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Environmental Impact Statement – Appendix H2: Flood Risk Analysis

Warragamba Dam Raising

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WATER NSW

WARRAGAMBA EIS FLOOD RISK CHAPTER

FINAL REPORT

FEBRUARY 2020

WARRAGAMBA EIS FLOOD RISK CHAPTER

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AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
ALS	Airborne Laser Scanning
ARR	Australian Rainfall and Runoff
BOM	Bureau of Meteorology
DECC	Department of Environment and Climate Change (now OEH)
DNR	Department of Natural Resources (now OEH)
DRM	Direct Rainfall Method
DTM	Digital Terrain Model
GIS	Geographic Information System
GPS	Global Positioning System
IFD	Intensity, Frequency and Duration (Rainfall)
mAHD	meters above Australian Height Datum
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
SRMT	Shuttle Radar Mission Topography
TUFLOW	one-dimensional (1D) and two-dimensional (2D) flood and tide simulation software (hydraulic model)
WBNM	Watershed Bounded Network Model (hydrologic model)

ADOPTED TERMINOLOGY

Australian Rainfall and Runoff (ARR, ed Ball et al, 2016) recommends terminology that is not misleading to the public and stakeholders. Therefore the use of terms such as “recurrence interval” and “return period” are no longer recommended as they imply that a given event magnitude is only exceeded at regular intervals such as every 100 years. However, rare events may occur in clusters. For example there are several instances of an event with a 1% chance of occurring within a short period, for example the 1949 and 1950 events at Kempsey. Historically the term Average Recurrence Interval (ARI) has been used.

ARR 2016 recommends the use of Annual Exceedance Probability (AEP). Annual Exceedance Probability (AEP) is the probability of an event being equalled or exceeded within a year. AEP may be expressed as either a percentage (%) or 1 in X. Floodplain management typically uses the percentage form of terminology. Therefore a 1% AEP event or 1 in 100 AEP has a 1% chance of being equalled or exceeded in any year.

ARI and AEP are often mistaken as being interchangeable for events equal to or more frequent than 10% AEP. The table below describes how they are subtly different.

For events more frequent than 50% AEP, expressing frequency in terms of Annual Exceedance Probability is not meaningful and misleading particularly in areas with strong seasonality.

Therefore the term Exceedances per Year (EY) is recommended. Statistically a 0.5 EY event is not the same as a 50% AEP event, and likewise an event with a 20% AEP is not the same as a 0.2 EY event. For example an event of 0.5 EY is an event which would, on average, occur every two years. A 2 EY event is equivalent to a design event with a 6 month Average Recurrence Interval where there is no seasonality, or an event that is likely to occur twice in one year.

The Probable Maximum Flood is the largest flood that could possibly occur on a catchment. It is related to the Probable Maximum Precipitation (PMP). The PMP has an approximate probability. Due to the conservativeness applied to other factors influencing flooding a PMP does not translate to a PMF of the same AEP. Therefore an AEP is not assigned to the PMF.

This report has adopted the approach recommended by ARR and uses % AEP for all events rarer than the 50 % AEP and EY for all events more frequent than this.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	19.5
	0.02	2	50	49.5
	0.01	1	100	99.5
Very Rare	0.005	0.5	200	199.5
	0.002	0.2	500	499.5
	0.001	0.1	1000	999.5
	0.0005	0.05	2000	1999.5
Extreme	0.0002	0.02	5000	4999.5
			↓	
			PMP/ PMP Flood	

1. INTRODUCTION

This report documents the hazard and hydraulic categorisation undertaken for the Warragamba Dam Environmental Impact Assessment. Sections 2 to 4 are to provide background information so that the model used is documented with the methodology for the hazard and hydraulic categorisation. Section 5 provides details of the methodology for the hazard and hydraulic categorisation as well as discussion of the resultant maps for the SEARs events. The existing Conditions - (pre Warragamba dam raising is compared to the Raised dam case. This section is intended to be lifted out to form the chapter of the Environmental Impact Assessment.

2. BACKGROUND

2.1. Study Area

The Warragamba River is a major tributary of the Hawkesbury Nepean River system. Although the Nepean catchment at its junction with the Warragamba is only 20% of the size of the Warragamba catchment, the Nepean River drains a region of very high rainfall along the top of the Illawarra Escarpment, and its contribution to downstream flooding is usually greater than a simple portion of catchment area might suggest.

Downstream of the junction, the Nepean continues to flow through a narrow gorge until it emerges into more open country just upstream of Penrith. The elevation of the floodplain in the vicinity of Penrith, including Emu Plains and the Penrith Lakes Scheme, is surprisingly high and does not convey floodwaters until floods almost reach the magnitude of a 1% Annual Exceedance (AEP) event.

The Richmond/Windsor lowlands are encountered below the Grose River Junction. These are extensive floodplains inundated by minor and moderate flooding. The main towns in the area, Richmond and Windsor, are in the most part elevated above smaller floods, but are seriously affected by medium sized floods.

South Creek joins the river just below Windsor. While the creek is not a major contributor to flood flows, it has a large floodplain which is inundated by backwater from the Hawkesbury River.

Below Wilberforce the Hawkesbury River enters another gorge, the Hawkesbury Gorge, which extends for over 100 km to the ocean at Broken Bay. Along this gorge, it is joined by the Colo River from the west and the MacDonald River from the north, along with a number of small tributaries.

There are five other major dams in the catchment: four on the headwaters of the Nepean River and one near the head of the Wingecarribee River. The total area controlled by the other dams is a very small proportion of the total catchment and they have minimal impact on even relatively minor floods.

2.2. Warragamba Dam Environmental Impact Assessment

An Environmental Impact Assessment is currently being undertaken for the proposed raising of the Warragamba Dam wall. The latest design raised dam with an approximate 14m raising as been used for this assessment. This report details the methodology for the hazard and hydraulic categorisation as well as discussion of the resultant maps for the SEARs events. Section 5 of this report is intended to be lifted out to form the chapter of the Environmental Impact Assessment.

3. AVAILABLE DATA

3.1. Topographic Data

3.1.1. LiDAR

Airborne Laser Scanning (ALS) or LiDAR ground levels were available for the study area. The ALS was flown by Lands and Property Information (LPI) and Digital Elevation Model (DEM) tiles were output at 1m resolution.

The 2017 LiDAR (flown between May and June 2017) covers the Hawkesbury-Nepean catchment, extending from four kilometres upstream of Warragamba Dam and approximately 15 kilometres upstream of Wallacia downstream to Wisemans Ferry on the Hawkesbury River and approximately five kilometres up the Colo River. Spatial accuracy of the 2017 LiDAR in the horizontal and vertical directions was reported as 0.8 metres and 0.3 metres, respectively.

Areas such as the Upper Colo and the Hawkesbury River downstream of Wisemans Ferry were supplemented with 2011 LiDAR, which was flown by LPI between February and May 2011, with the same reported accuracy as the 2017 LiDAR data.

Joins between the two datasets were designed to transition in gorge country and along the ridge lines. The join was designed to maximise the use of the 2017 ALS.

3.1.2. Channel Data Downstream of the Dam

While hydrosurvey exists for downstream portions of the Hawkesbury River, it can be sparse, and uses inconsistent datums. A simplified set of hydrosurvey data were available from Sydney Water and was included in the TUFLOW model to represent bed levels between the Nepean Junction with Warragamba River, and Spencer.

3.2. Hydrologic Data

A RORB model was developed as part of the Hawkesbury Nepean Valley Regional Flood Study (HNVRFS). The model incorporates the existing dam H14 protocol to simulate the impact of Warragamba Dam.

The RORB model was used in the monte carlo modelling approach adopted for the HNVRFS (WMAwater, 2019) which resulted in 20,000 possible events. Events from this modelling have been selected as Representative events and have been adopted for the TUFLOW model.

4. MODELLING APPROACH

WMAwater has independently developed a TUFLOW model of the Hawkesbury-Nepean floodplain as part of a separate research project. This model has been adopted for the assessment of downstream impacts of a raised dam. The extent of the downstream model is shown on Figure 1.

4.1. Adopted Model

4.1.1. TUFLOW

The TUFLOW model has many features that enable complex floodplain behaviour to be reliably defined and includes a finite difference numerical model for the solution of the depth averaged shallow water flow equations in both one and two dimensions. TUFLOW is widely used in Australia and internationally for assessing flood behaviour and hydraulic hazard. The model is capable of dynamically simulating complex overland flow regimes in conjunction with tidal tailwater effects. An advantage of TUFLOW is its ability to represent hydraulic structures such as bridges, road/rail embankments, weirs, buildings, culverts and other key controls that play an important role in overbank flood behaviour. The layout of the TUFLOW model is shown on Figure 2.

4.1.2. High performance computing

The Hawkesbury-Nepean floodplain is largely rural with development concentrated around the townships of Penrith, Richmond and Windsor. A grid resolution of 20 metres was selected for the model. However, a grid resolution of that size for an area of 1,333 square kilometres using the TUFLOW Classic solver would result in extremely large model run-times. In 2017, a new TUFLOW version was released with High-Performance Computing (HPC). A grid size of 20m provides the best compromise between model resolution and run time for such a large catchment.

For this dam breach assessment, TUFLOW HPC has been adopted. TUFLOW HPC is a finite volume model, which makes it very suitable for dam breach assessments. This is because it can handle steep waves and high velocities, and generally with good volume conservation. Finite volume models are also very amenable to parallel computing, which is used in TUFLOW HPC. The TUFLOW standard solver (TUFLOW classic) by comparison uses finite difference.

TUFLOW HPC can be used on both a Graphics Processing Unit (GPU) and a traditional Central Processing Unit (CPU). However, the new HPC models are significantly faster on a GPU processor. The HPC solver allows the timestep to be dynamically reduced for more complex hydraulic aspects of the floodplain.

4.1.3. Calibration and Verification

The TUFLOW model is quasi-calibrated to historic events and representative design events from the Hawkesbury Nepean Regional flood study (2019). The hydraulic efficiency of the creeks is represented (in part) within the TUFLOW model by the roughness or friction factor, Manning's "*n"* value. Manning's "*n"* is used to describe the influence of the following factors on flow behaviour:

- channel roughness,
- channel sinuosity,
- vegetation and other debris/obstructions in the channel, and
- bed forms and shapes.

As part of the calibration process the Manning's "n" roughness value was adjusted within reasonable limits to best match the recorded flood heights along the creek system. Adopted values were selected based on an assessment of the ground cover types and vegetation density within the floodplain. The adopted values were then used for the hydraulic modelling of the current study.

Table 1 lists the Manning's value and their described application in the model. This is also shown on Figure 3.

Table 1: Adopted Manning's Values

'n'	Land Use
0.07	Built up areas
0.07	Bush - High Density
0.05	Bush - Low Density
0.05	Other floodplain
0.045	Riparian zone
0.04	Penrith Lakes
0.04	Wallacia Farm Land
0.03	Farm Land/ grassed area
0.03	Floodplain Low Grass
0.025	Creeks
0.025	Channel US Penrith Lakes
0.02	Channel Penrith Lakes to Yarramundi
0.018	Channel Yarramundi to Windsor
0.015	Channel DS of Sackville

4.1.4. Boundary Conditions

A flat tide of 0.9m AHD was adopted for runs in this study as tidal influence was not a key parameter being assessed. Initial water levels were varied along the river system up to Wallacia to match the in bank water level.

Inflow locations to the downstream model are the same as the RUBICON model other than refinement of Mulgoa Creek to facilitate flow in the upper reaches of the creek prior to the breakout from Wallacia in larger events.

4.1.5. Limitations

This model has been calibrated to observed flood behaviour ranging from a less than 1 in 4 AEP event (April 1989) to 1 in 44 AEP event (November 1961). A Probable Maximum Flood event is defined in ARR 2019 (Ball et al, 2019), as a hypothetical flood event relevant to a specific catchment whose magnitude is such that there is a negligible chance of it being exceeded. Using the procedure in ARR 2019 the probability of the PMF in the Hawkesbury Nepean Valley is in the order of 1 in 100, 000 AEP. This is much rarer than the AEP of the calibration events. Extrapolation of the model to an extreme event such as the PMF should therefore be treated with caution.

4.1.6. Representative Design Flood Events

A Monte Carlo approach and a fast quasi-two-dimensional model was used for this study. A fast quasi-two-dimensional model is required to run the thousands of events in a realistic timeframe. Running a more detailed two-dimensional model of the entire catchment for all Monte Carlo events would take an extremely long time.

The 1996 Flood Study has historically provided boundary Conditions - for detailed two-dimensional models established in the valley since 1996. As this study adopted a Monte Carlo sampling approach rather than a standard design event approach, most events will have a range of exceedance probabilities at the various locations of interest within the model, rather than a single exceedance probability assumed at all locations with the traditional approach. This is due to the likelihood of the rank of peak flood levels within the Monte Carlo events changing as the flood progresses downstream.

To provide design events that can be used as boundary Conditions - for future detailed modelling and that can be visualised using WaterRIDE, a set of representative events were chosen. These are different to the evacuation events. As much as possible the events were selected to maintain AEP as the flood progressed downstream. The representative events for a given AEP should be enveloped to form a design flood surface. More details on the derivation of the representative events can be found in WMAwater (2019).

Table 2 summarises the number of events chosen per design quantile. These events were run through the hydraulic model and enveloped as per WMAwater (2019) recommendations.

Table 2: Number of Representative Events per Design Event Quantile

AEP	Number of events
1 in 5	4
1 in 10	3
1 in 20	2
1 in 50	3
1 in 100	2
1 in 200	3
1 in 500	2
1 in 1,000	3
1 in 2,000	3
1 in 5,000	3

4.1.7. Steady State Releases – 100GL/D

In order to model a sustained release from Warragamba Dam during the drawdown phase a constant 100 GL/D flow on the Hawkesbury Nepean River was modelled. Minor inflows for the other tributaries were assumed.

5. HAZARD and HYDRAULIC CATEGORIES

5.1. Hazard Classification

Hazard classification plays an important role in informing floodplain risk management in an area as it reflects the likely impact of flooding on development and people. In the Floodplain Development Manual (NSW Government, 2005) hazard classifications are essentially binary – either Low or High Hazard as described on Figure L2 of that document. However, in recent years there has been a number of developments in the classification of hazard especially in *Managing the floodplain: a guide to best practice in flood risk management in Australia (Third Edition)* (AIDR 2017). This study presents hazard mapping based on the methodology outlined in AIDR 2017. The classification is divided into 6 categories (H1-H6), listed in Table 3 which indicate constraints of hazard on people, buildings and vehicles appropriate to apply in each zone. The criteria and threshold values for each of the hazard categories are presented in Diagram 1.

Table 3: Hazard Categories

Category	Constraint to people/vehicles	Building Constraints
H1	Generally safe for people, vehicles and buildings	*No constraints*
H2	Unsafe for small vehicles	*No constraints*
H3	Unsafe for vehicles, children and the elderly	*No constraints*
H4	Unsafe for vehicles and people	*No constraints*
H5	Unsafe for vehicles and people	All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure.
H6	Unsafe for vehicles and people	All building types considered vulnerable to failure

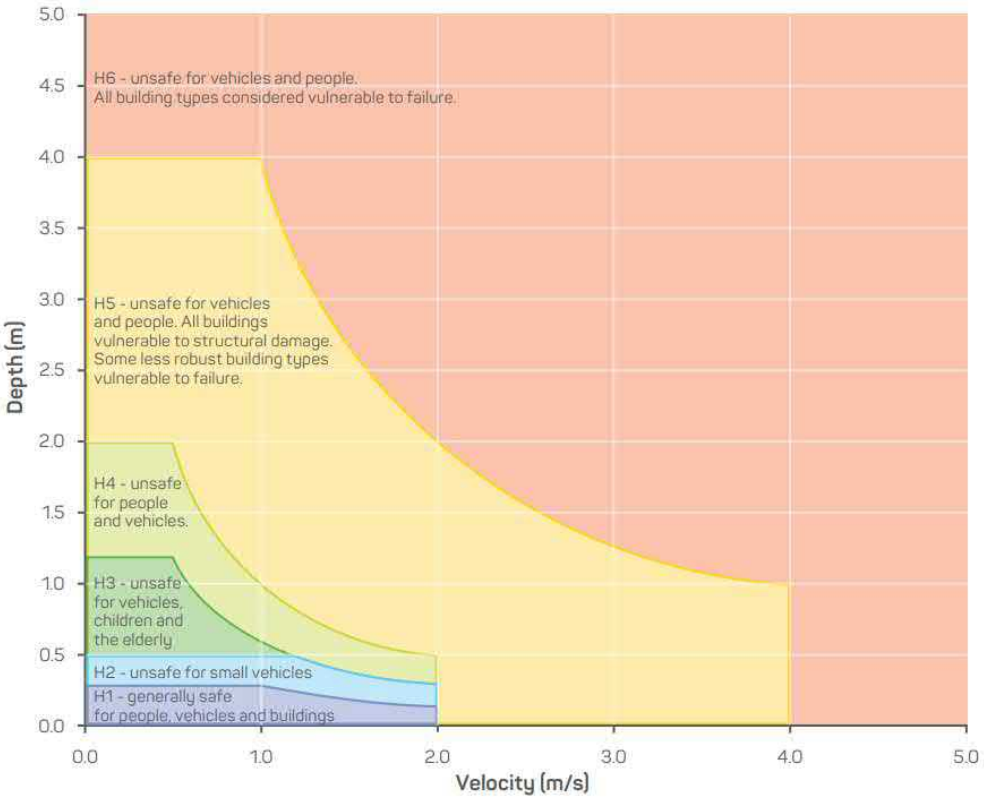

Diagram 1: Hazard Classifications (AIDR, 2017)

5.1.1. Existing Conditions

The following section presents a discussion of the existing Conditions - hazard classifications for a range of flood events (1 in 5, 1 in 20, 1 in 100, 1 in 200, 1 in 500, 1 in 2000 AEP and PMF).

5.1.1.1. 1 in 5 AEP Event

Figure 4 to Figure 7 present the flood hazard classifications for the 1 in 5 AEP event. While most of the floodplain is classified as unsafe for vehicles and people (H4 to H6), majority of the flow is contained within its banks. Wallacia and Penrith areas mostly consist of a H6 classification (Unsafe for vehicles and people. All building types considered vulnerable to failure) however this is mostly contained to the immediate channel vicinity. Less hazardous areas occur on the Windsor floodplain, where water overflowing from the banks is classified as H1 to H4. Upstream of Wisemans Ferry, most of the overbank areas are classified as a H1 to H4 hazard.

