Lismore City Council

Lismore Floodplain Risk Management Plan - Land Use Planning and Development Control

Interim Report

DRAFT

4 May 2023

M92000_007-REP-701-4

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0	30/11/2022	Draft for Client Review	KM	MP	MP	DN
1	22/12/2022	Draft for Further Review	KM	MP	MP	DN
2	16/03/2023	Draft for Further Review	KM	MP	MP	DN
3	6/04/2023	Draft Report for Community Engagement	KM	MP	MP	DN
4	4/05/2023	Draft Report for Community Engagement	KM	MP	MP	DN
Signatures						

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Abbreviations

AEP -	Annual Exceedance Probability	
AHD -	Australian Height Datum	
AIDR -	Australian Institute of Disaster Resilience	
ARR -	Australian Rainfall and Runoff	
CBD -	Central Business District	
DFE -	Defined Flood Event	
DPE -	Department of Planning and Environment	
FLA -	Flood Liable Area	*Area with the Probable Maximum Flood (PMF) extent.*
FPA -	Flood Planning Area	*The area of land below the Flood Planning Level (FPL).*
FPL -	Flood Planning Level	*The combination of the flood level per the Defined Flood Event (DFE) and suitable freeboard.*
FRMP -	Floodplain Risk Management Plan	
FRMS -	Floodplain Risk Management Study	
GIS -	Geographic Information System	
IPPC -	Intergovernmental Panel on Climate Change	
LCC -	Lismore City Council	
LEP -	Local Environmental Plan	
NRRC -	Northern Rivers Reconstruction Corporation	
NSW -	New South Wales	
PMF -	Probable Maximum Flood	
RCP -	Representative Concentration Pathway	
VHR -	Voluntary House Raising	
VHP -	Voluntary House Purchase	

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1 INTRODUCTION

Engeny was engaged by Lismore City Council (LCC or Council) in late 2021 to update the Lismore Floodplain Risk Management Plan (FRMP). However, due to the February and March 2022 flood events, components of the scope have been placed temporarily on hold, however the land use planning and development control elements of the FRMP proceeded. Therefore, this document acts as an interim report to summarise recommendations regarding these elements as a separable portion of work.

This report provides flood risk advice to facilitate further land use planning and development control determinations by LCC with input from relevant stakeholder including the community. This report will be revised as feedback is provided and further planning is undertaken.

1.1 SCOPE OF WORKS

This document outlines the outcomes from the following scope of works:

- Hydrologic and hydraulic analysis of additional extreme design flood events (1:1,000, 1:2,000, 1:10,000 and 1:100,000 Annual Exceedance Probability (AEP) utilising the models developed for the Lismore *Floodplain Risk Management Study* (FRMS) (Engeny, 2021).
- Preparation of flood planning mapping in accordance with the latest available New South Wales (NSW) Department of Planning and Environment (DPE) guidelines and Australian Institute of Disaster Resilience (AIDR) recommendations, inclusive of:
  - Flood hazard.
  - Flood function.
  - Flood Liable Area (FLA).
  - Flood risk precincts.
  - Flood emergency response classifications.
  - Climate change impacts.
- Provision of flood risk related advice on land use planning and development controls in light of the latest design event and flood planning mapping.
- Review of the current Voluntary House Raising (VHR) and Voluntary House Purchase (VHP) schemes.

2 ADDITIONAL DESIGN EVENT ANALYSIS

The URBS hydrologic model and TUFLOW hydraulic model previously developed for the Lismore FRMS have been utilised to simulate the 1:1,000, 1:2,000, 1:10,000 and 1:100,000 AEP extreme flood events. These events were not previously simulated, nor reported on in the Lismore FRMS. These additional events have been utilised to inform the determination of the flood planning mapping discussed in the following sections. Further details on the modelling and results are provided in Appendix C, and full model development details are outlined in the Lismore FRMS report (Engeny, 2021).

3 FLOOD PLANNING MAPPING

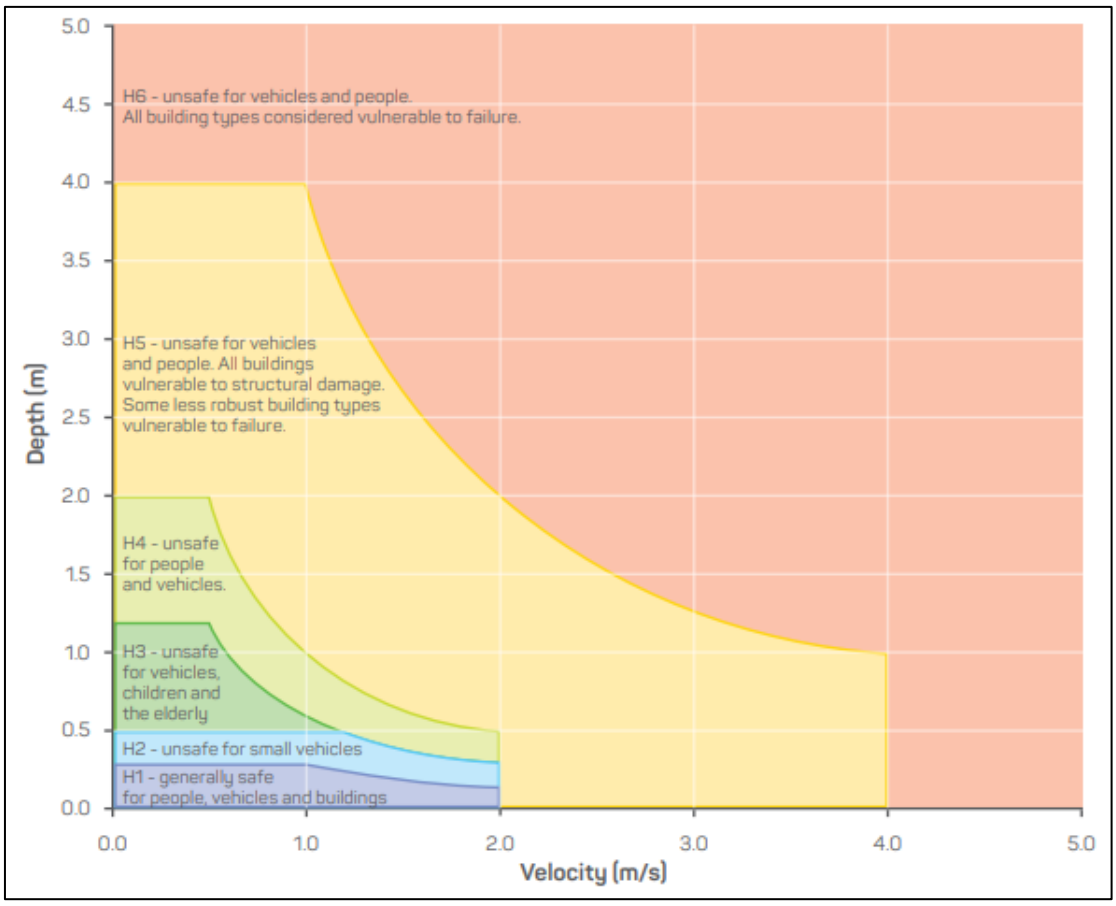
A full set of flood planning maps for Lismore have been developed using the latest flood results, to support Council in determining potential future land use planning and development controls. Description of the approaches to the mapping and the subsequent delineations are discussed in the following sections.

3.1 FLOOD HAZARD

Flood hazard maps for Lismore have been produced for all design events from the 5% AEP to the Probable Maximum Flood (PMF) event, and are provided in Appendix B. The 1% AEP flood hazard map is also provided in Figure 3.2. The hazard scheme applied is 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).

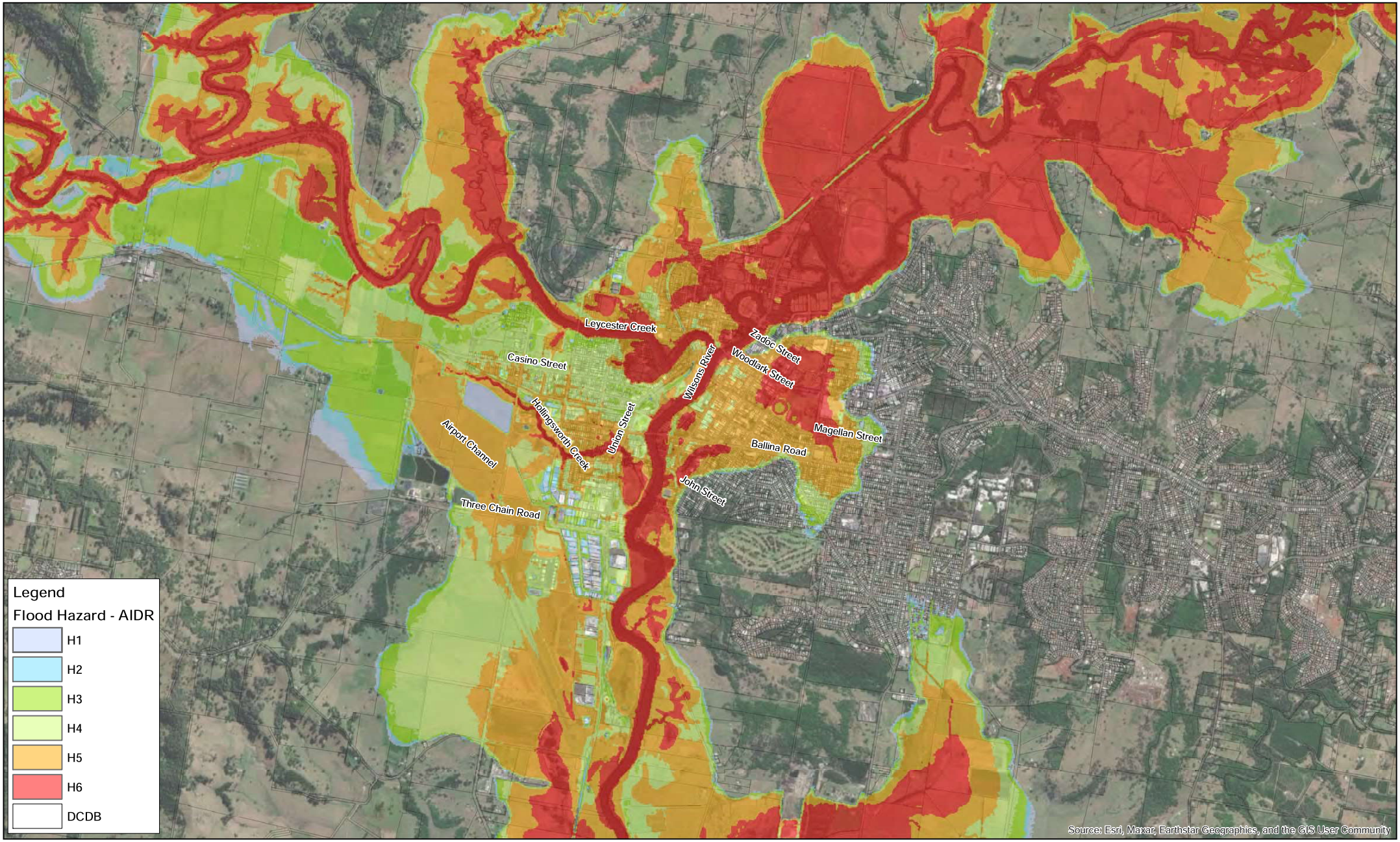
The AIDR flood hazard vulnerability curves associated with this classification are provided in Figure 3.1.

Figure 3.1: AIDR Flood Hazard Vulnerability Curves



The following was observed regarding the 1% AEP flood hazard in Lismore:

- The main floodways of Leycester Creek and Wilsons River, along with the Central Business District (CBD) basin have the highest hazard rating of H6.
- The majority of the inundated area behind the CBD levee has a hazard classification of H5, meaning that less robust building types are vulnerable to failure.
- South Lismore generally has a hazard rating of H3 and H4, which is considered unsafe for vehicles.
- North Lismore generally has a hazard rating of H5 and H6, which is considered unsafe for vehicles and people and buildings are vulnerable to failure.



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DATA SOURCE
QLD Government Open Source Data

DESIGNER
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lismore city council

Figure 3.2

Lismore Floodplain Risk Management Plan
Flood Hazard - AIDR
1% AEP

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3.2 FLOOD PLANNING AREA AND FLOOD LIABLE AREA

Council currently places controls on development in flood prone areas as identified on the Local Environment Plan (LEP) 2012 Flood Planning Area (FPA) Map. The following definitions specified in the *Flood Risk Management Manual* (NSW DPE, 2022) 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.

Lismore's current FPA mapping extent was developed based on the 1% AEP flood extent available at the time of the development of the 2012 LEP. The current Lismore FPL is the 1% AEP flood event level plus a freeboard of 500 mm.

Until suitable consultation has been completed with Council and relevant stakeholders on consideration of the implications of the determination of the FPA and FPL, an alternative Flood Liable Area (FLA) has been mapped, defining the floodplain where potential development controls could apply. The proposed Flood Liable Area (FLA) is based on the PMF extent and is shown in Figure 3.3.

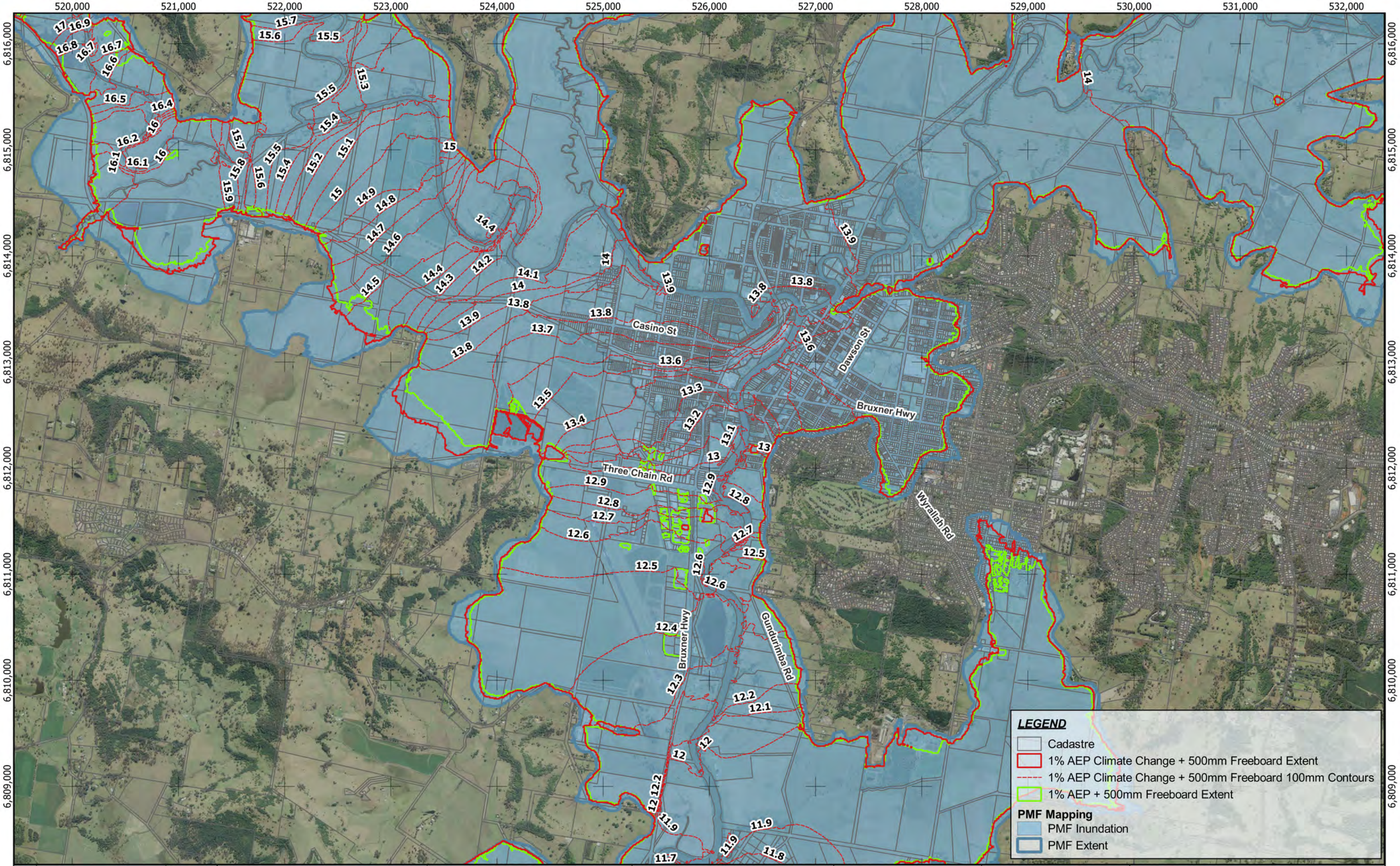
Consideration of any amendments to the FPA and FPL within the FLA are at the discretion of Council, with potential options including, but not limited to;

1. Retainment of the 1% AEP plus 500 mm freeboard for the FPL (shown on Figure 3.3).
2. Adoption of the 1% AEP 2090 Climate Change level plus 500 mm freeboard for the FPL. 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. (shown on Figure 3.3).
3. Adoption of a flood event between the 1% AEP and the 1:2,000 AEP flood event as the FPL.
4. Adoption of the February 2022 peak flood height as the FPL, estimated as sitting between the 1:2,000 AEP and 1:10,000 AEP design flood levels.
5. Consideration of different FPLs for different land uses, such as residential versus commercial, could be also be incorporated.

