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Caboolture West Total Water Cycle Management Implementation Plan

Moreton Bay Regional Council

Caboolture West Total Water Cycle Management Plan

Prepared for:	Moreton Bay Regional Council
Prepared by:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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BMT WBM Pty Ltd Level 8, 200 Creek Street Brisbane 4000 Queensland Australia PO Box 203 Spring Hill 4004 Tel: +61 7 3831 6744 Fax: + 61 7 3832 3627 ABN 54 010 830 421 www.bmtwbm.com.au	**Document:**	R.B20132.005.03.docx
	Title:	Caboolture West Total Water Cycle Management Plan
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	Client:	Moreton Bay Regional Council
	Client Contact:	Andrew Vanderent
	Client Reference:	
Synopsis:	This document presents the results of investigations undertaken to develop a Total Water Cycle Management Plan for the Caboolture West Master Planned Area (CWMPA). The results will be used to assist Moreton Bay Regional Council with the finalisation of the Structure Plan for the CWMPA.	

REVISION/CHECKING HISTORY

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3	24/01/2014	Brad Dalrymple		Lucy Peljo	Lucy Peljo

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Executive Summary

Executive Summary

Introduction

Moreton Bay Regional Council (MBRC) is currently in the process of developing their planning scheme. The new planning scheme will replace the three existing planning schemes created by the former Caboolture, Pine Rivers and Redcliffe councils. As part of the new planning scheme, MBRC are working towards the preparation of a Structure Plan (broad land use plan and infrastructure strategy) for the Caboolture West Master Planned Area (CWMPA), which can then be incorporated in the new MBRC Planning Scheme.

To assist with the finalisation of the Structure Plan for CWMPA, BMT WBM was engaged by MBRC to amend the Total Water Cycle Management Plan (TWCMP) for the Caboolture Identified Growth Area (CIGA) (BMT WBM, 2012) to align with the final land use plan using the following management options:

The objective of this TWCMP is to provide an assessment of potential management options, and describe the recommended strategy for the CWMPA, including a conceptual layout plan and cost estimates.

Management Options

A total of eight management options have been assessed as part of this report. These are:

- New development to satisfy best practice stormwater management targets;
- Stormwater harvesting;
- Sewer mining for public open space and/ or discharge to land;
- Recycled water usage;
- Prevention of illegal stormwater connections to sewer to reduce sewage overflows;
- Waterway riparian revegetation on waterways to Q100 boundaries;
- Increased implementation/ enforcement of erosion and sediment control on development sites; and
- Education and capacity building to support implementation of solutions.

As part of our assessment, we have provided a detailed description of each option, undertaken modelling to determine the pollutant load reduction and/ or potable water saved, and given advice in relation to whether the management option is recommended or otherwise. The results of this assessment are summarised in Table ES-1 and ES-2. The recommended management options for the CWMPA TWCMP are illustrated in Figure ES-1.

Table ES-1 Summary of Management Options Assessment

Management Option	Recommended ?	Net Present Value ($Million, 2013)	Reduction in Pollutant Loads (tonnes/year)			Levelised Cost ($/kg)		
			TSS	TP	TN	TSS	TP	TN
New Development to Satisfy Best Practice Stormwater Management Targets options:								
1. Bioretention without rainwater tanks	✓	155.1	3 305	4.1	20	2.0	1 621	321
2. Bioretention with rainwater tanks	X	133.5	3 289	4.2	21	2.0	1 609	316
3. Wetlands without rainwater tanks	X	543.2	3 175	4.8	21	8.6	5 650	1 270
4. Wetlands with rainwater tanks	X	483.1	3 124	4.9	22	7.7	4 940	1 080
Stormwater Harvesting	✓*	43.7	310	0.6	2.8	7.1	3 790	786
Sewer Mining for Public Open Space Irrigation &/ or discharge to land	X	-	-	-	-	-	-	-
Recycled Water Usage	Dependent on investigations by Seqwater	-	-	-	-	-	-	-
Prevention of Illegal Stormwater Connections to Sewer	✓	-	-	-	-	-	-	-
Waterway Riparian Revegetation	✓	20.4	1.9	-	-	0.53	-	-
Increased implementation/ enforcement of E&SC on development sites	✓	0.02	150	-	-	0.01	-	-
Education and Capacity Building to Support Implementation of Solutions	✓	-	-	-	-	-	-	-
Total of Recommended Solutions		**219.2**						

*Stormwater harvesting also provides an estimated 389 ML/year in potable water savings.

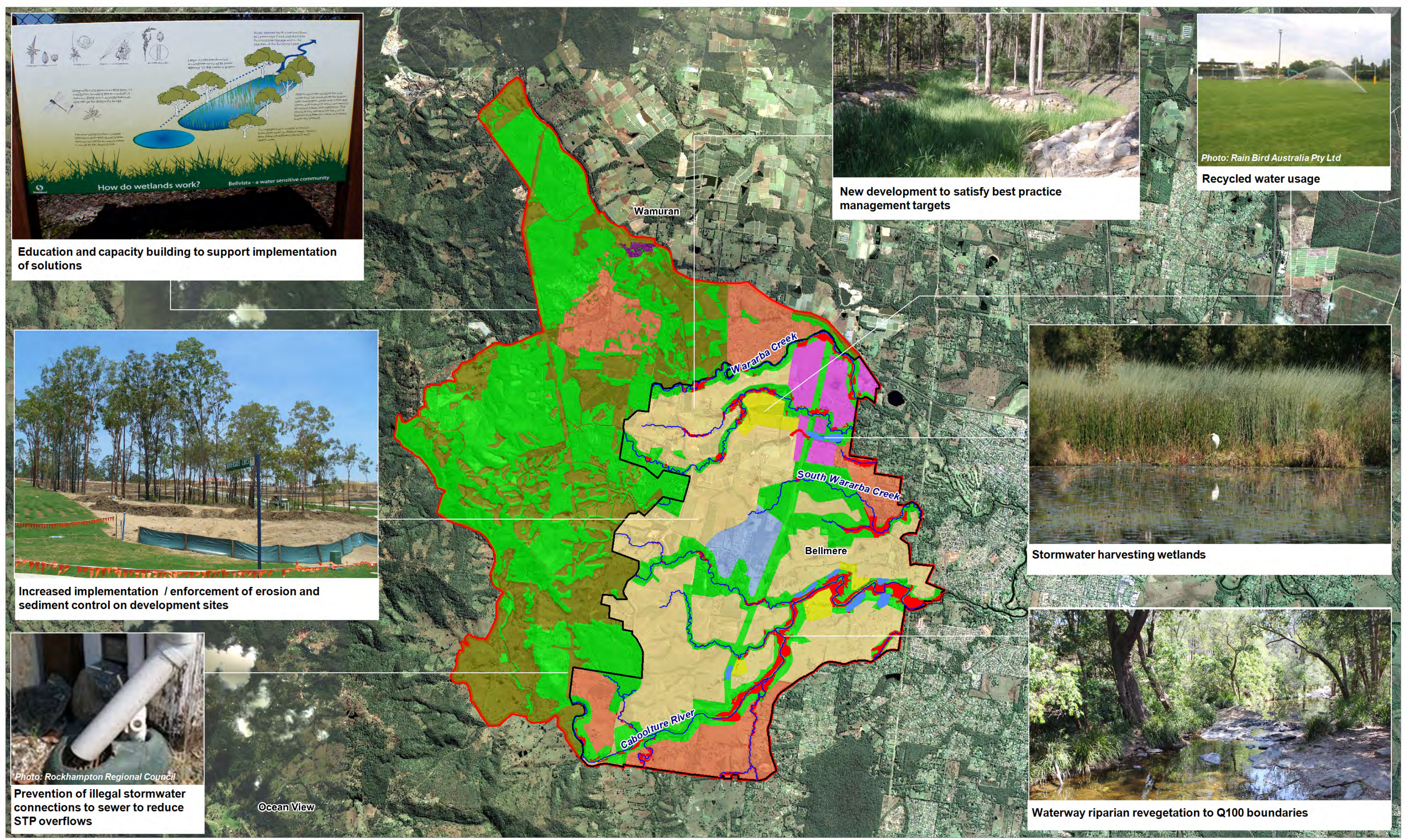
Table ES-2 Summary of Capital & Operational Costs of Management Options

Management Option	Recommended?	Capital Cost ($Million, 2013)	Annual Maintenance Cost ($Million, 2013)
New Development to Satisfy Best Practice Stormwater Management Targets options:			
1. Bioretention Systems without Rainwater Tanks	✓	140.2	2.3
2. Bioretention Systems with Rainwater Tanks		120.7**	2.0*
3. Wetlands without Rainwater Tanks		506.7	6.7
4. Wetlands with Rainwater Tanks		450.7**	5.9*
Stormwater Harvesting	✓	45.4	0.6
Sewer Mining for Public Open Space Irrigation and/ or discharge to land	×	-	-
Recycled Water usage	Dependent on investigations by Seqwater	-	-
Prevention of Illegal Stormwater Connections to Sewer	✓	-	-
Waterway Riparian Revegetation	✓	20.4	0
Increased implementation/ enforcement of E&SC on development sites	✓	-	0.02
Education and Capacity Building to Support Implementation of Solutions	✓	N/A	N/A
Total of Recommended Options		**149.1**	**2.5**

** This cost does not include the capital or operational costs associated with rainwater tanks.

Where to From Here?

This TWCMP has assessed a range of potential management options for the CWMPA. Based on this assessment, several of the management options have been recommended for implementation. The findings from this report will be presented to the Council and, if endorsed; the recommended management options will be considered in a revised version of MBRC's Total Water Cycle Management Implementation Plan.



LEGEND

- Master Plan Area
- Urban Development Area
- Potential Stormwater Harvesting Wetlands
- Revegetation
- Waterways

Future Land Use

- Agriculture
- Commercial
- Green Space
- Industrial
- Rural Residential
- Sports
- Township
- Urban

Aerial Imagery:
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Title:
Concept Plan of Recommended Strategy for the Caboolture West Master Planned Area

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Figure: **ES-1**

Rev: **A**

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1. Introduction

Moreton Bay
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1 Introduction

1.1 Background

Moreton Bay Regional Council (MBRC) completed a detailed Total Water Cycle Management (TWCM) Planning Study in 2012 (BMT WBM, 2012a) and a TWCM Implementation Plan in 2013 (BMT WBM, 2013), both for the Moreton Bay Region. The detailed planning study identified optimal catchment management solutions to address water cycle management issues based on environmental, economic and social considerations while the Implementation Plan was undertaken to clearly set out the strategies and actions required to achieve the vision for the water cycle.

During the planning study process, the need for a Sub-Regional (S-R) TWCMP for the Caboolture Identified Growth Area (CIGA) was identified and commissioned by the former Queensland Water Commission (QWC). In February 2012, the CIGA was gazetted as a master planned area under the *Sustainable Planning Act 2009* and is now referred to as the Caboolture West Master Planned Area (CWMPA). The Sub-regional Total Water Cycle Management Plan for the CIGA was completed in 2012 (BMT WBM, 2012b).

MBRC is currently in the process of developing their planning scheme. The new planning scheme will replace the three existing planning schemes created by the former Caboolture, Pine Rivers and Redcliffe councils. As part of the new planning scheme, MBRC are working towards the preparation of a Structure Plan (broad land use plan and infrastructure strategy) for the Caboolture West Master Planned Area (CWMPA) which can then be incorporated in the new MBRC Planning Scheme.

To assist with the finalisation of the Structure Plan for the CWMPA, BMT WBM was engaged by MBRC to amend the TWCMP for the Caboolture Identified Growth Area (CIGA) (BMT WBM, 2012b) to align with the final land use plan and with an amended set of management options.

1.2 Purpose of this Report

The objective of this TWCMP is to provide an assessment of potential management options, and outline the recommended strategy for the CWMPA, including a conceptual layout plan and the cost estimates associated with these management options.

A total of eight management options have been assessed as part of this report. These include:

1. New development to satisfy best practice stormwater management targets;
2. Stormwater harvesting;
3. Sewer mining for public open space irrigation and/ or discharge to land;
4. Recycled water usage;
5. Prevention of illegal stormwater connections to sewer to reduce sewage overflows;
6. Waterway riparian revegetation on waterways to Q100 boundaries;
7. Increased implementation/ enforcement of erosion and sediment control on development sites; and
8. Education and capacity building to support implementation of solutions.

As part of our assessment, we have provided a detailed description of each option, modelling to determine the pollutant load reduction and/ or potable water saved and advice in relation to whether the management option is recommended.

2. Legislation, Planning & Policy

Moreton Bay Regional Council

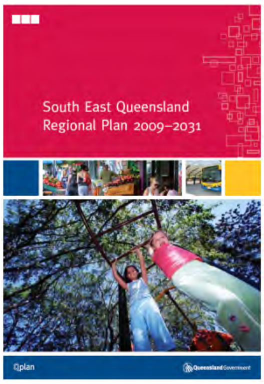
2 Legislation, Planning and Policy

The key legislation, planning and policy drivers which play a significant role in the development of a sub-regional (S-R) TWCMP within South East Queensland (SEQ) include the following:

- SEQ Regional Plan 2009-2031;
- SEQ Water Strategy;
- Water Resource Plans; and
- SEQ Regional Water Security Program.

These are briefly described in the following sections.

2.1 SEQ Regional Plan



The *SEQ Regional Plan* was developed by the former Department of Infrastructure Planning (now the Department of State Development, Infrastructure and Planning). The *SEQ Regional Plan* is the overarching planning document for the SEQ region. The purpose of the Plan is to manage regional growth and change in the most sustainable way to protect and enhance quality of life in the region.

The *SEQ Regional Plan* (in Part D, Section 11.1) identifies QWC as the lead agent for the development of S-R TWCPs. S-R TWCMPs must be consistent with the requirements set out in the Regional Plan.

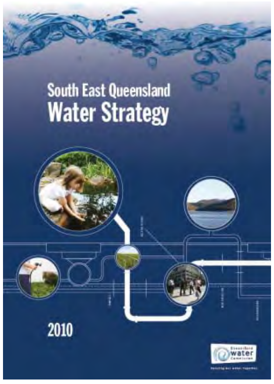
The *SEQ Regional Plan* (in Part D, Section 11.1) also describes the matters and key principles that are to be considered when a S-R TWCMP is being prepared. S-R plans are to integrate land use policy and decision with waterway health and water supply planning and will be the method used to identify where there are regionally significant issues that relate to bulk water supply and security in key development areas.

Key principles identified in the *SEQ Regional Plan* that S-R TWCMPs must consider include:

- **Natural cycles –** minimising the alteration to natural flow and water quality regimes.
- **Sustainable limits –** ensuring that the volume of water extracted from a source is sustainable for the community and the environment.
- **Water conservation –** minimising water use and losses by reducing demand and by maximising efficient use and reuse.
- **Diversity in new supplies –** considering all potential sources of water when new supplies are needed, including reusing water and stormwater.
- **Water quality –** managing the water cycle at all phases to preserve water quality for the community and the environment.
- **Water quality ‘fit for purpose’ –** aiming for water supply quality to be no better than is required for the proposed use, i.e. not supplying potable water for uses that do not require potable quality.

It should be noted that the current regional plan is under review with the new plan to be completed by the end of 2014.

2.2 SEQ Water Strategy

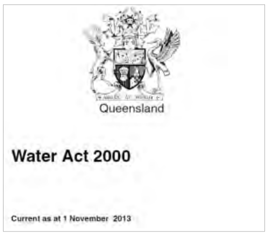


The *SEQ Water Strategy* was developed by the former Queensland Water Commission (now the Department of Energy and Water Supply). The *SEQ Water Strategy* sets out the means to ensure a secure water supply over the next 50 years and beyond, to support our lifestyles and provide for our water use needs as well as those of the environment. The Strategy includes level of service objectives that are to be met by a range of supply infrastructure, such as dams, desalination plants, purified recycled water plants and a grid linking them up, as well as an ongoing demand management program.

The *SEQ Water Strategy* provides important regional context on integrated water management, reliable water supply security and Level of Service objectives. The Strategy was developed as a comprehensive planning and implementation framework to secure water supplies for SEQ for the long term. S-R TWCMPs will have regard to, and be consistent with, the strategic direction and specific actions of the SEQ Water Strategy. The S-R TWCMPs may inform future revisions of the *SEQ Water Strategy* where the subregional plan identifies issues or potential new sources that had not previously been considered (DEWS, 2010).

It should be noted that it is planned for Seqwater to develop a new Water Security Program for SEQ, which will replace the existing strategy. It is expected that this program will be developed by mid-2015. The Water Security Program will outline the arrangements and measures in place to facilitate the desired level of service objectives for SEQ. It will include information about operating the bulk water supply system, potential future bulk water infrastructure needs and drought response.

2.3 Water Resource Plans



Water Resource planning is governed by the *Water Act 2000*. Water Resource Plans provide for the allocation and sustainable management of water to meet Queensland's future water requirements. The plans strive to achieve a sustainable balance between meeting human needs and those of the environment. S-R TWCMPs must be consistent with and have regard to relevant water resource plans (QWC, 2010).

2.4 SEQ Regional Water Security Program

The legislative and policy framework for water management in SEQ includes specifications for a number of required (and enforceable) programs and plans. The *SEQ Regional Water Security Program* is one of these. The *SEQ Regional Water Security Program* is made by the Minister for Energy and Water Supply. It specifies, at a high level, how regional water security is to be achieved. The *SEQ Regional Water Security Program* was adopted on 13 November 2006, providing for the construction of significant infrastructure.

Prior to inclusion into the Regional Water Security Program, significant water infrastructure projects are evaluated and scrutinised. Issues from the S-R TWCM planning process that are deemed of regional significance will be further investigated and evaluated by the Seqwater. As required, Seqwater provides advice to the Minister on regional water security options.

3. Site Description

3 Site Description

3.1 Location

The CWMPA extends over an area approximately of 6,663 hectares, and is located to the west of Caboolture. The location of the site is illustrated in Figure 3-1.

3.2 Site Drainage and Topography

Stormwater from the CWMPA generally flows to Wararba Creek (through the north of the site) and Caboolture River (extending through the south of the site). Wararba Creek subsequently discharges to the Caboolture River, and eventually into Deception Bay. Photos of both of these waterways within the CWMPA are provided in Figure 3-2.

Existing ground elevations with the site range from 25 m AHD (in the east) to approximately 275 m AHD (in the west)

The topography of the existing site is illustrated in Figure 3-3.

3.3 Existing Water-bodies

Many water-bodies are integrated throughout the existing site. The location of these water-bodies is illustrated in Figure 3-4. Figure 3-5 also provides photos of some of these water-bodies. It is anticipated that these water-bodies have been constructed for on-site water supply (e.g. irrigation) purposes. As for the examples provided in Figure 3-5, these water-bodies are typically open water, fringed with aquatic and semi-aquatic plant species – and generally appear to be in very good condition.

3.4 Water Quality

The Caboolture catchment (freshwater) received an EHMP score of C+ in 2012 and B in 2013 (refer to Figure 3-6), while Caboolture estuary received a score of C- in 2012 and D+ in 2013 (refer to Figure 3-7). This indicates an improvement in water quality and macroinvertebrate indicators in the freshwater areas and a decline in water quality in the estuarine areas of the Caboolture catchment over the last 12 months.

3.5 Environmentally Sensitive Areas

A number of areas have been identified within MBRC which are environmentally sensitive and require protection from adverse environmental stressors. These areas are important environmental assets, on both a local and regional scale. The location of these areas within the Caboolture River catchment is illustrated in Figure 3-8.

3.6 Flooding

A flood model of the Caboolture River was developed as part of Stage 2 of the *Regional Floodplain Database* (BMT WBM, 2012c). More recently the model has been upgraded to include additional developments that have occurred in the catchment and additional structure details (BMT WBM, 2012d).

The 1% Annual Exceedance Probability (AEP) flood extent from the recent modelling is illustrated in Figure 3-9.

3.7 Potable Water Supply

Potable water for the Caboolture catchment is currently sourced from the reticulated water network, with supply from the Northern Pipeline Interconnector (NPI) and North Pine Dam.

The Caboolture catchment has previously sourced a significant portion of its drinking water from the Caboolture Water Treatment Plant (with water sourced from the Caboolture River, downstream of the CWMPA). However, it is understood that this treatment plant has not been operational for an extended period (James Moffat, Seqwater, *Pers.Comm.*: 29 October 2013)

Seqwater is currently undertaking long-term planning of the bulk water supply network through their Water Security Program. Whilst this is still to be finalised, initial indications are that the Caboolture Water Treatment Plant is likely to be permanently decommissioned and to remain so for the foreseeable future (James Moffat, Seqwater, *Pers.Comm.*: 29 October 2013).

3.8 Wastewater

Wastewater within the sewered portions of the Caboolture catchment is currently treated at the Caboolture South sewage treatment plant (STP), which discharges into the Caboolture River upper estuary 19km upstream from the mouth of the river, or 19km AMTD (Adopted Middle Thread Distance). Treated wastewater from the Burpengary East STP (from the adjoining Burpengary Creek catchment) is also discharged into the Caboolture River lower estuary at 1.2 km AMTD.

The CWMPA is currently unsewered with existing areas utilising lot-scale wastewater treatment system.

3.9 Existing Land Use

The existing land use in the CWMPA consists predominantly of agricultural and green space (or forest), with a small area of rural residential land use and the township of Wamuran in the north west.

The existing CWMPA has a population of 3,500 of which an estimated 780 live within the area being considered for urban development.

Example photos of the existing site are also provided in Figure 3-10, and the existing land use within the CWMP is illustrated in Figure 3-11. A pie-chart of the land use types within the catchment is also shown in Figure 3-13.

Existing Agricultural Areas

It should be noted that although a large proportion of the existing land use has been classified as 'agricultural', it is understood that 25% of the area is used for cropping, 32% for 'grazing' activity on native grasses and as a low cost form of land management, and a large proportion of the 'agricultural' land is not actively used for agricultural purposes but for rural lifestyle lots, and native forest. MBRC's reports *Agricultural Land and Production* (MBRC, 2013a) and *Existing Conditions Report* (MBRC, 2013b) for the CWMPA provide a summary of activities within the CWMPA (Peter Rawlinson, MBRC, *Pers. Comm.*: 22 October 2013).

3.10 Proposed Development

Approximately 3,200 hectares of the CWMPA is proposed for development, including a combination of urban and rural residential, commercial and industry/ employment areas. The remainder of the study area (approximately 3,480 hectares) will retain the existing land use rights and is not planned to be included in the urban area.

The population with the CWMPA is expected to increase to approximately 68,760 by 2056.

The proposed land use within the CWMPA is illustrated in Figure 3-12. A pie-chart of the proposed land use types within the CWMPA is shown in Figure 3-14.

3.11 Water Cycle Accounts

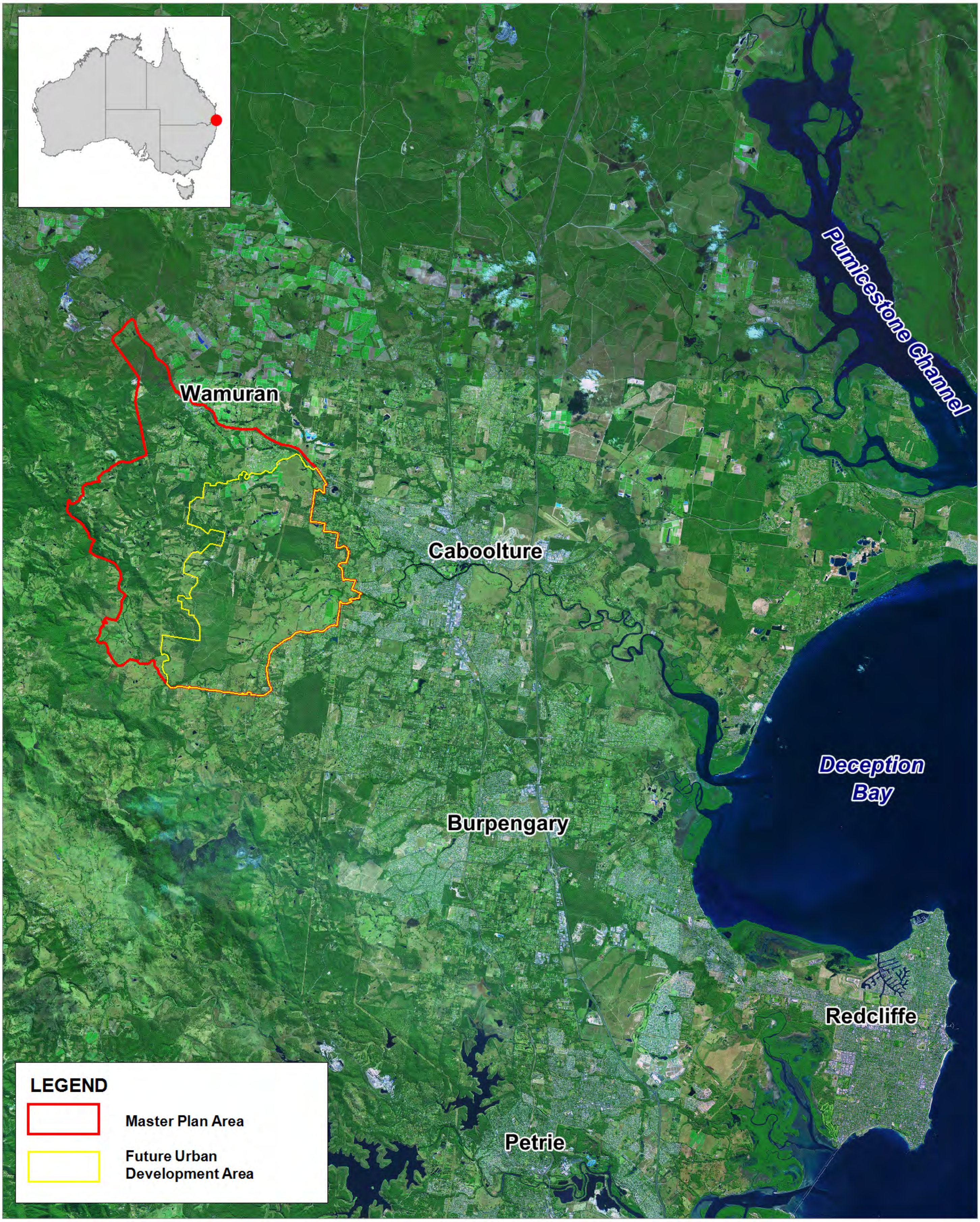
Water cycle accounts have been developed for the CWMPA (as part of this report). These water accounts attempt to quantify, as much as practical, the inputs and outputs of the water cycle, and to identify where water related issues (e.g. water shortages and water quality impacts) may exist currently and in the future in comparison to 'pre-European' conditions. These water cycle accounts (and the methodology applied in their preparation) are provided in Appendix B.

The water cycle accounts illustrate the increase in both stormwater runoff and pollutant loads from the pre-European scenario to the existing conditions. A summary of the sustainable loads for TSS, TP and TN are outlined in Table 3-1.

Table 3-1 Flow & Pollutant Loads and Flows from Pre-European, Current and Future Conditions

Parameter	Pre-European (Sustainable Loads)	Current Condition	Future (2056) Condition
TSS (tonnes/year)	1,177	6,886	6,343
TP (tonnes/year)	1.2	7.1	9.4
TN (tonnes/year)	14	48	62
Flows (GL/year)	14	22	30

With the land use changing from agricultural to urban within the CWMPA in the future, the water accounts show that the sustainable load targets would greatly be exceeded in 2056 for all parameters if no management measures were implemented.



Title:
Location of Caboolture West Master Planned Area

Figure: 3-1

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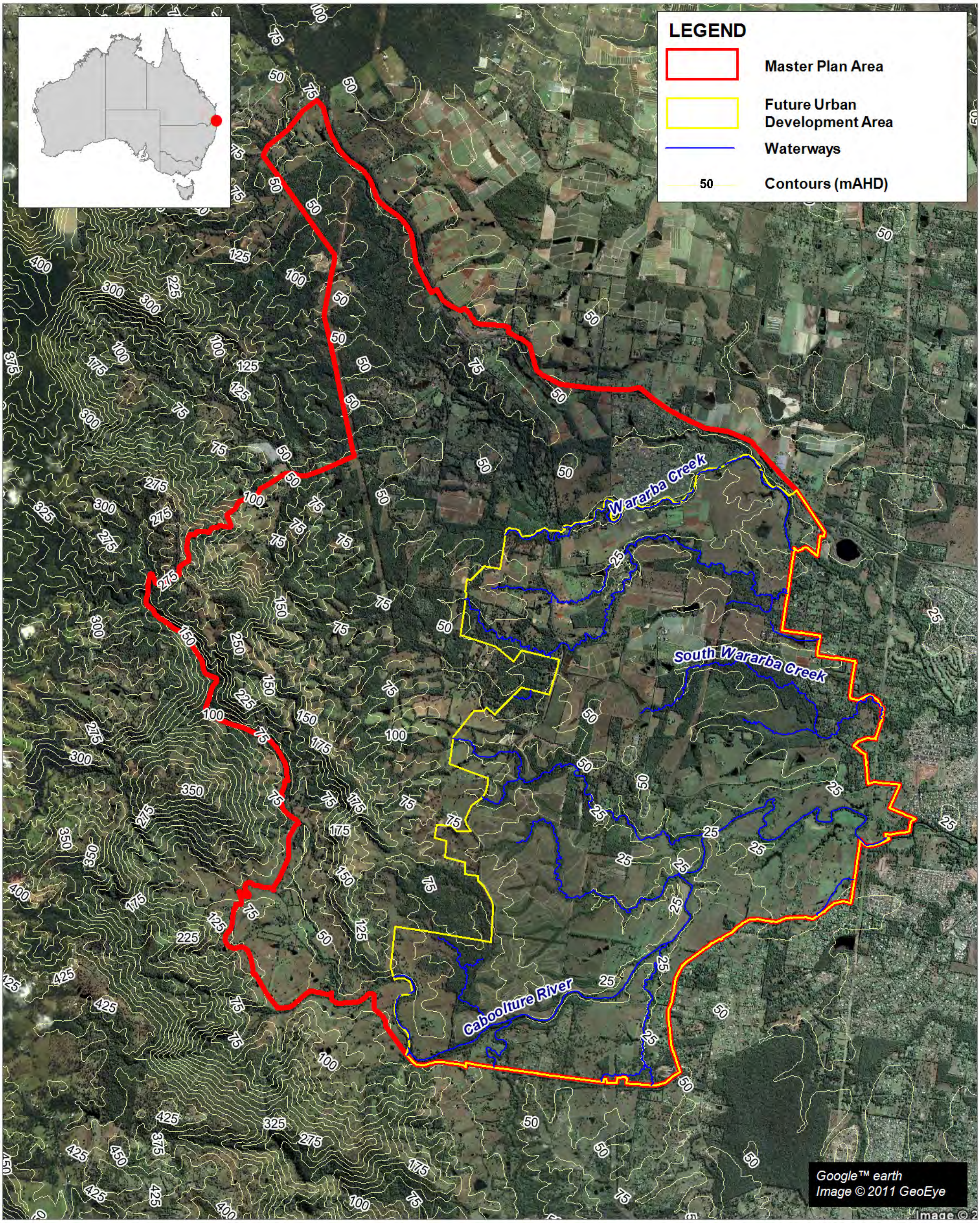
Figure 3-2 Photos of Waterways within the CWMPA



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Existing Topography

Figure: **3-3**

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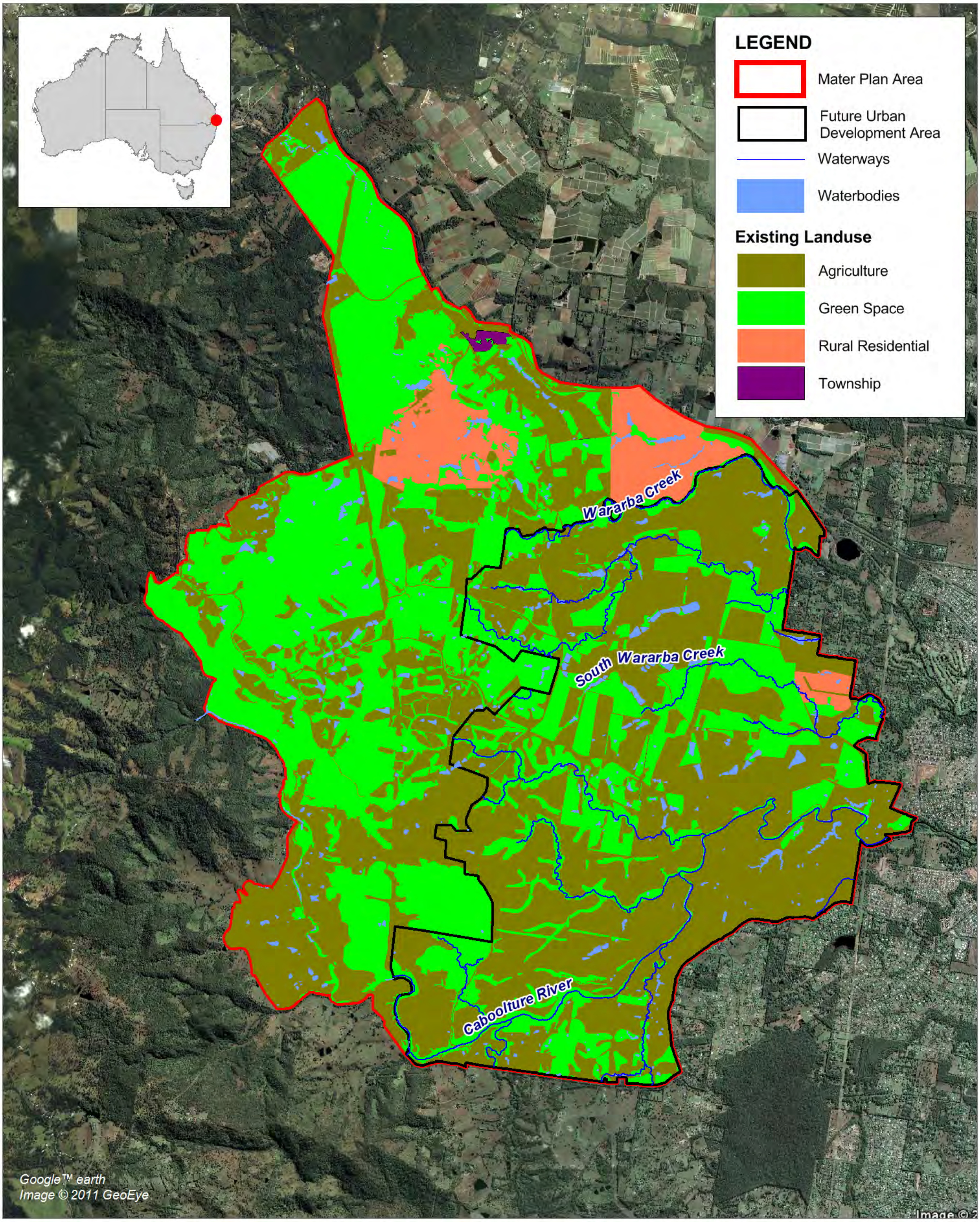

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Location of Existing Water-Bodies in the Caboolture West Master Planned Area

Figure: **3-4**

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Figure 3-5 Examples of Existing Water-bodies in the CWMPA

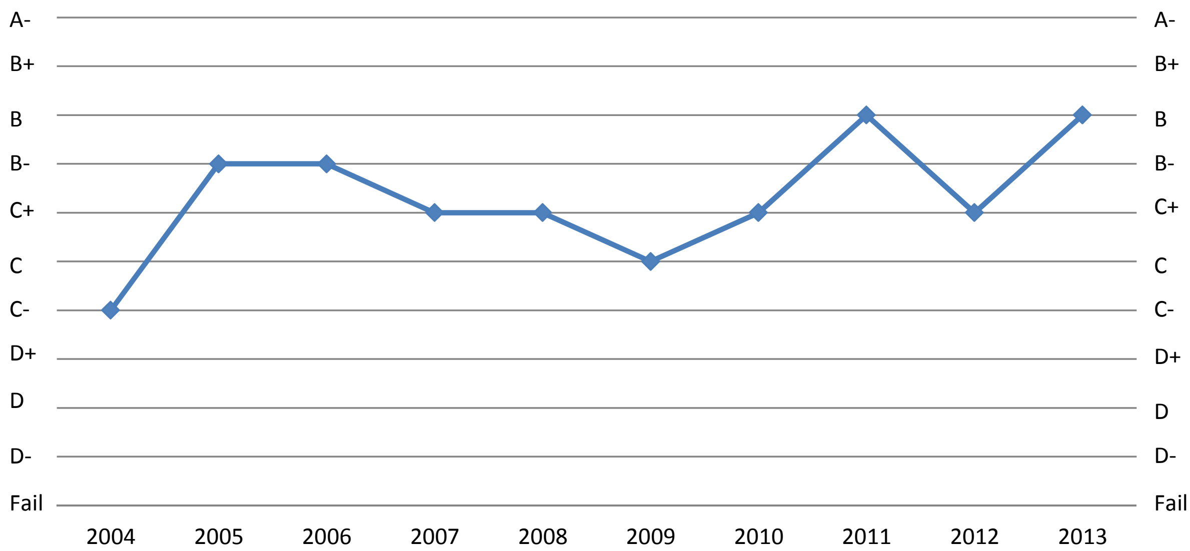


Figure 3-6 Caboolture River Freshwater EHMP Grades

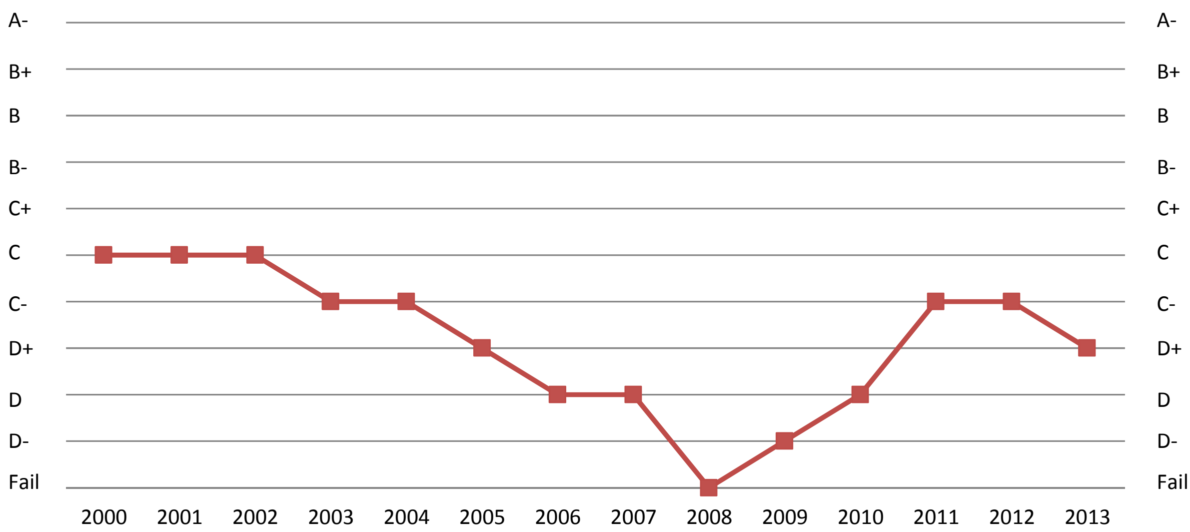
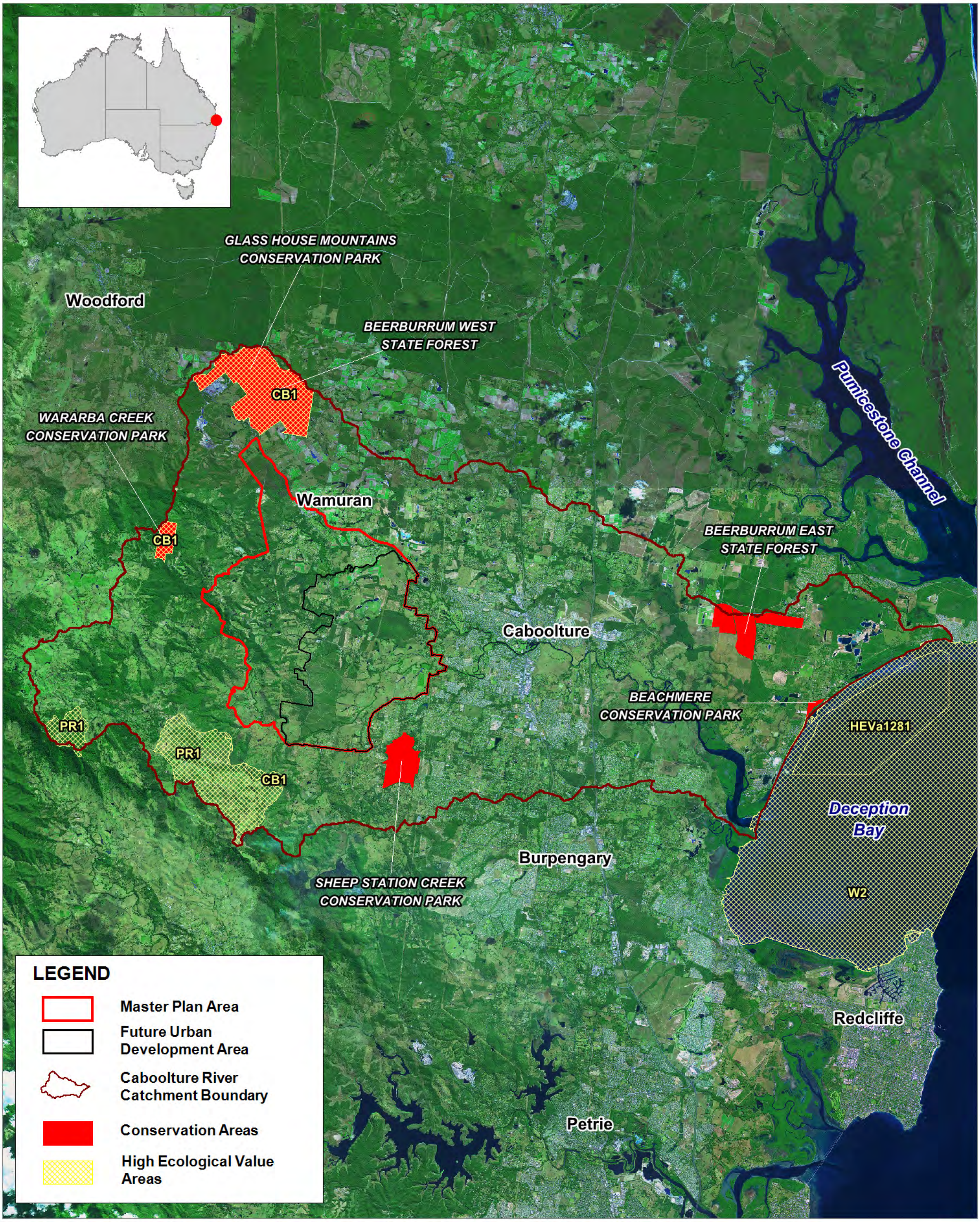


Figure 3-7 Caboolture River Estuary EHMP Grades



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Environmentally Sensitive Areas within Caboolture River Catchment

Figure: 3-8

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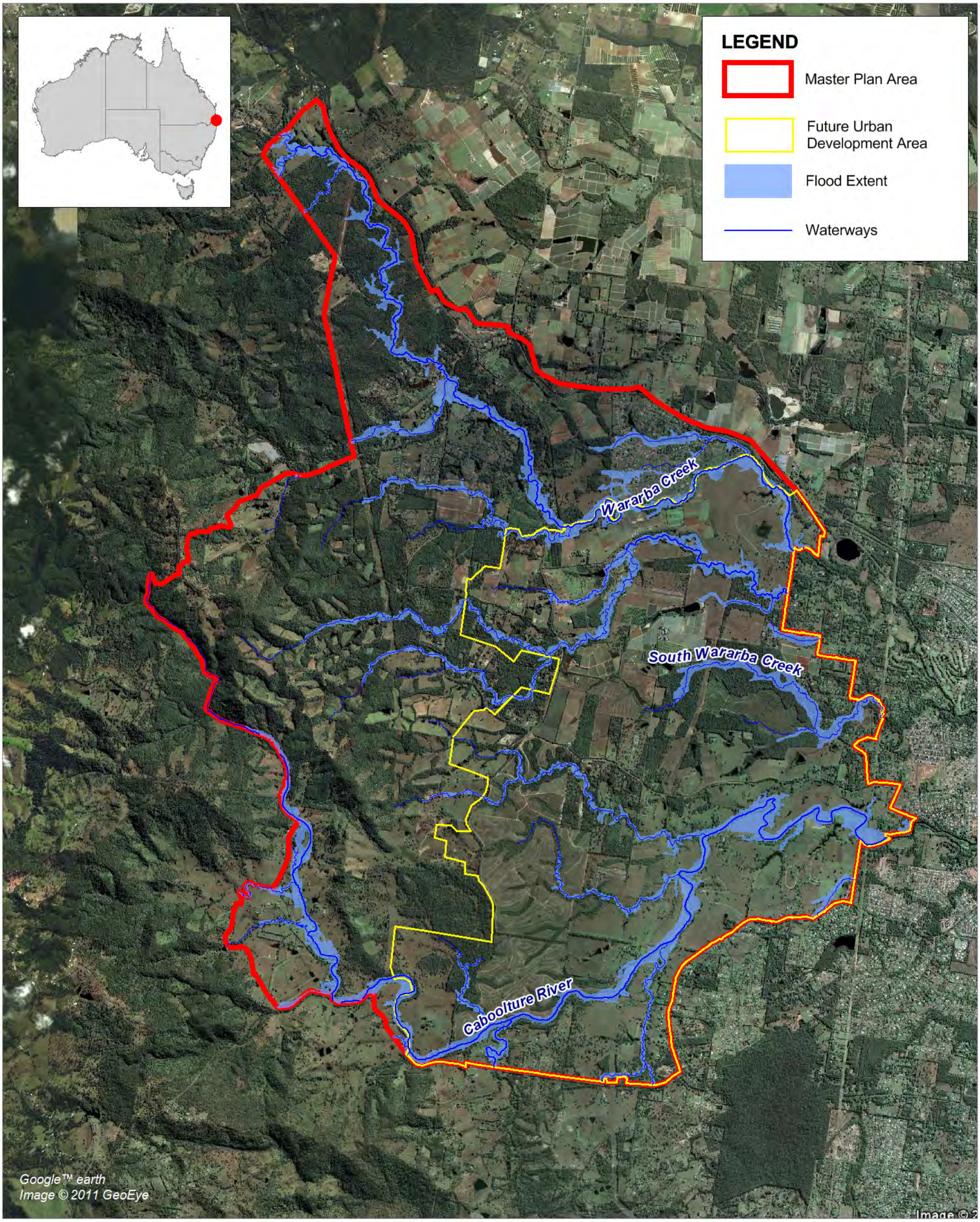

Title:

1% Annual Exceedance Probability Flood Extent in the CWMPA

Figure: 3-9

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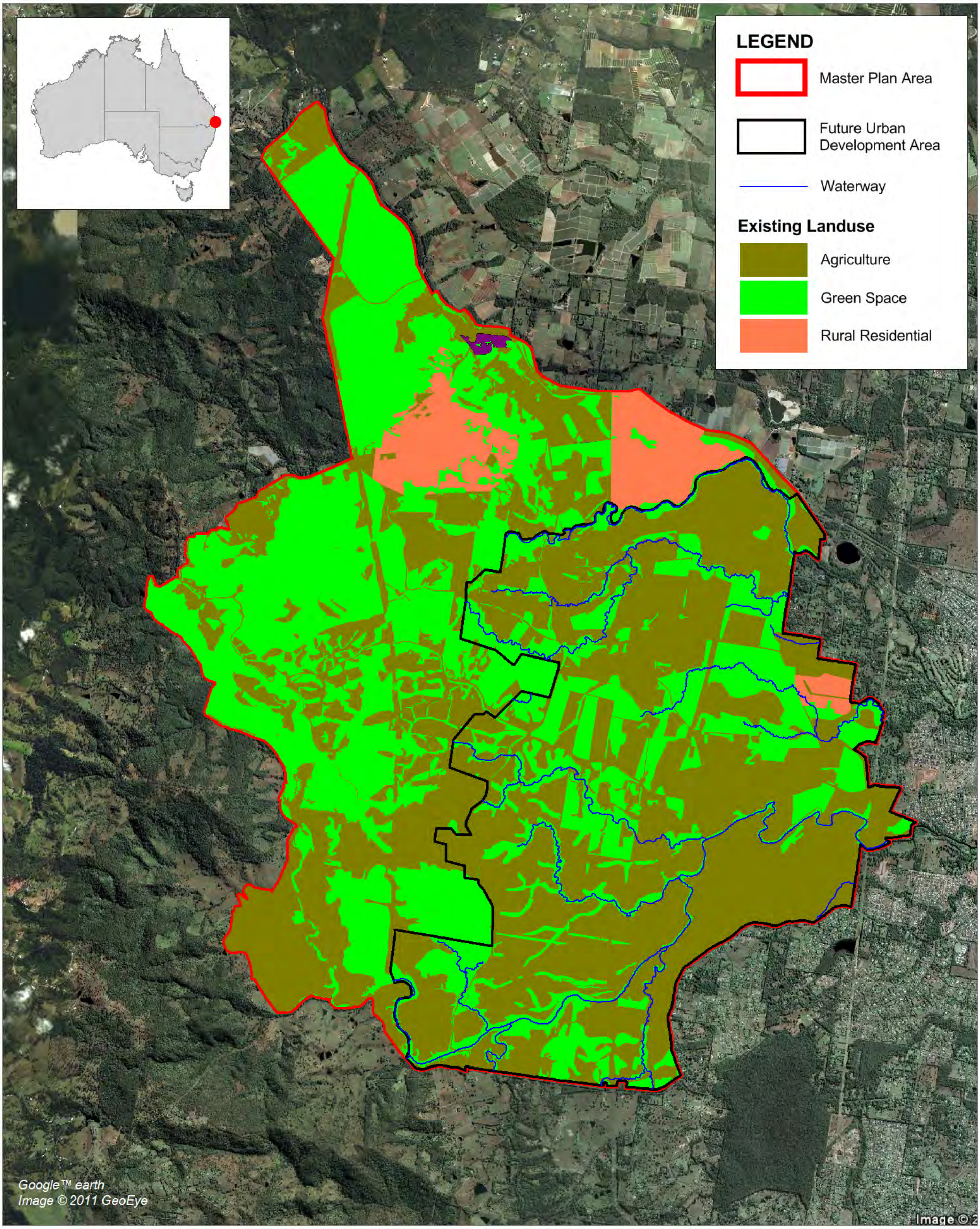
Figure 3-10 Example Photos of Existing Land Usage within the CWMPA



Title:
Existing Land Use within the Caboolture West Master Planned Area

Figure: **3-11**

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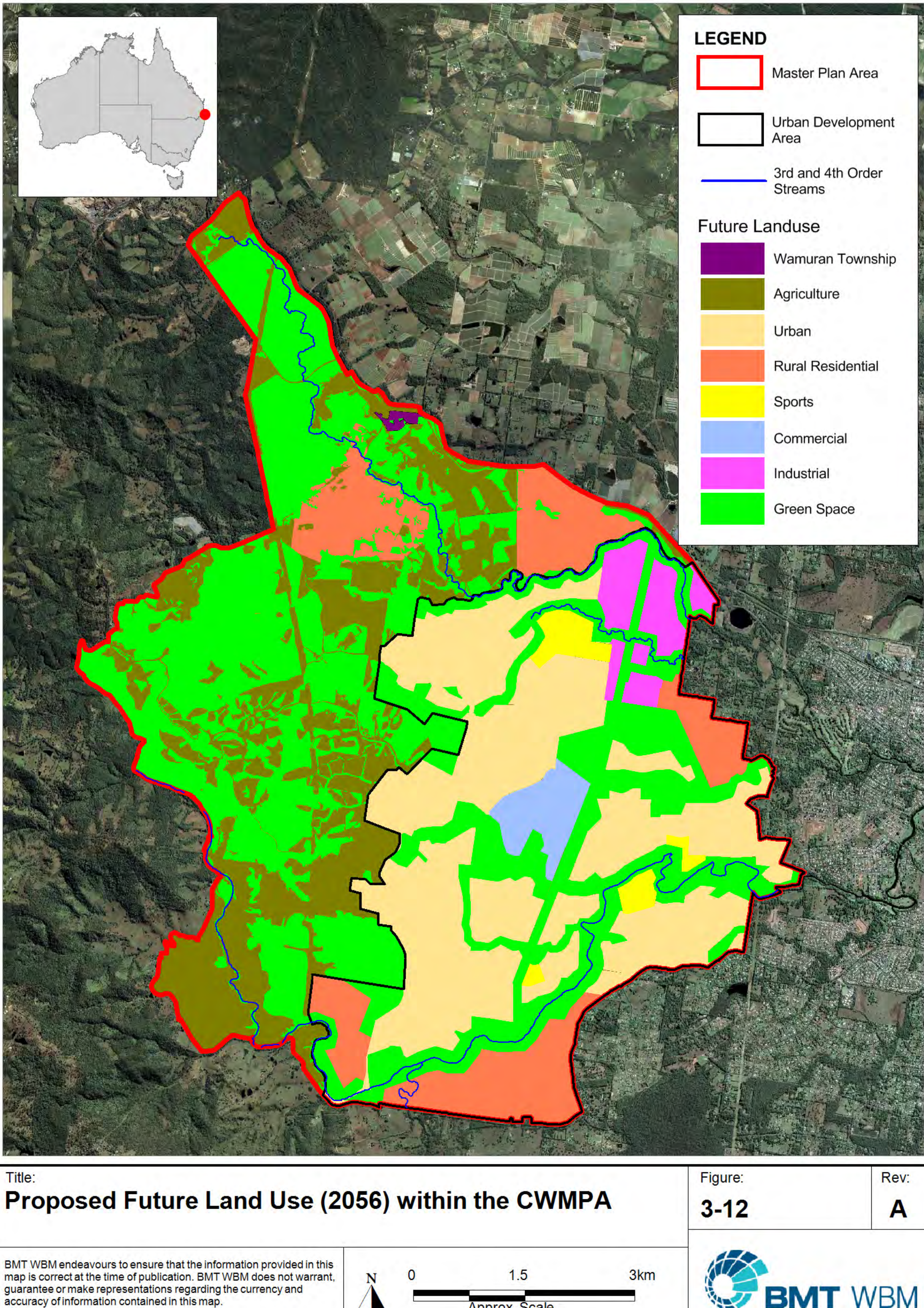

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Proposed Future Land Use (2056) within the CWMPA

Figure: **3-12**

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BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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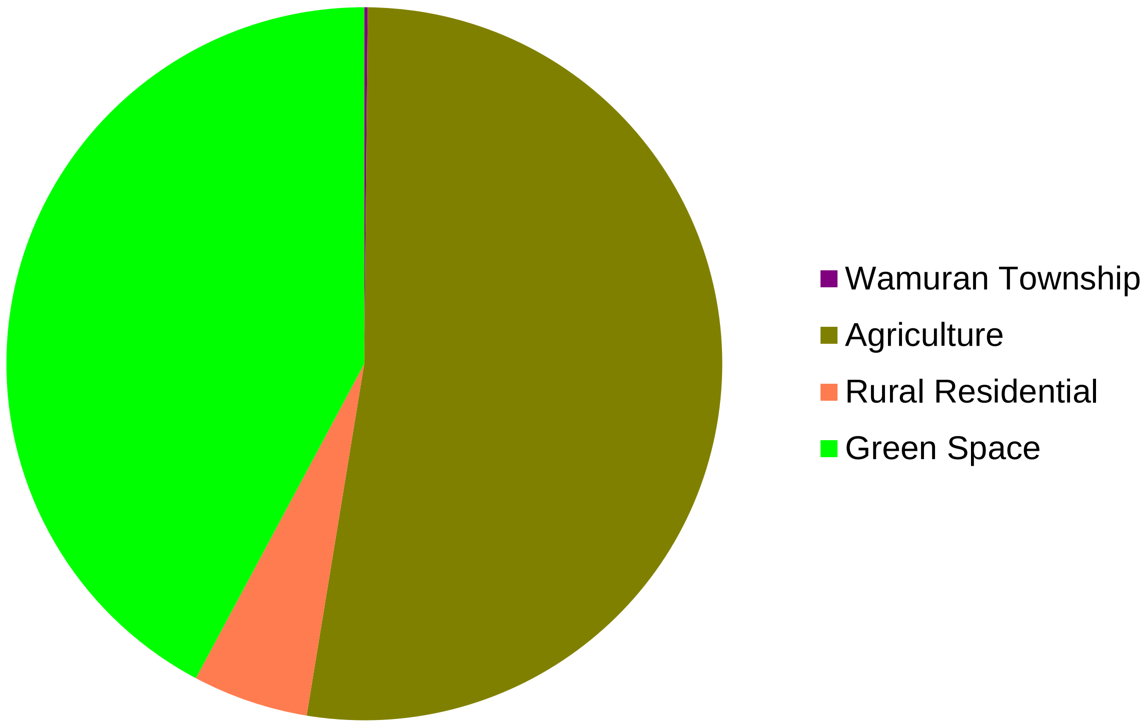


Figure 3-13 Pie Chart of Land Use for Existing CWMPA

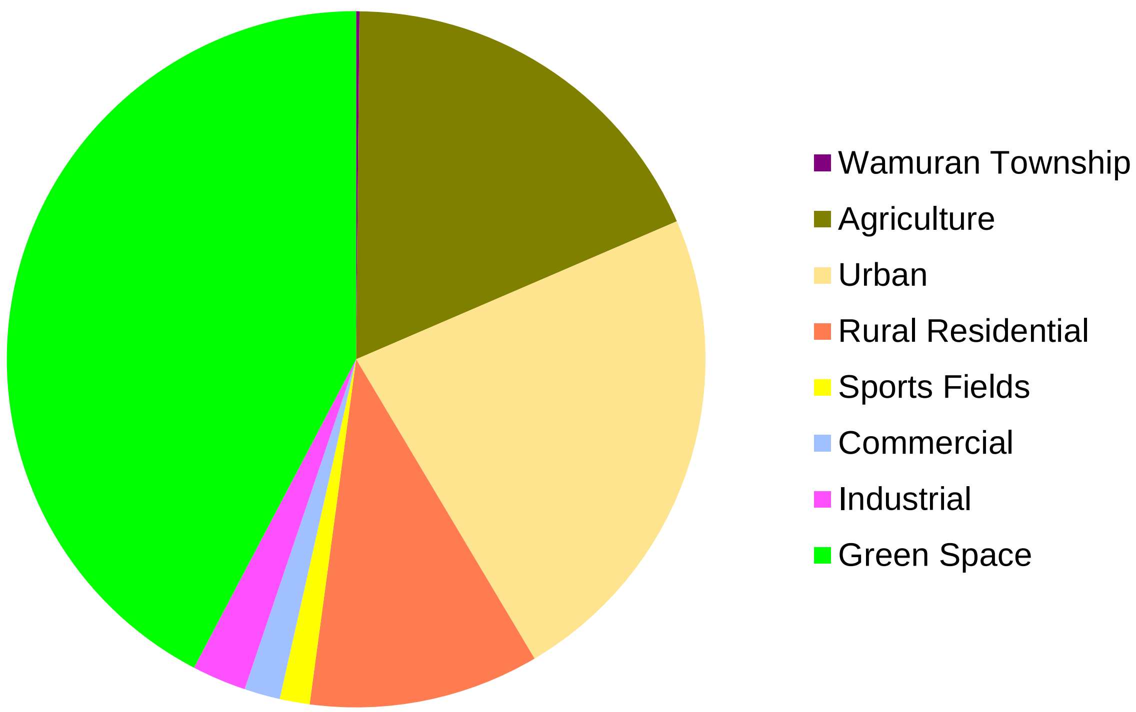


Figure 3-14 Pie Chart of Land Use for Future (2056) CWMPA

4. Issues & Drivers

4 Issues and Drivers

This section describes the issues and drivers for total water cycle management in the CWMPA in a sub-regional planning context. The issues and drivers presented in this section are based on the following:

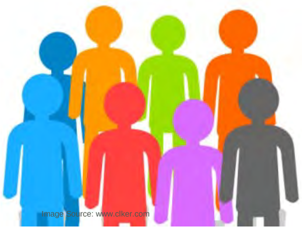
- Findings of the TWCM Strategy developed for the region as part of the LG TWCM planning process (BMT WBM, 2010a); and
- Subsequent discussions with representatives from Council and Unitywater.

The following issues and drivers have been identified as being influential in terms of TWCM planning in the CWMPA:

- Population growth;
- Water supply;
- Environmental flows;
- Climate change;
- Water conservation;
- Wastewater management;
- Water quality;
- Protection of environmentally sensitive areas; and
- Legislative and policy drivers.

These are described in the following sub-sections.

4.1 Population Growth



It is estimated that population growth will remain strong in SEQ and in certain parts of MBRC, in particular. The population within the CWMPA, in the area being considered for urban development, is expected to increase from 780 people in 2011 to approximately 68 000 by 2056.

4.2 Water Supply

The *South East Queensland Water Strategy* (QWC, 2010) includes a 'Water Supply Guarantee'.

The Water Supply Guarantee

"*It is our vision that there will be sufficient water to support a comfortable, sustainable and prosperous lifestyle while meeting the needs of urban, industrial and rural growth and the environment.*

Known as the Water Supply Guarantee, this water security vision will be achieved by:

- *balancing community expectations of water security, quality and cost*
- *embedding water efficiency throughout the water supply and demand chain*
- *managing water security through diversified and integrated water supplies and drought preparedness*
- *improving environmental outcomes, including healthier waterways, through integrated strategic planning and catchment management.*"

South East Queensland Water Strategy (QWC, 2010)

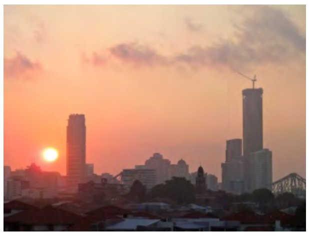
From discussions with MBRC, it is our understanding that Seqwater have advised that the 'Water Supply Guarantee' applies to the CWMPA, with water to be supplied to the CWMPA from the Northern Pipeline Interconnector (NPI).

Despite this 'Water Supply Guarantee', it is evident that the security of water supply to the CWMPA and wider MBRC area is a driver of the TWCM planning process. When developing TWCMPs, water supply sources and their future security should be considered. It will also be important to investigate other potential sources of potable water in the region (such as recycled water and stormwater harvesting), so that water supply sources are diversified to improve water supply security and achieve other objectives (e.g. improved waterway health through harvesting and reuse of stormwater).

4.3 Environmental Flows

Environmental flow objectives for a number of waterways in MBRC, including Caboolture River, are contained in the *Water Resource (Moreton) Plan 2007.* The consequence of having to maintain environmental flow objectives in the Caboolture River can potentially adversely impact on the available water supply and associated harvestable yield in the CWMPA. If water storages are required to release a certain amount of water to downstream reaches, this can reduce yields. Combine this with the potential impacts of climate change and increasing population on water supplies, and it is evident that the TWCM planning process will need to account for environmental flow requirements in any future water accounting scenarios to ensure that storage yields are properly determined.

4.4 Climate Change



In SEQ, it is estimated that climate change may impact on future water supplies. This impact may potentially result in a reduction in surface water supply/ yield, and it is therefore essential that this impact is considered in any future scenarios from a water supply perspective.

This also places emphasis on the need for the investigation of other sources of water which are less susceptible to climate change impacts given the current reliance on surface water supplies in the region. It is, however, noted that the *SEQ Water Strategy* has seen a shift from traditional climate dependent supply sources (i.e. dams), to include a greater diversification of water supply sources (e.g. purified recycled water and desalination), which will assist to manage the impacts of climate change on level of service objectives.

4.5 Water Conservation

Water savings targets were previously set in the *SEQ Regional Plan* in order to reduce residential and non-residential water demand. Water restrictions in SEQ were, however, removed in January 2013. Laws mandating the installation of rainwater tanks and other water savings measures in Queensland were also repealed by the State Government in February 2013.

Despite these removed requirements for water conservation, it is considered essential that water conservation maintains a continued focus in order to minimise inefficient water use. This can delay the need for new water supply sources, such as desalination plants, and also contributes to wastewater flow/ load reduction targets.

4.6 Wastewater Management

Wastewater from the first stage of the CWMPA is planned to be transferred and treated at Caboolture South STP (until around 2024). After this, wastewater will likely be transferred to a centralised sewage treatment plant (Partha Susarla, UnityWater, *Pers. Comm.*: 23 September 2013).

These centralised treatment options will provide an appropriate system for the transfer and treatment of wastewater from the CWMPA. Nevertheless, reduced wastewater discharges from the CWMPA could provide significant benefits, including:

- Reduced and/ or delayed infrastructure requirements for the transfer, treatment and disposal of wastewater.
- Reduced operational expenditure (e.g. electricity) associated with the transfer, treatment and disposal of wastewater.
- Reduced impacts to receiving waters (from the discharge of treated wastewater).

4.7 Water Quality

There are several key water quality drivers for the CWMPA, including the following:

- Satisfy the regulatory requirements of the *EP Act 1994* and *EPP Water 2009*, which prescribe water quality objectives (WQOs) to protect Environmental Values.
- Satisfy the commitments of the SEQ Healthy Waterways Strategy 2007-2012, which aims to achieve waterways and catchments that are healthy ecosystems supporting the livelihoods and lifestyles of people in SEQ by 2026.
- Satisfy targets set in the SEQ Natural Resources Management Plan that are aligned with desired regional outcomes and policies for Water Management in the SEQ Regional Plan.
- Implement planning and management of urban stormwater to comply with the design objectives as set out in the *SEQ Regional Plan 2009-2031 Implementation Guideline No. 7: Water Sensitive Urban Design.*
- Management of urban stormwater and waste water to comply with the *SPA (2009)* and the *State Planning Policy (2013)*.

As described in Section 4.2, the CWMPA is also located upstream of the Caboolture Weir, which was previously utilised as a water supply source. Seqwater have, however, advised that the Caboolture Water Treatment Plant (which has not been operational for an extended period) is likely to be permanently decommissioned and to remain so for the foreseeable future (James Moffat, Seqwater, *Pers. Comm.*: 29 October 2013).

4.8 Protection of environmentally sensitive areas

As described in Section 3.5, a number of areas have been identified within MBRC which are environmentally sensitive and require protection from adverse environmental stressors. One of these areas is a high ecological value (HEV) area within Deception Bay near the mouth of the Caboolture River. These areas are important environmental assets, on both a local and regional scale.

One outcome from the TWCM planning process will be the development of measures which minimise existing and future environmental impacts on these areas.

4.9 Legislative and Policy Drivers

The various legislation and policy which are relevant in the context of TWCM planning include the following:

- Sustainable Planning Act 2009;
- Environmental Protection Act 1994;
- Water Act 2000;
- Water Supply (Safety and Reliability) Act 2008;
- Public Health Regulation 2008;
- Restructuring Act 2009;
- State Planning Policy (SPP, effective December 2013);
- SEQ Regional Plan 2009-2031 Implementation Guideline No. 7: Water Sensitive Urban Design;
- SEQ Regional Plan 2009-2031;
- SEQ Water Strategy;
- SEQ Healthy Waterways Strategy;
- SEQ Natural Resource Management Plan;
- SEQ Regional Water Security Program; and
- Draft SEQ Climate Change Management Plan.

The key legislation, planning and policy drivers which play a significant role in the development of a S-R TWCMP within SEQ are described further in Section 2.

5. Management Options

5 Management Options

This section describes options identified for TWCM in the CWMPA, in a sub-regional planning context. It also contains a high level assessment of the indicative costs and treatment performance of each to assist in evaluating the effectiveness of each option.

The management options assessed have been selected based on:

- Findings of the TWCM Strategy developed for the region as part of the LG TWCM planning process (BMT WBM, 2010a).
- Inspections of the CWMPA.
- Subsequent discussions with representatives from Council and Unitywater.
- Opportunities to optimise total water cycle management outcomes.

The life cycle costs for each solution have been assessed over the 20-year planning period from 2016 to 2036. For simplicity, the annual performance of each solution has been assessed assuming most solutions will be implemented at full potential for 20 years.

5.1 Identification and Assessment of Options

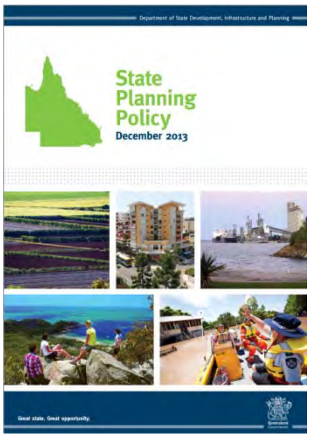
There are a number of opportunities to optimise total water cycle management outcomes within the CWMPA, including:

- New development to satisfy best practice stormwater management targets;
- Stormwater harvesting;
- Sewer mining for public open space irrigation and/ or discharge to land;
- Recycled water usage;
- Prevention of illegal stormwater connections to sewer;
- Waterway riparian revegetation to Q100 boundaries;
- Increased implementation/ enforcement of erosion and sediment control on development sites; and
- Education and capacity building to support implementation of solutions.

These opportunities inherently exist due to the fact that the CWMPA is a large greenfield development site. Essentially, this means that any infrastructure required for alternative water can be more readily incorporated into designs and installed as part of the development at less cost than retrofitting at a later date.

The options identified and the opportunities associated with their inclusion in this TWCMP are summarised in the following sections.

5.2 New Development to Satisfy Best Practice Stormwater Management Targets



In accordance with *State Planning Policy* (December 2013), all new development (greater than 2500m^2 that results in an impervious area greater than 25% of the net developable area or 6 or more dwellings) are required to achieve the following minimum reductions in mean annual stormwater pollutant loads (relative to unmitigated development):

- 80% for total suspended solids;
- 60% for total phosphorus;
- 45% for total nitrogen; and
- 90% for gross pollutants.

A variety of stormwater management measures and/ or strategies can be utilised to achieve these targets.

Bioretention systems are typically a key component of stormwater management strategies required to achieve the aforementioned targets given that they can be integrated at a variety of scales and can provide a high amount of stormwater treatment per unit of area required. Stormwater treatment wetlands are also often integrated within new developments to achieve the aforementioned targets (although they are significantly less common than bioretention systems given that they typically require more area to achieve the same or similar amount of stormwater treatment). Proprietary devices (e.g. gully baskets, cartridge systems) are commonly installed in privately owned (e.g. industrial, commercial) lots, where the lot-owner (or manager) is responsible for the management of these devices (and not Council).

For the purposes of this report, the following four scenarios were investigated to determine their stormwater-related benefits and the area requirements to meet the aforementioned targets:

1. Bioretention systems (without rainwater tanks);
2. Bioretention systems with rainwater tanks;
3. Wetlands (without rainwater tanks); and
4. Wetlands with rainwater tanks.

Rainwater tanks have been analysed in conjunction with bioretention systems and wetlands given that the inclusion of rainwater tanks as part of the treatment train can reduce the size of the other treatment devices, along with providing a number of other benefits.

5.2.1 Description

5.2.1.1 Bioretention Systems

Bioretention systems are a plant and soil-based stormwater treatment devices in which stormwater is directed into the system and infiltrates through the plant and soil environment. Stormwater is treated via a combination of physical, chemical and biological processes.

Bioretention systems are flexible in size, shape and appearance, and can be readily integrated into a range of landscapes, including individual development sites, streetscapes, parklands and adjacent to riparian and bushland settings. Examples of small streetscape systems are shown in Figure 5-1. Examples of larger 'end-of-pipe' bioretention basins, which could potentially be integrated into the areas of 'green space' in the CWMPA are shown in Figure 5-2.

Figure 5-1 Examples of Streetscape Bioretention Systems in South East Queensland

Figure 5-2 Examples of Bioretention Basins in South East Queensland

5.2.1.2 Wetlands

Stormwater wetlands are shallow vegetated water bodies which provide stormwater treatment via sedimentation, filtration and biological processes.

Examples of stormwater treatment wetlands in South East Queensland are presented in Figure 5-3.

Figure 5-3 Examples of Stormwater Treatment Wetlands in South East Queensland

5.2.1.3 Rainwater Tanks

Rainwater tanks collect roof runoff, which can be used to supplement non-potable water demands (e.g. toilet flushing, laundry).

Queensland Development Codes MP4.2 and MP4.3 (Queensland Government, 2007) previously mandated the requirement for alternative water supplies (typically supplied by rainwater tanks) for new residential and commercial developments within Queensland. This legislation was, however, removed in February 2013. At the time of writing this report, MBRC are not mandating the installation of rainwater tanks within the Council area. Nevertheless, we have included an assessment of the option of utilising rainwater tanks (in conjunction with bioretention systems and wetlands) to demonstrate the potential benefits of their use.

5.2.2 Assessment

To investigate the effectiveness of this management option (and the aforementioned modelling scenarios), all new development areas were identified in each sub-catchment, and a range of treatment scenarios were tested to achieve best practice targets.

eWater's MUSIC (Version 5.1) software package was used to quantify this solution's performance in reducing pollutant loads from the CWMPA over the planning period. Appendix A provides a description of the modelling methodology applied in this assessment.

The model results of implementing bioretention systems and wetlands (both with and without rainwater tanks) are provided in the following sections.

5.2.2.1 Bioretention Systems

As described in Section 5.2.1.1, bioretention systems can be integrated into a range of landscapes (e.g. as 'streetscape' systems and/ or 'basins').

Streetscape bioretention systems can provide additional benefits (relative to 'end-of-pipe' basins), particularly in terms of treating stormwater 'at the source', and improved integration (e.g. self-watered landscape areas within streetscapes).

Topography can, however, significantly limit the appropriate integration of bioretention systems within a streetscape, and streetscape systems are generally not recommended for areas with steep topography (with gradients greater than approximately 4%).

Figure A-15 illustrates the urban areas within the study area that have a slope less than 4%, and hence are more readily suitable for streetscape bioretention systems. It should, however, be noted that on terrain greater than 4%, aligning road reserves tangentially to contour lines to achieve longitudinal grades of less than 4% will assist in the integration of 'at source' stormwater management. Furthermore, by strategically locating public open space within the urban areas, opportunities can also be created for a combination of distributed 'at source' solutions. Where it is not practical to achieve road reserves and public space slopes of less than 4%, then an end-of-pipe treatment option may be more appropriate.

Table 5-1 presents the estimated values of bioretention filter area (as a percentage of upstream land use), which may be in the form of 'at source' or end-of pipe systems, required to meet the *State Planning Policy* Best Practice Targets (given in Section 5.2). Also included in this table are the bioretention filter area requirements if rainwater tanks with reuse were installed (in residential and commercial areas) upstream of the bioretention systems.

Table 5-1 Bioretention System Area Requirements (as % of upstream land use)

Land Usage	% of Land Area Required for Bioretention Filter Area	
	Without Rainwater Tanks	With Rainwater Tanks
Urban Residential	1.4%	1.0%
Rural Residential	1.5%	-*
Wamuran Township	1.0%	-*
Commercial	1.3%	1.2%
Industrial	1.8%	-*

* Only 'Urban Residential' and 'Commercial' land uses were used with the Rainwater Tanks analysis due to the highly variable nature of the rainwater reuse for the other land uses.

An estimate of the bioretention treatment area required for each subcatchment, both with and without rainwater tanks is detailed in Table 5-2. The location of the subcatchments is illustrated in Figure A-4 (in Appendix A).

Table 5-2 Bioretention Area Requirements for Each Subcatchment

Subcatchment Label	Subcatchment Area (ha)	Bioretention Area Required (ha)	
		Without Rainwater Tanks	With Rainwater Tanks
S1	215	0.0	0.0
S2	849	3.3	2.4
S3	279	3.2	3.0
S4	355	3.5	2.8
S5	300	2.8	2.2
S6	489	2.7	2.0
S7	405	4.3	3.1
S8	282	2.5	1.9
S9	328	1.8	1.7
S10	1340	3.1	2.8
S11	384	4.1	3.6
S12	585	0.0	0.0
S13	617	0.4	0.3
Total	**6 428**	**31.8**	**25.8**

Predicted performance results of implementing this solution in each catchment is detailed in Table 5-3. In calculating the net present value, an operating period of 20 years has been assumed (for maintenance costs).

Table 5-3 Pollutant Reduction Achieved with Bioretention for CWMPA

Solution	Net Present Value ($2013)	Reduction in Pollutant Loads (kg/yr)			Levelised Cost ($/kg)		
		TSS	TP	TN	TSS	TP	TN
Bioretention without Rainwater Tanks	$155 109 000	3 305 000	4 060	20 490	$1.99	$1 621	$321
Bioretention with Rainwater Tanks	$133 525 000*	3 289 000	4 150	21 140	$2.03*	$1 609*	$316*

*: This cost does not include the capital or operational costs associated with rainwater tanks.

The estimated capital and operational costs of implementing this solution is detailed in Table 5-4.

Table 5-4 Capital and Operational Costs of Implementing Bioretention in the CWMPA

Solution	Capital Cost (incl. 2 yr establishment)	Maintenance Cost per Annum
Bioretention without Rainwater Tanks	$140 213 000	$2 337 000
Bioretention with Rainwater Tanks	$120 703 000*	$2 012 000*

* This cost does not include the capital or operational costs associated with rainwater tanks.

It should be noted that the capital and establishment costs are typically borne by the developer, while the maintenance costs (after the asset is considered established and fully operational) is typically incurred by Council.

5.2.2.2 Wetlands

Presented in Table 5-5 is the wetland area required (as a percentage of upstream land use) to meet the *State Planning Policy* Best Practice Targets (given in Section 5.2). Also included in this table are the wetland area requirements if rainwater tanks with reuse were utilised upstream of the wetland.

Table 5-5 Wetland Area Requirements (as % of upstream land use)

Land Usage	% of Land Use Area Required for Wetlands	
	Without Rainwater Tanks	With Rainwater Tanks
Urban Residential	10%	8%
Rural Residential	8%	-*
Wamuran Township	8%	-*
Commercial	8%	8%
Industrial	8%	-*

* Only 'Urban Residential' and 'Commercial' land uses were used with the Rainwater Tanks analysis due to the highly variable nature of the rainwater reuse for the other land uses.

An estimate of the wetland treatment area required for each subcatchment, both with and without rainwater tanks is detailed in Table 5-6. The location of the subcatchments is illustrated in Figure A-4 (in Appendix A).

Table 5-6 Wetland Area Requirements for Each Subcatchment

Subcatchment Label	Subcatchment Area (ha)	Wetland Area Required (ha)	
		Without Rainwater Tanks	With Rainwater Tanks
S1	215	0.0	0.0
S2	849	23.7	19.3
S3	279	18.7	17.3
S4	355	23.2	19.9
S5	300	18.5	15.7
S6	489	19.1	15.7
S7	405	30.8	24.8
S8	282	17.9	14.9
S9	328	9.4	8.7
S10	1340	19.0	17.2
S11	384	24.8	22.5
S12	585	0.0	0.0
S13	617	2.9	2.3
Total	**6 428**	**208.0**	**178.5**

Predicted performance results of implementing this solution in each catchment is detailed in Table 5-3. In calculating the net present value, an operating period of 20 years has been assumed (for maintenance costs).

Table 5-7 Pollutant Reduction Achieved with Wetlands for CWMPA

Solution	Net Present Value ($2013)	Reduction in Pollutant Loads (kg/yr)			Levelised Cost ($/kg)		
		TSS	TP	TN	TSS	TP	TN
Wetlands without Rainwater Tanks	$543 192 000	3 175 000	4 810	21 410	$8.6	$5 650	$1 270
Wetlands with Rainwater Tanks	$483 109 000*	3 124 000	4 890	22 300	$7.7*	$4 940*	$1 080*

*: This cost does not include the capital or operational costs associated with rainwater tanks.

The estimated capital and operational costs of implementing this solution is detailed in Table 5-8.

Table 5-8 Capital and Operational Costs of Implementing Wetlands in the CWMPA

Solution	Capital Cost (incl. 2 year establishment)	Maintenance Cost per Annum
Wetlands without Rainwater Tanks	$506 730 000	$6 668 000
Wetlands with Rainwater Tanks	$450 680 000*	$5 930 000*

* This cost does not include the capital or operational costs associated with rainwater tanks.

As previously noted, the capital and establishment costs are currently borne by the developer, while the maintenance cost is typically (after the asset is handed over) a Council responsibility in most cases.

5.2.2.3 Rainwater Tanks

The harvesting and use of roof runoff has multiple benefits, including:

- Reducing mains water demands (and associated costs);
- Improving catchment hydrology (through runoff retention);
- Reduced pollutant load discharged downstream; and
- Reduced size (and associated costs and land requirements) for stormwater treatment measures (used in combination with rainwater tanks to satisfy *State Planning Policy* Best Practice Targets given in Section 5.2).

The water balance figures provided in Appendix B highlight that the inclusion of rainwater tanks will significantly reduce potable water demand for the CWMPA (by approximately 2,000 ML/year, or 30% of total water demands for the CWMPA).

The runoff volume and frequency analyses (provided in Section 6.3) and the water balance figures (provided in Appendix B) also demonstrate that the inclusion of water tanks will reduce the volume and frequency of runoff discharged from the site – reducing the increased runoff due to the development of the CWMPA (to rates more similar to ‘Pre-European’ conditions and the existing site).

The results in the previous sections also demonstrate the significant reduction in the size of treatment measures (and associated costs) associated with the inclusion of rainwater tanks.

Although the provision of rainwater tanks are predicted to provide significant benefits, at the time of report writing, MBRC will not be mandating their requirement for new development within the CWMPA.

5.2.2.4 Assessment Summary of Options for New Development

Table 5-9 and Table 5-10 provide an assessment summary of the management options for new development to satisfy best practice stormwater management targets.

Table 5-9 Assessment Summary of Management Options for New Development

Management Option	Net Present Value ($Million, 2013)	Reduction in Pollutant Loads (tonnes/year)			Levelised Cost ($/kg)		
		TSS	TP	TN	TSS	TP	TN
Bioretention without rainwater tanks	155.1	3 305	4.1	20	1.99	1 621	321
Bioretention with rainwater tanks	133.5*	3 289	4.2	21	2.03	1 609	316
Wetlands without rainwater tanks	543.2	3 175	4.8	21	8.6	5 650	1 270
Wetlands with rainwater tanks	483.1*	3 124	4.9	22	7.7*	4 940*	1 080*

* This cost does not include the capital or operational costs associated with rainwater tanks.

Table 5-10 Assessment Summary of Capital & Operational Costs of Management Options for New Development

Management Option	Capital Cost ($Million, 2013)	Annual Maintenance Cost ($Million, 2013)
Bioretention Systems without Rainwater Tanks	140.2	2.3
Bioretention Systems with Rainwater Tanks	120.7*	2.0*
Wetlands without Rainwater Tanks	506.7	6.7
Wetlands with Rainwater Tanks	450.7*	5.9*

* This cost does not include the capital or operational costs associated with rainwater tanks.

The results presented above demonstrate that the implementation of bioretention systems will require significantly less area and expenditure relative to wetlands.

Stormwater treatment wetlands typically provide greater benefits (relative to bioretention systems), particularly in terms of greater integration of water into the landscape to enhance visual, social, cultural and ecological values. Nevertheless, the significantly reduced area and cost requirements for bioretention systems (relative to wetlands) is anticipated to result in more bioretention systems (relative to wetlands) being integrated throughout the CWMPA.

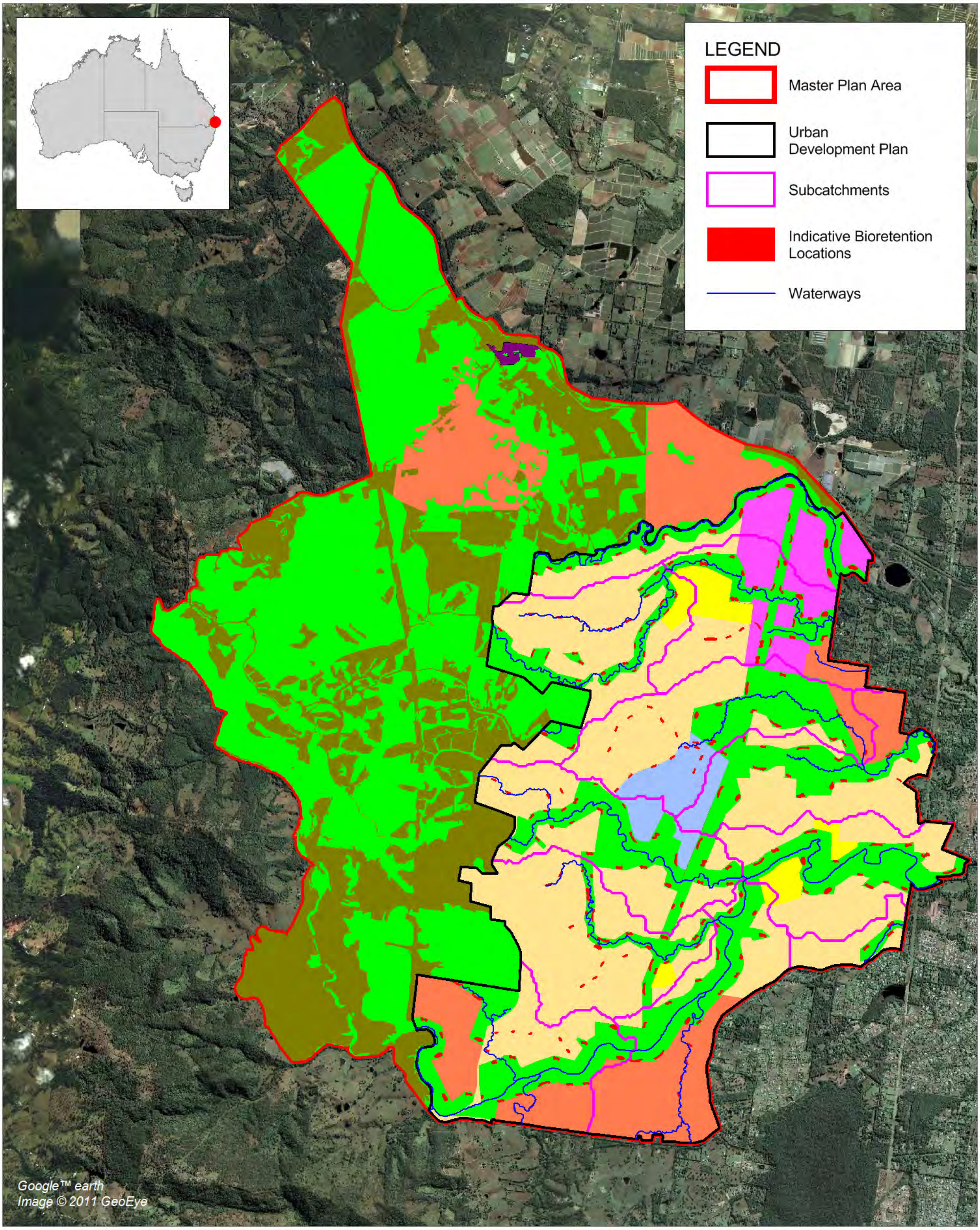
As described in the previous section, the results also demonstrate the significant reduction in the size of treatment measures (and associated costs) associated with the inclusion of rainwater tanks – although MBRC will not be mandating their requirement for new development within the CWMPA.

5.2.3 Recommendation

New development (greater than 2500m^2 that results in an impervious area greater than 25% of the net developable area or 6 or more dwellings) within the CWMPA will be required to achieve stormwater management objectives outlined in *State Planning Policy*. It is recommended that this generally be achieved through the following:

- Bioretention systems distributed within the catchment as 'at source' where feasible:
  - These will be integrated at multiple locations to provide stormwater treatment to developed areas;
  - These will typically be limited to low-lying areas (within the eastern portion of the CWMPA) where gradients do not limit their application.
  - Alternatively, through the design of urban areas, including aligning streets parallel or tangential to contours to reduce longitudinal street grades, and strategically locating public open space, opportunities can be created to distribute 'at source' measures throughout the catchment.
- Where 'at source' bioretention systems are not feasible end-of-pipe bioretention systems may provide the solution to meeting the objectives outlined in *State Planning Policy*:
  - These would be generally located immediately downstream of developed areas, with provision for suitable access for inspections and maintenance;
  - These should be located external to waterways, and suitably located to minimise any risks associated with waterway flooding and/ or high velocity flows; and
  - Figure 5-4 provides *indicative* locations of the potential distribution of end-of-pipe bioretention basins throughout the CWMPA. It should be noted that the large end-of-pipe bioretention systems may only be feasible on larger developments or where developers provide a joint solution.
  - Figure A16 to Figure A-28 provides an approximate indication of the potential distribution of end-of-pipe biorentention basins throughout the CWMPA on a subcatchment basis.

The aforementioned recommended strategy is likely to be the most cost-effective solution for the majority of the CWMPA to achieve the stormwater management objectives outlined in *State Planning Policy.* Wetlands and other stormwater management measures may, however, be a preferred solution in selected areas to achieve the objectives outlined in *State Planning Policy* and other 'Water Sensitive Urban Design' principles – particularly in terms of stormwater harvesting strategies and integrating water into the landscape to enhance visual, social, cultural and ecological values.



Title:

Future Indicative Bioretention Locations

Figure: **5-4**

Rev: **A**

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Approx. Scale

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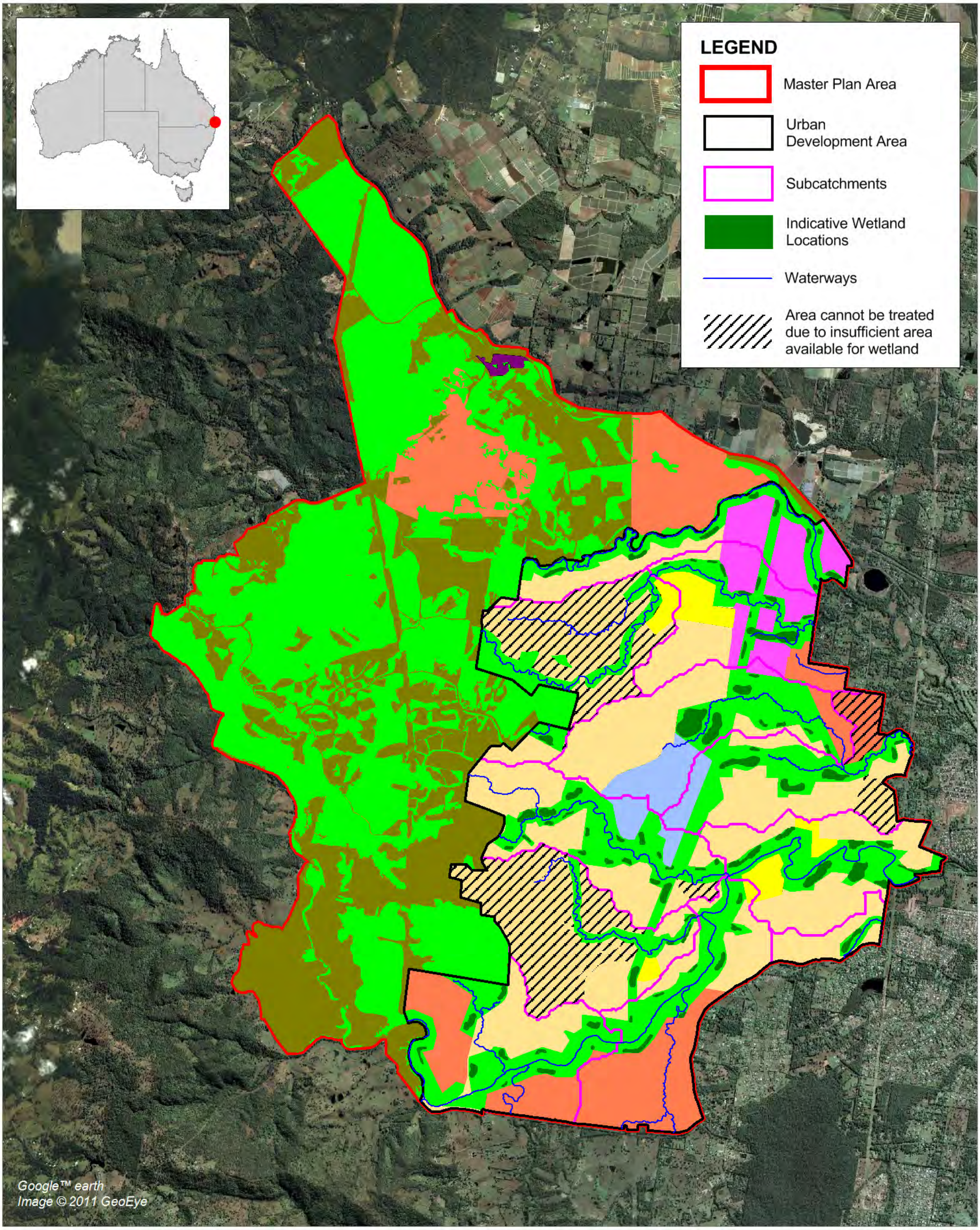

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Future Indicative Wetland Locations

Figure: **5-5**

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5.3 Stormwater harvesting

5.3.1 Description

Stormwater harvesting is the diversion, storage and treatment of stormwater runoff from urban catchments, to enable the stormwater to be reused. Stormwater harvesting differs from roofwater harvesting, which only captures and reuses the relatively uncontaminated runoff from roof areas. Stormwater harvesting is also distinguished from large-scale surface water systems and dams (Water by Design, 2009).

Stormwater harvesting could be undertaken within the CWMPA using two approaches:

- Utilising a selection of existing water-bodies (described in Section 3.3); and/ or
- Utilise constructed wetlands.

The preferred use of harvested stormwater would likely be for the irrigation of sporting fields within the CWMPA.

Constructed wetlands (with a stormwater harvesting function) have been successfully implemented at a number of locations in Australia (refer to Appendix D for examples).

5.3.2 Assessment

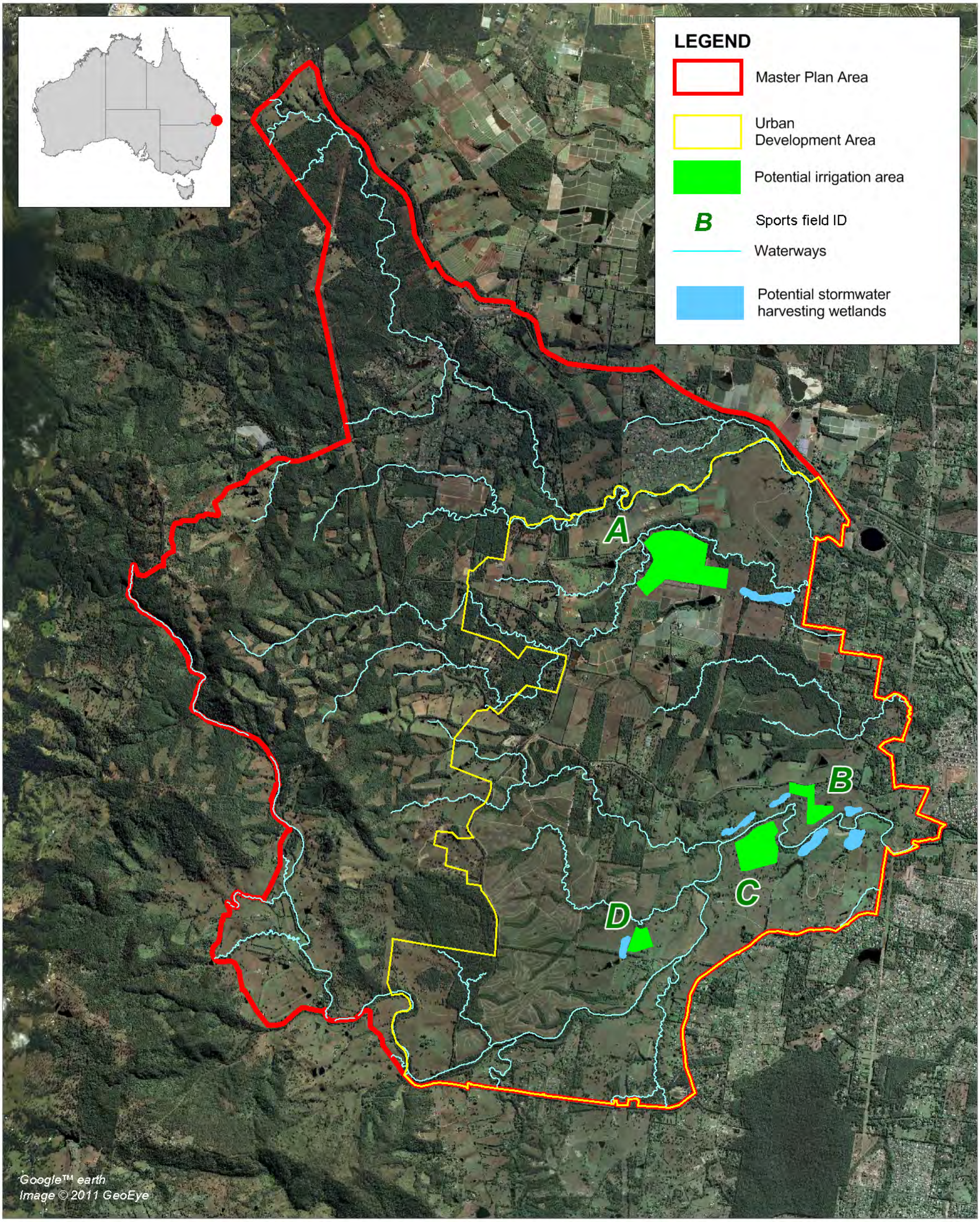
Stormwater harvesting can provide multiple benefits, including:

- Reduced mains water demand;
- Improved security of water supply for open space areas;
- Reduced pollutant loads discharged to waterways; and
- Improved catchment hydrology (by partially off-setting the increased frequency and volume of stormwater flows, and associated ecological impacts, caused by urbanisation of upstream catchment areas).

