



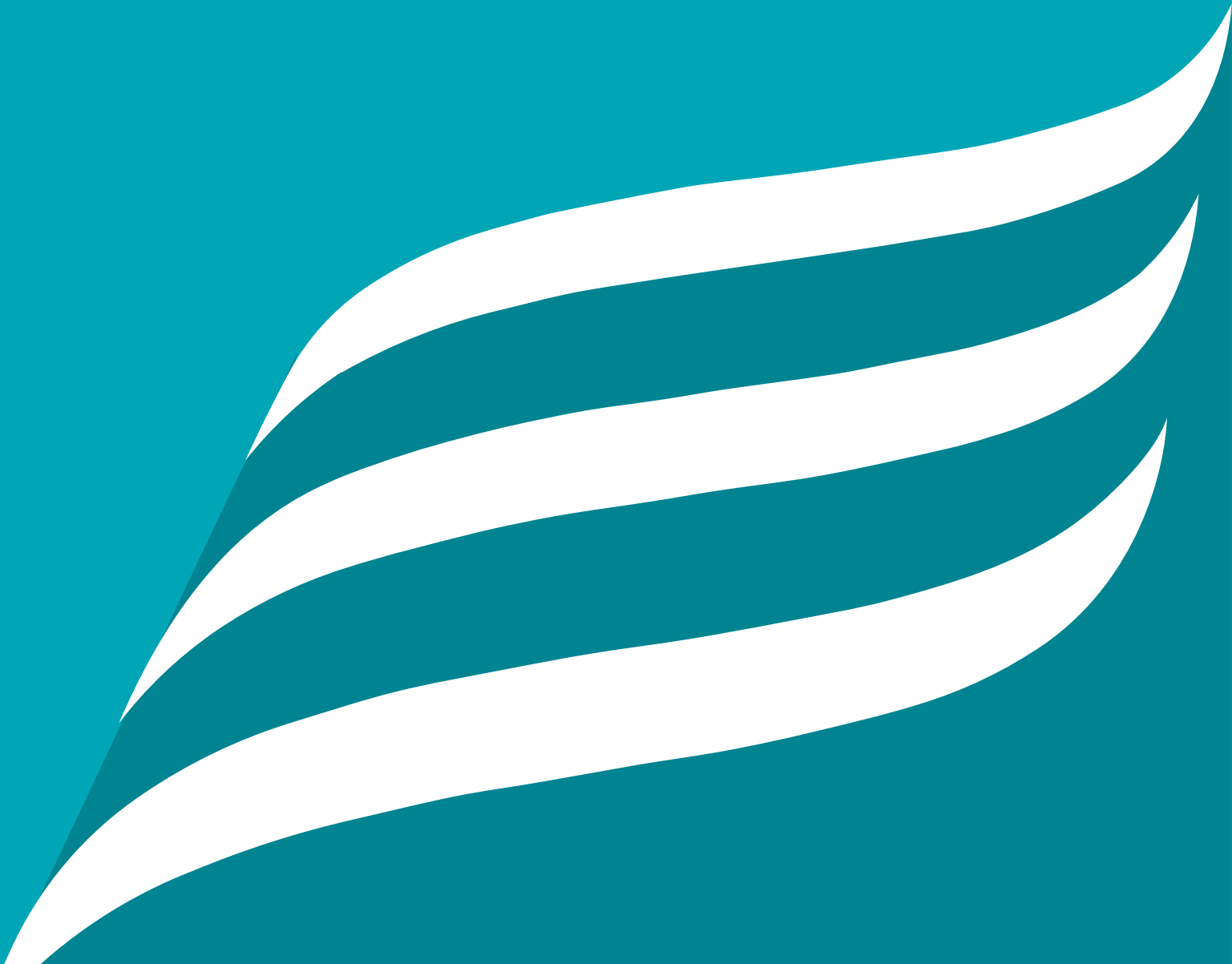
LISMORE CITY COUNCIL

Lismore Flood Risk Management Plan

Report

QC2030_004-REP-702-1

5 APRIL 2024



DISCLAIMER

This Report has been prepared on behalf of and for the exclusive use of Lismore City Council and is subject to and issued in accordance with Lismore City Council instruction to Engeny Australia Pty Ltd (Engeny). The content of this Report was based on previous information and studies supplied by Lismore City Council.

Engeny accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this Report by any third party. Copying this Report without the permission of Lismore City Council or Engeny is not permitted.

Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
0	27/03/2024	Client Issue for Review	Kelsey Mundt	Mark Page	Mark Page	Mark Page
1	5/04/2024	Client Issue for Review	Kelsey Mundt	Mark Page	Mark Page	Mark Page
Signatures:						

CONTENTS

1.	Introduction	1
1.1	Objective of the FRMP	1
1.2	Study Area	1
2.	Flood Hazard and Risk Categorisation	3
2.1	Introduction	3
2.2	Flood Hazard Categorisation	3
2.3	Flood Planning Area and Flood Liable Area	5
2.3.1	Rationale for Updating Flood Planning Level	5
2.4	Flood Function Categorisation	7
2.5	Flood Risk Precincts	9
2.6	Flood Emergency Response and Evacuation Analysis	11
2.6.1	Flood Emergency Response Classification	11
2.6.2	Impact of Flooding	11
2.6.3	Evacuation Analysis	12
2.7	Climate Change Impacts	16
3.	Flood Risk Management Options	18
3.1	Introduction	18
3.2	Property Modification Measures	18
3.2.1	PM01 – Zoning and Development Control	18
3.2.2	PM02 – Voluntary House Purchase (VHP)	18
3.2.3	PM03 – Voluntary House Raising (VHR) and Retrofitting	18
3.2.4	PM04 – Increase Access by Raising Access Roads	19
3.3	Response Modification Measures	19
3.3.1	RM01 – Community Flood Awareness Readiness Programs	19
3.3.2	RM02 – Improve Flood Predictions and Warning	19
3.3.3	RM03 – Update Local Flood Plan (LFP) to Assist with Emergency Response for Floods	20
3.3.4	RM04 – Floor Level Survey	20
3.3.5	RM05 - Regional Evacuation Route and Infrastructure Assessment Program	20
3.3.6	RM06 – Extension of Lismore Hydraulic Model for LGA	20
3.4	Flood Behaviour Modification Measures	20
3.4.1	FB01 – Raise CBD Levee to Provide 5% AEP Flood Immunity	20
3.4.2	FB02 – Raise South Lismore Levee to Provide 5% AEP Flood Immunity	20
3.4.3	FB03 - Excavate to Increase Conveyance on Wilsons River Bend	21
3.4.4	FB04 - Increase Conveyance at key Hydraulic Controls at Bruxner Highway, Caniaba Road and Krauss Avenue	21
3.4.5	FB05 - Combined Option, Reflective of Implementing Options 1 to 5 in the FRMS	21
3.4.6	FB06 – Nature Based Solutions for Flood Risk Management	21
3.4.7	FB07 – East Lismore Defence at Monaltrie Road	21
3.4.8	FB08 – Flood Defence at Wyrallah Road	21
3.4.9	FB09 – East Lismore Flood Defence at Wilson Park School	21
3.4.10	FB10 - Leicester Creek Bypass Channel	22
3.4.11	FB11 - Raise of South Lismore Levee to the 1% AEP Flood Level	22
3.4.12	FB12 – Raise of South Lismore Levee to the 1% AEP Flood Level plus Leicester Creek Bypass Channel	22

3.4.13	FB13 – Raise of CBD Levee to the 5% AEP Flood Level plus Leycester Creek Bypass Channel	22
3.4.14	FB14 – Raise of CBD Levee to the 1% AEP Flood Level plus Leycester Creek Bypass Channel	22
3.4.15	FB15 – Flood Risk Management Infrastructure	22
3.4.16	FB16 – Removal of Constriction at Brewster Street	23
3.5	Multi-Criteria Analysis Approach	24
3.6	Multi-Criteria Analysis Results	30
4.	Flood Risk Management Implementation Plan	31
5.	References	35
6.	Qualifications	36

Appendices

Appendix A: Multi-criteria Analysis Detailed Scoring	37
Appendix B: Previous Investigations	38

Tables

Table 2.1: Flood Emergency Response Classifications	11
Table 2.2: Building Inundation Frequency	12
Table 2.3: Evacuation Considerations	12
Table 3.1: Summary of Flood Risk Management Measures.....	24
Table 3.2: MCA Criteria and Scoring	26
Table 3.3: Assessment of Flood Risk Management Options	30
Table 4.1: Lismore FloodRisk Management Implementation Plan	32

Figures

Figure 1.1: FRMP Study Area	2
Figure 2.1: AIDR Flood Hazard Vulnerability Curves	3
Figure 2.2: 1% AEP Flood Hazard	4
Figure 2.3: Flood Planning Area and Level.....	6
Figure 2.4: Flood Function	8
Figure 2.5: Flood Risk Precinct Matrix	9
Figure 2.6: Flood Risk Precincts	10
Figure 2.7: Flood Emergency Response Classifications.....	14
Figure 2.8: Key Routes and Precincts for Evacuation.....	15
Figure 2.9: Climate Change Impacts	17

1. INTRODUCTION

Lismore City Council (LCC) engaged Engeny Australia Pty Ltd (Engeny) to develop an updated Flood Risk Management Plan (FRMP) for Lismore. The updated FRMP has been informed by the Lismore Floodplain Risk Management Study (FRMS) (Engeny, 2021) and subsequent work including the Land Use Planning and Development Control Interim Report (Engeny, 2023). The FRMP has been developed in accordance with the Flood Risk Management Manual (NSW Gov, 2023).

1.1 Objective of the FRMP

The purpose of this FRMP is to provide a short to medium-term plan to manage flood risk in the Lismore Township. At the time of preparing this FRMP, numerous flood risk management initiatives were being implemented at a local, state, and federal government level as a result of the 2022 flood event, of which many are captured in this document. Additionally, the regional flood mitigation assessment is being undertaken by CSIRO under the Northern Rivers Resilience Initiative which was funded by the National Emergency Management Agency.

Therefore, given the dynamic nature of flood management initiatives in the catchment, and ongoing strategic visioning for Lismore, it is recommended that this FRMP is reviewed and updated following the release of CSIRO's report on regional flood mitigation.

1.2 Study Area

The Study Area for which this FRMP applies is the flood prone urban land in the Lismore Township. The Study Area is defined by the extent of the Probable Maximum Flood (PMF) for Lismore, in accordance with the hydraulic modelling completed for the FRMS. The extent for which this FRMP applies is shown in Figure 1.1.

The FRMS study area comprises the urban areas of North Lismore, South Lismore, Central Lismore, and East Lismore. There are additional urban areas beyond these defined extents within the Lismore City Council (LCC) Local Government Area (LGA) which are subject to flood risk but are not within the defined spatial extents of this FRMP nor the FRMS from which the flood risk has been defined. The population considered within the Study Area is estimated to be approximately 27,900 (ABS, 2021) in 2021, noting that this population is likely to have been affected by the 2022 flood events.



FIGURE 1.1: FRMP STUDY AREA

2. FLOOD HAZARD AND RISK CATEGORISATION

2.1 Introduction

Flood hazard and risk for the Study Area has been determined in accordance with the Flood Risk Management Manual (NSW Gov, 2023), utilising the hydraulic modelling completed for the FRMS. Full details regarding flood risk are provided in the FRMS and the Land Use Planning Development and Control interim document (Engeny, 2023). Key outcomes, however, are summarised in the following sections.

2.2 Flood Hazard Categorisation

Flood hazard classification has been applied in accordance with the Australian Institute for Disaster Resilience (AIDR) flood hazard classification. This classification scheme is discussed in Guideline 7-3 of the Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR, 2017). The AIDR flood hazard vulnerability curves associated with this classification are provided in Figure 2.1. Flood hazard classification for the Study Area for the 1% AEP flood event is provided in Figure 2.2.

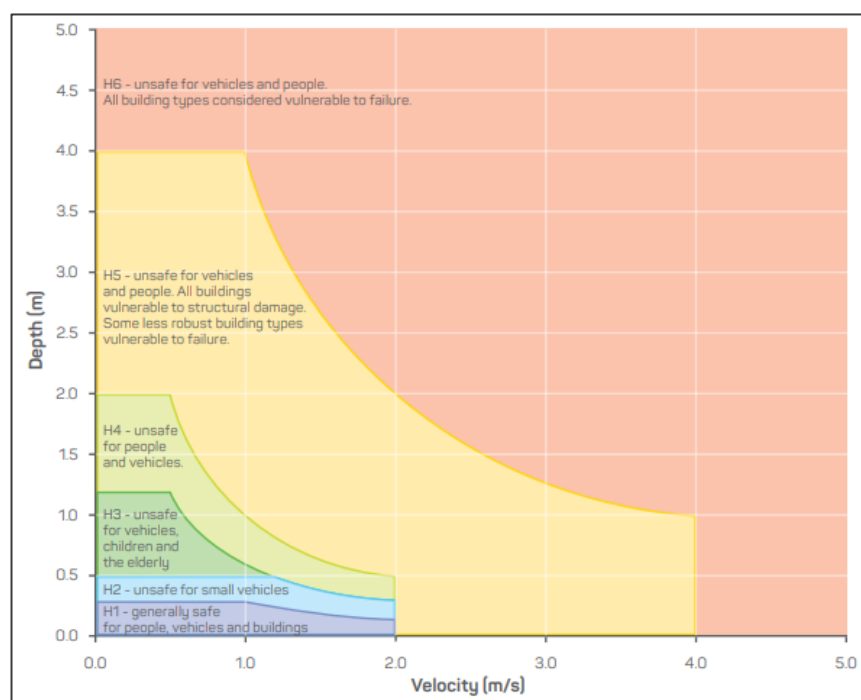
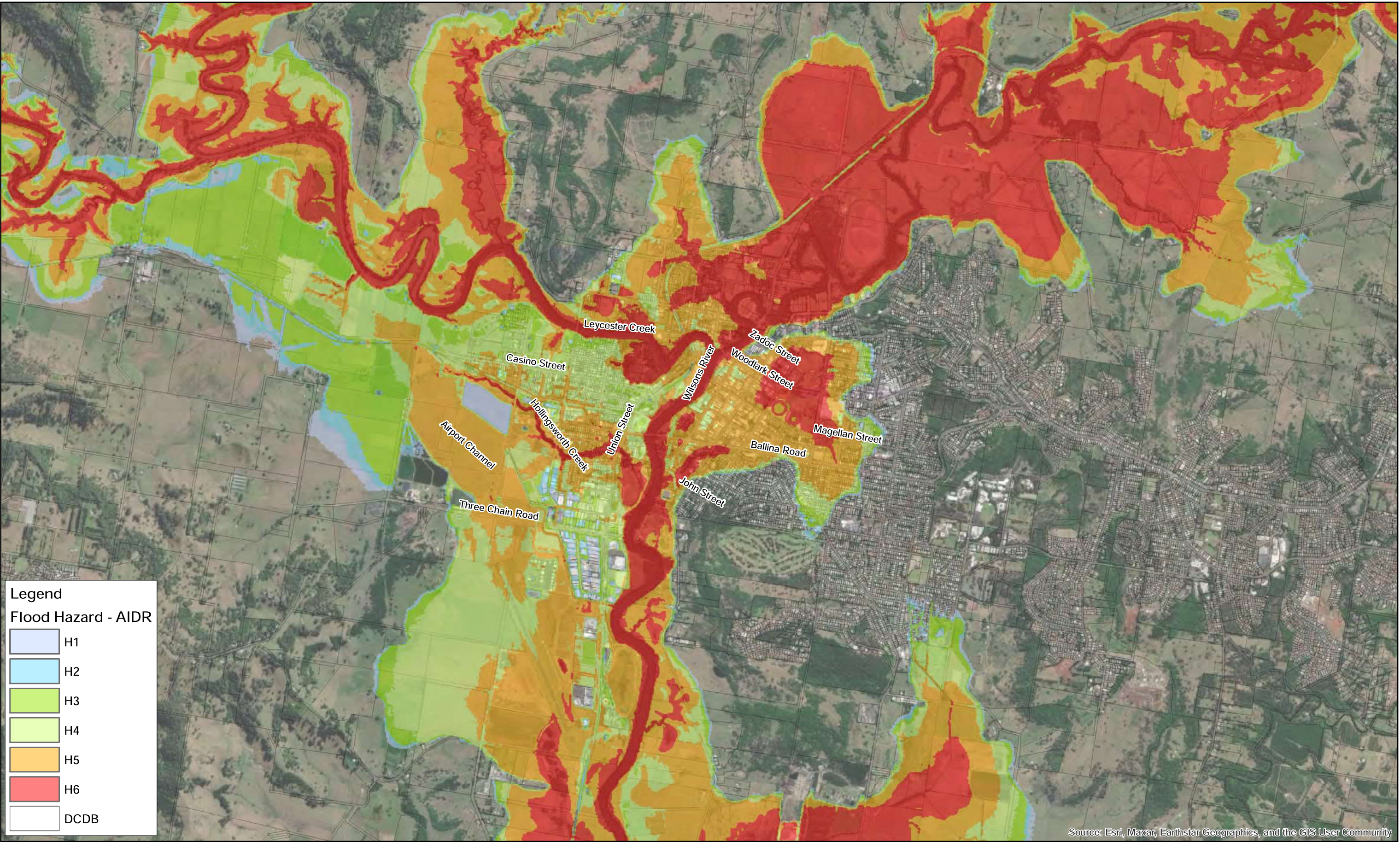


FIGURE 2.1: AIDR FLOOD HAZARD VULNERABILITY CURVES



Legend
Flood Hazard - AIDR

	H1
	H2
	H3
	H4
	H5
	H6
	DCDB

R	Details	Date	©COPYRIGHT Engeny Water Management This drawing is confidential and shall only be used for the purpose of this project.					DISCLAIMER Engenyh has endeavoured to ensure accuracy and completeness of the data. Engeny assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map. DATA SOURCE QLD Government Open Source Data	DESIGNER	CLIENT	Fig 2.2
1	Client Issue	16/12/22									Lismore Floodplain Risk Management Plan Flood Hazard - AIDR 1% AEP
-			DESIGNED	TS	CHECKED	KM					
-			DRAWN	TS	CHECKED	KM					
-			APPROVED	MP	DATE	16/12/22					
-			Notes:								
-											
-											DRG Ref:

2.3 Flood Planning Area and Flood Liabile Area

Council currently places controls on development in flood prone areas. The following definitions specified in the Flood Risk Management Manual (NSW Gov, 2023) apply:

- **Flood Planning Area:** the area of land below the Flood Planning Level (FPL). It is possible for different types of development to have differing FPLs applied within the FPA.
- **Flood Planning Level:** the combination of the flood level per the Defined Flood Event (DFE) and suitable freeboard. The typically adopted DFE is the 1% AEP at a minimum.
- **Probable Maximum Flood (PMF):** The largest flood that could conceivably occur at a particular location, estimated from probable maximum precipitation, coupled with the worst flood-producing catchment conditions.

The Lismore Local Environmental Plan (LEP) 2012 includes two clauses relevant to flood prone lands:

- **Clause 5.21 Flood planning:** applies to development for land within the flood planning area.
- **Clause 5.22 Special flood considerations:** applies to sensitive and hazardous development between the FPA and PMF or land the consent authority believes may cause a particular risk to life or requires the evacuation of people or other safety considerations in the event of a flood.

The FPL for Lismore is currently the 1% AEP + 500mm freeboard. At the time of preparing the FRMP, adoption of a new FPL is currently being determined through consultation with Council and stakeholders as part of a revised Flood Prone Lands DCP.

As recommended in the Update on Addressing Flood Risk in Planning Decisions Planning Circular (NSW Gov, 2024), incorporation of climate change into land use planning is recommended, and thus adoption of the 1% AEP 2090 Climate Change level plus 500 mm freeboard or the 0.2% AEP + 500 mm freeboard for the FPL should be carefully considered. The recommended FPL, and the FPA is shown on Figure 2.3.

It is noted that the 1% AEP 2090 Climate Change levels are generally 500-600 mm above the current scenario 1% AEP flood levels in Lismore, and similar to the 0.2% AEP.

2.3.1 Rationale for Updating Flood Planning Level

The following considerations support revision of the FPL for Lismore to a more stringent level beyond the 1% AEP flood event level plus 500 mm freeboard:

- **Flood Hazard:**
 - During a 1% AEP flood event, a large proportion of Lismore's urban area that is flood prone has a hazard classification of H5 or H6. This means that due to depth and/or velocity of flood water, the area is unsafe for both humans and vehicles and buildings are considered vulnerable to failure.
- **Evacuation:**
 - A number of localities in Lismore have evacuation constraints potentially resulting in people becoming trapped by roads being cut off early in a flood event. A higher FPL would provide greater safety due to increased potential for shelter in place until extraction in the worst-case scenario where the evacuation window is missed.
- **Climate Change:**
 - The Intergovernmental Panel on Climate Change (IPCC) research indicates that long-term weather projections predict increased intensity of rainfall events, and resultant increased risk of flooding. This could lead to flood depths increasing by up to 600 mm by 2090 (as per Section 2.7). A higher FPL could help to protect against possible increases in flood water depths as a result of climate change. Flood planning controls in the Lismore LEP require Council to take into account projected changes as a result of climate change.
- **Risk Appetite:**
 - Following devastating historical floods that overtopped Lismore's levee system, including in 2017 and two floods in 2022, and the amount of damage and trauma caused, there is likely to be a desire within the community to reduce, as much as practicable, Lismore's future flood risk. Raising the FPL is one way Lismore can decrease flood risk for new development, however it should be noted that this does not eliminate the risk.

2.4 Flood Function Categorisation

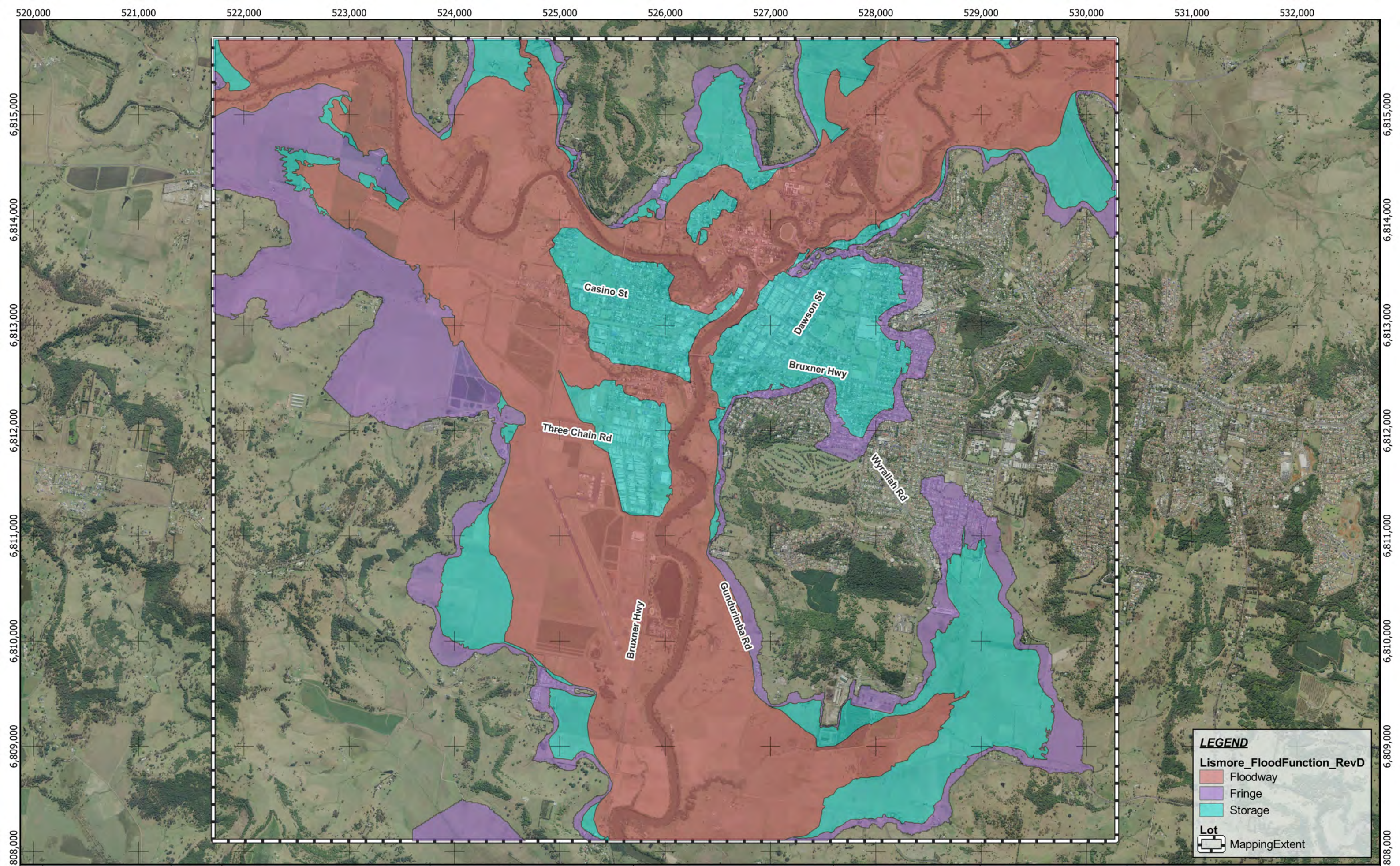
Flood function mapping identifies various areas within the floodplain extent (defined by the PMF flood event extent) in accordance with the following definitions provided by the Flood Risk Management Manual (NSW Gov, 2023):

- Floodways: also known as flood conveyance areas, floodways generally convey a significant discharge of water during floods and generally align with naturally defined channels.
- Flood storage areas: areas of the floodplain that are outside of floodways that generally provide for temporary storage of floodwaters during a flood event.
- Flood fringe areas: the remaining areas within the floodplain that have not been defined as floodways or flood storage areas.

Flood function mapping for Lismore has been defined as shown in Figure 2.4.

The following general area classifications have resulted from the flood function mapping activities:

- Floodway areas generally align with locations where the 1% AEP depth x velocity (DxV) results exceed 0.45 m²/s in the latest hydraulic modelling results. The flood extents of Leycester Creek, Leycester Creek breakout, Wilsons River, and Hollingworth Creek all fall within this classification.
- Flood storage areas generally align with locations where low velocity (less than 0.5 m/s) water is stored at depth greater than 1 m in the 1% AEP event. Flood storage areas were largely identified in South Lismore and much of the CBD flood extent.
- Flood fringe classifications has been applied to all remaining areas within the PMF flood extent and include areas west of the Leycester Creek breakout floodway and in localised areas on the edge of the PMF flood extent not included under the floodway or flood storage classifications.



LEGEND

Lismore_FloodFunction_RevD

- Floodway
- Fringe
- Storage

Lot

- MappingExtent

R	DETAILS	DATE
1	Final Issue	22-12-2022

© COPYRIGHT Engeny This drawing is confidential and shall only be used for the purpose of this project.			
DRAWN	KM	CHECKED	MP
APPROVED	MP	DATE	22-12-2022
NOTES:			

0 0.7 1.4 km

SCALE @ A3 - 1:1
GDA94 / MGA zone 56

DISCLAIMER
Engeny has endeavoured to ensure accuracy and completeness of the data. Engeny assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE
NSW Six Map Open Data



Fig 2.4

Lismore Floodplain Risk Management Plan
Flood Function

Dwg Ref:
M92000_007

2.5 Flood Risk Precincts

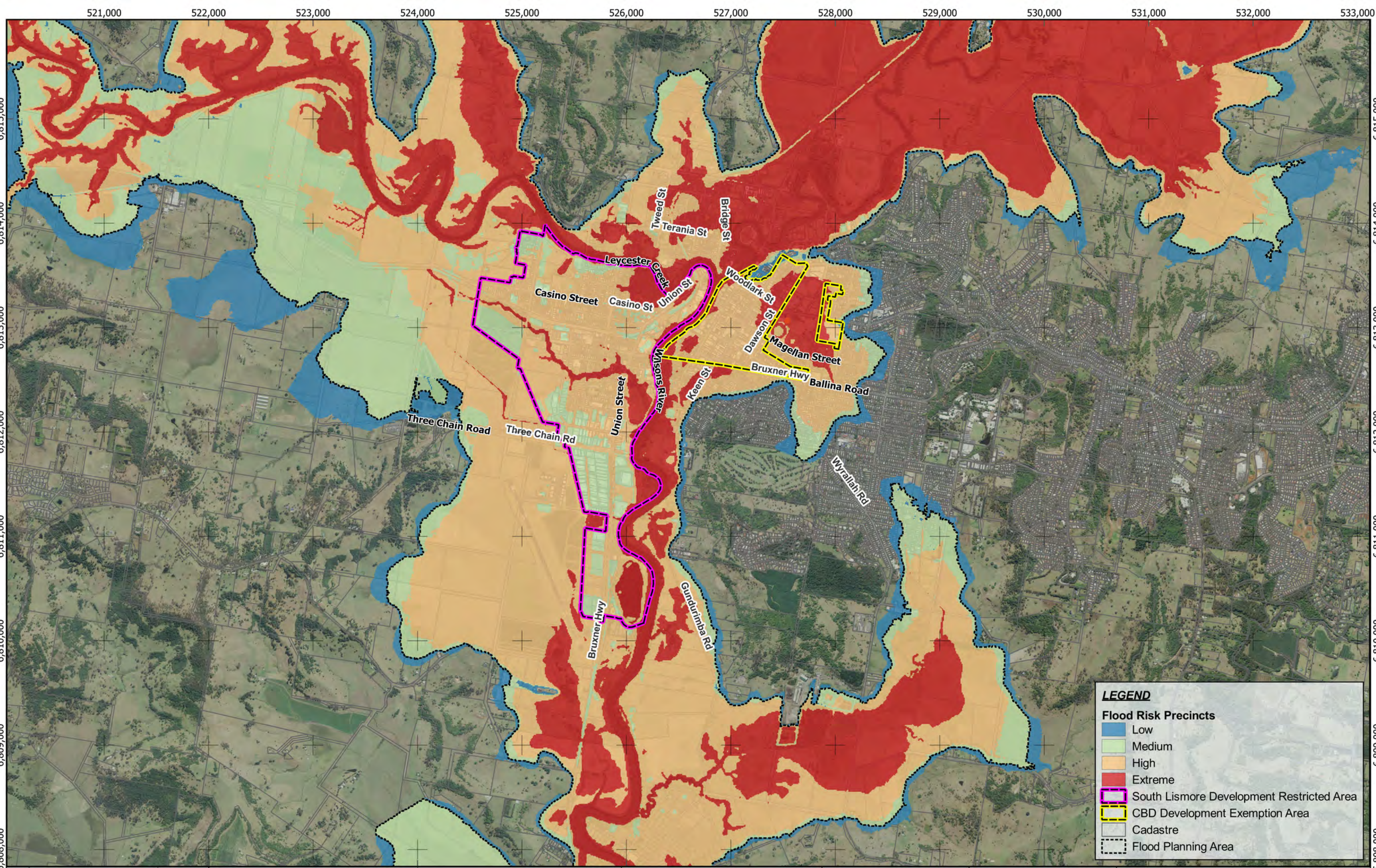
Determination of flood risk is recommended to be undertaken through consideration of the likelihood of the flood event, and the severity of its consequence as outlined in the Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR, 2017). The flood risk classifications are a result of the combination of flood hazard and flood frequency, as shown in Figure 2.5.