3.2.1 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 flood planning level 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 point to 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 3.6). 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 Local Environmental Plan 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 flood planning level is one way Lismore can decrease flood risk for new development, however it should be noted that this does not eliminate the risk.



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DATA SOURCE
NSW Six Map Open Data

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Figure 3.3

Lismore Floodplain Risk Management Plan
Flood Liable Land

Drg Ref.
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3.3 FLOOD FUNCTION

Flood function mapping identifies various areas within the floodplain extent (defined by the PMF) in accordance with the following definitions provided by the *Flood Risk Management Manual* (NSW DPE, 2022):

- 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 3.4.

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 m^2/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.

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Casino St
Dawson St
Bruxner Hwy
Three Chain Rd
Wyrallah Rd
Bruxner Hwy
Gundurimba Rd

LEGEND

Lismore_FloodFunction_RevD
- Floodway
- Fringe
- Storage

Lot
- MappingExtent

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Figure 3.4

Lismore Floodplain Risk Management Plan
Flood Function

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3.4 FLOOD RISK PRECINCT MAPPING

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). A flood risk classification matrix was developed for Lismore that utilises the flood hazard (in accordance with the AIDR flood hazard vulnerability curves as discussed in Section 3.1), and the frequency (the design flood event Annual Exceedance Probability). The adopted flood risk matrix is provided in Figure 3.5.

Figure 3.5: Flood Risk Precinct Matrix

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

The matrix has been applied to the design event flood results to classify the entirety of the Lismore floodplain contained within the PMF flood extent. The resultant map is the maximum risk classification observed in any one grid cell within the hydraulic model from application of a risk rating to the individual flood hazard results for each AEP. For example, extreme risk classification can only occur where a H5 or H6 hazard occurs in a 10% AEP event or a H6 hazard in a 5% AEP or 1% AEP event.

The resultant Flood Risk Precincts map is provided in Figure 3.6. 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 “CDB Development Exemption Area” precinct has been applied to areas in the CBD 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.

The number of buildings broadly estimated to be located within each precinct is summarised in Table 3.1. These have been calculated using a Geographic Information System (GIS) layer containing all buildings (residential houses and commercial/industrial buildings) observed in the aerial imagery available at the time of writing this report and has been quality checked to ensure sheds and other non-habitable or non-business use buildings are removed from the dataset.

Table 3.1: Building Estimates within Each Flood Risk Precinct

Flood Risk Precinct	Estimated Number of Buildings
Low	567
Medium	433
High	1,831
Extreme	223

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Casino St
Dawson St
Bruxner Hwy
Three Chain Rd
Wyrallah Rd
Bruxner Hwy
Gundurimba Rd

LEGEND

Flood Risk Precincts

- Low
- Medium
- High
- Extreme
- South Lismore Development Restricted Area
- CBD Development Exemption Area
- Cadastre
- Extent of Analysis

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NSW Six Map Open Data

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Figure 3.6

Lismore Floodplain Risk Management Plan
Flood Risk Precincts

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3.5 FLOOD EMERGENCY RESPONSE CLASSIFICATION

The Lismore floodplain, defined up to the PMF flood extent, has been assessed against the *Support for Emergency Management Planning – Flood Risk Management Guide EM01* (NSW DPE, 2022) 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 is presented in Figure 3.7, and a summary of the definitions are summarised in Table 3.2. Not all classifications have been deemed relevant to Lismore.

Table 3.2: Flood Emergency Response Classifications

Flood Emergency Response Classification	Description
High Flood Island	Areas suitable for refuge remain flood free in the PMF. Evacuation is not practical prior to flooding and 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. Evacuation is not practical prior to flooding, however, the area is not completely surrounded by floodwater.
Low Flood Island	The area is flooded in a PMF event. Evacuation is not practical prior to flooding.
Low Trapped Perimeter Area	The area is flooded in a PMF event. Evacuation is not practical prior to flooding, however, the area is not completely surrounded by floodwater.
Areas with Rising Road Access	The area is flooded in a PMF event. Evacuation is practical prior to flooding, with access to a road that rises continually out of the PMF.
Areas with Overland Escape Route	The area is flooded in a PMF event. Evacuation is practical prior to flooding, via overland means on foot.

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Casino St
Three Chain Rd
Bruxner Hwy
Dawson St
Bruxner Hwy
Wyrallah Rd
Gundurimba Rd

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

Evacuation Zones
- East
- South
- Central
- North

Evacuation Routes
- East
- South
- Central
- North

Cadastre
- Extent of Analysis

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Figure 3.7

Lismore Floodplain Risk Management Plan
Flood Emergency Response Classifications

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3.6 ROAD EVACUATION ANALYSIS

3.6.1 Overview

For the purpose of the road evacuation analysis, Lismore has been designated into four precincts; South Lismore, North Lismore, CBD and East Lismore. The residential building and population numbers for each evacuation precinct are summarised in Table 3.3. For this analysis, it has been assumed that commercial and industrial buildings do not have a permanent population and therefore have been excluded from the estimated population required to evacuate during a flood event. The key roads utilised for evacuation are shown on Figure 3.8.

Table 3.3: Evacuation Precincts

Evacuation Precinct	Number of Residential Buildings*	Estimated Population**
South Lismore	766	1,840
North Lismore	227	540
CBD	1215	2,800
East Lismore	257	590

**Building polygons as supplied by Lismore City Council, manually gap-filled to capture buildings assumed to be habitable.*

***Utilising Australian Bureau of Statistics Census 2021 'Average Number of People per Household' data.*

3.6.2 Flood Risk for Evacuation Routes

In order to provide context on trafficability, flood risk, and availability of the key evacuation routes in Lismore, extraction of flood behaviour information for the 10% AEP, 1% AEP, March 2017, and February 2022 flood events has been undertaken. Peak depths and flood hazard (Depth x Velocity products) for each event at key locations (refer to Figure 3.8) along the evacuation routes have been extracted and are provided in Table 3.4. The depth and hazard values provided for the 10% AEP and 1% AEP flood events correspond to the critical duration for these events. The 10% AEP flood event has a critical duration of 48 hours, and the 1% AEP has a critical duration of 24 hours. These locations are indicated on Figure 3.8.

Depth x Velocity product has been utilised as an informative indicator of trafficability for the road. The maximum limits for vehicle trafficability and stability recommended in Australian Rainfall and Runoff 2019 (ARR 2019) (Ball, et. al., 2019) have been applied and are:

- Small passenger vehicle: DxV ≤ 0.30 m^2/s
- Large passenger vehicle: DxV ≤ 0.45 m^2/s
- Large 4WD: DxV ≤ 0.60 m^2/s.

The limits for pedestrian stability are:

- Children: DxV ≤ 0.40 m^2/s (providing depth <0.5 m and velocity <3 m/s)
- Adults: DxV ≤ 0.60 m^2/s (providing depth <1.2 m and velocity <3 m/s).

Flood mapping of the depth x velocity result for the analysed events is provided in Appendix D.

Table 3.4: Peak Depth and Flood Hazard for Evacuation Routes

Location	Route	10% AEP Flood Event		1% AEP Flood Event		March 2017		February 2022	
		Peak Depth (m)	Flood Hazard (m^2/s)	Peak Depth (m)	Flood Hazard (m^2/s)	Peak Depth (m)	Flood Hazard (m^2/s)	Peak Depth (m)	Flood Hazard (m^2/s)
1	South 1	0.11	0.1	1.60	0.5	0.86	0.3	3.36	1.5
2	South 1	0.00	0.0	1.01	0.5	0.36	0.1	2.71	1.8
3	South 1	0.04	0.0	0.57	1.0	0.00	0.3	2.49	1.7
4	South 2	0.00	0.0	1.36	0.7	0.70	0.2	3.32	1.0
5	South 2	0.00	0.0	2.75	1.0	2.04	0.5	4.84	2.7
6	South 3	2.14	0.6	3.42	0.9	2.89	1.0	5.20	1.6
7	CBD 1	0.00	0.0	0.38	0.0	0.00	0.0	2.07	0.7
8	CBD 1	0.98	0.1	3.49	1.6	2.68	0.8	5.32	2.9
9	CBD 1	0.00	0.0	1.70	0.4	0.58	0.2	3.42	1.0
10	CBD 1	0.80	0.1	3.12	0.6	2.21	0.3	4.99	0.7
11	CBD 1	0.00	0.0	0.00	0.0	0.00	0.0	1.25	0.0
12	CBD 2	0.23	0.0	2.53	0.7	1.59	0.5	4.34	1.1
13	CBD 2	1.53	0.1	3.84	0.6	2.84	0.9	5.67	0.8
14	CBD 3	0.39	0.0	2.71	0.1	1.76	0.1	4.54	1.2
15	CBD 3	1.79	0.1	3.20	0.3	2.48	0.1	4.92	0.7
16	North 1	1.16	0.5	2.57	1.4	1.67	0.8	4.35	2.3
17	North 1	0.00	0.0	1.02	0.6	0.29	0.2	2.80	1.8
18	North 1	0.40	0.2	1.88	1.0	0.88	0.5	3.53	1.2
19	North 2	0.12	0.0	1.53	0.3	0.60	0.1	3.24	0.9
20	North 2	0.88	0.0	2.29	0.3	1.53	0.2	4.03	0.7
21	North 2	1.22	0.0	2.63	0.1	1.76	0.1	4.30	0.1
22	North 3	2.98	0.0	4.39	0.3	3.70	0.1	6.20	1.1
23	East	0.73	0.0	2.37	0.1	1.83	0.3	4.24	0.2

3.6.3 Bridge Crossing Immunities

Bridge crossings of Leycester Creek and Wilsons River are key to the evacuation routes. Commentary on the immunity of the various crossings and use for evacuation are listed in Table 3.5.

Table 3.5: Bridge Crossings

Bridge Name	Precincts Served	Estimated Immunity	Use in Evacuation
Fawcett Bridge	North Lismore (east of Pine Street, and south of Exton Street)	Deck level at 14.24 m AHD. 1:2,000 AEP flood event estimated immunity.	Southern approach trafficable up to levee overtopping. Northern approach must be utilised early in a flood event, before trafficability is lost.
Ballina Street Bridge	South Lismore (primary)	Deck level at 14.65 m AHD. 1:10,000 AEP flood event estimated immunity.	Preferred evacuation route for South Lismore. Eastern approach trafficable up to levee overtopping. Western approach trafficable in events up to a 1:20 AEP flood event, otherwise must be utilised early in a flood event.
Robert White Bridge	South Lismore (secondary)	Deck level at approximately 15.7 m AHD. 1:10,000 AEP flood event estimated immunity.	Feasible evacuation route for flood events up to an expected 1:20 AEP flood event. Both northern and southern approaches become inundated in events larger than 1:20 AEP, route to only be used early in events of this magnitude.
Union Street Bridge	Not a recommended evacuation route.	Deck level at 12.92 m AHD. 1:100 AEP flood event estimated immunity	Access from the south along Union Street is limited due to early inundation, in events as frequent as the 1:10 AEP flood event. Not recommended as an evacuation route.
Hollingsworth Creek Bridge	South Lismore internal	Deck at approximately 8.8 m AHD. Less than 1:10 AEP immunity.	Evacuation from South of Hollingsworth Creek must occur early in a flood event, as both crossing locations are inundated quickly.
Wilson Street Causeway	South Lismore internal	Deck at approximately 9 m AHD. Less than 1:10 AEP immunity.	Evacuation from South of Hollingsworth Creek must occur early in a flood event, as both crossing locations are inundated quickly.

3.6.4 Rate of Rise

Rate of rise indicates how quickly from the start of an event floodwaters are expected to increase. Typically, the rate of rise varies during the event and is influenced by rainfall, physical structures (i.e. levees, etc.) and floodplain characteristics, Commentary of the observed rate of rise for the critical storm duration for the 10% AEP and 1% AEP design events, and for the modelled March 2017 and February 2022 flood events, is provided in Table 3.6. It is noted that the reported numbers are extracts from the flood model and not actual flood event records.

Table 3.6: Typical Rate of Rise in Evacuation Precincts

Evacuation Precinct	10% AEP Flood Event	1% AEP Flood Event	March 2017	February 2022
South Lismore	*Flood depths too minor to provide commentary due to protection from South Lismore levee.*	Flood depths reach **1.6 m in 10 hours.**	Flood depths reach **0.9 m in almost 6 hours.**	An average rate of rise of **1 m per 5.3 hours** to the peak of the modelled event is observed. Total depth at analysed location is **3.4 m**.
North Lismore	Flood depths reach **0.5 m in almost 8 hours.**	Flood depths reach **1.9 m in almost 12 hours.**	Flood depths reach **1.1 m in almost 9 hours.**	An average rate of rise of **1 m per 5.1 hours** to the peak of the modelled event is observed. Total depth at analysed location is **3.7 m**.

Evacuation Precinct	10% AEP Flood Event	1% AEP Flood Event	March 2017	February 2022
CBD	Local flow initially inundates some localities in Lismore (not captured in modelling). Following overtopping of the levee, an average rate of rise of **1 m per 3.5 hours** to the peak of the modelled event is observed. Total depth at analysed location is **3.5 m.**	An average rate of rise of **1 m per 1.9 hours** to the peak of the modelled event post levee overtopping is observed. Total depth at analysed location is **6 m**.	An average rate of rise of **1 m per 1.8 hours** to the peak of the modelled event post levee overtopping is observed. Total depth at analysed location is **4.9 m**.	An average rate of rise of **1 m per 2.4 hours** to the peak of the modelled event post levee overtopping is observed. Total depth at analysed location is **7.7 m**.

3.6.5 Duration of Closure and Time to Closure

Duration of closure in this analysis is an indicator of how long the evacuation routes are unable to be used in the flood events (based on flood depths exceeding 300 mm). Extraction of this data at various location (as shown on Figure 3.8) is provided in Table 3.7.

Time to closure is the time it takes for flood depths to reach 300 mm. To provide context for road closure to flood warnings in Lismore, the time from which the Lismore Rowing Club gauge reaches the closest corresponding flood warning level to road closure has been provided. Extraction of this data at various location (as shown on Figure 3.8) is provided in Table 3.8.

Note that the data extracted for the 10% AEP and 1% AEP flood events correspond to the critical duration for these events. The 10% AEP flood event has a critical duration of 48 hours, and the 1% AEP has a critical duration of 24 hours.