5.1.1.2. 1 in 20 AEP Event

Figure 8 to Figure 11 present the flood hazard classifications for the 1 in 20 AEP event. In a 1 in 20 AEP event the majority of the floodplain is considered unsafe for vehicles and people and is classified as a H5 Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure to H6 (Unsafe for vehicles and people. All building types considered vulnerable to failure). Most of the flow is contained within the river banks upstream of Yarramundi. Significant overbank flooding occurs on the Windsor floodplain, with the majority of the flood extent in this area classified unsafe for vehicles and people with all building types considered vulnerable to failure (H6). Significant overbank flow occurs between Richmond to Pitt Town and is predominantly classified between H5 (Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure) and H6 (Unsafe for vehicles and people. All building types considered vulnerable to failure) with less hazardous classifications visible on the edges of the floodplain. The majority of the flood extent around Wallacia and Penrith is classified as unsafe for vehicles and people, with all buildings being vulnerable to failure (H6 flood hazard classification).

5.1.1.3. 1 in 100 AEP Event

Figure 12 to Figure 15 present the flood hazard classifications for the 1 in 100 AEP event. In a 1 in 100 AEP event, the majority of the floodplain is considered unsafe for vehicles and people, with buildings requiring special engineering design and construction or buildings being vulnerable to failure (H5 to H6 flood hazard classification). All but the very edges of the flood extent at Wallacia is classified as H6 (unsafe for vehicles and people, with all buildings being vulnerable to failure). At Penrith overbank flow occurs and is classified H1 to H5. Richmond and Windsor are mostly inundated and is largely given a H6 classification other than patches at Pitt Town Road and between Hawkesbury Valley Way and Blacktown Road.

5.1.1.4. 1 in 200 AEP Event

Figure 16 to Figure 19 present the flood hazard classifications for the 1 in 200 AEP event. The 1 in 200 AEP event flood hazard is very similar to the 1 in 100 AEP event hazard. Upstream of Pitt

Town, almost all of the floodplain is considered unsafe for vehicles and people, with building types being vulnerable to failure (H5 to H6 flood hazard classification). A small increase in the extent of flooding and consequent increase in H6 classification extent is observed in the breakout of Rickabys Creek near Blacktown Road. The flooded area between Hawkesbury Valley Way and Blacktown Road is now largely H5 (Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure). Additionally, an increase in H1 to H3 hazard classification is visible in Penrith and Emu Plains as more flowpaths join up and the extent of flooding increases. Apart from an increase in the width of the floodway and consequent H6 hazard, little change in hazard classification is observed in Wallacia between the 1 in 100 AEP and 1 in 200 AEP.

5.1.1.5. 1 in 500 AEP Event

Figure 20 to Figure 23 present the flood hazard classification for the 1 in 500 AEP event. In a 1 in 500 AEP event, the majority of the floodplain is considered unsafe for vehicles and people, with all building types considered vulnerable to failure (H6 flood hazard classification). Larger breakouts occur in Penrith from Lapstone Creek, Peach Tree Creek, and Mulgoa Creek but are mostly classified as safe for people, larger vehicles and buildings (H1 to H2 flood hazard classification). The Richmond to Windsor Region is mostly given a H6 flood hazard classification, however breakouts that occur near Blacktown Road are classified as less hazardous (H1 to H4 flood hazard classification). As with the 1 in 200 AEP Wallacia remains mostly unsafe for vehicles and people with all building types considered vulnerable to failure (H6 flood hazard classification).

5.1.1.6. 1 in 2000 AEP Event

Figure 24 to Figure 27 present the flood hazard classification for the 1 in 2000 AEP event. With the exception of Penrith, most of the floodplain is considered unsafe for vehicles and people, with all building types considered vulnerable to failure (H6 flood hazard classification). A large breakout occurs directly south of Penrith Lakes at the sharp bend in the Nepean River. This area is predominantly classified as H3 and H5 with the edges of the floodplain considered generally safe for people, vehicles and buildings (H1 flood hazard classification).

5.1.1.7. PMF Event

Figure 28 to Figure 31 present the flood hazard classification for the probable maximum flood (PMF) event. The majority of the floodplain is considered unsafe for vehicles and people with all building types considered vulnerable to failure (H6 flood hazard classification). At the very edges of the floodplain and some areas around Emu Plains are subject to lower hazard categories.

5.1.2. Raised Dam

The following section presents a discussion of the raised dam hazard classifications for a range of flood events (1 in 5, 1 in 20, 1 in 100, 1 in 200, 1 in 500, 1 in 2000 AEP and PMF). Note that the same representative event (event IDs) were used for both the existing and raised dam cases for direct comparison. Due to the extreme flood depths that occur under existing conditions in the Hawkesbury Nepean Valley much of the floodplain is classified Unsafe for vehicles and people and all building types considered vulnerable to failure (H6). While the raised dam significantly reduces flood depths it is not enough to significantly alter the hazard classification (due to the nature of the classification scheme) as the depths are still enough to classify the floodplain as H6.

5.1.2.1. 1 in 5 AEP Event

Figure 40 to Figure 43 present the flood hazard classifications for the 1 in 5 AEP event. For the 1 in 5 AEP event, most of the floodplain is classified as unsafe for vehicles and people (H4 to H6 flood hazard classification). Similar to the existing conditions, the majority of the flow for this event is contained within the river banks. The tributaries upstream of Wisemans Ferry experience a decrease in hazard categorisation from an overall H1 to H4 in the existing case to H1 to H3 under the raised dam conditions. The Windsor floodplain also experiences an overall decrease in the extent of flooding and therefore in the level of hazard classification. In particular, there is a large decrease in the extent of the H5 and H6 hazard classifications. As the flow is contained to the river at Penrith in a 1 in 5 AEP event there is little change in the hazard between the raised dam and existing conditions. This is also true for Wallacia.

5.1.2.2. 1 in 20 AEP Event

Figure 44 to Figure 47 present the flood hazard classifications for the 1 in 20 AEP event. The majority of the floodplain at Windsor is considered unsafe for vehicles, people and buildings and is classified as H5 to H6 under existing conditions. In the raised dam case there is considerable reduction in the area of H6 under the raised dam conditions. With some areas no longer flooded or now classified H1 to H3. At Penrith there is minimal change in flood extent as the flow is within banks. With a raised dam the hazard at the bend in the Hawkesbury River Downstream of Victoria Bridge is reduced from H6 to H5 on the western bank. Less regional flooding occurs in Peach Tree Creek, School House Creek, and Mulgoa Creek under a raised dam. Therefore reducing the hazard in these areas. Reduced flooding in the breakouts from Rickabys Creek and Cooley Creek lead to a reduction in hazard in these areas. No change is observed in Wallacia and immediately downstream of the dam between the raised dam and existing conditions 1 in 20 AEP.

5.1.2.3. 1 in 100 AEP Event

Figure 48 to Figure 51 present the flood hazard classifications for the 1 in 100 AEP event. In a 1 in 100 AEP event for the raised dam scenario, the majority of the floodplain is considered unsafe for vehicles and people, with buildings requiring special engineering design and construction or buildings being vulnerable to failure (H5 to H6 flood hazard classification). This is similar to the existing case but the extent is reduced. Upstream of Spencer, the hazard classification for the tributaries is reduced from mostly H5 to H4. Unlike the existing conditions, the Richmond Lowlands are not all classified as a H6 hazard under a raised dam.

Rickabys Creek is yet to break out towards Blacktown Road in comparison to the existing conditions. Therefore hazard in this area is reduced. Additionally, Mckenzies Creek, South Creek and Rickabys Creek remain as three separate flowpaths under the raised dam scenario and do not join up. Similarly, there is yet to be any major breakout from the Nepean River in Penrith under the raised dam conditions. No measurable change is observed in hazard at Wallacia and immediately downstream of the dam.

5.1.2.4. 1 in 200 AEP Event

Figure 52 to Figure 55 present the flood hazard classifications for the 1 in 200 AEP event. Under both existing and raised dam conditions most of the floodplain is considered unsafe for vehicles and people, with most building types considered vulnerable to failure (H5 to H6 flood hazard classification). The majority of the flood hazard differences between the raised dam and existing Conditions hazard can be found between Pitt Town and Penrith.

The hazard in the vicinity of North Richmond, Rickabys Creek and Cooleys Creek is reduced under raised dam conditions. Additionally, the breakout from Rickabys Creek towards Blacktown Road and the joining of the flowpath across Pitt Town Bottoms does not occur in the raised dam scenario. No change is observed in Wallacia and immediately downstream of the dam.

5.1.2.5. 1 in 500 AEP Event

Figure 56 to Figure 59 present the flood hazard classifications for the 1 in 500 AEP event. Similar to the existing conditions, the Windsor floodplain is predominantly classified as a H6 hazard under the raised dam conditions. Noticeably, the Rickabys Creek breakout towards Blacktown Road is mostly classified as a H1 to H5 hazard in comparison to the H4 to H6 hazard classification under the existing conditions. Under the raised dam conditions the flow path across Emu Plains is yet to merge back into the main river and the Boundary Creek breakout does not occur therefore reducing the hazard in these areas.

Similar to the raised dam conditions in the 1 in 200 AEP event, flooding within Penrith and Emu Plains is significantly reduced with lower hazards in areas still flooded. No significant change is observed in Wallacia.

5.1.2.6. 1 in 2000 AEP Event

Figure 60 to Figure 63 present the flood hazard classifications for the 1 in 2000 AEP event. With the exception of Penrith, most of the floodplain is considered unsafe for vehicles and people, with all building types considered vulnerable to failure (H6 flood hazard classification) as with the existing conditions case. Aside from the Rickabys Creek breakout towards Blacktown Road not joining up with the main river under a raised dam scenario, the overall trend of flood hazard classification between the raised dam and existing scenarios is the same. Under the raised dam conditions, the extent of H1 to H3 hazard classification is greater in comparison to the existing scenario. The hazard in Penrith and Emu plains is significantly reduced in a raised dam scenario. Furthermore, the Boundary Creek breakout does not merge with the Penrith Lakes floodplain in the raised dam scenario leading to reduced hazard to this area. No change is observed in Wallacia.

5.1.2.7. PMF Event

Figure 64 to Figure 67 present the flood hazard classifications for the PMF event. Like the flood hazard classification under the existing conditions, the majority of the floodplain is considered unsafe for vehicles and people with all building types considered vulnerable to failure (H6 flood hazard classification) with a raised dam. While in the existing scenario the flowpath from Rickabys

Creek towards Devlin Road does converge back with the Nepean River, this is not the case under the raised dam option.

5.2. Hydraulic Categorisation

Hydraulic categories describe the flood behaviour by categorising areas depending on their function during the flood event, specifically, whether they convey large quantities of water (floodway), store a significant volume of water (flood storage), or do not play a significant role in either storing or conveying water (flood fringe). As with categories of flood hazard, hydraulic categories play an important role in informing floodplain risk management in an area. Although the three categories of hydraulic function are described in the *Floodplain Development Manual* (NSW Government, 2005), their definitions are largely qualitative, and the manual does not prescribe a method to determine each area. Hydraulic categorisation is typically not undertaken for the full range of flood events. This study presents the 1 in 100 AEP and 1 in 500 AEP events which were available from WMAwater (2019) due to the complexity of defining floodways and limitations of the modelling.

The manual gives an indication of criteria for the quantification of flood storage areas. The manual defines flood storage areas as areas outside of the floodway which if completely filled with solid material, would increase peak flood levels by 'more than 0.1 metres and/or would cause the peak discharge anywhere downstream to increase by more than 10 per cent'.

A range of methods have been developed that aim to define these areas such as Howells et al. (2003), encroachment and conveyance methods. In order to define hydraulic categories for the Hawkesbury-Nepean, a conveyance and encroachment assessment was undertaken with detailed testing in the hydraulic model. The conveyance assessment defines the areas of the channel that convey the majority of the flood flow and are characterised by high velocities and depths. The floodplain outside this area was then tested in the hydraulic model through encroachment assessment by increasing the roughness and checking that flood levels are not increased by more than 0.1m. An iterative encroachment assessment is then used to refine the floodway extent and reduce impacts (increased flood levels) if necessary.

The encroachment analysis found that while through Penrith the floodway in a 1 in 100 AEP event is largely confined to the river and immediate adjoining low-lying floodplain, at Windsor large areas of floodplain are important for conveying floodwater. It was therefore prudent to undertake further analysis of the floodway, which led to it being subdivided into a primary floodway and a secondary floodway. The results presented herein are consistent with the approach undertaken for WMAwater (2019).

Flood storage and flood fringe areas make up the remaining area of the floodplain. These were combined given the negligible flood fringe areas.

5.2.1. Primary floodway

5.2.1.1. Method

The primary floodway was identified as any area that is subject to high relative velocities. The flow width was modified in accordance with Albert et al. (2018) to remove areas of low velocity or flow that do not contribute to the floodway.

The following definitions were adopted to define the total flow width:

- the depth x velocity product (VxD) along the crossline must be greater than 0.2
- the VxD at a point along the crossline proportional to the VxD at the centre must be greater than 0.1.

Specifically, the primary floodway was defined as the area that conveys 80 per cent of the flow width defined above *and* where velocities are greater than 0.5 m/s.

5.2.2. Secondary floodway

5.2.2.1. Method

While the majority of the flow is contained in the primary floodway, large areas in the Richmond Lowlands and Windsor area convey a significant amount of the flow, and still meet the strict floodway definition, but are characterised by lower velocities. These areas are typified by deep wide areas of the floodplain that when considered collectively convey a significant amount of the flow. These areas are also very important for flood storage and have many of the characteristics of a traditional flood storage area and could be considered as the transition zone from floodway to flood storage. Standard encroachment analysis confirmed that blockage of these areas results in unacceptable increases in flood levels. Analysis also indicated that because of the relatively low velocities, the impact of small isolated obstructions such as individual buildings and farm sheds is small and very localised.

Velocity and depth results were adopted to indicate areas of higher flow conveyance. At each grid cell, the peak velocity (v), peak depth (d) and their product (VxD) was considered, and the cell was categorised based on the following criteria:

1. if VxD > 0.5 or
2. if both v and VxD > 0.2

The result of the above criteria was modified using engineering knowledge of the catchment characteristics to produce a continuous secondary floodway. This floodway was tested by increasing the Manning’s ‘n’ roughness on all areas of the catchment outside of the secondary floodway to a value of 0.2. The increased roughness on all areas outside of the secondary floodway resulted in a flood level impact of less than 0.1 metres, confirming the adopted secondary floodway.

5.2.3. Existing Conditions

The following section presents a discussion of the raised dam hazard classifications for a range of flood events (1 in 100 and 1 in 500 AEP). These events are those presented by the WMAwater (2019).

Defining a floodway is difficult in areas where a large proportion of the flood flow is conveyed as deep, low velocity floodwaters. Small localised obstructions will only have a minor impact, but it is essential that the ability of these areas to convey significant flow is not reduced. These areas are also performing an important flood storage function. The analysis shows that any significant filling of the flood storage areas in the Richmond and Windsor areas will have a very broad impact on multiple suburbs.

5.2.3.1. 1 in 100 AEP Event

Figure 32 to Figure 35 present the hydraulic categorisation for the 1 in 100 AEP event.

Primary Floodway

In the 1 in 100 AEP event, the primary floodway is generally located within the main river channel. At Wallacia and Penrith, the primary floodway does not extend beyond the low-lying overbank areas. On the Windsor floodplain, the primary floodway extends beyond the banks of Rickabys Creek and South Creek in small areas, but does not intersect existing residential or industrial development.

Secondary Floodway

At Penrith, nearly all of the flow is contained in the river while in the Windsor area, a significant amount of the flow is conveyed down the Richmond lowlands as relatively deep, low velocity flow. In a 1 in 100 AEP event at Penrith, approximately 99 per cent of the flow is contained within the river at a level just below the level required for major break outs at Penrith and Emu Plains to occur. The area north of Windsor, which contains a large area of farmland, conveys a significant amount of the flow. Downstream of Gronos Point, the floodway is once again largely confined to the river and adjoining low lying floodplain. In a 1 in 100 AEP event, the overbank in the Wallacia area is a floodway.

5.2.3.2. 1 in 500 AEP Event

Figure 36 to Figure 39 present the hydraulic categorisation for the 1 in 500 AEP event.

Primary Floodway

In the 1 in 500 AEP event, there is little change in the primary floodway in comparison to the 1 in 100 AEP event. However, the primary floodway does extend further into the Windsor floodplain, particularly around the suburbs of Mulgrave, South Windsor, and Bligh Park. The calculation and assessment of a primary floodway for the 1 in 500 AEP event did not result in any additional primary floodways developing.

Secondary Floodway

In the 1 in 500 AEP event, an additional floodway breaks out along Nepean Street, Emu Plains before joining Lapstone Creek and returning to the Nepean River floodway. The secondary floodway also widens at Wilberforce, north of Windsor, in the 1 in 500 AEP event, allowing for an additional floodway to develop, connecting to Currency Creek. Downstream of Sackville, there are only very minor differences between the floodways of the 1 in 100 AEP and 1 in 500 AEP events.

5.2.4. Raised Dam

The following section presents a discussion of the raised dam hazard classifications for a range of flood events (1 in 100, 1 in 500 AEP). These events are those presented by the WMAwater (2019). Note that the same representative event (event IDs) were used for both the existing and raised dam cases for direct comparison.

5.2.4.1. 1 in 100 AEP Event

Figure 68 to Figure 71 present the hydraulic categorisation for the 1 in 100 AEP event.

Primary Floodway

In the 1 in 100 AEP event, the primary floodway is generally located within the main river channel. Similar to the primary floodway under the existing conditions, at Wallacia and Penrith, the primary floodway does not extend beyond the low-lying overbank areas. There is a slightly smaller breakout at the Rickabys Creek confluence with the main river at Windsor in comparison with the existing scenario. The primary floodway extends beyond the banks of Rickabys Creek and South Creek in small areas, but does not intersect existing residential or industrial development. Additionally, there is a smaller breakout of the Hawkesbury River at Pitt Town.

Secondary Floodway

At Penrith, as with the existing scenario, nearly all of the flow is contained in the river. However, while the floodway extents are similar between the raised dam and existing scenarios, there is minimal flood storage and flood fringe in Penrith under the raised dam conditions in comparison to the existing case. In the Windsor area, there is a large reduction in the secondary floodway for the raised dam scenario. The secondary floodway is mostly confined to the banks of the Hawkesbury Nepean River from the Richmond Lowlands to Yarramundi Bridge. Additionally, the secondary floodway does not consistently cover the area between Richmond and Pitt Town on the Windsor floodplain, unlike the secondary floodway in the existing conditions scenario. The extent of flood storage and flood fringe in the Windsor floodplain as well as on Rickabys Creek and South Creek confluences are much greater in the existing scenario than in the raised dam scenario. The overbank in the Wallacia area remains as a floodway under the raised dam scenario.

