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Merimbula Lake and Back Lake Floodplain Risk Management Study

Final FRMS

Bega Valley Shire Council

January 2021

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Document Control

Ver	Effective Date	Description of Revision	Prepared by:	Reviewed by:
Stage 1 Report				
0	March 2019	Draft for Council Review	Akhil Sud Luke Evans Sean Garber	Emma Maratea
Stage 2 Report				
0	December 2019	Draft for Council Review	Luke Evans Sophie Cant Akhil Sud	Emma Maratea
Stage 3 Report				
0	June 2020	First Draft FRMS for Council Review	Luke Evans	Emma Maratea
Stage 3 Report				
0	September 2020	Draft FRMS for Internal Review	Luke Evans	Emma Maratea
1	September 2020	Draft FRMS for Council Review	Luke Evans	Emma Maratea
Stage 4 Report				
2	October 2020	Draft FRMS for Public Exhibition	Luke Evans	Emma Maratea
Stage 5 Report				
0	December 2020	Final FRM Study	Luke Evans	Emma Maratea
1	January 2021	Revision to Final FRM Study for Council Adoption (Adopted by Council 17 February 2021)	Luke Evans	Emma Maratea

Prepared For: Bega Valley Shire Council

Project Name: Merimbula Lake and Back Lake Floodplain Risk Management Study

Document Location: J1148 - Merimbula and Back Lake FRMSP\4. Reports\Stage 5 - Final Reports\J1148_R05_Final-FRM-Study_Rev1.docx

Cover Image Source: http://www.environment.nsw.gov.au/images/estuaries/stats/169merimbula9.jpg

Foreword

The primary objective of the New South Wales (NSW) Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible.

Through the NSW Department of Industry, Planning and Environment (DPIE) and the NSW State Emergency Service (SES), the NSW Government provides specialist technical assistance to local government on all flooding, flood risk management, flood emergency management and land-use planning matters.

The *Floodplain Development Manual* (NSW Government 2005) is provided to assist councils to meet their obligations through the preparation and implementation of floodplain risk management plans, through a staged process. **Figure F1**, taken from this manual, documents the process for plan preparation, implementation and review.

The *Floodplain Development Manual* (NSW Government 2005) is consistent with Australian Emergency Management Handbook 7: *Managing the floodplain: best practice in flood risk management in Australia* (AEM Handbook 7) (AIDR 2017).

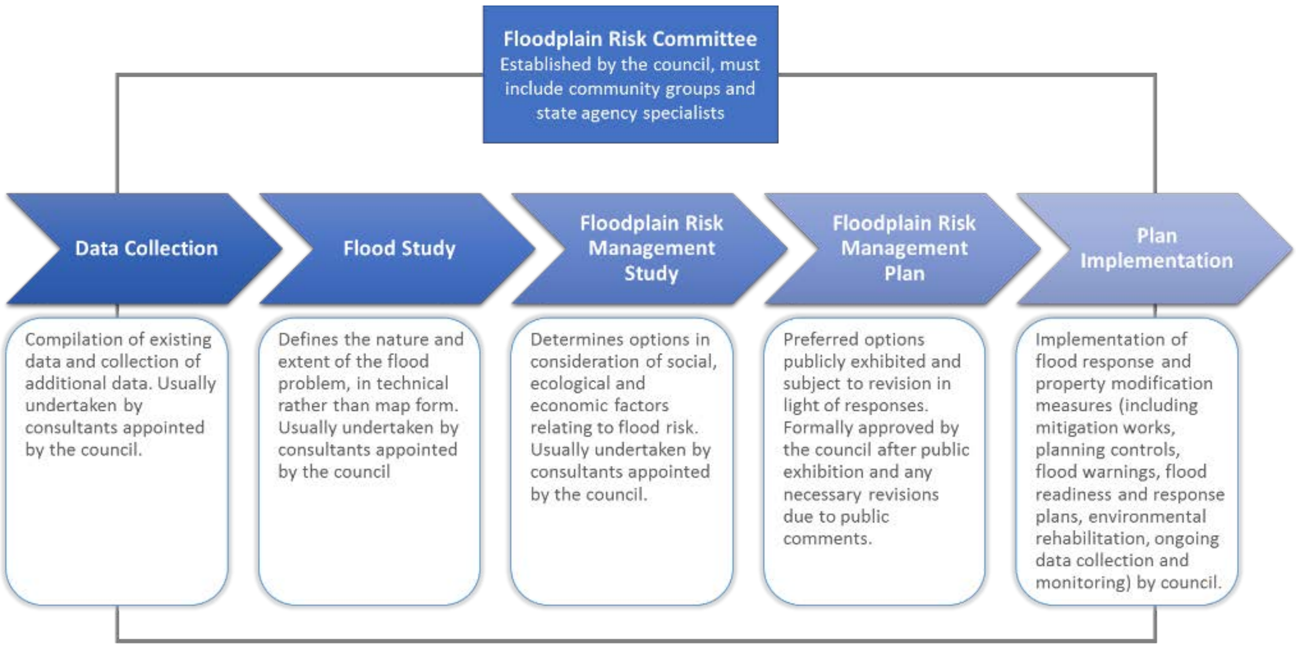

Figure F1 The Floodplain Risk Management Process (source: NSW Government, 2005)

Bega Valley Shire Council is responsible for local land use planning in its service area, including in the Merimbula Lake and Back Lake catchments and their floodplains. Through its Floodplain Risk Management Focus Group, Council has committed to prepare a comprehensive floodplain risk management plan for the study area in accordance with the NSW Government's *Floodplain Development Manual* (2005). This document relates to the floodplain risk management study and plan phase of the process.

Executive Summary

The Merimbula Lake and Back Lake Floodplain Risk Management Study (FRMS) has been prepared for Bega Valley Shire Council ('Council') to assess and address the flood risks identified in the Merimbula Lake and Back Lake Flood Study (Cardno, 2017). This FRMS will allow Council to better manage the existing, continuing and future flood risk to the community around Merimbula Lake and Back Lake, by identifying mitigation strategies in both catchments, to ensure the safeguarding of residents, properties and other infrastructure.

Background

The Flood Study (Cardno, 2017) prepared for Council identified the existing flood risk associated with mainstream catchment flows and ocean storms within the Merimbula Lake and Back Lake catchments. Key flooding issues identified in the Flood Study included foreshore inundation of properties along Merimbula Lake and property and road flooding along Merimbula Creek, particularly when the entrance to Back Lake is closed prior to a large storm event.

Merimbula Lake drains into the Tasman Sea through a sandbar entrance at the northern end of Merimbula Beach, while Merimbula Creek flows through the Merimbula township before flowing into the Tasman Sea at Back Lake, which is intermittently closed at the southern end of Short Point Beach.

Objectives

Flood risk management measures identified in this FRMS include an evaluation of preliminary costs to allow for planning of any implementation and integration with Council's existing long-term financial planning and asset planning processes. All options have been assessed utilising a triple bottom line approach in the form of a multi-criteria assessment.

This FRMS is intended to be used to:

- Identify measures to reduce the risk of flooding impacts on the community
- Reduce the manageable impact and risk of flooding on the community
- Assist in informing the community of flood risks in the study area
- Inform Council planning guidelines for the study area.

The outcomes of this FRMS are presented in the Floodplain Risk Management Plan (FRMP) which documents and conveys the decisions on the management of flood risk into the future. The FRMP outlines a range of measures to manage existing, future and residual flood risk effectively and efficiently. This includes a prioritised implementation strategy; what measures are proposed and how they will be implemented.

Stakeholder Consultation

Stakeholder consultation was undertaken throughout the project. Key stakeholders consulted with as part of the study include:

- Bega Valley Shire Council
- State Emergency Services
- NSW Government departments
- Local business and community groups
- Sapphire Valley Caravan Park
- Acacia Ponds Village.

Community engagement and education was also a key component of the study. The community engagement methods undertaken were:

- An initial project inception workshop
- Electronic questionnaire
- Follow up discussions with interested parties
- Public exhibition workshops (yet to be undertaken).

The newsletter was mailed to approximately 207 properties. One submission was received via mail and eight surveys were completed online. This is a low response rate (4.3%). However, this could be due to a number of factors including:

- The Flood Study engagement (drop-in sessions, newsletters, surveys and public exhibition) was undertaken relatively recently and engagement was fairly high. The community may not feel the need to revisit the same issues already discussed as part of the Flood Study engagement.
- Approximately ten people attended the drop-in sessions in December 2018. These attendees may not have felt the need to also provide a survey response. If these attendees are included as respondents, then the return rate is 9.7%.
- The mail out to residents only included the project information and directed the community to complete the survey online. The community may prefer to complete the survey on paper and mail it. This will be considered for engagement undertaken in the future studies.

The submissions that were received identified that

- The respondents were generally aware of flooding issues within the study area
- Flooding had impacted roads, access, property and assets in the past
- Information on road closures was the most common information that respondents were looking for during a flood
- Respondents used a variety of sources to get flood updates and information including websites, radio, television, social media and word of mouth.

The draft FRMS and FRMP documents were placed on public exhibition from 31 October 2020 to 29 November 2020. During the public exhibition period:

- The reports were made available on Council's website;
- A community survey was hosted on Council's "Have Your Say" page to collect feedback from the community (5 responses were received from the community); and,
- Two community information sessions were held to discuss the study with the community on:
    - Session 1: Tuesday 10 November from 12.30pm to 2.30pm; and,
    - Session 2: Wednesday 11 November from 2.30pm to 4.30pm.

The submissions received (5 survey responses and an addition 2 email submissions) and comments received from the community at the information sessions (approximately 24 attendees) were considered in the finalisation of the documents.

ARR2019 Sensitivity

Since the Flood Study (Cardno, 2017) was completed, the Australian Rainfall and Runoff 2019 (ARR2019) has been published. ARR2019 has a number of changes to the hydrological methods that have been traditionally employed, including those in the Flood Study. This includes updated design rainfall intensities, new ensemble storms and other catchment parameters such as losses.

Sensitivity analysis was undertaken on the Flood Study model by applying ARR2019 IFDs, temporal patterns and losses.

The results show that the impact of applying ARR2019 compared with ARR87 are negligible in Merimbula Lake. However, the impacts are considerable (up to 0.8m reduction in flood levels) in Back Lake, particularly upstream of Sapphire Coast Drive. However, it is noted that under both ARR approaches there are only a few properties in Back Lake impacted by flooding. Further, almost all existing dwellings or significant building on these properties are outside of the existing 1% AEP extent.

Following discussions with Council and DPIE it was considered reasonable to proceed with the Floodplain Risk Management Study utilising the Flood Study (Cardno 2017) results based on ARR87.

Overland Flow Analysis

Overland flow is considered to be an issue for the study area, both by local residents and Council. In September 2014 roads and shop fronts within the Merimbula CBD were impacted by flash flooding caused by an intense local rainfall burst. No foreshore flooding from the lake was experienced during this event. However, overland flow issues may be exacerbated by elevated lake levels, due to a reduction in the discharge capacity of the local drainage network (as a result of the elevated tailwater levels). This was a key contributor to the 2014 flood event.

To assess the overland flood behaviour within the study area, a Tuflow model was developed. The model covered the Merimbula CBD and the northern shore of Merimbula Lake. Flows were sourced from the previously developed RAFTS model and applied directly to the model grid in order to assess overland flow behaviour. The model was run for the 1% AEP and 20% AEP events using the ARR87 guidelines, as per the Flood Study. The 90 minute event was critical for local catchment flows for both events.

Overall, the catchment was not heavily impacted by overland flow, with the majority of overland flowpaths restricted to open space corridors and roadways.

Two locations experienced impacts from overland flow; the CBD along Merimbula Drive and Market Street and along Main Street between Henwood Street and Cliff Street.

Overland flow in the CBD is significant (highlighted in the inset on the maps). This behaviour was noted prior to the construction of the Merimbula Bypass. Although the bypass has delivered some benefits with regard to flood behaviour, overland flow remains an issue (refer **Section 7.4**). Much of the flooding occurs across the carpark on Merimbula Drive, however flow that breaks out of the carpark then passes through commercial buildings to the east. Ponding along Market Street also affects adjacent businesses. While depths in the carpark reach 0.7 metres, depths at commercial properties are lower, typically within 0.4 – 0.6 metres.

Major Works

A number of major works have been completed within the floodplain or are proposed to be constructed in the future. The works assessed were:

- The Merimbula Airport Masterplan (currently in a planning stage)
- The Merimbula Service Road (completed)
- The Merimbula By-Pass (completed)

The airport works propose to extend the runway at both north and south ends by 200 metres and 120 metres respectively, and the tarmac raised to increase the airports flood immunity. The assessment found that the works proposed under the airport masterplan do not impact flood behaviour, with no level differences observed either across the site or within the adjacent floodplain. This is due to the flood storage being removed as part of the works being negligible compared to the storage available in the wider lake system.

The Merimbula Service Road runs from Sapphire Coast Drive to the rear of properties facing Main Street. A review of the bypass against the 1% AEP flood found that the northern portion of the road passes through storage and flood fringe zones of the 1% AEP. Given that there is substantial storage within the Back Lake system, it is not expected that the loss of this relatively small volume of flood storage will have any impact on peak flood levels. It is noted that the northern extent of the service road lies close to the floodway, and that velocities in this region are in the order of 0.8 – 0.9 m/s in the 1% AEP event. Sufficient protection should be provided to the embankment in this region to prevent erosion in large flood events.

The Merimbula Bypass was constructed in 2015 to improve traffic flow within the Merimbula CBD. The results of the assessment show that the bypass has reduced the depths of flooding through the plaza downstream of the carpark, facing Main Street. Reductions were typically in the order of 0.02 – 0.05 metres in both events, although there were reductions of up to 0.1 metres in the 5% AEP event along Main Street. This improvement is being driven by improved conveyance of floodwaters from within the carparks upstream of the plaza, and along the bypass, reducing the level of ponding occurring in the carparks, and hence the amount of flow breaking out of the carpark and flowing through the downstream commercial area.

Property Flooding and Flood Damages

Tangible flood damages were based on a relationship between the depths of flooding on a property and the likely damage within the property.

Individual damage curves have been prepared for residential and commercial properties. No industrial properties were found to be flood affected in the Merimbula catchment.

The results of the assessment are presented in **Table i**.

The assessment showed that over floor flooding commenced in the 5% AEP event, with three residential properties affected. This affectation increased steadily for larger events with a total of 17 properties (12 residential and five commercial) affected in the 1% AEP and 36 (25 residential and 11 commercial) affected in the PMF.

Depths were relatively modest for the larger events, with peak depths not exceeding 0.5 metres at properties in events up to and including the 0.5% AEP and were less than 1 metre in the PMF.

As a result of no over floor flooding occurring in events smaller than the 5% AEP, the AAD is relatively low, as it is these events that contribute most to AAD. While the damages in the 0.5% AEP are more substantial ($1.3M) when these are annualised, the contribution to AAD is only $6,668.

Table i Merimbula Existing Property Flooding and Damages Results

	Over Ground Flooding	Over Floor Flooding	Max Over Floor Depth (m)	Total Damages ($2019)
PMF	57	36	0.94	$2,764,963
0.5% AEP	36	24	0.48	$1,636,976
1% AEP	31	17	0.42	$1,271,603
2% AEP	17	9	0.27	$718,089
5% AEP	9	3	0.14	$360,481
10% AEP	1	0	-	$12,675
Average Annual Damage				$54,251

Flood Risk Management

Flood risk is a combination of the likelihood of occurrence of a flood event and the consequences of that event when it occurs. It is the human interaction with a flood that results in a flood risk to the community. This risk will vary with the frequency of exposure to this hazard, the severity of the hazard, and the vulnerability of the community and its supporting infrastructure to the hazard. Understanding this interaction can inform decisions on which treatments to use in managing flood risk.

Measures available for the management of flood risk can be categorised according to the way in which the risk is managed. There are three broad categories of management:

- Flood modification measures – options aimed at preventing/avoiding or reducing the likelihood of flood risks through modification of flood behaviour in the catchment.
- Property modification measures – options focused on preventing/avoiding or reducing the consequences of flood risks. Rather than necessarily modify flood behaviour, these options aim to modify existing properties (e.g. by house raising) and/or impose controls on property and infrastructure development to modify future properties. Property modification measures, such as effective land use planning and development controls for future properties, are essential for ensuring that future flood damages are appropriately contained, while at the same time allowing ongoing development and use of the floodplain.
- Emergency response modification measures – options focused on reducing the consequences of flood risks, by generally aiming to modify the behaviour of people during a flood event.

A range of floodplain risk management options were assessed against economic, social and environmental criteria, and ranked according to their overall performance.

Of the 14 options assessed, the top ranked options were:

- Flood warning systems
- Land use planning and building control updates
- The preparation of an emergency response plan for the Acadia Ponds Retirement Village

Outcomes and Recommendations

This report presents the findings of the Floodplain Risk Management Study stage of the Flood Risk Management Process for Merimbula Lake and Back Lake, in accordance with the Floodplain Development

Manual (NSW Government, 2005). The investigations undertaken as part of this process identified a number of issues within the floodplain. Based on these issues, a series of floodplain management options were developed and recommended.

The outcomes of the multi-criteria assessment provide a sound basis upon which Council can make decisions about undertaking works, making planning decisions and developing response arrangement to reduce the impact of flooding on property and life.

The implementation strategy associated with the outcomes of this study may not necessarily approach the options from "highest ranking to lowest ranking" but will also need to incorporate various other considerations such as existing works programs, availability of funding and other opportunities to combine floodplain works with other activities.

The options identified as having significant flood risk reductions that also do not have adverse social or environmental impacts are incorporated into the Floodplain Risk Management Plan (FRMP) as proposed management actions. The FRMP provides a realistic strategy to manage flood risk and will outline the process of implementation for recommended management actions within the floodplain.

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Maps (included in attachment)

Glossary

Annual exceedance probability (AEP)	The chance of a flood of a given size (or larger) occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (i.e. a 1 in 20 chance) of a peak discharge of 500 m^3/s (or larger) occurring in any one year. (See also average recurrence interval).
Australian Height Datum (AHD)	National survey datum corresponding approximately to mean sea level.
Attenuation	Weakening in force or intensity.
Average recurrence interval (ARI)	The long-term average number of years between the occurrence of a flood as big as (or larger than) the selected event. For example, floods with a discharge as great as (or greater than) the 20 year ARI design flood will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event. (See also annual exceedance probability).
Catchment	The catchment, at a particular point, is the area of land that drains to that point.
Chart Datum	The level of water that charted depths displayed on a nautical chart are measured from. A chart datum is generally a tidal datum; that is, a datum derived from some phase of the tide. Common chart datums are lowest astronomical tide and mean lower low water.
Design flood	A hypothetical flood representing a specific likelihood of occurrence (for example the 100 year ARI or 1% AEP flood).
Development	Is defined in Part 4 of the AP&A Act as: - Infill Development: development of vacant blocks of land that are generally surrounded by developed properties. - New Development: development of a completely different nature to that associated with the former land use. - Redevelopment: Rebuilding in an area with similar development.
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
Flood	Relatively high river or creek flows, which overtop the natural or artificial banks, and inundate floodplains and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood Awareness	Awareness is an appreciation of the likely effects of flooding and knowledge of the relevant flood warning, response ad evacuation procedures.
Flood Education	Education that seeks to provide information to raise awareness of the flood problem to enable individuals to understand how to manage themselves and their property in a flood event.

Flood fringe	Land that may be affected by flooding but is not designated as floodway or flood storage.
Flood hazard	The potential risk to life and limb and potential damage to property resulting from flooding. The degree of flood hazard varies with circumstances across the full range of floods.
Flood level	The height or elevation of floodwaters relative to a datum (typically the Australian Height Datum). Also referred to as “stage”.
Floodplain	Area of land which is subject to floods up to and including the probable maximum flood.
Floodplain risk management plan	A document outlining a range of actions aimed at improving floodplain management. The plan is the principal means of managing the risks associated with the use of the floodplain. A floodplain risk management plan needs to be developed in accordance with the principles and guidelines contained in the NSW Floodplain Development Manual. The plan usually contains both written and diagrammatic information describing how particular areas of the floodplain are to be used and managed to achieve defined objectives.
Flood planning levels (FPLs)	Flood planning levels selected for planning purposes are derived from a combination of the adopted flood level plus freeboard, as determined in floodplain management studies and incorporated in floodplain risk management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also consider the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plans. The concept of FPLs supersedes the “standard flood event”. As FPLs do not necessarily extend to the limits of flood prone land, floodplain risk management plans may apply to flood prone land beyond that defined by the FPLs.
Flood prone land	Land susceptible to inundation by the probable maximum flood (PMF) event. Under the merit policy, the flood prone definition should not be seen as necessarily precluding development. Floodplain Risk Management Plans should encompass all flood prone land (i.e. the entire floodplain).
Flood storage	Floodplain area that is important for the temporary storage of floodwaters during a flood.
Floodway	A flow path (sometimes artificial) that carries significant volumes of floodwaters during a flood.
Freeboard	A factor of safety usually expressed as a height above the adopted flood level thus determining the flood planning level. Freeboard tends to compensate for factors such as wave action, localised hydraulic effects and uncertainties in the design flood levels.
Gauging (tidal and flood)	Measurement of flows and water levels during tides or flood events.
Hazard	A source of potential harm or a situation with a potential to cause loss.
Historical flood	A flood that has actually occurred.

Hydraulic	The term given to the study of water flow in rivers, estuaries and coastal systems, in particular the evaluation of flow parameters such as water level and velocity.
Hydrograph	A graph showing how a river or creek's discharge changes with time.
Hydrologic	Pertaining to rainfall-runoff processes in catchments.
Hydrology	The term given to the study of the rainfall-runoff process in catchments, in particular, the evaluation of peak flows and flow volumes. .
Isohyet	Equal rainfall contour.
Peak flood level, flow or velocity	The maximum flood level, flow or velocity that occurs during a flood event.
Pluviometer	A rainfall gauge capable of continuously measuring rainfall intensity.
Probable maximum flood (PMF)	An extreme flood deemed to be the maximum flood that could conceivably occur.
Probability	A statistical measure of the likely frequency or occurrence of flooding.
Riparian	The interface between land and waterway. Literally means "along the river margins".
Runoff	The amount of rainfall from a catchment that actually ends up as flowing water in the river or creek.
Stage	See flood level.
Stage hydrograph	A graph of water level over time.
Topography	The shape of the surface features of land.
Velocity	The speed at which the floodwaters are moving. A flood velocity predicted by a 2D computer flood model is quoted as the depth averaged velocity, i.e. the average velocity throughout the depth of the water column. A flood velocity predicted by a 1D or quasi-2D computer flood model is quoted as the depth and width averaged velocity, i.e. the average velocity across the whole river or creek section.

Terminology in this Glossary has been adapted from the NSW Government Floodplain Development Manual, 2005, where available.

Abbreviations

1D	One Dimensional
2D	Two Dimensional
AHD	Australian Height Datum
ARI	Average Recurrence Interval
AR&R	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
BVSC	Bega Valley Shire Council
DCP	Development Control Plan
DEM	Digital Elevation Model
DPE	Department of Planning and Environment
DPIE	Department of Planning, Industry and Environment
FPL	Flood Planning Level
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
FPRMSP	Floodplain Risk Management Study & Plan
ha	hectare
km	kilometres
km^2	Square kilometres
LEP	Local Environment Plan
LGA	Local Government Area
LiDAR	Light Detection and Ranging
m	metre
m^2	Square metres
m^3	Cubic metres
mAHD	metres to Australian Height Datum
mm	millimetres
m/s	metres per second
NSW	New South Wales
OEH	Office of Environment and Heritage (NSW)
PASS	Potential Acid Sulfate Soils
PMF	Probable Maximum Flood
RMS	Roads and Maritime Services
SES	State Emergency Service (NSW)

1 Introduction

The Merimbula Lake and Back Lake Floodplain Risk Management Study (FRMS) has been prepared for Bega Valley Shire Council (Council) to assess the flood risks identified in the Flood Study (Cardno, 2017). The FRMS will enable Council to become aware of flood prone locations within their LGA, as well as mitigation strategies in the Merimbula Lake and Back Lake catchments, to ensure the safeguarding of residents, properties and other infrastructure.

1.1 Study Background and Context

Council has received financial support from the State Floodplain Management program managed by the Department of Planning, Industry and Environment (DPIE) to undertake a floodplain risk management study and plan of the Merimbula Lake and Back Lake Catchments.

Council successfully completed the Merimbula Lake and Back Lake Flood Study in March 2017. The Flood Study identified the existing flood risk associated with mainstream catchment flows and ocean storms within both catchments. Key flooding issues identified in the Flood Study included foreshore inundation of properties along Merimbula Lake. Property and road flooding were also identified along Merimbula Creek, particularly when then entrance to Back Lake is closed prior to a large storm event.

The purpose of this FRMS is to assess options that address the flood risk identified in the flood study. The findings of the FRMS will inform the Floodplain Risk Management Plan (FRMP). The implementation of the FRMP will allow Council to better manage the existing, continuing and future flood risk to the community around Merimbula Lake and Back Lake.

1.2 Study Objectives

The overall objective of this study is to improve understanding of flood behaviour and impacts, and better inform management of flood risk in the study area in consideration of the available information, and relevant standards and guidelines.

The outcomes of the FRMS Study will be to identify a number of structural and non-structural measures suitable for inclusion in the FRMP. Flood risk management measures identified in this FRMS include an evaluation of preliminary costs to allow for planning of any implementation and integration with Council's existing long-term financial planning and asset planning processes. All options have been assessed utilising a triple bottom line approach in the form of a multi-criteria assessment.

This FRMS is intended to be used to:

- Identify measures to reduce the risk of flooding impacts on the community
- Reduce the manageable impact and risk of flooding on the community
- Assist in informing the community of flood risks in the study area
- Inform Council planning guidelines for the study area.

The outcomes of this FRMS are presented in the FRMP which documents and conveys the decisions on the management of flood risk into the future. The FRMP outlines a range of measures to manage existing, future and residual flood risk effectively and efficiently. This includes a prioritised implementation strategy; what measures are proposed and how they will be implemented.

2 Study Area

Merimbula Lake is located in the Bega Valley Shire Council Local Government Area (LGA), which is approximately 450 km south of Sydney via the Princes Highway, and approximately 250 km south-east of Canberra via the Monaro Highway and Snowy Mountains Highway. Back Lake is located adjacent to Merimbula Lake, in a north-east direction.

The Merimbula Lake and Back Lake catchments including their tributaries of Millingandi Creek, Boggy Creek, Bald Hills Creek and Merimbula Creek converge at the township of Merimbula where they drain into the Tasman Sea (**Refer Figure 2-1, Study Area**). Their catchment areas to the west and north west of Merimbula are generally heavily forested with some small areas of rural land in the Merimbula Lake catchment. The combined catchment area of the two drainage systems is approximately 75 km^2. The Merimbula Lake catchment is the larger of the two drainage systems contributing a catchment area of some 43 km^2.

Merimbula Creek flows through the Merimbula township before flowing into the Tasman Sea at Back Lake which is intermittently closed at the southern end of Short Point Beach near Mirador Estate. The entrance of Back Lake is managed by Council and is opened when water levels in the lake reach a set trigger level of 1.4 mAHD. Millingandi Creek, Boggy Creek and Bald Hills Creek drain into the Merimbula Lake before draining into the Tasman Sea through a sandbar entrance at the northern end of Merimbula Bay at Merimbula Beach. Critical infrastructure such as the regional airport, Princes Highway, Merimbula Sewage Treatment Plant and Merimbula CBD may be affected by creek, lake or ocean water levels.

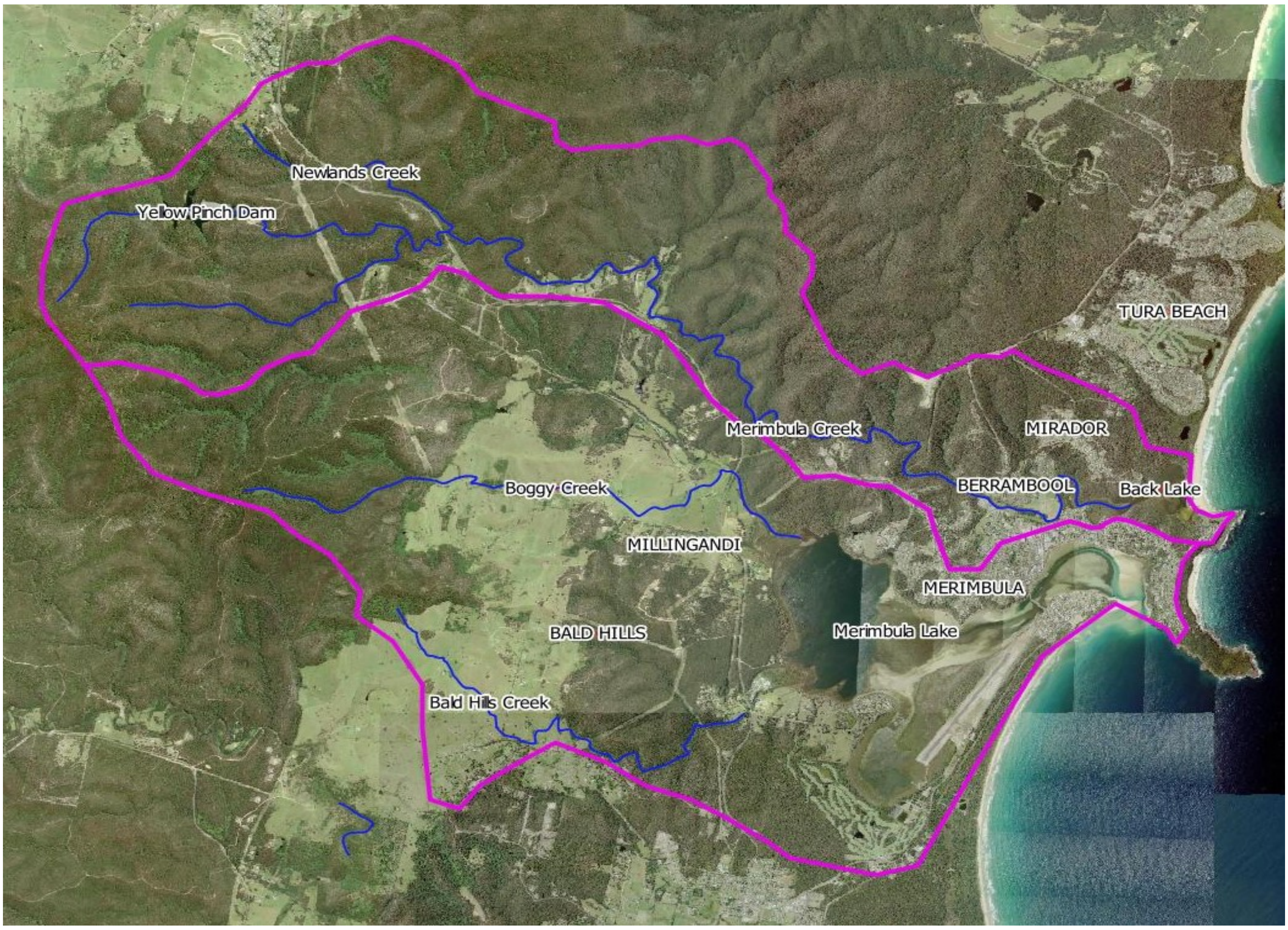


Figure 2-1 Study Area

2.1.1 Description of flood behaviour

The Flood Study (2017) focused on assessing the flood risk associated with mainstream catchment flows and ocean storms. Overland flow issues have been noted within the Merimbula CBD in the past, however, this type of flooding was not assessed in the Flood Study.

Flooding within the Merimbula Lake catchment is largely contained to creeks and open space. Some properties adjoining the Merimbula Lake foreshore begin to become inundated with approximate depths ranging from 0.1m in the 20% AEP event to 1.1 m in the 1% AEP event.

The regional airport site remains flood free in the 5% AEP event. Inundation of buildings and infrastructure begin to occur at the 2% AEP event with approximate depths of 0.02m ranging to 0.15m in the 1% AEP event to 0.55m in the PMF event. The airport runway becomes overtopped in the PMF event with flood waters reaching its edges in the 1% AEP.

Flooding within the Back Lake catchment is well confined within creeks and open space downstream of Henwood Street to the lake entrance. Low lying properties between Henwood Street and Sapphire Coast Drive[1] become inundated in the 20% AEP event at the rear of their properties. All affected properties retain open road access in events up to the PMF.

Berrambool Sports Field buildings become inundated with depths ranging from 0.49m in the 20% AEP to 1.03m in the 1% AEP and 2.03m at the PMF events.

Upstream of the Sapphire Coast Drive crossing the Sapphire Valley Caravan Park becomes inundated in the 10% AEP with site access being cut at the 5% AEP event. Caravans and buildings become inundated with depths ranging from 0.17m in the 5% AEP to 0.48m in the 1% AEP and 2.23m at the PMF.

The number of property lots affected range from 219 at the 20% AEP to 323 at the PMF. The estimates of property inundation do not indicate the number of structures affected.

With climate change impacts, an additional 20 lots are anticipated to be inundated at 2050 increasing to 27 by 2100.

Results from the community survey questionnaire undertaken during the Merimbula Lake and Back Lake Flood Study revealed recent flooding experiences during April 2010, May 2011 and December 2014. Historical newspaper clippings establish flood behaviour between the period 1906 – 1978. Other reports used as Flood Study references point to events during the 1970s as floods of significance.

Although not the focus of the Flood Study, overland flow flooding has been known to occur within Merimbula CBD. Overland flow issues may also be compounded if rainfall coincides with elevated lake levels, which restrict the ability of the local drains to discharge water. In September 2014 roads and shop fronts were impacted by flash flooding caused by an intense local rainfall burst. No foreshore flooding from the lake was experienced during this event. It is understood that Council has subsequently undertaken drainage improvements and the Merimbula Bypass has been completed, both of which may have impacted the overland flow behaviour within the CBD. The analysis of overland flow has been undertaken as part of this FRMS (**Section 7.4**).

[1] In previous studies, such as the 1986 Flood Study (Willing and Partners), the road section north of the Merimbula Drive intersection and south of the Merimbula Creek was referred to as Reid Street. This section of road is now officially known as Sapphire Coast Drive, and Reid Street is only the portion of the road south of the intersection with Merimbula Drive.

Figure 2-2 Overland Flow Flooding in Merimbula September 2014 (www.abc.net.au)

2.1.2 Historical Flooding

Flooding has been observed and recorded within the study area dating back to 1898. Observations and recordings have varied from creek flooding, lake foreshore flooding and overland flooding. The summary of the flooding observed in the catchment is provided below.

The following reports of historical flooding in the study area have been obtained from Newspaper Clippings collated by Council:

- February 1898: The Pambula mail coach was lost when trying to cross Millingandi Creek. The driver and horses escaped.
- February 1898: Flood damage to the flats (fences destroyed, and corn levelled to the ground). Back Lake opened and let the water out avoiding further damages.
- March 1914: Culvert at the foot of Long Hill, north of Millingandi swept away.
- March 1919: A 13 year old boy died crossing a log over a stream at Merimbula.
- February 1971: worse floods since 1919. Merimbula water pipeline damaged.
- March 1978: Merimbula airstrip closed due to rain and high seas.

Community responses to a survey undertaken as part of the Flood Study in May 2015 provided the following flood observations:

- Flooding of gardens, yards, garages and shed on private property:
  - Berrambool Drive, Berrambool
  - Boggy Creek Road, Millingandi

  - Henwood Street, Merimbula
  - Munn Street, Merimbula
  - Oaklands Road, Pambula
  - Sapphire Coast Drive, Merimbula
  - Stringybark Place, Merimbula
  - Watershed Drive, Millingandi.
- Flooding over residential and commercial floor levels:
  - Sapphire Coast Drive, Merimbula
  - Oaklands Road, Pambula
  - Berrambool Drive, Berrambool
  - Munn Street, Merimbula.

The Flood Study (2017) calibrated the flood models using data from the following flood events:

- A catchment event for Back Lake: 21-22 March 2011.
- An ocean storm tide event for Merimbula: 23-24 June 1998.
- The flooding event of 14-16 February 2010, which included both extreme rainfall as well as storm tide. However, it was noted that the overall levels in Merimbula Lake didn't reach foreshore flooding levels due to the surge coinciding with a low, neap tide.

Overland flooding has been observed within the Merimbula CBD as noted by:

- News reports of overland flow flooding in Merimbula in September 2014.
- A community member who attended the drop-in sessions in December 2018 (**Section 5.6**) provided a photo and described overland flooding in 1996.

3 Review of Available Data

3.1 Site Inspections

The following site inspections have been undertaken as part of this FRMS.

Date	Location	Purpose
17 October 2018	Entire Study Area	Overview of study area and identification of issues with known flooding issues
19 February 2019	Green Point Road	To follow up on road flooding issues identified by a resident at the community drop-in sessions (December 2018).

3.2 Previous Studies and Reports

A number of studies have been previously undertaken that are relevant to the preparation of this FRMS. The studies will be used to better understand flood risk and inform the assessment of flood management options, including the potential social and environmental impacts of implementing the options.

The key study informing this FRMS is the Flood Study (Cardno, 2017). This study and the modelling undertaken as part of it are reviewed in detail in **Section 4**. Other relevant studies are summarised in **Table 3-1**.

Table 3-1 Previous Studies and Reports

Document	Relevance to the Study
Floods of February 1971 on the South Coast (Water Resources Commission of NSW, 1976)	A quantitative representation of the floods that inundated the South Coast of NSW in 1971. Hydrographs and meteorological data have been presented for gauges in the region, spanning from Kangaroo Valley to Bombala. A list of historical floods is also included, from 1851 to 1966. No specific mention of flooding in the study area is provided. This study provides context to floods across the region.
Survey of erosion and siltation within the catchment of Merimbula Lake (Soil Conservation Service of NSW, 1978)	There is a minor degree of soil erosion in the Merimbula Lake Catchment. Mitigation measures are suggested for the future, including stabilisation of the downstream shoreline (southern) of the bridge and the retention of timber in high risk areas. These works and the potential for erosion have been considered in the development of flood risk management options.
Merimbula Lake Tourist Centre Environmental Study (David Grogan Planning Services, 1982)	This study provides an environmental assessment for the proposed development of two tourist resort complexes at the mouth of Boggy Creek on the foreshore of Merimbula Lake. The report provides information on the environmental conditions prior to development including geology, soils, water quality and ecology. This information will be used to inform the assessment of the likely impacts and feasibility of flood risk options. The report also provides a description of local flooding and it is stated that the development would convey the 5 Year ARI flows within pipes and the 100 Year ARI flows within grassed swales. All road would have flood immunity from the 100 Year ARI flows. Hydrodynamic modelling was undertaken to assess catchment flows and tidal behaviour.

Document	Relevance to the Study
Merimbula Creek Flood Study - Reid Street Crossing (Willing and Partners, 1986) [2]	Report detailing the effects of the installation of the Reid Street Bridge on Merimbula Creek flood levels upstream of Reid Street. Includes hydraulic analysis, water surface profile analysis and tabulated flood levels.
Merimbula Lake and Back Lake Estuary Processes Study (Webb, McKeown and Associates, 1995)	Outlines the waterway usage, tidal processes, flood processes and water quality parameters - such as pH, turbidity, nitrogen and phosphorous - within the Merimbula Lake Catchment. This study has been used to inform environmental and social constraints and opportunities for flood risk management options.
Yellow Pinch Dam - Preliminary Dambreak Study (NSW Public Works and Services - Dams and Civil, 2001)	Details the dam break model created on Yellow Pinch Dam and the hazard rating, referring to potential consequences as a result of dam failure. There are residential properties located downstream of the dam, and approximately 20 of these houses will be inundated due to a dam break.
Report for Yellow Pinch Hydrological and Dam break study (GHD, 2009)	Council engaged GHD to conduct a hydrological and dam break study for Yellow Pinch Dam. The assessment involved a RAFTS model of the dam catchment, dam break modelling using FLDWAV, and hydraulic modelling using MIKE 11. The PMF dam break event appeared to be the most critical, inundating at least 7 houses. This document has informed the dam break risk assessment in **Section 7.5**.
Merimbula Estuary Management (nghEnvironmental, 2003)	The study aimed to: • Map vegetation around the lake foreshore; • Map the extent of seagrasses; • Review the existing fauna studies and undertake an assessment of potential fauna habitat and diversity; • Determine the conservation significance of vegetation communities in the foreshore and riparian areas; and • Identify opportunities for, and any constraints against, foreshore protection. This study has been used to inform environmental and social constraints and opportunities for flood risk management options. In addition, opportunities have been review where foreshore protection and floodplain management can complement each other.
DIPNR Merimbula Lake, Pambula Lake and Back Lagoon Tidal Data Collection (NSW Department of Commerce, 2004)	Presents data collected from 2003 (September to November); water level, velocity, discharge and water quality from 12 sites in the Merimbula region. This study has been used to inform environmental and social constraints and opportunities for flood risk management options.
Flood Risk Assessment - Bega Valley Shire Council (URS Australia, 2006)	This flood risk assessment for the entire LGA predicts that tourism will continue to grow in the Merimbula region, resulting in further development and increases in population. It also recommends the formation of a Floodplain Risk Management Committee, to act as an advisory body to Council. Its main roles will be to strategically generate flood risk mitigation measures, collecting data, considering development controls and evaluating the effectiveness of implemented floodplain management plans. Of relevance to this FRMS, the report recommends:

[2] The road that crosses Merimbula Creek is now known as Sapphire Coast Drive.

Document	Relevance to the Study
	• Council consider the impacts of global warming in its consideration of future development. • Flood awareness should be increased through detailed emergency management plans and community education programs.
Potential Sea Level Rise Impacts and Coastline Hazards at Merimbula Airport (WorleyParsons, 2011)	The Merimbula Airport precinct is affected by estuarine inundation and illustrations delineate the extent of the 100-year ARI flood presently, in 2030, 2060 and 2100. A 2100 coastal hazard line is also hypothesised, which is at least 180 metres from the airport, rendering erosion effects as insignificant. However, rising sea levels will result in a raising of the water table and groundwater levels, predicted to be approximately 0.9m by 2100. Furthermore, climate change will also increase evaporation rates, but these forecasts have not been conducted for the Merimbula region yet.
Merimbula Airport Master Plan 2033 for Bega Valley Shire Council (Rehbein Airport Consulting, 2013)	The master plan frameworks the future development of Merimbula Airport from an infrastructure and land use perspective. The development strategy outlines planned upgrades to the airport. The details in these reports have informed modelling of future scenarios and have been considered in the development of flood risk management options.
Merimbula Airport Development Strategy and Options Assessment Report (Aurecon, 2011)	
Bega Valley Shire Coastal Processes and Hazards Definition Study (BMT WBM, 2015)	Describes coastal processes and coastal hazards that have a major impact on the Council LGA. This enabled a qualitative assessment to be undertaken, which concluded hazard probably zones defined by a likelihood ranging from rare to almost certain. Conditions in these hazard zones are also estimated for circa 2050 and 2100. Additionally, rising sea levels, changes to wave climate and storm surges have been identified as coastal effects of climate change.

3.3 Local Emergency Management Plans

The NSW SES undertakes flood planning as a legislative responsibility to determine how to best respond to floods as the combat agency. The NSW SES hierarchy of plans for flooding is shown in **Figure 3-1**.

The Emergency Management Plan (EMPLAN) describes emergencies and the responsible combat and support agencies in NSW. Supporting plans are action plans that describe the support which is to be provided to the combat agency by a NSW Government agency or Functional Area.

Flood plans typically describe the risk to the community, outlines roles and responsibilities for the NSW SES and supporting agencies and describes how the NSW SES will manage flood events.

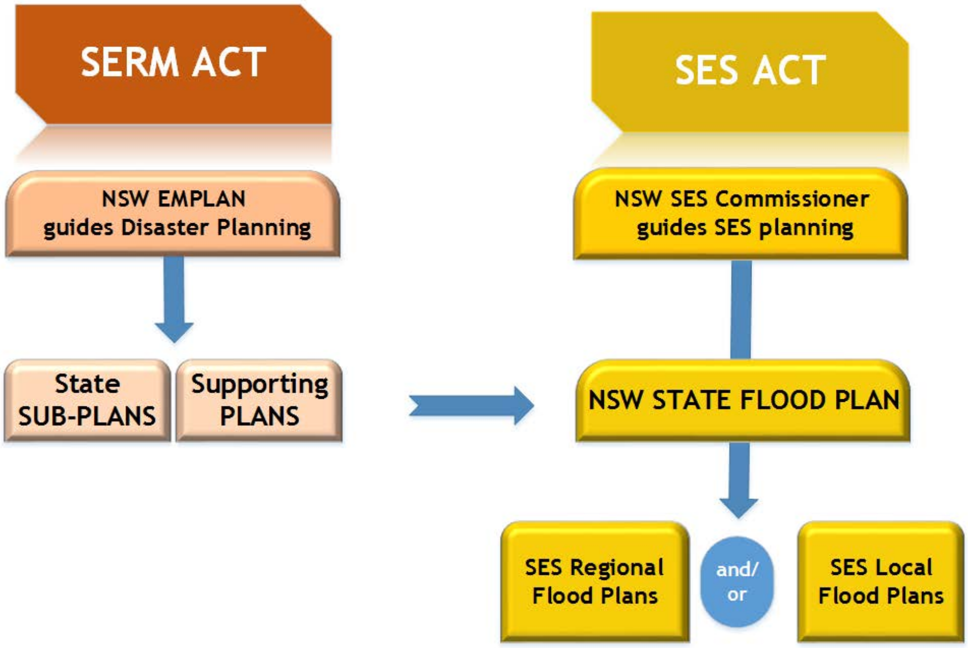


Figure 3-1 NSW SES Heirachy of Plans for Flood

Table 3-2 Local Emergency Management Plans

Document	Relevance to the Study
Bega Valley Shire Local Flood Plan (Floodsafe and NSW SES, 2007 – 2013)	Outlines the role of the NSW State Emergency Service (SES) in response to a flood in the vicinity of the Council. Evacuation procedures are also detailed, along with 'usual road closures', which illustrate areas susceptible to flooding. The document consists of three volumes: • Volume 1: Bega Valley Shire Flood Emergency Sub Plan (2013) • Volume 2: Hazard and Risk in the Bega Valley Shire (2007) • Volume 3: SES Response Arrangements for Bega Valley Shire (2007).
Bega Valley Shire Local Flood Plan - A sub-plan of the Bega Valley Shire Local Disaster Plan (DISPLAN) (Council and SES, 2007)	Explains the responsibilities of all stakeholders involved in a flood plan, including, but not limited to, the SES, Council, Ambulance Service of NSW, BoM, caravan park proprietors, NSW Fire Brigade, NSW Police Force, RFS and RMS. It also outlines the response procedure and logistical processes involved to minimise disruption to the region.

3.4 Survey Information

3.4.1 Terrain and Bathymetric Data

The terrain data summarised in **Table 3-3** was supplied to Cardno by Council for use in the Flood Study (Cardno, 2017). The topographic and bathymetric data used to develop the flood models for the Flood Study (2017) has not been altered as part of this FRMS.

It is noted that during the course of the environmental impact assessment undertaken as part of the Merimbula Airport runway extension project, it was identified that the LiDAR in the salt mash region to the south of the airport was reported as 0.1 – 0.2m higher in the LiDAR data compared to the collected ground survey cross section data.

This was likely due to the low, dense vegetation cover in this region that was reported as ground level in the LiDAR, rather than being filtered out, as is typically done with LiDAR returns from vegetation.

For this study, the higher LiDAR levels were retained, as the minor loss of storage in this region, compared to the storage available in Merimbula Lake, is negligible from a flooding perspective, so will not alter the reported flood behaviour.

Table 3-3 Summary of Topographic & Bathymetric Data

Data Set	Year
Topographic LiDAR – 1 m Resolution	2013
Topographic LiDAR – 1 m Resolution	2008
Merimbula & Pambula Hydrographic Survey	2003
Merimbula Lake Entrance Historical Photogrammetry	1962, 1972, 1975, 1977, 1979, 1989, 2001, 2007and 2011
Survey of assets around the estuary foreshores of Back Lake, Curalo Lake, Wonboyn Lake and Bega River completed by D. Wiecek (DPIE) and K. Crane (Council) using RTK GPS and Corsnet NSW VRS RTK Network	2014
Cross Sections of Merimbula Creek at Vicinity of Reid St	Unknown

3.4.2 Structures

Structure survey and design information was supplied by Council to Cardno for use in the Flood Study (Cardno 2017) for the following:

- The Imlay Shire Council Bridge Over Merimbula Creek
- The Reid Street Bridge over Merimbula Creek
- The Millingandi Deviation from Shand's Corner to the Caravan Park
- The Bald Hills Creek Culvert
- The Bridge Over Millingandi Creek at Merimbula Bypass
- The Culvert on Boggy Creek Road
- The Market Street Bridge over Merimbula Lake.