Table 3.7: Duration of Closure for Evacuation Routes

Location	Route	10% AEP Flood Event Duration of Closure (hours)	1% AEP Flood Event Duration of Closure (hours)	March 2017 Duration of Closure (hours)	February 2022 Duration of Closure (hours)
1	South 1	0	23	15	43
2	South 1	0	19	6	40
3	South 1	0	23	15	43
4	South 2	0	37	42	66
5	South 2	0	36	32	57
6	South 3	158	79	103	147
7	CBD 1	0	0	0	29
8	CBD 1	134	71	98	143
9	CBD 1	0	22	10	43
10	CBD 1	20	41	30	61
11	CBD 1	0	0	0	18
12	CBD 2	0	33	22	53
13	CBD 2	27	46	38	66
14	CBD 3	0	38	27	58

Location	Route	10% AEP Flood Event Duration of Closure (hours)	1% AEP Flood Event Duration of Closure (hours)	March 2017 Duration of Closure (hours)	February 2022 Duration of Closure (hours)
15	CBD 3	36	46	44	67
16	North 1	23	35	27	56
17	North 1	0	17	9	39
18	North 1	0	26	17	46
19	North 2	0	23	12	44
20	North 2	18	32	24	53
21	North 2	22	34	26	55
22	North 3	49	69	48	80
23	East	23	45	40	62

Table 3.8: Time to Closure for Evacuation Routes

Location	Route	10% AEP Flood Event Time to Closure	1% AEP Flood Event Time to Closure	March 2017 Time to Closure	February 2022 Time to Closure
1	South 1	-	20.5 hours from minor flood warning	13 hours from minor flood warning	84 hours from minor flood warning
		-	18.5 hours from moderate flood warning	8.5 hours from moderate flood warning	17 hours from moderate flood warning
		-	5.5 hours from major flood warning	3 hours from major flood warning	5 hours from major flood warning
2	South 1	-	22 hours from minor flood warning	17.5 hours from minor flood warning	85 hours from minor flood warning
		-	20 hours from moderate flood warning	13 hours from moderate flood warning	17.5 hours from moderate flood warning
		-	7 hours from major flood warning	7.5 hours from major flood warning	5.5 hours from major flood warning
3	South 1	-	21.5 hours from minor flood warning	15 hours from minor flood warning	85 hours from minor flood warning
		-	19.5 hours from moderate flood warning	10.5 hours from moderate flood warning	17.5 hours from moderate flood warning
		-	6.5 hours from major flood warning	4.5 hours from major flood warning	5.5 hours from major flood warning
4	South 2	-	23 hours from minor flood warning	13.5 hours from minor flood warning	85.5 hours from minor flood warning

Location	Route	10% AEP Flood Event Time to Closure	1% AEP Flood Event Time to Closure	March 2017 Time to Closure	February 2022 Time to Closure
		-	20.5 hours from moderate flood warning	9 hours from moderate flood warning	18.5 hours from moderate flood warning
		-	8 hours from major flood warning	3 hours from major flood warning	6.5 hours from major flood warning
5	South 2	-	22 hours from minor flood warning	13.5 hours from minor flood warning	85 hours from minor flood warning
		-	19.5 hours from moderate flood warning	9 hours from moderate flood warning	18 hours from moderate flood warning
		-	7 hours from major flood warning	3 hours from major flood warning	6 hours from major flood warning
6	South 3	33.5 hours from minor flood warning	16.5 hours from minor flood warning	10 hours from minor flood warning	81 hours from minor flood warning
		30 hours from moderate flood warning	14.5 hours from moderate flood warning	5.5 hours from moderate flood warning	13.5 hours from moderate flood warning
		-	1.5 hours from major flood warning	-	1.5 hours from major flood warning
7	CBD 1	-	-	-	89 hours from minor flood warning
		-	-	-	22 hours from moderate flood warning
		-	-	-	10 hours from major flood warning
8	CBD 1	57.5 hours from minor flood warning	24.5 hours from minor flood warning	14 hours from minor flood warning	85 hours from minor flood warning
		54 hours from moderate flood warning	22.5 hours from moderate flood warning	9.5 hours from moderate flood warning	17.5 hours from moderate flood warning
		18 hours from major flood warning	9.5 hours from major flood warning	4 hours from major flood warning	5.5 hours from major flood warning
9	CBD 1	-	26 hours from minor flood warning	21 hours from minor flood warning	88 hours from minor flood warning
		-	23.5 hours from moderate flood warning	16.5 hours from moderate flood warning	20.5 hours from moderate flood warning
		-	11 hours from major flood warning	11 hours from major flood warning	8.5 hours from major flood warning
10	CBD 1	46 hours from minor flood warning	24 hours from minor flood warning	18.5 hours from minor flood warning	86.5 hours from minor flood warning

Location	Route	10% AEP Flood Event Time to Closure	1% AEP Flood Event Time to Closure	March 2017 Time to Closure	February 2022 Time to Closure
		42 hours from moderate flood warning	21.5 hours from moderate flood warning	14 hours from moderate flood warning	19 hours from moderate flood warning
		7 hours from major flood warning	9 hours from major flood warning	8.5 hours from major flood warning	7 hours from major flood warning
11	CBD 1	-	-	-	93 hours from minor flood warning
		-	-	-	25.5 hours from moderate flood warning
		-	-	-	13.5 hours from major flood warning
12	CBD 2	-	25 hours from minor flood warning	17.5 hours from minor flood warning	87 hours from minor flood warning
		-	22.5 hours from moderate flood warning	13 hours from moderate flood warning	20 hours from moderate flood warning
		-	10 hours from major flood warning	7.5 hours from major flood warning	8 hours from major flood warning
13	CBD 2	44 hours from minor flood warning	23 hours from minor flood warning	16 hours from minor flood warning	85.5 hours from minor flood warning
		40 hours from moderate flood warning	20.5 hours from moderate flood warning	11.5 hours from moderate flood warning	18 hours from moderate flood warning
		5 hours from major flood warning	8 hours from major flood warning	6 hours from major flood warning	6 hours from major flood warning
14	CBD 3	-	24.5 hours from minor flood warning	19 hours from minor flood warning	87 hours from minor flood warning
		-	22 hours from moderate flood warning	14.5 hours from moderate flood warning	19.5 hours from moderate flood warning
		-	9.5 hours from major flood warning	8.5 hours from major flood warning	7.5 hours from major flood warning
15	CBD 3	30.5 hours from minor flood warning	14.5 hours from minor flood warning	11 hours from minor flood warning	78.5 hours from minor flood warning
		27 hours from moderate flood warning	12.5 hours from moderate flood warning	6.5 hours from moderate flood warning	11.5 hours from moderate flood warning
		-	-	0.5 hours from major flood warning	-
16	North 1	34.5 hours from minor flood warning	17.5 hours from minor flood warning	13 hours from minor flood warning	81.5 hours from minor flood warning

Location	Route	10% AEP Flood Event Time to Closure	1% AEP Flood Event Time to Closure	March 2017 Time to Closure	February 2022 Time to Closure
		31 hours from moderate flood warning	15.5 hours from moderate flood warning	8.5 hours from moderate flood warning	14.5 hours from moderate flood warning
		-	2.5 hours from major flood warning	2.5 hours from major flood warning	2.5 hours from major flood warning
17	North 1	-	23.5 hours from minor flood warning	18 hours from minor flood warning	87 hours from minor flood warning
		-	21 hours from moderate flood warning	13.5 hours from moderate flood warning	19.5 hours from moderate flood warning
		-	8 hours from major flood warning	8 hours from major flood warning	7.5 hours from major flood warning
18	North 1	-	21 hours from minor flood warning	16.5 hours from minor flood warning	84.5 hours from minor flood warning
		-	19 hours from moderate flood warning	12 hours from moderate flood warning	17.5 hours from moderate flood warning
		-	6 hours from major flood warning	6 hours from major flood warning	5.5 hours from major flood warning
19	North 2	-	21.5 hours from minor flood warning	17.5 hours from minor flood warning	85 hours from minor flood warning
		-	19.5 hours from moderate flood warning	13 hours from moderate flood warning	17.5 hours from moderate flood warning
		-	6.5 hours from major flood warning	7.5 hours from major flood warning	5.5 hours from major flood warning
20	North 2	36.5 hours from minor flood warning	18.5 hours from minor flood warning	14 hours from minor flood warning	82.5 hours from minor flood warning
		32.5 hours from moderate flood warning	16.5 hours from moderate flood warning	9.5 hours from moderate flood warning	15.5 hours from moderate flood warning
		-	3.5 hours from major flood warning	4 hours from major flood warning	3.5 hours from major flood warning
21	North 2	35.5 hours from minor flood warning	18 hours from minor flood warning	13.5 hours from minor flood warning	82 hours from minor flood warning
		31.5 hours from moderate flood warning	16 hours from moderate flood warning	9 hours from moderate flood warning	15 hours from moderate flood warning
		-	3 hours from major flood warning	3 hours from major flood warning	3 hours from major flood warning
22	North 3	22 hours from minor flood warning	9 hours from minor flood warning	8 hours from minor flood warning	74.5 hours from minor flood warning

Location	Route	10% AEP Flood Event Time to Closure	1% AEP Flood Event Time to Closure	March 2017 Time to Closure	February 2022 Time to Closure
		21 hours from moderate flood warning	6.5 hours from moderate flood warning	3.5 hours from moderate flood warning	7 hours from moderate flood warning
		-	-	-	-
23	East	45 hours from minor flood warning	22.5 hours from minor flood warning	10.5 hours from minor flood warning	87 hours from minor flood warning
		41.5 hours from moderate flood warning	20 hours from moderate flood warning	6 hours from moderate flood warning	20 hours from moderate flood warning
		6 hours from moderate flood warning	7.5 hours from major flood warning	-	8 hours from major flood warning

Duration of closure mapping for the analysed events is provided in Appendix D. These maps indicate the total time in hours that the model area is inundated at a depth greater than 300 mm.

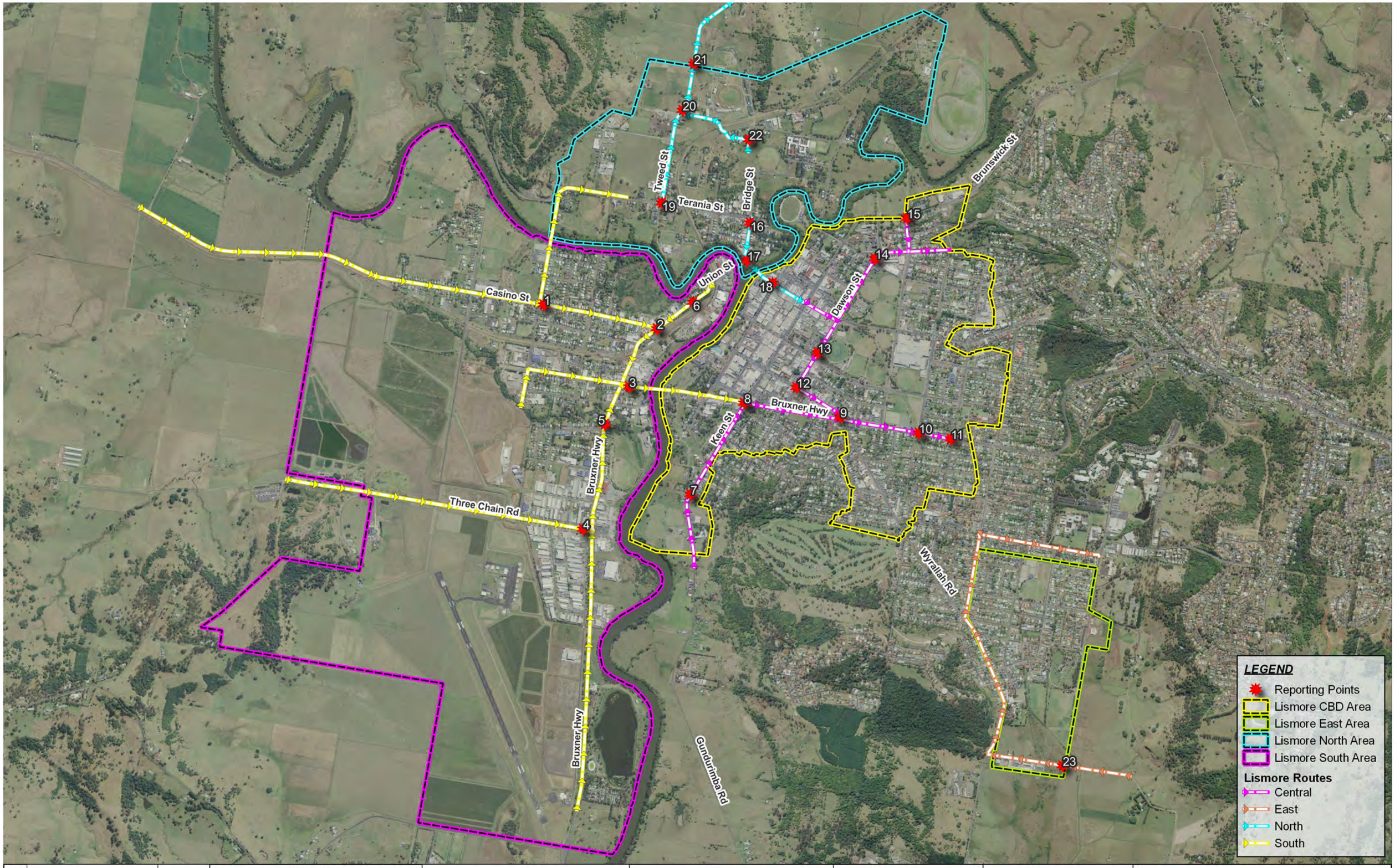
3.6.6 Constraints and Considerations for Evacuation

Utilising the above assessment, key constraints to consider for evacuation are outlined in Table 3.9 for each evacuation precinct in Lismore.

Table 3.9: 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 necessary, with inundation of isolated areas observed in a 10% AEP flood event, and widespread flooding from a 20% 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 20% AEP flood event or greater. Ballina Steet Bridge has a high immunity, however, trafficability of the route is impacted by the surrounding roads in South Lismore and the Lismore CBD. Trafficability of the Hollingworth Creek Bridge 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, as this crossing only has an estimated 1:100 AEP event immunity and Leycester Creek flooding is observed from a northerly direction onto Union Street.
North Lismore	North 1 - South along Bridge Street and across Fawcett's Bridge. North 2 - North on Tweed Street 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.

Evacuation Precinct	Evacuation Routes	Commentary
		Route North 3 is a viable option for evacuation whilst flood levels remain low in South Lismore.
CBD	CBD 1 – North along Keen Street then east along Bruxner Highway. CBD 2 - North towards Leycester 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 with significant velocity causing risk to persons and vehicle stability is likely to be experienced.
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.



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1	Final Issue	05-04-2023

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SCALE @ A3 - 1:22,000
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DISCLAIMER
Engeny has endeavoured to sure 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

ENGENY WATER MANAGEMENT

lismore city council

Figure 3.8

Key Routes and Precincts for Evacuation

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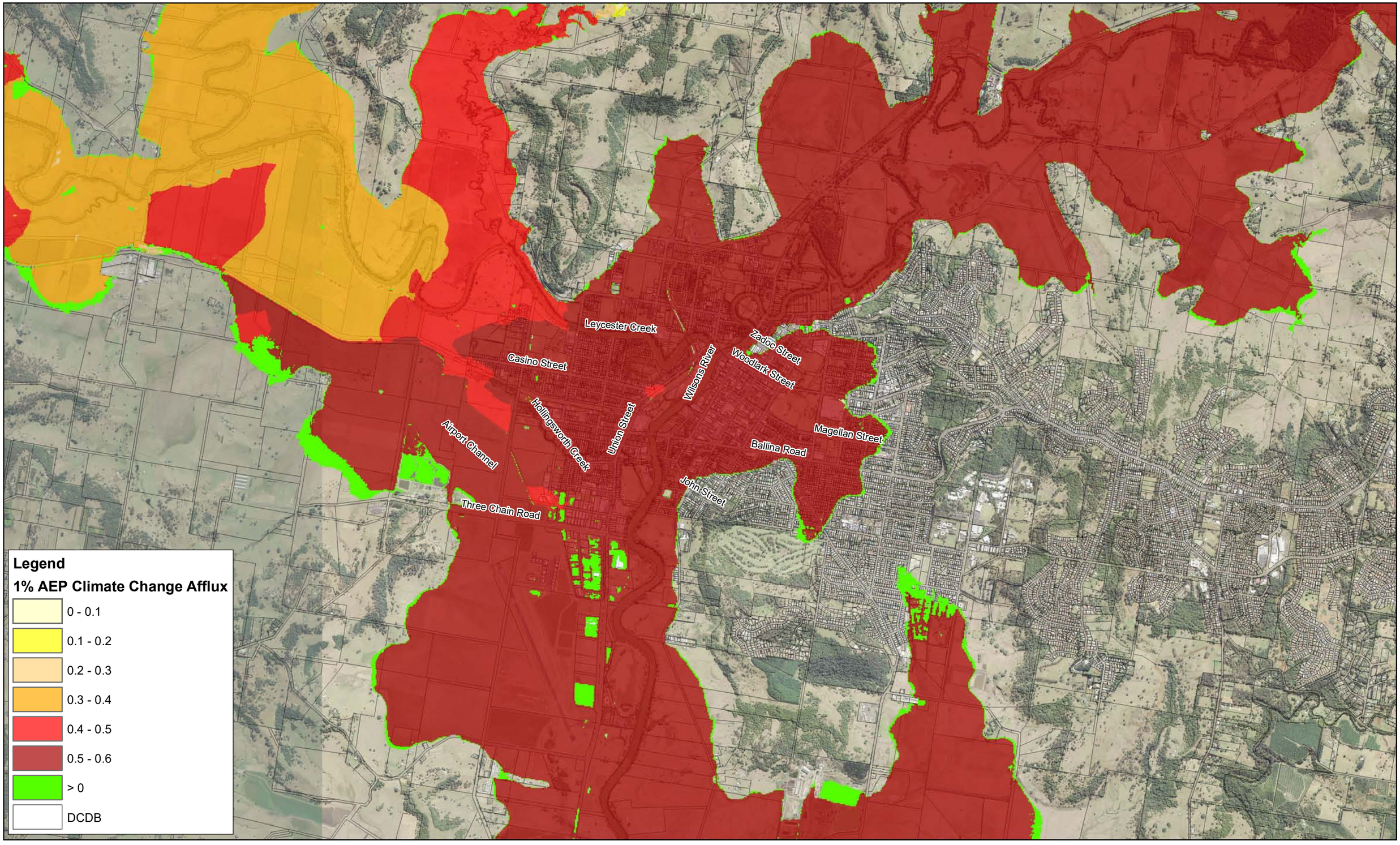
3.7 CLIMATE CHANGE IMPACTS

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. It aligns with the Intergovernmental Panel on Climate Change (IPCC) high emissions scenario, broadly described as the temperature increases expected if mitigating action is not taken. The hydrologic and hydraulic models were simulated for the 1% AEP flood event.

