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Caloundra South Development: Integrated Water Management Plan

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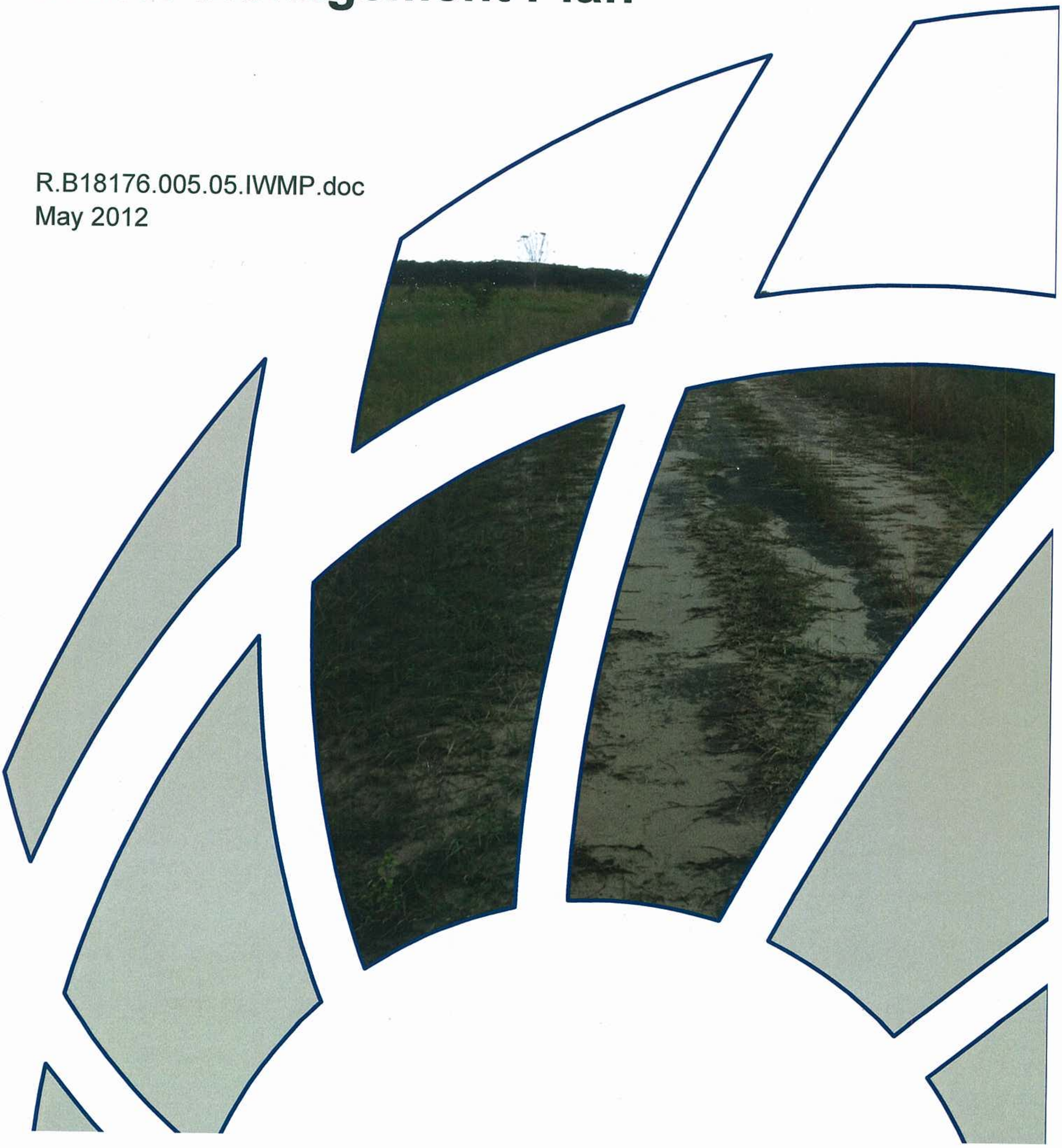

Caloundra South Development: Integrated Water Management Plan

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Title :	Caloundra South Development: Integrated Water Management Plan (Final Report)
Author :	Brad Dalrymple, Richard Sharpe
Synopsis :	This report presents the integrated water management strategy for the proposed 'Caloundra South' master-planned community, including stormwater quality, flooding and groundwater aspects of the water cycle.

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SUMMARY

Introduction

The Caloundra South site covers an area of approximately 2,400 hectares, and has been identified under the SEQ Regional Plan (2009 – 2031) as being contained within the Urban Footprint. A master-planned community is proposed for the Caloundra South site, including a variety of land uses including urban residential, industrial, commercial, recreational, conservation areas and public open spaces.

The Caloundra South site is located upstream of Pumicestone Passage and associated Ramsar wetlands. A holistic approach to water management is essential for the proposed master-planned community to ensure that these environments are not negatively impacted.

BMT WBM has prepared this Integrated Water Management Plan, which describes some of the main elements of the holistic approach to water management for the site. The main elements of this report are:

- *Flood risk management strategy*: describes what areas of the site are susceptible to flooding and what strategies can be implemented to manage the flood risk of the proposed development.
- *Stormwater management plan*: provides a conceptual assessment and plan relating to runoff from the site and how it will achieve the given stormwater management objectives during the operational (post-construction) phase of the master-planned community.
- *Groundwater quantity and quality strategy*: provides an assessment of groundwater quantity and quality for the Caloundra South site.

While the above study activities are described within the main body of this report as individual sections, it is important to highlight that all study activities were conducted in an integrated and coordinated approach. This was imperative for the Caloundra South site as water management elements are all closely related, specifically with respect to surface water and groundwater.

Project Objectives

For the aforementioned elements, objectives which have been defined and which need to be complied with in order for development of the Caloundra South site to proceed without adverse environmental impacts are as follows:

- ***Flooding***:
  - No adverse impact on flood inundation of properties outside the site, whilst simultaneously providing appropriate levels of flood immunity for those areas of the site to be developed for urban uses.
- ***Stormwater Management***:
  - The Queensland Department of Environment and Resource Management (DERM) has defined adjacent sections of Pumicestone Passage as having High Ecological Value (HEV) status in the Environmental Protection Policy (EPP) – Water (2009). The commensurate Water Quality Objective (WQO) which accompanies this designation is of the nature of 'no

change', but more specifically is quantified as "maintain existing water quality (20th, 50th and 80th percentiles)".

- For the purposes of this report, we have applied that the aforementioned objective will require a commensurate objective of 'no increase' in the load of pollutants exiting the site, as diffuse load/ stormwater runoff.

- ***Groundwater Quantity and Quality*:** In order to comply with relevant SEWPaC Ramsar wetland criteria, the following groundwater related objectives were defined:
  - No adverse impact on groundwater levels within the sensitive Ramsar wetlands to the east of the Caloundra South site.
  - No adverse impact on the patterns and qualities of groundwater passing from the Caloundra South site to these Ramsar wetlands.

Investigation Summary

Investigations have included the following key activities:

- ***Flooding*:**
  - Development of site hydrologic and hydraulic models for the existing and developed site.
  - Testing and evaluation of a range of potential site development/floodplain management scenarios to support the selection and design of an appropriate 'no impact' flooding case.
  - Refinement of the preferred design solution to ensure no offsite impacts and to optimise site design characteristics.
- ***Stormwater Management*:**
  - Development of MUSIC models for the existing and developed site.
  - Design and evaluation or a range of potential stormwater management options.
  - Refinement of the preferred design solution to achieve the given objectives.
- ***Groundwater Quantity and Quality*:**
  - Collection and analysis of sufficient data to enable a comprehensive interpretation to be developed of how groundwater quantity and quality processes operate on the Caloundra South site, and how such processes extend beneath the adjacent sensitive wetland areas.
  - Development of comprehensive numerical models of groundwater processes and demonstration by appropriate calibration and validation techniques that these models adequately and reliably simulate groundwater behaviour in and adjacent to the site.
  - Identification and evaluation of a range of site development scenarios and commensurate investigation of offsite impacts such that a suitable 'no impact' case can be identified and justified.