5.2.4.2. 1 in 500 AEP Event

Figure 72 to Figure 75 present the hydraulic categorisation for the 1 in 500 AEP event.

Primary Floodway

In the 1 in 500 AEP event, there is little change in the primary floodway in comparison to the 1 in 100 AEP event and very little change in comparison to the 1 in 500 AEP event under existing conditions. The calculation and assessment of a primary floodway for the 1 in 500 AEP event did not result in any additional primary floodways developing from the 1 in 100 AEP event.

Secondary Floodway

In the 1 in 500 AEP event, the secondary floodway breaks out from the Hawkesbury River banks at the Richmond Lowlands. However, unlike the existing scenario, it does not completely cover the whole floodplain. Additionally, unlike the existing scenario, there is no development of additional floodways at Emu Plains and Penrith. The flowpath across Pitt Town also remains relatively narrow in comparison to the secondary flowpath under the existing conditions. Furthermore, Currency Creek does not connect to the Hawkesbury River at Wilberforce, north of Windsor, under the raised dam conditions in the 1 in 500 AEP event. Downstream of Sackville, there are only very minor differences between the floodways of the 1 in 100 AEP and 1 in 500 AEP events.

5.3. Steady State Releases (100GL/D)

A steady state flow of 100 GL/D was modelled to represent sustained releases from the dam. For the steady state scenario, the majority of the flow is contained within the river and creek banks, with the exception of Sackville, Cattai, Pitt Town, South Creek, Rickabys Creek and the Windsor floodplain.

5.3.1. Hazard Categorisation

Figure 76 to Figure 79 present the flood hazard classifications for the steady state release (100GL/D) event. Only the Hawkesbury/Nepean River and its confluences, within their banks, are classified as a H6 hazard (Unsafe for vehicles and people, All building types considered vulnerable to failure). Where overbank areas are flooded they are mostly given a H1 to H3 classification (representing a relatively low hazard). However, in the vicinity of major creeks, such as Rickabys Creek, South Creek, and Little Cattai Creek, H4 (Unsafe for vehicles and people) to H5 (Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure) hazard classifications exist. In the Wallacia region, most of the main stream is contained within its bank and is mostly classified as a H5 hazard with some regions of H4 and H6 present.

5.3.2. Hydraulic Categorisation

Figure 80 to Figure 83 present the hydraulic categorisation for the steady state release (100GL/D) event.

5.3.2.1. Primary Floodway

In the steady sate event, the primary floodway does not extend beyond any low-lying overbank areas and is completely contained within the river channels.

5.3.2.2. Secondary Floodway

At Penrith and Windsor, most of the secondary floodway is contained in the river. In Wallacia, the secondary floodway is completely contained within the banks. Under the steady state conditions, no flow is conveyed down the Richmond Lowlands in the Windsor region.

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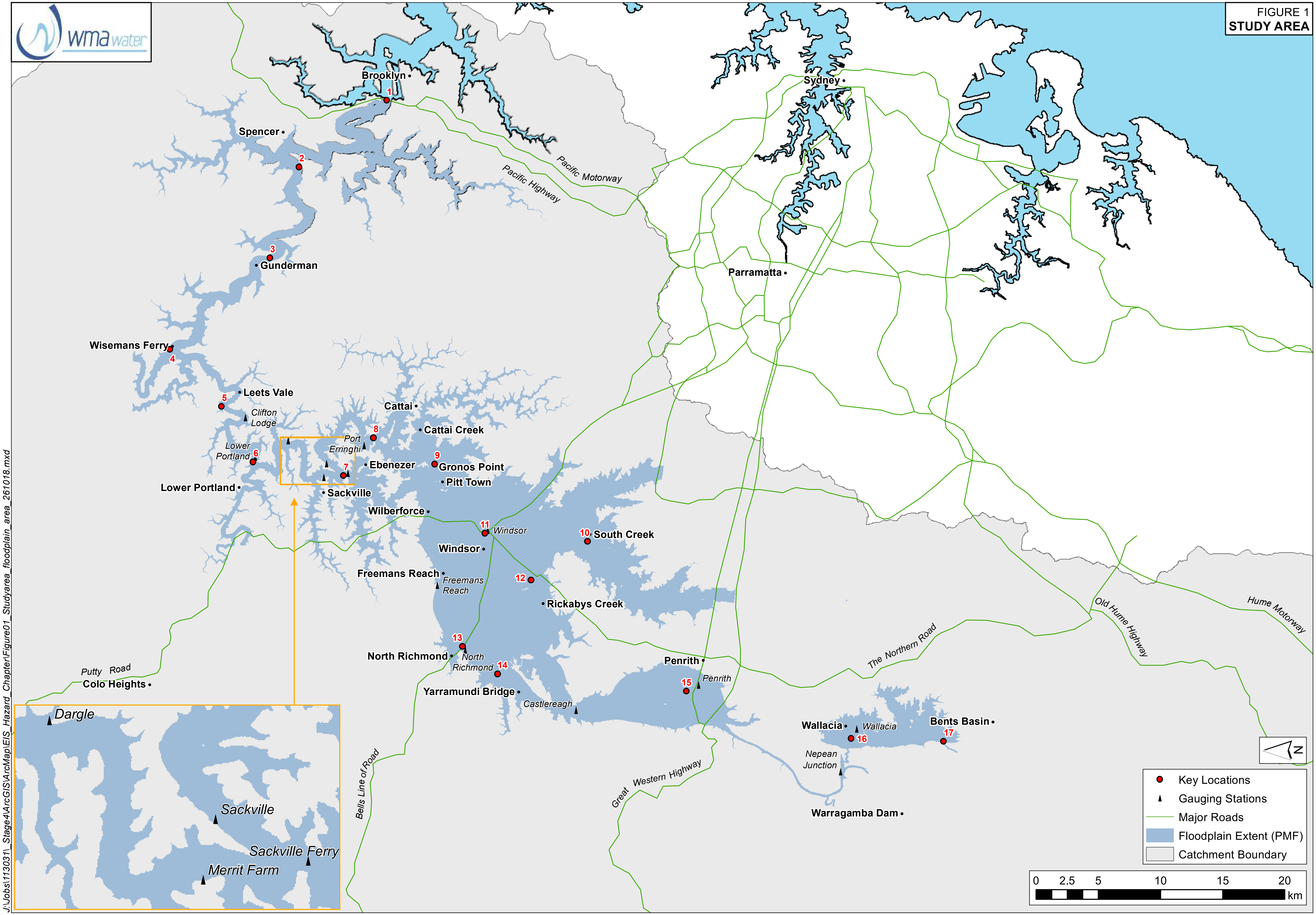
LIST OF FIGURES



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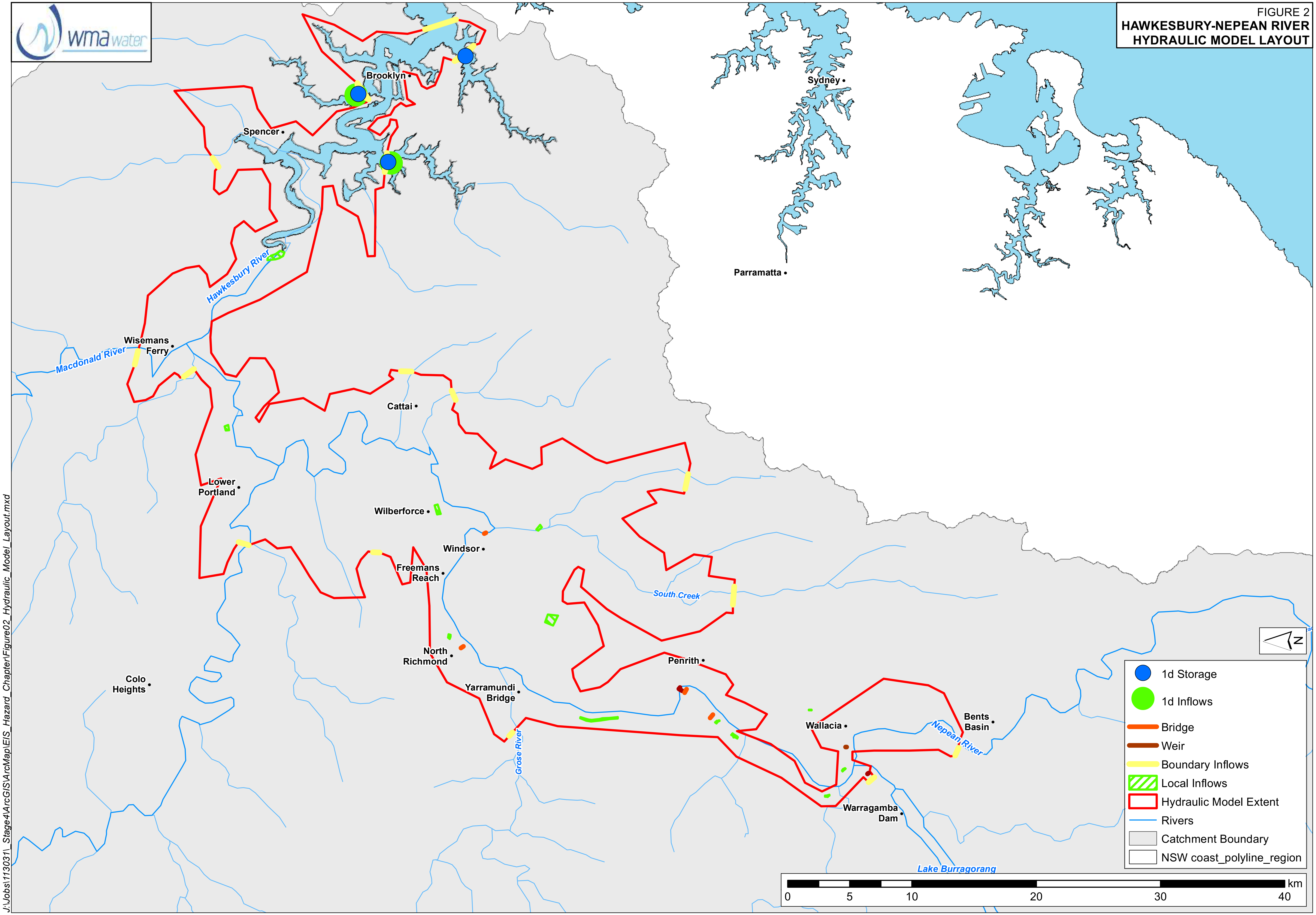

FIGURE 2
HAWKESBURY-NEPEAN RIVER
HYDRAULIC MODEL LAYOUT

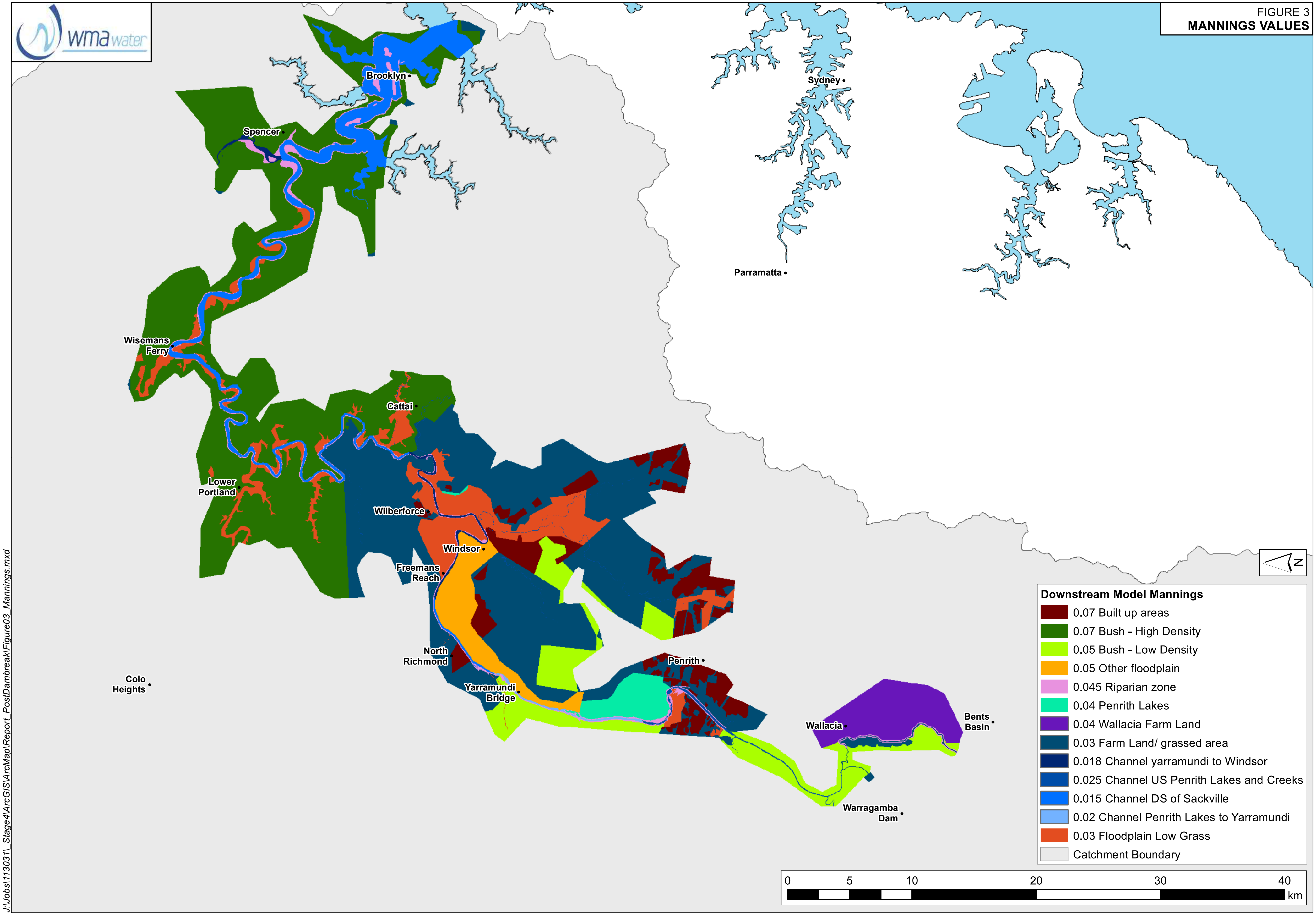

FIGURE 3
MANNINGS VALUES

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FIGURE 4
PROVISIONAL FLOOD HAZARD EXISTING CONDITIONS 1 IN 5 AEP EVENT FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

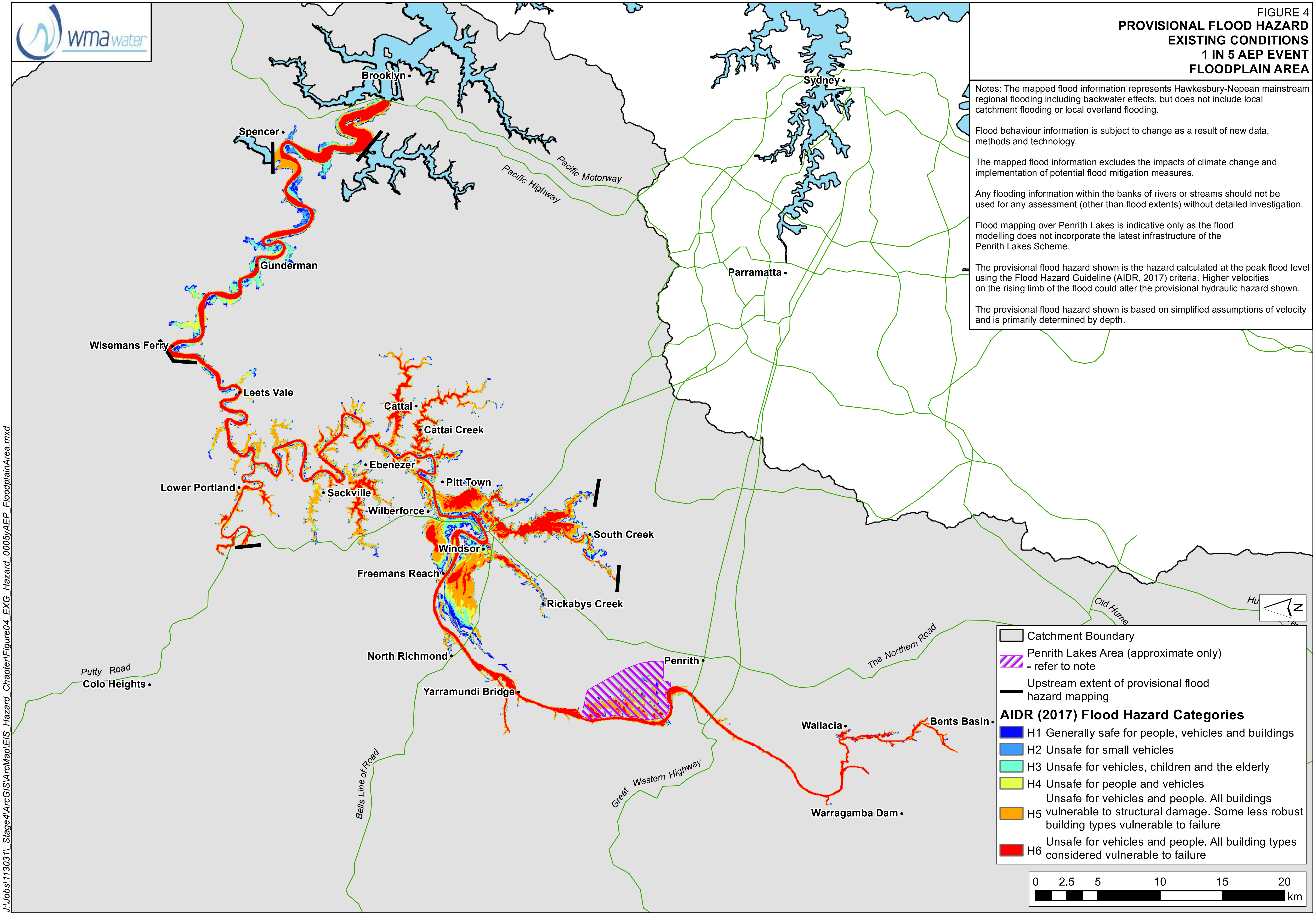
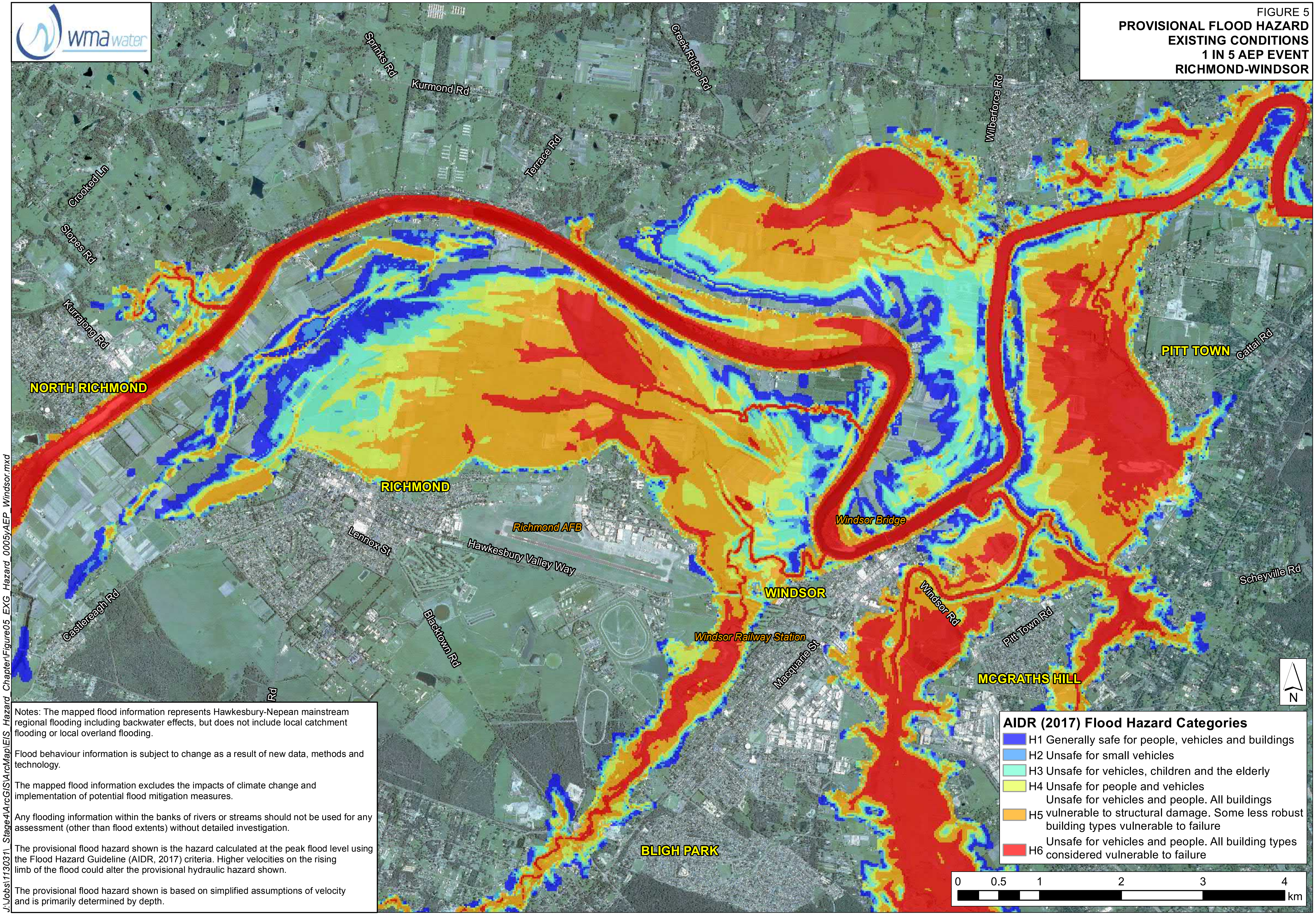