Additional survey was collected as part of this FRMS for the culvert under Green Point Road.

3.4.3 Property Survey

Property survey was undertaken as part of the FRMS for 144 properties. The following data has been collected for each property:

- Floor level
- Ground level at front of property
- Construction type
- Number of stories
- Photo.

3.5 Future Development Information

A future development scenario will be assessed based on a "fully developed" scenario based on permissible development within existing land use zones. The Bega Valley Local Environmental Plan 2013 (BVLEP 2013) land use zones have been provided by Council in GIS.

The proposed airport upgrade (minor filling in the floodplain) will also be considered in the future development scenario.

Council has also provided details of a deferred matter at Lot 721 DP 826975, 2529 Princes Hwy, Millingandi. This site covers an area of 16.5 Ha on the western side of Merimbula Lake adjacent to Millingandi Creek. Council officers have recommended the land retain its E3 zoning but revised with a new extended Environmental Conservation area to reflect the new course of the creek after erosive processes. A 7ha minimum lot size, providing for one (1) additional lot is recommended. This will be considered in the preparation of a future development scenario for modelling.

3.6 GIS Data

Digitally available information such as aerial photography, cadastral boundaries, topography, watercourses, drainage networks, land zoning, vegetation communities and soil landscapes were provided by Council in the form of GIS datasets.

4 Review of Flood Study

As part of the 2017 Flood Study (Cardno) a RAFTS hydrological model and a Delft3D hydrodynamic model were prepared to define the flood behaviour of the study area.

The RAFTS model covers the full catchment area and has been delineated to allow inflow hydrographs to be applied to the Delft3D model at sub-catchment outlets.

A review of the models prepared as part of the 2017 study is provided below.

4.1 Hydrological Model

4.1.1 Model Setup

The details of the hydrological model schematisation and summarised and discussed in **Table 4-1**.

Table 4-1 RAFTS Setup Parameters

Data	Comment
Catchment Delineation	For the 2017 study, the 75km^2 catchment area was broken down into 45 sub-catchments based 2013 LiDAR data. The sub-catchment delineation appears reasonable, with subcatchment generally of a similar size and shape.
Flow Routing	Flow routing in RAFTS can be done either by a simple 'lag' link, whereby flows are delayed between sub-catchments for a user-specified period or RAFTS can also automatically calculate lag times if the user enters a channel cross section. The 2017 study adopted individual lag times for each subcatchment based on catchment flow length (the length of the primary flowpath through the catchment) and an assumed flow rate through the subcatchments of 1m/s. While ARR2019, released subsequently to this study, provides some further guidance on estimated flow rates, the approach adopted is suitable for the study, given the calibration and validation undertaken.
Impervious Area	The impervious area was calculated individually for each sub-catchment. The impervious area was calculated by measuring the area of roads and developed areas in the sub-catchments. Impervious areas were found to be appropriate for the land use within the subcatchments.
Roughness	Based on recommendations outlines in the RAFTS user manual (WP Software, 1994) standard roughness values of 0.015 for impervious surfaces and 0.025 for pervious surfaces was adopted. Some catchment were further broken down into pasture (n = 0.05) and forest (n = 0.10). It is noted that a more detailed roughness layer was utilised in the hydraulic model. For the purposes of hydrological modelling, these values are reasonable.
Losses	Rainfall losses were applied through an initial and continuing loss method. The values adopted in the 2017 study were: • Impervious Areas: 1.5mm IL / 0mm/hr CL • Pervious Areas: 10mm IL / 2.5mm/hr These values are within typical ranges for ARR87.

<table>
<tr><th>Data</th><th>Comment</th></tr>
<tr><td>Rainfall</td><td>
Only one rainfall gauge was located within the catchment area, at Merimbula Airport. The gauge could only provided 1min rainfall data for one historical storm.
The next nearest pluvio gauge was 20km to the west in Wyndham. For other historical events, the temporal pattern from this gauge was adopted, with intensities scaled based on daily rainfall totals.
For design events, intensity-frequency-duration (IFD) data for the study area was used for storm durations of 30 minutes, to 12 hours. Temporal patterns for all storm durations were generated by RAFTS in accordance with methods described in AR&R (1987).
A check of the IFD parameters was undertaken using the online BoM tool (http://www.bom.gov.au/cgi-bin/hydro/has/CDIRSWebBasic). The table below shows that the parameters used in the study area a close match for those provided by the BoM tool, with differences likely due to the selection of slightly different points for sampling.
<table>
<tr><td rowspan="2">Source</td><td colspan="3">1-hour Duration Intensity (mm)</td></tr>
<tr><td>20% AEP</td><td>5% AEP</td><td>1% AEP</td></tr>
<tr><td>2017 Study</td><td>51.5</td><td>71.0</td><td>93.5</td></tr>
<tr><td>BoM IFD Tool</td><td>51.3</td><td>70.9</td><td>93.3</td></tr>
</table>
</td></tr>
</table>

4.1.2 Calibration / Validation

Due to the lack of streamflow gauges in the catchment, it was not possible to calibrate the RAFTS model to discharge estimates. A validation exercise was undertaken by comparing the RAFTS flows with peak flow estimates calculated using the Probabilistic Rational Method (PRM).

The assessment found that PRM peak flows were typically within 10% of the peak RAFTS flows.

Further validation was undertaken through comparison of the hydraulic model results with observed flood levels.

4.1.3 Outcomes of Hydrological Model Review

The hydrological model developed for the catchment utilised appropriate parameters and methodologies and is suitable for defining the hydrology of the study area.

Some minor changes may be warranted to ensure sub-catchment boundaries and impervious fractions are representative of current conditions, but no major revisions are required.

4.2 Hydraulic Model

4.2.1 Model Setup

The Merimbula Lake and Back Lake Flood Study was developed using a hydrological (XP-RAFTS) and hydrodynamic model (Delft 3D) only. No hydraulic model was deemed necessary at the time of the flood study for the purpose of assessing flood risk. This is primarily due to the following reasons:

- The primary flood risk mechanism is flood from the lakes' foreshores.
- The tributary creeks to the lakes were able to be represented in the Delft 3D model sufficiently to address the flood risk identified. The upper reaches of the tributaries are primarily located within bushland or remote farming land and no overland flow was assessed.

The details of the hydraulic model schematisation and summarised and discussed in **Table 4-2**.

Table 4-2 Delft3D Setup Parameters

Data	Comment
Survey	Terrain was sourced from 1m LiDAR, collected in 2013. The bathymetry was drawn from the Merimbula & Pambula Hydrodynamic Survey, collected in 2003. Further data was available for the entrance, with photogrammetry from 1962, 1972, 1975, 1979, 1989, 2001, 2007 and 2011.
Structures	Structure survey and design information was utilised for the inclusion in the model of: • Market Street Bridge over Merimbula Lake; and, • The Millingandi Deviation from Shand's Corner to the caravan park.
Hydrologic Inputs	Inflow hydrographs were taken directly from the RAFTS model and applied at sub-catchment outlets in the hydraulic model, with routing undertaken by the hydrodynamic model.
Downstream Boundary	The offshore boundaries of the hydrodynamic model are driven by recorded tide at Eden. Due to the apparent "bumpiness" of the recorded tide signal, a low-pass filter was applied to the data with a cut-off frequency of 3 hours. This process was undertaken to provide a smooth tidal signal to the boundary, preventing boundary driven hydrodynamic instabilities. The offshore boundaries of the coupled wave model were driven by Eden Wave Rider Buoy (WRB) data. The Eden WRB only had recorded directional wave data from December 2011 onwards. For the calibration and validation exercise, where offshore wave directions were required for period pre-December 2011, additional offshore wave data was obtained from the global/regional NSW WaveWatch III.
Model Processes	Delft3D offers a number of processes that can be turned on or off during model runs, depending on the type of model and the desired outputs. The Flood Study model has many of these processes turned on, namely: • Sediment transport across the whole model; • Two-way coupled waves; • Rainfall across the whole model; • A three level nested grid; and, • A substantial model area (20km up and down the coast and 15km inland). While these processes have resulted in a robust flood model, the result is that design events take 7 to 20 days to complete a single run. While not a significant issue for the Flood Study, having a run time of this magnitude when running numerous flood mitigation options is a concern. This is discussed further in **Section 4.2.4**.

4.2.2 Calibration / Validation

The hydrodynamic model was calibrated to two historical events, from 2010 and 2011. A third event from 1998 was used to validate the model. Historical lake levels were sourced from MHL water level gauges located in Merimbula Lake and Back Lake.

The Delft3D model showed a reasonably good match to these levels. Results were particularly good for the high tide peaks, while for the low tide troughs, the Delft3D model generally predicted higher levels than observed.

Overall, the calibration and validation were considered reasonable, and the model was deemed suitable for use in the design runs.

4.2.3 Design Runs

Modelling was undertaken for the 20%, 10%, 5%, 2%, 1% and 0.5% AEP events and the PMF event, for durations of 30 minutes to 12 hours.

4.2.4 Outcomes of the Hydrodynamic Model Review

The Delft3D model developed for the Flood Study was found to be largely suitable for use in the Floodplain Risk Management Study.

The only concern with the model is the significant run times associated with the range of processes included and spatial extent of the model. A single design run takes between 7 and 20 days with the current model setup, depending on the duration of the simulation and computing infrastructure used. While the inclusion of these processes provided Council with a robust assessment of flood behaviour for the Flood Study (2017), The FRMS requires the assessment of numerous management and mitigation strategies and therefore the long run time is problematic.

A model optimisation exercise was undertaken that considered the importance of the various processes applied in the Flood Study model and the overall model extent, with the objective of decreasing the run times. The following was considered as part of the model optimisation:

- **Sediment transport**: Within the Flood Study model, sediment transport is turned on across the full study area. The key area of interest with regard to sediment transport is the Lake entrances. In fact, the sediment availability layer in the existing model only allows for morphological changes of the bed to occur around the entrances to Merimbula Lake and Back Lake. This process is more critical at Back Lake, being an Intermittently Open and Closed Lagoon (ICOLL). Review of the Flood Study results at Merimbula Lake entrance indicate that for lower ARI (i.e. lower volume) events, minimal morphological change occurs. It is proposed to deactivate sediment transport processes when assessing management options for lower ARIs that do not impact on Back Lake.
- **Rainfall on the Grid:** The Flood Study model setup applies spatially varying meteorological inputs (rainfall and evaporation) across all model grids. This includes vast areas of the upper catchment, to elevations above 150m AHD, that extend many kilometres upstream of the RAFTS catchment flow inputs to the Delft3D model, potentially double counting the rainfall inputs to the Lake tributaries. However, on closer inspection of the available result files very little catchment flow is generated within the Delft3D model making the inclusion of these upper catchment areas redundant with regard to flooding in the Lake basins.
- **Wave setup**: The current model incorporates a wave setup process that is calculated through two-way coupling of a spectral wave model that propagates offshore waves to the lake entrances and

coastline along the study area. Wave setup is a key process in establishing tailwater conditions at the Lake entrances and should be incorporated, however, the spatial extent over which this is calculated is unnecessarily large. For example, the existing model is calculating wave setup within Two-fold Bay, some 22km south of Merimbula.

- **Model extent**: The model currently extends approximately 20km both up and down the coast from Merimbula and 15km inland over the upper catchment. It is unclear why such a large model extent, albeit at lower resolutions than used over the Lakes, was established. However, for the purposes of options assessment in the Merimbula and Back Lake catchments, a more targeted model extent that covers the immediate offshore area and catchment tributaries (up to the RAFTS input locations) surrounding the lake entrances can be adopted.
- **Model duration**: The existing Flood Study model has been set up to run for a period of three days before the design storm event so as to allow the hydrodynamic and wave models to reach a dynamic equilibrium with the boundary conditions over such a large model domain. By reducing the model extent, the model durations can be substantially reduced to hours instead of days, translating to a marked reduction in model run time.

Following the review of the Flood Study model, changes have been made to the model set-up to optimise its use for this FRMS (see **Section 7.2**). These modifications were undertaken for the purpose of reducing model run times to allow an efficient assessment of mitigation options. As discussed in **Section 7.2**, the revised model results were compared against the previous flood results to ensure that no major changes to flood behaviour occurred as a result of the model optimisation.

5 Consultation

5.1 Consultation Strategy

The consultation strategy outlined in **Table 5-1** describes the approach to consultation in accordance with the IAP2 framework and the requirements of the NSW Government's Floodplain Development Manual (2005).

Table 5-1 Consultation Strategy Outline

IAP2 Engagement Strategy Guide	Merimbula Lake and Back Lake FRMS
Context ***The internal and external drivers, pressures and other background information that is of relevance to the consultation strategy, and in particular how these may influence how the community receives and responds to the consultation program.***	The context of the consultation will be defined by the following: • Floodplain Development Manual and Australian Emergency Management Handbook 7 • Council's policies. • Flood behaviour (e.g. lake levels, riverine flooding and overland flow and the coincidence of these). • Past flooding experiences and local, regional and national media on flooding. • Council and SES's contact with flood impacted residents following previous flood events. • Consultation undertaken as part of the Flood Study (it is important to build on this rather than just repeat or supersede it).
Scope ***The scoping statements are based on the project context and articulate why the consultation is being undertaken for this project, what the desired outcomes would be, and what the limitations of the engagement are.***	The scope of the consultation strategy is to engage with stakeholders and the community to better understand the flood risks within the study area, to identify preferred methods of floodplain management and to develop community understanding and ownership of the study outcomes.
Stakeholders ***This section provides an overview of the different categories of stakeholders, and their relative level of interest, influence and impact.*** ***This process is useful in identifying the level of engagement under the IAP2 Consultation Spectrum that may be suitable for different types of stakeholders.***	A stakeholder matrix has been provided below this strategy. This has informed the selection of appropriate consultation methods.
Purpose ***The purpose relates to the purpose of the consultation not the overall project.*** ***Stakeholders will be linked to each purpose and the goals within each purpose for each stakeholder will be identified.***	The purpose of the consultation is to: ▪ Inform the community and stakeholders of the study; ▪ Gain an understanding of the community and stakeholders' concerns relating to flooding in the study area; ▪ Seek input from the community on management options. ▪ Gather information from the community by participation; ▪ Obtain feedback on the Draft Floodplain Risk Management Study and Plan; and ▪ Develop and maintain community confidence and collaboration with the study results.

IAP2 Engagement Strategy Guide	Merimbula Lake and Back Lake FRMS
Methods	The engagement methods selected for this study, along with the associated engagement goals, are outlined in Table 5-3.

5.1.1 Stakeholder Matrix

It is important to ensure that all those who need to be involved in the floodplain management (i.e. those with responsibility for managing flood risk and those with a vested interest in its management, such as property owners) are kept informed and invited to contribute to the process to establish a common understanding of flood risk and how decisions are made.

Stakeholders may tend to make judgements about risk based solely on their own perceptions. These perceptions can vary due to differences in values, needs, assumptions, concepts, concerns and degrees of knowledge. Stakeholders' views can have a significant impact on the decisions made, so it is important that differences in their perceptions of risk be identified, recorded and addressed.

A stakeholder matrix has been developed for the project to provide an overview of the different categories of stakeholders, and their relative level of interest, influence and impact on the Flood Study. Each stakeholder has been assigned a recommended type of consultation based on the IAP2 consultation spectrum, conceptualised in **Figure 5-1**.

Figure 5-1 IAP2's Public Participation Spectrum

Table 5-2 Stakeholder Matrix

Stakeholder	Level of Impact	Level of Interest	Level of Influence	Recommended Type of Consultation
Impacted Agency Stakeholders				
Bega Valley Shire Council	High	High	High	Empower
Department of Planning, Industry and Environment (DPIE)	High	High	High	Empower
Floodplain Risk Management Focus Group	High	High	High	Collaborate
State Emergency Service	High	High	Moderate	Collaborate
Roads and Maritime Service	High	High	Moderate	Collaborate
Airport Lessee	High	High	Low	Consult
Impacted Infrastructure Service Providers (to be confirmed by Council)	High	Moderate	Moderate	Collaborate
Interested Agency Stakeholders				
Technical Officers at Council	Moderate	Moderate	Moderate	Involve
Water NSW	Low	Low	Low	Inform
MHL	Low	Low	Low	Inform
Bureau of Meteorology	Low	Low	Low	Inform
NSW DPI – Crown Lands	Moderate	Moderate	Low	Consult

Stakeholder	Level of Impact	Level of Interest	Level of Influence	Recommended Type of Consultation
Emergency services	Moderate	Moderate	Moderate	Consult
South East Local Land Services	Low	Low	Low	Inform
Impacted Community Stakeholders				
Flood affected property owners	High	High	Low	Consult
Flood affected residents	High	High	Low	Consult
Flood affected business owners	High	High	Low	Consult
Residents and owners of properties not affected by flooding but within the study area (e.g. impacted by flood access)	Moderate	Moderate	Low	Consult
Users of the area (e.g. impacted by flood access)	Moderate	Low	Low	Consult
Berrambool Sports Ground	Low	Moderate	Low	Consult
Sapphire Valley Caravan Park	High	High	Low	Consult
Acacia Ponds Village	High	High	Low	Consult
Interested Community Stakeholders				
Merimbula Chamber of Commerce	Low	Moderate	Low	Consult
Merimbula-Imlay Historical Society	Low	Low	Low	Inform
Sapphire Coast Tourism Limited	Low	Low	Low	Inform
Wider community	Low	Low	Low	Consult

5.1.2 Engagement Methods Selection

Based on the objectives of the consultation (identified in the consultation strategy outline), the level of consultation identified for each of the stakeholders (in the preliminary stakeholder matrix), and discussions with Council, engagement methods were selected. A summary of the engagement methods and the key goals of each method are provided in **Table 5-3**.

Table 5-3 Engagement Methods Selection

Method	Stakeholders	Goals	Timing	Responsibility / Details
Media and social media updates.	▪ All stakeholders. ▪ Wider community.	▪ To inform stakeholders of the study. ▪ To increase later engagement with survey and feedback on draft documents. ▪ To capture stakeholders (e.g. visitors and users of the area) not targeted by other consultation methods.	Project inception. Prior to newsletter and survey release, and drop-in sessions. Prior to and during public exhibition.	Council uses their own website, local media and social media to engage with the community. Rhelm has assisted Council in the preparation of media updates for this purpose. A summary of the media updates released during the project is provided in **Section 5.3**.
Letter / email of introduction to the study and follow up phone call.	▪ All agency stakeholders. ▪ Community groups.	▪ To inform stakeholders of the study. ▪ To identify any additional relevant documents or data sets to be included in the data analysis and review. ▪ To establish a stakeholder mailing list for ongoing project email updates.	Project inception.	Rhelm has contacted the relevant agency and community stakeholders (outlined in **Table 5-2**) to inform them of the purpose of the study and how they can provide input. The outcomes of the agency engagement are outlined in **Section 5.2**.
Project Website	▪ Public	▪ To inform the public of the study. ▪ To provide additional information to interested stakeholders and community. ▪ To provide information of how stakeholders can provide input.	Duration of project.	Council has utilised its own website to provide a project webpage. They have also used their 'Have Your Say website for the purposes on community engagement during Stage 1 and the Public Exhibition period. Rhelm has assisted with providing the content for the webpages. Details on the website are outlined in **Section 5.3**.

Method	Stakeholders	Goals	Timing	Responsibility / Details
Community information brochure and questionnaire	▪ All flood impacted landowners, business owners and residents. ▪ Wider community	▪ Inform. ▪ Gain interest and improve likelihood of participation during the public exhibition period. ▪ Obtain input of floodplain risk management options. ▪ To establish a stakeholder mailing list for ongoing project email updates.	Data collection and Review (initial project stages)	A newsletter was prepared that provided information about the study. This was sent to all properties within the catchment. The newsletter was also available on Council's website. An online survey was made available to collect information on what the community perceived as the key flood risks and how they would like to see them managed. The responses provided are summarised in **Section 5.4**.
Public Information Session 1	▪ Impacted Community Stakeholders. ▪ Interested Community Stakeholders.	▪ Provide an overview of the study purpose, methodology and aims. ▪ Obtain input on potential floodplain risk management options. ▪ Increase engagement with survey. ▪ Gain interest and improve likelihood of participation during the public exhibition period. ▪ To establish a stakeholder mailing list for ongoing project email updates.	Data collection and Review (initial project stages)	The sessions were formatted to allow attendees to drop in at any time during the session and have a one on one chat with the project team. These discussions were facilitated by posters showing each of the catchments (and key features). Attendees were encouraged to mark up the posters with suggested floodplain risk management options, or key flooding concerns. The project team also did this on their behalf, if needed. Copies of the community questionnaire were provided in paper and on iPads. However, none were completed by attendees. The information sessions were held on consecutive days at the same location. A summary of the drop in sessions and the information provided by the community is outlined in **Section 5.6.1**.
Targeted Stakeholder Meetings	▪ Agency and / or community groups	▪ Discuss specific issues or opportunities for flood risk management	Following preliminary identification of options (or can be undertaken following	Key stakeholders were identified through the agency mail out and community consultation. These stakeholders included both individuals and groups who have particular concerns regarding flooding to be addressed or have responsibilities for locations

Method	Stakeholders	Goals	Timing	Responsibility / Details
			modelling of options)	where potential flood risk management options have been identified. One on one meetings were undertaken with these stakeholders during the early stages of the project. Details of these meetings are provided in **Section 5.2**.
Options Workshop	▪ Risk Management Focus Group	▪ Present the outcomes of the community information session and questionnaire. ▪ Identify a preferred set of management options for further analysis.	Following preliminary identification of options (or can be undertaken following modelling of options)	An informal workshop will be undertaken to present: • The initial options presented to the community (and how they were identified). • The scope and outcomes of the community consultation. The full list of potential options will then be workshopped with the attendees to identify the preferred set of options for detailed analysis. This will include flood modification option modelling and development of planning and emergency response options.
Public Exhibition Period	▪ All stakeholders	▪ Provide an opportunity for feedback on the Draft Study.	Following completion of the Draft Study.	The draft document was placed on public exhibition for a period of 4 weeks. During the public exhibition period the document was placed online, an online survey was made available through Council's "Have Your Say", and two community drop in sessions were held. The outcomes of the exhibition period are provided in Section **Section 5.7**. Due to COVID restrictions engagement during the public exhibition period will be online only.

5.2 Agency Consultation

In accordance with the stakeholder matrix provided in **Section 5.1.1**, a number of agencies have been contacted to provide input to the study. This input may be data, feedback or information regarding related projects or plans within the study area.

The agency consultation is summarised in Table 5-4.

Table 5-4 Agency Consultation

Agency	Outcomes of Consultation
Bega Valley Shire Council	Council *Civil Asset Superintendent* is the project manager for the FRMS. He provides ongoing input throughout the project duration, including document review at key project stages. Council *Strategic Planning Co-ordinator* has provided input to the project through his attendance at the Committee Meetings. Council *Communications Manager* has provided input to the engagement strategy and the engagement materials produced.
Floodplain Risk Management Focus Group	The meeting details are provided in **Section 5.5**.
State Emergency Services	The SES local controller attended the project inception meeting to gain an understanding of the project scope and provide input as to the key flood related issues for SES. A local SES member and the Deputy Region Controller attended the Committee Meetings in February and October 2019. They provide input on local response management issues and regional planning matters and requirements for the project outputs to assist SES in their operations. A workshop with local and regional SES representatives was held on 1 May to evaluate any access issues associated with the flooding of roads (discussed in **Section 8.5**) and identify potential emergency response management measures (details of these measures are provided in **Section 9.2**). The draft FRMS was reviewed by both the local SES member and the Deputy Region Controller.
Transport for NSW	TfNSW advised that there are works proposed on Princes Highway at Green Point Road to provide for a left turning lane. There may be opportunities to incorporate entrance upgrades at Acacia Ponds Village (i.e. to allow for flood free access to the village) with the Princes Highway upgrade.
Marine Rescue Merimbula	During the community engagement as part of the flood study (2017) it was identified that there could be impacts on boat launching operations due to the boat ramp being inundation during a flood event. Additional engagement with Marine Rescue was undertaken in April and May 2020 and their representative advised that the recue vessels are housed on airberth on a floating pontoon next to the Marine Rescue Base off Spencer Park. They further advised that Marine Rescue do not use the boat ramp and would only use it to trailer their smaller vessel if needed outside of the local area.

Agency	Outcomes of Consultation
Merimbula Chamber of Commerce	The president of the Merimbula Chamber of Commerce met with Rhelm's project manager on 3 June 2019. She provided information on the possible impacts of flooding on commercial properties and the desire to incorporate flood management options into any urban design and master planning for the area.
Sapphire Valley Caravan Park	The caravan park owner met with Rhelm's project manager and undertook a walkover of the banks of Merimbula Creek downstream of the site. He had observed flooding conditions to be worsened by the presence of dense vegetation along the creek banks and fallen trees within the channel. Black Wattle was considered to be the main cause of issues.
Acacia Ponds Village	The front desk was visited in person by Council, DPIE and Rhelm during site inspections. They provided access to the grounds for site inspections, however, the manager had only been there for a few weeks and did not have any flood related information to provide to the study. A follow up meeting was held with the park manager on the 3 June 2019. Flood risk issues such as those associated with access during a flood event were discussed. Photos of past flooding were provided for use in the study. It was noted that the site was flooded in 2015 as a result of an east coast low, but no structures were impacted.
Resident at Green Point Road	Following his visit to the drop in sessions in December 2018, Rhelm's project manager met with a resident at Green Point Road to discuss the validation of flood mapping from the Flood Study, and flooding of Green Point Road at the low points, not currently identified in the flood study.

5.3 Website and Media

A webpage was created as part of Council's website in November 2018. The webpage contains information relating to the study, its context and purpose. The webpage is updated at key project milestones.

The community newsletter was available for download through the webpage, and access to the online survey was also available in December 2018.

The community has been informed of key project updates and how they can be involved in the study through media releases. The media releases are summarised in **Table 5-5** and provided in **Appendix A**.

Table 5-5 Summmary of Media Releases

Date	Content
20 November 2018	Advise the community of the study, how it relates to the Flood Study and how they can provide input and get information.
4 November 2020	Advise the community that the study is nearing completion, and to invite feedback on the draft Floodplain Risk Management Study and Plan documents.

5.4 Community Newsletter and Survey

Information of the project was sent out to residents and property owners within the study area, this same information was also available on Council's Have Your Say website where an online feedback survey could be completed. Feedback closed on 16 December 2018.

A copy of the community information and survey are provided in **Appendix A**.

The newsletter was mailed to approximately 207 properties. One submission was received via mail and eight surveys were completed online. This is a low response rate (4.3%). However, this could be due to a number of factors including:

- The Flood Study engagement (drop-in sessions, newsletters, surveys and public exhibition) was undertaken relatively recently and engagement was fairly high. The community may not feel the need to revisit the same issues already discussed as part of the Flood Study engagement.
- Approximately ten people attended the drop-in sessions in December 2018. These attendees may not have felt the need to also provide a survey response. If these attendees are included as respondents, then the return rate is 9.7%.
- The mail out to residents only included the project information and directed the community to complete the survey online. The community may prefer to complete the survey on paper and mail it. This will be considered for engagement undertaken in the future studies.

The submissions that were received identified that

- The respondents were generally aware of flooding issues within the study area
- Flooding had impacted roads, access, property and assets in the past
- Information on road closures was the most common information that respondents were looking for during a flood
- Respondents used a variety of sources to get flood updates and information including websites, radio, television, social media and word of mouth.

Some of the flooding issues that were identified are summarised in **Table 5-6.**

Respondents had suggestions on how they would like Council to manage flooding. These are summarised in **Table 5-7**.

Table 5-6 Flood Issues Identified by the Community

Flood Issue	Implication for FRMS
Each year Boggy Creek Rd tends to have water over it.	The flood study did not undertake full 2D modelling of the culverts at this location. 1D model testing at this location identified that the depth of over

Flood Issue	Implication for FRMS
	topping of the Highway is not significant, even under blocked conditions. An assessment was undertaken which showed that the highway remains flood free in the 1% AEP event (refer Section 7.5).
Berrambool sports field can be covered with water from the Merimbula Creek.	The Flood Study results concur with this observation. An option to undertake vegetation management works within Merimbula Creek was assessed. The option found that the works would not provide any benefits to the sports fields (refer Section 9.1.1).
We have owned our property for eight years and twice in that time we have been unable to get home due to flooding of Green Point Road. The culvert on Green Point road, approx.100m east of the highway at Millingandi is subject to flooding. This road is access road to 8 properties.	A site inspection was undertaken of this location following receipt of this submission and again in June 2019. Survey of the culvert and adjoining flow paths was collected. An option to raise Green Point Road and upgrade the existing culverts was assessed. The option developed a design for 1% AEP flood immunity, and this option has been incorporated in the MCA assessment (refer Section 9.1.1).
My concerns are the increased opening of the back lake at short point when there has been heavy rainfall and the Berrambool soccer ovals get slightly soggy around the edges. It should not be opened unless there is a major rain event. As we are on high ground, the present situation with the opening of the entrance after heavy rain suits us fine.	There is a current entrance policy that Council follows as part of opening of Back Lake. This policy considers flood risk as well as the environmental implications of opening the lake manually. A review of the entrance management policy for Back Lake was undertaken as part of this study (refer Section 9.1.2.4). The assessment found that the existing entrance management policy was effective at reducing peak flood levels. An alternative, proactive, strategy has also been formulated that would see the berm crest maintained at 2mAHD.
The flooding has continued to cause erosion of our property (on Henwood Street). The erosion is getting closer to the house and destroying the backyard.	Erosion management is not a specific objective of this Floodplain Risk Management Plan. However, the appropriate Council staff have been advised of the erosion issue and will investigate options for managing the erosion.

Table 5-7 Flood Management Strategies Suggested by the Community

Flood Management Strategy	Implication for FRMS
Constructed wetlands will take up much of the flooding and then filter through natural plant uptake.	Opportunities for wetlands were considered as part of identifying floodplain management options.

Flood Management Strategy	Implication for FRMS
	However, no additional wetland areas could be identified to provide for flood management works.
The culvert on Green Point road requires lifting with larger pipes which will allow the water to go under the road instead of over the road which would reduce gravel wash from the road into the lake.	A site inspection was undertaken of this location following receipt of this submission and again in June 2019. Survey of the culvert and adjoining flow paths was collected. An option to raise Green Point Road and upgrade the existing culverts was assessed. The option developed a design for 1% AEP flood immunity, and this option has been incorporated in the MCA assessment (refer Section 9.1.1). It is noted that region of the road requiring works is a Crown Road.
Raise Green Point Road by at least 2 metres with decent pipes or small bridge.	
The area around Merimbula Creek could be widened and deepened to allow the flood water to escape easier. The lake at Back Lake entrance to the ocean at near Short Point could be opened regularly to allow the water to escape to the ocean.	Back Lake entrance management was considered in identifying floodplain management options. A review of the entrance management policy for Back Lake was undertaken as part of this study (refer Section 9.1.2.4). The assessment found that the existing entrance management policy was effective at reducing peak flood levels. An alternative, proactive, strategy has also been formulated that would see the berm crest maintained at 2mAHD.
Opening of Back Lake at short point should only take place when there has been a major rain fall event and is required. That would allow the Merimbula creek to have a proper clean out. If it is opened when there has just been heavy rain it does not getting a proper clean.	
The Merimbula Creek and Back Lake could be regularly cleaned. Woolworths trolleys removed. Tin roofs from the tornado in the early 90's are still in Back Lake.	An option to undertake management works within Merimbula Creek was assessed. The option found that the he works would not provide any benefits with respect to flooding (refer Section 9.1.1). It is noted that the option made provide environmental or aesthetic benefits which are outside the scope of this assessment.
Construction of a retaining wall along Merimbula Creek bank to protect Henwood Street properties from erosion.	Erosion management is not a specific objective of this Floodplain Risk Management Plan. However, the appropriate Council staff have been advised of the erosion issue and will investigate options for managing the erosion. Estuary management plans are undertaken by Council concurrently with this Flood Study to focus on estuarine health issues such as water quality, erosion and sedimentation.

5.5 Risk Management Focus Group

The Focus Group is a requirement of the floodplain risk management process and is both the focus of, and a forum for, the discussion of technical, social, economic and ecological issues and for the distillation of possible differing viewpoints on these issues into management plans. The Focus Group comprises community representatives, councillor representatives, Council staff and State agency representation.

Also, a technical sub-committee comprising the following members deals with technical issues related to flood risk management ahead of Focus Group meetings:

- Bega Valley Shire Council – 5 staff
- Council's nominated consultant
- Department of Planning, Industry and Environment (DPIE) – 2
- South East Local Land Services (South East LLS) – 1
- State Emergency Services – 1
- The Bureau of Meteorology – 1

There are also vacancies within the sub-committee for representatives from the Bureau of Meteorology and Local Land Services.

This FRMS has been an agenda item at the focus group and technical sub-committee meetings, as outlined in **Table** 5-8**.**

Table 5-8 Risk Management Focus Group Meetings

Meeting	Purpose
Technical Sub-Committee Meeting **17 October 2018**	Project inception meeting: introduction to the Rhelm project team, overview of project scope, optional additional tasks, key project issues and proposed project timing. The meeting was followed by a half day site inspection of key locations across the study area.
Focus Group Meeting: **22 February 2019**	Project update: as this was the first focus group meeting since project inception the discussion involved an overview of the project purpose, its relationship to the Flood Study (2017), the outcomes of the community engagement and key issues identified by the focus group members.
Technical Sub-Committee Meeting **29 July 2019**	Project update to discuss the property survey, flood damages assessment, and climate change flood modelling.
Focus Group Meeting **15 October 2019**	Project update: the outcomes of the Stage 1 report were presented along with the key Stage 2 tasks that were completed to date.
Focus Group Meeting **26 March 2020**	Project update: presented and received feedback on the preliminary options and the detailed assessments to be undertaken.
Technical Sub-Committee Meeting **24 September 2020**	Gather final comments on the draft documents prior to public exhibition.
Focus Group Meeting **9 October 2020**	Discuss program for community engagement during the public exhibition period.

5.6 Community Drop-in Information Sessions

5.6.1 Project Inception Sessions

Two community drop-in sessions were held at the Merimbula Regional Learning Centre on the 6th and 7th of December 2018. The sessions were facilitated by a representative from Council, DPIE and Rhelm. The sessions were formatted to allow the community to drop in at any time during the 3 hour session and discuss the project and local flooding issues with the project team. Flood maps from the Flood Study (2017) were printed at A1 to allow the community to mark up locations of interest and known flooding issues.

The sessions were attended by approximately ten community members. The community were interested in understanding the purpose and scope of the project and also provided the input summarised in **Table 5-9**.

Table 5-9 Issues Raised at Community Drop-In Sessions December 2018

Community Issue	Implications for FRMS
Erosion of Henwood Street (near number 7): 140cm over 20 years. Number 3 Henwood Street put in rock protection about 10 years ago.	Erosion management is not a specific objective of this Floodplain Risk Management Plan. However, the appropriate Council staff have been advised of the erosion issue and will investigate options for managing the erosion. Estuary management plans are undertaken by Council concurrently with this Flood Study to focus on estuarine health issues such as water quality, erosion and sedimentation.
Underground car park excavation in Fishpen area: observed tidal impacts	Noted
Opening of Back Lake under the revised opening policy seems to have reduced flood levels.	A review of the entrance management policy for Back Lake was undertaken as part of this study (refer Section 9.1.2.4). The assessment found that the existing entrance management policy was effective at reducing peak flood levels. An alternative, proactive, strategy has also been formulated that would see the berm crest maintained at 2mAHD.
Natural flushing of Back Lake seems less	This may allude to increased sedimentation which could impact flooding. An option examined the impact of the removal of sediment throughout the creek and lagoon to assess the impacts on flood levels (refer Section 9.1.1). The assessment found that the removal of sediment had no impact on the peak flood levels within the system.
About 10 years ago sediment was being washed into the lagoon from the Mirador Drive development.	

Community Issue	Implications for FRMS
The channel at the Market Street Bridge used to be along the southern bank (see deep section still visible). Opening this channel again and allowing it to run along the Fishpen foreshore would increase flushing and might reduce flooding.	Options were assessed that included a second bridge along the Market Street causeway, a fully open bridge, and a channel along the Fishpen foreshore (refer Section 9.1.1). The results indicated that none of the assessed options were successful at reducing peak flood levels within the lake and no cost / benefit analysis was undertaken as a result.
There is a location of flooding on Green Point Road from catchment flows.	A site inspection was undertaken of the Green Point Road location. Survey of the culvert and adjoining flow paths was collected. An option to raise Green Point Road and upgrade the existing culverts was assessed. The option developed a design for 1% AEP flood immunity, and this option has been incorporated in the MCA assessment (refer Section 9.1.1).
The surface of Green Point Road is significantly impacted by rainfall and local flows because there is no camber to the road (i.e. road survey become channelised and washes into the Lake).	
No flooding has been observed between the dam at the end of Green Point Road and Merimbula Lake.	
Numerous sensitive and rare species exist in Merimbula Lake.	Any structural options or modifications to flow patterns would need to consider the ecological impacts (refer Section 9.4).

5.7 Public Exhibition

Following the preparation of the draft Floodplain Risk Management Study the report was placed on Public Exhibition to allow the community and other stakeholders to review and comment on the report prior to it being finalised and adopted by Council.

The public exhibition period was undertaken from 31 October 2020 to 29 November 2020. During the public exhibition period:

- The reports were made available on Council's website;
- A community survey was hosted on Council's "Have Your Say" page to collect feedback from the community; and,
- Two community workshops were held to discuss the study with the community on:
    - Session 1: Tuesday 10 November from 12.30pm to 2.30pm; and,
    - Session 2: Wednesday 11 November from 2.30pm to 4.30pm,

Over the course of the public exhibition period, Council received:

- 5 survey response via "Have Your Say";
- 2 email responses to Council's project manager; and,
- Approximately 24 attendees across the two workshops.

The responses received and comments provided at the sessions are summarised in **Table 5-10**.

Table 5-10 Community Responses from Public Exhibition Period

Source	Comment	Action Undertaken
Email	Issue with completing the survey due to broken links	Links corrected and no further issues recorded during exhibition.
	The Study does not seem to take into account the dam that is the Princess Highway southern road approach to the Millingandi Bridge.	The road embankment and the cross drainage have been incorporated into the model. Model results show that ponding does occur upstream of the highway due to the embankment and culvert capacity. Overtopping of the highway was observed to occur in extreme events, as well as in the 2100 climate change scenario.
	The whole study seems to avoid any consideration of silt entering the Lakes and specifically its impact on the oyster industry.	The investigation of any siltation occurring within the lakes, and its consequent impacts, was not the focus of this study, which was to identify and address flood risk. Council is considering other estuary issues such as siltation as part of its estuary management program.
Survey	Back Lake silt build up needs attention.	As discussed above, the assessment of siltation and its impacts was beyond the scope of the study.
Discussion at Workshop	Overland flows down Sapphire Coast Drive have been noted to cause flooding of properties on Berrambool Drive.	The overland flow modelling undertaken as part of this study (refer Section 7.4) showed a local depression that runs through properties upstream of the intersection of Sapphire Coast Drive and Berrambool Drive. Council currently has a project in planning phase to modify the intersection. The overland flow modelling will be used to inform planning and assist in managing flows better.
	Flooding has been observed on Millingandi Road, just North-West of the model extent.	SES has been advised of this issue.
	Significant concern was raised regarding the sediment build up and aquatic weed growth in Merimbula Lake near Fish Pen.	Flood modelling found that sediment build up in the entrance and dredging of this sediment does not impact flood behaviour during large flood events, as the flows during a flood event are enough to scour the sediment. However, environmental and recreational impacts of the sedimentation in this area are being assessed by Council as part of the Estuary Management Program.

Discussion at Workshop	It looks like Fish Pen is cut of by flooding across the Market Street Bridge, and also across Arthur Kaine Drive (south of the airport).	The bridge and causeway are flood free in all events up to and including the PMF. The depths shown on the mapping are for flows under the bridge. A note has been added to the mapping to this effect. Access is lost along Market Street, between the bridge and Short Street and along Arthur Kaine Drive. An option has been added to raise Market Street and Arthur Kaine Drive (see Option RI-9 and RI-9).
	Fish Pen drainage works well. Any ponding of water during rainfall events appears to drain away quickly	Noted.
	2016 East Coast Low impacted Fish Pen but only with waves washing over the foreshore.	This confirms what the flood modelling showed.
	Several attendees supported the raising of Fish Pen Road.	Fish Pen Road option is recommended for implementation in the FRMP.
	Support for raising of Green Point Road option (RI-5).	This option has been recommended for implementation in the Risk Management Plan.
	Resident on Henwood Street said there had been no flooding of their property since the entrance management policy had been adopted by Council.	Noted.
	Back Lake water backs up onto the pedestrian track near the school.	This is reflected in the model results and mapping.
	An attendee was happy that the study was in place and that Council and SES had a proves to prepare for and respond to flooding.	Support noted.

6 Flood Planning Review

6.1 Purpose

Within the study area, development is largely controlled through the Bega Valley Local Environmental Plan 2013 (BVLEP 2013) and a series of Development Control Plans (DCP). The LEP is an environmental planning instrument (EPI) which designates land uses and development in the study area, while the DCPs regulate development with specific guidelines and parameters. There are also a number of EPIs and related planning documents that can affect the development of property within the study area. These may be in the form of State Environmental Planning Policies (SEPP) such as:

- SEPP Exempt and Complying Development Codes (2008),
- SEPP Educational Establishments and Child Care Facilities (2017),
- SEPP Infrastructure (2007)
- SEPP Housing for Seniors and People with a Disability (2004),
- SEPP Affordable Rental Housing (2009),
- SEPP 21 Caravan Parks,
- SEPP 65 Design Quality of Residential Apartment Development,
- SEPP Primary Production and Rural Development (2019),
- SEPP 33 Hazardous and Offensive Development,
- SEPP 36 Manufactured Home Estates,
- SEPP Coastal Management (2018),
- Other SEPPs as relevant to land use and/or development type, and
- Other Council plans, policies or other publications.

The review of SEPP provisions is relevant insofar as they relate to how they might inter-relate with local provisions are it is generally not possible for a SEPP to be modified as a recommendation of this review.

All relevant planning controls for individual land parcels are summarised in a Section 10.7 certificate (formerly a Section 149 certificate) issued under the Environmental Planning and Assessment Act, 1979.

A review of flood-related controls incorporated within the LEP, relevant DCPs, Council policies and plans has been completed. Recommendations for updates to improve the management of flood risk are provided in **Section 6.4**.

At the time of preparation of this report, the Department of Planning, Industry and Environment released a Draft Floodprone Land Package for comment (over the period May-June 2020). Reference is made here to the documents in this package as they relate directly to potential changes for any revision to existing environmental planning instruments (EPIs) and any new EPIs. This draft package has been referred to in this review (**Section 6.2.2**).

Additionally, at the time of preparation of this report, Eurobodalla Shire Council had recently adopted their Local Strategic Planning Statement (LSPS, adopted 24 June 2020). Reference is made to the relevant aspects of the Draft LSPS pertinent to flood risk management in **Section 6.2.3**.

This review does not specifically deal with matters related to building construction (such as the National Construction Code, which includes the Building Code of Australia, both of which are updated every three years by the Australian Building Codes Board). However, it is important to note that these types of controls are sometimes called or referenced in planning controls and therefore their content and direction are of relevance. In the regard, how they are applied is directed under the NSW Planning System via numerous mechanisms but primarily via Building System Circulars issued by the Department of Planning and Environment. The most relevant circular is BS 13-004, dated 16 July 2013 entitled *The NSW Planning System and the Building Code of Australia 2013: Construction of Buildings in Flood Hazard Areas*. Importantly the BCA deals with the concept of the 'defined flood event' (DFE) and imposes minimum a construction standard across Australia for specified building classifications 'flood hazard areas' (FHA) up to the DFE. These requirements will be referenced when developing appropriate recommendations for policy and planning approaches within the study area.

6.2 Existing Flood Planning Documents

6.2.1 Bega Valley Local Environmental Plan 2013

The Bega Valley Local Environmental Plan 2013 (BVLEP 2013) is a legal document that sets the direction for land use and development in the study area by providing controls and guidelines for development. It determines what can be built, where it can be built and what activities can occur on land.

The BVLEP 2013 is based on a standard format used by all Councils in NSW and can be viewed on the NSW legislation website (www.legislation.nsw.gov.au).

6.2.1.1 Flood Planning

The objectives for land at or below the flood planning level (100 Year ARI event plus 0.5m freeboard) are outlined in Clause 6.3 of the BVLEP. The objectives of this clause are:

- to minimise the flood risk to life and property associated with the use of land,
- to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change, and
- to avoid significant adverse impacts on flood behaviour and the environment.

The land to which this clause applies is that "at or below the flood planning level", which is defined under sub-clause (5) as the 1% AEP flood extent plus a 0.5 m freeboard.

It is stated that development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

- is compatible with the flood hazard of the land, and
- is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and
- incorporates appropriate measures to manage risk to life from flood, and
- is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and
- is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

The BVLEP also provides objectives and consent conditions for coastal risk planning in Clause 6.4. This clause could also apply to flooding within the Merimbula Lake and Back Lake study area that are impacted by coastal inundation. The objectives of this clause are:

- to avoid significant adverse impacts from coastal hazards,
- to ensure uses of land identified as coastal risk are compatible with the risks presented by coastal hazards,

- to enable the evacuation of land identified as coastal risk in an emergency,
- to avoid development that increases the severity of coastal hazards.

This clause applies to land in the coastal zone below the 3 mAHD contour, or land at or below the level of a 1:100 ARI coastal inundation event.

It is stated that development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

- is not likely to cause detrimental increases in coastal risks to other development or properties, and
- is not likely to alter coastal processes and the impacts of coastal hazards to the detriment of the environment, and
- incorporates appropriate measures to manage risk to life from coastal risks, and
- is likely to avoid or minimise adverse effects from the impact of coastal processes and the exposure to coastal hazards, particularly if the development is located seaward of the immediate hazard line, and
- provides for the relocation, modification or removal of the development to adapt to the impact of coastal processes and coastal hazards.

The above objectives and consent considerations are consistent with the LEP standard template.

6.2.1.2 Land Use Zones

The BVLEP defines the land-use zoning for the study area, thereby determining which type of development are allowable through the study area. The general land zoning for the study area is illustrated in **Figure 6-1**.