Flood Likelihood	Flood Hazard (AIDR)					
	H1	H2	H3	H4	H5	H6
10% AEP	Low	Medium	Medium	High	Extreme	Extreme
5% AEP, 1% AEP	Low	Low	Medium	High	High	Extreme
0.2% AEP	Low	Low	Medium	Medium	High	High
1:1,000 AEP, 1:2,000 AEP	Low	Low	Low	Low	Medium	High
1:10,000 AEP, 1:100,000 AEP, PMF	Low	Low	Low	Low	Low	Medium

FIGURE 2.5: FLOOD RISK PRECINCT MATRIX

The resultant Flood Risk Precincts map is provided in Figure 2.6. A summary of the flood risk precincts as they pertain to Lismore is:

- The “Extreme” risk precinct classification applies to the deepest areas within the CBD basin, along with the creek areas of Leycester Creek, Wilsons River and Hollingworth Creek, where the highest flow velocities exist.
- “High” risk precincts apply to the majority of the remaining CBD basin area, South Lismore, the airport and through to Gundurimba.
- “Medium” and “Low” risk precincts include the remaining areas not mentioned above, within the PMF extent.
- An additional “South Lismore Development Restricted Area” precinct has been applied to South Lismore due to the limitations associated with evacuation from this area and potential for property damage.
- An additional “CBD Development Exemption Area” precinct has been applied to the CBD and surrounding commercial areas that are noted as high risk, due to the protection the levee provides and the extended time and potential for evacuation to the east via rising roads.



LEGEND

Flood Risk Precincts

- Low
- Medium
- High
- Extreme

South Lismore Development Restricted Area

CBD Development Exemption Area

Cadastre

Flood Planning Area

R	DETAILS	DATE
1	Final Issue	31-01-2024

© COPYRIGHT Engeny This drawing is confidential and shall only be used for the purpose of this project.			
DRAWN	ST	CHECKED	KM
APPROVED	MP	DATE	31-01-2024
NOTES:			



0 0.8 1.6 km

SCALE @ A3 - 1:32,000

GDA94 / MGA zone 56

DISCLAIMER

Engeny has endeavoured to ensure accuracy and completeness of the data. Engeny assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE

NSW Six Map Open Data



Figure 2.6

Lismore Floodplain Risk Management Plan
Flood Risk Precincts

M92000_007

2.6 Flood Emergency Response and Evacuation Analysis

2.6.1 Flood Emergency Response Classification

The Wilsons River floodplain, defined up to the PMF flood extent, has been assessed in accordance with the Support for Emergency Management Planning – Flood Risk Management Guide EM01 (NSW Gov, 2023) guidelines. The guideline takes into consideration whether dwellings are flood affected and the availability of evacuation routes both leading to, and after, the flood peak.

Flood emergency response classifications for Lismore are presented in Figure 2.7. A summary of the Flood Emergency Response Classifications is provided in Table 2.1.

TABLE 2.1: FLOOD EMERGENCY RESPONSE CLASSIFICATIONS

Flood Emergency Response Classification	Description
High Flood Island	Areas suitable for refuge remain flood free in the PMF. The island is isolated due to floodwater, terrain, development, or infrastructure. Evacuation may be possible prior to access routes being inundated by floodwaters, otherwise resupply by boat or air will be required until access is reinstated.
High Trapped Perimeter Area	Areas suitable for refuge remain flood free in the PMF. The area is not completely surrounded by floodwaters. The area is isolated by floodwater and land/property may be inundated, however there is opportunity for people to retreat to higher ground above the PMF. Evacuation may be possible prior to access routes being inundated by floodwaters, otherwise resupply by boat or air will be required until access is reinstated.
Low Flood Island	The area is flooded in a PMF event. Isolation occurs initially due to access routes being cut by floodwater, terrain, development, or infrastructure, before the land on the island is inundated by floodwater in a PMF event.
Low Trapped Perimeter Area	The area is flooded in a PMF event. The area is not completely surrounded by floodwater. The area becomes isolated by floodwater and land/property will be inundated, to the point where the area will be completely covered in a PMF event.
Areas with Rising Road Access	The area is flooded in a PMF event. The area is not completely surrounded by floodwater. The community will not be completely isolated before inundation reaches its maximum extent, with access roads that rise continually out of the PMF.
Areas with Overland Escape Route	The area is flooded in a PMF event. The area is not completely surrounded by floodwater. The community will not be completely isolated before inundation reaches its maximum extent, with evacuation possible by traversing overland.

2.6.2 Impact of Flooding

The Lismore FRMS (Engeny, 2021) details the flood risks present in Lismore. A flood damages assessment was carried out in the Lismore FRMS (Engeny, 2021), taking into account inundation of residential and commercial/industrial properties. The total Average Annual Damage (AAD) estimate in the FRMS for residential and commercial/industrial properties in Lismore was calculated at \$63 million. This number represents the flood damage cost expected in any given year, from the total cost of damage due to theoretical flood events (design flood events) over a long period of time. In addition, the recently completed NSW State Disaster Mitigation Plan (NSW Gov, 2024) estimates the Average Annual Damage for Lismore at \$44 million.

The Lismore 2022 Post Flood Event Analysis (Engeny, 2024) estimated the total direct costs to residential and commercial/industrial properties in Lismore for the February 2022 event to be in the order of \$1.6 billion. This estimate was based on adoption of the flood damages assessment methodology provided by the Department of Climate Change, Energy, Environment and Water (DCCEEW).

2.6.3 Evacuation Analysis

The number of buildings impacted in Lismore, broken down into evacuation zones utilised for emergency management, for the full range of design flood events is summarised in Table 2.2. It includes both residential and commercial/industrial buildings. The locality of the evacuation zone boundaries is provided in Figure 2.8. Figure 2.8 also shows locations of reporting points, where detailed duration of inundation and time to inundation analysis of roads has been undertaken, and summarised in the Land Use Planning Development and Control interim document (Engeny, 2023).

TABLE 2.2: BUILDING INUNDATION FREQUENCY

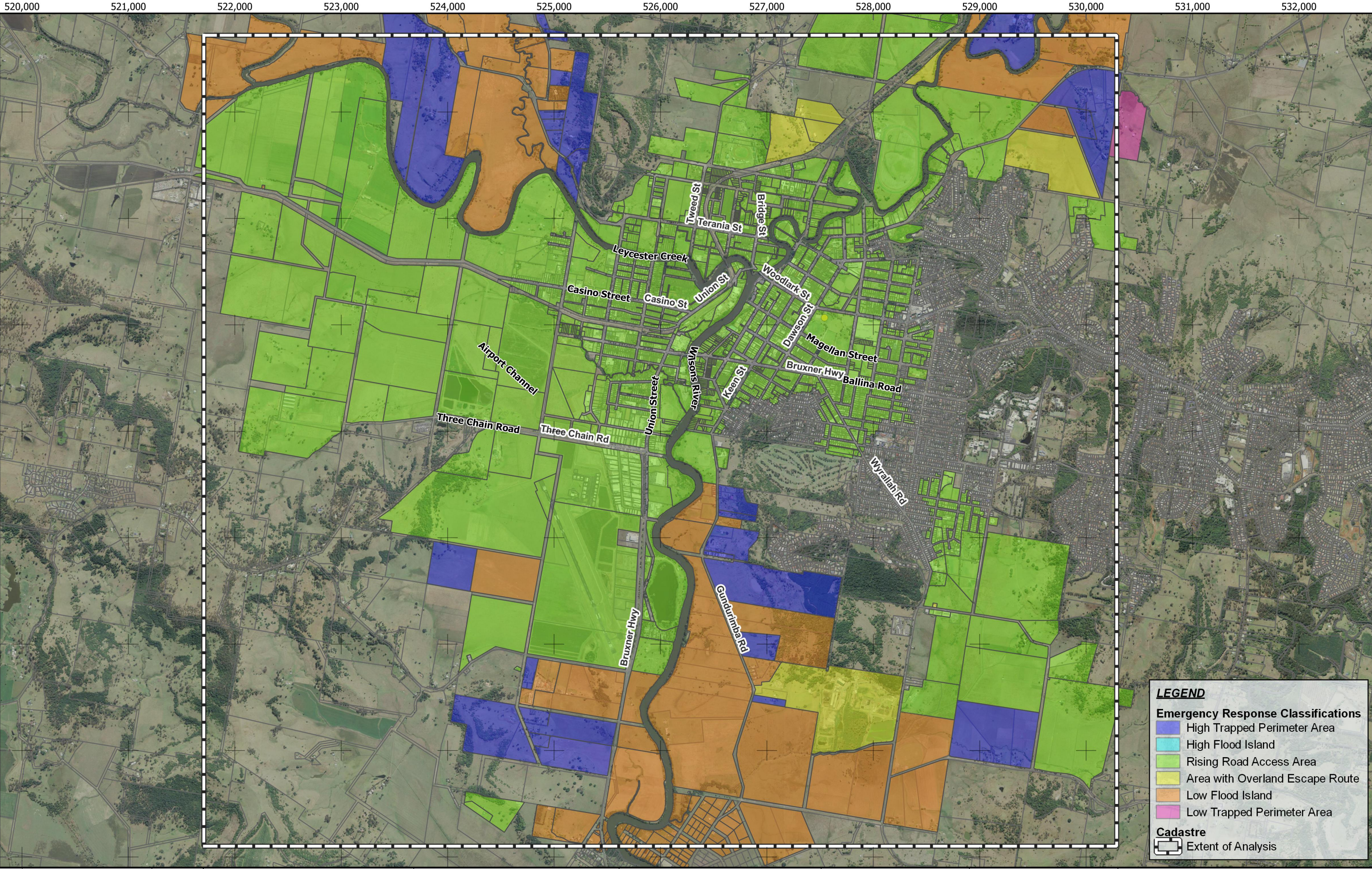
Evacuation Zone	Flood Likelihood - Number of Buildings Inundated										
	10% AEP	5% AEP	1% AEP	0.2% AEP	1:1,000 AEP	1:2,000 AEP	1:10,000 AEP	1:100,000 AEP	PMF	February 2022	March 2022
Central Lismore	179	376	727	1,079	1,273	1,295	1,319	1,375	1,400	1,320	220
East Lismore	34	96	172	220	246	251	258	269	271	258	39
North Lismore	9	39	89	144	233	244	248	265	281	248	11
South Lismore	58	125	306	517	709	749	776	856	927	778	73
TOTAL	280	636	1,294	1,960	2,461	2,539	2,601	2,765	2,879	2,604	343

Key constraints to consider for evacuation are outlined for each evacuation precinct in Lismore, with evacuation routes shown on Figure 2.8.

TABLE 2.3: EVACUATION CONSIDERATIONS

Evacuation Precinct	Evacuation Routes	Commentary
South Lismore	South 1 - East along Casino Street, south onto Union Street, and across Ballina Street Bridge. South 2 - East along Three Chain Road, north onto Union Street, and across Ballina Street Bridge. South 3 – Union Street residents should evacuate south to route South 1. South 4 – North along Wilson Street and across Robert White Bridge and joining North 1 or 2.	Timely evacuation from South Lismore is critical, with inundation of isolated areas observed in a 10% AEP flood event, and widespread flooding from a 5% AEP flood event and greater. Evacuation route South 1 remains trafficable in a 10% AEP flood event, with closure of roads in South Lismore and along the route occurring in a 5% AEP flood event or greater. Ballina Steet Bridge has a high immunity, however, trafficability of the route is impacted by inundation and low immunity of the surrounding roads in South Lismore and the Lismore CBD. Trafficability of the Hollingworth Creek Bridge and approaches is a key constraint for evacuation along route South 2 and will close relatively early during flood events whilst the remainder of the route remains trafficable. For residents along Union Street, evacuation across Union Street Bridge is not recommended. Whilst the bridge itself has an estimated 1% AEP flood event immunity, the approaches are inundated by Leycester Creek flooding in as low as a 10% AEP flood event. For South 4, Robert White Bridge only remains an option for evacuation in an event less than a 5% AEP flood event, with the northern and southern approaches becoming inundated in events exceeding this.

Evacuation Precinct	Evacuation Routes	Commentary
North Lismore	North 1 - South along Bridge Street and across Fawcett Bridge. North 2 - North on Tweed Street or Bridge Street/Alexandra Parade, then Dunoon Road.	Route North 1 is a viable option for evacuation up to the point at which the levee overtops if localised access in North Lismore can be achieved. It is crucial that evacuation utilising North 2 is considered early in a flood event, with this evacuation route becoming significantly inundated in flood events with as small a magnitude as the 10% AEP event.
CBD	CBD 1 – North along Keen Street then east along Bruxner Highway. CBD 2 – South along Dawson Street then east along Bruxner Highway. CBD 3 – North along Dawson Street then east along New Ballina Road.	The CBD levee provides significant opportunity for evacuation of this area, and full evacuation of the CBD should be actioned prior to the levee overtopping, as flows through the CBD have significant velocity causing risk to persons and vehicle stability.
East Lismore	North on Wyrallah Road, Dibbs Street.	Evacuation via Wyrallah Road is recommended as this route remains flood free up to the PMF event from north of the intersection with Skyline Road.



LEGEND

Emergency Response Classifications

High Trapped Perimeter Area

High Flood Island

Rising Road Access Area

Area with Overland Escape Route

Low Flood Island

Low Trapped Perimeter Area

Cadastral

Extent of Analysis

R	DETAILS	DATE
1	Final Issue	05-04-2024

© COPYRIGHT Engeny This drawing is confidential and shall only be used for the purpose of this project.			
DRAWN	ST	CHECKED	MP
APPROVED	MP	DATE	05-04-2024
NOTES:			

N

0

0.7

1.4 km

SCALE @ A3 - 1:30000

GDA94 / MGA zone 56

DISCLAIMER

Engeny has endeavoured to ensure accuracy and completeness of the data. Engeny assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE

NSW Six Map Open Data

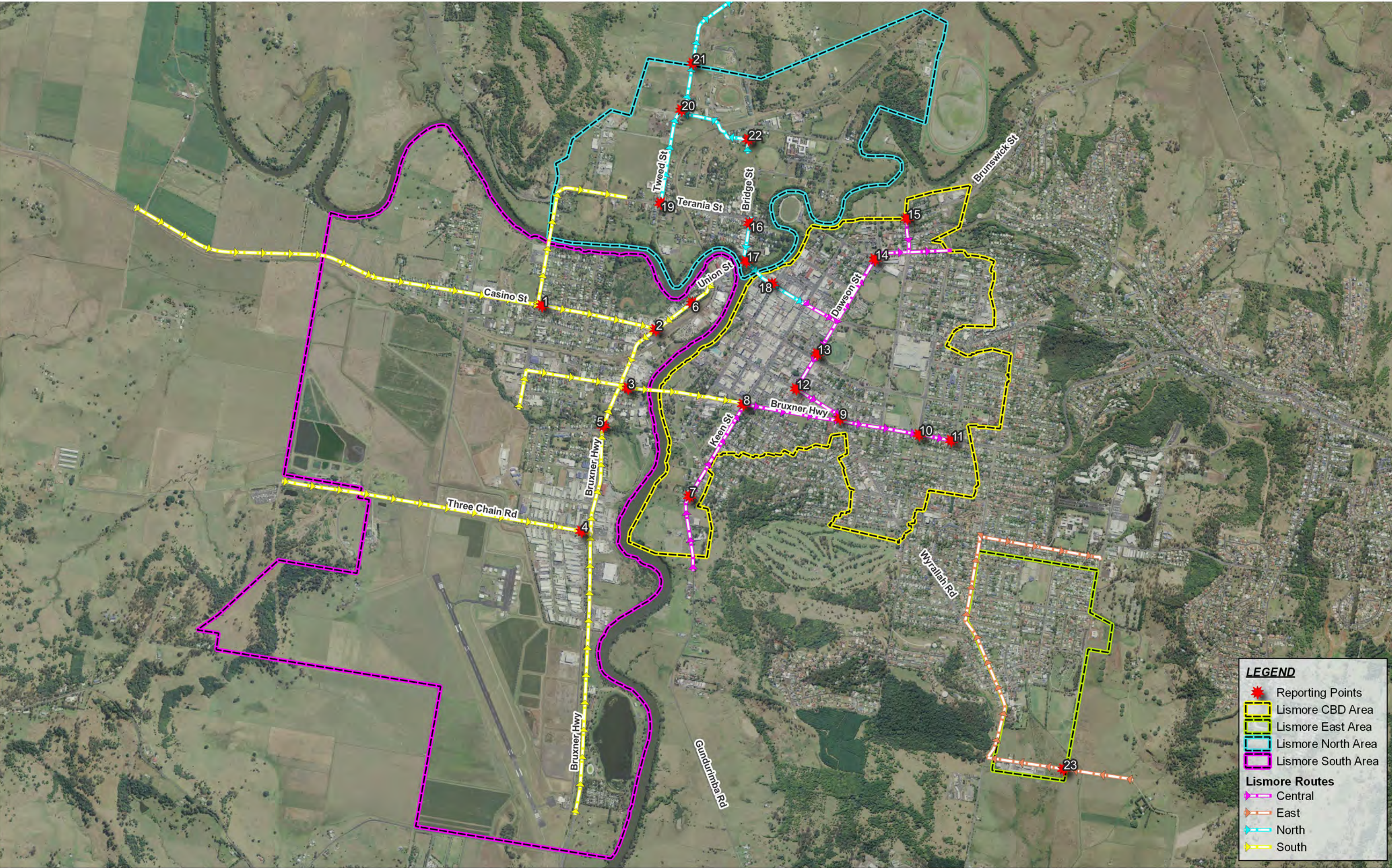


Figure 2.7

Lismore Floodplain Risk Management Plan
Flood Emergency Response Classifications

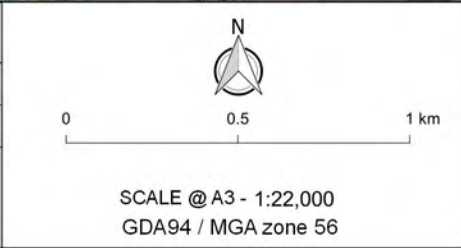
Drg Ref.

M92000_007



R	DETAILS	DATE
1	Final Issue	05-04-2023

© COPYRIGHT Engeny This drawing is confidential and shall only be used for the purpose of this project.			
DRAWN	ST	CHECKED	MP
APPROVED	KM	DATE	05-04-2023
NOTES			



DISCLAIMER
Engeny has endeavoured to ensure accuracy and completeness of the data. Engeny assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE
NSW Six Map Open Data

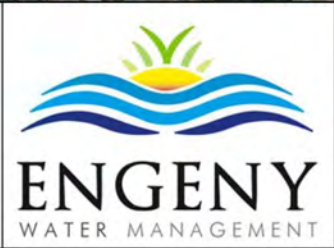
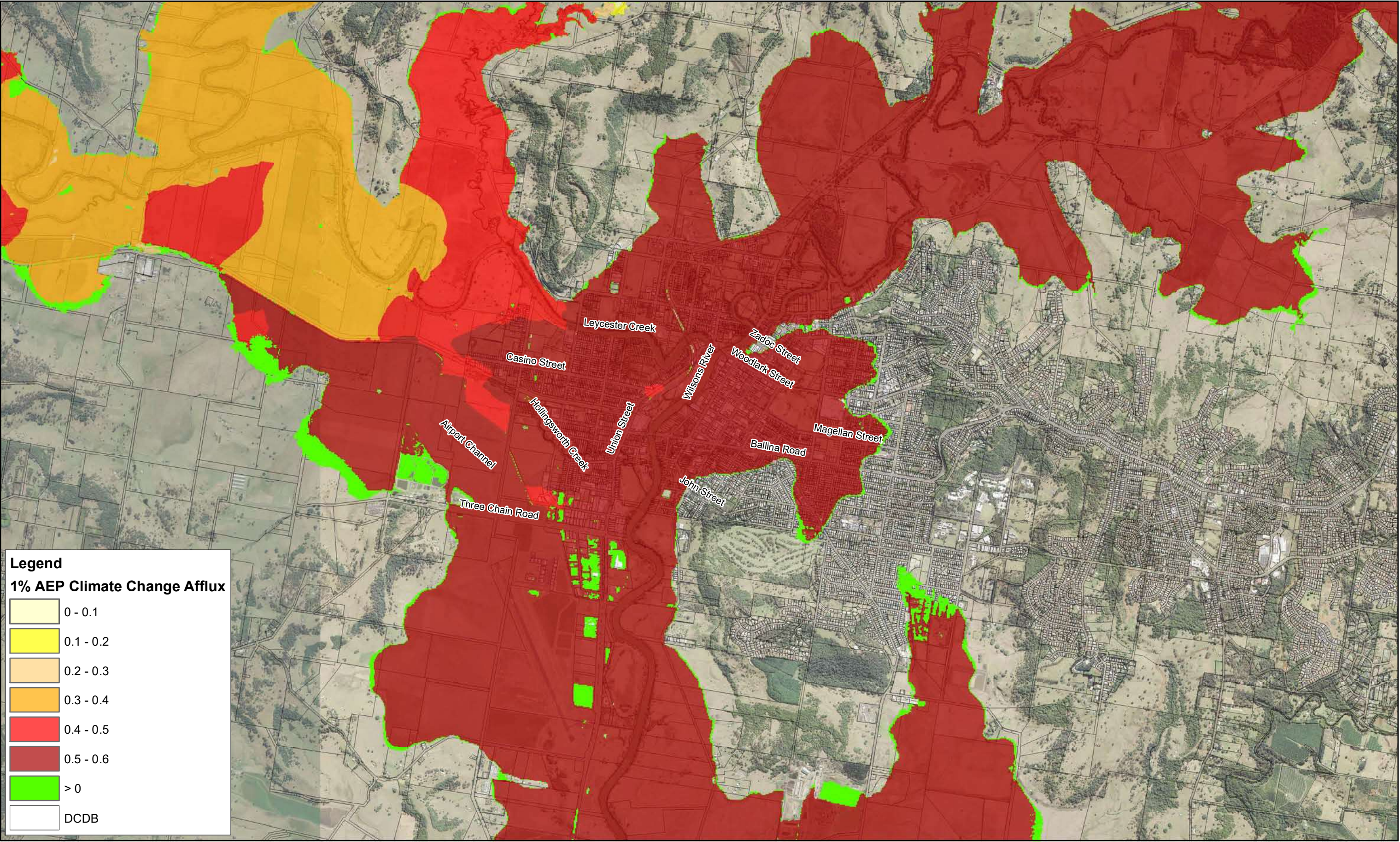


Figure 2.8
Key Routes and Precincts for Evacuation

Doc Ref
M92000_007

2.7 Climate Change Impacts

To estimate the impact of climate change on flood conditions in Lismore, Representative Concentration Pathway (RCP) 8.5 future climate conditions was adopted. This reflects an increase in rainfall intensity of 19.7% to account for a temperature increase of about 4.3°C by 2090, considered the “worst-case” as provided by the Australian Rainfall and Runoff (ARR) 2019 Data Hub. The resultant 1% AEP flood afflux mapping, shown as a difference between the climate change scenario and the design scenario 1% AEP flood height results, is provided in Appendix A. The mapping indicates that the estimated increase in intensity will result in increases to design flood levels of approximately 350-600 mm across the PMF flood extent and is provided in Figure 2.9. The extent of inundation was shown to be increased (indicated on flood impact map as ‘was dry now wet’), particularly within South Lismore and the fringe areas of the floodplain. This is likely to result in impacts to currently unaffected properties. In particular, impacts to multiple properties surrounding Wade Park and Nielson Park were observed due to backwater from the Wilsons River up the Gundurimba Canal.



R	Details	Date	©COPYRIGHT Engeny Water Management This drawing is confidential and shall only be used for the purpose of this project.				Scale @ A3 -1:31,852 GCS GDA 1994 MGA Zone 55	DISCLAIMER Engenyh has endeavoured to ensure accuracy and completeness of the data. Engeny assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map. DATA SOURCE QLD Government Open Source Data	DESIGNER	CLIENT	Figure 2.9
1		09/11/22									Lismore Floodplain Risk Management Plan Climate Change Impacts 1% AEP Climate Change Afflux
-			DESIGNED	MD	CHECKED	MD					
-			DRAWN	MD	CHECKED	MD					
-			APPROVED	MD	DATE	09/11/22					
-			Notes:								
-											
-											

3. FLOOD RISK MANAGEMENT OPTIONS

3.1 Introduction

Due to the Northern Rivers Resilience Initiative by CSIRO, determination of preferred flood behaviour modification measures has not been included in this FRMP. However, previously considered structural mitigation measures including additional measures beyond those identified in the FRMS have been considered, in consultation with DCCEEW and the Lismore Flood Risk Management Committee (FRMC) following the 2022 flood event.

Flood risk management measures are categorised into the following:

- Property modification measures
- Response modification measures
- Flood behaviour modification measures.

The following sections describe the details pertaining to each identified flood risk management measure.

3.2 Property Modification Measures

3.2.1 PM01 – Zoning and Development Control

This option is centred around a review of the Lismore LEP and DCP, considering latest flood risk information and the 2022 flood events. This action is currently being completed by LCC, utilising detailed information and recommendations provided in the *Lismore Floodplain Risk Management Plan – Land Use Planning and Development Control* document (Engeny, 2023) and the *Update on Addressing Flood Risk in Planning Decisions* Planning Circular (NSW Gov, 2024).

Restricting the type, locality and flood immunity levels for future development is an effective tool in managing future flood risk. Effective planning controls may allow appropriate development in constrained areas. This measure has little impact on existing flood risk and is reliant on suitable planning and development assessment.

Council has already made amendments to the Lismore LEP 2012, by adopting the Special Flood Considerations clause. A revised Flood Prone Lands DCP should be adopted that incorporates risk precincts from this FRMP and defines a new FPL.

3.2.2 PM02 – Voluntary House Purchase (VHP)

A \$700M Resilient Homes Program (RHP) is currently being implemented by the NSW Reconstruction Authority (RA) following the 2022 flood events. Within this, homes have been identified for VHP. VHP is effective at managing current and future flood risk, by removing populations from flood risk. While the scope of the program applies to areas of greatest of flood risk across the Northern Rivers region, some properties have been deemed ineligible and some landowners have refused buybacks. Expansion of the program by Council within Lismore should be considered to provide additional opportunities for VHP for those remaining properties in the areas of highest risk.

Prioritisation of properties for VHP within the floodplain by LCC should be based on a review of the RA criteria, process, and outcomes.

Additionally, it is also recommended that LCC work closely with the RA to identify suitable flood-free land to assist with relocation of flood-affected properties at a price that is affordable to those seeking relocation. The \$100M Resilient Lands Program currently being administered by the RA is identifying new parcels of land that could be released for future residential development, which could be considered in conjunction with relocation of flood-affected properties.

3.2.3 PM03 – Voluntary House Raising (VHR) and Retrofitting

Also included under the RHP is state funding for VHR and retrofitting of homes within the floodplain. Similarly to VHP, prioritisation of properties for VHR and retrofitting within the floodplain by LCC beyond those identified in the RHP is recommended based on a review of the RA criteria, process, and outcomes.

3.2.4 PM04 – Increase Access by Raising Access Roads

This option was identified in the FRMS (Engeny, 2021), and involves raising of local roads to allow for improved access and egress to flooded properties during flood events. Although not yet hydraulically assessed, there is concern that the option will result in an increase to flood hazard and risk to existing properties that are located below the roads. It is unlikely that isolated upgrades to local roads will provide enhanced flood free access due to the complexity and extent of the floodplain. However, further investigation of infrastructure upgrades to evacuation routes by the NSW RA, funded by the Northern Rivers Recovery and Resilience Program (NRRRP), will continue to explore possible options.

No further action is recommended for Council in this FRMP for this measure.

3.3 Response Modification Measures

3.3.1 RM01 – Community Flood Awareness Readiness Programs

Continuation of education and increase to local community awareness through regular Council business functions such as proposed development guidance and assessment as well as developing a community awareness strategy to disseminate the latest flood information is a recommended action under this FRMP. Elements that could be incorporated include:

- Provision of up-to-date flood information to households within the identified Lismore floodplain (i.e. affected by PMF event). The information should incorporate the latest 1% AEP flood levels, 2022 flood levels, nearest evacuation routes and destinations. Key contact numbers for Council and NSW SES, and advice on being ‘flood ready’ should be included.
- Update of flood-related information on Council’s website to ensure ease of access to up-to-date information for residents.
- Increased awareness of historical flooding using a range of flood markers showing historical events including the 2022 flood levels around the floodplain on totem poles, power poles, buildings, etc.
- Continuation of the FRMC, as a group tasked with identification, review, and implementation of education strategies for the broader community.
- A Flood Awareness Week update to reflect the latest information gained from the 2022 flood events to continue annually in Lismore. The intent of the week would be to undertake community consultation and education, and promotion of emergency response, services, and procedures in the instance of a flood.

In addition, it should be noted that a Regional Community Flood Awareness Project is currently being delivered under the NRRRP, with an expected completion date of June 2025. The objectives of the program include:

- To develop local flood risk information, resources, and tools to support the effective rollout of the Resilient Homes Program and the engagement about place-based adaptation.
- To collaborate with key stakeholders and the community in creating a shared history of flooding in the region increasing trust and ownership in flood information.
- To create broad and targeted communication and campaigns to increase local and regional flood risk awareness and ensure evacuation readiness for future floods.

