West Coonamble Floodplain Risk Management Study and Plan

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IA194100 - West Coonamble

July 2021

Coonamble Shire Council

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Contents

Foreword

The primary objective of the New South Wales 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. Under the Policy, the management of flood prone land remains the responsibility of local government.

The policy provides for a floodplain management system comprising the following five sequential stages:

1.	**Data Collection**	Involves compilation of existing data and collection of additional data
2.	**Flood Study**	Determines the nature and extent of the flood problem
3.	**Floodplain Risk Management Study**	Evaluates management options in consideration of social, ecological and economic factors relating to flood risk with respect to both existing and future development
4.	**Floodplain Risk Management Plan**	Involves formal adoption by Council of a plan of management for the floodplain
5.	**Implementation of the Plan**	Implementation of flood, response and property modification measures (including mitigation works, planning controls, flood warnings, flood preparedness, environmental rehabilitation, ongoing data collection and monitoring by Council

Coonamble Shire Council is undertaking this study for West Coonamble to update flooding behaviour and identify and develop measures to mitigate flood risk to people and development in the Study Area in accordance with the NSW Government's *Floodplain Development Manual*.

This report represents the second, third and fourth stages of the management process and has been prepared for Council by Jacobs. The report defines the social and economic impacts of flooding in West Coonamble under the existing conditions and the report identifies works and measures required to address on-going and future flood risk for West Coonamble. A set of floodplain management measures was recommended for consideration by Council and other stakeholders and Council has endorsed this study. This report is the Floodplain Risk Management Study and Plan.

Executive Summary

The Study Area for West Coonamble is located on the western side of the Castlereagh River (catchment area 8,400 km^2 at the confluence of the Castlereagh River and Warrena Creek). The Study Area is bounded by Old Dubbo Road to the east, Effie Durham Street and Gadsens Street to the south and Conimba Street to the north. Quambone Road forms the south-western boundary of the Study Area and Coonamble Levee forms the north-eastern boundary of the Study Area. Developed areas of Coonamble Township which are located on the western floodplain of the Castlereagh River are included within the Study Area. Rezoned areas 'Meglo' and 'Riverview' are included in the Study Area. There are approximately 680 dwellings and 1,700 population in West Coonamble. West Coonamble has a history of riverine flooding along the west bank of the Castlereagh River and on either side of Eurimie Creek.

The main town of Coonamble has suffered severe inundation on several occasions, notably 1920, 1921, 1950 and 1955. Major flooding occurred in Warrena Creek in 1974, 2007 and 2009 and Coonamble Levee was about to be overtopped during the flood events of 2007 and 2009. There was minor flooding in the Castlereagh River during the flood events of 2007 and 2009.

The Flood Study for West Coonamble (Jacobs, 2016) has been updated to refine flood behaviour in the Study Area using an integrated one-dimensional and two-dimensional TUFLOW hydraulics model and guidelines presented in Australian Rainfall and Runoff 2016. Flood depth/level, hazard and hydraulic function/categories mapping has been prepared to define the flooding behaviour for the Study Area and is presented in this report. Modelled peak water levels and gauge heights in the Castlereagh River at Coonamble gauge are presented in Table 1.

Table 1 Modelled peak water levels and gauge heights in the Castlereagh River at Coonamble gauge

Flood Event	Peak Water Level (m AHD)	Gauge height (m)*
5% AEP	180.81	5.64
1% AEP	180.82	5.65
0.5% AEP	180.83	5.66
Extreme	18.87	5.70

*Gauge zero = 175.169 m AHD (refer to Section 2.3)

Emergency classification mapping has also been prepared to characterise the ability of the community to respond and evacuate during a flood event. Flood planning area mapping has been prepared to assist Council with flood planning and development controls administration. Property flood affectation has been assessed, as summarised in Table 2.

Table 2 Number of buildings subject to above floor flooding in West Coonamble

Flood Event	Residential building	Non-residential building
5% AEP	0	4
1% AEP	2	6
0.5% AEP	4	7
Extreme	51	16

An assessment of climate change impacts on flooding, based on review of expected increases in flood event rainfall and the flood modelling results, indicated that as a result of climate change and increased rainfall and flood flows, the 1% AEP flood level would increase by approximately 0.1 m.

An assessment of flood modification, property modification and response modification measures has been conducted including modelling of mitigation works and review of existing planning policy and emergency management framework. Only two residential buildings are subject to above floor flooding, as such, a focus has been placed on property and response modification measures in the formulation of the Floodplain Risk Management Plan (the "Plan"), shown in Table 3.

Community and stakeholder consultation have been undertaken throughout the study including public exhibition of the Draft Floodplain Risk Management Study and Plan, prior to Council adoption of the Plan.

Table 3 Floodplain Risk Management Plan

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
PM1	Section 10.7 certificates	Council	Council staff costs	N/A	• Section 10.7 certificates should provide flood information for properties such as flood levels, flood planning levels, flood hazard and hydraulic categories present on each lot.	**High**
PM2	New DCP	Council	Council staff costs	N/A	• A new Development Control Plan is to be prepared to address mainstream flood risk for Coonamble Shire. • The new DCP should refer to flood mapping available for Coonamble Shire which were prepared as part of floodplain risk management studies and subsequently adopted by Coonamble Shire. • The flood planning matrix specific to Coonamble Shire is to be appended to the new DCP (refer to Appendix C). • Consider the flood hazard rating and hydraulic category rating of the land in determining compatibility of development and appropriate development controls. • Define an appropriate design flood standard for non-residential development. A 1% AEP design flood may be appropriate for most non-residential development. Critical facilities such as emergency services, childcare, aged care etc. may require placement outside/above the PMF extent. Refer to proposed flood planning matrix (Appendix C). • All new/redeveloped buildings in appropriate flood areas are to be constructed with flood compatible materials to withstand the hydrostatic force and flow velocity.	**High**

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
					• New developments or redevelopments should not impact on flooding of neighbouring properties (consistent with provision in LEP 2011).	
RM1	Flood education and awareness program	Council, NSW SES	$30K	Staff costs	Measures may include: • Install flood depth indicators at key locations e.g. Castlereagh Highway sag points within the Study Area. • Local newspaper articles on the historic flood events during anniversaries of the events. For example, the flood event of February 1955. • Council or the NSW SES may wish to run educational workshops or distribute information sheets to help people plan and prepare for a flood. Knowledge about local flooding issues is a valuable tool to equip the public with. • Section 10.7 certificates issued by Council could be used to inform property owners about flood risk to their properties. • The program should be reviewed on a regular (e.g. 5 yearly) basis.	**High**
RM2	Revision of Coonamble Shire Local Flood Plan	NSW SES, Council	NSW SES/Council costs	N/A	• Review roles and responsibilities, systems and procedures in consultation with key stakeholders • Update flood intelligence based on additional information on flood behaviour presented in the FRMS for West Coonamble • Update list of evacuation centres in consideration of the updated flood behaviour.	**High**

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
RM3	Preparation of concept design and cost estimates for upgrade of Quambone Road at Gidgenbar watercourse (Euronne gully)	Council	$70K	Staff costs	Measures may include: Undertake a detailed hydrologic and hydraulic assessment to identify feasible options to improve flood immunity for Quambone Road from flooding in Gidgenbar watercourse. Prepare concept drawings and cost estimates for the preferred upgrade option in consultation with Council.	**Medium**

Important note about this report

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1. Introduction

1.1 General

Coonamble Shire is a local government area (LGA) located in the Orana region of New South Wales. The Shire is located adjacent to the Castlereagh Highway and the Castlereagh River and the Shire encompasses an area of 9,926 km^2. Coonamble Shire includes the towns of Coonamble, Gulargambone and Quambone.

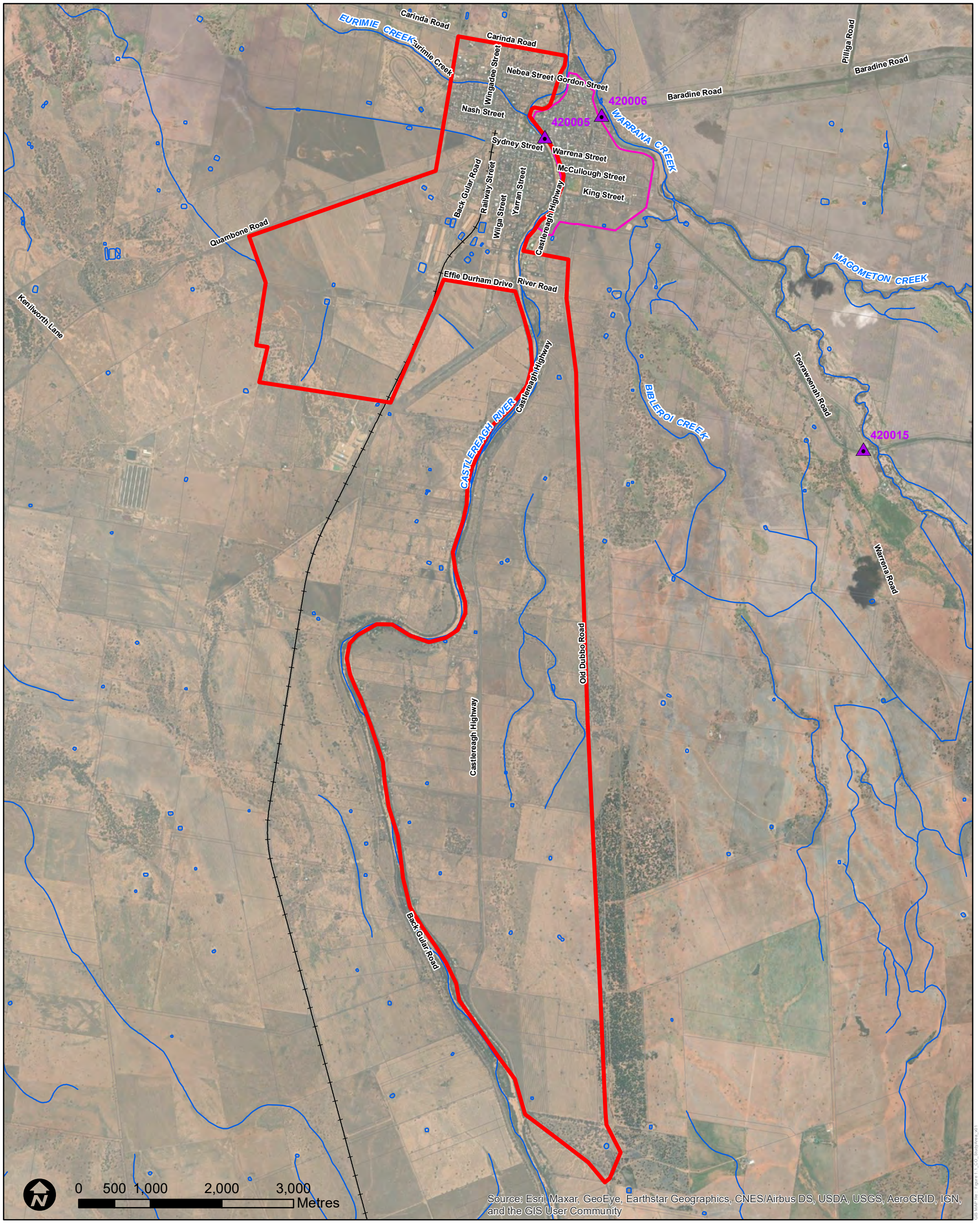
The town of Coonamble is located at the confluence of the Castlereagh River (catchment area 8,400 km^2 at the confluence) and Warrena Creek (catchment area 1,240 km^2 creek outlet), approximately 165 km north of Dubbo in north-central NSW. Coonamble is one of the major urban centres in the Castlereagh Valley and had a population of 2409 at the 2016 Census. The Central Business District (CBD) of Coonamble lies between the Castlereagh River and Warrena Creek and is protected from flooding by a ring levee approximately 7 km long. The administrative centre of Coonamble Shire is located at Coonamble and the economic activity in the town is mainly concerned with the provision of services to the surrounding rural areas. Agriculture in the rural areas is based on extensive grazing and dry land farming.

The Study Area for West Coonamble (refer Figure 1.1), is located on the western side of the Castlereagh River. The Study Area is bounded by Old Dubbo Road to the east, Effie Durham Street and Gadsens Street to the south and Conimba Street to the north. Quambone Road forms the south-western boundary of the Study Area and Coonamble Levee forms the north-eastern boundary of the Study Area. Developed areas of Coonamble Township which are located on the western floodplain of the Castlereagh River are included within the Study Area. Rezoned areas 'Meglo' and 'Riverview' are included in the Study Area. There are approximately 680 dwellings and 1,700 population in West Coonamble. West Coonamble has a history of riverine flooding along the west bank of the Castlereagh River and on either side of Eurimie Creek. Eurimie Creek is a breakout of the Castlereagh River located approximately 1 km upstream of the confluence of the Castlereagh River and Warrena Creek. Eurimie Creek initially flows west before turning north and eventually re-joins the Castlereagh River approximately 8-10 km downstream. Coonamble Shire Council ("Council") commissioned Jacobs to prepare a floodplain risk management study and floodplain risk management plan for West Coonamble. This report is the Floodplain Risk Management Study and Plan.

1.2 Floodplain Risk Management Process

Council is responsible for managing the existing, continuing and future flood risk for its LGA. The floodplain risk management planning process, as set out in the Floodplain Development Manual (NSW Government, 2005) has a number of steps which are illustrated in Figure 1.2.

Council's Flood Risk Management Committee (FRMC) includes a number of Council representatives, staff from the Department of Planning, Industry and Environment (formerly Office of Environment and Heritage (OEH)), the State Emergency Services (SES), in addition to local stakeholders including community representatives.



Legend

- Study Area
- Cadastre
- Coonamble levee
- Railway
- Water course
- Stream Gauge

JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:51,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Study area**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure 1.1**	REV 1 VER 1
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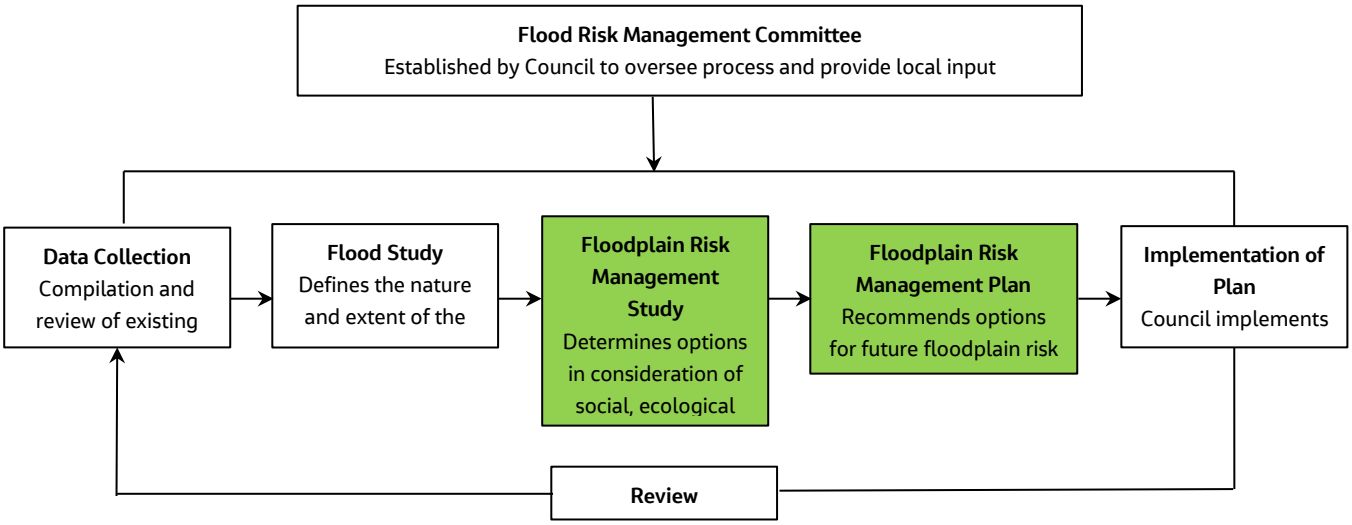
GIS MAP file - Figure 1.1_CIO_StudyArea_v01

Figure 1.2: Floodplain Risk Management Process



1.3 Purpose of this Report

The purpose of this study is to provide a framework to reduce the flood risk in West Coonamble by way of structural works to physically reduce the impacts of flooding on development, policy and planning provisions to ensure future development does not increase the flood risk, and emergency planning and public education aimed at reducing the potential harm to people presented by the residual flood risk in future flood events.

Key objectives of this study are to:

- Update flood modelling for the Study Area based on Australian Rainfall and Runoff (ARR) 2016 (Ball et al, 2016).
- If changes are considered significant, update the design flood modelling and mapping based on agreed changes.
- Review existing planning, policy and emergency management for gaps and inconsistencies, then develop proposed amendments to make these consistent with and cognisant of the flood risk in the three area.
- Define flood problem priority areas and identify and develop structural and non-structural mitigation measures to manage flood risk.
- Prioritise the measures, including economic and multi criteria appraisal of structural options.
- Develop an implementation program for recommended measures including timing, responsibility and sources of funding.
- Conduct consultation with the community and key stakeholders to obtain information and intelligence for input into the study, and then to obtain feedback on the findings and recommendations of the study.

1.4 Structure of this Report

The Floodplain Risk Management Study and Plan provides an overview of the catchment setting and flooding conditions, policy and organisational background, identifies and assesses management measures and provides a plan for adoption and implementation of measures. The report is structured accordingly:

- Section 2 Study Area – Summary of the physical setting, history of flooding and social, environmental and heritage aspects of the catchment.
- Section 3 Review of Available Information – Discusses previous studies and relevant available information and data on flooding and hydrology in the catchment.

- Section 4 Community Consultation – Summary of consultation activities undertaken for the study.
- Section 5 Flood Policies and Planning Controls – Summary of relevant State and local government policies and planning framework.
- Section 6 Existing Flood Environment – Describes flood behaviour and flood hazard.
- Section 7 Local Emergency Planning Context – Overview of existing flood emergency planning.
- Section 8 Defining the Flood Problem – Impacts of flooding on the community including high hazard properties, flood damages, land use compatibility, evacuation considerations.
- Section 9 Discussion of Floodplain Management Measures – Identifies, reviews and assesses structural and non-structural management measures.
- Section 10 Floodplain Risk Management Plan – A proposed plan of implementation for recommended floodplain risk management measures.
- Section 11 Acknowledgements
- Section 12 References – Literature cited in this report.
- Section 13 Glossary – Definition of terms used in this report.

2. Study Area

2.1 Catchment Characteristics

The town of Coonamble is located at the confluence of the Castlereagh River (catchment area 8,400 km^2 at the confluence) and Warrena Creek (catchment area 1,240 km^2 creek outlet), approximately 165 km north of Dubbo in north-central NSW.

The headwaters of the Castlereagh River are located within the eastern slopes of the Warrumbungle Ranges (typical elevation approximately 1,100 m above sea level), west of Coonabarabran. The river meanders generally eastwards, then southwards through Coonabarabran, Binnaway, Mendooran, Gilgandra, as a generally well-defined watercourse, with relatively confined floodplains.

Downstream of Gilgandra, the Castlereagh River meanders generally westward, through Gulargambone and Coonamble, before meeting the Macquarie River approximately 40 km west of Walgett. The lower reaches of the Castlereagh River downstream of Gilgandra are generally broad and flat, with numerous areas where the river channel is poorly defined whilst within other the river is perched.

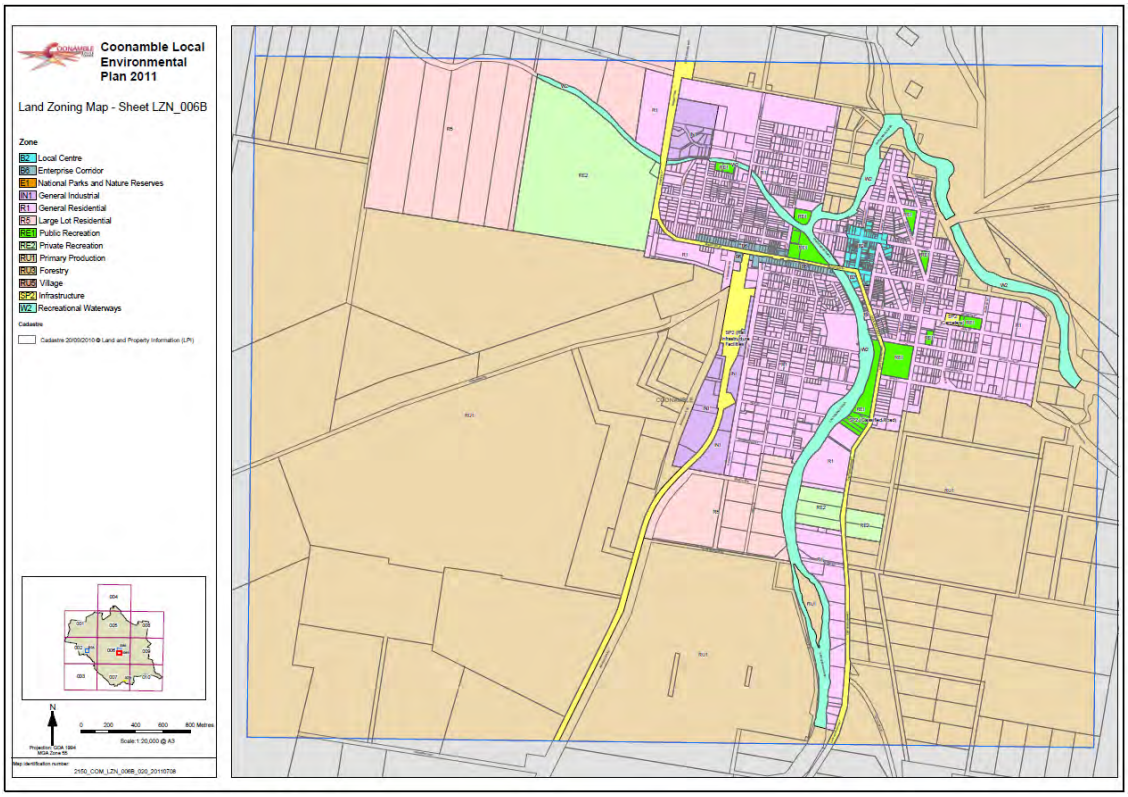
Warrena Creek Joins the Castlereagh River just downstream of Coonamble township. Both Warrena Creek and its major tributary, Magometon Creek, rise on the western sides of the Warrumbungle Ranges and drain extensive floodplain areas before joining the Castlereagh River.

2.2 Existing Land Use and Development

The Study Area is located within the Coonamble Local Government Area (LGA) and is predominantly surrounded by agricultural land uses on land zoned 'RU1 Primary Production' under the Coonamble Local Environmental Plan (LEP) 2011 (See Figure 2.1). Castlereagh River flows through the Coonamble town centre and is classed as 'W2 Recreational Waterways'. The Study Area includes the following land zones:

- IN1 General Industrial
- R1 General Residential
- R5 Large Lot Residential
- B2 Local Centre
- B6 Enterprise Corridor
- SP2 Infrastructure
- RE1 Public Recreation
- RE2 Private Recreation
- W2 Recreational Waterways

Figure 2.1: Coonamble Town Centre Land Zoning Map



Additionally, the Castlereagh River is crossed by Castlereagh Highway through the centre of Coonamble township. Castlereagh Highway is a 790 km state rural highway which is part of the 'Great Inland Way' that links Sydney to Cairns. Castlereagh Highway is the only river bridge crossing in Coonamble.

2.3 History of Flooding

The township of Coonamble has suffered severe inundation on several occasions, notably 1920, 1921, 1950 and 1955 due to flooding in the Castlereagh River recorded at staff gauge (GS 420005) located in the vicinity of Aberford Street Bridge. The "flood of record" is generally thought to be the 1950 flood though opinion on this is divided. It is to be noted that Aberford Street Bridge was a timber bridge up to 1990s. The existing bridge is a concrete bridge. Hence, it is expected that the flood behaviour at the gauge would be different with the old timber bridge and with the existing concrete bridge. In addition, there were some discussions within then Department of Land & Water Conservation (currently, Department of Planning, Industry and Environment) regarding the gauge zero datum of the staff gauge. This appears to be resolved with the accepted gauge zero datum as 175.169 mAHD.

Ranked by stage, the ten largest floods to have occurred in Coonamble, for which reliable records are available, are presented in Table 2.1 (sourced from SKM, 2002 and Lyall, 2013).

Table 2.1: Ten largest floods recorded in the Castlereagh River at Coonamble gauge (Jacobs, 2016)

Rank	Year	Elevation (mAHD)
1	1950	180.82
2	1955	180.76
3	1971	180.70
4	1969	180.65
5	1974	180.61
6	1973	180.48
7	2000	180.47
8	1998	180.46
9	2010	180.39
10	1990	180.27

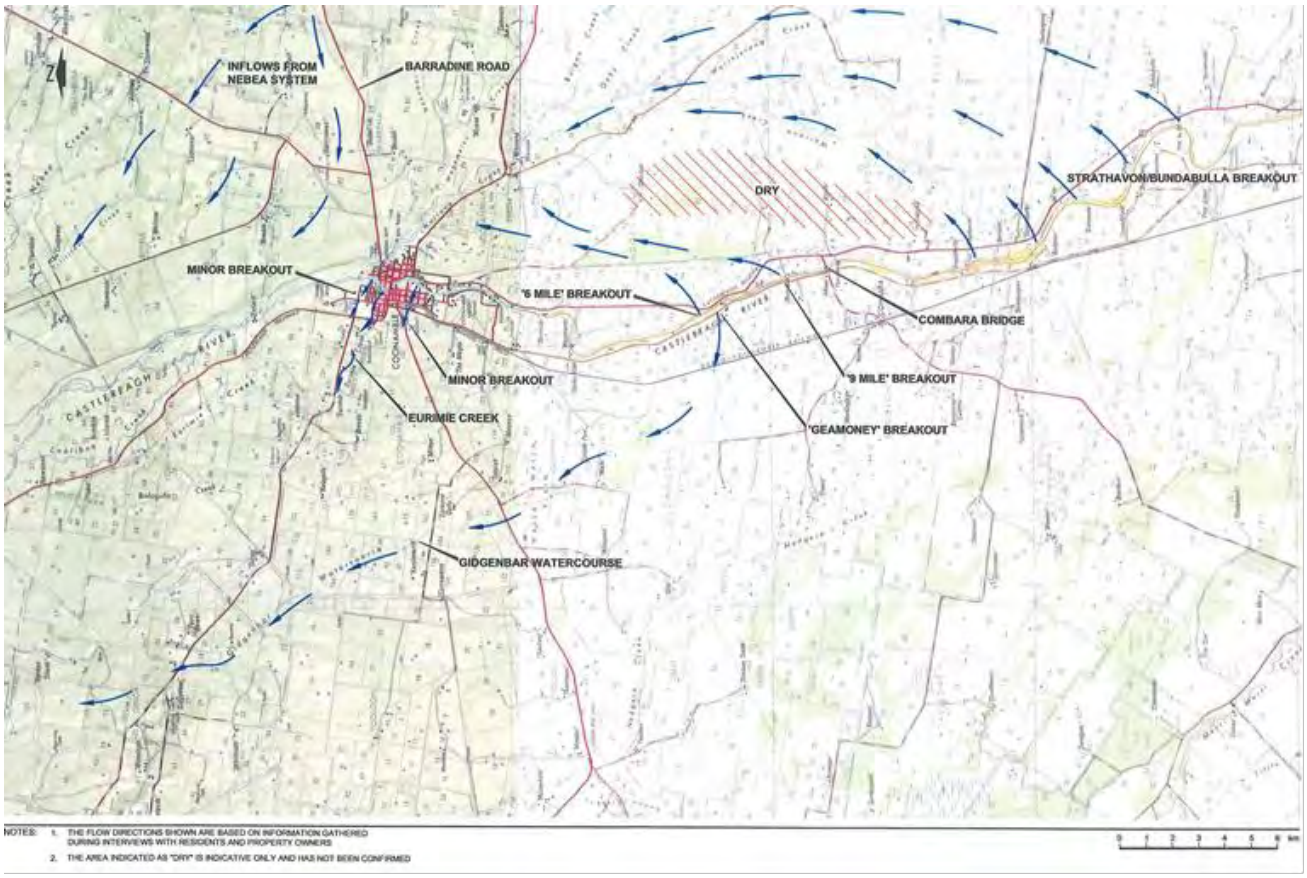
Major flooding occurred in Warrena Creek in 1974, 2007 and 2009 and Coonamble Levee was about to be overtopped during the flood events of 2007 and 2009. There was minor flooding in the Castlereagh River during the flood events of 2007 and 2009. It is to be noted that the Castlereagh River at Coonamble gauge (GS 420005) does not represent the magnitude of flooding in Warrena Creek.

2.4 Nature of Flooding

The nature of flooding in the vicinity of Coonamble township is complex. Both the Castlereagh and Warrena systems have significant catchment areas. The Castlereagh system represents 87% of the catchment at the Castlereagh/Warrena confluence and the Warrena system the remaining 13%. The Central Business District (CBD) of Coonamble lies between the Castlereagh River and Warrena Creek and is protected from flooding by a ring levee approximately 7 km long.

The flattening of the terrain upstream of Coonamble township results in decreased flow velocity and thus a greater flow area is required. This is evidenced through known and identified overbank breakouts from the Castlereagh River to both the east and west. The breakouts cause flooding to large areas of farmland and often result in the cross connection of water courses. The breakouts to the north generally join the Warrena system and breakouts to the south join the Nedgera system. Both the Warrena and Nedgera systems re-join the Castlereagh River downstream. The Warrena re-joins at Coonamble and the Nedgera over 10 km downstream. The general flood behaviour in the vicinity of Coonamble is shown in Figure 2.2.

Figure 2.2: General Flood Behaviour in the vicinity of Coonamble



The most significant breakouts identified in previous study reports (SKM 2000 and SKM 2009) include the following:

- Strathavon-Bundabulla Breakout – right bank breakout with flow initially to the northeast then north. Water exits the Castlereagh approximately 22 km south of Coonamble and flows Northeast along a 10 km front between the Strathavon and Bundabulla properties and joins the Warrena system;
- Nine Mile Breakout – right bank breakout located approximately 15 km south of Coonamble. Flows north generally parallel to the Castlereagh joining with water from the "Six Mile Break" (see below) and then flowing into Warrena Creek;
- Geamoney Breakout – left bank breakout located approximately 11 km south of Coonamble. Water exits the Castlereagh to the west before flowing north-west generally overland and parallel to the Castlereagh before re-joining the Castlereagh via Eurimie Creek downstream of Coonamble;
- Six Mile Breakout – right bank breakout located approximately 10 km south of Coonamble. Floodwaters flow north-east generally to meet waters from the Nine Mile Breakout and flow into Warrena Creek; and
- Eurimie Creek breakout – left bank breakout where Eurimie Creek flows due west forming an anabranch of the Castlereagh River. Eurimie Creek initially flows west before turning north and eventually re-joins the Castlereagh 8-10 km downstream.

Two additional breakouts are also identified in Lyall 2013 report. One breakout is located approximately 3 km upstream of Combara Bridge on the eastern bank of the Castlereagh River whilst the second breakout is located on the northern bank of Baronne Creek, a tributary of the Castlereagh River. Breakout from Baronne Creek joined flows in the upper reaches of Warrena Creek.

2.5 Social Profile

The Australian Bureau of Statistics (ABS) census 2016 indicates the following information on the population of Coonamble which is assumed to be representative of the Study Area population:

- Approximately 82% of the population speak only English at home. This suggests that the use of English in flood warnings and messages, such as brochures and signage, is likely to be adequate. The social character of Coonamble is such that a large portion of the remaining 15% of the population are likely to speak English in addition to other languages and hence single language brochures is likely to be suitable.
- Approximately 56% of households accessed internet from the dwelling, indicating a moderate rate of accessibility to information on flooding on websites of Council and other agencies such as BOM and SES. This suggests that warnings and messages accessed via websites will not be adequate.
- Approximately 20% of the population are aged 65 years and over. Flood emergency, evacuation and recovery needs of this older cohort need to be considered, with aspects including communication of key messages and mobility of individuals.
- The median total household income of $933 per week is low compared to the NSW average of $1,486. Additionally, the median monthly mortgage is relatively high ($870) in comparison to earnings and therefore earnings may be significantly tied up in these repayments. This suggests it is likely that flood damages will be considerable for West Coonamble residents.

2.6 Natural Environment

The majority of the catchment is located on highly disturbed, agricultural land and derived grassland, with the Castlereagh River flowing through the centre of the Coonamble township. No significant bushland areas are seen to be situated within the vicinity of Study Area, apart from a small strip of vegetation within the riparian corridor. A significant portion of the Study Area is mapped as having 'Biodiversity values' in the Coonamble LEP (2011) Natural Resource – Biodiversity Map.

Coonamble LGA is listed under the State Environmental Planning Policy No 44 – Koala Habitat Protection, however no mapping was publicly available for the LGA area. The NSW Bionet Altas Search indicated a Koala (*Phascolarctos cinereus)* sighting approximately 7.5 km east of the Study Area. Considering this, it is likely that the design and placement of any structural floodplain management measures would require detailed site-specific environmental impact assessment to confirm Koala habitat.

Additionally, the Bionet Altas Search indicated the presence of Black-necked Stork, Black Falcon and Brolga protected species in the Study Area. Since most bird species are highly mobile, any structural floodplain management measures that may be proposed is unlikely to cause a significant species impact. However, design and placement of structural floodplain measures may require detailed site-specific environmental impact assessment to determine presence of nesting and/or foraging sites.

The NSW Bionet Atlas Search indicated that the Study Area may contain a number of Endangered Ecological Communities (EECs). Whilst it is unknown where these communities are situated within the study zone, it is likely that some may occupy the riparian corridor adjacent to the Castlereagh River, therefore the design and placement of any structural floodplain management measures need to consider the presence of EECs. This may require detailed site-specific environmental impact assessment to be undertaken to confirm biodiversity values and constraints.

3. Review of Available Information

3.1 Previous Studies

3.1.1 West Coonamble Flood Study Report (Jacobs,2016)

Jacobs was engaged by Coonamble Shire Council to undertake a data collection and review the data and prepare a Flood Study for West Coonamble. A community consultation process was undertaken to collect information on flooding from the community. In total, thirty-five (35) responses were received from the community to the questionnaire and thirty (30) respondents were residents of the Study Area. Sixteen (16) respondents identified that highest priority be given to protecting residents/ business from flooding. Maintaining an emergency flood free access was given the highest priority by four (4) respondents and four (4) respondents gave the highest priority to providing flood warning.

LiDAR and ground surveys were undertaken to capture the required topographic data for this flood study. The topographic data was used to update an available MIKE11 hydraulic computer model for Coonamble which were used to analyse sensitivity of design peak water level profiles along Coonamble Levee.

The available flood frequency analysis for the Castlereagh River @ Gilgandra gauge and the 1955 inflow hydrograph for the gauge were used in this study to estimate design inflow hydrographs for the Castlereagh River for all modelled events. An existing RORB hydrologic model was utilised in the estimation of design inflows hydrographs for Warrena Creek catchment. Coincident flooding in the Castlereagh River and Warrena Creek catchment was considered. Flood behaviour in the Study Area for the 0.5%, 1% and 5% AEP events and an extreme flood event (i.e. 3 times 1% AEP event) were assessed.

Modelled peak water levels for the 1% and 5% AEP events and an extreme event were utilised to create flood extent maps. The flood map for the 5% AEP map shows that the Study Area is cut-off from the neighbouring towns and lands within the entire Study Area is located below 1% AEP flood level with 0.5 m freeboard. However, some areas which are not flooded in the extreme event are flooded in the 1% AEP event plus 0.5m freeboard. Provisional hydraulic and hazard category mapping was undertaken for the Study Area.

The Flood Study for West Coonamble has been updated as part of this study due to the following limitations of the 2016 Flood Study:

- The study is based on Australian Rainfall and Runoff 1987 and the current best practice is to use the latest guidelines on Australian Rainfall and Runoff.
- A Quasi 1D MIKE11 hydraulic model was used in the 2016. Due to the flat topography and two-dimensional flood behaviour in Coonamble, a two-dimensional hydraulic model is considered appropriate based on the current best practice.

Outcomes from the updated Flood Study are included in Appendix A.

3.1.2 Coonamble Shire Flood Emergency Sub Plan (SES,2013)

The Plan covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the Coonamble Shire Council area. The plan covers all levels of flooding within the Council area. The plan does not include any flood intelligence. The plan identifies that the following locations may be suitable for use as flood evacuation centres in Coonamble:

- Coonamble Public School, Bertram Street;
- St Bernard's School, Tooloon Street;
- Coonamble High School, Aberford Street;
- Coonamble RSL Club, Aberford Street;
- Coonamble Bowling Club, Aberford Street; and
- Coonamble Golf Club, Caswell Street.