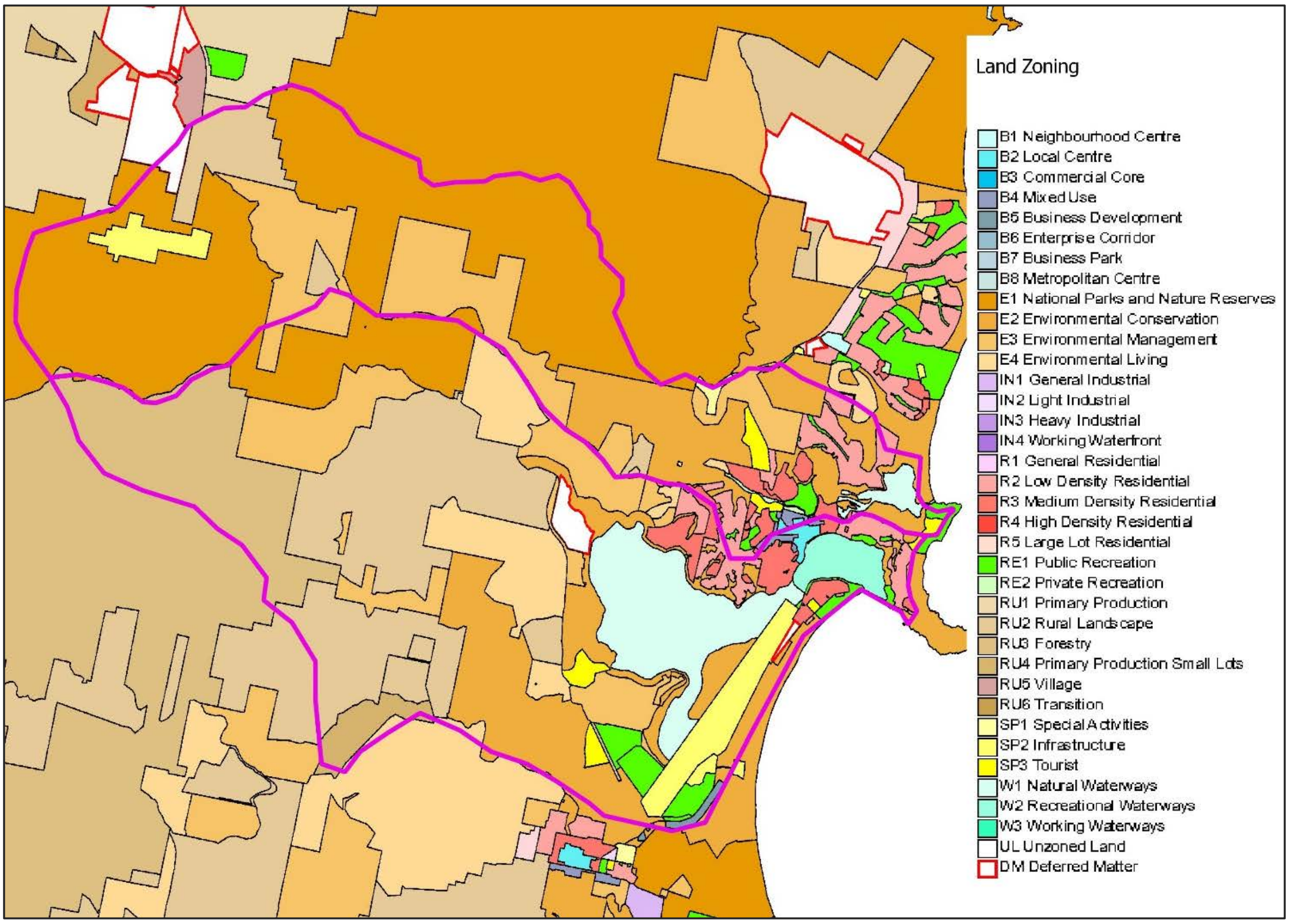


Figure 6-1 Bega Valley LEP 2013 Land Use Zones

6.2.1.3 Flood Mitigation Works

The BVLEP permits flood mitigation works in the following zones:

- RU1 Primary Production
- RU2 Rural Landscape
- SP3 Tourist
- RE1 Public Recreation
- RE2 Private Recreation
- E4 Environmental Living

All flood mitigation options assessed in **Section 9** are within these zones, with the exception of options to manage the entrance of Merimbula Lake. These options are within W1 (natural waterway).

6.2.1.4 Environmental Considerations

The BVLEP contains an Acid Sulphate Soils (ASS) Map, which shows Classes 1 to 5 ASS in the study area, primarily in and within the vicinity of Merimbula Lake and Back Lake. Clause 6.1 of the BVLEP specifies were and when development consent is required for the carrying out of works on land shown on the ASS Map, with the objective of the clause being to ensure that development does not disturb, expose or drain ASS and cause environmental damage.

The BVLEP also contains a Heritage Map, which shows items of state and local heritage significance as well as Aboriginal Places of Heritage Significance and heritage conservation areas throughout the LGA. Within the study area the Heritage Map shows several items of local heritage significance and one item of State significance. Consideration has been given to heritage items when considering the potential impacts of proposed works / options.

6.2.2 Draft Flood Prone Land Package

In May 2020 the Department of Planning, Industry and Environment released a Draft Flood Prone Land Package which contains a series of documents that seek to update the manner in which local planning is conducted for flood prone lands. In summary, the key relevant aspect for strategic planning is the consideration of three types of flood prone areas:

- Flood Planning Area (FPA), which has commonalities with the flood planning level concept in the ELEP and seeks to ensure development is compatible with flood risks within the FPA (noting that there are some circumstances where no development is compatible with flood risks)
- Special Flood Considerations (SFC), which seeks to control certain types of vulnerable and hazardous development within the floodplain in its entirety (i.e. potentially up to the extent of the Probable Maximum Flood)
- Regional Evacuation Consideration Area (RECA), which seeks to ensure lands which are indirectly affected by flood behaviour with respect to being unable to evacuate due to flooding in adjacent areas and becoming isolated.

Whilst only being a draft package, consideration of the potential application of the draft from a strategic planning perspective has been made as part of this study. **Map G601** and **Map G602** show the extent of a potential Flood Planning Area (FPA), **Section 6.3** provides more detail on the selection of the FPA. A Special Flood Consideration (SFC) area is also shown on these maps (which is the extent of the Probable Maximum Flood where it is greater than the 1%AEP plus 0.5 m).

6.2.3 Local Strategic Planning Statement

The Bega Valley Shire Local Strategic Planning Statements (LSPS, BVSC, 2020) is a strategic document, setting out a 20-year vision for land use planning in the Shire. It outlines how growth and change will be managed to ensure high levels of liveability, prosperity and environmental protection are achieved in the Bega Valley Shire.

The LSPS sets the direction for the revision of the LEP 2013 and the update of the DCP 2013.

With respect to flooding, the LSPS identifies the following actions:

- Identify gaps and/or limitations in flood and coastal hazards data and develop flood risk management plans to address identified gaps and/or limitations (ongoing)
- Complete Pambula / Yowaka Rivers Flood Study and Wolumla Creek Flood Study (short term)
- Develop adaptation and hazard response plans for communities subject to high natural hazards (medium term)
- Review planning controls for flood planning and sea level rise for new developments (medium term)

6.2.4 Bega Valley Development Control Plan 2013

A Development Control Plan (DCP) is prepared by Council and gives effect to the requirements of the LEP by specifying detailed development guidelines and controls.

The following sections of the existing DCP have relevance to floodplain management.

- Section 5.8.1 Flood Planning
- Section 5.8.5 Climate Change
- Section 6.1 Roads & Easements
- Section 6.3 Soil & Stormwater Management

6.2.5 Merimbula District Structure Report 2008

This report is a preliminary planning investigation of land use needs for the Merimbula District for the next 20 years. The Structure Report will be used to guide decisions and plans made by Council that affect the Merimbula district. It will also be used to inform private sector investment.

The Structure Report makes a series of rezoning recommendations to account for the increase in population and other objectives in the Structure Report. These zones were considered in the assessment of future cumulative development (refer **Section 8.6**).

The assessment found that possible future development had the potential to lead to increased local flows indicating a need to consider the local drainage network in any future development. However, possible future development was not found to impact peak flows or creek and / or lake water levels.

6.2.6 Community Land Generic Plan of Management 2010

Council manages an extensive network of public land, including Council owned “community land” and Crown owned public reserves. This generic plan of management provides a framework for how the cultural and recreational resources managed by Council such as the parks, natural areas, sporting fields and community/cultural facilities can be used by the public, while being sustainably managed for the future.

6.2.7 CBD Landscape Master Plan 2015

The Master Plan guides the development of the public spaces and landscapes in the Merimbula CBD for the next 10 - 20 years.

A review of the Landscape Master Plan suggested that the works proposed were largely aesthetic, with no major earthworks or structure changes that would alter flood behaviour. The exception was the Merimbula Bypass, which has been constructed, and has been assessed in Section 8.7.3. The assessment found that the bypass resulted in improved flood behaviour as a result of providing better conveyance through the CBD.

6.2.8 Australia Rainfall and Runoff

The ARR87 and ARR2019 guidelines are used to determine hydrologic and hydraulic processes across Australia. These guidelines will be used in the estimation of flood behaviour in various modelled design storm events.

The Flood Study (Cardno, 2017) was undertaken utilising the ARR87 guidelines, hence any additional flood modelling will need to be consistent with this version of the guidelines. With the release of the more robust and defensible ARR2019, it is also necessary to consider the impacts of the updated guidelines. A sensitivity analysis of the impacts of using the updated ARR2019 guidelines has been undertaken (refer **Section 7.3.1**). Given the outcomes of this analysis, it has been considered reasonable to utilise the Flood Study (Cardno 2017) results based on ARR87 in the Floodplain Risk Management Study.

6.3 Flood Planning Level and Flood Planning Area

The Flood Planning Area (FPA) is the area within development has the potential to impact flood behaviour or be impacted upon by flooding. Therefore, flood related development controls may apply to development proposed on properties that fall fully or partially within the FPA. All relevant planning controls for individual land parcels are summarised in a Section 10.7 certificate (formerly a Section 149 certificate) issued under the Environmental Planning and Assessment Act, 1979.

The FPA is usually defined as the area below the Flood Planning Level (FPL). The selection of an appropriate FPL for the study area is discussed in **Sections 6.3.3 and 6.3.5** for mainstream and overland flow respectively. This discussion also investigates the appropriateness of defining the FPA through the application of the FPL, or other options (**Section 6.3.4**).

6.3.1 Consideration of Climate Change

Sea levels are rising globally and around the Australian coastline and will continue to rise through this century and beyond. Consistent with global increases, sea levels have risen in Australia at an average rate of 2.1 mm/ year over the past half century, with annual rises of 3.4mm observed from satellite altimetry data for the period 1993 – 2018) (CSIRO 2020). Council's recently adopted *Climate Resilience Strategy 2050* notes that the RCP 8.5 pathway or "business as usual" scenario models significant sea level rise for south east Australia. The *Climate Resilience Strategy 2050* also notes that this projection is supported by observed rates of recent sea level rise which highlights the ocean of south eastern Australia as having one of the largest increases in sea level rise across the globe. Sea level rise under the RCP 8.5 pathway by 2050 is projected to be 0.22m and 0.94m by 2100 above current levels.

In 2009 the NSW Government issued the NSW Sea Level Policy Statement and the Draft Sea Level Rise Planning Guidelines. The policy cited that national and international projections of sea level rise along the NSW coast are for a rise of 0.4 m by 2050 and 0.9 m by 2100. The policy statement set these levels as benchmarks for councils across the state to use in their planning instruments and processes to assess development applications. In February 2013, the NSW Government commenced Stage 1 of the NSW Coastal Reforms which included a significant change in their policy position on sea level rise. Underpinning these reforms was the decision to rescind the 2009 NSW Sea Level Policy Statement in September 2012. From this time, the NSW Government no longer recommended state-wide sea level rise projections. Instead it decided to provide information on available sea level rise projections to assist councils to develop projections relevant to their local area (Eurobodalla Shire Council, 2018).

Based on the now repealed NSW Government Guidelines (2009), Bega Valley Shire Council included sea level rise values of 0.4m and 0.9m in its flood studies at the time. For consistency, and in consideration of RCP 8.5 projections, these values have also been incorporated in subsequent flood studies, including for Merimbula. Discussion of the climate change flood modelling undertaken for Merimbula is provided in **Section 8.8**. Flood planning for the study area can confidently use this information to inform the application of flood related planning controls. It is recommended that sea level rise scenarios be applied in consideration of the design life of the development.

Climate change modelling in **Section 8.8** also assessed the impacts of rainfall increases of flood behaviour. The modelling found that a 10% increase in rainfall (assumed for 2050 conditions) led to a 0.1m increase in peak Merimbula Lake and Back Lake levels, and a 30% increase in rainfall (assumed for 2100 conditions) led to a 0.2 to 0.25m increase in lake levels.

Uncertainty arising from future rainfall intensities has been incorporated in freeboard recommendations for the study area, and is discussed further in the **Section 6.3.2**.

6.3.2 Freeboard

Freeboard is used to account for uncertainties in the prediction of peak flood levels, and is used as a factor of safety when setting the flood planning level for development.

Freeboard accounts for such factors as:

- Changes in catchment development and vegetation following the flood modelling;
- Accuracy of the flood model inputs (survey, rainfall, roughness)
- Wave action (either wind driven or wash from vehicles)
- Afflux (local increase in flood level due to small obstructions below the level of the model grid resolution
- Climate change.

The contribution of these factors to a potential increase in flood level over that reported by the hydraulic model is summarised in **Table 6-1**.

The total variation from these factors is estimated to be up to 0.45m.

As such, a 0.5m freeboard is considered suitable for the study area.

Table 6-1 Factors Incorportaed in Freeboard Estimate

Factor	Flood Level Variation Estimated From	Flood Level Variation (m)
Catchment changes	It has been assumed that future development would be required to not adversely affect flood behaviour. Changes to vegetation have been incorporated through the model roughness sensitivity, incorporated below.	0
Accuracy of ground survey used in the model	General accuracy of LiDAR data on vegetated surfaces.	0.15
Sensitivity of the model	Sensitivity testing of model parameters undertaken in the Flood Study.	0.1
Afflux	Advice provided in *Determining Freeboard* (Gillespie, 2005)	0.1
Climate Change	Only an allowance for increased rainfall has been allowed for. Council is incorporating sea level rise in the design flood event. Estimated sourced from modelling (refer **Section 6.3.1**).	0.1

6.3.3 Flood Planning Levels

The flood planning levels for development within the areas impacted by lake or creek flooding provided below are consistent with the recommendations of the Flood Study (Cardno 2017).

The Flood Study (Cardno, 2017) undertook a detailed review of the FPL as a result of lake foreshore and creek flooding. The FPL investigation and associated recommendations largely supported Council's existing FPLs, with some modifications proposed to address the increase in risk under the PMF (when compared to the 1% AEP event):

- For re-development of existing residential properties, FPLs should be set at the 1% AEP plus freeboard of 0.5 m.

- For major re-developments of existing residential properties and new residential developments, FPLs should be set at the 1% AEP plus a freeboard of 0.5 m, taking into account climate change as appropriate to the design life of the development.
- FPLs for development of new critical infrastructure, or re-development of existing critical infrastructure be set at the PMF.
- FPLs for new vulnerable developments be set at the PMF, unless the proponent can demonstrate evacuation via rising road egress route is possible within the effective warning time, in which case the FPL can be set at the 0.2% AEP plus a freeboard of 0.5 m.

6.3.4 Flood Planning Area

The Flood Planning Area (FPA) provided in the Flood Study (Cardno, 2017) did not include any provision for climate change. The following extents have been mapped to assist in selecting an appropriate planning area:

- 1% AEP flood levels plus 0.5m freeboard
- 1% AEP under 0.4m sea level rise conditions plus 0.5m freeboard
- 1% AEP under 0.9m sea level rise conditions plus 0.5m freeboard
- Probable Maximum Flood (PMF), also referred to as Special Flood Consideration (SFC) area; see **Section 6.2.2**.

The extents are shown in **Map G601**.

The LEP 2013 flood planning clauses apply to land at or below the flood planning level. To ensure FPLs can be applied to the development types above, the following FPA is recommended for adoption for the study area:

- 1% AEP under 0.9m sea level rise conditions plus 0.5m freeboard

This is extent, along with the PMF extent is shown on **Map G602**.

6.3.5 Overland Flow

Since the completion of the Flood Study (Cardno, 2017) additional modelling has been undertaken to define the significant overland flowpaths through Merimbula township (**Section 7.4**). This information can be used to inform the identification of properties where flood related planning controls may need to be applied.

To ensure consistency with the foreshore and lake flooding within the study area, it is recommended that the 1% AEP event is used for planning purposes.

The overland flood modelling (and associated mapping) presented in **Section 7.4** is preliminary only, to utilise this information for flood planning purposes it is recommended that the 1% AEP mapping be refined to remove disconnected inundation flood extents and possibly apply a depth filter of 0.1m or 0.15m.

6.4 Flood Planning Constraint Categories

The Flood Study (Cardno, 2018) and this Floodplain Risk Management Study have produced a large number of maps, each focusing on a particular design event and element of the flood behaviour. Collectively, they provide a detailed description of the flood behaviour and the issues that are important in different areas of the floodplain.

Combining these elements of flood behaviour can produce a succinct set of information that breaks the floodplain down into areas with similar degrees of constraint. Flood Planning Constrain Categories (FPCC) can better inform and support land-use planning activities. FPCCs identify where flood related constraints (or the tools used to manage these constraints) can be treated similarly in land-use planning activities. Four FPCCs are defined in the *Australia Disaster Resilience Handbook: Guideline 7-5* (AIDR, 2017) to separate areas of the floodplain from the most constrained (and therefore least suitable for intensification of land use or development – FPCC1), to the least constrained (and therefore more suitable for intensification of land use or development – FPCC4).

The flood constraints and implications for each category are outlined in **Table 6-1**, and the FPCC mapping is provided in **Map G603**.

Table 6-2 Flood Planning Constrint Categories

FPCC	Constraint	Implications	Key considerations
1	Flow conveyance and storage areas and H6 hazard	Significant changes to flow behaviour as a result of alterations to Conveyance. Hazardous conditions considered unsafe for people and vehicles. Risk of structural failure for buildings.	The majority of developments and uses have adverse impacts on flood behaviour. Consider limiting uses and development to those compatible with flood hazard H6 while also maintaining flood function
2	Flow conveyance larger than design flood, H5 hazard, isolated areas	Hazardous conditions considered unsafe for people and vehicles. Risk of structural damage for buildings. Inability to evacuate residents from isolated areas.	Many uses and developments will be vulnerable to flood hazard. Consider limiting new uses to those compatible with flood hazard H5. Consider the need for additional development conditions to reduce the effect of flooding on the development and its occupants
3	Outside FPCC2—generally below the DFE and the freeboard	Hazardous conditions may exist creating issues for vehicles and people. Structural damage to buildings that meet building standards unlikely because of flooding	Standard land-use and development controls aimed at reducing damage and the exposure of the development to flooding in the DFE are likely to be suitable. Consider the need for additional conditions for emergency response facilities, key community infrastructure and vulnerable users
4	Outside FPCC3, but within the probable maximum flood (or similar extreme event)	Emergency response may rely on key community facilities such as emergency hospitals, emergency management headquarters and evacuation centres operating during an event. Recovery may rely on key utility services being able to be readily re-established after an event	Consider the need for conditions for emergency response facilities, key community infrastructure and land uses with vulnerable users

6.5 Recommendations

Based on the review of the flood planning documents in **Section 6.2**, a series of recommendations have been made to assist Council in achieving best practice flood planning in the Merimbula Lake and Back Lake Floodplain and across the LGA (**Table 6-1**). Consideration has also been given to the existing recommendations made in the *Bega River and Brogo River FRMS* (Cardno, 2017). Overall, the recommendations regarding the LEP are consistent with the recommendations made in Cardno (2017). The recommendations relating to the DCP are to be considered in addition to those made in Cardno (2017).

Table 6-3 Flood Planning Recommendations

	Issue	Recommendation
1	Under the SEPP (Exempt and Complying Development Codes) 2008, complying development cannot be undertaken on land defined as: • Flood storage • Floodway • Flow path • High Hazard • High risk. Whilst flood storage and floodways are clearly defined in the analysis of Flood Function (Section 8.3), flood hazard is not specifically defined as "high" or "low", instead is provided across 6 hazard categories that link hazard to consequence (Section 8.2). Additionally, areas that are "high risk" are not specifically set out and mapped and would require interpretation of the study outputs.	Consideration of Flood Planning Constraint Categories (FPCC) may assist with reducing ambiguity relating to where complying development can or cannot be undertaken. FPCC analysis is undertaken in Section 6.4 can be used to inform the application of complying development. It is considered reasonable that complying development is permitted in FPCC 3 and 4. This approach excludes development within the following areas from complying development: • Flood storage for the 1% AEP event, • Floodway in all events up to and including the PMF event, • H5 Hazard classification for the 1% AEP event, • H6 Hazard classification for all events up to and including the PMF event, and • Isolated areas in events up to the PMF event.
2	The LEP requires proposed development to consider the impacts of climate change on flooding (Clause 6.3(b)). However, the definition of the FPL does not give consideration to climate change.	The LEP be updated to provide the ability to include climate change in the definition of Flood Planning Levels. This may consist of an additional clause under 6.3. This is consistent with the recommendations made in *Bega River and Brogo River FRMP (Cardno, 2017)*.
3	Clause 6.3(2) identifies that the flood planning clause applies only to land at or below the FPL (1%+0.5m). The *Bega River and Brogo River FRMP (Cardno, 2017)* recommends that sub clause 6.3 (2) be amended to apply to all flood prone land (i.e. all land at or below the PMF) and land mapped in the FRMS as being high flood island, rather than just land at or below the flood planning level.	The LEP be updated to identify that the flood planning clause applies to: • The flood planning area mapped in the relevant Flood Study or Floodplain Risk Management Plan; or • Land at or below the Flood Planning Level. This provides Council with the flexibility to identify within each catchment the appropriate design flood upon which

	Issue	Recommendation
		to base the FPL, an appropriate freeboard and whether climate change should be incorporated. It is not recommended that the FPA mapping is included in the LEP. It is noted that the recommendation in Cardno (2017) to include all land below the PMF and high flood island areas would require ‘exceptional circumstances’ to be sought under PS 07-003. Based on the flood risk, the FPA and the PMF within the Merimbula and Back Lake study area, it is not considered necessary to apply ‘exceptional circumstances’ within the study area. The inclusion of flood planning provisions above the FPL (up to the PMF) has been considered in recommendation 4. It is also noted that PS-07-003 will be repealed once the *Draft Flood Prone Land Package* is adopted.
4	The LEP only provides for flood planning provisions below the FPL.	Within the study area there is only a small area outside the recommended FPA that falls within the PMF extent (see **Map G602**). However, this may not be the case in other floodplains within the LGA. The recommendations in the *Draft Flood Prone Land Package* seek to address flood planning outside of the FPA through the application of the Special Flood Considerations (SFC). The SFC seeks to control certain types of vulnerable and hazardous development within the floodplain in its entirety (i.e. potentially up to the extent of the Probable Maximum Flood).
5	Section 5.8.1 of the DCP 2013 provide flood related development controls for development below the FPL (see Section 5.8.1.2 of the DCP). However, no flood related development controls are provided for development above the FPL but below the PMF.	It is recommended that the DCP be updated to include appropriate flood related development controls to ensure the LEP objectives in recommendation 4 (above) are met. This is of relevance to the Merimbula Lake Study Area which has seniors living, caravan parks and an airport that can be impacted by flooding.
6	DCP 2013 does not provide specific controls relating to overland flow, with the exception of Section 2.6.1.2 that requires fencing not to obstruct overland flows.	A preliminary assessment of overland flow has been undertaken for the urban areas of Merimbula (see **Section 7.4**). It is recommended that Council consider the results of the overland flow assessment when assessing proposed development within the affected flow paths. The key objective should be keeping overland flow paths free of obstructions. It is recommended that the DCP be amended to incorporate controls to achieve this objective.

	Issue	Recommendation
7	Defining the Flood Planning Level for the study area.	It is recommended that the FPLs proposed in the Flood Study (Cardno, 2017) be adopted for mainstream flooding: • For re-development of existing residential properties, FPLs should be set at the 1% AEP plus freeboard of 0.5 m; • For major re-developments of existing residential properties and new residential developments, FPLs should be set at the 1% AEP plus a freeboard of 0.5 m, taking into account climate change as appropriate to the design life of the development; • FPLs for development of new critical infrastructure, or re-development of existing critical infrastructure be set at the PMF; and • FPLs for new vulnerable developments be set at the PMF, unless the proponent can demonstrate evacuation via rising road egress route is possible within the effective warning time, in which case the FPL can be set at the 0.2% AEP plus a freeboard of 0.5 m. These are consistent with the recommendations made in the *Bega River and Brogo River FRMP*.
8	Defining the Flood Planning Area for the study area.	It is recommended that the FPA for mainstream flooding be defined as the land below the 1% AEP flood event (based on 0.9m sea level rise) plus a freeboard of 0.5m.

7 Flood Modelling

7.1 Modelling Approach

The Flood Study (2017) developed modelling of the Merimbula Lake and Back Lake systems and physical processes using a calibrated Delft3D Hydrodynamic Model system, as well as the SWAN Wave Model system, operating in coupled mode. Hydrological inputs were developed using RAFTS.

This FRMS utilised the same models developed for the Flood Study (2017). The Delft3D model was modified to reduce runtimes while still providing results consistent with the Flood Study (see **Section 4.2.4 and 7.2**).

The objective of the modelling undertaken in this FRMS was to:

- Undertake sensitivity analysis of the application of ARR2019 (the Flood Study applied ARR87)
- Assess the cumulative impacts for a future development scenario
- Assess the impacts of selected proposed works
- Undertake additional climate change runs not included in the Flood Study (2017)
- Assess the impacts and benefits of a range of flood mitigation measures.

In addition, hydraulic modelling using Tuflow was undertaken to investigate:

- Overland flow risk for the Merimbula urban areas; and
- The impacts of flooding on Boggy Creek Road upstream of Princes Highway.

7.2 Model Refinement

Following the review of the Flood Study Delft3D model (see **Section 4.2.4**), extensive changes have been made to the model set-up to optimise its use for this FRMS. Changes to the model include:

- Removal of the outer hydrodynamic grid (Grid A), reducing the number of nested grids to 2 (from 3)
- Reduction of extent and de-refinement of Grid B. The upper catchment areas (upstream of the RAFTS input locations) have been removed and the grid resolution reduced by a factor of 2, from 100m to 200m resolution
- Removal of spatially varying meteorological inputs (rainfall) on all grids
- Optimisation of the model timestep.

The above changes have resulted in a model run time between 10 to 15 times faster than the original Flood Study setup. Figures of the original and updated model extents are presented in **Figure 7-1 and Figure 7-2**. It should be noted that the wave model extents and settings, used for two-way coupling with the hydrodynamics for the calculation of wave setup, have not been changed.

Further optimisations may be made on a scenario basis by way of reducing the model warmup duration and/or removing sediment transport processes (for low ARI events in Merimbula Lake).

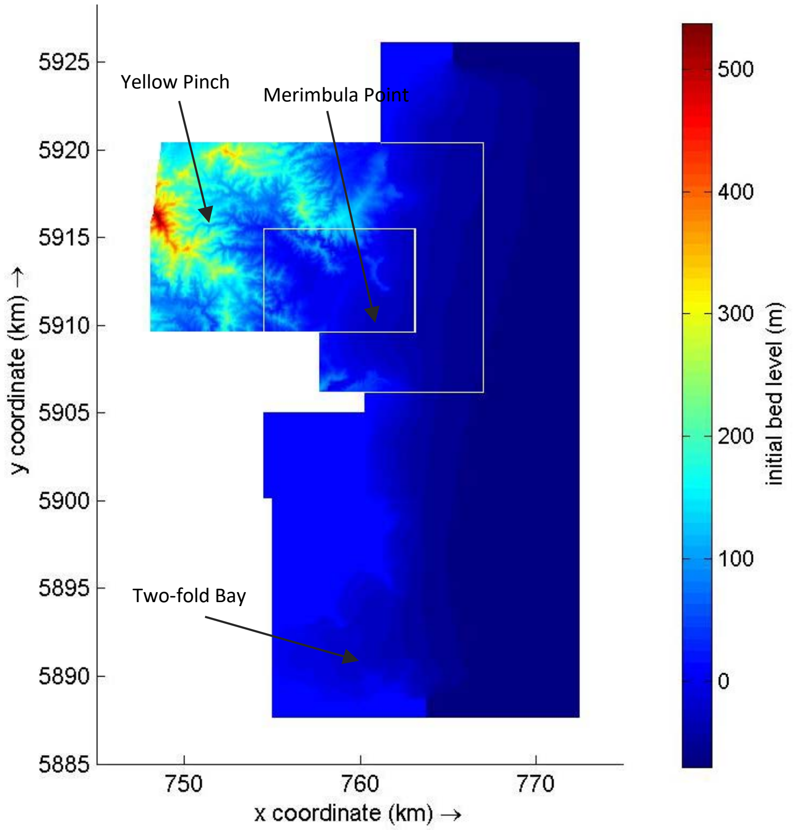


Figure 7-1 Flood Study Model Extend (3 nested grid setup)

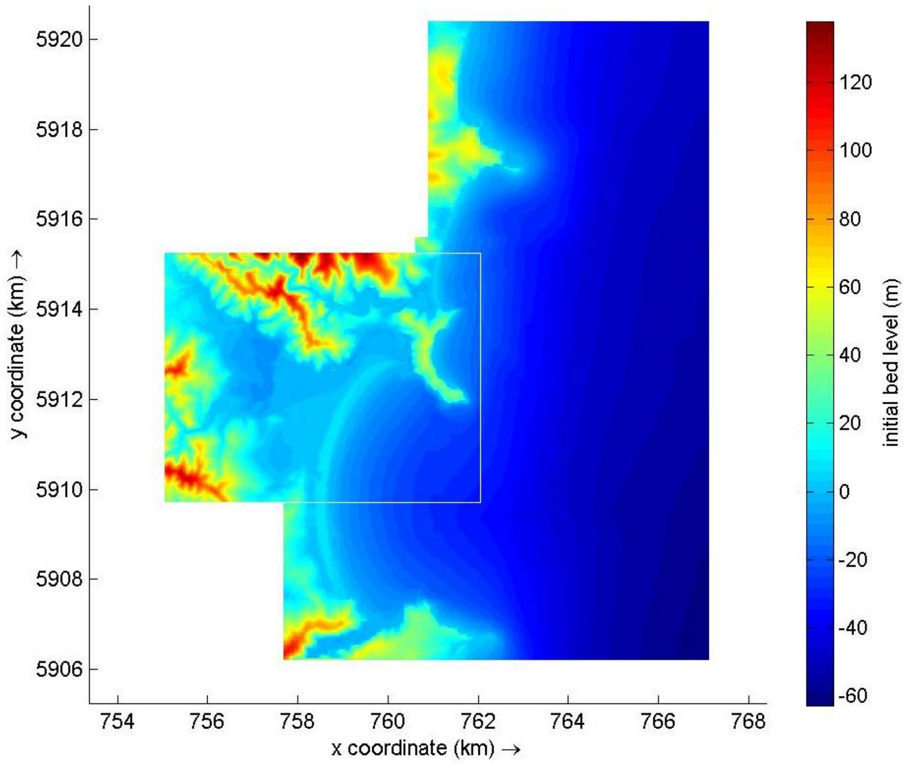
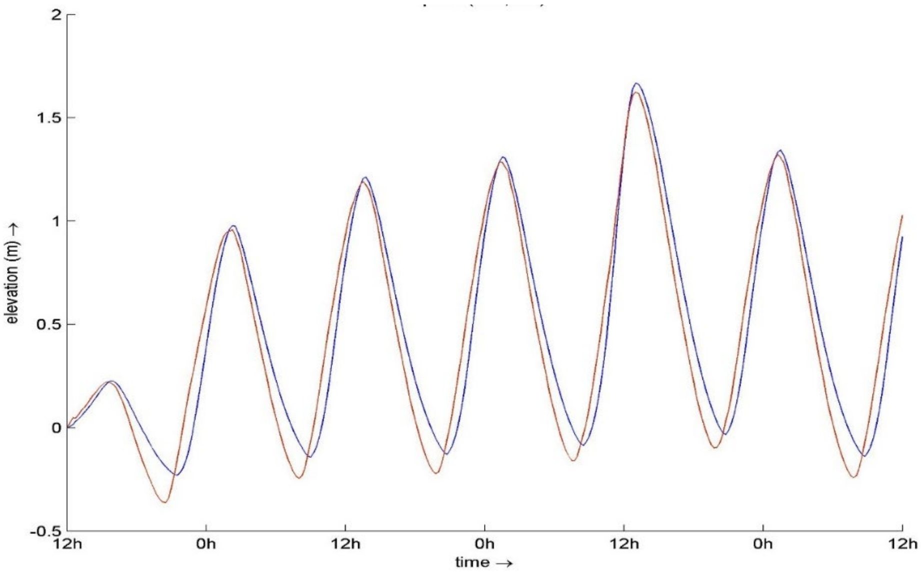


Figure 7-2 Revised Model Extent (2 nested grid setup)

The revised model setup has been run for a 100-year 6-hour duration event with the exact same catchment inflow and boundary conditions (water level and waves) as applied in the Flood Study. A comparison of the resulting water levels with Merimbula Lake are presented in **Figure 7-3**. It can be seen that the flood behaviour is comparable. The timing of the flood peak is the same in both models, while the peak level estimated is 0.04 metres lower in the revised model.

As a result, the revised model is considered fit-for-purpose to be used as a base model against which mitigation options can be compared.



Comparison of Water Levels from the Original Flood Study Model (blue) and Revised FPRMSP Model (red) within Merimbula Lake for a 100-year 6-hour duration event (Run ID: 59915100_DF100Yr_CI100Yr_WL020Yr_Hs020Yr_RE6hrs_TS0hrs)

Figure 7-3 Comparison of Water Levels from the Original Flood Study Model and Revised FPRMSP Model

7.3 Sensitivity Analysis

A comprehensive sensitivity analysis was undertaken of the hydrological and hydrodynamic models as part of the Flood Study (Cardno, 2017) and as such, no additional sensitivity of model parameters is being undertaken as part of this FRMS.

Sensitivity analysis has been undertaken for the application of Australian Rainfall and Runoff hydrological methods, as discussed below.

7.3.1 Australian Rainfall and Runoff 2019

Since the Flood Study (Cardno, 2017) was completed, the Australian Rainfall and Runoff 2019 (ARR2019) has been published. The new ARR2019 has a number of changes to the hydrological methods that have been traditionally employed, including those in the Flood Study. This includes updated design rainfall intensities, new ensemble storms and other catchment parameters such as losses.

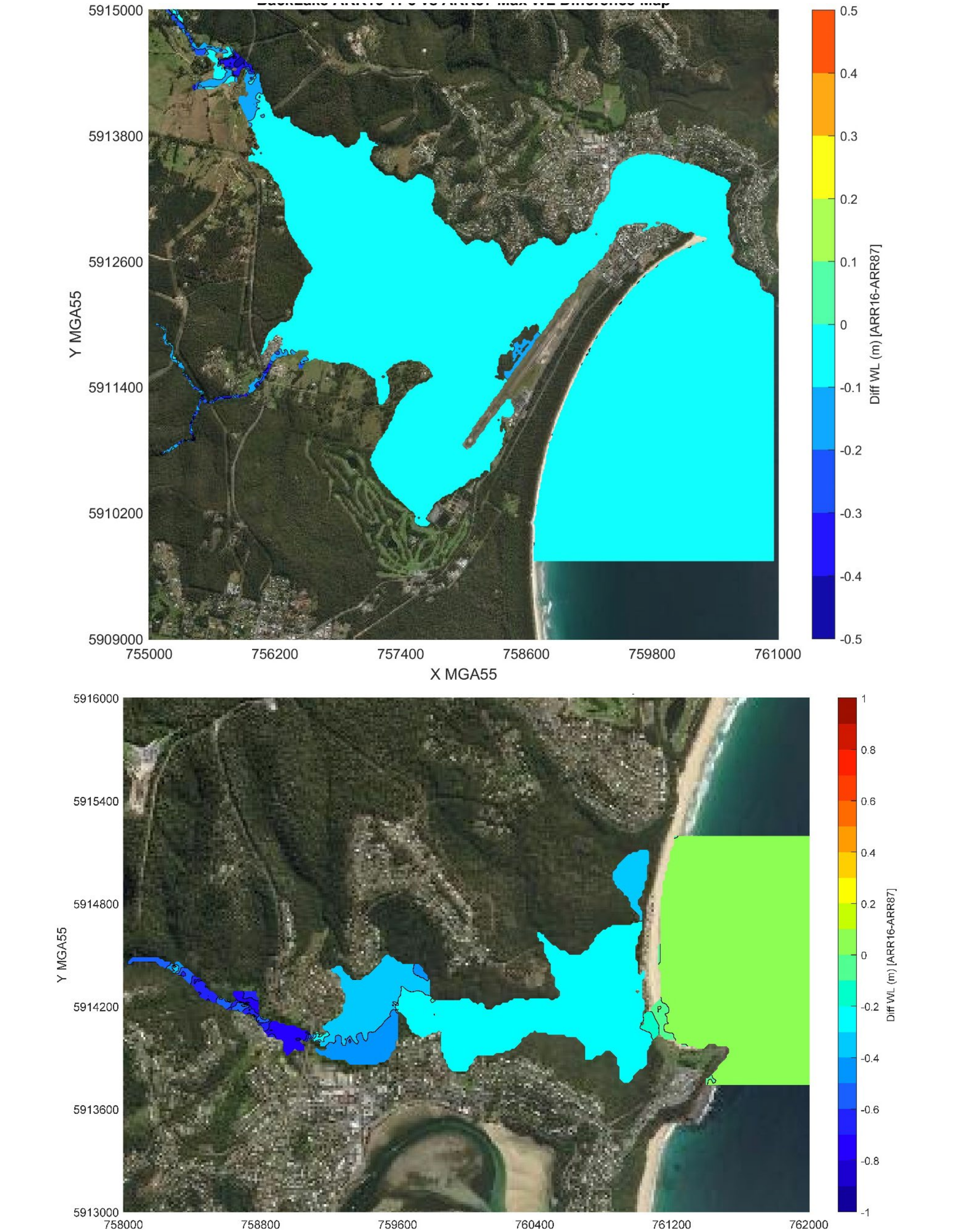
The floodplain management industry is currently in a transitional phase between ARR87 and the new ARR2019. Generally, it is recommended to continue with the use of ARR87 where studies are in progress or there is a minor update or design scenario to be assessed within an existing model that was established. Where a completely new model is established, ARR2019 represents the best and most up to date information and would be recommended. This is in line with guidance from DPIE.

Sensitivity analysis was undertaken on the Flood Study model by applying ARR2019 IFDs, temporal patterns and losses. The sensitivity assessment was undertaken for the 1% 2h event for temporal patters 5 and 10 (TP5 and TP10). The comparison of the results against the Flood Study (ARR87) results are shown in **Figure 7-4**.

The results show that the impact of applying ARR2019 compared with ARR87 are negligible in Merimbula Lake. However, the impacts are considerable (up to 0.8m reduction in flood levels) in Back Lake, particularly upstream of Sapphire Coast Drive. However, it is noted that under both ARR approaches the number of properties impacted in Back Lake is not significant. And almost all existing dwellings or significant building are outside of the existing 1% AEP extent.

Following discussions with Council and DPIE it was considered reasonable to proceed with the current Floodplain Risk Management Study utilising the Flood Study (Cardno 2017) results based on ARR87.

Water Level Difference ARR2019 TP5 – ARR87 (Flood Study)



Water Level Difference ARR2019 TP10 – ARR87 (Flood Study)

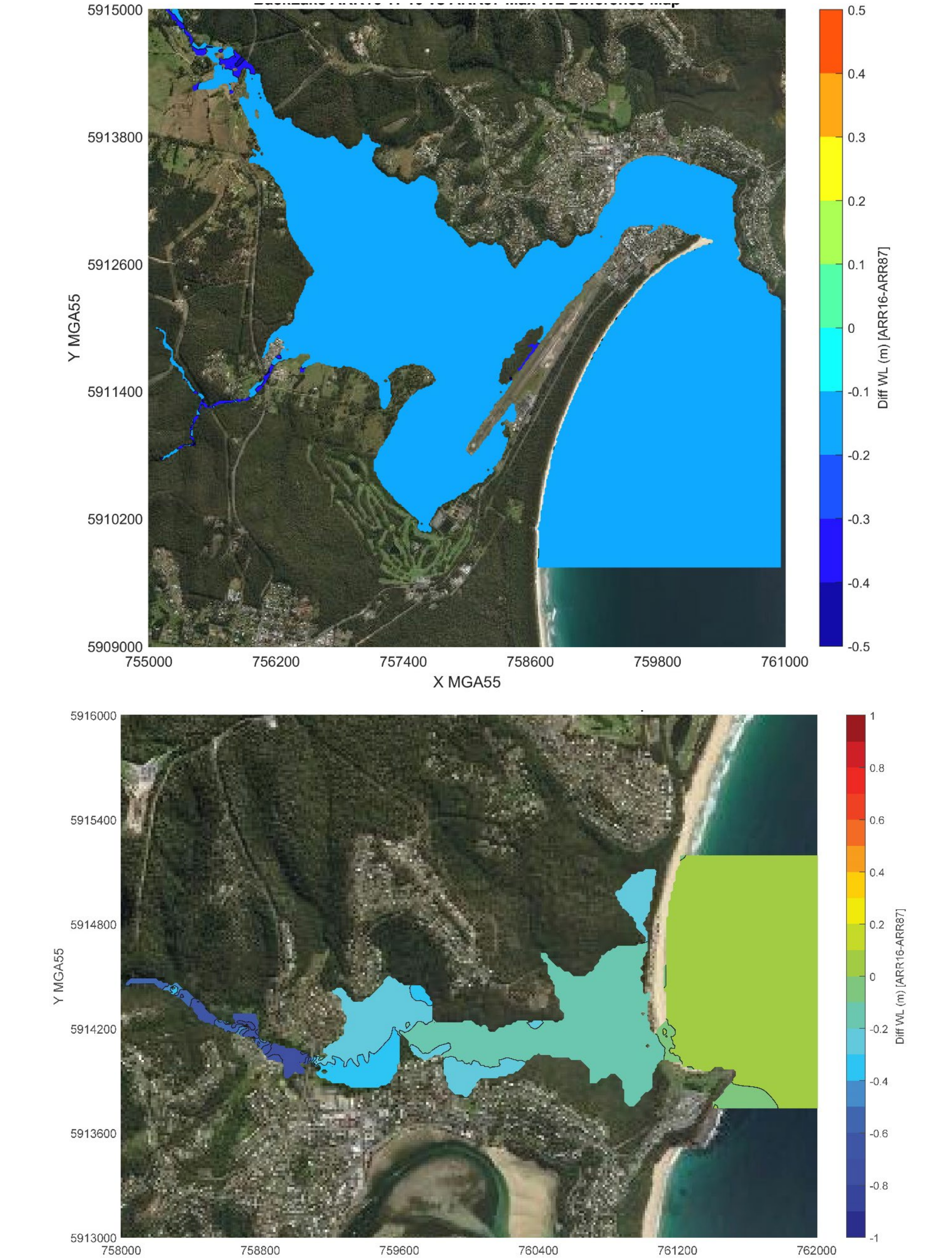


Figure 7-4 ARR2019 Sensitivity Analysis

7.4 Overland Flow Analysis

Overland flow is considered to be an issue for the study area, both by local residents and Council. In September 2014 roads and shop fronts within the Merimbula CBD were impacted by flash flooding caused by an intense local rainfall burst. No foreshore flooding from the lake was experienced during this event. However, overland flow issues may be exacerbated by elevated lake levels, due to a reduction in the discharge capacity of the local drainage network (as a result of the elevated tailwater levels). To assess the overland flood behaviour within the study area, a Tuflow model was developed.

The Tuflow model is shown **Map G701**. Model parameters are summarised in **Table 7-1**.

Table 7-1 Overland Flow Tuflow Model Parameters

Data	Comment
Survey & Culverts	The hydraulic model used the publicly available 1m LiDAR data from ELVIS (https://elevation.fsdf.org.au). Council also provided survey data for the Merimbula bypass, which was incorporated in the model. Pit and pipe data were sourced from Council's GIS. Pipe sizes were generally available; however invert data was limited. A 600mm cover depth was assumed for pipes with no invert data.
Hydrologic Inputs	Rainfall timeseries were taken directly from the Flood Study RAFTS model with rainfall applied directly to the 2D grid.
Downstream Boundary	The model discharges directly to Merimbula Lake. Peak lake levels were extracted from the Flood Study hydraulic model. The overland model adopted a constant downstream boundary based on peak lake levels from the Flood Study for the 5% AEP event (1.43mHAD). This level was used for both the 5% AEP and 1% AEP model.
Roughness	Roughness layers were discretised based on aerial imagery and Council land use. Roughness values adopted were: • Vegetation 0.10 • Urban Lots 0.15 • Buildings 0.10 • Road Reserves 0.025 • Open Space 0.045 • Water 0.02

The model was run for the 1% AEP and 20% AEP events using the ARR87 guidelines, as per the Flood Study. The 90 minute event was critical for local catchment flows for both events.

Peak depths for the modelled events are shown in **Map G702** and **Map G703**.

Overall, the catchment was not heavily impacted by overland flow, with the majority of overland flowpaths restricted to open space corridors and roadways.

Two locations experienced impacts from overland flow; the CBD along Merimbula Drive and Market Street and along Main Street between Henwood Street and Cliff Street.

Overland flow in the CBD is significant (highlighted in the inset on the maps). Much of the flooding occurs across the carpark on Merimbula Drive, however flow that breaks out of the carpark then passes through commercial buildings to the east. Ponding along Market Street also affects adjacent businesses. While depths in the carpark reach 0.7 metres, depths at commercial properties are lower, typically within 0.4 – 0.6 metres.

Along Main Street, the overland flow runs through a local depression in the front of residential lots, rather than along the roadway. No properties are impacted by this flow in either the 20% or 1% AEP.

7.5 Princes Highway Culverts at Millingandi Road Analysis

A local Tuflow model was built to assess the overtopping of the Princess Highway at Millingandi Road. These culverts had previously been assessed using a in the Flood Study (Cardno, 2017) 1D model. The 1D/2D Tuflow model was developed to provide a more robust definition of flow in the region, and the overtopping of the highway in particular.

Inflows were extracted from the RAFTS hydrological developed for the Flood Study. A minor change was made to this model to split subcatchment M25 (which covers the full study area) to allow flows to be distributed throughout the Tuflow model. All catchment parameters were retained as per the original RAFTS model, with only the catchment area and slope revised to reflect the new subcatchment breakdown.

The Tuflow model layout is shown in **Map G704**. Model parameters are summarised in **Table 7-2**.

Table 7-2 Millingandi Culvert Tuflow Model Parameters

Data	Comment
Survey & Culverts	The hydraulic model used the publicly available 1m LiDAR data from ELVIS (https://elevation.fsdf.org.au). Culvert sizes were available from Council's GIS data set.
Hydrologic Inputs	Inflow hydrographs were taken directly from the RAFTS model and applied at sub-catchment outlets in the hydraulic model, with routing undertaken by the hydraulic model.
Downstream Boundary	The local system discharges directly to Merimbula Lake. Peak lake levels in events up to and including the 1% AEP are sufficiently far downstream that back water affects at the highway are minimal. As such, the local model adopted a constant downstream boundary based on peak lake levels of the same AEP. That is, 1% AEP lake levels were adopted for the 1% AEP local model. This is conservative as the local catchment responds much quicker than Merimbula Lake.
Roughness	The land use within the model area is generally homogenous. As such, a single roughness has been adopted or the model based on the cleared, grassed spaces that dominate the model area. The roughness value adopted was 0.045.

The Tuflow model was run for the 20% AEP, 5% AEP and 1% AEP events, using the ARR87 guidelines, as per the Flood Study. The critical duration for peak flow at the Princes Highway culverts was found to be the 2 hour event. Blockage for the Princes Highway culverts was set at 25%, based on a conservative approach to the ARR2019 blockage guidelines.

Peak depths for the modelled events are shown in **Map G705** to **Map G707**.

The results show that the highway remains flood free in all design events. The original 1D assessment in the Flood Study reported overtopping in the 1% AEP, with a similar blockage assumption of 30%. The change in behaviour between the flood models is expected to be due to better routing of local subcatchment flows through the upstream channels and minor culverts, an allowance for storage and ponding behind upstream roadways and the availability of more accurate terrain data.

A sensitivity assessment was undertaken with a higher blockage rate of 50%. With this blockage rate, the highway remained flood free in the 20% AEP and 5% AEP events, while overtopping depths of 0.12 metres were observed in the 1% AEP. Overtopping occurred for 1.5 hours, with depths of greater than 0.1m occurring for 30 – 40 minutes.

7.6 Dam Break Analysis

Located in the upper reaches of Merimbula Creek, Yellow Pinch Dam is used as an off-stream storage dam for the Tantawangalo-Kiah Water Supply Scheme. The dam is located approximately 2 kilometres south of Wolumla and 10 kilometres north-west of Merimbula. The dam was built in 1987 and has a storage capacity of 3,000 ML at Full Supply Level (FSL). The area draining to the dam is approximately 225 hectares, compared to the full Merimbula Creek catchment area of 2,950 hectares.

A dam break assessment was undertaken in 2009 by GHD. The study developed:

- A RAFTS hydrological model of the catchment upstream of the dam to determine inflows into the dam;
- A FLDWAV model to describe the failure of the dam wall; and,
- A MIKE-11 model that extended from the dam wall to the entrance to Back Lake, at the downstream end of Merimbula Creek. The model included structure details for major crossings at the Princes highway, the old highway, Sapphire Coast Drive and the pedestrian crossing at Munn Street.

The study examined 1% AEP, 0.1% AEP, 0.05% AEP and 0.02% AEP events and the PMF event.

The assessment found that no overtopping occurred of the dam wall in events up to and including the PMF. As such, only piping failure was assessed. The failure parameters are summarised in **Table 7-3**.