3.3.2 RM02 – Improve Flood Predictions and Warning

It is recommended that Council consider utilising the flood results from the FRMS to further identify localities for passive and active flood warning signs. It is noted that since the 2022 flood events, additional signage has already been placed at Wyrallah Road, Boatharbour Road, and Nimbin Road.

Flood warnings are currently provided by the Bureau of Meteorology. A \$15M program led by DCCEEW, and specific to Lismore, is underway to develop a Richmond and Wilsons Valleys Flood Warning System. Dependent on the outcomes from this project there could be scope for Council to further expand upon the system within the Wilsons River catchment, utilising the URBS and TUFLOW models developed for the FRMS.

3.3.3 RM03 – Update Local Flood Plan (LFP) to Assist with Emergency Response for Floods

An update to the Lismore Local Flood Plan (LFP) has been completed by NSW SES in 2024. For consistency, flood risk management identified under the LFP has not been repeated in this FRMP document.

3.3.4 RM04 – Floor Level Survey

A NRRRP project relating to floor level survey is expected to be completed in 2024. It is understood that floor level surveys will be undertaken across all LGAs within the Northern Rivers region. Surveys will be undertaken using vehicle-based LiDAR to infer floor levels from the front doorstep (or weepholes in brick houses) at +/- 0.1 m vertical accuracy. This information has the potential to be rolled back through as inputs to flood risk assessments, to enhance the identification of at-risk properties, and to support the extension of the VHP and VHR schemes. Council should incorporate this information into its property flood information portal and flood certificates. Council should also endeavour to complete floor level surveys for any properties not included in the regional program so that it has floor level data for all properties within the PMF extent.

3.3.5 RM05 - Regional Evacuation Route and Infrastructure Assessment Program

A NRRRP project is currently underway to assess regional evacuation routes, their capacity, and options for infrastructure upgrades across all Northern Rivers Region LGAs. The project is expected to be complete in 2025. It will include:

- Mapping of subsectors and evacuation routes.
- Assessment of evacuation routes for low points/risks to being cut off.
- Localised flood modelling for each low point, to understand detailed flood risk exposure.
- Identification and scoping of smaller evacuation route upgrades.
- A source of truth for consistent flood modelling for region, including need for further flood modelling to identify range of hydrographs.
- A source of truth for property information (no. of dwellings, cars), including one database for the floor level surveys.
- A Flood Evacuation Model to support modelling for larger road upgrades.

There are no current actions identified for Council in this FRMP related to this measure, however outcomes from the project should be incorporated into relevant flood emergency management communication (RM01 and RM03).

3.3.6 RMO6 – Extension of Lismore Hydraulic Model for LGA

Following the completion of the CSIRO regional hydraulic modelling underway at the time of this FRMP, Council should undertake a review of the local Lismore hydraulic model, with the intent of extending it to cover the entirety of the LGA. An extension of the model would enable increased knowledge on flood risk for the entirety of the LGA, beyond the Study Area for which this FRMP applies to.

3.4 Flood Behaviour Modification Measures

3.4.1 FB01 – Raise CBD Levee to Provide 5% AEP Flood Immunity

This option was assessed in the FRMS (Engeny, 2021), and involves raising the existing CBD levee along the current alignment, to achieve 5% AEP immunity. The adopted levels vary down the length of the levee from approximately 12.2 m AHD at the northern end to 11.4 m AHD at the southern end. Relatively, this represents an average raise of between 200 and 400 mm along the entire length of the levee. This levee height should be sufficient to protect against flood events in the magnitude of the 1887 and 2017 flood events, but events larger than this such as the 1880, 1889, 1956, 1974, and 2022 flood events would be expected to overtop the levee.

3.4.2 FB02 – Raise South Lismore Levee to Provide 5% AEP Flood Immunity

This option was assessed in the FRMS (Engeny, 2021), and is reflective of a raise to the existing South Lismore levee along the current alignment, to achieve 5% AEP immunity. The adopted levels vary down the length of the levee from approximately 12.6 m AHD at the northern end to 11.8 m AHD around Hollingworth Creek. Relatively, this represents an average raise of between 200 and 500 mm along the levee.

3.4.3 FB03 - Excavate to Increase Conveyance on Wilsons River Bend

This option was assessed in the FRMS (Engeny, 2021), and the intent of the option was to increase conveyance downstream of Lismore, by reducing the constriction at the Wilsons River bend through excavation. Excavating the land located at 363-389 Keen Street which is on the eastern bank of Wilsons River by 1-3 m down to 4.9 m AHD was investigated.

3.4.4 FB04 - Increase Conveyance at key Hydraulic Controls at Bruxner Highway, Caniaba Road and Krauss Avenue

This option was assessed in the FRMS (Engeny, 2021), and represents upgrades to key hydraulic controls downstream of Lismore to increase conveyance through South Lismore. Generally, the option would involve widening the existing bridge or increasing the number of culverts at crossings. The three locations chosen to undertake upgrades are the bridge crossing at Bruxner Highway (approximate 40 m widening), the culvert crossing at Caniaba Road (approximate 40 m widening) and the parallel adjacent bridge crossings at Krauss Avenue and Bruxner Highway (both approximate 10 m widening).

3.4.5 FB05 - Combined Option, Reflective of Implementing Options 1 to 5 in the FRMS

This option was assessed in the FRMS (Engeny, 2021), and reflects implementation of the five flood modification measures discussed above into a single option. The only change to the options as previously described was the removal of the excavation at the baseball fields in Option 3, leaving only the proposed excavation at 363-389 Keen Street.

3.4.6 FB06 – Nature Based Solutions for Flood Risk Management

A regional long-term project investigating riparian revegetation and reforestation for flood resilience in the Clarence, Richmond, Tweed, and Brunswick catchments is underway. Revegetation of riparian zones and reforestation of marginal grazing country achieves the benefits of slowing overland and stream water flows, retaining additional water until saturation and full runoff occurs, stabilising erodible soils including on streambanks and reducing stream and estuarine siltation and turbidity. Completion is proposed in 2027.

The “Heal the Rivers” Flood Recovery and Landscape Restoration project is also being completed throughout the Northern Rivers catchments. An indigenous led integrated knowledge system combining knowledge of first nations communities with other cultural and environmental data to inform and plan local strategies and activities including revegetation, erosion control and wetland restoration along with cultural site protection. Completion is proposed in 2027.

\$2.8M has also been made available through the RA for the Resilience in the Lismore Catchment project, which is currently being administered by Richmond Landcare.

Depending on the outcomes from these programs, and available funding, Council should consider further expanding the application of NBS in the Wilsons River catchment.

3.4.7 FB07 – East Lismore Defence at Monaltrie Road

This option was assessed as requested by the Lismore FRMC in June of 2023 (see Appendix B for documentation). This option involves a levee alignment extending from the ridge south of Monaltrie Road to adjacent the sewage treatment plant (STP) for a total length of 1,750 m. Average existing ground elevations through the alignment are approximately 8 m AHD. In order to provide mitigation for a flood event equivalent to the February 2022 flood height, the levee would need to be constructed to a height of approximately 13 m AHD, resulting in an average embankment height of 5 m.

3.4.8 FB08 – Flood Defence at Wyrallah Road

This option was assessed as requested by the Lismore FRMC in June of 2023 (see Appendix B for documentation). This option involves a levee alignment located to protect the STP from floods with a levee surrounding the STP. The total length of the levee is 1,200 m. Average existing ground elevations through the alignment are approximately 8 m AHD. In order to mitigate for a flood event equivalent to the February 2022 flood height, the levee would need to be constructed to a height of approximately 13 m AHD, resulting in an average embankment height of 5 m.

3.4.9 FB09 – East Lismore Flood Defence at Wilson Park School

This option was assessed as requested by the Lismore FRMC in June 2023 following the 2022 flood event (see Appendix B for documentation). This option is a levee alignment to provide flood protection the East Lismore residential areas. The total length of the levee is 960 m. Average

existing ground elevations through the alignment are approximately 9 m AHD. In order to mitigate for a flood event equivalent to the February 2022 flood height, the levee would need to be constructed to a height of approximately 13 m AHD, resulting in an average embankment height of 4 m.

3.4.10 FB10 - Leycester Creek Bypass Channel

This option was requested for assessment by DCCEEW in October 2022 following the 2022 flood event (formerly Department of Planning and Environment (DPE)) (see Appendix B for documentation). The option configuration involves an upstream off-take from Leycester Creek at 9 m AHD (estimated event causing offtake is 50%-20% AEP flood event) and a downstream tie-in to Wilsons River at 4 m AHD. The estimated channel capacity is 1,400 m³/s, almost the 10% AEP peak flow in Leycester Creek.

3.4.11 FB11 - Raise of South Lismore Levee to the 1% AEP Flood Level

This option was requested for assessment by DCCEEW in October 2022 following the 2022 flood event (refer Appendix B for documentation). The option involves raising of the South Lismore levee to ensure no overtopping of Leycester Creek breakout flows from the west in the 1% AEP flood event. A consistent raise of 500 mm is required for 1% AEP immunity.

3.4.12 FB12 – Raise of South Lismore Levee to the 1% AEP Flood Level plus Leycester Creek Bypass Channel

This option was requested for assessment by DCCEEW in October 2022 following the 2022 flood event (refer Appendix B for documentation). It is a combination of FB10 and FB11.

3.4.13 FB13 – Raise of CBD Levee to the 5% AEP Flood Level plus Leycester Creek Bypass Channel

This option was requested for assessment by DCCEEW in October 2022 following the 2022 flood event (refer Appendix B for documentation). It is a combination of FB10 and FB01.

3.4.14 FB14 – Raise of CBD Levee to the 1% AEP Flood Level plus Leycester Creek Bypass Channel

This option was requested for assessment by DCCEEW in October 2022 following the 2022 flood event (refer Appendix B for documentation). It is a combination of FB10, with a raise to the CBD levee consisting of a 13 m extension of the levee at John Street. Also includes a 185 m extension of the levee at Molesworth Street, a raise to 1,150 m of the concrete sections of the levee to an additional 1 m, and a raise to 800 m of the of the earthen embankment sections of the levee to an additional 400 mm.

3.4.15 FB15 – Flood Risk Management Infrastructure

\$25M of funding has been made available under the NRRRP to upgrade pumps and pump stations in Lismore, inclusive of the below items:

- Extra pump at the Lower Hollingworth pump station.
- Increase capacity in Browns Creek pump station.
- Power supply backups for all pump stations (levee/sewer).
- Raise pump control rooms/towers in all pump stations.
- Refurbish Browns Creek flood gate.
- Refurbish Upper Hollingworth Creek flood gate.
- New electric submersible pump stations (x2) at levee near Snow Street and Three Chain Road.

Expected to be completed by February 2025, benefits include improved resilience to floods by improving pump station infrastructure, flood control infrastructure, and power supply backups across a number of different locations. These measures will decrease the severity and impact of floods on the local community and ensure a higher level of resilience.

An additional \$2.7M project is underway to electrify/install SCADA pump system to replace the current tractor pump to remove stormwater from the Lismore CBD, thereby improving evacuation from the CBD and providing better access to critical infrastructure and emergency services.

There are no further actions identified for Council in this FRMP related to this measure.

3.4.16 FB16 – Removal of Constriction at Brewster Street

A \$1M project is underway through RA to modify the Browns Creek flood channel and upgrade the culvert and re-route services currently restricting flow at Brewster Street. The project is expected to improve evacuation routes and extend evacuation timeframes.

There are no further actions identified for Council in this FRMP related to this measure.

3.5 Multi-Criteria Analysis Approach

A multi-criteria assessment (MCA) was used to compare and prioritise implementation of the measures based on feasibility, in accordance with guidance provided in Flood Risk Management Measures – Flood Risk Management Guideline MM01 (NSW Gov, 2023). Of the flood risk management measures identified in Section 3, only options yet to be implemented, and within Council’s responsibility to implement, have been captured in the below MCA. The full list of measures and their inclusion in the MCA or not are provided in Table 3.1.

TABLE 3.1: SUMMARY OF FLOOD RISK MANAGEMENT MEASURES

Measure	Status	Included in MCA?
PM01 – Zoning and Development Control	Partial completion by Council at time of preparing this FRMP.	Yes
PM02 – Voluntary House Purchase (VHP)	Partial completion through RA at time of preparing this FRMP.	Yes
PM03 – Voluntary House Raising (VHR) and Retrofitting	Partial completion through RA at time of preparing this FRMP.	Yes
PM04 – Increase Access by Raising Access Roads	-	Yes
RM01 – Community Flood Awareness Readiness Programs	-	Yes
RM02 – Improve Flood Predication and Warning	Partially underway through DCCEEW. Opportunity for Council to extend passive warnings.	Yes
RM03 – Update Local Flood Plan (LFP) to Assist with Emergency Response for Floods	Completed by NSW SES.	No
RM04 – Floor Level Survey	Currently being implemented through NRRRP. Council to consider extending program if all buildings within PMF not surveyed.	Yes
RM05 – Regional Evacuation Route and Infrastructure Assessment Program	Currently being implemented through NRRRP.	No
RM06 – Extension of Lismore Hydraulic Model	-	Yes
FB01 – Raise CBD Levee to Provide 5% AEP Flood Immunity	-	Yes
FB02 – Raise South Lismore Levee to Provide 5% AEP Flood Immunity	-	Yes
FB03 – Excavate to Increase Conveyance on Wilsons River Bend	-	Yes
FB04 – Increase Conveyance at key Hydraulic Controls at Bruxner Highway, Caniaba Road, and Krauss Avenue	-	Yes
FB05 – Combined Option, Reflective of Implementing Options 1 to 5 in the FRMS	-	Yes

Measure	Status	Included in MCA?
FB06 – Nature Based Solutions for Flood Risk Management	Currently being implemented through NRRRP. Opportunity for further expansion in the Wilsons River catchment.	Yes
FB07 – East Lismore Defence at Monaltrie Road	-	Yes
FB08 – Flood Defence at Wyrallah Road	-	Yes
FB09 – East Lismore Flood Defence at Wilson Park School	-	Yes
FB10 – Leycester Creek Bypass Channel	-	Yes
FB11 – Raise of South Lismore Levee to the 1% AEP Flood Level	-	Yes
FB12 – Raise of South Lismore Levee to the 1% AEP Flood Level plus Leycester Creek Bypass Channel	-	Yes
FB13 – Raise of CBD Levee to the 5% AEP Flood Level plus Leycester Creek Bypass Channel	-	Yes
FB14 – Raise of CBD Levee to the 1% AEP Flood Level plus Leycester Creek Bypass Channel	-	Yes
FB15 – Flood Risk Management Infrastructure	Currently being implemented through NRRRP.	No
FB16 – Removal of Constriction at Brewster Street	Currently being implemented through NRRRP.	No

Through the MCA, the measures were assessed for their ability to reduce flood risk while also considering their economic, social, and environmental impacts. The broad categories of criteria included the following:

- Implementation/construction feasibility.
- Flood behaviour – impacts and benefits (assessment of flood behaviour modification measures focusing on reduction of flood risk in minor to moderate magnitude flood events have previously been assessed by Engeny as a component of the FRMS, and in response to requests from the NSW DCCEEW and the Lismore FRMC).
- People – impacts and behaviour.
- Social set – impacts and benefits.
- Cultural impacts and benefits.
- Public administration – impacts and benefits.
- Economic efficiency.

The criteria and scoring system which contributes to the development of the MCA is provided in Table 3.2. The resultant detailed scoring against criteria is provided in Appendix A.

The results from the MCA and the subsequent prioritisation of the measures are discussed in the following sections.

TABLE 3.2: MCA CRITERIA AND SCORING

Category	Criteria	Metric	Score						
			-3	-2	-1	0	1	2	3
Feasibility	Technical Feasibility	Potential design, implementation, or operational constraints	Major constraints and uncertainties which may render the option unfeasible	Constraints or uncertainties which may significantly increase costs or timeframes	Constraints or uncertainties which may increase costs or timeframes moderately	Not applicable for option	Constraints that can be overcome with moderate investment of time and resources	Constraints that can be overcome easily	No constraints or uncertainties
	Financial Feasibility	Likely feasibility of funding of capital cost of option	Significant capital and ongoing costs, or no external funding or assistance available	Moderate capital and ongoing costs, no funding available	High capital and ongoing costs, partial funding	Not applicable for option	Moderate capital and ongoing costs, partial funding available; or low capital and ongoing costs, no funding available	Low to moderate capital and ongoing costs, partial funding available	Full external funding and management available
	Adaptability to change for long term feasibility	Performance under future climate change conditions, contribution to mitigation of or adaptation to changing climate	Flood risk likely to increase over time	Benefits fully removed over time	Benefits partially removed over time	Neutral	Provides some mitigation in a changing climate	Provides moderate mitigation in a changing climate	Entirely mitigates changing climate
	Community Acceptability	Level of agreement (expressed via formal submissions and informal discussions)	Strong opposition by numerous submissions	Moderate opposition in several submissions	Individual submissions with opposition	Neutral	Individual submissions with support	Moderate support in several submissions	Strong support by numerous submissions

Category	Criteria	Metric	Score						
			-3	-2	-1	0	1	2	3
Flood Behaviour Impacts and Benefits	Impact on Properties	Change to number of properties flooded over floor in flood events analysed	Above floor inundated increased	Moderate increase to number of lots affected	Some increase to number of lots affected	None / Change Acceptable	Reduction to number of lots affected	Reduction to number of lots affected, minor reduction to above floor inundation	Above floor inundation reduced, significant reduction in lot affectation
	Impact on Flood Hazard / Risk to Life	Change in hazard classification	Significantly increased in highly populated area	Moderately increased in populated area	Slightly increased	No Change	Slightly reduced	Moderately reduced in populated area	Significantly reduced in highly populated area
People Impacts and Benefits	Community Flood Awareness	Change in community flood awareness, preparedness, and response	Significantly reduced	Moderately reduced	Slightly reduced	No Change	Slightly improved	Moderately improved	Significantly improved
	Evacuation and Access	Improvement to access and evacuation	Significant increase to flood depths and/or hazard over key roads	Moderate increase to flood depths and/or hazard over key roads	Slight increase to flood depths and/or hazard over key roads	No Change	Slight decrease to flood depths and/or hazard over key roads	Moderate decrease to flood depths and/or hazard over key roads	Significant decrease to flood depths and/or hazard over key roads
	Impact on Emergency Services	Change in demand on emergency services (SES, Police, Ambulance, Fire, RFS etc)	Major disbenefit	Moderate disbenefit	Minor disbenefit	Neutral	Minor benefit	Moderate benefit	Major benefit

Category	Criteria	Metric	Score						
			-3	-2	-1	0	1	2	3
Environmental	Environmental and Ecological Impacts	Impacts or benefits to flora/fauna	Likely broad-scale vegetation/habitat impacts	Likely isolated vegetation/habitat impacts	Removal of isolated trees, minor landscaping.	Neutral	Opportunity for planting of isolated trees, minor landscaping.	Opportunity for moderate enhancement of disparate area	Opportunity for large scale enhancement / improved connectivity of habitats
Social impacts and benefits	Recreation	Impacts to recreation or public domain	Significant decrease or removal of recreation and/or public domain	Moderate decrease or removal of recreation and/or public domain	Slight decrease or removal of recreation and/or public domain	No Change	Slight improvement or introduction of recreation and/or public domain	Moderate improvement or introduction of recreation and/or public domain	Significant improvement or introduction of recreation and/or public domain
	Property and insurance	Improvement to property prices or reduction in insurance	Significant decrease in property prices or reduction in insurance risk	Moderate decrease in property prices or reduction in insurance risk	Slight decrease in property prices or reduction in insurance risk	No Change	Slight increase in property prices or reduction in insurance risk	Moderate increase in property prices or reduction in insurance risk	Significant increase in property prices or reduction in insurance risk
Cultural impacts and benefits	Cultural heritage improvement	Impacts or benefits to cultural sites and practices	Significant negative impact to cultural sites or practices	Moderate negative impact to cultural sites or practices	Slight negative impact to cultural sites or practices	No Change	Slight positive impact to cultural sites or practices	Moderate positive impact to cultural sites or practices	Significant positive impact to cultural sites or practices
Public administration – impacts and benefits	Legislative Compliance	Consistency with legislative or policy requirements	Non-compliant	Compliance issues considered possible to overcome	Resource burden to navigate approvals	Neutral	Minor approvals required, compliant	No approvals required, compliant	Improves compliance

Category	Criteria	Metric	Score						
			-3	-2	-1	0	1	2	3
	Impact on Critical and/or Vulnerable Facilities	Disruption to critical facilities	Significant increase in flood risk	Moderate increase in flood risk	Minor increase in flood risk	No Change	Minor reduction in flood risk	Moderate reduction in flood risk	Significant reduction in flood risk
	Compatibility with existing Council plans, policies, or strategic direction	Level of compatibility	Conflicts directly with objectives of several plans, policies, or projects	Conflicts with several objectives or direct conflict with one or few objectives	Minor conflicts with some objectives, with scope to overcome conflict	Not Relevant	Minor support for one or few objectives	Some support for several objectives, or achieving one objective	Achieving objectives of several plans, policies, or projects
Economic Efficiency	Benefit-Cost	Comparison to the capital cost of the option, per building with above floor flooding likely removed in the 5% AEP event	Decrease in number of buildings protected	No additional buildings protected	>100k per property	50-100k per property OR Not applicable for option	20-50k per property	5-20k per property	<5k per property

3.6 Multi-Criteria Analysis Results

Each flood risk management measure identified as applicable for the MCA as per Table 3.1 has been assessed, and a raw score and ranking applied in order to determine whether the options should be considered for implementation. In the instances of the flood behaviour modification measures, further investigation is recommended prior to implementation. The MCA scores and ranking are provided in Table 3.3.

TABLE 3.3: ASSESSMENT OF FLOOD RISK MANAGEMENT OPTIONS

Option ID	Option	Raw Score	Raw Rank	Recommended for Implementation or Further Investigation?
PM01	Zoning and Development Control	18	1	Yes
RM02	Improve Flood Warning	18	1	Yes
FB01	Raise CBD Levee to Provide 5% AEP Flood Immunity	17	3	Yes
RM01	Community Flood Awareness Readiness Programs	15	4	Yes
FB02	Raise South Lismore Levee to Provide 5% AEP Flood Immunity	14	5	Yes
PM02	Voluntary House Purchase (VHP)	13	6	Yes
FB11	Raise of South Lismore Levee to the 1% AEP Flood Level	13	6	Yes
FB06	Nature Based Solutions for Flood Risk Management	13	6	Yes
RM06	Extension of Lismore Hydraulic Model	12	9	Yes
FB14	Raise of CBD Levee to the 1% AEP Flood Level plus Leycester Creek Bypass Channel	12	9	Yes
PM03	Voluntary House Raising (VHR) and Retrofitting	11	11	Yes
FB07	East Lismore Defence at Monaltrie Road	11	11	Yes
FB10	Leycester Creek Bypass Channel	11	11	Yes
FB12	Raise of South Lismore Levee to the 1% AEP Flood Level plus Leycester Creek Bypass Channel	11	11	Yes
FB13	Raise of CBD Levee to the 5% AEP Flood Level plus Leycester Creek Bypass Channel	11	11	Yes
RM04	Floor Level Survey	11	11	Yes
FB04	Increase Conveyance at key Hydraulic Controls at Bruxner Highway, Caniaba Road, and Krauss Avenue	10	17	No
FB09	East Lismore Flood Defence at Wilson Park School	9	18	No
FB03	Excavate to Increase Conveyance on Wilsons River Bend	8	19	No
FB08	Flood Defence at Wyrallah Road	6	20	No
FB05	Combined Option, Reflective of Implementing Options 1 to 5 in the FRMS	1	21	No
PM04	Increased access during flood events by raising of roads	-2	22	No

4. FLOOD RISK MANAGEMENT IMPLEMENTATION PLAN

The Lismore Flood Risk Management Implementation Plan is provided in Table 4.1. Flood risk management measures as identified for implementation or further investigation in Table 3.3 have been included. Flood behaviour modification measures have been combined where they concern the same structural location (such as a raise to the South Lismore levee to either a 5% or 1% AEP flood level) and are recommended for further hydraulic investigation and feasibility studies prior to implementation.

The Implementation Plan outlines the following elements:

- Brief description of the action pertaining to the recommended flood risk management measures
- Resources and responsibility for implementation
- Timeframe for implementation
- Relative cost.

TABLE 4.1: LISMORE FLOODRISK MANAGEMENT IMPLEMENTATION PLAN

FRM Measure ID	Action	Responsibility	Resources and Funding	Timing
PM01	Zoning and Development Control <i>A review of the Lismore LEP and DCP is currently being completed by LCC, utilising detailed information and recommendations provided in the Lismore Floodplain Risk Management Plan – Land Use Planning and Development Control document (Engeny, 2023) and the Update on Addressing Flood Risk in Planning Decisions Planning Circular (NSW Government, 2024).</i>	LCC – Strategic Planning	Staff time	2024
PM02	Voluntary House Purchase (VHP) <i>It is recommended that dependent on available funding, extension of the Reconstruction Authority (RA) Resilient Homes Program (RHP) VHP program is extended by Council to include more properties in Lismore.</i> <i>Additionally, it is also recommended that LCC work closely with the RA to identify suitable flood-free land to assist with relocation of flood-affected properties at a price that is affordable to those seeking relocation.</i>	LCC – Strategic Planning DCCEEW NSW Department of Planning, Housing, and Infrastructure (DPHI) RA	NSW Flood Recovery and Resilience Grant Program NSW RA Resilient Lands Program.	Following RHP cessation
PM03	Voluntary House Raising (VHR) and Retrofitting <i>It is recommended that dependent on available funding, extension of the RA RHP VHR program is extended by Council to include more properties in Lismore.</i>	LCC – Strategic Planning DCCEEW DPHI RA	NSW Flood Recovery and Resilience Grant Program	Following RHP cessation
RM01	Community Flood Awareness Readiness Programs <i>Continuation of education and increase to local community awareness through regular business functions (i.e. development assessment, etc.) as well as developing a community awareness strategy to disseminate the latest flood information.</i>	LCC – Strategic Planning LCC – Community Engagement LCC – Media and Communications	Staff time	Ongoing

FRM Measure ID	Action	Responsibility	Resources and Funding	Timing
RM02	Improve Flood Predictions and Warning <i>It is recommended that Council consider utilising the flood results from the FRMS to further identify localities for passive and active flood warning signs. It is noted that since the 2022 flood events, additional signage has already been placed at Wyrallah Road, Boatharbour Road, and Nimbin Road.</i> <i>A \$15M program led by DCCEEW is underway to develop a Richmond and Wilsons Valleys Flood Warning System. Dependent on the outcomes from this project there could be scope for Council to further expand upon the system within the Wilsons River catchment, utilising the URBS and TUFLOW models developed for the FRMS.</i>	LCC – Chief Operating Office (COO)	Grant funding	Ongoing, depending on funding availability
RM04	Floor Level Survey <i>Extension of floor level surveys for any properties not included in the NRRRP regional program so that Council has floor level data for all properties within the PMF extent.</i>	LCC – COO NRRRP	Grant funding	Ongoing, depending on funding availability
FB06	Nature Based Solutions for Flood Risk Management <i>Depending on the outcomes from the “Heal the Rivers” Flood Recovery and Landscape Restoration and Resilience in the Lismore Catchment projects, and available funding, Council should consider further expanding the application of NBS in the Wilsons River catchment.</i>	LCC - COO RA	Grant funding	Ongoing, depending on funding availability
FB01 FB10 FB13 FB14	/ Raise CBD Levee to Provide 5% or 1% AEP flood immunity, in possible conjunction with Leycester Creek Bypass Channel / Further hydraulic assessment and feasibility assessment should be undertaken to determine the cost-benefit proposition of raising of the CBD levee to provide either 5% AEP or 1% AEP flood immunity. Further consideration of the Leycester Creek Bypass Channel, either in isolation or in conjunction with the CBD levee raise should also be undertaken.	LCC – COO DCCEEW DPHI RA	Grant funding	Following CSIRO flood mitigation options report, dependent on funding

FRM Measure ID	Action	Responsibility	Resources and Funding	Timing
FB02 / FB10 / FB11 / FB12	Raise South Lismore Levee to Provide 5% or 1% AEP flood immunity, in possible conjunction with Leycester Creek Bypass Channel <i>Further hydraulic assessment and feasibility assessment should be undertaken to determine the cost-benefit proposition of raising of the South Lismore levee to provide either 5% AEP or 1% AEP flood immunity. Further consideration of the Leycester Creek Bypass Channel, either in isolation or in conjunction with the CBD levee raise should also be undertaken.</i>	LCC – COO DCCEEW DPHI RA	Grant funding	Following CSIRO flood mitigation options report, dependent on funding
FB07	East Lismore Flood Defence at Monaltrie Road <i>Further hydraulic assessment and feasibility assessment should be undertaken to determine the cost-benefit proposition of constructing a levee at Monaltrie Road, to provide flood protection to the Sewerage Treatment Plant, Wilson Park School, and East Lismore.</i>	LCC – COO DCCEEW DPHI RA	Grant funding	Following CSIRO flood mitigation options report, dependent on funding

5. REFERENCES

- Australian Wetlands Consulting Pty Ltd (2021), *Nature Based Solutions for Flood Mitigation*. Revision A: December 2021.
- Engeny (2021), *Lismore Floodplain Risk Management Study – Final Report*. Revision 4 April 2021.
- Engeny (2023), *Lismore Floodplain Risk Management Plan – Land Use Planning and Development Control*. Revision 4: May 2023.
- Engeny (2024), *Lismore 2022 Post Flood Event Analysis*. Revision 3: January 2024.
- NSW Government (2022), *2022 Flood Inquiry – Volume Two Full Report*. July 2022.
- NSW Government (2024), *Update on Addressing Flood Risk in Planning Decisions*. Reference PS 24-001, dated 1 March 2024.
- NSW Government (2023), *Flood Risk Management Manual*. State of NSW: June 2023.
- NSW Government (2023), *Flood Risk Management Measures – Flood Risk Management Guideline MM01*. June 2023.
- NSW Government (2024), *State Disaster Mitigation Plan*. February 2024.

6. QUALIFICATIONS

- (a) In preparing this document, including all relevant calculation, and modelling, Engeny Australia Pty Ltd (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.
- (b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.
- (c) Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:
- (d) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or
- (e) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.
- (f) Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents, and representatives of Engeny to the same extent that they apply for the benefit of Engeny.
- (g) This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this Report.
- (h) If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the Report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.
- (i) This Report does not provide legal advice.