3.1.3 Flood Intelligence Report Castlereagh Valley December 2010 Flood, Draft Report (Lyall, 2013)

The draft report documents flood behaviour for the December 2010 flood event in the Castlereagh Valley on the basis of data collected on the impacts of the December 2010 flood in four urban centres which include Mendooran, Gilgandra, Gulargambone and Coonamble. Key findings from the report on Coonamble are provided below:

- The December 2010 flood reached a peak of 5.22 m on the Coonamble Gauge (GS 420005) and remained near this level for 4-5 days.
- In addition to "Nine Mile", "Six Mile" and "Geamoney" breakouts, two additional breakouts were also expected to be in operation. One breakout was located approximately 3 km upstream of Combara Bridge on the eastern bank of the Castlereagh River whilst the second breakout was located on the northern bank of Baronne Creek, a tributary of the Castlereagh River. Breakout from Baronne Creek joined flows in the upper reaches of Warrena Creek.
- The newly constructed Combara Bridge was overtopped.
- High flows were experienced in Warrena Creek which resulted in the peak water level being 0.26m to the crest of Coonamble Levee between the Castlereagh Highway and the Coonamble-Tooraweenah Road.
- Two flood gauges operated by SES located on Warrena Creek at Coonamble were washed out.
- One rural property was impacted by flooding due to floodwaters from the Castlereagh River breaking out through Geamoney Breakout as section of the railway embankment failed.
- Several rural properties located both upstream and downstream of Coonamble were isolated for up to 3 weeks requiring resupply operations by SES.

It is to be noted that the flood event of 2000 is not identified by Lyall & Associates as a major event.

3.1.4 Review of Environmental Factors, Coonamble Levee Upgrade (Geolyse, 2012)

Geolyse Pty Ltd reviewed environmental factors for Coonamble Levee Upgrade proposal. A flood impact assessment for the proposal was undertaken by SKM for Geolyse using a hydraulic model, which was developed as part of two studies entitled "Coonamble Levee Flood Gradient Sensitivity Modelling Study" (SKM 2009) and "Flood Affection to Properties due to Failure of Coonamble Levee" (SKM 2010). The hydraulic model allowed for overtopping of the existing and the proposed levee due to higher flood levels than crest levels along the levee. Potential impacts due to the proposed levee upgrade on peak water levels, discharges, velocities, duration of flooding and flood affection to properties were assessed for four flood scenarios. A review of modelling results for the existing levee and the proposed levee upgrade indicated up to a maximum 0.11 m increment in 100-year ARI flood levels in Warrena Creek on the southern side of the Coonamble - Tooraweenah Road. The increment in flood levels resulted from up to a 19% increase in peak flows in the 100-year ARI event. The increment in peak flows was due to the fact that in the 100-year ARI event, the existing levee was overtopped and the levee with the proposed upgrade was not overtopped. Changes in peak velocities in the 100-year ARI event were less than 0.05 m/s.

It is to be noted that the scope of this study does not include Coonamble Levee and the area protected by the levee.

3.1.5 Coonamble Levee Upgrade, Concept Design Report (NSW Public Works, 2011)

A concept design for upgrade works of Coonamble Levee (approximately 7 km long) was prepared by NSW Public Works on the basis of prior investigations which included an audit of the levee undertaken by NSW Public Works, geotechnical investigations undertaken by Douglas Partners and a flood gradient sensitivity study and an internal drainage study undertaken by SKM. The design water level profile along the levee was based on concurrent 100-year ARI flooding in the Castlereagh River and 100-year ARI flooding in Warrena Creek catchment. The design freeboard allowance varied between 0.8 m and 1.0 m. Other features included in the design were three floodgates for a temporary installation to provide flood protection and a 150 m long spillway to cater for possible overtopping.

3.1.6 Coonamble Levee Flood Gradient Sensitivity Modelling Study (SKM, 2009)

Sensitivity of flood gradients along Coonamble levee for 50-year ARI, 100 year ARI and an extreme flood event were estimated using a hydrologic model (RORB) and a quasi-two-dimensional hydraulic computer model (MIKE11). A detailed topographic survey was undertaken as part of the study. The RORB model used to estimate catchment runoff from Warrena Creek catchment. The RORB and MIKE11 models were calibrated/verified against flood events of 1955, 1998, 1999, 2000 and 2007. The modelled flood levels agreed closely with the limited observed flood level data available for Coonamble. The calibrated/verified models were utilised to assess sensitivity of flood gradients along Coonamble Levee for a range of flood scenarios.

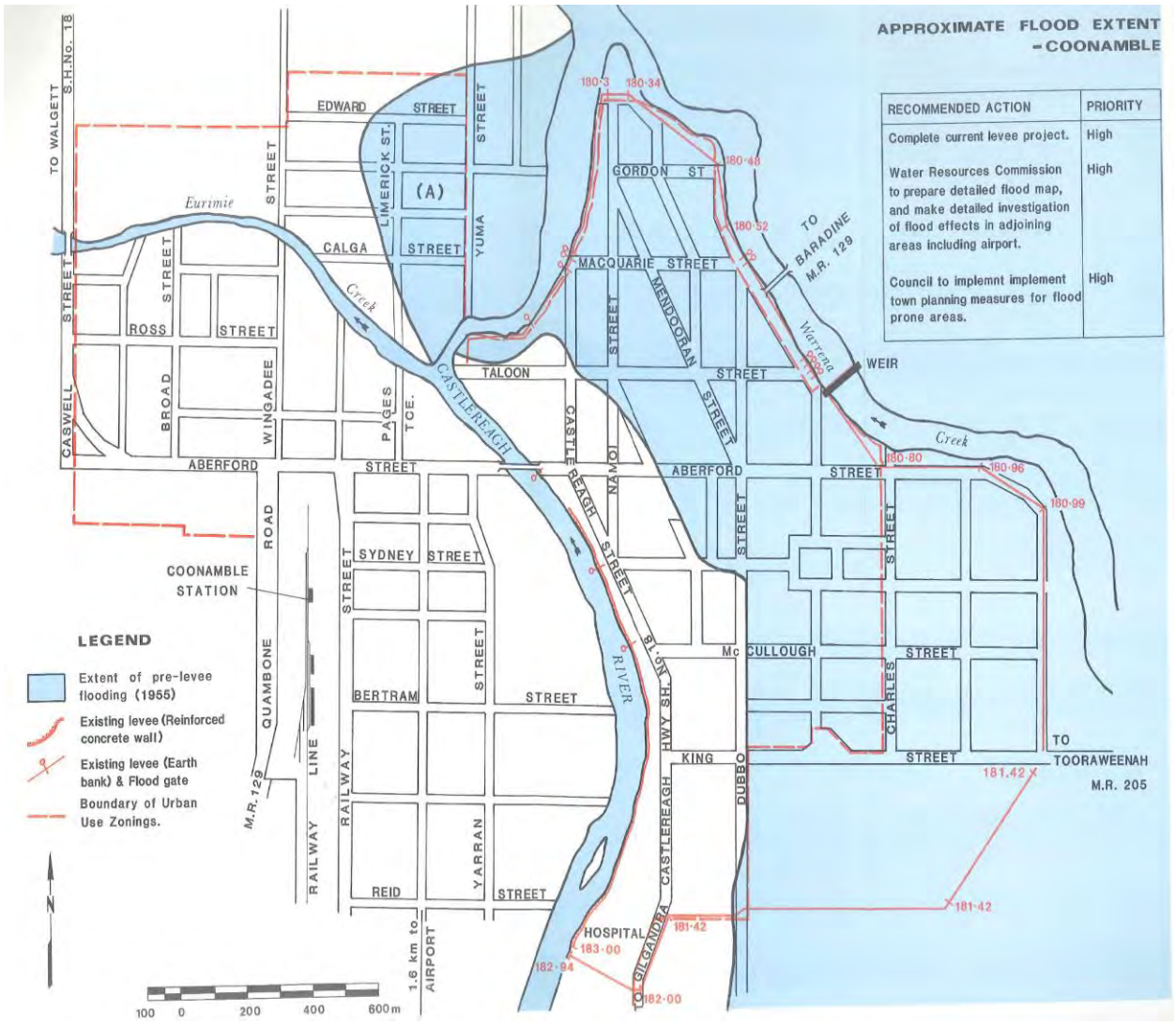
3.1.7 Coonamble Flood Scoping Study (SKM, 2002)

The study was commissioned by the then Department of Land & Water Conservation (DLWC). The aim of the study was to identify the nature of flooding in and around Coonamble and to advise on and scope issues that need to be addressed in developing a flood model for Coonamble. Investigations involved review of calculation folders available in DECCW, interviews with Statutory Authorities, Emergency Services, Coonamble Shire Council Staff and local residents.

3.1.8 New South Wales Inland Rivers Flood Plain Management Studies - Castlereagh Valley (Rankine & Hill, 1983)

The scope of the study included mapping of flood affected land throughout the whole valley; development of floodplain management plan for both urban centres and rural areas; identification of environmental factors and the preparation of a programme of works. The study report provides information on land use; availability of streamflow records; flood behaviour along the Castlereagh River around urban centres; nature of historic flooding; flood frequency curves; flood hydrographs for major flood events including the flood event of 1955; flood inundation mapping for urban centres including Coonamble shown in Figure 3.1.

Figure 3.1: Approximate flood extent and zonings (source: Figure 9.6 Rankin & Hill, 1983)



4. Community Consultation

4.1 Community Survey

4.1.1 Newsletter and Questionnaire

A community consultation process was initiated to obtain views of the community on flooding issues and potential flood mitigation measures suitable for the Study Area. This involved sending a newsletter and a questionnaire (refer Appendix B) to residents and landowners within the Study Area. The newsletter introduced the floodplain management process to the residents of the Study Area, described the purpose of the questionnaire and provided the residents with contacts for their responses. The questionnaire was prepared in consultation with Council to help identify flooding issues and potential flood mitigation measures for the Study Area.

The information that was requested included:

- General information, such as:
  - Residents from the study Area
  - Ownership of the residence
  - How long residents lived at the property
- Specific flood information, such as:
  - Experience on flooding in residence and/or at work
  - Identify information (e.g. flood photographs, newspaper clippings, flood marks etc) that can be provided to Consultant
  - Flooding to residence improved or worsened by works on other properties or by construction of roads or other structures
- Opinion on floodplain risk management measures
  - Ranking of development types for protection against flooding
  - Ranking of potential flood mitigation measures
  - Ranking of flood risk management measures for consideration by Council
  - Preference for different types of notifications to be given by Council to individual property owners about flood affectation
- Additional comments on any other issues associated with this study.

4.1.2 Summary of Responses to Questionnaire

In total, ten (10) responses were received from the community to the questionnaire. A summary of responses is provided in the following paragraphs.

Residency status (Question 1)

Nine (9) respondents were residents of the Study Area.

Length of Residency in West Coonamble and Business Activity (Questions 2-4)

Respondents lived in the Study Area between 3 to 70 years with an average residency of 25 years. Six (6) respondents managed business located within the Study Area.

Experiences of Flooding (Questions 5-6)

Five (5) respondents were aware of flooding in West Coonamble and three (3) respondents had some knowledge on flooding in the Study Area. Only one respondent had flood photographs.

Ranking of Development Types for Protection from Flooding (Question 7)

Respondents were asked to rank different types of development for protection against flooding. Six (6) respondents gave the highest priority for protection residences against flooding and three (3) respondents gave the highest priority of protecting critical utilities from flooding and one respondent gave the highest priority of protecting emergency facilities from flooding. Protection of commercial properties from flooding was ranked fourth followed by protection of community facilities.

Ranking of Flood Management Options (Question 8)

Protecting residents/business from flooding was ranked highest followed by protecting land of residents/business. Maintaining an emergency flood free access was ranked third. Providing flood signage for public safety, support from SES and providing flood warning were ranked last.

Potential Flood Impacts due to any Works (Question 9)

Only one responded living outside the Study Area identified potential flood impacts on the property due to raising of Walgett Road.

Identification of Works Which Improved Flooding at Property (Question 10)

No respondents identified any works which improved flood behaviour at their properties.

Identification of Potential Flood Mitigation Measures to Reduce Flooding at Property (Question 11)

Seven (7) respondents identified improved drainage infrastructure and flood mitigation works as the preferred option for reducing flooding at their properties followed by planning controls and upgrade of roads. Six (6) respondents identified public awareness & education as the least preferred measure to mitigate flooding to their properties.

What Notification Should Council Give about the Potential Flood Affectation of Individual Properties (Question 12)

Five (5) respondents identified that Council should advise every resident and property owner on a regular basis of the known potential flood affection. Five (5) respondents also identified that Council should advise prospective purchasers/developers on the control of development of land potentially affected by flooding. Only one respondent identified that Council should advise community on a regular basis on development controls applicable to flood liable land.

Additional Comments

The following additional comments were received from respondents:

- Road works on Walgett Road have the potential to impact on flood behaviour at a property located 8 km North of Coonamble on Walgett Road. The property is located outside the Study Area.
- A respondent claimed that residential property owned by the respondent was located on high ground which was not impacted by flooding.
- Extreme caution should be exercised for development of property or infrastructure upstream of the airport area.
- There should not be any blockage on Eurimie Creek or Euronne Gully.

- Except for flooding from Eurimie Creek, West Coonamble is unlikely to be subject to flooding from the Castlereagh River.

4.2 Stakeholder Consultation

A meeting was held on 28 May 2019 with the Bureau of Meteorology (BOM) in Sydney to understand the existing flood warning and flood forecasting for Coonamble. It is understood that BOM issues flood warning for Coonamble on the basis of gauge reading in the Castlereagh River at Gilgandra. It is also understood that BOM does not issue any flood warning for the Warrena Creek System at this point in time. It would be necessary to install new rain gauges and stream gauges to provide flood warning for the Warrena Creek System. Council needs to seek funding from NSW Government for installation of a flood warning system for the Warrena Creek System. However, Council needs to provide funding for operation and maintenance of the gauges.

4.3 Floodplain Risk Management Committee

Ongoing consultation with the FRMC was undertaken during the course of the FRMS and included discussion on potential flood mitigation works and selection of options for detailed modelling. Consultation with the FRMC was also undertaken in June 2019 to discuss the written submissions from the community on the Draft FRMS and updates for the Final FRMSP.

4.4 Public Exhibition and Community Information Session

The Draft FRMSP was placed on public exhibition for a period of 4 weeks following review and comment from the Flood Risk Management Committee (FRMC) and Coonamble Shire Council.

5. Flood Policies and Planning Controls

5.1 Background

This section provides an overview on the NSW flood risk management framework and existing policies and planning controls applicable to West Coonamble and outlines potential amendments and updates for consideration in developing a Floodplain Risk Management Plan.

5.2 NSW Flood Risk Management Framework

5.2.1 Objectives and Approach

The primary objective of NSW Flood Risk Management (FRM), as expressed within the NSW Flood Prone Lands Policy (Floodplain Development Manual 2005, page 1) is as follows:

"*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*."

Within the scope of this report, the relevance of the above objective is primarily to ensure that the Floodplain Risk Management Plan (FRMP) for West Coonamble does not lead to increased flood risk to property and persons and that the planning controls and emergency management planning provisions proposed to achieve this outcome form part of a consistent and coordinated strategy to reduce flood risks.

5.2.2 NSW FRM Policy and Guidelines

The NSW Flood Prone Land Policy is produced within Section 1.1 of the Floodplain Development Manual (FDM 2005). This policy is consistent with that first introduced in 1984, which places the primary responsibility for implementation on local councils. This provides the opportunity for FRM to be integrated within council's normal planning processes. The NSW Government provides financial and technical assistance, and indemnity is provided in Section 733 of the Local Government Act 1993, subject to acting in "good faith" - being performance in accordance with the principles and guidelines of the FDM unless proven otherwise.

The FDM requires a merit approach to be adopted for the purposes of formulating a FRMP that provides a basis for decision making in the floodplain. This is in recognition that flood prone land is a valuable resource which should not be unnecessarily sterilised by the rigid application of prescriptive criteria, and to equally avoid the approval of inappropriate proposals. The merit approach is defined as follows:

"The merit approach weighs socio-economic, ecological and cultural impacts of land use options for different flood prone land areas together with flood damage, hazard and behaviour implications, and environmental protection and wellbeing of the State's rivers and floodplains."

The NSW Flood Prone Land Policy and the FDM provide a platform for the management of floodplains in a manner that follows a risk management approach. Consistent with this approach the FDM defines the floodplain for the purposes of establishing the broadest area potentially at risk from flooding for the preparation of studies and ultimately the FRMP, as follows:

"Floodplain means: Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land."

"Flood prone land means: Land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land."

"Probable maximum flood means: The PMF is the largest flood that could conceivably occur at a particular location; usually estimated from probable maximum precipitation, where applicable, snow melt, coupled with the

worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land that is the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study."

The FDM is a manual which provides guidance with regard to how to implement the NSW Flood Prone Land Policy. The FDM requires the level of flood risk acceptable to the community is to be determined through a process overseen by a committee comprised of local elected representatives, community members and state and local Government officials (including the SES). This process is shown in Figure 1.2. The ultimate outcome is the preparation of a Floodplain Risk Management Plan (FRMP), which is a plan formally adopted by a local council in accordance with the NSW Flood Prone Land Policy. FRMPs should have an integrated mix of management measures that address existing, future and continuing risk.

5.2.3 2007 Flood Planning Guideline

On January 31, 2007 the NSW Planning Minister announced a new guideline for development control on floodplains (the "Flood Planning Guideline"). An overview of the new Guideline and associated changes to the Environmental Planning and Assessment Act, 1979 (EPA Act) and Environmental Planning and Assessment Regulation 2000 (Regulation) was issued by the Department of Planning in a Circular dated January 31, 2007 (Reference PS 07-003). The Flood Planning Guideline issued by the Minister in effect relates to a package of directions and changes to the EPA Act, Regulation and FDM.

This Flood Planning Guideline provides an amendment to the Manual. The Guideline confirms that unless there are "exceptional circumstances", Councils are to adopt the 100 year flood (i.e. 1% AEP flood) as the flood planning level (FPL) for residential development, with the exception of some sensitive forms of residential development such as seniors living housing. The Guideline does provide that controls on residential development above the 100 year flood may be imposed subject to an "exceptional circumstance" justification being agreed to by the Department of Natural Resources and the Department of Planning (both now incorporated into the Department of Planning, Industry and Environment - DPIE) prior to the exhibition of a Draft LEP or Draft DCP.

The Flood Planning Guideline provides various potentially ambiguous statements in regard to what is the Residential FPL for the purposes of applying the directions in the Guideline. The DPE advised that the reference to the FPL is a reference to both the 100-year flood plus freeboard (typically 0.5 metres). The Guideline only applies to the introduction of "new" controls and does not rescind pre-existing controls.

5.2.4 2020 Draft Updates to Flood Prone Land Package

Significant flood events, like those in Brisbane in 2011 and those more recently in NSW show the importance of managing flood risk up to and beyond the 1% AEP flood and considering flood risks up to the probable maximum flood level. This will build resilience in communities located on floodplains and reduce the extent of property damage and potential loss of life from severe to extreme flooding throughout NSW.

The NSW Department of Planning Industry and Environment has been working to update the Flood Prone Land Package (including the 2007 flood planning guideline – refer to Section 5.2.3) which provides advice to councils on considering flooding in land use planning and consists of:

- A proposed amendment to Schedule 4, Section 7A of the Environmental Planning and Assessment Regulation 2000
- A revised planning circular
- A revised local planning direction regarding flooding issued under Section 9.1 of the Environmental Planning and Assessment Act 1979
- Revised Local Environmental Plan flood clauses

- A new guideline: Considering Flooding in Land Use Planning (2020)
- Revoking the Guideline on Development Controls on Low Flood Risk Areas (2007).

The proposed updates promote the effective consideration of flood risk in land use planning, which involves developing an understanding of the full range of flood behaviour up to the PMF and considering this in management of flood risk.

The proposed local planning direction has been revised to remove the need to obtain exceptional circumstances to apply flood-related residential development controls above the 1% AEP flood event.

The proposed updates support the principles of the Floodplain Development Manual and provide advice to local councils on land use planning within flood-prone land. It provides councils greater flexibility in defining the areas to which flood-related development controls apply, with consideration of both defined flood events (used to set flood planning levels) and low probability/high-consequence flooding. In addition, it allows for land requiring controls related to regional evacuation consideration to be identified. The Floodplain Development Manual states that a defined flood event (DFE) of the 1% AEP, or a historic flood of similar scale, plus a freeboard should generally be used as the minimum recommended level for setting residential FPLs. Councils proposing a different FPL are required to demonstrate the merits of this approach through the FRM process.

The consultation period for the updated Flood Prone Land Package concluded on 25 June 2020. Further information is expected from the NSW Department of Planning, Industry and Environment in due course.

5.2.5 Relationship with EPA Legislation

The plan-making processes under the EPA Act, such as for a Local Environmental Plan (LEP) and a Development Control Plan (DCP) operate independently of the preparation of FRMPs under the FDM. While these two processes could be overlapped, it has been the usual practice to undertake the processes separately. Ultimately the planning recommendations of the FRMP will need to be reflected in planning instruments and policies brought into force in accordance with the EPA Act.

Ultimately the planning recommendations of the FRMP will need to be reflected in planning instruments and policies brought into force in accordance with the EPA Act. Accordingly, the FRMP can provide appropriate input to the EPA Act planning processes in three ways:

- Providing direction at a local (and state) strategic planning level in addressing FRM (e.g. where urban growth should occur, and the distribution of land uses therein);
- Recommending development controls to be incorporated in appropriate planning instruments (e.g. LEPs and DCPs) to mitigate the risk to development where permitted in the floodplain; and
- Ensuring that the planning controls and associated documents (e.g. S149 Planning Certificates) contribute to ensuring the community is appropriately informed about the flood risk.

To understand how these FRMP outcomes may be best achieved, the existing EPA Act framework and guidelines that relate to FRM are discussed later in this section.

5.3 Existing Policies & Planning Controls

The imposition of planning controls can be an effective means of managing flood risks associated with future development (including redevelopment). Such controls might vary from prohibiting certain land uses to specifying development controls such as minimum floor levels and building materials.

In principle, the degree of restriction that is imposed on development due to flooding relates to the level of risk that the community is prepared to accept after balancing economic, environmental and social considerations. In practice, the planning controls that may ultimately be imposed are influenced by a complex array of considerations including state-imposed planning policy and directions, existing local planning strategies and

policies and ultimately the acceptability of conditions that could be imposed through the development application process.

The following provides an outline of policy that is potentially relevant because it either directs the FRM planning controls that could be adopted or affects the way flood risk is identified in the planning controls.

5.3.1 State Environmental Planning Policies

A State Environmental Planning Policy (SEPP) is a planning document prepared in accordance with the EPA&A Act and eventually approved by the Minister, which deals with matters of significance for environmental planning for the State. Clause 1.19 of the Codes SEPP has been amended so that land identified as 'flood control lot' is no longer excluded from the application of the General Housing Code. Instead, specified development and development standards have been added to the General Housing Code for development on low hazard flood control lots. The development standards have been designed to ensure that complying development is not allowed on high hazard or high-risk flood control lots including floodways, flood storage areas, a flowpath or areas identified in local flood plans as high hazard or high risk.

Recommendation

The flood hazard and hydraulic categories mapping is to be considered by Council in the planning and approval of proposed developments for flood-affected lots. Proposed developments are not to be approved on high hazard or floodway areas.

5.3.2 Climate Change Policies

Climate change is expected to have adverse impacts upon rainfall intensities which may have a significant influence on flood behaviour in West Coonamble. Coonamble is located inland and hence sea level rise would have no impact on flood behaviour.

While the expected general trend is for overall reductions in long-term rainfall and a drier climate, flood-producing storm systems are still expected to occur and the severity, including intensity of rainfall and total rainfall depths produced by such systems is expected to increase under climate change.

Scientific data regarding the magnitude of effects of climate change on rainfall intensities at the local scale is relatively new and indicative only and may not be sufficiently advanced to provide specific guidance for the assessment of flood risk. No relevant planning benchmarks have been adopted by NSW Government related to rainfall intensity changes. However, recent research by BOM suggests increases in rainfall intensities of storm systems of 10.1% by 2050 and 20.8% by 2090 under the upper range Representative Concentration Pathways (RCP) 8.5. RCP 8.5 refers to the upper range projection of greenhouse gas concentrations in the atmosphere as adopted by the IPCC in 2014 for the assessment of climate change impacts.

5.3.3 Section 9.1(2) Directions

Ministerial directions pursuant to section 9.1(2) of the EPA Act specify matters which local councils must take into consideration in the preparation of LEPs. Direction 4.3, as currently applies, deals specifically with flood prone land and has the following two objectives:

(a) To ensure that the development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual, 2005.

(b) To ensure that the provisions of an LEP on flood prone land is commensurate with flood hazard and includes consideration of the potential flood impacts both on and off the subject land.

The Direction applies to all councils that contain flood prone land when an LEP proposes to "*create, remove or alter a zone or provision that affects flood prone land*." In such cases, the Direction requires draft LEPs to ensure the following:

1. *A planning proposal must include provisions that give effect to and are consistent with the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas).*

2. *A planning proposal must not rezone land within the flood planning areas from Special Use, Special Purpose, Recreation, Rural or Environmental Protection Zones to a Residential, Business, Industrial, Special Use or Special Purpose Zone.*

3. *A planning proposal must not contain provisions that apply to the flood planning areas which:*

    a. *permit development in floodway areas,*

    b. *permit development that will result in significant flood impacts to other properties,*

    c. *permit a significant increase in the development of that land,*

    d. *are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services, or*

    e. *permit development to be carried out without development consent except for the purposes of agriculture (not including dams, drainage canals, levees, buildings or structures in floodways or high hazard areas), roads or exempt development.*

4. *A planning proposal must not impose flood related development controls above the residential flood planning level for residential development on land, unless a relevant planning authority provides adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).*

5. *For the purposes of a planning proposal, a relevant planning authority must not determine a flood planning level that is inconsistent with the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas) unless a relevant planning authority provides adequate justification for the proposed departure from that Manual to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).*

5.3.4 Local Environmental Plan (LEP)

The *Coonamble Local Environmental Plan 2011* (LEP 2011) provides land use controls for the Coonamble local government area and has been developed to be consistent with the Floodplain Development Manual. Part 6.6 of the LEP 2011 addresses flood planning. Excepts of this clause are provided below:

Flood planning

(1) The objectives of this clause are as follows—

(a) to minimise the flood risk to life and property associated with the use of land,

(b) 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,

(c) to avoid significant adverse impacts on flood behaviour and the environment.

(2) This clause applies to land at or below the flood planning level.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development—

(a) is compatible with the flood hazard of the land, and

(b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) 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 riverbanks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) A word or expression used in this clause has the same meaning as it has in the *Floodplain Development Manual (*ISBN 0 7347 5476 0*)*, published in 2005 by the NSW Government, unless it is otherwise defined in this clause.

(5) In this clause, ***flood planning level*** means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

While the LEP does require consideration of the compatibility of development to the "flood hazard of the land", it only makes reference to the flood liable lands and flood planning level. It does not make reference to the actual flood hazard rating, that being governed by flood depth, velocity and/or velocity-depth product, or to the hydraulic function of the floodplain (floodway, flood storage etc.).

5.3.5 Development Control Plan (DCP)

The Coonamble Shire Council Development Control Plans (No. 1 and No. 2) provide detailed guidelines to guide the design and assessment of development applications for land covered by Coonamble LEP. There is no provision for flood-related development controls in the DCP No. 1 applicable to Coonamble township and surrounds. However, the DCP No. 2 applicable to rural small holdings identifies that buildings, access roads and other development should be sited away from land deemed flood liable to inundation such as drainage lines, streams, rivers and floodplains.

The DCP does not provide development controls requiring that new development be compatible with the flood hazard and hydraulic function (i.e. floodway, flood storage and flood fringe). New development is typically prohibited in high flood hazard or floodway areas in the 1% AEP event to manage the population at risk to hazardous flooding conditions i.e. not increase the level of risk over time. Council should consider inclusion of development controls in the DCP to manage development in high hazard and floodplain areas in the 1% AEP event.

Recommendation

Council should consider the following amendments to the DCP:

1. Council should prepare a new DCP to address floodplain risk management for the Coonamble Local Government Area. The new DCP should refer to flood mapping undertaken for West Coonamble.

2. For all development types, consideration of the flood hazard rating and hydraulic function of the land in determining compatibility of development and appropriate development controls. This may mean restricting development to outside of high hazard (i.e. H5 and H6 hazard categories) or floodway areas in the 1% AEP event.

3. Define an appropriate design flood standard for non-residential development. A 1% AEP design flood may be appropriate for most non-residential development. Critical facilities such as emergency services, childcare, aged care etc. may require placement outside/above the flood extent for the extreme flood event.

4. All new/re-developed buildings are to be constructed with flood compatible materials to withstand the hydrostatic force and flow velocity (subject to item 2 above).

5. New developments or re-developments should not impact on flooding of neighbouring properties (consistent with provision in the Coonamble LEP).

5.3.6 Section 10.7 Certificates

Council under the provisions of Section 10.7 of the Environmental Planning and Assessment Act 1979 issues certificates which are also known as Planning Certificates. The certificate provides the relevant legislation and policies, information on planning controls and any development restrictions which may apply to a particular parcel of land within the Council area. They are usually required upon the sale or purchase of a property.

There are two types of certificates:

- 10.7 (2) Certificate - Provides information about the zoning of the property, the relevant state, regional and local planning controls, other planning affectations such as heritage, land contamination and road widening and whether or not complying development can be carried out on the land.
- 10.7 (2) & (5) Certificate - Provides additional advice regarding demolition, foreshore building lines, other heritage considerations and general advice.

Coonamble Shire Council Section 10.7 certificates does not make reference to the flood planning provisions in the certificates. Council could consider make reference to the flood planning provisions in the certificates.

Recommendation

Given that information on flooding for the Study Area is available to Coonamble Shire Council from this study, Council should include information on flood levels, flood hazards and flood planning level in Section 10.7 Certificates.

5.4 Other Environmental Legislation

5.4.1 Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is administered by the Commonwealth Department of the Environment, Water, Heritage and the Arts and aims to ensure that actions likely to have a significant impact on matters of national environmental significance are subject to a rigorous assessment and approval process. Matters of national significance that may be impacted by flood control works include Ramsar wetlands, nationally threatened species and ecological communities, and migratory species. An

assessment of the potential impacts on matters of national environmental significance, as defined and listed under the EPBC Act, would need to be undertaken before any flood control works are implemented.

5.4.2 Fisheries Management Act 1994 (NSW)

The *Fisheries Management Act 1994* (FM Act) is administered by the Fisheries division of the NSW Department of Primary Industries. The broad objectives of the FM Act are to conserve, develop and share the fishery resources of NSW for the benefit of present and future generations. Floodplains provide important spawning, nursery and feeding habitat for a number of native freshwater fish species. The Act makes provision for the conservation of key fish habitats (including floodplain-0ns) through habitat protection plans, and for the conservation of threatened species, populations and ecological communities of fish.

Most fish species undertake local or large-scale migration, with some species such as golden perch and silver perch migrating onto the floodplain to spawn. The Act requires that NSW Fisheries be notified whenever any barrier to fish passage is constructed, altered or modified. The Act also requires a permit from NSW Fisheries for dredging and reclamation works on wetlands and floodplains. These works may include the construction of levees, drains, storages and other works.

5.4.3 National Parks and Wildlife Act 1974 (NSW)

The NSW National Parks and Wildlife Service (NPWS), a division of the DPIE, is responsible for the protection and care of Aboriginal relics, the protection and care of native fauna, and the protection of native plants under the *National Parks and Wildlife Act 1974* (NPW Act). The NPW Act also allows for the establishment, preservation and management of areas of cultural, environmental and archaeological significance.

Of particular relevance to flood control works, it is an offence to knowingly destroy or disturb any Aboriginal site or relic in NSW. Aboriginal sites that may be relevant to the outcomes of the Floodplain Risk Management Plan would include any carved or scarred trees that may rely on flooding for their longevity and any sites of spiritual significance that are sustained by periodic flooding. An Aboriginal archaeological and cultural heritage assessment, to identify the presence of and potential impacts on Aboriginal objects and sites of Aboriginal cultural significance within the floodplain, would need to be undertaken before any flood control works are implemented.

5.4.4 Threatened Species Conservation Act 1995 (NSW)

The *Threatened Species Conservation Act 1995* (TSC Act) is administered by the DPIE and provides for the protection of threatened species, populations, ecological communities, and their habitats (with the exception of fish and marine plants). The Act ensures that threatened species are taken into consideration during the development planning process and in decision making by authorities. Threatened species whose ecology may depend on flood inundation will be an important consideration when identifying environmentally important areas and determining outcomes in the FRMP.

In relation to development assessment, the provisions of the TSC Act are linked to the EP&A Act. Specifically, Section 5A of the EP&A Act identifies the factors that must be taken into account in determining whether there is likely to be a significant impact on threatened species, populations or ecological communities, or their habitats (the 'Seven Part Test'). An assessment of the potential impacts on threatened species, populations and ecological communities would need to be undertaken before any flood control works are implemented.

6. Flood Behaviour

6.1 Flood Study Revision

The West Coonamble Floodplain Risk Management Study and Plan – Flood Study Revision (refer to Appendix A) was undertaken as a part of this study and provided an update of the previous West Coonamble Flood Study Report (Jacobs, 2016). Key objectives of the Flood Study Revision were to:

- Update hydrologic analysis and modelling based on Australian Rainfall and Runoff (ARR) 2016 (Ball et al 2016).
- Develop a two-dimensional (2D) TUFLOW hydraulic model for defining mainstream flood behaviour in the Study Area. Verify modelled flood behaviour against observed and design flood events.
- Determine flooding behaviour and flood risk in the Study Area for a range of flood events including 0.5%, 1% and 5% annual exceedance probability (AEP) events and an extreme flood event.
- Map flood hydraulic and provisional hazard categories.
- Assess the sensitivity of flood behaviour to changes in hydrologic and hydraulic characteristics in the catchments.

The Draft Flood Study Revision Report prepared by Jacobs in June 2020 was on public exhibition http://www.coonambleshire.nsw.gov.au/AboutCouncil/Plans.html (accessed on 26 September 2020) and Council did not receive any submissions from the community on the Draft Flood Study Revision Report. The outcomes from the Flood Study Revision (attached in Appendix A) forms the basis for identification, assessment and prioritisation of management measures in the Floodplain Risk Management Study and Plan for West Coonamble.

6.2 Flood Depths

Flood depth maps for the 5%, 1%, 0.5% AEP events and an extreme flood event are shown in Appendix A and the following observations are made from Figure A1 to Figure A4.

In the 5% AEP event (refer to Figure A1 in Appendix A), the majority of the Study Area located between the Castlereagh Highway and Old Dubbo Road is subject to flood depths more than 0.5 m. Parts of the Study Area located between the Castlereagh Highway and Back Gular Road are subject to shallow flooding. An area located east of Railway Street, western end of Effie Durham Drive and south-west of Wilga Street is subject to up to 0.5 m flood depths. The north-east corner of the Study Area located along the Castlereagh River is subject to up to 1 m depth of flooding. Parts of the north-western corner of the Study Area located south of Quambone Road are also subject to flooding.

In the 1% AEP event (refer to Figure A2 in Appendix A), the flood extent and flood depths are further increased than the 5% AEP event. In particular, the area located at the north-east corner of the Study Area along the Castlereagh River is subject to more extensive flooding. Also, both the extent and depths of flooding are increased in the 1% AEP event near the western end of Effie Durham Drive. The majority of the Study Area located between the Castlereagh Highway and Old Dubbo Road is subject to flood depths more than 1 m.

The extent and depth of flooding is further increased in the 0.5% AEP event (refer to Figure A3 in Appendix A) than the 1% AEP event. The area located at the north-east corner of the Study Area along the Castlereagh River is subject to more extensive flooding than the 0.5% AEP event. The southern portion of the Study Area located between the Castlereagh Highway and Old Dubbo Road is completely impacted by flooding.

In the extreme flood event (refer to Figure A4 in Appendix A), almost all areas located within the Study Area between the Castlereagh Highway and Old Dubbo Road are impacted by flooding. Almost two-thirds of the Study Area located north of Eurimie Creek are subject to flooding.

6.3 Flow Velocities

Flow velocities are generally up to 0.75 m/s on the floodplain in the 5% AEP event (refer to Figure A5 in Appendix A). However, flow velocities in water courses are generally high.

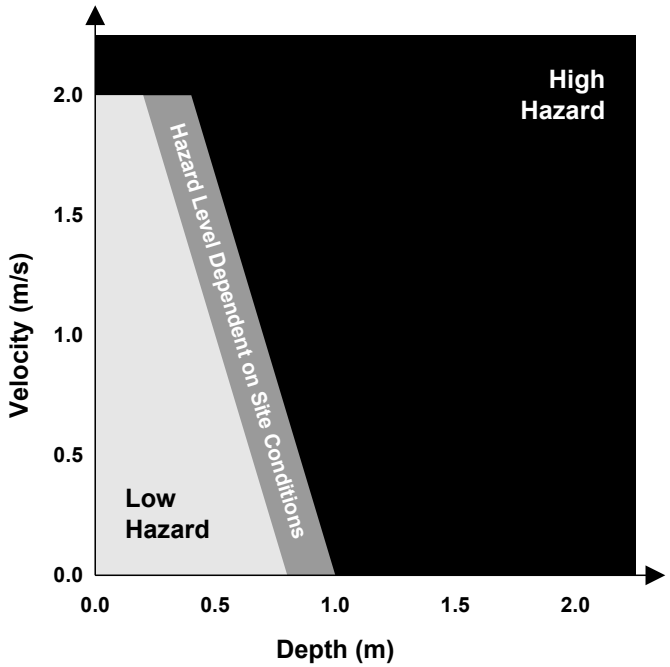
In the 1% AEP event (refer to Figure A6 in Appendix A), parts of the Study Area located between the Castlereagh Highway and Old Dubbo Road are subject to up to 1 m/s flow velocity. The area located at the north-east corner of the Study Area along the Castlereagh River is subject to up to 0.75 m/s flow velocity in the 0.5% AEP event (refer to Figure A7 in Appendix A).