Existing Conditions

Key findings of the aforementioned studies in relation to the existing site are as follows:

- ***Flooding***:
  - Portions of the site are currently flood prone, but the relevant flood risk in those areas outside the immediate proximity of waterway corridors on the site is extremely low.
- ***Stormwater Management***:
  - In its existing (mostly cleared) condition, the site contributes surface water runoff and associated pollutant loads to relevant receiving waters.
- ***Groundwater Quantity and Quality***:
  - Existing groundwater processes are dominated by site land use and commensurate vegetated cover. There is a close linkage between tree coverage of the site and associated groundwater levels. When the site was covered (historically) with vegetation (be that pine plantation or native forest), groundwater levels were lower than those currently observed on the site.
  - Existing groundwater quality is good with no adverse manifestations of land use change such as elevated nutrient, pesticide or acid (pH) levels.

Major Mitigation Measures Proposed

Having identified the above and developed robust numerical models of key surface water quantity and quality, flooding and groundwater processes, evaluations were conducted of those mitigation measures required to see the development proceed without unacceptable or detectable offsite impacts. In summary, these proposed mitigation measures are as follows:

- ***Flooding:***
  - The site will be configured with relevant dedicated flood detention storage, flood conveyance and other appropriate mitigation measures to ensure no offsite impacts.
- ***Stormwater Management:***
  - A 'beyond best practice' stormwater management strategy has been proposed for the site, consisting of education, rainwater harvesting tanks, rain gardens, ephemeral wetlands, lakes, shallow wetlands and environmental protection and rehabilitation.
- ***Groundwater:***
  - With the placement of appropriate internal site controls (specifically via required drainage infrastructure and, more importantly, the reduction by the reestablishment of vegetation across the site and the capture and reuse of stormwater of currently unnaturally high rates of net groundwater recharge) groundwater levels beneath the site will progressively fall such that current shallow groundwater tables will not affect the development.
  - The groundwater levels, post development, will revert to levels close to those typically present before the site was cleared of pine plantation.
  - No other specific groundwater quantity or quality mitigation works are required.

Conclusions

In relation to the aforementioned elements, we can conclude the following:

- ***Flooding:***
  - ➢ The site can be developed in a manner which will provide appropriate levels of flood immunity within Caloundra South (including the potential influences of future climate change factors such as sea level rise and increases in rainfall intensities).
  - ➢ The development can occur with no adverse off site flooding impacts.
- ***Stormwater Management:***
  - ➢ With the integration of the proposed stormwater management strategy, significant reductions in stormwater pollutant loads can be achieved.
  - ➢ A 'no worsening' in stormwater pollutant loads from the site can be achieved with the proposed development (and associated stormwater management strategy).
- ***Groundwater:***
  - ➢ The development can achieve a no adverse impact on:
    - ▪ Groundwater levels within the Ramsar wetlands to the east of the Caloundra South site.
    - ▪ Patterns and groundwater levels within the Ramsar wetlands to the east of the Caloundra South site.
    - ▪ Patterns and qualities of groundwater passing from the Caloundra South site to these Ramsar wetlands.

1 INTRODUCTION

BMT WBM has been commissioned by Stockland (in support of a Material Change of Use Master Plan Application to the Urban Land Development Authority) to prepare an Integrated Water Management Plan (IWMP) for the 'Caloundra South' master-planned community, located on the Sunshine Coast.

This Integrated Water Management Plan provides a holistic approach to water management for the proposed master-planned community. The main elements of this report are:

- ***Flood Risk Management Strategy (Section 3 of this report):*** This section describes what areas of the site are susceptible to flooding and what strategies can be implemented to manage the flood risk of the proposed development.
- ***Stormwater Management Plan (Section 4 of this report):*** This section provides a conceptual assessment and plan relating to the runoff from the site and how it will achieve the given stormwater management objectives during the operational (post-construction) phase of the master-planned community.
- ***Groundwater Quantity and Quality Assessment (Section 5 of this report):*** This section provides an assessment of groundwater quantity and quality for the Caloundra South site.

2 SITE DESCRIPTION

2.1 Location

The Caloundra South site is located within the Sunshine Coast Regional Council area, to the east of the Bruce Highway and to the south-west of Caloundra. The locality of the site is presented in Figure 2-1.

The site covers an area of approximately 2,400 hectares and has been identified under the SEQ Regional Plan as being contained within the Urban Footprint.

2.2 Site Topography and Drainage

There are three watercourses that flow through the site – Lamerough Creek, Bells Creek North and Bells Creek South. On site, these three watercourses are characterised by a network of smaller channels with a relatively wide and flat floodplain. The site generally slopes downwards to the east with a typical channel slope of about 1 in 400 to 1 in 500 in the upper reaches (western part of the site).

Further downstream, the eastern part of the site is characterised as typical coastal plains. In this area, the site is relatively flat with ground levels generally ranging between 1m AHD and 2m AHD (around the eastern boundary of the site).

The highest ground elevations on the Caloundra South site occur adjacent to the Bruce Highway with levels up to approximately 31m AHD in these areas. The topography of the existing site is shown in Figure 2-2.

2.3 Baseline Water Quality

A baseline water quality monitoring program was designed and implemented within the Caloundra South site to help characterise the site in its current (pre-development) condition. The program involved collecting water quality data to determine the quality of runoff from the site. BMT WBM's reports "*Caloundra Downs: Baseline Monitoring Program – Final Report*" and "*Caloundra Downs Stormwater Quality Management Master Planning Assistance*" provides a summary of the data that has been collected between May 2008 and October 2010.

Baseline ambient and event concentrations of key water quality constituents show that guideline values for Total Nitrogen (TN), Total Phosphorus (TP) and Total Suspended Solids (TSS) were typically exceeded for both event and ambient conditions.

2.4 Pumicestone Passage Water Quality

The Ecosystem Health Monitoring Program (EHMP), a multi-agency funded (lead by the Queensland Government) environmental monitoring program, has been collecting water quality data at monthly intervals at a number of sites along Pumicestone Passage for more than 10 years.

BMT WBM's (2011) report "*Caloundra South Integrated Water Quality Modelling Assessments*" provides a review of this data. The report describes that much of Pumicestone Passage is naturally not compliant with relevant water quality objectives, including those for pH, dissolved oxygen, turbidity, total nitrogen, total phosphorus and chlorophyll-a.

2.5 Bells Creek Water Quality

BMT WBM undertook a water quality survey on 15th February 2011 to collect a snapshot of conditions in the Bells Creek waterway. The methodology and results of this investigation are described in BMT WBM's (2011) report "*Caloundra South Integrated Water Quality Modelling Assessments*". Although this was a snapshot survey only (and cannot capture seasonal or tidal trends) in water quality, the survey showed the following:

- There were low dissolved oxygen levels in Bells Creek, especially in the upper estuary.
- There is limited connectivity of the upper portions of Bells Creek with Pumicestone Passage, resulting in poorer water quality in those reaches.
- Nitrogen may be an issue in Bells Creek, particularly oxidised and total nitrogen. Any actions which would reduce these nitrogen concentrations to closer to the stated WQO's would benefit the ecosystem health of Bells Creek.

2.6 Soils, Geology and Groundwater

Section 5 of this report provides a detailed description of existing site soils, geology and groundwater. In summary:

- Many of the shallow boreholes constructed on the Caloundra South site intersected soils with very sandy A horizons over clayey subsoil layers at depths generally in the order of 0.75 m.
- Regional geological mapping indicates that the basement rocks of the Caloundra South site consist of the Landsborough Sandstone of the Nambour Basin.
- Previous groundwater studies have shown the water table to be at very shallow depth, typically 0 to 2 m below the surface.
- The quality of shallow groundwater at the Caloundra South site is generally good with generally relatively low salinity (excepting a locally developed salt scald), although some slightly elevated nutrient and dissolved iron concentrations have been recorded for the shallow groundwater.