Table 7-3 Breach Parameters

Parameter	Sunny Day	1% AEP	PMF
Reservoir Elevation when Breach Commences (mAHD)	188	188.6	189.7
Breach time (min)	20	20	20
Final Breach Width (m)	20	20	20
Breach Invert (mAHD)	150	150	150
Breach Side Slope	1:1	1:1	1:1

The assessment found that property affectation due to dam failure occurred in the 1% AEP event (the smallest design event assessed). The dam break report included maps showing flood extents for all modelled scenarios, along with the location of affected infrastructure and properties

Affectation of both property and infrastructure was found to be most severe in the PMF dam break scenario, with:

- Seven properties affected downstream of the dam; and,
- Increased flood levels across the Princes Highway, the old highway, Sapphire Drive and the pedestrian crossing and Munn Street.

This affectation data has been summarised in **Table 7-4** below, with locations shown in **Map G708.**

Table 7-4 Property and Infrastructure Affectation in PMF Dam Break Scenario

Location	Arrival Time (min)	Duration of Flooding (min)	Max Depth (m)
Princes Highway	15	15	4.81
Old Highway	20	30	5.82
House 1	20	5	0.14
House 2	20	10	0.22
House 3	20	10	0.44
House 4	20	15	1.02
House 5	25	20	1.44
House 6	25	65	5.32
House 7 (caravan park)	30	190	6.06
Sapphire Drive	30	145	4.62
Pedestrian Crossing (Munn Street)	30	185	6.53

The Dam Break study also reported the potential for break out flows to occur between Back Lake and Merimbula Lake in the PMF dam failure scenario. The location is shown in **Figure 7-5**.

An analysis of the terrain in this area has been undertaken based on the latest LiDAR. The analysis confirmed the location of this low point, and that, given the levels from the dam break study, it would overtop in the PMF dam break scenario.

A preliminary assessment of possible impacts is shown in **Figure 7-6**. Based on the terrain, the PMF dam break breakout has the potential to affect over 20 properties (21 are identified below), including the Merimbula Public School, which is located in the centre of the low point.

The assessment makes no allowance for depth, and it may be that along the edges of Merimbula Lake, or at the fringes of the breakout, the depths and velocities are low enough that no tangible risk will be posed to residents.

It is noted however that the peak PMF depth dam break level at the breakout is in the order of 6.8 – 6.9 mAHD, while the crest of the low point is approximately 5.1 mAHD. This would suggest that flows of up to 1.8 metre depths may be possible through the public school grounds.

Figure 7-5 Location of possible break out (adapted from GHD, 2009)

Figure 7-6 Additional property impacts from PMF dam break outbreak into Merimbula Lake

8 Flood Behaviour and Flood Risk

8.1 Flood Damages

8.1.1 Damage Categories

In order to quantify the economic impacts of flooding, a flood damage assessment has been undertaken. A property may suffer economic impacts from flooding through several ways. These are broadly grouped into three categories, as summarised in **Table 8-1**.

Table 8-1 Flood Damages Categories

Type of Flood Damages		Description
Tangible	**Direct**	Building contents (internal) Structure (building repair and clean) External items (vehicles, contents of sheds etc.) Infrastructure
	Indirect	Clean-up (immediate removal of debris) Financial (loss of revenue, extra expenditure) Opportunity (non-provision of public services)
Intangible		Social – increased levels of insecurity, depression, stress General inconvenience in post-flood stage

Damage dealt directly to a property or its contents (direct damages) are only component of the total damages accrued during a flood event. Indirect costs, while also tangible, arise as a result of consequences of the flood event, such as clean up costs, opportunity costs, and other financial impacts.

In addition to tangible damages, there are also a category of damages referred to as intangible damages. Intangible costs relate to social impacts, such as insecurity and depression, that arise as a result of major flood event, or general inconveniences that occur during the post-flood stage. The intangible costs are difficult to calculate in economic terms.

8.1.2 Damage Assessment

The damage assessment undertaken for this study has examined the tangible damages only. Assessment of the tangible flood damages is based on a relationship between the depths of flooding on a property and the likely damage within the property.

Individual damage curves have been prepared for residential and commercial properties. No industrial properties were found to be flood affected in the Merimbula catchment, so this set of curves was not used. The generation of the residential and commercial damage curves are discussed in **Appendix B**.

8.1.3 Average Annual Damage

Average Annual Damage (AAD) is a probability approach to aggregating damages across the full range of design events. The process seeks to define the average flood damage a property experiences each year, based on the expected damage from a flood event, and the likelihood of that event occurring in any given year. A full description of the AAD methodology is provided in Appendix M of the Floodplain Development Manual (NSW Government, 2005).

8.1.4 Damage Assessment Results

The results from the damage assessment are summarised in **Table 8-2**.

The average annual damage for the Merimbula study area under existing conditions was $54,251.

These damages were calculated based on the tangible damages only.

The assessment showed that over floor flooding commenced in the 5% AEP event, with three residential properties affected. This affectation increased steadily for larger events with a total of 17 properties (12 residential and five commercial) affected in the 1% AEP and 36 (25 residential and 11 commercial) affected in the PMF.

Depths were relatively modest for the larger events, with peak depths not exceeding 0.5 metres at properties in events up to and including the 0.5% AEP and were less than 1 metre in the PMF.

As a result of no over floor flooding occurring in events smaller than the 5% AEP, the AAD is relatively low, as it is these events that contribute most to AAD. While the damages in the 0.5% AEP are more substantial ($1.3M) when these are annualised, the contribution to AAD is only $6,668.

Table 8-2 Merimbula Existing Damages Assessment Results

	Over Ground Flooding	Over Floor Flooding	Max Over Floor Depth (m)	Total Damages ($2019)
PMF				
Residential	47	25	0.94	$2,272,919
Commercial	10	11	0.78	$492,045
Total	57	36		$2,764,963
0.5% AEP				
Residential	30	17	0.48	$1,513,113
Commercial	6	7	0.47	$123,862
Total	36	24		$1,636,976
1% AEP				
Residential	28	12	0.42	$1,205,075
Commercial	3	5	0.37	$66,528
Total	31	17		$1,271,603
2% AEP				
Residential	15	7	0.27	$696,245
Commercial	2	2	0.23	$21,844
Total	17	9		$718,089
5% AEP				
Residential	9	3	0.14	$360,481
Commercial	0	0	0	$0
Total	9	3		$360,481
10% AEP				
Residential	1	0	0	$12,675
Commercial	0	0	0	$0
Total	1	0		$12,675

8.2 Flood Hazard

Flood hazard varies with flood severity (i.e. for the same location, the rarer the flood the more severe the hazard) and location within the floodplain for the same flood event. This varies with both flood behaviour and the interaction of the flood with the topography.

It is important to understand the varying degree of hazard and the drivers for the hazard, as these may require different management approaches. Flood hazard can inform emergency and flood risk management for existing communities, and strategic and development scale planning for future areas.

The hazard categories mapped are summarised in **Table 8-3** and **Figure 8-2**. These are based on the categories as defined in the AIDR (2017) Guideline. The industry is moving towards this method of classification, due to the implicit link between hazard and consequence. With respect to the high-transitional-low categories system (as outlined in the Floodplain Development Manual, 2005), the two classifications are not directly comparable, as shown in **Figure 8-2**. However, the two systems can be broadly compared by assuming:

- H6, H5 relate to high hazard
- H4 to H1, with velocities between 0.8m/s and 1m/s are comparable relate to transitional hazard
- H4 to H1, with velocities less than 0.8m/s are comparable relate to low hazard

It is noted that this comparison is not exact but allows some measure of comparison between the two methods.

Flood hazard mapping is provided for the full set of design events in **Maps G801-1** to **8**.

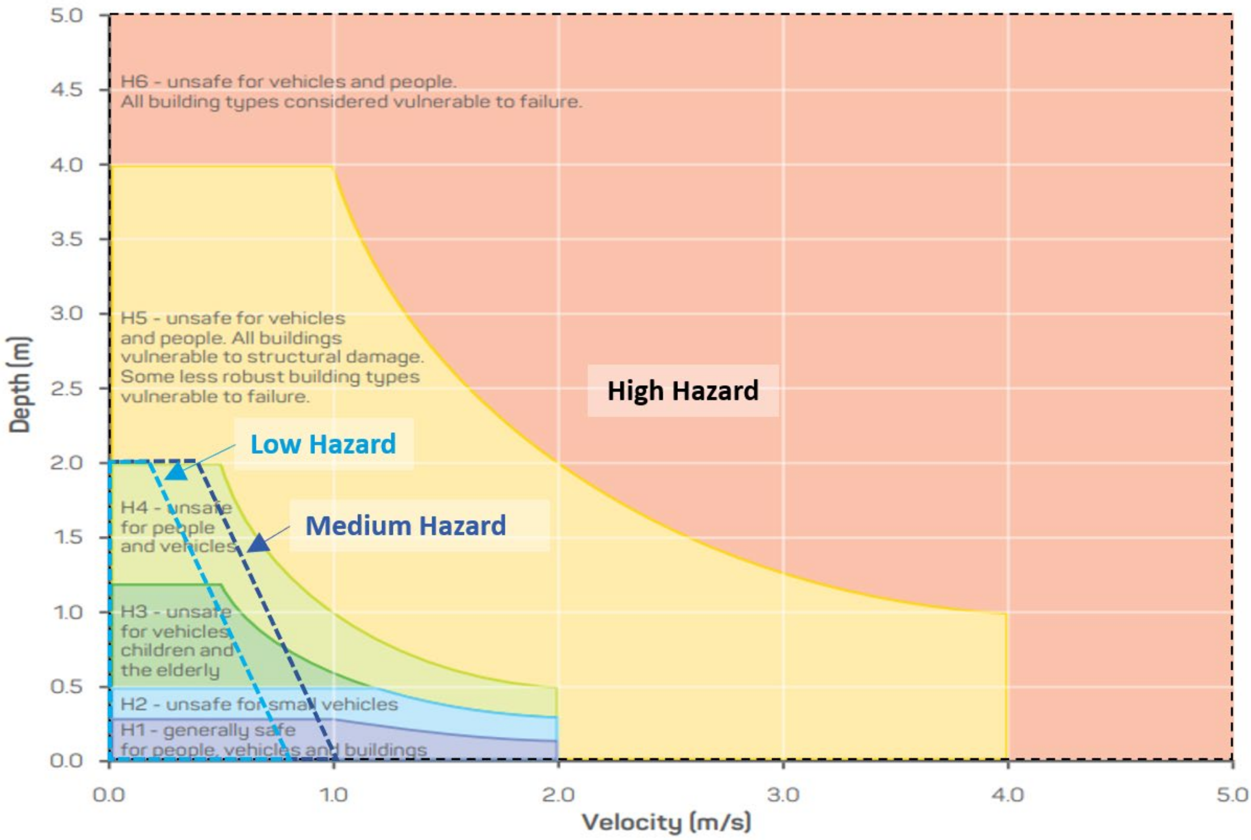


Figure 8-1 **Comparison of FDM and AIDR Flood Hazard Categories**

Table 8-3 Hazard Categories

Hazard Category	Description
H1	Generally safe for vehicles, people and buildings
H2	Unsafe for small vehicles
H3	Unsafe for vehicles, children and the elderly
H4	Unsafe for vehicles and people
H5	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure

8.3 Flood Function

Identifying the flood functions of the floodplain is a key objective of best practice in flood risk management in Australia, because it is essential to understanding flood behaviour. The flood function across the floodplain will vary with the magnitude in an event. An area which may be dry in small floods may be part of the flood fringe or flood storage in larger events and may become an active flow conveyance area in an extreme event. In general flood function is examined in the defined flood event (DFE), so it can be accommodated as part of floodplain development, and in the PMF so changes in function relative to the DFE can be considered in flood risk management.

The hydraulic categories (also known as flood function), as defined in the Floodplain Development Manual (2005), are:

- Floodway - areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.
- Flood Storage - areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated water levels and/or elevated discharges.
- Flood Fringe - remaining area of flood prone land, after Floodway and Flood Storage areas have been defined. Blockage or filling of this area will not have any significant effect on the flood pattern or flood levels.

An initial categorisation was undertaken for the PMF and the 1% AEP as part of the Flood Study. The categorisation was undertaken based on the criteria described in Howells et all (2003), with categories defined as:

- Floodway – Velocity × Depth Product is greater than $0.25m^2/s$ and Velocity >0.25m/s
- Flood Storage –Depth is greater than 0.2m and is not classed as floodway
- Flood Fringe – areas in the flood extent outside of the above criteria.

The maps prepared in the Flood Study presented the raw results with no further filtering.

The flood function mapping has been revised as part of the Floodplain Risk Management Study. The first pass criteria have been revised based on recent encroachment analysis undertaken at Eden as part of the Eden and Surrounds Flood Study (Rhelm, 2019).

The criteria adopted is as follows:

- Floodway – Velocity × Depth Product is greater than $0.5m^2/s$
- Flood Storage – Velocity × Depth Product is less than $0.5m^2/s$ and depth is greater than 1m
- Flood Fringe – areas in the flood extent outside of the above criteria.

It is noted that there is no "one size fits all approach" to hydraulic category / flood function definition. Thomas & Golaszewski (2012) investigated a number of different approaches in some case study catchments, and some of these adopted similar criteria to those identified in the Eden and Surrounds Flood Study.

Minor revisions were made to the initial classifications were undertaken:

- Floodways were made continuous
- Isolated pockets (less than 5 grid cells) of floodway were converted to storage, and isolated pockets of storage converted to fringe
- Thin wedges of storage along the lake edge were converted to fringe.

The revised mapping is provided for the PMF, 0.5% AEP, 1% AEP and 5% AEP in **Map G802-1** to **G802-5**.

8.4 Emergency Response Classification

Flood Emergency Response Classification aims to categorise the floodplain based upon differences in isolation due to the potential for entrapment of an area by floodwaters, potentially in combination with impassable terrain. It also considers the potential ramifications for an isolated area based upon its potential to be completely submerged in the probable maximum flood (PMF) or a similar extreme flood (AIDR, 2014).

Flood Emergency Response Classification mapping is a useful tool emergency services and evacuation planning for a floodplain.

AIDR (2014) provides guidance on mapping response classification mapping, which is intended to be undertaken at the community or precinct scale (i.e. not at the lot scale). A summary of the classifications is provided in **Table 8-4**. Maps have been prepared for the 20% AEP, 1% AEP and PMF events, and are presented in **Map G803-1** to **Map G803-3**. It is noted that the Flood Free category was not shown on the map.

Table 8-4 Emergency Response Classifications (AIDR, 2014)

Primary Classification	Description	Secondary Classification	Description	Tertiary Classification	Description
Flooded (F)	The area is flooded in the PMF	Isolated (I)	Areas that are isolated from community evacuation facilities (located on flood-free land) by floodwater and/or impassable terrain as waters rise during a flood event up to and including the PMF. These areas are likely to lose electricity, gas, water, sewerage and telecommunications during a flood.	Submerged (FIS)	Where all the land in the isolated area will be fully submerged in a PMF after becoming isolated.
				Elevated (FIE)	Where there is a substantial amount of land in isolated areas elevated above the PMF.
		Exit Route (E)	Areas that are not isolated in the PMF and have an exit route to community	Overland Escape (FEO)	Evacuation from the area relies upon overland escape routes that rise out of the floodplain.

			evacuation facilities (located on flood-free land).	Rising Road (FER)	Evacuation routes from the area follow roads that rise out of the floodplain.
Not Flooded (N)	The area is not flooded in the PMF			Indirect Consequence (NIC)	Areas that are not flooded but may lose electricity, gas, water, sewerage, telecommunications, and transport links due to flooding.
				Flood Free (NFA)	Areas that are not flood affected and are not affected by indirect consequences of flooding.

8.5 Flood Impacts on Infrastructure and Transport

The flood study (Cardno 2017) provided a review of the flood affectation of key infrastructure within the study area. The findings of this review have been reproduced in **Table 8-5**.

There are many transportation routes through the study area. Major arterial roads include the Princes Highway, Sapphire Coast Drive, Merimbula Drive and Arthur Kaine Drive. In the event of a flood-related emergency in Merimbula, people will primarily be required to use these major roads to evacuate the affected area. Consequently, it is critical to understand when and what sections of these roads overtop for effective emergency response planning. **Map G804** provides the details of flooded roads, including peak flood depths for a range of design flood events.

Table 8-5 Flood Affectation of Key Infrastructure (from Cardno, 2017)

Location	Flood Affectation
Emergency Responders	
Merimbula Police Station	The police station is located outside of the PMF extent and access from the station is not flood affected in events up to and including the PMF.
Merimbula Fire Station	The fire station is located outside of the PMF extent and access from the station is not flood affected in events up to and including the PMF.
SES	There are no SES facilities located within the study area.
Merimbula Ambulance Station	The ambulance station is located outside of the PMF extent and access from the station is not flood affected in events up to and including the PMF.
Merimbula Medical Centre	The centre is located outside of the PMF extent and access from the centre is not flood affected in events up to and including the PMF.
Main Street Medical Centre	The centre is located outside of the PMF extent and access from the centre is not flood affected in events up to and including the PMF.
Hospitals	There are no hospitals located within the study area.
Marine Rescue Merimbula	The Marine Rescue site is first inundated in the 20% AEP event by depths of up to 0.6m. These depths increase to 1.1m in the 1% AEP and 1.3m in the PMF The duration of flooding is typically dependent on the tidal cycle of the lakes, with flood water receding as the tide drops. During the community engagement as part of the flood study (2017) it was identified that there could be impacts on boat launching operations due to the boat ramp being inundation during a flood event. Additional engagement with Marine Rescue was undertaken in April and May 2020 and their representative advised that the recue vessels are housed on airberth on a floating pontoon next to the Marine Rescue Base off Spencer Park. They further advised that Marine Rescue do not use the boat ramp and would only use it to trailer their smaller vessel if needed outside of the local area.
Schools	
Merimbula Public School	The school is located outside of the PMF extent and access from the school is not flood affected in events up to and including the PMF.
Merimbula-Tura Kindergarten	The kindergarten is located outside of the PMF extent and access from the school is not flood affected in events up to and including the PMF.

Location	Flood Affectation
Aged Care Facilities	
Acacia Ponds	The Acacia Ponds retirement complex was classified as a high hazard zone in the 1% AEP and the PMF, and a low flood island in the emergency response classification. The site is first inundated in the 5% AEP event, although depths are low (0.02m). Depths of 0.16m occur in the 1% AEP and increase further to 0.56m in the PMF. The duration of flooding is typically dependent on the tidal cycle of the lakes, with flood water receding as the tide drops.
Sewer Treatment	
Sewerage treatment plant	The treatment facility is located outside of the PMF extent. Access is lost in the PMF to the north along Arthur Kaine Drive towards Merimbula but remain open in the PMF to the south, towards Pambula.
Caravan Parks	
Merimbula Lake Holiday Park	The park is located outside of the PMF extent. Access along the Pacific Highway is lost in the PMF to the north but remains open to the south towards Pambula.
Sapphire Valley Caravan Park	The caravan park experiences flooding at the edge of the site over internal roadways in the 20% AEP. Caravans and buildings are first affected in the 5% AEP event, with depths of 0.17m occurring onsite. These depths increase to 0.48m in the 1% AEP and to 2.23m in the PMF. The site is a high risk area as it operates as a low flood island, losing access along the driveway before the caravans themselves are inundated. The duration of flooding is typically dependent on the tidal cycle of the lakes, with flood water receding as the tide drops. Access from the caravan park is further restricted due to overtopping of Sapphire Coast Drive, albeit only for extreme events, with 0.35, of overtopping occurring in the PMF.
Regional Airport	
Merimbula Airport	The airport runway only experiences overtopping in the PMF event, although flood water encroaches right up to the runway edge in the 1% AEP event. The associated building and infrastructure are first inundated in the 2% AEP event by 0.02m. Flooding depths at buildings increase to 0.15m in the 1% AEP and 0.55m in the PMF event. Access is lost along Arthur Kaine Drive to the north in the PMF event and to the south in the 2% AEP event.

8.6 Cumulative Development Impacts

The cumulative impacts of development in the catchment and floodplain are often overlooked when assessing individual development applications. Without an understanding of how development may cumulatively impact on flooding, it is difficult for Council to advise on appropriate flood related controls on development as it occurs.

An assessment was undertaken to determine expected changes in flood behaviour if all land within the catchment was fully developed in accordance with the permissible land uses under Council's LEP. Potential future development areas (i.e. where development is permissible but does not already occur) are shown in **Map G805**. These locations are not within the floodplain and so development within these locations will only impact upon the hydrology (i.e. runoff into the floodplain) rather than obstructing floodwaters or reducing flood storage.

The potential future development areas were assumed be fully impervious and the impacts on catchment hydrology were assessed using the XP-RAFTS model developed for the Flood Study (Cardno, 2017). The changes in flows are shown in **Table 8-6** for both local subcatchment and total catchment flows.

For subcatchment M13, which flows directly into Merimbula Lake, both local and total flows from XP-RAFTS are the same, as there are no upstream catchment areas. While future development resulted in an increase in total flows, as the subcatchment is located right on the shore of Merimbula Lake it will not result in increased lake levels, as the flow increase is negligible compared to the total flow into the lake.

The subcatchment of B11 is located upstream of Back Lake. There was a 28% increase in local flows as a result of possible future development. The impact on total flows was negligible. These results indicate that future development in this location is not going to impact peak flood levels. The increase in local flows indicate that the impacts on local drainage will need to be assessed. The marginal increase in total flows however will not result in any change to peak lake levels.

The final region for which future development is possible is located in subcatchment B13, on the northern shores of Back Lake. The future development resulted in an increase in local flows of 8%. No change was observed in the total flows. As such, similar to the other areas, the increased local flows indicate a need to consider the local drainage network in any future development, but the development would not result in any peak water level changes in Back Lake.

Table 8-6 Impact of Future Development on XP-RAFTS Flows

Subcatchment	Local Flows		Total Flows	
	Existing Flow (m^3/s)	Developed Flow (m^3/s)	Existing Flow (m^3/s)	Developed Flow (m^3/s)
M36	58	74	58	74
B11	29	37	316	317
B13	51	55	317	317

8.7 Impacts of Proposed Works

8.7.1 Airport Masterplan

An airport masterplan has been developed for Merimbula Airport (Rehbein Airport Consulting, 2013) as well as a development strategy (Aurecon, 2011) to assist Council in managing development and land-use for the airport precinct.

The works aim to address future aviation needs, as well as ensuring the runways and associated infrastructure are protected from the higher lake levels expected to occur as a result of climate change.

The proposed masterplan would see the runways extended at both north and south ends by 200 metres and 120 metres respectively, and the tarmac raised to increase the airports flood immunity. An indication of the extent of the proposed works is shown in **Figure 8-3**.

These changes were incorporated into the Delt3D model and run for the 1% AEP event for existing and climate change scenarios.

The assessment found that the works proposed under the airport masterplan do not impact flood behaviour, with no level differences observed either across the site or within the adjacent floodplain.

This is due to the flood storage being removed as part of the works being negligible compared to the storage available in the wider lake system.

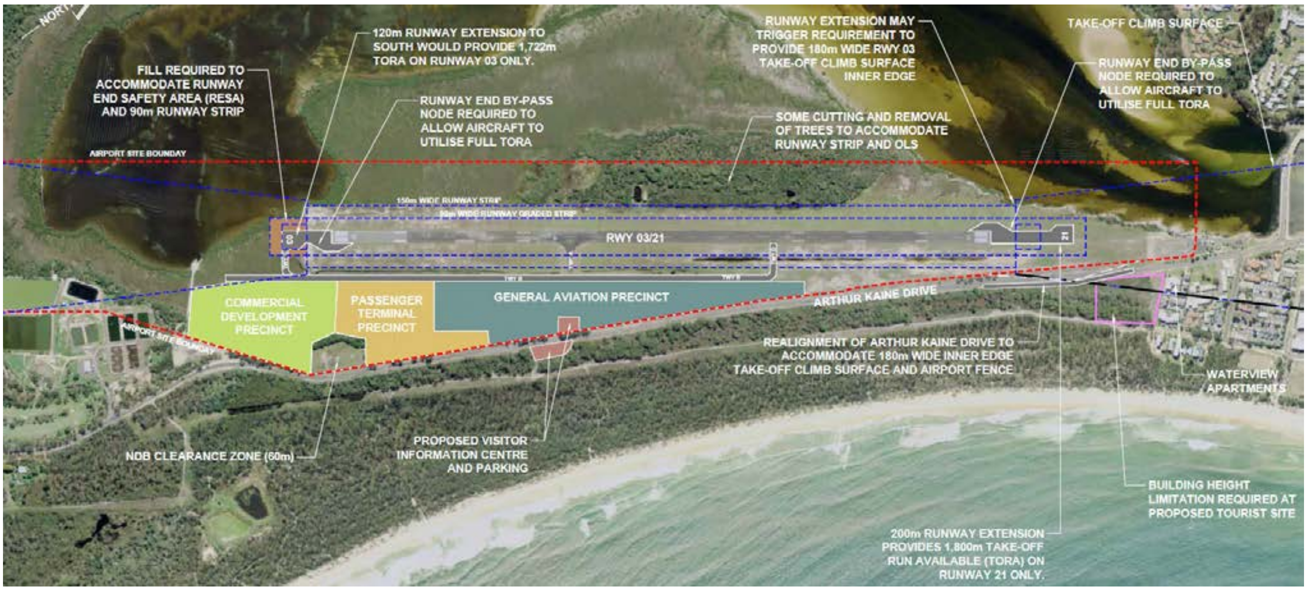


Figure 8-2 Proposed Airport Revisions (taken from Rehbein Airport Consulting, 2013)

8.7.2 Merimbula Service Road

The location of the Merimbula Service Road is shown in **Figure 8-4**. As can be seen in the figure, the road runs from Sapphire Coast Drive to the rear of properties facing Main Street. The northern portion of the road passes through the 1% AEP flood extent.

Flood function has been revised as part of this study (refer Section 8.3). Figure 8-4 shows that the bypass is outside of the floodway and lies within storage and flood fringe zones of the 1% AEP.

Given that there is substantial storage within the Back Lake system, it is not expected that the loss of this relatively small volume of flood storage will have any impact on peak flood levels.

It is noted that the northern extent of the service road lies close to the floodway, and that velocities in this region are in the order of 0.8 – 0.9 m/s in the 1% AEP event. Sufficient protection should be provided to the embankment in this region to prevent erosion in large flood events.

Figure 8-3 Merimbula Service Road Location and Flood Function

8.7.3 Merimbula Bypass

The Merimbula Bypass was constructed in 2015 to improve traffic flow within the Merimbula CBD. The location of the bypass is shown in Figure 8-5. The bypass was incorporated into the Tuflow model and the model was run for the 5% AEP and 1% AEP events to investigate the impacts on flood behaviour.

Flood level differences are shown in **Figure 8-6** and **Figure 8-7** for the 5% AEP and 1% AEP respectively. Note that level differences are not shown across the works area, as the change in ground levels through these regions makes comparisons difficult.

The results show that the bypass has reduced the depths of flooding through the plaza downstream of the carpark, facing Main Street. Reductions were typically in the order of 0.02 – 0.05 metres in both events, although there were reductions of up to 0.1 metres in the 5% AEP event along Main Street.

This improvement is being driven by improved conveyance of floodwaters from within the carparks upstream of the plaza, and along the bypass, reducing the level of ponding occurring in the carparks, and hence the amount of flow breaking out of the carpark and flowing through the downstream commercial area.

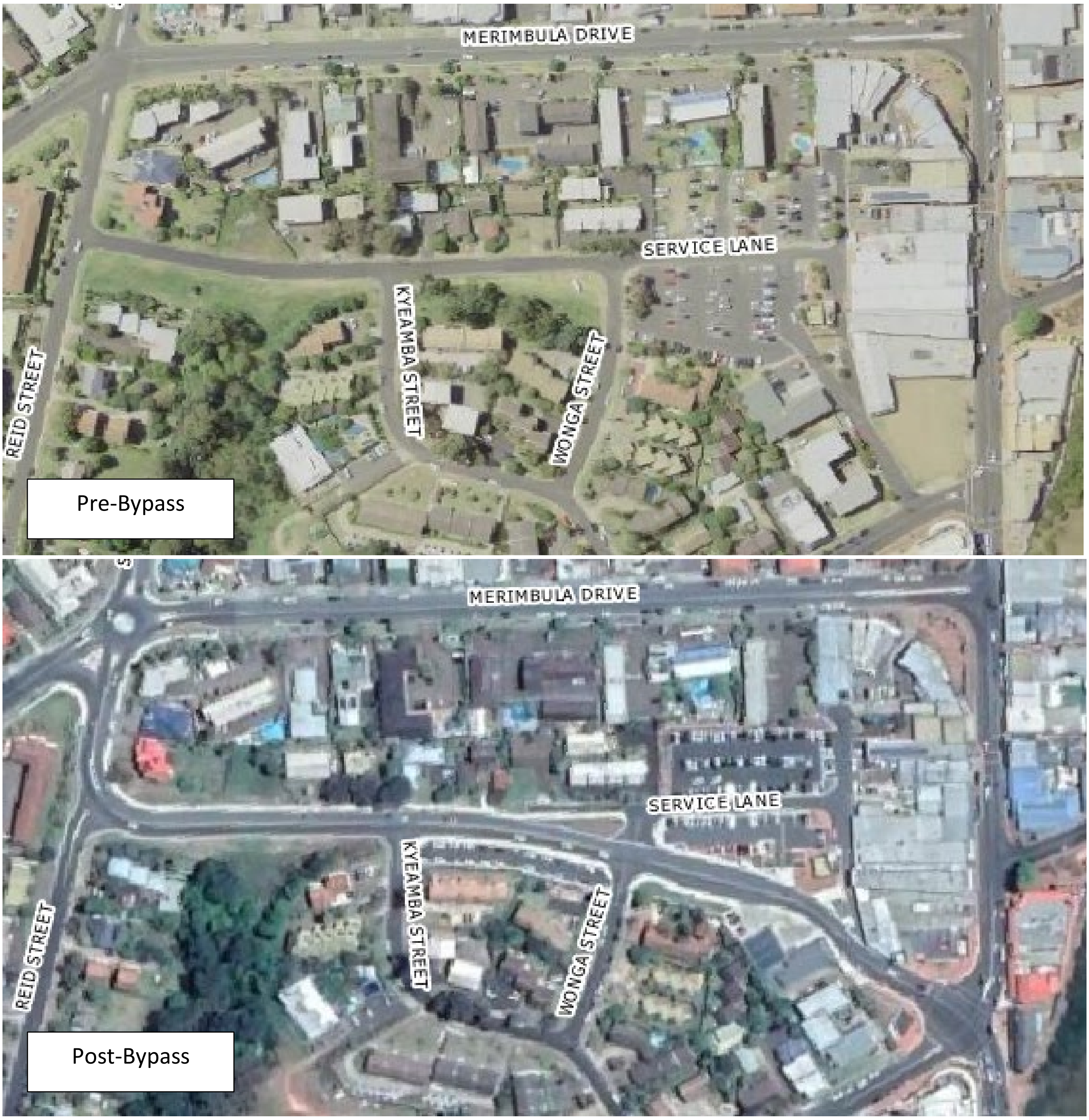


Figure 8-4 Merimbula Bypass Works

Figure 8-5 **5% AEP Bypass Impacts**

Figure 8-6 **1% AEP Bypass Impacts**

8.8 Climate Change Impacts

The Flood Study (2017) assessed climate change scenarios incorporating a 0.4m and a 0.9m rise in sea levels for the 1% AEP event, representing 2050 and 2100 climatic conditions. The assessment examined the impacts on both tidal extents and flood behaviour. The results show that flooding increases vary significantly across properties. As would be expected, those properties near the lake edges are most prone to affectation by sea level rises, while the impacts are reduced for those properties located further upstream. While the average flood increase across affected properties was 0.22m in 2050 and 0.45m in 2100, peak impacts were almost double these heights; 0.38m and 0.87m in 2050 and 2100 respectively.

Additional modelling was undertaken as part of this FRMS to assess a wider range of climate change scenarios. The results of the analysis are shown in **Map G806-1 to G806-10**. The results are shown as an increase in flood depth when compared to the existing scenario.

Table 8-7 Climate Change Model Runs

Climate Change Scenario	Description	Difference Map (difference in peak flood levels when compared to existing case)
A	1% AEP 0.4m SLR	G806-1
B	0.5% AEP 0.4m SLR	G806-2
C	0.2% AEP 0.4m SLR	G806-3
D	PMF 0.4m SLR	G806-4
E	1% AEP 0.9m SLR	G806-5
F	0.5% AEP 0.9m SLR	G806-6
G	0.2% AEP 0.9m SLR	G806-7
H	PMF 0.9m SLR	G806-8
I	1% AEP 0.4m SLR with 10% increase in rainfall intensity	G806-9
J	1% AEP 0.9m SLR with 30% increase in rainfall intensity	G806-10

9 Floodplain Risk Management

Flood risk is a combination of the likelihood of occurrence of a flood event and the consequences of that event when it occurs. It is the human interaction with a flood that results in a flood risk to the community. This risk will vary with the frequency of exposure to this hazard, the severity of the hazard, and the vulnerability of the community and its supporting infrastructure to the hazard. Understanding this interaction can inform decisions on which treatments to use in managing flood risk.

As defined in the *Australian Disaster Resilience Handbook 7 – Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR, 2017), there are three types of flood risk:

- Existing flood risk – the risk associated with current development in the floodplain. Knowing the likelihood and consequences of various scales of floods can assist with decisions on whether to treat this risk and, if so, how
- Future flood risk – the risk associated with any new development of the floodplain. Knowing the likelihood and consequences of flooding can inform decisions on where not to develop and where and how to develop the floodplain to ensure risks to new development and its occupants are acceptable. This information can feed into strategic land-use planning
- Residual flood risk – the risk remaining in both existing and future development areas after management measures, such as works and land-use planning and development controls, are implemented. This is the risk from rarer floods like the PMF, which may exceed the management measures. Residual risk can vary significantly within and between floodplains. Emergency management and recovery planning, supported by systems and infrastructure, can assist to reduce residual risk

The alternate approaches to managing risk are outlined in **Table 9-1**.

Table 9-1 Flood Risk Management Alternatives

Alternative	Examples
Preventing/avoiding risk	Appropriate development within the flood extent
Reducing the likelihood of risk	Structural measures to reduce flooding risk such as drainage augmentation, levees, and detention
Reducing the consequences of risk	Development controls to ensure structures are built to withstand flooding
Transferring risk	Via insurance – may be applicable in some areas depending on insurer
Financing risk	Natural disaster funding
Accepting risk	Accepting the risk of flooding because of having the structure where it is

Measures available for the management of flood risk can be categorised according to the way in which the risk is managed. There are three broad categories of management:

- Flood modification measures – options aimed at preventing/avoiding or reducing the likelihood of flood risks through modification of flood behaviour in the catchment
- Property modification measures – options focused on preventing/avoiding or reducing the consequences of flood risks. Rather than necessarily modify flood behaviour, these options aim to modify existing properties (e.g. by house raising) and/or impose controls on property and

infrastructure development to modify future properties. Property modification measures, such as effective land use planning and development controls for future properties, are essential for ensuring that future flood damages are appropriately contained, while at the same time allowing ongoing development and use of the floodplain

- Emergency response modification measures – options focused on reducing the consequences of flood risks, by generally aiming to modify the behaviour of people during a flood event.

A range of possible options were considered as part of this FRMS and are discussed in the following sections. The proposed measures contemplate catchment and ocean flooding, since the study area is subjected to both.

9.1 Flood Modification Measures

9.1.1 Preliminary Options Identification

A range of potential flood modifications options were identified that could reduce the impact of flooding in the study area. These options were based on the flood modelling results and the outcomes of the community engagement process.

A list of the preliminary options is provided in **Table 9-2**, along with an initial review of their suitability for further assessment.

The locations of the options are shown in **Map G901**.

Several options were assessed in further details through one or more of the following:

- Preliminary flood modelling (testing of impacts of option on 1% AEP flood behaviour)
- Detailed flood modelling (modelling of design flood events)
- Economic damages assessment.

Table 9-2 Preliminary List of Flood Mitigation Options

ID	Option Description	Issue at Location	Expected Benefit	Constraints / Feasibility	Compatible with Climate Change Conditions	Detailed Assessments Undertaken
Road Improvements These options propose to lift road levels to improve access during flood events, and to protect adjacent properties from inundation						
RI-1	Raising of Fishpen Road 0.2m in 10% AEP 0.4m for 5% AEP 0.5m for 2% AEP 0.6m for 1% AEP	Access along Fishpen Road is lost before properties are inundated, create evacuation and emergency access issues. Adjacent properties are also flooded from elevated lake levels.	A raised road would improve access during flood events, and also function as a flood wall to protect adjacent properties from lake inundation.	Maintaining connections to adjacent roads and properties would need to be considered as part of any design for the road raising.	Yes, although the level of protection will be reduced over time as sea level rise. Alternatively, adaption could be undertaken in stages to respond to climate change.	Flood damages assessment undertaken in Section 9.1.2.3
RI-2	Provision of second bridge (or opening) on Market Street causeway.	Community submission noted that the channel used to run adjacent to Fishpen Road. It was perceived that the relocation of the channel has resulted in a reduction in lake flushing.	Improved conveyance through the structure, with a possible reduction in peak levels upstream.	Major works that would likely result in disruption to traffic. There is also likely to be a limited benefit in terms of flooding, due to minimal impacts across the upstream shores of Merimbula Lake, and the fact that levels are largely controlled by the entrance and ocean levels.	Yes	1% AEP modelling showed no significant benefit of this option - Section 9.1.2.1
RI-3	Raising of access road to Acacia Ponds Village	Development is currently isolated in the 1% AEP event, and a low flood island in the PMF	Provide rising road access from development up to and including the PMF	RMS have advised that they plan to add a turning lane on the Princes Highway at this location. These works could be incorporated together with the entrance improvement to Acacia Ponds.	Yes. Rising road access will be maintained under climate change scenarios.	Assessed further as an emergency response option in Section 9.2.1
RI-4	Raising of footpath at Main St - Beach St intersection (raised 0.2m to achieve 1% AEP level)	Overland flows currently breakout of the road reserve upstream of the intersection and flow through downstream properties to lake.	Would force water to remain within road reserve and would move discharge location to the open space on Beach Street.	No major constraints given relatively small height to be raised.	Yes.	This option addresses road flooding and has be assessed further as an emergency response option in Section 9.2.2
RI-5	Raising of Green Point Road and augmentation of culvert under Green Point Road	Residents have raised a concern with the crossing. The low point of the road cuts off all properties along Green Point Road. Residents noted that this can be for up to 6 hours.	This is a key access issue as flooding of the road at this location cuts off properties along Green Point Road for up to 6 hours (based on residents' observations).	No major constraints.	Yes	Assessed further as an emergency response option in Section 9.2.3
RI-6	Replace the causeway with an open span bridge	Community observation has suggested that flushing has been reduced since the causeway has been constructed.	Increased flushing of upstream regions, with a possible reduction in peak upstream levels.	Major works that would likely result in disruption to traffic. There is also likely to be a limited benefit in terms of flooding, due to minimal impacts across the upstream shores of Merimbula Lake, and the fact that levels are largely controlled by the entrance and ocean levels.	Road could be raised above the 1%AEP with SLR	1% AEP modelling showed no significant benefit of this option - Section 9.1.2.1

ID	Option Description	Issue at Location	Expected Benefit	Constraints / Feasibility	Compatible with Climate Change Conditions	Detailed Assessments Undertaken
RI-7	Raising of Millingandi Road	Local catchment flows upstream of Millangandi Road result in loss of access in 20% AEP and greater events, with depths of up to 0.45m occurring in the 1% AEP.	This is a key access issue as flooding of the road at this location cuts off properties along Millingandi Road.	No major constraints.	Road could be raised above the 1%AEP with SLR	Assessed further as an emergency response option in Section 9.2.3.
RI-8	Raising of Arthur Kaine Drive	Overtopping of road with depths of up to 0.25m in the 1% AEP. The route is an important access route for the Fishpen Road precinct, allowing access south in the event that access across the lake is lost.	Improved access and evacuation for the Fishpen Road precinct and Merimbula Airport. Coupled with the option below, this would provided a flood free route from Pambula to Merimbula and Berrambool.	No major constraints	Road could be raised above the 1% AEP with SLR	Assessed further as an emergency response option in Section 9.2.5.
RI-9	Raising of Market Street	Despite the Market Street bridge and causeway remaining flood free in the PMF, the length of Market Street between the bridge and Short Street is flooded in the 1% AEP preventing access to the Fishpen Road region from the north.	Improved access and evacuation for the Fishpen Road precinct and Merimbula Airport. Coupled with the option above, this would provided a flood free route from Pambula to Merimbula and Berrambool.	No major constraints	Road could be raised above the 1% AEP with SLR	Assessed further as an emergency response option in Section 9.2.5.
Vegetation and Sediment Management These options are associated with managing the build-up of sediment and vegetation within creeks						
VSM-1	Removal of sediment from within Merimbula Creek	Residents have noted a build up on sediment within the lower portion of Merimbula Creek and are concerned that it is impacting flood behaviour.	The removal of deposited sediment may result in improved conveyance, and lower upstream flood levels.	The process may need to be undertaken on an ongoing basis, as additional material is deposited in the system.	It is uncertain whether sediment loads would increase under changing rainfall and sea level conditions. This would require ongoing monitoring.	1% AEP modelling showed no significant benefit of this option - Section 9.1.2.1
VSM-2	Vegetation management along Merimbula Creek (between Sapphire Valley Caravan Park and Munn Street)	Dense riparian vegetation growth and fallen trees lying across the channel have been observed by residents to cause blockage during high flow events, causing road overtopping and flooding of overbank areas.	The management of vegetation will increase conveyance and reduce channel and bridge blockages, reducing the flooding.	Management of vegetation would need to be done in a manner that maintains (or enhances) existing riparian habitat and native species.	Yes, conveyance improvements would continue to provide benefits under climate change scenarios.	1% AEP modelling showed no significant benefit of this option - Section 9.1.2.1
Entrance Management These options are associated with the management of the entrances with regard to improving flood conditions in the system						

ID	Option Description	Issue at Location	Expected Benefit	Constraints / Feasibility	Compatible with Climate Change Conditions	Detailed Assessments Undertaken
E-1	Wide scale dredging across Merimbula Lake entrance - reduce bed levels by 0.5m across whole area downstream of Market Street Bridge.	The community has raised concerns about the impact of deposited sediments within the Merimbula Lake Entrance and the impact of these on flooding.	During a flood event, the whole mouth of the estuary is active flow. Targeted dredging (e.g. along the deeper channel) is unlikely to improve conveyance. This option aims to evaluate the impacts of large scale entrance conveyance increase.	Likely impacts on benthic species, oyster leases and visual amenity (turbidity immediately following dredging).	Unknown. Improved entrance conveyance could actually increase the volume of flow into the estuary during storm surge event, resulting in increased flood levels. This could worsen under sea level rise conditions.	1% AEP modelling showed no significant benefit of this option - Section 9.1.2.1
E-2	Permanently open the entrance of Merimbula Lake (e.g. training wall along western side of channel)	The community has raised concerns about the impact of deposited sediments within the Merimbula Lake Entrance and the impact of these on flooding.	A training wall at the entrance may improve conveyance through the entrance during a flood event. This could allow catchment flows to drain into the ocean more effectively, or it may allow additional flow into the lake during a storm surge event.	Visual impacts. Impacts on the surfing conditions. Impacts of dredging on benthic species.	Unknown. Improved entrance conveyance could actually increase the volume of flow into the estuary during storm surge event, resulting in increased flood levels. This could worsen under sea level rise conditions.	1% AEP modelling showed no significant benefit of this option - Section 9.1.2.1
E-3	Testing of Back Lake entrance management plan.	Flooding during more frequent events appears to be driven by the water level at which the entrance is mechanically or naturally opened. The community have questioned the impact of the opening level on more significant flood events.	A reduced berm height and starting water levels would be reviewed to assess the impacts of changing the entrance management plan (i.e. reducing the trigger level).	The trigger level in the currently adopted EMP has been based upon a balance of asset protection and estuarine health and natural function. Any changes to this level would need to be assessed against the full range of issues raised within the REF supporting the current EMP.	Large flood events in Back Lake are sensitive to rainfall intensity. If rainfall intensity increases with climate change, there may be merit in reducing the EMP trigger level. Reducing the trigger level within the EMP may result in an increase in flooding associated with storm surge.	Detailed assessment provided in Section 9.1.2.4

9.1.2 Detailed Options Assessment

9.1.2.1 Preliminary Flood Modelling of Flood Modification Options

For those options noted as being suitable for further assessment using the flood models in **Table 9-2**, an initial analysis was undertaken for the 1% AEP event to determine if the option was delivered improvements in flood behaviour before running the full suite of AEP events.

This assessment was undertaken for:

- RI-2 Provision of second bridge on Market Street causeway
- RI-6 Replacing Market Street causeway with an open span bridge
- VSM-1 Removal of sediment from within Merimbula Creek
- VSM-2 Vegetation management along Merimbula Creek
- E-1 Wide-scale dredging across Merimbula Lake entrance
- E-2 Permanently open entrance.

The 1% AEP assessment found that none of these options delivered any benefits to flood behaviour, with peak lake levels either remaining unchanged, or changing by less than 0.02 meters. This is because while catchment flows can drain from the lake with less resistance, the same increased efficiency allows coastal water levels to enter the lake system. With catchment inflows being relatively small compared to the volume of Lake Merimbula it is the interaction of the inflows and coastal water levels that determine peak flood levels in the Lake. Hence, increased entrance efficiency does not reduce peak flood levels and may result in adverse flood conditions due to the influence of coastal driven flood events.

The vegetation management option was further assessed for the 20% AEP to determine if it was any more effective in smaller events. The results found that vegetation works along the creek did not result in any water level changes for the long duration 6 hour event, and only minor reductions of less than 0.02m in the shorter 3 hour duration storm. The lack of benefit, from a flooding perspective, is due to the entrance and lake storage governing flood levels in the region.

As such, these options have not been considered further.

9.1.2.2 Detailed Assessment of Flood Modification Options

For those options that were deemed suitable for further assessment, the following has been undertaken:

- An assessment of the model in the hydrodynamic and/or hydraulic model to quantify the changes in flood behaviour; and,
- A damages assessment to ascertain the reduction in flood damages that arises from the option.

This analysis is detailed for those options deemed suitable for further assessment based on the preliminary investigations.

9.1.2.3 RI-1 Raising of Fishpen Road

Description

Fishpen Road is an 800 metre arc running along the Merimbula Lake foreshore between the southern end of the Merimbula Bridge (Market Street) to the roundabout with Ocean Street at Mitchies Jetty. Under existing conditions, access to properties along Fishpen Road is lost during flood events, due to the road submerging at various points. Although many properties are not inundated, appropriate evacuation procedures still need to be undertaken to ensure the safety of all individuals.

Opportunities and Constraints

The main purpose of raising Fishpen Road is to enhance its flood immunity and mitigate the risk of blocked access to properties along it. This will increase the benchmark for flood evacuation and also act as a flood wall to further protect properties from inundation. Due to its proximity to Merimbula Lake, which has a large storage capacity and flows out to Merimbula Bay and the South Pacific Ocean, the raising of Fishpen Road is expected to have a negligible impact on storage levels within the lake. The raised road will result in some storage area being made available upstream of the road. Due to the small contributing catchment, local rainfall is not expected to result in significant ponding in this area. Cross drainage would require flood gates to allow this region to drain once lake levels have fallen.

Damages Analysis

There is a total of 21[3] flood-affected properties within the vicinity of Fishpen Road that can potentially benefit from its raising. Four alternatives were considered as part of the damages analysis; raising to the 1%, 2%, 5% and 10% AEP levels. These are detailed in **Table 9-3**.

Table 9-3 RI-1 Raising of Fishpen Road – Results

Amount of Raising (m)	Flood Event (AEP)	Flood-Affected Properties			Average Annual Damage (AAD) ($)			Benefit-Cost Ratio (BCR)
		Base Case	Upgrade	Change	Base Case	Upgrade	Change	
0.2	10%	0	0	-	54,251	54,251	-	-
0.4	5%	3	0	-3		43,014	-11,237	0.17
0.5	2%	9	2	-7		31,495	-22,756	0.20
0.6	1%	17	5	-12		24,735	-29,516	0.18

As expected, the AAD savings increase as Fishpen Road is raised further. This location represents the highest concentration of flood affected properties in the study area. As such, the higher road raising options result in significant reductions in the AAD. In the case of providing 1% AEP immunity, the option reduces the damages by more than 50%.

Despite this improvement however, the relatively low AAD for the study area means that the construction costs of the options (refer Appendix) significantly outweigh the flood damage benefits. All the options had a benefit-cost ratio (BCR) of approximately 0.2, indicating that the options cost five-times as much to construct, compared to the benefits they offer.