A desktop review and discussions with MBRC identified four regional sporting fields as the most preferred locations where stormwater harvesting could be included as part of this TWCMP as they would potentially require large volumes of water for irrigation.

An initial review of the existing water-bodies (described in Section 3.3) in close proximity to the four regional sporting fields was undertaken, however the existing water-bodies were located within ‘urban’ land use and were not deemed to be suitable due to the loss of developable land. Utilising constructed wetlands is subsequently the preferred stormwater harvesting approach for the CWMPA.

The location of the regional sporting fields and the potential constructed wetlands proposed for stormwater harvesting are illustrated in Figure 5-6.



Title:

Potential stormwater harvesting wetlands

Figure: 5-6

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Stormwater harvesting in the CWMPA was investigated through the use of eWater's MUSIC (Version 5.1) software package.

Based on recommendations given in Water by Design (2009), the following assumptions were used as a basis for calculating the demands and volume of reuse provided through the stormwater harvesting solution:

- 90% of gross area of regional sporting fields to be irrigated
- Total annual irrigation demand assumed to be 700 mm/year (scaled by daily 'PET minus rain').
- Extraction from wetlands would not occur if wetland water levels were 200mm (or more) below the normal water level (to assist in ensuring appropriate wetland hydrology and that water level draw-down was unlikely to have a significant negative impact on wetland plant health).

A summary of the potential water savings and annual pollutant load reductions of this solution is detailed in Table 5-11.

Table 5-11 Summary of Proposed Stormwater Reuse Schemes

Scheme ID	Target Yield (ML/yr)	Predicted Yield (ML/yr)	Annual Pollutant Load Reduction (kg/yr)		
			TSS	TP	TN
Sporting Field A	316	192	110 000	230	1 200
Sporting Field B	65	57	74 000	130	570
Sporting Field C	139	109	89 000	170	790
Sporting Field D	40	31	29 000	48	220
Total	**560**	**389**	**310 000**	**580**	**2 800**

The predicted performance results of implementing this solution are detailed in Table 5-12.

Table 5-12 Summary Stormwater Harvesting Results for the CWMPA

Net Present Value ($2013)	Reduction in Pollutant Loads (kg/yr)			Levelised Cost ($/kg)		
	TSS	TP	TN	TSS	TP	TN
$43 665 000	310 000	580	2 800	7.1	3 790	786

It should be noted that the above results include both the capital and operational costs. The operational expenses include maintenance costs to the wetlands, pumping costs and the cost of water saved by replacing potable water with water from the stormwater harvesting scheme. The levelised cost of water was calculated to be $5.60/kL.

It should also be noted that the stormwater harvesting wetlands provides multiple functions, including both the provision of an alternative water source, reduced pollutant loads discharged to waterways, improved amenity and provision of habitat. By excluding the cost of the wetland construction and maintenance, the levelised cost of water becomes cost negative.

The estimated capital and operational costs of implementing this solution is detailed in Table 5-13.

Table 5-13 Capital and Operational Costs of Implementing Stormwater Harvesting in the CWMPA

Solution	Capital Cost	Maintenance Cost per Annum
Stormwater harvesting	$45 379 000	$617 600

Further assessment of the wetland hydrology is recommended at the subsequent design phases of the stormwater harvesting wetlands to ensure the sustainability of the wetland. The assessment should include the analyses outlined in Appendix D, at a minimum.

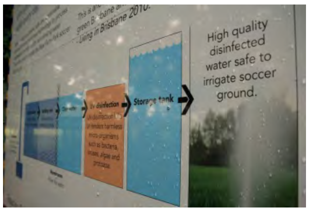
5.3.3 Recommendation

The following recommendations are provided:

- Four regional sporting fields in the CWMPA could potentially be irrigated using stormwater harvested from constructed wetlands.
- The potential of utilising additional constructed wetlands and existing water-bodies for stormwater harvesting purposes should be investigated further.
- Although roofwater differs from stormwater harvesting, it is recommended that the potential of utilising harvested roofwater from the urban and commercial developments should be investigated further. Amongst other suitable uses, harvested roofwater could potentially be used for the irrigation of the sporting fields.

5.4 Sewer mining for public open space irrigation and/ or discharge to land

5.4.1 Description



Sewer mining involves the extraction of raw sewage from an existing sewer, treatment of the raw sewage (to produce recycled water) and the return of the treatment by-products to the sewer (where possible).

The recycled water could be utilised to irrigate open space areas and/ or discharged to land, and could provide multiple benefits, including:

- Reduced potable water demands
- Reduced transportation and treatment of sewage at a centralised facility.
- Reduced discharge of treated wastewater.

This solution has been identified by MBRC for the CWMPA to address water supply issues only (by providing an alternative supply source).

5.4.2 Assessment

This solution is not considered appropriate for the CWMPA for the following reasons:

- In previous studies undertaken for MBRC, including the "*Total Water Cycle Management Plan for Moreton Bay Regional Council*" (BMT WBM, 2012), sewer mining was identified to have significant risks and not likely to be cost effective on a small scale basis.
- As described in Section 4.6, the planned centralised wastewater management strategy for the CWMPA (and wider area) is also anticipated to provide an appropriate system for the transfer and treatment of wastewater from the CWMPA.

5.4.3 Recommendation

As outlined in the previous section, sewer mining is not considered appropriate for the CWMPA.

5.5 Recycled water usage

5.5.1 Description

Sewage from a centralised Sewage Treatment Plan could be treated to produce recycled water for subsequent usage (and not discharged to receiving waters). This recycled water could be used to supply/ supplement open space irrigation requirements and other non-potable usages (e.g. industrial applications).

5.5.2 Assessment

Recycled water supplied to agricultural users or irrigated to land was identified as a solution to manage impacts to receiving water quality from point sources of discharge (i.e. STPs) as part of the "*Total Water Cycle Management Plan for Moreton Bay Regional Council*" (BMT WBM, 2012a).

It also provides the dual benefit of providing an alternative supply of water in line with fit for use principles. Under the *Water Supply (Safety and Reliability) Act 2008*, this solution also constitutes 'demand management' by "substituting one water resource for another", effectively reducing the demand on potable water supplies.

There is currently an agricultural reuse scheme proposed to provide recycled water from the Caboolture South STP to a third party proponent who will supply the water to surrounding agricultural irrigators to the north of the CWMPA. Moodlu quarry (located to the north-east of the CWMPA, and owned by Seqwater) may be used as the storage reservoir for this scheme.

As the recycled water scheme is developed by Seqwater, it may be feasible to use recycled water within the CWMPA – particularly for open space irrigation and dual reticulation for light industrial area in the north-west of the CWMPA.

Following discussions with Unitywater and MBRC, it was agreed that the option of using recycled water for public open space irrigation and/ or discharge to land may be a potential option for the CWMPA to be explored in the future. However, this option will not be assessed further as part of this report given that it is dependent on the outcomes of future investigations by Seqwater.

5.5.3 Recommendation

This option may be feasible, but will not be considered further within this report given that it is dependent on the outcomes of future investigations by Seqwater.

5.6 Prevention of illegal stormwater connections to sewer

5.6.1 Description

Stormwater infrastructure (e.g. guttering/ pipework collecting runoff from roof areas) should be connected to the stormwater system, and it is illegal to connect stormwater infrastructure to the sewerage system. Nevertheless, illegal stormwater inflow connections to the sewerage system often occur.

The illegal connection of stormwater infrastructure to the sewerage system significantly increases the volume of water in the sewerage systems, which can result in the capacity of the network being exceeded. This can cause the network to overflow, resulting in environmental harm and creating risks to human health. Major capital expenditure is also required to mitigate this through the construction of larger pipes, pump stations and treatment plants.

5.6.2 Assessment

In this solution, increased activities would be undertaken to reduce the likelihood of illegal stormwater connections to sewer. These increase activities could include more inspections of new and existing infrastructure and could have multiple benefits (e.g. reduced sewage overflows/ flooding).

While this solution has been included as an option in a number of catchments in the MBRC region, it has not been quantified or assessed further in this section for the following reasons:

- The complexity of trying to quantify the effectiveness of programs to prevent illegal connections prohibits any meaningful assessment.
- Illegal connections predominantly impact on STP overflows, which were not accounted for in this investigation.
- Unitywater already have a policy in place to attempt to rectify this issue.

5.6.3 Recommendation

It is recommended that this solution is included as part of the final preferred management scenario.

As previously mentioned, Unitywater has a strategy in place currently to address illegal stormwater connections. This strategy, referred to as the 'Sewer Overflow Abatement Strategy', aims to minimise current and future illegal stormwater connections to sewer. As such, future development in the MBRC region will be scrutinised by Unitywater to ensure these illegal connections are prevented as much as practicable.

5.7 Waterway riparian revegetation

5.7.1 Description

The riparian zone for waterways is the interface between the waterway and adjacent land, and provides several functions critical to the health of waterways. These functions include water quality improvement (e.g. through filtration), habitat provision, reducing erosion, and flow attenuation. Anthropogenic pressures (e.g. development) can encroach into riparian areas and significantly reduce their benefits.

The condition of riparian vegetation along the banks of waterways has an important role in the stability of these banks. In areas where riparian vegetation is fully intact, waterway banks are stabilised by the root systems which provides some protection against erosive forces from the flow of water in the waterways.

Along with water quality benefits, riparian vegetation may also provide flood mitigation benefits. Revegetation of riparian areas in the upper catchment would improve flow attenuation which may lead to decreased flood levels in the lower catchment areas during large storm events.

Furthermore, this solution also provides valuable habitat and movement corridors for koalas and other fauna species.

The waterway riparian revegetation solution involves revegetation of waterways up to the Q100 flood boundary within the Caboolture West Urban Development Area.

It should be noted that the strategy was only assessed in areas of 'green space' and future 'rural residential' land uses.

5.7.2 Assessment

The extent of the revegetation areas are presented in Figure 5-7.

In areas where riparian vegetation is minimal and waterway banks are susceptible to erosive forces, revegetating these riparian areas would be expected to decrease the amount of sediment transported downstream by minimising stream bank erosion. To quantify the reduction in sediment loads as a result of riparian revegetation of all areas within the Q100 in the Caboolture West Urban Development Area, calculations of existing and future (i.e. revegetated) stream bank erosion were used. Appendix E describes the methodology applied to calculate the area of riparian revegetation required and the reduction in sediment loads as a result of implementing this solution.

The results of this assessment are summarised in Table 5-14.

Table 5-14 Waterway Riparian Revegetation Results for the CWMPA

Net Present Value ($2013)	Reduction in Pollutant Loads (kg/yr)			Levelised Cost ($/kg)		
	TSS	TP	TN	TSS	TP	TN
$20 400 000	1 935 000	-	-	$0.53	-	-

The estimated capital and operational costs of implementing this solution is detailed in Table 5-13.

Table 5-15 Capital and Operational Costs of Waterway Riparian Revegetation in the CWMPA

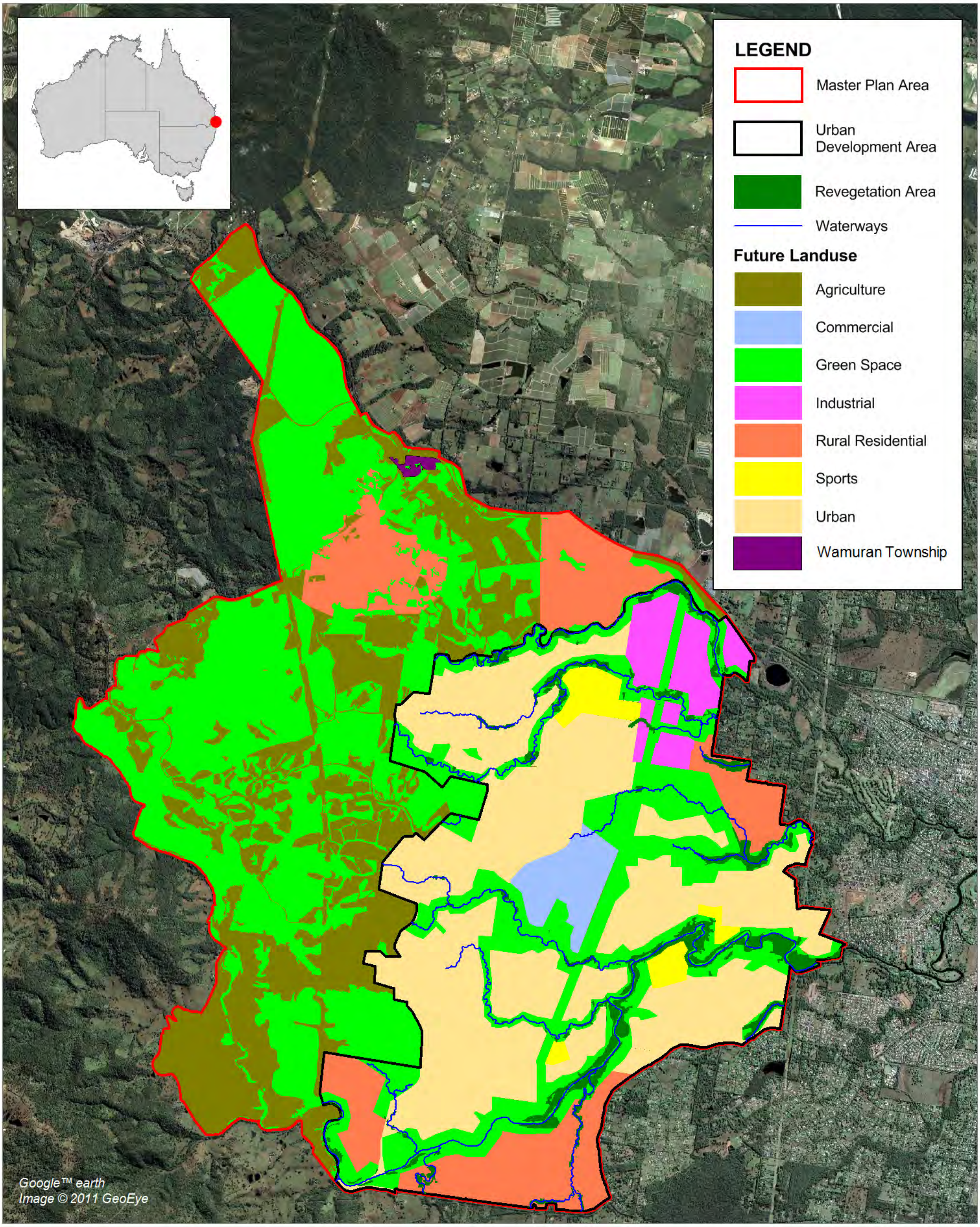
Solution	Capital Cost	Maintenance Cost per Annum
Waterway Riparian Revegetation	$20 400 000	-

The above results demonstrate that waterway riparian revegetation up to the Q100 flood boundary within the Caboolture West Urban Development Area will result in a significant decrease in sediment loads from the CWMPA. This solution also has a relatively low levelised cost (relative to the bioretention systems, wetlands and stormwater harvesting).

Previous flood modelling investigations have been undertaken to demonstrate the flooding benefits associated with the proposed revegetation of waterways within the Caboolture River catchment (BMT WBM (2012c), Sharpe (2012)). However, further investigations are recommended to quantify the flooding benefits associated with the proposed revegetation works – and (if appropriate) assess the flooding benefits associated with a range of revegetation scenarios (e.g. revegetating up to 30m from 'top of bank' only) to ensure the most appropriate extent and distribution of waterway riparian revegetation is identified.

5.7.3 Recommendation

It is recommended that this solution be implemented. It is, however, recommended that further investigations be undertaken to appropriately assess the flooding benefits of this solution – and confirm the recommended extent/ distribution of riparian revegetation.



Title:

Potential Riparian Revegetation Areas

Figure: **5-7**

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5.8 Increased implementation/ enforcement of erosion and sediment control on development sites

5.8.1 Description

Sediment laden-runoff from construction sites can have a major negative impact to waterway health and stormwater infrastructure. These impacts can be significantly mitigated through the implementation of appropriate erosion and sediment control (E&SC) management practices (e.g. minimising disturbance areas, buffer strips, mulch bunds).

In this solution, the implementation of appropriate E&SC management practices would be improved through capacity building initiatives (e.g. education to construction industry personnel) and enforcement of E&SC requirements (e.g. Council officers frequently inspecting construction sites and, where appropriate, providing appropriate education and/ or penalties in response to poor performance).

5.8.2 Assessment

Increased implementation of erosion and sediment control (E&SC) on development sites through increased enforcement was identified as a key management solution to address future impacts to water quality from large development areas within the Moreton Bay region. The effect of improved E&SC within the CWMPA has been further quantified below.

In order to assess the potential effectiveness of this management solution, the future developable area within the CWMPA over the planning period (2016 to 2056) was determined. The developable area was calculated to be the area of development within CWMPA less the areas already developed and the future land uses of ‘green space’ and ‘sport and recreation’. The total development area for the CWMPA was then divided by the time period under review (20 years) to identify the approximate annual development area.

Annual sediment load generation from development sites within each catchment were then estimated using eWater’s MUSIC software package. As E&SC measures targets coarse sediment, this solution was assumed not to provide any treatment of nutrients, which are typically associated with fine sediment. Results from an E&SC monitoring program within Brisbane City Council (BCC, 2000) were used to estimate event mean sediment concentrations from construction sites in MUSIC as follows:

- Baseflow: 25 mg/L; and
- Stormflow: 1,000 mg/L.

Taylor & Wong’s (2002) review of case studies found that strong enforcement of E&SC regulation (supported by town planning and education) could reduce Total Suspended Solids (TSS) generated from development sites by approximately 12-18% in the short term (<3 years) and 36-42% over a decade. This equates to an average annual sediment load reduction of 39% based on the 20 year time period of this project’s investigation.

The net present value of implementing this solution and an estimate of the levelised cost for TSS reduction is as follows:

Predicted performance results of implementing this solution during the construction phase are detailed provided in Table 5-16.

Table 5-16 Summary E&SC Results for the CWMPA

Net Present Value ($2013)	Reduction in Pollutant Loads (kg/yr)			Levelised Cost ($/kg)		
	TSS	TP	TN	TSS	TP	TN
$17 274	150 000	-	-	$0.01	-	-

The estimated capital and operational costs of implementing this solution is detailed in Table 5-17.

Table 5-17 Capital and Operational Costs of Implementing E&SC in the CWMPA

Scenario	Capital Cost NPV ($2013)	Maintenance Cost NPV ($2013)
Increased implementation/ enforcement of E&SC on building sits	-	$17 274

The above results demonstrate that the increased implementation of E&SC will result in a significant decrease in sediment loads from the CWMPA. This solution also has a relatively low levelised cost (relative to all other potential management options).

5.8.3 Recommendation

It is highly recommended that this solution is implemented to reduce the impact of future development on the health of downstream waterways.

It is recommended that MBRC undertake a review of the existing erosion and sediment control program to ensure the following key elements of a successful erosion and sediment control program are included (Taylor, 2003):

- Strong commitment from politicians and senior managers;
- A comprehensive educational program;
- A strong regulatory framework;
- Strategies to ensure MBRC own operations sets the standards for E&SC in the region;
- A strong enforcement program;
- An annual auditing program to measure on-the ground-performance and to identify barriers to further improvement;
- initiatives that provide an incentive for best practice and/ or innovative E&SC; and
- An effective administration system.

5.9 Education and capacity building to support implementation of solutions

5.9.1 Description

This solution relates to education and/or capacity building programs to promote water cycle management issues such as water efficiency, WSUD, and recycled water.

This solution could include:

- Implementation of community education campaigns to assist in preventing illegal stormwater connections to the sewer.
- Water Sensitive Urban Design (WSUD) demonstration sites for the community, private industry and Council.
- Educational signage regarding WSUD-related assets/ initiatives.
- Capacity building (e.g. for private industry, Council) for to augment the successful implementation of WSUD.
- Capacity building for Council staff on E&SC compliance and inspections.

5.9.2 Assessment

Education has significant potential to improve the appropriate management of water resources.

Due to the indeterminate nature of this solution, it has not been possible to quantify the effectiveness of implementing this solution. This solution would also be implemented to support other water cycle management solutions adopted. Therefore, the likely costs and benefits of this solution have not been quantified as part of this report.

5.9.3 Recommendation

Although this solution cannot be quantified at this stage, education and/ or capacity building is recommended to be included as part of the final preferred management scenario – as a supporting solution to all other recommended solutions. Education and/ or capacity building will play an integral role in ensuring water cycle management solutions are adopted fully and are effective.

5.10 Summary of Solutions

Table 5-18 and Table 5-19 provide a summary of each of the management options assessed for this project.

Table 5-18 Summary of Management Options Assessment

Management Option	Recommended ?	Net Present Value ($Million, 2013)	Reduction in Pollutant Loads (tonnes/year)			Levelised Cost ($/kg)		
			TSS	TP	TN	TSS	TP	TN
New Development to Satisfy Best Practice Stormwater Management Targets options:								
1. Bioretention without rainwater tanks	✓	155.1	3 305	4.1	20	2.0	1 621	321
2. Bioretention with rainwater tanks	x	133.5	3 289	4.2	21	2.0	1 609	316
3. Wetlands without rainwater tanks	x	543.2	3 175	4.8	21	8.6	5 650	1 270
4. Wetlands with rainwater tanks	x	483.1	3 124	4.9	22	7.7	4 940	1 080
Stormwater Harvesting	✓*	43.7	310	0.6	2.8	7.1	3 790	786
Sewer Mining for Public Open Space Irrigation &/ or discharge to land	x	-	-	-	-	-	-	-
Recycled Water Usage	Dependent on investigations by Seqwater	-	-	-	-	-	-	-
Prevention of Illegal Stormwater Connections to Sewer	✓	-	-	-	-	-	-	-
Waterway Riparian Revegetation	✓	20.4	1.9	-	-	0.53	-	-
Increased implementation/ enforcement of E&SC on development sites	✓	0.02	150	-	-	0.01	-	-
Education and Capacity Building to Support Implementation of Solutions	✓	-	-	-	-	-	-	-
Total of Recommended Solutions		**219.2**						

*Stormwater harvesting also provides an estimated 389 ML/year in potable water savings.

Table 5-19 Summary of Capital & Operational Costs of Management Options

Management Option	Recommended?	Capital Cost ($Million, 2013)	Annual Maintenance Cost ($Million, 2013)
New Development to Satisfy Best Practice Stormwater Management Targets options:			
1. Bioretention Systems without Rainwater Tanks	✓	140.2	2.3
2. Bioretention Systems with Rainwater Tanks		120.7**	2.0**
3. Wetlands without Rainwater Tanks		506.7	6.7
4. Wetlands with Rainwater Tanks		450.7**	5.9**
Stormwater Harvesting	✓	45.4	0.6
Sewer Mining for Public Open Space Irrigation and/ or discharge to land	×	-	-
Recycled Water usage	Dependent on investigations by Seqwater	-	-
Prevention of Illegal Stormwater Connections to Sewer	✓	-	-
Waterway Riparian Revegetation	✓	20.4	0
Increased implementation/ enforcement of E&SC on development sites	✓	-	0.02
Education and Capacity Building to Support Implementation of Solutions	✓	N/A	N/A
Total of Recommended Options		**149.1**	**2.5**

** This cost does not include the capital or operational costs associated with rainwater tanks.

6. Recommended Strategy

6 Recommended Strategy

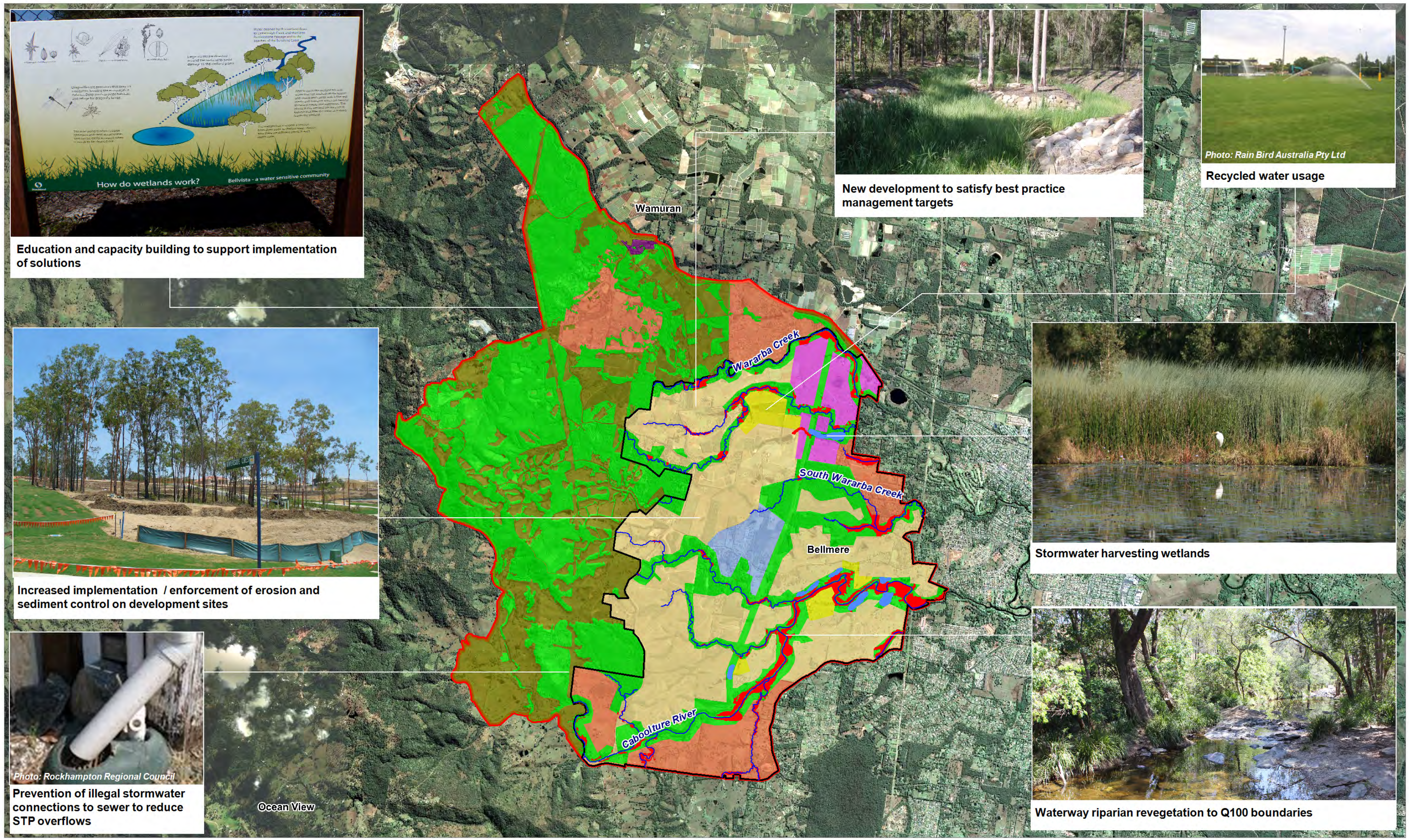
This section contains a summary of the recommended strategy, including a description of each management option. In addition, the section provides an assessment of the recommended strategy against both the sustainable loads target and the current scenario.

6.1 Summary of Recommended Strategy

Table 6-1 provides a summary of the proposed total water cycle management strategy for the CWMPA. Figure 6-1 illustrates a concept plan of the proposed recommended strategy.

Table 6-1 Summary of Recommended Strategy

Management Option	Description
New development to satisfy best practice stormwater management targets	New development (greater than 2500m^2 that results in an impervious area greater than 25% of the net developable area or 6 or more dwellings) within the CWMPA will be required to achieve stormwater management objectives outlined in the *State Planning Policy*. It is recommended that this generally be achieved through the integration of 'at source' (or distributed) treatment systems.
Stormwater harvesting	Four regional sporting fields in the CWMPA could be irrigated using stormwater harvested from constructed stormwater treatment wetlands. Other sites should be investigated further.
Recycled water usage	Recycled water could be utilised to supply/ supplement open space irrigation requirements and other non-potable usages (e.g. industrial applications). This option is, however, dependent on the outcomes of future investigations by Seqwater.
Prevention of illegal stormwater connections to sewer	Unitywater has a strategy in place currently to address illegal stormwater connections. This strategy, referred to as the 'Sewer Overflow Abatement Strategy', aims to minimise current and future illegal stormwater connections to sewer. As such, future development in the MBRC region will be scrutinised by Unitywater to ensure these illegal connections are prevented as much as practicable.
Waterway riparian revegetation	It is recommended that this solution be implemented. It is, however, recommended that further investigations be undertaken to appropriately assess the flooding benefits of this solution – and confirm the recommended extent/ distribution of riparian revegetation.
Increased implementation/ enforcement of erosion and sediment control on development sites	It is highly recommended that this solution is implemented to reduce the impact of future development on the health of downstream waterways. It is also recommended that MBRC undertake a review of the existing erosion and sediment control program to ensure the key elements of a successful erosion and sediment control program are included.
Education and capacity building to support implementation of solutions	It is recommended that stakeholders (e.g. residents, businesses, land-owners) receive education (and/ or other capacity building) about existing and/ or planned schemes to encourage the implementation of TWCM principles.



LEGEND

- Master Plan Area
- Urban Development Area
- Potential Stormwater Harvesting Wetlands
- Revegetation
- Waterways

Future Land Use

- Agriculture
- Commercial
- Green Space
- Industrial
- Rural Residential
- Sports
- Township
- Urban

Aerial Imagery: Image Google™ earth Image © 2011 GeoEye

Title:
Concept Plan of Recommended Strategy for the Caboolture West Master Planned Area

Figure: **6-1**

Rev: **A**

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6.2 Sustainable Loads Assessment

An important component in assessing the recommended management scenario is to determine the sustainable load targets for receiving waters. Sustainable load targets provide an indication of the capacity of receiving waters to assimilate pollutant loads without adversely impacting on aquatic ecosystems. The target refers to the quantity (tonnes/year) of catchment pollutant loads able to discharge into receiving waters without causing concentrations of those pollutants to exceed water quality objectives (WQOs).

In previous work undertaken as part of the *"Total Water Cycle Management Plan for Moreton Bay Regional Council"* (BMT WBM, 2012a), the pre-European condition for the CWMPA was adopted as the sustainable load target for the CWMPA. For this report the sustainable load target for the CWMPA was calculated using eWater's MUSIC software (version 5.1) with the results presented in Table 6-2.

To determine what the catchment conditions would be like in 2056 without any effort to implement management measures, a future scenario was developed and referred to as the 'Future Case (2056) with no stormwater management'. Using the results from the 'Future Case (2056) with no stormwater management', the pollutant load reduction required to meet the sustainable load target was determined.

Table 6-2 presents the existing and future pollutant loads in the CWMPA, along with the load reductions required to meet sustainable loads. Also included are the load reductions required to maintain pollutant loads at existing levels, or a 'no worsening' scenario. It is noted that pollutant loads from an STP treating wastewater from the CWMPA have not been included in the prediction of the future loads as these loads are expected to occur outside the CWMPA. Pre-European existing, future and the future scenario (with the recommended management strategy) pollutant loads and flows are also presented in Figure 6-2.

Table 6-2 Load Reductions Required to Meet Targets

Pollutant	Sustainable Load Target	Existing Condition	Future Case (2056) with No Stormwater Management	Load Reduction Required	
				For 'No Worsening' from Existing	For Sustainable Load Target
TSS (tonnes/year)	1 200	6 900	6 300	-600	5,100
TP (tonnes/year)	1.2	7.1	9.4	2.3	8.2
TN (tonnes/year)	14	48	62	14	48
Flow (ML/year)	14 100	22 100	29 600	-	-

It should be noted that existing TSS loads are more than in the 'Future Case (2056) with no stormwater management' scenario. This is a result of using the existing land use mapping from *MBRC Regional Floodplain Database* (SKM, 2010). However, a large proportion of existing land use that has been classified as 'agricultural' land is not actively used for agricultural purposes (Peter Rawlinson, MBRC, *Pers. Comm*.: 22 October 2013). Nevertheless, the results are still useful as a guide to decision making.

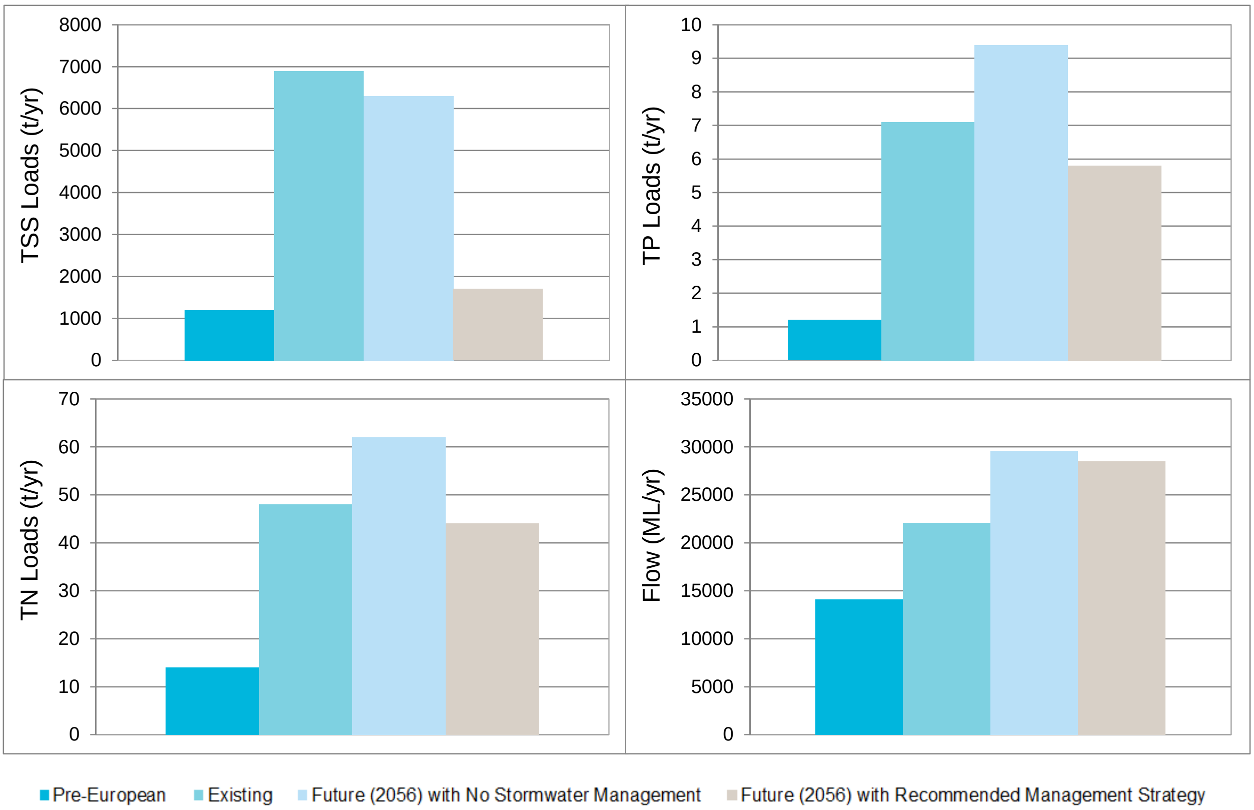


Figure 6-2 Pre-European, Existing, Future and Future with Recommended Strategy Pollutant Loads from CWMPA

As can be seen in Figure 6-2 the future scenario with the recommended strategy does not meet the sustainable load target for TSS, TP or TN. However, the no worsening targets for TSS, TP and TN are met. Flow volumes also increase as a result of development in the CWMPA as a result of increased hard surfaces in the catchment and these are only marginally reduced with the implementation of the recommended management strategy.

By incorporating rainwater tanks throughout the CWMPA, the flow volumes would be further reduced – in addition to providing a significant reduction in the potable water demand for the CWMPA (as highlighted in the water balance figures provided in Appendix B). Although the provision of rainwater tanks are predicted to provide significant benefits, at the time of report writing, MBRC will not be mandating their requirement for new development within the CWMPA.

6.3 Environmental Flow Assessment

In this section we use the results of MUSIC modelling to explore the hydrological changes associated with urbanisation in the CWMPA. This information can then be used to inform environmental flow management actions to ensure the waterways within the CWMPA retain a more natural hydrology.

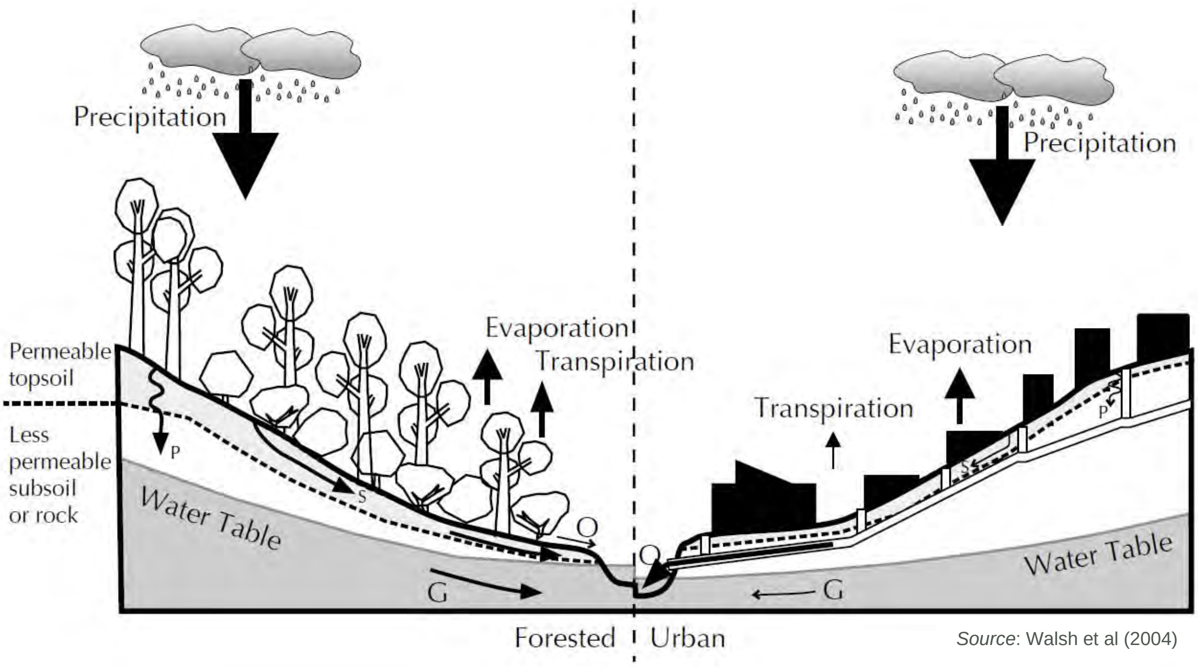
The science of 'environmental flows' has recently been expanded to consider changes to flow regimes resulting from land use change, including urbanisation. For example, Poff et al. (2010) has developed an approach which initially involves developing an understanding of the natural hydrology and exploring the subsequent changes post development, then relating these hydrological changes to associated changes to in-stream ecological health.

The impact of urbanisation on hydrology has been well documented with urbanisation affecting nearly every component of the water cycle (refer to

Figure 6-3), including:

- Reduction in infiltration due to increased impervious areas
- Reduction in evapotranspiration due to both diminished vegetation cover and lower soil moisture
- An increase in runoff from the increased impervious areas.

Another key change to the waterway is the increased frequency of events resulting from urbanisation. Recent research has demonstrated that design objectives directed more at reducing the frequency of flow disturbance are more effective at protecting the in-stream ecological health than other factors (Walsh et al., 2009). It is for this reason that the number of surface runoff days (or frequency of events) was analysed for the CWMPA.



Source: Walsh et al (2004)

Figure 6-3 Changes in Water Cycle Due to Urbanisation

The runoff volume and runoff frequency for five scenarios were assessed, including:

- Pre-European;
- Existing;
- Future (2056) with no stormwater management;
- Future (2056) with bioretention basins only; and

- Future (2056) with bioretention basins and rainwater tanks.

It should be noted that the rainwater tanks were assumed to capture only 50% of urban residential roof area and 100% of commercial and light industrial roof area.

The results of the assessment are illustrated in Figure 6-4.

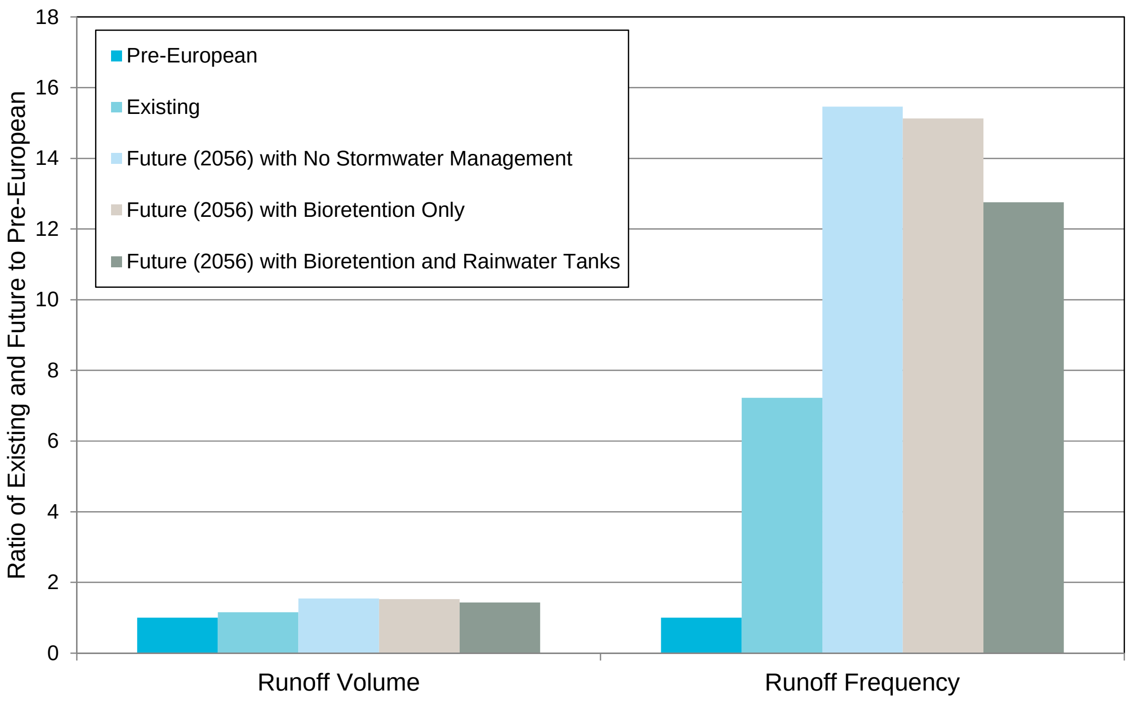


Figure 6-4 Changes to Runoff Volume and Frequency as a Result of the Proposed Development and Impact of Including Rainwater Tanks

The results of the analysis indicate that for the CWMPA area the number of surface runoff days was 1.8 (or 2) runoff day/year for the pre-European scenario. The frequency of disturbance to the waterway as a result of the future proposed development is estimated to increase the number of runoff days by just over 15 times the number of runoff days of the pre-European scenario. With the inclusion of rainwater tanks into the future TWCM strategy the frequency of disturbance is reduced to approximately 12 times that of the pre-European scenario.

The results demonstrate that through the implementation rainwater tanks, the runoff frequency would be reduced. Although it would not not reduced to the frequency of the pre-European scenario, it should be noted that the scenario assumes that only a portion of the roof area (50% for residential lots, and 100% for commercial and light industrial lots) would be directed to a rainwater tank for subsequent resuse. With a greater proportion of the roof area from residential lots diverted to a rainwater tank, the runoff frequency would be expected to decrease further.

Work previously undertaken in Victoria by Walsh and Kunapo (2009) has shown that the frequency of runoff will increase even when the level of ‘directly connected’ imperviousness (i.e. the proportion of area across the site where runoff from impervious areas is not intercepted and harvested for reuse, evapotranspired, infiltrated and/ or treated needs) is as low as 1%

6.4 Potential Implementation Pathways

Potential implementation pathways of the recommended strategy are outlined in Table 6-3.

Table 6-3 Potential Implementation Pathways of Preferred Management Scenario

Management option	Primary Responsibility	Notes on Implementation Pathway
New development to satisfy best practice stormwater management targets	MBRC, Developers	This is a legislative requirement. To ensure compliance, MBRC should include provisions in its local planning scheme and ensure development approvals are only granted where it can be demonstrated that they comply with these requirements. Developers would be responsible for stormwater management measures until (if appropriate) they are 'handed over' to MBRC.
Stormwater harvesting	MBRC	This could be implemented via Council's Planning Scheme and Priority Infrastructure Plan.
Prevention of illegal stormwater connections to sewer	Unitywater	Investigate a change in design standards to one way valve (at overflow points) to prevent inflows. Implement community education campaigns to assist in preventing illegal connections. Additional staff may be needed for compliance inspect ions and follow up notices of illegal connections. These actions should be investigated in conjunction with Unitywater's Sewer Overflow Abatement Strategy.
Waterway riparian revegetation	MBRC	This could be implemented via Council's Planning Scheme and Priority Infrastructure Plan. Opportunity exists to undertake this in partnership with community groups and local residents (schools, etc.).
Increased implementation/ enforcement of erosion and sediment control on development sites	MBRC	MBRC would be responsible for ensuring this is implemented through internal policies. It would involve a review of the existing erosion and sediment control program to ensure the key elements of a successful erosion and sediment control program are included and dedicating more time to Council staff for on-site compliance inspections.
Education and capacity building to support implementation of solutions	MBRC, Unitywater	This would be needed both within Council/Unitywater as well as in the general community to aid in successful implementation of solutions. For example: • WSUD demonstration sites for community/developers /consultants • Signage educating community about WSUD elements in CWMPA • Information packages educating community on WSUD and illegal stormwater connections to sewer with purchase of property • Capacity building for Council DA staff on WSUD requirements • Capacity building for Council staff on E&SC compliance and inspections

7. Conclusion

7 Conclusion

This report has assessed a range of management options for the Total Water Cycle Management Plan for the CWMPA. As part of our assessment, we have provided a detailed description of each option, modelling to determine the pollutant load reduction and/ or potable water saved and advice in relation to whether the management option is recommended.

Cost estimates of both the capital and maintenance costs associated with the recommended management options along with a conceptual layout plan of the recommended strategy is also included.

The eight management options assessed as part of this report included:

1. New development to satisfy best practice stormwater management targets;
2. Stormwater harvesting;
3. Sewer mining for public open space irrigation and/ or discharge to land;
4. Recycled water usage;
5. Prevention of illegal stormwater connections to sewer to reduce sewage overflows;
6. Waterway riparian revegetation;
7. Increased implementation / enforcement of erosion and sediment control on development sites; and
8. Education and capacity building to support implementation of solutions.

This report also highlighted the benefits of incorporating rainwater tanks into the CWMPA.

Based on this assessment, several of the management options have been recommended for implementation. The findings from this report will be presented to the Council and, if endorsed; the recommended management options will be considered in a revised version of MBRC's Total Water Cycle Management Implementation Plan.

8 References

Australian Bureau of Statistics, 2010. *Water Use on Australian Farms, 2008-09* (cat. No. 4618.0).http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1318.3Feature%20Article13Oct%202008

BMT WBM (2010a). *Total Water Cycle Management Strategy for Moreton Bay Regional Council*.

BMT WBM (2010b). *The Children's Hospital at Westmead – Alternative Water Supply for Irrigation Report*

BMT WBM (2012a). *Total Water Cycle Management Plan for Moreton Bay Regional Council*.