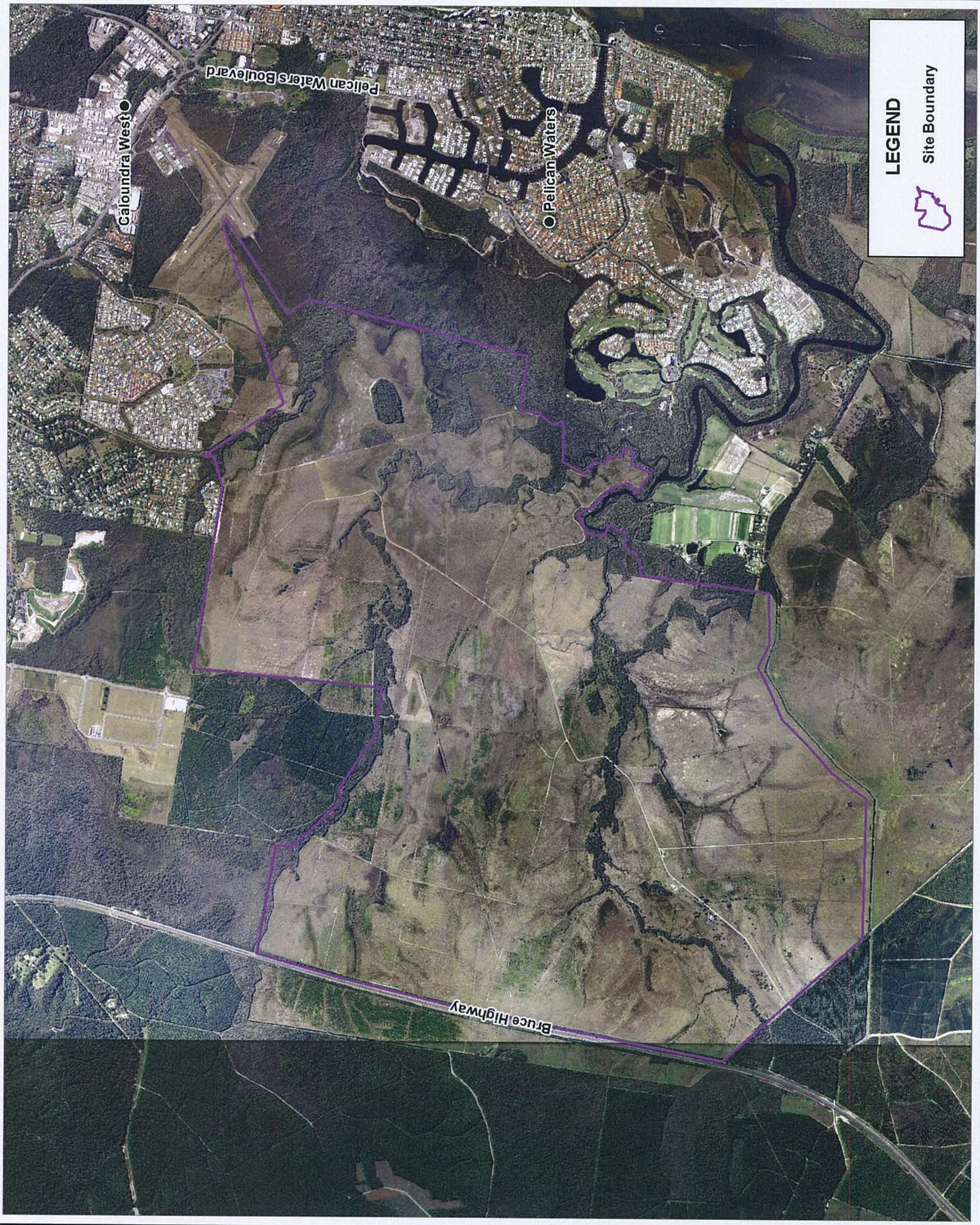
2.7 Existing Land Usage

The Caloundra South site, as it currently exists, comprises large tracts of land being actively grazed by cattle. BMT WBM's (2011) "*Caloundra South Consolidated Water Report*" further describes the temporal land use changes across the site.

An aerial photo of the site is provided in Figure 2-1. Photos of the existing site are also provided in Figure 2-4.

2.8 Proposed Development

A master-planned community is proposed for the site, including variety of landuses including urban residential, industrial, commercial, recreational, conservation areas and public open spaces. A layout plan of the proposed development is provided in Figure 2-3.



Title:
Location of Site

Figure:
2-1

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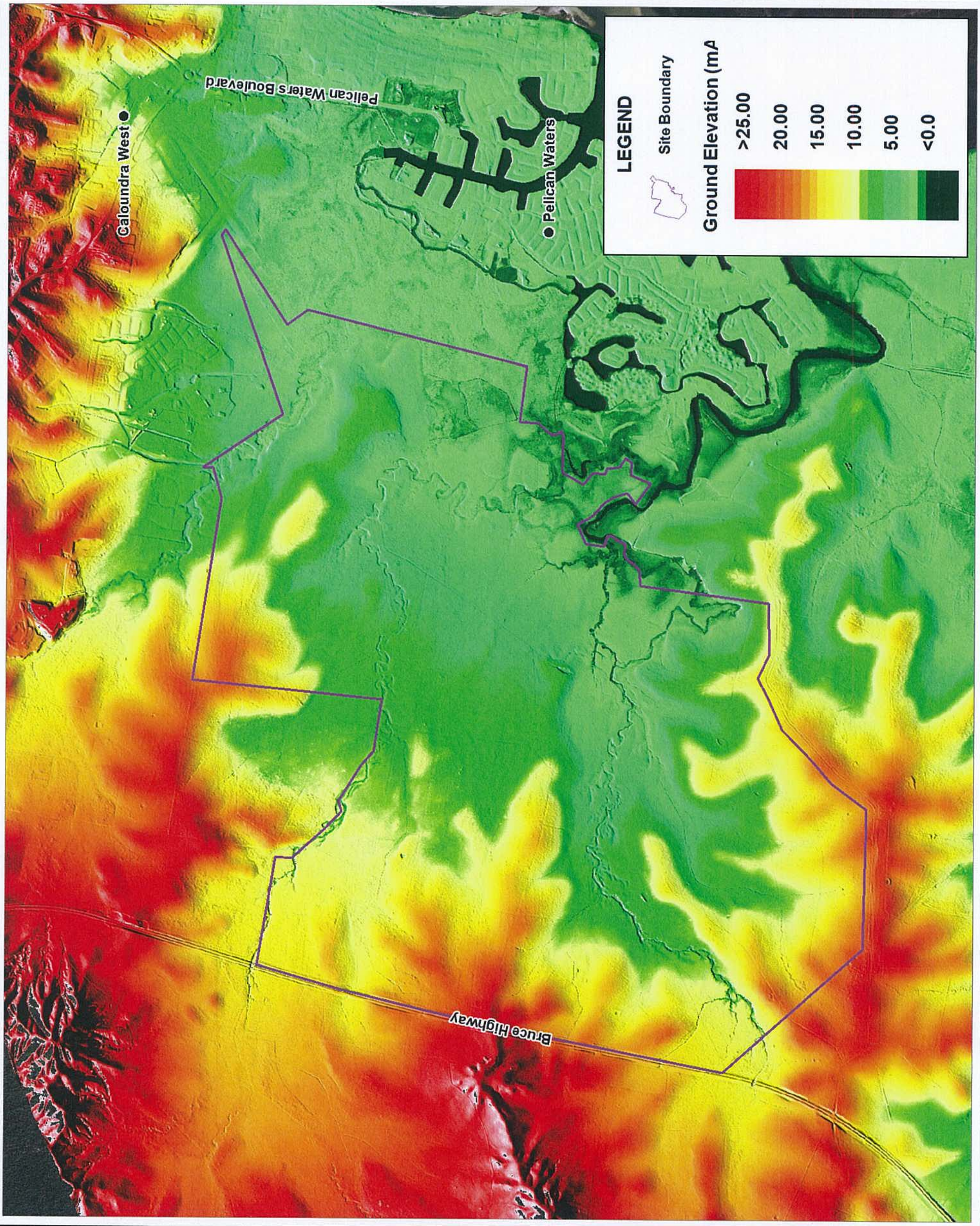