FIGURE 5
PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 5 AEP EVENT
RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 6
PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 5 AEP EVENT
PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

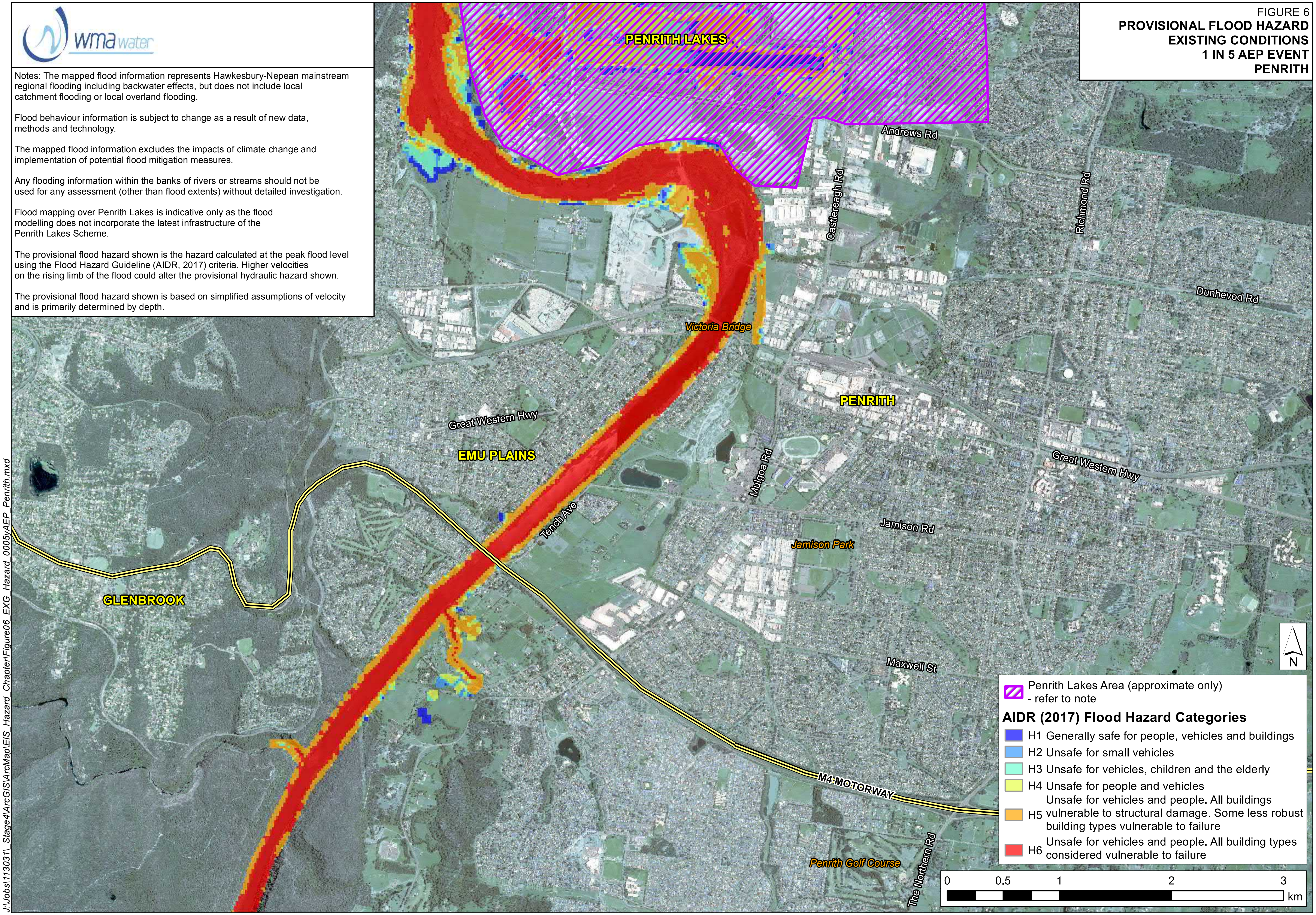
The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.



Penrith Lakes Area (approximate only) - refer to note

AIDR (2017) Flood Hazard Categories

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

0 0.5 1 2 3 km

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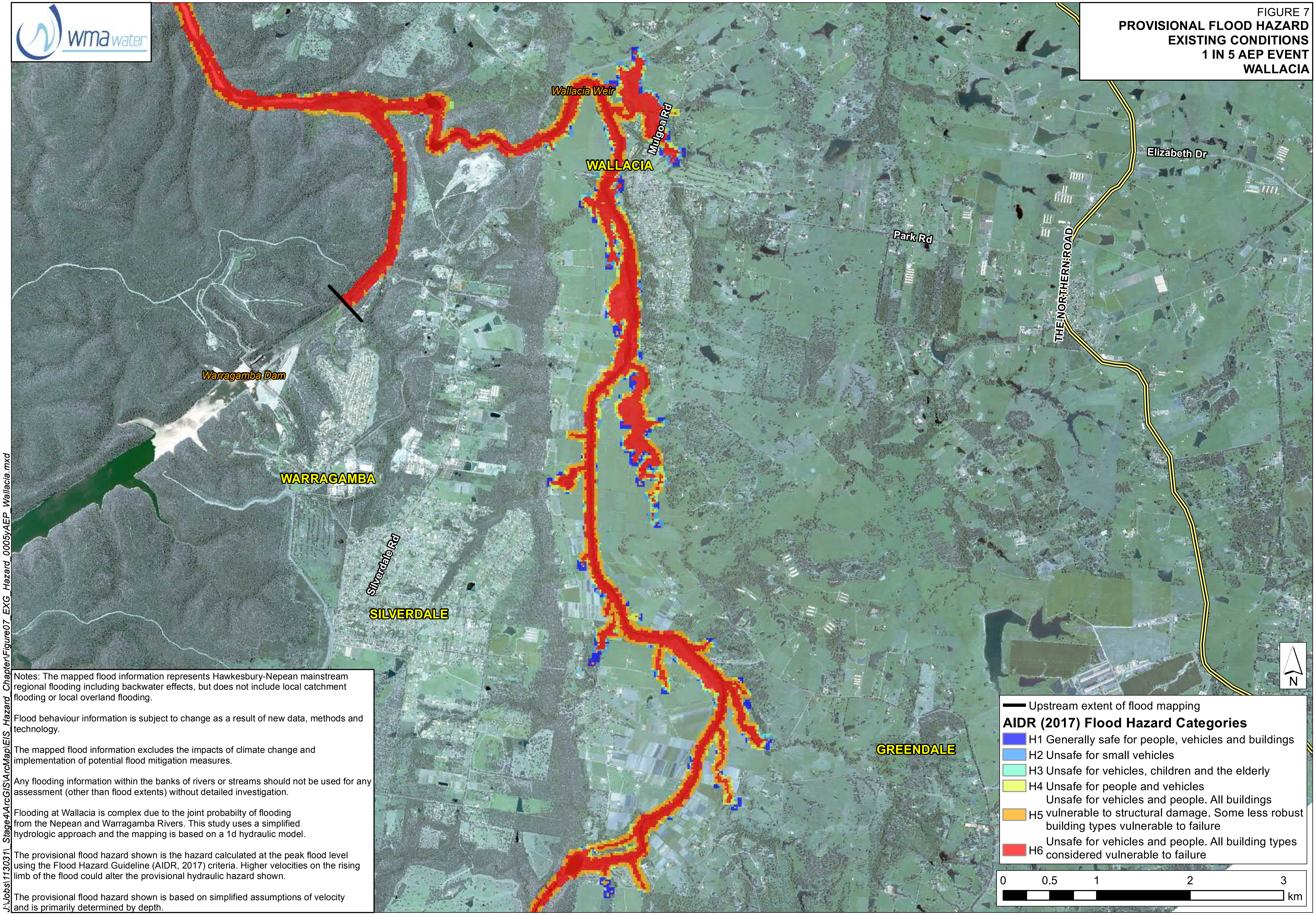
FIGURE 7
PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 5 AEP EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

FIGURE 8

PROVISIONAL FLOOD HAZARD EXISTING CONDITIONS 1 IN 20 AEP EVENT FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

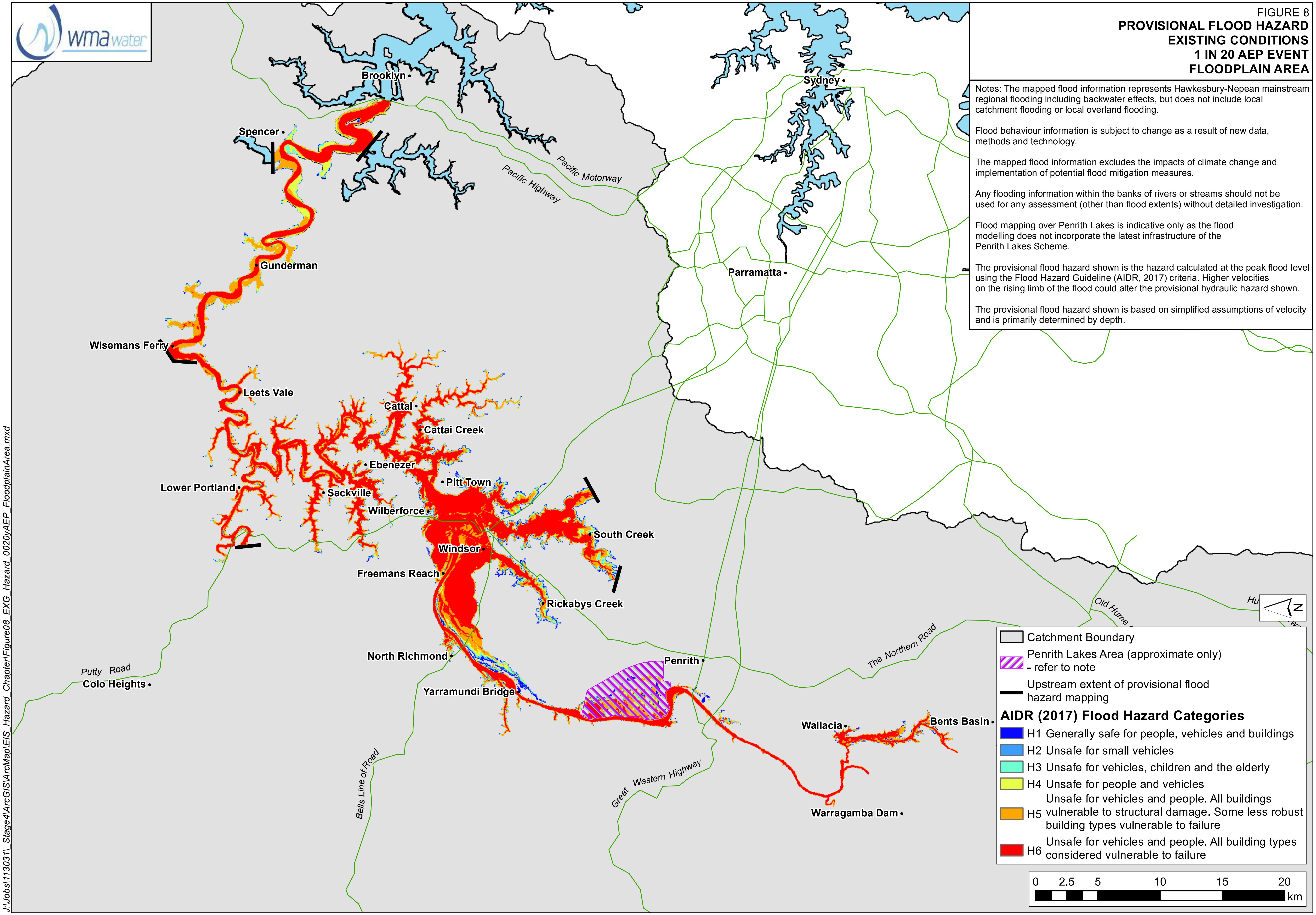
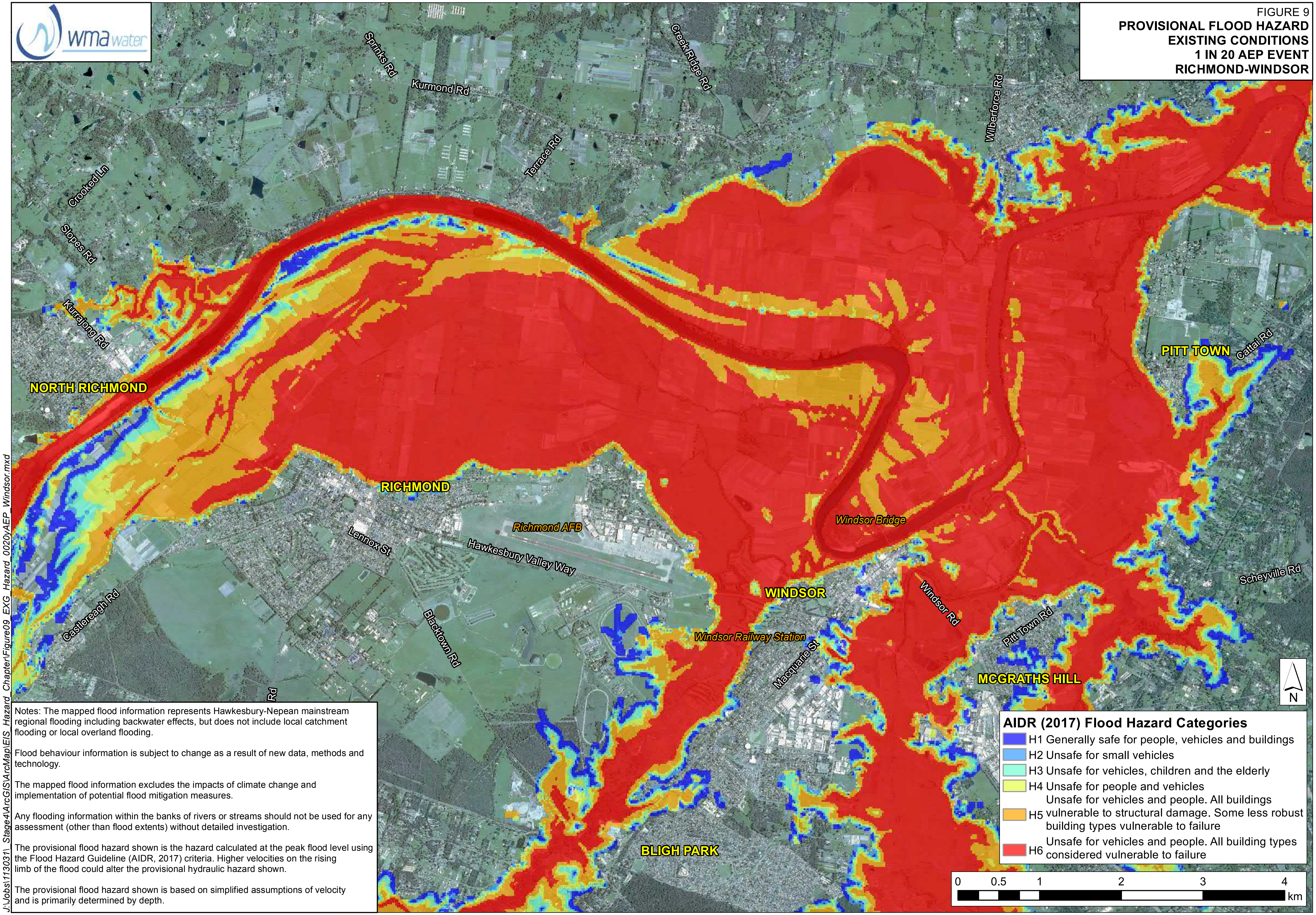