APPENDIX A: MULTI-CRITERIA ANALYSIS DETAILED SCORING

The bottom half of the page features a series of four thick, white, wavy lines that sweep from the bottom left towards the right, creating a sense of movement and depth against the solid teal background.

Option ID	Option	Raw Score	Raw Rank	Technical Feasibility	Financial Feasibility	Adaptability to change for long term feasibility	Community Acceptability	Impact on Properties	Impact on Flood Hazard / Risk to Life	Community Flood Awareness	Evacuation and Access	Impact on Emergency Services	Environmental and Ecological Impacts	Recreation	Property and insurance	Cultural heritage improvement	Legislative Compliance	Impact on Critical and/or Vulnerable Facilities	Compatibility with existing Council plans, policies or strategic direction	Benefit-Cost (applicable for flood behaviour modification measures only)
PM01	Zoning and Development Control	18	1	3	0	2	0	1	2	1	0	1	0	0	1	0	3	1	3	0
PM02	Voluntary House Purchase (VHP)	13	6	1	1	2	1	2	2	1	0	2	0	0	0	0	0	1	0	0
PM03	Voluntary House Raising (VHR) and Retrofitting	11	11	1	2	1	1	1	1	1	0	1	0	0	1	0	0	1	0	0
PM04	Increased access during flood events by raising of roads	-2	22	-3	-2	1	0	-1	1	1	2	1	0	0	-1	0	0	-1	0	0
RM01	Community Flood Awareness Readiness Programs	15	4	3	3	0	0	0	2	3	0	2	0	0	0	0	0	0	2	0
RM02	Improve Flood Warning	18	1	3	2	0	3	0	2	2	0	3	0	0	0	0	0	1	2	0
RM04	Floor Level Survey	11	11	3	1	0	2	0	0	2	0	1	0	0	0	0	0	0	2	0
RM06	Extension of Lismore Hydraulic Model	12	9	3	1	1	0	0	0	3	0	3	0	0	0	0	0	0	1	0
FB01	Raise CBD Levee to Provide 5% AEP Flood Immunity	17	3	1	1	1	1	3	2	0	2	1	-1	0	1	0	0	2	1	2
FB02	Raise South Lismore Levee to Provide 5% AEP Flood Immunity	14	5	1	1	1	1	2	1	0	1	1	-1	0	1	0	0	2	1	2
FB03	Excavate to Increase Conveyance on Wilsons River Bend	8	19	1	-1	1	1	2	1	0	1	1	-2	0	1	0	0	2	1	-1
FB04	Increase Conveyance at key Hydraulic Controls at Bruxner Highway, Caniaba Road, and Krauss Avenue	10	17	2	1	1	0	0	2	0	1	1	0	0	1	0	0	2	1	-2
FB05	Combined Option, Reflective of Implementing Options 1 to 5 in the FRMS	1	21	1	-2	1	0	3	0	0	0	0	-2	0	0	0	0	0	1	-1
FB06	Nature Based Solutions for Flood Risk Management	13	6	1	1	0	3	0	0	0	0	0	3	2	0	2	0	0	2	-1
FB07	East Lismore Defence at Monaltrie Road	11	11	1	-2	2	1	2	2	0	0	1	0	0	1	0	0	3	1	-1
FB08	Flood Defence at Wyrallah Road	6	20	2	-1	2	1	0	0	0	0	0	0	0	0	0	0	3	1	-2
FB09	East Lismore Flood Defence at Wilson Park School	9	18	1	-1	2	1	1	1	0	0	1	0	0	1	0	0	3	1	-2
FB10	Leycester Creek Bypass Channel	11	11	-3	-3	2	0	3	3	0	2	3	-2	0	2	0	0	3	0	1
FB11	Raise of South Lismore Levee to the 1% AEP Flood Level	13	6	-2	1	2	1	2	2	0	2	1	-2	0	1	0	0	2	1	2
FB12	Raise of South Lismore Levee to the 1% AEP Flood Level plus Leycester Creek Bypass Channel	11	11	-3	-3	2	0	3	3	0	2	3	-2	0	2	0	0	3	0	1
FB13	Raise of CBD Levee to the 5% AEP Flood Level plus Leycester Creek Bypass Channel	11	11	-3	-3	2	0	3	3	0	2	3	-2	0	2	0	0	3	0	1
FB14	Raise of CBD Levee to the 1% AEP Flood Level plus Leycester Creek Bypass Channel	12	9	-3	-3	2	0	3	3	0	2	3	-2	0	2	0	0	3	0	2

APPENDIX B: PREVIOUS INVESTIGATIONS

An abstract graphic consisting of three thick, white, wavy lines that curve upwards from the bottom left towards the right side of the page. The lines are set against a solid teal background.

MEMORANDUM

Project:	Lismore Flood Mitigation	Date:	28 October 2022
To:	Department of Planning and Environment	From:	Engeny
ATT:	Toong Chin	CC:	Lismore City Council
Subject:	Concept Flood Mitigation Options Assessment		

INTRODUCTION

Engeny was engaged by the NSW Department of Planning and Environment (DPE) to undertake a concept flood behaviour modification measure option assessment for Lismore to provide context for consideration of funding for future construction projects. The options assessed were similar to those previously identified in either the *Lismore Floodplain Risk Management Study (FRMS)* (Engeny, 2021) or the *Lismore Flood Study and Floodplain Management Study* (SKM, 1994).

This memorandum outlines the options assessed and construction limitations, the flood assessment results, concept construction cost estimate and a benefit-cost analysis. This assessment has been undertaken at a high, conceptual-level and further assessment is required to determine further refine the options.

IDENTIFICATION OF OPTIONS

In total, five flood behaviour modification options were assessed, which are summarised below:

1. Leycester Creek Bypass Channel.
2. Raise of South Lismore Levee to the 1% AEP flood level.
3. Combination of Leycester Creek Bypass Channel and raise of South Lismore Levee to the 1% AEP flood level.
4. Combination of Leycester Creek Bypass Channel and raise of CBD Levee to the 5% AEP flood level.
5. Combination of Leycester Creek Bypass Channel and raise of CBD Levee to the 1% AEP flood level.

Further details regarding the configuration of each option and any identified construction constraints are discussed below.

OPTION DETAILS AND CONSTRUCTION FEASIBILITY

Leycester Creek Bypass Channel (Options 1, 3-5)

The design elements of the Leycester Creek Bypass Channel are:

- Upstream off-take from Leycester Creek at 9 m AHD (estimated event causing offtake is 50%-20% AEP flood event)
- Downstream tie-in to Wilsons River at 4 m AHD
- Base width of 250 m, average depth of 3 m, batter slopes of 1:6.
- Estimated channel capacity of 1,400 m³/s, almost the 10% AEP peak flow in Leycester Creek.

The design earthworks TIN for the channel is shown in Figure 1. The construction constraints associated with the option are:

- The channel alignment will likely impact the sewer main to the Lismore Water Treatment Plant
- The alignment interacts with numerous roads east of South Lismore. Smaller local access roads are proposed to be retained as causeways, with the following treatments adopted for the main crossings;
 - Casino Street/Kyogle Road, retained as bridge crossing
 - Three Chain Road, retained as causeway
 - Caniaba Road, retained as causeway
 - Bruxner Highway, retained as a bridge crossing.

Figure 1 – Leycester Creek Bypass Channel Alignment

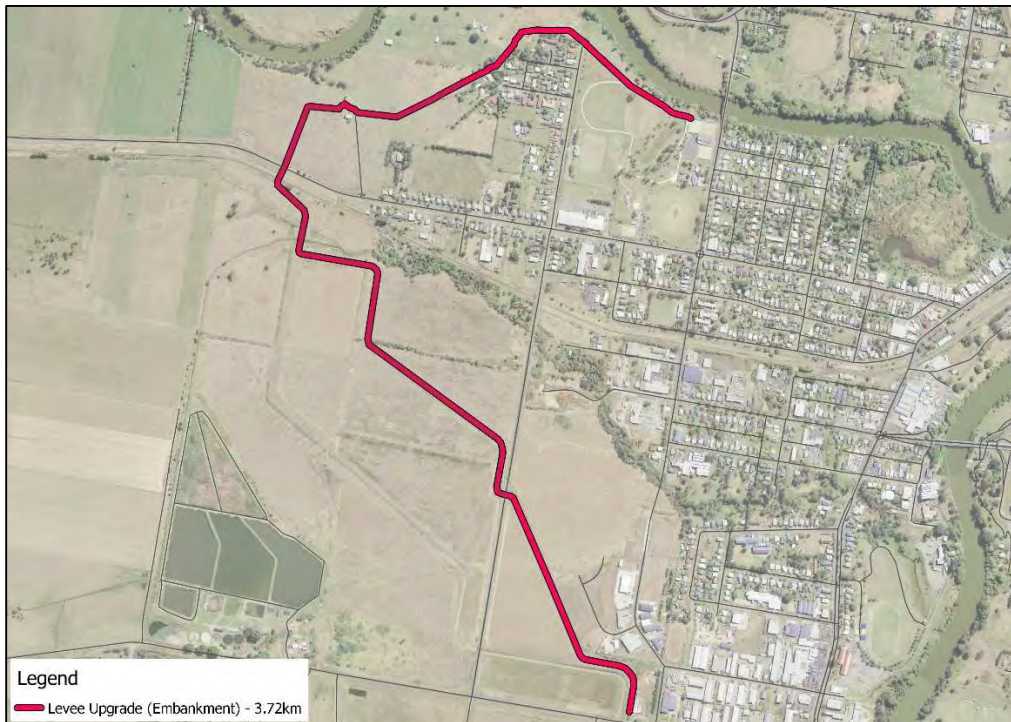


South Lismore Levee Raise (Option 2-3)

The proposed alignment of the South Lismore Levee raise to ensure no overtopping of Leycester Creek breakout flows from the west in the 1% AEP flood event is shown in Figure 2. A consistent raise of 500 mm is required for 1% AEP immunity.

It is expected that the levee will require an increase to the base width to ensure embankment stability, which may require further resumption of easements on private property. In its current form, the levee alignment ties into Casino Street, therefore in order to achieve 1% AEP immunity the road in the vicinity of the levee will need to be locally raised to the proposed levee level.

Figure 2 – South Lismore Levee Raise Alignment



CBD Levee Raise to 5% AEP level (Option 4)

The CBD levee raise has been assessed in combination with the Leycester Creek bypass channel and therefore, requires little adjustment to achieve a 5% AEP flood event immunity (given the current immunity of the levee is the 10% AEP flood event). The key improvements to the levee required to ensure no ingress to the CBD in a 5% AEP flood event are:

- 13 m extension of the levee at John Street
- 185 m extension of the levee at Molesworth Street
- Raise of the level by 1 m for 65 m at the Gas Works spillway.

The alignment of the upgrade is shown in Figure 3. Construction constraints associated with the proposed extension include determination of the exact length and alignment at Molesworth Street to minimise impacts to private properties and access.

Figure 3 – CBD Levee Raise to 5% AEP Level Alignment



CBD Levee Raise to 1% AEP level (Option 5)

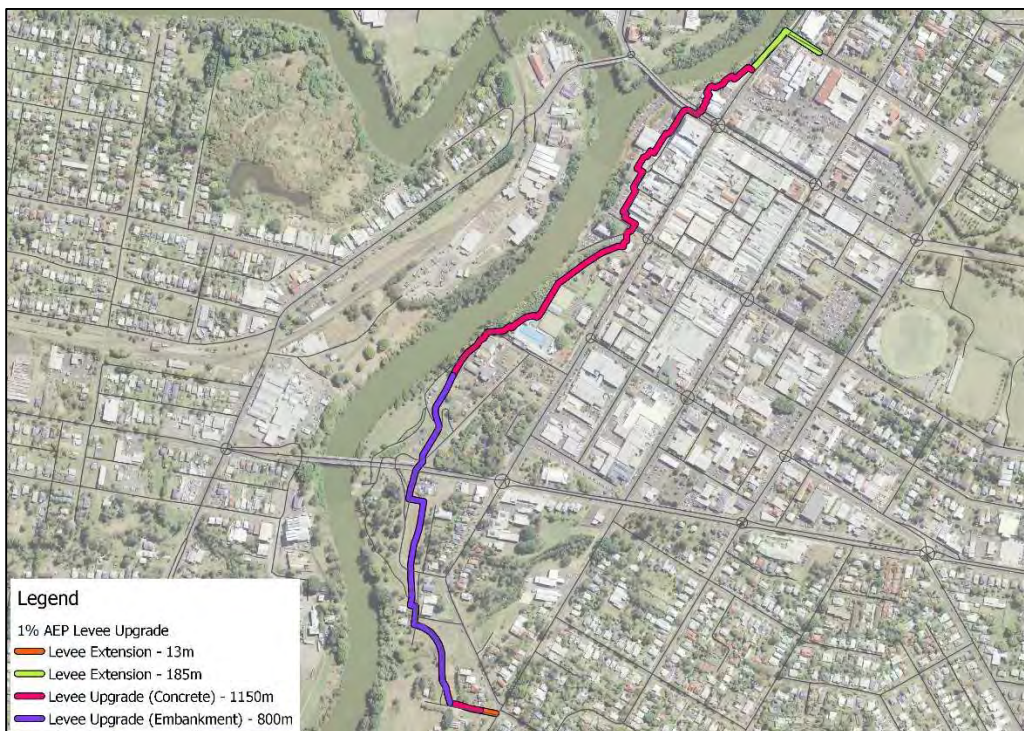
The CBD levee raise has been assessed in combination with the Leycester Creek bypass channel, with levels proposed to ensure no ingress to the CBD in the 1% AEP flood event.

- 13 m extension of the levee at John Street
- 185 m extension of the levee at Molesworth Street
- Raise to 1,150 m of the concrete sections of the levee to an additional 1 m
- Raise to 800 m of the of the earthen embankment sections of the levee to an additional 400 mm.

The alignment of the levee upgrade is shown in Figure 4. Construction constraints associated with the raise include:

- The Bruxner Highway, Gerard Street and Union Street interactions would require major works to the highway vertical alignment due to the proposed 1% AEP levee raise being higher in elevation compared to the current highway elevation, or incorporation of functional levee gates across the highway that can be closed following evacuation of South Lismore.
- Determination of the exact length and alignment at Molesworth Street to minimise impacts to private properties and access will need to be undertaken.

Figure 4 – CBD Levee Raise to 1% AEP Level Alignment



FLOOD ASSESSMENT

A flood impact assessment of all five flood behaviour modification measures has been completed using the TUFLOW hydraulic model developed for the *Lismore FRMS*, with simulation of the options for the 5% AEP, and 1% AEP flood events and comparison against the current scenario flood results for the same flood events.

FLOOD MODELLING

The flood behaviour modification measure options were represented using the following TUFLOW modelling elements:

1. A 12D earthworks design tin for the Leicester Creek bypass channel was developed and incorporated into the topographical data of the hydraulic model.
2. A 2D z-shape topographical alteration element was utilised to represent the raise to the South Lismore levee.
3. The elements from Option 1 and 2 were combined together in the model.
4. A 2D z-shape topographical alteration element was utilised to represent the alterations to the CBD levee to the 5% AEP flood level.
5. A 2D z-shape topographical alteration element was utilised to represent the alterations to the CBD levee to the 1% AEP flood level.

FLOOD IMPACT RESULTS

Following simulation of the 5% AEP and 1% AEP flood events incorporating each of the options, flood impact maps were produced indicating the changes in flood levels for each simulation in comparison to the current scenario results. The flood impact maps are presented in Attachment 1, and absolute flood level maps are presented in Attachment 2. A summary of the flood benefits are provided further below in Table 1, within the benefit-cost analysis section.

1% AEP FLOOD DAMAGE ASSESMENT

A flood damages assessment for the 1% AEP design flood event was completed utilising the NSW Department of Planning and Environment's (DPE) latest Flood Damage Tool spreadsheet as detailed in *Flood Risk Management Measures: Flood Risk Management Guide* (NSW DPE, 2022).

GIS Input Data

To undertake a flood damage assessment, the following GIS data inputs were required:

- Building polygons / assumed floor size of building
- Floor levels
- Classification of the type of building and number of storeys.

The following process was undertaken to prepare the GIS dataset for the flood damage assessment:

1. Delineation of all building polygons within the greater Lismore urban footprint. Initially, building polygons as provided by Lismore City Council were used where possible, with gaps filled by utilisation of the open data Bing Maps Building Footprints layer. Finally, any remaining buildings observed in the aerial were delineated manually.
2. Calculation of the floor area using geometry analysis tools.
3. Classification of the various buildings as either 'slab on ground', 'on short stumps', or 'on high stumps'.
4. Classification of the various buildings into the Property Types specified in the Flood Damage Tool. Due to lack of information about specific commercial uses, the default average (type 7) has been selected for commercial/industrial uses.
5. The Lismore City Council 2013 floor level survey was adopted where possible to apply ground and floor levels to the buildings. Where this survey information was not available, the ground level was determined by inspecting the average topographical level from the 2010 1m LiDAR dataset underneath the footprint, and the floor level was determined adding the following additional height to the ground level:
 - a) 150 mm for 'slab on ground'
 - b) 500 mm for 'on short stumps'
 - c) 1500 mm for 'on high stumps'.
6. Finally, an inspection of the 1% AEP flood level for the existing scenario and all five mitigation options was made against the building dataset.

Damage Curves

Full details of the development, assumptions and limitations of the damage curves utilised in the assessment are available in *Flood Risk Management Measures: Flood Risk Management Guide* (NSW DPE, 2022), and has not been repeated in this report. In summary, the flood damage assessment considers the following:

- Residential flood damages, comprising:
 - Structural damages
 - Contents damage
 - External damage
 - Vehicles at home
 - Relocation costs
 - Clean up costs.
- Non-residential buildings:
 - Classification based damage costs
 - Vehicles at work
 - Loss of trading costs
 - Clean up costs.
- Intangible damages:
 - Risk to life.

Additional Assessment Inputs

The following adjustments were made in the Flood Damage Tool to be specific to Lismore:

- A regional cost adjustment factor of 5% was applied in accordance with Lismore being located in the Eastern Land Division, north of Newcastle.
- The latest available Average Weekly Earnings and Consumer Price Index values were updated to December 2021 in accordance with the Australian Bureau of Statistics data.

The outcomes from the flood damage assessment are summarised further below in Table 1, within the benefit-cost analysis section.

CONCEPT CONSTRUCTION COST ESTIMATE

A concept-level construction cost estimate has been completed for all five mitigation options. A summary of the key assumptions are:

- Direct costs are based on scaled costs, order of magnitude quantities and lumped line items.
- No consideration of price escalation
- No land acquisition provision in the estimate
- *Australian Construction Handbook* (Rawlinsons, 2021) was utilised generally to develop base rates.
- Design level of options is at concept level with significant unknowns in the project scope and nominal allowances made for unknown items.
- Indirects and owner's costs have been scaled based on % of direct costs as follows:
 - Owner's cost (PM, design investigation, and approvals) = 17%
 - Contractor indirects = 15%.
- Allowance of 10% contractor profit has been made.
- A growth allowance of 10% has been added to the base estimate.
- A contingency of 30% has been added to the base estimate.
- No specific equipment or haul distances have been identified for earthworks at this stage.
- Cost estimate has been completed with limited consideration of current levee design.
- The cost estimates have been completed separately for each option, i.e. the material won from the channel hasn't been considered for use in the levee raise options.

The breakdown of the cost-estimate is provided in Attachment 3, and estimates summarised in Table 1.

BENEFIT-COST ANALYSIS

A concept-level benefit cost analysis has been undertaken and summarised in Table 1. The intent of the analysis is to enable simple comparison between each option, and includes the following criteria:

- Flood benefits; extent of flood height reduction in the events modelled.
- Flood impacts; extent of flood height increase in the events modelled.
- Construction constraints; additional constraints upon the construction feasibility of the option not necessarily captured in the cost estimate.
- 1% AEP flood damage estimate; the flood damage estimated for a 1% AEP flood event for each option. The existing scenario 1% AEP flood damage estimate is \$848M.
- 1% AEP flood damage reduction; the reduction in the flood damage estimate for a 1% AEP flood event compared to the existing scenario for each option.

- Concept Construction Cost Estimate; cost for construction for each option.
- Simplified Benefit Cost Ratio (BCR); the ratio of the 1% AEP flood damage estimate reduction over the concept construction cost estimate.

DRAFT FOR DPE REVIEW

Table 1 – Benefit-Cost Analysis

Parameter	Option 1 – Leycester Creek Bypass Channel	Option 2 – South Lismore Levee Raise	Option 3 - Leycester Creek Bypass Channel and South Lismore Levee Raise	Option 4 - Leycester Creek Bypass Channel and 5% AEP CBD Lismore Levee Raise	Option 4 - Leycester Creek Bypass Channel and 1% AEP CBD Lismore Levee Raise
Flood Benefits	Reductions of up to 940 mm in the CBD are observed in the 5% AEP event, and up to 470 mm in the 1% AEP event. Reductions of up to 420 mm in North Lismore are observed in the 5% AEP event, and up to 440 mm in the 1% AEP event. Reductions of up to 700 mm in South Lismore are observed in the 5% AEP event, and introduction of flood free areas. Reductions of up to 600 mm in the 1% AEP event.	Reductions in flood level of up to 400 mm in South Lismore and introduction of flood free areas in the 5% AEP flood event and 700 mm in the 1% AEP flood event. Reduction in flood levels in the CBD and Wilsons River of up to 30 mm in the 1% AEP flood event, no change in the 5% AEP flood event.	Reductions of up to 940 mm in the CBD are observed in the 5% AEP event, and up to 470 mm in the 1% AEP event. Reductions in flood level of up to 730 mm in South Lismore and introduction of flood free areas in the 5% AEP flood event and 1,200 mm in the 1% AEP flood event. Reduction in flood levels North Lismore of up to 420 mm in the 5% and 1% AEP flood event.	Reductions of up to 500 mm in the CBD are observed in the 1% AEP event, the CBD is flood free in the 5% AEP flood event. Reductions in flood level of up to 730 mm in South Lismore and introduction of flood free areas in the 5% AEP flood event and 930 mm in the 1% AEP flood event. Reduction in flood levels North Lismore of up to 380 mm in the 5% AEP flood event and 450 mm in the 1% AEP flood event.	The CBD is flood free up to and including the 1% AEP flood event. Reductions in flood level of up to 730 mm in South Lismore and introduction of flood free areas in the 5% AEP flood event and 800 mm in the 1% AEP flood event. Reduction in flood levels North Lismore of up to 380 mm in the 5% AEP flood event and 340 mm in the 1% AEP flood event
Flood Impacts	Conveyance of flows through to Wilsons River from Leycester Creek causes flood impacts in the 5% AEP flood event in the order of 80 mm. Minimal impacts are observed in the 1% AEP flood event.	Impacts to the airport and floodway area of up to 30 mm in the 5% AEP flood event. Impacts along Leycester Creek up to 200 mm in the 1% AEP flood event. Impacts of up to 15 mm in North Lismore in the 5% AEP flood event and 30 mm in the 1% AEP flood event extending up Wilsons River.	Conveyance of flows through to Wilsons River from Leycester Creek causes flood impacts in the 5% AEP flood event in the order of 80 mm. Minimal impacts are observed in the 1% AEP flood event.	Conveyance of flows through to Wilsons River from Leycester Creek causes flood impacts in the 5% AEP flood event in the order of 100 mm. Minimal impacts are observed in the 1% AEP flood event.	Conveyance of flows through to Wilsons River from Leycester Creek causes flood impacts in the 5% AEP flood event in the order of 100 mm and 50 mm in the 1% AEP flood event.
Construction Constraints	Bridges required at Casino Street and Bruxner Highway. Causeways proposed at other minor local channel crossings. Alignment impacts upon sewer main to Wastewater Treatment Plant.	Localised raise to Casino Street required. Minor land acquisition required.	Bridges required at Casino Street and Bruxner Highway. Causeways proposed at other minor local channel crossings. Alignment impacts upon sewer main to Wastewater Treatment Plant.	Further consideration of levee extension alignment is required. Bridges required at Casino Street and Bruxner Highway. Causeways proposed at other minor local channel crossings.	Further consideration of levee extension alignment is required. Cost estimates exclude any vertical alignment changes due to levee raise if required to Union Street, Gerard Street, and Bruxner Highway.

	Land acquisition required.		Localised raise to Casino Street required. Land acquisition required.	Alignment impacts upon sewer main to Wastewater Treatment Plant. Localised raise to Casino Street required. Land acquisition required.	Bridges required at Casino Street and Bruxner Highway. Causeways proposed at other minor local channel crossings. Alignment impacts upon sewer main to Wastewater Treatment Plant. Localised raise to Casino Street required. Land acquisition required.
1% AEP Flood Damage Estimate	\$667 M	\$817M	\$658M	\$660M	\$284M
1% AEP Flood Damage Reduction	-\$182M	-\$31M	-\$190M	-\$188M	-\$564M
Concept Construction Cost Estimate	\$184M	\$1.7M	\$186M	\$193M	\$198M
Simplified BCR	0.99	18.00	1.02	0.98	2.86

DISCUSSION AND RECOMMENDATIONS

OPTIONS ASSESSMENT DISCUSSION

A discussion on the results from assessment of each flood behaviour modification option is provided below:

1. Leycester Creek Bypass Channel

- In more frequent flood events it expected that the channel will cause adverse impacts to properties downstream of Lismore along the Wilsons River. However, there are considerable flood improvements observed north of Loftville Creek in events of varying magnitude.
- The Leycester Creek bypass channel is the most expensive component of the flood behaviour modification options assessed.
- In terms of the BCR, the construction costs of the channel are comparable to the reduction in flood damages expected in a 1% AEP flood event, however these benefits would need to be weighted up against downstream flooding risk in more frequent events.

2. Raise of South Lismore Levee to the 1% AEP flood level.

- From a flood impact perspective, an isolated raise to the South Lismore levee is not recommended if increases to flood levels through the airport floodway, north Lismore, Wilsons River upstream of Lismore, and Leycester Creek are to be avoided.
- A South Lismore levee raise is a low cost option, and results in a high BCR due to the reduction in flood impacts expected in a 1% AEP flood event, however these benefits would need to be weighted up against downstream flooding risk in more frequent events.

3. Combination of Leycester Creek Bypass Channel and raise of South Lismore Levee to the 1% AEP flood level.

- Inclusion of the South Lismore levee raise in combination with the Leycester Creek bypass channel only marginally improves the flood reductions in comparison to the Leycester Creek bypass channel in isolation.
- Impacts to Wilsons River downstream of Lismore remain for frequent events.
- In terms of the BCR, the construction costs of this option are comparable to the reduction in flood damages expected in a 1% AEP flood event, however these benefits would need to be weighted up against downstream flooding risk in more frequent events.

4. Combination of Leycester Creek Bypass Channel and raise of CBD Levee to the 5% AEP flood level.

- This option ensures that the CBD is flood free up to and including a 5% AEP flood event.
- Impacts to Wilsons River downstream of Lismore remain for frequent events.
- This option generally has a slightly lower BCR than Option 3, due to higher flood levels expected in South Lismore with this option, and the slightly higher construction cost estimate for this option.

5. Combination of Leycester Creek Bypass Channel and raise of CBD Levee to the 1% AEP flood level.

- This option ensures that the CBD is flood free up to and including a 1% AEP flood event.
- Impacts to Wilsons River downstream of Lismore are observed in events of varying magnitude.

RECOMMENDATION

Of the options assessed, there is no fully favourable option in terms of ensuring flood level increases are avoided over the entirety of Lismore. Of the options assessed, Option 5 (Leycester Creek bypass channel and 1% AEP CBD levee) has the greatest reduction in flood damages and the most favourable BCR, however, the downstream impacts observed in events up to and including the 1% AEP flood event may not be viewed favourably and there are significant construction constraints associated with this option.

As an option that performs generally well across all criteria, it would be recommended that Option 3 (Leycester Creek bypass channel and 1% AEP South Lismore levee) could be considered a suitable compromise.

The flood behaviour modification options in order of recommendation for further investigation based upon this assessment are:

- Option 3 - Combination of Leycester Creek Bypass Channel and raise of South Lismore Levee to the 1% AEP flood level.
- Option 4 - Combination of Leycester Creek Bypass Channel and raise of CBD Levee to the 5% AEP flood level.
- Option 5 - Combination of Leycester Creek Bypass Channel and raise of CBD Levee to the 1% AEP flood level.
- Option 1 - Leycester Creek Bypass Channel.
- Option 2 - Raise of South Lismore Levee to the 1% AEP flood level.