Title:
Existing Topography of Site

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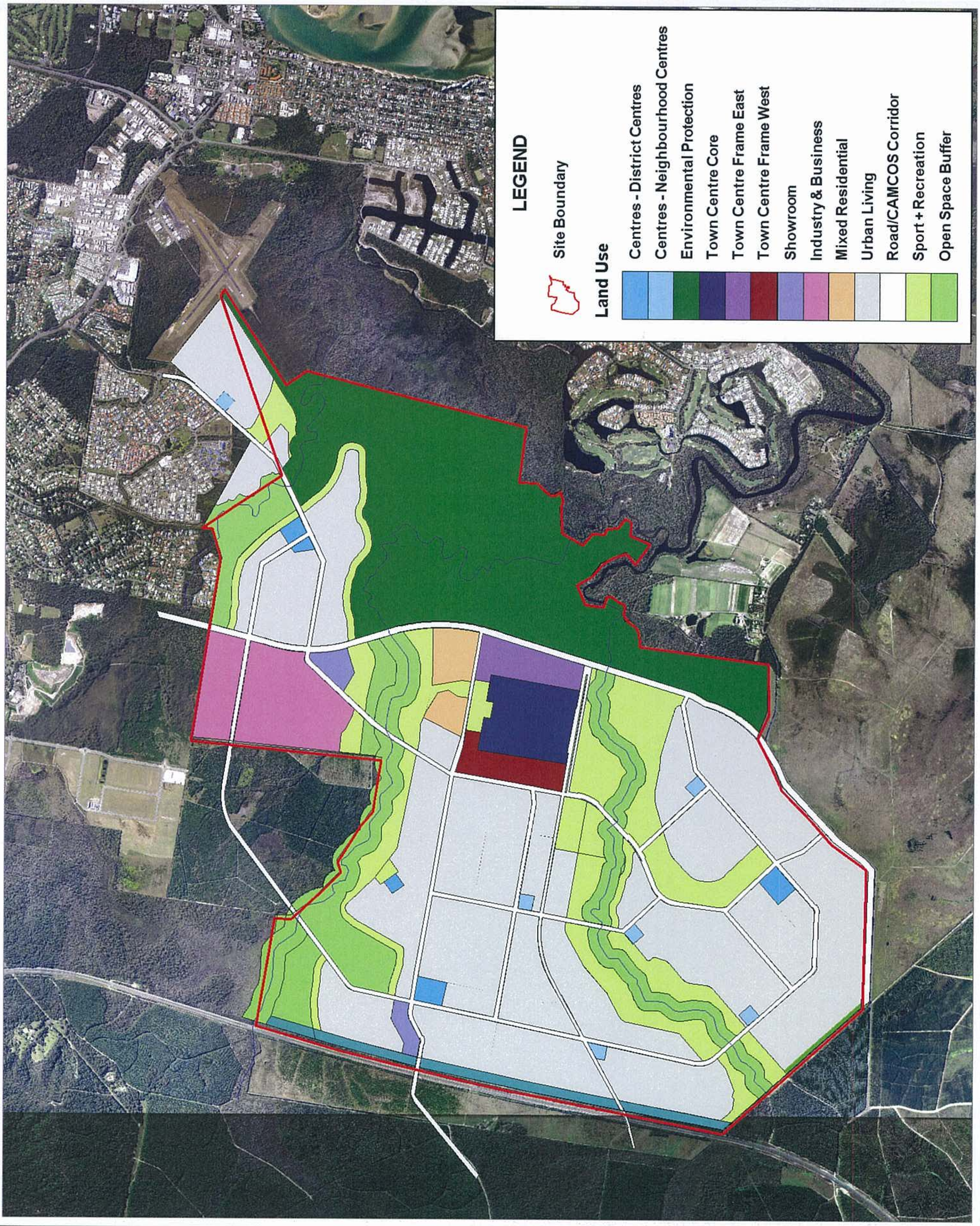

Title:
Proposed Site Layout

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Figure 2-4 Photos of the Existing Site

3 FLOOD RISK MANAGEMENT STRATEGY

3.1 Preamble

This section outlines the Flood Risk Management Strategy for the Caloundra South site.

The purpose of this Flood Risk Management Strategy is to inform Stockland which areas of the Caloundra South site are susceptible to flooding and what strategies can be implemented to manage flood risk of the proposed development. As such, the Flood Risk Management Strategy aims to:

- Define the flooding characteristics of the pre and post developed Caloundra South site;
- Determine the flood impacts caused by the proposed development;
- Develop strategies to mitigate flood impacts; and
- Identify what actions are required to manage flood risk.

The main elements of the Flood Risk Management Strategy are:

- ***Flood Model Development (Sections 3.2 and 3.3):*** These sections describe the model development undertaken to assess the flood behavior of the site.
- ***Flooding Assessment (Section 3.4):*** This section describes the flood modelling assessment undertaken to investigate the pre and post development flooding characteristics of the site.
- ***Flood Impact Assessment (Section 3.5):*** This section is an assessment of the flood impacts of the proposed development for a range of flood events in order to validate the strategies employed to mitigate flood impacts.
- ***Climate Change Assessment (Section 3.6):*** This section describes an assessment of potential flood impacts of climate change and includes recommendations on design flood levels for the proposed development.

3.1.1 Previous Studies

A number of previous flooding investigations of the Caloundra South region have been completed including:

- Caloundra South Informal Land Use Investigation Flooding Assessment - Supporting Technical Study no.5 (Cardno MBK, 1999);
- Caloundra South 2 Hydrological & Hydraulic Analysis Supplementary Report - Supporting Technical Study no.17 (Cardno MBK, 2000);
- Caloundra City Storm Tide Study – Development Report (Connell Wagner, 2003a);
- Caloundra City Storm Tide Study – Counter Disaster Planning Report (Connell Wagner, 2003b);
- Lamerough Creek and Duckholes Creek Flood Study and Stormwater Management Plan; Volumes 1, 2 & 3 (Cardno MBK, 2003);
- Joint Probability Assessment – Storm Tide and Freshwater Flooding, Caloundra City and Maroochy Shire Councils, in Draft (Connell Wagner, 2005);
- Caloundra South Flood Study – Caloundra Local Growth Management Strategy (SKM, 2006);

- Caloundra South Development: Flood Risk Management Strategy (BMT WBM, 2011a); and
- Bellvista II Development Reconfiguration of a Lot Application: Flood Impact Assessment (BMT WBM, 2011b).

Apart from the recent BMT WBM studies, the SKM study is the most recent flooding investigation and includes a review of all the aforementioned investigations. The study area of the SKM study included the Bells Creek and Lamerough Creek catchments; the catchments in which the Caloundra South site is located. The study was undertaken as part of the development of a Local Growth Management Strategy for Caloundra City, and used hydrological and hydraulic models to investigate flooding characteristics of seven coastal catchments that discharge into Pumicestone Passage. This study formed the basis of the BMT WBM studies that followed.

3.1.2 Flood Modelling Overview

3.1.3 Background

The term 'flood model' is used in this report to refer to the hydrological and hydraulic models in combination. The hydrological models were used to estimate runoff rates through the site based on design rainfall events, and the hydraulic models to estimate the hydraulic properties of flood flows (such as flood levels and depths) within the site based on the runoff rates derived from the hydrological models.