FIGURE 9
PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 20 AEP EVENT
RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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wmawater

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

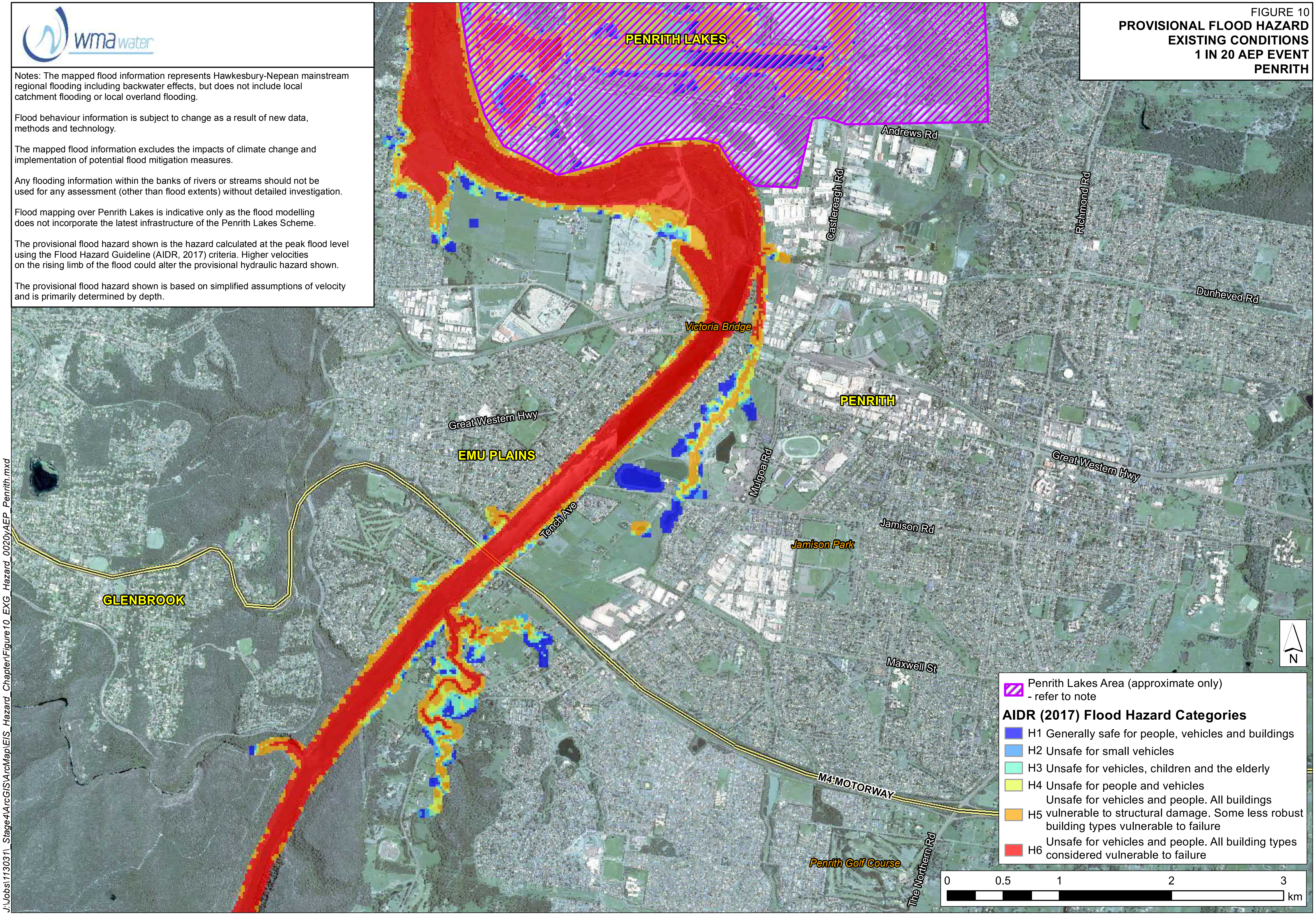
Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

FIGURE 10

PROVISIONAL FLOOD HAZARD EXISTING CONDITIONS 1 IN 20 AEP EVENT PENRITH



Penrith Lakes Area (approximate only) - refer to note

AIDR (2017) Flood Hazard Categories

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

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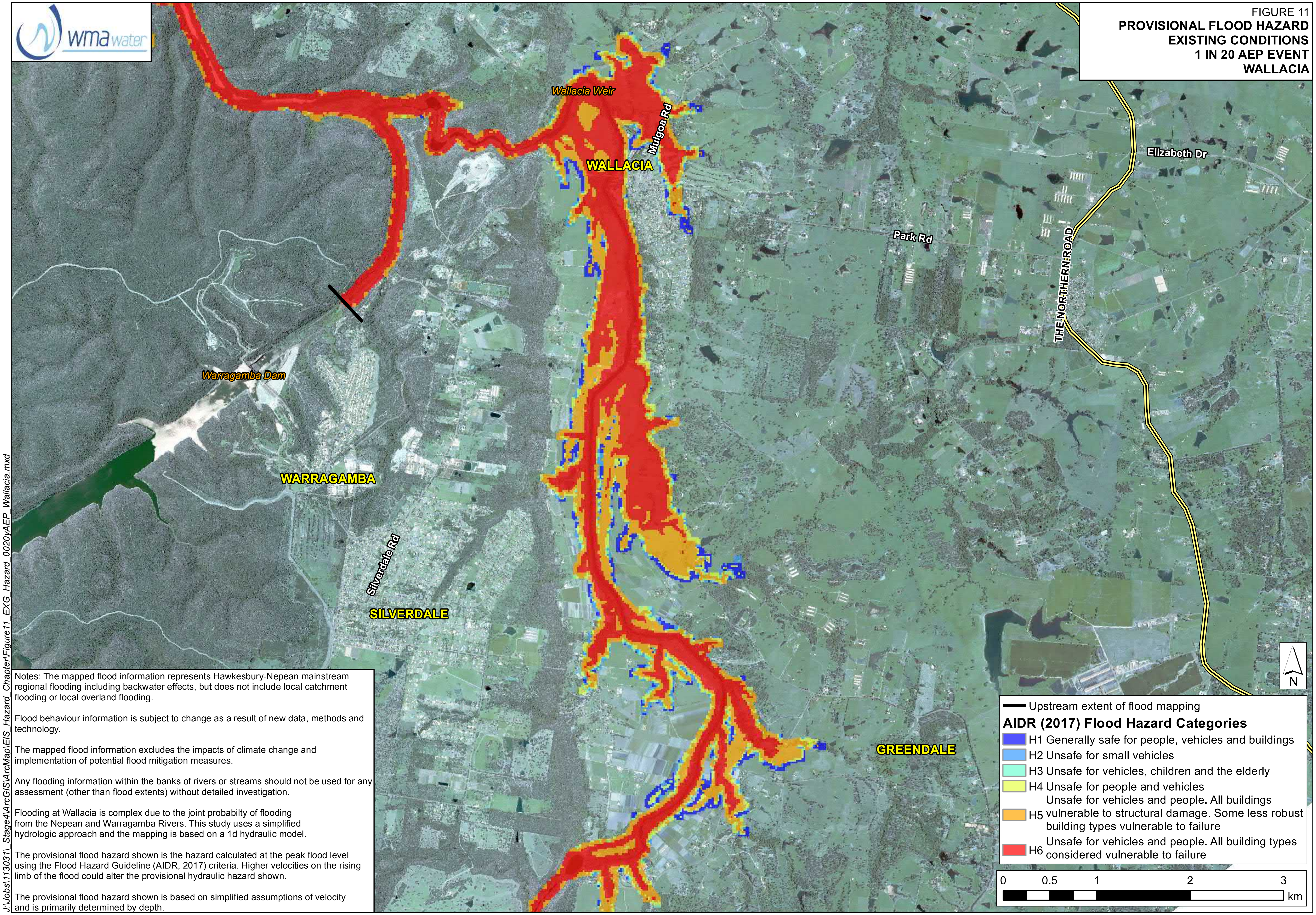
FIGURE 11
PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 20 AEP EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 12
PROVISIONAL FLOOD HAZARD EXISTING CONDITIONS 1 IN 100 AEP EVENT FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

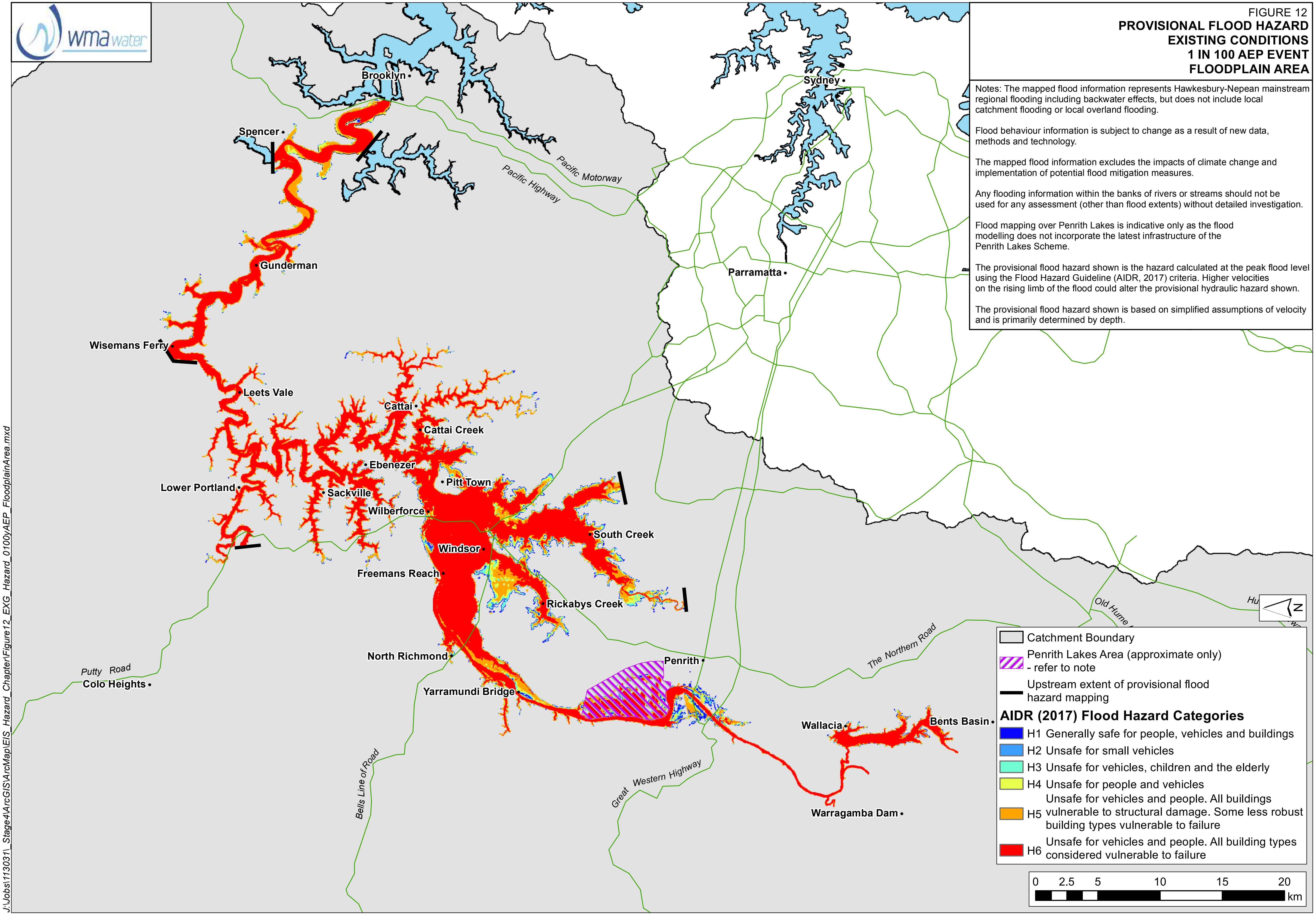
The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.



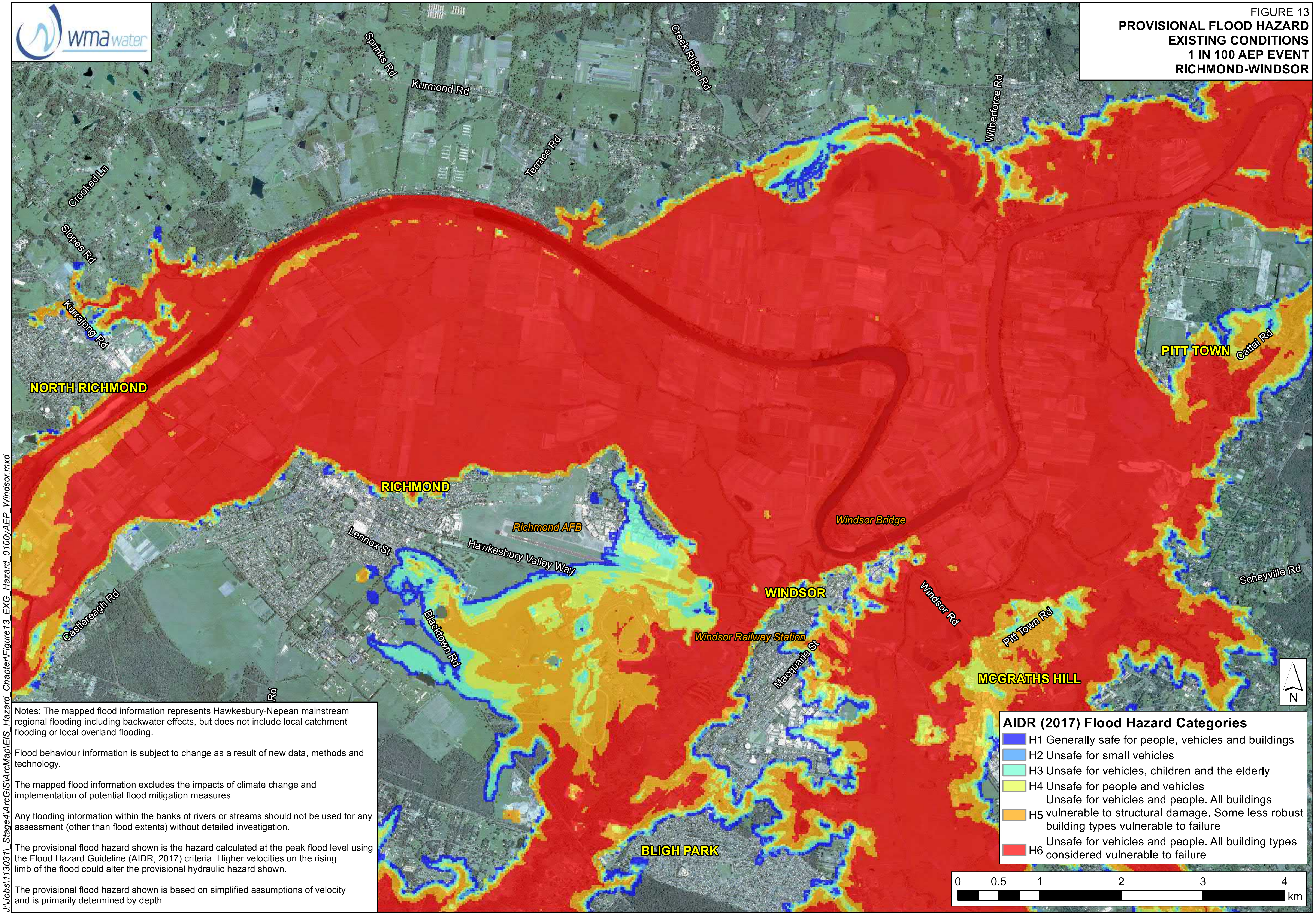


FIGURE 13
PROVISIONAL FLOOD HAZARD EXISTING CONDITIONS 1 IN 100 AEP EVENT RICHMOND-WINDSOR

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

FIGURE 14
PROVISIONAL FLOOD HAZARD EXISTING CONDITIONS 1 IN 100 AEP EVENT PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