Parts of the Study Area located between the Castlereagh Highway and Old Dubbo Road are subject to up to 2 m/s flow velocity in the extreme flood event (refer to Figure A8 in Appendix A).

6.4 Hazard Categorisation

Flood hazard mapping was previously prepared in the West Coonamble Flood Study (Jacobs, 2016) based on the definition in the Floodplain Development Manual (NSW Government, 2005) and shown on Figure 6.1, where the flood hazard is rated based on the corresponding depth and velocity at any one time during a flood event. The definition of high and low flood hazard conditions defined in the Manual are generalised and do not differentiate between the susceptibility of different members of the community and of different types of assets and property. A provisional flood hazard map for the 1% AEP event for the Study Area is shown in Figure A9 in Appendix A. Figure A9 shows that high hazard areas within the Study Area are located between the Castlereagh Highway and Old Dubbo Road.

Figure 6.1: FDM flood hazard category diagram (reproduced from Figure L2 in *NSW Floodplain Development Manual*)

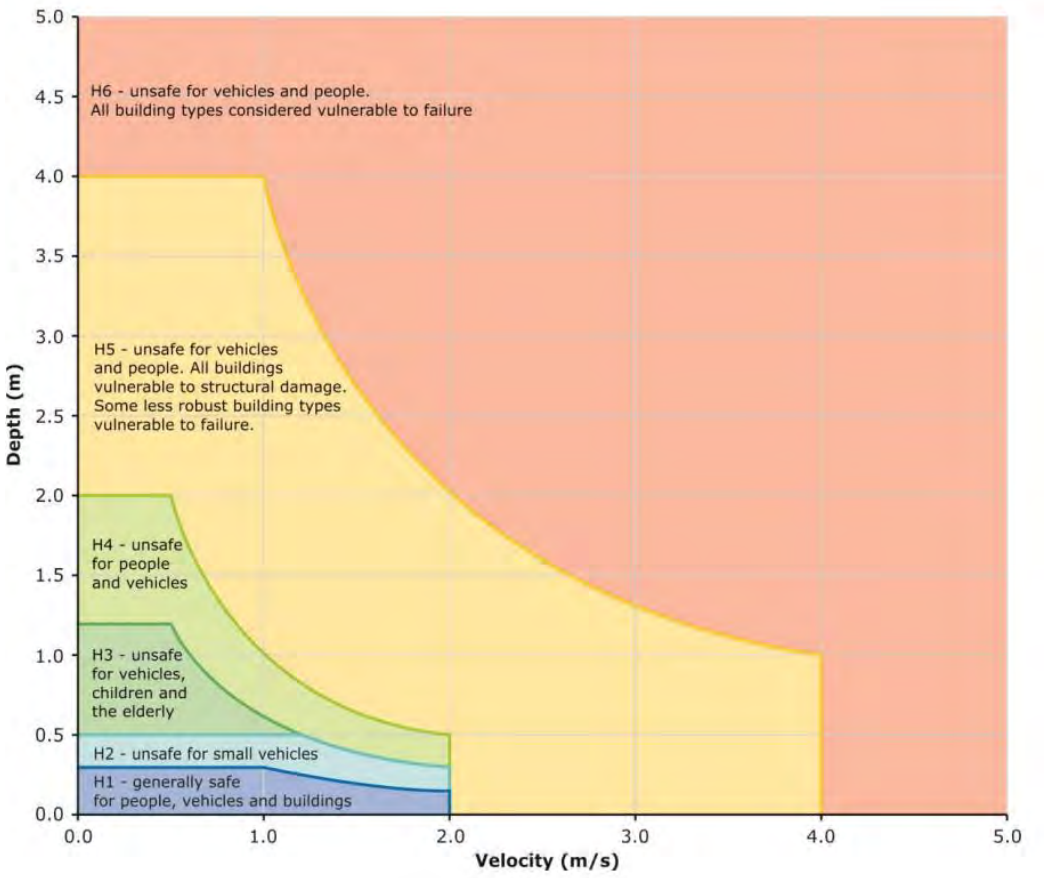


Recent research has been undertaken into the hazard that flooding poses and the vulnerability of the public and assets when interacting with floodwaters. A combined flood hazard classification is presented in *Australian Disaster Resilience Handbook 7. Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR, 2017a) and *Guideline 7-3 Flood Hazard* (AIDR, 2017b) based on this research, and is illustrated in Figure 6.2. The flood hazard categories according to the AIDR definition are:

- H1 – Generally safe for people, vehicles and buildings;

- H2 – Unsafe for small vehicles;
- H3 - Unsafe for vehicles, children and the elderly;
- H4 - Unsafe for people and vehicles;
- H5 - Unsafe for people and vehicles. Buildings require special engineering design and construction; and
- H6 – Unsafe for people or vehicles. All buildings types considered vulnerable to failure.

Figure 6.2: General flood hazard vulnerability curves, Australian Institute for Disaster Resilience (AIDR) definition. Reproduced from Figure 6 in *Guideline 7-3: Flood Hazard* (AIDR, 2017b)



The flood hazard classification is more discrete and provides guidance on flood hazard thresholds to different members of the community (e.g. children and elderly) and different assets (small versus larger vehicles, standard versus specialized engineered buildings). The AIDR flood hazard definition potentially provides a more suitable guideline for assessing flood hazard on the floodplain from an emergency management perspective.

The provisional flood hazard map for 1% AEP event (refer to Figure A10 in Appendix A) shows that most of the Study Area is classified as 'H1 – Generally safe for people, vehicles and buildings'. However, at several locations within the Study Area including the following, flood hazard categories are different:

- H3 - Quambone Road (within the Study Area), Carinda Road (eastern end), North of Nebea Street near the Castlereagh River, east of the railway near Effie Durham Drive and between Coonamble Airport and the railway, and the majority of several of the area located within the Study Area between Old Dubbo Road and the Castlereagh Highway, and sections of Old Dubbo Road and the Castlereagh Highway.
- H4 – A significant portion of the Study Area located between Old Dubbo Road and the Castlereagh Highway, and sections of the railway and Quambone Road located outside the Study Area.
- H5 - Isolated low lands, water courses, overland flow paths located between the Castlereagh Highway and Old Dubbo Road.

- H6 - Castlereagh Highway and Old Dubbo Road.

It is to be noted that sections of the railway are located on H6 hazard category.

Recommendation

It is recommended that Council should consider adoption of the AIDR definition of flood hazard for both flood planning and emergency management purposes.

6.5 Hydraulic Categorisation

Three flood hydraulic categories are identified in the Floodplain Development Manual (NSW Government, 2005) are:

- Floodway, where the main body of flow occurs, and blockage could cause redirection of flows. Generally characterised by relatively high flow rates, depths and velocities;
- Flood storage, characterised by deep areas of floodwater and low flow velocities. Floodplain filling of these areas can cause adverse impacts to flood levels in adjacent areas; and
- Flood fringe, areas of the floodplain characterised by shallow flows at low velocity.

There is no firm guidance on hydraulic parameter values for defining the above hydraulic categories, and appropriate parameter values may differ from catchment to catchment. In this study, the floodway was delineated first and then the remaining floodplain was classified into flood storage or flood fringe on the basis of flood depth. Further details on the hydraulic categorisation are provided in Section 4.3.2 in Appendix A and hydraulic categories are shown in Figure A11 in Appendix A. The majority of the Study Area located between the Castlereagh Highway and Old Dubbo Road is categorised as floodway in the 1% AEP event and the remaining flooded areas within the Study Area are categorised as flood fringe.

Recommendation

Council should prohibit development on floodways for the 1% AEP event.

6.6 Flood Emergency Response

Flood emergency response is an important outcome of the Floodplain Risk Management Process. It is anticipated that the NSW SES will use the information contained in this section to update the local flood plan. Areas within the Study Area have been classified based on the floodplain risk management *Guideline 7-2 Flood Emergency Response Classification of the Floodplain* (AIDR, 2017b). The classification indicates the relative vulnerability of different areas of the catchment and considers the ability to evacuate certain parts of the community.

The categories include the following:

- FEO – Flooded area, with an Exit Route via Overland Escape
- FER – Flooded area, with an Exit Route via Rising Road
- FIE – Flooded Area, Isolated with an Area Elevated Above flood event of interest
- FIS – Flooded Area, Isolated and Fully Submerged
- NIC – Not Flooded, Indirect Consequences.

The guideline in AIDR (2017b) recommends classification of the floodplain for the PMF only. Mapping of the classification is provided in Figure A13 in Appendix A. Figure A13 shows that almost all areas located within the Study Area between the Castlereagh Highway and Old Dubbo Road are categorised as FIS. There are few isolated high grounds on the land located between the Castlereagh River and the Castlereagh Highway which are

classified as FIE. Isolated high grounds are also located on the northern side of the Study Area. Generally, flooded areas located on the northern side of the Study Area have exit routes via either rising roads or overland. A small portion of the Study Area located north of Eurimie Creek is not impacted in the extreme flood event. However, this area would have indirect consequences as the majority of the developed areas would be flooded and access to neighbouring towns would be lost.

Recommendation

Council should control development on Flooded Area, Isolated and Fully Submerged in the PMF event to ensure public safety.

6.7 True Flood Hazard

In assessing the true flood hazard, considerations have been made about aspects and characteristics of flooding and the flooding problem including the size of flood, rate of rise, effective warning times, risk to life, risk of isolation, duration of flooding and emergency access. The resulting true flood hazard map for the 1% AEP event for the Study Area is shown in Figure 6.3.

6.8 Flood Planning Area

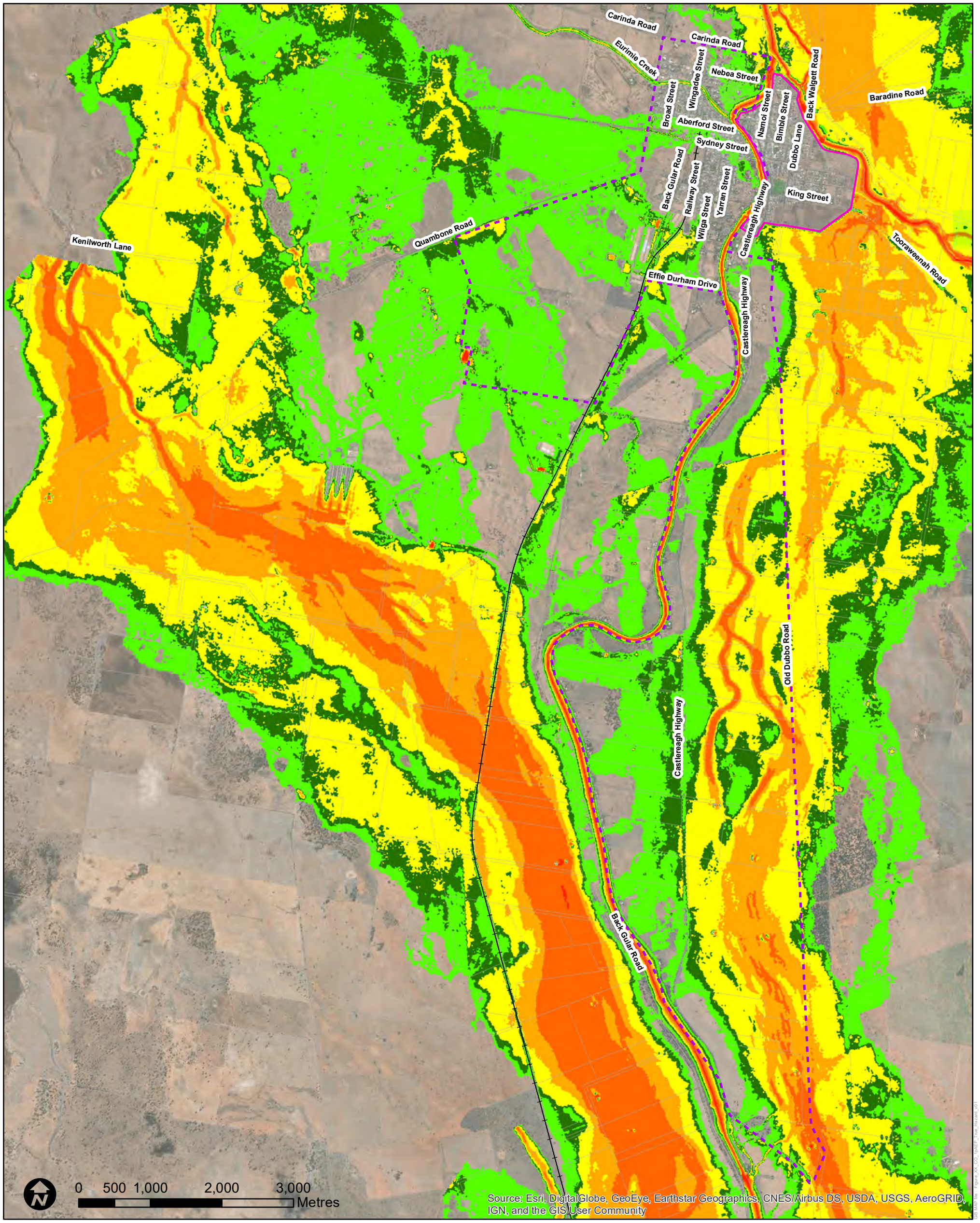
The flood planning area (FPA) is defined by the extent of the area below the flood planning level (usually the 1% AEP flood plus a freeboard) and delineates the area and properties where flood planning controls are proposed, for example, minimum floor levels to ensure that there are sufficient freeboards of building habitable floor levels above the 1% AEP flood.

A freeboard of 0.5 m is often applied for defining the flood planning level on mainstream floodplains, including the Study Area. This flood planning level was then extended until it intersected with the ground. This defines the flood planning area. An illustration of this is provided in Section 4.3.4 in Appendix A.

The flood planning area map for West Coonamble is shown in Figure A12 in Appendix A. Apart from a few isolated areas, almost the entire Study Area is located at or below the flood planning level. The extent of the flood planning area is more extensive than the flood extent for the extreme flood event. This implies that flood levels for the extreme flood event are generally less than 0.5 m higher than the corresponding 1% AEP flood levels.

Recommendation

Council should adopt a freeboard of 0.5 m above the 1% AEP flood level to define the flood planning level and flood planning area for the Coonamble LGA.



Legend

- Study Area
- Railway
- Cadastre
- Coonamble levee

Flood hazard

- H1 - No restrictions
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6 - Not suitable for people, vehicles or buildings

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:51,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Flood Hazard Classification for 1% AEP Event**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure 6.3**	REV 1 VER 1
CHECK AH	DATE 3/06/2020		

Note: Flood hazard extents outside the study area are indicative only.

6.9 Impacts of Climate Change

Impacts of climate change have been assessed for the 1% AEP event in the year 2090 with 20.8% increase in adopted inflows in the Castlereagh River for the 1% AEP event and 20.8% increase in rainfall depths for the 5% AEP event for the catchment areas of Warrena Creek and Magometon Creek.

Changes in 1% AEP flood levels due to climate change are presented in Figure B3 in Appendix A. Following observations are made from Figure B3 in Appendix A:

- Flood behaviour in the majority of the Study Area is not impacted by climate change in the 1% AEP event.
- Increase in 1% AEP flood levels are limited within the area bounded by the Castlereagh River to the west and Old Dubbo Road to the east.
- The maximum increase in 1% AEP flood levels within the Study Area is up to 0.1 m.

Recommendation

The recommended freeboard of 0.5 m above the 1% AEP flood level is considered adequate to address potential impacts of climate change on flood planning level for the Study Area.

7. Information to Support Emergency Management

7.1 Review of Coonamble Shire Local Flood Plan

The Coonamble Shire Local Flood Plan (NSW SES, 2013) covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the Coonamble local government area. It covers operations for all levels of flooding within the council area. The NSW SES Local Controller is responsible for the Coonamble area. The NSW SES Local Controller is responsible for:

- Preparing for emergencies
- Coordinating emergency responses
- Helping with recovery efforts.

Roles and responsibilities for agencies including regional and local SES (including Coonamble unit), Police, Council, NSW Rural Fire Service, BOM, Office of Water (at present, WaterNSW), Office of Environment and Heritage (at present, DPIE) etc. and pre-, during and post-flood procedures appear to be appropriately defined. The responsibility of BOM defined in the Plan is to:

- Provide Flood Watches for the Castlereagh River Basin (Basin no. 420).
- Provide Flood Warnings, incorporating height-time predictions, for Coonamble (AWRC no. 420005), Gilgandra (AWRC no. 420001), and Mendooran (AWRC no. 420004) gauges.
- Provide severe weather warnings when flash flooding is likely to occur.

While this Plan does not preclude BOM from providing flood watch and flood warning products for the Castlereagh River Basin including catchment areas upstream of Coonamble, it is appropriate for the Plan to specifically mention the requirement for these products for flood emergency management in Coonamble and other villages located in Coonamble Shire and formalise BOM's responsibility for providing these products.

The following evacuation centres are identified in the Plan:

- Coonamble Bowling Club, Aberford Street
- Coonamble Public School, Bertram Street
- St. Bernard's School, Tooloon Street
- Coonamble High School, Aberford Street
- Coonamble RSL Club, Aberford Street
- Coonamble Golf Club, Caswell Street Coonamble

It is to be noted that St Bernard's School and Coonamble RSL club identified in the Local Flood Plan above do not exist at present as such the list of evacuation centres need to be updated. Both the Coonamble High School and the former St. Bernard's School (currently St Brigid's School) sites are located inside Coonamble Levee. It may be necessary to evacuate residents living inside Coonamble Levee during extreme flood events and hence it is recommended that both sites should be avoided as far as practical.

Coonamble Bowling Club and Coonamble Golf Club are considered appropriate flood evacuation centres as both centres are accessible during flooding. However, access to the Coonamble Public School, Bertram Street is likely to be cut-off during extreme flood event.

Recommendation

Upon completion of this floodplain risk management study and plan, the Coonamble Shire Local Flood Plan should be updated with consideration of the information and findings of this study on the flooding behaviour for West Coonamble.

Revision of the Coonamble Shire Local Flood Plan and preparation of new responsibilities, systems and procedures should be undertaken with input from all key stakeholders.

7.2 Flood Intelligence

Flood intelligence describes flood behaviour and its effects on the community and the NSW SES maintains a centralised flood intelligence system. The flood intelligence for Coonamble is based on a detailed flood intelligence card for the Coonamble gauge (SES, 2013). The Coonamble gauge, AWRC Number 420005, is located on the Castlereagh River and the gauge zero is connected to AHD. Modelled peak water levels and gauge heights at the Coonamble gauge are provided in Table 7.1.

Table 7.1: Modelled peak water levels at Coonamble gauge

Flood Event	Peak Water Level (m AHD)	Gauge height (m)*
5% AEP	180.81	5.64
1% AEP	180.82	5.65
0.5% AEP	180.83	5.66
Extreme	18.87	5.70

*Gauge zero = 175.169 m AHD (refer to Section 2.3)

Modelled peak water levels at the selected locations for four design flood events are provided in Table 4.2 in Appendix A. The NSW SES could adopt the modelled peak water levels in the flood intelligence for Coonamble.

7.3 Flood Warning Systems

The flood behaviour in West Coonamble is dominated by flooding in the Castlereagh River. Flooding in Warrena Creek may influence flood behaviour in the Castlereagh River downstream of Aberford Street Bridge.

The only automated telemetry system currently in operation in the Castlereagh Valley is the stream gauge located in the Castlereagh River at Mendooran (catchment area 3,600 km^2). The telemetry system provides real-time river height data which is not quality controlled. The data is provided for flood warning purposes and most data is not available during non-flood periods. Most river height data is provided to BOM by other agencies and separate approval may be required to use the data for other purposes.

There is currently no flood warning system, including any stream gauging, specific to Warrena Creek (catchment area at Coonamble approximately 1,240 km^2). The catchment response time to rainfall events in Warrena Creek is generally short and flooding is expected to occur shortly after the start of a storm event with a short time to peak (typically less than six hours). Hence, a catchment specific flood warning system is not considered an appropriate option for implementation.

Relevant to Warrena Creek, BOM issues forecasts and warnings of possible flood events across Australia in the form of generalised flood warnings (Flood Watch) that flooding is occurring or is expected to occur in a particular region, including flash flooding and riverine flooding. Severe Thunderstorm Warnings and Severe

Weather Warnings are also issued when significant weather is expected to occur in certain areas, and which may cause flash flooding.

BOM also issues Flood Warnings of minor, moderate or major flooding in areas where specialised warning systems have been installed, although these are generally for main river flooding and are not directly relevant to Warrena Creek.

The NSW SES uses information provided by BOM and assists in communication flood warnings and recommendation on what action communities should take before, during and after flood events.

8. Flood Damages

8.1 Introduction

The quantification of flood damages is an important part of the floodplain risk management process. By quantifying flood damages for a range of design events, appropriate management measures can be evaluated in terms of their benefits (reduction in flood damage) versus the cost of implementation.

The cost of flood damage and disruption to a community depend on a number of factors which include:

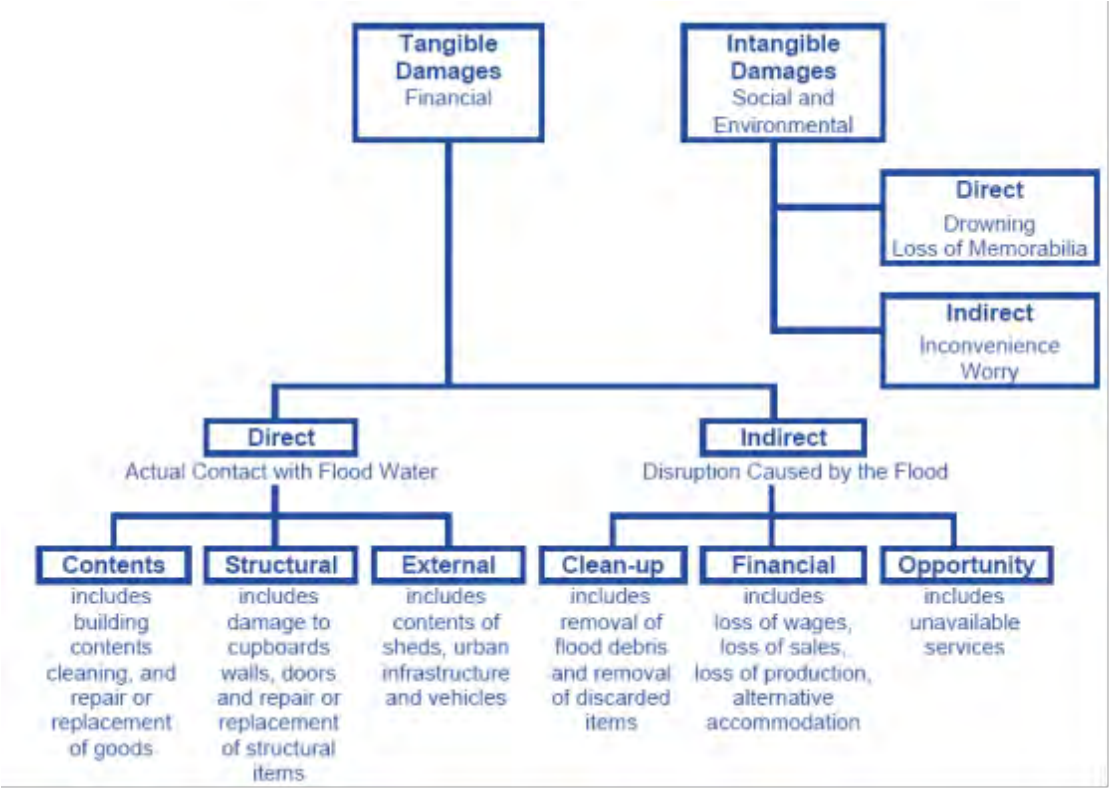
- Flood magnitude (depth, velocity and duration)
- Type of structures at risk and their susceptibility to damage
- Nature of the development at risk (residential, commercial, industrial)
- Awareness and readiness of the community to flooding
- Effective warning times
- Availability of Evacuation Plans.

The potential damage associated with a particular sized flood can be divided into a number of components, which are grouped into two major categories:

- Tangible damages – financial costs of flooding quantified in monetary terms
- Intangible damages – social costs of flooding reflected in increased levels of mental stress, physical illness, inconvenience to people, etc.

Intangible damages are difficult to measure and impossible to meaningfully quantify in dollar terms. For this reason, intangible damages have not been assessed for West Coonamble and the following damage assessment focuses on tangible damages only. Tangible damages can be further sub-divided into two categories, direct and indirect damages, as illustrated in Figure 8.1.

Figure 8.1: Types of flood damages (Source: NSW Floodplain Development Manual, 2005)



Flood damage estimation procedures have been formulated using data collected following real flood events. Information collected includes identification of properties flooded, the extent of flooding, depth of flooding experienced, flooding mechanism etc. This information can then be used to guide and calibrate models used to calculate flood damages for a particular area. One of the most thoroughly studied flood damage assessments was that undertaken at Nyngan, following the flood in 1990.

The most common approach to present flood damage data is in the form of flood-damage curves for a range of property types, i.e. residential, commercial, public property, public utilities etc. These relate flood damage to depth of flooding above a threshold level (usually floor level).

8.2 Approach

Estimation of flood damage has focussed on residential and commercial properties in the Study Area using guidelines issued by the Department of Environment and Climate Change (OEH, 2016b) and recognised damage assessment methodologies. The estimation of damage is based upon flood depth above 'protection level', where protection level relates to the floor level minus 0.5m for properties affected by mainstream flooding (i.e. all areas within the West Coonamble Study Area). It is recommended by DECC (October, 2007) that the freeboard allowance is included to ensure calculation of damage is not under-estimated.

8.2.1 Property Database

A property database was assembled using estimated floor levels of buildings in the Study Area. The database includes address (where available), floor level, ground level, modelled flood levels for each event and data source for each habitable building identified within the Study Area. For residential buildings floor levels were assumed to be 0.3 m higher than the ground elevation at respective building location and for other property types (Commercial, Industrial and Sheds) it was considered that floor levels were located 0.15 m above the surrounding grounds. This included 259 residential buildings, 118 sheds and 43 non-residential buildings (shops, hotel, cafes, police station and other emergency services, churches and halls). All properties are impacted in the extreme flood event. Flood levels were assigned to each property based on the modelled flood

surface at the building. The database was used to determine the number and extent of properties inundated above protection level for the range of flood events modelled (5%, 1%, 0.5% AEP and the extreme flood event).

8.2.2 Residential Damage

Flood damage of residential buildings was calculated using a residential damage spreadsheet developed by the NSW Department of Environment, Climate Change and Water (DECCW, now NSW Office of Environment and Heritage) in 2007. This includes a representative stage-damage curve derived for a typical house on a floodplain to estimate structural, contents and external damage. The amount of damage is based on the flood inundation depth, for a suite of annual exceedance probability events. These values are then summed to provide a total damage for each flood event analysed. The AEP of the extreme flood event (considered as the Probable Maximum Flood) has been estimated using ARR 2019. The AEP of the PMF event for Coonamble was estimated to be 1 in 10^5.

A number of input parameters are required to determine which stage-damage curve will be adopted. The key parameters used in this assessment are shown in Table 8.1.

Table 8.1: Parameters adopted in residential damages assessment

Parameter	Adopted Value	Comment
Building Damage Repair Limitation Factor	1.0	Suggested range of 0.85 to 1.00 (short to long duration events). Riverine flooding in this region has total durations of 2 – 3 days and time of immersion in the village 1 – 2 days.
Contents Damage Repair Limitation Factor	0.9	Suggested range of 0.75 to 0.90 (short to long duration events).
Effective Warning Time (hrs)	0	The Study Area is located on the floodplain of Castlereagh River, with generally flat terrain, dictates potentially rapid rise of floodwaters. Whilst flood warning for Coonamble is issued by BOM, it is assumed that there is no effective warning time for property flood preparation.
Level of flood awareness	Low	Guidelines suggest 'low' is adopted unless 'high' can be justified. While flooding has been experienced in Coonamble, it is assumed that the level of awareness of the extent and magnitude of flooding for large events is low.
House type and size	Single Storey, 200m^2	The houses in Coonamble are typically single storey detached dwellings (supported by evidence gathered by Google Street View). House size was taken to be the recommended average size.

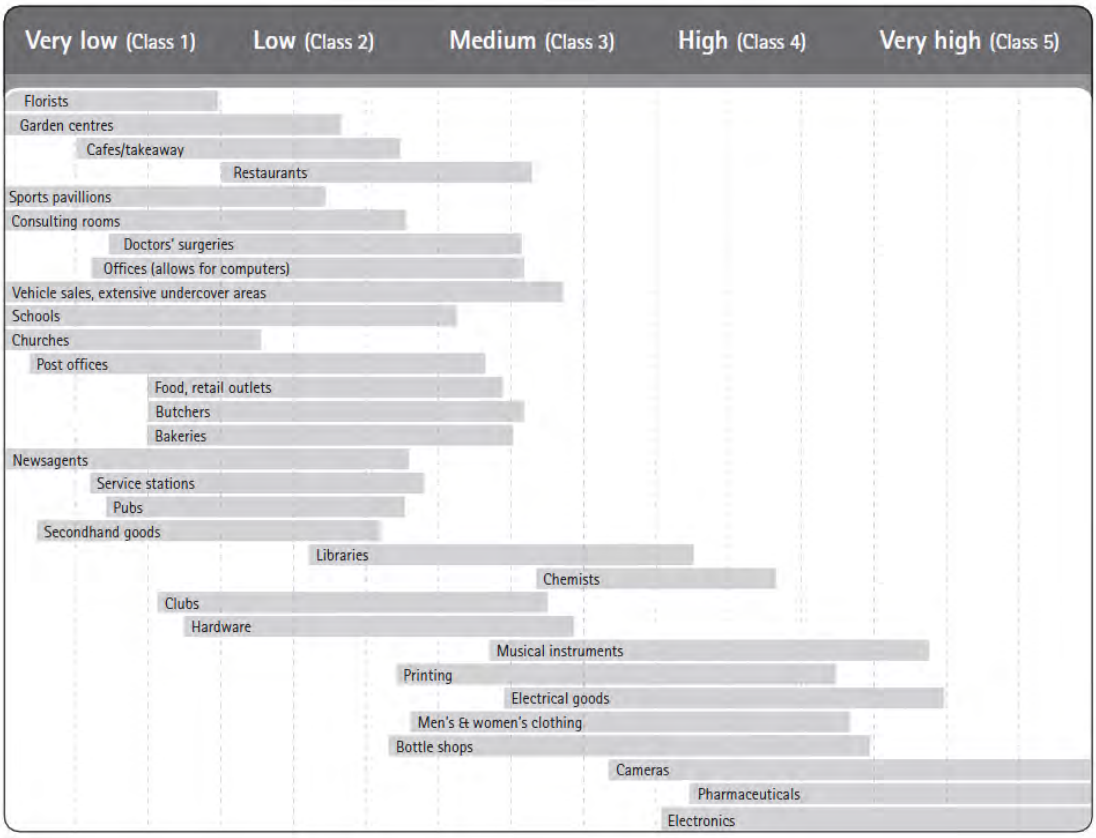
The DECCW stage-damage curves within the spreadsheet are derived for late 2001 and have been updated using an Average Weekly Earnings (AWE) factor to August 2007. AWE is used to update residential flood damage curves rather than the inflation rate measured by the Consumer Price Index (CPI). The most recent AWE value from the Australian Bureau of Statistics (ABS, 2019) at the time of the assessment was November 2018, however, this resulted in a multiplication factor on 2001 dollars of 2.37, which was significantly out of step from the factor value derived from November 2017 AWE of 1.76 and from previous recent years. On this basis, a factor of 1.8 was assumed to keep in trend with AWE increases for the years prior to November 2017.

The spreadsheet was developed for the Sydney urban area. A regional cost variation factor of 1.2 was applied for Coonamble based on Australian Construction Handbook (Rawlinsons, 2019).

8.2.3 Non-residential Building Damage

No information on commercial property flood damage costs in NSW was found during a literature search. The most relevant information obtained was published in the Queensland Government Natural Resources and Management Department's *Guidance on the Assessment of Tangible Flood Damages* (2002). This document contains flood damage curves for commercial properties over a range of property footprint areas and degrees of susceptibility to flooding and is based on information published in *ANUFLOOD: A Field Guide* (Centre for Resource and Environmental Studies (Australian National University), 1992). Different types of commercial and non-residential properties were assigned a susceptibility rating, as illustrated in Figure 8.2.

Figure 8.2: Damage categories for commercial properties (reproduced from Guidance on the Assessment of Tangible Flood Damages (Qld. Government, 2002)



The stage-damage data were factored up by a value of 1.8 from late 2001 dollars to current values based on Average Weekly Earnings (AWE) for November 2018, similar to the approach adopted for the residential flood damages.

An additional multiplication factor of 1.6 was applied based on guidance in *Rapid-Appraisal Method (RAM) for Floodplain Management* (Victorian Government Natural Resources and Environment, 2000), which suggests that the ANUFLOOD values are underestimated and should be increased by 60%.

8.2.4 Vehicle Damage

An estimation of vehicle damage has been excluded from this assessment. Significant damage can be attributed to vehicles, but these can be readily moved from the path of flood waters and have not been included in the flood damages calculations.

8.3 Estimated Tangible Flood Damages

An estimation of the number of properties impacted (flooding occurring on the property), number of properties with above floor flooding and total damage costs for selected flood events was undertaken. The assessment was performed with the recommended protection level of 0.5 m for mainstream, and by using nominal floor levels also (no freeboard applied). Residential external damages are assumed to start accumulating when floodwater is within 0.5 m of the nominal floor level or floor level minus protection level (i.e. the property is impacted). The results are presented in Table 8.2.

The most convenient way to express flood damage for a range of flood events is by calculating the Annual Average Damage (AAD). The AAD value is determined by multiplying the damages that can occur in a given flood by the probability of that flood actually occurring in a given year, and then summing across a range of floods. This method allows smaller floods, which occur more frequently to be given a greater weighting than the larger catastrophic floods. The AAD for the existing case then provides a benchmark by which to assess the merit of flood management options.

The AAD for the existing situation for the Study Area is $131,000 for residential and $2,000 for non-residential properties based on flooding above floor levels. The AAD is $797,000 for residential and $5,000 for non-residential properties based on flooding nominal protection levels with the freeboard applied. Note that residences and non-residential premises were assessed. Sheds on properties within the Study Area were excluded.

Table 8.2: Estimated Tangible Flood Damage for West Coonamble

Flood Event AEP	Nominal Flood Levels		Nominal Flood Levels Plus Freeboard	
	Number of properties flooded above floor level	Estimated Flood Damage	Number of properties flooded above protection level	Estimated Flood Damage
Residential				
5%	0	$1.40 M	107	$9.07 M
1%	2	$1.82 M	138	$11.74 M
0.5%	4	$2.20 M	158	$13.49 M
PMF	51	$6.50 M	256	$22.70 M
AAD		***$131 K***		***$797 k***
Non-residential				
5%	4	$0.02 M	15	$0.58 M
1%	6	$0.03 M	20	$0.79 M
0.5%	7	$0.04 M	20	$0.80 M
PMF	16	$0.17 M	38	$1.88 M
AAD		***$2 K***		***$5 K***

8.4 Summary

Flood damages in the Study Area are dominated by damages to residential properties, accounting for approximately 98% of the total AAD. The total AAD is $133,000 when the flood damages are estimated based on flooding above floor level, and $802,000 when based on flooding above the nominal protection level with 0.5 m freeboard. The flood damages profile and the AAD is skewed by the low flood-affectation of the Study Area in frequent and up to moderately rare floods, that is, none or few properties affected and low flood damages in the 5% AEP event, resulting in relatively low AAD.

Although this damage assessment is based upon tangible damages only, it is worthy to note that intangible damages could be significant for the Study Area. This is due to the duration of flooding being more than a day on most properties. While flood damage estimates for the Study Area are indicative only, they are useful in the evaluation of flood management options, aimed at reducing flood damage estimates while being economically viable to implement.

9. Floodplain Risk Management Measures

9.1 Overview

One of the objectives of this Floodplain Risk Management Study is to identify and compare various floodplain risk management options to deal with existing and future flood risk in the Study Area, considering and assessing their social, economic, ecological and cultural impacts and their ability to mitigate flood impacts.