9.1.2.4 E-3 Testing of Back Lake Entrance Management Plan

The management policy was not investigated as part of the flood study, which adopted a berm level of +3.10mAHD and starting lake water level of +1.40mAHD in the 1% AEP modelled scenarios. As part of the management option assessment the following entrance management actions were assessed in the Delft3D model:

- **Base Case**: No manual opening or entrance management undertaken. Berm height at 3.1mAHD.
- **Option E-3a**: Existing Entrance Management Policy: The simulation was started with a pilot channel dredged at +1.4mAHD through the berm (at 3.1mAHD) to promote breakout at the trigger level.

[3] Considers properties along Burton Avenue, Calendo Court, Chapman Avenue, Fishpen Road and Marine Parade.

- **Option E-3b**: Entrance Management Policy with a trigger level of +2.0mAHD. The simulation was started with a pilot channel dredged at +2.0mAHD through the berm (at 3.1mAHD) to promote breakout at a higher trigger level.
- **Option E-3c**: Alternate Entrance Management Policy of Berm Level Maintenance with a crest level at or below +2.5mAHD. The berm crest level in the model was reduced to +2.5mAHD. The management strategy assumes that no pilot channel is dredged in advance of the flood.
- **Option E-3d**: Alternate Entrance Management Policy of Berm Level Maintenance with a crest level at or below +2.0mAHD. The berm crest level in the model was reduced to +2.0mAHD. The management strategy assumes that no pilot channel is dredged in advance of the flood.

All options were modelled with a dynamic entrance that allowed the berm to scour based on the flow behaviour.

The results of the entrance management options are shown in Figure 9-1. The results showed that entrance management has a direct influence on 1% AEP peak flood levels, with the existing policy (Option 3a) providing a material reduction in peak flood levels when compared to not applying the policy (Base Case). However, these results also indicate that if these management works are not undertaken then the flooding will be significantly adversely affected. The ability to implement opening works during flood events is an inherent concern with reactive entrance management policies, where safety, personnel or equipment issues may prevent Council from being able to open the entrance in advance of the flood.

Option 3b demonstrate that raising the trigger level for the entrance management policy by 0.6m, will increase the peak 1% AEP flood level by approximately 0.1m.

Options 3c and 3d demonstrate the influence of the berm crest level at the time of the storm:

- If the berm height is at 2.5mAHD and no manual opening is undertaken, the peak flood levels are significantly higher than the peak levels when the berm is at 3.1mAHD, but manually opened when water levels reach 1.4mAHD (i.e. the existing entrance management policy).
- However, if the berm height is at 2mAHD and no manual opening is undertaken, the peak flood levels are slightly reduced when compared to the peak levels when the berm is at 3.1mAHD, but manually opened when water levels reach 1.4mAHD (i.e. the existing entrance management policy).

Council may therefore consider an alternate method for entrance management of maintaining berm crest levels by way of beach scrapping. Such an option would require regular entrance works, however would be considered a proactive management option, as opposed to reactive one in response rising lake water levels or forecast rainfall.

It is noted that any revision to the entrance management policy would need to be undertaken within a Coastal Management Program, in line with the Coastal Management Act.

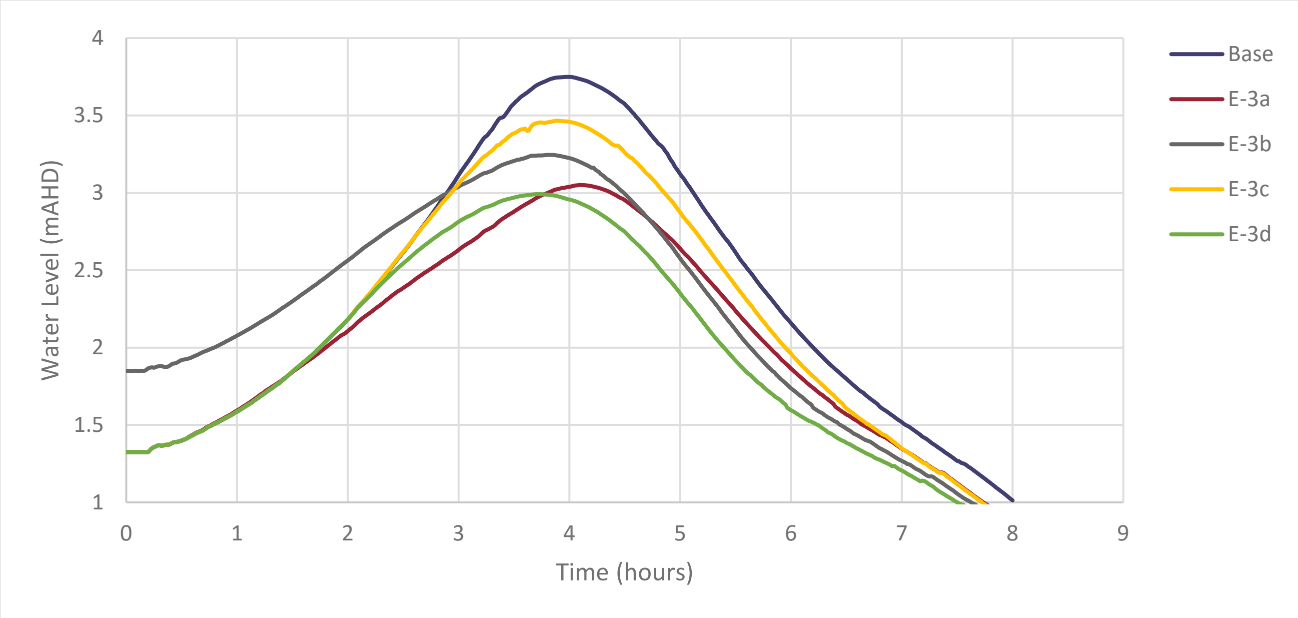


Figure 9-1 Back Lake Water Levels under various Entrance Management Options

9.2 Emergency Response Options

Emergency response modification measures aim to reduce the consequences of flood risks by:

- Increasing the effective warning time, such as via the use of flood warning systems
- Planning the evacuation of an area so that it proceeds smoothly during a flood event
- Preparing for a flood event (e.g. stockpiling sand and sandbags for future deployment)
- Enabling recovery following a flood event.

These types of measures are typically incorporated into the local flood plan, and education of the community on the contents of the plan is very important. As noted within the Floodplain Development Manual (NSW Government, 2005) these measures effectively modify the response of the community at risk to better cope with a flood event.

Of all the floodplain risk management options available for consideration, it is only emergency management modifications (which includes community planning) that addresses the residual flood risk after all the flood and property modification options have been implemented. Emergency management and education measures are an effective ongoing flood risk management tool (NSW Government, 2005).

The emergency response options assessed in this study were developed in consultation with both local and regional representatives from NSW SES.

9.2.1 RI-3 Raising of Access Road to Acacia Ponds Village

Acacia Pond Village is located on the western foreshore of Merimbula Lake, with access from the Princes Highway. The village is a senior living development. Development on this site is controlled under the *State Environmental Planning Policy (Housing for Seniors and People with a Disability) 2004*. Being a private property with State Government development controls (rather than Council) means that managing flood risk on the site by Council may be limited. However, this study has identified that the access road to Acacia Ponds (off Princes Highway, opposite Stringy Bark Place) is inundated in 2% AEP and greater events. An estimate of the maximum depth of flooding for a range of design events is provided in **Table 9-4**. It is recommended that Council liaise with the Acacia Ponds management to ensure that they are aware of this issue. It should be recommended to the village management that the access road be raised to improve access during a flood event.

Consultation with TfNSW during this study (**Section 5.2**) identified that an additional left turning lane is being proposed on Princes Highway for turning into Green Point Road, it may be useful for Acacia Ponds Village to liaise with TfNSW to see if any upgrades to the access road can be done in conjunction with the Princes highway works.

Table 9-4 Acacia Ponds Village Access Road Flooding

Flood Event (AEP)	Maximum Depth of Flooding on Acacia Ponds Access Road (m)
5%	-
2%	0.14
1%	0.28
PMF	0.69

9.2.2 RI-4 Footpath Raising at Main Street

It was observed in the overland flow assessment that flows currently breakout of the road reserve upstream of the intersection and flow through downstream properties to lake. In the 5% AEP event and greater, overland flow breaks out of the road reserve to cut through properties south of the road towards the lake.

The option proposes the construction of an earthen bund for approximately 100 metres between the gutter and the footpath along side Main Street to better contain overland flows within the road reserve. The raising would contain flows up to and including the 1% AEP within the road corridor and preventing overland flow through adjacent properties.

This option removes nuisance flooding from adjacent properties and improves pedestrian mobility during flood events, which may assist in emergency access or resident evacuation.

9.2.3 RI-5 Raising of Green Point Road

Residents living on Green Point Road attended the community drop in sessions in December 2018. They raised the issue of flooding of Green Point Road approximately 240m from Princes Highway due to flows from the small unnamed creek. This flooding was observed by residents as occurring after 'heavy rain' and effectively cutting off access to properties on Green Point Road for up to 6 hours.

This location was not included in the flood modelling and mapping presented in the Flood Study (2017). As such, a site specific assessment of flooding was undertaken to assess the flood impacts at this location and to provide preliminary design inputs to assist with upgrading the road to reduce flooding of the road and maintaining access during flood events.

A local 1D hydraulic model was constructed that incorporated the road crest, the culvert and the upstream flow from the hydrological model. A stage discharge relationship was developed for the downstream boundary.

The option developed provides immunity in the 1% AEP event and is comprised of:

- Three 1200 * 600 box culverts to convey the flow; and
- Raising the roadway by 0.5 metres which provides a 0.5 metre freeboard in the 1% AEP, and provides some capacity to manage future increases in flow arising from climate change.

9.2.4 RI-7 Raising of Millingandi Road

Millingandi Road provides a key access route for a number of rural properties. There is access to Millingandi Road via Princes Highway in the South, Millingandi Short Cut Road, and Princes Highway to the North (outside of the study area). Millingandi Road is flooded at the causeway in all design events assessed as a result of upstream catchment flows exceeding the cross drainage capacity. This flooding is considered high hazard (H5) in all events. It is noted that Millingandi Short Cut Road is also flooded and that Millingandi Road is likely to flood at other locations for short periods of time due to local flows from small creeks. However, this location poses the greatest impact on access.

A local 1D hydraulic model was constructed that incorporated the road crest, the culvert and the upstream flow from the hydrological model. A stage discharge relationship was developed for the downstream boundary.

The option developed provides immunity in the 1% AEP event and is comprised of:

- Three 2400 *1500 box culverts to convey the flow; and
- Raising the roadway by 1.1 metres which provides a 0.5 metres freeboard in the 1% AEP, and provides some capacity to manage future increases in flow arising from climate change.

Figure 9-2 Causeway on Millingandi Road

9.2.5 RI-8 Raising of Arthur Kaine Drive

Arthur Kaine Drive is the sole access route south for the Fishpen Road precinct and Merimbula Airport, should access be lost across the causeway, as a result of flooding on Market Street south of Short Street (the bridge remains flood free). Arthur Kaine Drive is first inundated in the 2% AEP event by depths of up to 0.15m. These depths increase to 0.3m in the 1% AEP event and 0.7m in the PMF event.

The proposed option would see an approximately 500m long section of road raised to the 1% AEP flood level. It is noted that additional raising may be required in the future due to rising sea levels if this level of immunity is desired to be retained.

The raising would see a minor loss of flood storage on the eastern side of the roadway. Given this storage volume is negligible compared to the volume of Merimbula Lake, the loss is unlikely to adversely affect flood levels in the region.

9.2.6 RI-9 Raising of Market Street

Market Street is the sole access route North for the Fishpen Road precinct and Merimbula Airport, should access be lost along Arthur Kaine Drive. Market Street is flooded between the bridge abutment and Short Street, and is first inundated in the 1% AEP event by depths of up to 0.15m. These depths increase to 0.3m in the PMF event.

The proposed option would see an approximately 250m long section of road raised to the 1% AEP flood level. It is noted that additional raising may be required in the future due to rising sea levels if this level of immunity is desired to be retained.

The raising would see a minor loss of flood storage on the western side of the roadway. Given this storage volume is negligible compared to the volume of Merimbula Lake, the loss is unlikely to adversely affect flood levels in the region.

9.2.7 Emergency Response for Acacia Ponds

The Acacia Ponds retirement complex was classified as a high hazard zone in the 1% AEP and the PMF, and a low flood island in the emergency response classification.

The site is first inundated in the 5% AEP event, although depths are low (0.02m). Depths of 0.16m occur in the 1% AEP and increase further to 0.56m in the PMF. The duration of flooding is typically dependent on the tidal cycle of the lakes, with flood water receding as the tide drops.

Given that residents at this location are elderly, the timely evacuation of these residents is critical to ensure it occurs before access from the site is lost.

It is recommended that the retirement village prepare a flood response plan that includes:

- Details of roles and responsibilities in the case of a flood event
- Sources of information to inform when actions detailed in the plan are required
- Trigger levels for lake levels and / or rainfall for implementing the plan
- Identifies alternative meeting / accommodation locations for residents during and after a flood event.

It is noted that the responsibility for the preparation of this plan lies with the retirement village. However, it is recommended that Council communicate the outcomes of this study with the owners, and attempt to work with them, and SES in developing a flood plan for this site.

9.2.8 Emergency Response for Sapphire Coast Holiday Park

The caravan park experiences flooding at the edge of the site over internal roadways in the 20% AEP. Access along the entry road is lost in the 10% AEP and caravans and buildings are first affected in the 5% AEP event, with depths of 0.17m occurring onsite. These depths increase to 0.48m in the 1% AEP and to 2.23m in the PMF.

The site is a high-risk area as it operates as a low flood island, losing access along the driveway before the caravans themselves are inundated. The duration of flooding is typically dependent on the tidal cycle of the lakes, with flood water receding as the tide drops.

As per the retirement village above, it is recommended that the caravan park prepare a flood response plan. Again, as per the retirement village, the responsibility for this plan lies with the caravan park. However, Council would be able to discuss the findings of this study with the park owners and assist them in developing the plan in consultation with Council and SES.

9.2.9 Flood warning system

A flood warning system provides Council and the community with advance notice of potential flood events based either on rainfall or lake levels.

There is already flood warning system in place for dangerous weather conditions, based on BoM advice of potential and actual east coast low events, as well as weather warnings related to high rainfalls. These warnings are typically provided for large regions of the eastern coast, rather than on a per township basis.

Warnings for the local catchment, based on local conditions could be tied to either rainfall or lake levels. Given the fact that the most significant flood impacts in the catchment are driven by lake flooding, the existing MHL gauges installed for both Merimbula and Back Lake could be utilised for this purpose.

At a minimum, the operators of the Sapphire Coast Holiday Park and Acacia Ponds, and the properties along Fishpen Road should be made aware of this data. An automated alert could also be created to warn these locations if lake levels are approaching, or have reached, the trigger levels within any flood response plans that are developed.

9.2.10 Flood Education

Community awareness and behaviour is an important aspect of reducing flood risk within a catchment. If a community is aware of how flood risks develop within their local area, and the correct ways in which to respond, risk to life can be substantially reduced.

It is recommended that Council take the adoption of this study as an opportunity to engage with the community in discussions relating to flood risk, management, and responses.

At a minimum, it is recommended that Council's website be updated with the outcomes and recommendations of the study. Further community awareness could be raised by issuing media releases, either through social media or in local papers.

The involvement of NSW SES members in community engagement and educations programs has been successful in engagement activities undertaken by Council and across NSW. SES members could be invited to participate in face to face education activities at community events, pop up stalls, or even door knocking of key locations.

Furthermore, a number of the emergency response options proposed require the works to be undertaken by a third party (caravan and aged care providers, crown lands, RMS, etc). It is recommended that a focussed engagement process be undertaken with these parties to inform them out the outcomes and recommendations of this study, in particular, as they relate to their business and/or asset.

9.2.11 Information Transfer

The flood data developed as part of this study should be transferred to the SES for incorporation into their own flood intelligence database. This would be facilitated by the NSW Government Flood Data Portal. The key data sets for transfer to SES would be the GIS layers showing:

- Flood depth and extent maps for various events (from the Flood Study (Cardno, 2017))
- Hazard and flood function mapping (as per **Map G801** and **Map G802**)
- Flood emergency response classifications (as per **Map G803**)
- Location and depth of road inundation within the study area for the modelled flood events (as per **Map G804**)
- Map of flooded properties, including the events in which the properties are inundated, and events in which over floor flooding occurs (is applicable) – this data is not provided within this FRMS and will be provided to SES as a GIS layer.

The provision of the hazard mapping and flood emergency response classifications would also assist the SES is prioritising and scheduling actions as a flood event progresses through the catchment.

The provision of flood intelligence to the SES should also be ongoing. For example, if Council collects any post-flood survey, or receives reports of local flooding issues, this should also be passed to the SES for their consideration.

9.3 Property Modification Options

Property modification measures refer to modifications to existing development and / or development controls on property and community infrastructure for future development. These are aimed at steering inappropriate development away from areas with a high potential for damage and ensuring that potential damage to development likely to be affected by flooding is limited to acceptable levels by means of measures such as minimum floor levels, and flood proofing requirements.

Property modification options incorporate a variety of options from structural works (house raising, flood proofing and re-development), land-use, planning and development control updates, through to voluntary purchase and land swaps.

The property modification options assessed for Merimbula are discussed below.

9.3.1 Land Use Planning and Building Control Recommendations

A review of Council's land use planning and building controls has been undertaken in **Section 6**.

This review recommended a number of revisions to the documentation, which are reproduced in **Table 9-5**.

Table 9-5 Flood Planning Recommendations

	Issue	Recommendation
1	Under the SEPP (Exempt and Complying Development Codes) 2008, complying development cannot be undertaken on land defined as: • Flood storage • Floodway • Flow path • High Hazard • High risk. Whilst flood storage and floodways are clearly defined in the analysis of Flood Function (Section 8.3), flood hazard is not specifically defined as "high" or "low", instead is provided across 6 hazard categories that link hazard to consequence (Section 8.2). Additionally, areas that are "high risk" are not specifically set out and mapped and would require interpretation of the study outputs.	Consideration of Flood Planning Constraint Categories (FPCC) may assist with reducing ambiguity relating to where complying development can or cannot be undertaken. FPCC analysis is undertaken in Section 6.4 can be used to inform the application of complying development. It is considered reasonable that complying development is permitted in FPCC 3 and 4. This approach excludes development within the following areas from complying development: • Flood storage for the 1% AEP event, • Floodway in all events up to and including the PMF event, • H5 Hazard classification for the 1% AEP event, • H6 Hazard classification for all events up to and including the PMF event, and • Isolated areas in events up to the PMF event.
2	The LEP requires proposed development to consider the impacts of climate change on flooding (Clause 6.3(b)). However, the definition of the FPL does not give consideration to climate change.	The LEP be updated to provide the ability to include climate change in the definition of Flood Planning Levels. This may consist of an additional clause under 6.3. This is consistent with the recommendations made in *Bega River and Brogo River FRMP (Cardno, 2017)*.

	Issue	Recommendation
3	Clause 6.3(2) identifies that the flood planning clause applies only to land at or below the FPL (1%+0.5m). The *Bega River and Brogo River FRMP (Cardno, 2017)* recommends that sub clause 6.3 (2) be amended to apply to all flood prone land (i.e. all land at or below the PMF) and land mapped in the FRMS as being high flood island, rather than just land at or below the flood planning level.	The LEP be updated to identify that the flood planning clause applies to: • The flood planning area documented in the relevant Flood Study or Floodplain Risk Management Plan; or • Land at or below the Flood Planning Level. This provides Council with the flexibility to identify within each catchment the appropriate design flood upon which to base the FPL, an appropriate freeboard and whether climate change should be incorporated. It is not recommended that the FPA mapping is included in the LEP. It is noted that the recommendation in Cardno (2017) to include all land below the PMF and high flood island areas would require 'exceptional circumstances' to be sought under PS 07-003. Based on the flood risk, the FPA and the PMF within the Merimbula and Back Lake study area, it is not considered necessary to apply 'exceptional circumstances' within the study area. The inclusion of flood planning provisions above the FPL (up to the PMF) has been considered in recommendation 4. It is also noted that PS-07-003 will be repealed once the *Draft Flood Prone Land Package* is adopted.
4	The LEP only provides for flood planning provisions below the FPL.	Within the study area there is only a small area outside the recommended FPA that falls within the PMF extent (see **Map G602**). However, this may not be the case in other floodplains within the LGA. The recommendations in the *Draft Flood Prone Land Package* seek to address flood planning outside of the FPA through the application of the Special Flood Considerations (SFC). The SFC seeks to control certain types of vulnerable and hazardous development within the floodplain in its entirety (i.e. potentially up to the extent of the Probable Maximum Flood).
5	Section 5.8.1 of the DCP 2013 provide flood related development controls for development below the FPL (see Section 5.8.1.2 of the DCP). However, no flood related development controls are provided for development above the FPL but below the PMF.	It is recommended that the DCP be updated to include appropriate flood related development controls to ensure the LEP objectives in recommendation 4 (above) are met. This is of relevance to the Merimbula Lake Study Area which has seniors living, caravan parks and an airport that can be impacted by flooding.

	Issue	Recommendation
6	DCP 2013 does not provide specific controls relating to overland flow, with the exception of Section 2.6.1.2 that requires fencing not to obstruct overland flows.	A preliminary assessment of overland flow has been undertaken for the urban areas of Merimbula (see **Section 7.4**). It is recommended that Council consider the results of the overland flow assessment when assessing proposed development within the affected flow paths. The key objective should be keeping overland flow paths free of obstructions. It is recommended that the DCP be amended to incorporate controls to achieve this objective.
7	Defining the Flood Planning Level for the study area.	It is recommended that the FPLs proposed in the Flood Study (Cardno, 2017) be adopted for mainstream flooding: • For re-development of existing residential properties, FPLs should be set at the 1% AEP plus freeboard of 0.5 m; • For major re-developments of existing residential properties and new residential developments, FPLs should be set at the 1% AEP plus a freeboard of 0.5 m, taking into account climate change as appropriate to the design life of the development; • FPLs for development of new critical infrastructure, or re-development of existing critical infrastructure be set at the PMF; and • FPLs for new vulnerable developments be set at the PMF, unless the proponent can demonstrate evacuation via rising road egress route is possible within the effective warning time, in which case the FPL can be set at the 0.2% AEP plus a freeboard of 0.5 m. These are consistent with the recommendations made in the *Bega River and Brogo River FRMP*.
8	Defining the Flood Planning Area for the study area.	It is recommended that the FPA for mainstream flooding be defined as the land below the 1% AEP flood event (based on 0.9m sea level rise) plus a freeboard of 0.5m.

9.3.2 Flood Proofing

Flood proofing is the process of undertaking changes to both the structure and operating procedures of flood affected properties to reduce the damages experienced by the property during flood events.

The NSW SES Business Flash Flood Tool Kit provides business with tools and information to assist in flood proofing their premises. The tool may also assist residential properties with flood proofing their property, however not all factors may be as relevant.

Examples of flood proofing measures include:

- Any construction below the FPL to be of flood compatible materials
- Electrical wiring and other services to be waterproofed and protected below the FPL
- Raise belongings on shelves or move to a second storey
- Secure loose objects
- Re-locate electrical or dangerous goods to a flood-free area.

9.3.3 Voluntary House Purchase

Voluntary house purchase (VP) is a flood risk management tool, used in high hazard residential areas when there are no other feasible options for protecting an existing community from severe flooding, such as building levees, diverting flood flows, or improving evacuation access.

The main aim of VP is to permanently remove at risk people from high flood hazard areas (areas with high flood depths and velocities) by purchasing their properties. The dwelling is then removed and the property is zoned to a more flood compatible land use, such as recreational park.

The NSW State Government, through DPIE provides grants to councils under the Floodplain Management Program for eligible properties in defined VP schemes. Properties being considered for VP should be located:

- within high hazard areas where there is a significant risk to life for occupants
- within a floodway where the removal of the house may be part of a floodway clearance program
- within the footprint of a proposed flood mitigation measure or where a flood mitigation measure may result in a significant increase in flood risk to a house that cannot be protected.

There are no residential dwellings located in 1% AEP high hazard flood locations (H4 – H6) within the study area. As such, VP is not considered a suitable property modification option for the Merimbula region.

9.3.4 Voluntary House Raising

Under the NSW Floodplain Management Program, DPIE provides funding to assist home owners raise the floor level of their house to reduce the damages and trauma caused by flood water inundating their house.

Home Owners can only access this funding through a Voluntary House Raising (VHR) Scheme coordinated by Local Councils.

Assessing the viability of a VHR scheme or an individual property for VP is part of a collective assessment of floodplain risk management options for the community when an FRMP is developed. The suitability of VHR as an option conditional upon:

- the hydraulic function of the area, as VHR is generally excluded in floodways
- the area’s flood hazard classification, as VHR is generally limited to low hazard areas
- the effectiveness as an ongoing maintenance requirement of complementary measures to address risk to life, such as those based around supporting self-evacuation in response to directions from the State Emergency Service (SES)
- the identification of individual houses’ suitability for raising
- cost-effectiveness of the scheme (benefit–cost ratio) measured across the full range of floods with VHR aiming to generate positive financial returns from reduced damage relative to costs
- the viability of the scope and scale of the scheme and how the scheme will be prioritised (considering flood hazard exposure)
- the support of the affected community for VHR as determined through consultation with affected owners

- an implementation plan for the scheme.

Within the Merimbula study area, property affectation is relatively modest, with the bulk of properties affected located in the Fishpen Road precinct on the southern shores of Merimbula Lake. A review of the property types in this area indicate that the vast majority are slab on ground dwellings, which are not suitable for raising.

Furthermore, an economic analysis was undertaken to assess the economic viability of house raising and to identify which properties might be appropriate. It was concluded that, considering a $100,000 capital cost, raising a property would only be economically advantageous if the associated reduction in the average annual damage was higher than $6,772. Based on this conclusion, it was found that it would not be economically advantageous to raise the floor levels of existing dwellings for the purpose of floodplain management.

As such, VHR is not considered a suitable option for the Merimbula study area.

9.4 Multi-Criteria Assessment

A Multi-Criteria Assessment (MCA) approach has been developed for the comparative assessment of all floodplain management options identified within the study area using a similar approach to that recommended in the Floodplain Development Manual (NSW Government, 2005). This approach uses a subjective scoring system to assess the merits of various options. This assists Council in identifying the flood mitigation options that provide the most benefits for the community, by comparing all options across the entire study area against each other based on factors including, but not limited to, the reduction in flood risk and economic flood damages.

The principal merits of such a system are that it allows comparisons to be made between alternatives using a common index, as well as making the assessment of alternatives “transparent” (i.e. all important factors are included in the analysis). However, this approach does not provide an absolute “right” answer as to what should be included in the plan and what should be omitted. Rather, it provides a method by which stakeholders can re-examine options and, if necessary, debate the relative scoring assigned. Therefore, MCA provides opportunities for the direct participation of stakeholders in the analysis.

Each option is given a score according to how well the option meets specific considerations. A framework for scoring has been developed for each criterion.

9.4.1 Scoring System

A scoring system was devised to subjectively rank each measure for a range of criteria considering the background information on the nature of the catchment and floodplain. The scoring is based on a triple bottom line approach incorporating economic, social and environmental criterion.

Each of the criteria has been given a weighting to reflect its importance with regards to floodplain management. This weighting was developed in discussion with Council and the Floodplain Risk Management Focus Group and will also be reviewed with regards to submissions received from the public during the public exhibition period.

The categories and criteria adopted are:

- Economic
    - Reduction in flood damages
    - Capital cost of option
    - Operating and maintenance costs of option

  - Implementation complexity
  - Ability to stage works
- Social
  - Increased community flood awareness
  - Reduction in risk to life
  - Emergency access and traffic disruption
  - Compatible with Council's Plans and Policies
  - Likely community support
- Environmental
  - Flora / fauna impacts
  - Acid sulfate soils
  - Visual impacts
  - Recreational space

Each category is given a weighting based on its relative importance (compared to the other categories), which is then factored by the number of criteria within each category (i.e. so categories with more criteria do not influence the final score than those with less criteria).

Each criterion has been allocated a preliminary weighting based on the flood behaviour, outcomes of previous community engagement and other similar studies. These weightings will be reviewed with regards to submissions received from the public during the public exhibition period.

The details of the criteria adopted, scoring system applied and the relevant weightings are shown in **Appendix C**.

9.4.2 Outcomes

There was a total of 16 options assessed using the MCA. The results of the MCA, including the score for each criterion assigned to each option and the calculated total score, is shown in its entirety in **Appendix C**. An MCA rank based on the total score was calculated to identify those options with the greatest potential for implementation. The total scores and ranks are shown in **Appendix C**.

This ranking is proposed to be used as the basis for prioritising the components of the Floodplain Risk Management Plan. It must be emphasised that the scoring shown in **Appendix C** is not "absolute" and the proposed scoring and weighting should be reviewed carefully as part of the process of finalising the overall Floodplain Risk Management Plan.

The emergency and property modification options generally ranked higher than the flood modification options. This was due to the emergency and property options being able to deliver reasonable reductions in flood risk without the capital outlay required for the flood modification options. The highest ranked flood modification option was ranked nine (Raising Fishpen Road to the 5% AEP flood level), with the first eight options being emergency and property modification options.

These rankings were developed to allow the prioritisation of option implementation in the Floodplain Risk Management Plan. The ranking should not be viewed as final, as future changes (such as additional development, or changes in community and Council preferences) has the potential to alter the MCA and hence the option rankings.

10 Conclusions and Recommendations

The Merimbula Lake and Back Lake Floodplain Risk Management Study (FRMS) has been prepared for Bega Valley Shire Council ('Council') to assess and address the flood risks identified in the Merimbula Lake and Back Lake Flood Study (Cardno, 2017). This FRMS will allow Council to better manage the existing, continuing and future flood risk to the community around Merimbula Lake and Back Lake, by identifying mitigation strategies in both catchments, to ensure the safeguarding of residents, properties and other infrastructure.

The Flood Study (Cardno, 2017) prepared for Council identified the existing flood risk associated with mainstream catchment flows and ocean storms within the Merimbula Lake and Back Lake catchments. Key flooding issues identified in the Flood Study included foreshore inundation of properties along Merimbula Lake and property and road flooding along Merimbula Creek, particularly when the entrance to Back Lake is closed prior to a large storm event.

This FRMS is intended to be used to:

- Identify measures to reduce the risk of flooding impacts on the community
- Reduce the manageable impact and risk of flooding on the community
- Assist in informing the community of flood risks in the study area
- Inform Council planning guidelines for the study area.

A damages assessment has been undertaken to quantify the existing flood damages, based on design flood events, within the study area. The results are summarised below in Table 10-1.

The assessment showed that over floor flooding commenced in the 5% AEP event, with three residential properties affected. This affectation increased steadily for larger events with a total of 17 properties (12 residential and five commercial) affected in the 1% AEP and 36 (25 residential and 11 commercial) affected in the PMF.

Depths were relatively modest for the larger events, with peak depths not exceeding 0.5 metres at properties in events up to and including the 0.5% AEP and were less than 1 metre in the PMF.

As a result of no over floor flooding occurring in events smaller than the 5% AEP, the AAD is relatively low, as it is these events that contribute most to AAD. While the damages in the 0.5% AEP are more substantial ($1.3M) when these are annualised, the contribution to AAD is only $6,668.

Table 10-1 Damages Summary

	Over Ground Flooding	Over Floor Flooding	Max Over Floor Depth (m)	Total Damages ($2019)
PMF	57	36	0.94	$2,764,963
0.5% AEP	36	24	0.48	$1,636,976
1% AEP	31	17	0.42	$1,271,603
2% AEP	17	9	0.27	$718,089
5% AEP	9	3	0.14	$360,481
10% AEP	1	0	-	$12,675
Average Annual Damage				$54,251

A range of measures to manage existing, future and residual flood risk effectively and efficiently have been assessed. This includes a prioritised implementation strategy; what measures are proposed and how they will be implemented. Preliminary costs have been developed for feasible options to allow for planning, implementation and integration with Council's existing long-term financial planning and asset planning processes. All options have been assessed utilising a triple bottom line approach in the form of a multi-criteria assessment.

The outcomes of the multi-criteria assessment provide a sound basis upon which Council can make decisions about undertaking works, making planning decisions and developing response arrangement to reduce the impact of flooding on property and life.

Of the 16 options assessed, the top ranked options overall were:

- Flood warning system
- Emergency response plan for Acacia Ponds
- Land use planning and building control updates
- Emergency response plan for Sapphire Coast Caravan Park

The implementation strategy associated with the outcomes of this study may not necessarily approach the options from "highest ranking to lowest ranking" but will also need to incorporate various other considerations such as existing works programs, availability of funding and other opportunities to combine floodplain works with other activities.

The options identified as having significant flood risk reductions that also do not have adverse social or environmental impacts will be incorporated into the Floodplain Risk Management Plan as proposed management actions. This document will provide a realistic strategy to manage flood risk and will outline the process of implementation for recommended management actions within the floodplain.

11 References

AIDR (2017) Australian Emergency Management Handbook 7: Managing the floodplain: best practice in flood risk management in Australia (AEM Handbook 7)

Cardno (2017) Merimbula Lake and Back Lake Flood Study

CSIRO (2020) Sea Level Rise Trend 1993 – 2019, https://research.csiro.au/slrwavescoast/sea-level/sea-level-changes/, accessed 25 August 2020

DECC (2007) Practical Consideration of Climate Change

Eurobodalla Shire Council (2018) *Sea level rise background information*, https://www.esc.nsw.gov.au/development-and-planning/considerations/coastal-and-flooding-considerations/coastal-projects/sea-level-rise/sea-level-rise-background-information, accessed 25 August 2020

NSW Government (2005) Floodplain Development Manual

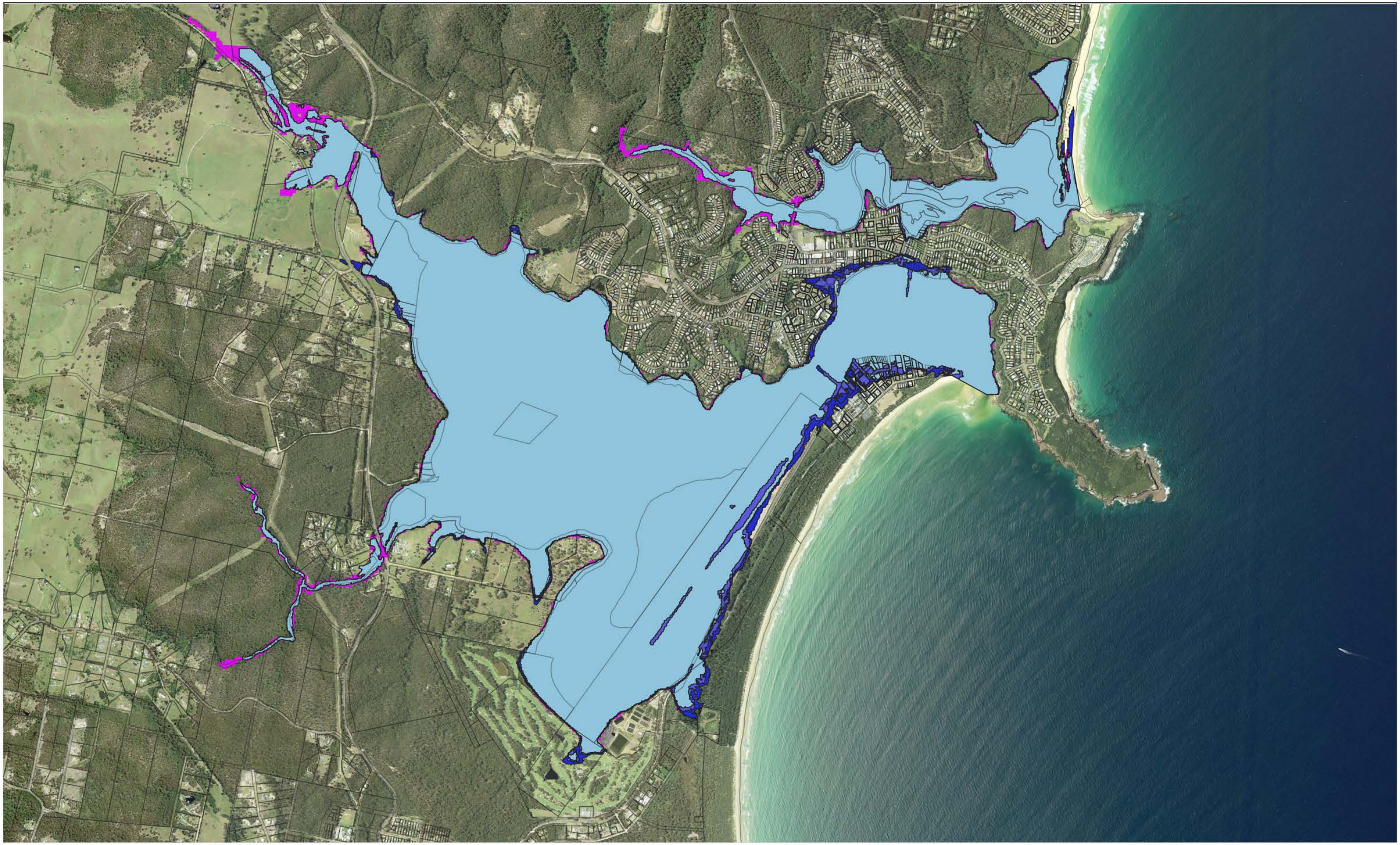
NSW Planning & Infrastructure (2013) The NSW Planning System and the Building Code of Australia 2013: Construction of Buildings in Flood Hazard Areas

Queensland Government (1983) ANUFLOOD: Flood Damages Estimation Program, developed by the Centre for Resource and Environmental Studies at the Australian National University for the Queensland Government

Rhelm

engineering | environmental | economics | engagement

MAPS



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Date : 19 November 2019
Revision : C
Created by : LRE
Coordinate System : MGA 55

0.25 0 0.25 0.5 0.75 km

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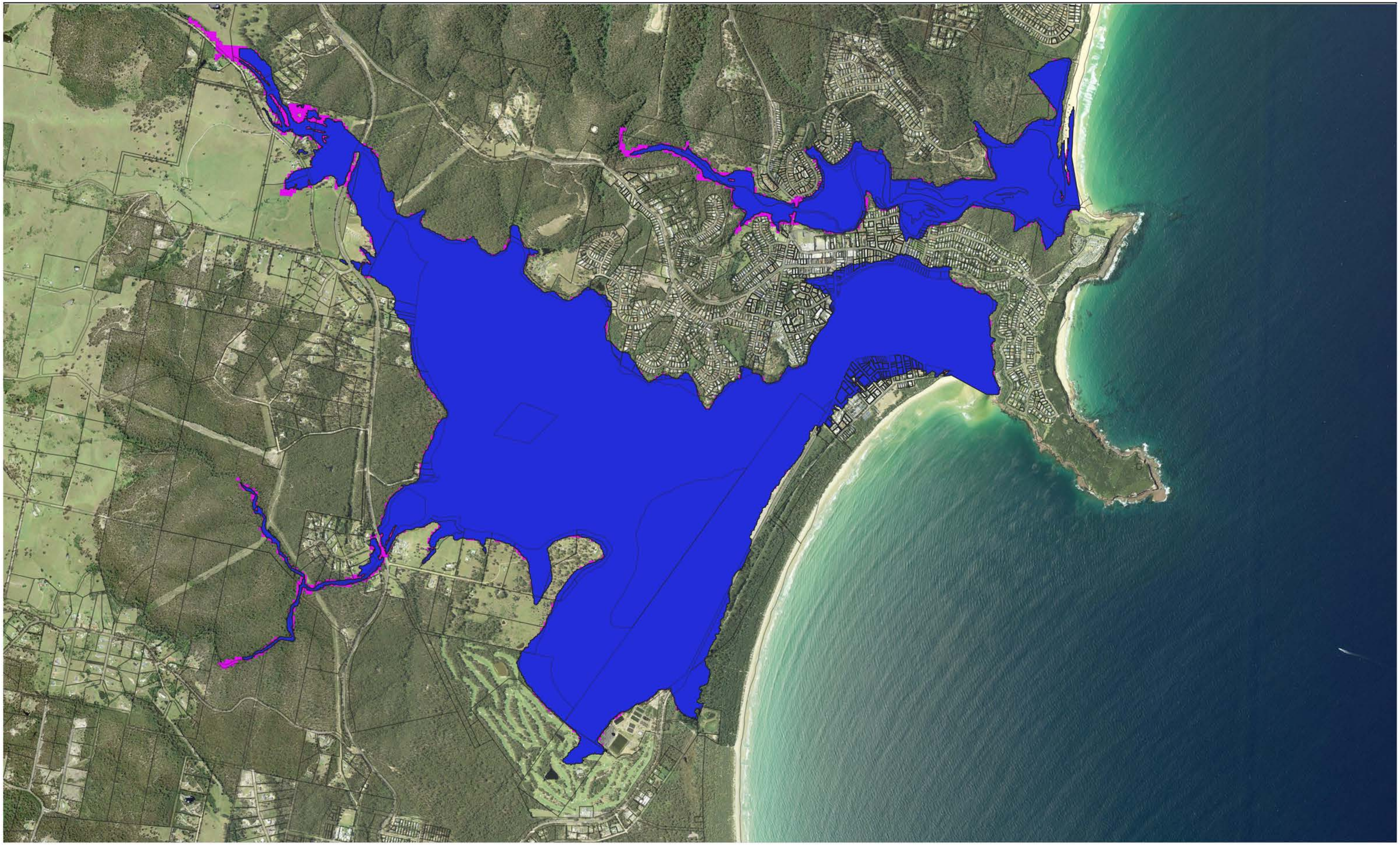
Existing Flood Planning Area (2018)
0.4m Sea Level Rise Flood Planning Area (2050)
0.9m Sea Level Rise Flood Planning Area (2100)
Probable Maximum Flood (PMF) (Special Flood Consideration Area) (2018)

N W E S

Map G601
Flood Planning Area Comparison



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Date : 19 November 2019
Revision : C
Created by : LRE
Coordinate System : MGA 55

0.25 0 0.25 0.5 0.75 km

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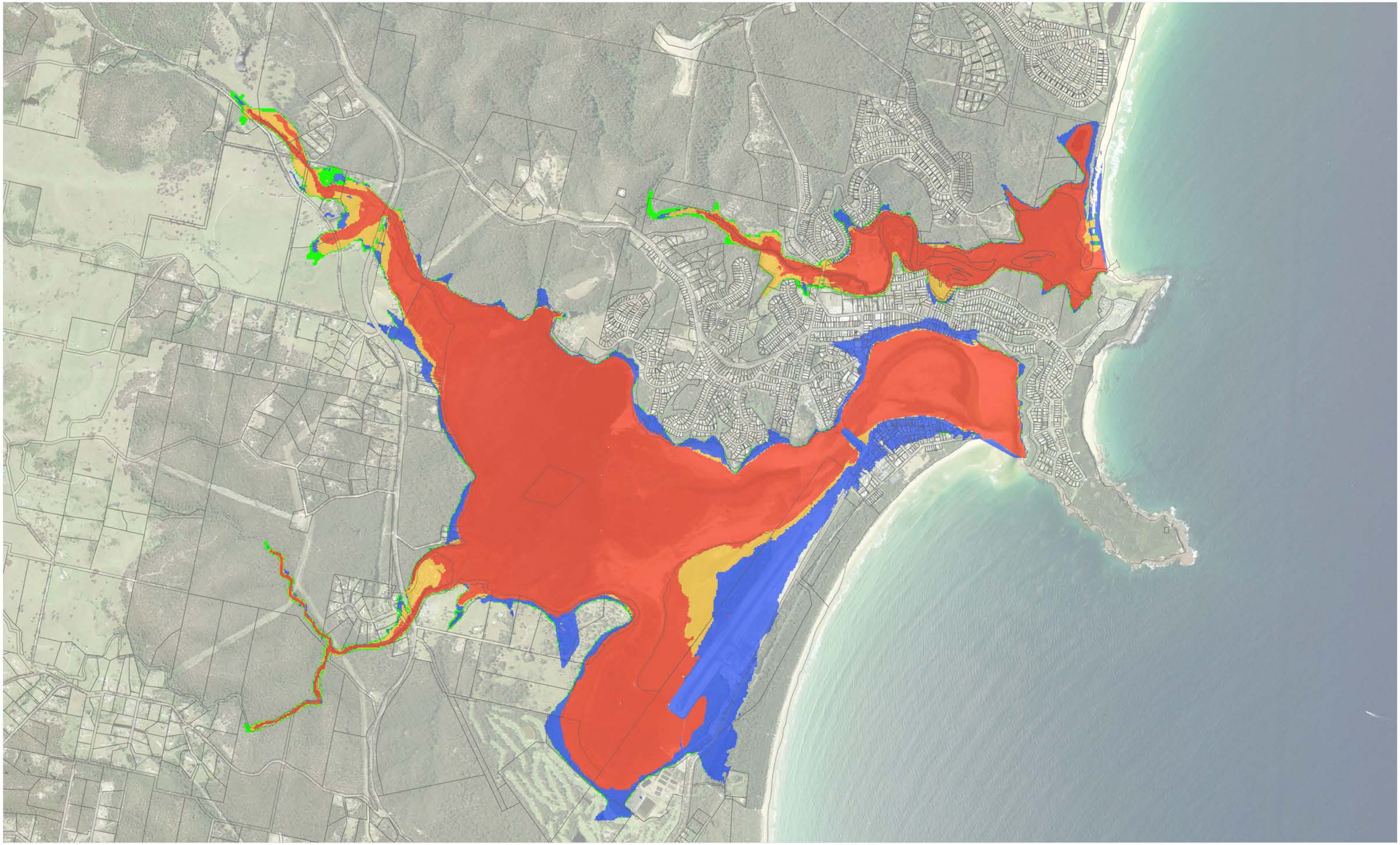
0.9m Sea Level Rise Flood Planning Area (2100)

Probable Maximum Flood (PMF) (Special Flood Consideration Area) (2018)

N W E S

Map G602
Flood Planning Area Recommendation
1% AEP with 0.9 Sea Level Rise +0.5m



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Date : 28 August 2020
Revision : A
Created by : JS
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend

Cadastre

Flood Planning Constraint Categories (FPCC)

FPCC1

FPCC2

FPCC3

FPCC4

N W E S

Map G603
Flood Planning Constraint Categories (FPCC)

Scale : 1:15000@A3
Date : 12 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 56

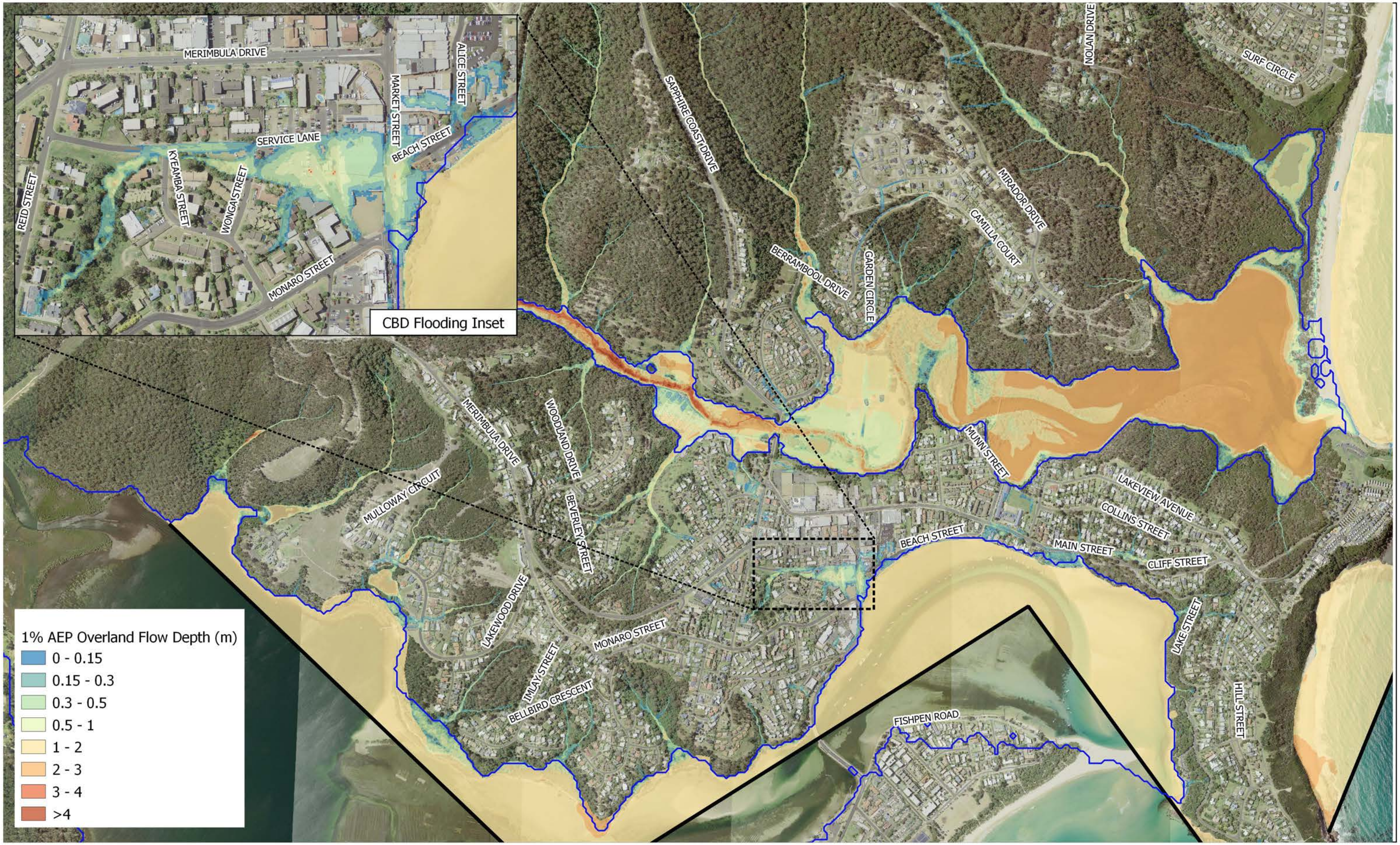
0 250 500 m

Legend

- Cadastre
- Model Area
- Downstream Boundary
- Pipes / Culverts
- Pits
- SA Polygon for upstream flows
- Building roughness layer
- Road roughness layer
- Urban roughness layer
- Water roughness layer