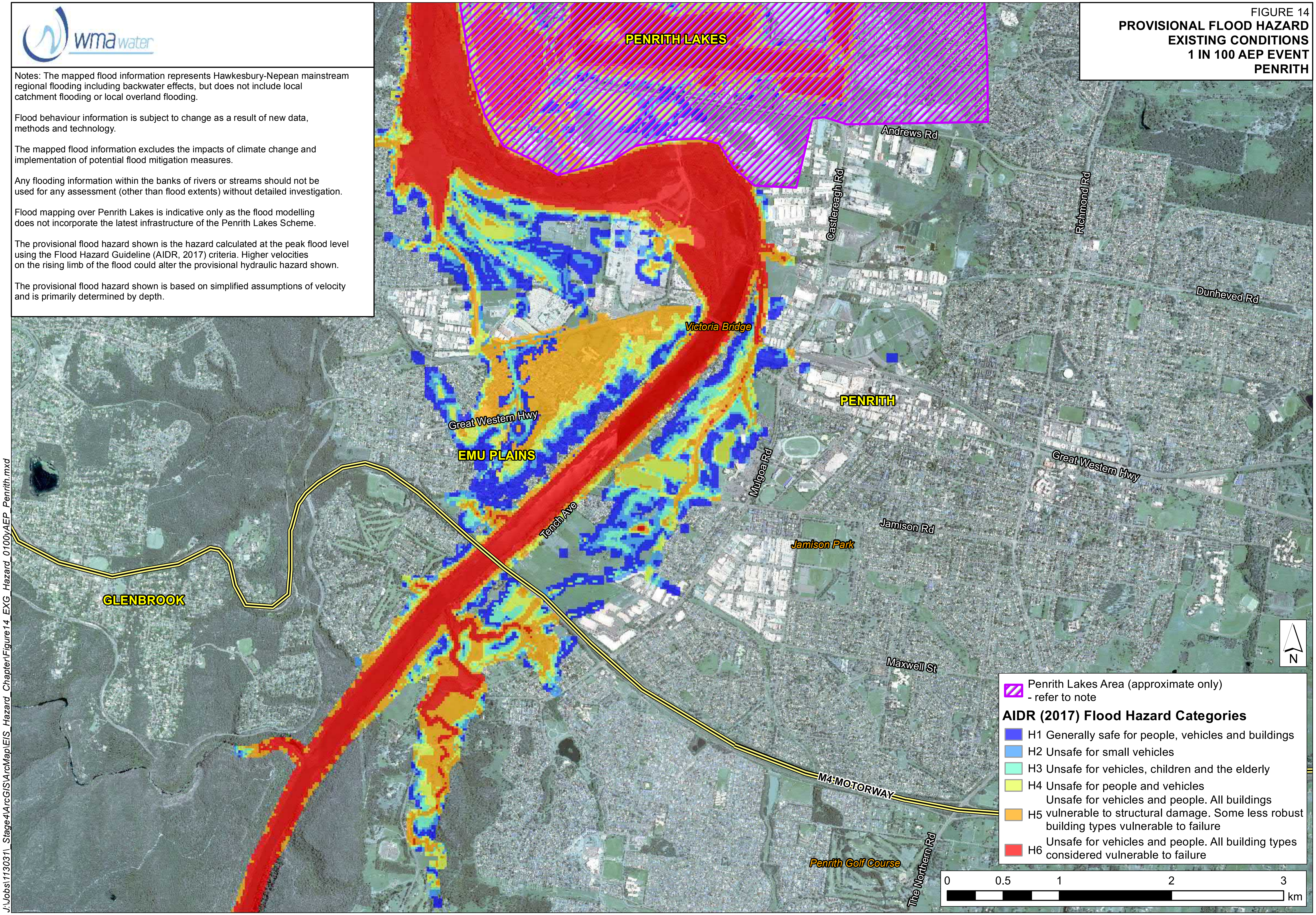


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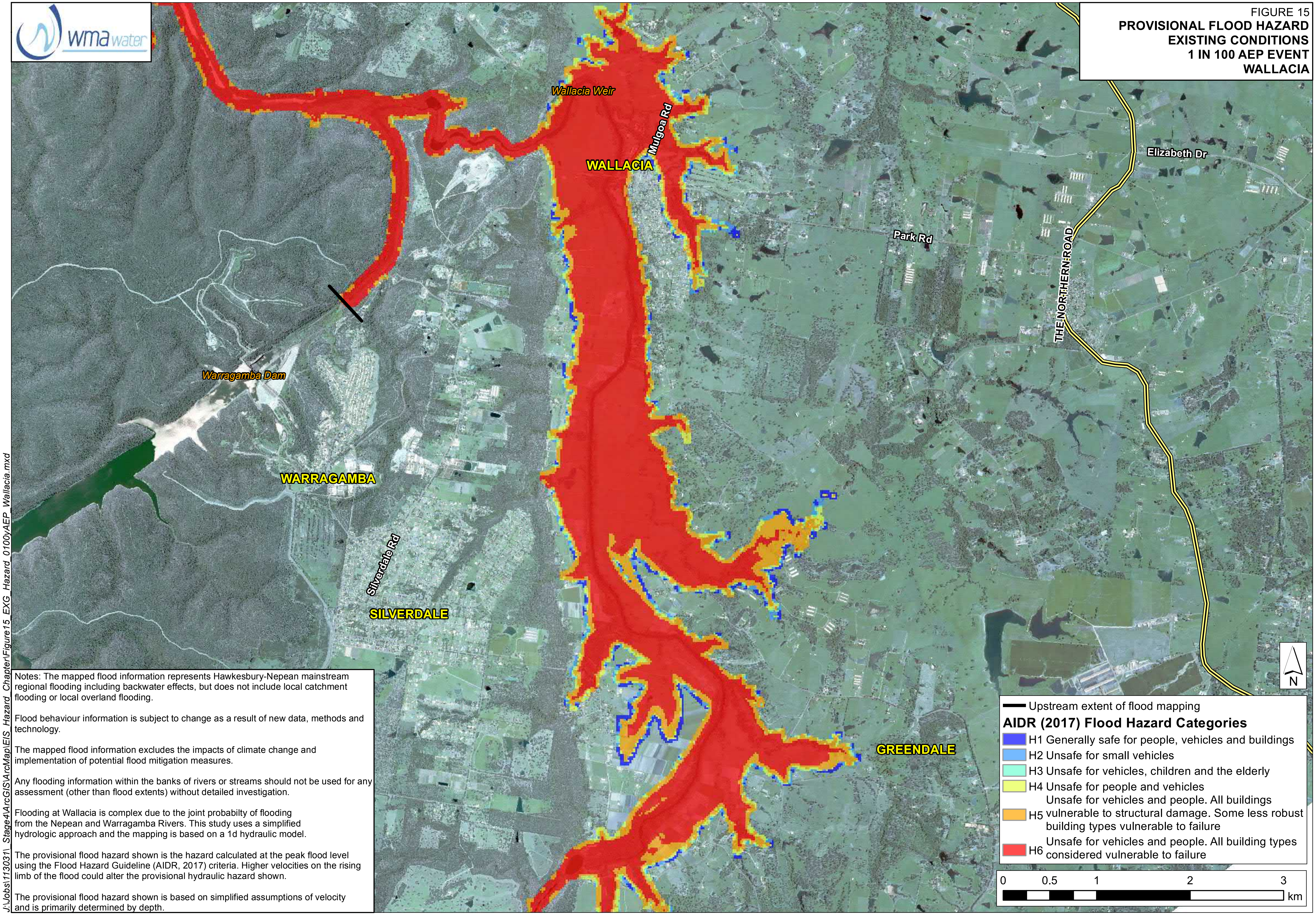
FIGURE 15
**PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 100 AEP EVENT
WALLACIA**



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 16
PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 200 AEP EVENT
FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

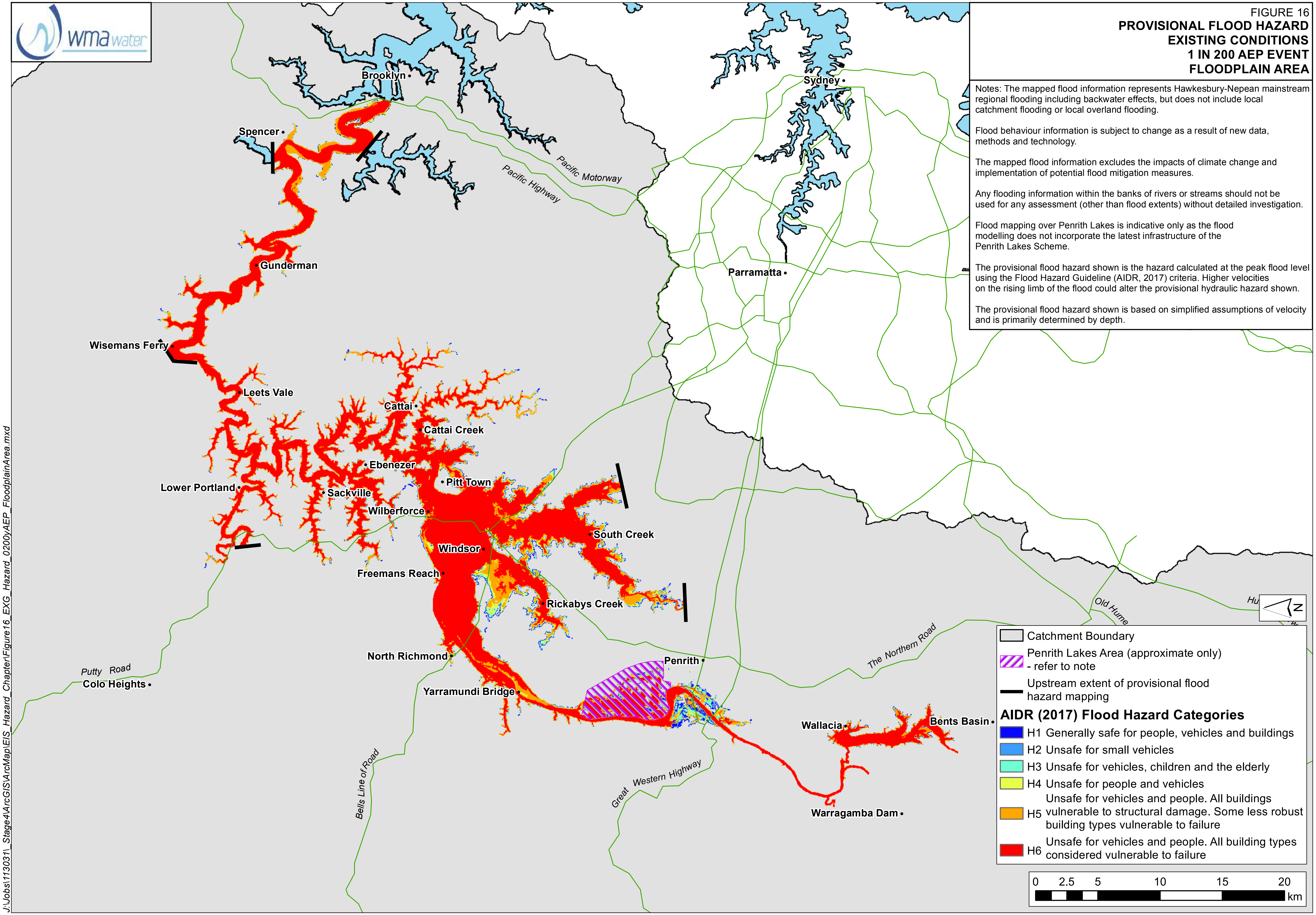

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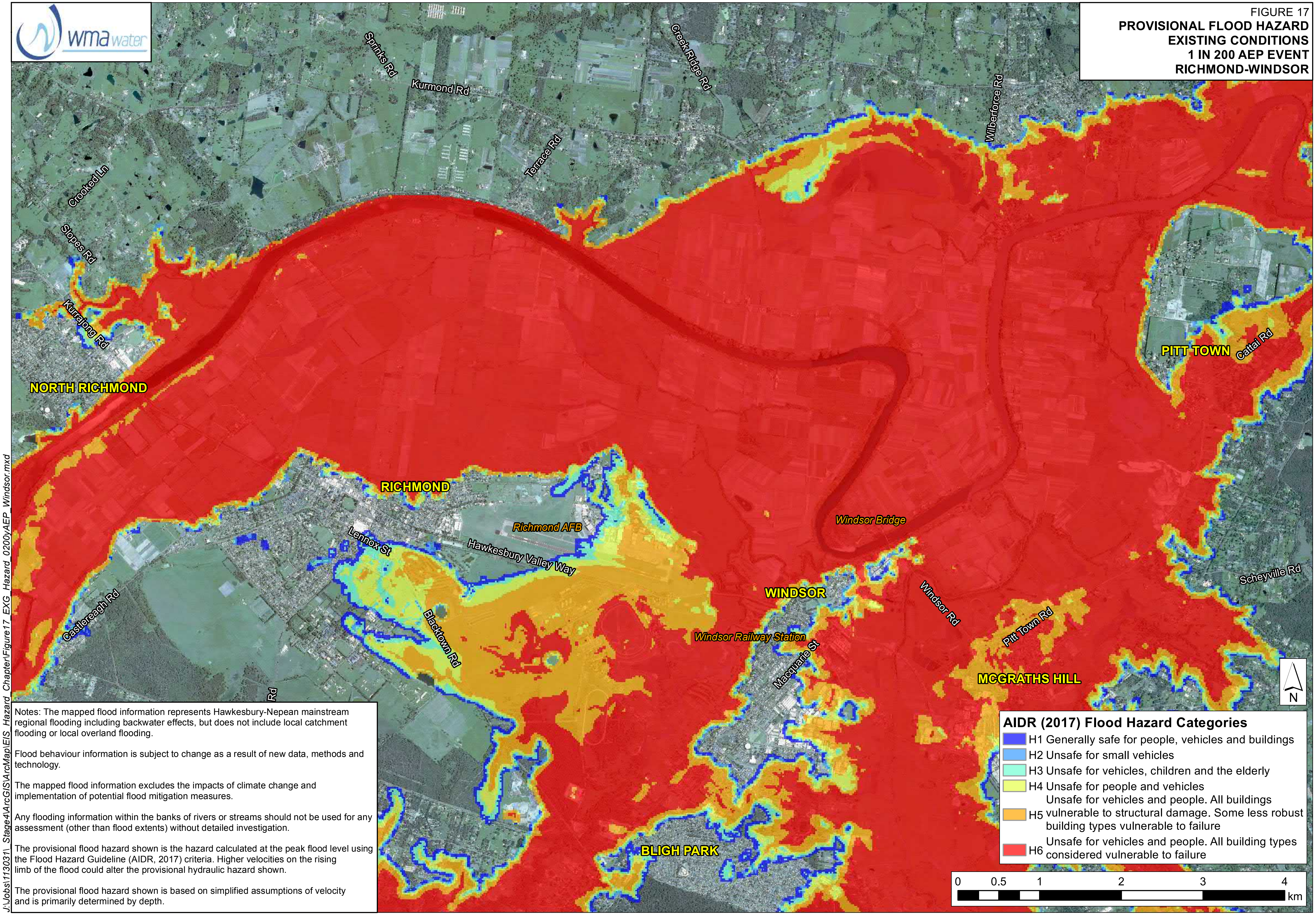
FIGURE 17
PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 200 AEP EVENT
RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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wmawater

FIGURE 18
PROVISIONAL FLOOD HAZARD EXISTING CONDITIONS 1 IN 200 AEP EVENT PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

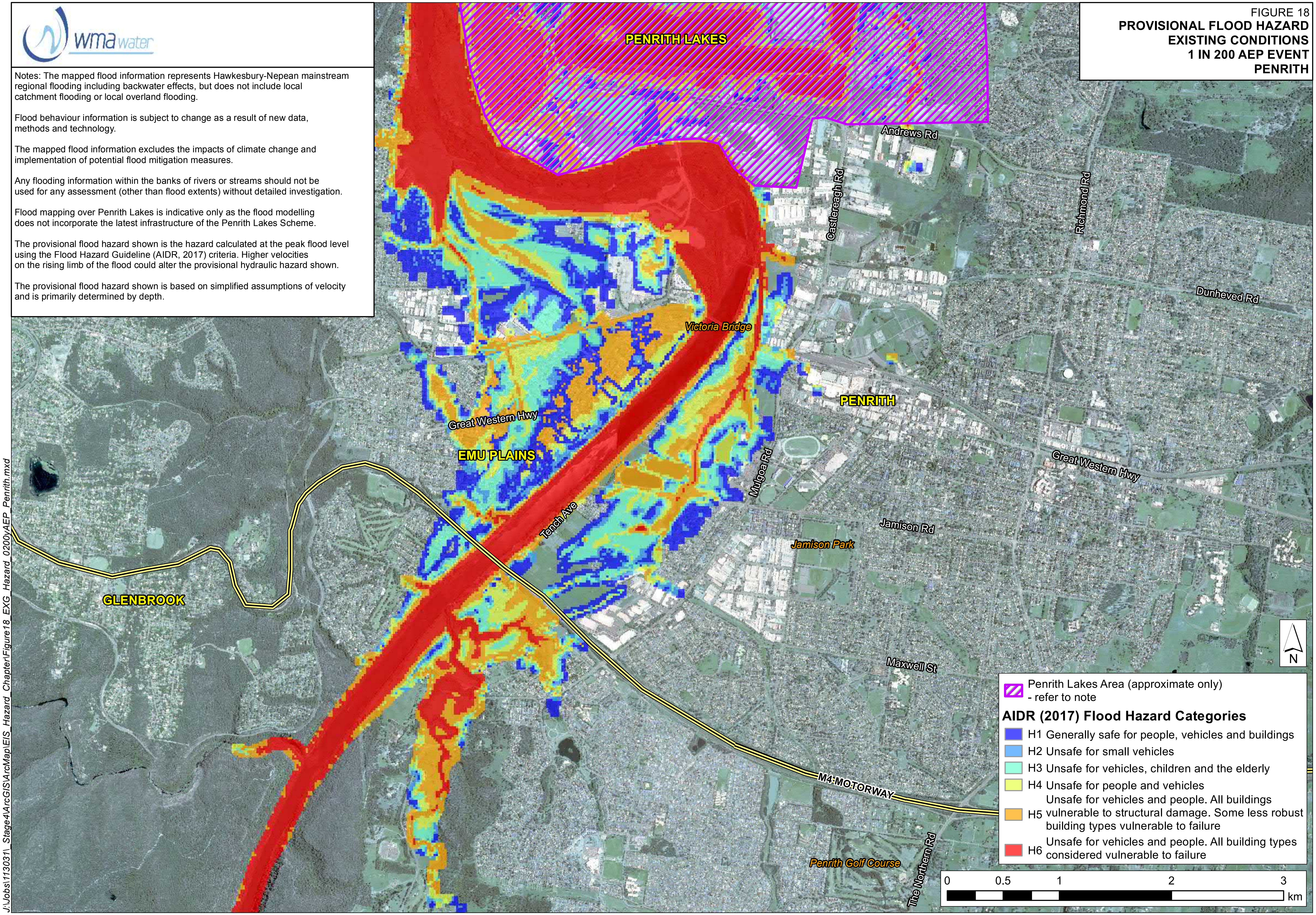
The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.



