		%	1	20	$ 17,323.92
Total					**$ 107,863.06**

Notes:
Total price based on the assumption that earthworks will go to spoil, material may be required for subdivision works in Bassett Lane.

Cleveland Stormwater Infrastructure Plan Costing Sheet

Description: Middle Street (Wharf Street Section)

Item	Description	Unit	Quantity	Rate	Amount
Preliminary Items					
1	Site Establishment and disestablishment	Each	1	$ 10,000.00	$ 10,000.00
2	Traffic Control (Minimum two people + truck)	Each	1	$ 20,000.00	$ 20,000.00
Pipe Construction					
3	750 RCP including supply, transport, excavation, backfilling, compaction of trenches, disposal of spoil, sand bedding, laying and jointing and blanking off temporary ends	m	140	$ 250.00	$ 35,000.00
4	Stormwater manholes 1050 mm complete in place including excavations, weepholes, step irons, frames, covers, gates and concrete benching	No.	3	$ 2,520.00	$ 7,560.00
5	Pavement cutting and disposal	m^2	220	$ 50.00	$ 11,000.00
6	Road pavement including base coarse and AC supply, surfacing, laying and compacting	m^2	220	$ 110.00	$ 24,200.00
7	Seeding and watering of disturbed areas	m^2	60	$ 0.60	$ 36.00
Miscellaneous					
Sub-Total					$ 107,796.00
Project On costs					
Construction Supervision		%	1	4	$ 4,311.84
Portable Long Service Levy		%	1	0.525	$ 565.93
Contingency		%	1	20	$ 21,559.20
Total					**$ 134,232.97**

Notes:
Total price based on the assumption that earthworks will go to spoil, material may be required for subdivision works in Bassett Lane.

Cleveland Stormwater Infrastructure Plan Costing Sheet

Description: Fitzroy Street

Item	Description	Unit	Quantity	Rate	Amount
Preliminary Items					
1	Site Establishment and disestablishment	Each	1	$ 10,000.00	$ 10,000.00
2	Traffic Control (Minimum two people + truck)	Each	1	$ 20,000.00	$ 20,000.00
Pipe Construction					
3	525 RCP including supply, transport, excavation, backfilling, compaction of trenches, disposal of spoil, sand bedding, laying and jointing and blanking off temporary ends	m	200	$ 170.00	$ 34,000.00
4	Stormwater manholes 1050 mm complete in place including excavations, weepholes, step irons, frames, covers, gates and concrete benching	No.	4	$ 2,520.00	$ 10,080.00
5	Supply and installation of headwall including scour protection	Each	1	$ 4,000.00	$ 4,000.00
6	Pavement cutting and disposal	m^2	300	$ 50.00	$ 15,000.00
7	Road pavement including base coarse and AC supply, surfacing, laying and compacting	m^2	300	$ 110.00	$ 33,000.00
8	Seeding and watering of disturbed areas	m^2	100	$ 0.60	$ 60.00
Miscellaneous					
Sub-Total					$ 126,140.00
Project On costs					
Construction Supervision		%	1	4	$ 5,045.60
Portable Long Service Levy		%	1	0.525	$ 662.24
Contingency		%	1	20	$ 25,228.00
Total					**$ 157,075.84**

Notes:
Total price based on the assumption that earthworks will go to spoil, material may be required for subdivision works in Bassett Lane.

APPENDIX D

MUSIC Model Screenshots

Bioretention_A - Life Cycle Cost Results

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

Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$5,360	Real Discount Rate (%)	5.50
Acquisition Cost	$176,849	Renewal Period (yrs)	1	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$14,904	Decommissioning Cost	$82,490	Base Year for Costing	2013
Annual Establishment Cost	$0	Establishment Period (yrs)	0		

Costing Results



Life Cycle Cost of Bioretention_A ($2013)	$524,149
Equivalent Annual Payment Cost of the Asset ($2013/annum)	$10,483
Equivalent Annual Payment per m3/s maximum flow reduction	$24,640.63
Equivalent Annual Payment/ML flow reduction/annum	$6,212.48
Equivalent Annual Payment/kg Total Suspended Solids/annum	$0.84
Equivalent Annual Payment/kg Total Phosphorus/annum	$603.31
Equivalent Annual Payment/kg Total Nitrogen/annum	$150.18
Equivalent Annual Payment/kg Gross Pollutant/annum	$6.00