N W E S

Map G701
Overland Flow Tuflow Model



Rhelm

Scale : 1:12500@A3 (1:4000 inset)
Date : 26 July 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 m

Legend
Cadastre
Overland Model Downstream Boundary
1% AEP Lake Flooding Extent

N W E S

Map G702
1% AEP Overland Flow Depth

Scale : 1:12500@A3 (1:4000 inset)
Date : 26 July 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 m

Legend

- Cadastre
- Overland Model Downstream Boundary
- 5% AEP Lake Flooding Extent

N W E S

Map G703
5% AEP Overland Flow Depth

Rhelm

Scale : 1:400@A3
Date : 15 June 2020
Revision : A
Created by : LRE
Coordinate System : MGA 55

Model Extent
Culverts
Boundaries
Downstream
Upstream

N
W E
S

Map G704
Culvert Assessment - Model Layout

Rhelm

Scale : 1:400@A3
Date : 15 June 2020
Revision : A
Created by : LRE
Coordinate System : MGA 55

50 0 50 100 150 m

Model Extent

N W E S

Map G705
Culvert Assessment - 20% AEP Depths

Scale : 1:400@A3
Date : 15 June 2020
Revision : A
Created by : LRE
Coordinate System : MGA 55

Rhelm

50 0 50 100 150 m

Model Extent

N W E S

Map G706
Culvert Assessment -5% AEP Depths

Scale : 1:400@A3
Date : 15 June 2020
Revision : A
Created by : LRE
Coordinate System : MGA 55

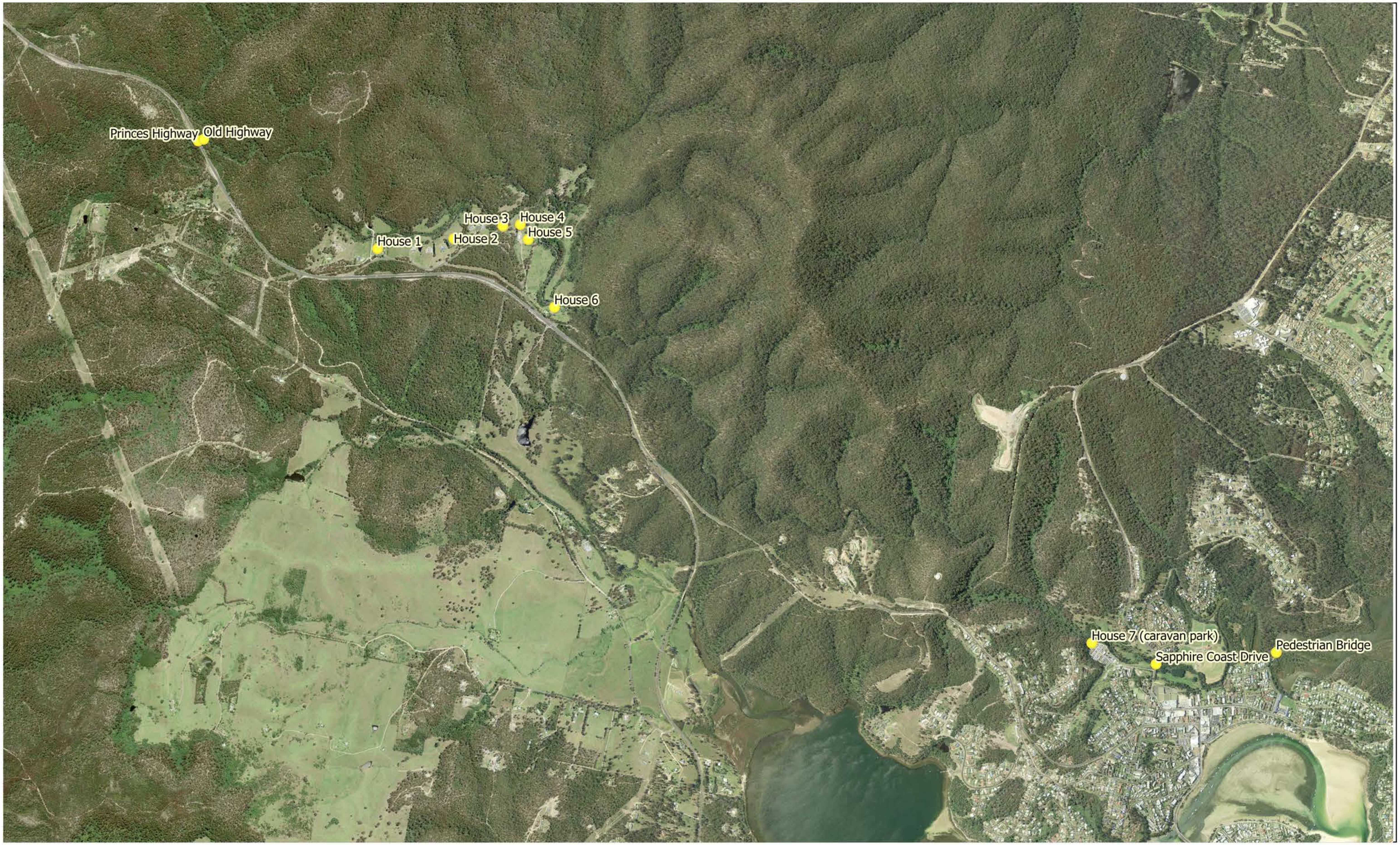
Model Extent

Rhelm

50 0 50 100 150 m

N W E S

Map G707
Culvert Assessment -1% AEP Depths



Rhelm

Scale : 1:25000@A3
Date : 13 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 750 1000 m

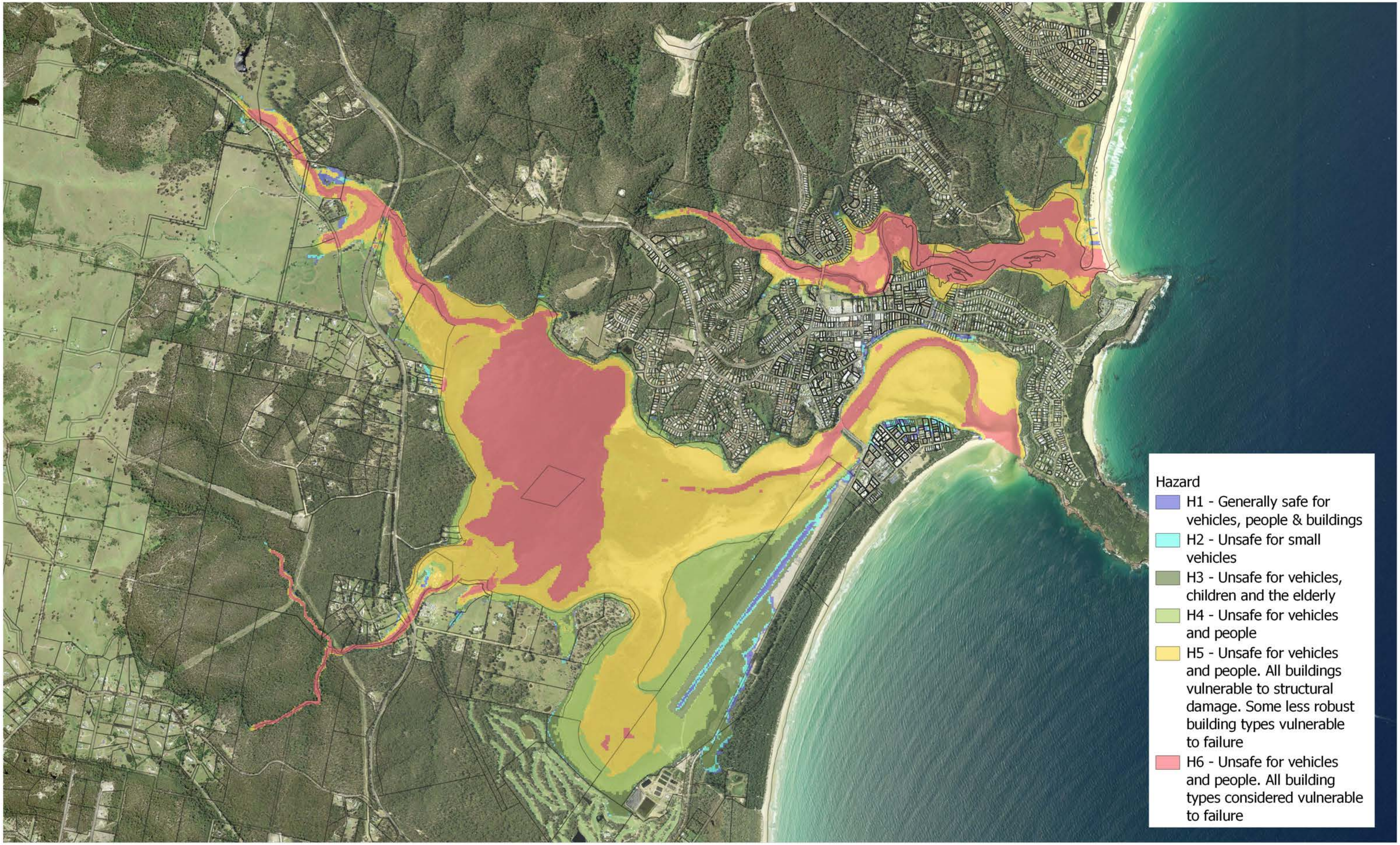
Legend

Yellow Pinch Dam failure affected locations

N W E S

Map G708

Dam Break Affected Properties and Infrastructure



Rhelm

Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

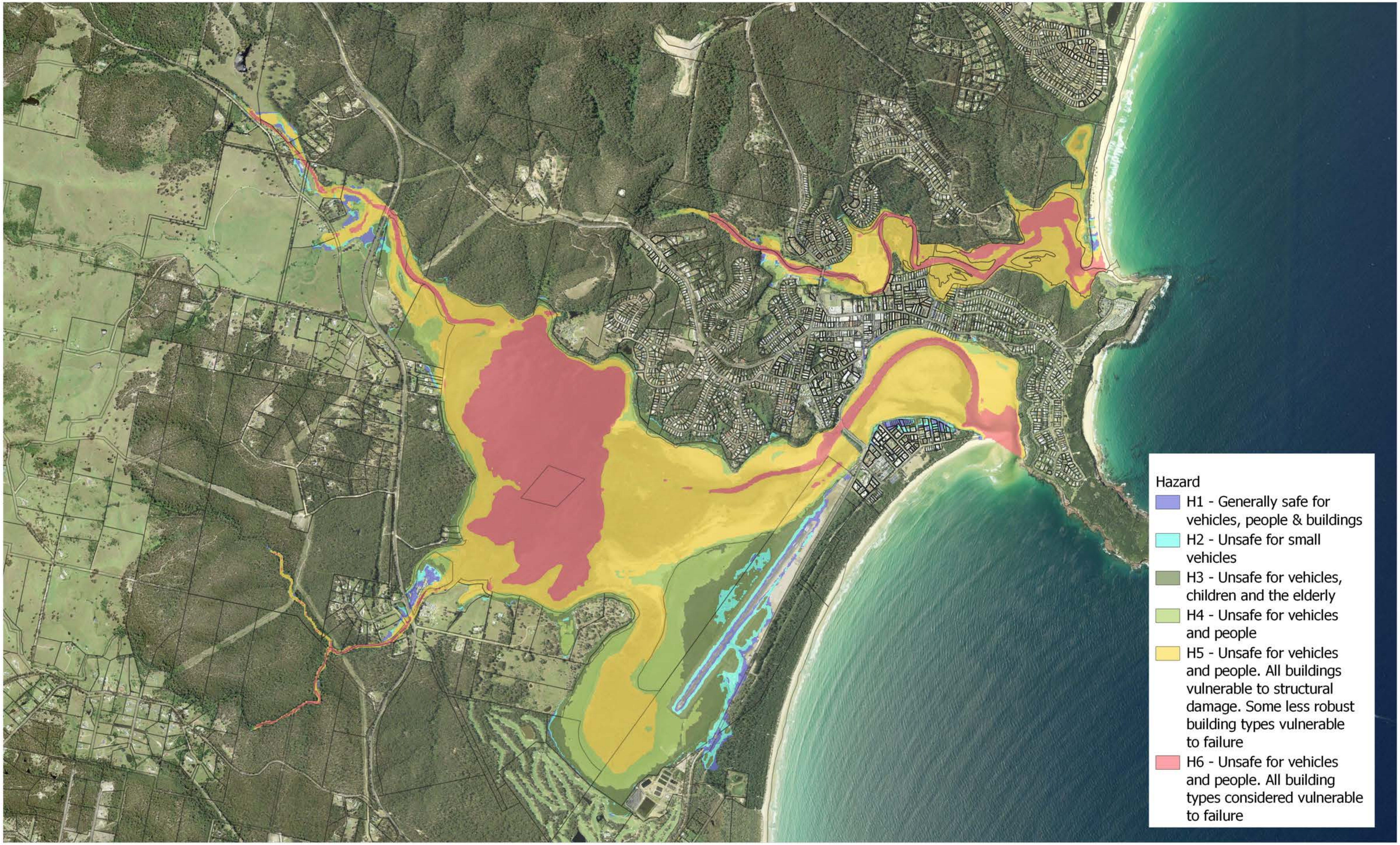
0 250 500 750 1000 m

Legend

Cadastre

N W E S

Map G801-1
PMF Hazard



Rhelm

Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend

Cadastre

N
W E
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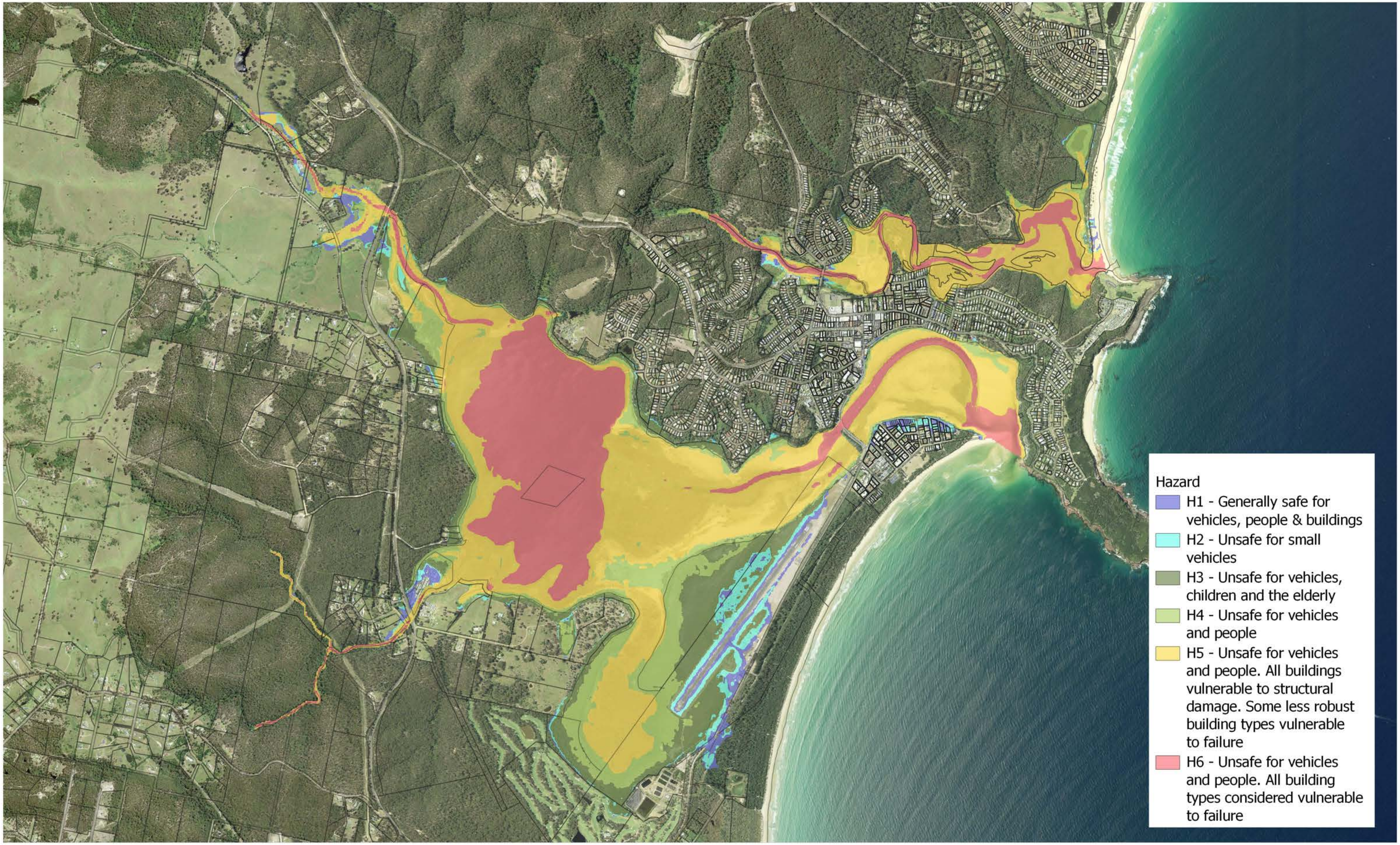
Map G801-3
0.5% AEP Hazard



Rhelm

Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

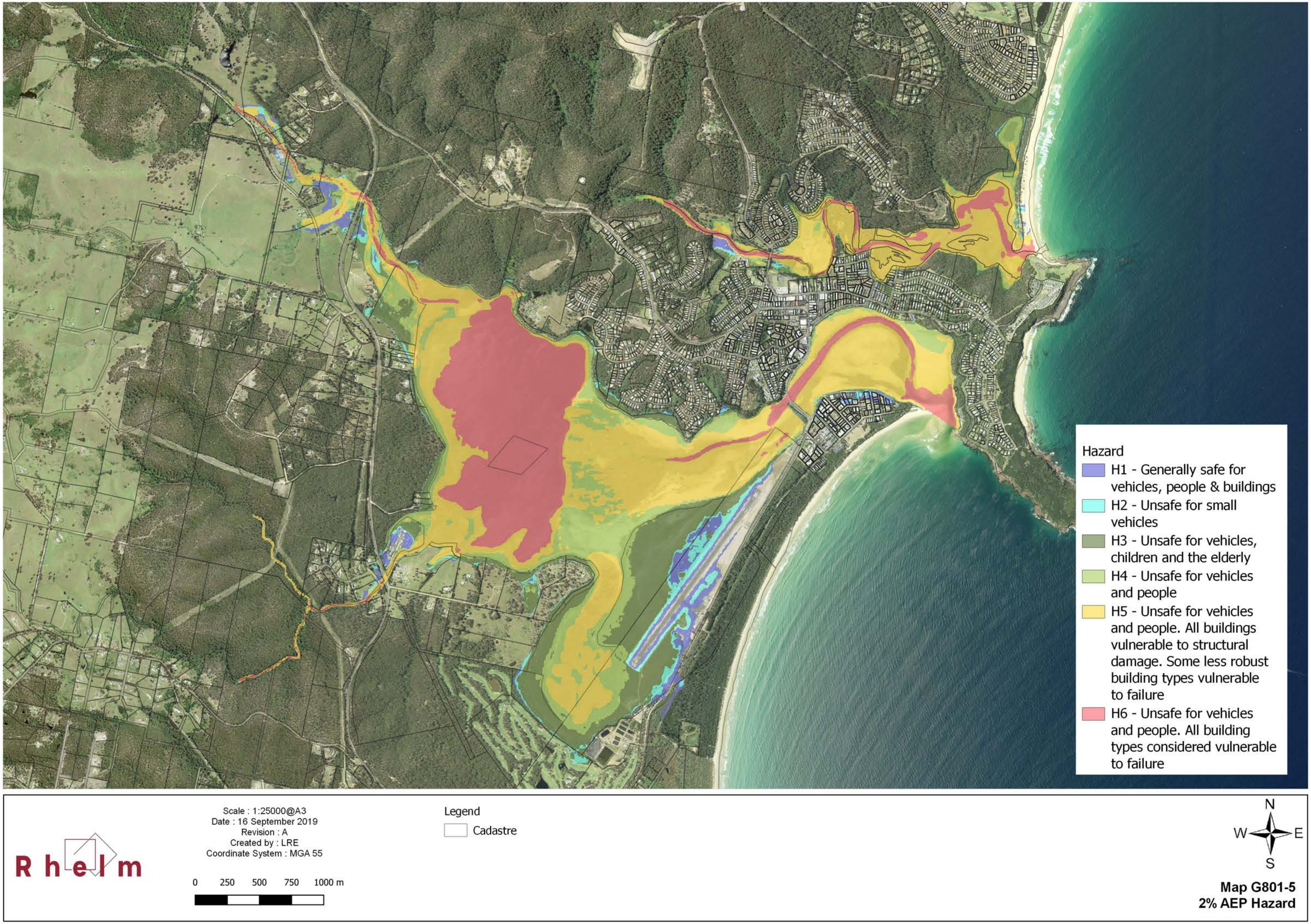
0 250 500 750 1000 m

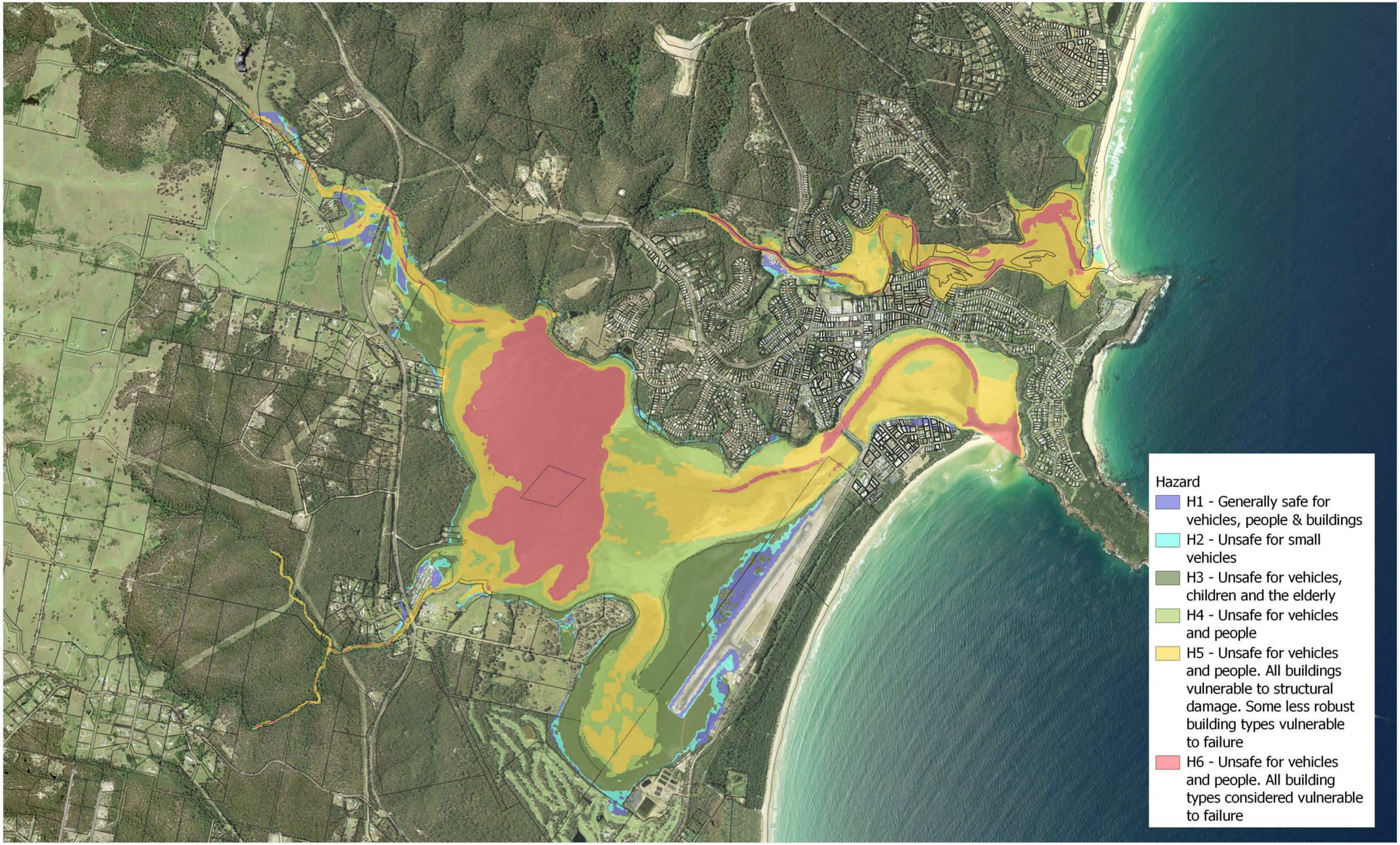
Legend

Cadastre

N W E S

Map G801-4
1% AEP Hazard


Hazard
H1 - Generally safe for vehicles, people & buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for vehicles and people
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55
0 250 500 750 1000 m
Legend
Cadastre
N
W
E
S
Rhelm
Map G801-5
2% AEP Hazard



Rhelm

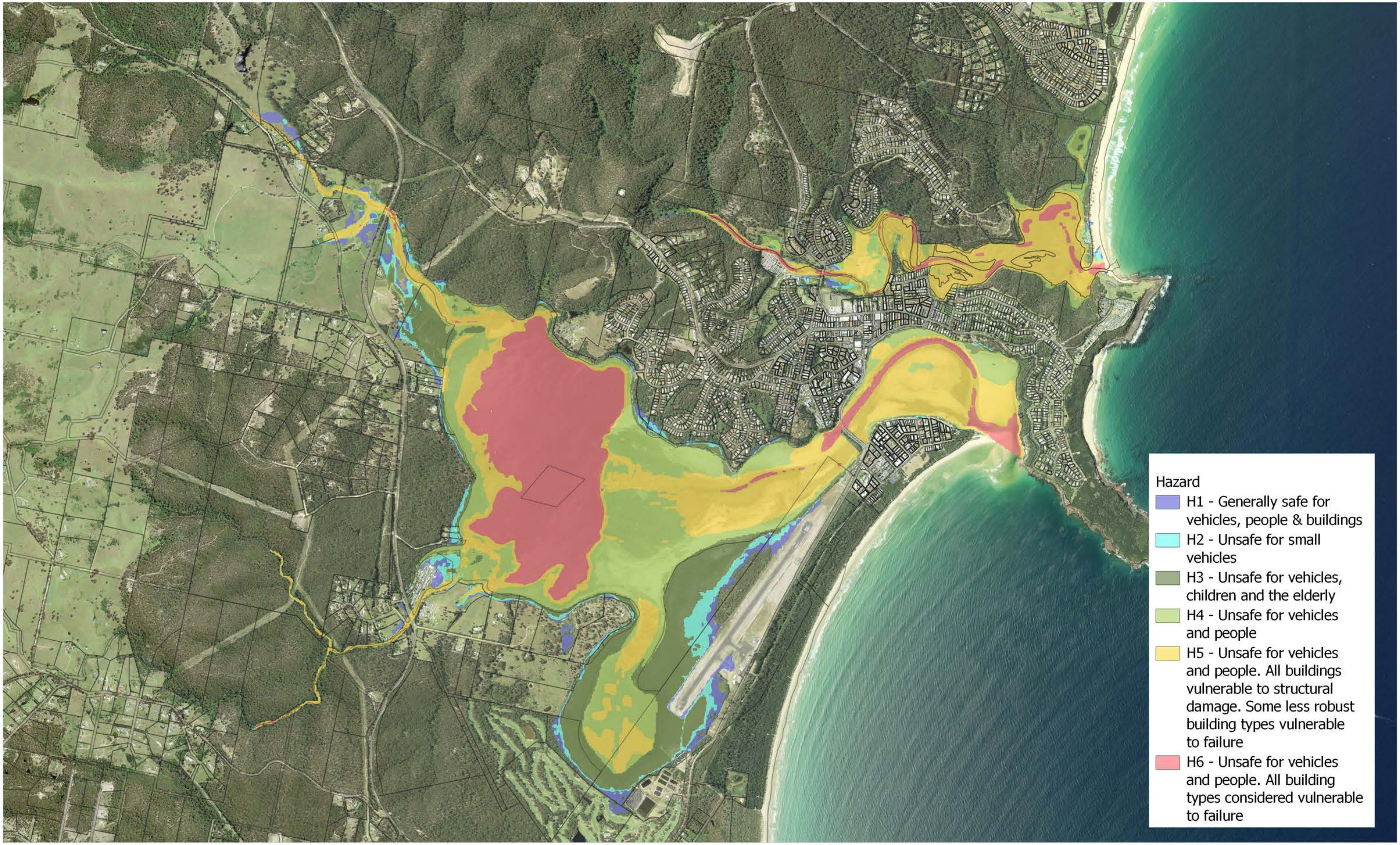
Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend
Cadastre