The resultant flood afflux mapping, shown as a difference between the climate change scenario and the design scenario 1% AEP flood height results, is provided in Figure 3.9. 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. 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.



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DESIGNED	MD	CHECKED	MD
DRAWN	MD	CHECKED	MD
APPROVED	MD	DATE	09/11/22

Notes:

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Scale @ A3 - 1:31,852
GCS GDA 1994 MGA Zone 55

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DATA SOURCE
QLD Government Open Source Data

DESIGNER
ENGENY WATER MANAGEMENT

CLIENT
lismore city council

Figure 3.9

Lismore Floodplain Risk Management Plan
Climate Change Impacts
1% AEP Climate Change Afflux

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4 LAND USE PLANNING AND DEVELOPMENT CONTROLS

The updated and extended design event modelling for Lismore, and the resultant flood planning mapping has been utilised to inform potential development controls to be considered by Council. Land use planning and development controls for Lismore will need to be defined with input from relevant stakeholders, including the community. As such, the potential development controls outlined in this section should be viewed as high level advice only and further consultation and review will be required to ensure there is alignment with the long-term vision and flood risk management strategy for Lismore. These development controls only apply to new development being completed in future, not current development.

Development controls should be applied to various types of future development on flood prone land throughout Lismore. Generally, the controls should be dependent on the flooding hazard that is experienced. It is recommended that LCC review and update the LEP and DCP with consideration for the flood risk outputs provided in this document. Flood risk considerations as applicable to the identified flood risk precincts are provided in Table 4.1.

Table 4.1: Flood Risk Considerations for Future Development Control

Flood Risk Precinct	Flood Risk Considerations	Potential Development Controls
South Lismore Development Restricted Area	Significant risk to life due to restricted evacuation. South Lismore (south of Hollingworth Creek) is isolated once South Lismore levee is overtopped. Evacuation route is via Union Street, the Ballina Street Bridge and Ballina Street or Conway Street to Wyrallah Road. The Hollingworth Creek Bridge represents a low point on the evacuation route that would be cut immediately when flood waters overtop the levee. Includes flood bypass through South Lismore once Leycester Creek breakout occurs. Flood impacts (including to North Lismore) associated with filling or restricting flood conveyance through South Lismore.	Restricted industrial and commercial development. Residential development not accepted. Consider higher Flood Planning Level (FPL) than applied to other flood risk precincts, refer Section 3.2 for options. Consider adoption of site-based Flood Emergency Management Plan for commercial and industrial businesses. Permissible and prohibited land uses should be defined in a new Development Control Plan (DCP) in consultation with the community. Achieve balanced cut to fill, no imported filling, no obstruction of flood conveyance, and completion of a flood impact assessment to demonstrate no worsening of existing flood conditions. Flood impact assessments should consider cumulative development impacts. VHP recommended to facilitate retreat for most vulnerable properties. Where VHP is not possible, consider VHR and retrofit of remaining structures to improve resilience. No critical public infrastructure should be in this precinct.
CBD Development Exemption Area	Significant risk to life and property damage due to Browns Creek conveyance once CBD levee is overtopped. Rising Road evacuation route. Longer evacuation time due to CBD levee.	Define and adopt FPL. Consider VHR or retrofit of structures to improve resilience. Permissible and prohibited land uses should be defined in a new Development Control Plan (DCP) in consultation with the community.
Extreme	Highest flood depth and velocity and is located in regions where H5 and H6 hazard occur over a range of flood events. Extreme flood hazard rating across all flood events.	VHP recommended to facilitate retreat. All development prohibited.
High	Generally represents floodway and flood storage function. Highest flood depth.	Permissible and prohibited land uses should be defined in a new Development Control Plan (DCP) in consultation with the community. Restricted industrial and commercial development. Residential development not accepted.

Flood Risk Precinct	Flood Risk Considerations	Potential Development Controls
	Includes Browns Creek conveyance corridor once CBD levee is overtopped. Includes flood bypass through South Lismore once Leycester Creek breakout occurs.	Define FPL and consider higher FPL for applicable land uses, refer Section 3.2 for options. Achieve balanced cut to fill, no imported filling, no obstruction of flood conveyance, and completion of a flood impact assessment to demonstrate no worsening of existing flood conditions. Flood impact assessments should consider cumulative development impacts. VHP recommended to facilitate retreat for most vulnerable properties. Where VHP is not possible, consider VHR and retrofit of remaining structures to improve resilience. No critical public infrastructure should be in this precinct.
Medium	Flood storage and flood fringe function. Longer evacuation time. Lower flood conveyance.	Define and adopt FPL. Achieve balanced cut to fill, no imported filling, no obstruction of flood conveyance, and completion of a flood impact assessment to demonstrate no worsening of existing flood conditions. Flood impact assessments should consider cumulative development impacts. Consider VHP to facilitate retreat for most vulnerable properties and VHR where VHP is not possible. Consider retrofit of remaining structures to improve resilience.
Low	Generally flood fringe function. Lower flood conveyance and flood depth.	Define and adopt FPL. A flood impact assessment should be completed to demonstrate no worsening of existing flood conditions. Flood impact assessments should consider cumulative development impacts. Consider VHR or retrofit of existing structures to improve resilience.

At the time of preparing this report, the Northern Rivers Reconstruction Corporation (NRRC) through the Resilient Homes Program and the Resilient Land Program was in the process of defining eligible properties for the scheme and flood risk advice has been provided by Engeny to support this. As such, LCC's voluntary house purchase (VHP) and voluntary house raising (VHR) scheme should be reviewed once more specific details of NRRC's program become available.

5 REFERENCES

AIDR (2017), *Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia.* © Commonwealth of Australia: 3rd Edition.

Ball et.al. (2019), *Australian Rainfall and Runoff 2019.* © Commonwealth of Australia

NSW DPE (2022), *Flood Risk Management Manual: The Management of Flood Liable Land.* © State of New South Wales.

NSW DPE (2022a), *Support for Emergency Management Planning: Flood Risk Management Guide EM01.* © State of New South Wales.

6 QUALIFICATIONS

a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (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:

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   ii) 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.

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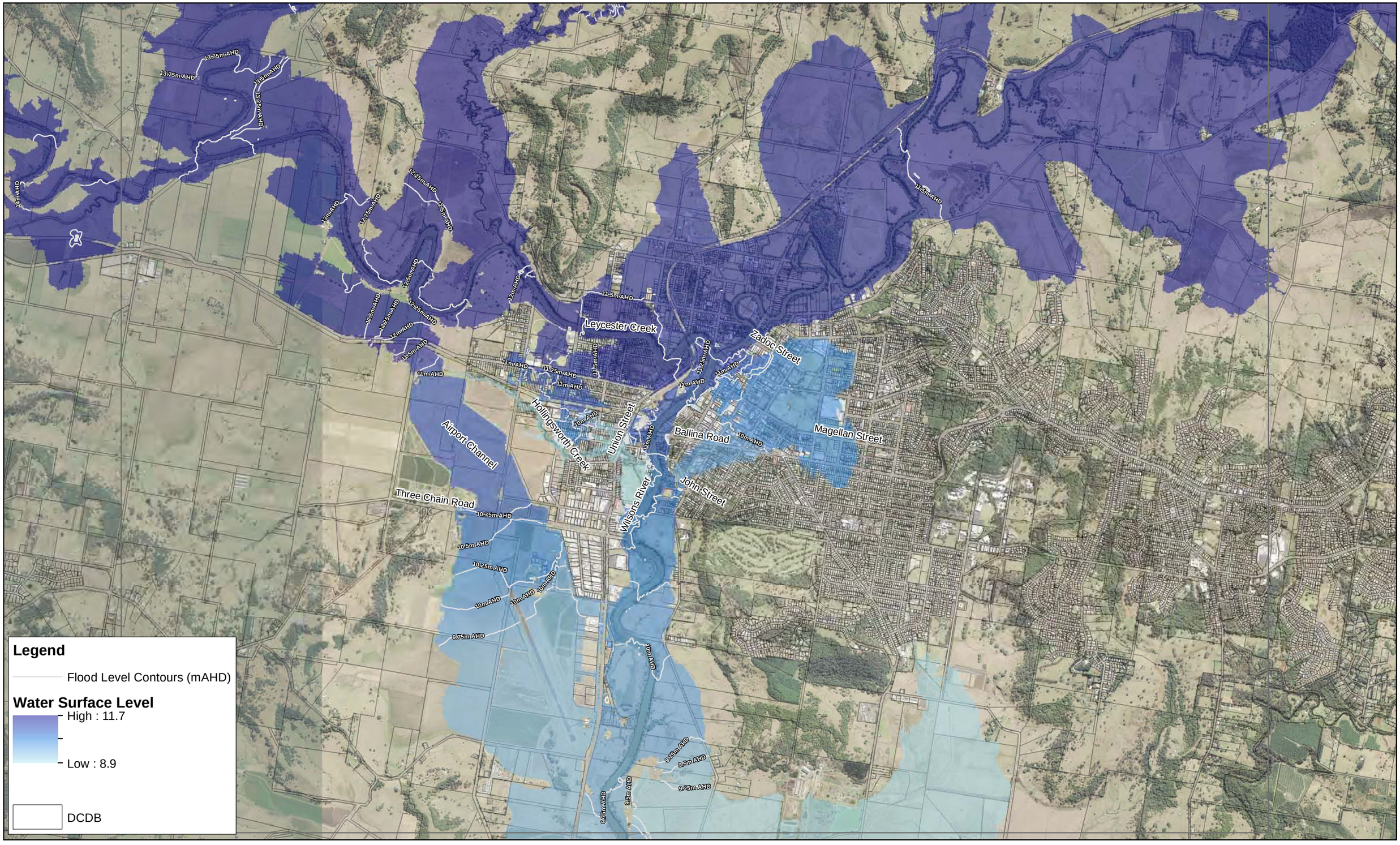
g) This Report does not provide legal advice.

Appendix A:
Design Event Flood Height Mapping



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Scale @ A3 - 1:31,852

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Lismore Floodplain Risk Management Plan
Flood Height
10% AEP

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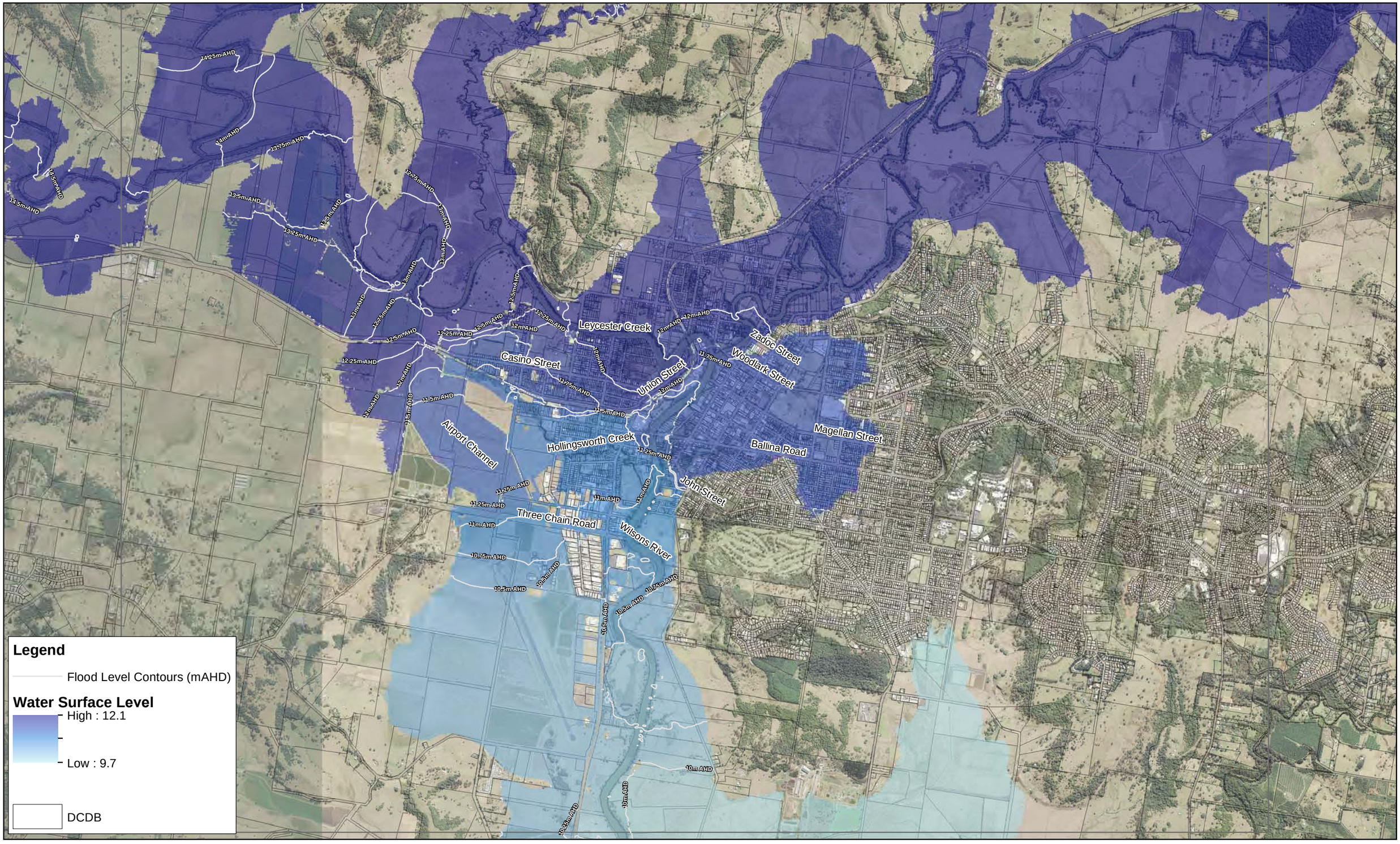

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Lismore Floodplain Risk Management Plan
Flood Height
5% AEP

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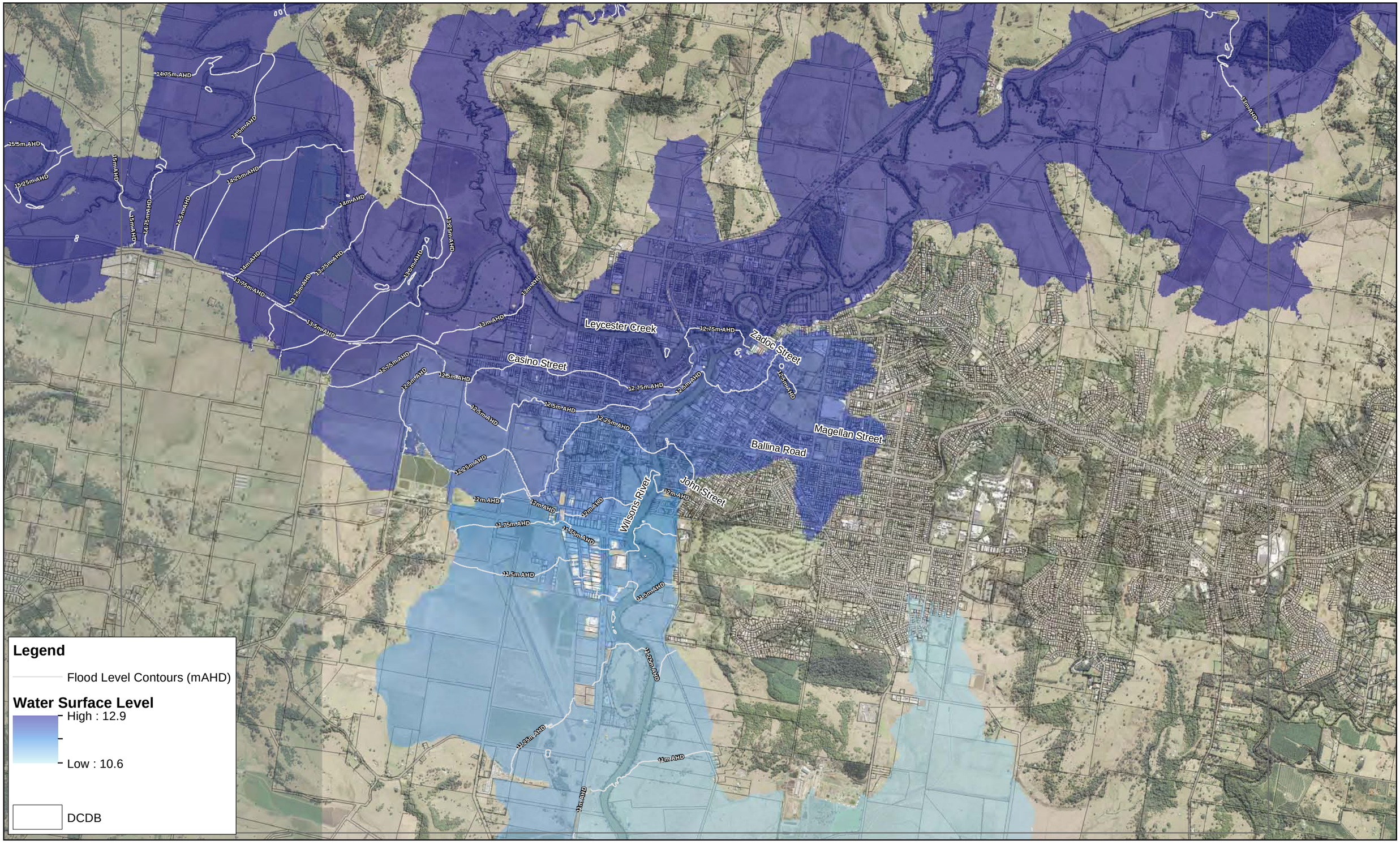