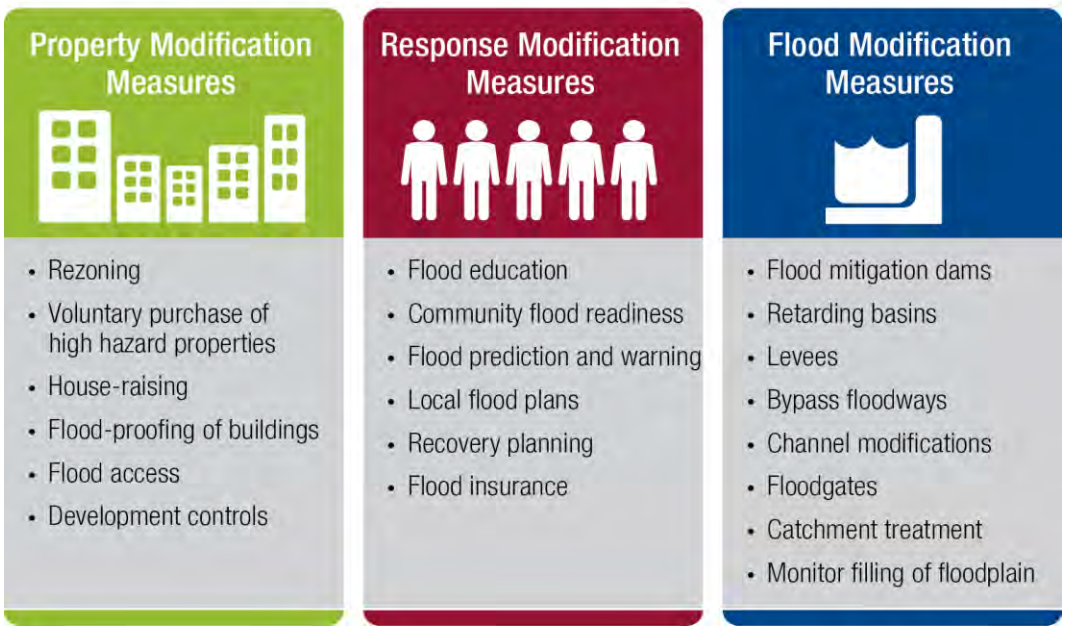
The *Floodplain Development Manual* (NSW Government, 2005) describes floodplain risk management measures in three broad categories as described below:

- Property modification measures involve modifying existing properties (for example, house-raising) and/or imposing controls on new property and infrastructure development (for example, floor height restrictions);
- Response modification measures involve modifying the response of the population at risk to better cope with a flood event (for example improving community flood readiness);
- Flood modification measures involve modifying the behaviour of the flood itself (for example, construction of a levee to exclude floodwaters from an area or flood retarding/detention basins to store floodwaters and reduce peak outflows).

Examples of measures falling under the three categories are outlined in Figure 9.1. Some of these measures may or may not be appropriate in a particular catchment, depending on factors such as the flooding behaviour and patterns of development.

A description and qualitative evaluation of potentially suitable works-based flood modification options for specific locations, nominated for further detailed modelling assessment, is provided in Section 9.2. Response and property modification measures are discussed in Section 9.4 and 9.3 respectively.

Figure 9.1: Floodplain Risk Management Measures *(Source: Floodplain Development Manual, 2005)*



9.2 Flood Modification Measures

Only four (4) residential buildings are impacted in the 0.5% AEP event within the Study Area and the impacted buildings are located in three different areas. Hence flood modification measures are not considered appropriate for the buildings due to potential high costs of flood modification measures.

9.3 Property Modification Measures

9.3.1 Voluntary Purchase of High Hazard Properties

Voluntary purchase of high flood hazard properties may be considered in order to eliminate the potentially high risk of loss of life and damage to property from these areas by physically removing the dwellings at risk to hazardous flood conditions.

DPIE previously prepared Guidelines for Voluntary Purchase Schemes (OEH, 2013b). This describes the eligibility criteria for NSW Government funding for VP schemes, which include:

- no other feasible flood risk management options are available to address the risk to life at the property;
- residential properties and not commercial and industrial properties;
- buildings were approved and constructed prior to 1986;
- properties are located either 1) within high hazard areas where there is a significant risk to life for occupants and those who may have to evacuate or rescue them, 2) within a floodway where the removal of the house may be part of a floodway clearance program aimed to reduce the significant impacts caused by the existing development on flood behaviour elsewhere in the floodplain, or 3) 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.

No dwellings in the Study Area were identified to be impacted by high hazard flooding. One dwelling within the Study Area is located within a floodway. However, the flood hazard at the dwelling was assessed being low (i.e. considered to be H4 or lower) and the building is not subject to above floor flooding in the 1% AEP event. Hence, no buildings are considered appropriate for voluntary purchase.

9.3.2 Voluntary House Raising

Voluntary house raising has long been a traditional response to flooding in New South Wales, as demonstrated by the number of raised houses in frequently flooded urban areas such as Lismore and Fairfield (*Floodplain Development Manual*, NSW Government, 2005). There are advantages associated with house raising which are noted as follows (Frost and Rice, 2003).

- A reduction of flood damages due to personal items being stored above the nominated flood level
- A reduction in danger to personal safety and a reduction in the cost of potentially needing to evacuate residents
- Potentially cost-effective alternative to voluntary purchase, with positive social outcomes (i.e. homeowners who have strong sentimental value on their properties can remain in the same location).

Some of the disadvantages include:

- Residents' concern over security and privacy due to an open, exposed ground floor
- Accessibility issues for the elderly or people with a disability
- Following raising, residents may develop a false sense of security from impacts. This can result in a belief that they will not be impacted by flooding or reluctance to evacuate when required.
- Over time and when flooding has not occurred, residents may be inclined to utilise the ground floor and converting it to a habitable area.

DPIE previously prepared *Guidelines for Voluntary House Raising Schemes* (OEH, 2013a). This describes the eligibility criteria for NSW Government funding of VHR schemes including:

- not located in floodways
- limited to areas of low flood hazard
- the suitability of individual houses for raising
- residential properties and not commercial and industrial properties
- buildings were approved and constructed prior to 1986
- properties cannot be benefiting substantially from other floodplain mitigation measures
- VHR should generally return a positive net benefit in damage reduction relative to its cost (benefit–cost ratio greater than 1).

Inclusion of a property in a voluntary house raising scheme places no obligation on the owner to sell the property or on the council or NSW Government to fund the purchase of the property. Owner participation in the scheme is voluntary and there are limitations on the availability of funding.

Based on the count of dwellings affected by low hazard (considered to be H4 or lower), above-floor flooding in the 1% AEP event, two residential properties are affected and could be eligible for voluntary house raising. However, both properties are subject to less than 0.01 m depth of flooding in the 1% AEP flooding as such both properties are unlikely to be eligible for funding.

9.3.3 Planning and Development Controls

9.3.3.1 General

Land use planning and development controls are an essential element in managing flood risk and the most effective way of ensuring future flood risk is managed appropriately. Planning controls including flood planning levels, flood related development control plans and restrictions on permissible types of development in different parts of the floodplain are recommended to ensure that development in the Study Area occurs in an appropriate manner in relation to flooding. Such measures aim to mitigate against increases in flood risk and flood damages to property which could result from inappropriate development.

9.3.3.2 A New DCP

It is identified in Section 5.3.5 that there is no reference to flood risk management in "Coonamble DCP No. 1 - Coonamble Township and Surrounds - as amended 12 Nov 2009" and there is limited reference to flood risk management in "Coonamble DCP No. 2 - Rural Small Holdings". Hence, a new DCP is recommended to address flood risk management for the Coonamble LGA. A number of new development controls to be included in the new DCP for the Coonamble LGA are recommended for consideration by Council:

- Reference should be made to available flood planning area map. Flood planning levels should be adopted for administering development controls.
- For all development types, consideration of the flood hazard rating and hydraulic category rating of the land in determining compatibility of development and appropriate development controls. This may mean restricting development to outside of high hazard (i. e. H5 and H6) or floodway areas in the 1% AEP event. Consider adoption of a flood planning matrix, refer to Section 9.3.3.3.
- Define an appropriate design flood standard for non-residential development. A 1% AEP design flood may be appropriate for most non-residential development. Critical facilities such as emergency services, childcare, aged care etc. may require placement outside/above the extent of the PMF event.
- All new/redeveloped buildings should be constructed with flood compatible materials to withstand the hydrostatic force and flow velocity (related to flood planning matrix).

- New developments or redevelopments should not impact on flooding of neighbouring properties (consistent with provision in LEP 2011).

9.3.3.3 Flood Planning Matrix

A flood planning matrix proposed for Coonamble LGA for application of flood-related development control is presented in Appendix C. The concept of the planning matrix was developed in the late 1990's[1] which seeks to provide a structure for planning controls that can deliver a risk management approach to address continuing and future flood risk.

The matrices would help implement various flood planning conditions for different development types and in different flood risk zones, or alternatively in different flood hazard or flood category zones. Such conditions include permissible development types in different flood zones, minimum floor levels, etc. The matrices allow easy referencing of the development types and flood zones and the applicable development controls.

There is scope to modify the format and planning controls in the matrix to suit flooding conditions in the Coonamble LGA. Flood planning matrices are provided for "urban" and "rural" areas within the Study Area. Refer to Appendix C for details.

9.3.3.4 Section 10.7 Certificates

It is recommended that Council should consider providing flood information for properties such as flood levels and flood hazard and hydraulic categories in Section 10.7 certificates.

9.4 Response Modification Measures

Response modification measures aim to reduce flood risk by improving the community's ability to respond during a flood event in addition to emergency services capacity to coordinate the response. Works-based options include improvement of evacuation routes. Measures such as flood forecasting, public education and revision of flood emergency plans also fall into this category and are discussed below.

9.4.1 Upgrade of Quambone Road

Road access between Coonamble and Quambone via Quambone Road is lost during frequent flood events due to flooding in waterways crossed Quambone Road and flooding in the Castlereagh River. Gidgenbar watercourse (Euronne gully) and Nedgera Creek are two major waterways crossed by Quambone Road in the vicinity of Coonamble. Gidgenbar watercourse (catchment area approximately 70 km^2) crosses Quambone Road approximately 10 km west of Coonamble and Nedgera Creek (catchment area approximately 650 km^2) crosses Quambone Road approximately 20 km west of Quambone. Breakout flows from the Castlereagh River at "Geamoney breakout" (refer to Figure 2.2) is another source of flooding on Quambone Road in the vicinity of Quambone.

Immunity from flooding in the Castlereagh River

The section of Quambone Road which is impacted by flooding is located outside of the Study Area and in addition, this study is focussed on mainstream flooding only. The FRMC identified that options for upgrade of Quambone Road due to flooding from the Castlereagh River need to be considered as part of the FRMS. Hence, a potential upgrade of Quambone Road was assessed as part of the study to provide flood free access to Quambone in the 5% AEP event flooding in the Castlereagh River. It is estimated that approximately 8 km (refer to Figure 9.2) long section of Quambone Road needs to be upgraded to provide a flood immunity in the 5% AEP event. Key works included in the preferred upgrade option are the following:

[1] Bewsher & Grech, May 1997, *A New Approach to the Development of Floodplain Controls for Floodplains*, paper presented to the 37th Annual Floodplain Management Conference, Maitland.

- Construction of an 8 m wide and 8 km long road embankment with varying heights
- Providing a total waterway area of approximately 810 m^2 under the road embankment in the form of culverts
- Erosion control
- Traffic management

The preliminary cost of the upgrade was estimated at $41 million using the Australian Construction Handbook (Rawlinsons, 2019). The preferred upgrade option would result in a maximum increase in flood levels up to 0.3 m (refer to Figure 9.2) along the upgrade in the 5% AEP event.

Immunity from flooding in Gidgenbar watercourse and Nedgera Creek

Information on existing culverts and bridges crossing Gidgenbar watercourse and Nedgera Creek was not available to this study. No culverts/bridge crossings were identified along Quambone Road in the vicinity of Gidgenbar watercourse through a review of Google Maps. This means the section of Quambone Road crossing Gidgenbar watercourse is subject to flood inundation during significant storm events occurring on the upstream catchment area. Quambone Road is likely to be impassable for several days during long duration storm events. The existing flooding issue at Gidgenbar watercourse would be resolved if Quambone Road is upgraded to achieve flood immunity in the 5% AEP event in the Castlereagh River. However, given the high cost (approximately $41 million), it would be prudent to upgrade a section of Quambone Road to achieve flood immunity from the upstream catchment area of Gidgenbar watercourse. A hydrologic and a hydraulic assessment is recommended for sizing the waterway crossing to achieve the required flood immunity for Quambone Road at Gidgenbar watercourse.

An approximately 30 m long creek crossing was identified along Quambone Road in the vicinity of Nedgera Creek. It is expected that the existing creek crossing protects Quambone Road from flooding during frequent storm events.

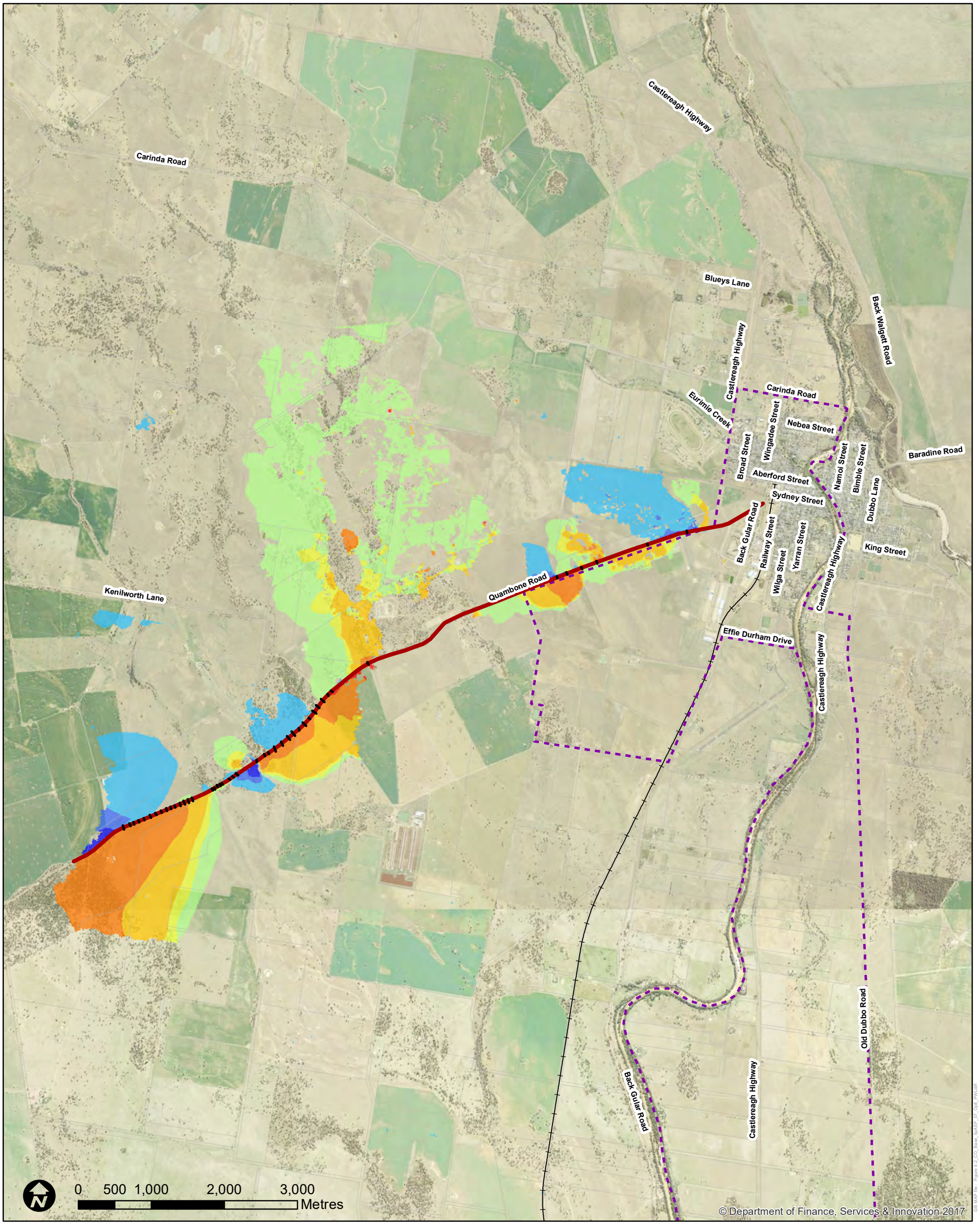
9.4.2 Flood Warning

The main source of flooding in the Study Area is the Castlereagh River as such, the existing flood warning system for the Study Area could include height-time predictions of the Castlereagh River flooding at the Coonamble gauge.

9.4.3 Flood Education and Awareness

Flood education and awareness should be promoted throughout the Study Area. This could be achieved with the following methods:

- Installation of flood depth indicators at key locations, such as the Castlereagh Highway sag points within the Study Area.
- Local newspaper articles on the historic flood events during anniversaries of the events. This already occurs and is recommended to continue.
- Council or the NSW SES may wish to run educational workshops or distribute information sheets to help people plan and prepare for a flood. Knowledge about local flooding issues is a valuable tool to equip the public with.
- Section 10.7 certificates issued by Council could be used to inform property owners about flood risk to their properties.



Legend

- Study Area
- Cadastre
- Poposed culverts
- Proposed road upgrade

Change in Flood Level (m)

- < -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to -0.01
- 0.01 to 0.03
- 0.03 to 0.05
- 0.05 to 0.1
- 0.1 to 0.3
- > 0.3

JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:50,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	Proposed Road Upgrade Impacts on 5% AEP Flood		
PROJECT	Coonamble Floodplain Risk Management Study		
CLIENT	Coonamble Shire Council		
DRAWN AI	PROJECT # IA194100	MAP # Figure 9-2	REV 1 VER 1
CHECK AH	DATE 26/08/2019		

10. Floodplain Risk Management Plan

10.1 Purpose of the Plan

The Floodplain Risk Management Plan (the "Plan") is provided in Table 10.1 and provides input into the strategic and statutory planning roles of Coonamble Shire Council. It provides a steering document to enable Council to effectively manage flood liable land moving forward. It also suggests an implementation plan based on priorities of floodplain risk management measures and availability of funding.

10.2 Funding and Implementation

10.2.1 Estimated Costs

The cost of upgrading an 8 km long section of Quambone Road to achieve a flood immunity in the 5% AEP event in the Castlereagh River was estimated at $41 million. The cost is considered very high compared to the benefits. It is a recommended that a detailed hydrologic and hydraulic assessment should be undertaken to prepare concept design and cost estimates for upgrade of a smaller section of Quambone Road to improve the existing flood immunity of the road from flooding in Gidgenbar watercourse (Euronne gully).

Costs were estimated for non-works-based measures. The costs of planning, policy, administrative and organisational non-works measures are largely unknown to the consultant. The timing of the proposed works will be dependent on Council's overall budgetary commitments and the availability of funding from external sources. The Plan can be progressively implemented with an anticipated timeframe of 1-2 years for high priority options and 2-5 years for medium priority options.

10.2.2 Funding Sources

There are a number of funding bodies, which Council could consider applying to for supplementary funds. DPIE offers support to local Councils through Floodplain Management Grants. Assistance under this Program is usually $2 from government for every $1 from Council.

The Natural Disaster Resilience Program (NDRP) is a joint Commonwealth/State program funded through the National Partnership Agreement on Natural Disaster Resilience. It provides funding through the Floodplain Grant Scheme (FRMGS) to address flood activities allocated through the existing Floodplain Management Program managed by DPIE (described above).

The Community Resilience Innovation Program (CRIP) is another program funded through the NDRP and supports a broad range of community-led projects designed to increase all-hazard disaster preparedness and build community capacity and resilience. Flood education and awareness programs may be eligible.

Applications for funding from State or Commonwealth programs are highly competitive and the limited funds are allocated on an annual basis. Options put forward for funding assistance must be well supported and justified through demonstrated strong cost/benefit ratio and inclusion of positive environmental and social outcomes.

In addition to State and Federal Government, Council could approach other organisations (for example Transport for NSW, NSW SES) or private owners (such as property developers, where appropriate) to assist with funding of measures.

10.3 On-going Review of Plan

The Floodplain Risk Management Plan should be regarded as a robust document, which requires review and amendments to be made over time. At a minimum, it is recommended that the Plan should be reviewed every five (5) years to ensure it remains relevant to the requirements of the area. In addition to scheduled reviews, the Plan should be reviewed following flood events, any change in State or Local Government legislation or alterations to funding availability. Implementation of the Plan should be monitored by the FRMC. The local

community should continue to be informed of progress through newsletters available via the Council website or displayed at Council Offices.

Table 10.1: Floodplain Risk Management Plan

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
PM1	Amendments Section 10.7 certificates	Council	Council staff costs	N/A	• Section 10.7 certificates should provide flood information for properties such as flood levels, flood planning levels, flood hazard and hydraulic categories present on each lot.	**High**
PM2	New DCP	Council	Council staff costs	N/A	• A new Development Control Plan is to be prepared to address mainstream flood risk for Coonamble Shire. • The new DCP should refer to flood mapping available for Coonamble Shire which were prepared as part of floodplain risk management studies and subsequently adopted by Coonamble Shire. • The flood planning matrix specific to Coonamble Shire is to be appended to the new DCP (refer to Appendix C). • Consider the flood hazard rating and hydraulic category rating of the land in determining compatibility of development and appropriate development controls. • Define an appropriate design flood standard for non-residential development. A 1% AEP design flood may be appropriate for most non-residential development. Critical facilities such as emergency services, childcare, aged care etc. may require placement outside/above the PMF extent. Refer to proposed flood planning matrix (Appendix C). • All new/redeveloped buildings in appropriate flood areas are to be constructed with flood compatible materials to withstand the hydrostatic force and flow velocity.	**High**

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
					• New developments or redevelopments should not impact on flooding of neighbouring properties (consistent with provision in LEP 2011).	
RM1	Flood education and awareness program	Council, NSW SES	$30K	Staff costs	Measures may include: • Install flood depth indicators at key locations e.g. Castlereagh Highway sag points within the Study Area. • Local newspaper articles on the historic flood events during anniversaries of the events. For example, the flood event of February 1955. • Council or the NSW SES may wish to run educational workshops or distribute information sheets to help people plan and prepare for a flood. Knowledge about local flooding issues is a valuable tool to equip the public with. • Section 10.7 certificates issued by Council could be used to inform property owners about flood risk to their properties. • The program should be reviewed on a regular (e.g. 5 yearly) basis.	**High**
RM2	Revision of Coonamble Shire Local Flood Plan	NSW SES, Council	NSW SES/Council costs	N/A	• Review roles and responsibilities, systems and procedures in consultation with key stakeholders • Update flood intelligence based on additional information on flood behaviour presented in the FRMS for West Coonamble • Update list of evacuation centres in consideration of the updated flood behaviour.	**High**

ID	Measures considered	Responsibility	Initial Cost	Ongoing Cost	Features of the Measure	Recommended Priority Rankings
RM3	Preparation of concept design and cost estimates for upgrade of Quambone Road at Gidgenbar watercourse (Euronne gully)	Council	$70K	Staff costs	Measures may include: Undertake a detailed hydrologic and hydraulic assessment to identify feasible options to improve flood immunity for Quambone Road from flooding in Gidgenbar watercourse. Prepare concept drawings and cost estimates for the preferred upgrade option in consultation with Council.	**Medium**

11. Acknowledgements

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A number of organisations and individuals have contributed both time and valuable information to this study. The assistance of the following in providing data and/or guidance to the study is gratefully acknowledged:

- Residents of the Study Area;
- Coonamble Shire Council;
- Bureau of Meteorology;
- NSW SES; and
- DPIE.

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13. Glossary

Annual Exceedance Probability (AEP)

The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. In this study AEP has been used consistently to define the probability of occurrence of flooding. It is to be noted that design rainfalls used in the estimation of design floods up to and including 100-year ARI (ie. 1% AEP) events were derived from 1987 Australian Rainfall and Runoff. The following relationships between AEP and ARI applies to this study (AR&R, 2016).

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very frequent	**12**			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.50
Frequent	**1**	**63.2**	1.58	1.00
	0.69	**50.00**	2	1.44
	0.5	39.35	2.54	2.00
	0.22	**20.00**	5	4.48
	0.2	18.13	5.52	5.00
Infrequent	0.11	**10.00**	10.00	9.49
	0.05	**5.00**	20	20.0
	0.02	**2.00**	50	50.0
	0.01	**1.00**	**100**	100
Rare	0.005	0.50	**200**	200
	0.002	0.20	**500**	500
	0.001	0.10	**1000**	1000
Extremely Rare	0.0005	0.05	**2000**	2000
	0.0002	0.02	5000	5000
			↓	
Extreme			PMP	

Australian Height Datum (AHD)

A common national surface level datum approximately corresponding to mean sea level.

Average Annual Damage (AAD)

Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year

	that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrences 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 flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
Catchment	The land area draining through the mainstream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Development	Is defined in Part 4 of the EP&A Act In fill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. New development: refers to development of a completely different nature to that associated with the former land use. E.g. The urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of exiting urban services, such as roads, water supply, sewerage and electric power. Redevelopment: refers to rebuilding in an area. E.g. As urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services.
Effective Warning Time	The time available after receiving advise of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
Exceedances per Year (EY)	The number of times an event is likely to occur or be exceeded within any given year.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
Flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.

Flood liable land	Is synonymous with flood prone land (i.e.) land susceptibility to flooding by the PMF event. Note that the term flooding liable land covers the whole floodplain, not just that part below the FPL (see flood planning area)
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is flood prone land.
Floodplain risk management options	The measures that might be feasible for the management of particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
Floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually include both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defines objectives.
Flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the SES.
Flood planning levels (FPLs)	Are the combination of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "designated flood" or the “flood standard” used in earlier studies.
Flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings and structures subject to flooding, to reduce or eliminate flood damages.
Flood readiness	Readiness is an ability to react within the effective warning time.
Flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. Existing flood risk: the risk a community is exposed to as a result of its location on the floodplain. Future flood risk: the risk a community may be exposed to as a result of new development on the floodplain. Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.

Flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
Hazard	A source of potential harm or situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community.
Local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
m AHD	Metres Australian Height Datum (AHD)
m/s	Metres per second. Unit used to describe the velocity of floodwaters.
m^3/s	Cubic metres per second or "cumecs". A unit of measurement of creek or river flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
Modification measures	Measures that modify either the flood, the property or the response to flooding.
Overland flow path	The path that floodwaters can follow as they are conveyed towards the main flow channel or if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads.
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation couplet with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain.

Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall which ends up as a streamflow, also known as rainfall excess.
Stage	Equivalent to water level (both measured with reference to a specified datum)
TUFLOW	TUFLOW is a computer program which is used to simulate free-surface flow for flood and tidal wave propagation. It provides coupled 1D and 2D hydraulic solutions using a powerful and robust computation. The engine has seamless interfacing with GIS and is widely used across Australia.

Appendix A. Flood Study Revision

West Coonamble Floodplain Risk Management Study and Plan

Flood Study Revision

IA194100 West Coonamble

April 2021

Coonamble Shire Council

West Coonamble Floodplain Risk Management Study and Plan

Project No:	IA194100
Document Title:	Flood Study Revision
Document No.:	IA194100 West Coonamble
Revision:	Final
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Client Name:	Coonamble Shire Council
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Author:	Prashant Kadam, Akhter Hossain
File Name:	IA194100 West Coonamble Flood Study Revision Final

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Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
A	2/6/2020	Draft Report	PK, AH	L Chong	A Hossain	A Hossain
B	12/4/2021	Final Report	PK, AH	L Chong	A Hossain	A Hossain

Contents

Important note about this report

The sole purpose of this report and the associated services performed by Jacobs is to undertake a floodplain risk management study and plan for West Coonamble, located in the Central-west Region of NSW, in accordance with the scope of services set out in the contract between Jacobs and Coonamble Shire Council (the Client). That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client, third parties, and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

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1. Introduction

1.1 Purpose of This Flood Study Review

The purpose of this flood study review is to provide an updated understanding of the existing and future flood risks in West Coonamble and to provide information for the development of the subsequent floodplain risk management study and plan in accordance with the NSW Government's Floodplain Development Manual (2005).

Key objectives of this flood study review are to:

- Update hydrologic analysis and modelling based on Australian Rainfall and Runoff (ARR) 2016 (Ball et al 2016).
- Develop a two-dimensional (2D) TUFLOW hydraulic model for defining mainstream flood behaviour in the study area. Verify modelled flood behaviour against observed and design flood events.
- Determine flooding behaviour and flood risk in the study area for a range of flood events including 0.5%, 1% and 5% annual exceedance probability (AEP) events and an extreme flood event.
- Map flood hydraulic and provisional hazard categories.
- Assess the sensitivity of flood behaviour to changes in hydrologic and hydraulic characteristics in the catchments.

The outcomes from this flood study review will form the basis for identification, assessment and prioritisation of management measures in the Floodplain Risk Management Study and Plan for West Coonamble.

2. Catchment Hydrology

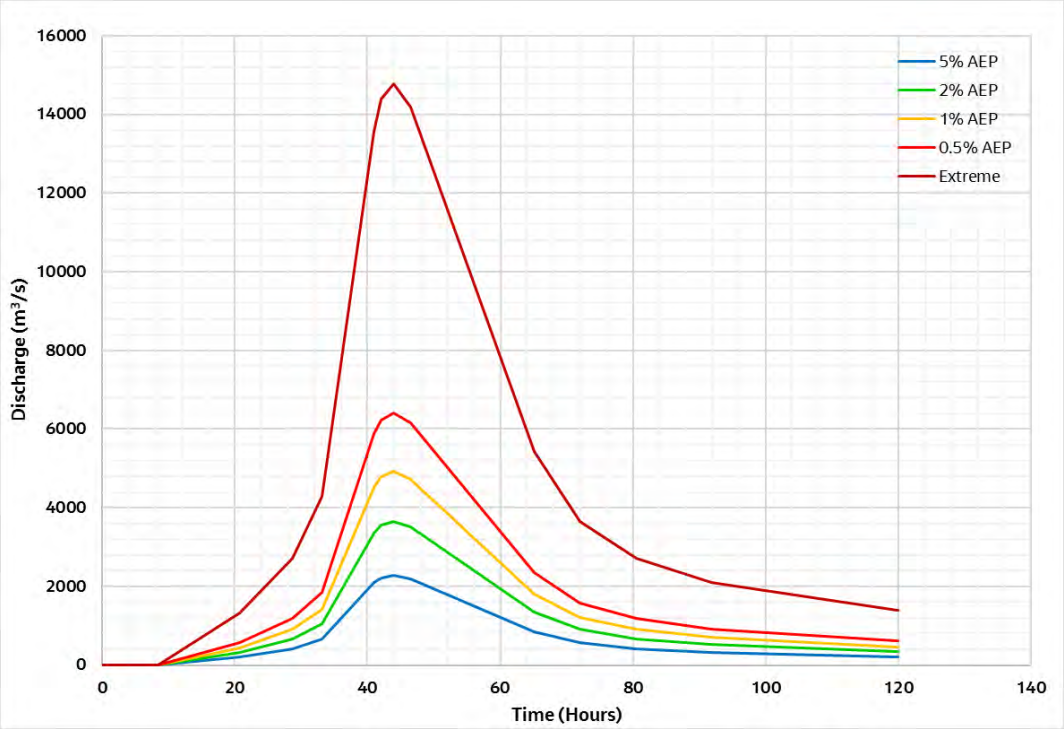
2.1 Overview

The major sources of flooding for West Coonamble are the Castlereagh River (catchment area 8,400 km^2 at the confluence with Warrena Creek) and Warrena Creek (catchment area 1,260 km^2 at the creek outlet). However, inflows in the Castlereagh River generally dominates the flood behaviour in West Coonamble. Inflow hydrographs adopted in the West Coonamble Flood Study Report (Jacobs, 2016) for the Castlereagh River are based on flood frequency results for the Castlereagh River at Gilgandra gauge adopted in the Gilgandra Floodplain Management Study (Lyall & Macoun, 1996). Rainfall runoff modelling using a calibrated RORB hydrology model was undertaken to estimate runoff hydrographs for Warrena Creek based on ARR 1987 (IEAust,1987).

2.2 Design Discharge for the Castlereagh River

Design discharges for the Castlereagh River adopted in the West Coonamble Flood Study (Jacobs, 2016) were not updated as part of this study as no additional streamflow records were available for the Castlereagh River at Gilgandra gauge since completion of the Gilgandra Floodplain Management Study (Lyall & Macoun, 1996). Figure 2-1 shows design discharge hydrographs for the Castlereagh River adopted in the 2016 West Coonamble Flood Study (Jacobs ,2016).

Figure 2-1 Adopted discharge hydrographs for design flood events for the Castlereagh River (Jacobs 2016)



2.3 Design Discharges for Warrena Creek

A RORB hydrology model was developed as part of the Coonamble Levee – Flood Gradient Sensitivity Modelling Study (SKM, 2009). The calibrated RORB model was utilised to estimate runoff hydrographs for Warrena Creek at Warrana gauge (catchment area 583 km^2) and its major tributary, Magometon Creek (catchment area 540 km^2 at Near Coonamble gauge) which joins Warrena Creek downstream of the Warrana gauge. Design flood events based on ARR 1987 (IEAust, 1987) were simulated for the 20% AEP, 5% AEP, 2% AEP and 1% AEP events as part of the 2016 Flood Study (Jacobs, 2016).

Given that the RORB model (SKM, 2009) was calibrated against recorded streamflow data, the same RORB model parameter values and rainfall losses were also adopted in the estimation of runoff hydrographs using ARR 2016 (Ball et al, 2016). The RORB model was used to simulate rainfall runoff for the 1% AEP and 2% AEP events based on ARR 2016. A comparison of peak discharges at the two gauging stations estimated using ARR 1987 and ARR 2016 are shown in Table 2-1 and Table 2-2. Table 2-1 and Table 2-2 show that ARR 2016 estimated peak flows for both 1% AEP and 2% AEP events at both gauges are smaller than ARR 1987 etimates due to slight reduction in design rainfall depths.

Table 2-1 Peak design discharges (m^3/s) for Warrena Creek at Warrana gauge

AEP Event	ARR 1987	ARR 2016
20%	88	RORB model not run
5%	163	RORB model not run
2%	229	209
1%	298	285

Table 2-2 Peak design discharges (m^3/s) for Magometon Creek at Near Coonamble gauge

AEP Event	ARR 1987	ARR 2016
20%	308	RORB model not run
5%	530	RORB model not run
2%	719	612
1%	906	809

As flood behaviour in West Coonamble is dominated by flooding in the Castlereagh River and the ARR 2016 estimated peak discharges for both Warrena Creek and Magometon Creek are generally smaller than ARR 1987 estimates, peak discharges adopted in the 2016 Flood Study (Jacobs, 2016) are also adopted in this study. Figure 2-2 and Figure 2-3 show the adopted design discharge hydrographs for Warrena Creek and Magometon Creek respectively.