BMT WBM (2012b). *Sub Regional Total Water Cycle Management Plan for the Caboolture Identified Growth Area*.

BMT WBM (2012c). *Regional Floodplain Database Hydrologic and Hydraulic Modelling Caboolture (CAB)*.

BMT WBM (2012d). *Update and rerun of the Caboolture River Model, Regional Floodplain Database*.

BMT WBM (2013). *Moreton Bay Regional Council Total Water Cycle Management Implementation Plan*.

Clearwater (2013), *Resource Library – Case Studies*, viewed 18 December 2013, http://www.clearwater.asn.au/resource-library/case-studies/

Crocetti, A. (2013) Alternative Water Harvesting Systems, *16th International River Symposium Proceedings*, 23-26 September, Brisbane, Queensland.

CSIRO. (2007). *Climate Change in Australia: Technical Report 2007*. Melbourne: Commonwealth Scientific and Industrial Research Organisation.

Department of Environment and Natural Resources (DERM) (2009*). Environmental Protection (Water) Policy 2009*. Queensland Government.

Department of Infrastructure and Planning (DIP) (2009). *South East Queensland Regional Plan 2009-2031 (SEQ Regional Plan). Queensland Government*.

Department of Natural Resources, Mines & Energy (DNRM&E) (2006). *South East Queensland Regional Water Security Program. Queensland Government*.

Department of State Development, Infrastructure and Planning (2013). *State Planning Policy*, December 2013, Queensland Government.

Fane, S. et al (2002). *The Use of Levelised Cost in Comparing Supply and Demand Side Options.* Water Supply Vol 3 No 3 pp185-192, IWA Publising.

Fane, S. and White, S. (2003). *Levelised Cost, a General Formula for Calculations of Unit Cost in Integrated Resource Planning.*

Healthy Waterways. (2007). *South East Queensland Healthy Waterways Strategy, 2007-2012.*

Mackay City Council (2008*). Engineering Design Guidelines: Constructed Lakes*. Planning Scheme Policy No. 15.15

Moreton Bay Regional Council (2013a). *Caboolture West – Agricultural Land and Production Report,* June 2013.

Moreton Bay Regional Council (2013b). *Caboolture West – Existing Conditions Report,* October 2013.

Moreton Bay Regional Council (2013c). *Caboolture West – Strategic Cropping Land Assessment,* October 2013*.*

MWH (2013). *Caboolture West Ultimate Water Supply and Sewerage Infrastructure Plans, Prepared for Unitywater*.

NSW Government (2013) *Water Recycling Projects*, Metropolitan Water Directorate, viewed 18 December 2013, http://www.waterforlife.nsw.gov.au/recycling/browse

Philp, M. McMahon, J. Heyenga, S., Marinoni, O., Jenkins, G., Maheelpala, S., Greenway, M. (2008). *Review of Stormwater Practices*, Urban Water Security Research Alliance Technical Report No. 9, Brisbane, Queensland.

Poff, N.L., Richter, B. D., Arthington, A. H., Bunn, S. E., Naiman, R. J., Kendy, E., Acreman, M., Apse, C., Bledsoe, B. P., Freeman, M. C., Henriksen, J., Jacobson, R. B., Kennen, J. G., Merritt, D. M., O'Keeffe, J. H., Olden, J. D., Rogers, K., Tharme, R. E. and Warner, A. (2010), *The ecological limits of hydrologic alteration (ELOHA): a new framework for developing regional environmental flow standards*. Freshwater Biology, 55: 147–170.

Queensland Government. (2010). *Queensland Development Codes MP 4.2 & 4.3.* Brisbane: Queensland Government.

Queensland Government (2009)*. South East Queensland Natural Resource Management Plan, 2009-2031,* Brisbane: Queensland Government.

Queensland Government (2007). *Water Resource (Moreton) Plan 2007*.

Queensland Water Commission (QWC) (2010). *Framework to Prepare Sub-regional Total Water Cycle Management Plans*.

Queensland Water Commission (QWC) (2009). *South East Queensland Water Strategy (SEQ Water Strategy). Queensland Government*.

SEQ Healthy Waterways Partnership (2007). *Constructed Waterbodies in Urban Areas of South East Queensland: Maintenance Issues and Costs to Local Governments, Version 1.0*.

Sharpe, R. (2012). *Back to Nature – Can revegetation of riparian zones reduce flood risks*. Presented at the Stormwater Industry Association of Queensland conference, Brisbane.

SKM (2010). *MBRC Regional Floodplain Database – Existing, Historic and Future Floodplain Land Use*.

Taylor, A and Wong, T. (2002). *Non-Structural Stormwater Quality Best Management Practices - A Literature Review Of Their Value And Life-Cycle Costs*. CRCCH Technical Report 02/13. Cooperative Research Centre for Catchment Hydrology, Melbourne.

UnityWater (2013). *New Pricing Structure for Community and Sporting Groups*. http://unitywater.com/Contact-us/Community-and-sporting-groups.aspx

Walsh, C.J. and Kunapo, J. (2009). *The importance of upland flow paths in determining urban effects on stream ecosystems*. Journal of the North American Benthological Society, 28 (977-990).

Walsh C. J., Leonard A. W., Ladson A. R., and Fletcher T. D. (2004). *Urban Stormwater and the Ecology of Streams*. CRC for Freshwater Ecology and CRC for Catchment Hydrology (Melbourne).

Water by Design, 2009. *Draft Stormwater Harvesting Guidelines*, South East Queensland Healthy Waterways Partnership

Water by Design. (2010a). *MUSIC Modelling Guidelines*. South East Queensland Healthy Waterways Partnership.

Water by Design (2010b). *A Business Case for Best Practice Urban Stormwater Management: Case Study Report (Version 1.1)*. South East Queensland Healthy Waterways Partnership, Brisbane.

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Appendices

Appendix A MUSIC Modelling

This appendix provides a summary of the MUSIC modelling undertaken for this project.

A.1 Objectives

Modelling was undertaken to achieve the following objectives:

- Provide an estimate of the stormwater flow and pollutant export rates from the existing and future land uses.
- Investigate the performance of various stormwater treatment systems applicable to the CWMPA.

A.2 Software

The performance of possible stormwater treatment strategies in managing stormwater pollutants has been assessed using the MUSIC software package (Version 5.1) developed by the CRC for Catchment Hydrology and now supported by the eWater CRC. MUSIC is well suited to the assessments required for this study, i.e. prediction of annual discharge loads of total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS). The software has been specifically designed to allow comparisons to be made between different stormwater management systems and thereby function as a decision support tool.

A.3 Meteorological Data

In accordance with Water by Design's (2010a) "*MUSIC Modelling Guidelines*", MUSIC modelling was undertaken using meteorological data from the Bureau of Meteorology weather station at the Dayboro Post Office (Station No. 4063) for a period of ten years (from 1 January 1980 to 31 December 1989) at 6-minute time steps. Average potential evapotranspiration data has been obtained from Water by Design (2010a).

A.4 Source Nodes

Within MUSIC, the different land-usage classifications (and hence pollutant generating properties) of the study site are represented by source nodes. For this study, the properties of the source nodes were determined using Water by Design (2010a). A summary of the source node properties is provided in Table A-1.

The approximate distribution of existing and future land-usage proportions for the study area was determined using mapping and plans provided by Moreton Bay Regional Council, and aerial photographs of the existing study area. The existing and future land usage distributions are shown in Figure 3-11 and Figure 3-12 respectively. A summary of the existing and future land usage within the study area is presented in Table A-2.

Table A-1 Land Use Proportions for the Study Area

Land Use Description	Water by Design (2010a) Rainfall-Runoff Classification	Impervious Percentage	Water by Design (2010a) Pollutant Export Parameters Classification
Wamuran Township	*Urban Residential*	55%	Lumped Catchment – *Urban Residential*
Agriculture	*Rural Residential*	2%	Lumped Catchment – *Agriculture*
Urban	*Urban Residential (20 dwellings/ha)*	62%	Lumped Catchment – *Urban Residential*
Rural Residential	*Rural Residential*	10%	Lumped Catchment – *Rural Residential*
Sports Fields	*Urban Residential*	10%	Lumped Catchment – *Urban Residential*
Commercial	*Commercial and Industrial*	90%	Lumped Catchment - *Commercial*
Industrial	*Commercial and Industrial*	90%	Lumped Catchment – *Industrial*
Open Space	*Forested*	0%	Lumped Catchment - *Forest*

Table A-2 Land Use Distribution for the Existing and Future Study Area

Land Use Description	Existing Area (ha)	Future Area (ha)
Wamuran Township	10	10
Agriculture	3370	1180
Urban	-	1476
Rural Residential	336	685
Sports Fields	-	89
Commercial	-	107
Industrial	-	161
Green Space	2713	2721

The rainfall-runoff process is largely dependent on the impervious fraction of the catchment, with an increase in imperviousness from urban development leading to an increase in rainfall-runoff and associated pollutant export. The distribution of imperviousness in the study area for the existing and future landuse is presented in Figure A-2 and Figure A-3 respectively.

A.5 Subcatchment Layout

The study area was divided into 13 subcatchments, which were sized to represent approximately 200 to 300ha of future development area. The subcatchment layout is presented in Figure A-4.

A.6 Stormwater Treatment Devices

MUSIC has a number of generic treatment nodes including bioretention systems, rainwater tanks and wetlands. Each treatment node has several default parameters which can be altered by the user to allow the treatment device to be 'customised' to better represent the treatment device that would ultimately be installed.

Section 5.2.1 provides a description of these devices (and their potential application to this project).

The following sections provide parameter values applied in the modelling of these devices for this project.

A.6.1 Bioretention Systems

The modelling properties of bioretention systems used in this study are shown in Table A-3.

Table A-3 Assumed Properties for the Bioretention Systems

Parameter	Value
Extended Detention Depth	0.20 m
Saturated Hydraulic Conductivity	200 mm/hour
Filter Depth	0.40 m
Submerged Zone Depth	0.0 m
Surface Area / Filter Area Ratio	1.0
Overflow Weir Width	10% of Filter Surface Area
TN Content of Filter Media	800 mg/kg
Orthophosphate Content of Filter Media	50.0 mg/kg
Vegetation Properties	Effective Vegetation with Nutrient Removal Plants
Exfiltration Rate	0.00 mm/hr

Figure A-1 provides a conceptual cross section of a bioretention system, illustrating the modelled properties applied for this project.

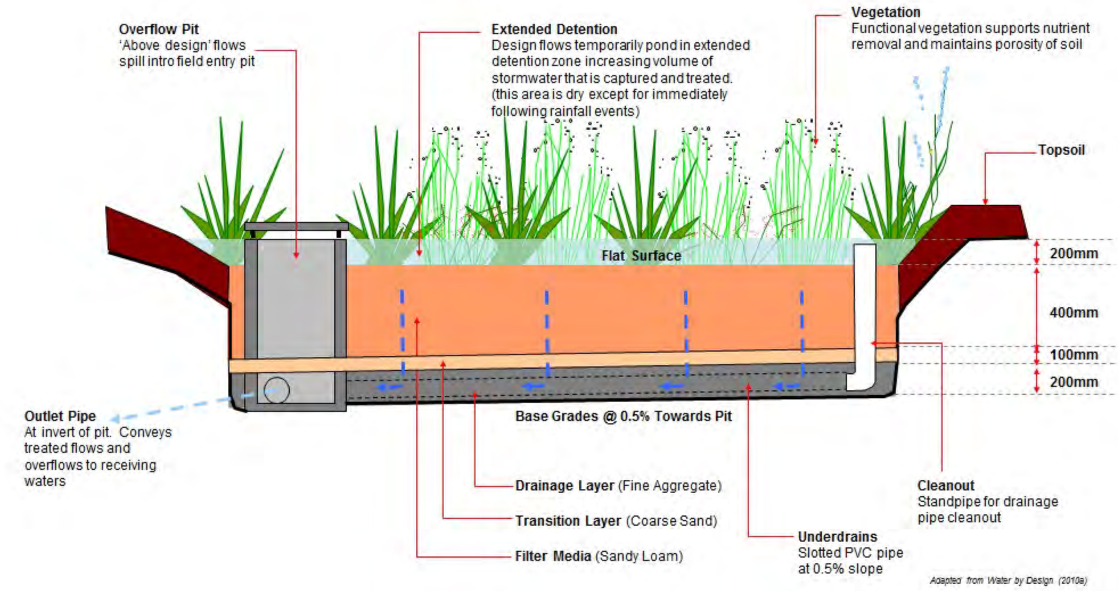


Figure A-1 Conceptual Cross Section of Assumed Bioretention Properties

A.6.2 Rainwater Tanks

For this project, it has been assumed that each lot in the urban residential areas with a rainwater tank will have 50% of the roof area draining to a 5kL tank.

For the commercial areas with rainwater tanks, it has been assumed that 100% of the roof area will drain to a tank with a volume equal to 1500 litres per 50 m^2 of roof area. This assumption is based on the requirements outlined in the Queensland Development Code MP 4.3 (Queensland Government, 2010) for 'small buildings'.

Where rainwater tanks are to be installed, the modelling has assumed that roof runoff will be harvested and used to supplement non-potable internal water demands (e.g. toilet and laundry) and irrigation demands. In the absence of water demand data for the 'commercial' and 'community areas, water demands have been based on the residential water demands given in Water By Design (2010a).

Irrigation rates have been calculated using the same methodology as applied to residential areas (i.e. 548mm/year scaled by daily PET minus rain – applied to 70% of all pervious ground level area). Applied internal water demands have been estimated by dividing the roof area by 250m^2 (typical roof area for a residential lot) and multiplying this by the estimated average internal water demand for a typical residential lot.

It should be highlighted that further investigations are required to more accurately predict the potential likely rainwater tank volume requirements and water demands for the commercial areas as the applied estimations should be considered preliminary only.

A.6.3 Wetlands

The modelling properties used for the wetlands in this study are outlined in Table A-4.

Table A-4 Assumed Modelling Properties for the Stormwater Wetlands

Parameter	Value
Inlet Pond Depth	1.5m
Inlet Pond Area	5% of the Wetland Surface Area
Extended Detention Depth	0.5 m
Exfiltration Rate	0.0 mm/hour
Evaporative Loss as % PET	125
Overflow Weir Width	10% of the Wetland Surface Area
Notional Detention Time	48 hours

A.7 Modelling Results

A.7.1 Flow and Pollutant Export

Using the MUSIC generated stormwater flows and loads the mean annual flow and pollution export concentration per hectare for each different land usage was calculated. These flows and loads are shown in the Table A-5.

Table A-5 Flow and Pollution Export Concentration for each Land Usage

Land Use Description	Flow (ML/ha/year)	TSS (kg/ha/year)	TP (kg/ha/year)	TN (kg/ha/year)	Gross Pollutants (kg/ha/year)
Wamuran Township	7.9	1 760	3.3	16.6	194
Agriculture	4.3	1 770	1.7	8.9	7
Urban	8.3	1 710	3.8	17.7	204
Rural Residential	4.9	1 430	1.8	12.9	58
Sports Fields	5.1	994	2.1	10.3	100
Commercial	11.0	2 220	5.9	35.5	249
Industrial	11.0	1 410	3.9	27.1	249
Open Space	3.5	214	0.2	2.3	0

Using GIS software, these flows and loads were also used to produce flow and pollution export concentration thematic maps of the study area for the existing and future land uses. These maps are presented in Figure A-5 to Figure A-14.

A.7.2 Stormwater Treatment Area Requirements

Table A-6 through to Table A-9 provides details regarding the treatment area required for bioretention areas and wetlands by land use for each subcatchment. to achieve the *State Planning Policy* Best Practice Targets.

Table A-6 Bioretention Area Requirements for Each Land Use (without rainwater tanks)

Subcatchment	Area of bioretention required for each land use (ha)					Total
	Urban	Rural Res	Commercial	Industrial	Sport & Rec	
S1	0.0	0.0	0.0	0.0	0.0	0.0
S2	3.1	0.0	0.0	0.0	0.2	3.3
S3	1.0	0.4	0.0	1.4	0.5	3.2
S4	2.3	0.3	0.7	0.1	0.0	3.5
S5	1.9	0.5	0.3	0.0	0.0	2.8
S6	2.4	0.0	0.4	0.0	0.0	2.7
S7	4.2	0.0	0.0	0.0	0.1	4.3
S8	2.1	0.0	0.0	0.0	0.4	2.5
S9	0.4	0.0	0.0	1.4	0.0	1.8
S10	1.2	1.9	0.0	0.0	0.0	3.1
S11	1.6	2.4	0.0	0.0	0.0	4.1
S12	0.0	0.0	0.0	0.0	0.0	0.0
S13	0.4	0.0	0.0	0.0	0.0	0.4

Table A-7 Bioretention Area Requirements for Each Land Use (with rainwater tanks)

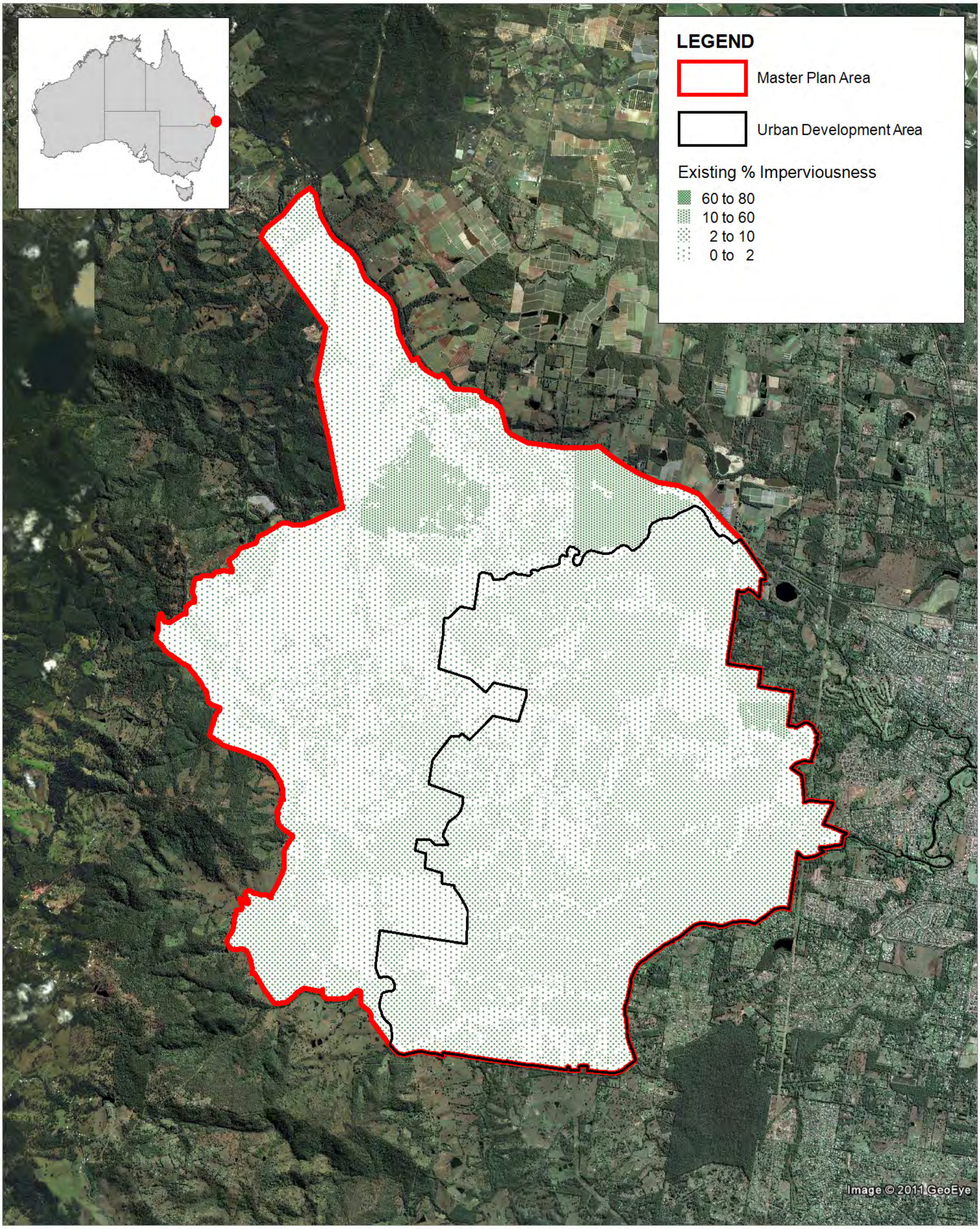
Subcatchment	Area of bioretention required for each land use (ha)					Total
	Urban	Rural Res	Commercial	Industrial	Sport & Rec	
S1	0.0	0.0	0.0	0.0	0.0	0.0
S2	2.2	0.0	0.0	0.0	0.2	2.4
S3	0.7	0.4	0.0	1.4	0.5	3.0
S4	1.6	0.3	0.7	0.1	0.0	2.8
S5	1.4	0.5	0.3	0.0	0.0	2.2
S6	1.7	0.0	0.3	0.0	0.0	2.0
S7	3.0	0.0	0.0	0.0	0.1	3.1
S8	1.5	0.0	0.0	0.0	0.4	1.9
S9	0.3	0.0	0.0	1.4	0.0	1.7
S10	0.9	1.9	0.0	0.0	0.0	2.8
S11	1.1	2.4	0.0	0.0	0.0	3.6
S12	0.0	0.0	0.0	0.0	0.0	0.0
S13	0.3	0.0	0.0	0.0	0.0	0.3

Table A-8 Wetland Area Requirements for Each Land Use (without rainwater tanks)

Subcatchment	Wetland Area required for each land use (ha)					Total
	Urban	Rural Res	Commercial	Industrial	Sport & Rec	
S1	0.0	0.0	0.0	0.0	0.0	0.0
S2	22.2	0.0	0.0	0.0	1.5	23.7
S3	6.9	2.1	0.0	6.2	3.5	18.7
S4	16.4	1.8	4.6	0.4	0.0	23.2
S5	13.9	2.8	1.8	0.0	0.0	18.5
S6	16.9	0.0	2.2	0.0	0.0	19.1
S7	30.2	0.0	0.0	0.0	0.6	30.8
S8	15.0	0.0	0.0	0.0	2.9	17.9
S9	3.1	0.0	0.0	6.3	0.0	9.4
S10	8.7	10.3	0.0	0.0	0.0	19.0
S11	11.4	13.0	0.0	0.0	0.4	24.8
S12	0.0	0.0	0.0	0.0	0.0	0.0
S13	2.9	0.0	0.0	0.0	0.0	2.9

Table A-9 Wetland Area Requirements for Each Land Use (with rainwater tanks)

Subcatchment	Wetland Area required for each land use (ha)					Total
	Urban	Rural Res	Commercial	Industrial	Sport & Rec	
S1	0.0	0.0	0.0	0.0	0.0	0.0
S2	17.8	0.0	0.0	0.0	1.5	19.3
S3	5.5	2.1	0.0	6.2	3.5	17.3
S4	13.1	1.8	4.6	0.4	0.0	19.9
S5	11.1	2.8	1.8	0.0	0.0	15.7
S6	13.5	0.0	2.2	0.0	0.0	15.7
S7	24.2	0.0	0.0	0.0	0.6	24.8
S8	12.0	0.0	0.0	0.0	2.9	14.9
S9	2.5	0.0	0.0	6.3	0.0	8.7
S10	7.0	10.3	0.0	0.0	0.0	17.2
S11	9.1	13.0	0.0	0.0	0.4	22.5
S12	0.0	0.0	0.0	0.0	0.0	0.0
S13	2.3	0.0	0.0	0.0	0.0	2.3



Title:

Assumed Imperviousness within the Existing CWMPA

Figure: A-2

Rev: B

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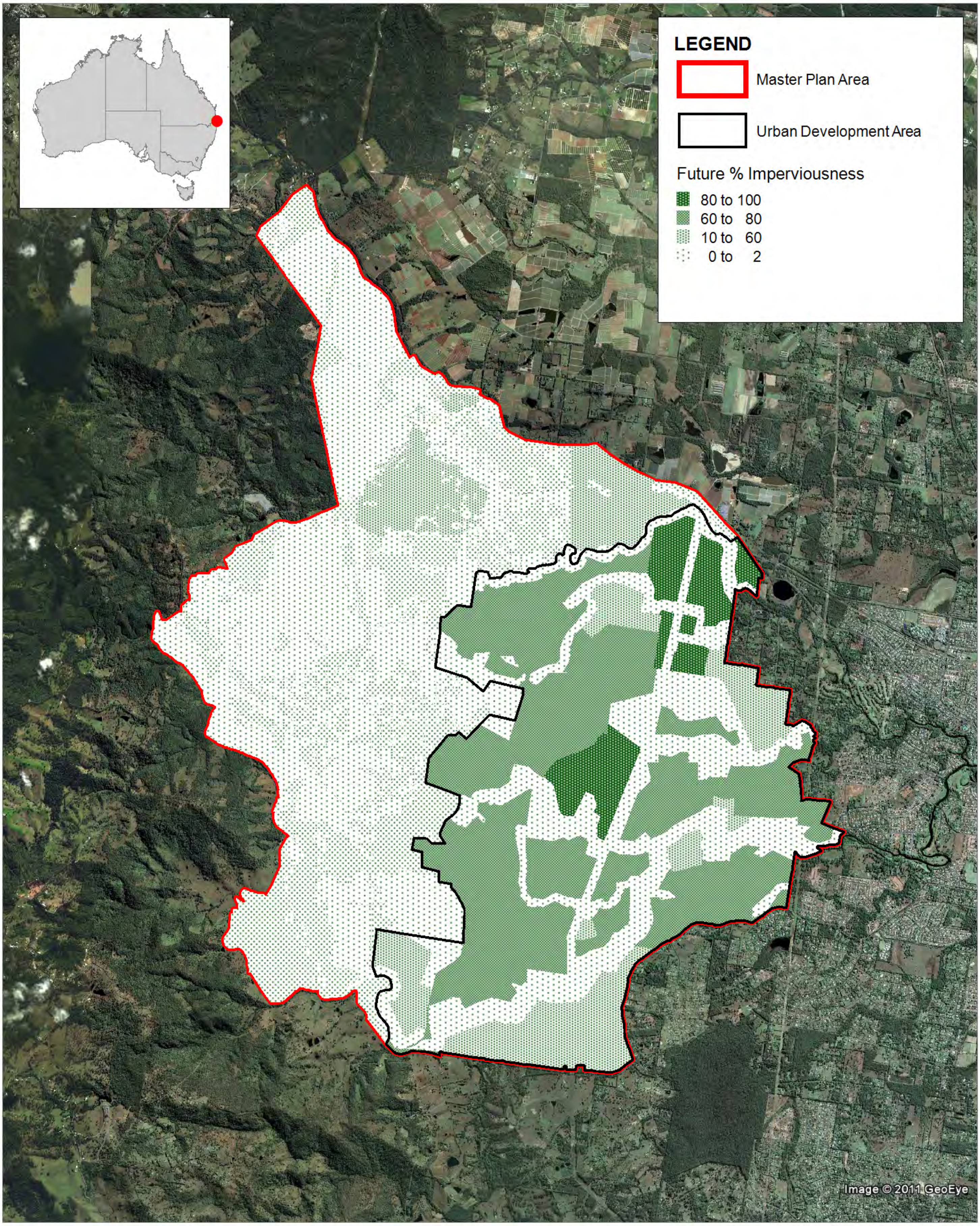

Title:

Assumed Imperviousness within the Future (2056) CWMPA

Figure: **A-3**

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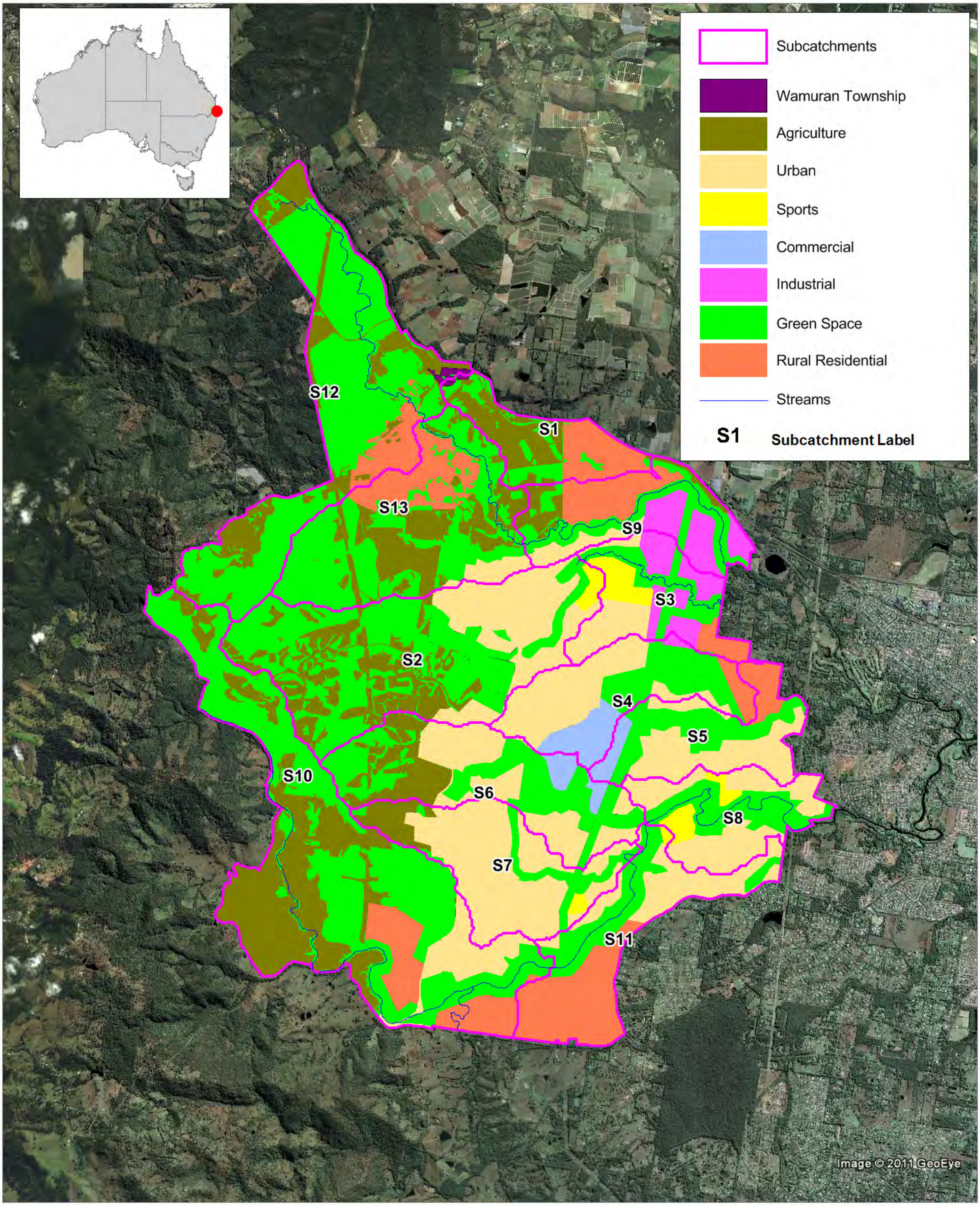
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures 131112\Figure A-3 Future Imperviousness.wor



Title:

Subcatchment Layout within the Future CWMPA

Figure: **A-4**

Rev: **B**

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N

0 1.5 3km

Approx. Scale

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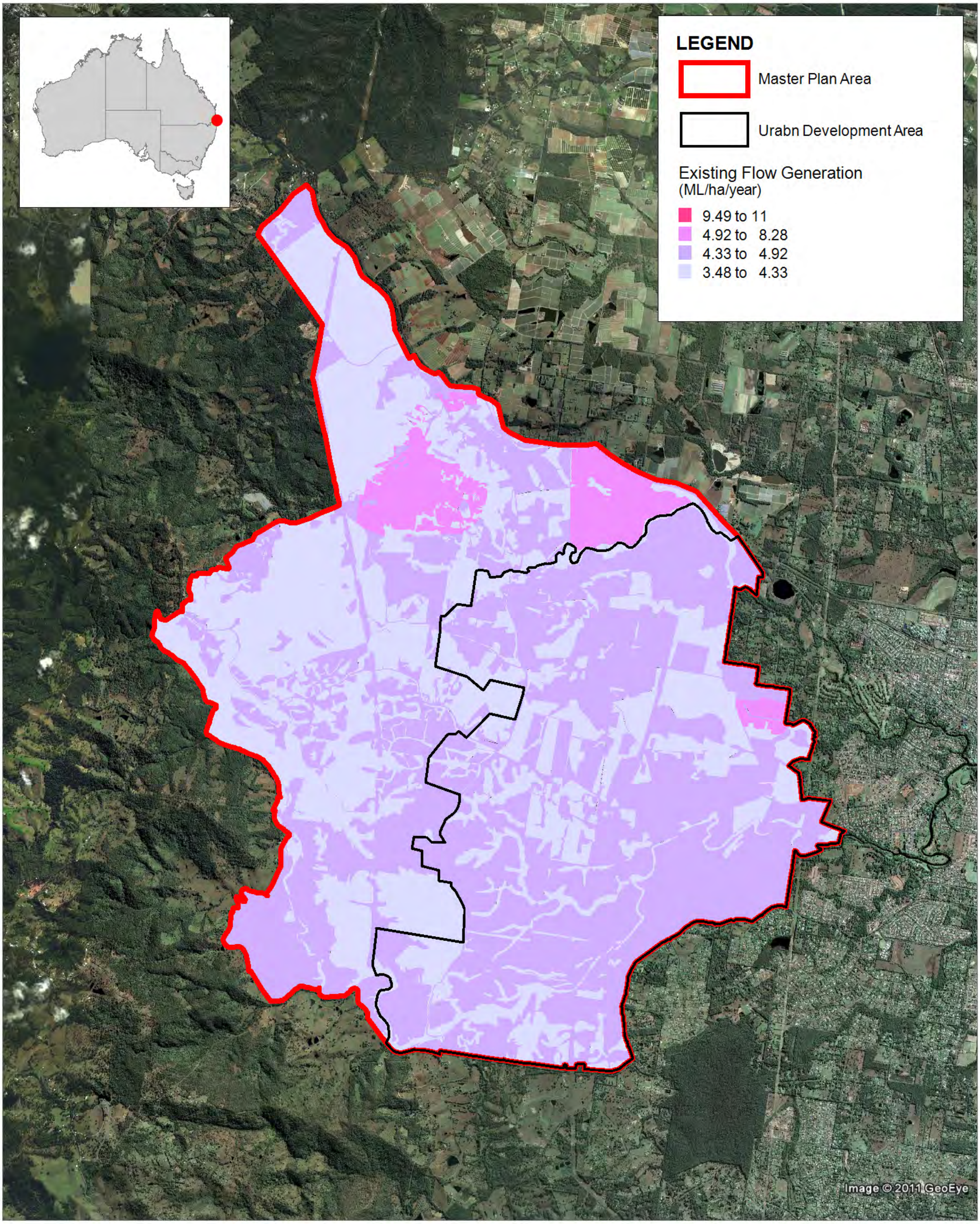
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures\Figure A-9 Future Subcatchments.wor



Title:

Average Annual Flow Generated from the Existing CWMPA

Figure: **A-5**

Rev: **B**

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N

0 1.5 3km

Approx. Scale

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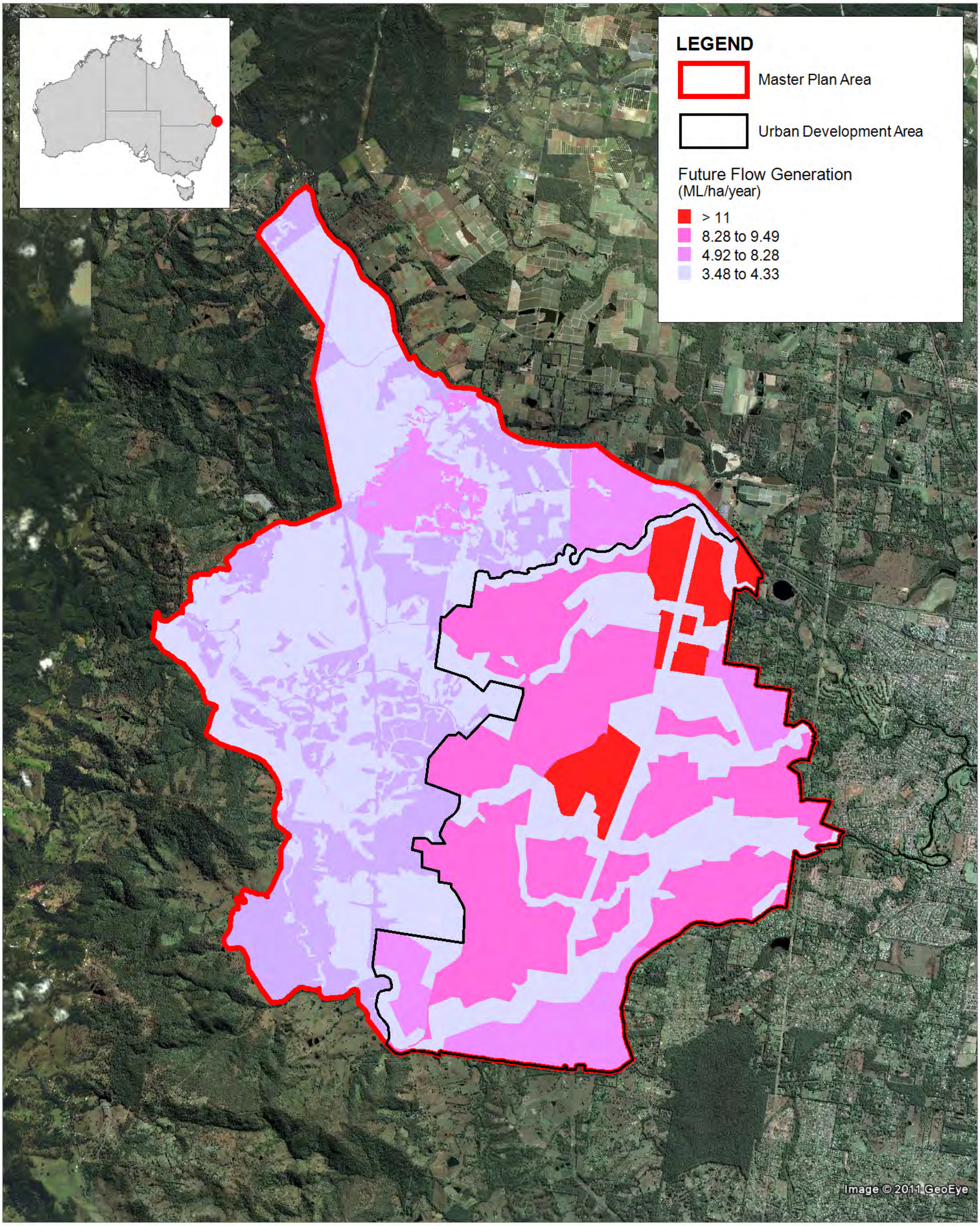
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures\Figure A-10 Existing Flow.wor



Title:

Average Annual Flow Generated from the Future CWMPA

Figure: **A-6**

Rev: **B**

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N

0 1.5 3km

Approx. Scale

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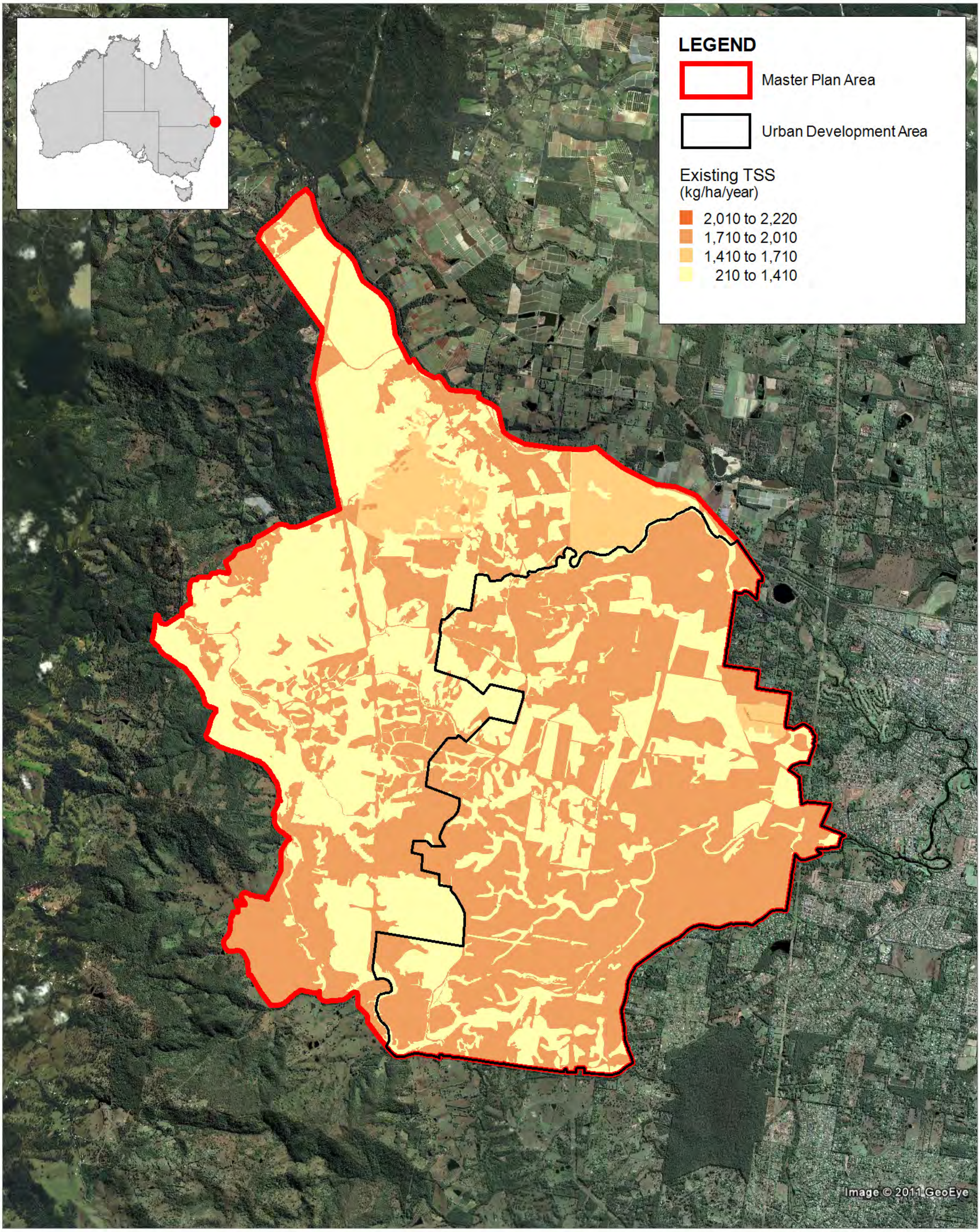
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures 131112\Figure A-6 Future Flow.wor



Title:

Average Annual Total Suspended Solids Generated from the Existing CWMPA

Figure: **A-7**

Rev: **B**

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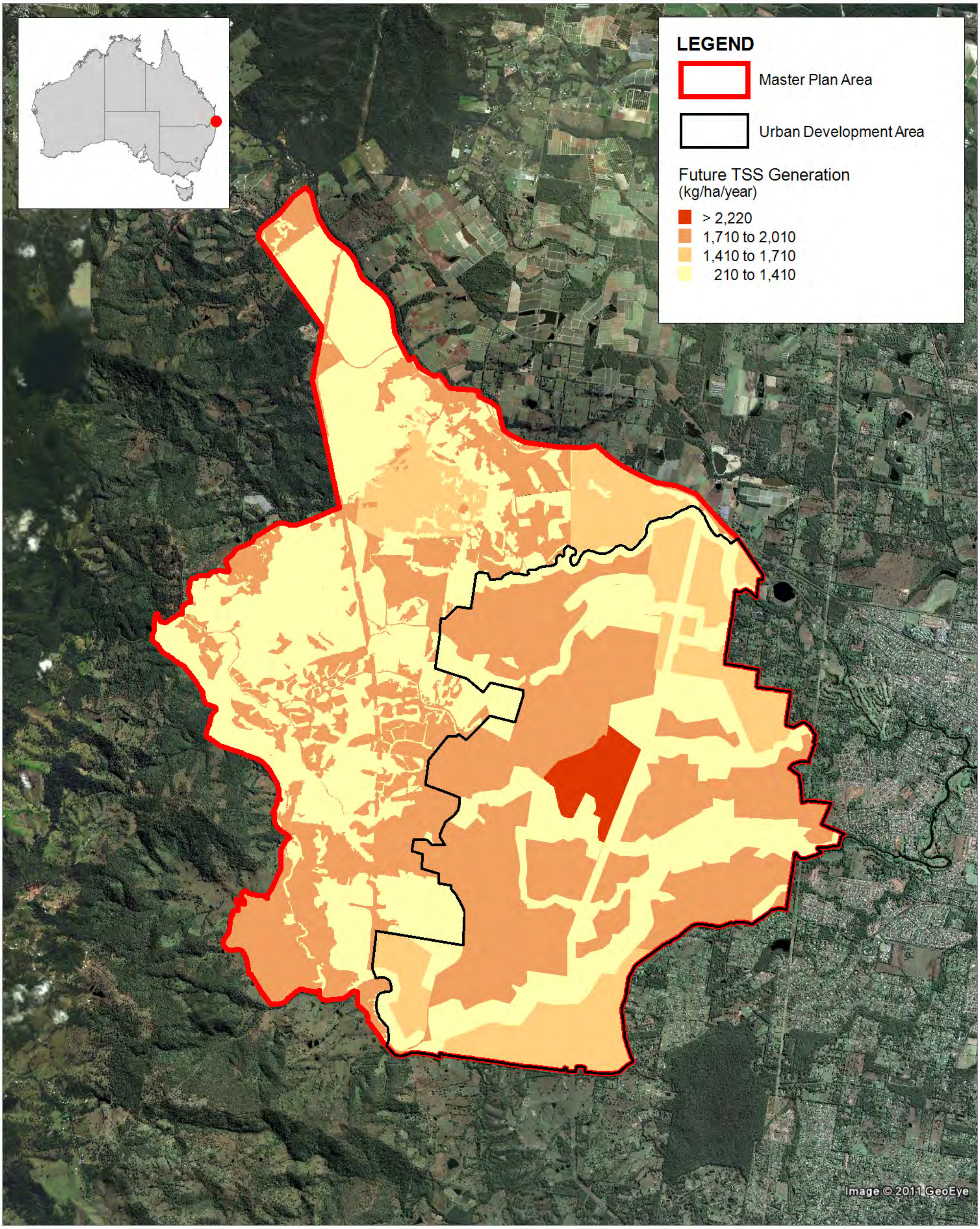
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures 131112\Figure A-7 Existing TSS.wor



Title:

Average Annual Total Suspended Solids Loads Generated from the Future CWMPA

Figure: **A-8**

Rev: **B**

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N

0 1.5 3km

Approx. Scale

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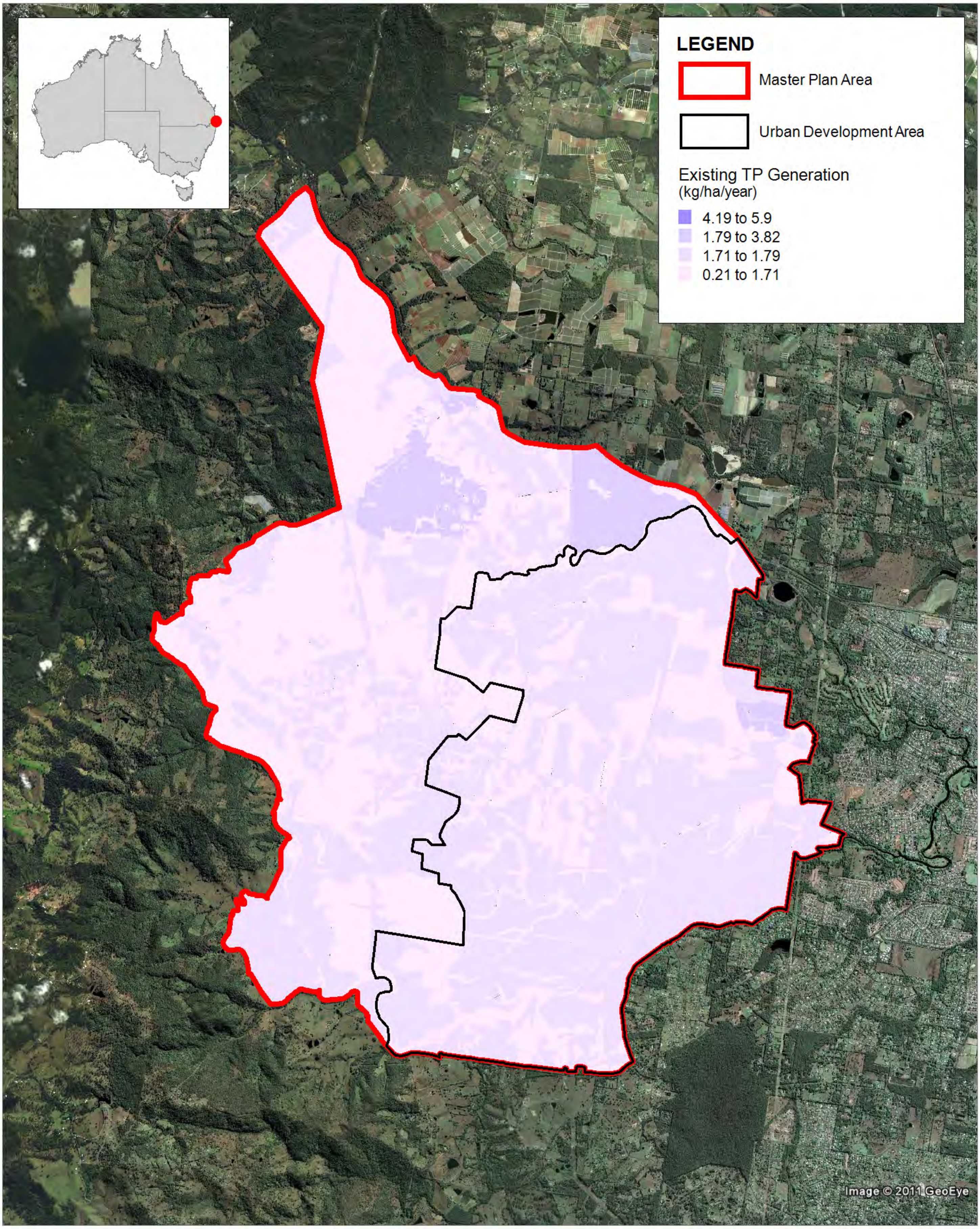
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures 131112\Figure A-8 Future TSS.wor



Title:

Average Annual Total Phosphorus Loads Generated from the Existing CWMPA

Figure: **A-9**

Rev: **B**

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N

0 1.5 3km

Approx. Scale

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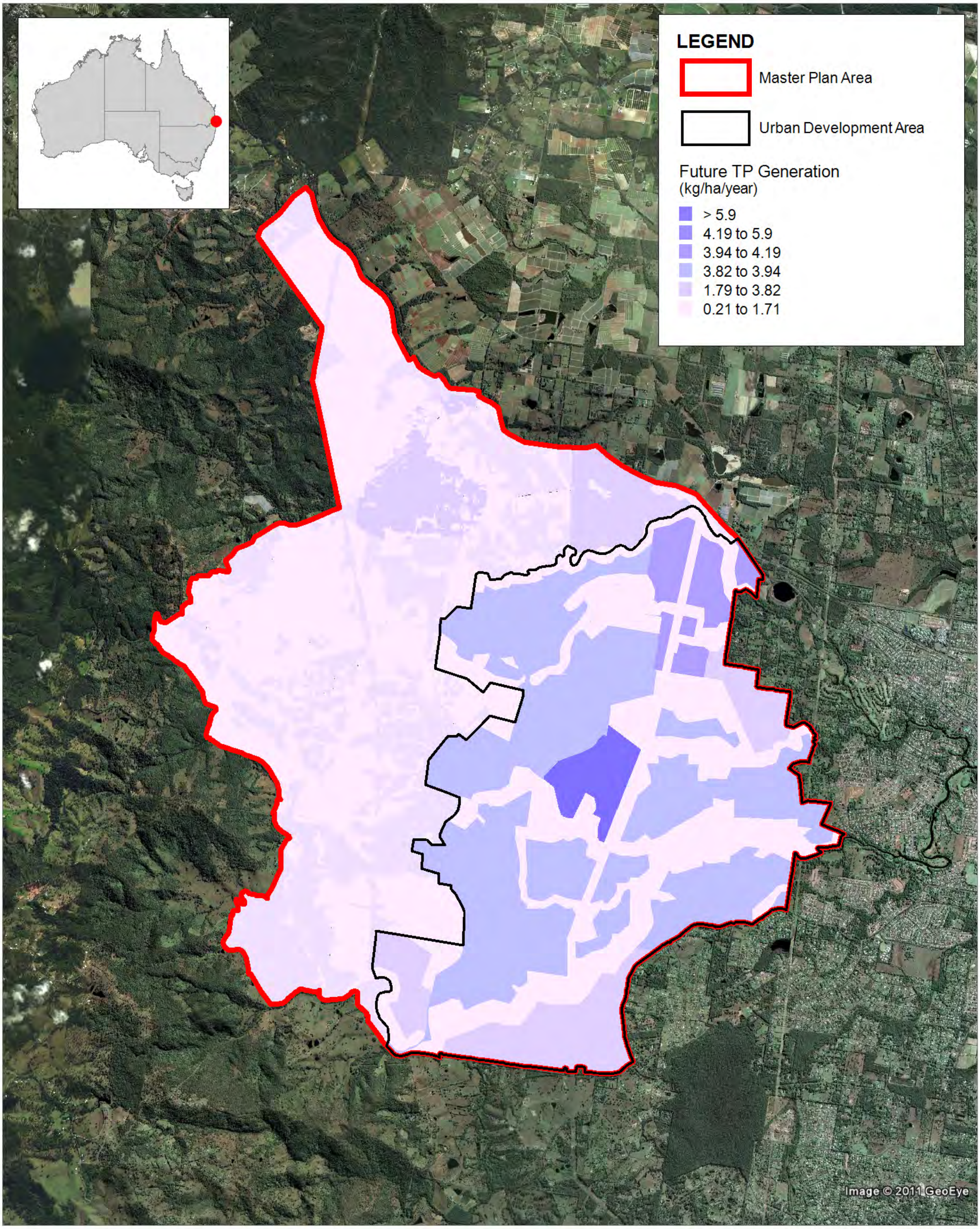
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures 131112\Figure A-9 Existing TP.wor



Title:

Average Annual Total Phosphorus Loads Generated from the Future CWMPA

Figure: **A-10**

Rev: **B**

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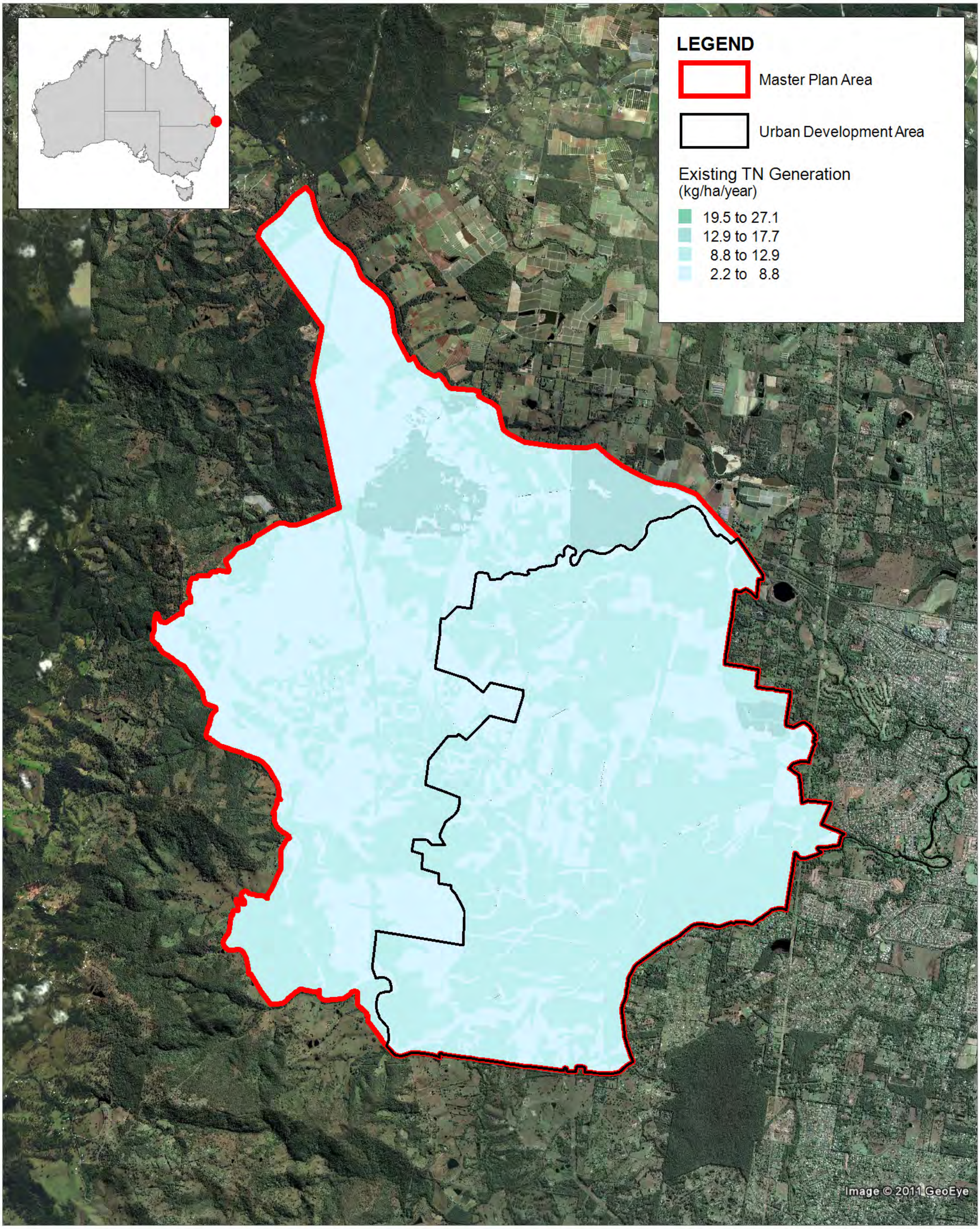

Title:

Average Annual Total Nitrogen Loads Generated from the Existing CWMPA

Figure: **A-11**

Rev: **B**

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N

0 1.5 3km

Approx. Scale

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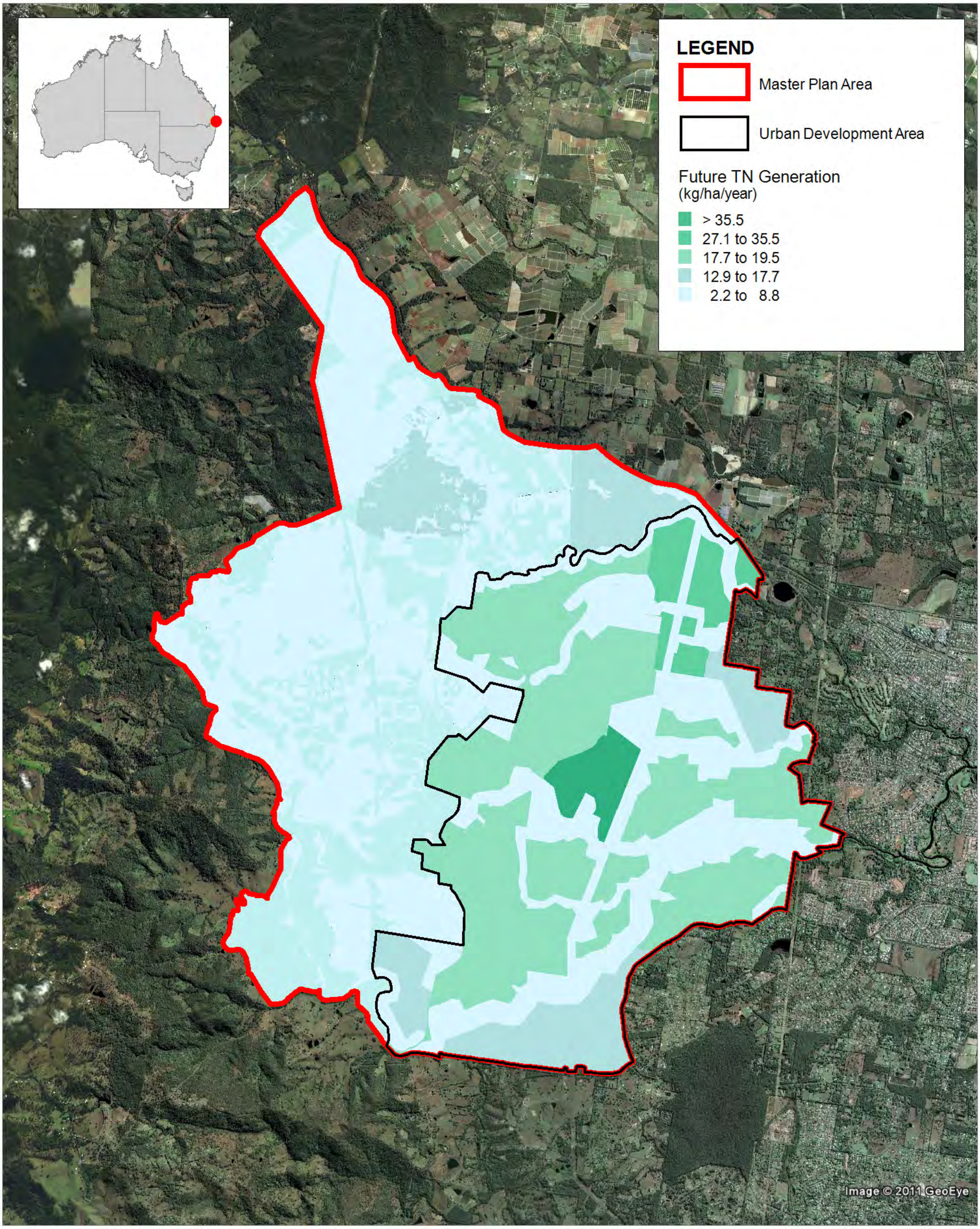
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures 131112\Figure A-11 Existing TN.wor



Title:

Average Annual Total Nitrogen Loads Generated from the Future CWMPA

Figure: A-12

Rev: B

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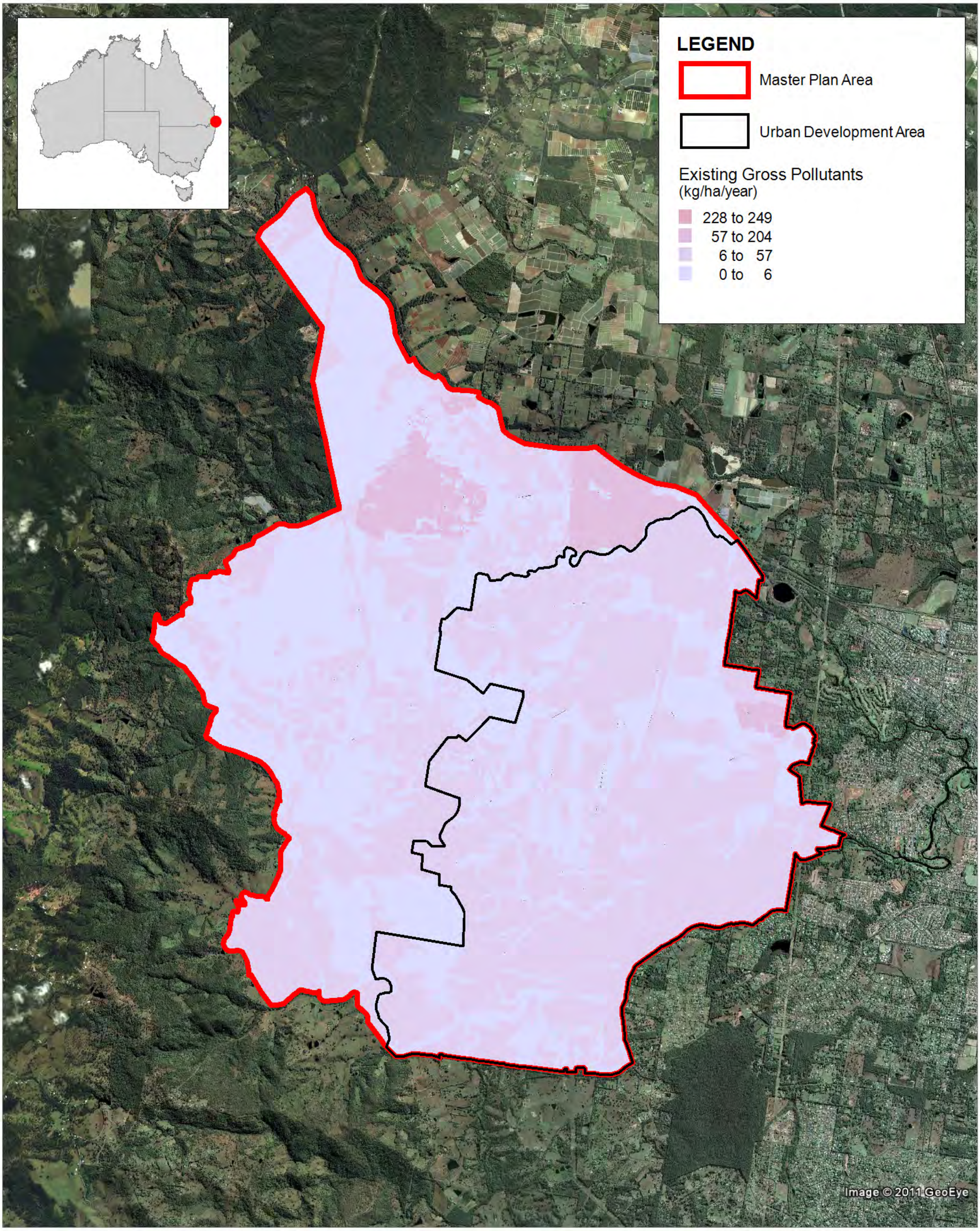
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures 131112\Figure A-12 Future TN.wor



Title:

Average Annual Gross Pollutant Loads Generated from the Existing CWMPA

Figure: **A-13**

Rev: **B**

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N

0 1.5 3km

Approx. Scale

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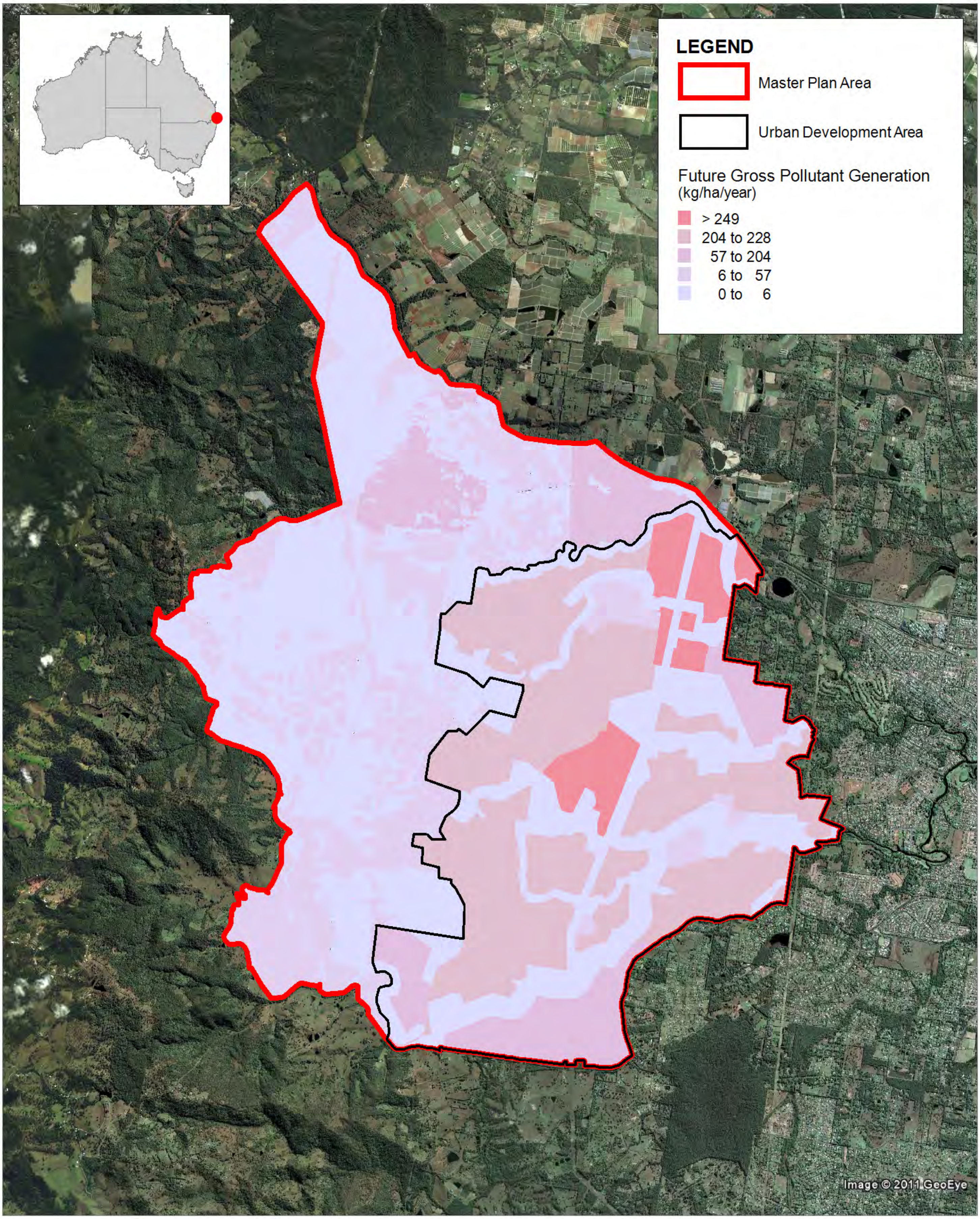
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures 131112\Figure A-13 Existing GP.wor



Title:

Average Annual Gross Pollutant Loads Generated from the Future CWMPA

Figure: A-14

Rev: B

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N

0 1.5 3km

Approx. Scale

BMT WBM

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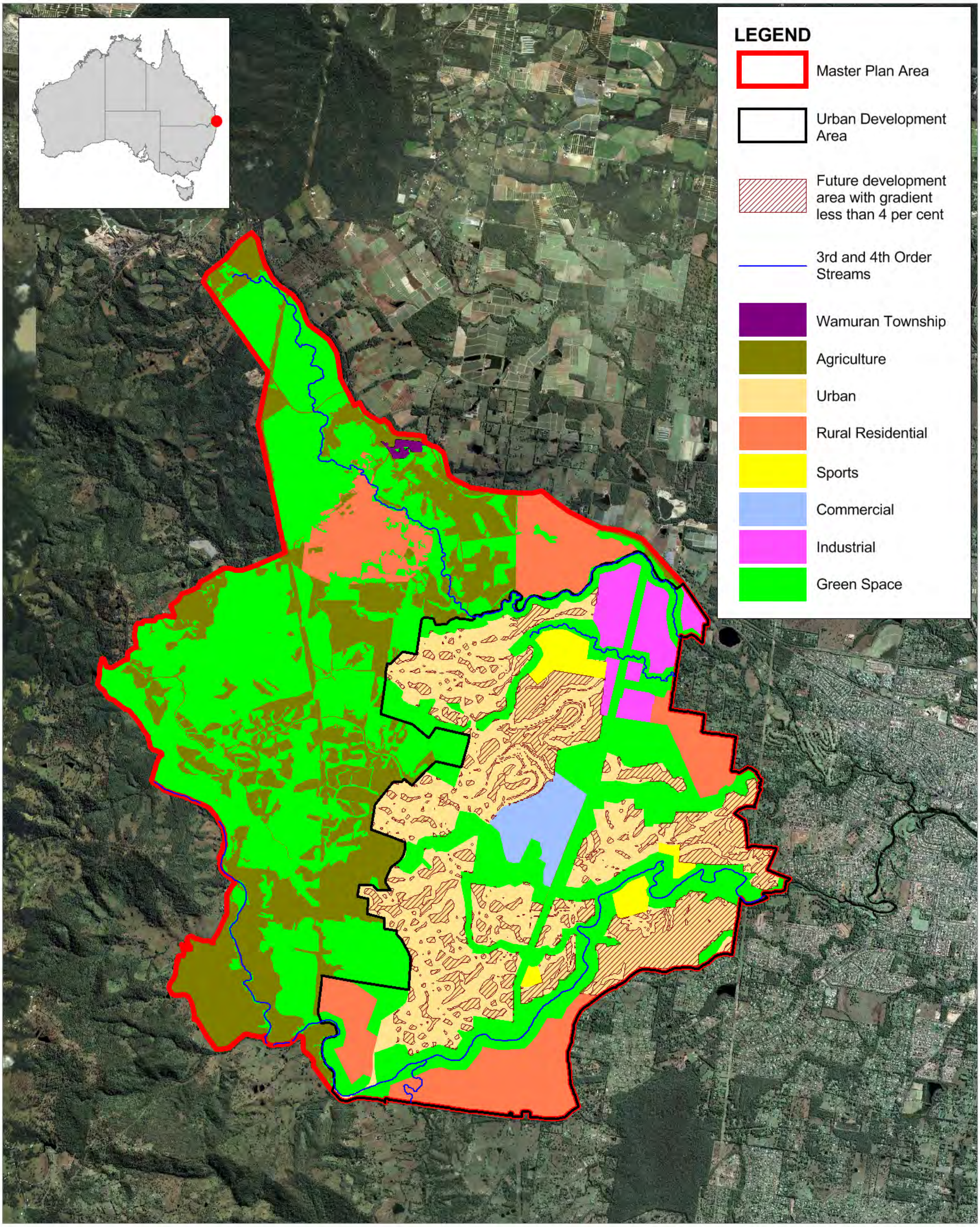
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures 131112\Figure A-13 Future GP.wor



Title:

Future Development Areas with Gradient less than 4%

Figure: A-15

Rev: B

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N

0 1.5 3km

Approx. Scale

BMT WBM

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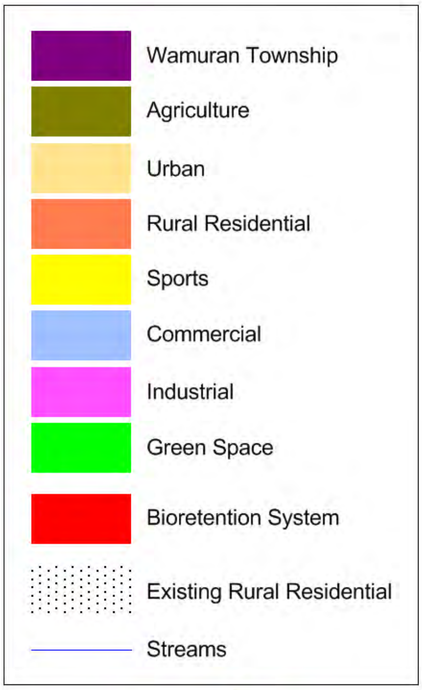

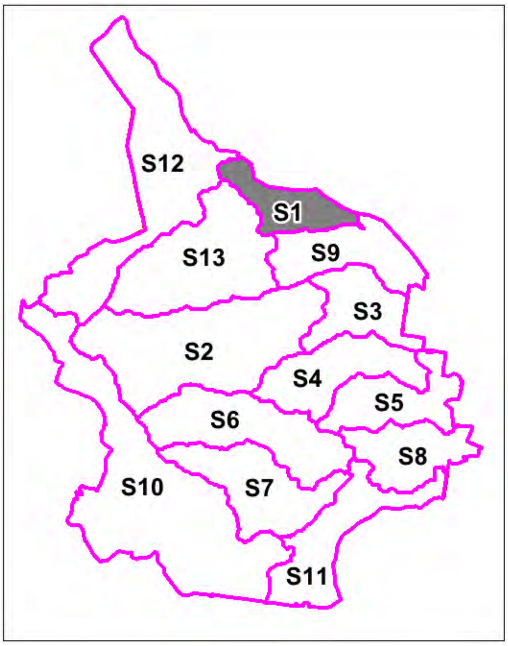

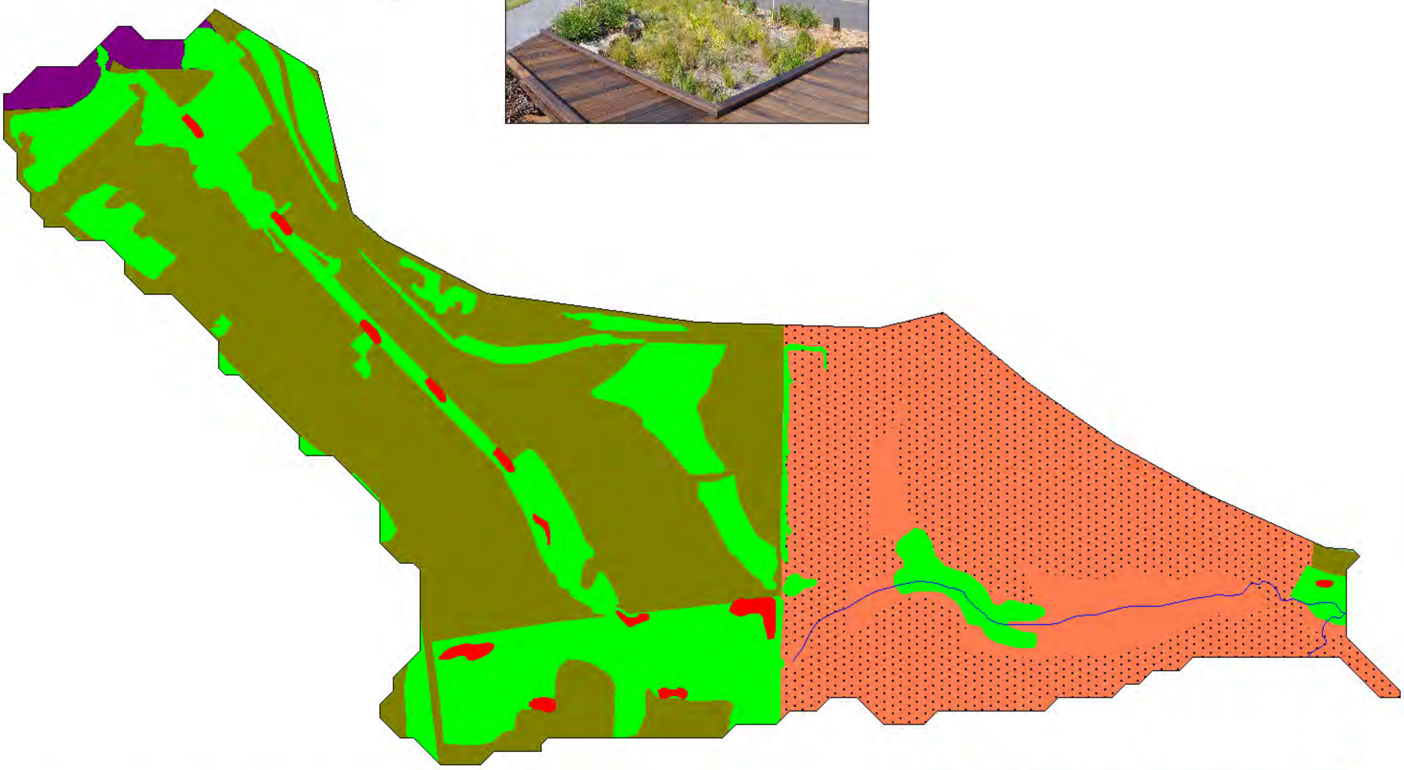

Title:

Caboolture West - Future Indicative Bioretention Locations - Subcatchment 1

Figure: A-16

Rev: A

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N

0 300 600m

Approx. Scale

BMT WBM

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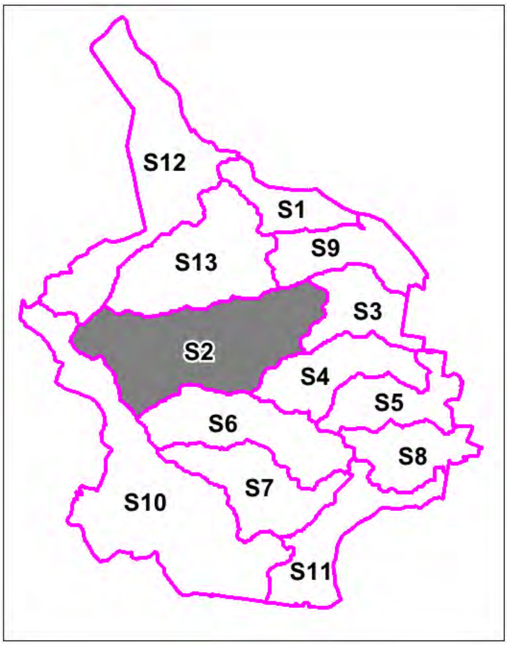
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures WSUD Locations\Figure A-16 Future Bioretention Sub1.wor



Title:

Caboolture West - Future Indicative Bioretention Locations - Subcatchment 2

Figure: **A-17**

Rev: **A**

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N

0 0.5 1km

Approx. Scale

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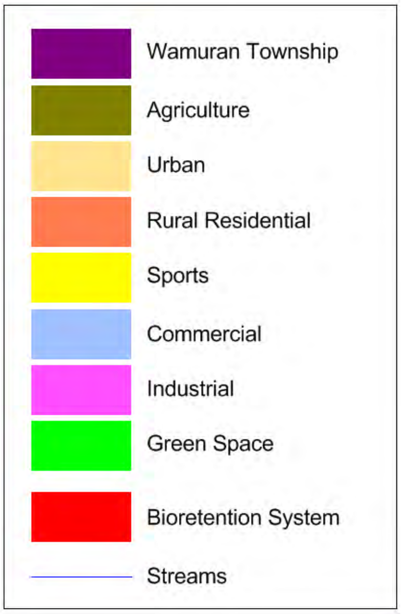
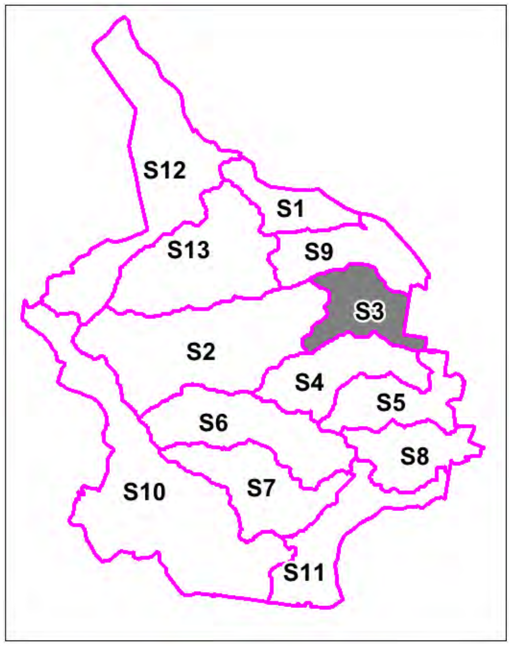
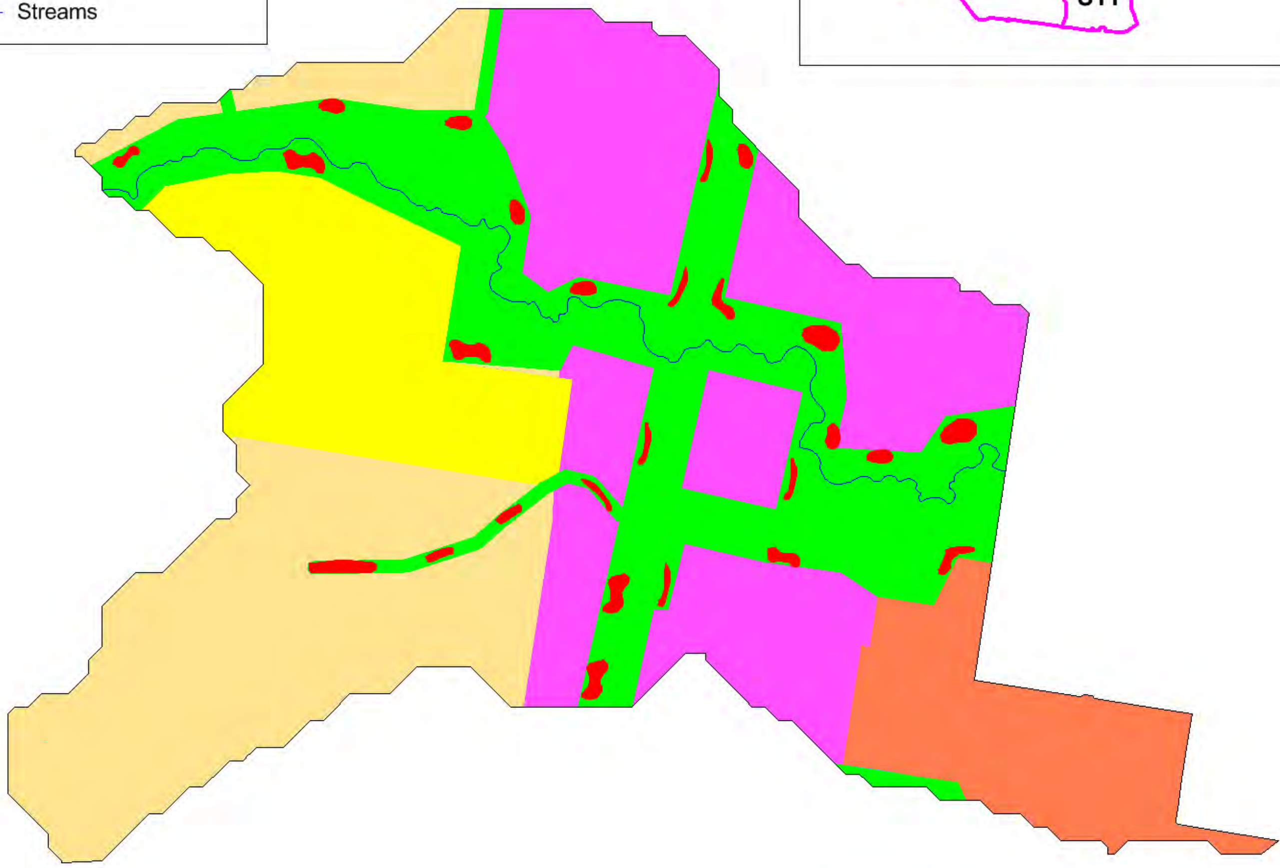
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures WSUD Locations\Figure A-17 Future Bioretention Sub2.wor







Title:

Caboolture West - Future Indicative Bioretention Locations - Subcatchment 3

Figure:

A-18

Rev:

A

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N

0 300 600m

Approx. Scale

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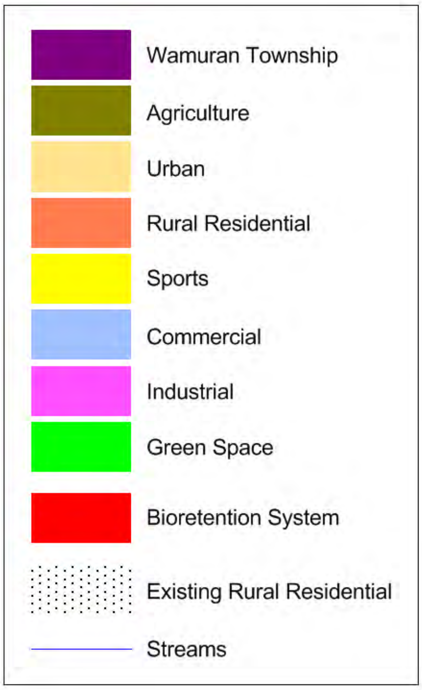

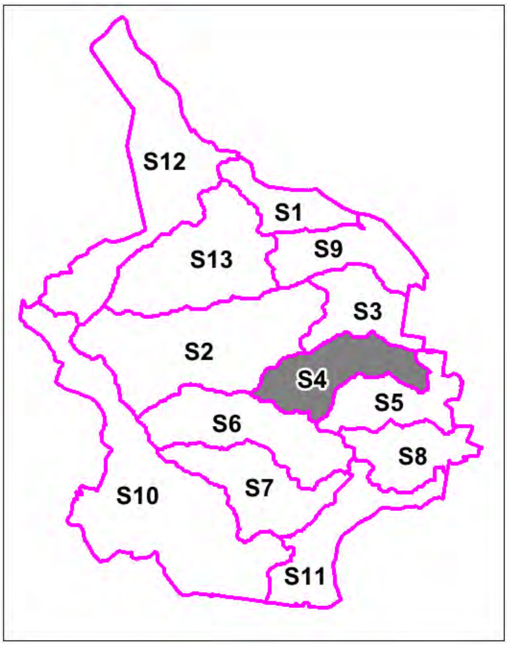

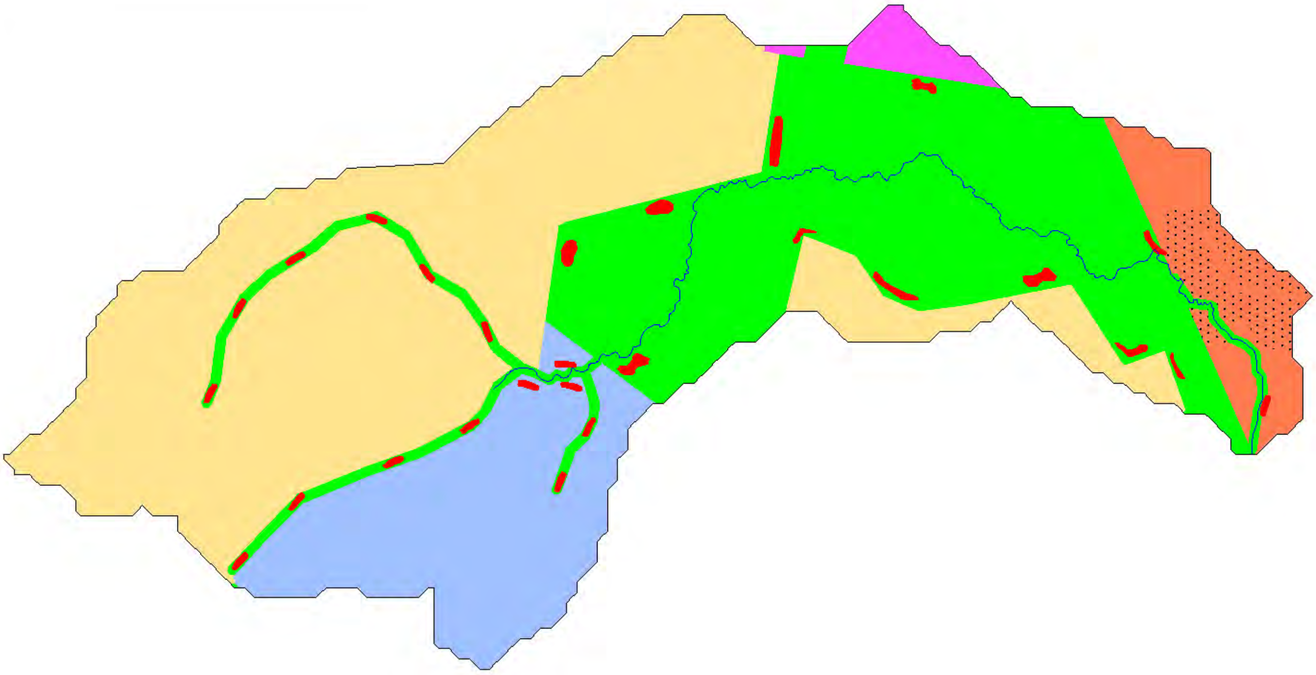

Title:

Caboolture West - Future Indicative Bioretention Locations - Subcatchment 4

Figure: A-19

Rev: A

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N

0 300 600m

Approx. Scale

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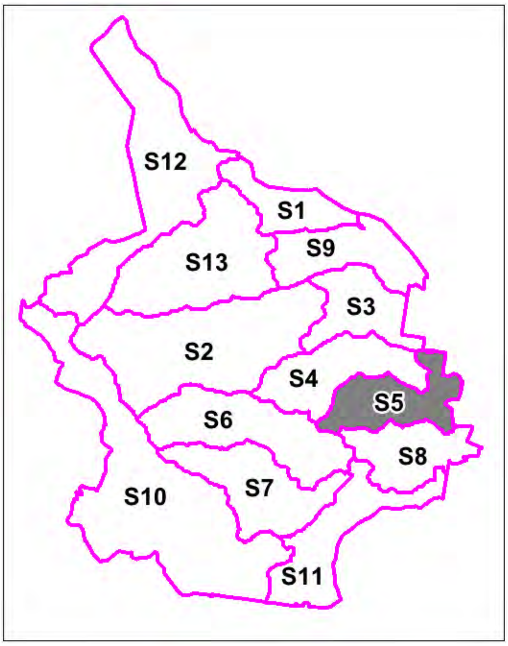
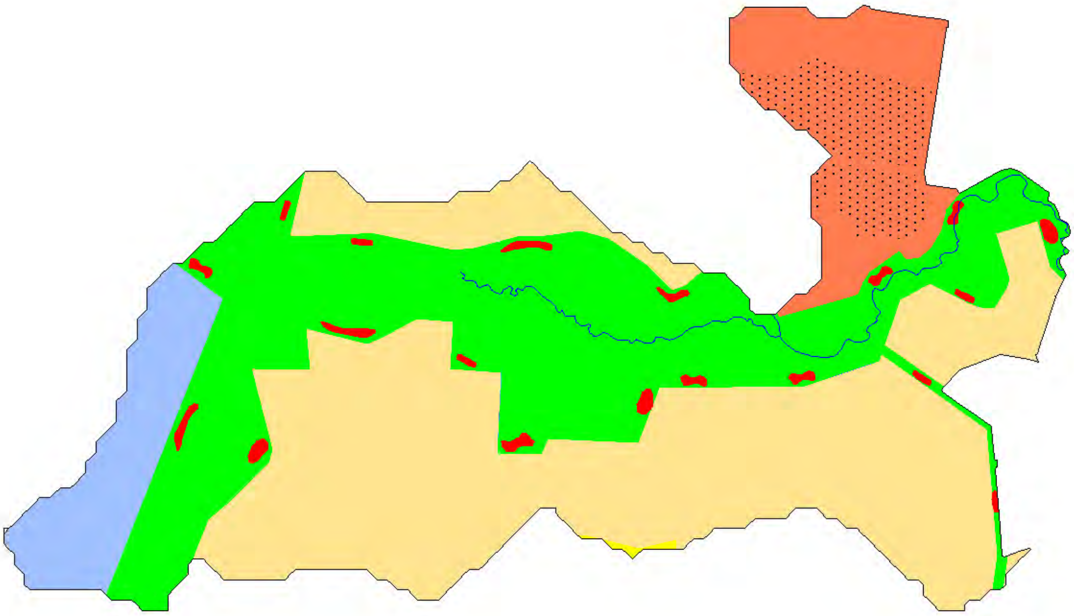
Wamuran Township
Agriculture
Urban
Rural Residential
Sports
Commercial
Industrial
Green Space
Bioretention System
Existing Rural Residential
Streams





Title:

Caboolture West - Future Indicative Bioretention Locations - Subcatchment 5

Figure: A-20

Rev: A

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N

0 300 600m
Approx. Scale

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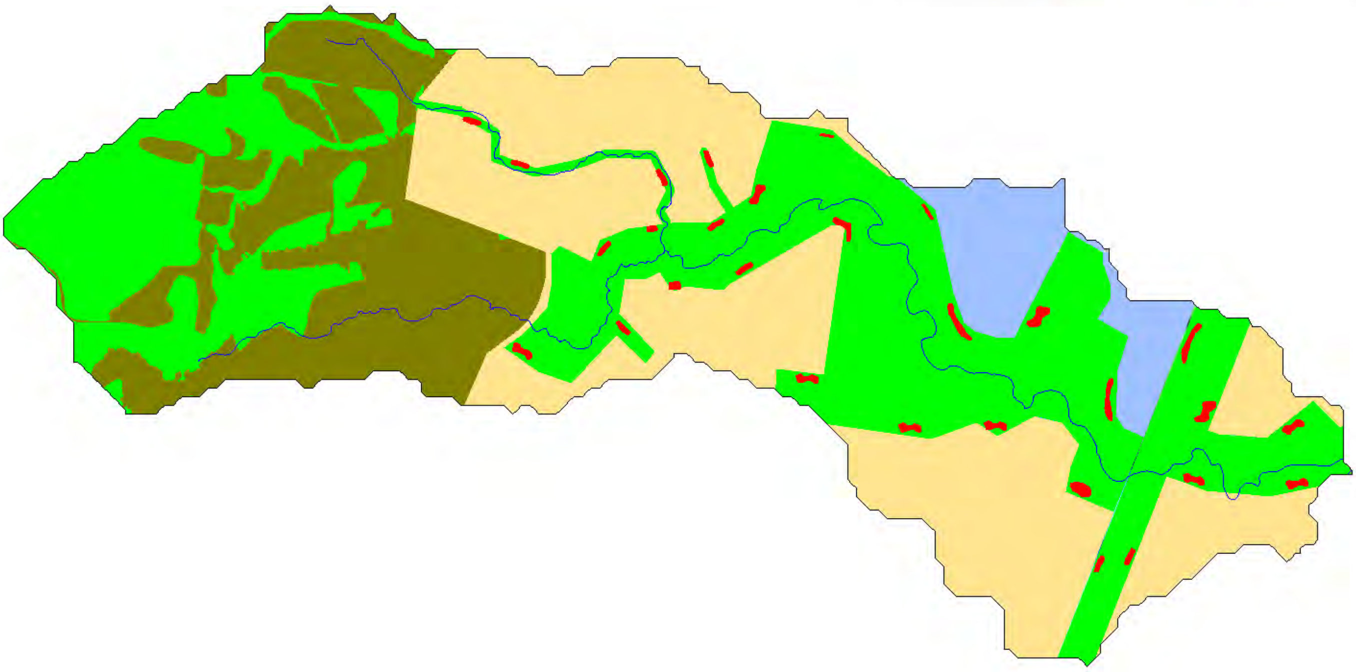
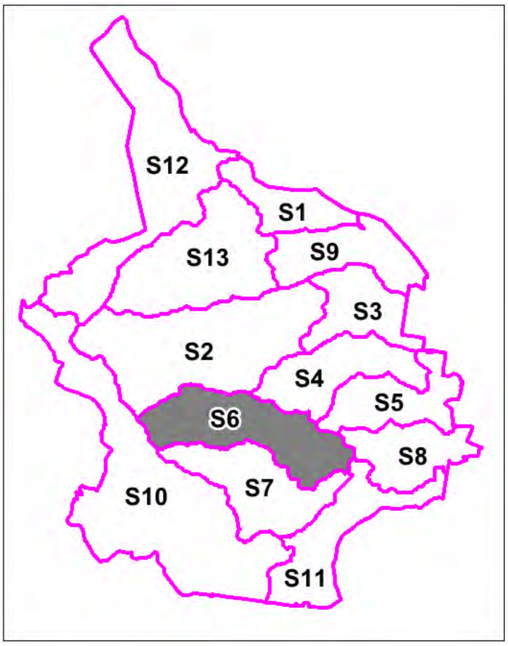
Wamuran Township
Agriculture
Urban
Rural Residential
Sports
Commercial
Industrial
Green Space
Bioretention System
Streams





Title:

Caboolture West - Future Indicative Bioretention Locations - Subcatchment 6

Figure: **A-21**

Rev: **A**

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N

0 0.5 1km

Approx. Scale

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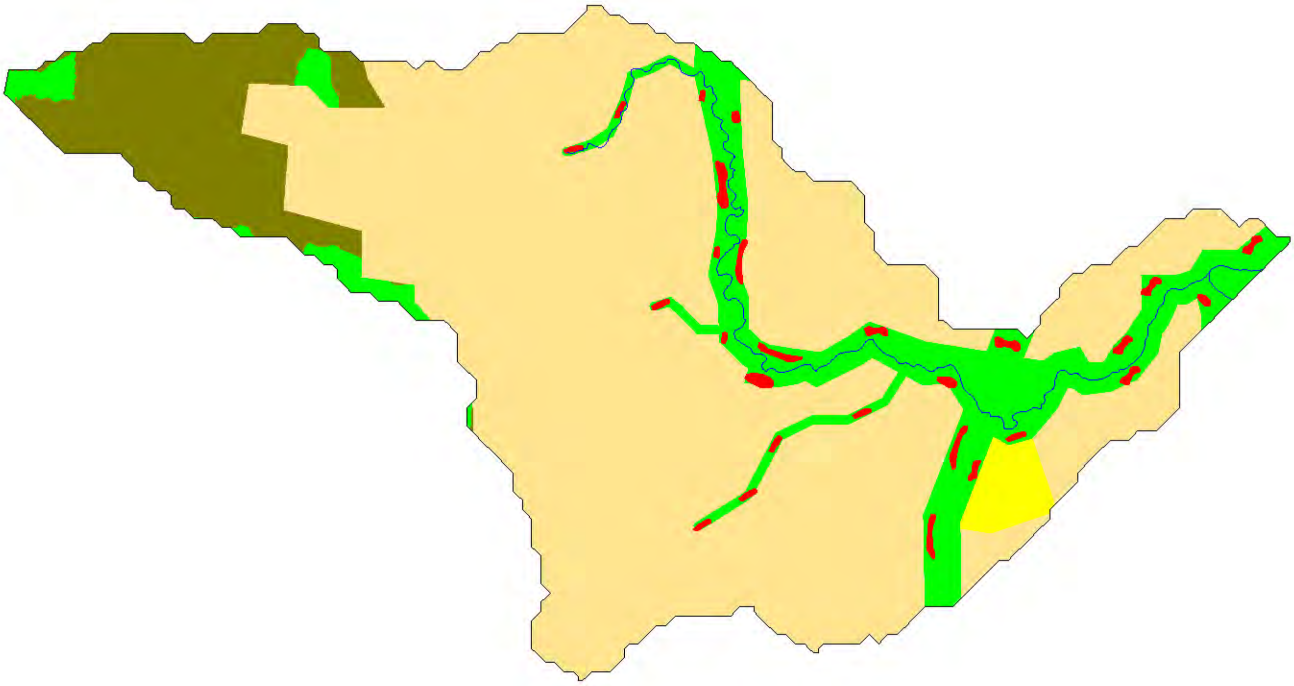
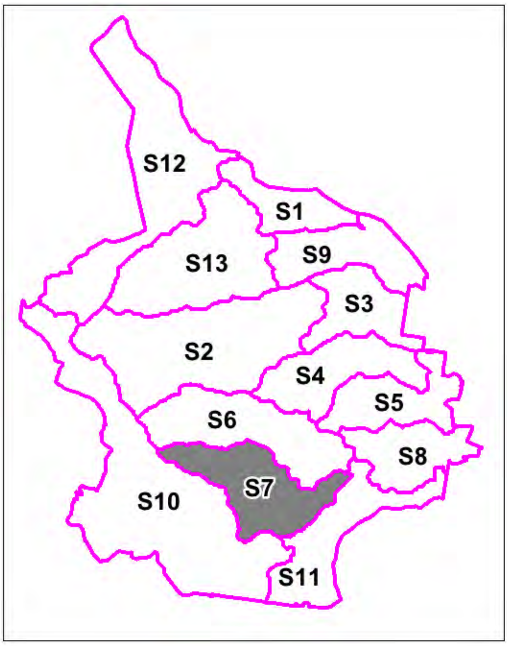
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures WSUD Locations\Figure A-21 Future Bioretention Sub6.wor

- Wamuran Township
- Agriculture
- Urban
- Rural Residential
- Sports
- Commercial
- Industrial
- Green Space
- Bioretention System
- Streams





Title:

Caboolture West - Future Indicative Bioretention Locations - Subcatchment 7

Figure: **A-22**

Rev: **A**

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N

0 0.5 1km

Approx. Scale

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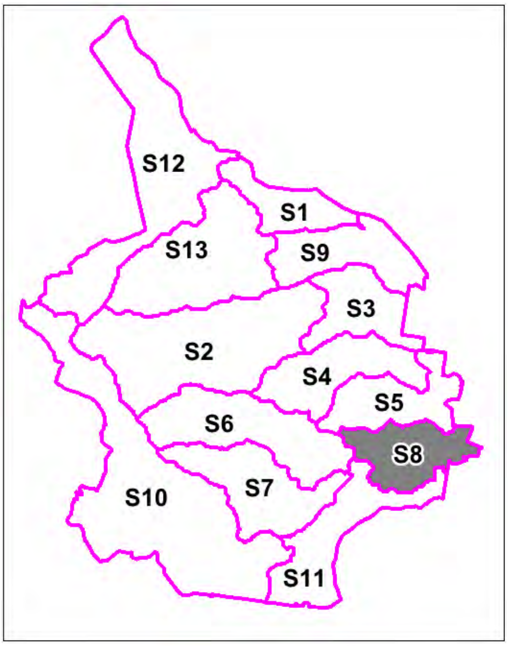

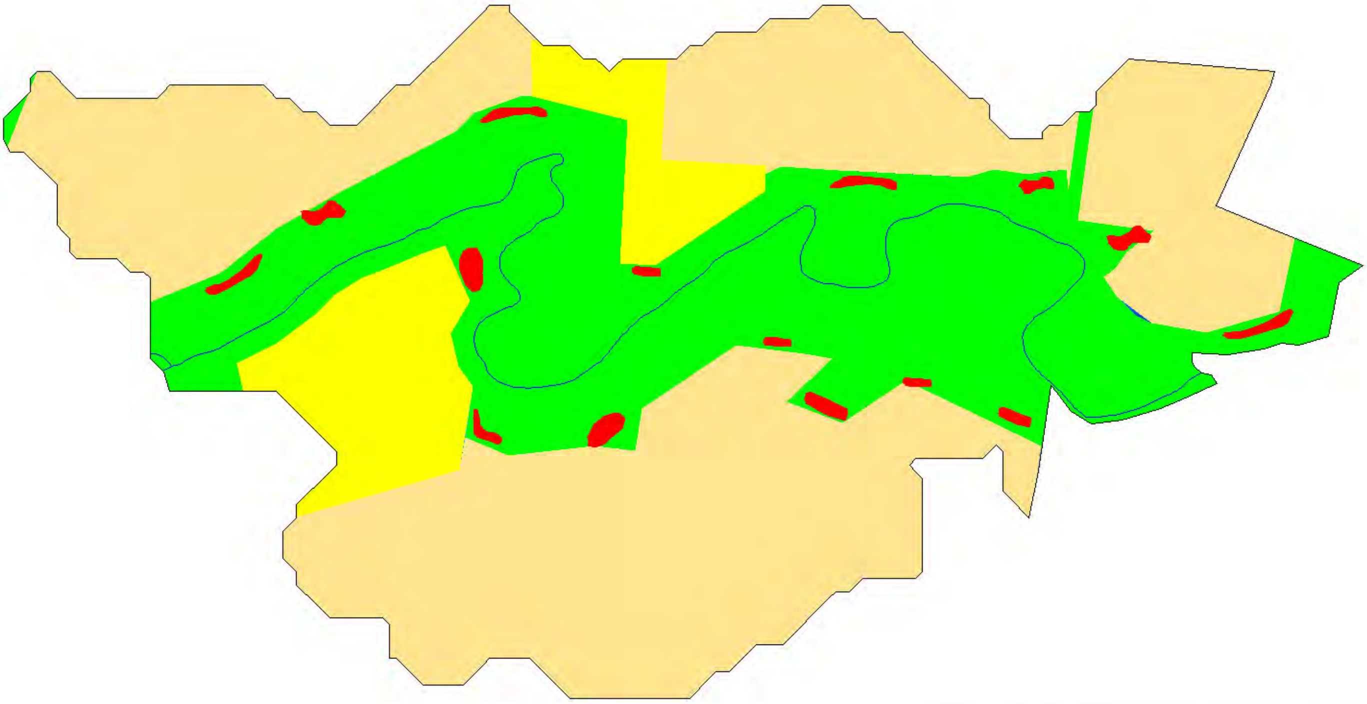

Title:

Caboolture West - Future Indicative Bioretention Locations - Subcatchment 8

Figure: **A-23**

Rev: **A**

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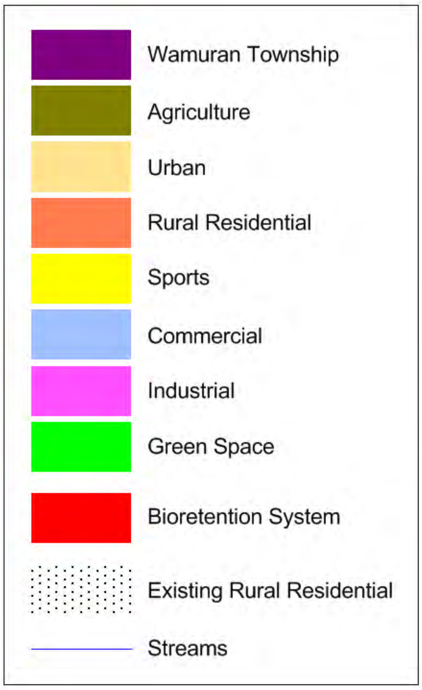

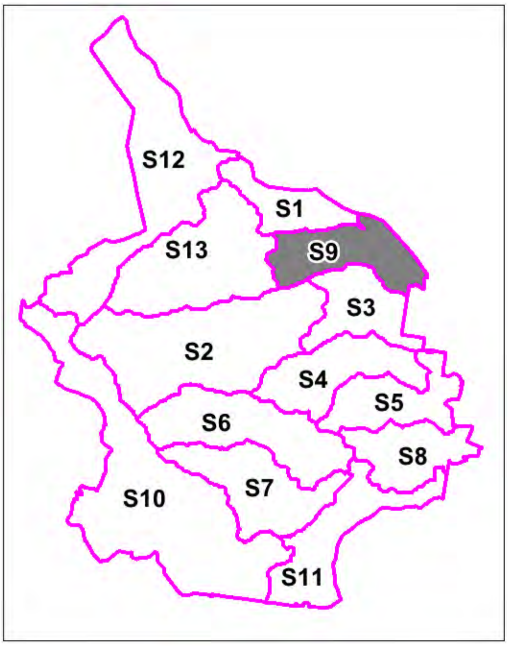

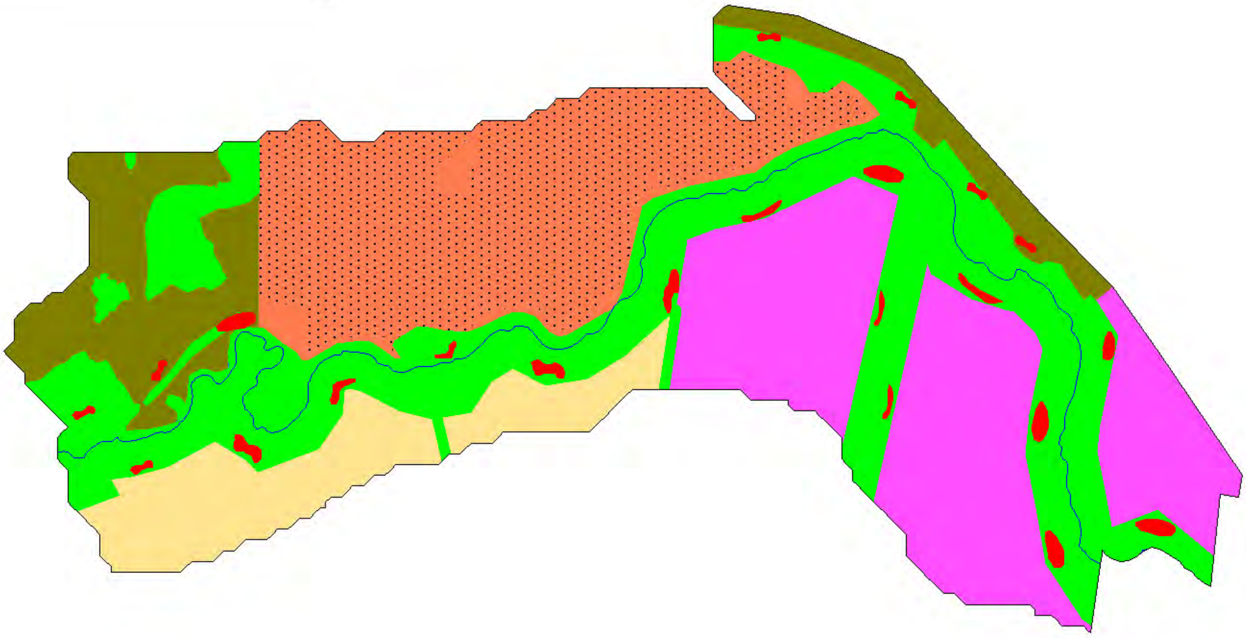

Title:

Caboolture West - Future Indicative Bioretention Locations - Subcatchment 9

Figure: A-24

Rev: A

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N

0 300 600m

Approx. Scale

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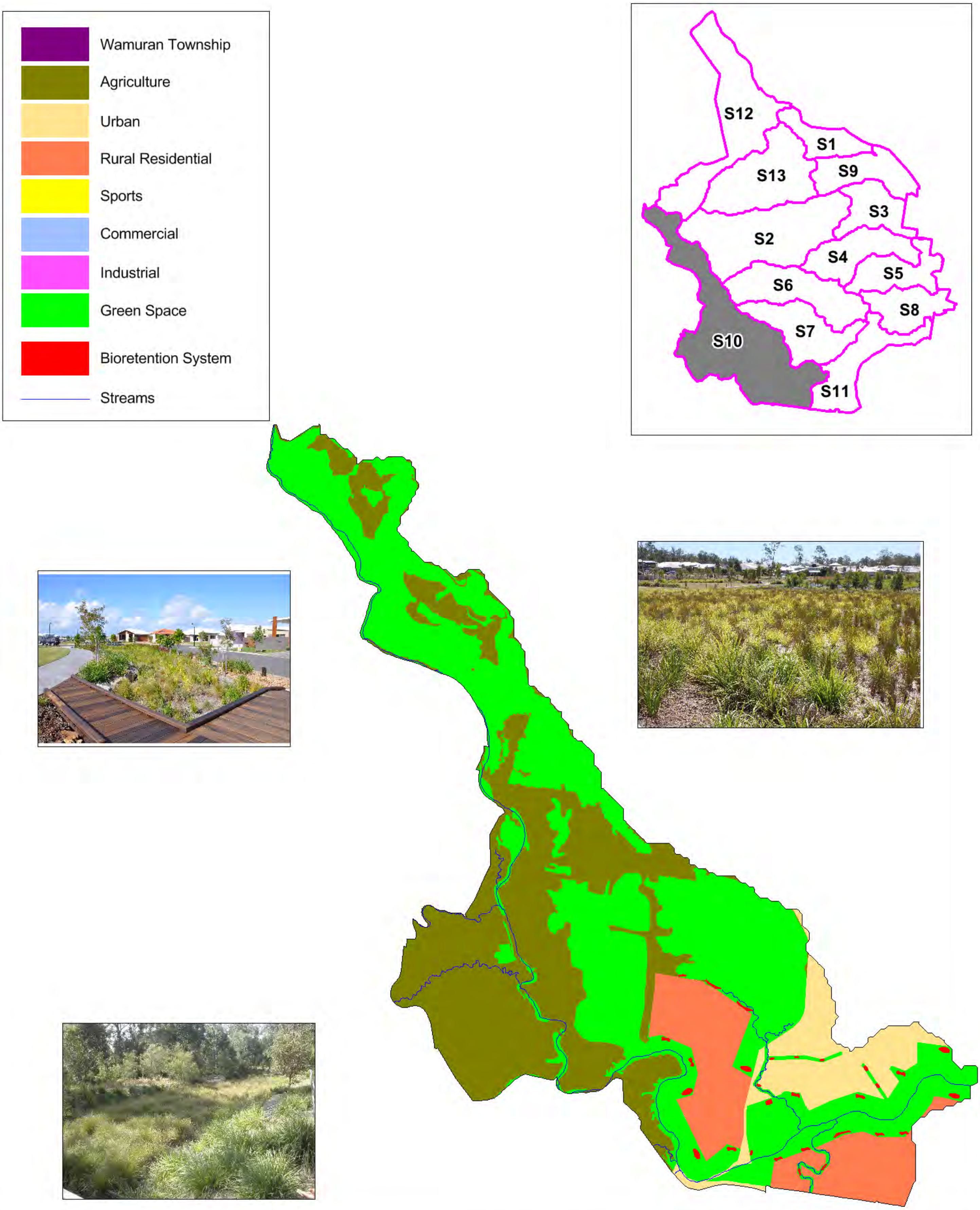
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures WSUD Locations\Figure A-24 Future Bioretention Sub9.wor



Title:

Caboolture West - Future Indicative Bioretention Locations - Subcatchment 10

Figure: **A-25**

Rev: **A**

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N

0 1 2km

Approx. Scale

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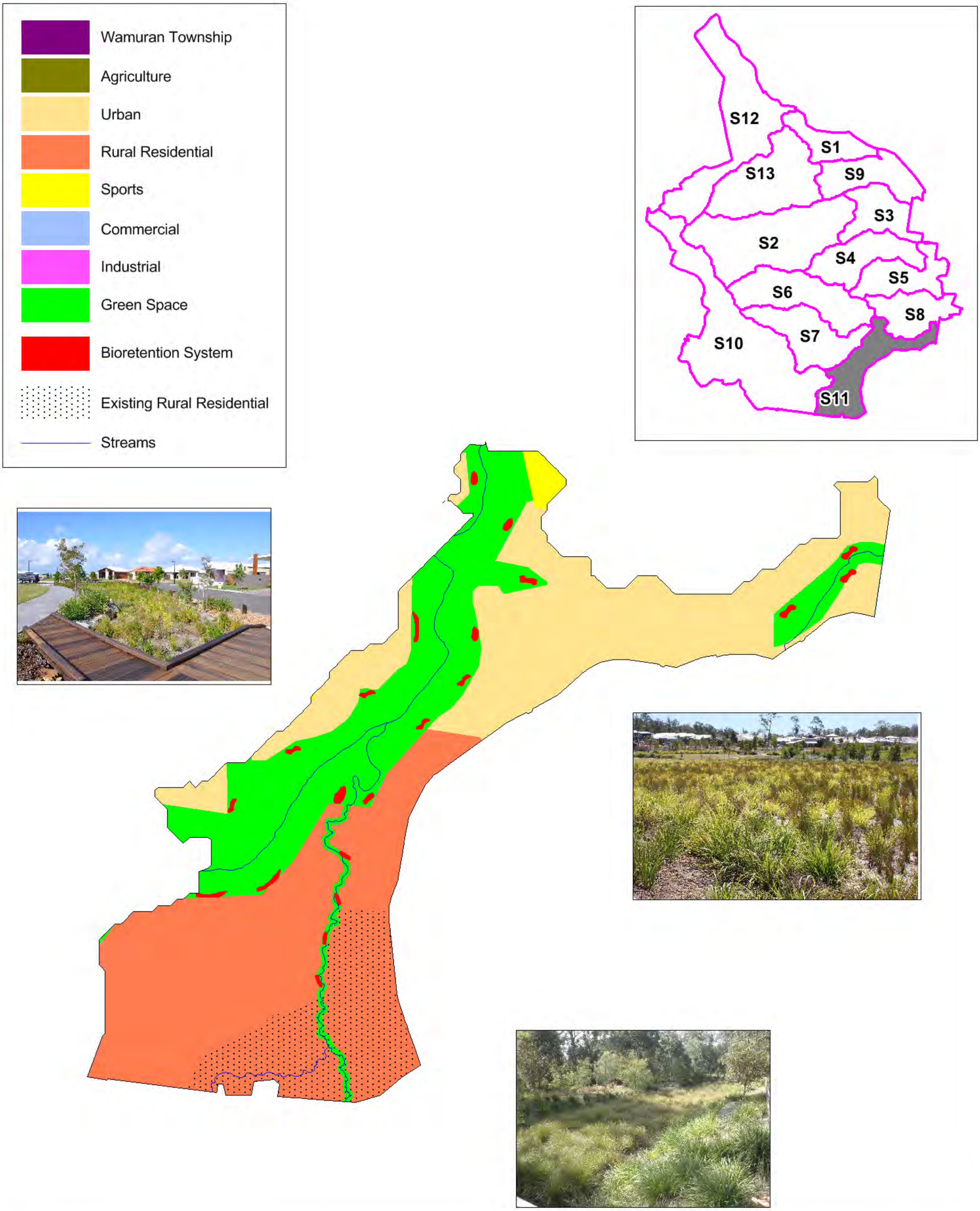
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures WSUD Locations\Figure A-25 Future Bioretention Sub10.wor



Title:

Caboolture West - Future Indicative Bioretention Locations - Subcatchment 11

Figure: **A-26**

Rev: **A**

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N

0 0.5 1km

Approx. Scale

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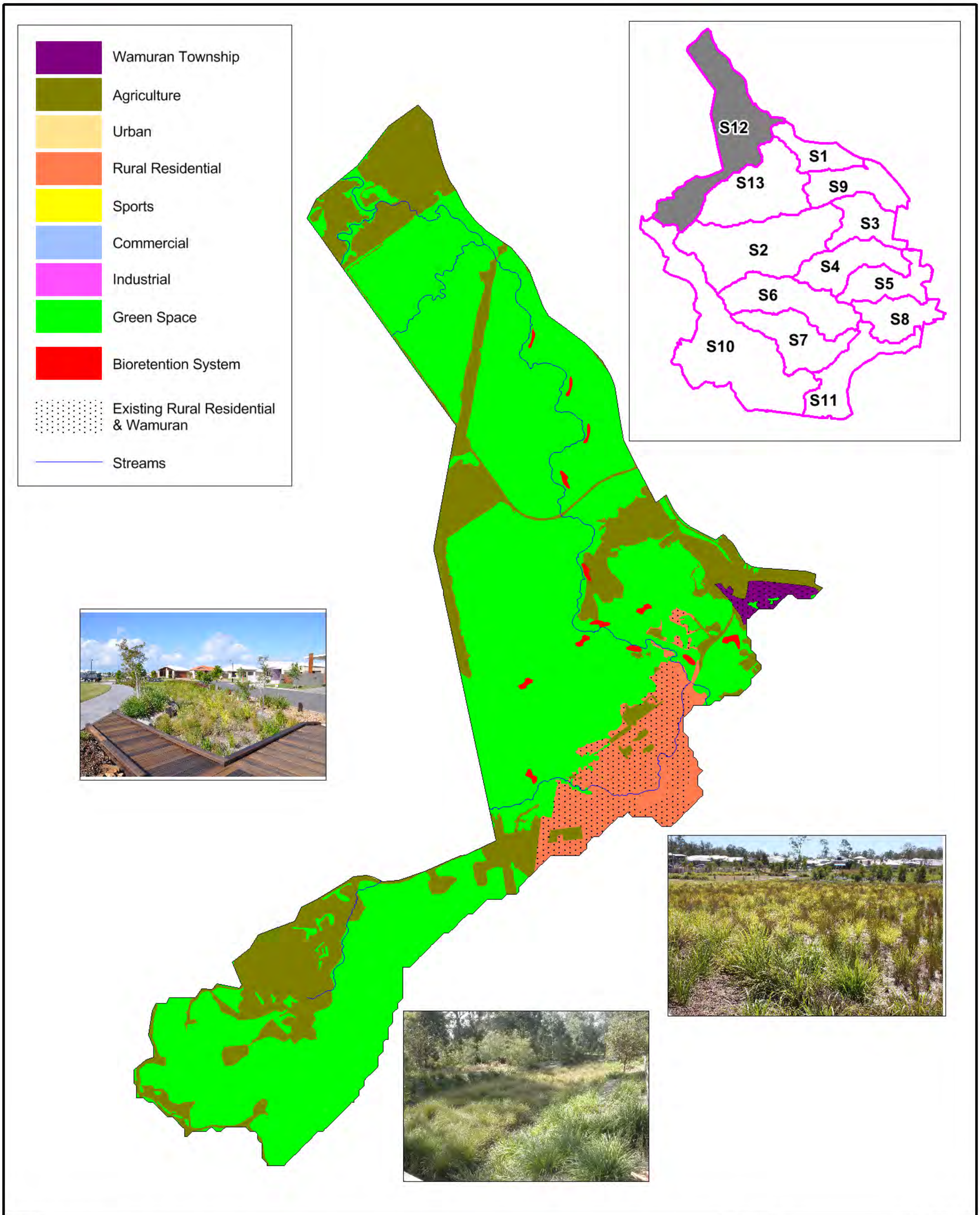
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\Report Figures WSUD Locations\Figure A-26 Future Bioretention Sub11.wor



Title:

Caboolture West - Future Indicative Bioretention Locations - Subcatchment 12

Figure: A-27

Rev: A

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N

0 0.5 1km
Approx. Scale

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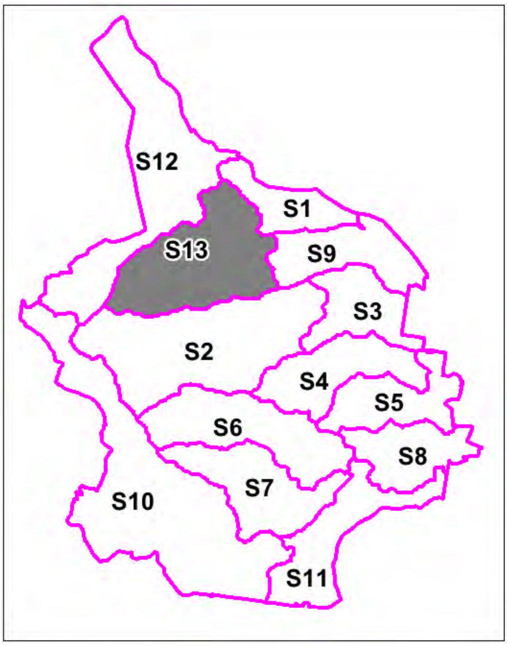
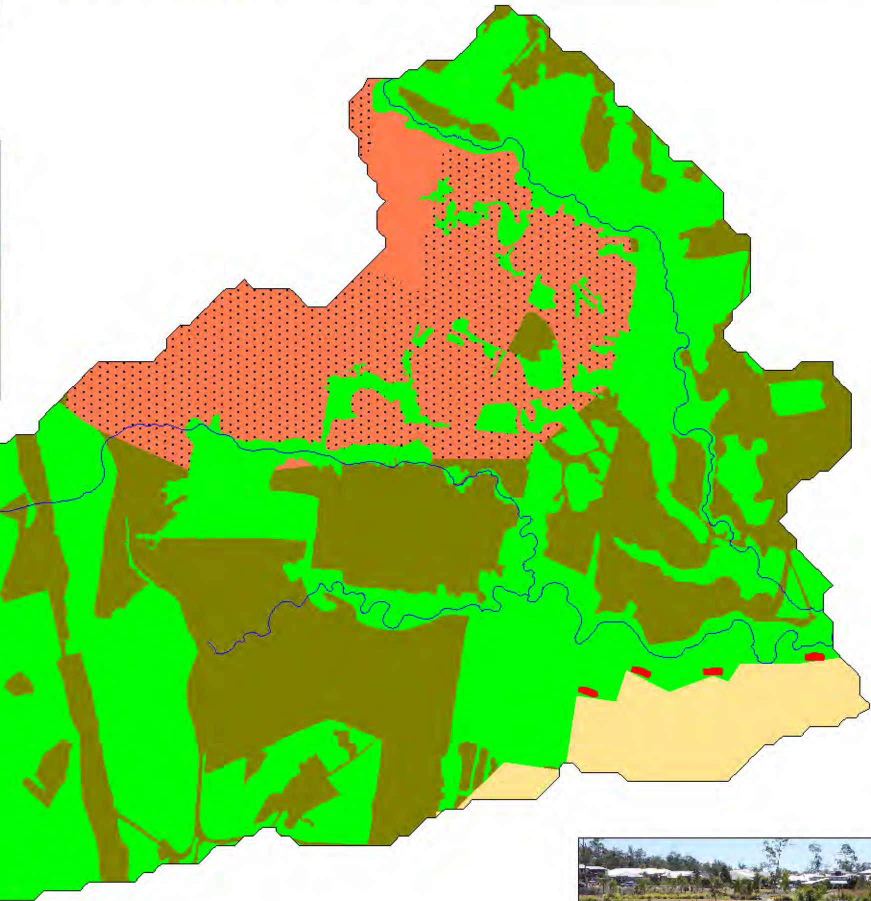
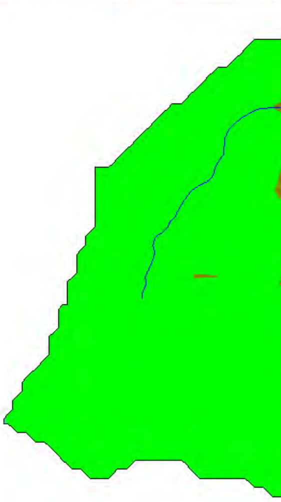
Wamuran Township
Agriculture
Urban
Rural Residential
Sports
Commercial
Industrial
Green Space
Bioretention System
Existing Rural Residential
Streams



Title:
Caboolture West - Future Indicative Bioretention Locations - Subcatchment 13

Figure: A-28

Rev: A

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Approx. Scale

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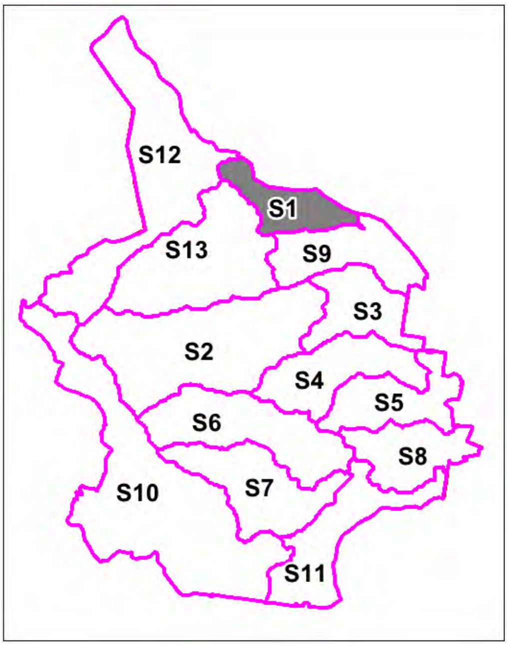

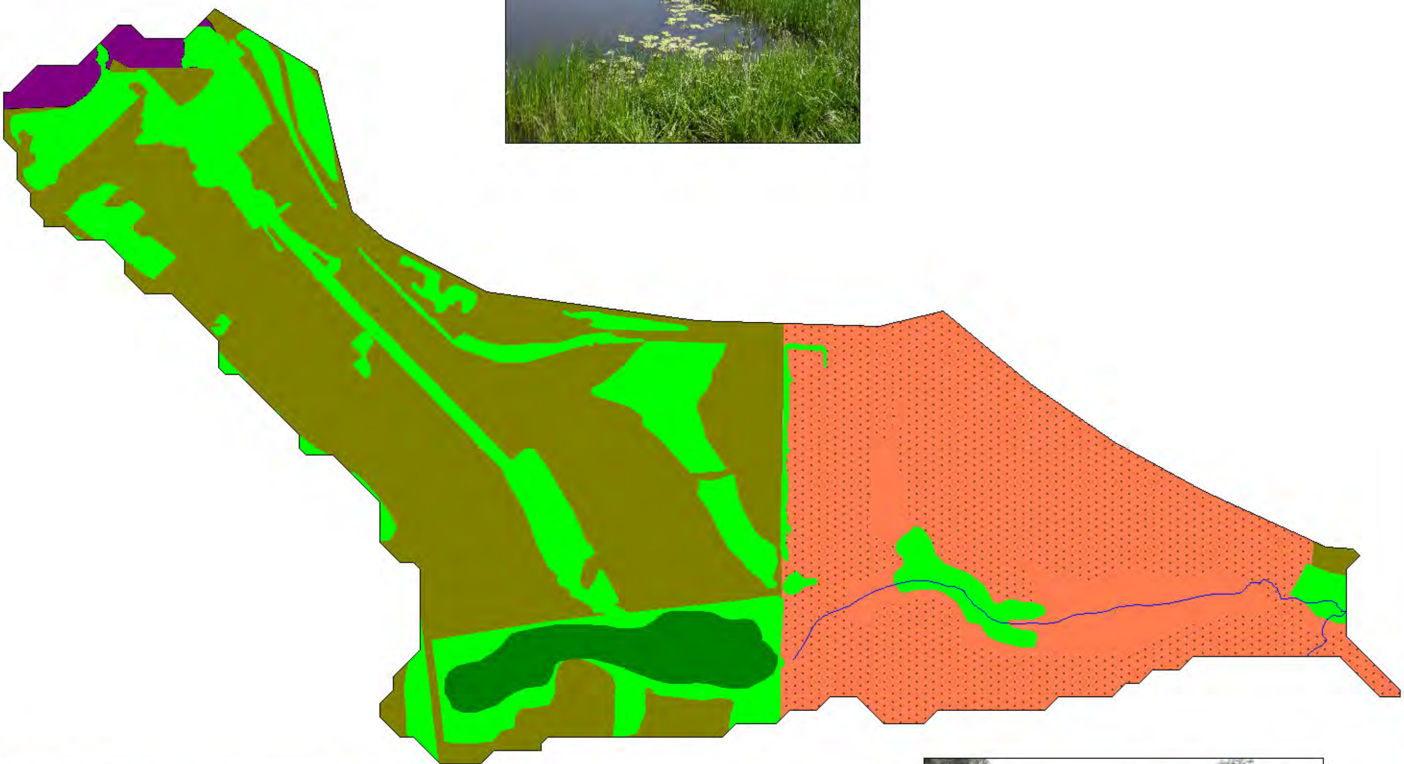

Title:

Caboolture West - Future Indicative Wetland Locations - Subcatchment 1

Figure: **A-29**

Rev: **A**

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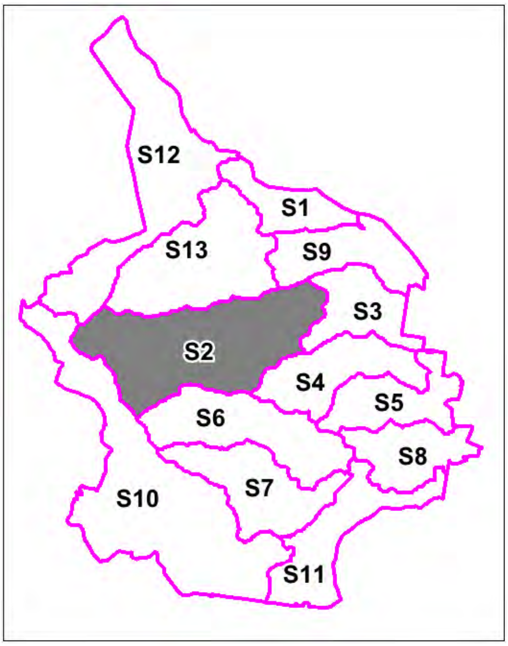
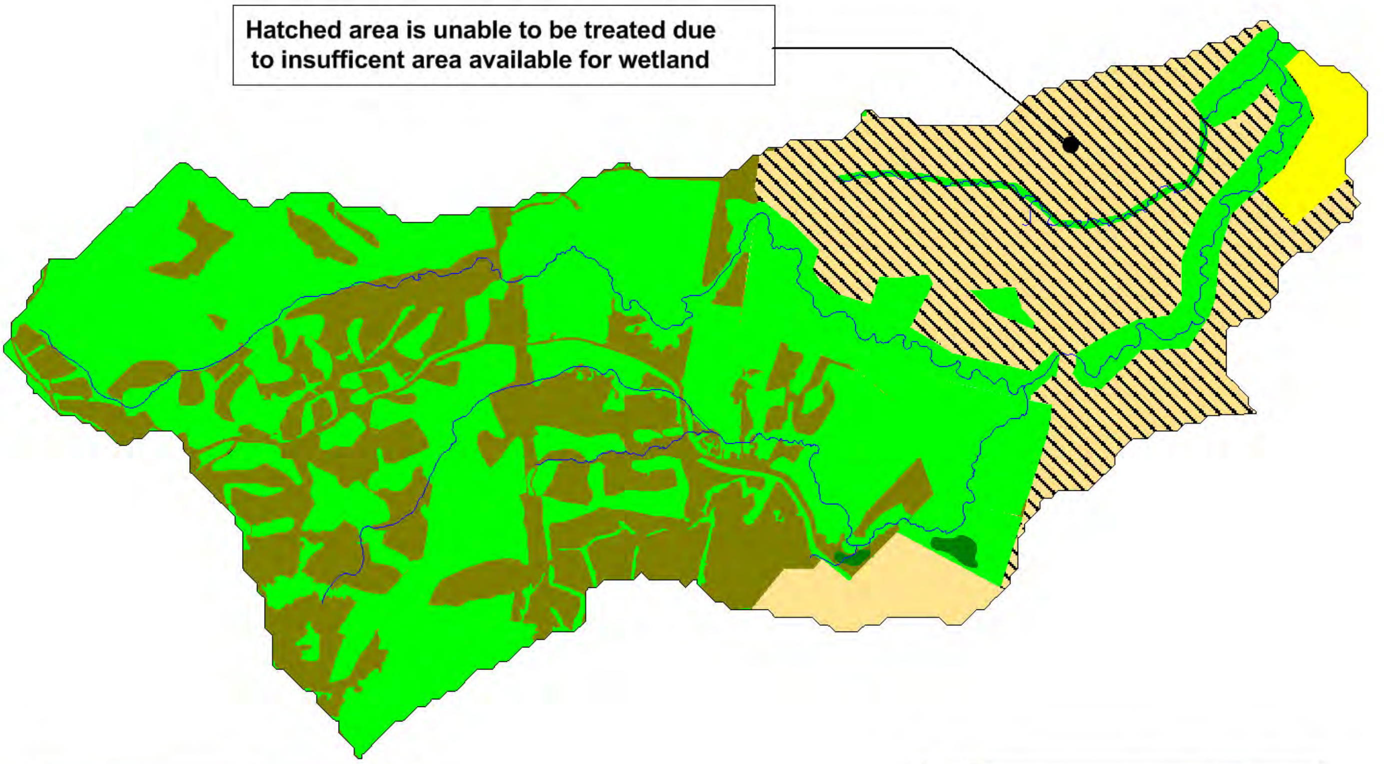
- Wamuran Township
- Agriculture
- Urban
- Rural Residential
- Sports
- Commercial
- Industrial
- Green Space
- Wetland
- Streams





Title:

Caboolture West - Future Indicative Wetland Locations - Subcatchment 2

Figure: **A-30**

Rev: **A**

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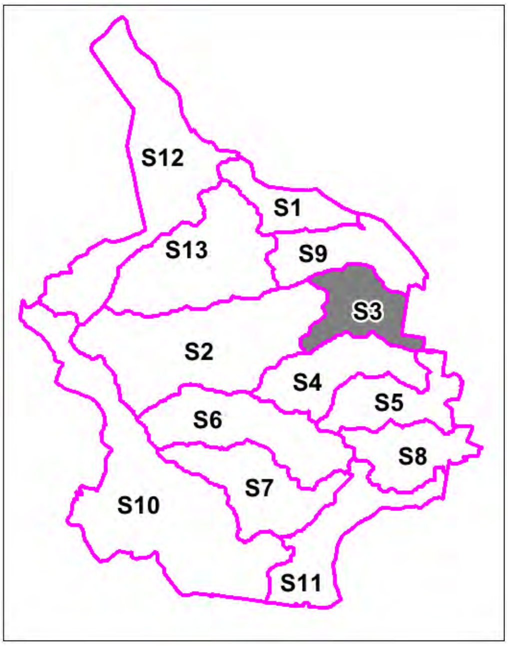

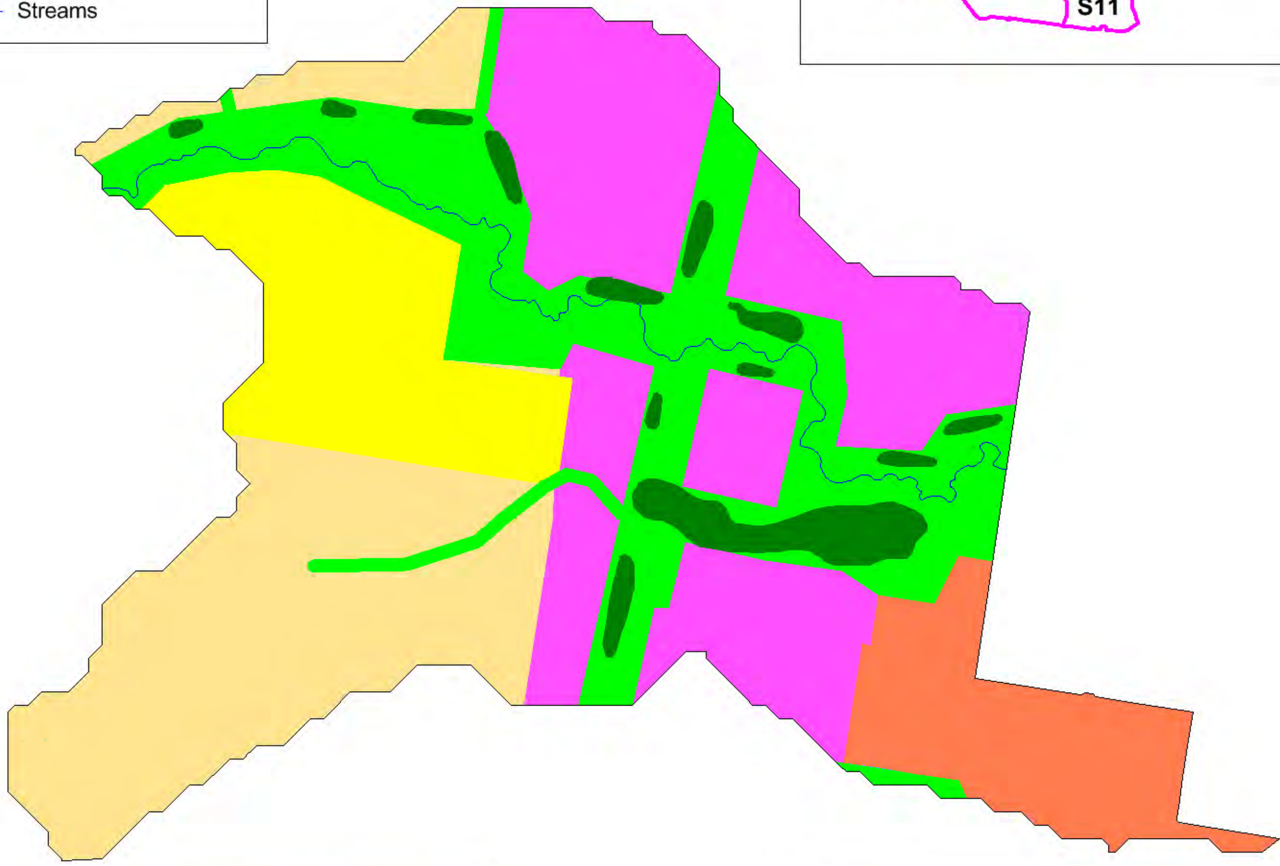

Title:

Caboolture West - Future Indicative Wetland Locations - Subcatchment 3

Figure: **A-31**

Rev: **A**

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Approx. Scale

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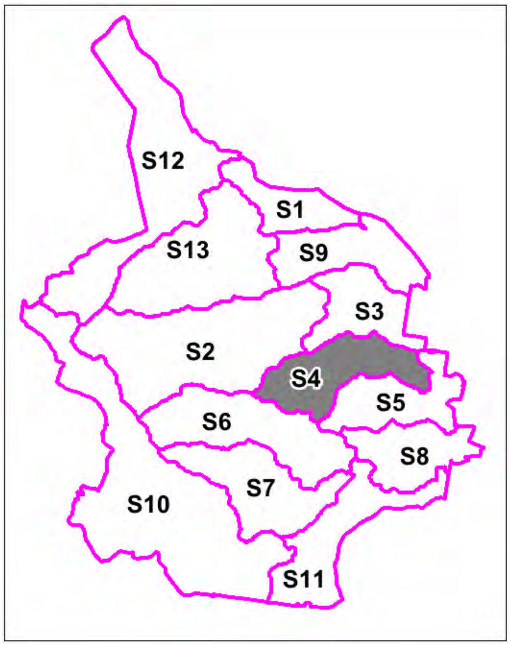