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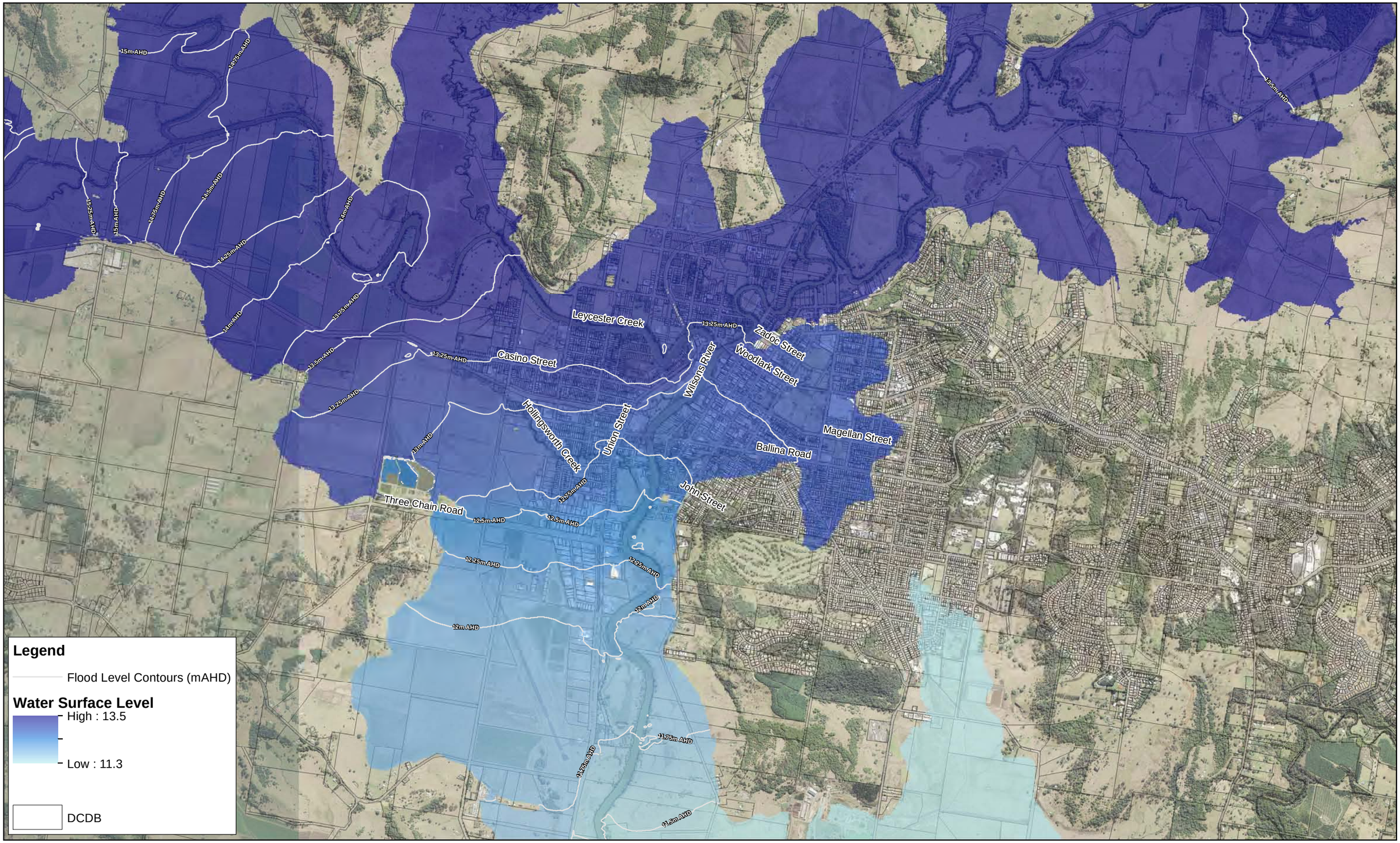
Lismore Floodplain Risk Management Plan
Flood Height
1% AEP



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CLIENT
lismore city council

Lismore Floodplain Risk Management Plan
Flood Height
0.2% AEP

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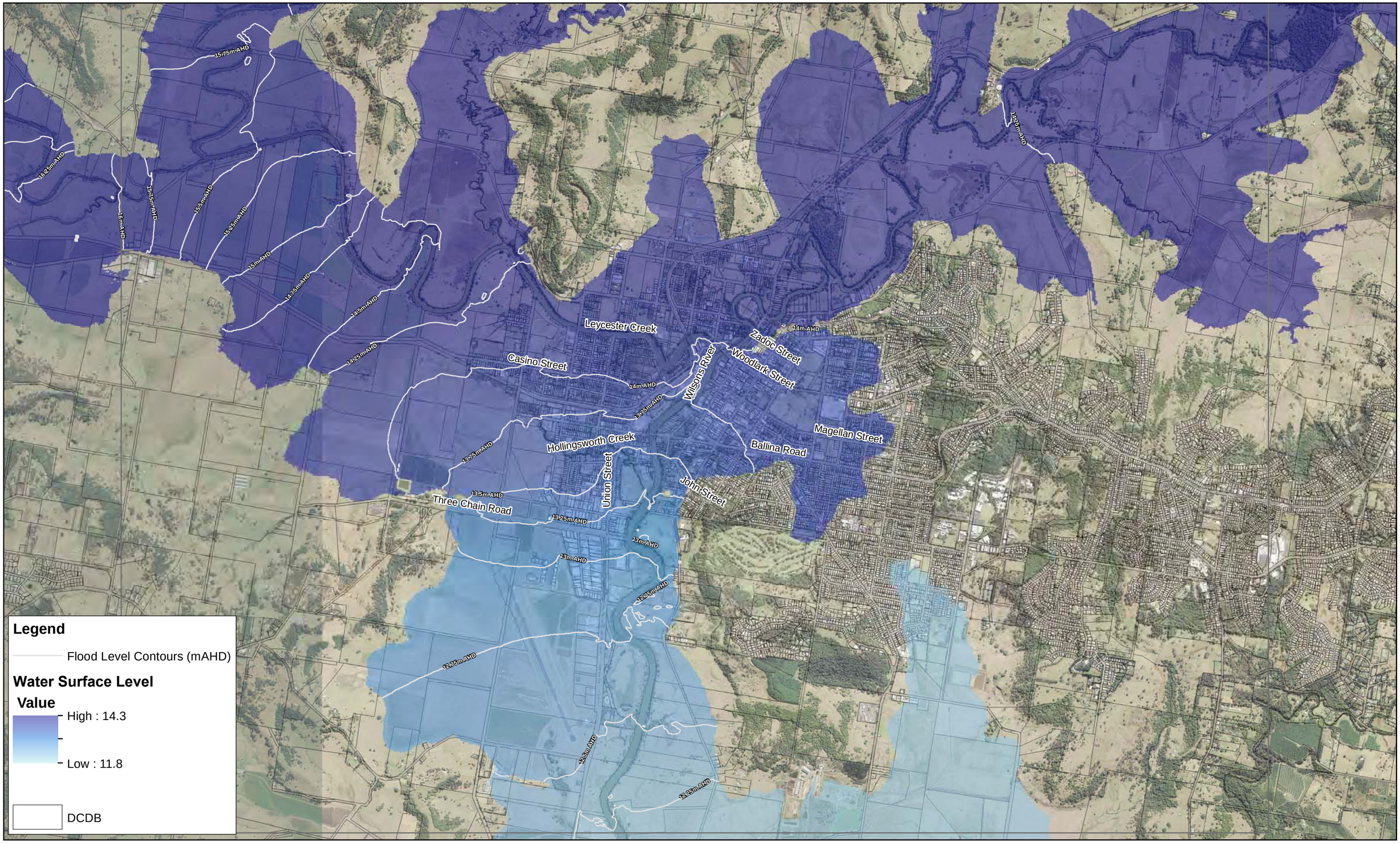

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Lismore Floodplain Risk Management Plan
Flood Height
1:1,000 AEP

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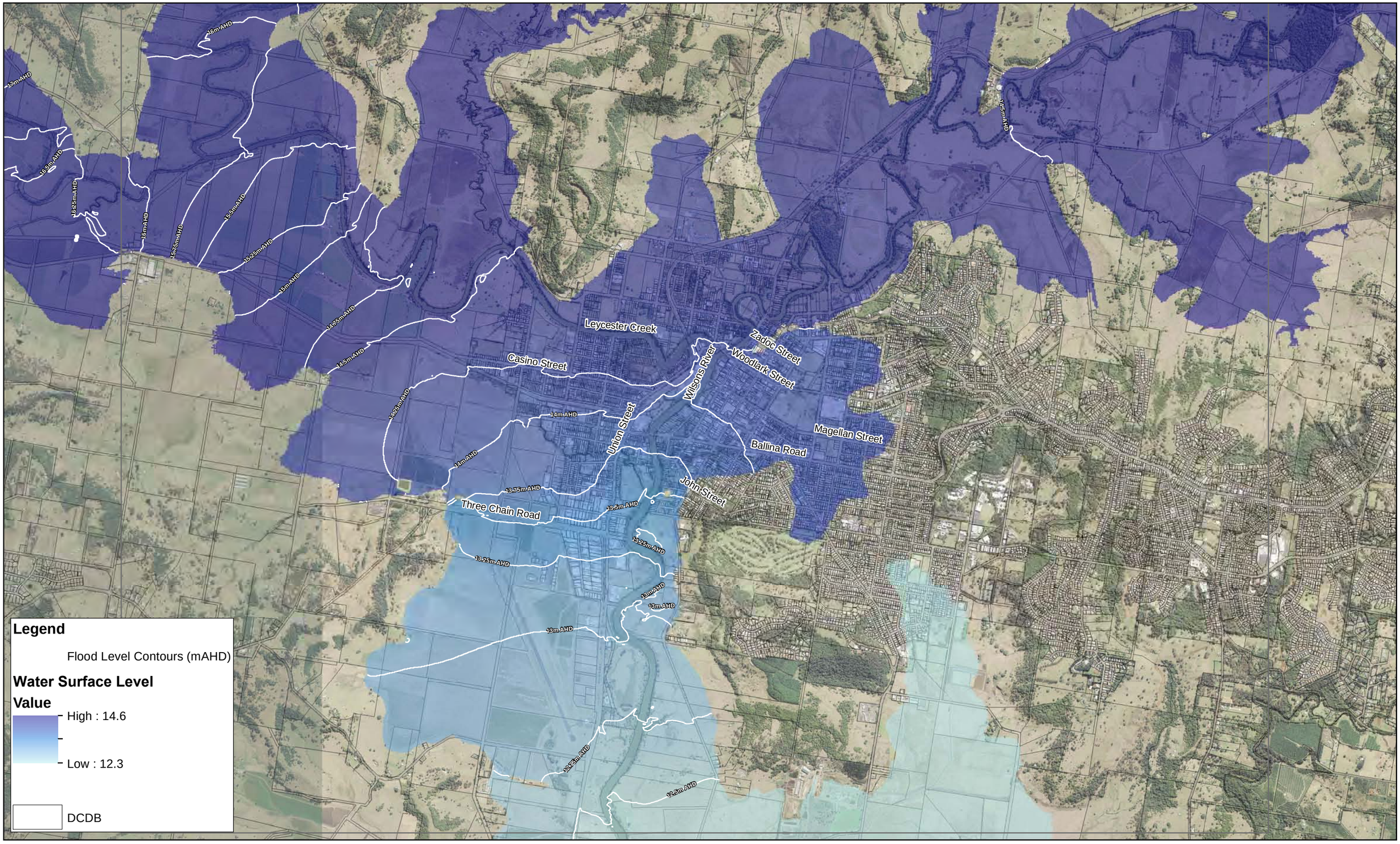

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Lismore Floodplain Risk Management Plan
Flood Height
1:2,0000 AEP

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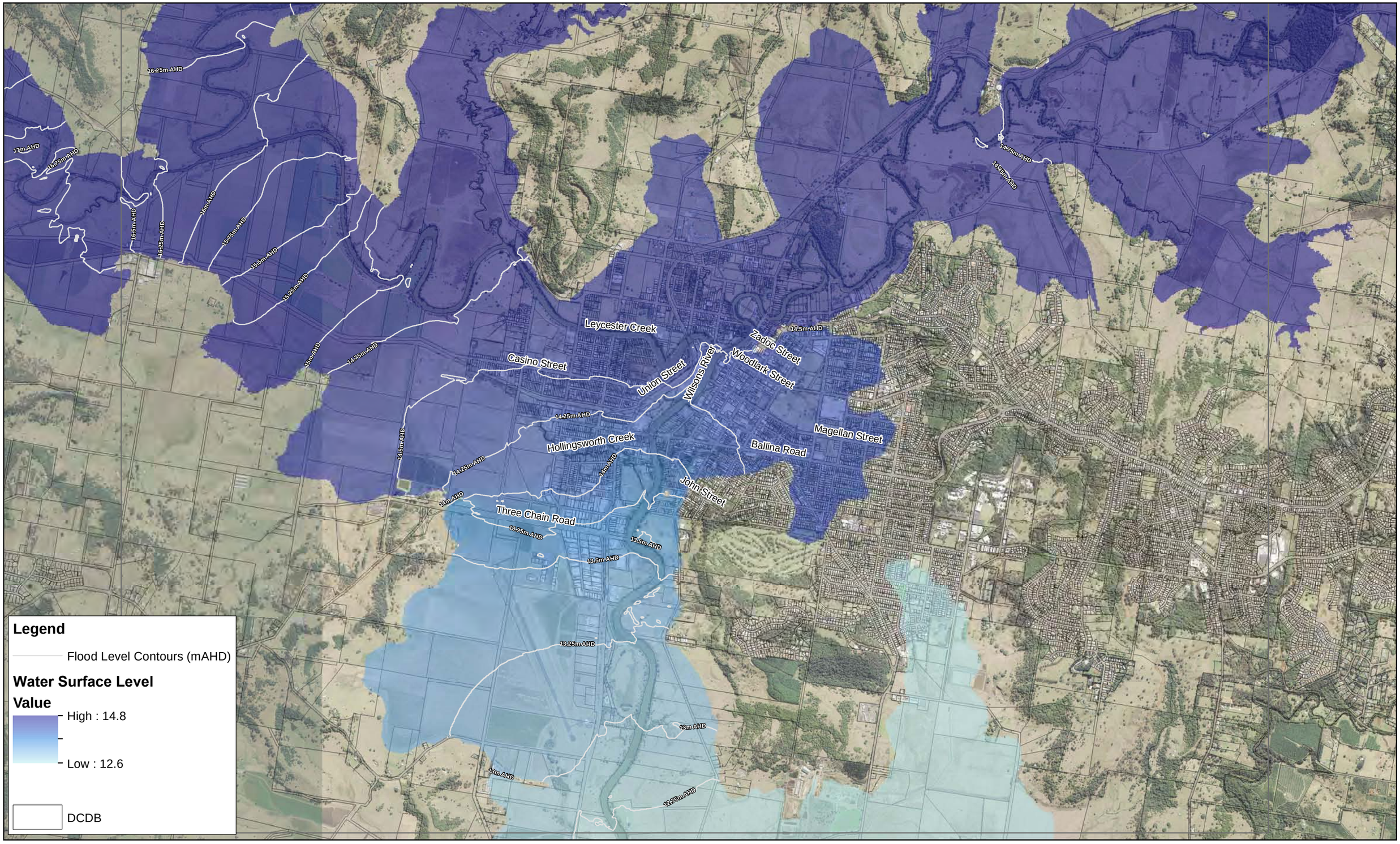