Close

Bioretention_B - Life Cycle Cost Results

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

Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$60,168	Real Discount Rate (%)	5.50
Acquisition Cost	$132,349	Renewal Period (yrs)	15	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$12,808	Decommissioning Cost	$61,734	Base Year for Costing	2013
Annual Establishment Cost	$0	Establishment Period (yrs)	0		

Costing Results



Life Cycle Cost of Bioretention_B ($2013)	$397,238
Equivalent Annual Payment Cost of the Asset ($2013/annum)	$7,945
Equivalent Annual Payment per m3/s maximum flow reduction	$45,844.20
Equivalent Annual Payment/ML flow reduction/annum	$6,657.28
Equivalent Annual Payment/kg Total Suspended Solids/annum	$0.97
Equivalent Annual Payment/kg Total Phosphorus/annum	$696.33
Equivalent Annual Payment/kg Total Nitrogen/annum	$166.13
Equivalent Annual Payment/kg Gross Pollutant/annum	$6.73

Close

Bioretention_C - Life Cycle Cost Results

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

Costing Inputs

Life Cycle (yrs)	50	Renewal/Adaptation Cost	$35,483	Real Discount Rate (%)	5.50
Acquisition Cost	$78,051	Renewal Period (yrs)	15	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$9,905	Decommissioning Cost	$36,406	Base Year for Costing	2013
Annual Establishment Cost	$0	Establishment Period (yrs)	0		

Costing Results



Life Cycle Cost of Bioretention_C ($2013)	$273,912
Equivalent Annual Payment Cost of the Asset ($2013/annum)	$5,478
Equivalent Annual Payment per m3/s maximum flow reduction	invalid
Equivalent Annual Payment/ML flow reduction/annum	$10,755.72
Equivalent Annual Payment/kg Total Suspended Solids/annum	$1.44
Equivalent Annual Payment/kg Total Phosphorus/annum	$728.21
Equivalent Annual Payment/kg Total Nitrogen/annum	$156.22
Equivalent Annual Payment/kg Gross Pollutant/annum	$10.40