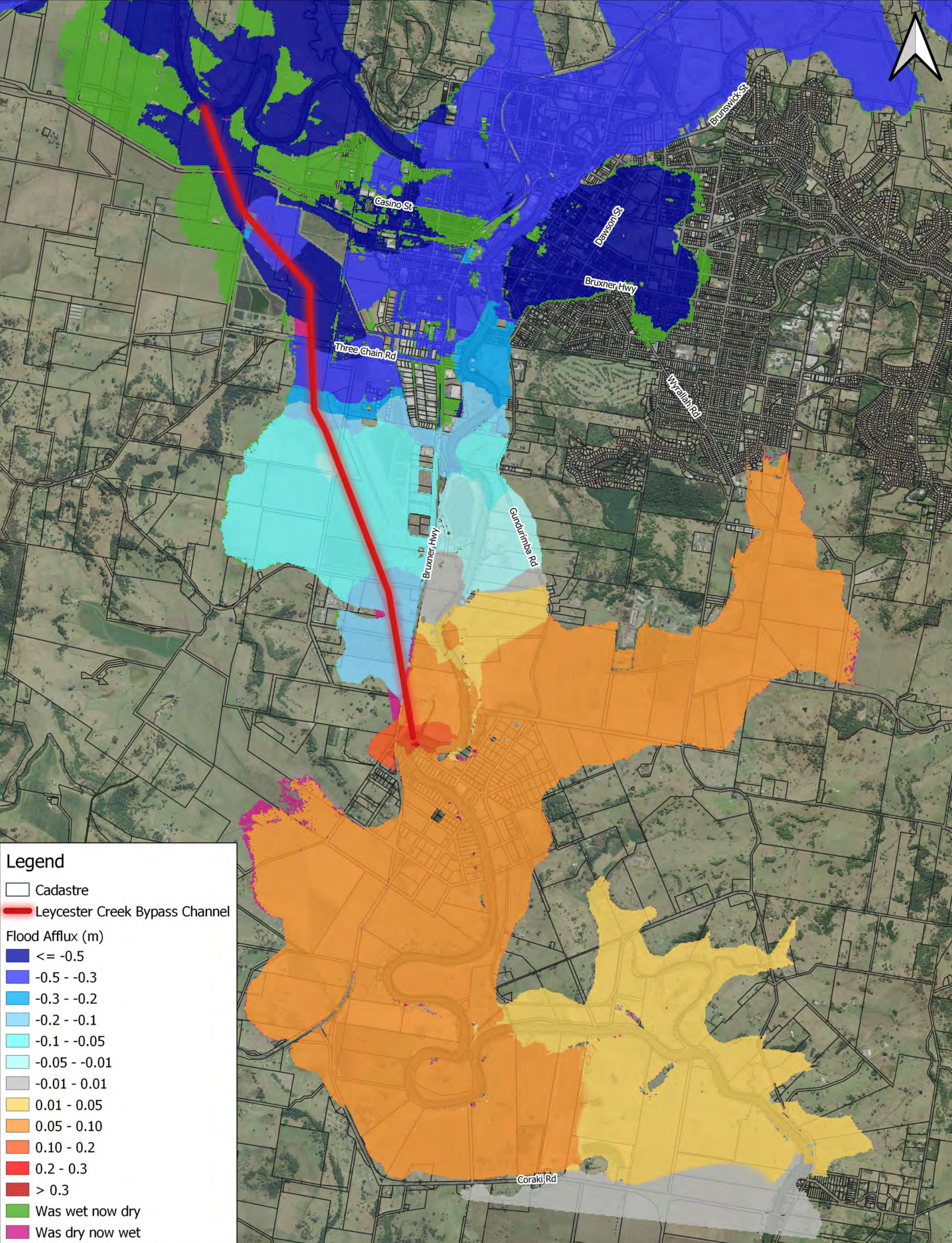
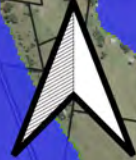
DISCLAIMER

This memo has been prepared on behalf of and for the exclusive use of Department of Planning and Environment and is subject to and issued in accordance with Department of Planning and Environment instruction to Engeny Water Management (Engeny). The content of this memo was based on previous information and studies supplied by Department of Planning and Environment

Engeny accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this memo by any third party. Copying this memo without the permission of Department of Planning and Environment or Engeny is not permitted.

ATTACHMENT 1 – FLOOD IMPACT MAPPING

DRAFT FOR DPE REVIEW



Legend

Cadastre

Leicester Creek Bypass Channel

Flood Afflux (m)

<= -0.5

-0.5 - -0.3

-0.3 - -0.2

-0.2 - -0.1

-0.1 - -0.05

-0.05 - -0.01

-0.01 - 0.01

0.01 - 0.05

0.05 - 0.10

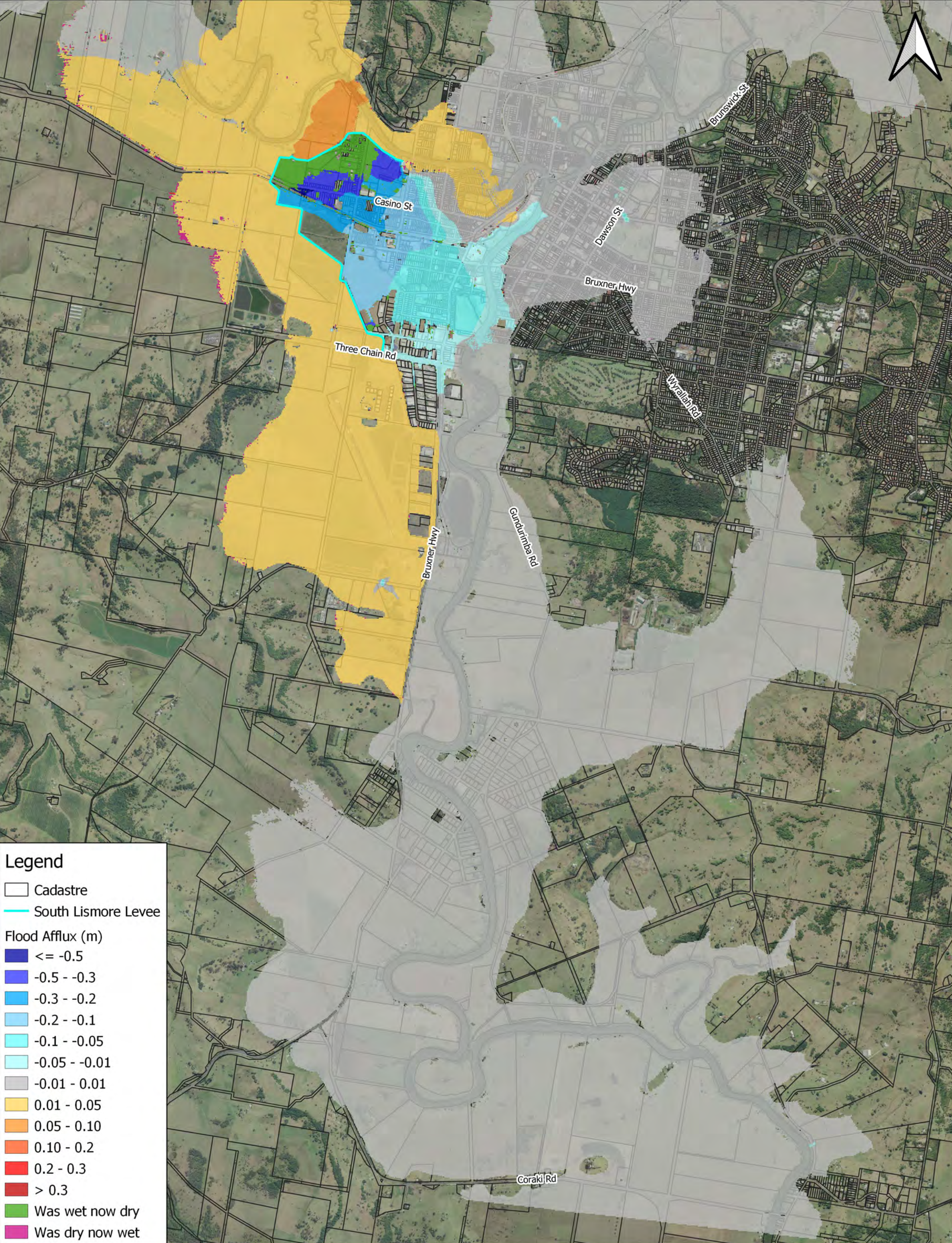
0.10 - 0.2

0.2 - 0.3

> 0.3

Was wet now dry

Was dry now wet



Legend

Cadastre

South Lismore Levee

Flood Afflux (m)

≤ -0.5

-0.5 - -0.3

-0.3 - -0.2

-0.2 - -0.1

-0.1 - -0.05

-0.05 - -0.01

-0.01 - 0.01

0.01 - 0.05

0.05 - 0.10

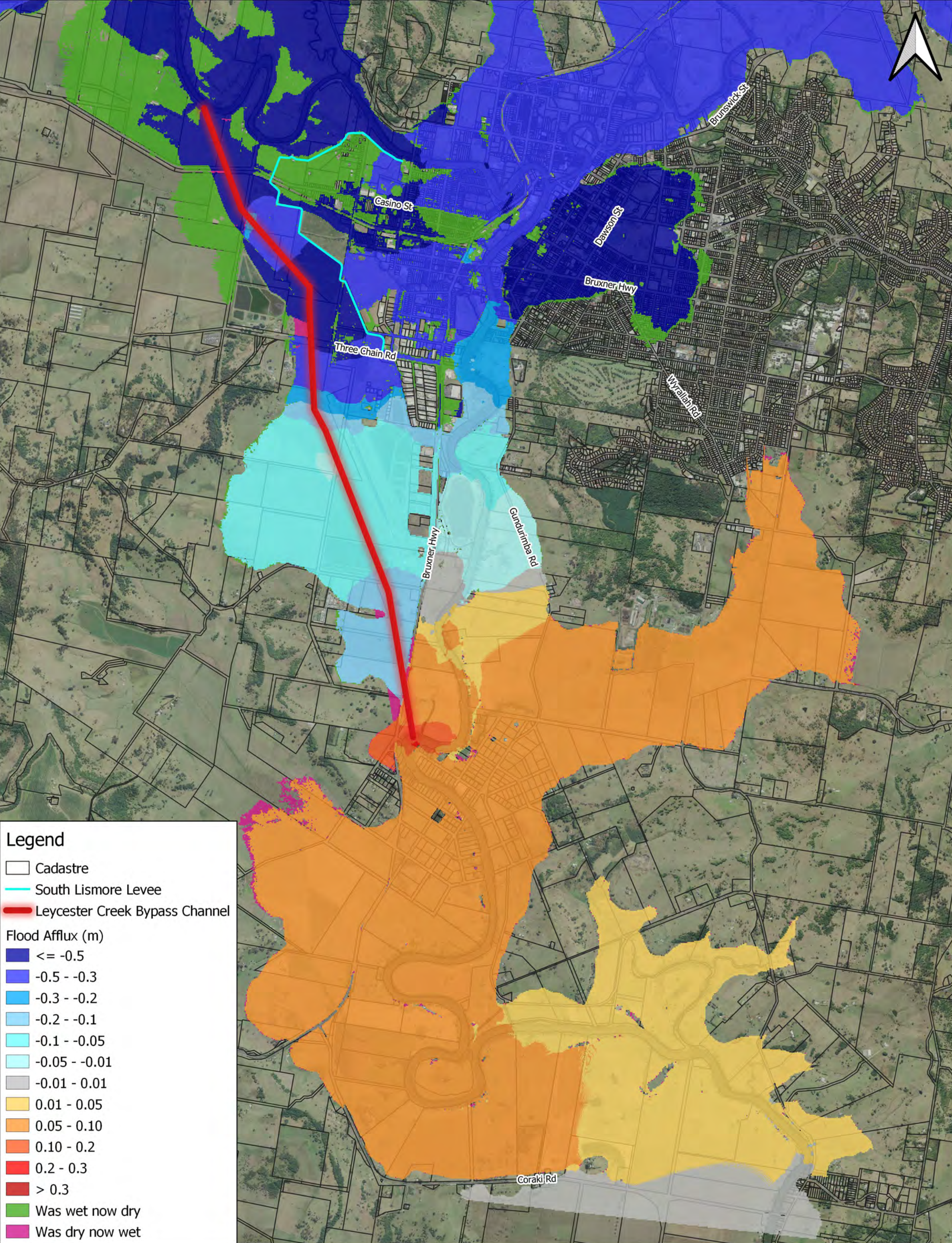
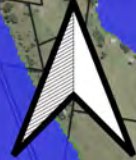
0.10 - 0.2

0.2 - 0.3

> 0.3

Was wet now dry

Was dry now wet

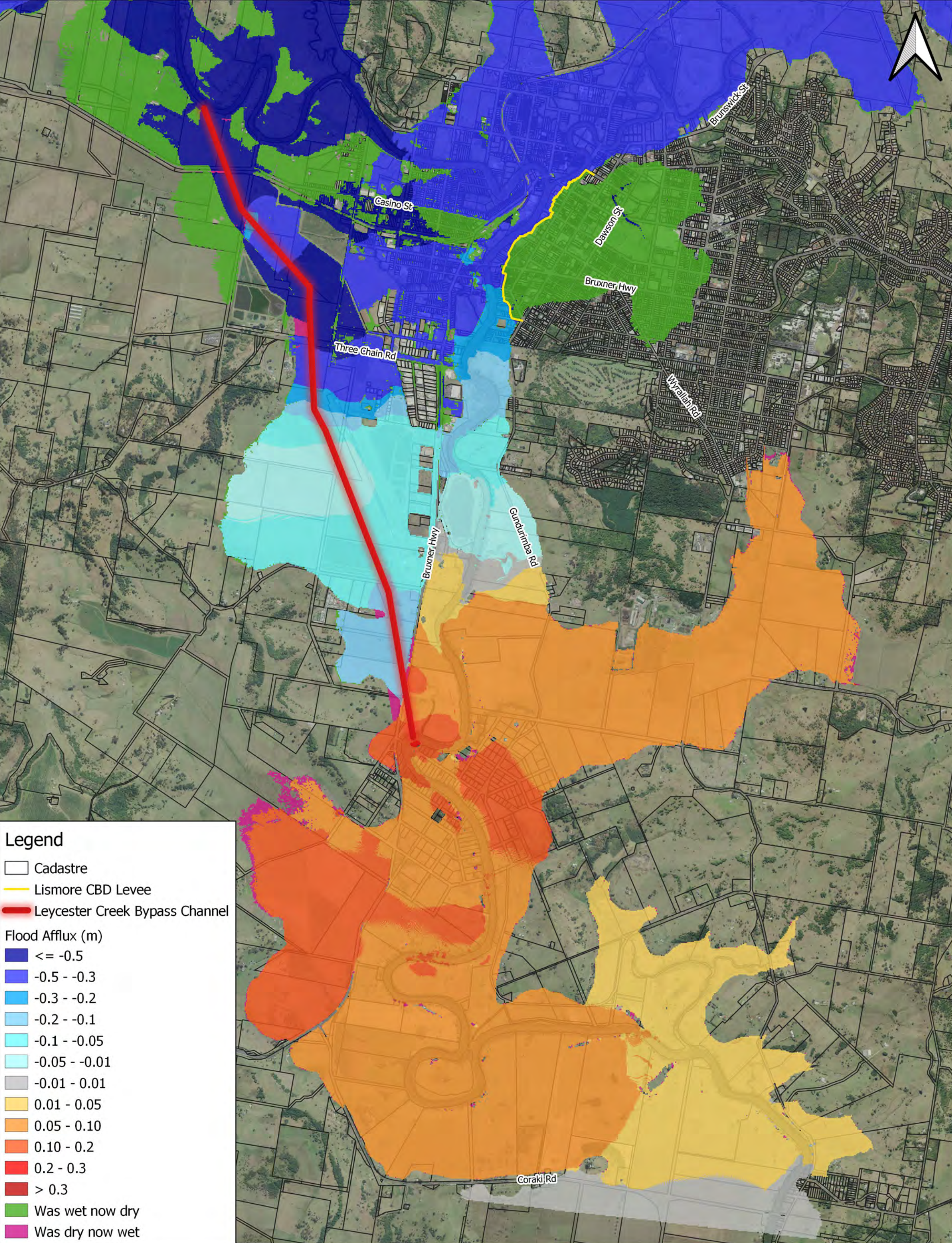
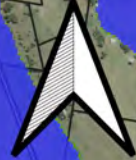


Legend

- Cadastre
- South Lismore Levee
- Leicester Creek Bypass Channel

Flood Afflux (m)

- <= -0.5
- 0.5 - -0.3
- 0.3 - -0.2
- 0.2 - -0.1
- 0.1 - -0.05
- 0.05 - -0.01
- 0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.2
- 0.2 - 0.3
- > 0.3
- Was wet now dry
- Was dry now wet

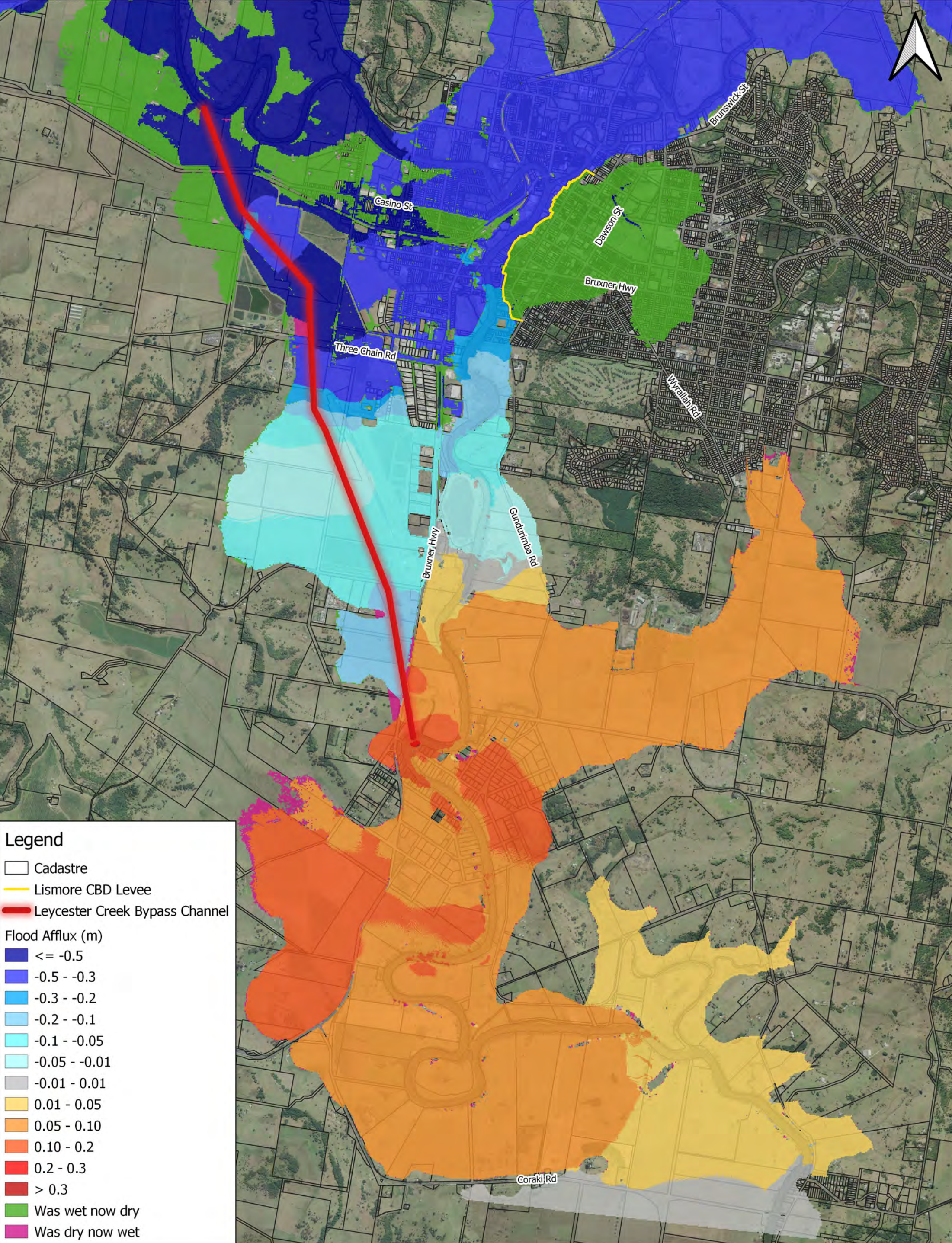
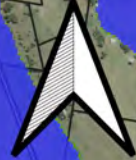


Legend

- Cadastre
- Lismore CBD Levee
- Leycester Creek Bypass Channel

Flood Afflux (m)

- <= -0.5
- 0.5 - -0.3
- 0.3 - -0.2
- 0.2 - -0.1
- 0.1 - -0.05
- 0.05 - -0.01
- 0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.2
- 0.2 - 0.3
- > 0.3
- Was wet now dry
- Was dry now wet

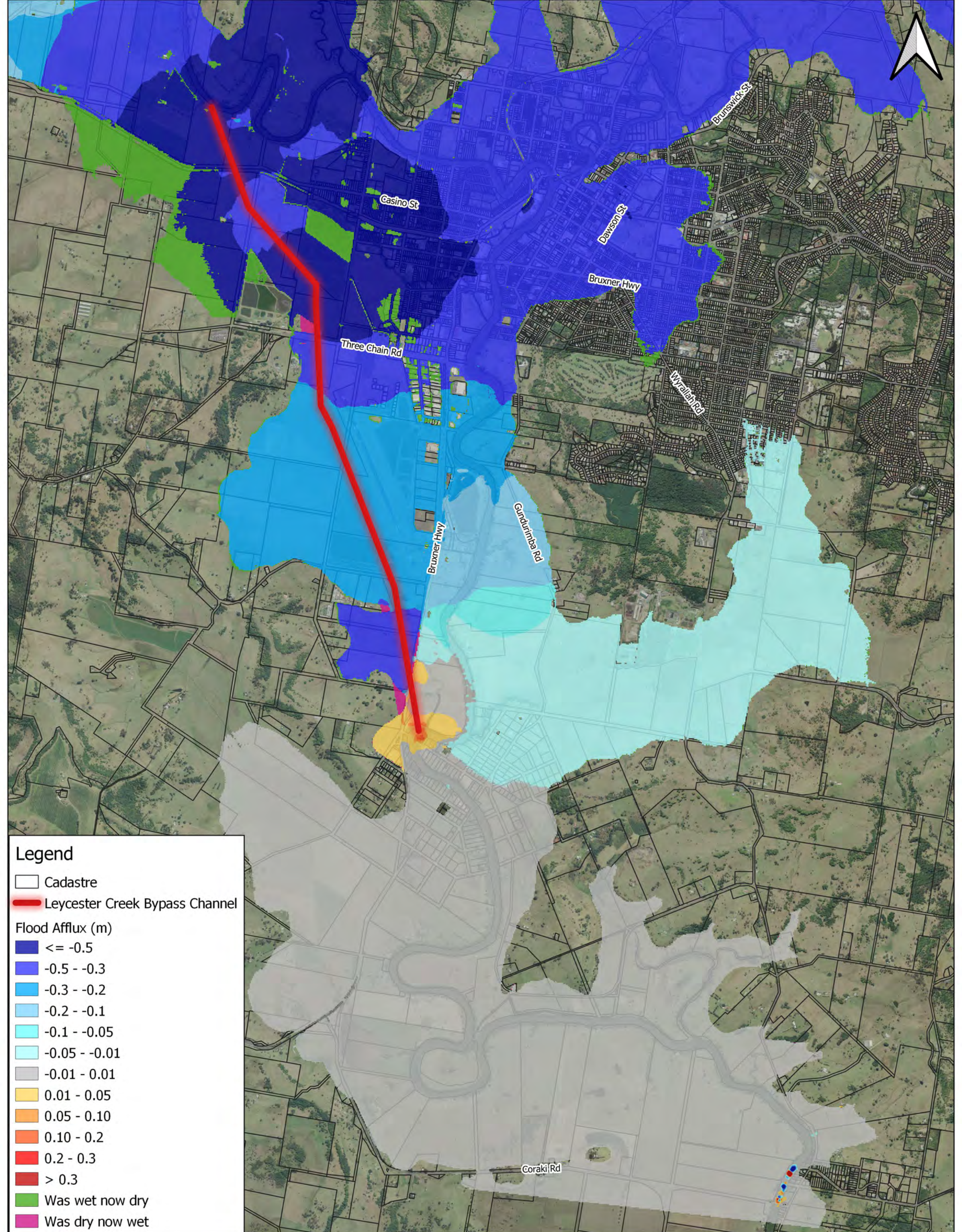


Legend

- Cadastre
- Lismore CBD Levee
- Leicester Creek Bypass Channel

Flood Afflux (m)

- <= -0.5
- 0.5 - -0.3
- 0.3 - -0.2
- 0.2 - -0.1
- 0.1 - -0.05
- 0.05 - -0.01
- 0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.2
- 0.2 - 0.3
- > 0.3
- Was wet now dry
- Was dry now wet



Legend

 Cadastre

 Leicester Creek Bypass Channel

Flood Afflux (m)