Penrith Lakes Area (approximate only) - refer to note

AIDR (2017) Flood Hazard Categories

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

0 0.5 1 2 3 km

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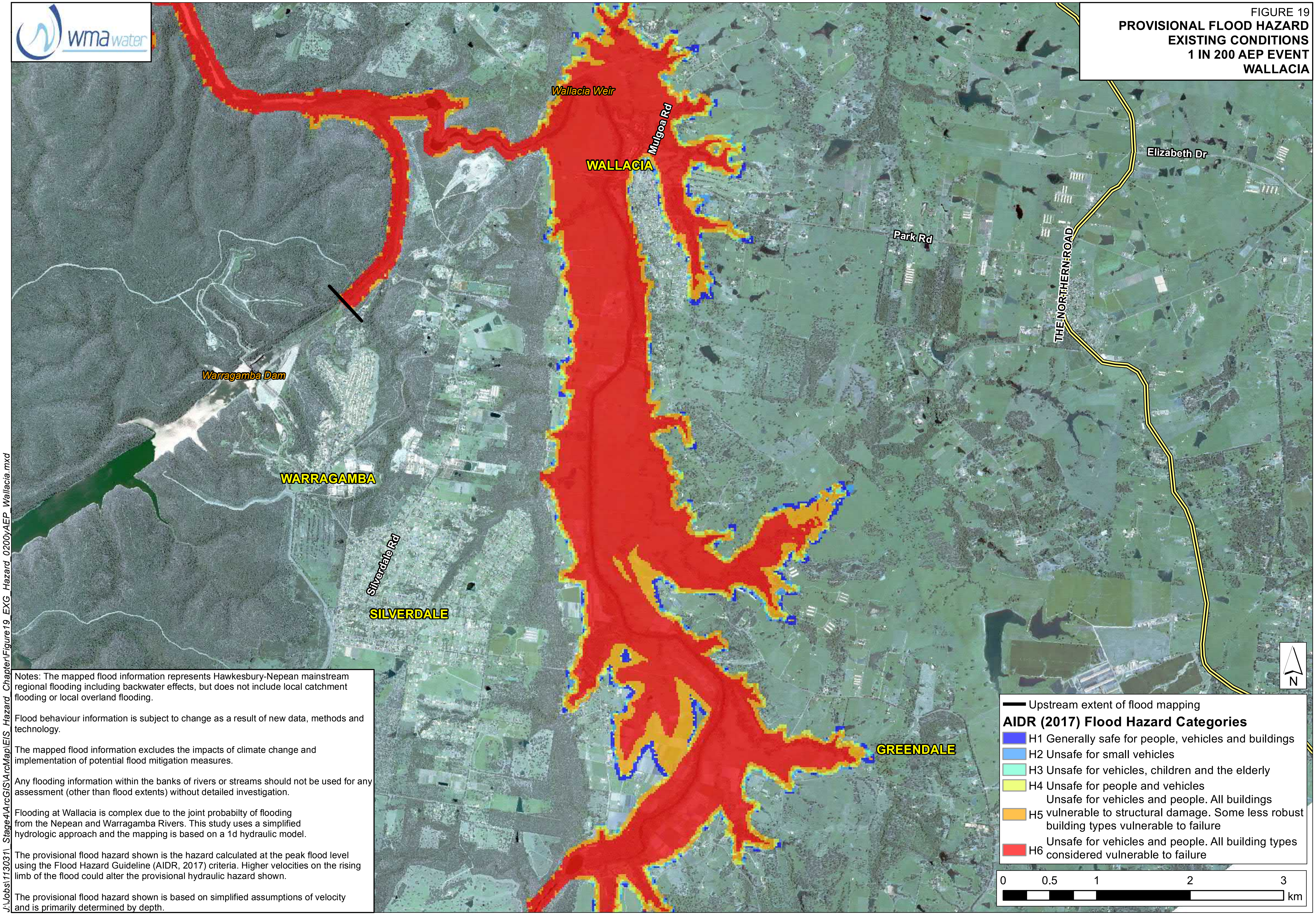
FIGURE 19
PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 200 AEP EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

Upstream extent of flood mapping

AIDR (2017) Flood Hazard Categories

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

0 0.5 1 2 3 km

J:\Jobs\113031_Stage4\ArcGIS\ArcMap\EIS_Hazard_Chapter\Figure19_EXG_Hazard_0200yAEP_Wallacia.mxd

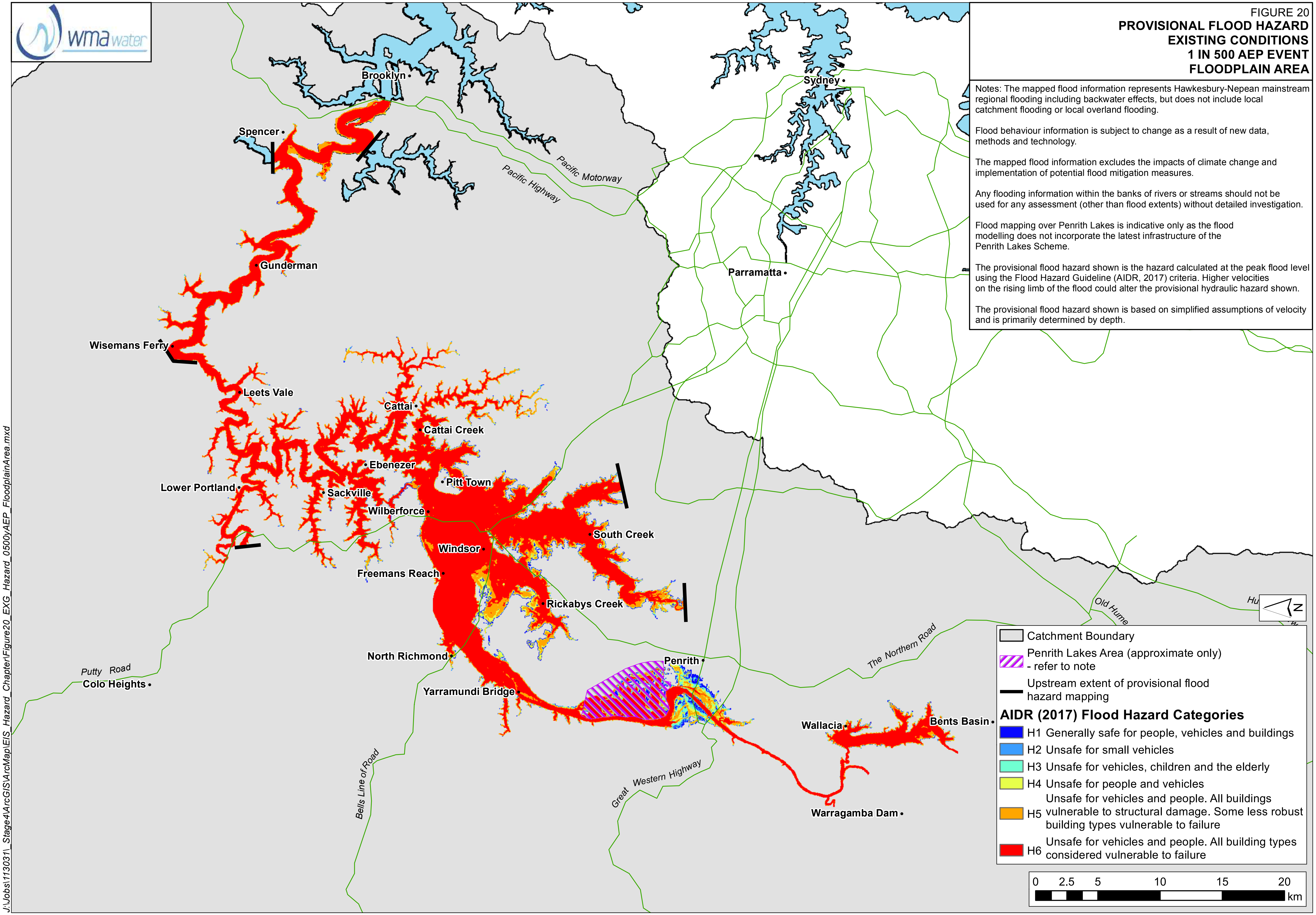


FIGURE 20
PROVISIONAL FLOOD HAZARD EXISTING CONDITIONS 1 IN 500 AEP EVENT FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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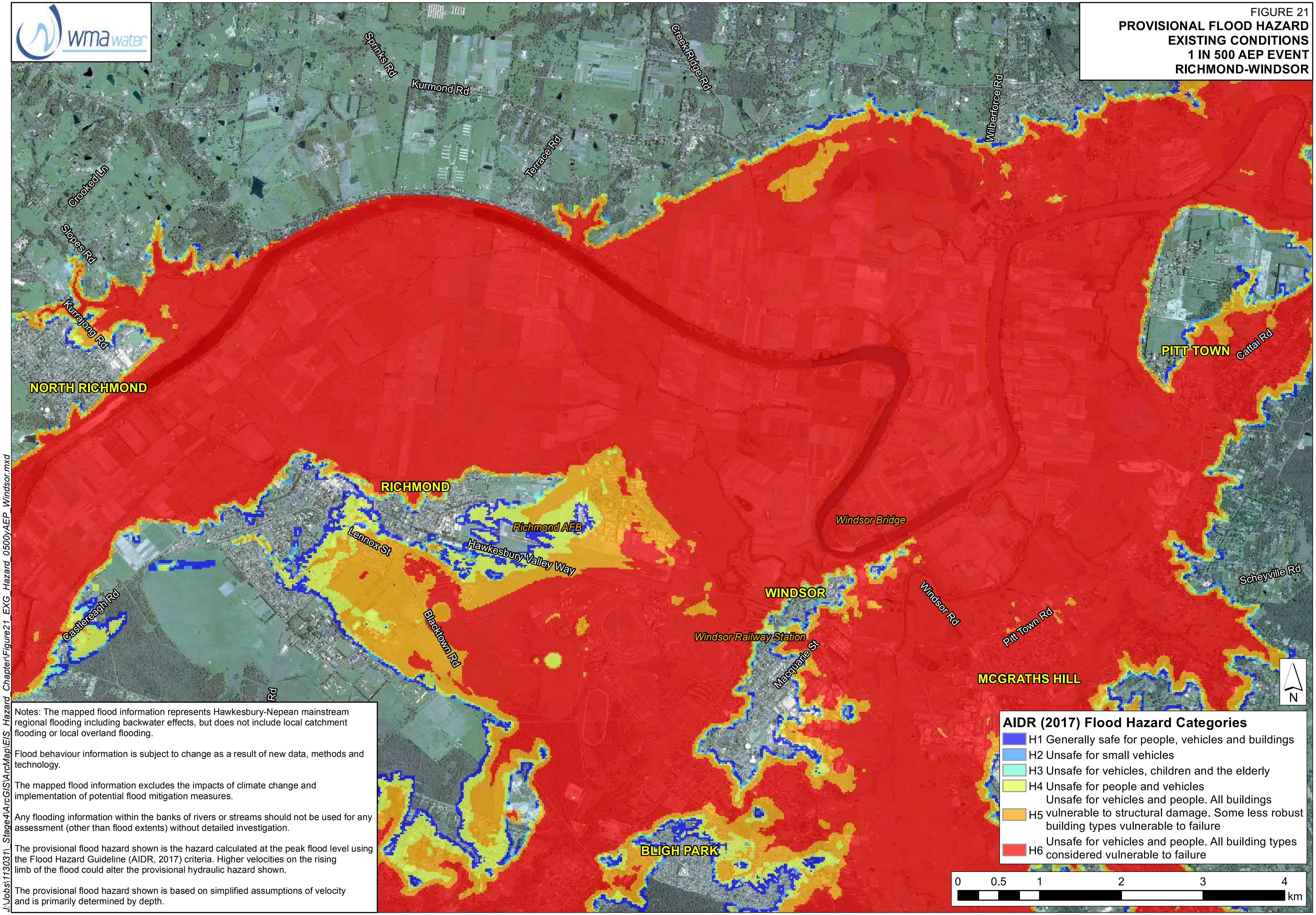
FIGURE 21

PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 500 AEP EVENT
RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

AIDR (2017) Flood Hazard Categories

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

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FIGURE 22
PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 500 AEP EVENT
PENRITH

wma water

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

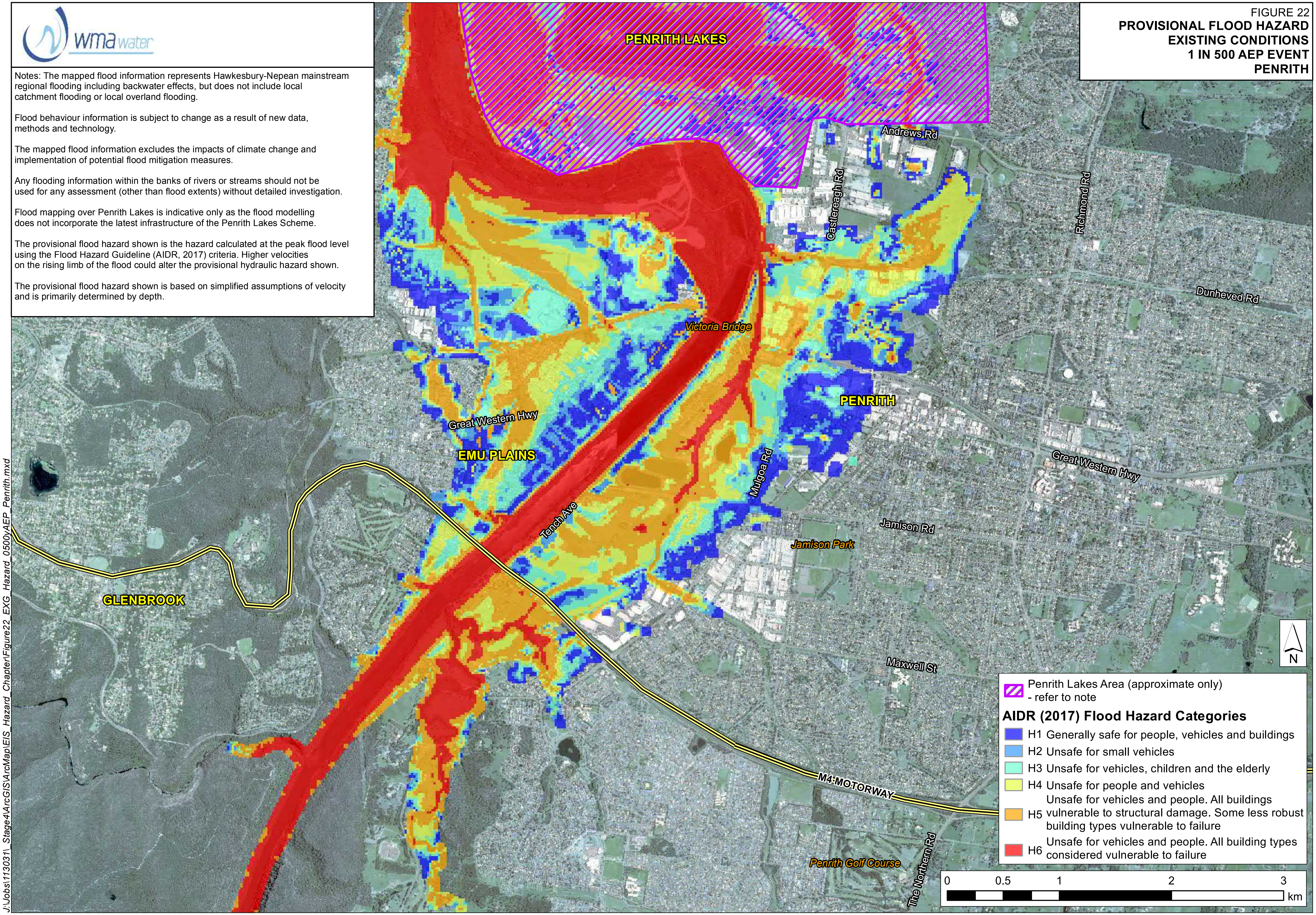
The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.



Penrith Lakes Area (approximate only) - refer to note

AIDR (2017) Flood Hazard Categories

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

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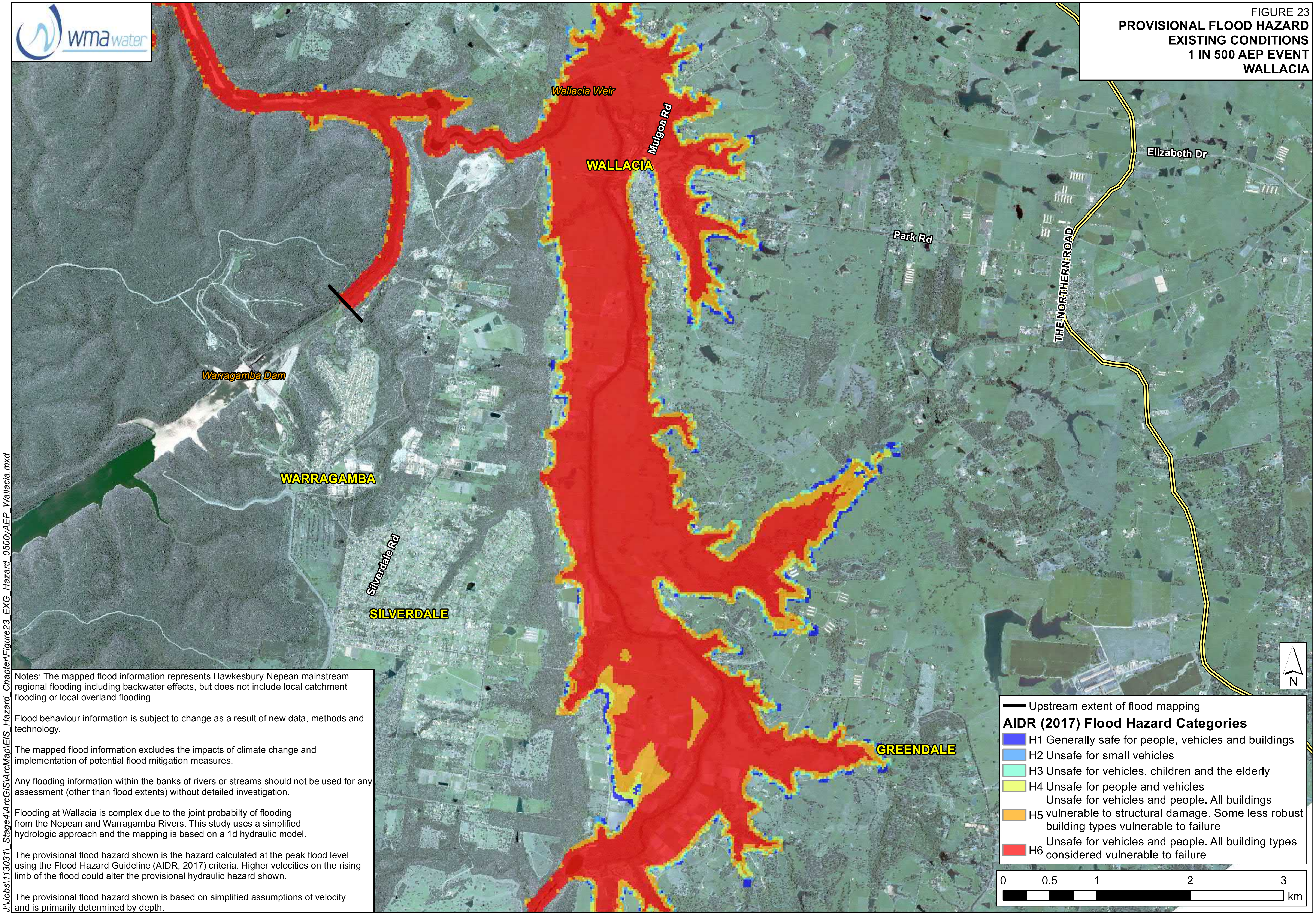
FIGURE 23
PROVISIONAL FLOOD HAZARD EXISTING CONDITIONS 1 IN 500 AEP EVENT WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 24
PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 2000 AEP EVENT
FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