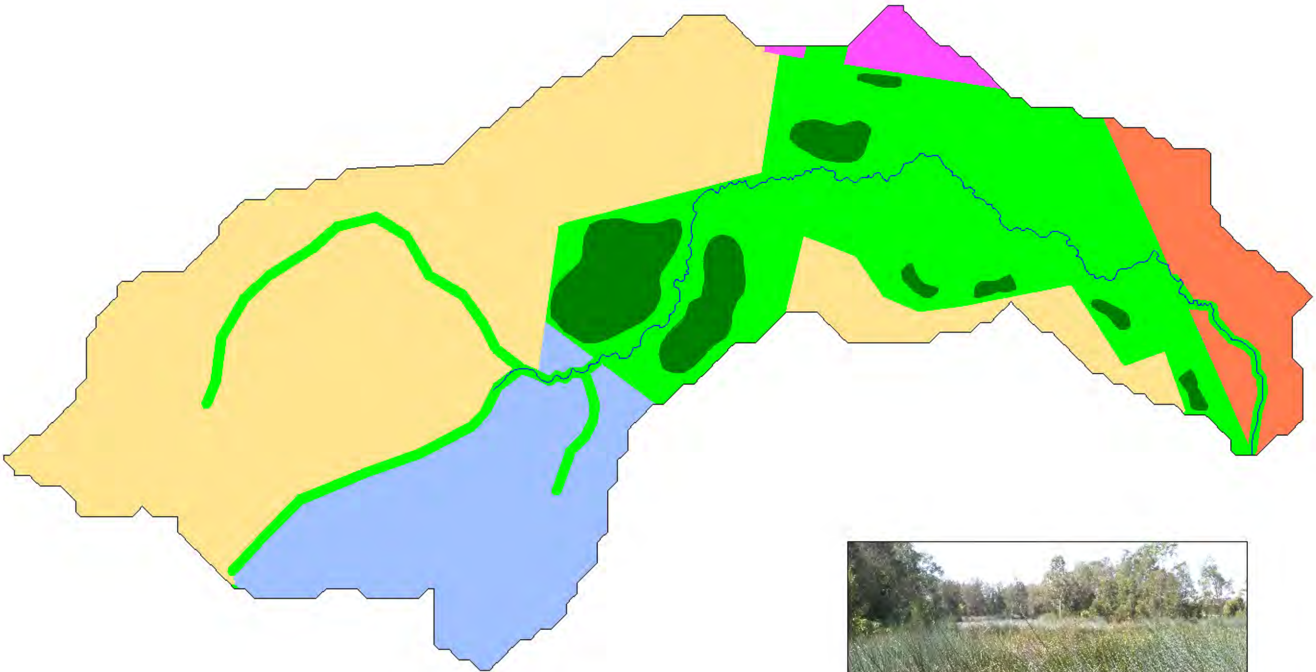

Title:

Caboolture West - Future Indicative Wetland Locations - Subcatchment 4

Figure: **A-32**

Rev: **A**

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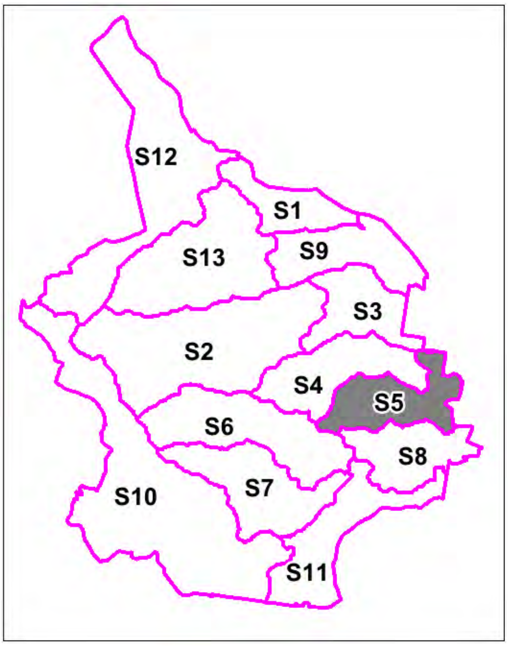
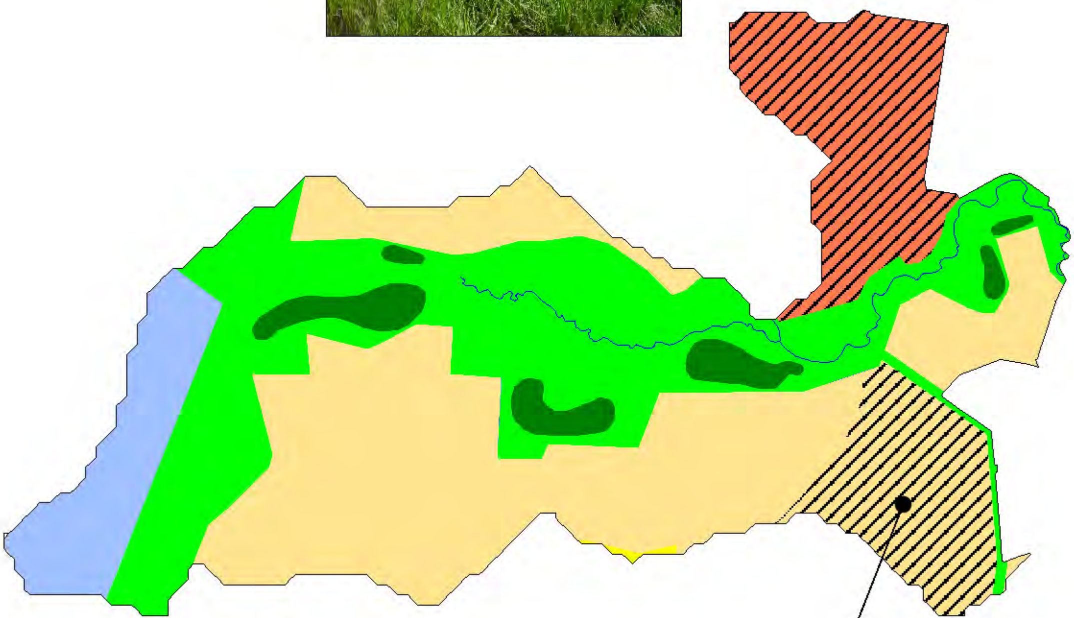
Wamuran Township
Agriculture
Urban
Rural Residential
Sports
Commercial
Industrial
Green Space
Wetland
Streams





Hatched area is unable to be treated due to insufficent area available for wetland

Title:
Caboolture West - Future Indicative Wetland Locations - Subcatchment 5

Figure: A-33

Rev: A

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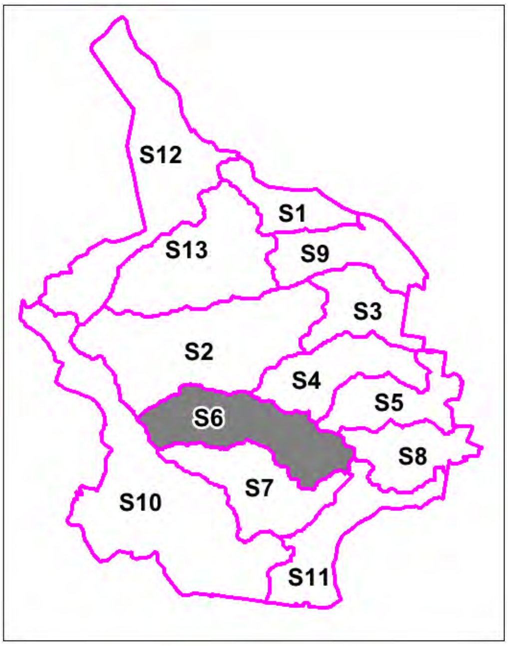
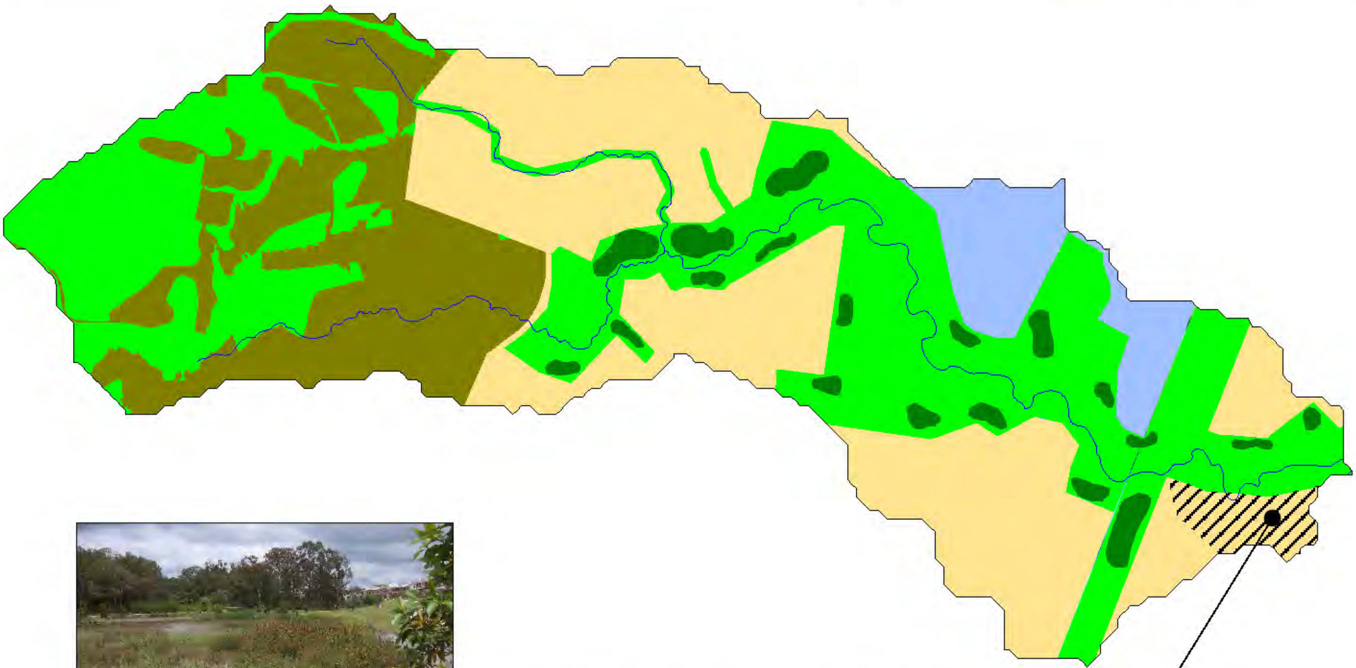
Wamuran Township
Agriculture
Urban
Rural Residential
Sports
Commercial
Industrial
Green Space
Wetland
Streams





Title:
Caboolture West - Future Indicative Wetland Locations - Subcatchment 6

Figure: **A-34**

Rev: **A**

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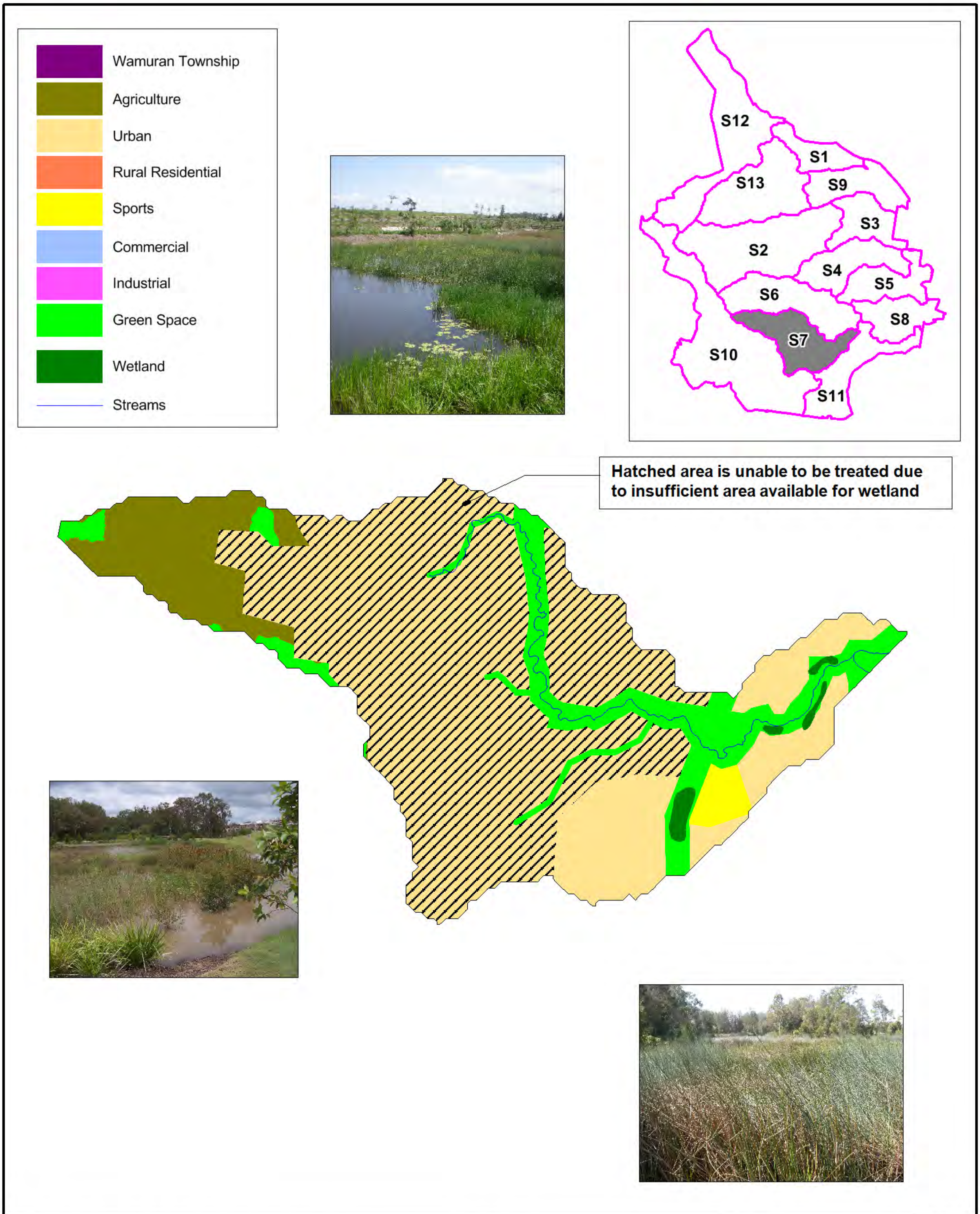

Title:

Caboolture West - Future Indicative Wetland Locations - Subcatchment 7

Figure: A-35

Rev: A

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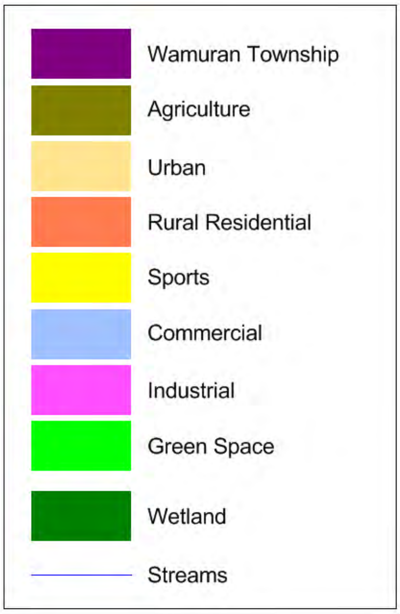

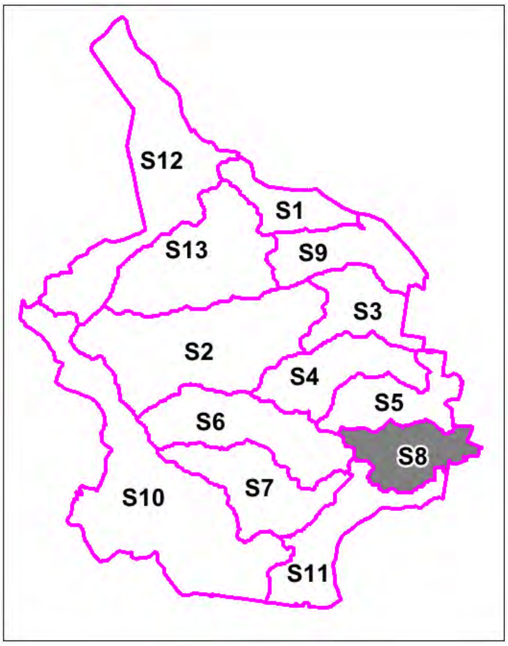

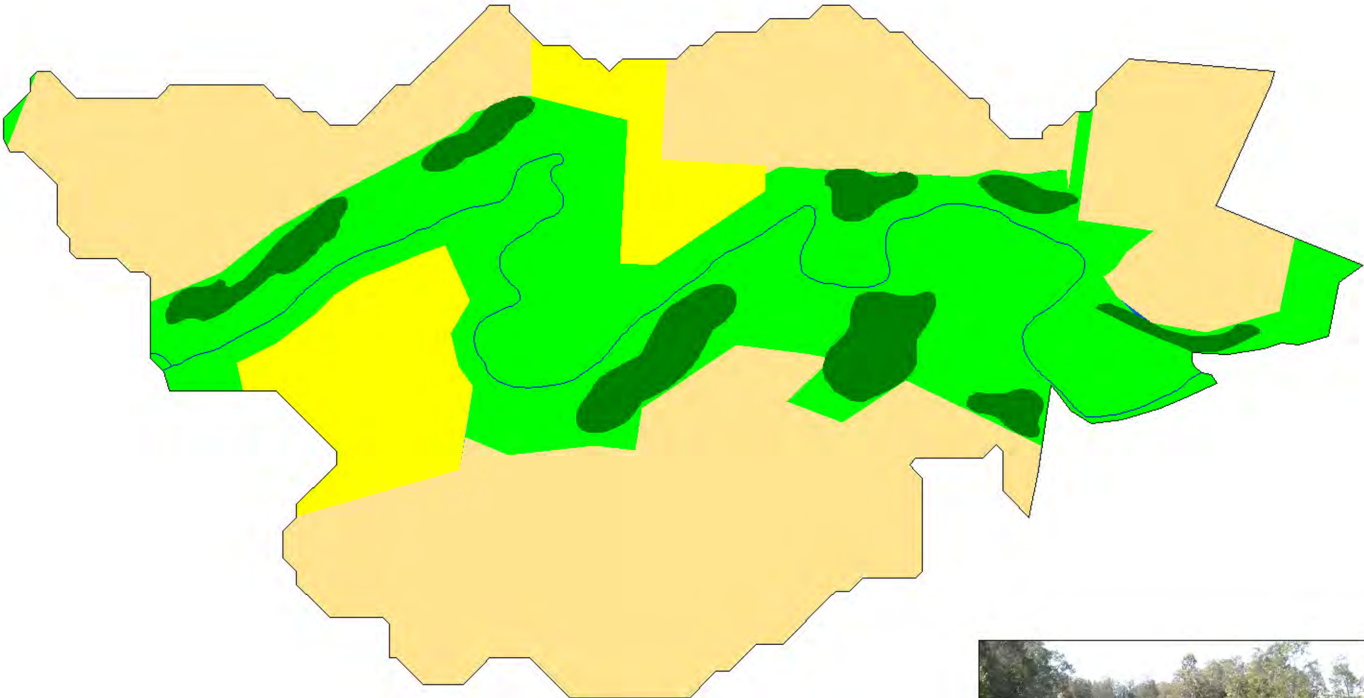

Title:

Caboolture West - Future Indicative Wetland Locations - Subcatchment 8

Figure: **A-36**

Rev: **A**

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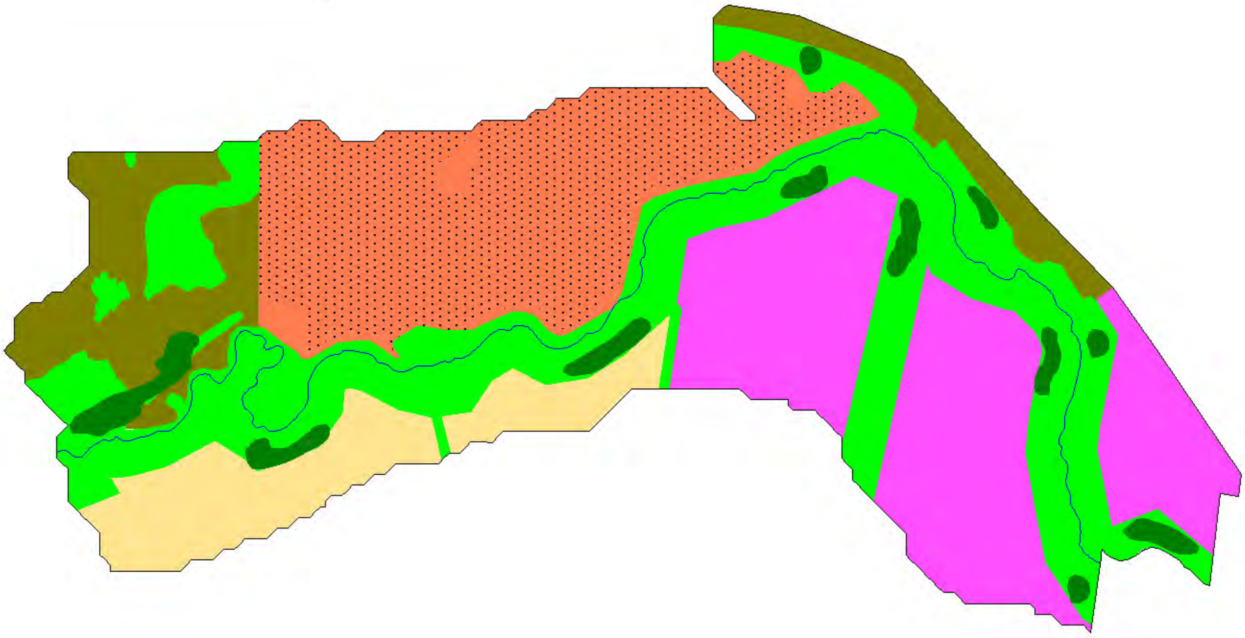

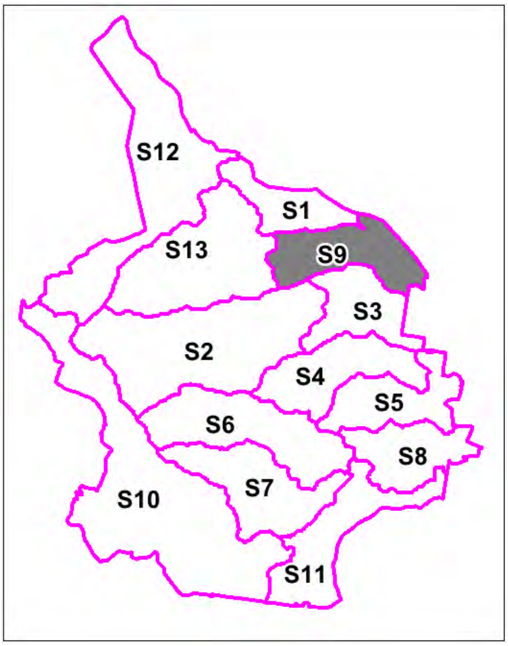

Title:

Caboolture West - Future Indicative Wetland Locations - Subcatchment 9

Figure: A-37

Rev: A

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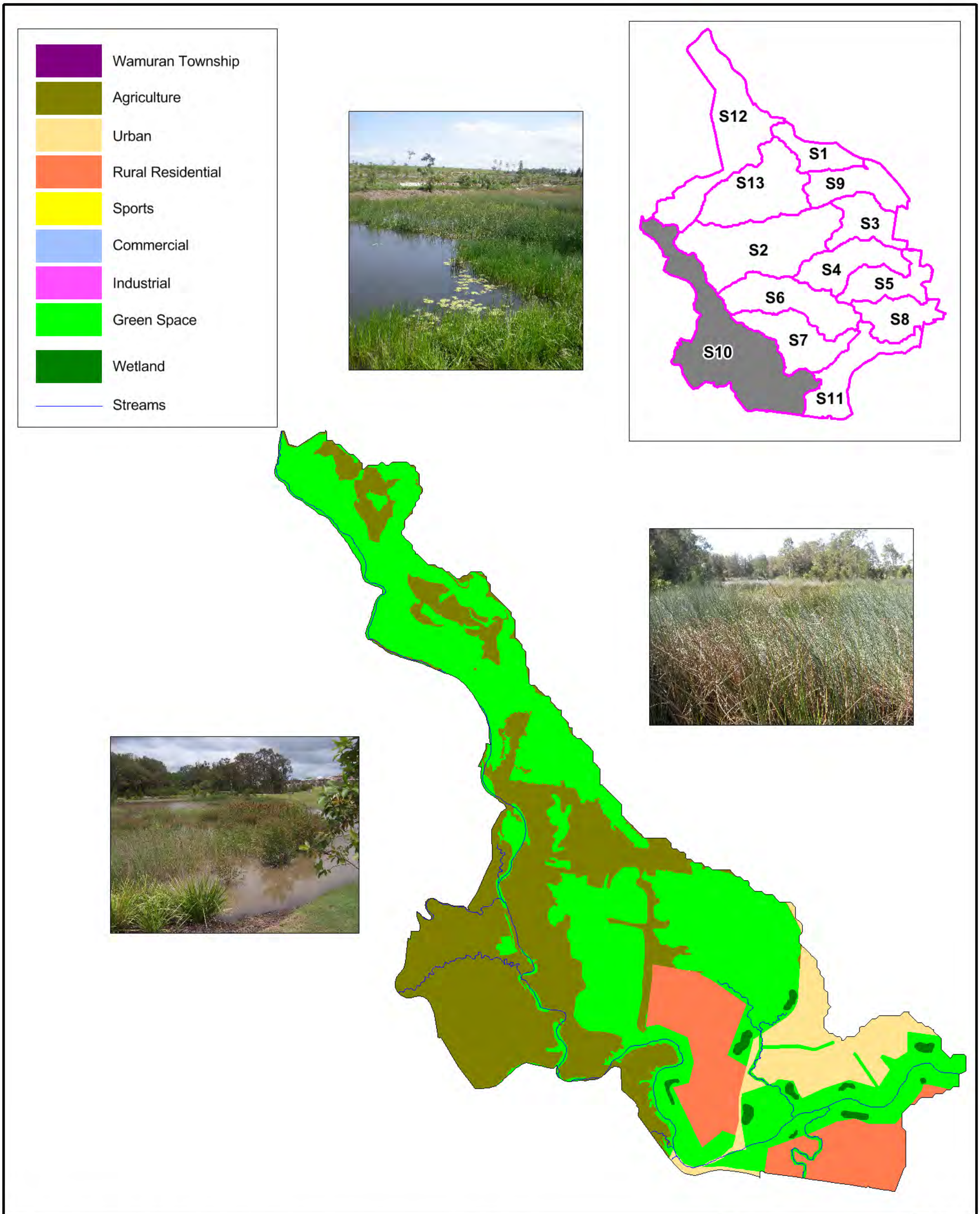

Title:

Caboolture West - Future Indicative Wetland Locations - Subcatchment 10

Figure: **A-38**

Rev: **A**

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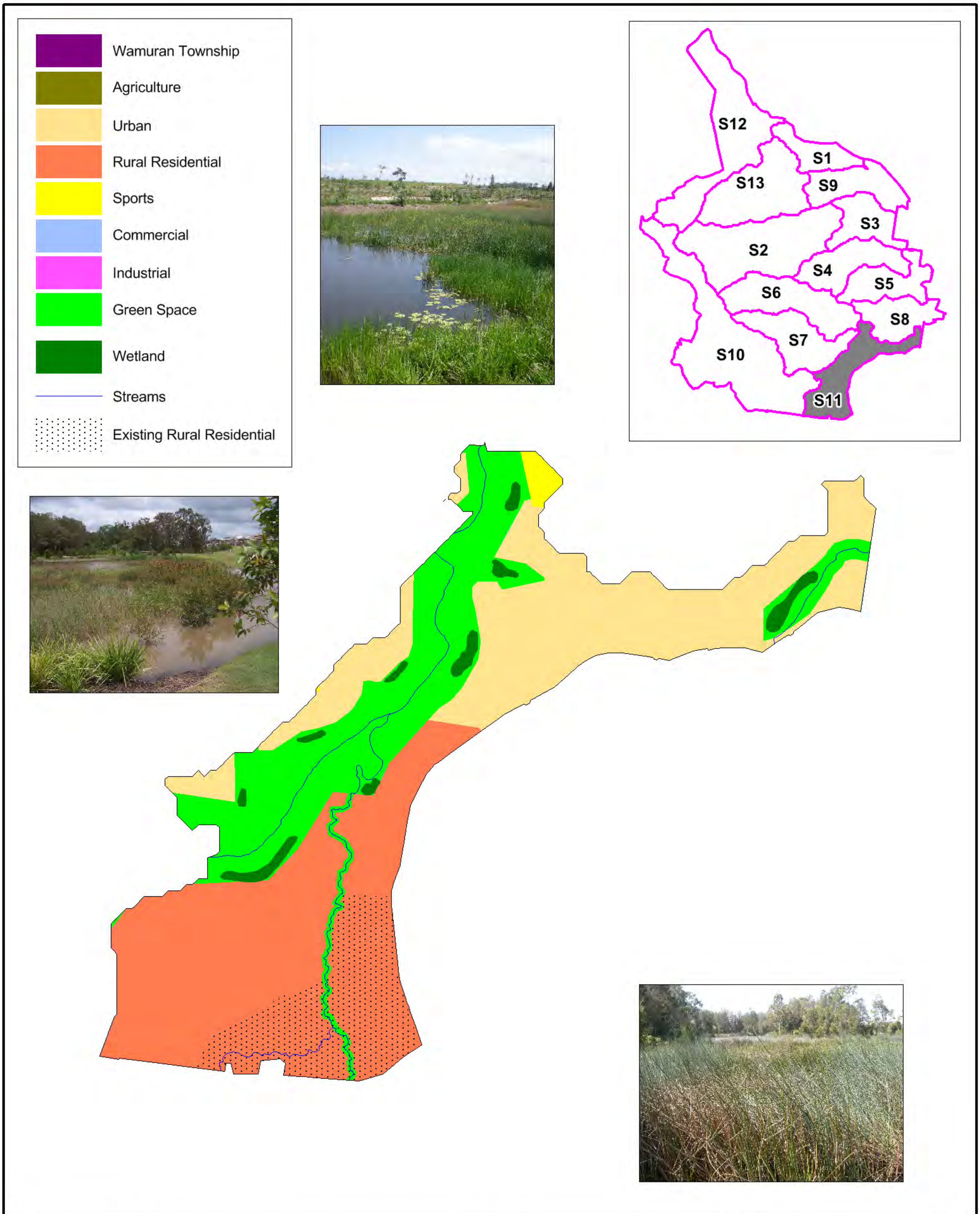

Title:

Caboolture West - Future Indicative Wetland Locations - Subcatchment 11

Figure: **A-39**

Rev: **A**

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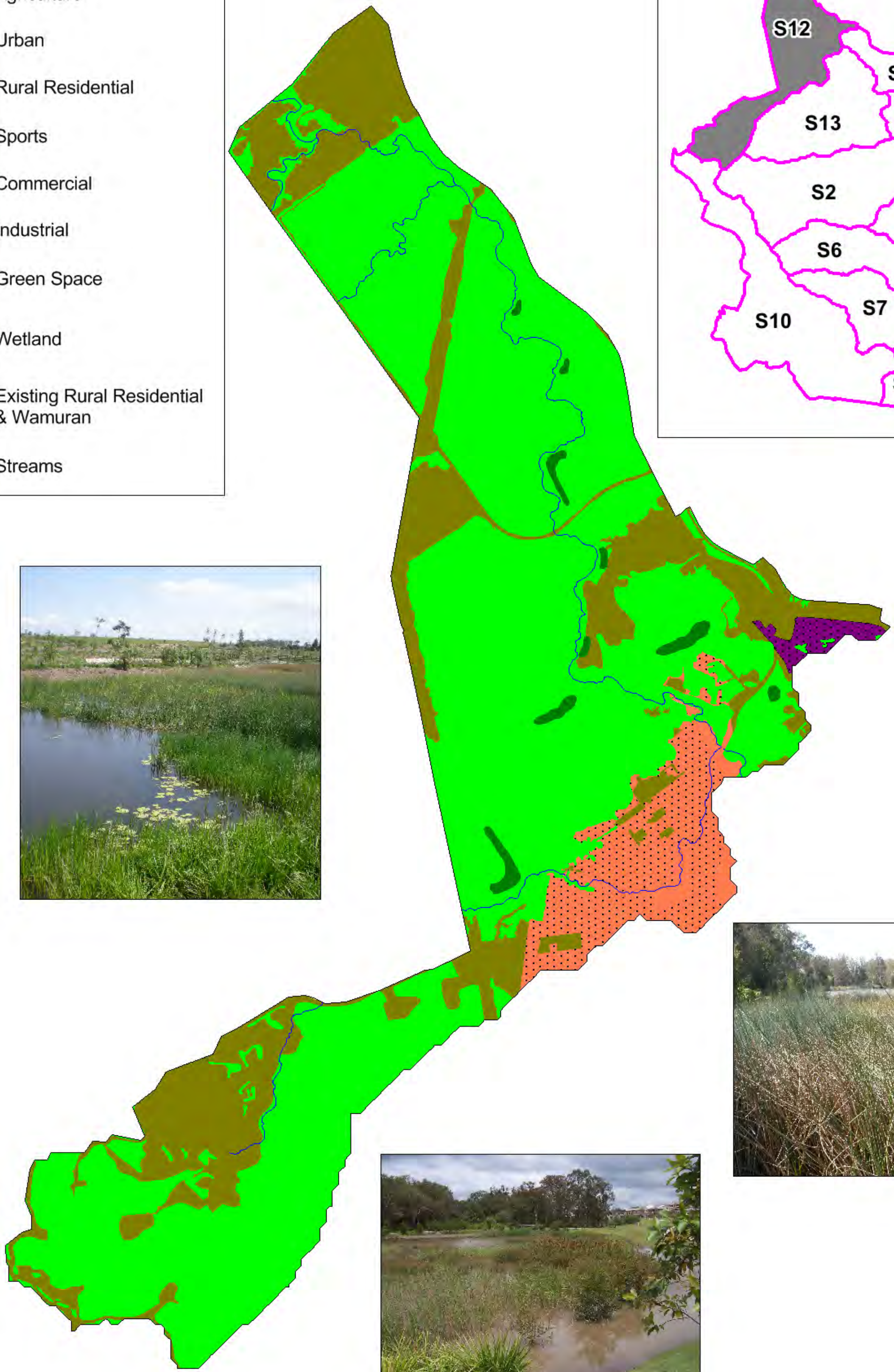

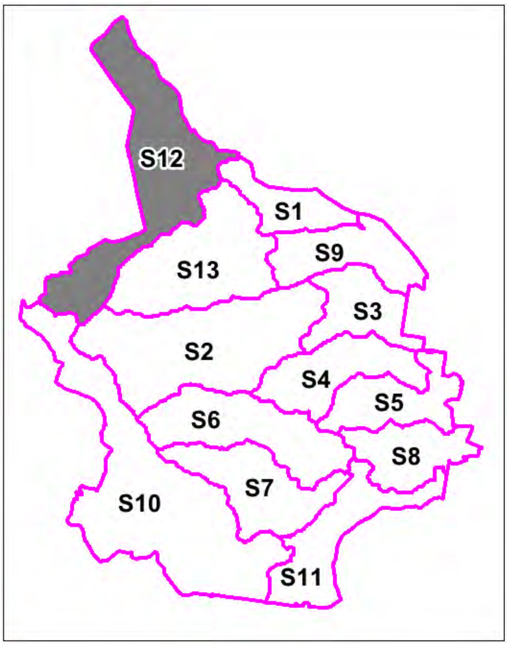

Title:

Caboolture West - Future Indicative Wetland Locations - Subcatchment 12

Figure: **A-40**

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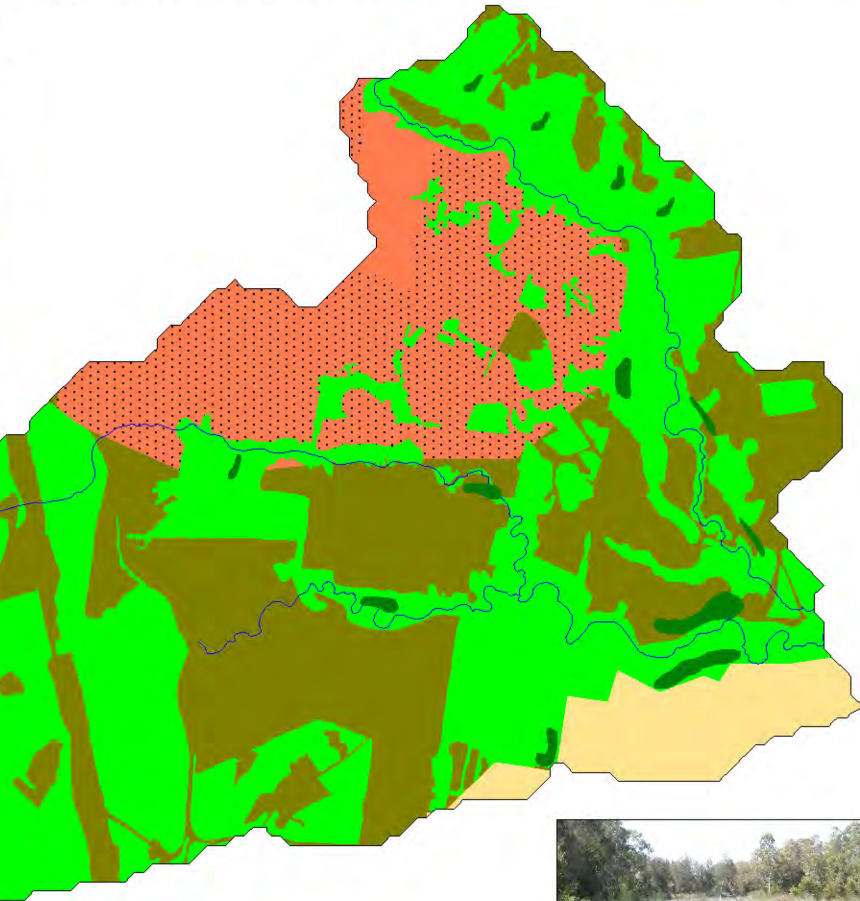

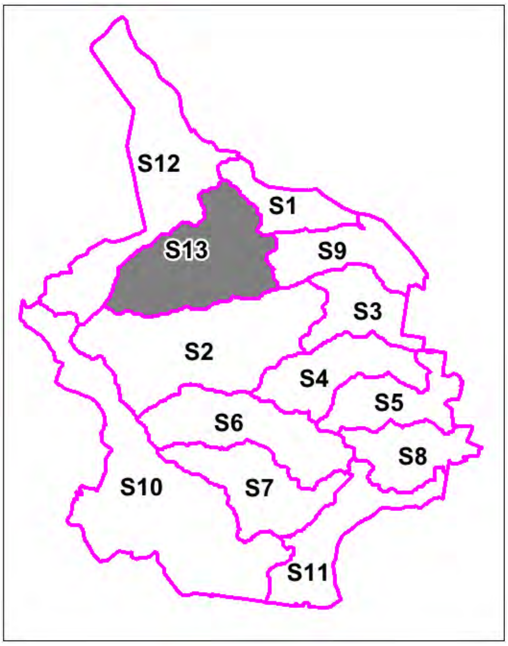

Title:

Caboolture West - Future Indicative Wetland Locations - Subcatchment 13

Figure: **A-41**

Rev: **A**

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Appendix B Water Balance Methodology & Results

This appendix contains the methodology used to develop water balance budgets for the CWMPA, and the associated results.

B.1 Key Elements

A water balance budget was developed to represent both current conditions and the future developed case (year 2056) conditions in the CWMPA by quantifying the key elements of the water cycle, including:

- Rainfall – accounts for all rainfall in the area, based on a typical average year.
- Evapotranspiration – volume of water evaporating from the ground and surface waters, along with transpiration losses from vegetation.
- Stormwater runoff – surface runoff and groundwater (baseflow) entering receiving waters.
- Potable water demand – residential and non-residential reticulated water demand.
- Water leakage – drinking water lost from the water distribution system due to leakage.
- Wastewater discharges – wastewater generated in the CWMPA that is then proposed to be exported from the area to Caboolture South WWTP or Redcliffe WWTP for treatment.
- Non-urban water extractions – water extracted from both surface water and groundwater for irrigation and stock watering purposes.
- Stormwater harvesting – stormwater removed from the water budget through treatment and use for non-potable demands (e.g. irrigation). Flows and pollutant loads for stormwater harvesting schemes have been subtracted from stormwater runoff entering receiving waters. Stormwater use has also been subtracted from potable water demands where applicable.

B.2 Scenarios

Water budgets were developed to investigate conditions for the following scenarios:

1. Pre-European;
2. Current Case;
3. Future Case (year 2056);
4. Future Case (year 2056) with Bioretention Only;
5. Future Case (year 2056) with Bioretention and Stormwater Harvesting;
6. Future Case (year 2056) with Bioretention, Stormwater Harvesting and Rainwater Tanks; and
7. Future Case (year 2056) with Bioretention, Stormwater Harvesting and Riparian Revegetation (Preferred Management Option).

The following section outlines the methodology used to quantify the key inflows and outflows for the water balance budgets.

It should be noted that the eWater MUSIC modelling software was used to provide estimates of rainfall, evapotranspiration and stormwater runoff for the water budgets. Further information on MUSIC modelling methodology is described in Appendix A.

A summary of the methodology and key assumptions used to develop the catchment water balance budgets is outlined in Table B-1.

Table B-1 Summary of Water Budget Methodology and Key Assumptions

Water Cycle Element	*Methodology & Key Assumptions Used to Quantify*
Rainfall	Rainfall sourced from Dayboro Post Office rainfall Station (Station no. 040063) to quantify average weather conditions
Evapotranspiration	MUSIC modelling used to quantify. Calculated as the difference between modelled inflows (rainfall) and modelled outflows (stormwater runoff plus extractions).
Stormwater Runoff	MUSIC modelling used to quantify.
Potable Water Demand	Future potable water demands were estimated using the Average Day (AD) consumption from "*Caboolture West Ultimate Water Supply and Sewerage Infrastructure Plans"* (MWH, 2013). This is estimated to be 230 L/EP/day. A total equivalent person (EP) was estimated to be 76,905 (MWH, 2013).
Water Leakage	Assumed to be 30 L/EP/day. This is the non-revenue water as specified in "*Caboolture West Ultimate Water Supply and Sewerage Infrastructure Plans"* (MWH, 2013). A total EP was estimated to be 76,905 (MWH, 2013).
Wastewater Discharges	Average Dry Weather Flows (ADWF) for sewerage planning purposes was developed based on the standards of service contained within the SEQ Code planning guidelines for water supply and sewerage (MWH, 2013). 210 L/EP/day was adopted. A total EP was estimated to be 76,905 (MWH, 2013).
Stormwater Harvesting	Demands for potential stormwater harvesting schemes have been calculated using "*Draft Stormwater Harvesting Guidelines*" (Water by Design, 2009). Potential future stormwater harvesting scheme volumes have been estimated assuming typical rainfall conditions. Future proposed stormwater harvesting schemes are assumed to substitute existing mains potable water demands.
Rainwater Tanks	Assumed each lot in urban residential areas has a rainwater tank with 50% of the the roof area draining to a 5 kL tank.100% of roof area in commercial areas to drain to a tank with volume equal to 1500 litres per $50m^2$. Demands calculated in accordance with Water by Design (2010a).
Rural Extractions	Water licence data was sourced from DNRM. The data contains details of the location of rural water extraction points and the irrigation in hectares. An average application rate of 4.0 ML/ha was assumed based on surveys of water use on Queensland farms (ABS, 2010).
Groundwater Infiltration	Baseflow (contributing to stream flow) quantified in MUSIC. Deep seepage (water lost to the system) assumed to be zero.

B.3 Evapotranspiration

Evapotranspiration is the amount of water that outflows from the catchment from surface evaporation and transpiration of water from plant leaves. It is one of the major components of the water cycle.

Potential evapotranspiration (PET) from the Dayboro Post Office was adopted for the CWMPA, in accordance with Water by Design's MUSIC Modelling Guidelines (Water by Design, 2010a). The PET data used is shown in Figure B- 1 and can be seen to vary from 67 mm in June to 189 mm in January.

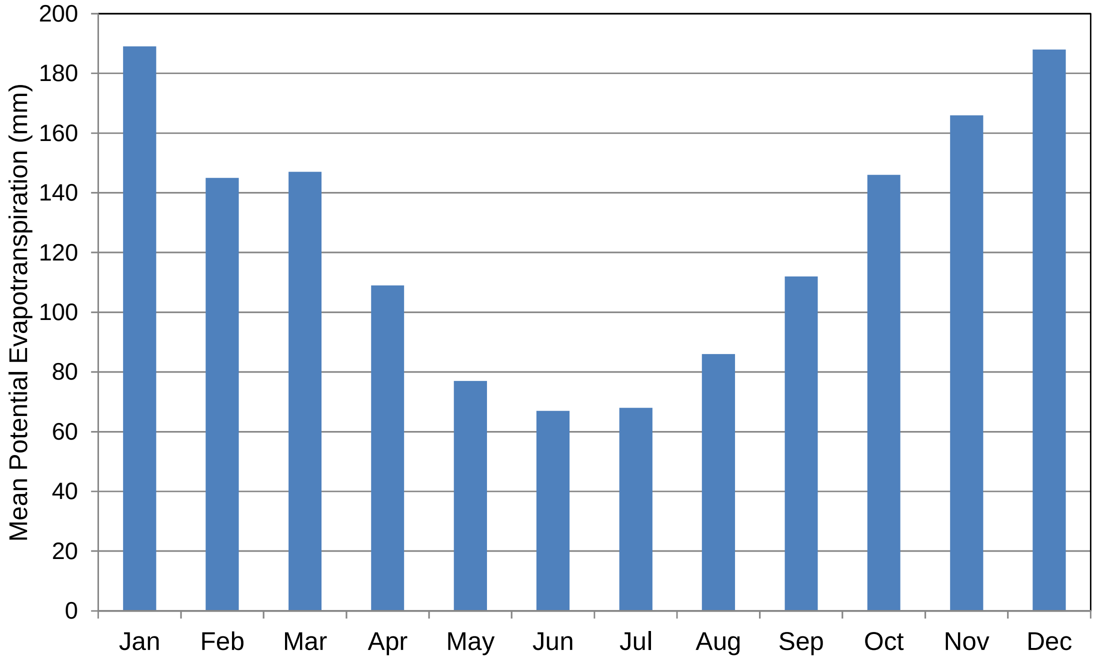


Figure B- 1 Potential Evapotranspiration for the CWMPA

B.4 Stormwater Runoff

Stormwater discharges relate to surface runoff after rainfall events as well as groundwater flow (i.e. baseflow) from both urban and rural land uses in the catchment. In the water budgets, these stormwater discharges are represented by average annual flow volume and associated pollutant loads into receiving waterways at the bottom of the catchment.

MUSIC modelling was used to quantify stormwater discharges and pollutant loads, using rainfall data to represent typical, wet and dry conditions.

B.5 Potable Water Demand

Potable water is consumed by residential, commercial, industrial and municipal users (e.g. parks and school ovals). The potable water demand was estimated to be 230 L/EP/day with EP estimated to be 76,905 MWH (2013). Note, this data was presented in a report in March 2013. Since this time the number of "equivalent people" (EP) may have changed.

Data provided by MWH (2013) shows that the volume of potable water use is expected to be approximately 6,500 ML/year.

B.6 Water Leakage

Water leakage refers to potable water lost from the system through leaks in the water distribution system (e.g. pipes). Based on estimates by MWH (2013), network leakage or non-revenue water was assumed to be 30 L/EP/day. With an estimate of EP at 76,905 this equates to approximately 840 ML/year.

B.7 Wastewater

Average Dry Weather Flows (ADWF) for sewerage planning purposes was developed based on the standards of service contained within the SEQ Code planning guidelines for water supply and sewerage (MWH, 2013). Using the estimated ADWF of 210 L/EP/day and a total EP estimated to be 76,905 the total wastewater generated is approximately 5,900 ML/yr.

B.8 Stormwater Harvesting

During discussions with Council four potential stormwater harvesting schemes were identified within the CWMPA for irrigation of the regional sporting fields. These sites are shown in Figure 5-6.

These sites present an opportunity to implement stormwater harvesting schemes to substitute current potable water demand for the irrigation of adjacent sporting fields.

Potential demands for these stormwater harvesting schemes were determined by estimating the irrigation volumes used for the sporting fields using the methodology outlined in “Draft Stormwater Harvesting Guidelines” (Water by Design, 2009).