N
W E
S

Map G801-6
5% AEP Hazard



Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

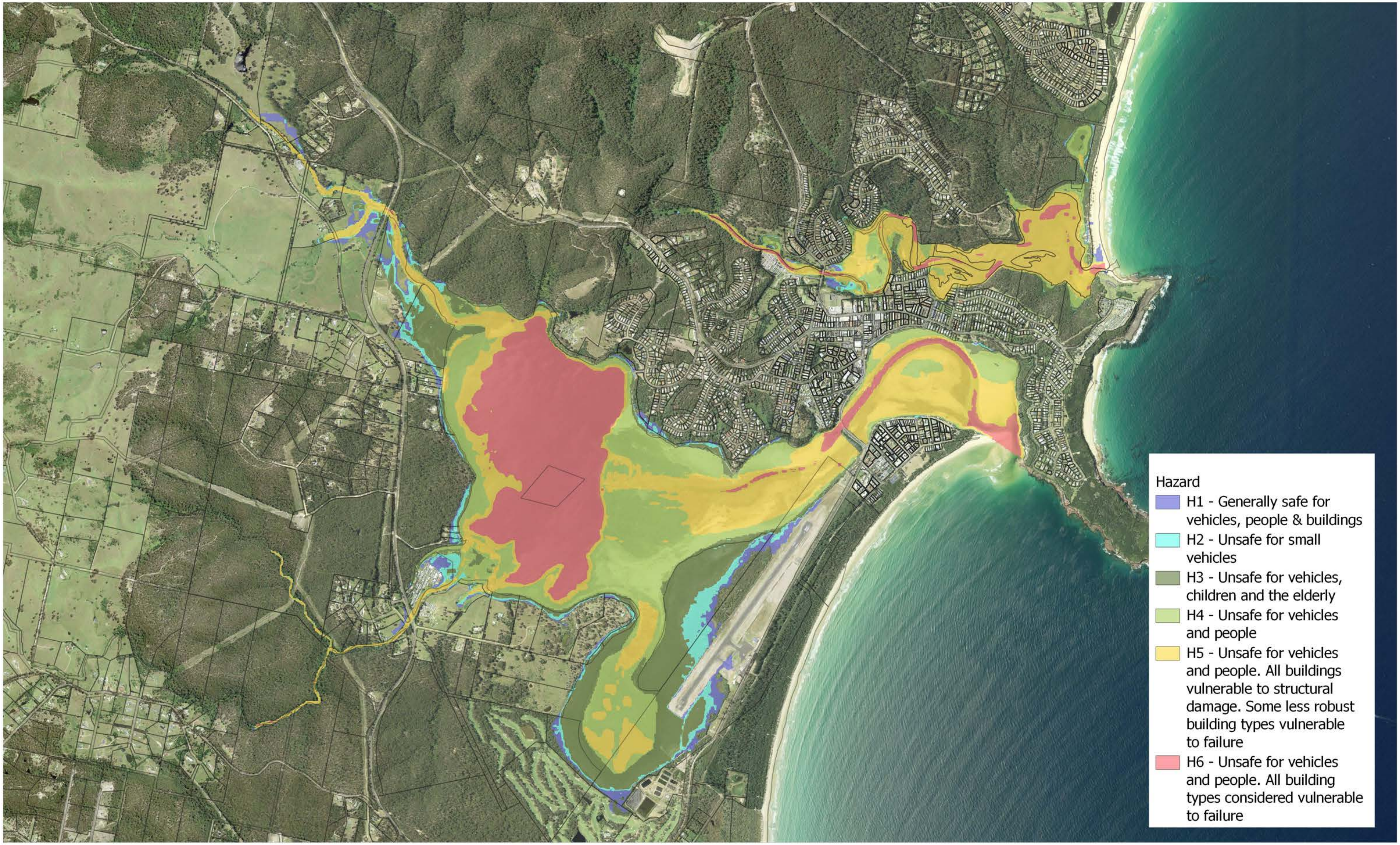
0 250 500 750 1000 m

Legend
Cadastre

N W E S

Rhelm

Map G801-7
10% AEP Hazard



Rhelm

Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

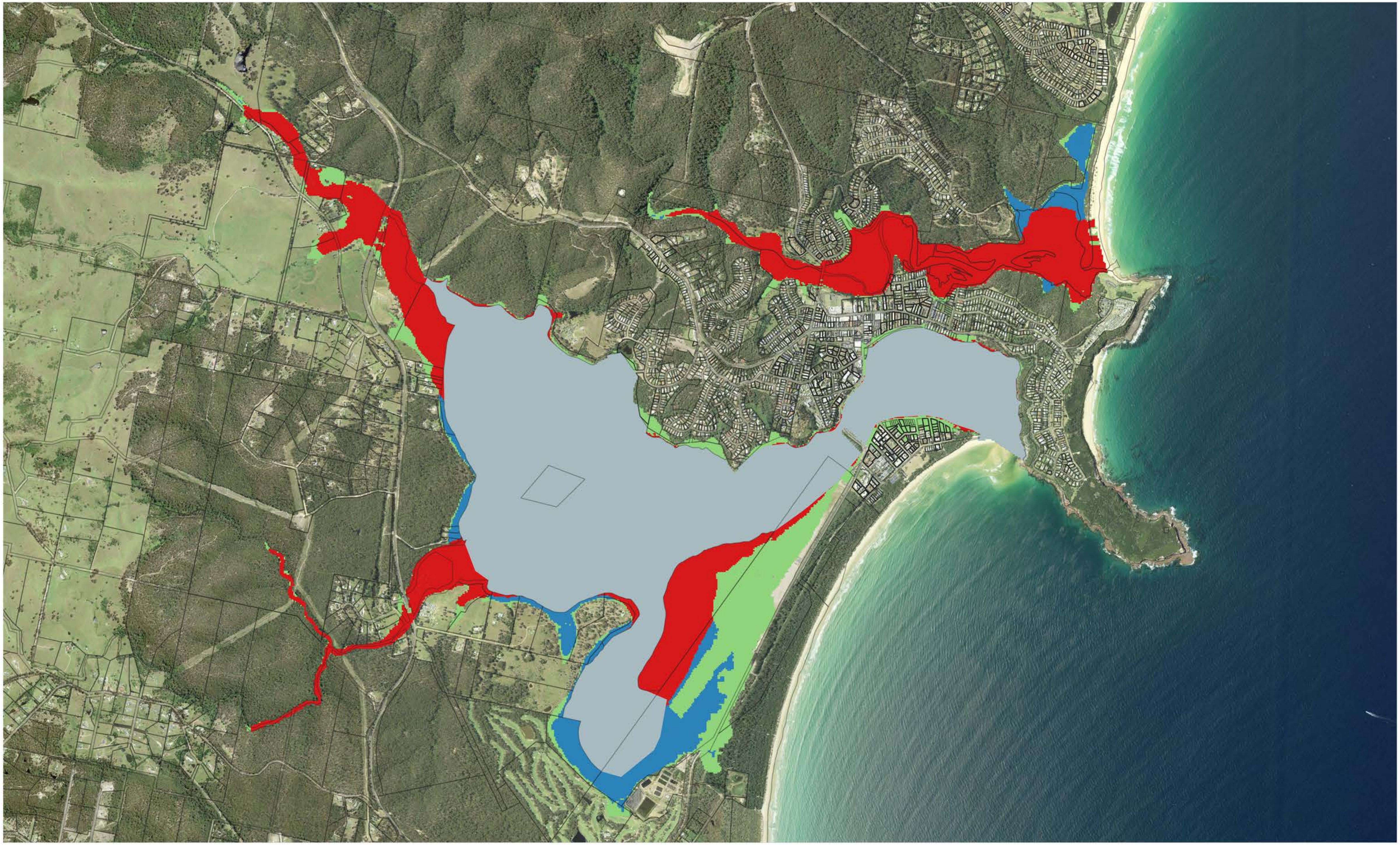
0 250 500 750 1000 m

Legend

Cadastre

N W E S

Map G801-8
5% AEP Hazard



Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 750 1000 m

Rhelm

Legend

Cadastre

Lake Flooding. Flood function not applicable

Flood Function

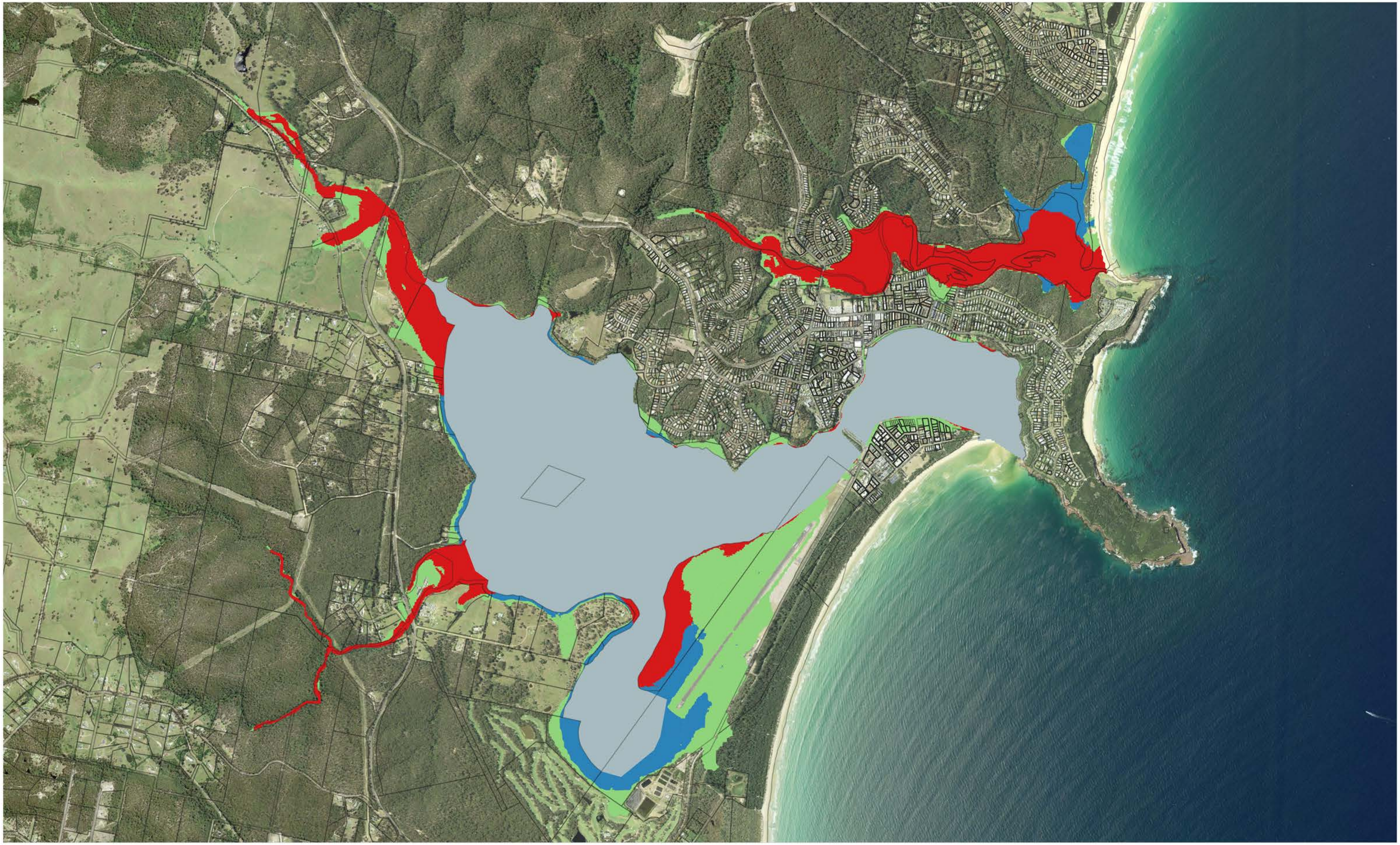
Floodway

Storage

Fringe

N W E S

Map G802-1
PMF Flood Function



Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

Rhelm

0 250 500 750 1000 m

Legend

Cadastre

Lake Flooding. Flood function not applicable

Flood Function

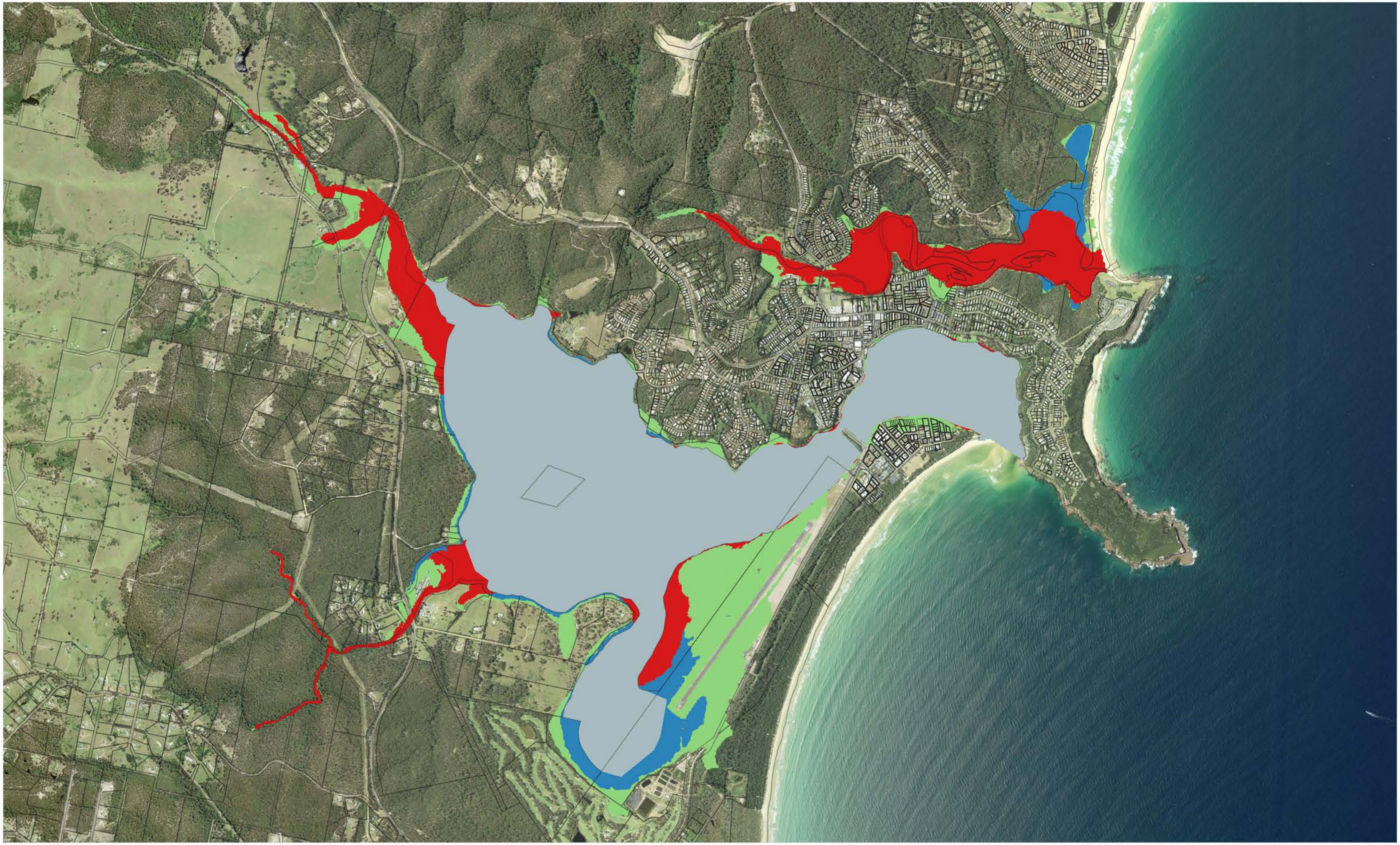
Floodway

Storage

Fringe

N W E S

Map G802-3
0.5% AEP Flood Function



Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

Rhelm

0 250 500 750 1000 m

Legend

Cadastre

Lake Flooding. Flood function not applicable

Flood Function

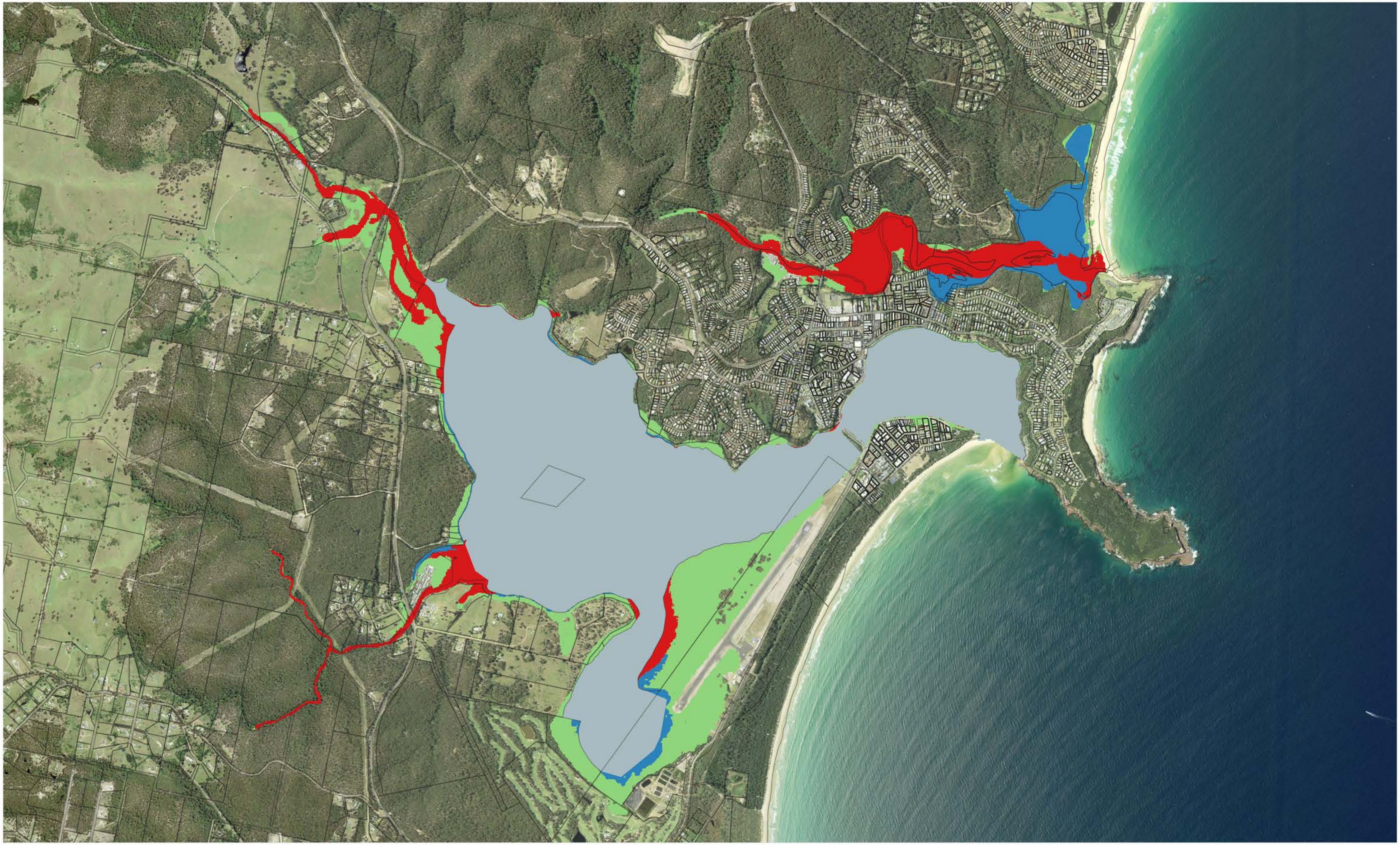
Floodway

Storage

Fringe

N
W E
S

Map G802-4
1% AEP Flood Function



Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend

Cadastre

Lake Flooding. Flood function not applicable

Flood Function

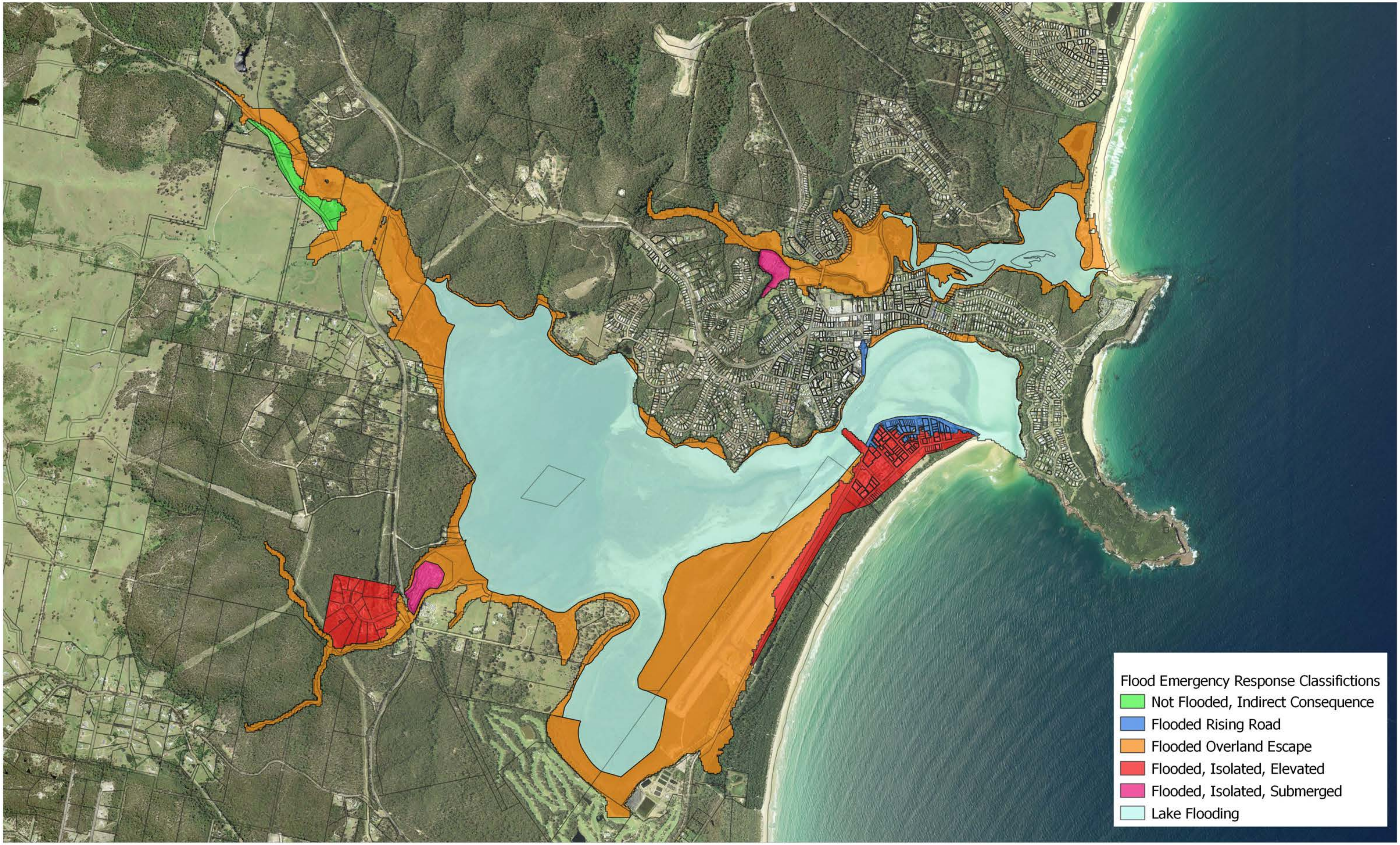
Floodway

Storage

Fringe

N W E S

Map G802-5
5% AEP Flood Function



Rhelm

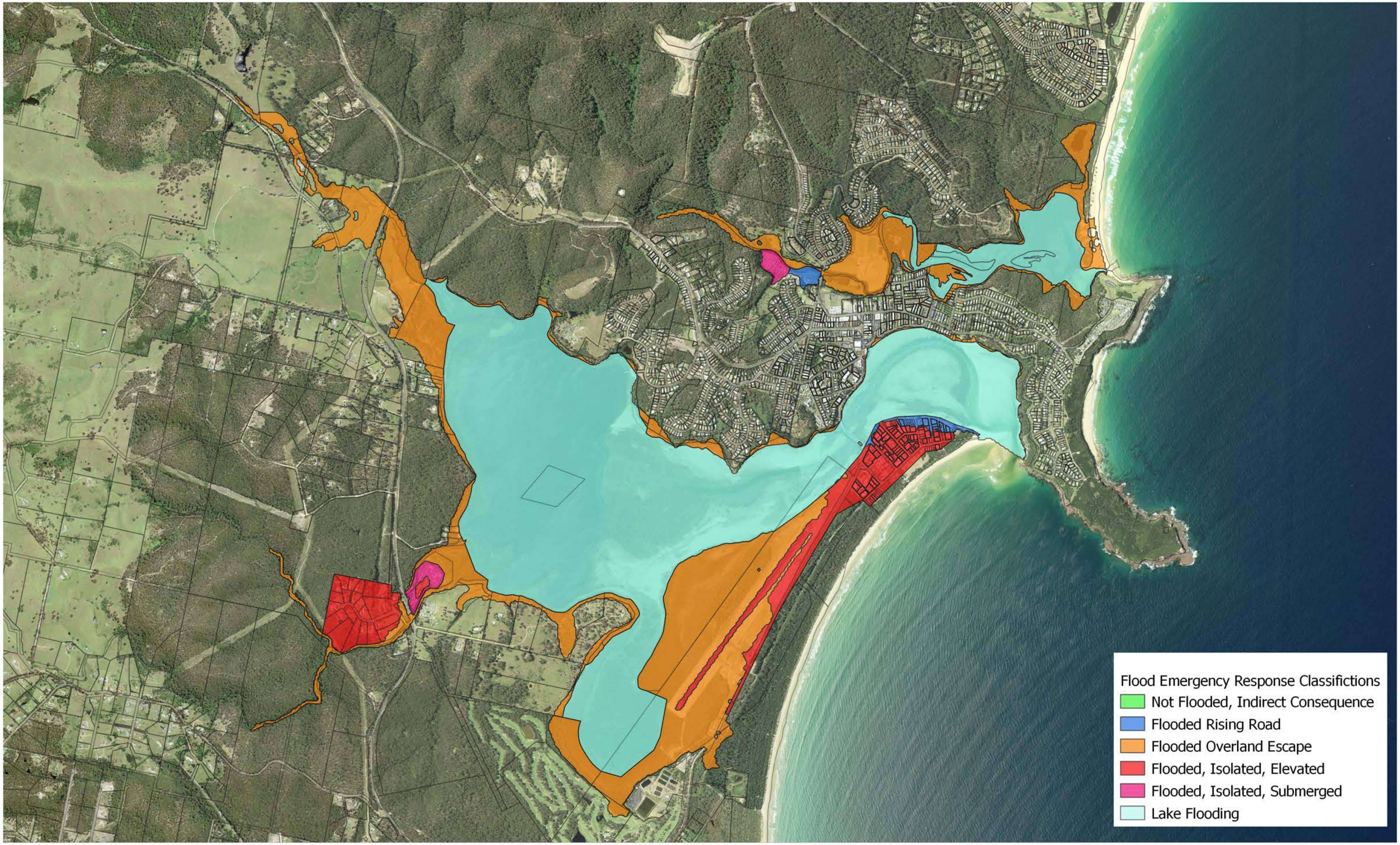
Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend
Cadastre

N W E S

Map G803-1
PMF Flood Emergency Response Classifications



Rhelm

Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

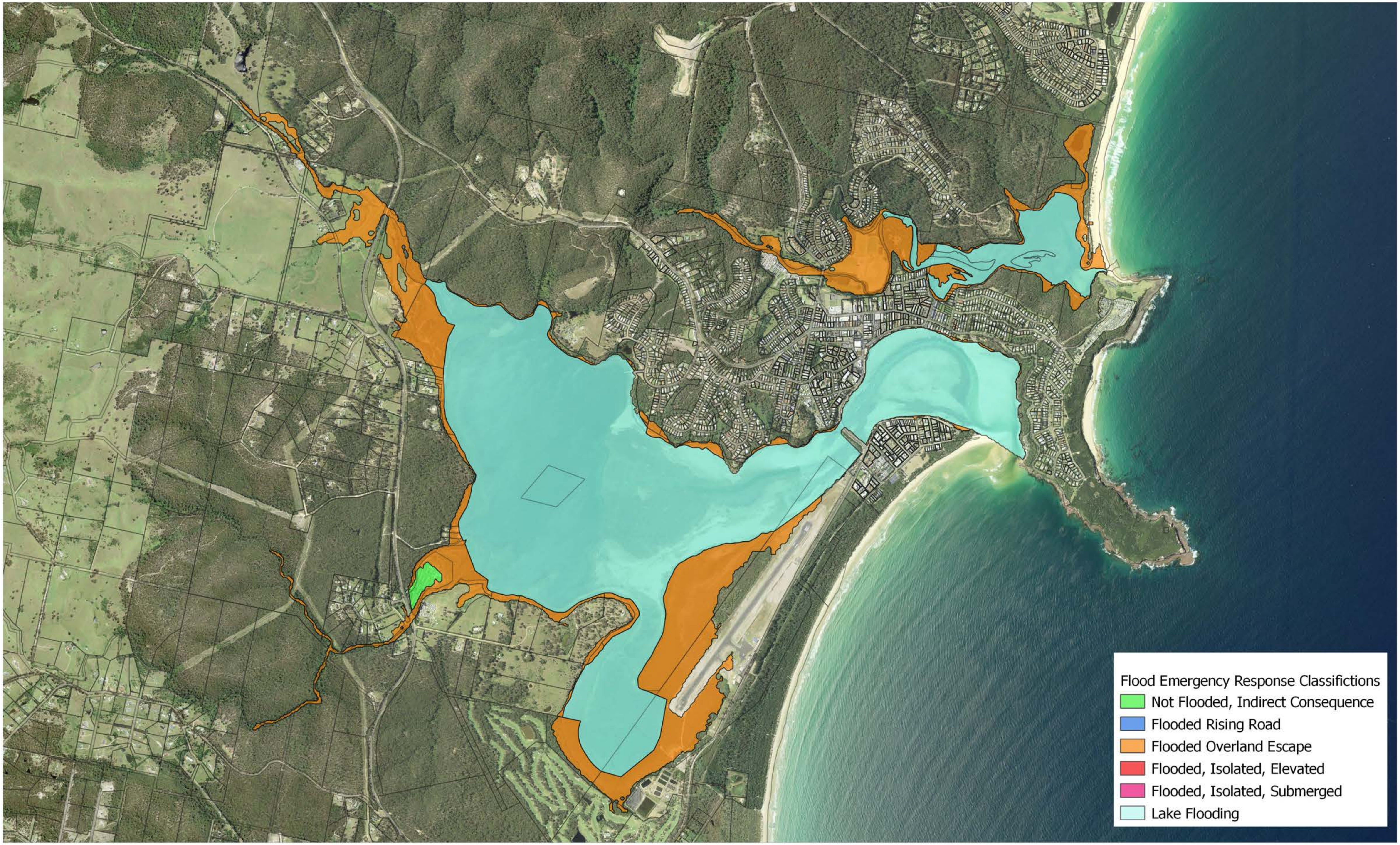
0 250 500 750 1000 m

Legend

Cadastre

N W E S

Map G803-2
1% AEP Flood Emergency Response Classifications



Rhelm

Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

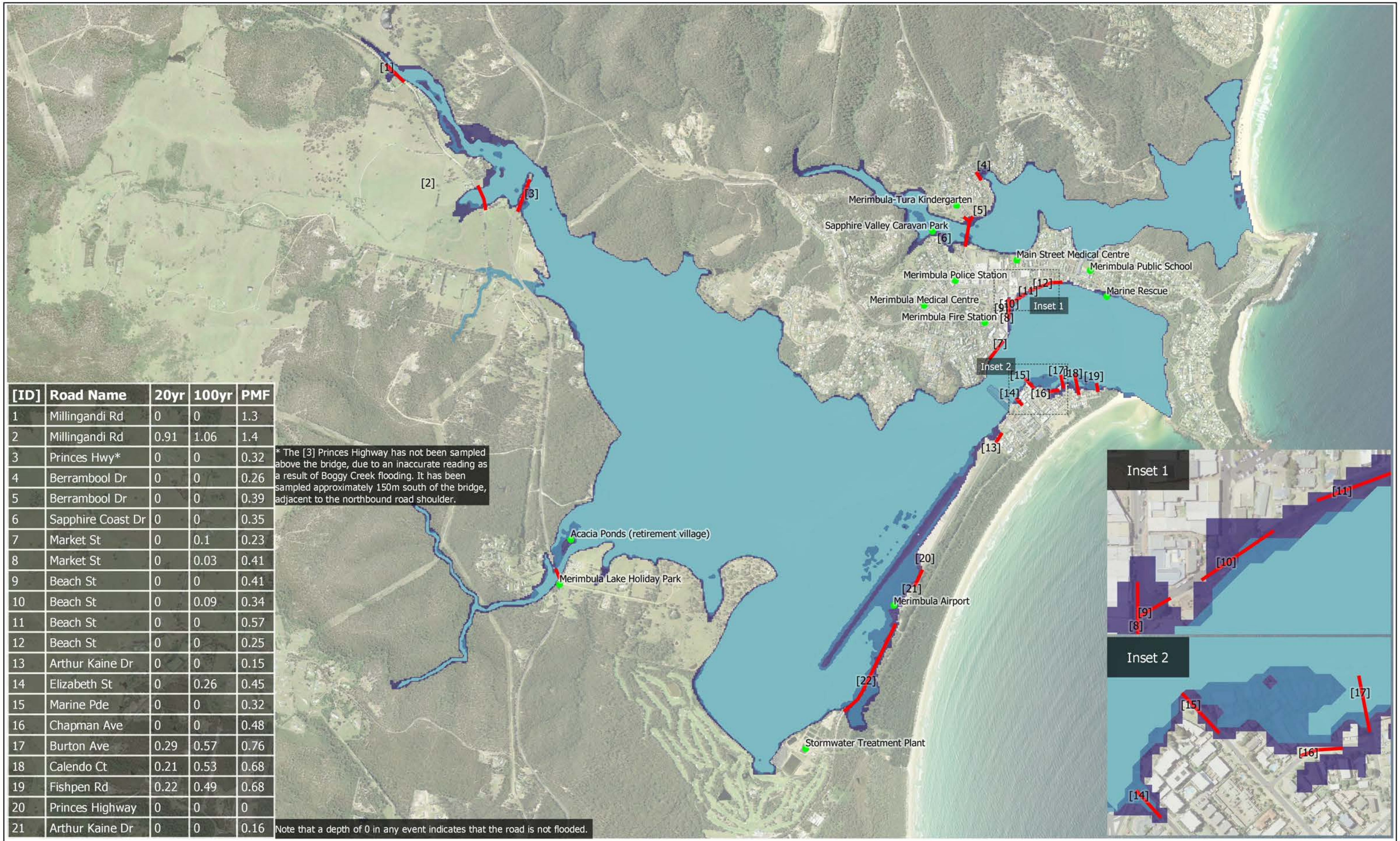
0 250 500 750 1000 m

Legend

Cadastre

N W E S

Map G803-3
20% AEP Flood Emergency Response Classifications



[ID]	Road Name	20yr	100yr	PMF
1	Millingandi Rd	0	0	1.3
2	Millingandi Rd	0.91	1.06	1.4
3	Princes Hwy*	0	0	0.32
4	Berrambool Dr	0	0	0.26
5	Berrambool Dr	0	0	0.39
6	Sapphire Coast Dr	0	0	0.35
7	Market St	0	0.1	0.23
8	Market St	0	0.03	0.41
9	Beach St	0	0	0.41
10	Beach St	0	0.09	0.34
11	Beach St	0	0	0.57
12	Beach St	0	0	0.25
13	Arthur Kaine Dr	0	0	0.15
14	Elizabeth St	0	0.26	0.45
15	Marine Pde	0	0	0.32
16	Chapman Ave	0	0	0.48
17	Burton Ave	0.29	0.57	0.76
18	Calendo Ct	0.21	0.53	0.68
19	Fishpen Rd	0.22	0.49	0.68
20	Princes Highway	0	0	0
21	Arthur Kaine Dr	0	0	0.16

* The [3] Princes Highway has not been sampled above the bridge, due to an inaccurate reading as a result of Boggy Creek flooding. It has been sampled approximately 150m south of the bridge, adjacent to the northbound road shoulder.

Note that a depth of 0 in any event indicates that the road is not flooded.

Rhelm
engineering | environmental | economics | engagement

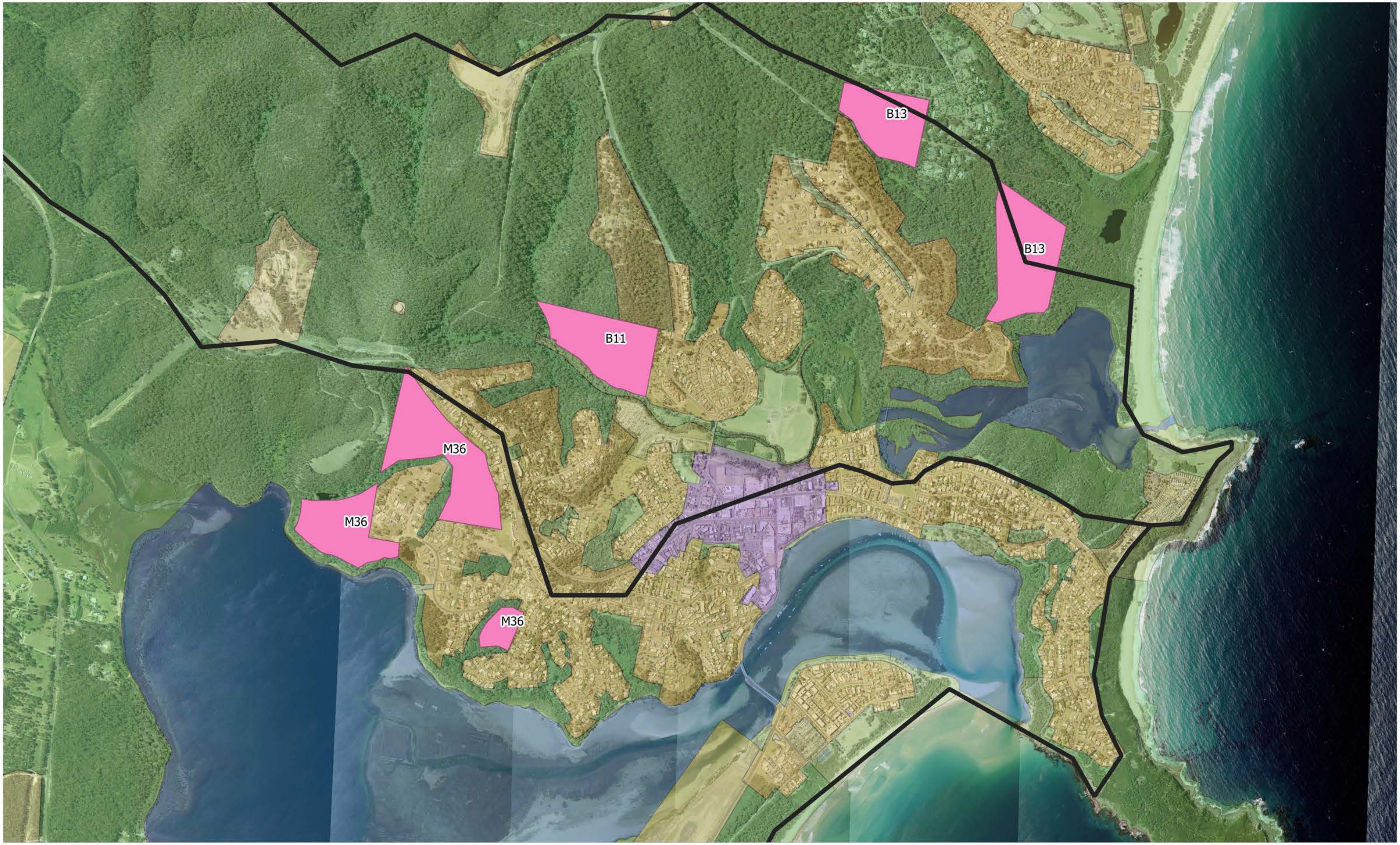
Scale : 1:25000@A3
Date : 20 November 2019
Revision : A
Created by : AXS
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend
- Key Infrastructure
- Overtopped Roads (with ID)
- PMF Extent

N W E S

Map G804
Flood Impact on Transport and Infrastructure



Rhelm

Scale : 1:15000@A3
Date : 12 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 56

0 250 500 m

Catchment Boundary
Possible development areas (noting RAFTS subcatchment ID as refered to in report)

Current Zoning
- Business
- Environmental
- Residential
- Recreation
- Primary Production
- Rural Landscape
- Forestry
- Primary Producton small lots
- Village
- Water

N W E S

Map G805
Future Development Areas

Rhelm

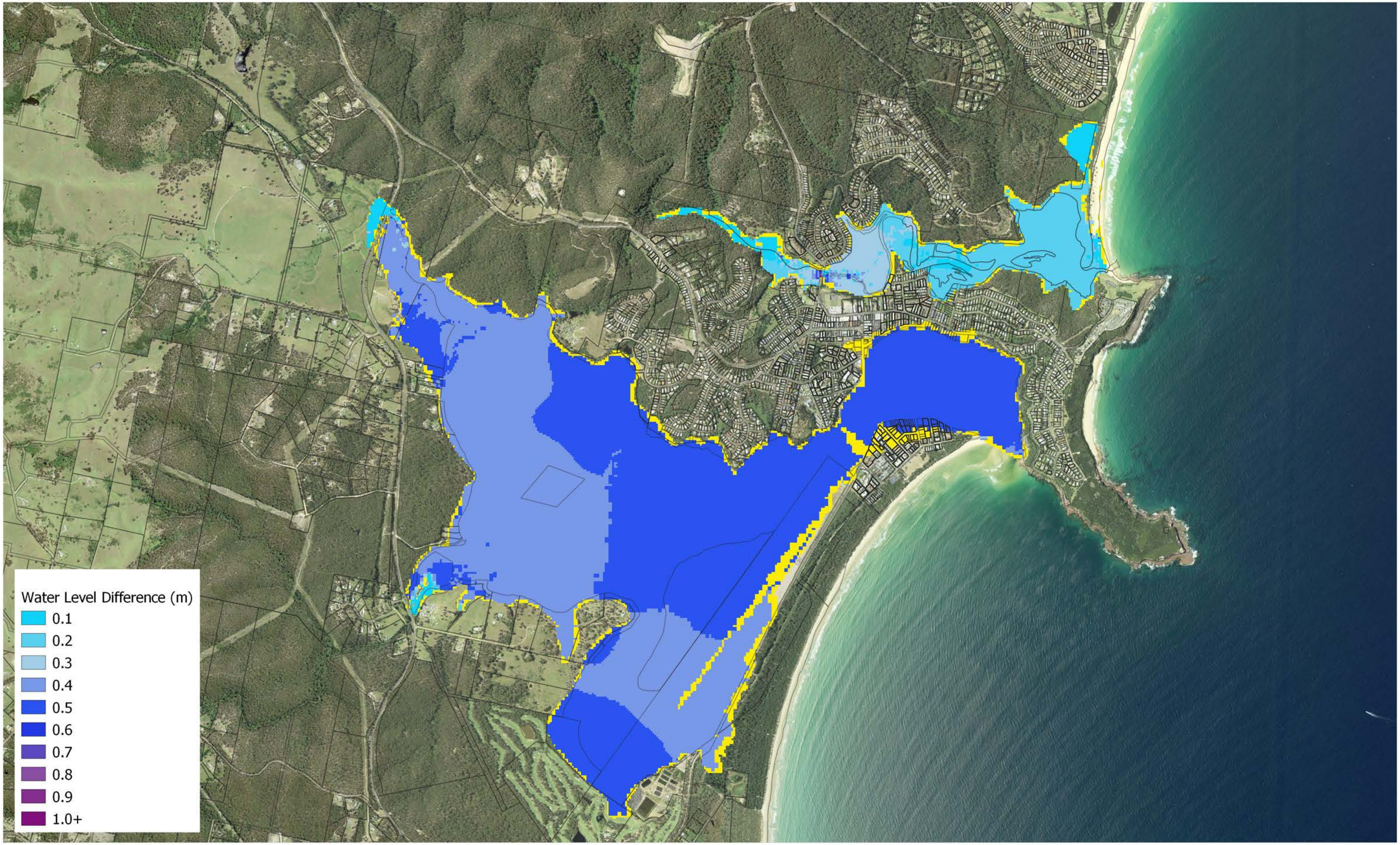
Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend
Cadastre
Additionally flooded areas under climate change scenario

N W E S

Map G806-1
1% AEP 0.4m Sea Level Rise Water Level Differences



Rhelm

Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend
Cadastre
Additionally flooded areas under climate change scenario

N W E S

Map G806-2
0.5% AEP 0.4m Sea Level Rise Water Level Differences

Rhelm

Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA94 Z55

0 250 500 750 1000 m

Legend

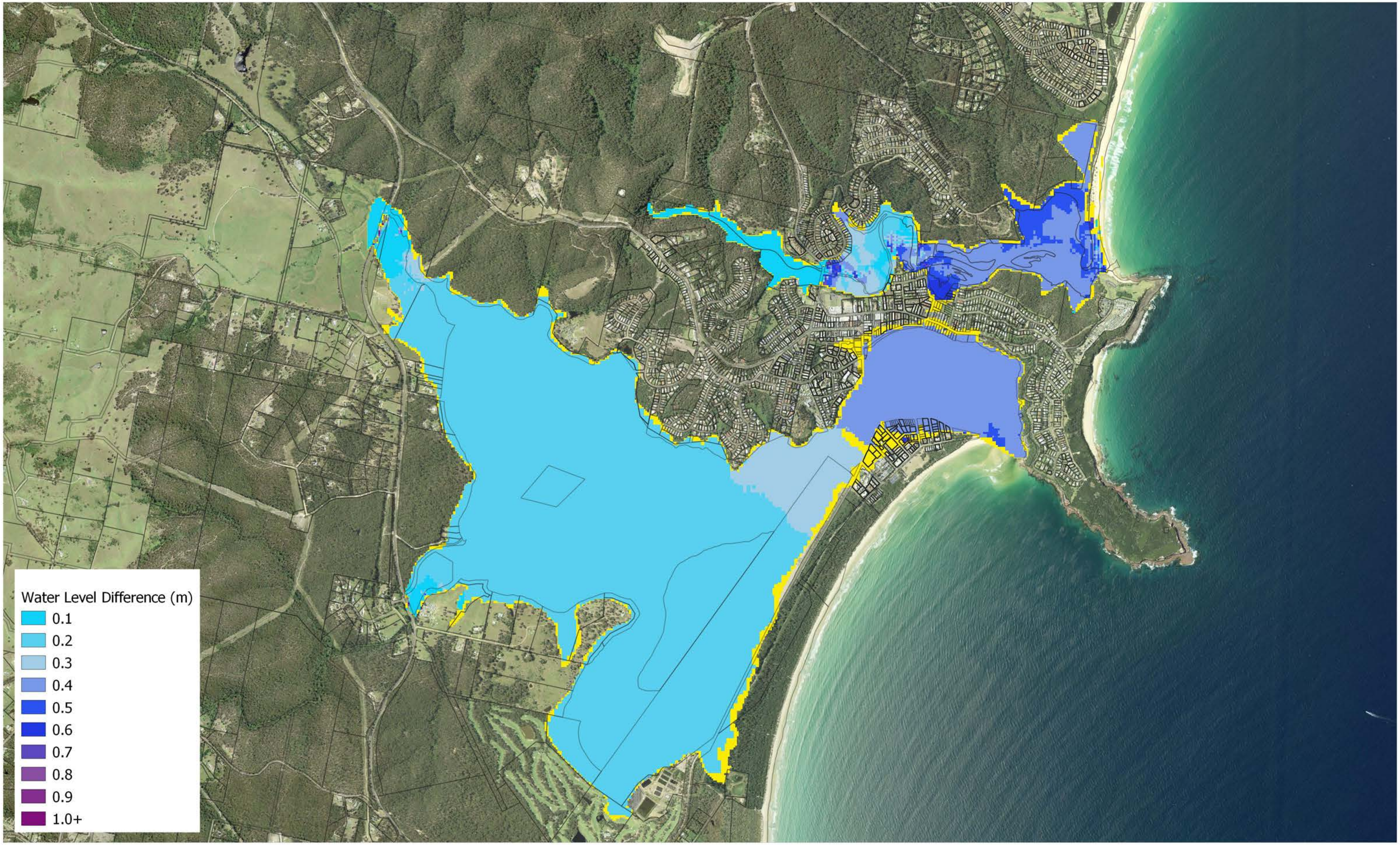
Cadastre

Additionally flooded areas under climate change scenario

N W E S

Map G806-3

0.2% AEP 0.4m Sea Level Rise Water Level Differences



Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA94 Z55

0 250 500 750 1000 m

Rhelm

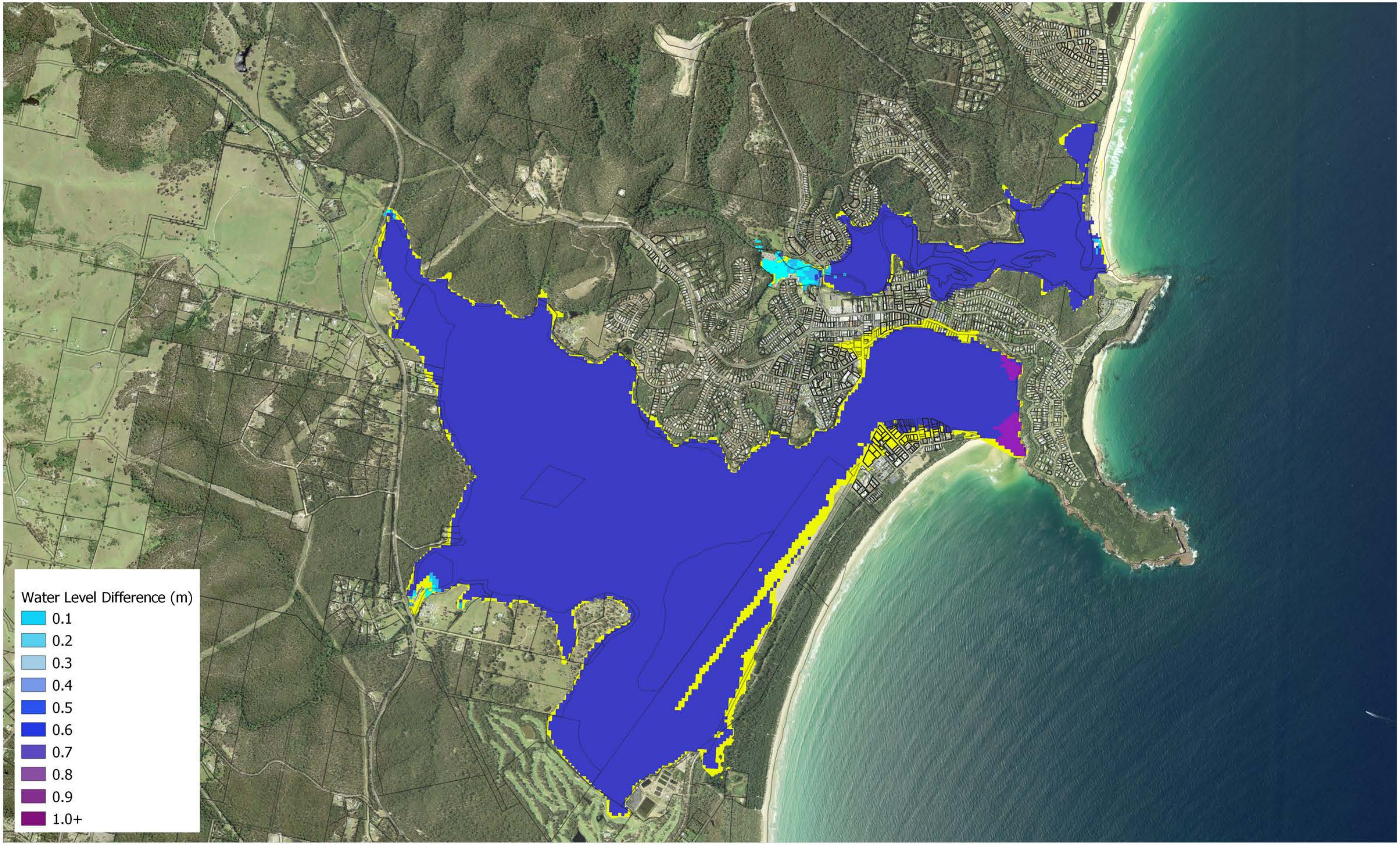
Legend

Cadastre

Additionally flooded areas under climate change scenario

N W E S

Map G806-4
PMF 0.4m Sea Level Rise Water Level Differences



Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend

Cadastre

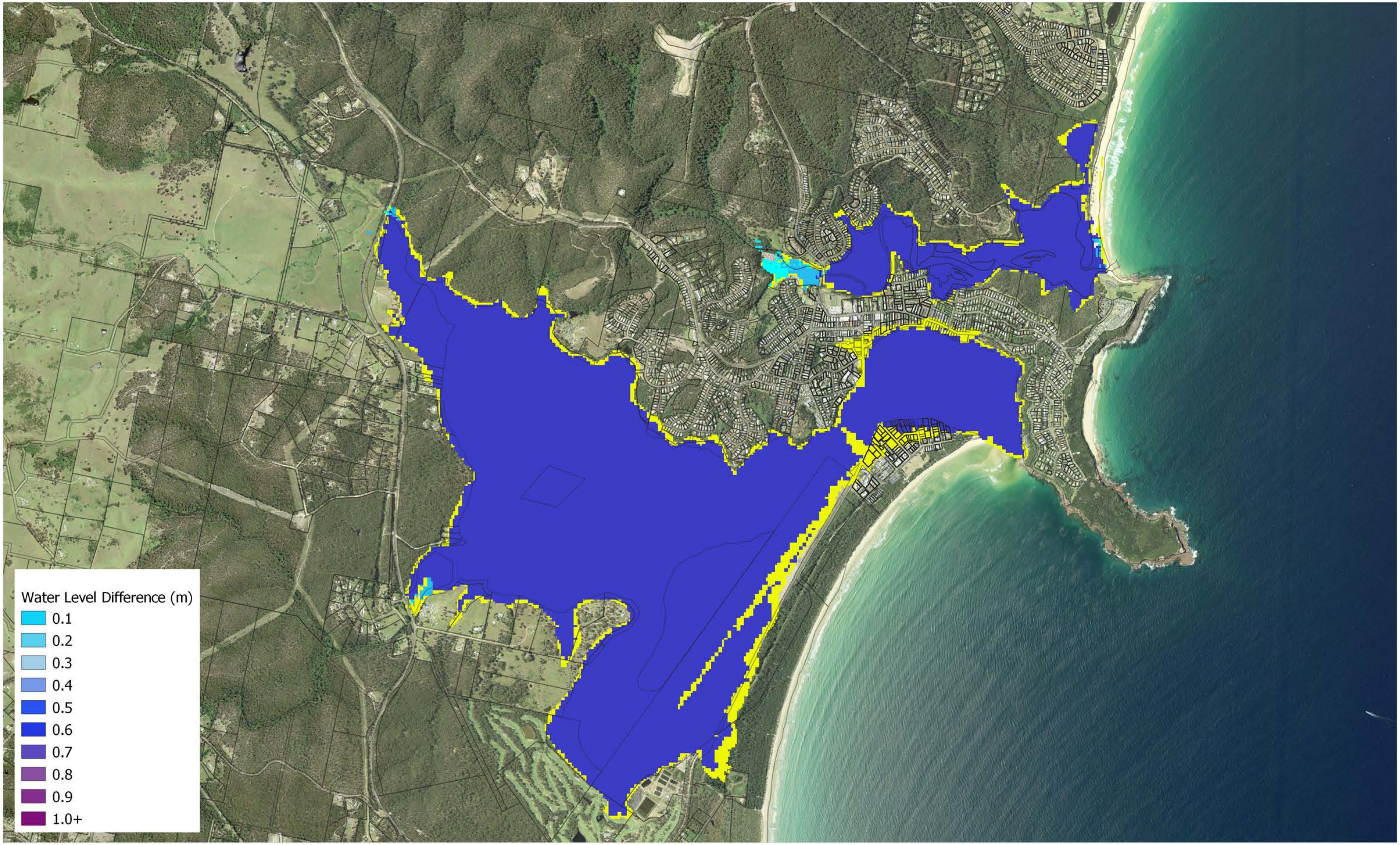
Additionally flooded areas under cliamte change scenario

Rhelm

N W E S

Map G806-5

1% AEP 0.9m Sea Level Rise Water Level Differences



Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

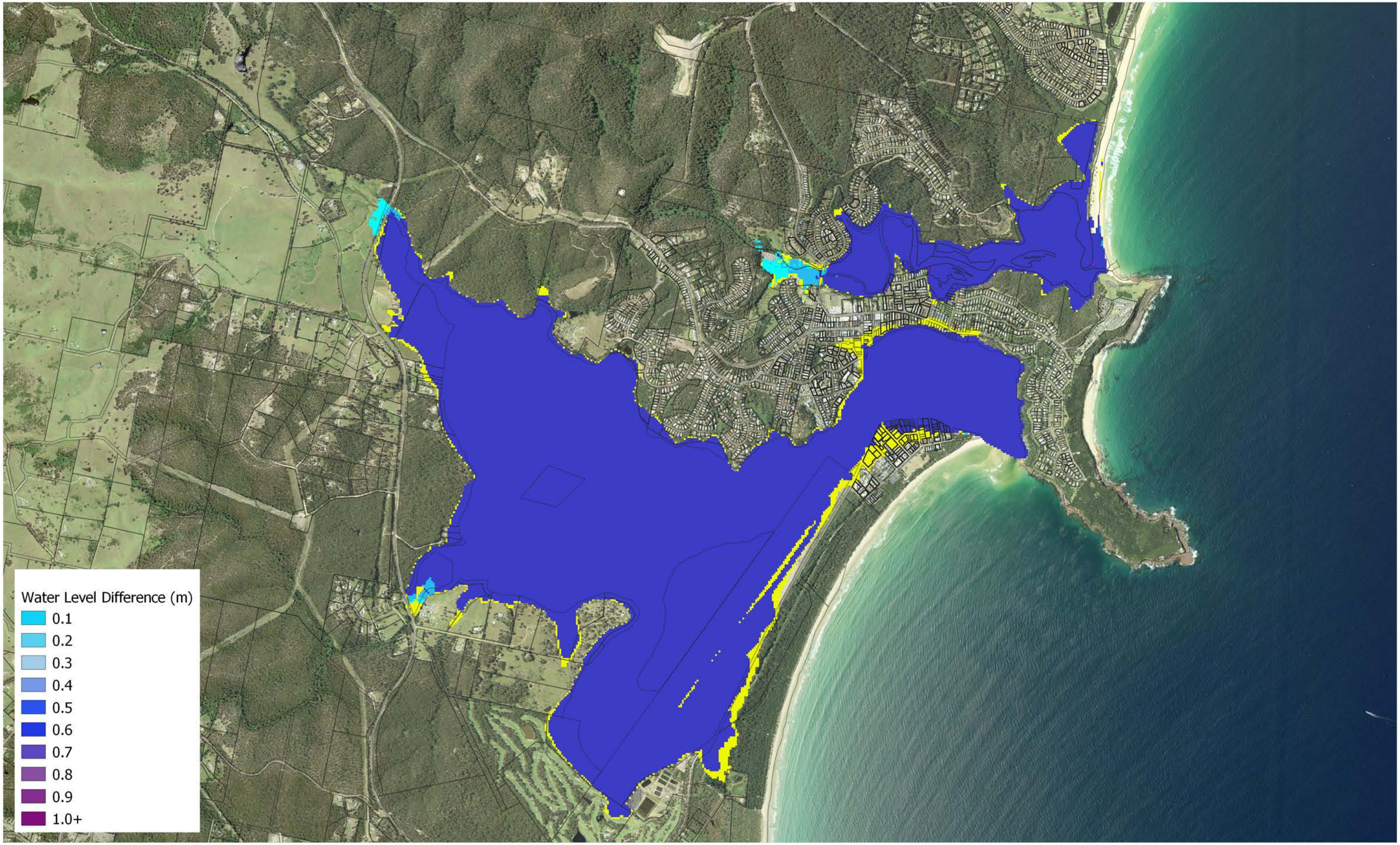
0 250 500 750 1000 m

Rhelm

Legend
Cadastre
Additionally flooded areas under cliamte change scenario

N W E S

Map G806-6
0.5% AEP 0.9m Sea Level Rise Water Level Differences



Rhelm

Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend

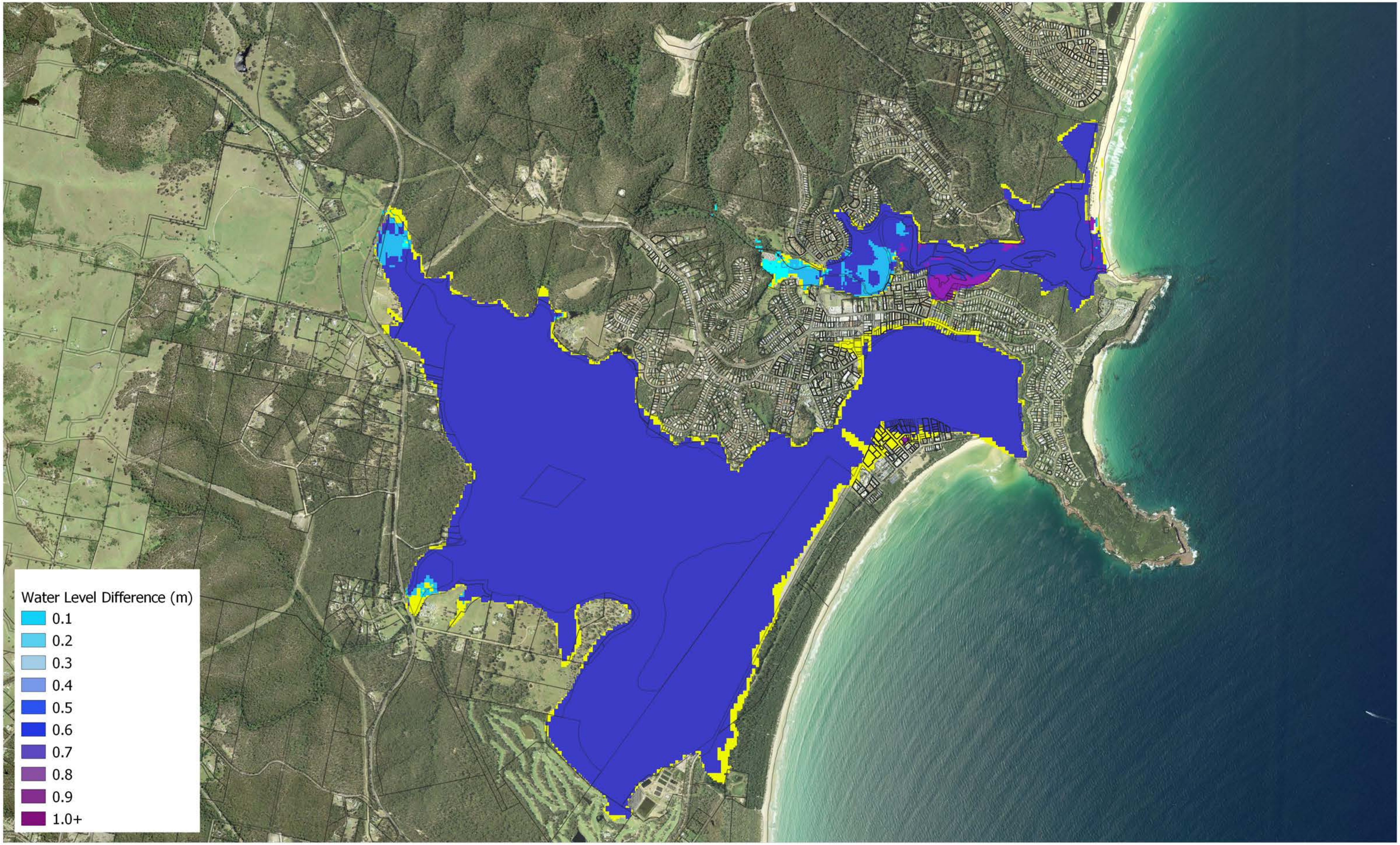
Cadastre

Additionally flooded areas under cliamte change scenario

N W E S

Map G806-7

0.2% AEP 0.9m Sea Level Rise Water Level Differences



Rhelm

Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend

Cadastre

Additionally flooded areas under cliamte change scenario

N W E S

Map G806-8

PMF 0.9m Sea Level Rise Water Level Differences

Rhelm

Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 750 1000 m

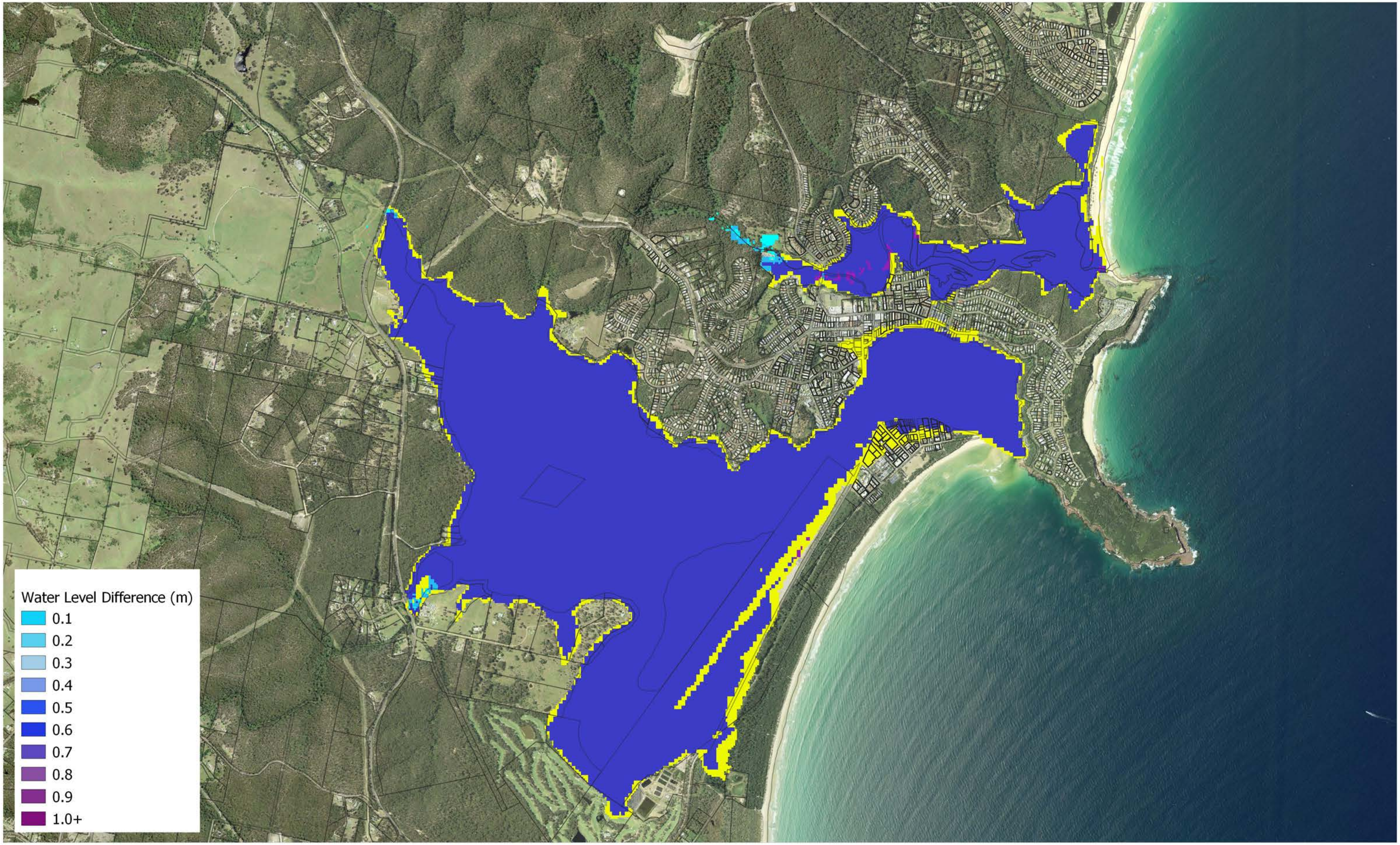
Legend

Cadastre

Addiionally flooded areas under cliamte change scenario

N W E S

Map G806-9
1% AEP 0.4m Sea Level Rise with 10% Rainfall Intesity Increase
Water Level Differences