Figure 2-2 Adopted discharge hydrographs for Warrena Creek at Warrana gauge

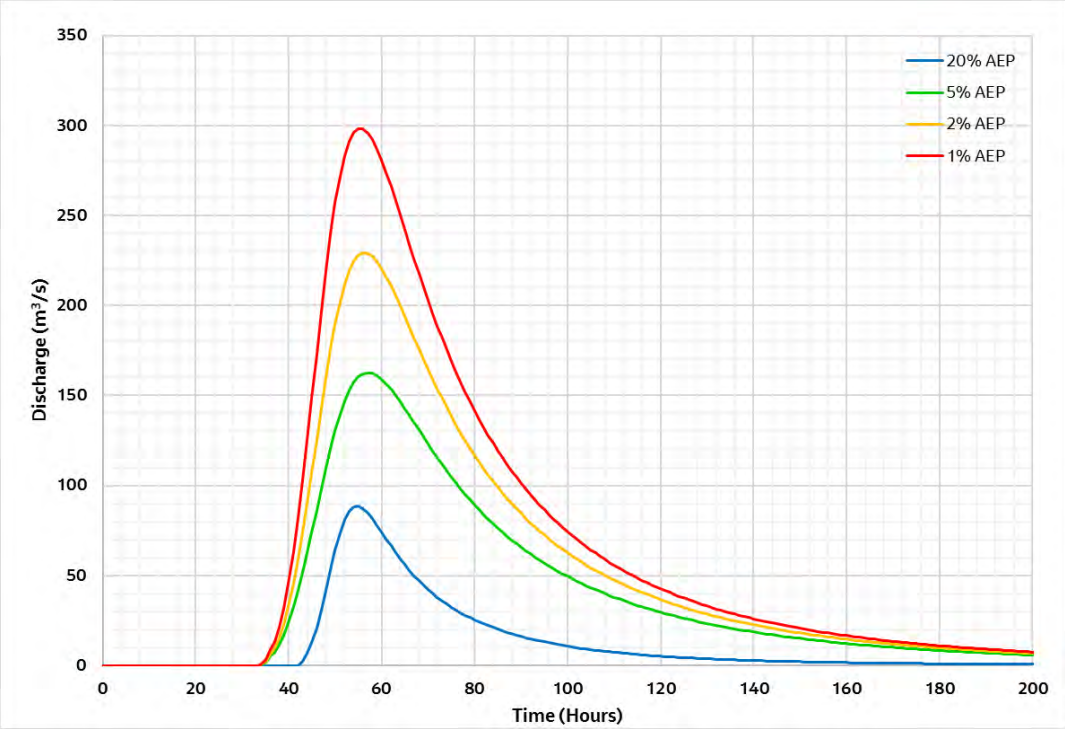
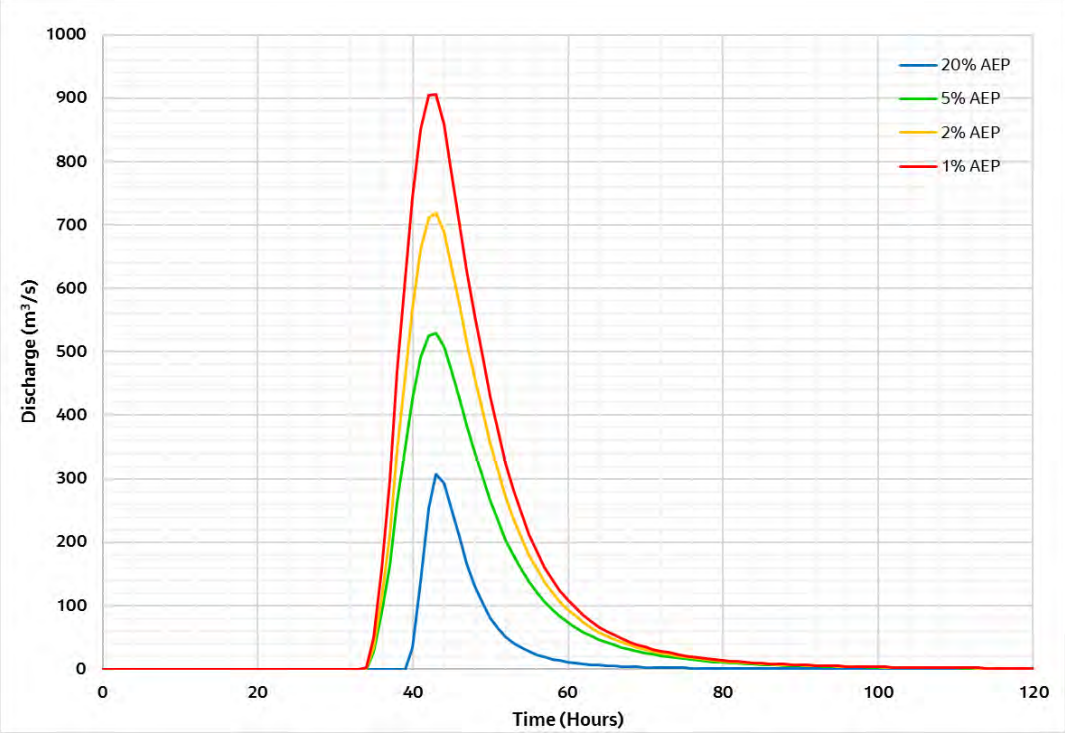


Figure 2-3 Adopted discharge hydrographs for Magometon Creek at Near Coonamble gauge



3. Hydraulic Modelling

3.1 Model Selection

A TUFLOW (BMT WBM, 2018) combined one-dimensional (1D) and two-dimensional (2D) hydrodynamic model was developed for this study. TUFLOW is an industry-standard flood modelling platform, which was selected for this assessment as it has:

- Capability in representing complex flow patterns on the floodplain, including flows through street networks and around buildings.
- Capability in representing the stormwater drainage network, including pit inlet capacities and interflows between the network and floodplain including system surcharges.
- Capability in accurately modelling flow behaviour in 1D channel, bridge and culvert structures and interflows with adjacent 2D floodplain areas.
- Easy interfacing with GIS and capability to present the flood behaviour in easy-to-understand visual outputs.

The model was developed and run in TUFLOW 2017-09-AC-iDP-w64, in double-precision mode.

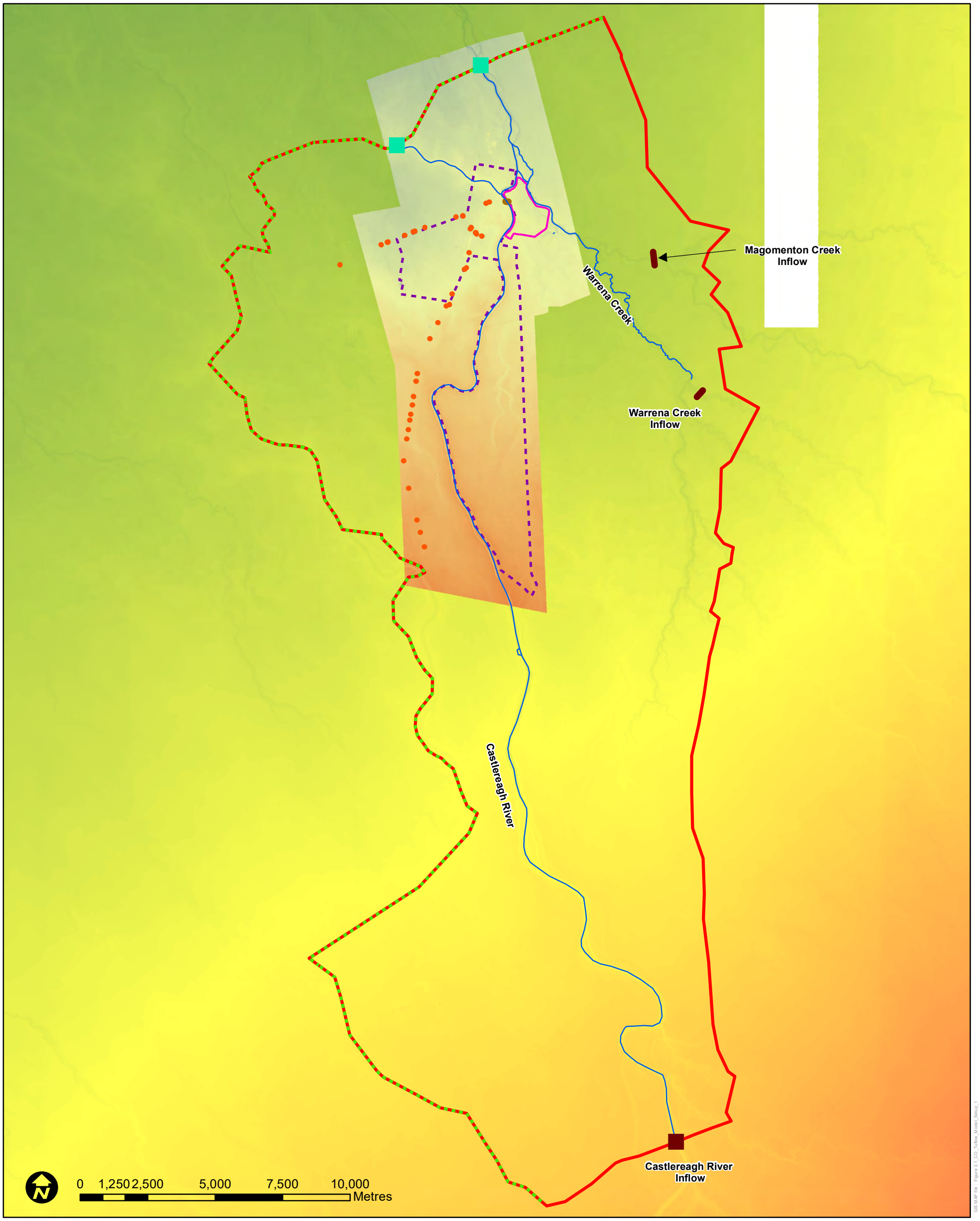
3.2 Configuration of the Hydraulic Model

3.2.1 Extent and structure

The extent of the TUFLOW model and various features represented in the model are shown in Figure 3-1 which shows that the model is comprised of:

- A 2D domain of the floodplain surface reflecting the floodplain topography, with varying roughness as dictated by land use. The 2D domain extends approximately 40 km upstream and 5 km downstream of Coonamble township, representing all significant breakouts from the Castlereagh River and flow paths contributing to the flooding in the township. All watercourses and flow paths are generally represented in 2D.
- A 1D network representing the Castlereagh River, Warrena Creek and Eurimie Creek. Cross-sections for the 1D network were extracted from the available 1 m digital elevation model (DEM) (refer to section 3.2.2).
- Major road and rail culverts and bridges are represented in the model.
- Obstructions to flow acting as hydraulic controls are represented as 2D objects. These include Coonamble Levee, railway and all major roads as identified from the DEM. Buildings are also represented as 2D objects with a very high roughness value.

Details on the features included in the TUFLOW model are provided in the following sections.



Legend

- Model domain
- Study area
- Coonamble levee
- 2-D Inflow
- 2-D Outflow
- 1-D Inflow
- 1-D Outflow
- 1-D Network
- Bridge
- Culverts

1m LiDAR
High : 200
Low : 160

5m LiDAR
High : 250
Low : 150

JACOBS

Data Sources: Coonamble Shire Council
LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:135,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**TUFLOW Model Setup**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure 3.1**	REV 1 VER 1
CHECK AH	DATE 5/02/2020		

GIS MAP file : Figure 3.1_CO_TuFlow_Model_Setup_1

3.2.2 Model topography

The topography of the floodplain was represented in the model using 20 m rectangular grids. The size of the grid is considered appropriate in order to find a balance between the representation of the large size of the floodplain, model run times and the objective of the study. The basis of the topographic grids used in the TUFLOW model was the LiDAR data sets of 1 m and 5 m spatial resolution as shown in Figure 3-1. Figure 3-1 shows that the 1 m DEM covers most of the important floodplain near Coonamble and the 5 m DEM (extracted from www.elevation.fsdf.org.au) fills up the gaps where the former is missing.

3.2.3 River and creeks

Main channels of the Castlereagh River, Warrena Creek and Eurimie Creek were represented in a 1D network in the TUFLOW model. Selection of location of cross-sections for the 1D waterways was guided by engineering judgement. Topographic data for the selected cross sections were extracted from the available DEMs with spacing of cross sections varying between 50 m and 400 m.

The 1D waterways included in the TUFLOW model were linked with floodplains on both banks to ensure connectivity between channels and floodplains. The 2D domain overlapping the 1D waterways were deactivated to avoid double counting of channel conveyance.

3.2.4 Hydraulic structures

Bridges on the Castlereagh River and Warrena Creek were represented as bridge components in the 1D network. Form losses for bridges were estimated considering pier geometry, abutments, location and skewness. Culverts under the railway and Quambone Road were also represented in the 1D network. Details of the bridges and culverts were adopted from the field survey undertaken for the 2016 Flood Study (Jacobs, 2016).

3.2.5 Hydraulic controls

Coonamble Levee, railway, Quambone Road and other elevated roads are expected to obstruct flood flow. These obstructions were represented as solid obstructions in the 2D domain based on the elevation extracted from the available DEMs.

3.2.6 Building polygons

Footprints of buildings located within the township were digitised from 2018 Google Satellite imagery. Buildings were represented in the TUFLOW model using a high Manning's roughness coefficient. A high roughness coefficient would allow storage of floodwaters within footprints of buildings.

3.2.7 Stormwater pits and pipes

No stormwater pits and pipes were represented in the TUFLOW model as the model was intended to be used for defining mainstream flood behaviour only.

3.2.8 Surface roughness

All parts of the study area within the TUFLOW model were assigned hydraulic roughness values according to the LEP zoning and ground cover as shown in Figure 3-2. Roughness values shown in Table 3-1 were assigned based on ARR 2016 and engineering judgement. The adopted relatively high Manning's roughness values for the residential land use accounts for expected obstructions such as sheds, fencing, vegetation etc.

0 1,350 2,700 5,400 8,100
Metres

Legend

- Model domain
- Study area
- Roads
- Buildings
- Urban block
- Medium brush
- Light brush

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:135,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**TUFLOW Manning's n**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure 3.2**	REV 1 VER 1
CHECK AH	DATE 5/02/2020		

GIS MAP file - Figure 3.2_CO_Tuflow_Mannings_n

Table 3-1 Adopted hydraulic roughness values

Land Use Type	Manning's n
River and Creeks	0.04
Floodplain with light brush	0.05
Floodplain with medium brush	0.07
Floodplain with dense brush	0.10
Road surface	0.02
Residential blocks	0.07
Buildings' footprints	1.00

3.3 Model Boundaries and Initial Conditions

3.3.1 Inflow boundaries

Estimated discharge hydrographs for the Castlereagh River, Warrena Creek and Magometon Creek were applied in the TUFLOW model (refer to Section 2.2 and Section 2.3).

3.3.2 Outflow boundaries

Twelve (12) slope boundaries were defined in the model with slopes varying between 0.001 and 0.0025. These boundaries were defined sufficiently downstream of the study area to ensure flood behaviour within the study area was not influenced by the adopted boundaries.

3.3.3 Initial water levels

No major storages (ponds, dams, etc.) are located within the study area and hence waterways and floodplains were assumed to be dry for all model runs.

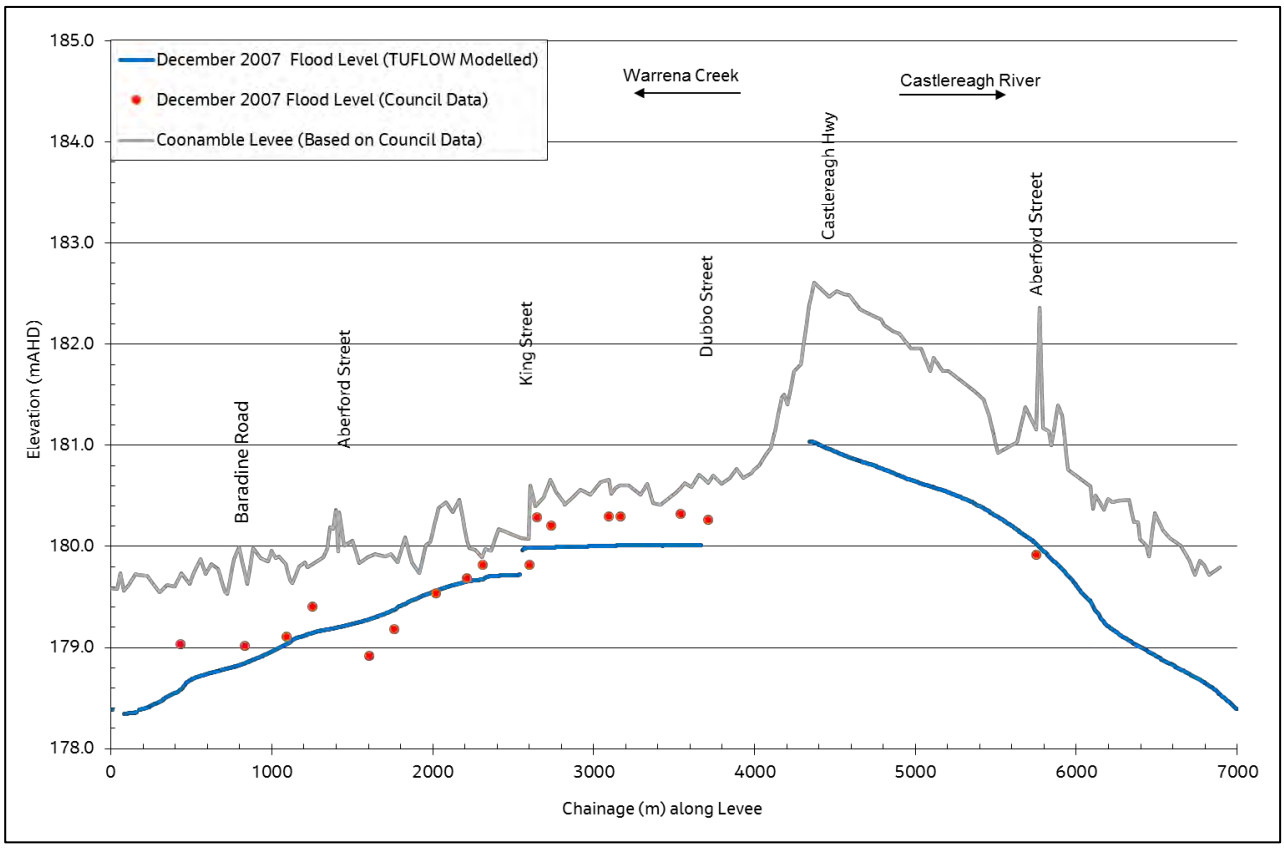
3.4 Comparison with Observed Flooding

Major flooding occurred in Coonamble in 1920, 1921, 1950 and 1955 and these events were dominated by flooding in the Castlereagh River. Coonamble also experienced major flooding during flood events of 1974, 2007 and 2009 which were dominated by flooding in Warrena Creek. Coonamble Levee was about to be overtopped during the flood events of 2007 and 2009 and Council collected flood levels in Coonamble for the flood event of 2007.

The TUFLOW model was run for the flood event of December 2007 utilising inflow hydrographs for the Castlereagh River, Warrena Creek and Magometon Creek from the SKM 2009 study. A comparison of observed flood levels and modelled peak flood level profile along Coonamble Levee between the Castlereagh River and Warrena Creek is presented in Figure 3-3.

Figure 3-3 shows a good agreement between observed and modelled flood levels along the Castlereagh River and a reasonable agreement between observed and modelled flood levels along Warrena Creek. It is to be noted that there are inconsistencies in observed flood levels along Warrena Creek and generally the TUFLOW model underestimated flood levels between King Street and Dubbo Street by approximately 0.2 m.

Figure 3-3 Comparison of December 2007 flood levels along Coonamble Levee



4. Estimation of Design Floods

4.1 Coincident Flooding

Coincident flooding adopted in the 2016 Flood Study (Jacobs, 2016) for the selected flood events in Castlereagh River and the corresponding events in Warrena Creek (including Magometon Creek) was also adopted in this study. The adopted coincident flooding is shown in Table 4-1.

Table 4-1 Adopted coincident inflows (Source: Jacobs, 2016)

Flood Event	Castlereagh River	Warrena Creek	Magometon Creek
5% AEP	5% AEP	20% AEP	20% AEP
1% AEP	1% AEP	5% AEP	5% AEP
0.5% AEP	0.5% AEP	2% AEP	2% AEP
Extreme	Extreme	1% AEP	1% AEP

4.2 Flood Behaviour

The TUFLOW model was run for the 0.5%, 1%, and 5% AEP events and an extreme flood event for the coincident flood events shown in Table 4-1. Modelling results for these flood events were analysed to define peak water levels, peak water level profiles along the Castlereagh River, flow distribution and depth of flooding on roads.

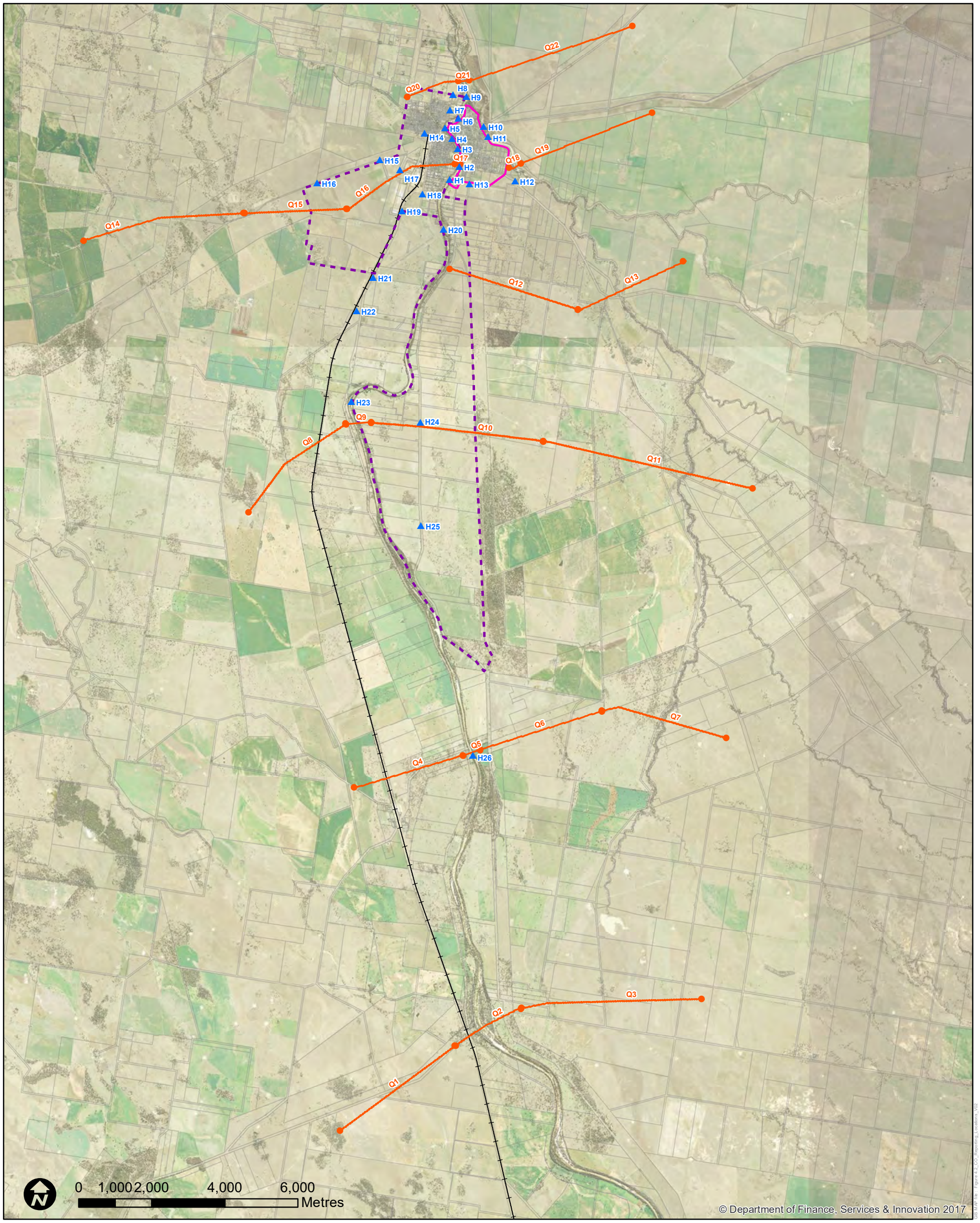
The flooding behaviour for the study area is discussed using peak flows and peak water levels at the locations shown in Figure 4-1.

4.2.1 Peak water levels

Modelled peak water level profiles along the Castlereagh River for the modelled flood events are shown in Figure 4-2 and modelled peak water levels at selected locations (refer to Figure 4-1) throughout the study area are presented in Table 4-2. Following observations are made from Figure 4-2 and Table 4-2:

- Peak water levels in the Castlereagh River upstream of Combara Bridge vary with the increased magnitude of flooding.
- The range of variation in peak water levels in the Castlereagh River downstream of Combara Bridge and upstream of Aberford Street Bridge (H1 to H4, H20 and H23) is insignificant for the modelled flood events. This due to the presence of major breakouts upstream of Combara Bridge and the limited capacity of the main channel of the Castlereagh River downstream of Combara Bridge.
- Peak water levels in the Castlereagh River downstream of Aberford Street (H5 to H9) are influenced by backwater flooding from Warrena Creek.
- Peak water levels in Warrena Creek and Bibleroi Creek (H10, H11, H12 and H13) vary with increased magnitude of flooding. This is due to the fact that flows that breakout the right bank of the Castlereagh River join these two creeks.

A review of modelling results indicates that Combara Bridge is subject to 0.35 m depth of flooding in the 5% AEP event and Aberford Bridge is not subject to flooding in the extreme flood event.



Legend

- Study Area
- Railway
- Cadastre
- Coonamble levee
- Water level location
- Discharge profile

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:100,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Reporting locations**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure 4.1**	REV 1 VER 1
CHECK AH	DATE 5/02/2020		

GIS MAP file - Figure 4.2_CO_Reporting_Locations_V02

Figure 4-2 Simulated peak water level profiles along the Castlereagh River

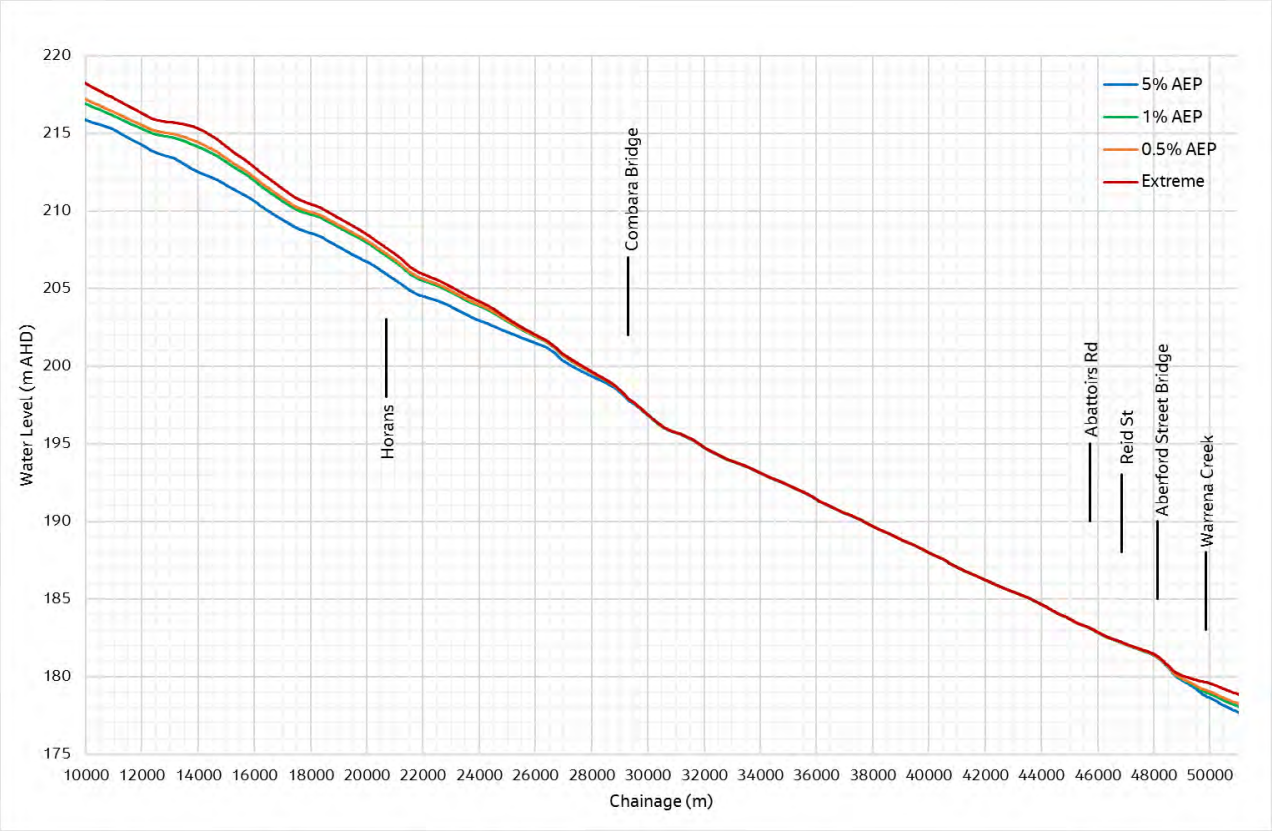


Table 4-2 Peak water levels at selected locations

Location ID	Description	Flood Event			
		5% AEP	1% AEP	0.5% AEP	Extreme
H1	Castlereagh River near Coonamble Hospital	181.95	181.97	181.98	182.01
H2	Castlereagh River near King Street	181.66	181.68	181.69	181.73
H3	Castlereagh River near Warrena Street	181.29	181.32	181.33	181.38
H4	Castlereagh River upstream of Aberford Street Bridge	180.84	180.86	180.87	180.91
H5	Castlereagh River near Tooloon Street	180.08	180.14	180.17	180.30
H6	Castlereagh River near intersection of Castlereagh and Macquarie Streets	179.52	179.62	179.67	179.92
H7	Intersection of Nebea and Yuma Streets	179.13	179.18	179.26	179.70
H8	Intersection of Conimbia and Yuma Streets	178.53	178.82	178.96	179.48
H9	Castlereagh River near Conimbia Street	178.67	178.94	179.08	179.62
H10	Warrena Creek upstream of Baradine Road Bridge	178.82	179.28	179.52	180.30
H11	Warrena Creek upstream of Warrena Weir	178.99	179.46	179.71	180.50
H12	Bibleroi Creek upstream of Tooraweenah Road Bridge	180.11	180.52	180.76	181.70
H13	Intersection of Dubbo Street (South) and Coonamble Levee	180.28	180.74	180.99	182.00

Location ID	Description	Flood Event			
		5% AEP	1% AEP	0.5% AEP	Extreme
H14	Intersection of Aberford Street and Quambone Road	178.76	178.78	178.79	178.87
H15	Quambone Road 700 m west of Coonamble Cemetery	177.68	177.69	177.69	177.69
H16	Quambone Road at western corner of study area	176.52	176.57	176.59	176.63
H17	Western corner of Coonamble Cemetery	178.04	178.07	178.07	178.08
H18	Intersection of Railway Street and Searle Avenue	179.59	179.61	179.61	179.62
H19	Intersection of Back Gular Road and Effie Durham Drive	179.60	179.62	179.62	179.63
H20	Castlereagh River near north-east corner of Coonamble Airport	183.10	183.11	183.11	183.12
H21	Junction of Back Gular Road and Abattoirs Road	181.52	181.54	181.54	181.55
H22	Intersection of Back Gular and Orchard Roads	183.11	183.12	183.12	183.12
H23	Castlereagh River 400 m north of Woodlands Road	188.56	188.57	188.57	188.57
H24	Intersection of Castlereagh Highway and Woodlands Road	Not flooded	185.93	185.96	186.28
H25	Castlereagh Highway near 'Whitewood'	Not flooded-	189.26	189.33	189.80
H26	Castlereagh River upstream of Combara Bridge	197.84	197.92	197.93	197.95

4.2.2 Peak discharges

Simulated peak discharges at selected locations for the modelled design flood events are presented in Table 4-3. Table 4-3 shows almost the same discharge in the Castlereagh River downstream of Combara Bridge (Q9) and near King Street (Q17) for all modelled events.

Table 4-3 Peak discharges (m^3/s) at selected locations

Location ID	Description	Flood Event			
		5% AEP	1% AEP	0.5% AEP	Extreme
Q1	Western breakout - approximately 10 km u/s of Combara Bridge	No flow	560	1210	5640
Q2	Castlereagh River - approximately 10 km u/s of Combara Bridge	2190	3720	3980	4810
Q3	Eastern breakout - approximately 10 km u/s of Combara Bridge (joins Warrena Creek)	No flow	440	910	3510
Q4	Western breakout near Combara Bridge	220	1030	1140	1490
Q5	Castlereagh River at Combara Bridge	1710	1830	1840	1880
Q6	Eastern breakout near Combara Bridge	290	760	930	2330
Q7	Eastern Breakout	No flow	380	780	2110
Q8	Western breakout approximately 10 km d/s of Combara Bridge	1020	1860	1970	2280
Q9	Castlereagh River approximately 10 km d/s of Combara Bridge	770	780	780	780

Location ID	Description	Flood Event			
		5% AEP	1% AEP	0.5% AEP	Extreme
Q10	Eastern breakout approximately 10Km d/s of Combara Bridge	380	890	1040	2440
Q11	Eastern Breakout	No flow	370	740	2100
Q12	Eastern breakout approximately 2.5 km u/s of Coonamble Levee	380	910	1100	3300
Q13	Combined flow of Warrena Creek and eastern breakout of the Castlereagh River	80	530	910	1540
Q14	Western breakout flow (partial) d/s of Quambone Road	950	1700	1780	2030
Q15	Western breakout flow (partial) d/s of Quambone Road	20	30	30	50
Q16	Western breakout flow (partial) u/s of Quambone Road	10	10	10	10
Q17	Castlereagh River (near King Street)	740	750	750	750
Q18	Warrena Creek (south-east of Coonamble Levee)	450	850	1010	1670
Q19	Warrena Creek right bank floodplain flow (south-east of Coonamble Levee)	30	620	1080	3370
Q20	Castlereagh River left bank floodplain – d/s of Coonamble township	40	120	160	470
Q21	Castlereagh River (d/s of Coonamble township)	620	670	710	890
Q22	Castlereagh River right bank floodplain – d/s of Coonamble township	520	1410	1940	4420

4.3 Flood Mapping

The simulated peak flood depths and other derived outputs based on model simulation results are presented in Appendix A. Peak flood levels, depths, velocities, flood hazard based on the Floodplain Development Manual (NSW Government, 2005) and flood hazard classification outlined by the Australian Institute for Disaster Resilience (AIDR) are the direct output of TUFLOW model simulations.

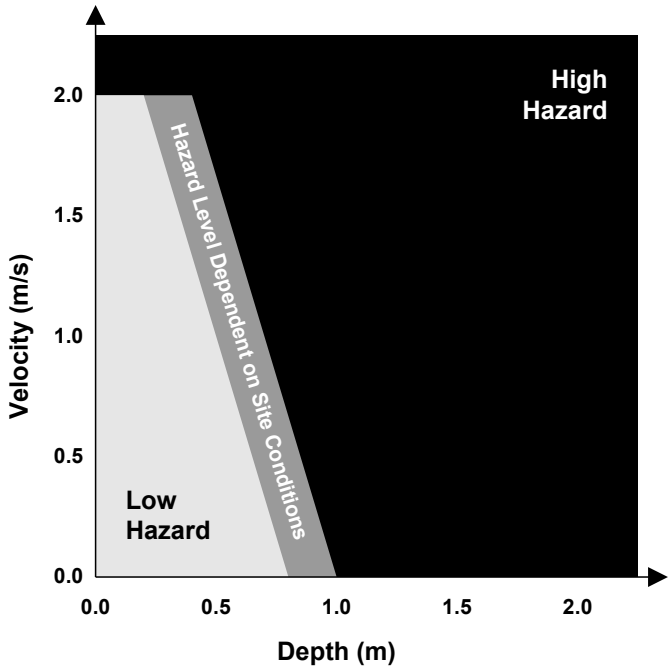
4.3.1 Hydraulic hazard categories

4.3.1.1 Floodplain Development Manual (NSW Government, 2005)

The Floodplain Development Manual (NSW Government, 2005) includes a hydraulic hazard category diagram (refer to Figure 4-3) for defining flood hazard based on a combination of peak flood depth and peak velocity. TUFLOW modelling results were used to delineate the provisional hazard categories for the 1% AEP event based on Figure 4-3. It is to be noted that TUFLOW model calculates flood hazard at each cell for each computational time step, rather than calculating the rating based on the peak depth and peak velocity. The "transitional" hazard areas (hazard level dependent on site conditions) have been nominally classified as areas affected by high hazard flooding.

Hazard categories delineated in this study are based on depths and velocities of floodwaters and do not consider evacuation, isolation, flood damages and social impacts of flooding, hence, these categories are considered provisional. The provisional flood hazard mapping is presented in Appendix A.

Figure 4-3 Hydraulic hazard category diagram (reproduced from Figure L2 in the NSW Floodplain Development Manual)



The provisional flood hazard map for the 1% AEP (refer to Appendix A) shows that the majority of the study area is classified as 'Low Hazard', excluding the 'High Hazard' areas along water courses, isolated low lands and the area located between Old Dubbo Road and Castlereagh Highway.