 ≤ -0.5

 -0.5 - -0.3

 -0.3 - -0.2

 -0.2 - -0.1

 -0.1 - -0.05

 -0.05 - -0.01

 -0.01 - 0.01

 0.01 - 0.05

 0.05 - 0.10

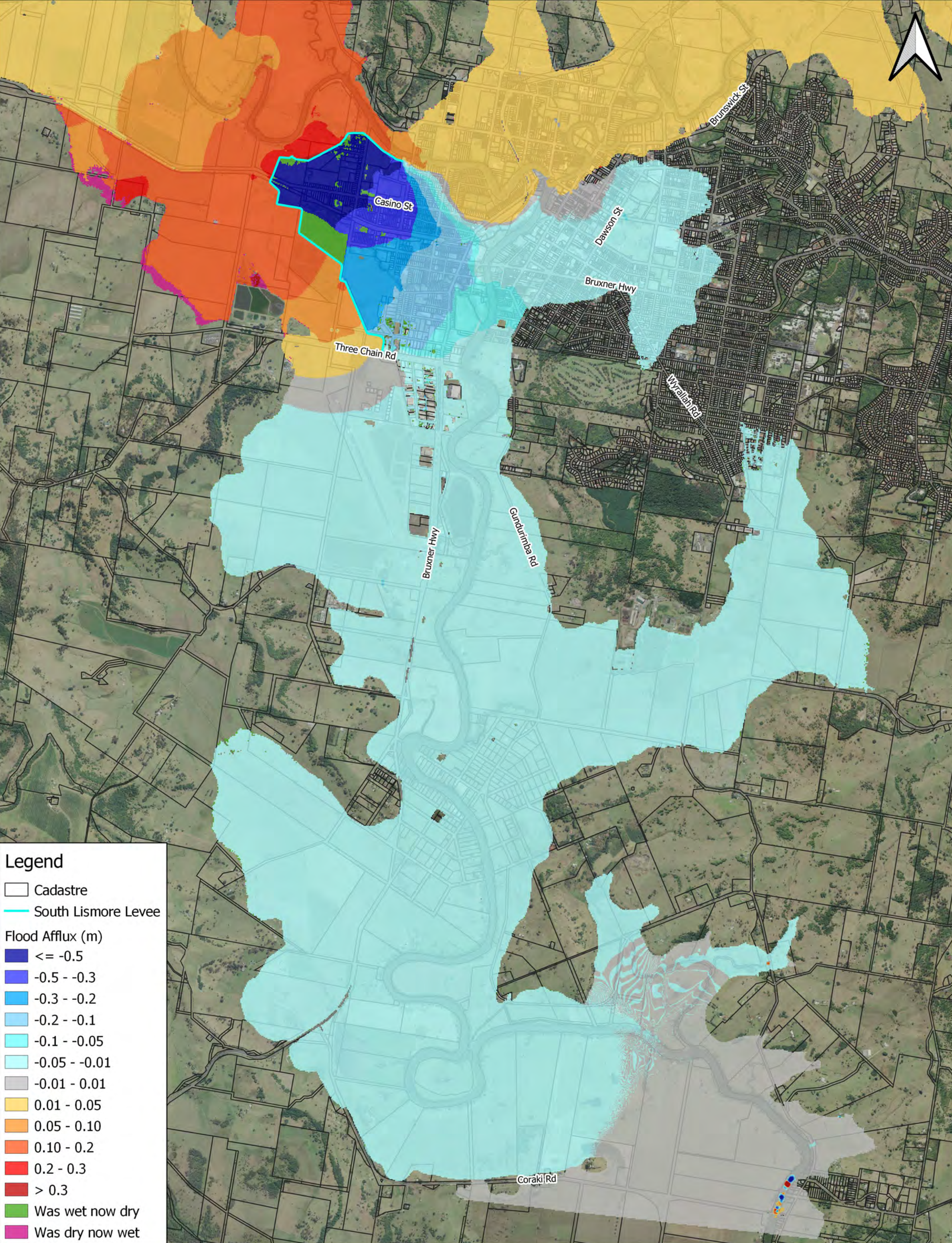
 0.10 - 0.2

 0.2 - 0.3

 > 0.3

 Was wet now dry

 Was dry now wet



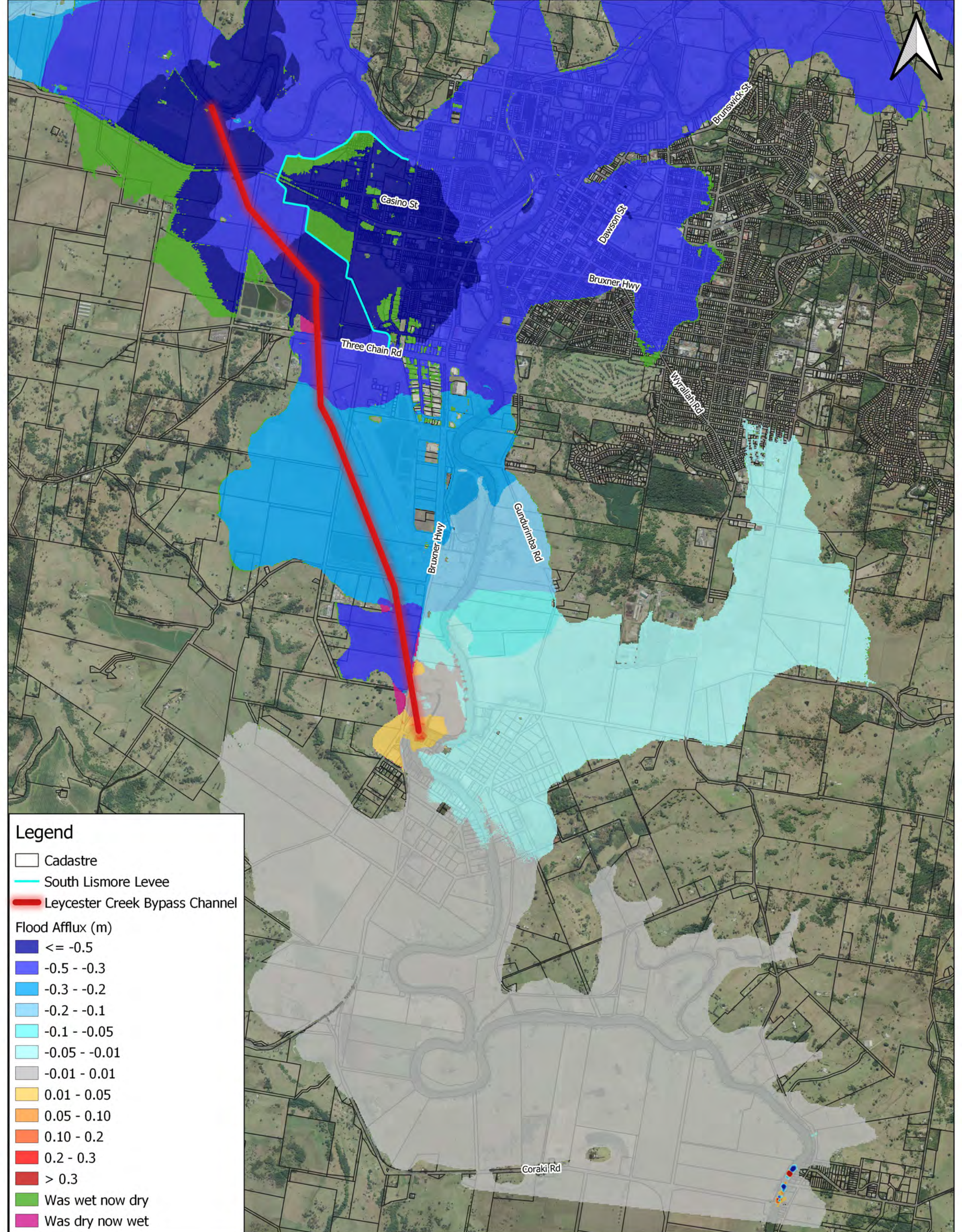
Legend

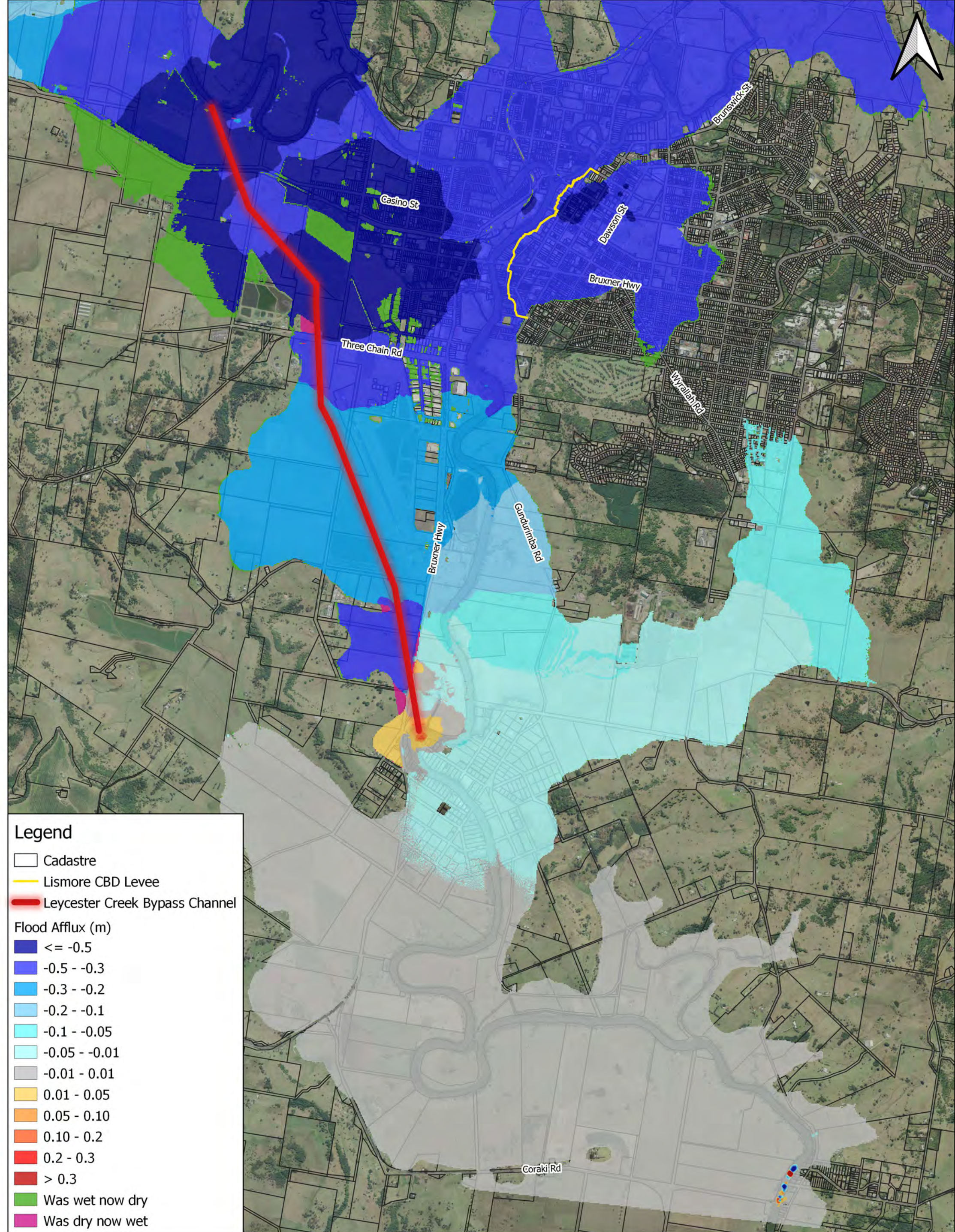
▬ Cadastre

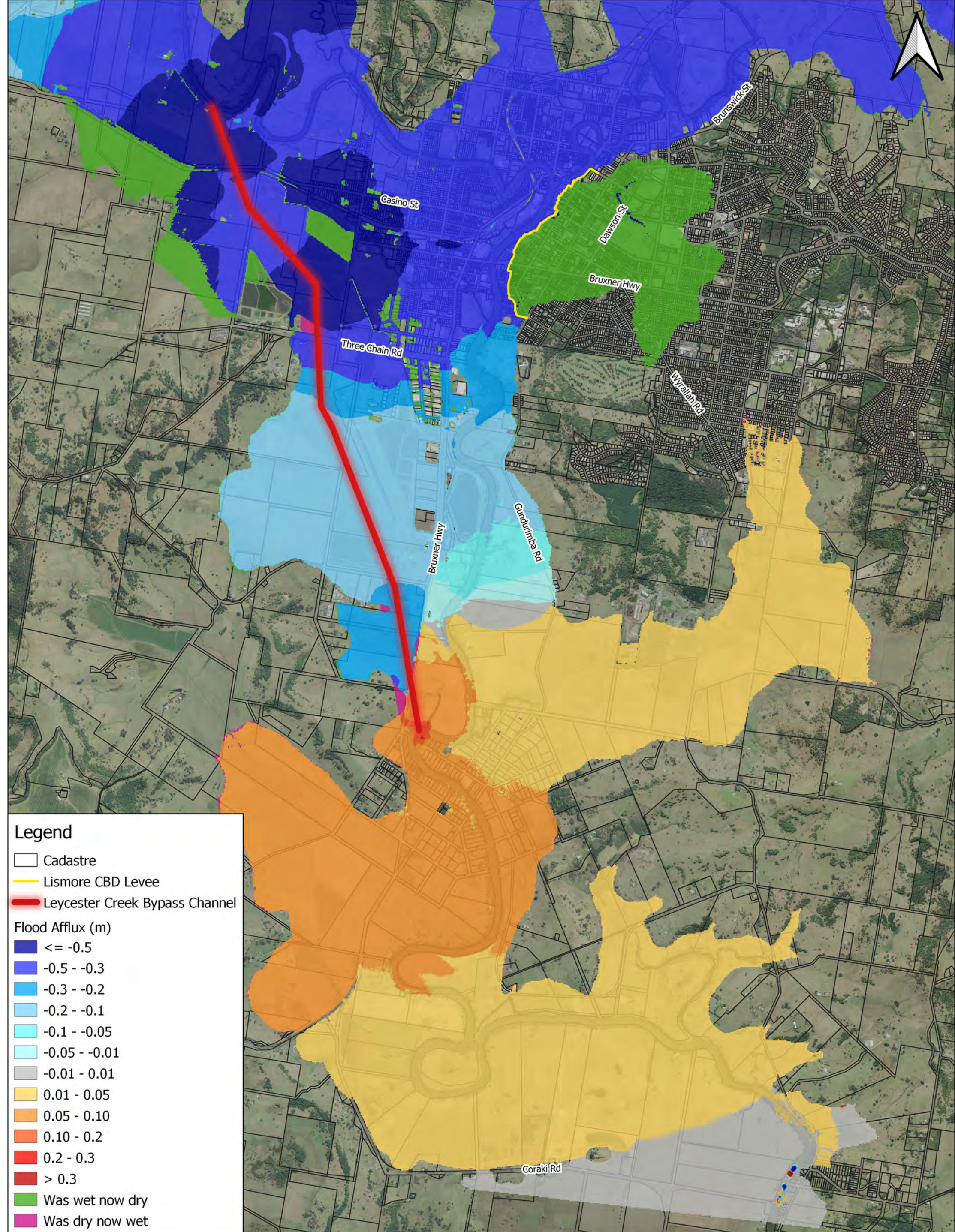
▬ South Lismore Levee

Flood Afflux (m)

- Dark Blue: ≤ -0.5
- Blue: $-0.5 - -0.3$
- Light Blue: $-0.3 - -0.2$
- Very Light Blue: $-0.2 - -0.1$
- Cyan: $-0.1 - -0.05$
- Light Cyan: $-0.05 - -0.01$
- Grey: $-0.01 - 0.01$
- Yellow: $0.01 - 0.05$
- Orange: $0.05 - 0.10$
- Dark Orange: $0.10 - 0.2$
- Red: $0.2 - 0.3$
- Dark Red: > 0.3
- Green: Was wet now dry
- Pink: Was dry now wet

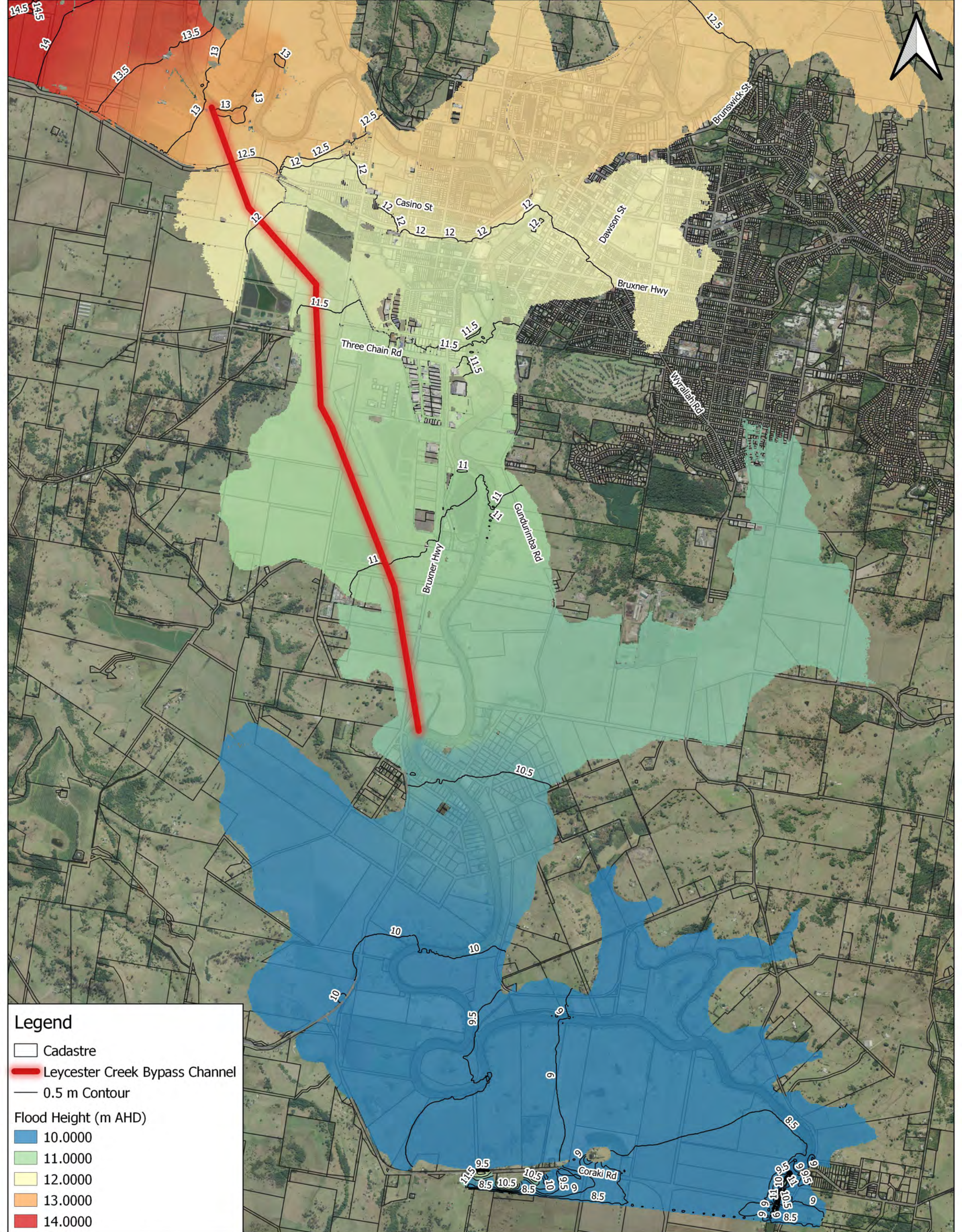






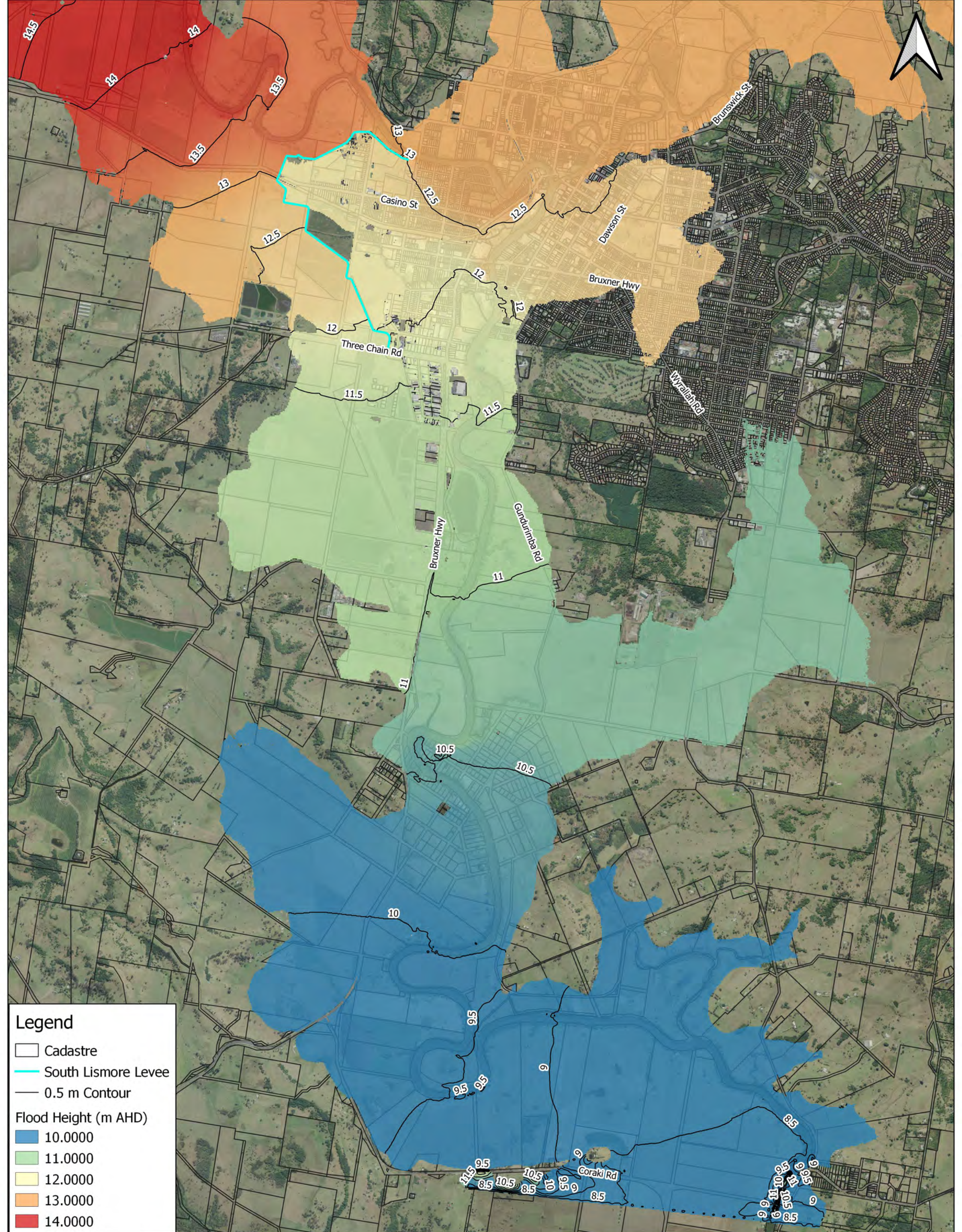
ATTACHMENT 2 – FLOOD LEVEL MAPPING

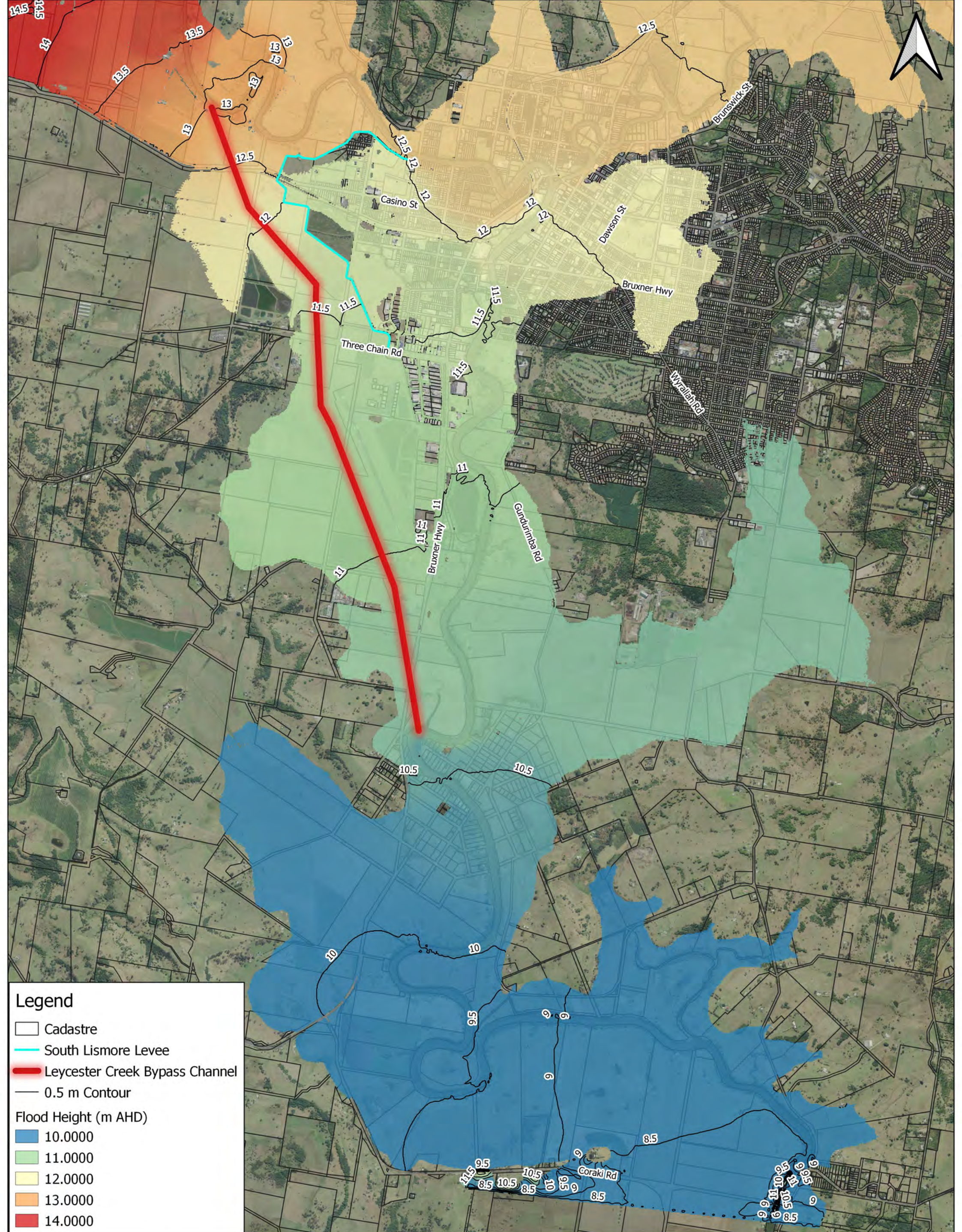
DRAFT FOR DPE REVIEW



Legend

- Cadastre
- Leicester Creek Bypass Channel
- 0.5 m Contour
- Flood Height (m AHD)
 - 10.0000
 - 11.0000
 - 12.0000
 - 13.0000
 - 14.0000



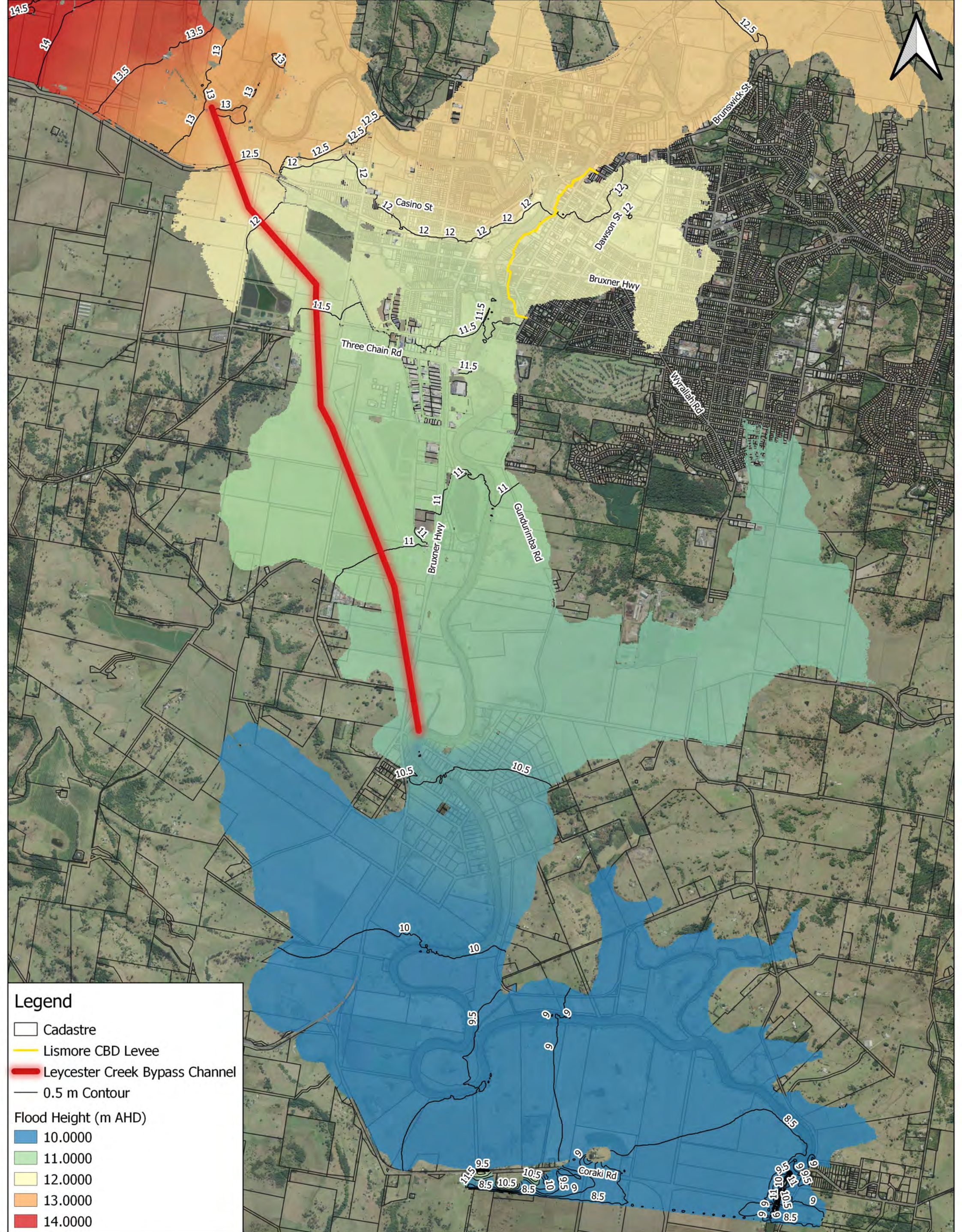


Legend

- Cadastre
- South Lismore Levee
- Leicester Creek Bypass Channel
- 0.5 m Contour

Flood Height (m AHD)

- 10.0000
- 11.0000
- 12.0000
- 13.0000
- 14.0000



Legend

- Cadastral
- Lismore CBD Levee
- Leicester Creek Bypass Channel
- 0.5 m Contour

Flood Height (m AHD)

- 10.0000
- 11.0000
- 12.0000
- 13.0000
- 14.0000



Planning & Environment

0 600 1,200 m

Projection: Map Grid of Australia, Zone 56
Horizontal Datum: Geocentric Datum of Australia 1994
Aerial Imagery Source: Copyright Google

Lismore Flood Mitigation Assessment

Mitigation 4 - Combination of Leicester Creek Bypass Channel and raise of CBD Levee to the 5% AEP flood level

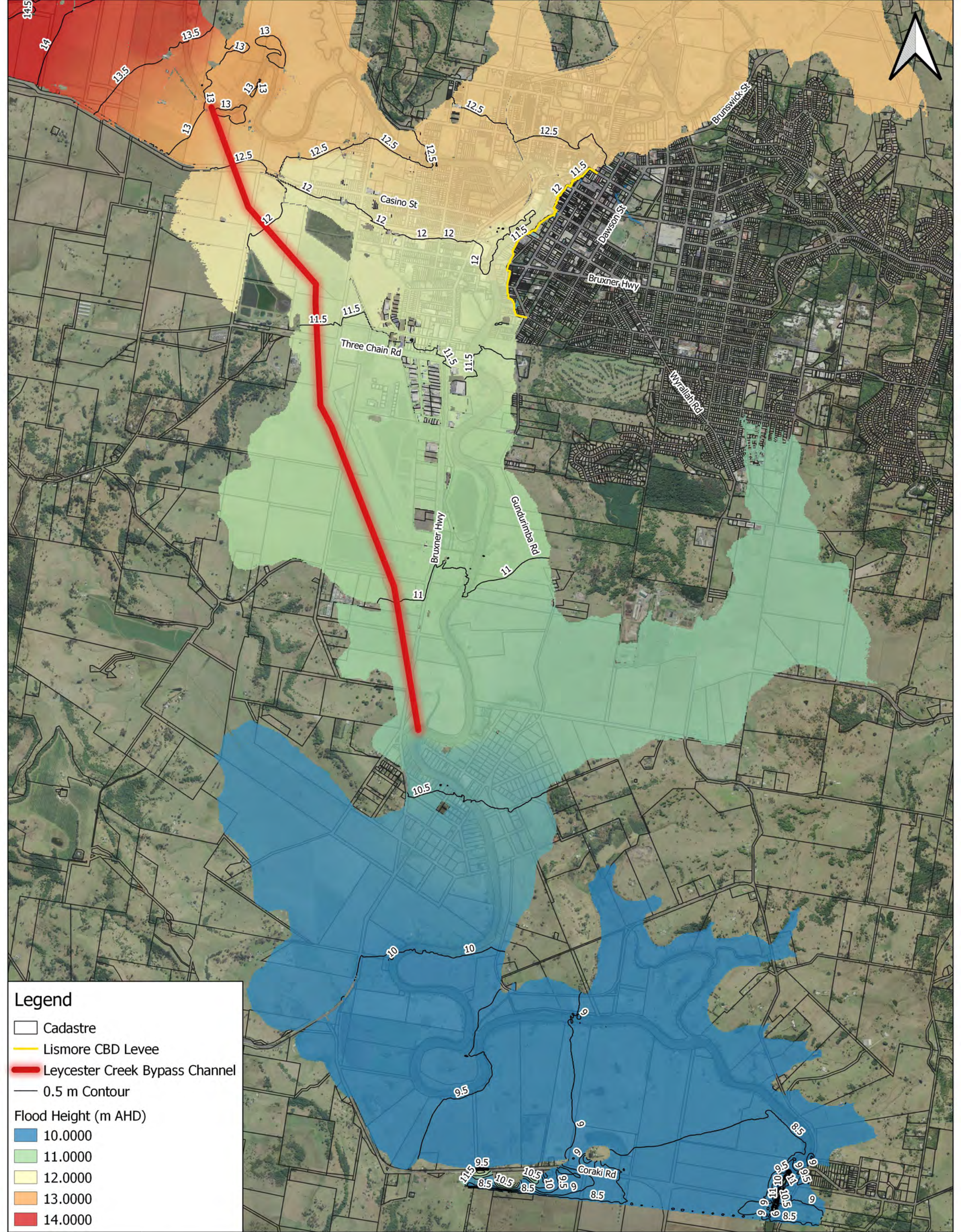
1% AEP - Flood Height



ENGENY
WATER MANAGEMENT

Job Number: M7372_004
Revision: 0
Drawn: ZL
Checked: CL
Date: 28/10/2022

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.



0 600 1,200 m

Projection: Map Grid of Australia, Zone 56
Horizontal Datum: Geocentric Datum of Australia 1994

Aerial Imagery Source: Copyright Google

Lismore Flood Mitigation Assessment

**Mitigation 5 - Combination of Leicester Creek Bypass Channel
and raise of CBD Levee to the 1% AEP flood level
1% AEP - Flood Height**



Job Number: M7372_004
Revision: 0
Drawn: ZL
Checked: CL
Date: 28/10/2022

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.