Table B-2 Summary of Assumptions for Stormwater Harvesting Assessment

Parameter	Assumption	Value
Adopted irrigated open space (% of gross area)	Assumed to be ‘Open Space’	90% of gross area of sporting fields to be irrigated
Total annual irrigation demand (mm/year)	As per Water by Design (2009)	700 mm/year
Irrigated Area	Sporting field A	45 ha
	Sporting field B	9 ha
	Sporting field C	20 ha
	Sporting field D	6 ha
Estimated Demands	Sporting field A	316 ML/ year
	Sporting field B	65 ML/ year
	Sporting field C	139 ML/ year
	Sporting field D	40 ML/ year

Pollutant load reductions from stormwater use at the potential stormwater harvesting sites have been extracted from MUSIC modelling results.

B.9 Rainwater Tanks

For this study it has been assumed that each lot in the urban residential areas will have a rainwater tank with 50% of the roof area draining to a 5kL tank.

For the commercial areas with rainwater tanks, it has been assumed that 100% of the roof area will drain to a tank with a volume equal to 1500 litres per 50 m^2 of roof area. This assumption is based on the requirements outlined in the Queensland Development Code MP 4.3 (Queensland Government, 2010) for 'small buildings'.

The modelling has assumed that roof runoff will be harvested and used to supplement non-potable internal water demands (e.g. toilet and laundry) and irrigation demands. In the absence of water demand data for the 'commercial' and 'community areas, water demands have been based on the residential water demands given in Water By Design (2010a).

Irrigation rates have been calculated using the same methodology as applied to residential areas (i.e. 548mm/year scaled by daily PET minus rain – applied to 70% of all pervious ground level area). Applied internal water demands have been estimated by dividing the roof area by 250m^2 (typical roof area for a residential lot) and multiplying this by the estimated average internal water demand for a typical residential lot.

B.10 Rural Extractions

Rural extractions includes water extracted from both surface water and groundwater sources, generally for irrigation and stock watering purposes. The approximate volumes of water extracted from groundwater and surface water sources for rural applications in the CWMPA, water licence data was sourced from the Department of Natural Resources and Mines (DNRM) as part of the "*Total Water Cycle Management Strategy for Moreton Bay Regional Council*" (BMT WBM, 2010a).

The water licence data contains details regarding the location of rural water extraction points and the irrigation area in hectares. Based on data from surveys of water use on Queensland farms (ABS, 2010), an average application rate of 4.0 ML/ha was used to calculate the approximate volume of water extracted for rural applications. Using this methodology, the volume of water extracted and used in rural applications in the CWMPA is estimated to be 142 ML/yr.

B.11 Groundwater Infiltration

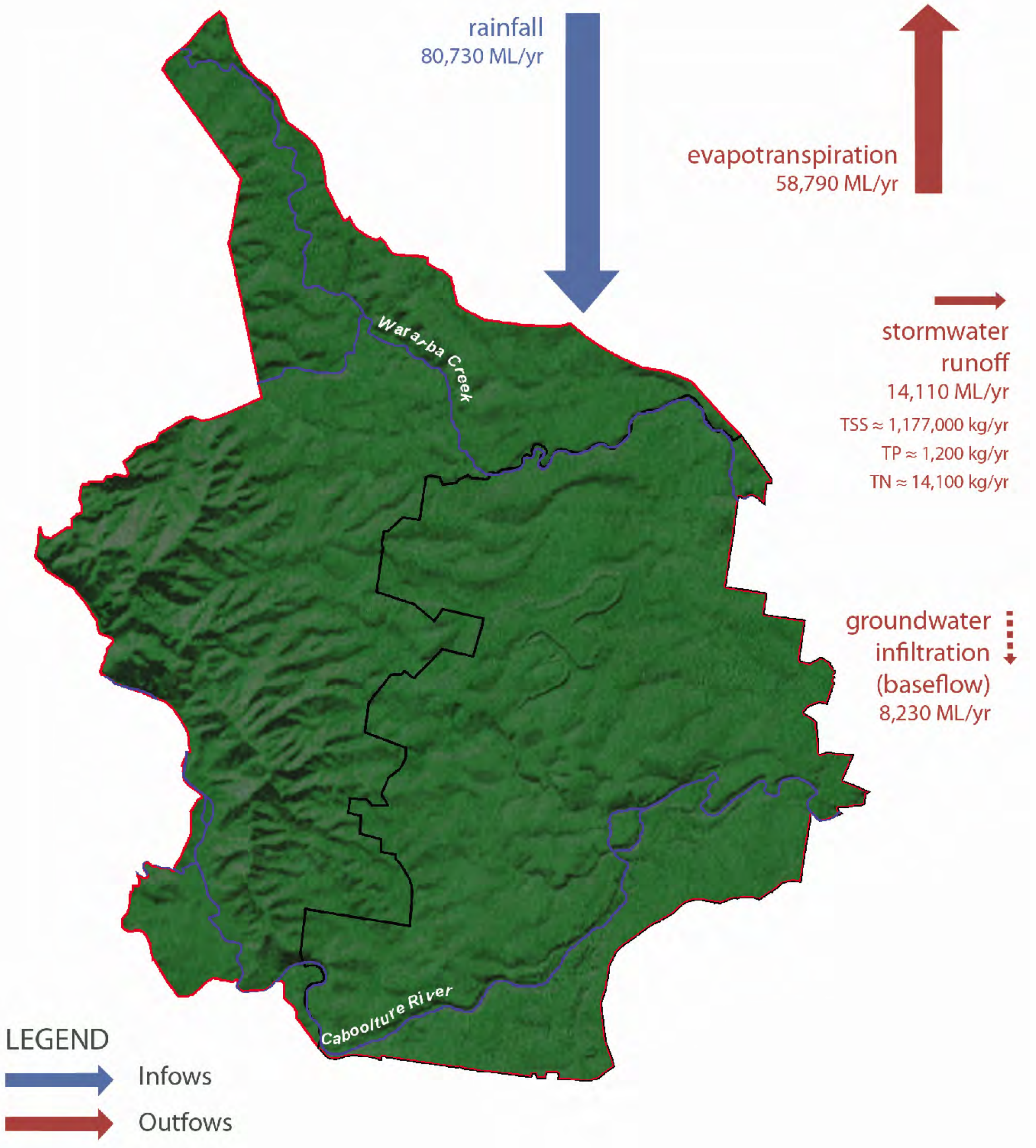
Groundwater infiltration in the catchment has been represented as baseflow. Baseflow includes groundwater infiltration which discharges from the catchment as a component of stream flow. Due to the uncertainty surrounding deep seepage properties in the catchment (groundwater lost permanently from the system), no deep seepage has been assumed.

B.12 Results

Results of the water balance assessment are shown in Figure B-2 to Figure B-8. These figures show the key inflows and outflows in the catchment under the following scenarios:

1. Pre-European;
2. Existing site;
3. Future (year 2056);
4. Future (year 2056) with Bioretention Only;
5. Future (year 2056) with Bioretention and Stormwater Harvesting;

6. Future (year 2056) with Bioretention, Stormwater Harvesting and Rainwater Tanks; and
7. Future (year 2056) with Bioretention, Stormwater Harvesting and Riparian Revegetation (Preferred Management Option).



Title:

Water Balance for the Pre-European Site

Figure: B-2

Rev: A

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Approx. Scale

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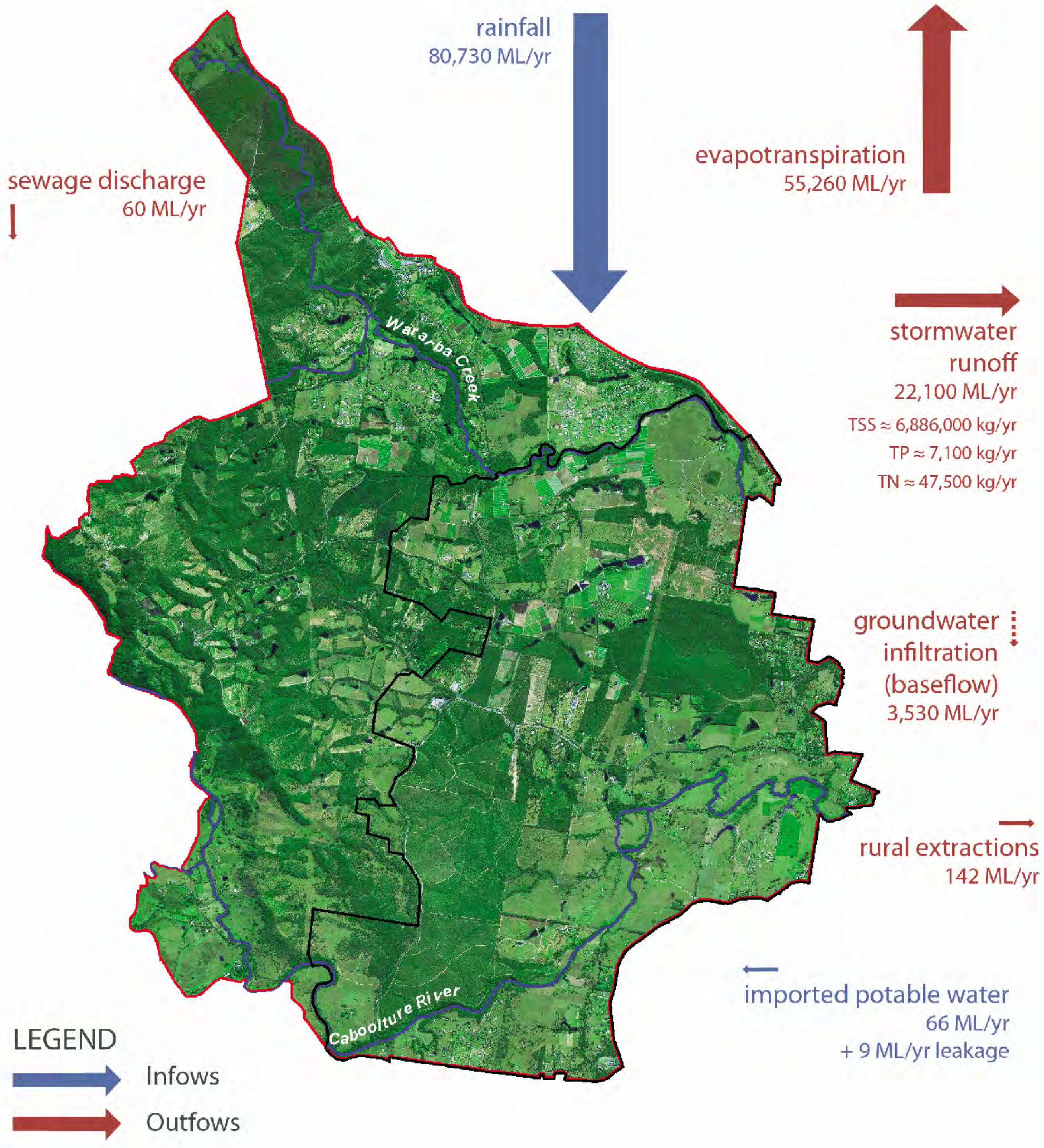

Title:
Water Balance for the Existing Site

Figure: **B-3**

Rev: **A**

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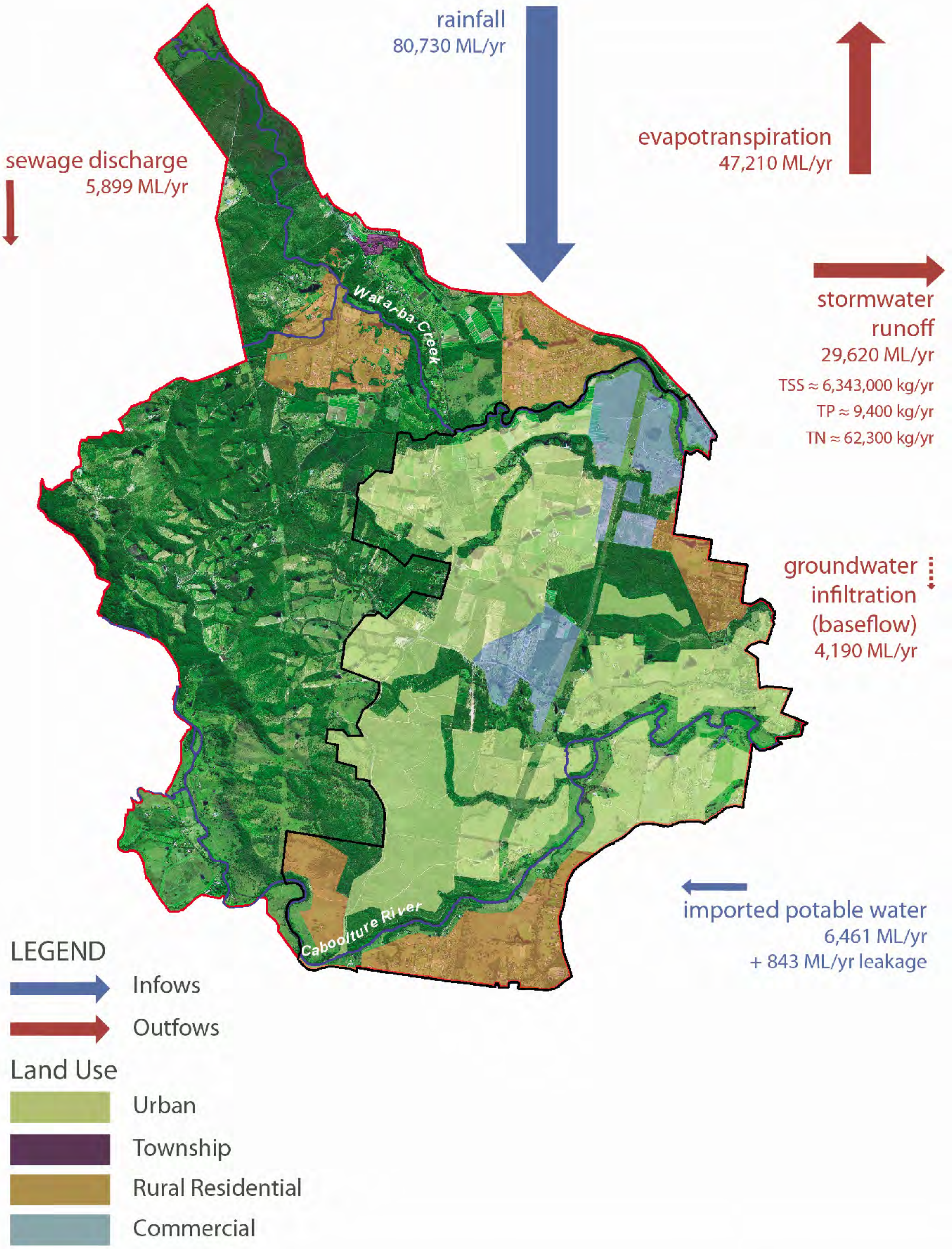

Title:

Water Balance for the Future (2056) Site with No Stormwater Management

Figure: **B-4**

Rev: **A**

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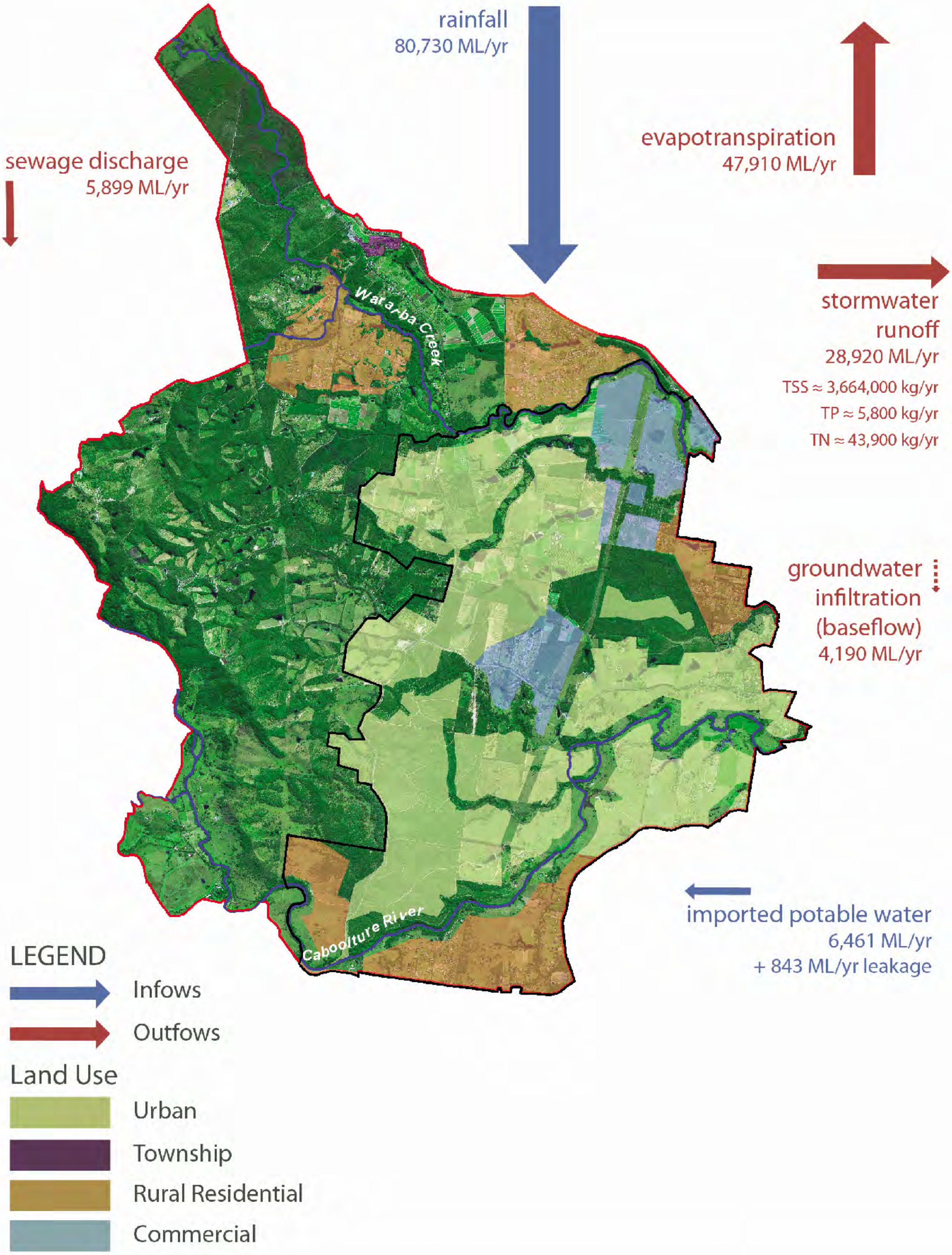

Title:

Water Balance for the Future (2056) Site with Bioretention Only

Figure: B-5

Rev: A

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Approx. Scale

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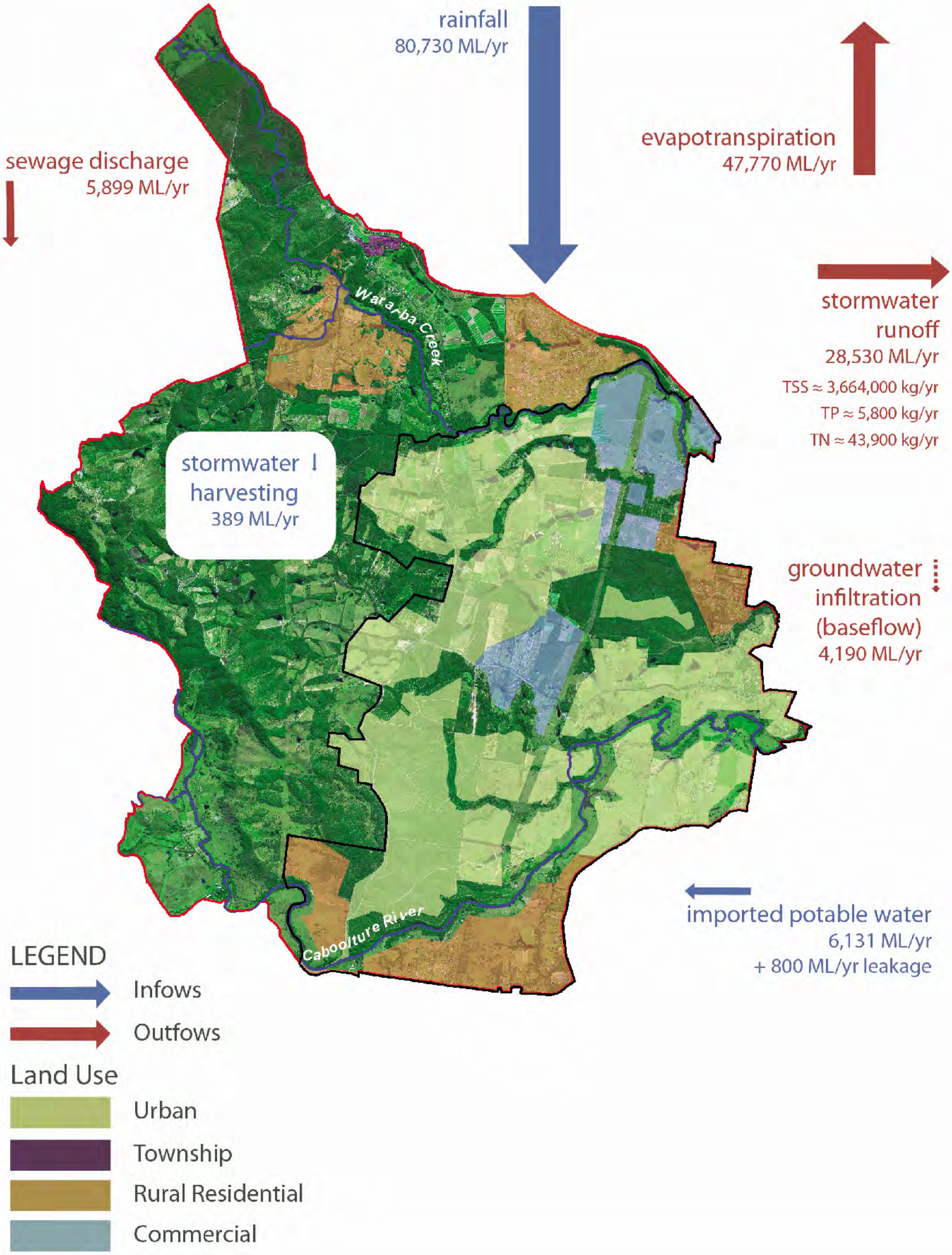

Title:
Water Balance for the Future (2056) Site with Bioretention & Stormwater Harvesting

Figure: B-6

Rev: A

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Approx. Scale

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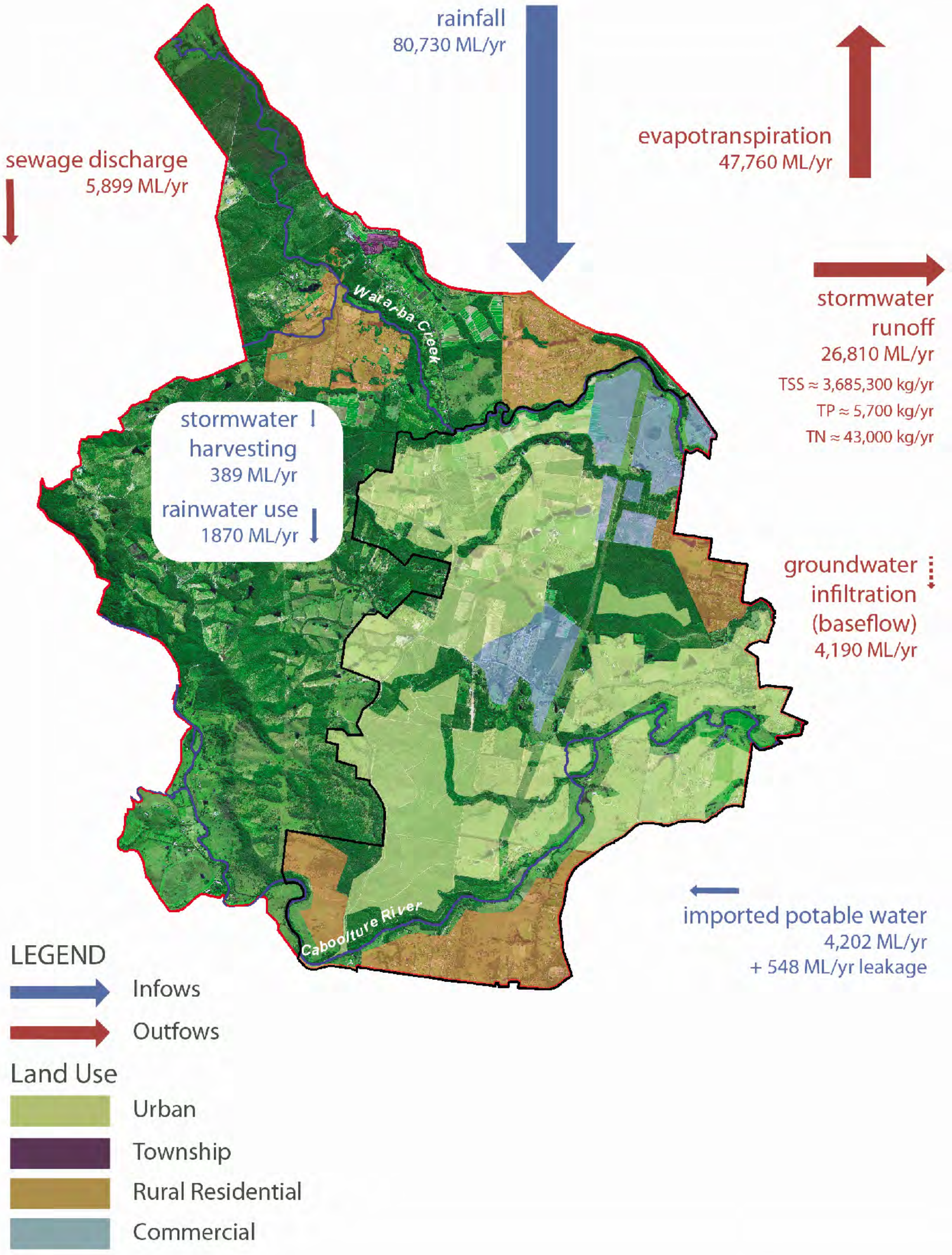
Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\WQU_016_131111_WB_Future Case Bio SW Harvest.wor



Title:

Water Balance for the Future (2056) Site with Bioretention, Stormwater Harvesting & Rainwater Tanks

Figure: **B-7**

Rev: **A**

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Approx. Scale

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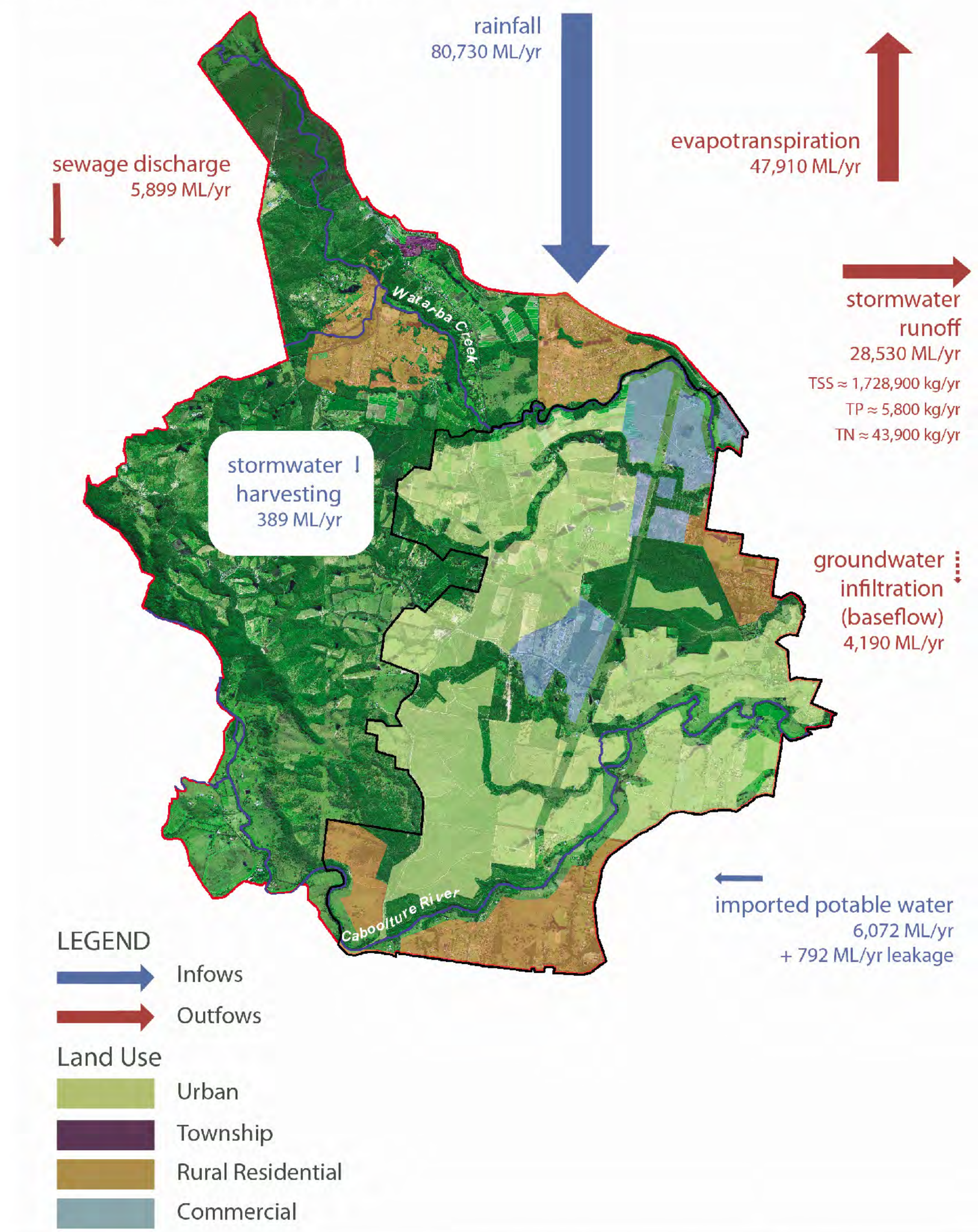
This is the recommended management strategy for the CWMPA



Title:

Water Balance for the Future (2056) Site with Bioretention, Stormwater Harvesting & Riparian Revegetation

Figure: **B-8**

Rev: **A**

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Approx. Scale

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Filepath : I:\B20132_I_BRH MBRC TWCM_NR\DRG\WQU_018_131111_WB_Future Case Bio SWH Revegetation.wor

Appendix C Cost Methodology and Assumptions

This appendix contains the key indicators and assumptions used to calculate the cost of each of the solutions. Each solution has been assessed over the 20-year planning period from 2016 to 2036. For simplicity, the annual performance of each solution has been assessed assuming most solutions will be implemented at full potential for 20 years (unless otherwise stated).

It is noted that there are some inherent limitations to some of the data used in these assessments, which is why the results presented in this section are only used as a high level assessment to indicate the general cost and effectiveness of each solution.

The key indicators used to evaluate each solutions performance are as follows:

- **Net Present Value (NPV)**: This is the total cost incurred over the planning period for establishment (i.e. capital) and during the operational phase (including maintenance), discounted to provide the cost in today's dollars (i.e. $2013). Net present value was calculated in accordance with AS/NZS 4536:1999. In determining NPV, a real discount rate of 6% per annum was used.
- **Levelised Cost**: The levelised cost is calculated as the ratio of the net present value (NPV) of projected capital and operating costs of an option, to the present value of the projected annual demand supplied or saved by the option. This is consistent with levelised cost methodology outlined by Fane et al (2002, 2003) to be an appropriate measure for identifying least cost options in Integrated Resource Planning. As part of the TWCMP process for Caboolture West a high level assessment of the indicative costs and treatment performance of each solution has been undertaken. The performance of the individual solutions is summarised in the following sections. Each solution has been assessed over the planning period of 2016-2036.

C.1 Assumptions

The following section outline the key assumptions made with regards to each of the solutions assessed.

C.1.1 Bioretention systems

Based on recommendations from Water by Design (2010a), the following assumptions were made when costing the establishment and maintenance of end-of-pipe bioretention basins, and adjusted for inflation:

- Acquisition cost: $298/m^2 ;
- Typical maintenance cost: $5.51/m^2 per annum;
- Annual establishment cost: $16.53/m^2 per annum; and
- Establishment period: 2 years.

C.1.2 Wetlands

Based on recommendations from Mark Bailey (AWC, *Pers. Comm:* 2013) the following assumptions were made when costing the establishment and maintenance of wetlands:

- Acquisition cost: $175/m^2;
- Typical maintenance cost: $2.50/m^2 per annum;
- Annual establishment cost: $7.50/m^2 per annum; and
- Establishment period: 2 years.

C.1.3 Stormwater Harvesting Wetlands

The following expenses for establishing and maintaining the stormwater harvesting systems were used to estimate the cost of implementing this solution:

- Establishment of Treatment System and Pumps: $58,000 (Source: BMT WBM, 2010b).
- Acquisition and maintenance costs as per wetlands.
- Pumping Costs: $66.40/ML.
- Water Costs for Sporting Fields: $1.30/kL (UnityWater, 2013).

C.1.4 Waterway Riparian Revegetation to Q100 Boundary

The cost of riparian revegetation works was assumed to be $15/m2 (Source: Peter Rawlinson, MBRC, *Pers. Comm*.: 11 November 2013).

C.1.5 Erosion and Sediment Control Program

The cost of implementing a regional E&SC program in Australia with increased enforcement was estimated by Taylor and Wong (2002) to range between $0.19 to $0.51 per capita per year, and on average $0.32 per capita per year. The per capita relates to the population in the development area. Assuming an average inflation rate of 3%, this equates to an average $0.44 per capita per year ($2013).

Appendix D Stormwater Harvesting Wetlands

This appendix contains:

- Items to be assessed in the detailed design phase of stormwater harvesting wetlands.
- A list of example stormwater harvesting wetlands that have been constructed around Australia.

D.1 Detailed design of stormwater harvesting wetlands

It is important to demonstrate that the water levels within the stormwater harvesting wetland storage provide a good reliability of supply whilst still ensuring adequate water levels are maintained to ensure healthy macrophyte plants are sustained. The following section highlights analyses required during the detailed design phase to demonstrate sustained macrophyte health and a minimised risk of algal blooms.

D.1.1 Macrophyte Health

To demonstrate the health of macrophytes in a stormwater harvesting wetland it is recommended that a *water level time series analysis* and *water level probability of exceedance analysis* and a *dry spell analysis* is undertaken (examples provided in Figure D-1). The results should illustrate:

- The percentage of time that the water levels within the storage remain above the stop extraction level.
- That the water level should not decrease by more approximately 400mm below the normal water level more than approximately once every five years. The appropriate water level draw-down will be based in part on plant selection.
- That ‘dry spells’ (periods when water level is less than approximately 400mm below the normal water level) are generally limited to less than a few days at a time. This will assist in ensuring that plants in the shallow macrophyte zones will be able to withstand the limited dry spells.
- That major water level drawdown (e.g. more than approximately 500mm below the normal water level) does not occur more than once every 20 years (on average).

D.1.2 Reducing the risk of algal blooms

Residence time analysis is required to compare the residence time of the storage against the most relevant residence time target – such as the 20-day 20th percentile residence time target provided for lakes in the *Engineering Design Guidelines Constructed Lakes* (Mackay City Council, 2008). This is because long/ extended residence times can occur when the system is below the ‘pump extraction limit’ and increase the risk of algal blooms.

It should be noted that the risk of algal blooms can be further reduced by dense planting of macrophyte plants.

D.1.3 Additional design features

Additional design features which should typically be included in the detailed design phase are outlined in the 'constructed stormwater wetlands' chapter of the *WSUD Technical Design Guidelines for South East Queensland* (Healthy Waterways Partnership, 2006). Although this guideline was not written specifically for stormwater harvesting wetlands, the majority of the design features outlined in the guideline are directly transferrable to vegetated stormwater harvesting wetlands. The accompanying guideline *Construction and Establishment Guidelines; Swales, Bioretention Systems and Wetlands* (Water by Design, 2009) will also assist in guiding detailed design.

Given that any stormwater harvesting wetlands would likely be integrated into open space areas, perhaps the most important aspect during concept and detailed design would be ensuring that the systems are well integrated with other park uses and achieve multiple benefits. The *Framework for the Integration of Flood and Stormwater Management into Open Space* (Water by Design, 2010) provides a useful framework for Council and developers to assist in the design of well-integrated places.

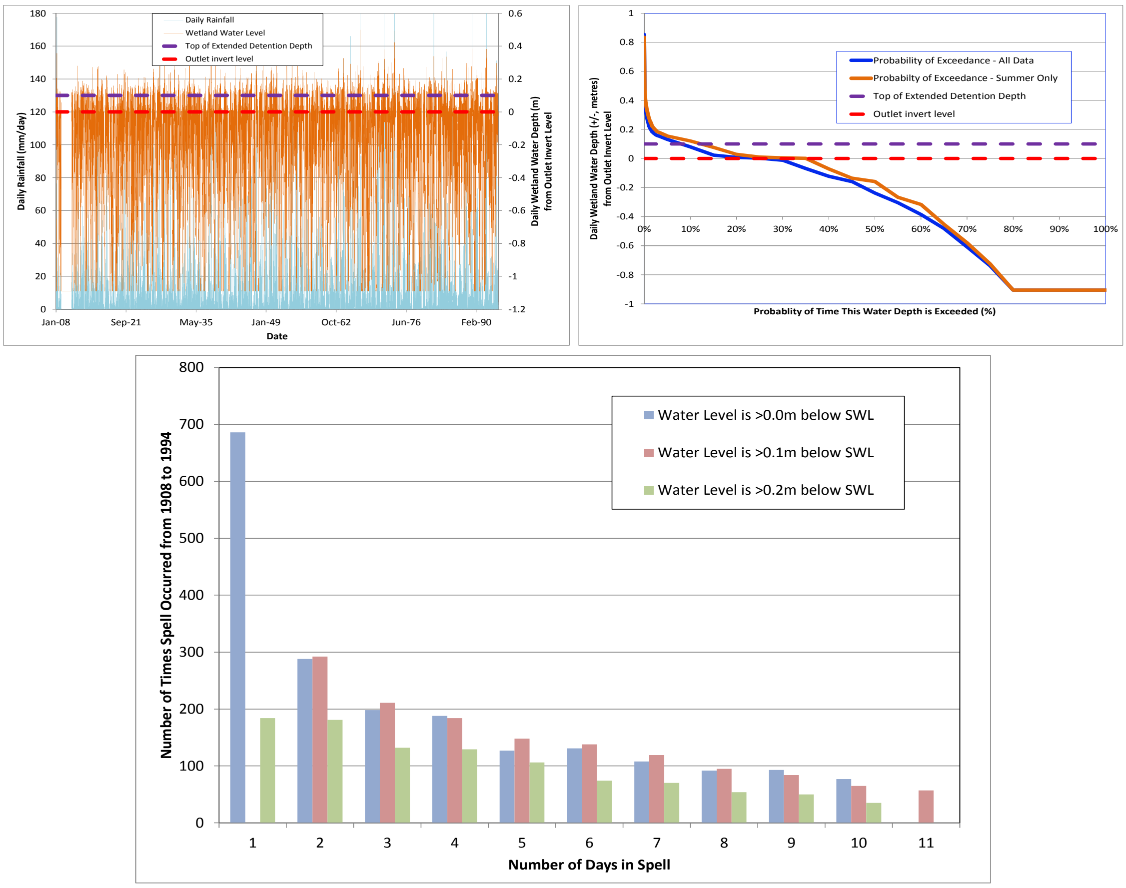

Figure D- 1 Example water level time series (top-left), water level probability of exceedance (top-right) and dry spell analysis (bottom) graphs

D.2 Stormwater harvesting wetland examples

Table D-1 provides examples of stormwater harvesting wetlands from around Australia.

Table D-1 Existing Stormwater Harvesting Wetlands in Australia

Project	Location	Capture	Treatment	Storage	Distribution	End Use
Hawkesbury Water Use Project[1]	NSW	Flood detention basins	Constructed Wetlands and settling pond	Dam	Irrigation network	Irrigation – university and TAFE grounds
Riverside Park[1]	NSW	Constructed wetland	Constructed wetland	Constructed wetland	Irrigation network	Irrigation – sports grounds
Homebush Bay Water Recylcing[1]	NSW	Diversion from existing stormwater pipe	Constructed wetland	Old brick pit	Dual reticulation and irrigation network	All non-potable purposes of residential, commercial and sporting facilities
Barra Brui Oval[2]	NSW	Diversion from existing stormwater pipe	Constructed wetland	Underground tank	Irrigation network	Irrigation – sports grounds
Riverside Park, Chipping Norton[2]	NSW	Diversion from existing stormwater pipe	Constructed wetlands, UV disinfection	Constructed wetland	Irrigation network	Irrigation – baseball fields
Wangal Park[2]	NSW	Diversion from existing stormwater pipe	Constructed wetland	Constructed wetland	Irrigation network	Irrigation
City of Salisbury Integrated Water Management[1]	SA	Diversion from existing stormwater pipe	Constructed wetlands, swales	Aquifer, constructed wetlands	Distribution mains	Industrial, commercial and community use
Royal Park Stormwater Harvesting Project[3]	VIC	Diversion from existing stormwater pipe	Constructed wetland, UV disinfection	Storage basin and underground tank	Irrigation network	Irrigation – sports grounds and parkland

[1] Philp, M. McMahon, J. Heyenga, S., Marinoni, O., Jenkins, G., Maheelpala, S., Greenway, M. (2008). *Review of Stormwater Practices*, Urban Water Security Research Alliance Technical Report No. 9, Brisbane, Queensland
[2] NSW Government (2013) *Water Recycling Projects,* Metropolitan Water Directorate, viewed 18 December 2013, http://www.waterforlife.nsw.gov.au/recycling/browse
[3] Clearwater (2013), *Resource Library- Case Studies*, viewed 18 December 2013, http://www.clearwater.asn.au/resource-library/case-studies/

Project	Location	Capture	Treatment	Storage	Distribution	End Use
Clayton South Wetlands[3]	VIC	Diversion from existing stormwater pipe and overland flow	Constructed wetland	Constructed wetland	Irrigation network and water trucks	Irrigation – sports grounds
Grinter Reserve Stormwater Harvesting[3]	VIC	Diversion from existing stormwater pipe	Constructed wetland, sand filtration	Constructed wetland	Irrigation network	Irrigation – sports grounds
Footscray Park[1]	VIC	Diversion from existing stormwater pipe	Constructed wetland	Underground tank	Irrigation network	Irrigation – public open space
Trinity Grammar Billabong Restoration[1]	VIC	Diversion from existing stormwater pipe	Constructed wetland	Constructed wetland	Irrigation network	Irrigation – sports grounds
Edinburgh Gardens [1]	VIC	Diversion from existing stormwater pipe	Constructed wetland, UV disinfection	Underground storage	Irrigation network	Irrigation – public open space
Wodonga Sustainable Sports Ground project[1]	VIC	Diversion from existing stormwater pipe	Constructed wetland	Constructed wetland	Irrigation network	Irrigation – sports grounds
Willawong Bus Depot[4]	QLD	Diversion from existing stormwater pipe	Biofiltration and constructed wetland	Constructed wetland, storage tank	Sub-surface irrigation network	Irrigation on site

[4] Crocetti, A. (2013) Alternative Water Harvesting Systems, *16th International River Symposium Proceedings*, 23-26 September, Brisbane, Queensland

Appendix E Riparian Revegetation Calculations

This appendix provides the detailed methodology used to calculate:

- The area of riparian revegetation required; and
- The reduction in sediment loads as a result of implementing the solution.

E.1 Riparian Revegetation Area Required

The waterway riparian revegetation solution involves revegetating up to the Q100 flood boundary of areas within the Urban Development Area, noting that only areas within future 'green space' and 'rural residential' areas were included. . Areas within future urban, industrial, and sporting land uses were excluded.

The status of the existing vegetation in these riparian areas had been previously determined by SKM (2010) as part of regional floodplain studies. SKM (2010) mapped areas of vegetation categories, including 'dense' vegetation, 'medium dense' vegetation and 'crops'. 'Dense' vegetation was assigned a Manning's n of 0.09, 'medium dense' vegetation was assigned a Manning's n of 0.075 and 'crops' was assigned a Manning's n of 0.04 by SKM (2010).

Riparian revegetation is a strategy that will achieve multiple benefits and these all need to be considered to determine the planting strategy. This is outlined in the following points:

- To ensure compatibility with koala habitats, this would involve ensuring the tree density is 250 trees/ ha.
- To ensure compatibility with previous flood modelling investigations undertaken by BMT WBM (2012c) it was assumed that areas of 'medium dense' vegetation would be revegetated so that they are of a similar Manning's n of 'dense' vegetation and areas of 'crops' would be revegetated so that they are of a similar Manning's n of 'medium dense' vegetation.

The total 'medium dense' and 'crops' vegetation areas within future 'green space' and 'rural residential' was calculated to be 136 ha. These revegetation areas, along with future land uses within the CWMPA, are presented in Figure 5-6.

The total area required for this solution was estimated to be 323 ha.

E.2 Sediment Load Calculations

The following methodology and equations were utilised by MBRC to determine stream bank erosion rates for all waterways within the MBRC area. This was used to quantify the effectiveness of riparian revegetation in the CWMPA. The resultant data was provided to BMT WBM in GIS format, providing erosion rates along with current condition of riparian vegetation for each stream length.

This data quantifies stream bank erosion only, and does not take into account gully erosion or hillslope erosion in the catchments.

Buffer Width (m)

$$B= k + h + (r \times t)$$

Where B is required buffer width for bank stabilisation, k is the minimum recommended buffer width (5m), h is the stream bank height, t is the time that it takes for vegetation to mature and r is the rate of bank erosion. (Abernathy and Rutherford 1999)

Stream Bank Erosion

The equation used for bank erosion was derived through studies in Northern Queensland where Rutherford (2000) found that there was a relationship between stream power and stream bank erosion.

$$\textit{Stream Power} = \rho g Q_{bf} S_X \qquad (1)$$

Where p=density of water, g=gravity, Q_{bf}=Bankfull Discharge rate and S_X = Slope)

A linear relationship has been adopted for this study similar to the works of Bartley and Wilkson (2006) under two main assumptions. Firstly, bank erosion rates decrease with the proportion of riparian vegetation until bank erosion is negligible under completely intact riparian vegetation (100% riparian proportion). The second assumption is that the rate of bank erosion is reduced in narrow valleys where there is limited exposure of rock and other un-erodible materials. To accommodate this factor, a relationship has been found between rock exposure and floodplain width (F_X) which is also included in the bank erosion equation.

$$\textit{Bank Erosion} = 0.00002\ \rho g Q_{bf} S_X\ (1-PR)(1-e^{-0.008\ F_X}) \qquad (2)$$

Where PR is the proportion of riparian vegetation and F_x is the flood plain width. Applications of this equation have produced the most consistent results within large river networks in Australia (DeRose et al 2005). For this reason it is now one of the underlying equations in the SedNet model used largely in catchments around the country.

The results from equation 2 can then be converted into sediment loss loads in tonnes/year by multiplying it by the mean bank height, the stream reach length and the mean dry bulk density (DBD) of sediments. This study was completed under the suggested assumption for DBD of 1.5 t/m^3. This gives the final equation below:

$$\textit{Bank Erosion Mass} = 0.00002\ \rho g Q_{bf} S_X\ (1-PR)(1-e^{-0.008\ F_X})L..H.DBD.Pb \qquad (3)$$

Where L is the length (m) of the stream link, h is the mean bank height of the stream and Pb is the proportion of bank material that contributes to bedload.

Bank Height

There is no record of bank heights within the MBRC region. Therefore, there is a need to determine a way of best estimating the bank heights for each minor basin as coastal areas are likely to differ from upper steeper catchments due to varying topology. In previous studies, a uniform bank height of 2 or 3m has been used. To be more precise, there is also the option to vary the bank height with the size of the contributing upstream catchment.

$$H = \textit{Coefficient} \times (\textit{Catchment Area})^{\textit{Exponent}} \qquad (4)$$

A series of bank height samples taken from each minor basin within a region were plotted against cumulative catchment area and were fitted with a power function curve to obtain the coefficients in equation 4.

A desktop assessment involved taking twenty stream cross-section samples for each minor basin using either 1m or 2.5m DEMs. The bank height equations obtained for the Caboolture River basin is as follows:

$$h = 0.7585 \times (\text{Catchment Area})^{0.4104}$$

The new bank heights that were determined from these equations were applied to the bank erosion rates to determine the quantity of sediment eroded from banks each year.

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