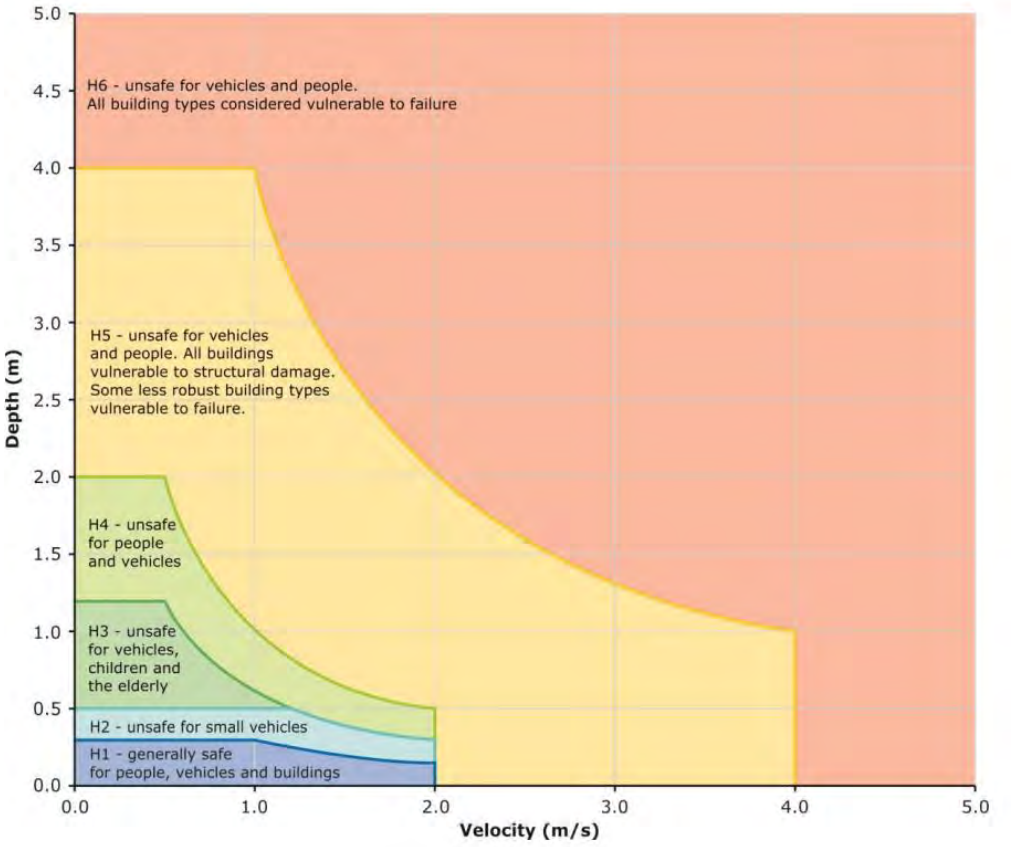
4.3.1.2 Australian Institute for Disaster Resilience (AIDR)

Recent research has identified the hazard that flooding poses and the vulnerability of the public and assets when interacting with floodwaters. A combined flood hazard classification is presented in the "Australian Disaster Resilience Handbook 7, Managing the Floodplain, A Guide to Best Practice in Flood Risk Management in Australia (AIDR, 2017a) and Guideline 7-3 Flood Hazard (AIDR, 2017b)" is based on this research, and is illustrated in Figure 4-4. The flood hazard categories according to the AIDR definition are:

- H1 – Generally safe for people, vehicles and buildings;
- H2 – Unsafe for small vehicles;
- H3 - Unsafe for vehicles, children and the elderly;
- H4 - Unsafe for people and vehicles;
- H5 - Unsafe for people and vehicles. Buildings require special engineering design and construction; and
- H6 – Unsafe for people or vehicles. All buildings types considered vulnerable to failure.

The flood hazard classification is more discrete and provides guidance on flood hazard thresholds to different members of the community (e.g. children and elderly) and different assets (small versus larger vehicles; standard versus specialized engineered buildings). The AIDR flood hazard definition potentially provides a more suitable guideline for assessing flood hazard on the floodplain from an emergency management perspective.

Figure 4-4 General flood hazard vulnerability curves (AIDR, 2017b)



The prepared hazard map for 1% AEP event (refer to Appendix A) shows that most of the study area is classified as 'H1 – Generally safe for people, vehicles and buildings'. However, at several locations within the study area including the following, flood hazard categories are different:

- H3 - Quambone Road (within the study area), Carinda Road (eastern end), North of Nebea Street near the Castlereagh River, east of the railway near Effie Durham Drive and between Coonamble Airport and the railway, and the majority of several of the area located within the study area between Old Dubbo Road and Castlereagh Highway, and sections of Old Dubbo Road and Castlereagh Highway.
- H4 – A significant portion of the study area located between Old Dubbo Road and Castlereagh Highway, and sections of the railway and Quambone Road located outside the study area.
- H5 - Isolated low lands, water courses, overland flow paths located between Castlereagh Highway and Old Dubbo Road.
- H6 - Castlereagh Highway and Old Dubbo Road.

It is to be noted that sections of the railway are located on H6 hazard category.

4.3.2 Flood hydraulic categories

Three flood hydraulic categories are identified in the Floodplain Development Manual (NSW Government, 2005) are:

- Floodway, where the main body of flow occurs, and blockage could cause redirection of flows. Generally characterised by relatively high flow rates, depths and velocities;
- Flood storage, characterised by deep areas of floodwater and low flow velocities. Floodplain filling of these areas can cause adverse impacts to flood levels in adjacent areas; and
- Flood fringe, areas of the floodplain characterised by shallow flows at low velocity.

There is no firm guidance on hydraulic parameter values for defining the above hydraulic categories, and appropriate parameter values may differ from catchment to catchment. In this study, the floodway was delineated first and then the remaining floodplain was classified into flood storage or flood fringe on the basis of flood depth. If the flood depth is greater than 0.5 m, then the floodplain is classified as a flood storage area, otherwise the floodplain is classified as flood fringe.

Initially, potential floodway outlines for the 1% AEP event were identified on the basis of the relevant technical papers and professional judgement based on the following considerations:

- VxD > 0.25 m^2/s and V > 0.25 m/s; or V >1.0 m/s (Howells et al, 2004);
- VxD > 0.50 m^2/s and V > 0.5 m/s; or V >1.0 m/s (Thomas and Golaszewski, 2012);
- High hazard areas (according to the Floodplain Development Manual) in the 1% AEP event; and
- Area flooded in the 5% AEP event.

The area flooded in the 5% AEP event is considerably more extensive than floodway identified using the other three criteria as it covers extensive areas which would otherwise be considered flood storage or flood fringe. Also, the high hazard (according to the Floodplain Development Manual) area in the 1% AEP event is more extensive than the other two criteria. An encroachment analysis was undertaken using the floodway defined by the four criteria using an iterative approach. Increase in 1% AEP flood levels was assessed after each iteration and a final encroachment analysis was undertaken to ensure no increase in flood levels in excess of 0.1 m. It is to be noted that the encroachment analysis was undertaken for the existing catchment and floodplain conditions. Hydraulic categories adopted in this study are mapped and presented in Appendix A. Floodways are identified along waterways, major overland flow paths and the majority portion of the area located between Castlereagh Highway and Old Dubbo Road within the study area.

4.3.3 Flood emergency response

Flood emergency response is an important outcome of the Floodplain Risk Management Process. It is anticipated that SES will use the information contained in this section to update the local flood plan. Areas within the study area have been classified based on the floodplain risk management *Guideline 7-2 Flood Emergency Response Classification of the Floodplain* (AIDR, 2017b). The classification indicates the relative vulnerability of different areas of the catchment and considers the ability to evacuate certain parts of the community.

The categories are identified as per the definitions in Table 4-4. In summary, these include:

- FEO – Flooded area, with an Exit Route via Overland Escape
- FER – Flooded area, with an Exit Route via Rising Road
- FIE – Flooded Area, Isolated with an Area Elevated Above flood event of interest
- FIS – Flooded Area, Isolated and Fully Submerged
- NIC – Not Flooded, Indirect Consequences.

The guideline in AIDR (2017b) recommends classification of the floodplain for the PMF only. Mapping of the classification is provided in Appendix A.

Table 4-4 Flood emergency response classifications (from Table 1 in AIDR, 2017b)

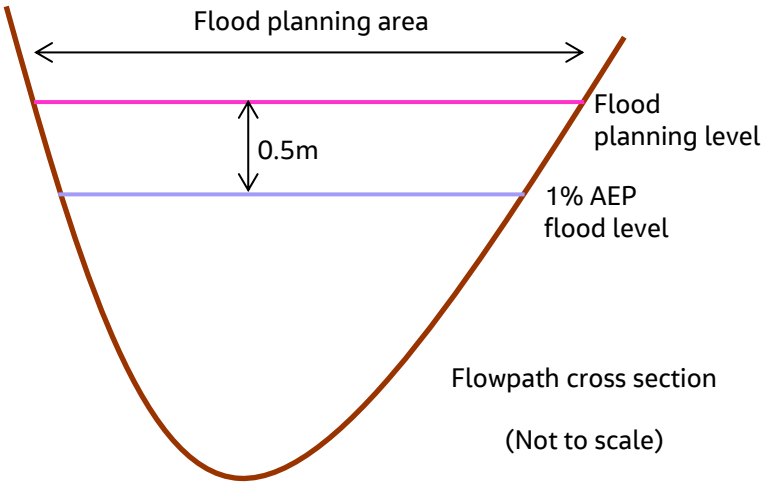
Primary Classification	Description	Secondary Classification	Description	Tertiary Classification	Description
Flooded (F)	The area is flooded in the flood event of interest*	Isolated (I)	Areas that are isolated from community evacuation facilities (located on flood-free land) by floodwater and/ or impossible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

4.3.4 Flood planning area

The flood planning area (FPA) is defined by the extent of the area below the flood planning level (usually the 1% AEP flood plus a freeboard) and delineates the area and properties where flood planning controls are proposed, for example, minimum floor levels to ensure that there are sufficient freeboards of building habitable floor levels above the 1% AEP flood.

A freeboard of 0.5m is often applied for defining the flood planning level on mainstream floodplains, including the study area. This flood planning level was then extended until it intersected with the ground. This defines the flood planning area. An illustration of this is provided below.

Mainstream flooding



The flood planning area map for West Coonamble is shown in Appendix A.

4.4 Comparison of Results with Previous Studies

4.4.1 Comparison of peak discharges

Peak discharges estimated using the TUFLOW model for the 1% AEP flood event are compared with the 2016 Flood Study (Jacobs, 2016) in Table 4-5. It is to be noted that the same coincident flooding (i.e. 1% AEP flooding in the Castlereagh River and 5% AEP flooding in Warrena Creek) is adopted in both studies. Table 4-5 shows that whilst the upstream inflows adopted in both studies are almost the same, significantly more flows are conveyed by the Castlereagh River at Combara Bridge than estimated in the 2016 Flood Study. The present study utilises a 1D-2D linked TUFLOW model where the representation of the topography and land use is more detailed than the 2016 Flood Study (Jacobs, 2016). This means that the breakouts are more realistically represented in the TUFLOW model.

Consequently, less flows breakout from the Castlereagh River upstream of Combara Bridge to the east towards the Warrena Creek system resulting in reduced peak discharges in Warrena Creek at Warrena Weir and the Castlereagh River downstream of its confluence with Warrena Creek. This study estimates marginally less peak discharges conveyed by the Castlereagh River at Aberford Street Bridge than the 2016 Flood Study.

Table 4-5 Comparison of 1% AEP peak discharges

Location	1% AEP Peak Discharge (m^3/s)	
	This Study	Jacobs (2016)
Upstream inflow - Castlereagh River	4926	4922
Combara Bridge	1833	1333
Aberford Street Bridge	744	776
Warrena Weir	1495	1893
Downstream of the confluence of the Castlereagh River and Warrena Creek	2198	2640

4.4.2 Comparison of peak water levels

Peak water levels in the Castlereagh River simulated by the TUFLOW model for the 5% AEP and 1% AEP events, and an extreme event are compared with previous flood studies (Jacobs, 2016 and SKM, 2009). Modelled peak

water levels along the Castlereagh River are compared in Figure 4-5, Figure 4-6 and Figure 4-7 for the three flood events.

Figure 4-5 shows that peak water levels simulated by the TUFLOW model for the 5% AEP event upstream of 'Horans' are approximately 0.9 m higher than the previous flood study (Jacobs, 2016). Figure 4-6 shows that 1% AEP peak water levels simulated by the TUFLOW model upstream of 'Horans' are up to 1.5 m higher than previous studies. In the case of the extreme flood event, peak flood levels simulated by the TUFLOW model are up to 1.2 m (refer to Figure 4-7) higher than previous studies. This is due to the fact that the TUFLOW model simulates less breakout of flows from the Castlereagh River upstream of 'Horans'.

Downstream of 'Horans', peak water levels simulated by the TUFLOW model in the Castlereagh River are consistently lower than previous studies for all three flood events upstream of Abattoirs Road, with the maximum difference near Combara Bridge. This is due to the fact that the TUFLOW model simulates major breakout of flow on both banks upstream of Combara Bridge.

Downstream of Abattoirs Road, peak water levels simulated by the TUFLOW model in the Castlereagh River are slightly higher than previous studies for both the 5% AEP and 1% AEP events. However, peak water levels simulated by the TUFLOW model in the Castlereagh River for the extreme event are similar to the 2016 flood study and lower than the SKM 2009 study.

Figure 4-5 Comparison of 5% AEP event peak water level profiles along the Castlereagh River

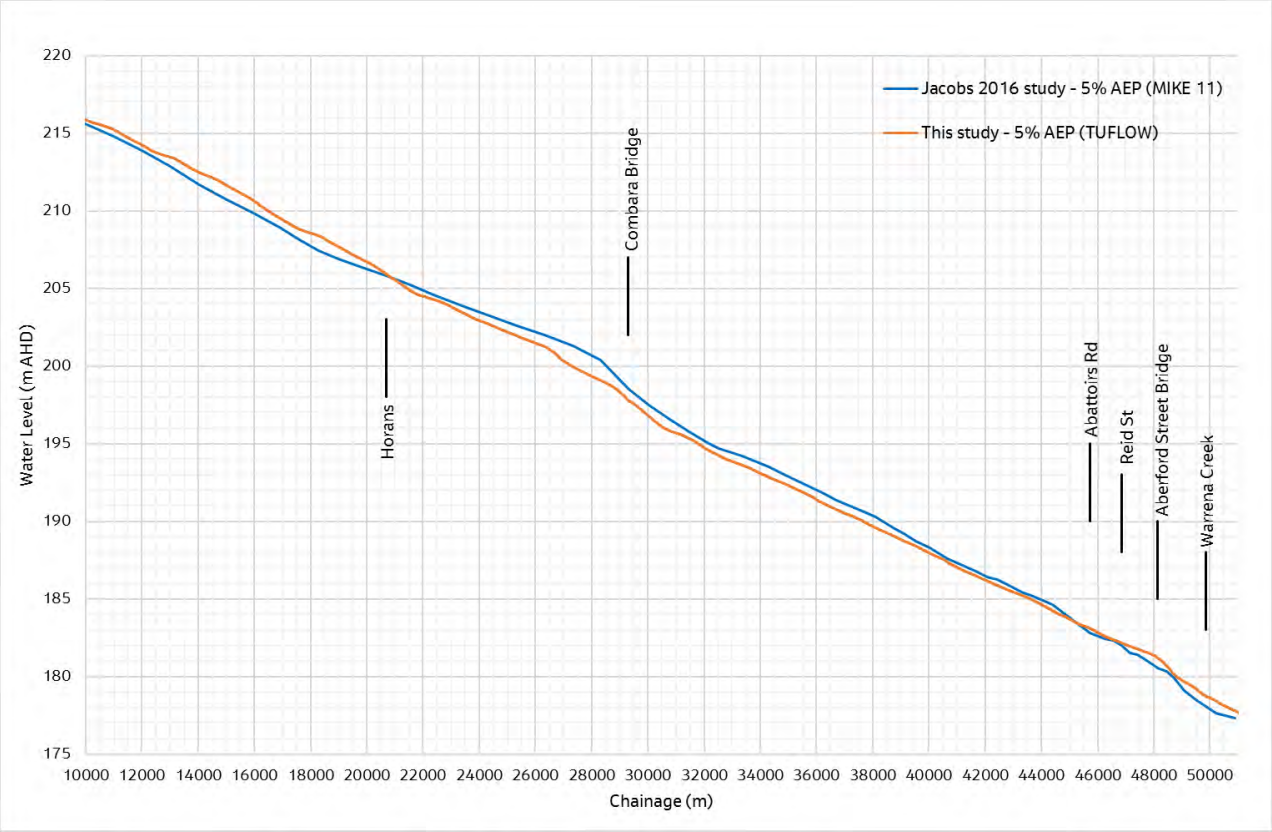


Figure 4-6 Comparison of 1% AEP event peak water level profiles along the Castlereagh River

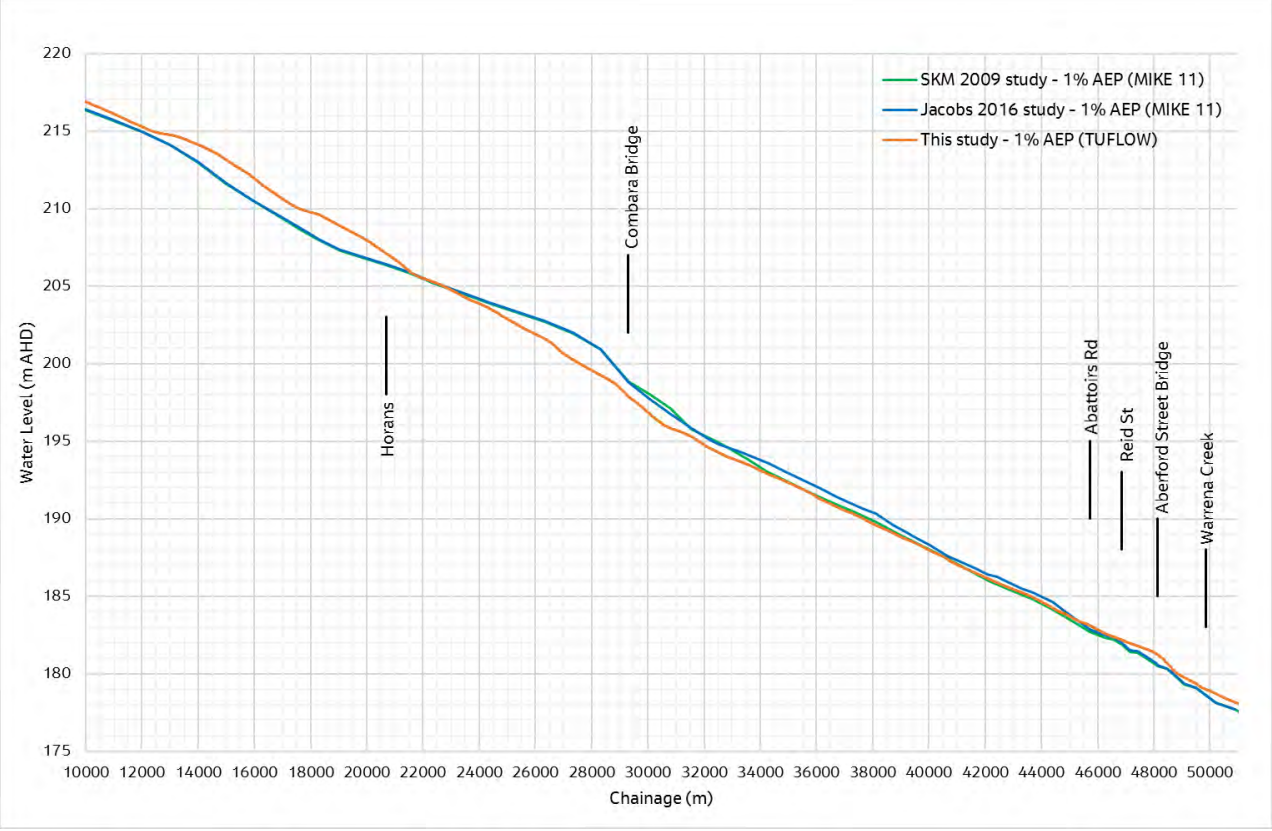
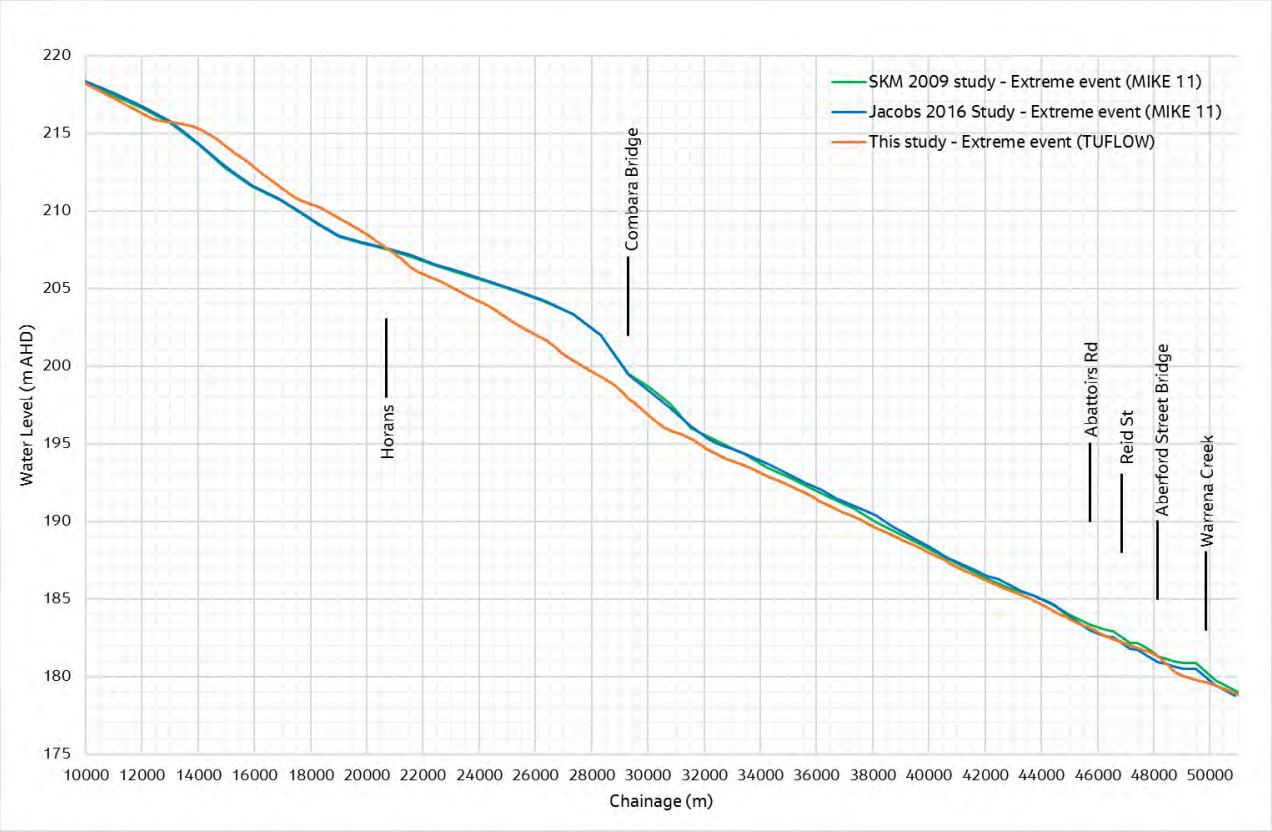


Figure 4-7 Comparison of extreme event peak water level profiles along the Castlereagh River



4.5 Sensitivity Analysis

4.5.1 Adopted Manning's roughness

A sensitivity analysis was undertaken to assess sensitivity of peak water levels within the study area for the 1% AEP event due to +/- 20% changes in the adopted Manning's n values. Changes in peak water levels due to 20% changes in the adopted Manning's n values are shown in Appendix B. Appendix B shows that a 20% increase in the adopted Manning's n values results in up to 0.1 m increase in peak water levels at the north-eastern corner of the study area near Nebea Street (east) and Carinda Road (east). Increases in peak water levels are generally limited up to 0.05 m on the south-eastern side of the study area between Old Dubbo Road and Castlereagh Highway.

A 20% reduction in the adopted Manning's n values results in up to 0.1 m reduction in peak water levels at the north-eastern corner of the study area near Nebea Street (east) and Carinda Road (east) and up to 0.05 m reduction in peak water levels on the south-eastern side of the study area between Old Dubbo Road and Castlereagh Highway.

4.5.2 Impacts of climate change

ARR 2016 provides interim climate change factors for a range of climate change impact increase scenarios up to the year 2090. For the upper range Representative Concentration Pathways (RCP) 8.5 scenario, in the year 2050 and the year 2090 an increase in rainfall depth and intensity of 10.1% and 20.8%, respectively, is predicted. RCP 8.5 refers to the upper range projection of greenhouse gas concentrations in the atmosphere as adopted by the IPCC in 2014 for the assessment of climate change impacts.

Impacts of climate change have been assessed for the 1% AEP event in the year 2090 with 20.8% increase in adopted inflows in the Castlereagh River for the 1% AEP event and 20.8% increase in rainfall depths for the 5%

AEP event for the catchment areas of Warrena Creek and Magometon Creek. The adopted coincident flooding for the 1% AEP event with climate change is based on Table 4-1.

Changes in 1% AEP flood levels due to climate change are shown in a map in Appendix B and the following observations are made from the map:

- Flood behaviour in the majority of the study area is not impacted by climate change in the 1% AEP event.
- Increase in 1% AEP flood levels are limited within the area bounded by the Castlereagh River to the west and Old Dubbo Road to the east.
- The maximum increase in 1% AEP flood levels within the study area is up to 0.1m.

4.6 Flooding Hot Spots

Castlereagh Highway along the southern boundary of the study area is subject to flooding in the 5% AEP event and consequently road access to Gulargambone is cut-off. Access to Quambone is also cut-off in the 5% AEP event. An approximately 3 km long section of the Coonamble Railway line is impacted by flooding in the 5% AEP event. Limited provision for cross drainage impedes movement of floodwaters across the railway.

Extensive flooding occurs along the south-eastern boundary of the study area located between Castlereagh Highway and Old Dubbo Road. Low floodplain areas located at the north-eastern boundary of the study area are also subject to flooding in the 5% AEP event. Sections of Effie Durham Drive, Wilaga Street and Railway Street are flooded in the 5% AEP event.

5. Conclusions and Recommendations

The Flood Study for West Coonamble (Jacobs, 2016) has been updated to refine flood behaviour in the study area using an integrated one-dimensional and two-dimensional TUFLOW hydraulics model. The study area and the adjoining floodplains have been represented in 20 m rectangular two-dimensional grids and main channels of the Castlereagh River, Warrena Creek and Eurimie Creek have been represented in one-dimension using a series of cross sections spaced between 40 m and 400 m. The main source of the terrain data was 1 m DEM collected by Council for the study area and 5 m DEM extracted from www.elevation.fsdf.org.au.

The TUFLOW model has been verified against recorded flood levels of December 2007. Flood levels simulated by the TUFLOW model for the flood event of December 2007 are in reasonable agreement with recorded flood levels.

The RORB hydrology model for Warrena Creek has been updated based on recommendations in ARR 2016. The updated RORB model results in slightly lower peak discharges for the modelled design flood events both in Magometon Creek and Warrena Creek due to slight reduction in design rainfall depths in ARR 2016. The same coincident flooding in the Castlereagh River and Warrena Creek catchment adopted in the 2016 Flood Study (Jacobs, 2016) has been adopted in defining flood behaviour for the 5%, 1% and 0.5% AEP events, and an extreme flood event (i.e. 3 times 1% AEP event).

Simulated flood behaviour by the TUFLOW model for the design flood events have been compared with flood behaviour simulated in previous flood studies (Jacobs, 2016; SKM, 2009) for the study area. In general, there is a reasonable agreement between flood behaviour simulated by the TUFLOW model and the previous studies. However, it is to be noted that the current study utilises a 1D-2D linked TUFLOW model where the representation of the topography and land use is more detailed than the 2016 Flood Study (Jacobs, 2016). Hence, flood behaviour simulated by the TUFLOW model is considered more realistic than previous studies.

Flood behaviour simulated by the TUFLOW model for the selected design flood events have been utilised to prepare flood depth maps, velocity maps, flood hazard maps and to delineate hydraulic categories.

It is recommended that Coonamble Shire Council considers the adoption of this Flood Study Review and the outputs to guide floodplain management and land use planning for the study area of West Coonamble. The subsequent Floodplain Risk Management Study should consider the management of flood risk in the study area.

6. References

Australian Disaster Resilience Handbook 7. Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR, 2017a) and Guideline 7-3 Flood Hazard (AIDR, 2017b).

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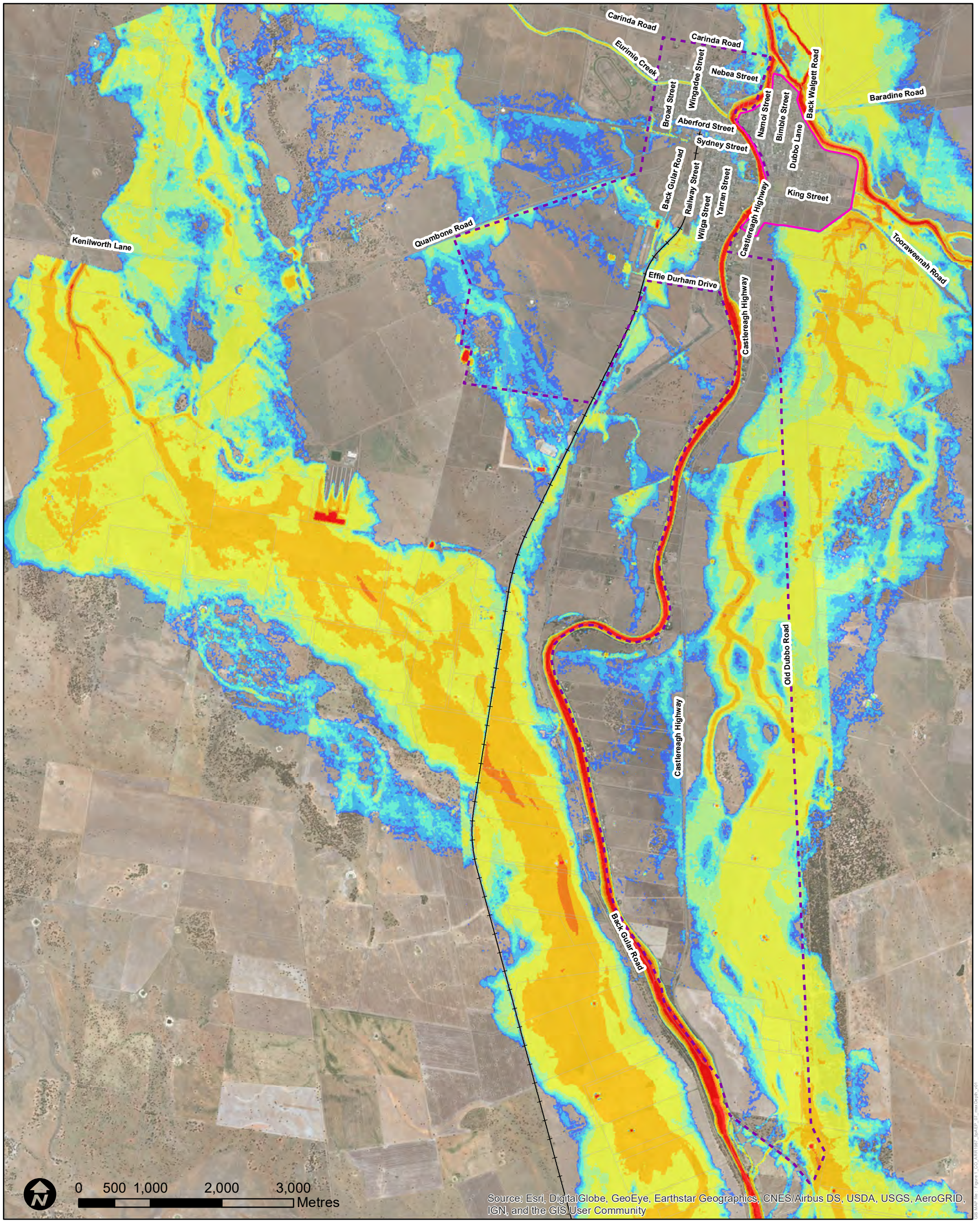
Appendix A. Flood Mapping



Legend

- Study Area
- Railway
- Cadastre
- Coonamble levee

Peak Flood Depths (m)

< 0.05	0.2 to 0.3	1.0 to 2.0
0.05 to 0.1	0.3 to 0.5	2.0 to 3.0
0.1 to 0.2	0.5 to 1.0	> 3.0

Note: Flood extents outside the study area are indicative only.

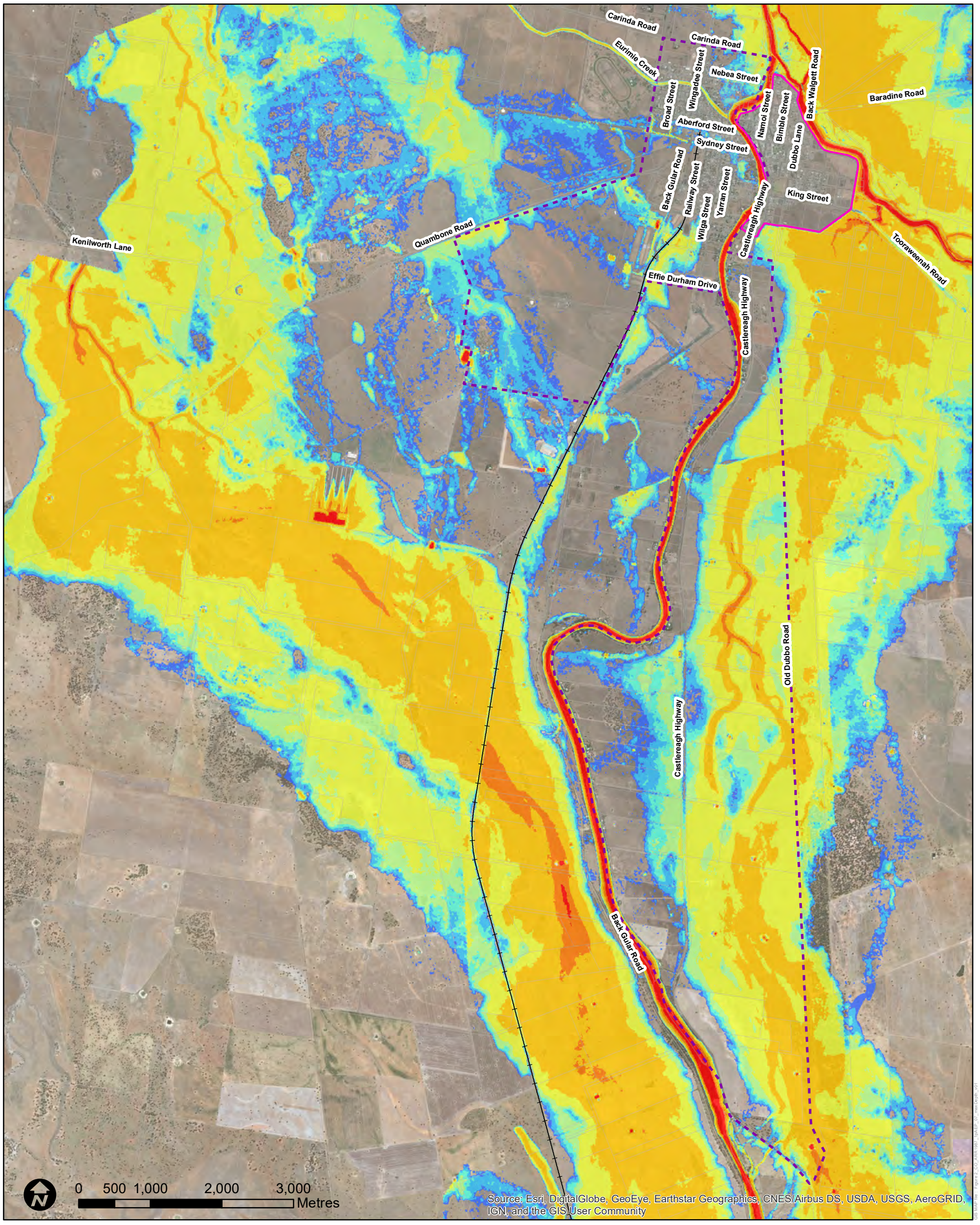
JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:51,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Peak Flood Depths for 5% AEP Event**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure A1**	REV 1 VER 1
CHECK AH	DATE 19/06/2019		

GIS MAP file: - Figure 1_CO_ARR1987_5pAEP_07_maxDepth_v01



Legend

Peak Flood Depths (m)

- Study Area
- Railway
- Cadastre
- Coonamble levee
- < 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- > 3.0

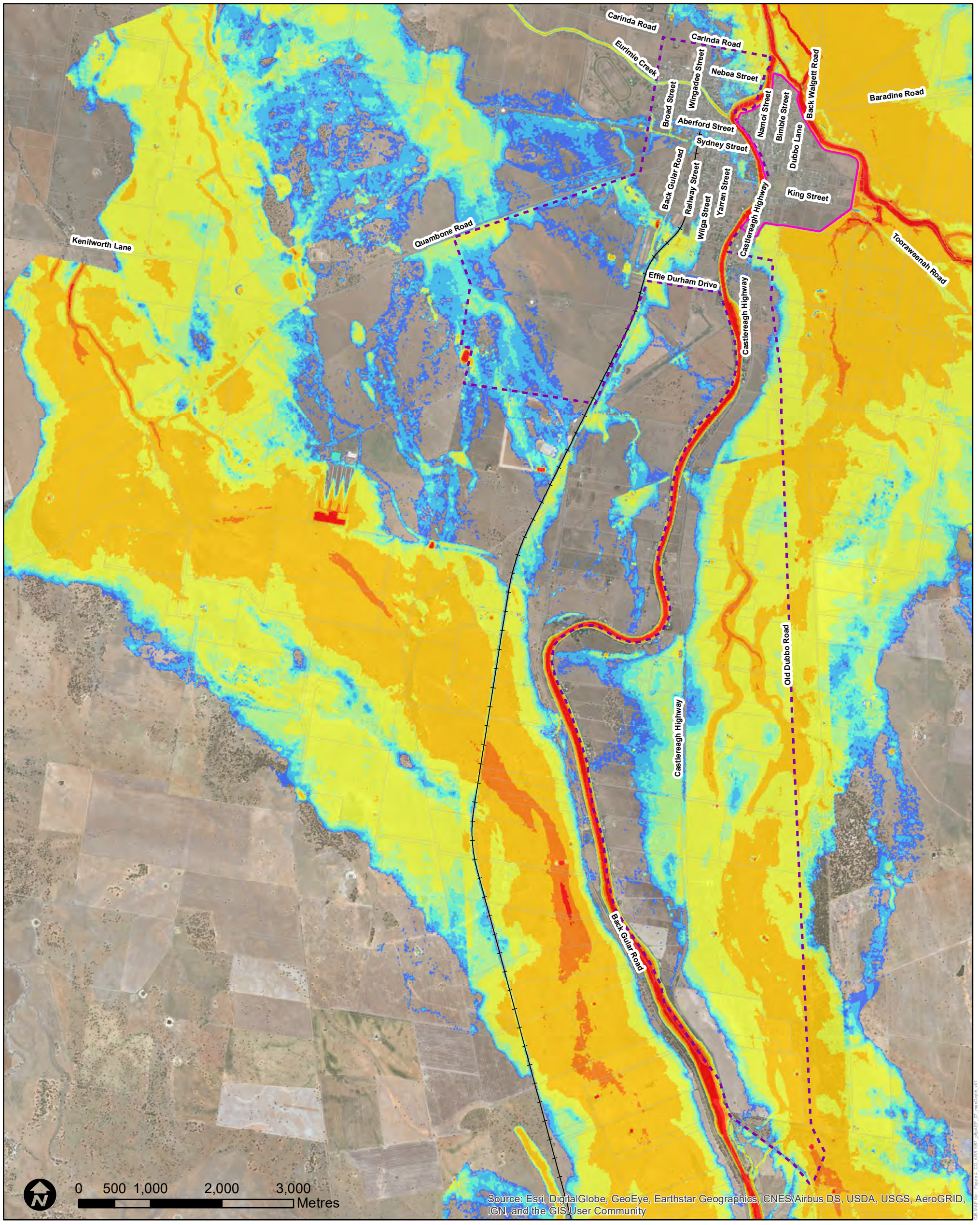
Note: Flood extents outside the study area are indicative only.

JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:51,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Peak Flood Depths for 1% AEP Event**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure A2**	REV VER 1 1
CHECK AH	DATE 19/06/2019		



Legend

- Study Area
- Railway
- Cadastre
- Coonamble levee

Peak Flood Depths (m)

< 0.05	0.2 to 0.3	1.0 to 2.0
0.05 to 0.1	0.3 to 0.5	2.0 to 3.0
0.1 to 0.2	0.5 to 1.0	> 3.0

Note: Flood extents outside the study area are indicative only.

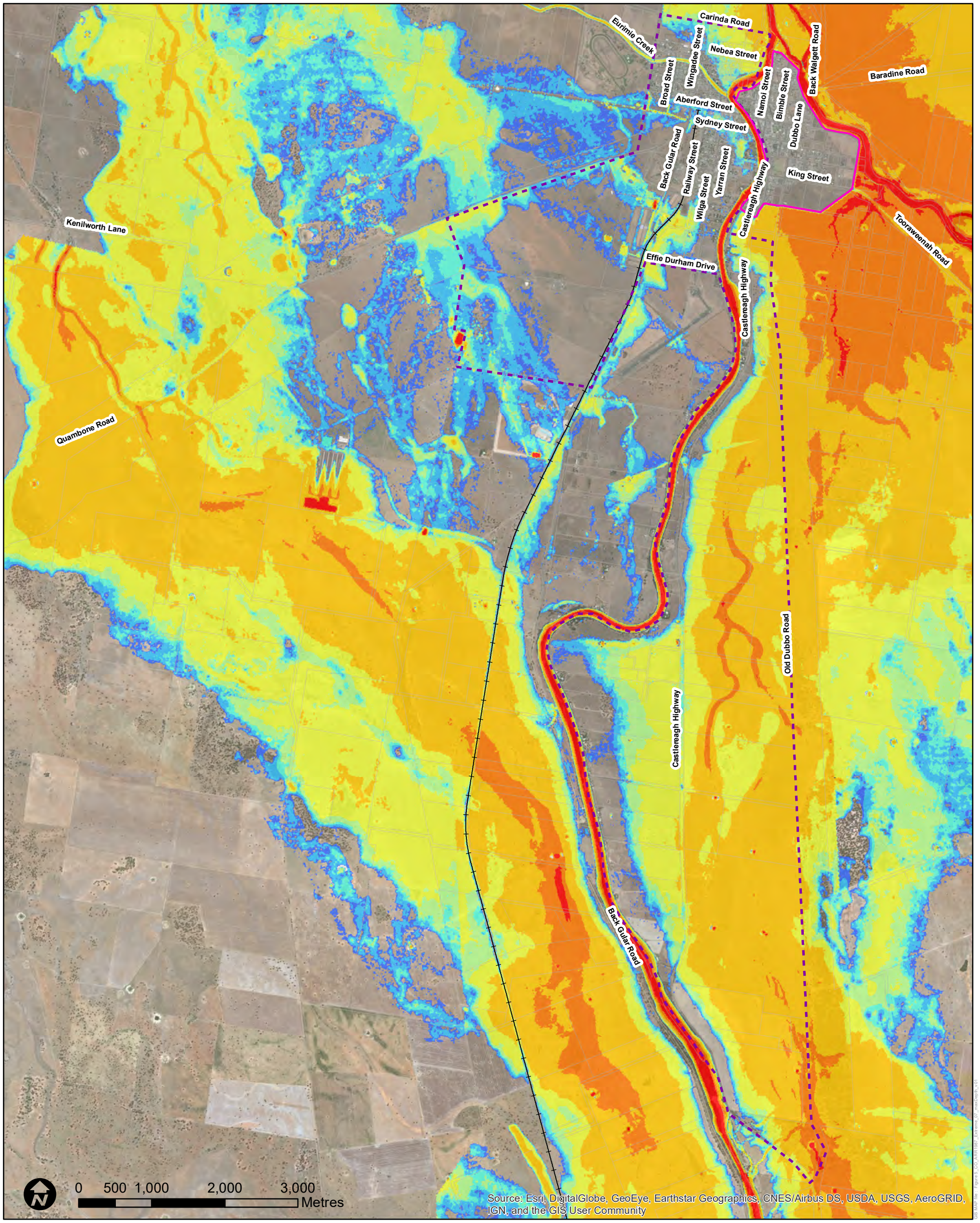
JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:51,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Peak Flood Depths for 0.5% AEP Event**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure A3**	REV VER 1 1
CHECK AH	DATE 19/06/2019		

GIS MAP file: Figure4_CO_ARR1987_05%AEP_07_maxDepth_v01



Legend

- Study Area
- Railway
- Cadastre
- Coonamble levee

Peak Flood Depths (m)

< 0.05	0.2 to 0.3	1.0 to 2.0
0.05 to 0.1	0.3 to 0.5	2.0 to 3.0
0.1 to 0.2	0.5 to 1.0	> 3.0

Note: Flood extents outside the study area are indicative only.

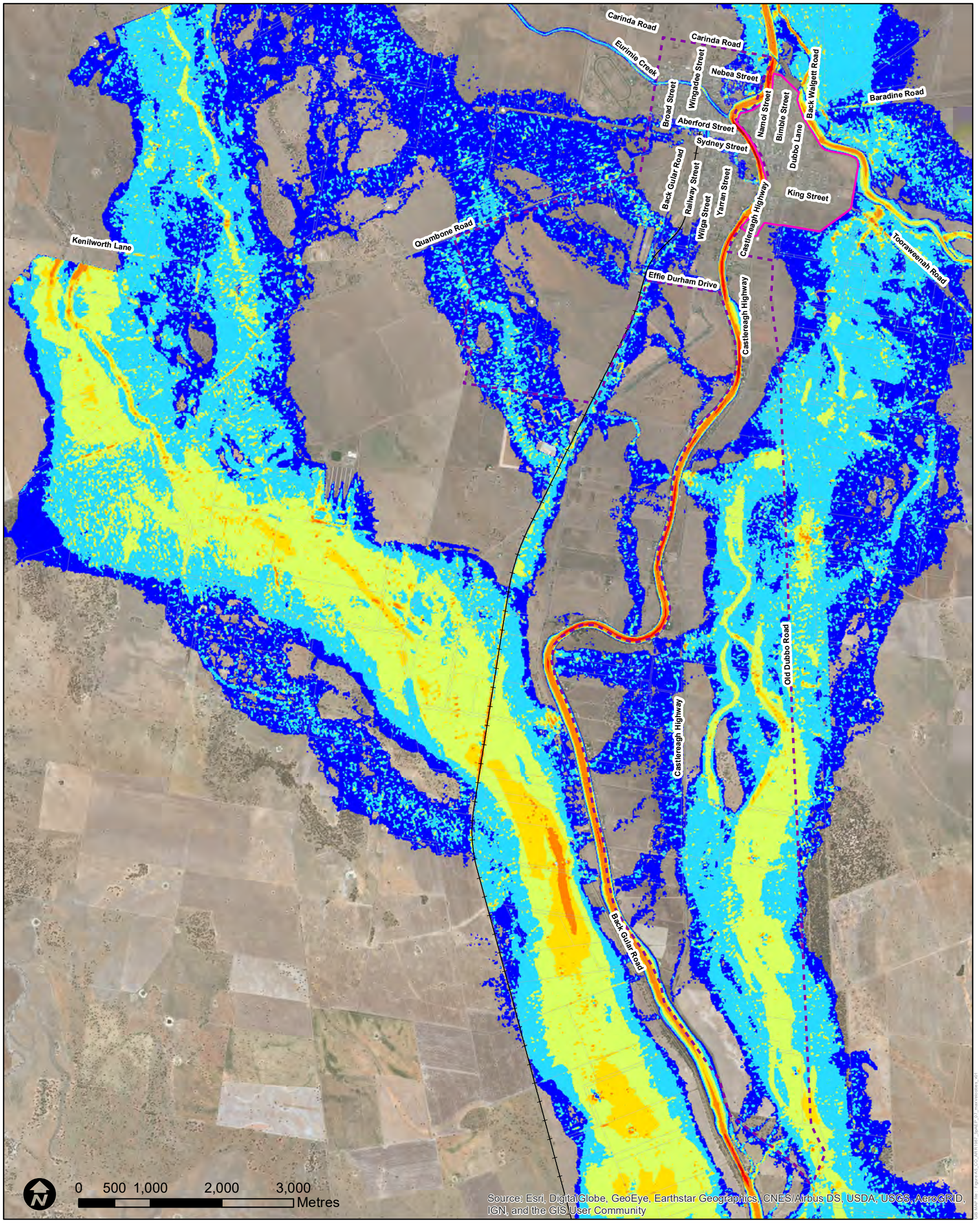
JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:50,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Peak Flood Depths for Extreme Event**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure A4**	REV VER 1 1
CHECK AH	DATE 19/06/2019		

GIS MAP file - Figure 5_CO_ARR1987_Extreme_07_maxDepth_v01



Legend

- Study
- Railway
- Cadastre
- Coonamble levee

Peak Flood Velocity (m/s)

- < 0.05
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 0.75
- 0.75 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- > 3.0

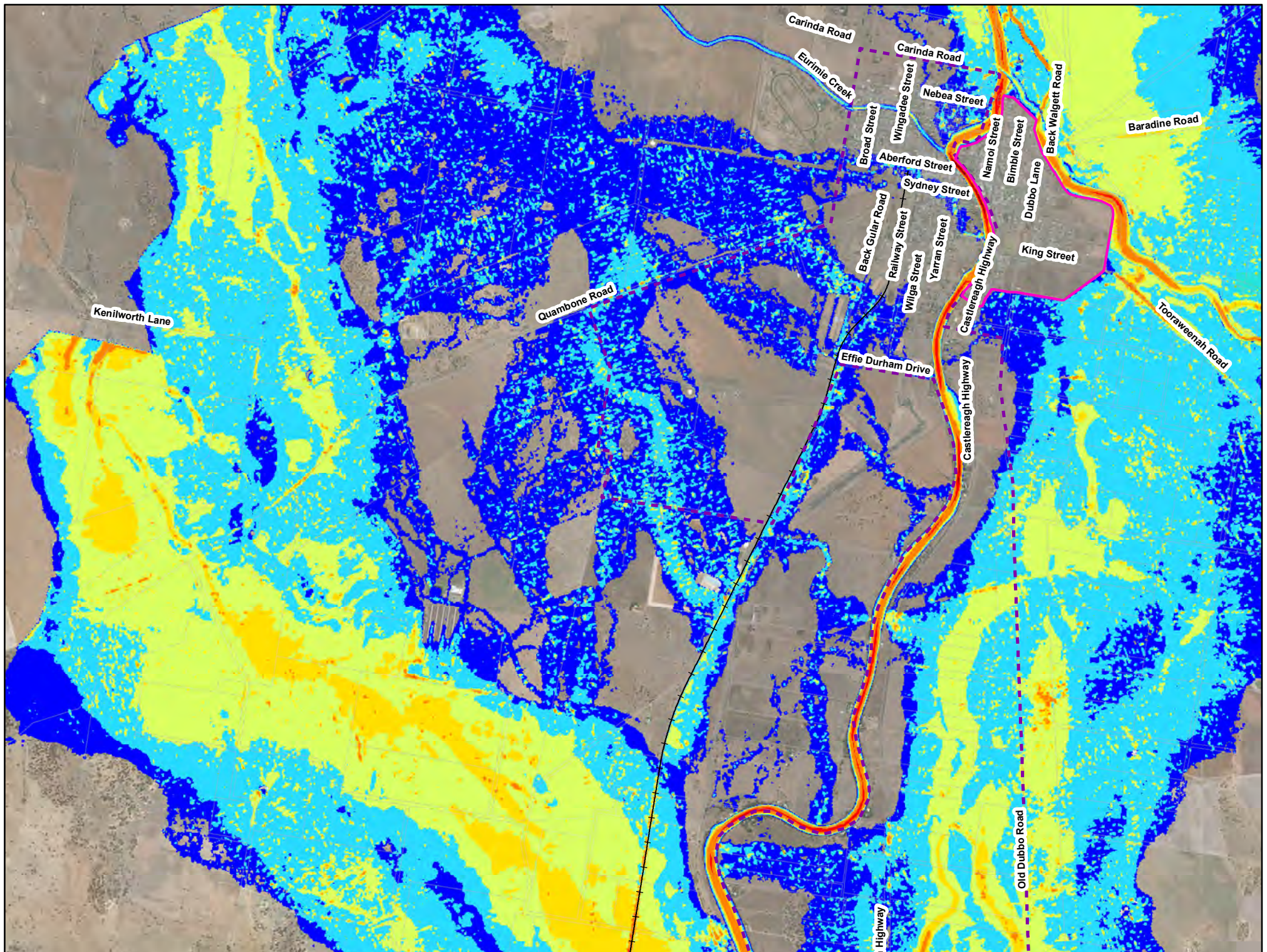
Note: Flood extents outside the study area are indicative only.

JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:51,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Peak Flood Velocities for 5% AEP Event**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure A5**	REV VER 1 1
CHECK AH	DATE 22/01/2020		



Legend

- Study
- Railway
- Cadastre
- Coonamble levee

Peak Flood Velocity (m/s)

- < 0.05
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 0.75
- 0.75 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- > 3.0

Note: Flood extents outside the study area are indicative only.

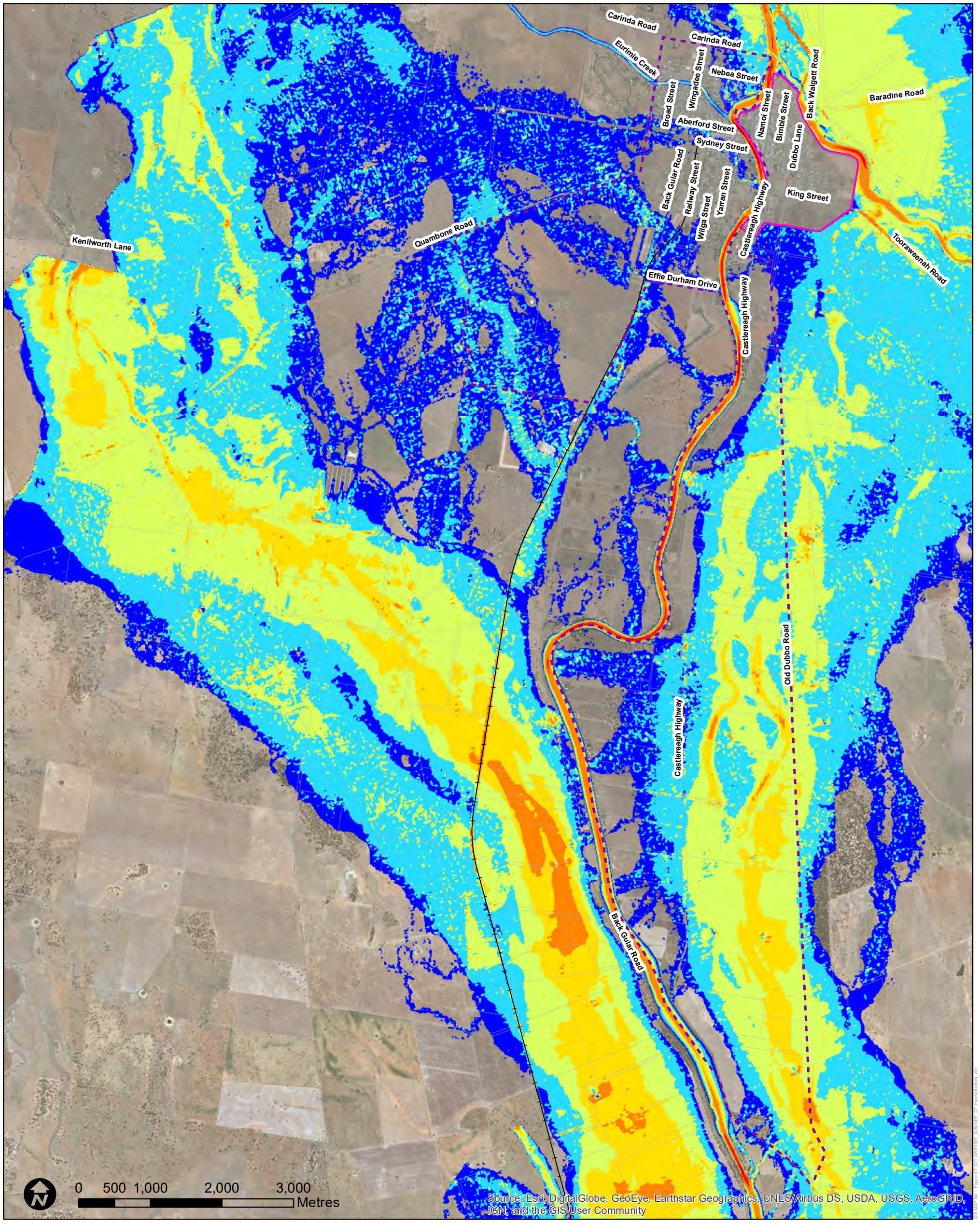
JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:51,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Peak Flood Velocities for 1% AEP Event**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure A6**	REV VER 1 1
CHECK AH	DATE 22/01/2020		

GIS MAP file: - Figure A6_CO_AR R1987_1pAEP_07_maxVelocities_v01



Legend

- Study
- Railway
- Cadastre
- Coonamble levee

Peak Flood Velocity (m/s)

- < 0.05
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 0.75
- 0.75 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- > 3.0

Note: Flood extents outside the study area are indicative only.

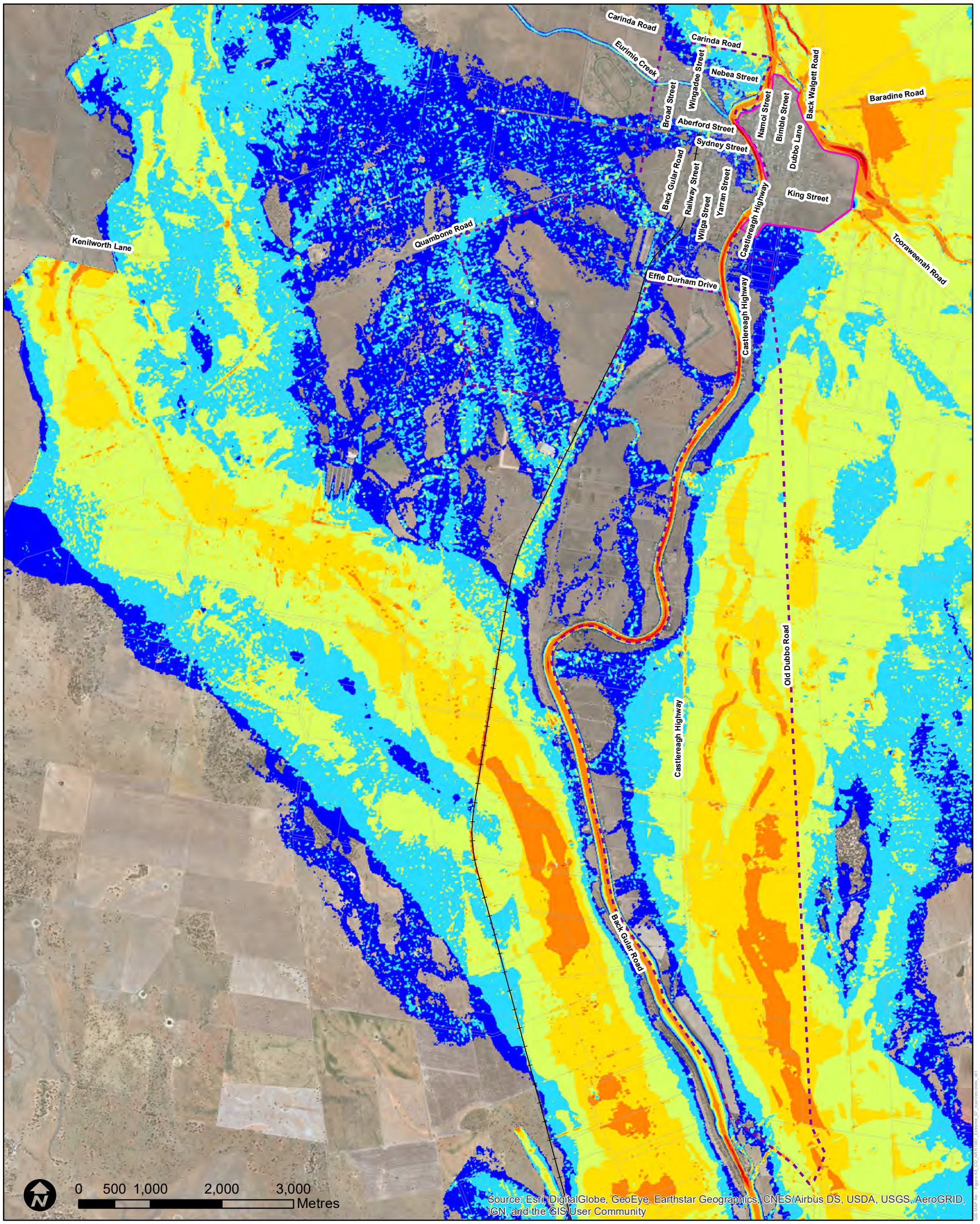
JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:51,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Peak Flood Velocities for 0.5% AEP Event**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure A7**	REV 1 VER 1
CHECK AH	DATE 22/01/2020		

GIS MAP file - Figure A7_CO_ARR1987_0p5pAEP_07_maxVelocities_V01



Legend

- Study Area
- Railway
- Cadastre
- Coonamble levee

Peak Flood Velocity (m/s)

- < 0.05
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 0.75
- 0.75 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- > 3.0

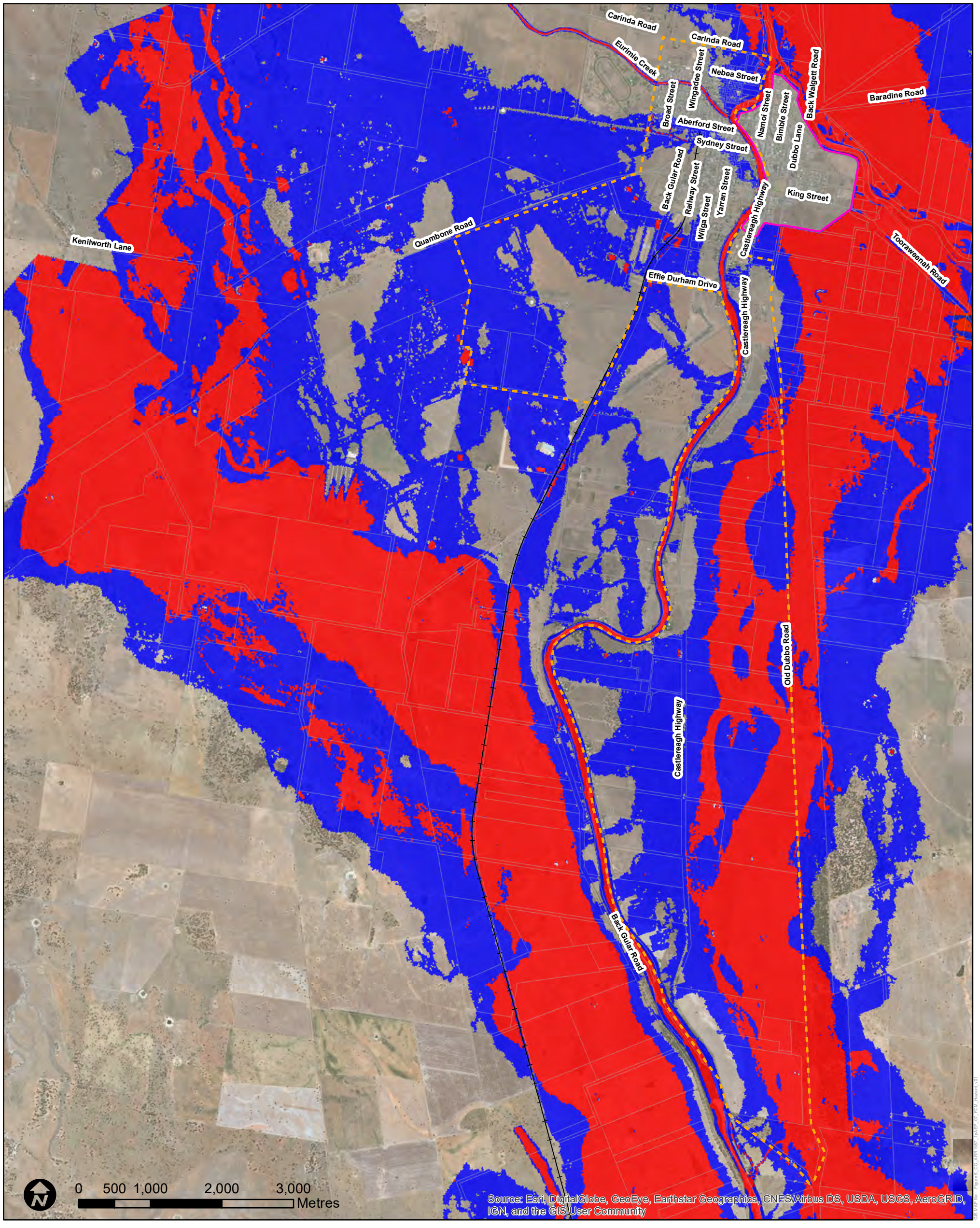
Note: Flood extents outside the study area are indicative only.

JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:51,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Peak Flood Velocities for Extreme Event**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure A8**	REV 1 VER 1
CHECK AH	DATE 22/01/2020		



Legend

Study Area
Railway
Cadastre
Coonamble levee

Hydraulic hazard categories

Low hazard
High hazard

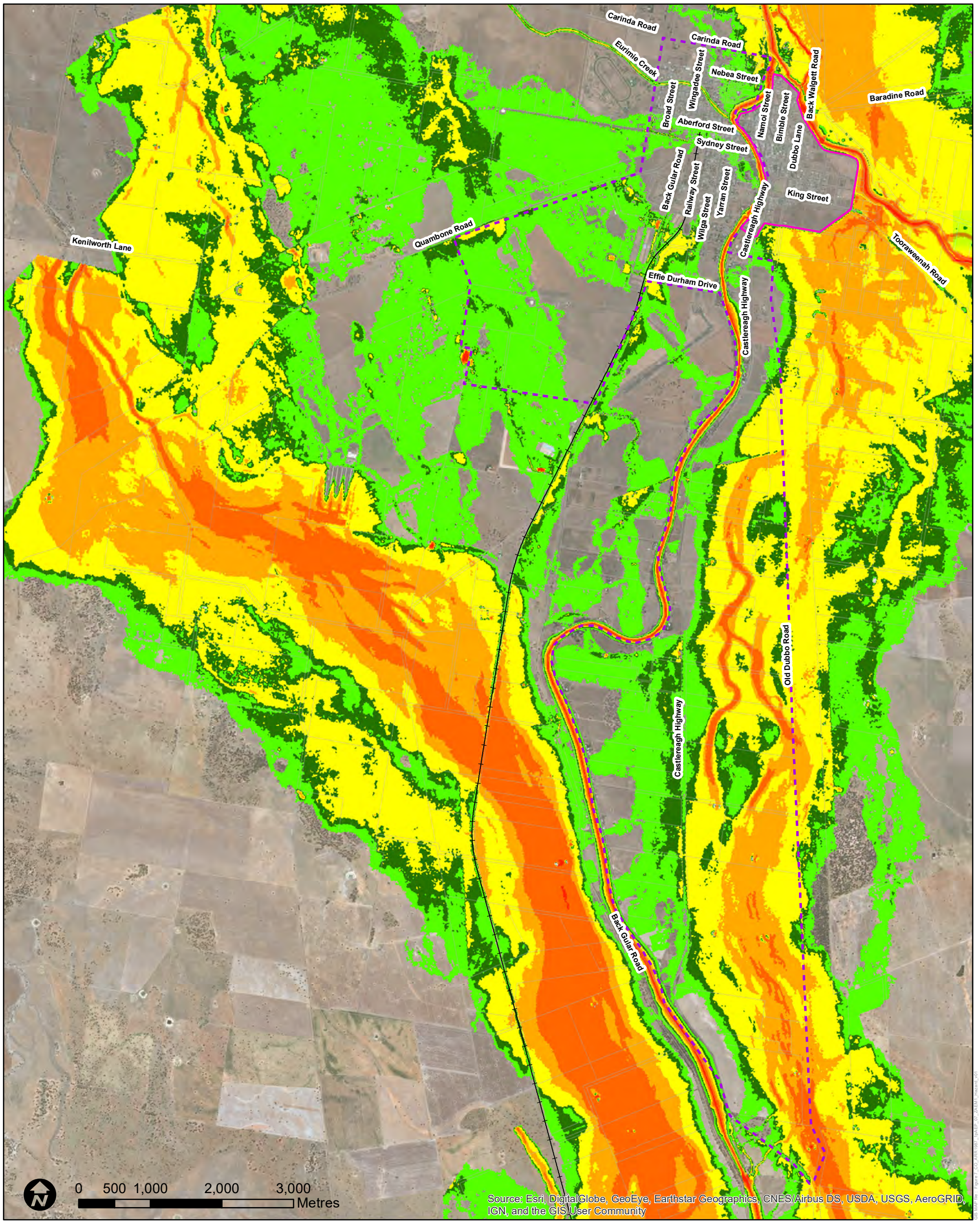
Note: Flood hazard extents outside the study area are indicative only.

JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:51,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Provisional Flood Hazard (FDM 2005) for 1% AEP Event**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure A9**	REV 1 VER 1
CHECK AH	DATE 19/06/2019		



Legend

- Study Area
- Railway
- Cadastre
- Coonamble levee

Flood hazard

- H1 - No restrictions
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6 - Not suitable for people, vehicles or buildings

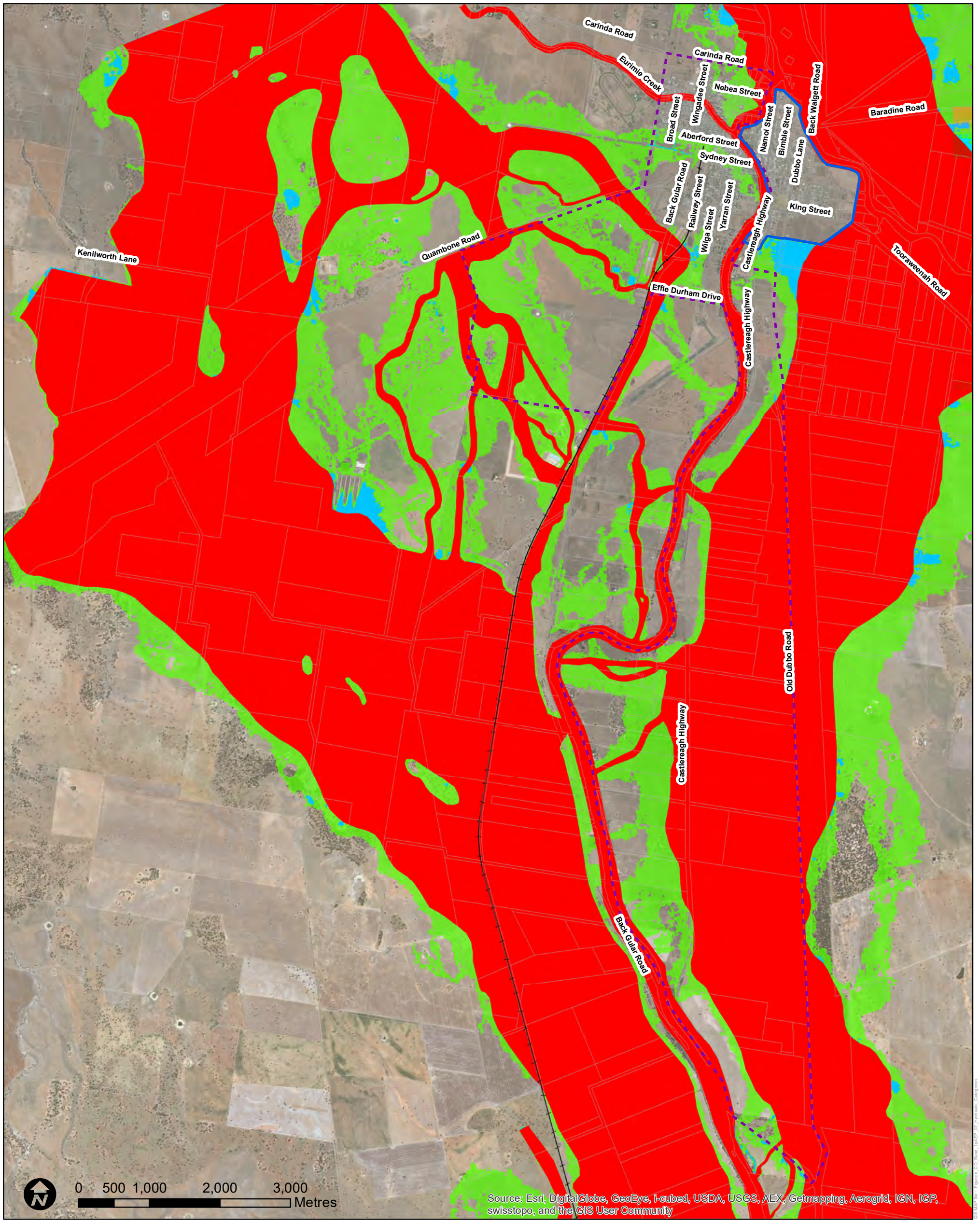
JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:51,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Provisional Flood Hazard Classification for 1% AEP Event**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure A10**	REV 1 VER 1
CHECK AH	DATE 19/06/2019		

Note: Flood hazard extents outside the study area are indicative only.