The reason for developing flood models of the site is that they were essential tools for assessing flood risk within the vicinity of the proposed development, as well as the effects of the development on flood risk.

3.1.3.1 Approach

The flood modelling undertaken in this study builds upon flood modelling developed during the two previous BMT WBM studies (BMT WBM, 2011a and 2011b), which, in turn, are based on flood modelling developed during the SKM study.

The SKM study employed RAFTS-XP for the hydrological modelling and the MIKE FLOOD software for developing 1D-2D hydraulic models. BMT WBM subsequently re-established the SKM models using RAFTS-XP for the hydrological modelling and TUFLOW for the hydraulic modelling (BMT WBM 2011a). This work was done to enable BMT WBM to develop a preliminary flood risk management strategy for the Caloundra South UDA.

BMT WBM have also recently completed a flood study for a Stockland development that lies adjacent to the Caloundra South UDA in the vicinity of Bellvista, called Bells Reach (previously called Bellvista II) (BMT WBM, 2011b). This modelling has been incorporated into the new flood model developed for this Master Plan application. It should be noted that the Bells Reach development does not form part of the current application, and approval has already been granted.

3.1.3.2 Updates to the Existing Flood Models

The existing flood models developed for the previous BMT WBM studies were updated for use in this study. Refinements made to the models include the following:

- The proposed Caloundra South Master Plan development footprint and land-uses have been refined since the previous study was undertaken. These refinements have been applied to the flood models; and
- The existing land use in the previous studies is based on old aerial imagery captured in 2004. The site has changed significantly over the last seven years. The land use categorisation in the flood models have therefore been updated based on the most recent aerial imagery available at the time of the assessment (May 2011).

3.2 Hydrological Model Development

3.2.1 Model Schematisation

The RAFTS-XP model includes the following catchments, Bells Creek North, Bells Creek South, Lamerough Creek and Duck Holes Creek. The subcatchment delineations are presented in **Error! Reference source not found.** and Figure 3-2 for the existing and developed cases respectively.

The adopted percent impervious and Manning's 'n' values for existing land use types are presented in Table 3-1. The land use delineation for the 'existing case' RAFTS-XP model is shown in Figure 3-3.

The existing case RAFTS-XP model formed the basis of the developed case hydrological model; subcatchment roughness, pervious area and percentage impervious were adjusted to reflect the proposed development. Percent impervious for developed land use types was based on land use and density data provided by Stockland. Manning's 'n' for developed land use types has been estimated using typical industry values.

The pervious Manning's 'n', and impervious and pervious areas for each of the subcatchments for the 'existing case' and 'developed case' RAFTS-XP models are presented in Appendix A.

Table 3-1 Pervious Percent and Manning's 'n' for Existing Land Use Types

Land Use Type	Percent Pervious	Pervious Manning's 'n'
Sparse Rural Pasture	100%	0.050
Medium Rural Pasture	100%	0.060
Very High Dense Rural Pasture	100%	0.080
Permanently Inundated Areas	0%	-
Forested	100%	0.100
Urban	40%	0.025
Sparse Urban	90%	0.035
Open Grazing	100%	0.05

3.2.2 Hydrological Design Conditions

3.2.2.1 Design Rainfall Intensities

The CRC-Forge method was used to estimate design rainfall intensities. CRC-Forge and AR&R rainfalls were compared in the *Caloundra South Flood Study* (SKM, 2006) and the CRC-Forge was found to result in slightly higher design rainfall depths. The design rainfall intensities adopted in this study are presented in Table 3-2.

Table 3-2 Design Rainfall Intensities (mm/hr)

Event Duration	Average Recurrence Interval (years)				
	5	10	20	50	100
3 hours	33.0	37.7	43.8	52.1	59.7
6 hours	21.5	24.9	29.3	35.2	40.3
12 hours	14.0	16.4	19.5	23.8	27.3

3.2.2.2 Areal Reduction Factors

In contrast to the *Caloundra South Flood Study* (SKM, 2006), no areal reduction was used in this investigation (i.e. an areal reduction factor of 1 was adopted). This is a conservative approach. The areal reduction factors used in the *Caloundra South Flood Study* varied between 0.98 and 1 (SKM, 2006).

3.2.2.3 Design Rainfall Depths

The design rainfall depths used in the study are presented in Table 3-3.

Table 3-3 Design Rainfall Depths (mm)

Event Duration	Average Recurrence Interval (years)				
	5	10	20	50	100
3 hours	99.0	113.0	131.5	156.4	179.1
6 hours	128.9	149.1	175.5	211.3	242.0
12 hours	168.1	197.0	234.5	286.1	327.6

3.2.2.4 Design Temporal Rainfall Pattern

Design temporal rainfall patterns from Australian Rainfall and Runoff (AR&R, 2000) Zone 3 were used in this investigation. This is consistent with the *Caloundra South Flood Study* (SKM, 2006).

3.2.2.5 Runoff Losses

The rainfall losses used in the SKM study for pervious areas were 10mm initial loss and 5mm continuing loss. This was based on the dominant land-use in the catchment being forested. In this study, however, the rainfall losses have been reduced to an initial loss of 0mm and continuing loss of 2.5mm for the following two reasons:

- In this study, design storm bursts are being modelled, which are theoretically preceded by lower intensity rainfall. It is typical, therefore, to assume that the catchment is relatively saturated at the start of the storm burst; and
- The portion of the catchment where the development is proposed was covered by pine plantation at the time that the SKM study was undertaken. However, this plantation has been cleared, which has led to lower infiltration rates within the proposed development area east of the Bruce Highway.

Included in the modelling of smaller flood events (1, 2 and 5 yr ARI) the initial water losses within the site associated with water sensitive urban design measures. These measures will occupy 4.5% of the developed area, and will typically store 0.25 m depth of water for a few hours after any rainfall event. This equates to an additional initial loss of 0.011 m across the site, we have adopted 0.01 m in this regard. This conservatively ignores the additional influence of the more than 20,000 rainwater tanks that will eventually be deployed across the site.