Rhelm

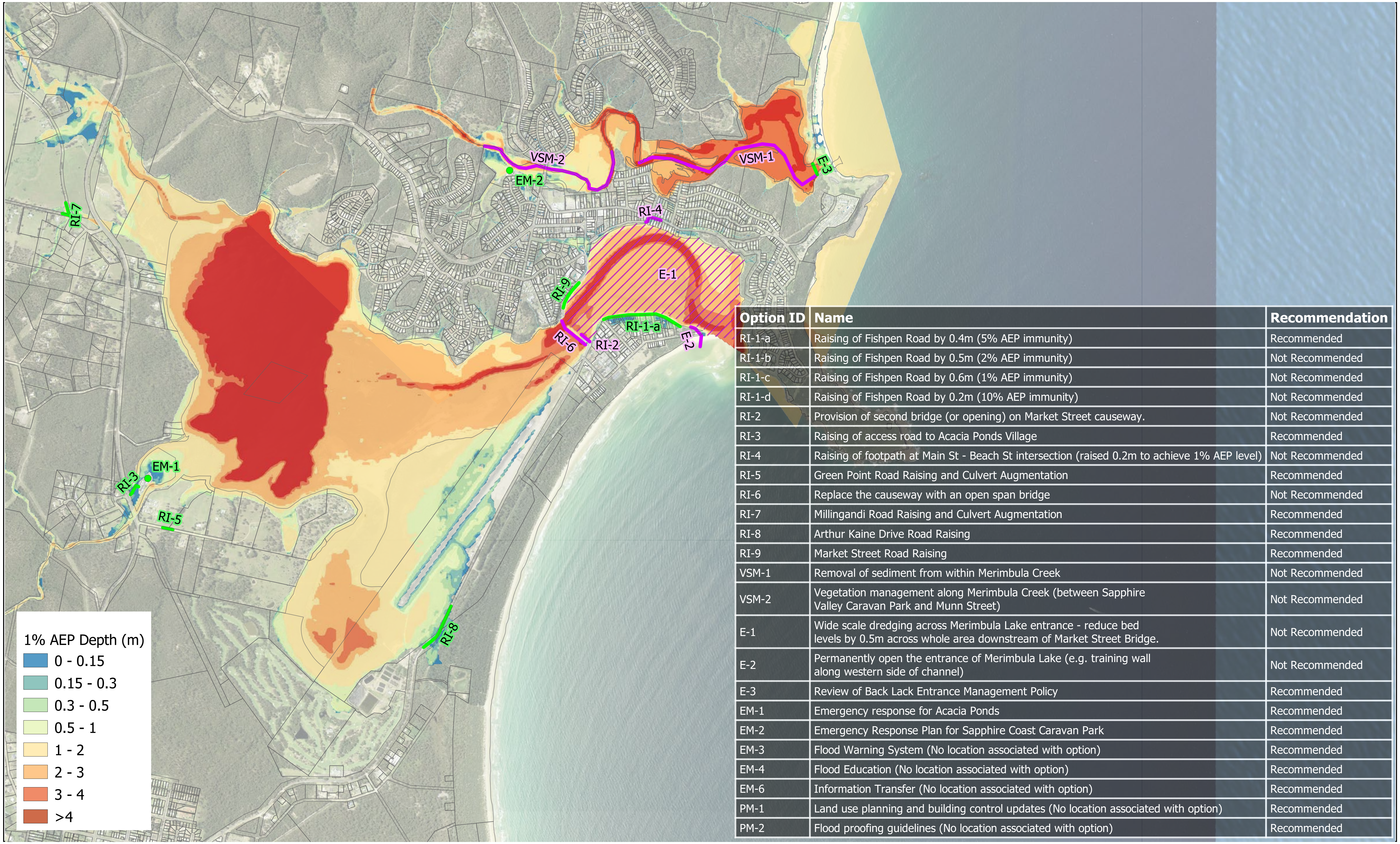
Scale : 1:25000@A3
Date : 16 September 2019
Revision : A
Created by : LRE
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend
Cadastre
Additionally flooded areas under cliamte change scenario

N W E S

Map G806-10
1% AEP 0.9m Sea Level Rise with 30% Rainfall Intesity Increase
Water Level Differences



Option ID	Name	Recommendation
RI-1-a	Raising of Fishpen Road by 0.4m (5% AEP immunity)	Recommended
RI-1-b	Raising of Fishpen Road by 0.5m (2% AEP immunity)	Not Recommended
RI-1-c	Raising of Fishpen Road by 0.6m (1% AEP immunity)	Not Recommended
RI-1-d	Raising of Fishpen Road by 0.2m (10% AEP immunity)	Not Recommended
RI-2	Provision of second bridge (or opening) on Market Street causeway.	Not Recommended
RI-3	Raising of access road to Acacia Ponds Village	Recommended
RI-4	Raising of footpath at Main St - Beach St intersection (raised 0.2m to achieve 1% AEP level)	Not Recommended
RI-5	Green Point Road Raising and Culvert Augmentation	Recommended
RI-6	Replace the causeway with an open span bridge	Not Recommended
RI-7	Millingandi Road Raising and Culvert Augmentation	Recommended
RI-8	Arthur Kaine Drive Road Raising	Recommended
RI-9	Market Street Road Raising	Recommended
VSM-1	Removal of sediment from within Merimbula Creek	Not Recommended
VSM-2	Vegetation management along Merimbula Creek (between Sapphire Valley Caravan Park and Munn Street)	Not Recommended
E-1	Wide scale dredging across Merimbula Lake entrance - reduce bed levels by 0.5m across whole area downstream of Market Street Bridge.	Not Recommended
E-2	Permanently open the entrance of Merimbula Lake (e.g. training wall along western side of channel)	Not Recommended
E-3	Review of Back Lack Entrance Management Policy	Recommended
EM-1	Emergency response for Acacia Ponds	Recommended
EM-2	Emergency Response Plan for Sapphire Coast Caravan Park	Recommended
EM-3	Flood Warning System (No location associated with option)	Recommended
EM-4	Flood Education (No location associated with option)	Recommended
EM-6	Information Transfer (No location associated with option)	Recommended
PM-1	Land use planning and building control updates (No location associated with option)	Recommended
PM-2	Flood proofing guidelines (No location associated with option)	Recommended

Rhelm

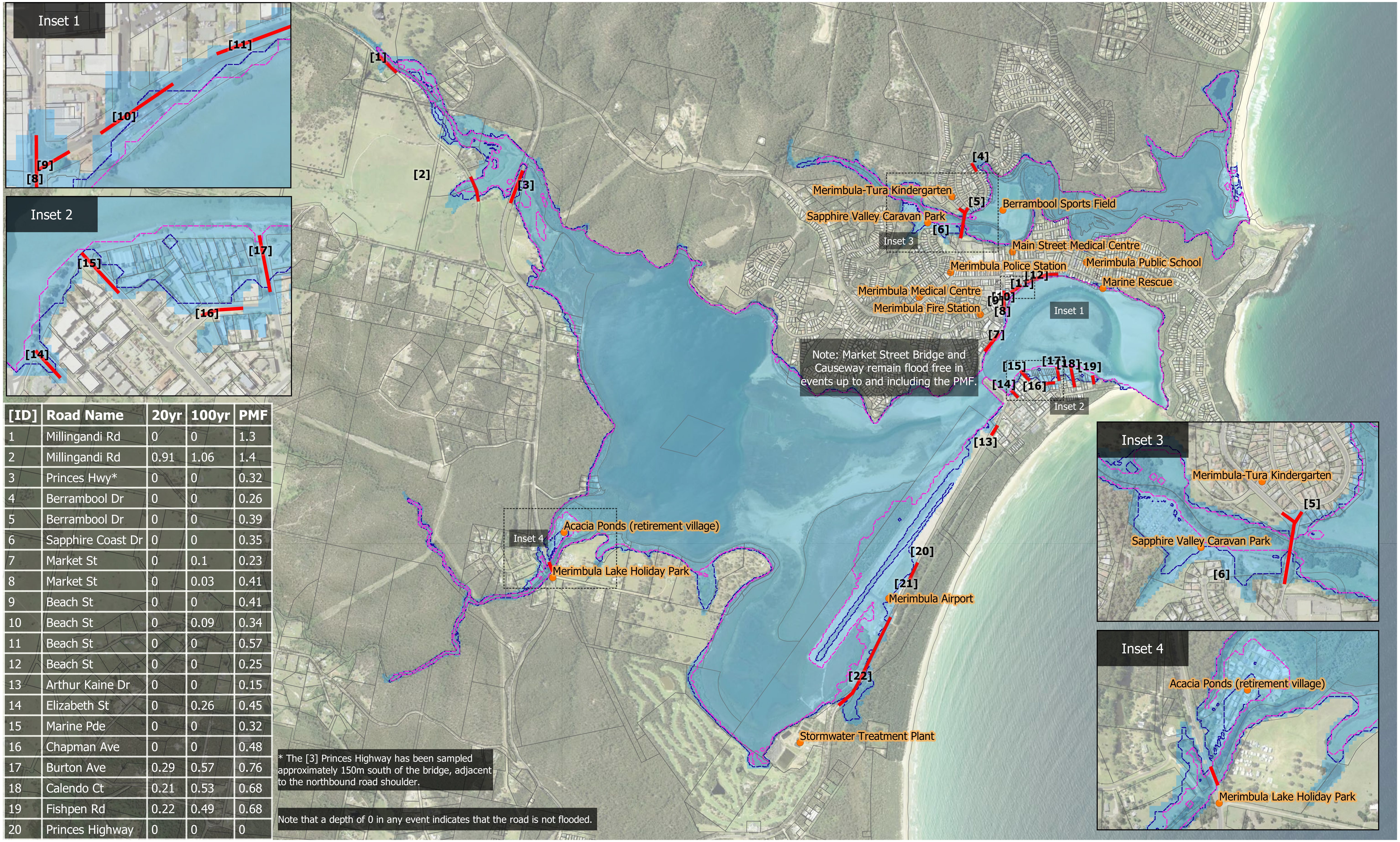
Scale : 1:25000@A3
Date : 10 December 2020
Revision : D
Created by : LRE
Coordinate System : MGA94 Z55

0 250 500 750 1000 m

Flood Risk Management Options
Recommended
Recommended
Not Recommended
Not Recommended

N W E S

Map G901
Flood Risk Management Options



[ID]	Road Name	20yr	100yr	PMF
1	Millingandi Rd	0	0	1.3
2	Millingandi Rd	0.91	1.06	1.4
3	Princes Hwy*	0	0	0.32
4	Berrambool Dr	0	0	0.26
5	Berrambool Dr	0	0	0.39
6	Sapphire Coast Dr	0	0	0.35
7	Market St	0	0.1	0.23
8	Market St	0	0.03	0.41
9	Beach St	0	0	0.41
10	Beach St	0	0.09	0.34
11	Beach St	0	0	0.57
12	Beach St	0	0	0.25
13	Arthur Kaine Dr	0	0	0.15
14	Elizabeth St	0	0.26	0.45
15	Marine Pde	0	0	0.32
16	Chapman Ave	0	0	0.48
17	Burton Ave	0.29	0.57	0.76
18	Calendo Ct	0.21	0.53	0.68
19	Fishpen Rd	0.22	0.49	0.68
20	Princes Highway	0	0	0

Rhelm
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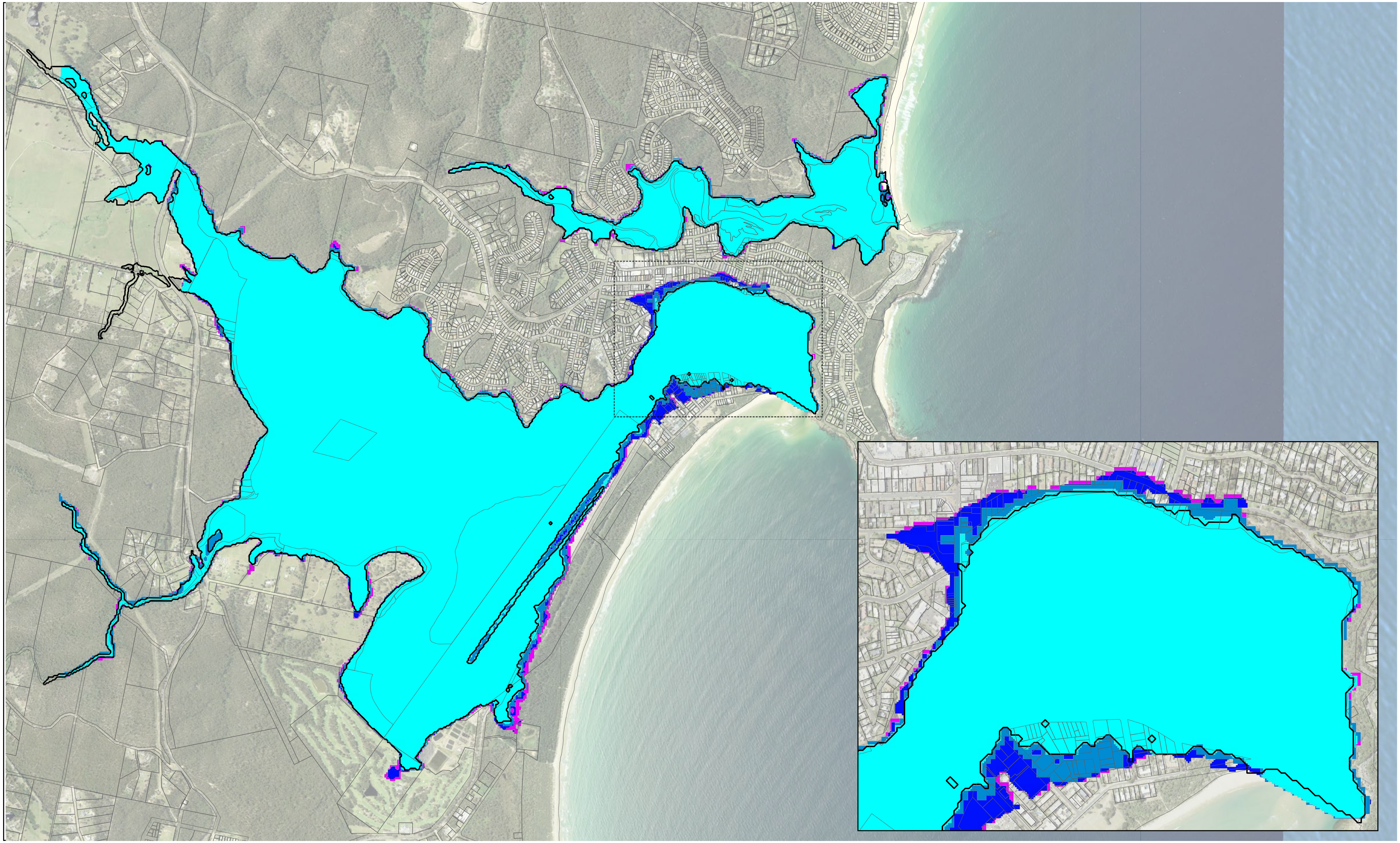
Scale : 1:10000@A3
Date : 02 September 2020
Revision : A
Created by : JS
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend
- Cadastre
- Key Infrastructure
- Overtopped Roads (with ID)
- PMF (Probable Maximum Flood) Extent
- 1% AEP Extent
- 20% AEP Extent

N W E S

Map G902
Flood Impact on Transport and Infrastructure



Scale : 1:25000@A3
Date : 02 September 2020
Revision : A
Created by : JS
Coordinate System : MGA 55

0 250 500 750 1000 m

Legend

Cadastre
1% AEP
1% AEP - 0.4m Sea Level Rise
1% AEP - 0.4m Sea Level Rise + 10% Increase in Rainfall
1% AEP - 0.9m Sea Level Rise
1% AEP - 0.9m Sea Level Rise + 30% Increase in Rainfall

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Map G903
Climate Change Scenarios

APPENDIX A

Engagement Materials

Merimbula Lake and Back Lake
Floodplain Risk Management Study and Plan

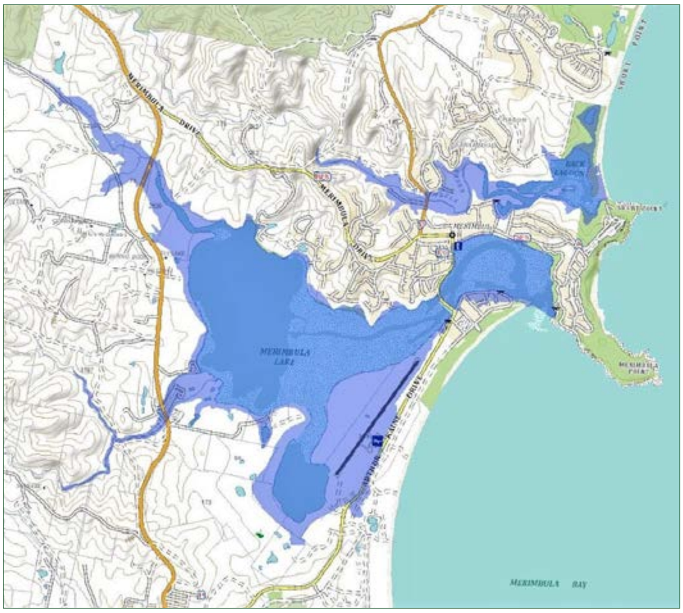
In 2017 Bega Valley Shire Council completed a Flood Study for the foreshore and low-lying areas surrounding Merimbula Lake and Back Lake. The study identified flood risks to people, property, infrastructure and assets. Council, with the assistance of State and Commonwealth Government, is now undertaking a Floodplain Risk Management Study and Plan to look at ways to manage flood risk.

In 2017 Council completed a Flood Study for Merimbula Lake and Back Lake.

Flooding has occurred within the study area due to ocean storms, local intense rainfall and extreme tides.

More than 300 properties within the study area could be affected by flooding.

Council is asking the community what flood risks they area concerned about and how they would like Council to address the risks.



At Bega Valley Shire Council we know some parts of the Local Government Area (LGA) are more prone to flooding that others and we're committed to finding solutions to reduce the social and economic damages of flooding.

A Flood Study was completed for Merimbula Lake and Back Lake in 2017. The study found a range of flooding issues including flooding of private properties, roads and public space. Flooding is caused by creek and lake flooding during large rainfall events, as well inundation from ocean storms.

The Floodplain Risk Management Study and Plan will be looking at options to manage flooding and its consequences. This may include drainage upgrades, foreshore barriers, detention basins, planning and development controls, community awareness programs or evacuation procedures. Council will be identifying potential options with the input from the community and will then assess the options and identify what actions Council, SES and the community can undertake to improve flood risk.

Do you have any local knowledge of flooding around Merimbula Lake and Back Lake?

Council would like to hear from you by email, phone or by filling in a brief online survey (the link is available from the Have Your Say page listed below). Your responses will help us understand the local flooding problems in more detail. Local knowledge and personal experiences of flooding are an invaluable source of data.

You can also share you knowledge and thoughts with the project team at the community drop in sessions (see below).

Community drop in sessions will be held **3pm—6pm Thursday 6th December and 11am—2pm Friday 7th December at Bega Valley Regional Learning Centre: 14 Cabarita Place, Merimbula**.
You are invited to come along to find out more about the study and to share with the project team your experiences and concerns about flooding in the local area.

Online: www.begavalley.nsw.gov.au (go to 'Have Your Say' link on main page

For more information phone:
(02) 6499 2222

Email: council@begavalley.nsw.gov.au
Mail: PO Box 492, Bega NSW 2550

Submissions should be provided by Friday 14th December

Merimbula Lake and Back Lake
Floodplain Risk Management Study and Plan

Community Online Survey

Contact Details:

Name ____

Address (including Lot / DP, if known)____

Email ____

Contact Phone Number ____

How have you lived, worked or visited in and around Merimbula Lake and Back Lake?

_______ Years

Are you aware of flooding in and around Merimbula Lake and Back Lake? (please select one)

Aware ___ Some knowledge ___ Not aware ___

Do you have any specific concerns about flooding related to Merimbula Lake and Back Lake?

(e.g. locations of frequent or severe flooding, or specific impacts of flooding on roads, properties, assets or access)

____

____

____

____

Do you have any suggestions on how this flooding could be managed better?

____

____

____

____

____

What information do you look for during a flood event (e.g. road closures, evacuation notices) and where do you currently get updates and information (e.g. websites, radio, TV, social media)

____

____

Can Council or our consultant contact you for further information relating to your responses to this survey? Yes / No

Can Council access your property to survey flood information, if provided above? Yes / No

Do you give Council permission to use your supplied photos and information for the purposes of publicity or inclusion in the project documents? Yes / No

Merimbula flood study enters new phase

Merimbula flood study enters new phase

20 November 2018

With the Merimbula Lake and Back Lake Flood Study report finalised, Council is now undertaking a Floodplain Risk Management Study and Plan to look at various options to reduce the risks and damages caused by flooding as identified by the Flood Study.

The Flood Study was based on a mix of first-hand accounts from residents, historic flood marks, tidal data, rainfall records and modern modelling techniques.

Asset Management Coordinator, Gary Louie, said that his team and consultants, Rhelm, are now asking for input from the community on how to manage the flooding problems connected with both lakes.

“We're going back to the community; people provided us with valuable information during the initial data collection phase in May 2015 and again in September 2016 when we met with the community to discuss the draft findings of the study.

“This time, we're looking for information on flooding problems that people are aware of and suggestions on how they would like to see these problems addressed.

“People can give us their input through a survey or we'll be holding community information sessions on Thursday 6 December and Friday 7 December 2018.

"We greatly appreciate the community's interest and support with this long-term project and in the past local information has helped to round out the picture of flood risks within the catchment area," he said.

Information about the next step of this project will be sent out to selected residents and property owners within the study area; this same information is available on Council's website where a survey can be completed online at www.begavalley.nsw.gov.au/haveyoursay.

The survey closes on Sunday 16 December 2018.

Drop-in information sessions for the community will be held at Bega Valley Regional Learning Centre, 14 Cabarita Place, Merimbula as follows:

Thursday 6 December, 3.00pm – 6.00pm

Friday 7 December, 11.00am – 2.00pm

Council staff and consultants from Rhelm will be available.

If you have any questions, please contact Gary Louie on (02) 6499 2222.

NSW Office of Environment and Heritage and the Minister of Police and Emergency Services are supporting Council by providing technical assistance and grant funding for the project.

Photograph: Merimbula from the air showing Merimbula Lake and Back Lake.

END

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APPENDIX B

Damage Curves

C.1 Residential Damage Curves

Residential damage curves were generated based on the curves prepared by the Department of Natural Resources (now DPIE) in 2007. The spreadsheet provides damage curves for three residential building types:

- Single storey, slab on ground
- Single storey, high set
- Two storey slab on ground.

The damage curves are calculated based on an assumed floor area, and the warning time available.

An assessment of property size was undertaken from the aerial imagery. An average house size of 240m^2 was adopted for this damage assessment.

A warning time of zero hours was adopted.

The final curves, adjusted to 2019 dollars, are shown in **Figure 8-1**.

C.2 Commercial Damage Curves

Commercial damages were adopted from the ANUFLOOD damage estimation program (Queensland Government, 1983). Individual curves were prepared for low, medium and high value commercial properties. The curves are based on the floor area of the property. Property areas for commercial properties were determined from aerial photography.

The final curves, adjusted to 2019 dollars, are shown in **Figure 8-1**.

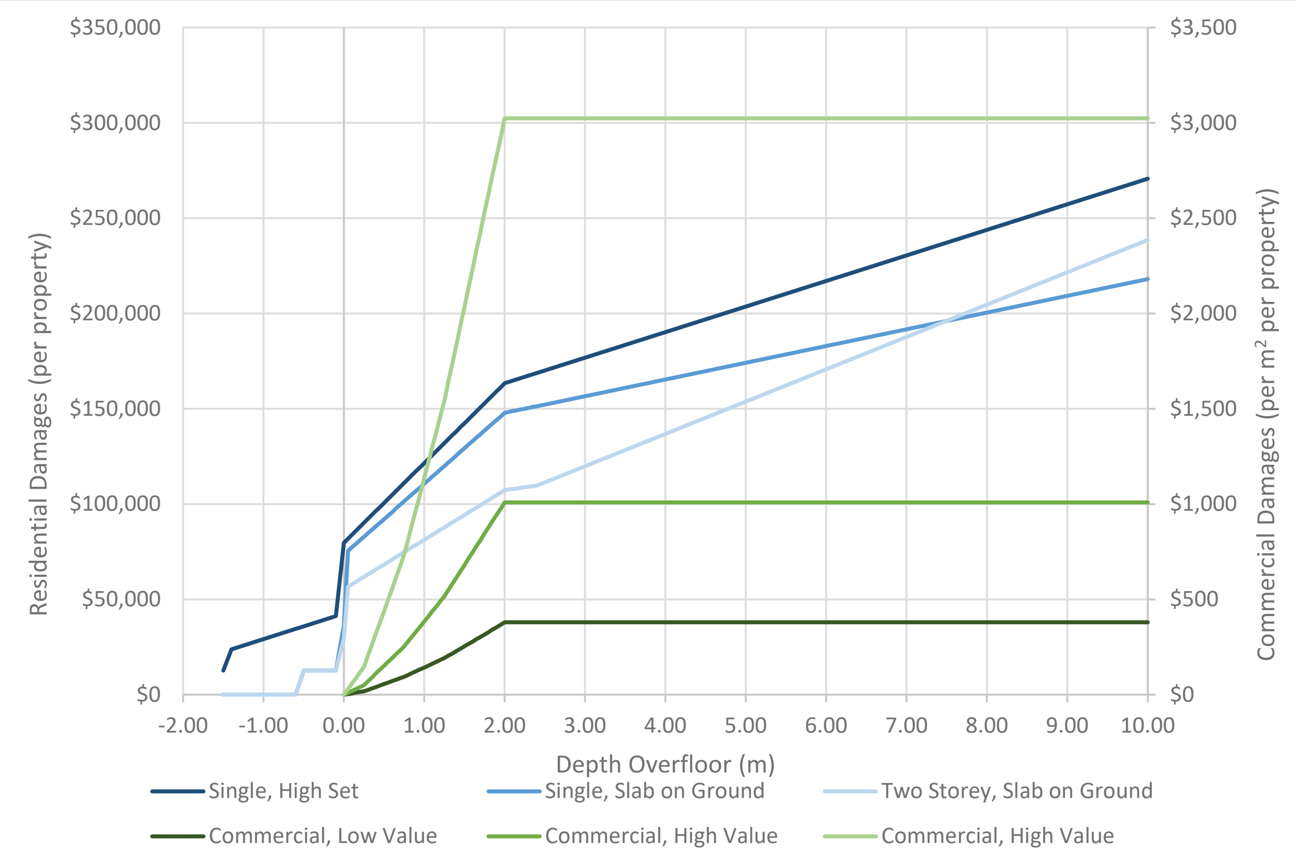

Figure 8-1 Residential and Commercial Property Damage Curves

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APPENDIX C

MCA and Costings

Table B-1 MCA Scoring and Weighting Values

Category	Category Weighting	Category Weighting (factored)	Criteria	Criteria Description	Criteria Weighting	Metric	-3	-2	-1	0	1	2	3
Economic	1	0.20	Reduction in Flood Damages	Where an economic assessment has been undertaken for an option, this would be an explicit value. Where no economic assessment has been undertaken, this should be an estimate based on catchment damages and flood behaviour.	5	Change in Annual Average Damage	> $1M	$500,000 to $1M	< $500,000	No change	> -$500,000	-$500,000 to -$1M	< -$1M
			Capital Cost	Cost of constructing or implementing the option.	4	Capital cost of option	> $500,000	$50,000 to $500,000	< $50,000	Existing infrastructure or council policy continued	N/A	N/A	N/A
			Operating and Maintenance Costs	Annual costs associated with operation and / or maintenance of the option. This is assumed to be in addition to existing maintenance programs undertaken by Council.	4	Annual operating cost of option	> $50,000	$5,000 to $50,000	< $5,000	No cost in addition to council's existing maintenance program	N/A	N/A	N/A
			Implementation Complexity	Consideration of constraints related to implementing the option (e.g. traffic impacts, works located on private property, etc).	3	Implementation or construction timeframe and challenges	Implementation timeframe > 1 year with major constraints, challenges and uncertainties which may render the option unfeasible	Implementation timeframe > 1 year with significant constraints, challenges and uncertainties which may increase costs or timeframes significantly	Implementation timeframe 6 months to 1 year with some significant constraints and challenges which may increase costs or timeframes slightly	N/A	Implementation timeframe < 6 months with significant constraints, challenges and uncertainties which may increase costs or timeframes significantly	Implementation timeframe < 6 months with constraints, challenges and uncertainties which may increase costs or timeframes slightly	Implementation timeframe < 6 months with no constraints or challenges / No construction requirements (e.g. planning related option)
			Staging of Works	If works can be staged this may increase the viability of the option, by spreading out costs.	3	Ability to stage proposed works	N/A	N/A	N/A	Works cannot be staged	Some minor components of the works may be staged	Significant components of the works can be staged	N/A
Social	1	0.20	Increased Community Flood Awareness	Increased flood awareness often results in a community preparing and responding to flooding better. This can result in both a reduction in property damages, social disruption and risk to life.	5	Level of likely increased awareness	N/A	N/A	N/A	No increased awareness of flooding and appropriate response	N/A	Increased awareness likely to protect property	Increased awareness likely to protect life

Category	Category Weighting	Category Weighting (factored)	Criteria	Criteria Description	Criteria Weighting	Metric	-3	-2	-1	0	1	2	3
			Reduction in Risk to Life and Social Impacts	Reduction in risk to life and social impacts can be achieved by reducing the number of properties being flooded, or through other means such as reducing flood depths on roads, informing the community of flooding (e.g. flood depth markers).	5	Change in number of properties with over floor flooding in 100 Year ARI event	Increase: > 1 property	N/A	N/A	No change	Reduction: 1 to 5 properties / May indirectly reduce risk to life	Reduction: 6 to 12 properties / Likely to reduce injury	Reduction: > 12 properties / Likely to save lives
			Emergency Access and Traffic Disruption	Reducing flooding of access routes, or providing alternative access during flooding.	4	Flood depth and duration changes for critical transport routes in 100 Year ARI event	Key access roads become flooded that were previously flood free	Significant increase in local or main road flooding	Minor increase in local or main road flooding	No change	Minor decrease in local or main road flooding	Significant decrease in local or main road flooding	All roads flood free in vicinity of option
			Compatible with DCP and LEP	Are the works permissible within the landuse zone, and in accordance with the DCP	3	Level of compatibility	Conflicts directly with objectives of several plans and policies	Some conflicts with several objectives or direct conflicts with one or few objectives	Minor conflicts with one or very few objectives	Not relevant to objectives	Minor support for one or very few objectives	Some support for several objectives or achieving one or few objectives	Achieving objectives of several plans and policies
			Likely Community Support	Likely community support to be estimated based on previous community engagement, and public exhibition of draft FRMS.	3	Level of agreement	Strong opposition by numerous submissions	Moderate opposition in several submissions	Individual submissions with opposition	No responses	Individual submissions with support	Moderate support in several submissions	Strong support by numerous submissions
Environmental	0.5	0.13	Flora / Fauna Impacts	Impacts on flora and fauna based on Council's vegetation GIS data and the presence of vegetation noted during site inspections.	3	Impacts or benefits to flora / fauna	Likely broad-scale vegetation / habitat impacts and/or impacts on threatened species	Likely isolated vegetation / habitat impacts	Removal of isolated trees or minor landscaping	No impact	Planting of isolated trees or minor landscaping	Likely isolated vegetation / habitat benefits	Likely broad-scale vegetation / habitat benefits and/or benefits for threatened species
			Acid Sulfate Soils	Impacts on ASS based on state based ASS mapping.	3	Disruption of PASS	N/A	- Any work within Class 1 ASS area. - Any excavation work within Class 2 ASS area. - Excavation >1m within Class 3 ASS area. - Excavation >2m within Class 4 ASS area	- Surface works within Class 2 ASS area - Excavation <1m or surface works within Class 3 ASS area - Excavation <2m or surface works within Class 4 ASS area	Works not within areas identified as PASS	N/A	N/A	N/A
			Visual Impacts		3	Impact of completed works on visual amenity	Complete loss of existing valued visual amenity	Partial loss of existing valued visual amenity	N/A	No change	N/A	Moderate improvement to visual amenity	Significant improvement to visual amenity
			Recreational Space		3	Impact on passive/active recreational areas	Significant reduction in recreational space	Minor reduction in recreational space	Loss of recreational opportunity	No impact	Embellishment of existing recreational space	Minor increase in recreational space	Significant creation of additional recreational space

Table B-1 MCA Assessment

Option ID	Option Description	Benefit - Cost Assessment						Economic						Social						Environmental						
		Category Weighting						0.2						0.20						0.13						
		Criteria Weighting						5	4	4	3	3		5	5	4	3	3		3	3	3	3			
		Capital Cost	Recurrent Cost	Reduction in AAD	NPV of Costs	NPV of Benefits	BCR	Reduction in Flood Damages	Capital Cost	Operating and Maintenance Costs	Implementation Complexity	Staging of Works	Economic Score	Increased Community Flood Awareness	Reduction in Risk to Life and Social Impacts	Emergency Access and Traffic Disruption	Compatible with DCP and LEP	Likely Community Support	Social Score	Flora / Fauna Impacts	Acid Sulfate Soils	Visual Impacts	Recreational Space	Environmental Score	**Total Score**	**Rank**
	Flood Modification Options																									
RI-1-a	Raising of Fishpen Road by 0.4m (5% AEP immunity)	$855,400	$5,000	$11,237	$924,404	$155,079	0.17	2	-2	-1	-2	1	-1	0	1	3	1	1	4.6	0	-1	-1	-1	-1.1	2.5	8
RI-1-b	Raising of Fishpen Road by 0.5m (2% AEP immunity)	$1,425,200	$10,000	$22,756	$1,563,207	$314,050	0.20	2	-3	-1	-2	1	-1.8	0	1	2	1	1	3.8	0	-1	-1	-1	-1.1	0.9	11
RI-1-c	Raising of Fishpen Road by 0.6m (1% AEP immunity)	$2,089,150	$15,000	$29,516	$2,296,161	$407,343	0.18	2	-3	-2	-2	1	-2.6	0	2	1	1	1	4	0	-1	-1	-1	-1.1	0.3	14
E-3	Revision of Back Lack Entrance Management Plan	$75,000	$0	N/A	N/A	N/A	N/A	0	-1	0	-1	0	-1.4	0	0	1	2	1	2.6	0	0	0	0	0	1.2	10
	Emergency Response Modification Options																									
RI-3	Raising of access road to Acacia Ponds Village	*Private Property*		N/A	N/A	N/A	N/A	-1	-1	-2	1	-1	-2.2	0	1	2	1	2	4.4	0	0	-1	0	-0.4	1.8	9
RI-4	Raising of footpath at Main St	$142,450	$2,500	N/A	N/A	N/A	-1	-1	-2	-2	-1	-2.2	-4.1	0	1	0	0	0.8	0	0	0	0	0	-3.3	-3.3	17
RI-5	Green Point Road Raising and Culvert Augmentation	$676,200	$5,000	N/A	N/A	N/A	-2	-1	-2	-2	-2	-2.2	-4.9	1	3	1	2	5.2	0	0	0	0	0	0.3	0.3	13
RI-7	Millingandi Road Raising and Culvert Augmentation	$861,700	$5,000	N/A	N/A	N/A	-2	-1	-2	-3	-2	-3	-5.4	1	2	1	2	4.4	0	0	0	0	0	-1.0	-1	16
RI-8	Artur Kaine Drive Road Raising	$1,232,700	$5,000	N/A	N/A	N/A	-2	-1	-2	-2	-2	-2	-4.8	0	1	3	1	1	4.6	0	0	0	0	-0.2	-0.2	15
		$646,450	$5000	N/A	N/A	N/A	-1	-1	-2	-2	-1	-2	-4.8	0	1	3	1	1	4.6	0	0	0	0	0.6	0.6	12
EM-1	Emergency response for Acacia Ponds	*Private Property*		N/A	N/A	N/A	N/A	0	0	1	0	0	0.6	2	1	0	1	1	4.2	0	0	0	0	0	4.8	2
EM-2	Emergency Response Plan for Sapphire Coast Caravan Park	*Private Property*		N/A	N/A	N/A	N/A	0	0	0	1	0	0.6	1	1	0	1	1	3.2	0	0	0	0	0	3.8	4
EM-3	Flood Warning System	$25,000	$1,500	N/A	N/A	N/A	0	-1	-1	1	1	-0.4	3	1	1	0	2	6	0	0	0	0	0	5.6	5.6	1
EM-4	Flood Education	$50,000	$2,500	N/A	N/A	N/A	0	-1	-1	-1	0	-2.2	3	1	0	0	3	5.8	0	0	0	0	0	3.6	3.6	5
EM-6	Information Transfer	$2,500	$0	N/A	N/A	N/A	0	-1	0	3	0	1	0	1	0	0	2	2.2	0	0	0	0	0	3.2	3.2	6

		Benefit - Cost Assessment						Economic						Social						Environmental						
		Category Weighting						0.2						0.20						0.13						
		Criteria Weighting						5	4	4	3	3		5	5	4	3	3		3	3	3	3			
Option ID	Option Description	Capital Cost	Recurrent Cost	Reduction in AAD	NPV of Costs	NPV of Benefits	BCR	Reduction in Flood Damages	Capital Cost	Operating and Maintenance Costs	Implementation Complexity	Staging of Works	Economic Score	Increased Community Flood Awareness	Reduction in Risk to Life and Social Impacts	Emergency Access and Traffic Disruption	Compatible with DCP and LEP	Likely Community Support	Social Score	Flora / Fauna Impacts	Acid Sulfate Soils	Visual Impacts	Recreational Space	Environmental Score	**Total Score**	**Rank**
Property Modification Options																										
PM-1	Land use planning and building control updates	$25,000	$0	N/A	N/A	N/A	N/A	0	-1	0	2	0	0.4	0	1	0	3	2	4	0	0	0	0	0	4.4	3
PM-2	Flood proofing guidelines	$20,000	$0	N/A	N/A	N/A	N/A	0	-1	0	2	0	0.4	0	0	0	3	1	2.4	0	0	0	0	0	2.8	7

Option RI-1-a   Fishpen Road Raising to 5% AEP

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	ESTABLISHMENT AND PRELIMINARIES				
1.1	Establishment	1	Item	$20,000	$20,000
1.2	Set out works	1	Item	$3,000	$3,000
1.3	Services location	1	Item	$5,000	$5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	$30,000	$30,000
1.5	Stabilised site access and wash bay	1	Each	$10,000	$10,000
	SUBTOTAL				$68,000
2	ROAD RAISING (assume road 10m wide)				
2.1	Demolition, clearing, site preparation	240	lin.m	$750	$180,000
2.2	Earthworks (raise by 0.4m)	96	cu.m	$500	$48,000
2.3	Road Pavement	240	lin.m	$1,000	$240,000
2.4	Drainage (nominal allowance)	1	item	$75,000	$75,000
	SUBTOTAL				$543,000
3	DESIGN AND CONTINENCY				
3.1	design, management, geotechnical, survey (10%)				$61,100
3.2	contingency (30%)				$183,300
	TOTAL (ex GST)				**$855,400**

Option RI-1-b Fishpen Road Raising to 2% AEP

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	ESTABLISHMENT AND PRELIMINARIES				
1.1	Establishment	1	Item	$20,000	$20,000
1.2	Set out works	1	Item	$3,000	$3,000
1.3	Services location	1	Item	$5,000	$5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	$30,000	$30,000
1.5	Stabilised site access and wash bay	1	Each	$10,000	$10,000
	SUBTOTAL				$68,000
2	ROAD RAISING (assume road 10m wide)				
2.1	Demolition, clearing, site preparation	400	lin.m	$750	$300,000
2.2	Earthworks (raise by 0.5m)	200	cu.m	$500	$100,000
2.3	Road Pavement	400	lin.m	$1,000	$400,000
2.4	Drainage (nominal allowance)	1	item	$150,000	$150,000
	SUBTOTAL				$950,000
3	DESIGN AND CONTINENCY				
3.1	design, management, geotechnical, survey (10%)				$101,800
3.2	contingency (30%)				$305,400
	TOTAL (ex GST)				**$1,425,200**

Option RI-1-c   Fishpen Road Raising to 1% AEP

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	ESTABLISHMENT AND PRELIMINARIES				
1.1	Establishment	1	Item	$20,000	$20,000
1.2	Set out works	1	Item	$3,000	$3,000
1.3	Services location	1	Item	$5,000	$5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	$30,000	$30,000
1.5	Stabilised site access and wash bay	1	Each	$10,000	$10,000
	SUBTOTAL				$68,000
2	ROAD RAISING (assume road 10m wide)				
2.1	Demolition, clearing, site preparation	585	lin.m	$750	$438,750
2.2	Earthworks (raise by 0.6m)	351	cu.m	$500	$175,500
2.3	Road Pavement	585	lin.m	$1,000	$585,000
2.4	Drainage (nominal allowance)	1	item	$225,000	$225,000
	SUBTOTAL				$1,424,250
3	DESIGN AND CONTINENCY				
3.1	design, management, geotechnical, survey (10%)				$149,225
3.2	contingency (30%)				$447,675
	TOTAL (ex GST)				**$2,089,150**

Option RI-4   Mainstreet Earthen Bund

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	ESTABLISHMENT AND PRELIMINARIES				
1.1	Establishment	1	Item	$20,000	$20,000
1.2	Set out works	1	Item	$3,000	$3,000
1.3	Services location	1	Item	$5,000	$5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	$30,000	$30,000
1.5	Stabilised site access and wash bay	1	Each	$10,000	$10,000
	SUBTOTAL				$68,000
2	FOOTPATH RAISING (assume road 2m wide)				
2.1	Demolition, clearing, site preparation	135	lin.m	$150	$20,250
2.2	Earthworks (raise by 0.2m)	27	cu.m	$500	$13,500
	SUBTOTAL				$33,750
3	DESIGN AND CONTINENCY				
3.1	design, management, geotechnical, survey (10%)				$10,175
3.2	contingency (30%)				$30,525
	TOTAL (ex GST)				**$142,450**

Option RI-5 Green Point Rd Raising and Augementation

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	ESTABLISHMENT AND PRELIMINARIES				
1.1	Establishment	1	Item	$20,000	$20,000
1.2	Set out works	1	Item	$3,000	$3,000
1.3	Services location	1	Item	$5,000	$5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	$30,000	$30,000
1.5	Stabilised site access and wash bay	1	Each	$10,000	$10,000
	SUBTOTAL				$68,000
2	ROAD RAISING (assume road 10m wide)				
2.1	Demolition, clearing, site preparation	100	lin.m	$750	$75,000
2.2	Earthworks (raise by 0.5m)	50	cu.m	$500	$25,000
2.3	Road Surface	100	lin.n	$750	$75,000
	SUBTOTAL				$175,000
3	DRAINAGE				
3.1	Provision of 600 * 1200 * 3 RCBC (10m each)	3	each	$80,000	$240,000
	SUBTOTAL				$240,000
3	DESIGN AND CONTINENCY				
3.1	design, management, geotechnical, survey (10%)				$48,300
3.2	contingency (30%)				$144,900
	TOTAL (ex GST)				**$676,200**

Option RI-7 Millingandi Rd Raising and Augementation

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	ESTABLISHMENT AND PRELIMINARIES				
1.1	Establishment	1	Item	$20,000	$20,000
1.2	Set out works	1	Item	$3,000	$3,000
1.3	Services location	1	Item	$5,000	$5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	$30,000	$30,000
1.5	Stabilised site access and wash bay	1	Each	$10,000	$10,000
	SUBTOTAL				$68,000
2	ROAD RAISING (assume road 10m wide)				
2.1	Demolition, clearing, site preparation	150	lin.m	$750	$112,500
2.2	Earthworks (raise by 0.5m)	165	cu.m	$500	$82,500
2.3	Road Surface	150	lin.n	$750	$112,500
	SUBTOTAL				$307,500
3	DRAINAGE				
3.1	Provision of 600 * 1200 * 3 RCBC (10m each)	3	each	$80,000	$240,000
	SUBTOTAL				$240,000
3	DESIGN AND CONTINENCY				
3.1	design, management, geotechnical, survey (10%)				$61,550
3.2	contingency (30%)				$184,650
	TOTAL (ex GST)				**$861,700**

Option RI-8 Arthur Kaine Drive Road Raising

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	ESTABLISHMENT AND PRELIMINARIES				
1.1	Establishment	1	Item	$20,000	$20,000
1.2	Set out works	1	Item	$3,000	$3,000
1.3	Services location	1	Item	$5,000	$5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	$30,000	$30,000
1.5	Stabilised site access and wash bay	1	Each	$10,000	$10,000
	SUBTOTAL				$68,000
2	ROAD RAISING (assume road 10m wide)				
2.1	Demolition, clearing, site preparation	500	lin.m	$750	$375,000
2.2	Earthworks (raise by 0.25m)	125	cu.m	$500	$62,500
2.3	Road Surface	500	lin.n	$750	$375,000
	SUBTOTAL				$812,500
3	DESIGN AND CONTINENCY				
3.1	design, management, geotechnical, survey (10%)				$88,050
3.2	contingency (30%)				$264,150
	TOTAL (ex GST)				**$1,232,700**

Option RI-9 Market Street Road Raising

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	ESTABLISHMENT AND PRELIMINARIES				
1.1	Establishment	1	Item	$20,000	$20,000
1.2	Set out works	1	Item	$3,000	$3,000
1.3	Services location	1	Item	$5,000	$5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	$30,000	$30,000
1.5	Stabilised site access and wash bay	1	Each	$10,000	$10,000
	SUBTOTAL				$68,000
2	ROAD RAISING (assume road 10m wide)				
2.1	Demolition, clearing, site preparation	250	lin.m	$750	$187,500
2.2	Earthworks (raise by 0.25m)	37.5	cu.m	$500	$18,750
2.3	Road Surface	250	lin.n	$750	$187,500
	SUBTOTAL				$393,750
3	DESIGN AND CONTINENCY				
3.1	design, management, geotechnical, survey (10%)				$46,175
3.2	contingency (30%)				$138,525
	TOTAL (ex GST)				**$646,450**

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