ATTACHMENT 3 – COST ESTIMATES

DRAFT FOR DPE REVIEW

ENGENY
WATER MANAGEMENT

Project:	M7372_004
Date:	28/10/2022
Revision:	0
Work By:	TR
Reviewed:	KM

Item	Type	Description	Unit	Qty	Rate	Total
Total Project Estimate						\$ 183,854,000
Risk Items						\$ 52,530,000
	Growth Allowance		%	10%	\$ 131,324,000	\$ 13,132,400
	Contingency		%	30%	\$ 131,324,000	\$ 39,397,200
	Escalation		excluded			
BASE ESTIMATE						\$ 131,324,000
Owners Costs						\$ 19,081,000
Project Management	Project Management		%	5%	\$ 112,243,000	\$ 5,612,150
Project Management	Design, Survey, Geotechnical, Environmental Investigations			10%	\$ 112,243,000	\$ 11,224,300
Project Management	Land acquisition		excluded			\$ -
Project Management	Approvals			2%	\$ 112,243,000	\$ 2,244,860
Construction Costs						\$ 112,243,000
Contractor Indirects	Mobilisation, Demobilisation, Site Facilities, Survey, Environmental Mgmt Plan, Traffic Mgmt plan, Traffic control, Doc Control, PM , HSE, QA		%	15%	\$ 89,794,000	\$ 13,469,100
Contractor Margin	Contractor Profit		%	10%	\$ 89,794,000	\$ 8,979,400
Contractor Directs	Topsoil Stripping Diversion		m2	1,740,408	\$ 6.0	\$ 10,442,448
Contractor Directs	Topsoil stripping of spoil area (assumed 0.5 sqkm)		m2	500,000	\$ 6.0	\$ 3,000,000
Contractor Directs	Excavation to Spoil (assumed <2km haul)		m3	4,988,288	\$ 8.0	\$ 39,906,304
Contractor Directs	Cut to Fill		m3	48,620	\$ 20.0	\$ 972,400
Contractor Directs	topsoil and seed diversion		m2	1,740,408	\$ 8.0	\$ 13,923,264
Contractor Directs	topsoil and seed spoil area		m2	500,000	\$ 8.0	\$ 4,000,000
Contractor Directs	Casino St/ Kyogle road crossing (300m bridge)		sqm	300	\$ 20,000	\$ 6,000,000
Contractor Directs	Rail Line Crossing - Causeway		item	1	\$ 200,000	\$ 200,000
Contractor Directs	Caniaba Street Crossing - Causeway		item	1	\$ 200,000	\$ 200,000
Contractor Directs	Caniaba Road Crossing - Casueway with low flow culverts (say 3x 1.5mx2.4m RCBC)		item	1	\$ 900,000	\$ 900,000
Contractor Directs	Leycester Creek interface works		item	1	\$ 1,000,000	\$ 1,000,000
Contractor Directs	Bruxner Highway Crossing (300m Bridge)		sqm	300	\$ 20,000	\$ 6,000,000
Contractor Directs	Wilson River Interface works		item	1	\$ 1,000,000	\$ 1,000,000
Contractor Directs	Drainage interface works loftville creek		Allowance	1	\$ 250,000	\$ 250,000
Contractor Directs	Existing Infrastructure impacts mitigation (relocation of utilities)		Allowance	1	\$ 2,000,000	\$ 2,000,000
	Directs Subtotal					\$ 89,794,000

Engeny Cost Estimate

South Lismore Levee Raise to 1:100 AEP (1% AEP)



Project: M7372_004
 Date: 28/10/2022
 Revision: 0
 Work By: TR
 Reviewed: KM

Description		Unit	Qty	Rate	Total
Total Project Estimate					\$ 1,728,698
Risk Items					\$ 288,116
Growth Allowance		%	10%	\$ 720,290.90	\$ 72,029
Contingency		%	30%	\$ 720,290.90	\$ 216,087
Escalation		excluded			
Base Estimate					\$ 720,291
Owners Costs					\$ 104,658
Project Management		%	5%	\$ 615,633	\$ 30,782
Design, Survey, Investigations			10%	\$ 615,633	\$ 61,563
Land acquisition		excluded			\$ -
Approvals			2%	\$ 615,633	\$ 12,313
Construction Costs					\$ 615,633
Contractor Indirects	Mobilisation, Demobilisation, Site Facilities, Survey, Environmental Mgmt Plan, Traffic Mgmt plan, Traffic control, Doc Control, PM , HSE, QA	%	15%	\$ 2,462,533	\$ 369,380
Contractor Margin	Profit margin	%	10%	\$ 2,462,533	\$ 246,253
<i>Contractor Directs Earth Levee Section</i>					
Contractor Directs	Earthen embankment - topsoil strip	m2	60,000	\$ 10	\$ 600,000
Contractor Directs	Earthen embankment - foundation strip	m3	3,753	\$ 10	\$ 37,533
Contractor Directs	Earthen embankment - fill (assume won within 2km)	m3	41,250	\$ 20	\$ 825,000
Contractor Directs	Earthen embankment - topsoil and reveg	m2	60,000	\$ 10	\$ 600,000
Contractor Directs	Road Raise - Kyogle Casino Road	Allowance	1	\$ 100,000	\$ 100,000
Contractor Directs	Road Raise - Caniaba St	Allowance	1	\$ 100,000	\$ 100,000
Contractor Directs	Existing Infrastructure impacts mitigation (Allowance)	Allowance	1	\$ 200,000	\$ 200,000
Directs Subtotal					\$ 2,462,533

Engeny Cost Estimate

CBD Levee Raise to 1:20 AEP (5% AEP)



Project: M7372_004
 Date: 28/10/2022
 Revision: 0
 Work By: TR
 Reviewed: KM

Description		Unit	Qty	Rate	Total
Total Project Estimate					\$ 8,784,715
Risk Items					\$ 1,464,119
	Growth Allowance	%	10%	\$ 3,660,298.08	\$ 366,030
	Contingency	%	30%	\$ 3,660,298.08	\$ 1,098,089
	Escalation	excluded			
Base Estimate					\$ 3,660,298
Owners Costs					\$ 531,838
	Project Management	%	5%	\$ 3,128,460	\$ 156,423
	Design, Survey, Investigations		10%	\$ 3,128,460	\$ 312,846
	Land acquisition	excluded			\$ -
	Approvals		2%	\$ 3,128,460	\$ 62,569
Construction Costs					\$ 3,128,460
Contractor Indirects	Mobilisation, Demobilisation, Site Facilities, Survey, Environmental Mgmt Plan, Traffic Mgmt plan, Traffic control, Doc Control, PM , HSE, QA	%	15%	\$ 2,502,768	\$ 375,415
Contractor Margin	Profit margin	%	10%	\$ 2,502,768	\$ 250,277
Contractor Directs	Earthen embankment - topsoil strip	m2	0	\$ 15	\$ -
Contractor Directs	Earthen embankment - foundation strip	m3	0	\$ 15	\$ -
Contractor Directs	Earthen embankment - fill (assume won within 3km)	m3	0	\$ 30	\$ -
Contractor Directs	Earthen embankment - topsoil and reveg	m2	0	\$ 15	\$ -
Contractor Directs Concrete Levee					
Contractor Directs	Reinforced concrete levee raise (1m height increase on existing, 100m length)	m2	45	\$ 1,500	\$ 67,500
Contractor Directs	Excavation and groundworks preparation around levee	m3	200	\$ 50	\$ 10,000
Contractor Directs	Foundation Reinforcement - Additional cutoff walls to 1.5m depth both sides of footing	lineal m	120	\$ 2,000	\$ 240,000
Contractor Directs	Foundation Reinforcement - Additional piles DN750mm to 2.5m depth, assume 1 per 5 lineal m	m3	18	\$ 2,000	\$ 35,343
Contractor Directs	New Concrete levee up to 3m high	lineal m	198	\$ 3,788	\$ 749,925
Contractor Directs	New Flood gate across Molesworth street at Zadoc Street	Allowance	1	\$ 1,000,000	\$ 1,000,000
Contractor Directs	Backflow Prevention upgrades (Allowance)	Allowance	1	\$ 200,000	\$ 200,000
Contractor Directs	Existing Infrastructure impacts mitigation (Allowance)	Allowance	1	\$ 200,000	\$ 200,000
Directs Subtotal					\$ 2,502,768

Engeny Cost Estimate

CBD Levee Raise to 1:100 AEP (1% AEP)



Project: M7372_004
 Date: 28/10/2022
 Revision: 0
 Work By: TR
 Reviewed: KM

Description		Unit	Qty	Rate	Total
Total Project Estimate					\$ 13,706,918
Risk Items					\$ 2,284,486
Growth Allowance		%	10%	\$ 5,711,215.94	\$ 571,122
Contingency		%	30%	\$ 5,711,215.94	\$ 1,713,365
Escalation		excluded			
Base Estimate					\$ 5,711,216
Owners Costs					\$ 829,835
	Project Management	%	5%	\$ 4,881,381	\$ 244,069
	Design, Survey, Investigations		10%	\$ 4,881,381	\$ 488,138
	Land acquisition	excluded			\$ -
	Approvals		2%	\$ 4,881,381	\$ 97,628
Construction Costs					\$ 4,881,381
Contractor Indirects	Mobilisation, Demobilisation, Site Facilities, Survey, Environmental Mgmt Plan, Traffic Mgmt plan, Traffic control, Doc Control, PM , HSE, QA	%	15%	\$ 3,905,105	\$ 585,766
Contractor Margin	Profit margin	%	10%	\$ 3,905,105	\$ 390,510
Contractor Directs					
Earth Levee Section					
Contractor Directs	Earthen embankment - topsoil strip	m2	13,600	\$ 15	\$ 204,000
Contractor Directs	Earthen embankment - foundation strip	m3	803	\$ 15	\$ 12,050
Contractor Directs	Earthen embankment - fill (assume won within 3km)	m3	14,400	\$ 30	\$ 432,000
Contractor Directs	Earthen embankment - topsoil and reveg	m2	13,600	\$ 15	\$ 204,000
Concrete Levee					
Contractor Directs	Reinforced concrete levee raise (0.42m height increase on existing, 1150m length)	m2	217	\$ 1,500	\$ 326,025
Contractor Directs	Excavation and groundworks preparation around levee	m3	2,300	\$ 50	\$ 115,000
Contractor Directs	Foundation Reinforcement - Additional cutoff walls to 1.5m depth both sides of footing	lineal m	120	\$ 1,500	\$ 180,000
Contractor Directs	Foundation Reinforcement - Additional piles DN750mm to 2.5m depth, assume 1 per 5 lineal m	m3	18	\$ 2,000	\$ 35,343
Contractor Directs	New Concrete levee up to 4.8m high. Avg 4m height	lineal m	185	\$ 4,388	\$ 811,688
Contractor Directs	Foundation Reinforcement - Piles DN750mm to 2.5m depth, assume 1 per 2 lineal m	lineal m	93	\$ 2,000	\$ 185,000
Contractor Directs	New Flood gate across Molesworth street at Zadoc Street	Allowance	1	\$ 1,000,000	\$ 1,000,000
Contractor Directs	Backflow Prevention upgrades (Allowance)	Allowance	1	\$ 200,000	\$ 200,000
Contractor Directs	Existing Infrastructure impacts mitigation (Allowance)	Allowance	1	\$ 200,000	\$ 200,000
Contractor Directs	Allowance for new flood gates (Approx 0.45m higher)	Allowance	10	\$ 200,000	\$ 2,000,000
Directs Subtotal					\$ 3,905,105

MEMORANDUM

Project:	Lismore FRMP	Date:	20 June 2023
To:	Lismore City Council	From:	Engeny
ATT:	Andy Parks	CC:	
Subject:	Assessment of Flood Mitigation Options for Lismore Floodplain Risk Management Committee		

INTRODUCTION

As part of the broader Lismore Floodplain Risk Management Plan (FRMP), the Lismore Floodplain Risk Management Committee has requested that Engeny complete a flood impact analysis for the following specific mitigation works:

- Mitigation Option 1: East Lismore Flood Defence at Monaltrie Road.
- Mitigation Option 2: Sewage Treatment Plant Flood Defence.
- Mitigation Option 3: East Lismore Flood Defence at Wilson Park School.

These options comprise of levee works to mitigate flooding experienced in East Lismore and the sewage treatment works. The options have been reflected conceptually in the Lismore TUFLOW hydraulic model, to determine the potential benefits and disbenefits associated with the options for the 5% AEP flood event, 1% AEP flood event and the February 2022 flood event. This assessment has utilised the Lismore FRMP TUFLOW hydraulic model.

The following sections outline the levee alignments and associated results from the assessment.

LEEVE OPTION CONFIGURATIONS

The three mitigation options all comprise of new levee systems within East Lismore. The following sections describe the alignment and height requirements for the options and describe how they were reflected in the TUFLOW hydraulic model to ascertain flood mitigation benefits and disbenefits.

Option 1 – East Lismore Flood Defence at Monaltrie Road

The Option 1 levee alignment extends from the ridge south of Monaltrie Road to adjacent the sewage treatment plant (STP) for a total length of 1,750 m. Average existing ground elevations through the alignment are approximately 8 m AHD. In order to provide mitigation for a flood event equivalent to the February 2022 flood height, the levee would need to be constructed to a height of approximately 13 m AHD, resulting in an average embankment height of 5 m.

Incorporation of culverts through the embankment would be required to drain local catchment flows from the upper Gundurimba Creek catchment. These culverts would require flap gates to prevent backflow in a flood event, and potentially a pumping system to drain the upstream ponded water.

The alignment of the Option 1 levee is shown in Figure 1.

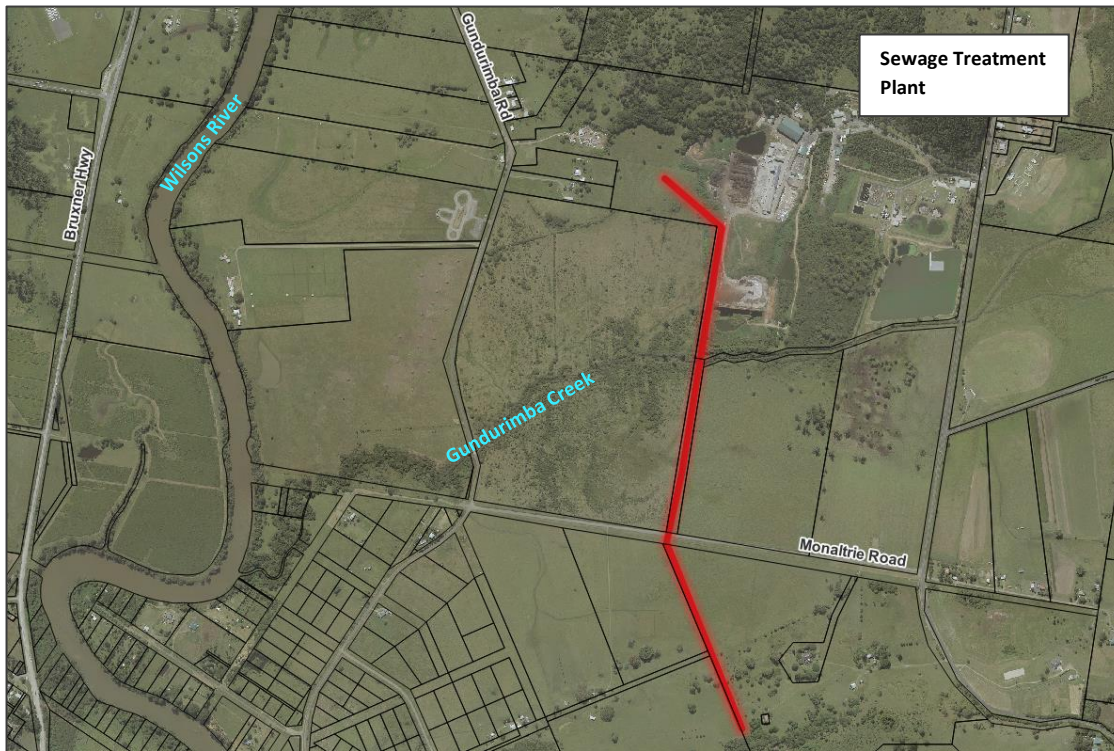


Figure 1: Option 1 Levee Alignment

Option 2 –Flood Defence at Wyrallah Road

The Option 2 levee alignment is located to protect the STP from floods with a levee surrounding the STP. The total length of the levee is 1,200 m. Average existing ground elevations through the alignment are approximately 8 m AHD. In order to mitigate for a flood event equivalent to the February 2022 flood height, the levee would need to be constructed to a height of approximately 13 m AHD, resulting in an average embankment height of 5 m. Design considerations for localised drainage relief inside the levee would also be required.

The alignment of the Option 2 levee is shown in Figure 2.

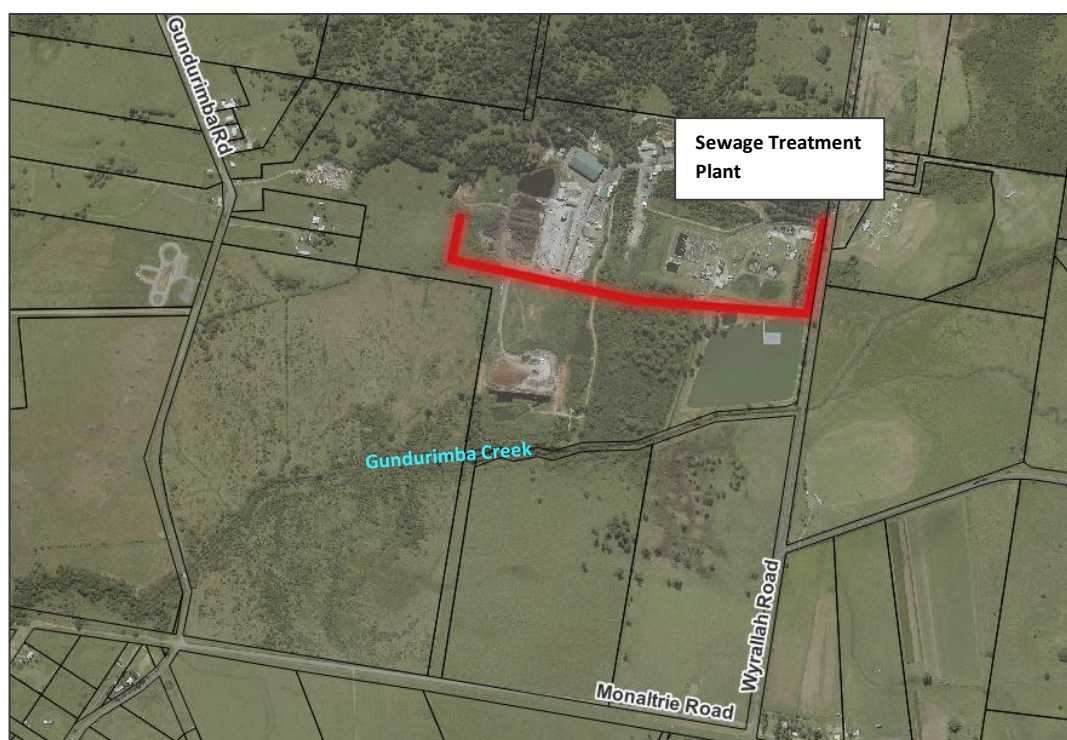


Figure 2: Option 2 Levee Alignment

Option 3 – East Lismore Flood Defence at Wilson Park School

The Option 3 levee alignment is located to provide flood protection the East Lismore residential areas. The total length of the levee is 960 m. Average existing ground elevations through the alignment are approximately 9 m AHD. In order to mitigate for a flood event equivalent to the February 2022 flood height, the levee would need to be constructed to a height of approximately 13 m AHD, resulting in an average embankment height of 4 m. Design considerations for localised drainage relief inside the levee would also be required.

The alignment of the Option 3 levee is shown in Figure 3.



Figure 3: Option 3 Levee Alignment

FLOOD ASSESSMENT RESULTS

Each of the three options outlined above have been simulated in the TUFLOW hydraulic model as simplified “glass wall” topographical alterations for the 5% AEP, 1% AEP and February 2022 flood events. Flood impact mapping for all simulations has been produced and is provided in Attachment 1. A summary of the observed benefits and disbenefits are provided in Table 1, noting that immunity is provided upstream of the particular levee assessed for all flood events analysed.

TABLE 1: SUMMARY OF MITIGATION OPTION FINDINGS

Flood Event	Mitigation Option 1: East Lismore Levee	Mitigation Option 2: STP Levee at Wyrallah Road	Mitigation Option 3: Levee at Wilson Park School
5% AEP	- Loss of Wilsons River floodplain storage. - Flood immunity to 46 properties upstream of the levee. - Impacts extend between the proposed mitigation option levee and Wilsons River to a maximum of 60 mm. - Impacts located upstream of the Bruxner Highway to a maximum of 80 mm. - Impacts of up to 30 mm extend from the confluence of Wilsons River and Leicester Creek to Coraki Road downstream.	- Flood immunity provided to the STP (1 property). - No tangible adverse impacts observed. - No significant loss of Wilsons River floodplain storage due to the levee.	- Flood immunity to 27 properties upstream of the levee. - No tangible adverse impacts observed. - No significant loss of Wilsons River floodplain storage.

Flood Event	Mitigation Option 1: East Lismore Levee	Mitigation Option 2: STP Levee at Wyrallah Road	Mitigation Option 3: Levee at Wilson Park School
1% AEP	- Flood immunity provided to approximately 126 residential properties and various industrial and community properties upstream of the levee. - Loss of Wilsons River floodplain storage. - Consistent impacts throughout the urbanised area of Lismore down to Coraki Road downstream with flood level increases of 10-30 mm.	- Flood immunity provided to the STP (1 property). - No tangible adverse impacts observed. - No significant loss of Wilsons River floodplain storage.	- Flood immunity provided to approximately 104 residential properties and various industrial and community properties upstream of the levee. - No tangible adverse impacts observed. - No significant loss of Wilsons River floodplain storage.
February 2022 Flood Event	- Flood immunity provided to approximately 309 residential properties and various industrial and community properties upstream of the levee. - Loss of Wilsons River floodplain storage. - Impacts extend to Tucki Tucki downstream and throughout the urbanised area of Lismore, with flood level increases of 10-30 mm.	- Flood immunity provided to the STP (1 property). - No tangible adverse impacts observed. - No significant loss of Wilsons River floodplain storage.	- Flood immunity provided to approximately 277 residential properties and various industrial and community properties upstream of the levee. - No tangible adverse impacts observed. - No significant loss of Wilsons River floodplain storage.

SIMPLIFIED COST-BENEFIT ANALYSIS

Preliminary Cost Estimate

A preliminary cost estimate has been completed at a high level for each of the levee mitigation options. It should be noted that these estimates are for indicative purposes only. The broad estimating assumptions included:

- No allowances have been included for land acquisition or pump system costs.
- Nominal allowances have been included for culverts, and flood gates on culverts. Given the magnitude of these elements, custom estimates will be required.
- Design level of confidence is concept. 30% contingency has been added to the base estimate and a 10% growth allowance.
- 17% owners costs have been included in the estimate, along with 15% contractor indirect costs and 10% contractor profit.
- Earthworks unit rates were assumed. No specific equipment or haul distances have been identified.

A summary of the preliminary cost-estimate for each option is provided in Table 2 below.

TABLE 2: INDICATIVE COST ESTIMATE

Option	Indicative Cost (\$AUD, 2023)
Option 1: East Lismore Levee	\$16.8M

Option	Indicative Cost (\$AUD, 2023)
Option 2: STP Levee at Wyrallah Road	\$10M
Option 3: Levee at Wilson Park School	\$7.1M

Benefit Analysis

The number of buildings (houses and large sheds) and properties protected by each of the levee options is provided in Table 3 below. For the purpose of this assessment, the number of buildings protected by the levee options for the February 2022 flood event was used as the basis for quantifying the benefit as this will directly result in a reduction in flood damage costs. The 2022 event was used as there were no buildings (other than the STP) estimated to be protect by Levee options 2 and 3 in the 1% AEP event. It should be noted that all options provide protection to the STP. The assumptions applied to identify buildings were:

- GIS data inputs were required:
 - Building polygons / assumed floor size of building.
 - Floor levels.
 - Classification of the type of building and number of storeys.
- Delineation of all building polygons within the greater Lismore urban footprint. Initially, building polygons as provided by Lismore City Council were used where possible, with gaps filled by utilisation of the open data Bing Maps Building Footprints layer.
- The Lismore City Council 2013 floor level survey was adopted where possible to apply ground and floor levels to the buildings. Where this survey information was not available, the ground level was determined by inspecting the average topographical level from the 2010 1m LiDAR dataset underneath the footprint, and the floor level was determined adding the following additional height to the ground level:
 - 150 mm for 'slab on ground'.
 - 500 mm for 'on short stumps'.
 - 1500 mm for 'on high stumps'.

TABLE 3: ESTIMATED NUMBER OF PROPERTIES AND BUILDINGS BENEFITTED

	5% AEP Design Event	1% AEP Design Event	Feb 2022 Event
<u>Option 1: East Lismore Levee</u>			
Number of Flood Affected Buildings Protected	2	4	218
Number of Flood Affected Properties Protected	46	126	309
<u>Option 2: STP Levee at Wyrallah Road</u>			
Number of Flood Affected Buildings Protected	0	0	0
Number of Flood Affected Properties Protected	1	1	1
<u>Option 3: Levee at Wilson Park School</u>			
Number of Flood Affected Buildings Protected	0	0	213
Number of Flood Affected Properties Protected	27	104	277

Based on the estimated construction cost and the benefit to buildings estimated to be flooded above floor level in the February 2022 event, the benefit/cost outcome for each option is:

- Option 1: 218 buildings at a cost of \$16.8M.
- Option 2: 0 building (STP only) at a cost of \$10M.
- Option 3: 213 buildings at a cost of \$7.1M.

Based on the assumed benefit and associated cost of each option, Option 3 was considered to provide the greatest value for money.

CONCLUSIONS

From the flood assessment completed for the East Lismore flood defence options, the conclusions were as follows:

- The East Lismore levee (Option 1) represents the highest cost option of the three options due to its proposed length and height. Although this option would provide flood immunity to East Lismore residential areas and the sewage treatment plant, minor flood level impacts of up to 80 mm (5% AEP design event) were predicted across the majority of the North Lismore, South Lismore and CBD. It was estimated that approximately 126 properties would be free of flood inundation in a 1% AEP design event. Further analysis into the consequences of these impacts should be undertaken including consideration for property floor levels.
- Protection of the STP in isolation (Option 2) could be considered as the lowest cost option with no adverse flood impacts expected. Other than the STP, no other properties would be protected in the events analysed.
- The levee at Wilson Park School (Option 3) is similar to the STP levee option in terms of it being a targeted mitigation solution. It will provide increased immunity to residential areas in East Lismore, including the football club and Wilson Park school. It was estimated that approximately 104 properties on and surrounding Nielson Street were predicted to be flood free in a 1% AEP design flood event. Due to its length and embankment height alone, it is considered the middle cost option of the three options considered.
- The preliminary cost estimate for each option were broadly estimated to be \$16.8M, \$10M and \$7.1M for Options 1, 2 and 3 respectively.
- The STP is a critical asset to the Lismore community and therefore in realist, the value of the levee options extends beyond the number of buildings or properties protected.
- Based on the assumed benefit and associated cost of each option, Option 3 was considered to provide the greatest value for money.

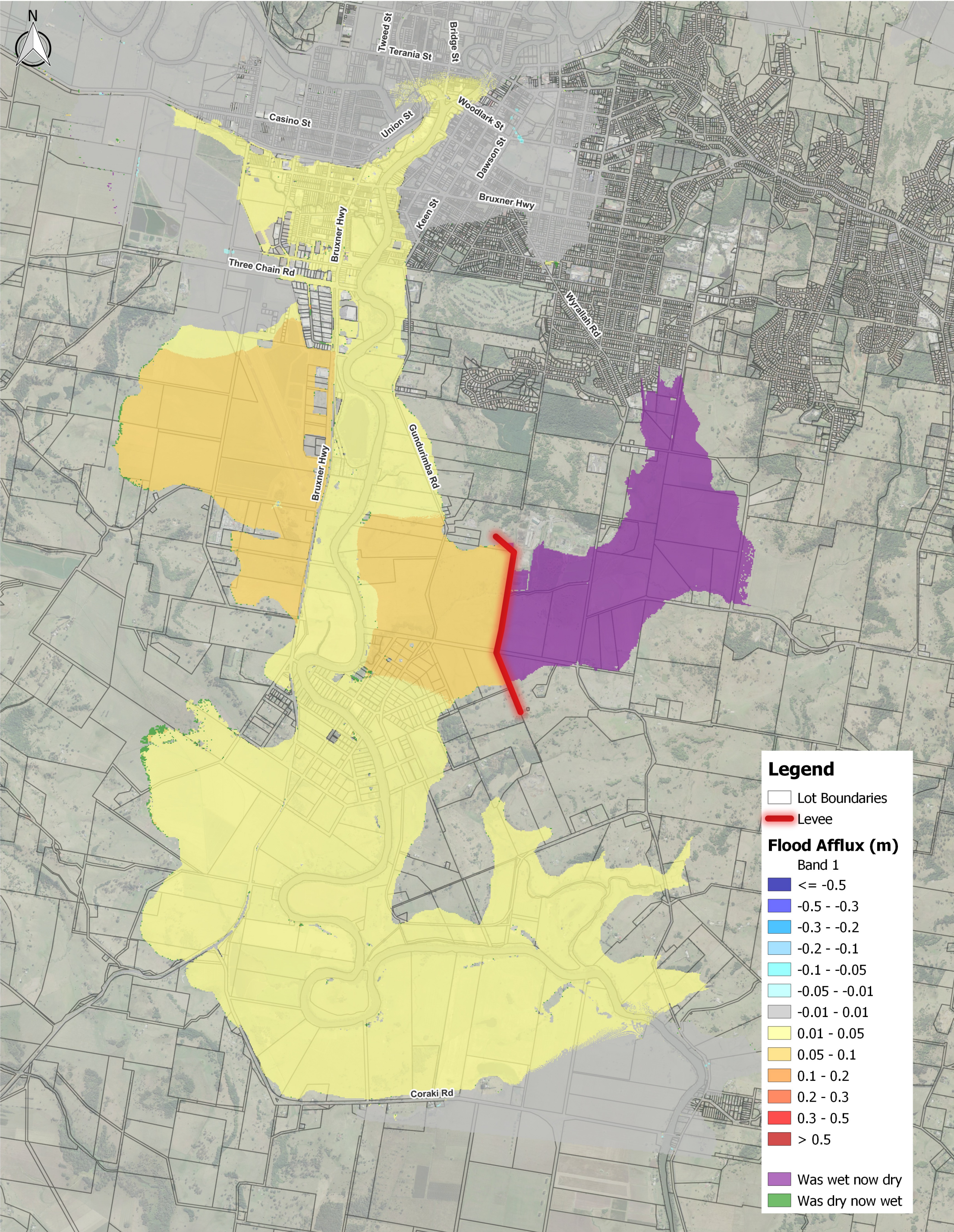
It is noted that the levee options assessed were based on details specified by the Lismore Floodplain Risk Management Committee to provide increased flood protection to the East Lismore STP and other flood affected areas within East Lismore. Whilst this assessment was completed as additional scope to the Lismore Floodplain Risk Management Plan, it does not serve the purpose of identifying and assessing flood mitigation options throughout Lismore.