Close

Wetland_A - Life Cycle Cost Results

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

Costing Inputs

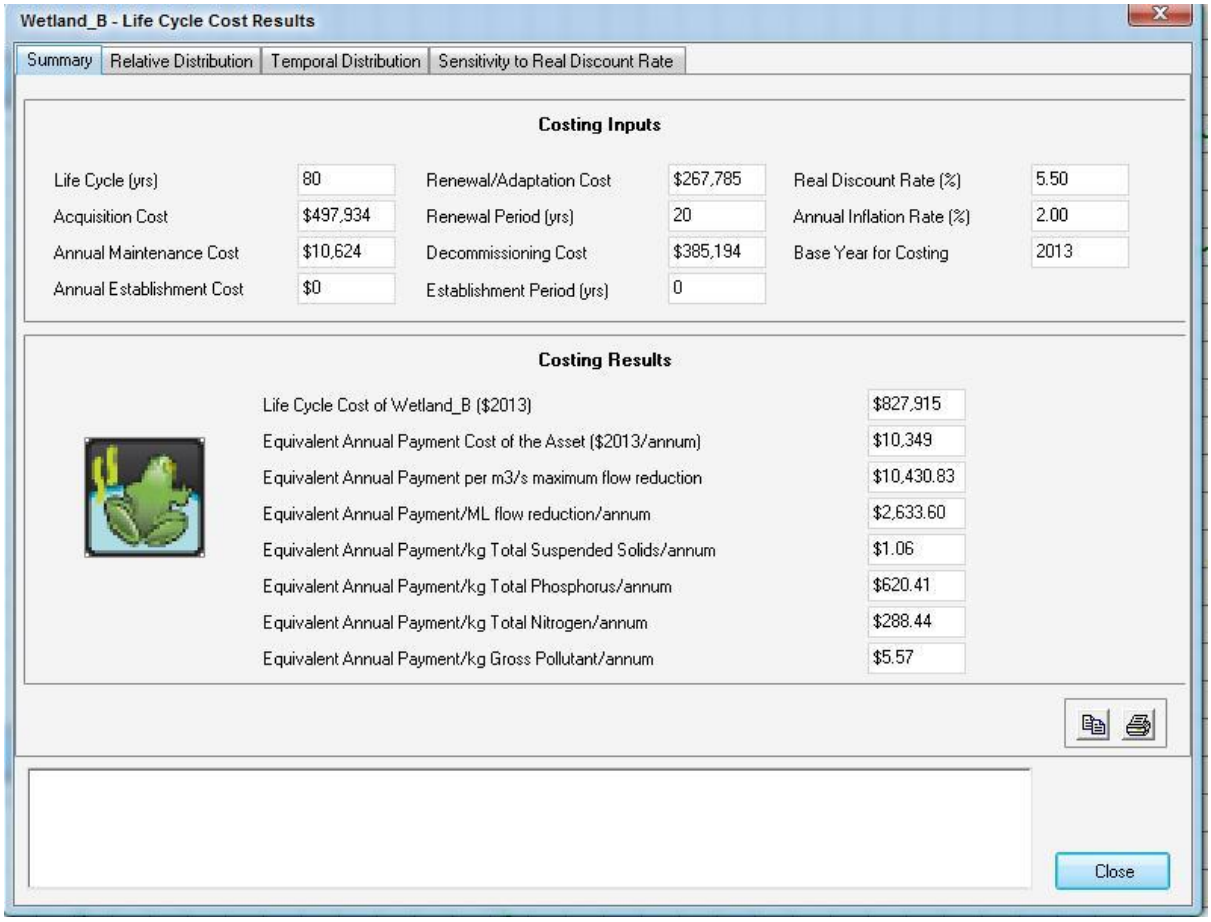
Life Cycle (yrs)	50	Renewal/Adaptation Cost	$860,605	Real Discount Rate (%)	5.50
Acquisition Cost	$1,600,257	Renewal Period (yrs)	20	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$54,567	Decommissioning Cost	$1,237,933	Base Year for Costing	2013
Annual Establishment Cost	$0	Establishment Period (yrs)	0		

Costing Results



Life Cycle Cost of Wetland_A ($2013)	$3,006,268
Equivalent Annual Payment Cost of the Asset ($2013/annum)	$60,125
Equivalent Annual Payment per m3/s maximum flow reduction	$3,434.60
Equivalent Annual Payment/ML flow reduction/annum	$2,358.73
Equivalent Annual Payment/kg Total Suspended Solids/annum	$0.79
Equivalent Annual Payment/kg Total Phosphorus/annum	$437.35
Equivalent Annual Payment/kg Total Nitrogen/annum	$186.82
Equivalent Annual Payment/kg Gross Pollutant/annum	$3.78

Close


Wetland_B - Life Cycle Cost Results
Summary
Relative Distribution
Temporal Distribution
Sensitivity to Real Discount Rate
Costing Inputs
Life Cycle (yrs) 80
Acquisition Cost $497,934
Annual Maintenance Cost $10,624
Annual Establishment Cost $0
Renewal/Adaptation Cost $267,785
Renewal Period (yrs) 20
Decommissioning Cost $385,194
Establishment Period (yrs) 0
Real Discount Rate (%) 5.50
Annual Inflation Rate (%) 2.00
Base Year for Costing 2013
Costing Results
Life Cycle Cost of Wetland_B ($2013) $827,915
Equivalent Annual Payment Cost of the Asset ($2013/annum) $10,349
Equivalent Annual Payment per m3/s maximum flow reduction $10,430.83
Equivalent Annual Payment/ML flow reduction/annum $2,633.60
Equivalent Annual Payment/kg Total Suspended Solids/annum $1.06
Equivalent Annual Payment/kg Total Phosphorus/annum $620.41
Equivalent Annual Payment/kg Total Nitrogen/annum $288.44
Equivalent Annual Payment/kg Gross Pollutant/annum $5.57
Close