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Lismore Floodplain Risk Management Plan
Flood Height
1:10,000 AEP

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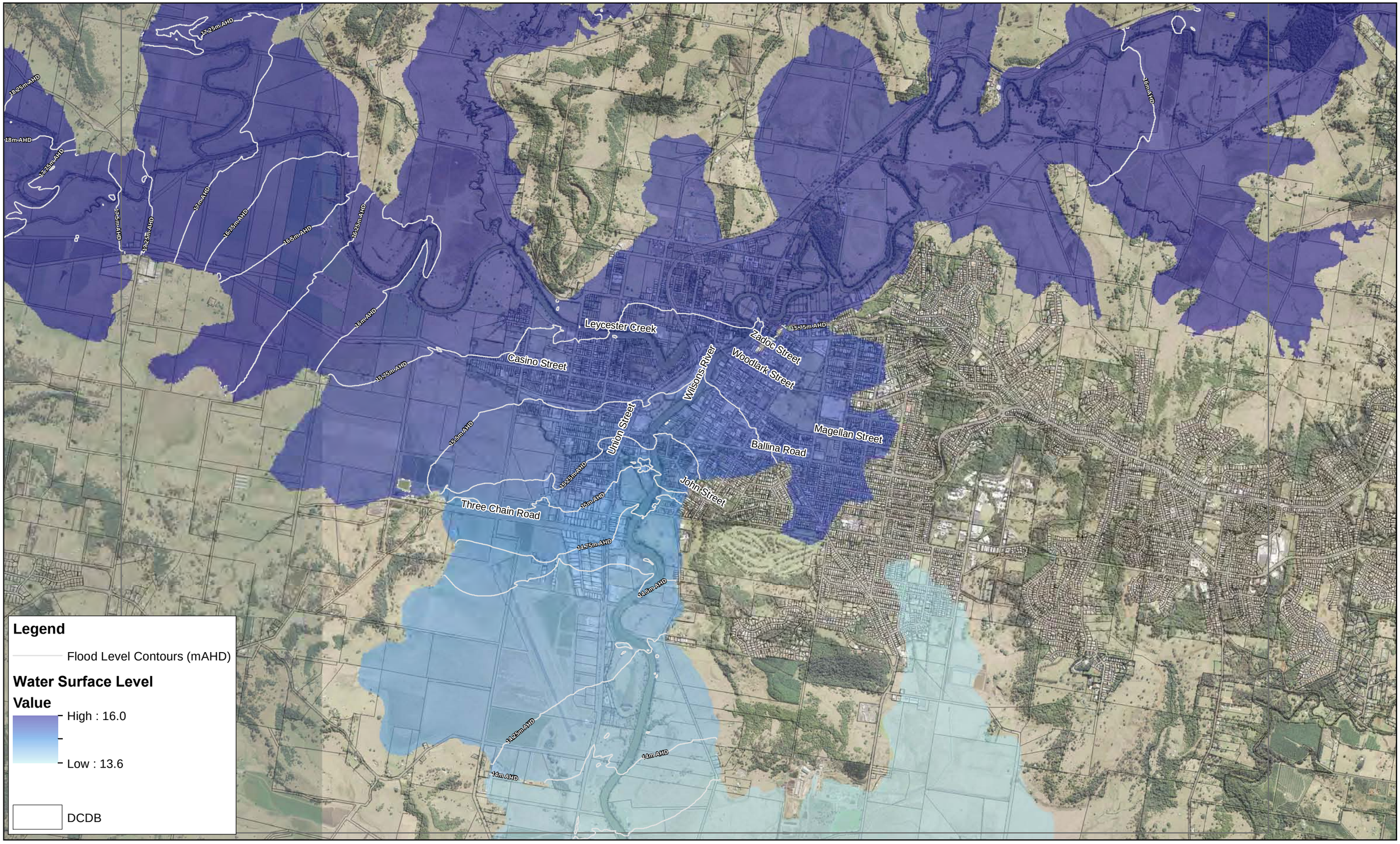

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Lismore Floodplain Risk Management Plan
Flood Height
1:100,000 AEP

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Lismore Floodplain Risk Management Plan
Flood Height
PMF

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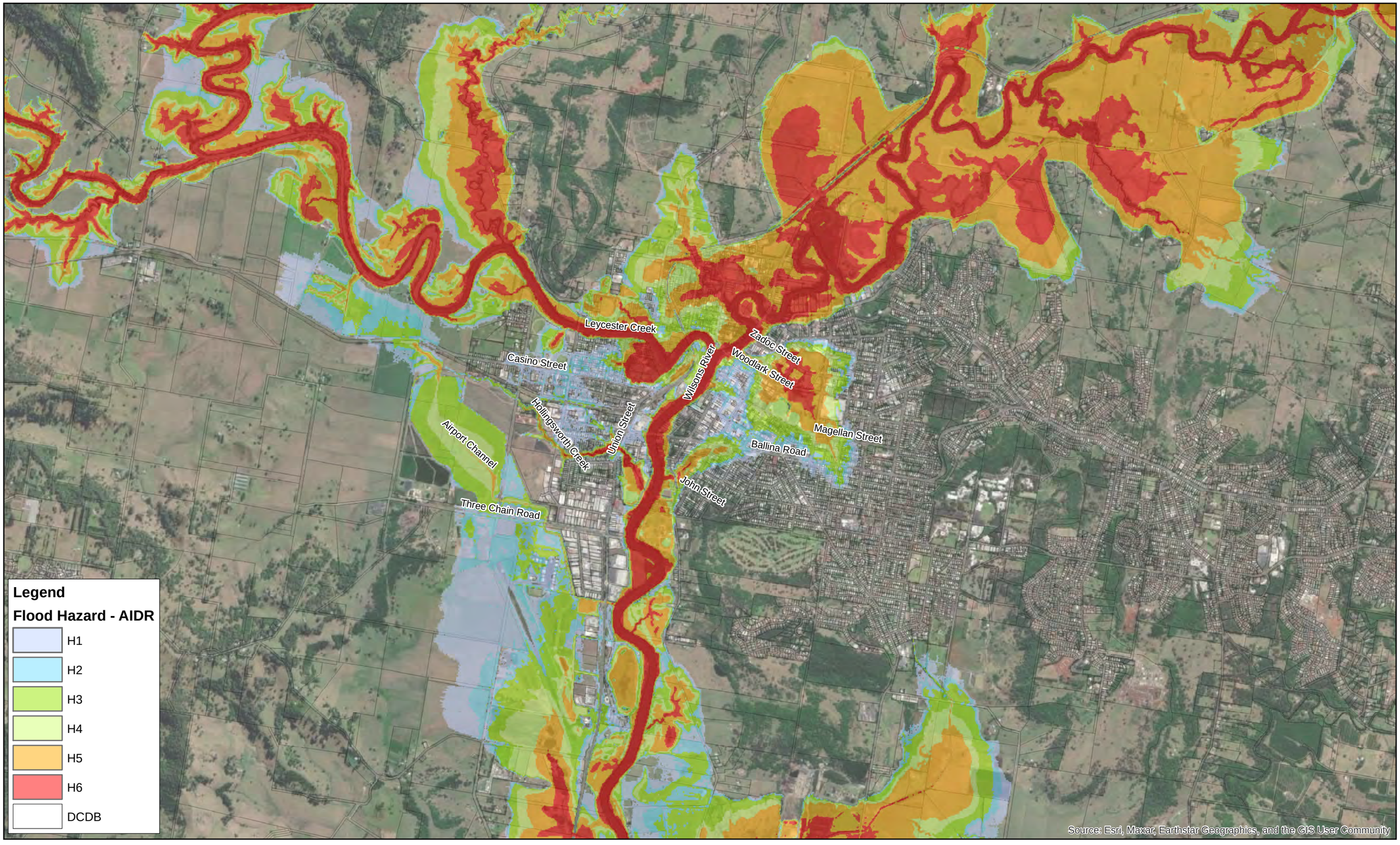
Appendix B:
Design Event Flood Hazard Mapping



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Lismore Floodplain Risk Management Plan
Flood Hazard - AIDR
10% AEP

DRG Ref:

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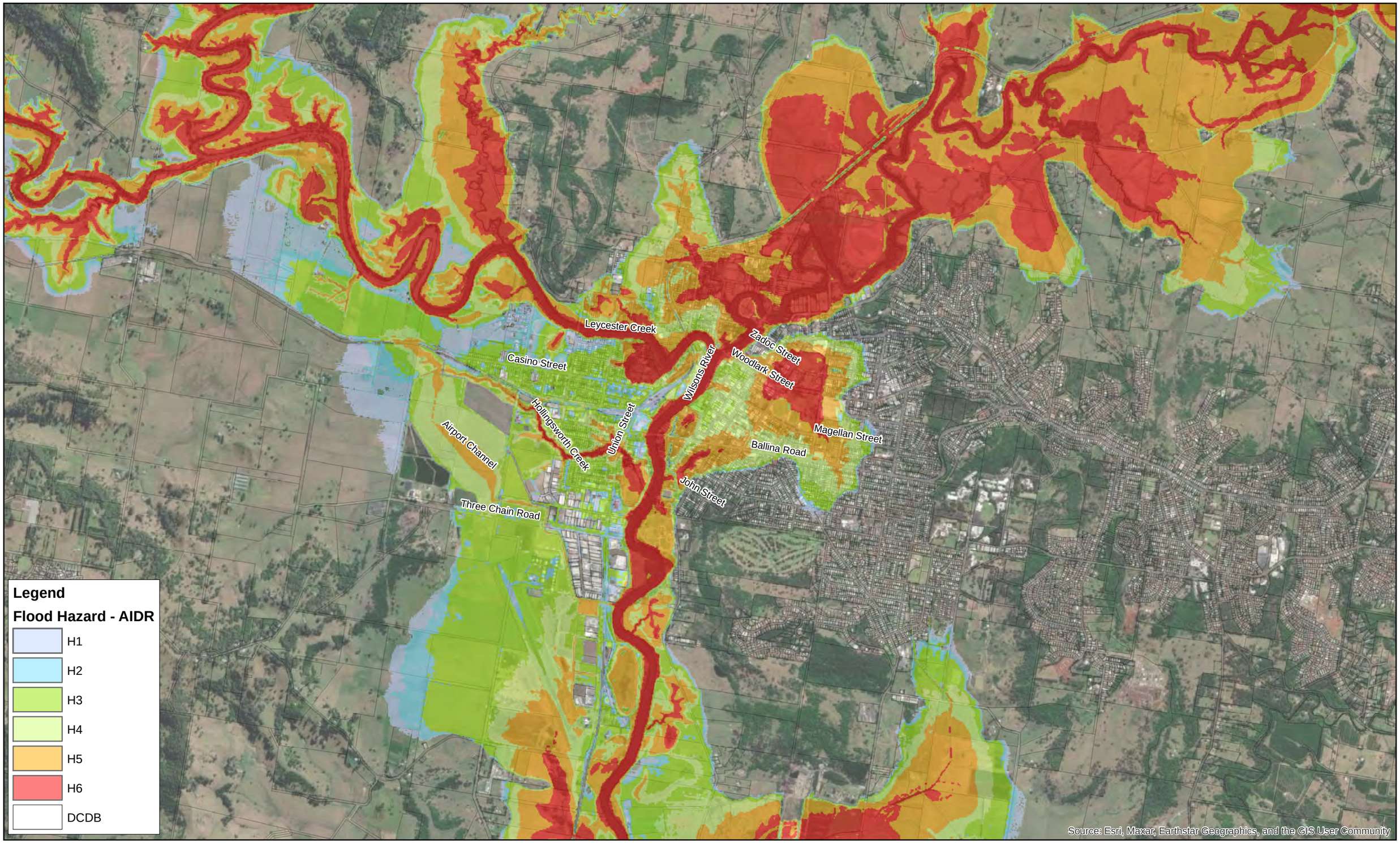

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Scale @ A3 -1:31,852
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Lismore Floodplain Risk Management Plan
Flood Hazard - AIDR
5% AEP

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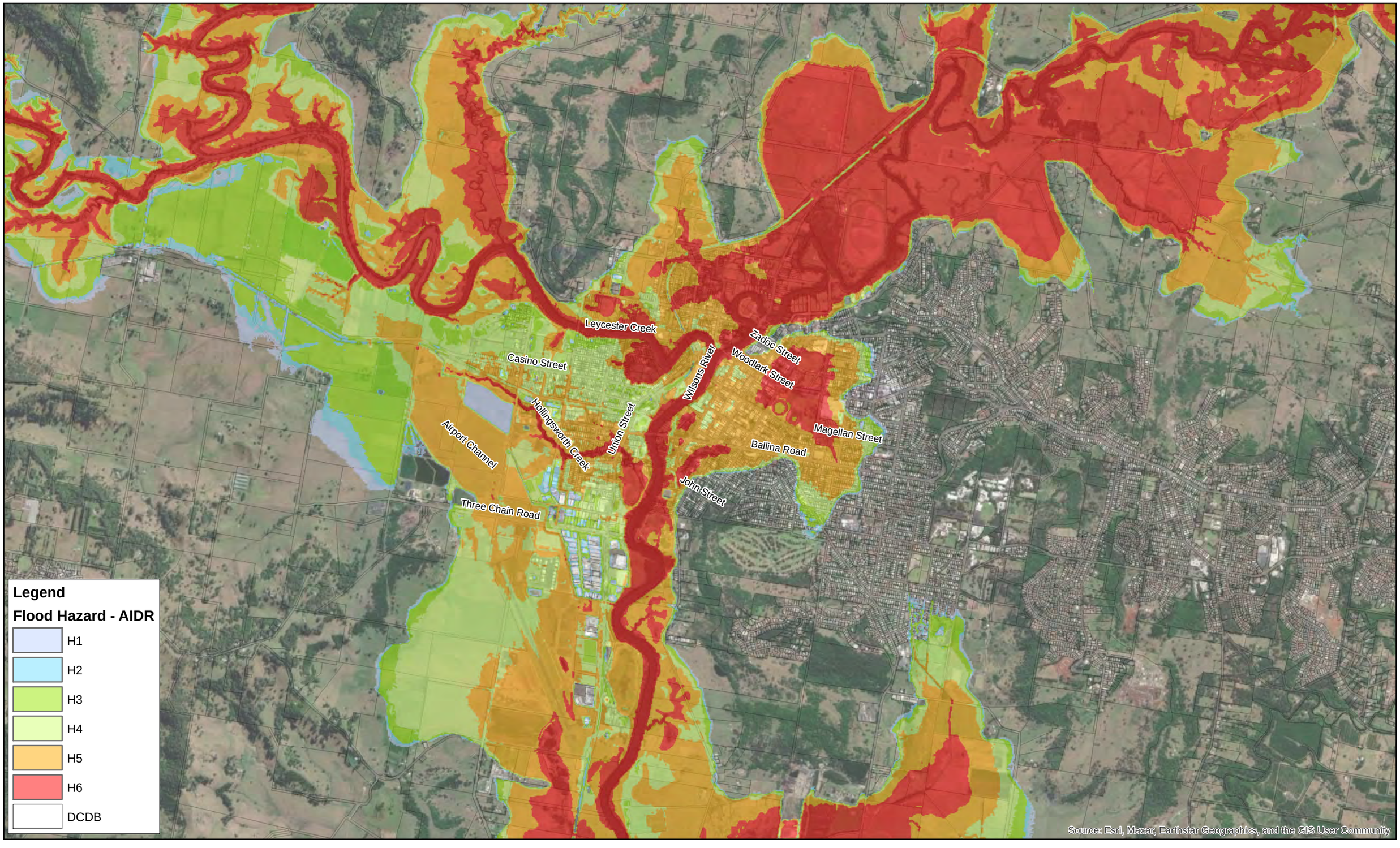

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Lismore Floodplain Risk Management Plan
Flood Hazard - AIDR
1% AEP