3.2.3 Proposed Works Affecting Runoff Behaviour

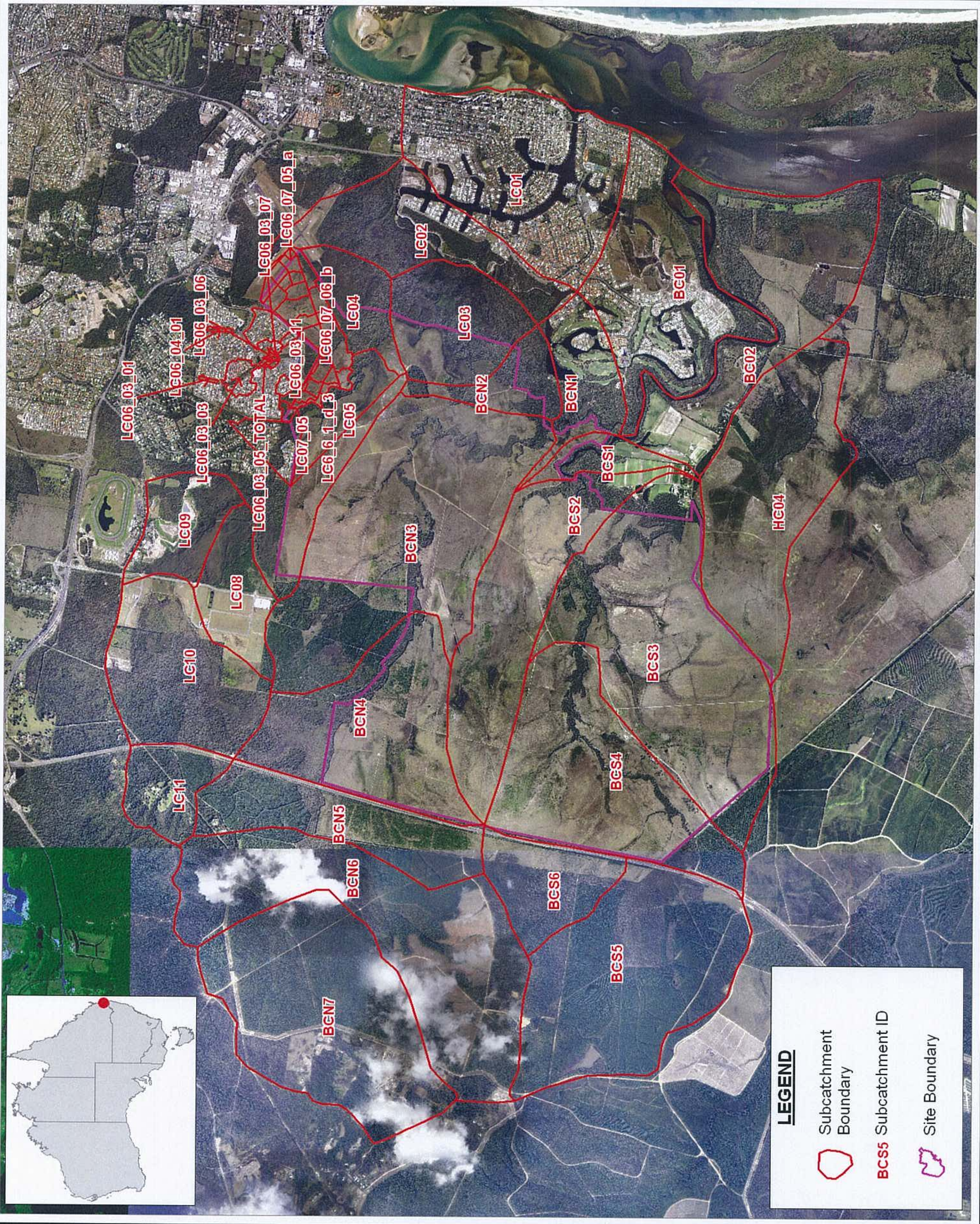
The proposed development includes changes to the characteristics of the catchment. The majority of the catchment is currently undeveloped. The development of the catchment will increase impervious surfaces and reduce catchment 'roughness' (i.e. decrease Manning's 'n') with the addition of roads, houses and other developments (except in area where revegetation is proposed). Both of these changes will increase peak runoff rates. The approximate proposed development footprint is presented in Figure 3-6.

The pervious Manning's 'n', and impervious and pervious areas, for each of the subcatchments in the RAFTS-XP model are detailed in Appendix A.

3.2.4 Hydrological Modelling Results

The relatively flat nature of the site means that runoff in the existing case is comparatively slow to respond. The increase in impervious area and reduced Manning's 'n' in the developed case mean that the affected catchments respond more quickly to rainfall. This can be seen in the existing and post-development runoff hydrographs (100 year ARI, 6 hour event) for subcatchment BCN1 (Bells Creek North) and BCS1 (Bells Creek South); which are both located just downstream of the development area (refer to Figure 3 4 and Figure 3 5 respectively).

Peak flows at each subcatchment for the 5, 50 and 100 year ARI events (existing and developed) are provided in Table B-1 in Appendix B. The peak flows for the climate change events are provided in Table B-2 in Appendix B.



Title:

RAFTS-XP Subcatchments Existing Case Model

Figure: 3-1

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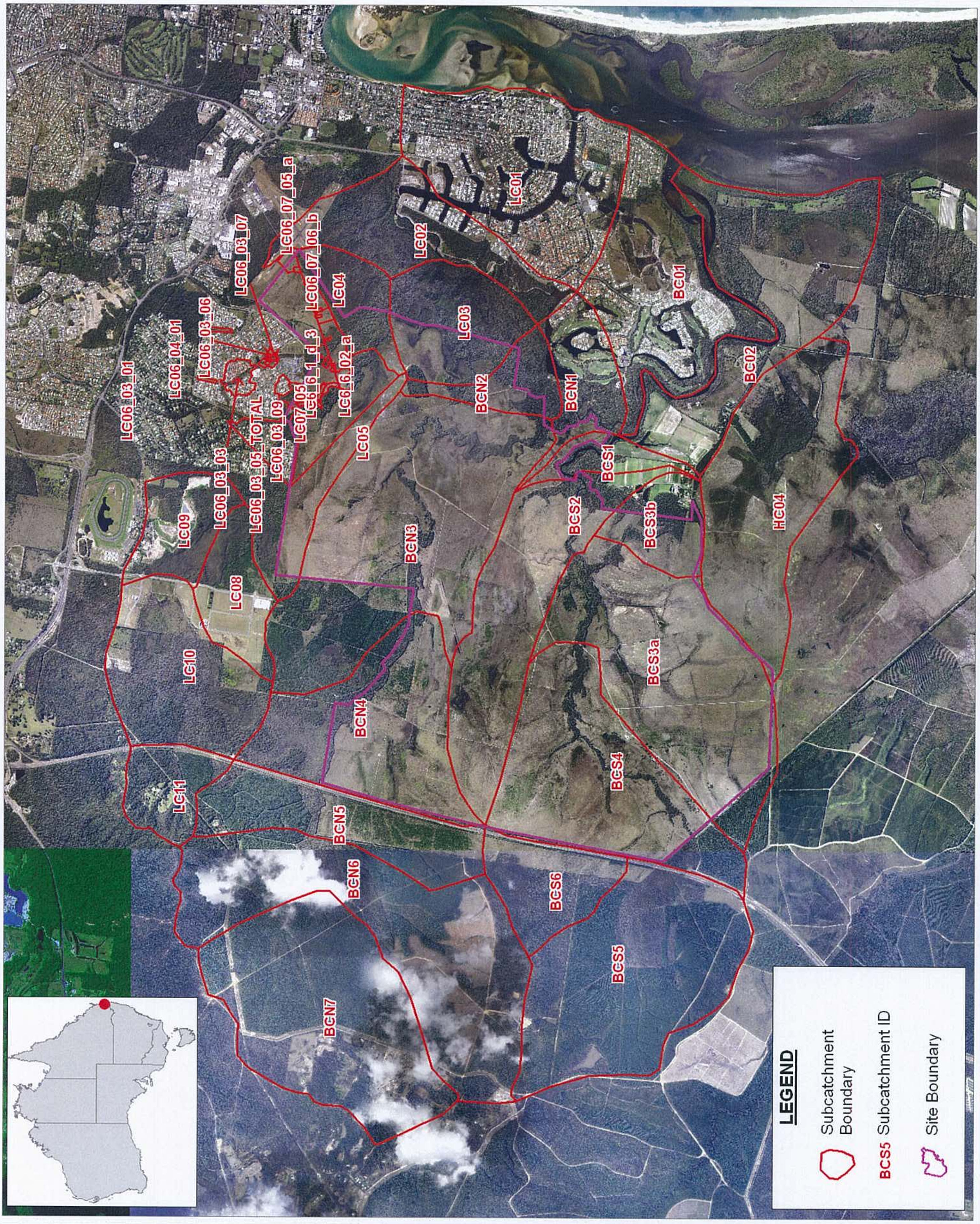

Title:

RAFTS-XP Subcatchments Developed Case Model

Figure: 3-2

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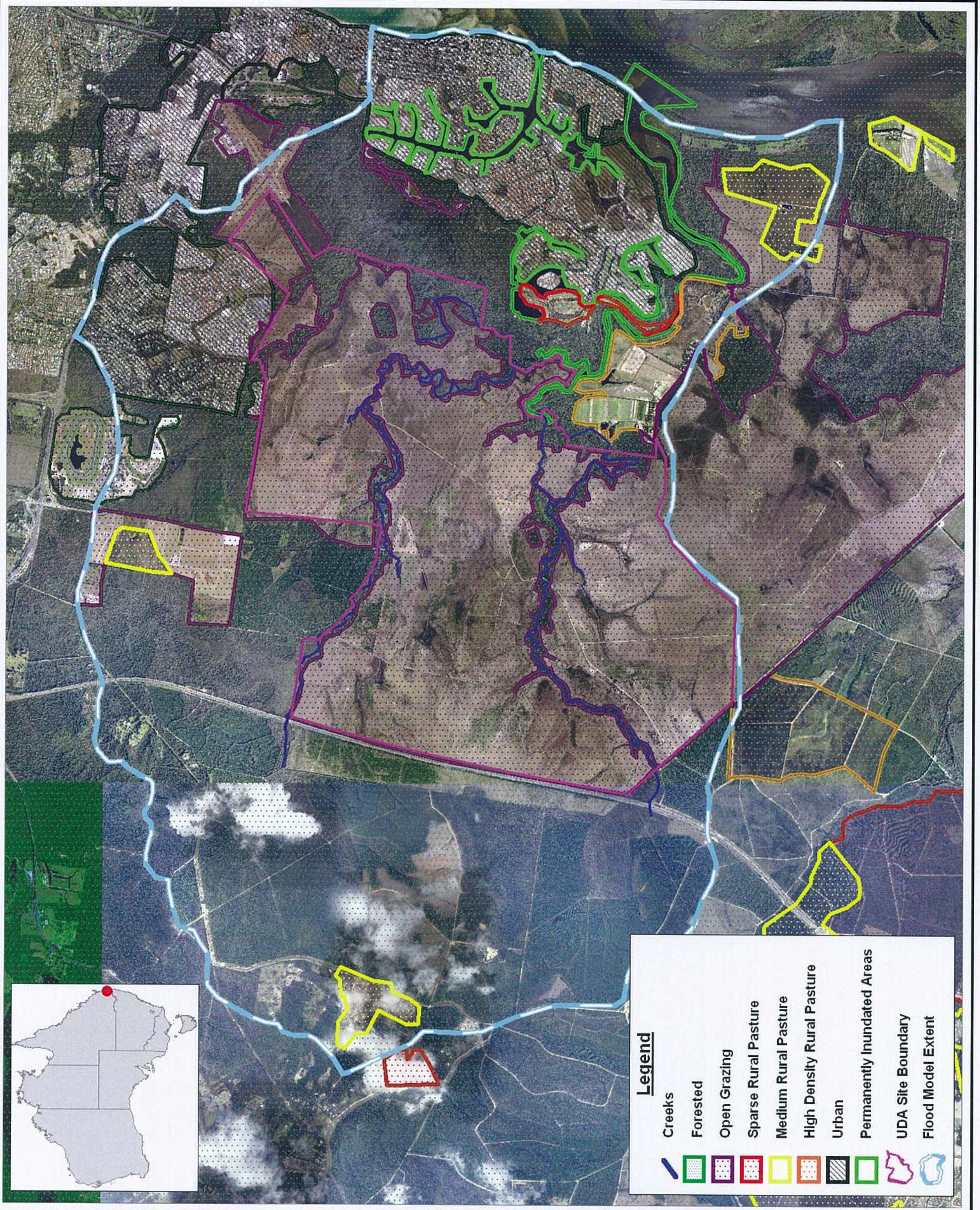

Title:

Land Use Delineation
Existing Case Model

Figure:
3-3

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Approx. Scale

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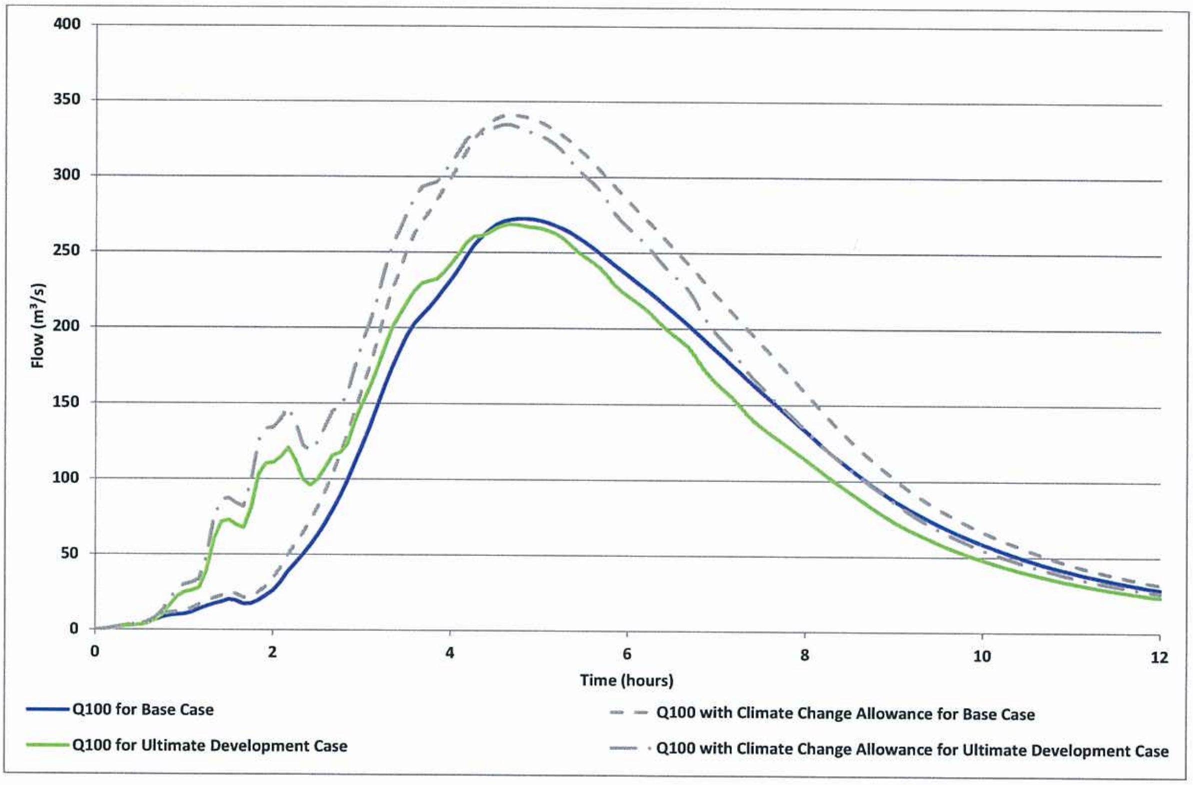