DISCLAIMER

This memorandum has been prepared on behalf of and for the exclusive use of Lismore City Council and is subject to and issued in accordance with Lismore City Council instruction to Engeny Australia Pty Ltd (Engeny). The content of this memorandum was based on previous information and studies supplied by Lismore City Council

Engeny accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this memorandum by any third party. Copying this memorandum without the permission of Lismore City Council or Engeny is not permitted.

ATTACHMENT 1 – FLOOD IMPACT MAPPING



0 600 1,200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

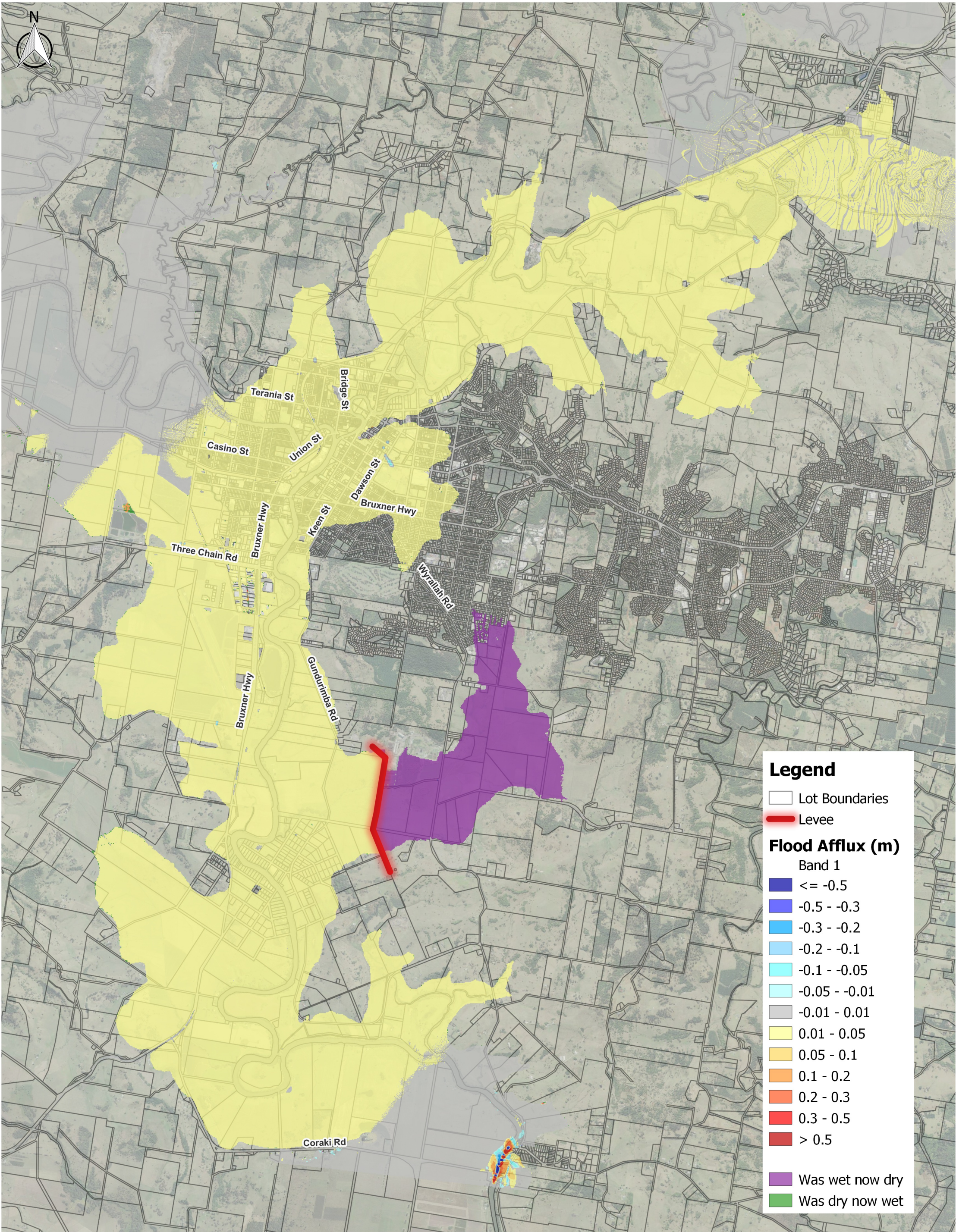
Lismore City Council
Lismore FRMP: Levee Options Analysis

Figure A1
Mitigation Option 1: East Lismore Levee
5% AEP Flood Impact



Job Number: M92000_007
Revision: 0
Drawn: JA
Checked: KM
Date: 14/6/2023

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.



Legend

Lot Boundaries

Levee

Flood Afflux (m)

Band 1

<= -0.5

-0.5 - -0.3

-0.3 - -0.2

-0.2 - -0.1

-0.1 - -0.05

-0.05 - -0.01

-0.01 - 0.01

0.01 - 0.05

0.05 - 0.1

0.1 - 0.2

0.2 - 0.3

0.3 - 0.5

> 0.5

 Was wet now dry Was dry now wet

0 800 1,600 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

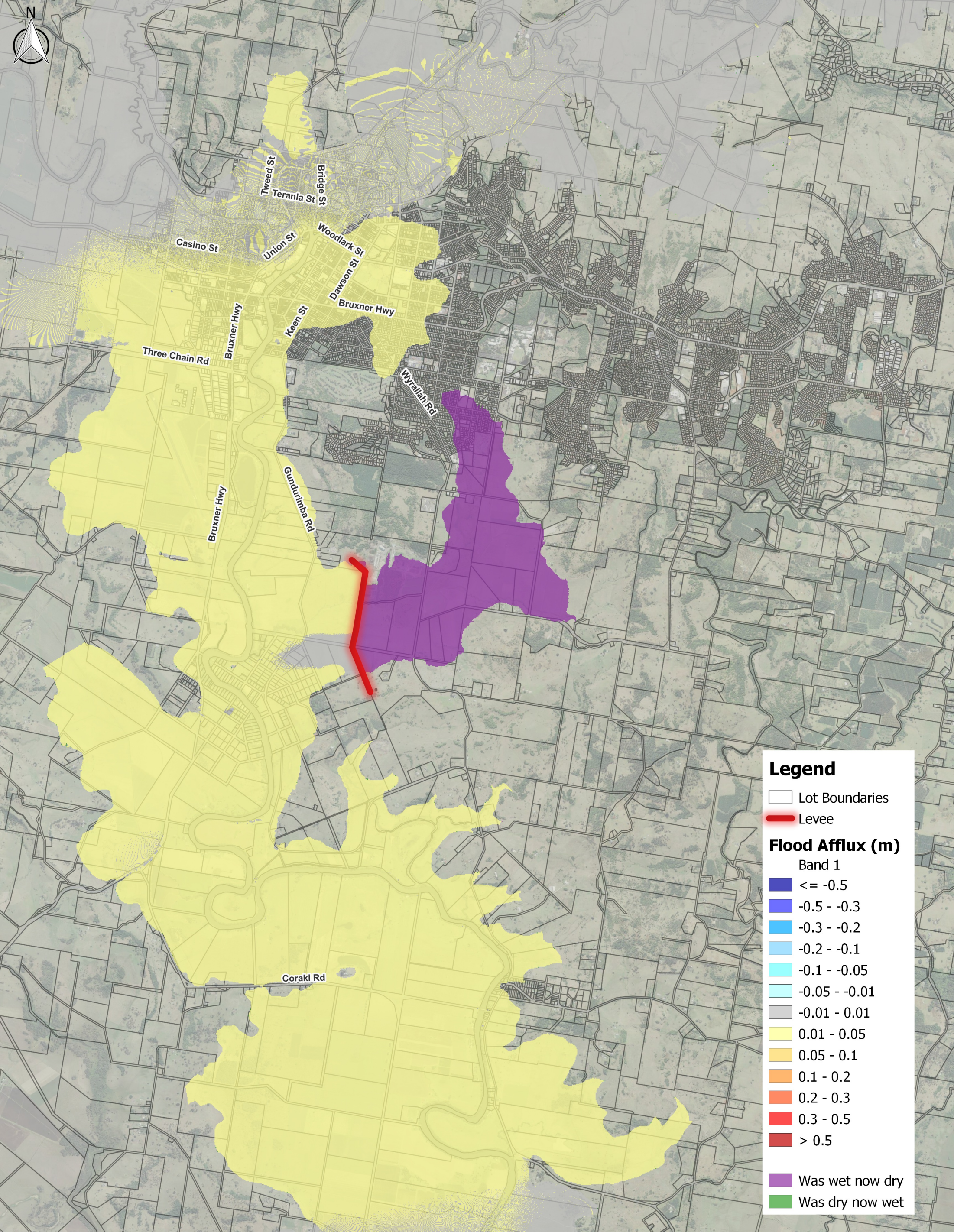
Lismore City Council
Lismore FRMP: Levee Options Analysis

Figure A2
Mitigation Option 1: East Lismore Levee
1% AEP Flood Impact



Job Number: M92000_007
Revision: 0
Drawn: JA
Checked: KM
Date: 14/6/2023

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.



Legend

Lot Boundaries

Levee

Flood Afflux (m)

Band 1

≤ -0.5

-0.5 - -0.3

-0.3 - -0.2

-0.2 - -0.1

-0.1 - -0.05

-0.05 - -0.01

-0.01 - 0.01

0.01 - 0.05

0.05 - 0.1

0.1 - 0.2

0.2 - 0.3

0.3 - 0.5

> 0.5

Was wet now dry

Was dry now wet



0 800 1,600 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

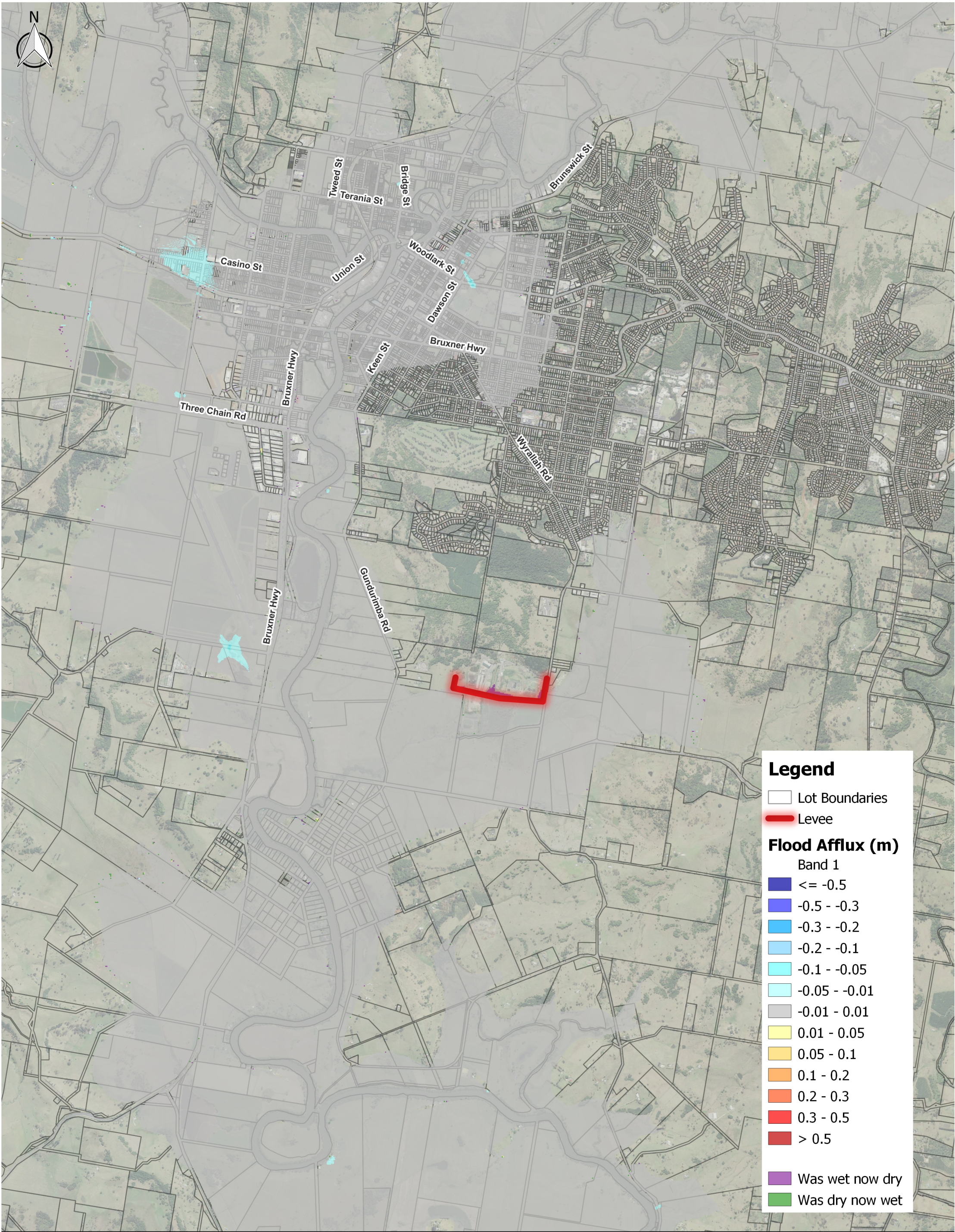
Lismore City Council
Lismore FRMP: Levee Options Analysis

Figure A3
Mitigation Option 1: East Lismore Levee
February 2022 Event Flood Impact



Job Number: M92000_007
Revision: 0
Drawn: JA
Checked: KM
Date: 14/6/2023

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.



Legend

 Lot Boundaries

 Levee

Flood Afflux (m)

Band 1

 <= -0.5

 -0.5 - -0.3

 -0.3 - -0.2

 -0.2 - -0.1

 -0.1 - -0.05

 -0.05 - -0.01

 -0.01 - 0.01

 0.01 - 0.05

 0.05 - 0.1

 0.1 - 0.2

 0.2 - 0.3

 0.3 - 0.5

 > 0.5

 Was wet now dry

 Was dry now wet



0 600 1,200 m

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

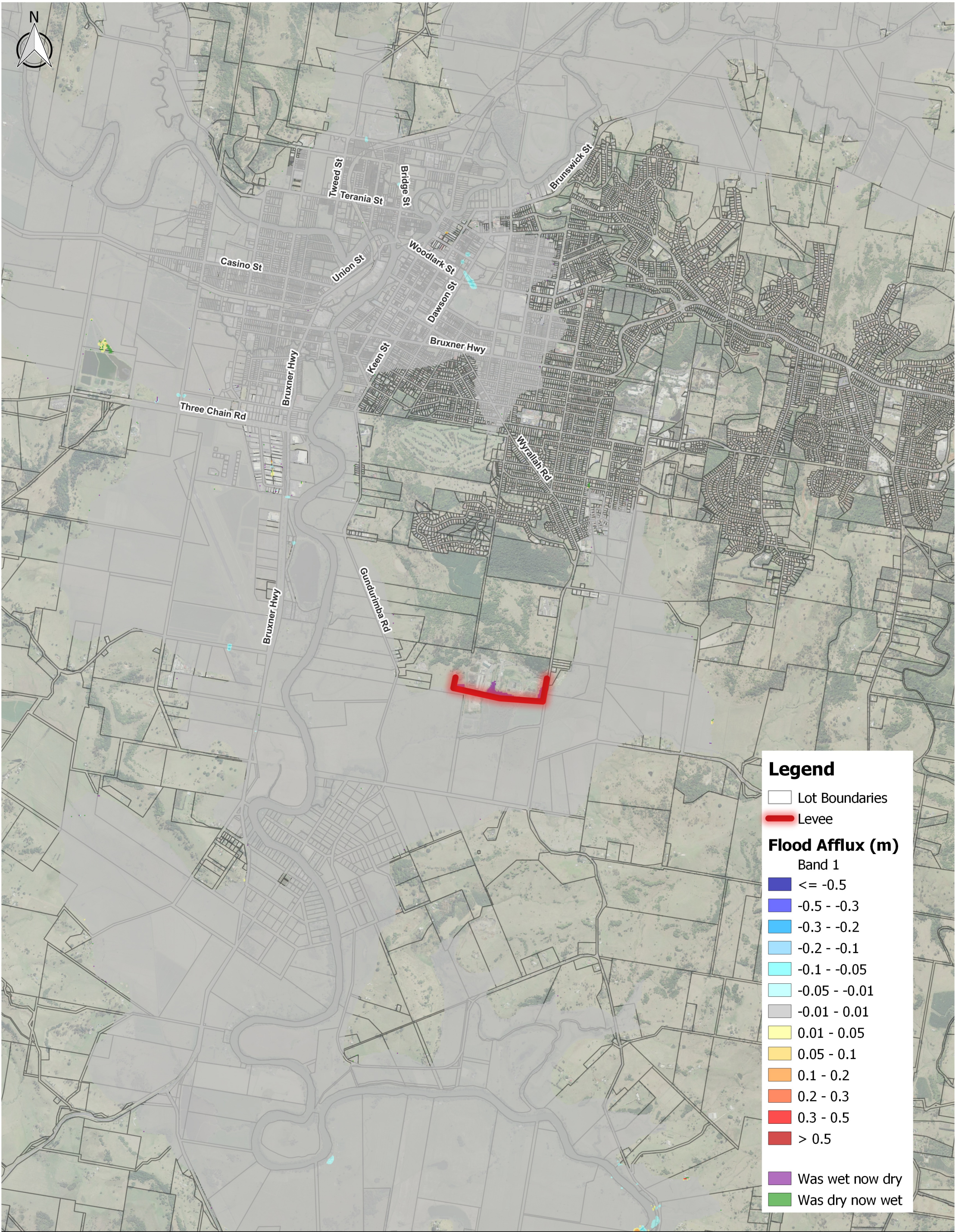
Lismore City Council
Lismore FRMP: Levee Options Analysis

Figure A4
Mitigation Option 2: STP Levee at Wyrallah Road
5% AEP Flood Impact



Job Number: M92000_007
Revision: 0
Drawn: JA
Checked: KM
Date: 14/6/2023

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.



Legend

- Lot Boundaries
- Levee

Flood Afflux (m)

- Band 1
- <= -0.5
 - 0.5 - -0.3
 - 0.3 - -0.2
 - 0.2 - -0.1
 - 0.1 - -0.05
 - 0.05 - -0.01
 - 0.01 - 0.01
 - 0.01 - 0.05
 - 0.05 - 0.1
 - 0.1 - 0.2
 - 0.2 - 0.3
 - 0.3 - 0.5
 - > 0.5
- Was wet now dry
- Was dry now wet



0 600 1,200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Lismore City Council
Lismore FRMP: Levee Options Analysis

Figure A5
Mitigation Option 2: STP Levee at Wyrallah Road
1% AEP Flood Impact



Job Number: M92000_007
Revision: 0
Drawn: JA
Checked: KM
Date: 14/6/2023

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.



Tweed St
Terania St
Bridge St
Brunswick St
Casino St
Union St
Woodlark St
Dawson St
Keen St
Bruxner Hwy
Three Chain Rd
Wyrallah Rd
Gundurimba Rd



Legend

- Lot Boundaries
- Levee

Flood Afflux (m)

- Band 1
- ≤ -0.5
 - $-0.5 - -0.3$
 - $-0.3 - -0.2$
 - $-0.2 - -0.1$
 - $-0.1 - -0.05$
 - $-0.05 - -0.01$
 - $-0.01 - 0.01$
 - $0.01 - 0.05$
 - $0.05 - 0.1$
 - $0.1 - 0.2$
 - $0.2 - 0.3$
 - $0.3 - 0.5$
 - > 0.5

- Was wet now dry
- Was dry now wet



0 600 1,200 m

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

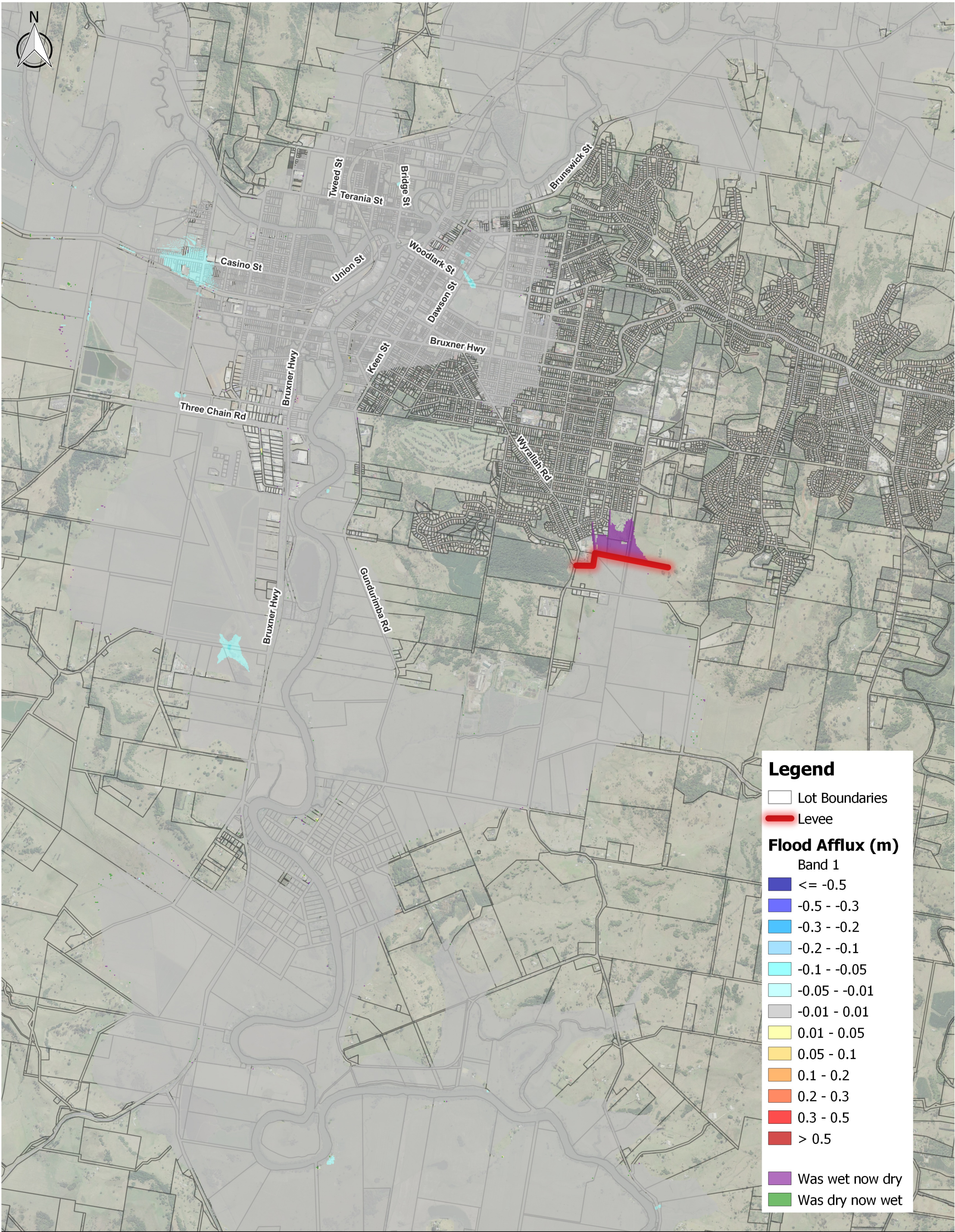
Lismore City Council
Lismore FRMP: Levee Options Analysis

Figure A6
Mitigation Option 2: STP Levee at Wyrallah Road
February 2022 Event Flood Impact



Job Number: M92000_007
Revision: 0
Drawn: JA
Checked: KM
Date: 14/6/2023

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.



Legend

- Lot Boundaries
- Levee

Flood Afflux (m)

- Band 1
- <= -0.5
 - 0.5 - -0.3
 - 0.3 - -0.2
 - 0.2 - -0.1
 - 0.1 - -0.05
 - 0.05 - -0.01
 - 0.01 - 0.01
 - 0.01 - 0.05
 - 0.05 - 0.1
 - 0.1 - 0.2
 - 0.2 - 0.3
 - 0.3 - 0.5
 - > 0.5

- Was wet now dry
- Was dry now wet



0 600 1,200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

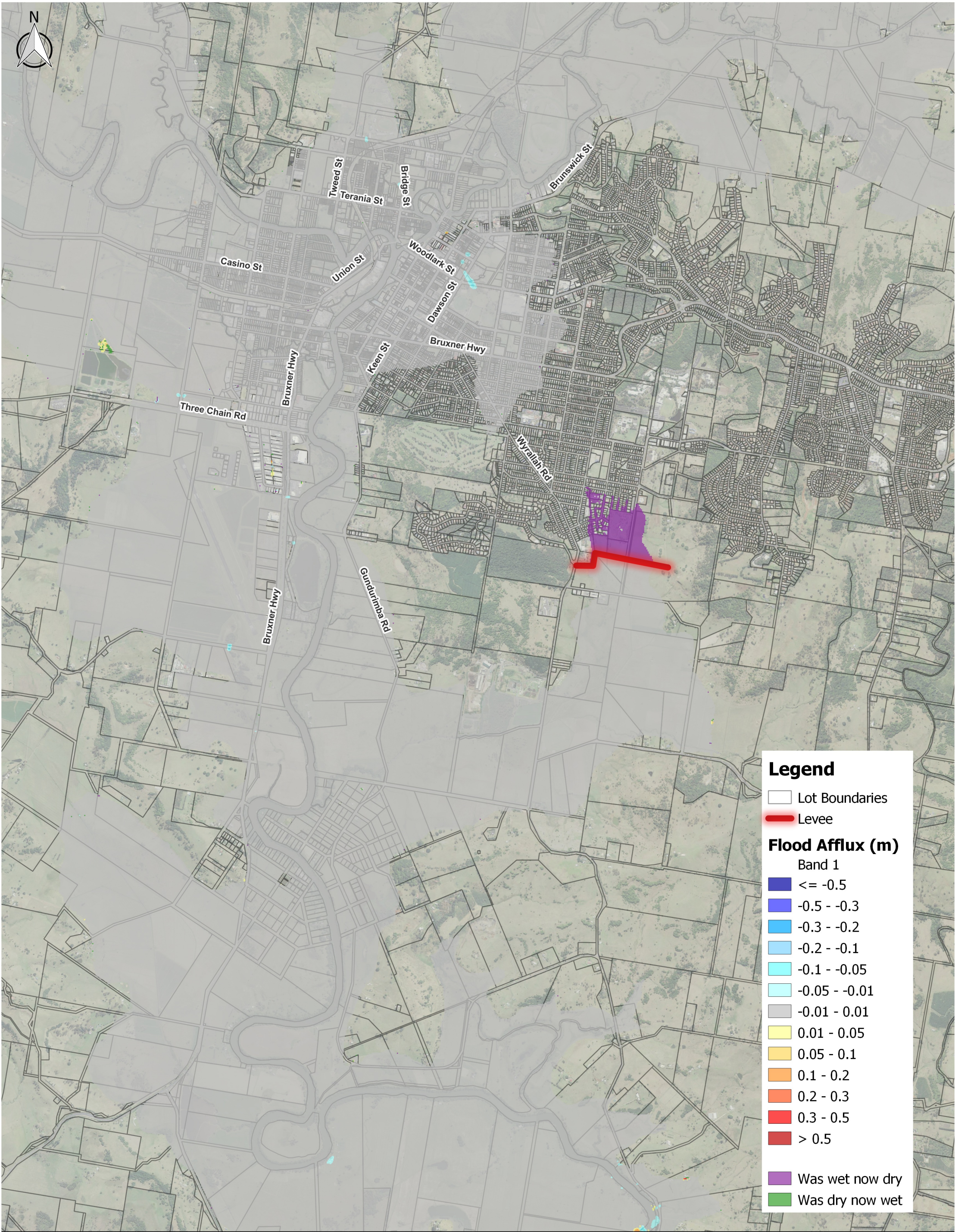
Lismore City Council
Lismore FRMP: Levee Options Analysis

Figure A7
Mitigation Option 3: Levee at Wilson Park School
5% AEP Flood Impact



Job Number: M92000_007
Revision: 0
Drawn: JA
Checked: KM
Date: 14/6/2023

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.



Legend

- Lot Boundaries
- Levee

Flood Afflux (m)

- Band 1
- <= -0.5
 - 0.5 - -0.3
 - 0.3 - -0.2
 - 0.2 - -0.1
 - 0.1 - -0.05
 - 0.05 - -0.01
 - 0.01 - 0.01
 - 0.01 - 0.05
 - 0.05 - 0.1
 - 0.1 - 0.2
 - 0.2 - 0.3
 - 0.3 - 0.5
 - > 0.5

- Was wet now dry
- Was dry now wet



0 600 1,200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Lismore City Council
Lismore FRMP: Levee Options Analysis

Figure A8
Mitigation Option 3: Levee at Wilson Park School
1% AEP Flood Impact



Job Number: M92000_007
Revision: 0
Drawn: JA
Checked: KM
Date: 14/6/2023

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.



Map showing streets and flood impact areas. Labeled streets include: Tweed St, Terania St, Bridge St, Brunswick St, Casino St, Union St, Woodlark St, Dawson St, Keen St, Bruxner Hwy, Three Chain Rd, Wyalah Rd, and Gundurimba Rd. A red line indicates the Levee location. A purple shaded area indicates 'Was wet now dry' flood impact. A green shaded area indicates 'Was dry now wet' flood impact.

Legend

 Lot Boundaries

 Levee

Flood Afflux (m)

Band 1

 <= -0.5

 -0.5 - -0.3

 -0.3 - -0.2

 -0.2 - -0.1

 -0.1 - -0.05

 -0.05 - -0.01

 -0.01 - 0.01

 0.01 - 0.05

 0.05 - 0.1

 0.1 - 0.2

 0.2 - 0.3

 0.3 - 0.5

 > 0.5

 Was wet now dry

 Was dry now wet



0 600 1,200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Lismore City Council
Lismore FRMP: Levee Options Analysis

Figure A9
Mitigation Option 3: Levee at Wilson Park School
February 2022 Event Flood Impact



Job Number: M92000_007
Revision: 0
Drawn: JA
Checked: KM
Date: 14/6/2023

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.