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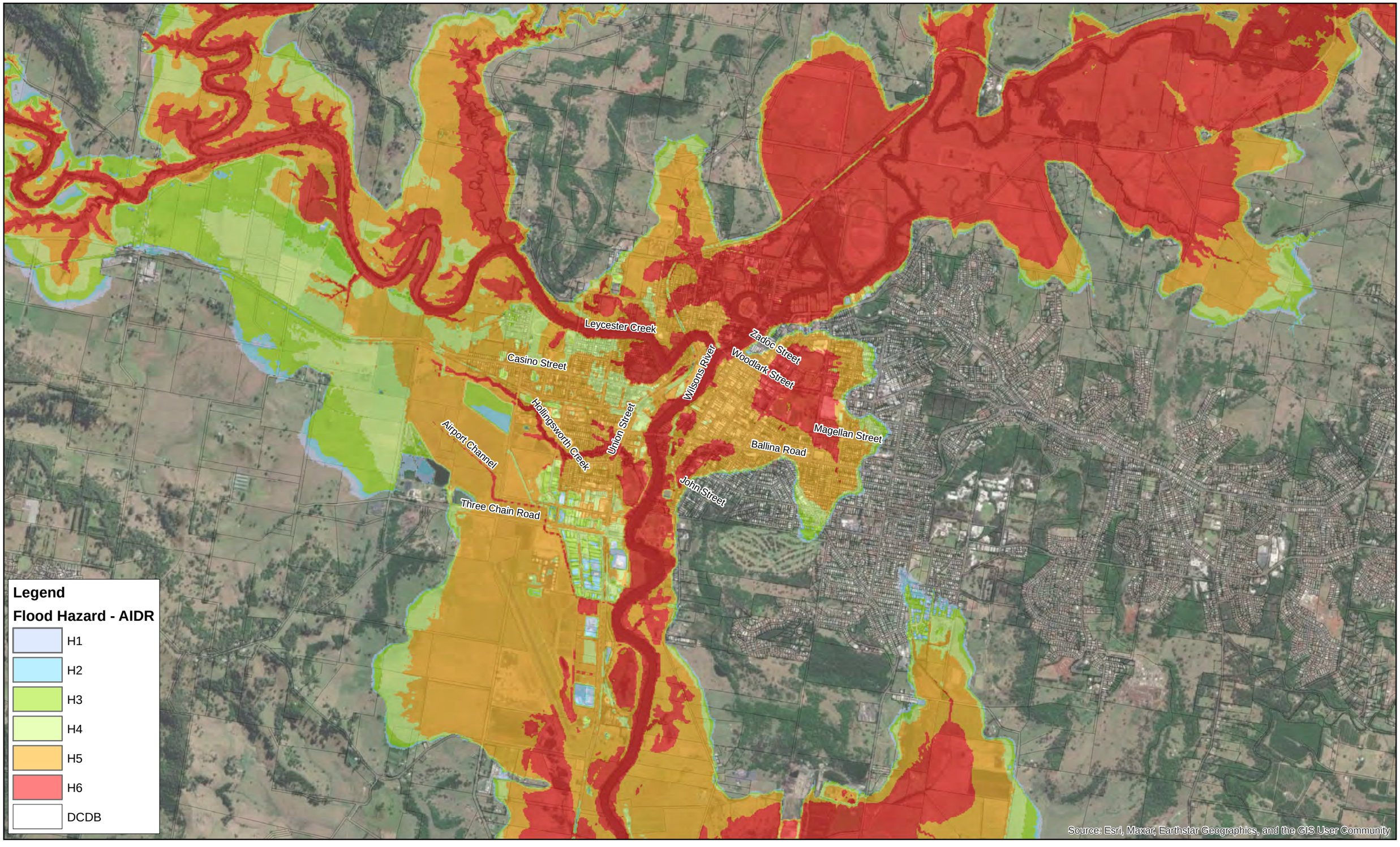

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Lismore Floodplain Risk Management Plan
Flood Hazard - AIDR
0.2% AEP

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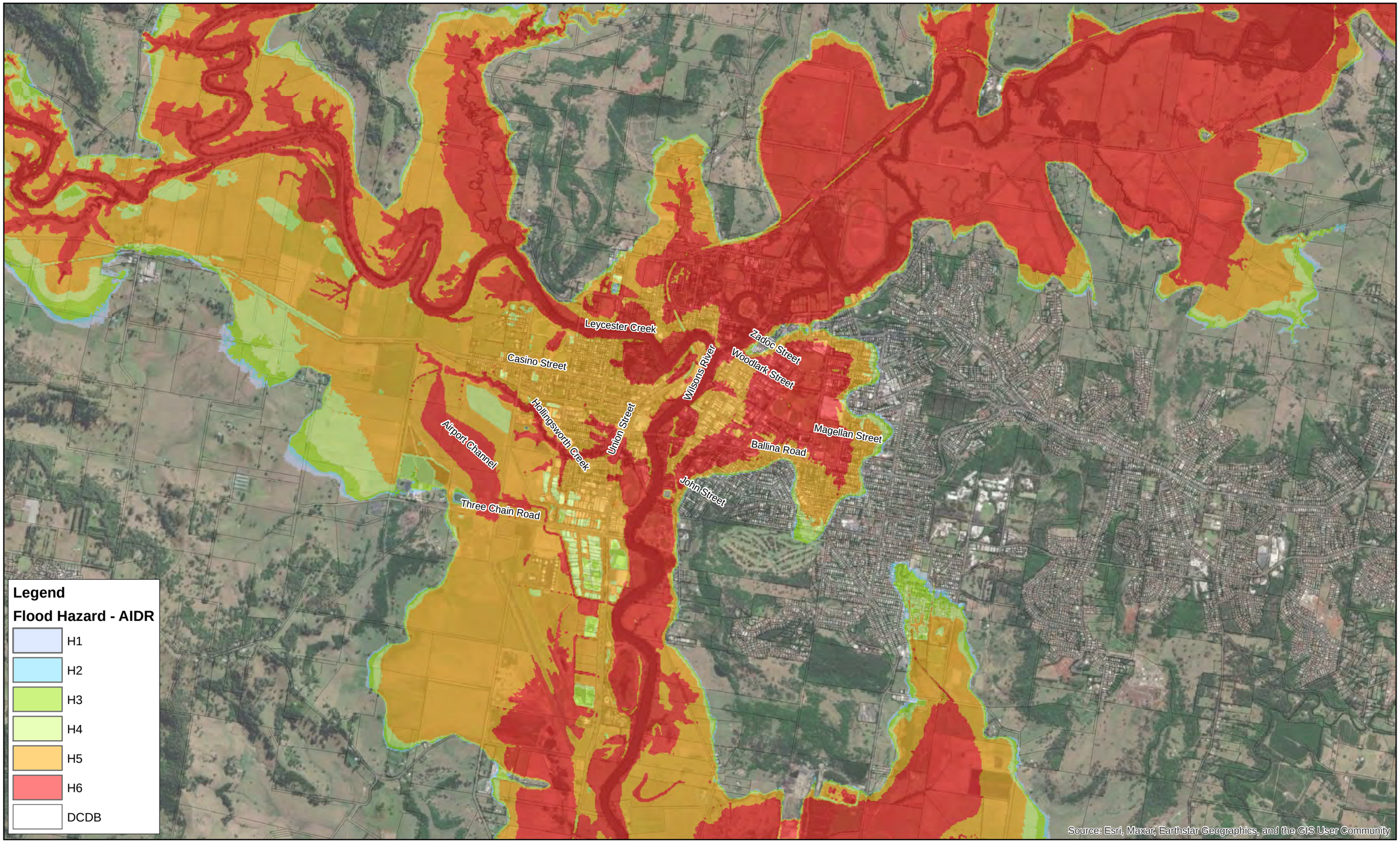

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Flood Hazard - AIDR
1:1,000 AEP

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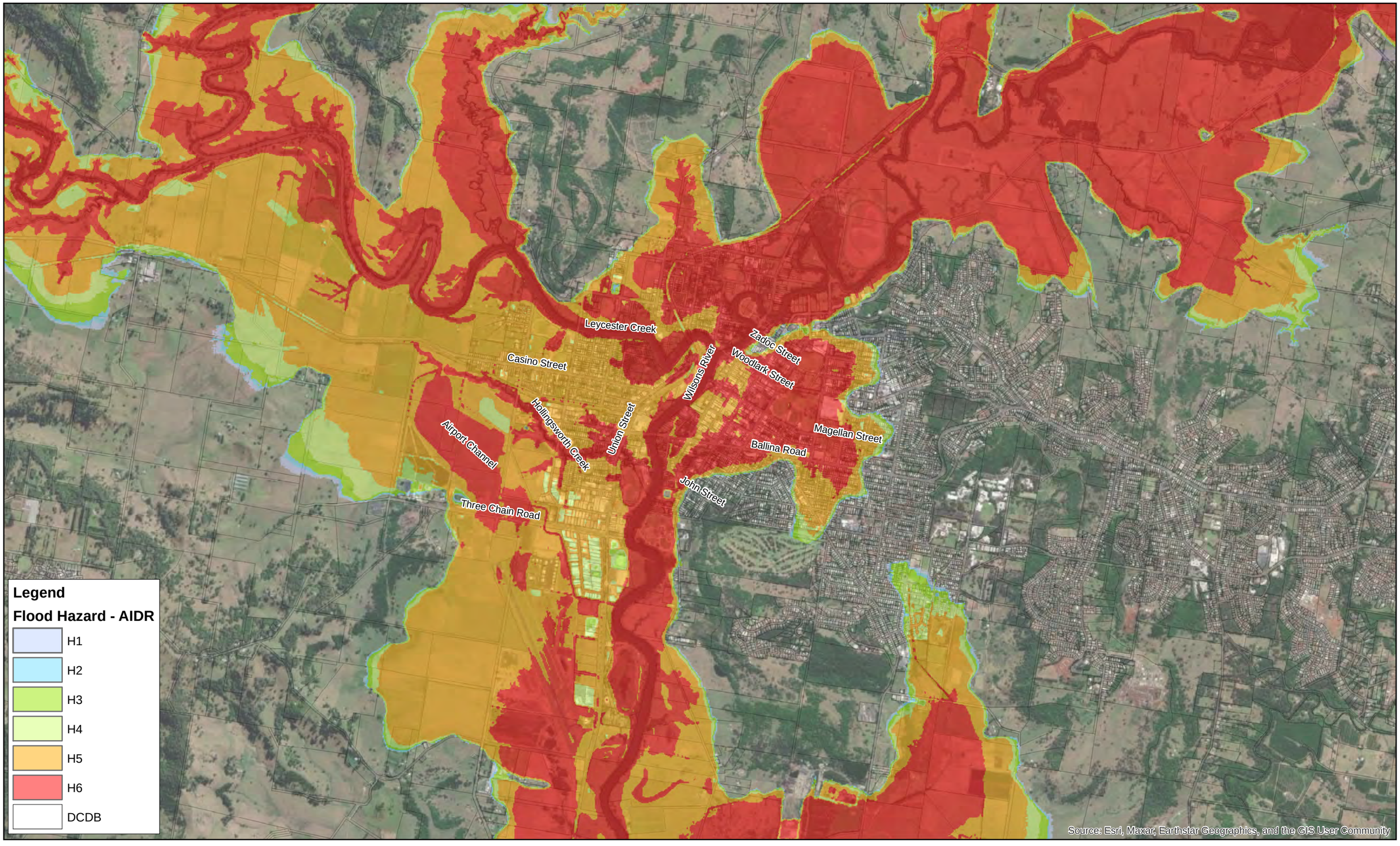

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Flood Hazard - AIDR
1:2,000 AEP

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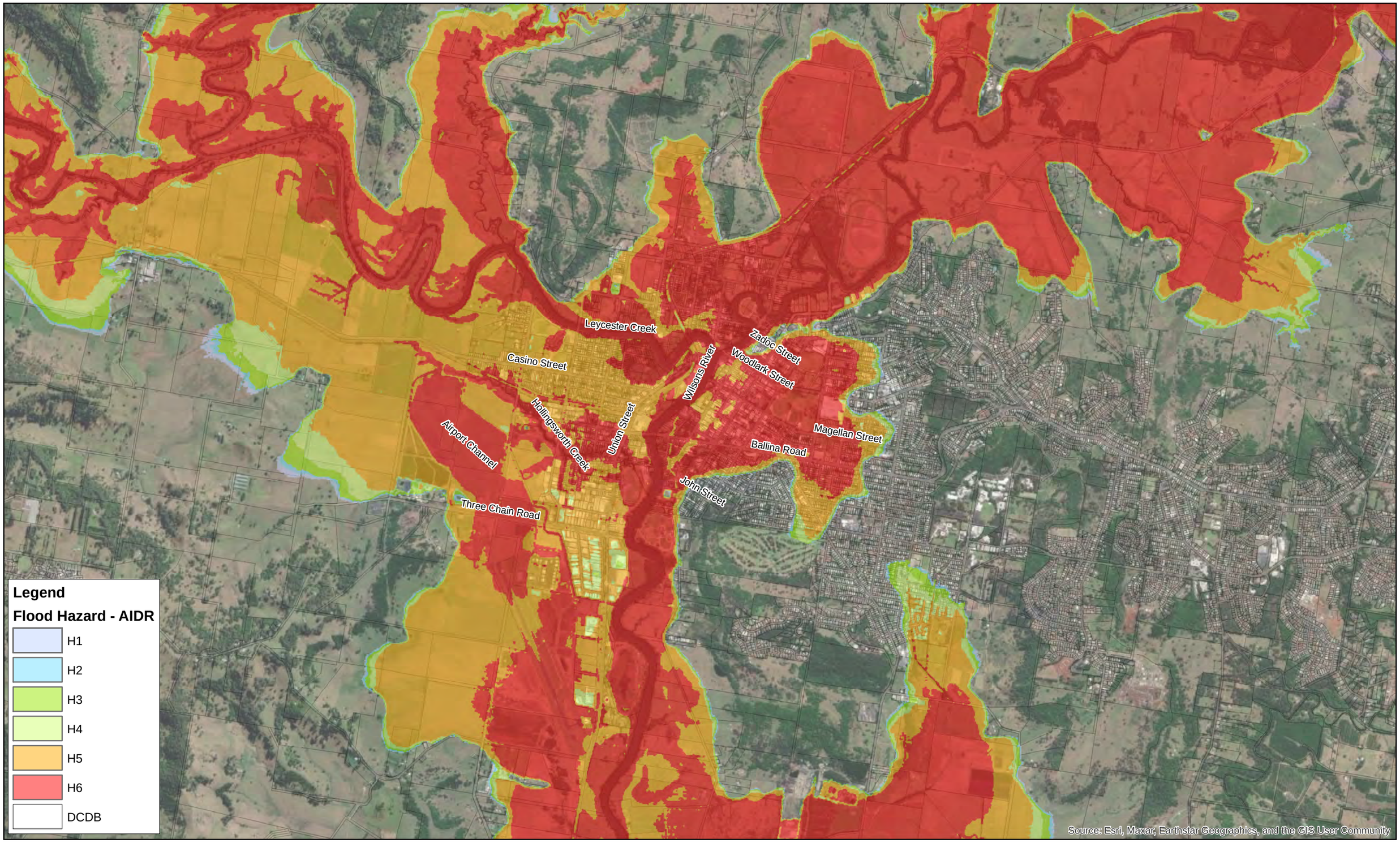

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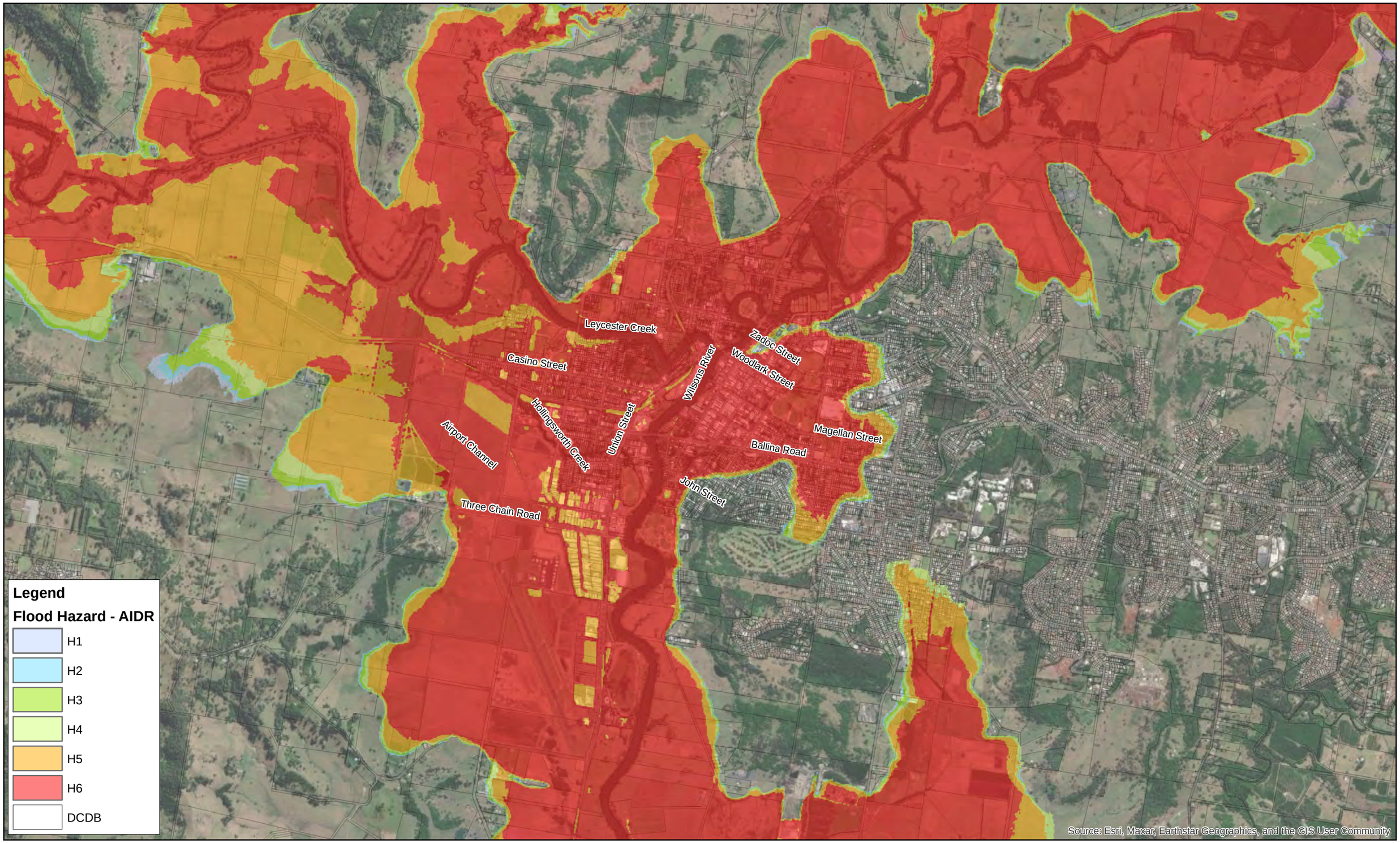