Figure 3-4 Modelled RAFTS-XP Flow Hydrographs at Subcatchment BCN1

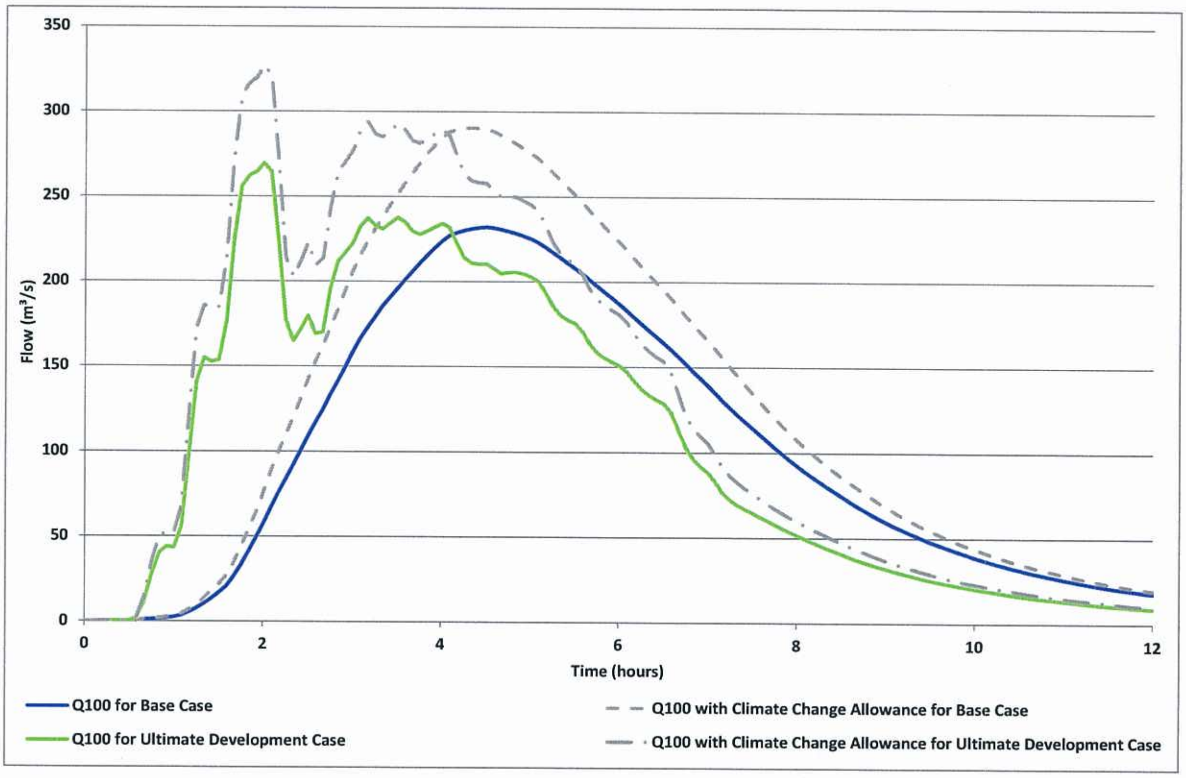
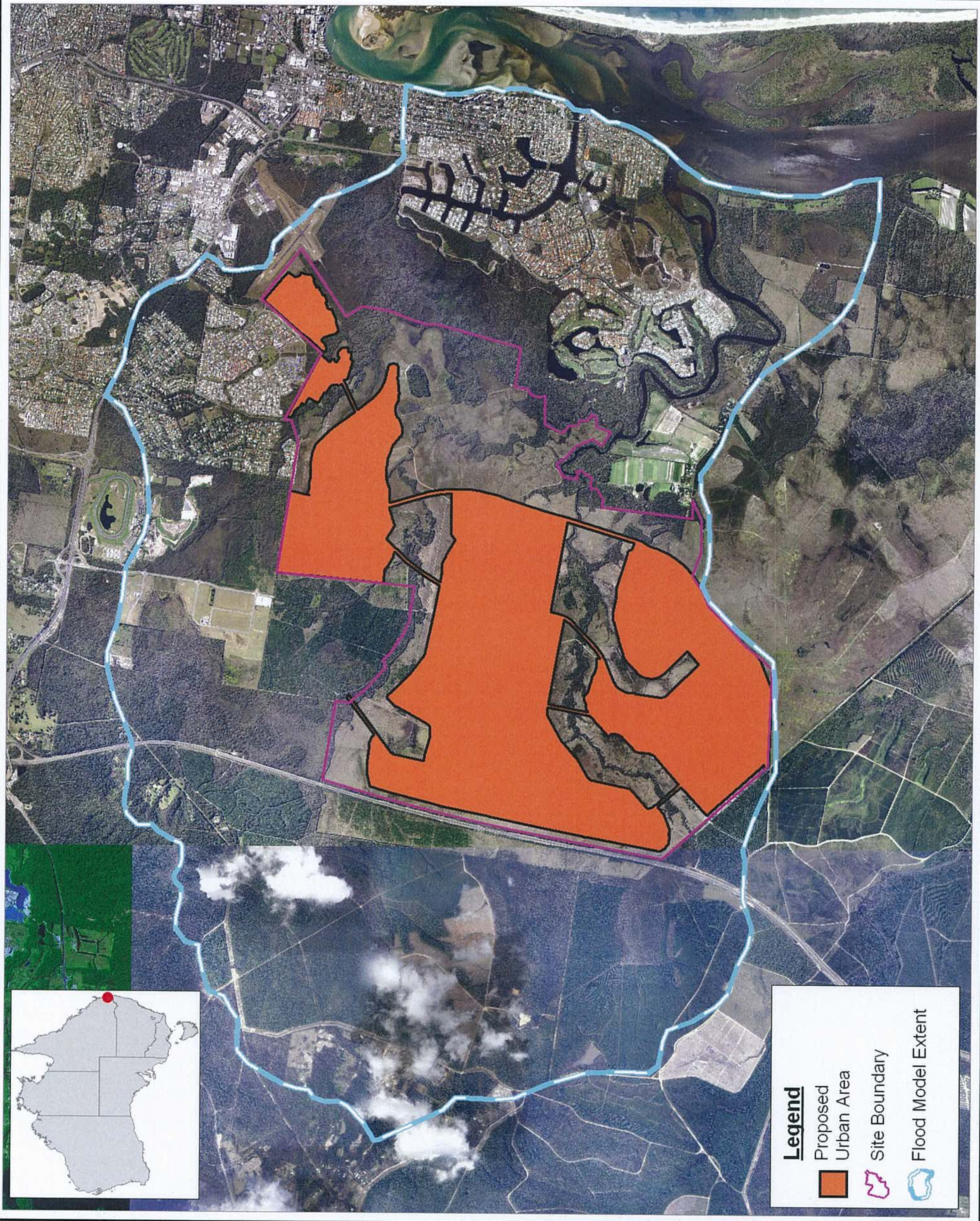


Figure 3-5 Modelled RAFTS-XP Flow Hydrographs at Subcatchment BCS1



Title:

Conceptual Plan of Investigated Caloundra South Proposed Development Footprint

Figure: 3-6

Rev: B

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.

N 0 1.5 3km Approx. Scale

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3.2.5 Hydrological Model Verification

The SKM study verified the adopted hydrological modelling assumptions against a regional flood frequency analysis and a historical rainfall event (March/April 1989) in the nearby Upper Mooloolah River catchment.

Further verification of the flows has not been possible due to the lack of available data in the area. As such, an indicative check of the flow has been undertaken using the Rational Method approach for the existing case. This check has been undertaken on the Bells Creek North catchment, which encompasses an area of approximately 2,270ha. Table 3-4 below shows the design flows and the rational method check for a storm event with a duration of 12 hours.

Table 3-4 Design Flow Check for Bells Creek North

Event	Design Flow (m^3/s)	Rational Method Flow (m^3/s)
5 year ARI	120	90
50 year ARI	220	180
100 year ARI	260	210

The Rational Method approach predicts flows that are 18% to 25% lower than the RAFTS-XP model, which has been considered acceptable for the purposes of this study, and the RAFTS model has been adopted in this study without further adjustment to the model assumptions.

3.3 Hydraulic Model Development

3.3.1 Introduction

The SKM MIKE-FLOOD model was not made available to BMT WBM by Sunshine Coast Regional Council for use in the BMT WBM studies. However, a Digital Elevation Model (DEM) of the study area together with the peak flood levels for the three design flood events modelled in the *Caloundra South Flood Study* was obtained. Furthermore, the *Caloundra South Flood Study* report was used to obtain further information in relation to the Caloundra South MIKE-FLOOD model.

On the basis of the information obtained, a TUFLOW model of the Bells Creek and Lamerough Creek catchments was developed during the previous BMT WBM flooding assessment for the Caloundra South development. This formed the basis of the hydraulic model developed for this flood assessment. Furthermore, the model was updated to run on the latest version of TUFLOW (version 2011-09).

3.3.2 Model Area

The modelled area covers the entire Bells Creek and Lamerough Creek catchments, extending from Pumicestone Passage in the east to upstream of the Glasshouse Mountains Road in the west. The extent of the TUFLOW model is shown in Figure 3-7.

The floodplain area and watercourses within the model area have been represented within a 2D model domain. The 2D model domain covers an area of approximately 67.5 km^2 and is based on a 12m by 12m square grid for the majority of the site, and a finer scale 5m by 5m square grid in the