Legend

- Coonamble levee
- Study Area
- Cadastre
- Railway
- Floodway
- Flood Storage
- Flood Fringe

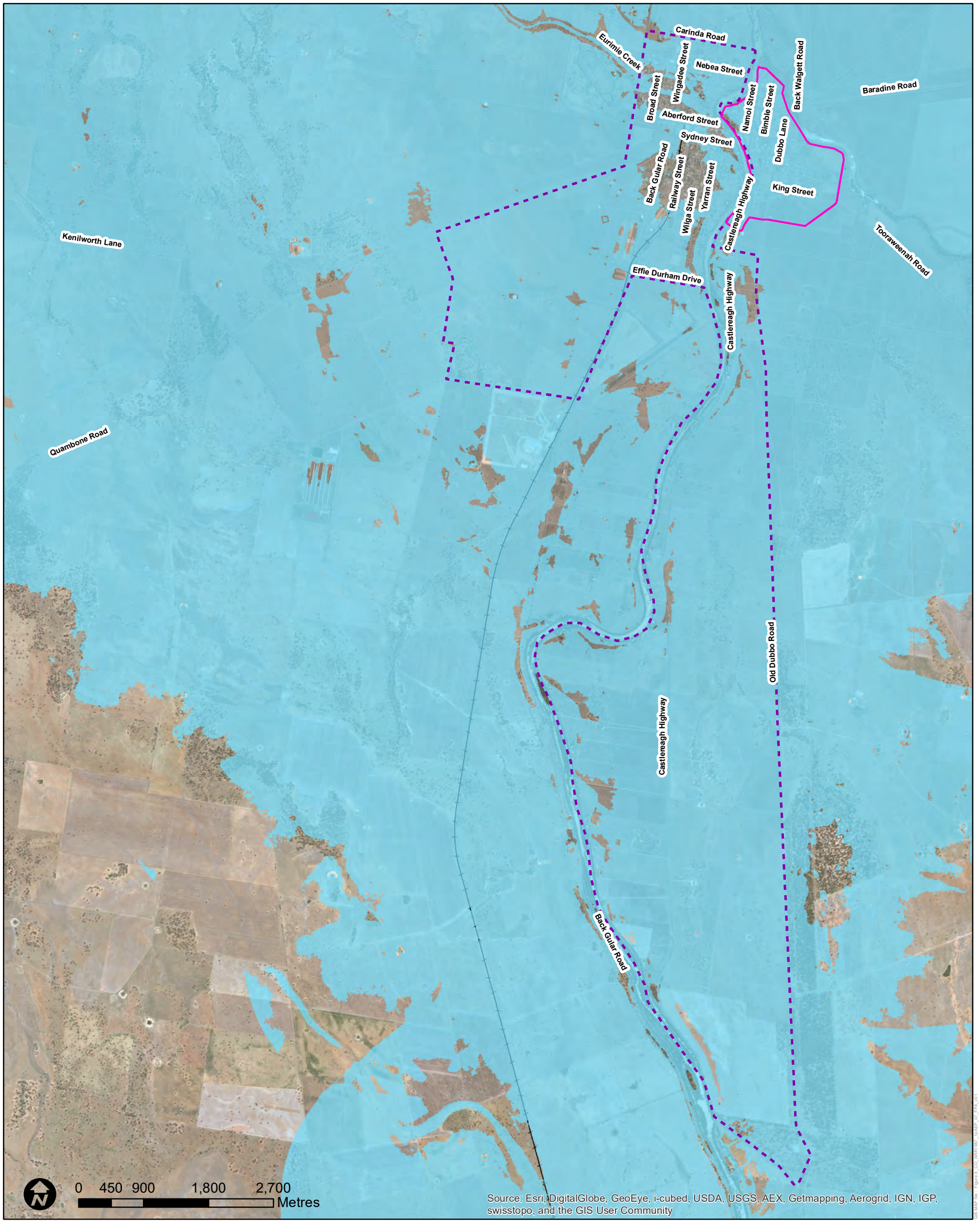
JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:51,711		A3
SHEET	1 Of 1		GDA 1994 MGA Zone 55
TITLE	**Provisional Flood Hydraulic Categories for 1% AEP Event**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN RK	PROJECT # IA194100	MAP # **Figure A11**	REV VER 1 1
CHECK AH	DATE 24/06/2019		

GIS MAP file - Figure x_CO_Base_1pAEP_07_Hydraulic_Categories



Legend

- Coonamble levee
- Flood planning area
- Study Area
- Railway
- Cadastre

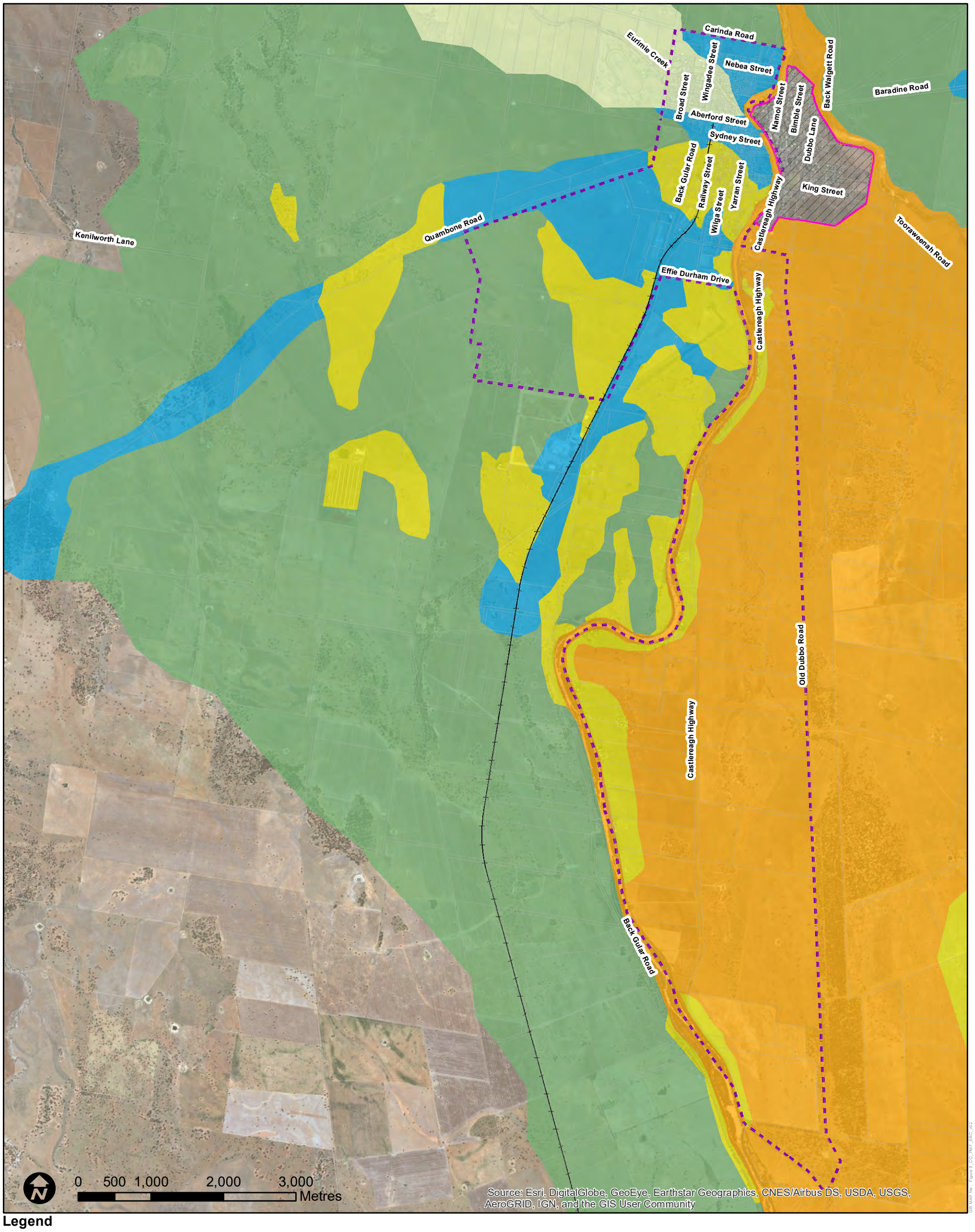
Note: Flood Planning Area outside the study area is indicative only

JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:50,614		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Provisional Flood Planning Area**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN PK	PROJECT # IA194100	MAP # **Figure A12**	REV 1 VER 1
CHECK AH	DATE 24/06/2019		



Legend

- Cadastre
- Railway
- Coonamble levee
- Study Area

Emergency Response Classification

- FIS - Flooded Area, Isolated and Fully Submerged
- FIE - Flooded area, Isolated with an Area Elevated Above flood event of interest
- FER - Flooded area, with an Exit Route via Rising Road
- FEO - Flooded area, with an Exit Route via Overland Escape
- NIC - Not Flooded, Indirect Consequences
- Unclassified

JACOBS

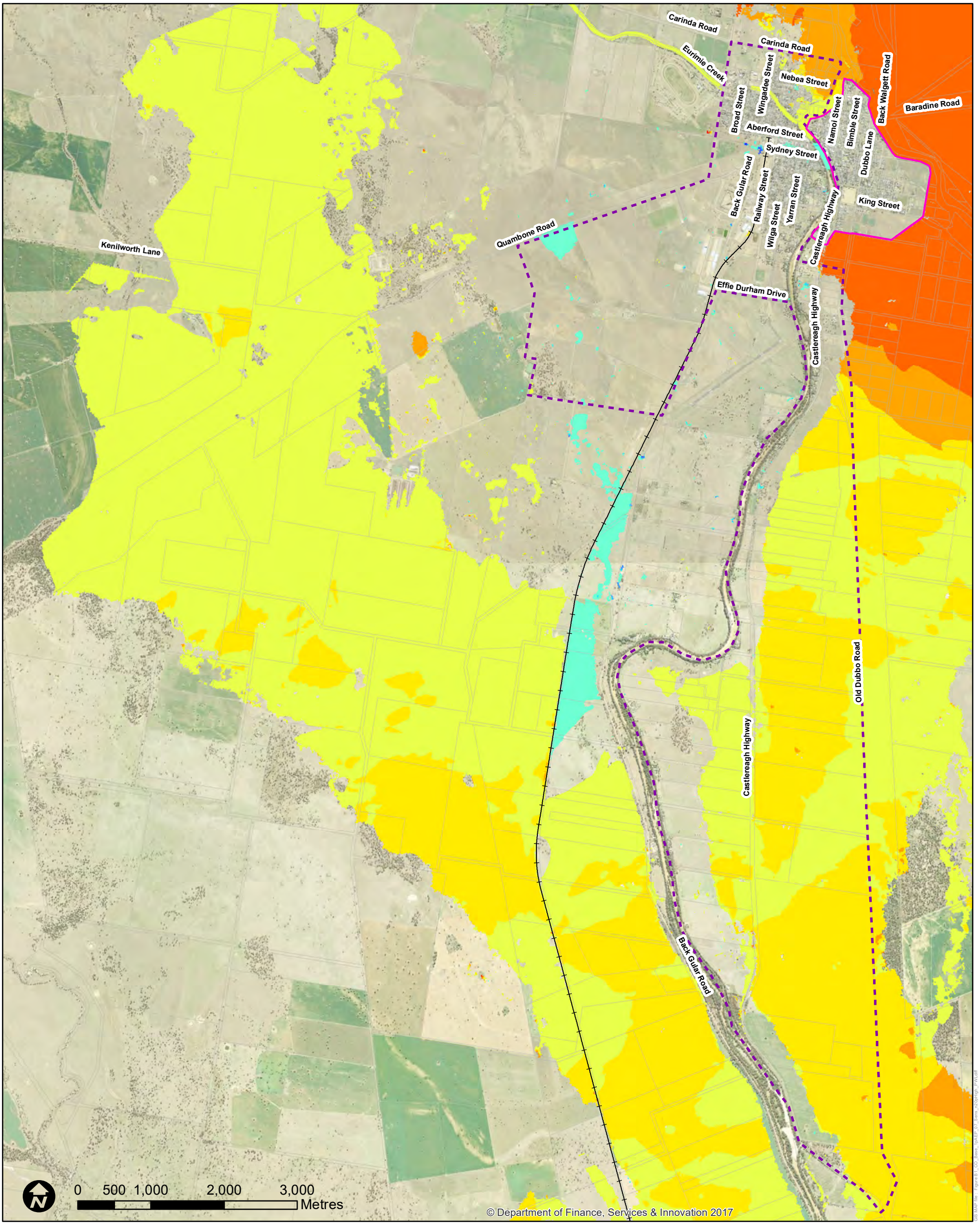
Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:50,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Emergency Response Classification of Communities - PMF**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN RK	PROJECT # IA194100	MAP # **Figure A13**	REV 1 VER 1
CHECK AH	DATE 29/08/2019		

GIS MAP file - Figure 9_CO_PMF_ERC_v02

Appendix B. Sensitivity Analysis



Legend

- Coonamble levee
- Study Area
- Railway
- Cadastre

Change in Flood Level (m)

< -0.3	-0.03 to -0.01	0.05 to 0.1
-0.3 to -0.1	-0.01 to 0.01	0.1 to 0.3
-0.1 to -0.05	0.01 to 0.03	>0.3
-0.05 to -0.03	0.03 to 0.05	

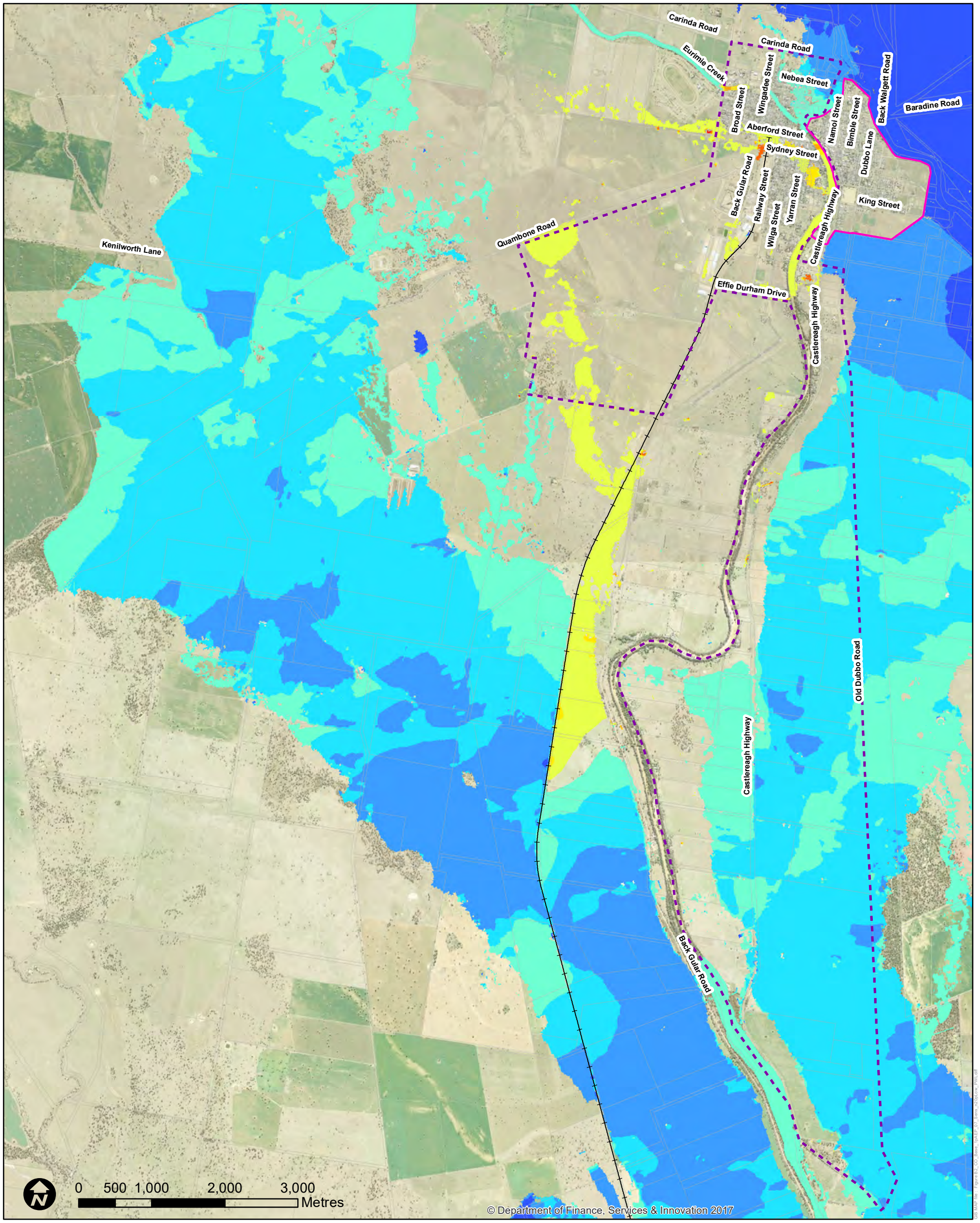
JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:50,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Changes in 1% AEP Flood Levels due to 20% increase in Manning's n values**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN AT	PROJECT # IA194100	MAP # **Figure B1**	REV VER 1 1
CHECK AH	DATE 11/03/2020		

Note: Flood extents outside the study area are indicative only.



Legend

- Coonamble levee
- Study Area
- Railway
- Cadastre

Change in Flood Level (m)

< -0.3	-0.03 to -0.01	0.05 to 0.1
-0.3 to -0.1	-0.01 to 0.01	0.1 to 0.3
-0.1 to -0.05	0.01 to 0.03	>0.3
-0.05 to -0.03	0.03 to 0.05	

JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:50,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Changes in 1% AEP Flood Levels due to 20% reduction in Manning's n values**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN AT	PROJECT # IA194100	MAP # **Figure B2**	REV 1 VER 1
CHECK AH	DATE 11/03/2020		

Note: Flood extents outside the study area are indicative only.

Carinda Road
Carinda Road
Eurimie Creek
Broad Street
Wingadee Street
Nebea Street
Back Walgett Road
Baradine Road
Namoi Street
Bimble Street
Dubbo Lane
Aberford Street
Sydney Street
Back Gular Road
Railway Street
Yarran Street
Wilga Street
Castlereagh Highway
King Street
Kenilworth Lane
Quambone Road
Effie Durham Drive
Castlereagh Highway
Old Dubbo Road
Back Gular Road
Castlereagh Highway
0 500 1,000 2,000 3,000
Metres
© Department of Finance, Services & Innovation 2017

Legend

- Coonamble levee
- Study Area
- Railway
- Cadastre

Change in Flood Level (m)

< -0.3	-0.03 to -0.01	0.05 to 0.1
-0.3 to -0.1	-0.01 to 0.01	0.1 to 0.3
-0.1 to -0.05	0.01 to 0.03	>0.3
-0.05 to -0.03	0.03 to 0.05	

JACOBS

Data Sources: Coonamble Shire Council

LIMITATIONS: Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	1:50,000		A3
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE	**Changes in 1% AEP Flood Levels due to Climate Change (2090)**		
PROJECT	West Coonamble Floodplain Risk Management Study and Plan		
CLIENT	Coonamble Shire Council		
DRAWN RK	PROJECT # IA194100	MAP # Figure B3	REV VER 1 1
CHECK AH	DATE 11/03/2020		

Note: Flood extents outside the study area are indicative only.

Appendix B. Community Survey

West Coonamble
Floodplain Risk Management Study & Plan

September 2018

Study Update

This newsletter is the first in a series being prepared to inform residents on the development of the West Coonamble Floodplain Risk Management Study and Plan.

Coonamble Shire Council recently engaged engineering consultants Jacobs to prepare a Floodplain Risk Management Study and Plan for West Coonamble, which is being undertaken with financial and technical assistance from Council and NSW Office of Environment and Heritage. This project is supported by the NSW and Australian Governments through the Natural Disaster Resilience Program.

The Study Area

The Study Area for West Coonamble, is located on the western side of the Castlereagh River. The Study Area is bounded by Old Dubbo Road to the east, Effie Durham Street and Gadsens Street to the south and Conimba Street to the north. Quambone Road forms the south-western boundary of the Study Area and Coonamble Levee forms the north-eastern boundary of the Study Area.

West Coonamble has a history of riverine flooding along the west bank of the Castlereagh River and on either side of Eurimie Creek. Eurimie Creek is a breakout of the Castlereagh River located approximately 1km upstream of the confluence of the Castlereagh River and Warrana Creek.

The Flood Study Report (http://www.coonambleshire.nsw.gov.au/AboutCouncil/Plans.html) (October 2016) for West Coonamble shows that the Study Area is cut-off from neighbouring towns in the 5% annual exceedance probability (AEP) event and lands within the entire Study Area are located below 1% AEP flood level plus a 0.5m freeboard.

The Floodplain Risk Management Process

This work is being undertaken to help Coonamble Shire Council meet the primary objective of the NSW Government's Flood Prone Land Policy

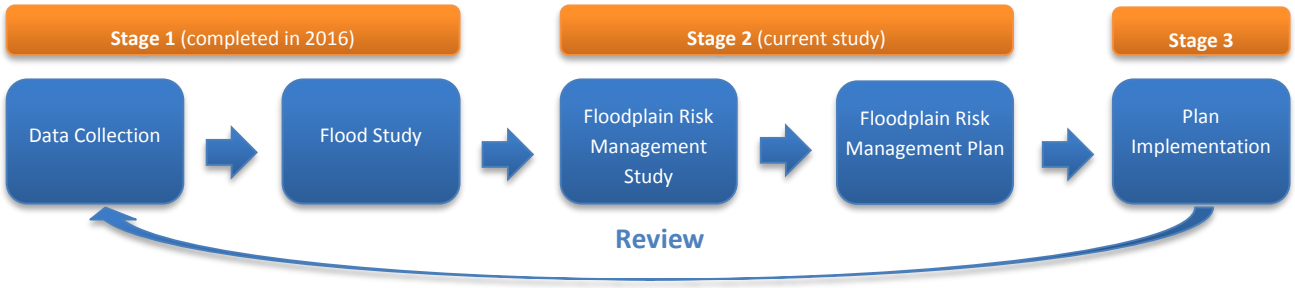
"to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible".

Coonamble Shire Council's Floodplain Risk Management Committee oversees all aspects of the floodplain risk management process and includes representatives from the community, state agencies, emergency services and Council.

West Coonamble
Floodplain Risk Management Study & Plan

September 2018

The floodplain risk management process outlined in the NSW Floodplain Development Manual is shown below. It is structured to provide a consistent and systematic approach to the management of floodplains throughout NSW.



- The first stage in the process is data collection and the preparation of a flood study to define existing flood behaviour, which was achieved with the completion of the 2016 Flood Study.
- The second stage, which is the focus of the current project, involves the preparation of a Floodplain Risk Management Study and Plan that identifies and documents a range of floodplain management measures to address any problems and areas of concern.
- The third stage of the process involves undertaking works, subject to availability of funding.

How to be involved

Engagement of the community in the floodplain risk management process is very important to Council. We will be providing a number of opportunities for the community to have input during the course of this study.

A key objective the consultation process is to ensure that the community has a say in how the flood risk should be managed in the Study Area. This includes the identification and prioritisation of mitigation works and management measures.

You can help us with this information by completing the questionnaire for your area and returning the completed community questionnaire by **12 October 2018**, even if you already completed a similar questionnaire for the previous flood study.

The community consultation programme includes these activities:

Newsletter & Council Website	• Background to the study • Updates on project progress • Contact details for queries relating to the study and how you can be involved.
Questionnaire	• An opportunity to tell us about your views on flooding and its management (via the attached questionnaire)
Community Forum	• Opportunity to find out more about flood studies and flooding in your area • Opportunity to provide some feedback
Public Exhibition	• Display of Draft Floodplain Managment Study and Plan • Incorporate submissions into the Study and Plan

Further information

For more information, including the West Coonamble Flood Study from 2016, please see Coonamble Shire Council's page http://www.coonambleshire.nsw.gov.au/AboutCouncil/Plans.html.

West Coonamble
Floodplain Risk Management Study & Plan

Questionnaire

Importance of Community Questionnaire for residents and businesses

Coonamble Shire Council has engaged Jacobs to carry out the Floodplain Risk Management Study and Plan for West Coonamble. The project builds on the Flood Study completed in 2016 for the Study Area. We are seeking feedback from the community on your views on how flooding should be managed in the Study Area.

If you cannot answer any question, or do not wish to answer a question, then leave it unanswered and proceed to the next question. Your input to this important study will be greatly appreciated. Any information that you provide will be treated as confidential. Specific information on the respondents or their responses will not be made available or reported on. There is a page at the back for additional comments. If you need additional space, please add sheets.

Please send your response to this questionnaire directly to the Consultant before 12 October 2018 at the address provided below.

Akhter Hossain

P O Box 632

NORTH SYDNEY, NSW 2059

or

email: *akhter.hossain@jacobs.com*

For additional Questionnaires or further information about the West Coonamble Floodplain Risk Management Study and Plan, please e-mail akhter.hossain@jacobs.com.

YOUR DETAILS

Please complete the questionnaire for the property in which you have an interest.

Your contact details would be appreciated in case we need to follow up on some details or seek additional comment. Can you please also mark the location of your residence/business with a clear dot on the attached map, as best as you can. **Please note that providing these details is optional.**

All information provided will remain confidential and will only be used for the purpose of this study. Specific information on the respondents or their responses will not be made available or reported on.

Name:_____

Address: _____

Phone:_____

Email (please provide if you wish to receive project updates electronically):

_____

Do you wish to remain on the mailing list to receive further details, such as Newsletters or Community Bulletins on the Study?

YES ❑ (please ensure relevant details entered above)

NO ❑

PART A – ABOUT YOUR PROPERTY AND FLOOD EXPERIENCE

1. Do you live in the study area?

a. Yes ☐

b. No ☐

If No, are you a frequent visitor to the area? Please specify

_____

2. Do you own or rent in the study area?

a. Own ☐

b. Rent ☐

How long have you occupied your property in the study area?

_____

3. Do you own or manage a business in the study area?

a. Yes ☐

How long has it operated in the study area?

_____

b. No (go to Question 5) ☐

4. If you answered yes to Q3, what kind of business is it?

a. Home Based Business ☐

b. Shop/Commercial premises ☐

c. Industrial ☐

d. Other ☐

Please specify

_____

5. Are you aware of flooding in West Coonamble?

a. Aware ☐

b. Some knowledge ☐

c. Not aware ☐

6. Do you wish to share any information on flooding on your property? (You can tick more than one box). Please write any descriptions at the end of the questionnaire

a. No information ☐

b. Own experience ☐

c. Information from Council ☐

d. Photographs ☐

e. Other

_____

_____

_____

_____

_____

_____

_____

_____

_____

9. Are you aware of any works that have been carried out near you that you believe have negatively impacted **on the flood behaviour at your property?** (Tick all boxes that apply)

a. Not aware of any measures ☐
b. Building or renovation activities ☐
c. Fencing ☐
e. Creek works ☐
f. Upgraded roads, culverts ☐
g. Overland flow obstructions ☐
h. Other (please specify):

_____

_____

_____

10. Are you aware of any works that have been carried out near you that you believe have improved **the flood behaviour at your property?** (Tick all boxes that apply)

a. Not aware of any measures ☐
b. Building or renovation activities ☐
c. Fencing ☐
d. Creek works ☐
e. Upgraded roads, culverts ☐
g. Overland flow obstructions ☐
h. Other (please specify):

_____

_____

PART B – YOUR OPINION ON THE FLOODPLAIN RISK MANAGEMENT MEASURES

7. Please rank the following development types according to what you consider should be assigned greatest priority in protecting from flooding (1 = greatest priority to 7 = least priority). **Please identify specific items if necessary**.

Rank	Development Type
	Commercial:
	Heritage items, please specify:
	Residential:
	Community facilities (schools, halls, Churches, etc.):
	Critical utilities (power substations, telephone exchanges, etc.):
	Emergency facilities (Hospital, Police Station, etc.):
	Recreation areas and facilities:

8. Please rank the following flood management options according to what you consider should be undertaken (1 = greatest priority to 6 = least priority).

Rank	Management option
	Protecting residents/business from flooding
	Protecting land of residents/businesses from flooding
	Maintaining an emergency flood free access
	Providing flood signage for public safety
	Support from SES
	Providing flood warning

11. Which of the following measures do you think Council should consider for reducing the flood risk at your property?
(Indicate your preferences by ranking with numbers, with "1" being the most preferred and "4" being the least preferred.)

Rank	Development Type
	Zoning, building & development controls, including fencing
	Improved drainage infrastructure and flood mitigation works
	Upgrading roads
	Public awareness & education

Other (please specify):

_____

12. What notifications do you consider Council should give about the potential flood affectation of individual properties?
(Tick all boxes that apply)

a. Advise every resident and property owner on a regular basis of the known potential flood affectation ☐

b. Advise every resident and property owner on a regular basis of Council's policies on the control of land potentially affected by flooding ☐

c. Advise prospective purchasers/developers on the control of development on land potentially affected by flooding ☐

d. Provide no notifications ☐

Other (please specify):

_____

_____

_____

PART C – ADDITIONAL COMMENTS

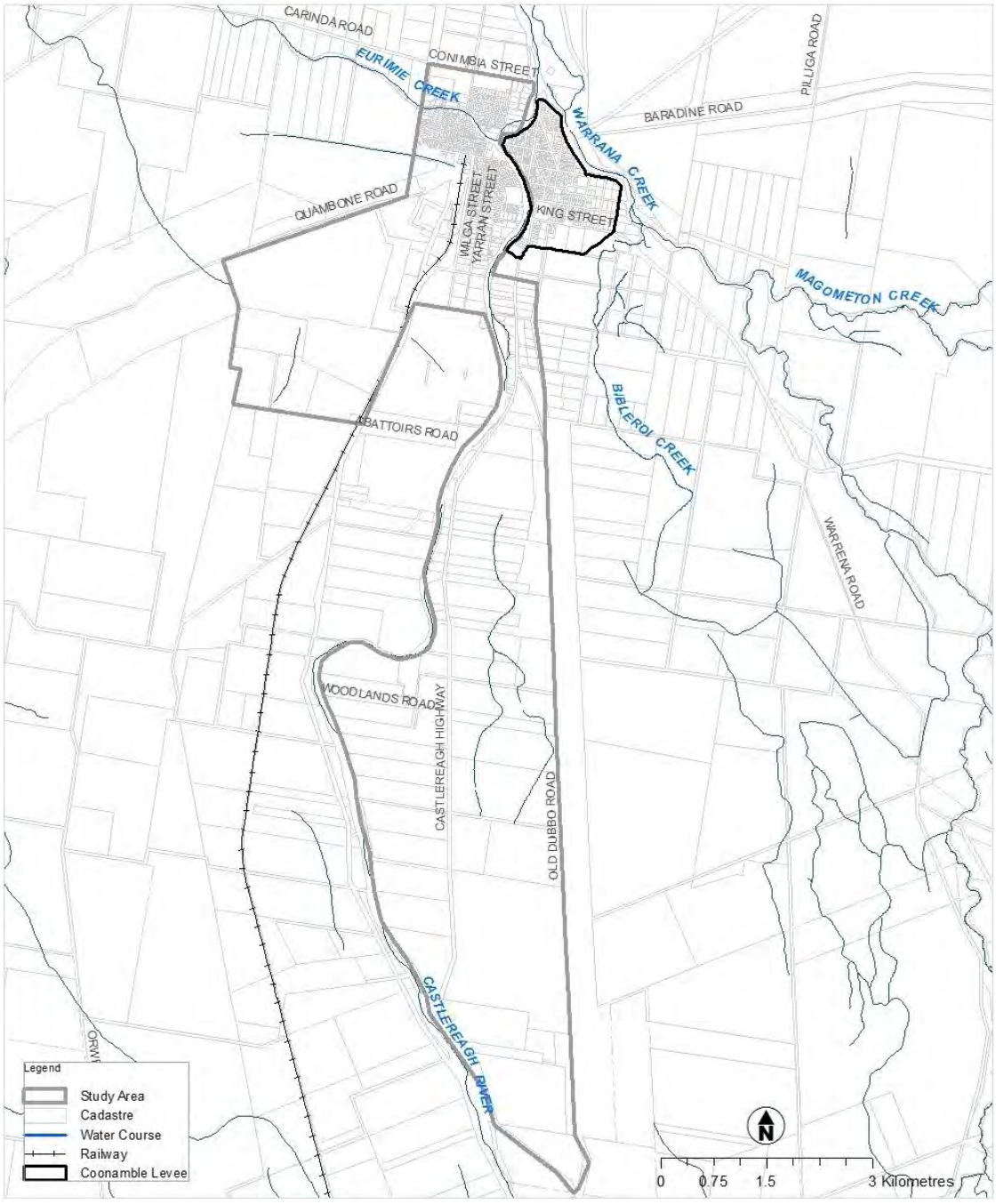
Do you wish to comment on any other issues associated with the development of the Floodplain Risk Management Plan?

Please add comments in the space below or please indicate your willingness to answer questions over the phone.

THANK YOU FOR YOUR TIME

Can you please also mark the location of your residence/business or any known flooding issues with a clear dot, as best as you can. **Please note that providing these details is optional.**

Study Area for West Coonamble



Appendix C. Flood Planning Matrix

Table C-1 Proposed Flood Planning Matrix – Draft Format

	Mainstream Flood Risk																							
	Low (Areas located above FPL and subject to flooding in the PMF event which are not isolated and fully submerged)								Medium (areas subject to H1 to H4 flood hazards in the 1% AEP event; areas flooded, isolated and fully submerged in the PMF event)								High (floodways in the 1% AEP event; areas subject to H5 and H6 flood hazards in the 1% AEP event)							
Planning Consideration	Critical Utilities & Uses	Sensitive Uses & Facilities	Subdivision	Residential **	Commercial & Industrial	Tourist Related Development	Open Space & Non-Urban	Concessional Development	Critical Utilities & Uses	Sensitive Uses & Facilities	Subdivision	Residential **	Commercial & Industrial	Tourist Related Development	Open Space & Non-Urban	Concessional Development	Critical Utilities & Uses	Sensitive Uses & Facilities	Subdivision	Residential **	Commercial & Industrial	Tourist Related Development	Open Space & Non-Urban	Concessional Development
Floor Level		3		2,6,7	5,6,7	2,6,7	1,6	4,7				2,6,7	5,6,7	2,6,7	1,6	4,7							1,6	4,7
Building Components		2		1	1	1	1	1				1	1	1	1	1							1	1
Structural Soundness		3		2	2	2	2	2				2	2	2	2	2							1	1
Flood Effects		2	2	2	2	2	2	2				2	2	2	2	2							1	1
Evacuation		2,3,4	5	2,3	1 or 2,3	2,3	3,4	2,3				2,3	1 or 2,3	2,3	3,4	2,3							3,4	2,3
Management and Design		4,5	1		2,3,5	2,3,5	2,3,5	2,3,5					2,3,5	2,3,5	2,3,5	2,3,5							2,3,5	2,3,5

Colour Legend Not relevant Unsuitable land

** For redevelopment of an existing dwelling refer also to 'Concessional Development' provisions

Refer following pages for notes and conditions.

General Notes

1. *Freeboard* equals an additional height of 500mm.

2. The relevant environmental planning instruments identify development permissible with consent in various zones in the LGA. Refer to Coonamble LEP 2011 and DCP 2014. Notwithstanding, constraints specific to individual sites may preclude Council granting consent to certain forms of development on all or part of a site. This matrix identifies where flood risks are likely to determine where certain development types will be considered "unsuitable" due to flood related risks.

3. Filling of the site, where acceptable to Council, may change flood risk considered to determine the controls applied in the circumstances of individual applications.

Floor Level

1. All floor levels to be no lower than the 1% AEP flood level unless justified by site specific assessment.

2. *Habitable floor* levels to be no lower than the 1% AEP flood level plus *freeboard*.

3. *Habitable floor* levels to be no lower than the *PMF* level. Non-habitable floor levels to be no lower than the *PMF* level unless justified by a site specific assessment.

4. Floor levels to be no lower than the *design floor level*. Where this is not practical due to compatibility with the height of adjacent buildings, or compatibility with the floor level of existing buildings, or the need for access for persons with disabilities, a lower floor level may be considered. In these circumstances, the floor level is to be as high as practical, and, when undertaking alterations or additions, no lower than the existing floor level.

5. The level of *habitable floor areas* to be equal to or greater than the 1% AEP flood level plus *freeboard*. If this level is impractical for a development in a Business zone, the floor level should be as high as possible.

6. Non-habitable floor levels to be equal to or greater than the 1% AEP flood level plus *freeboard* where possible, or otherwise no lower than the 1% AEP flood level unless justified by site specific assessment.

7. A restriction is to be placed on the title of the land, pursuant to S.88 of the Conveyancing Act, where the lowest *habitable floor* level is elevated more than 1.5m above finished ground level, confirming that the undercroft area is not to be enclosed.

Building Components and Method

1. All structures to have flood compatible building components below the 1% AEP flood level plus *freeboard*.

2. All structures to have flood compatible building components below the *PMF* level.

Structural Soundness

1. Engineer's report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 1% AEP flood plus *freeboard*, or a *PMF* if required to satisfy evacuation criteria (see below).

2. Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 1% AEP flood plus *freeboard*, or a *PMF* if required to satisfy evacuation criteria (see below). An engineer's report may be required.

3. Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a *PMF*. An engineer's report may be required.

Flood Effects

1. Engineer's report required to certify that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood conveyance; and (iii) the cumulative impact of multiple potential developments in the floodplain

2. The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood conveyance; and (iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required.

Evacuation

1. Reliable access for pedestrians or vehicles required during a 1% AEP flood.

2. Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest *habitable floor* level to an area of refuge above the *PMF level*, or a minimum of 20% of the gross floor area of the building to be above the *PMF level*.

3. The development is to be consistent with any relevant *flood evacuation strategy* or similar plan.

4. The evacuation requirements of the development are to be considered. An engineer's report will be required if circumstances are possible where the evacuation of persons might not be achieved within the *effective warning time*.

5. Applicant to demonstrate that evacuation in accordance with the requirements of this DCP is available for the potential development flowing from the subdivision proposal.

Management and Design

1. Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with this DCP.

2. *Site Emergency Response Flood Plan* required where floor levels are below the *design floor level*, (except for single dwelling-houses).

3. Applicant to demonstrate that area is available to store goods above the 1% AEP flood level plus *freeboard*

4. Applicant to demonstrate that area is available to store goods above the *PMF* level.

5. No storage of materials below the design floor level which may cause pollution or be potentially hazardous during any flood.