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1:100,000 AEP

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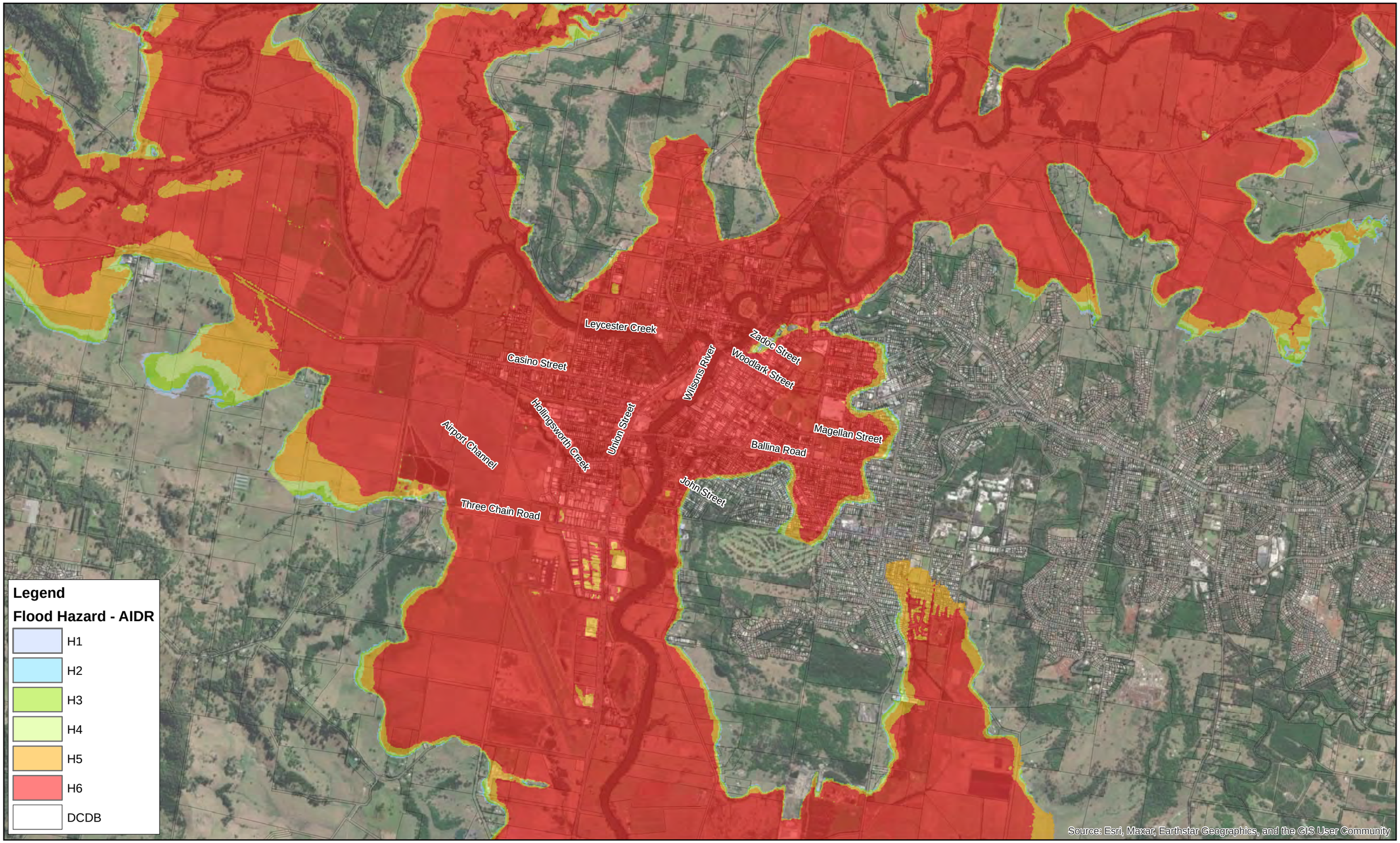

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Lismore Floodplain Risk Management Plan
Flood Hazard - AIDR
PMF

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Appendix C:
Extreme Flood Event Modelling

C.1 HYDROLOGIC MODELLING

C.1.1 Methodology

The following methodology was adopted for simulating the extreme events in the Lismore FRMS URBS hydrologic model:

- Rainfall intensities as accessed from the Australian Rainfall and Runoff (ARR) 2019 datahub were applied individually for each sub-catchment in URBS for the 1:1,000 and 1:2,000 AEP events. The rainfall intensities for the 1:10,000 and 1:100,000 AEP events were developed through interpolation between the 1:1,000 and 1:2,000 AEP flood events through to the PMF event in accordance with the procedures outlined in ARR 2019.
- The full ensemble of ten temporal patterns as specified in ARR 2019 were simulated.
- A full range of durations from 6 hours to 72 hours were simulated in the model.
- An Areal Reduction Factor (ARF) equivalent to the Lismore township catchment was applied to the model.
- Initial losses were interpolated from those specified in ARR 2019 for the 1% AEP event down to 0 mm for the PMF event. A continuing loss of 0.92 mm/h was specified for all extreme events modelled.
- An analysis was undertaken to determine the critical durations at the key TUFLOW hydraulic model inflow locations at Tuncester, Woodlawn and the Lismore township.

C.1.2 Results

The peak flows estimated for these extreme events, along with the existing design events from the Lismore FRMS, at the three key gauge locations in Lismore have been provided in Table 6.1.

Table 6.1: Summary of Design Event Flow Rates

Event	Tuncester Gauge (203443)	Woodlawn Gauge (203402)	Wilsons River at Lismore Gauge (58176)
10% AEP	1,520	930	2,310
5% AEP	1,880	1,140	2,890
1% AEP	2,780	1,660	4,150
0.2% AEP	3,280	2,130	5,130
1:1,000 AEP	3,720	2,290	5,770
1:2,000 AEP	4,080	2,480	6,320
1:10,000 AEP	5,120	2,520	7.350
1:100,000 AEP	7,140	3,520	10,250
PMF	10,840	5,270	15,330

C.2 HYDRAULIC MODELLING

C.2.1 Methodology

The inflows for the identified critical durations exported form the URBS hydrologic model were simulated in the Lismore FRMS TUFLOW hydraulic model for the 1:1,000, 1:2,000, 1:10,000 and 1:100,000 AEP extreme flood events. Flood height mapping for the design events is provided in Appendix A.

C.2.2 Results

The peak flood levels for the extreme events, along with the existing design events from the Lismore FRMS, at the three key gauge locations in Lismore have been provided in Table 6.2.

Table 6.2: Summary of Modelled Calibration Event Flood Levels Compared to Modelled Design Event Flood Levels

Event	Tuncester Gauge (203443)	Woodlawn Gauge (203402)	Wilsons River at Lismore Gauge (58176)	East Gundurimba Gauge (558047)
10% AEP	12.65	11.39	10.97	9.66
5% AEP	13.22	11.45	11.45	10.03
1% AEP	13.88	12.93	12.57	10.88
0.2% AEP	14.14	13.49	13.02	11.49
1:1,000 AEP	14.85	14.27	13.79	12.23
1:2,000 AEP	15.05	14.52	14.02	12.45
1:10,000 AEP	15.35	14.78	14.39	12.73
1:100,000 AEP	16.40	15.96	15.47	13.76
PMF	17.30	17.06	16.55	14.72

Appendix D:
Mapping to Support Road Evacuation Analysis

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6,815,000 6,814,000 6,813,000 6,812,000 6,811,000

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

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

LEGEND

Reporting Points

Flood Hazard (m^2/s)

- <= 0.3
- 0.3 - 0.45
- 0.45 - 0.6
- > 0.6

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NOTES:

N

0 0.5 1 km

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Appendix D

Lismore Floodplain Risk Management Plan
Flood Hazard
(Depth x Velocity)
10% AEP

Drg Ref.
M92000_007

M:\Projects\M92000 Lismore City Council\M92000_007 Lismore FRMP\05 Design\QGIS\Workspaces\M92000_007-WOR-FRMP-A-Working ST.qgz

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21 20 22 19 15 16 14 17 18 6 1 2 13 3 12 8 9 10 11 5 7 4 23

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

LEGEND

Reporting Points

Flood Hazard (m^2/s)

- <= 0.3
- 0.3 - 0.45
- 0.45 - 0.6
- > 0.6

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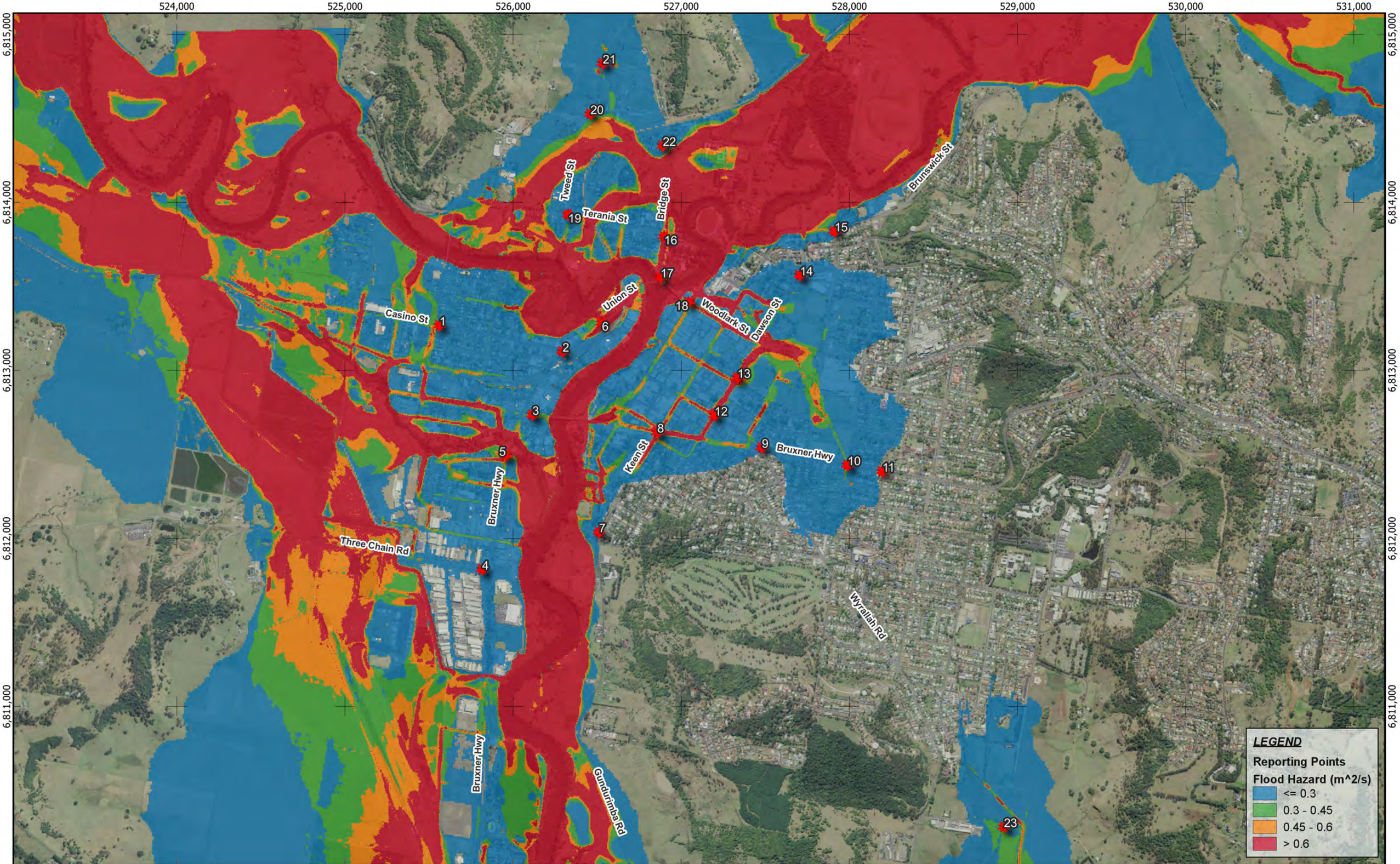
Lismore Floodplain Risk Management Plan
Flood Hazard
(Depth x Velocity)
1% AEP

Dg Ref.
M92000_007

M:\Projects\M92000 Lismore City Council\M92000_007 Lismore FRMP\05 Design\QGIS\Workspaces\M92000_007-WOR-FRMP-A-Working ST.qgz



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Appendix D

Lismore Floodplain Risk Management Plan
Flood Hazard
(Depth x Velocity)
"March 2017"

Dg Ref.
M92000_007

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Bruxner Hwy
Tweed St
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Bridge St
Union St
Keen St
Woodlark St
Dawson St
Brunswick St
Wyrallah Rd
Gundurimba Rd

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

LEGEND

Reporting Points

Flood Hazard (m^2/s)

- <= 0.3
- 0.3 - 0.45
- 0.45 - 0.6
- > 0.6

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Appendix D

Lismore Floodplain Risk Management Plan
Flood Hazard
(Depth x Velocity)
"February 2022"

Drg Ref.
M92000_007

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Brunswick St
Keen St
Bruxner Hwy
Three Chain Rd
Wyrallah Rd
Gundurimba Rd

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

LEGEND

Reporting Points

Time of Inundation (hrs)

- <= 15.0
- 15.0 - 30.0
- 30.0 - 45.0
- 45.0 - 60.0
- 60.0 - 75.0
- 75.0 - 90.0
- 90.0 - 105.0
- 105.0 - 120.0
- 120.0 - 135.0
- > 135.0

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Appendix D

Lismore Floodplain Risk Management Plan
Time of Inundation (hrs)
(Inundation greater than 300mm)
10% AEP

Drg Ref.
M92000_007

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

1 Casino St
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5 Bruxner Hwy
6 Union St
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8 Keen St
9 Bruxner Hwy
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14
15 Brunswick St
16 Bridge St
17
18 Woodlark St
19 Terania St
20
21
22 Tweed St
23 Wyrallah Rd

LEGEND

Reporting Points

Time of Inundation (hrs)

- <= 15.0
- 15.0 - 30.0
- 30.0 - 45.0
- 45.0 - 60.0
- 60.0 - 75.0
- 75.0 - 90.0
- 90.0 - 105.0
- 105.0 - 120.0
- 120.0 - 135.0
- > 135.0

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APPROVED	KM	DATE	04-04-2023

NOTES:

N

0 0.5 1 km

SCALE @ A3 - 1:20,000
GDA94 / MGA zone 56

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Appendix D

Lismore Floodplain Risk Management Plan
Time of Inundation (hrs)
(Inundation greater than 300mm)
1% AEP

Drg Ref.
M92000_007

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Brunswick St
Wyrallah Rd
Gundurimba Rd

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

LEGEND

Reporting Points

Time of Inundation (hrs)

- <= 15.0
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- 75.0 - 90.0
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Lismore Floodplain Risk Management Plan
Time of Inundation (hrs)
(Inundation greater than 300mm)
"March 2017"

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LEGEND

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Lismore Floodplain Risk Management Plan
Time of Inundation (hrs)
(Inundation greater than 300mm)
"February 2022"

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