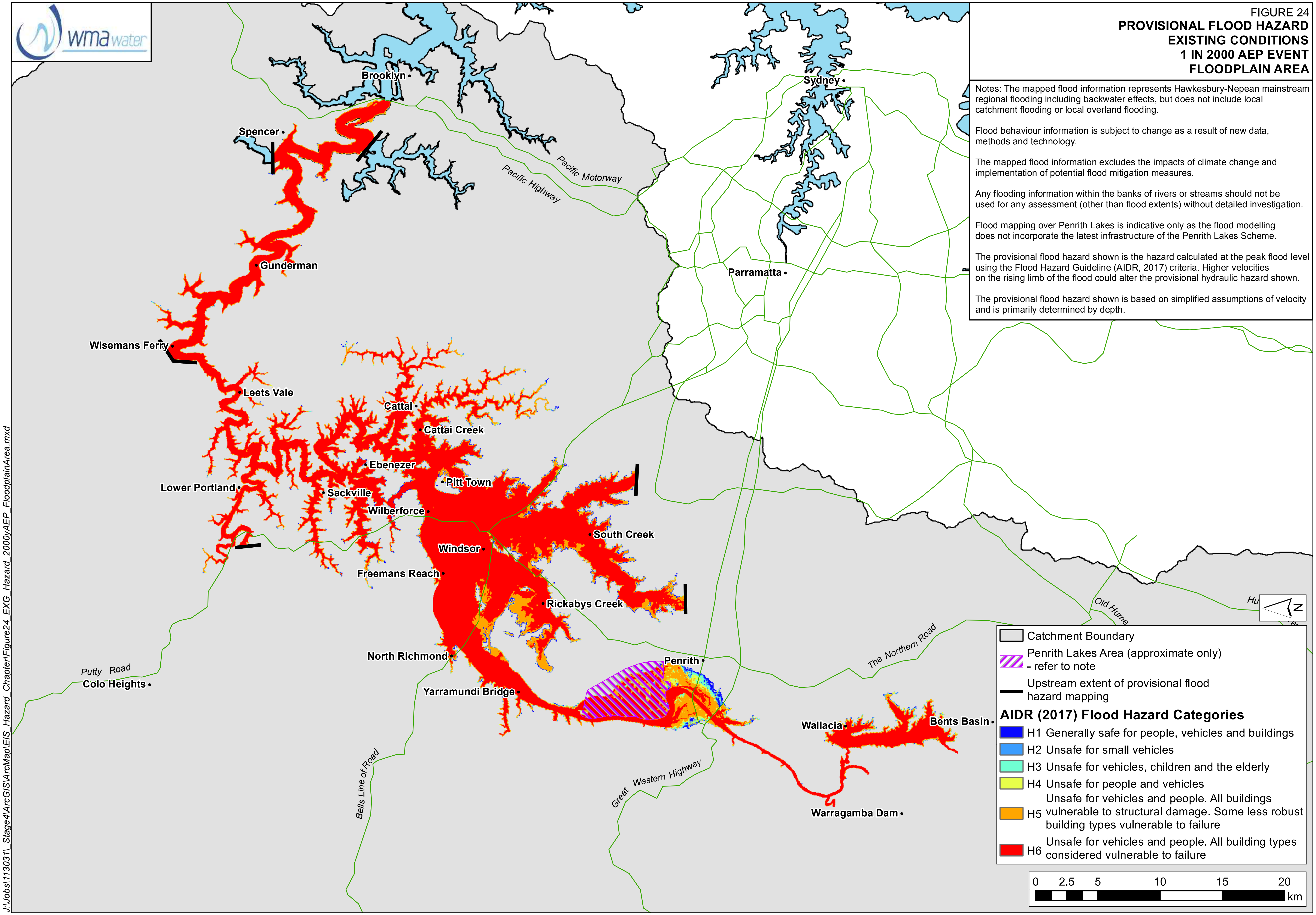

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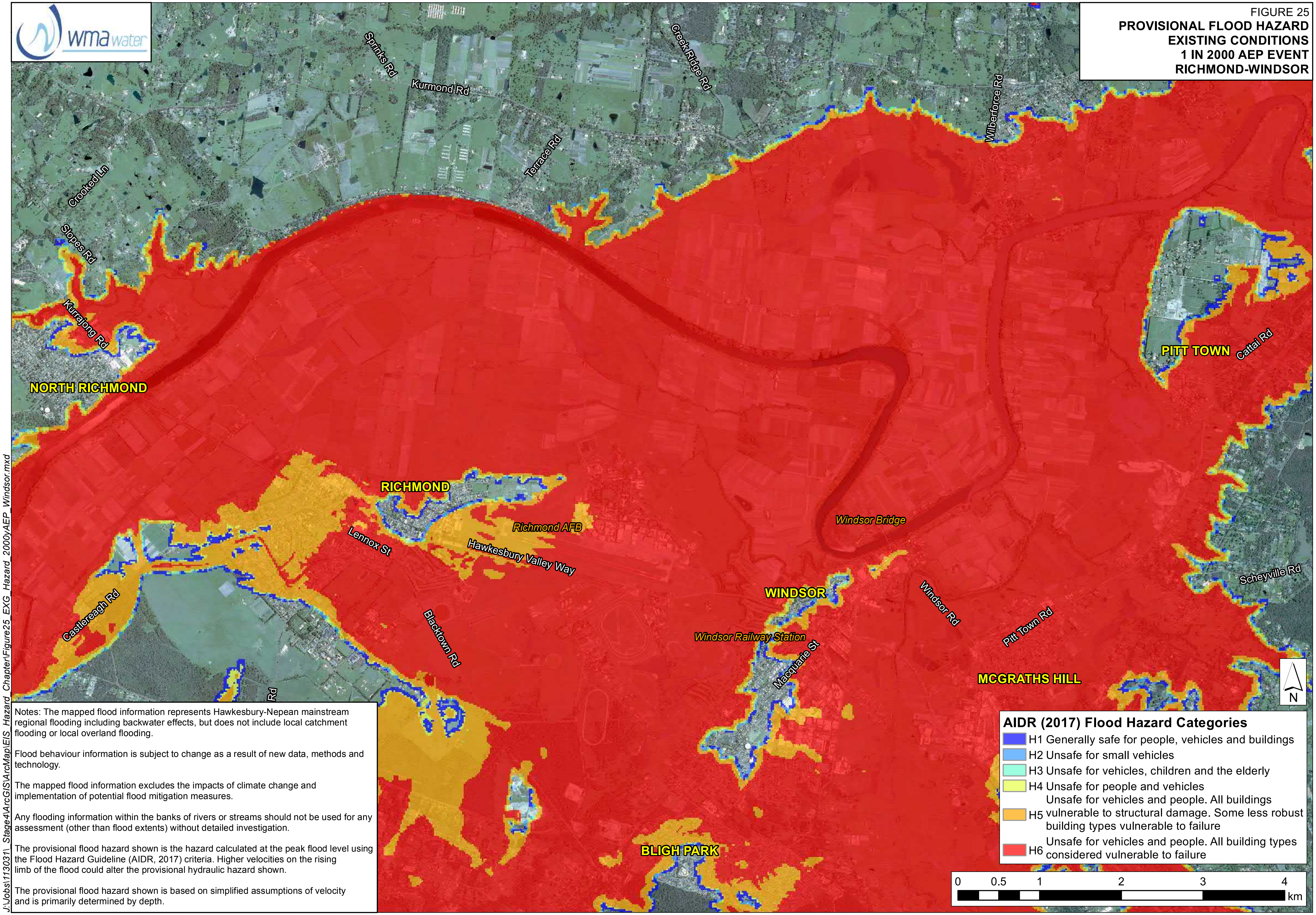
FIGURE 25
PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 2000 AEP EVENT
RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 26
PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 2000 AEP EVENT
PENRITH

wma water

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

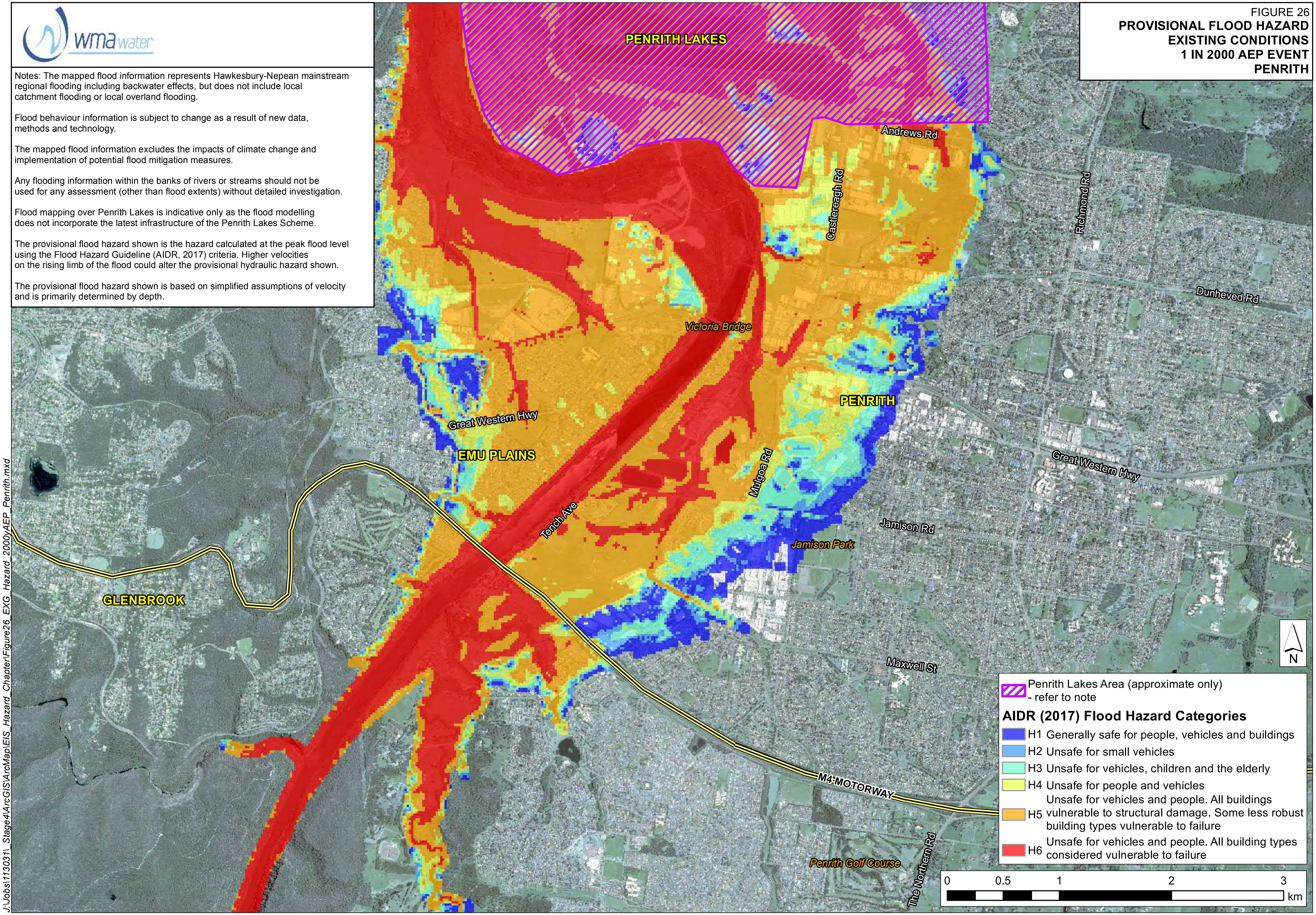

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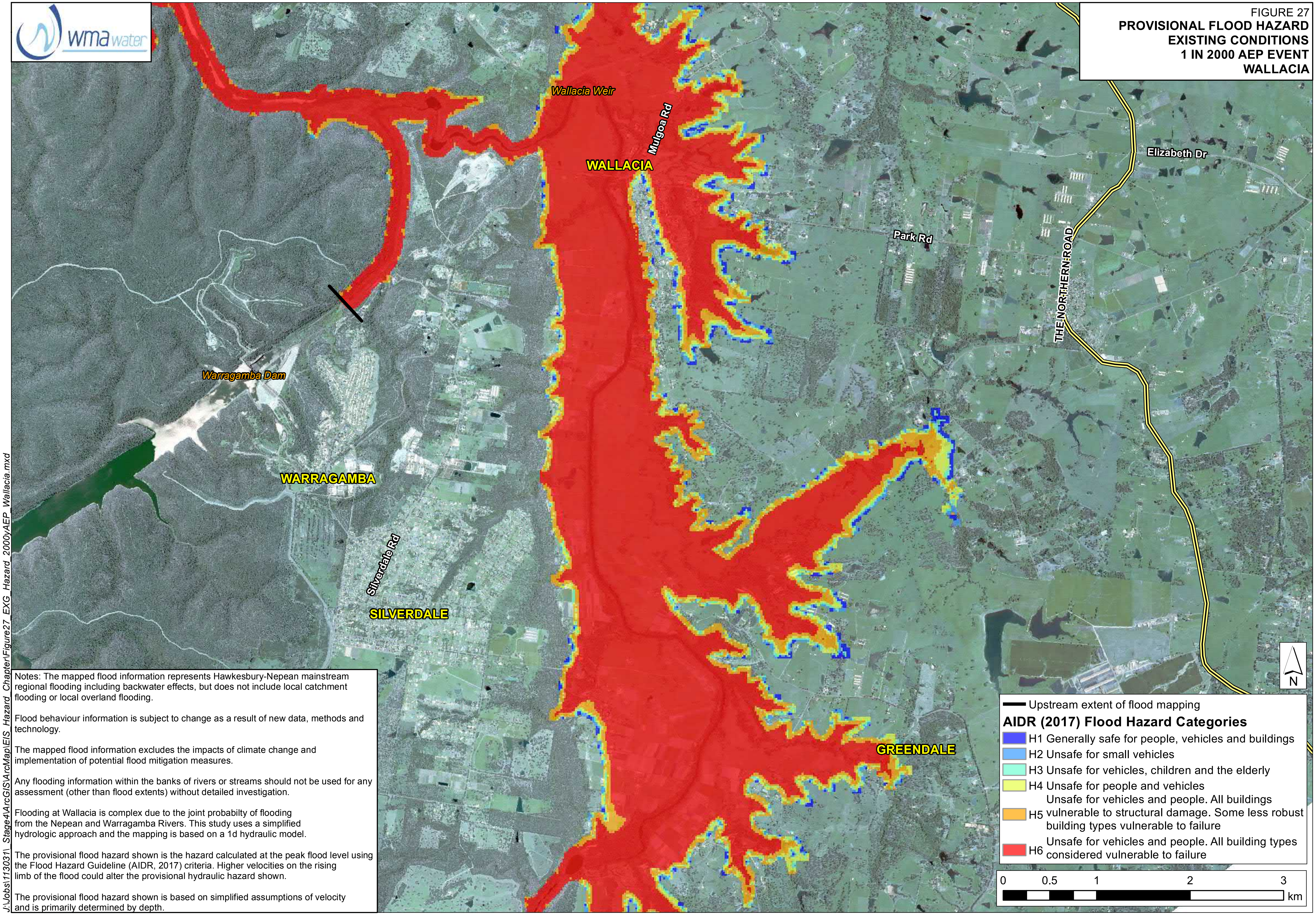
FIGURE 27
PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
1 IN 2000 AEP EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 28
PROVISIONAL FLOOD HAZARD EXISTING CONDITIONS PMF EVENT FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

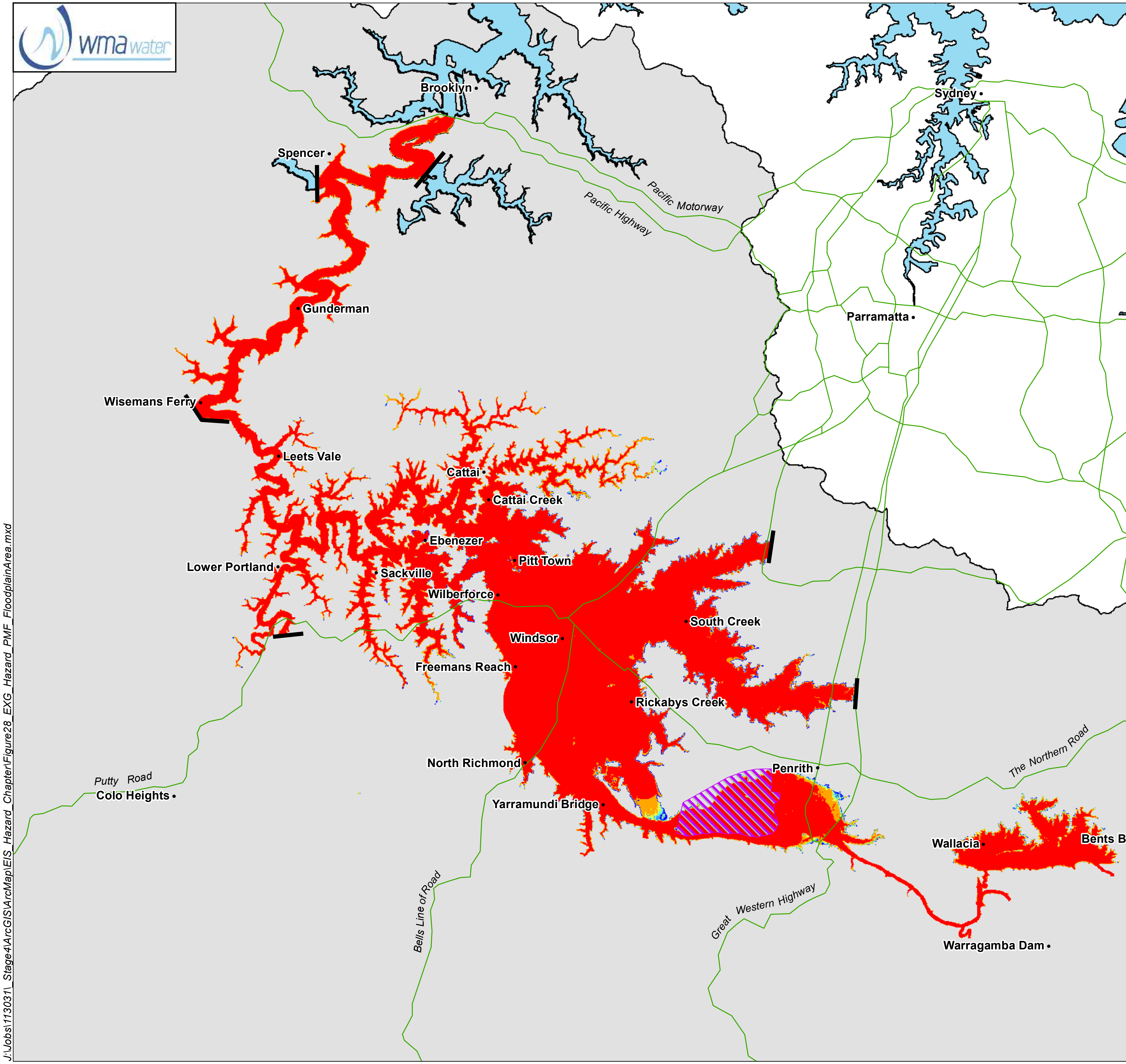
The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.



Catchment Boundary
Penrith Lakes Area (approximate only) - refer to note
Upstream extent of provisional flood hazard mapping

AIDR (2017) Flood Hazard Categories

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

0 2.5 5 10 15 20 km

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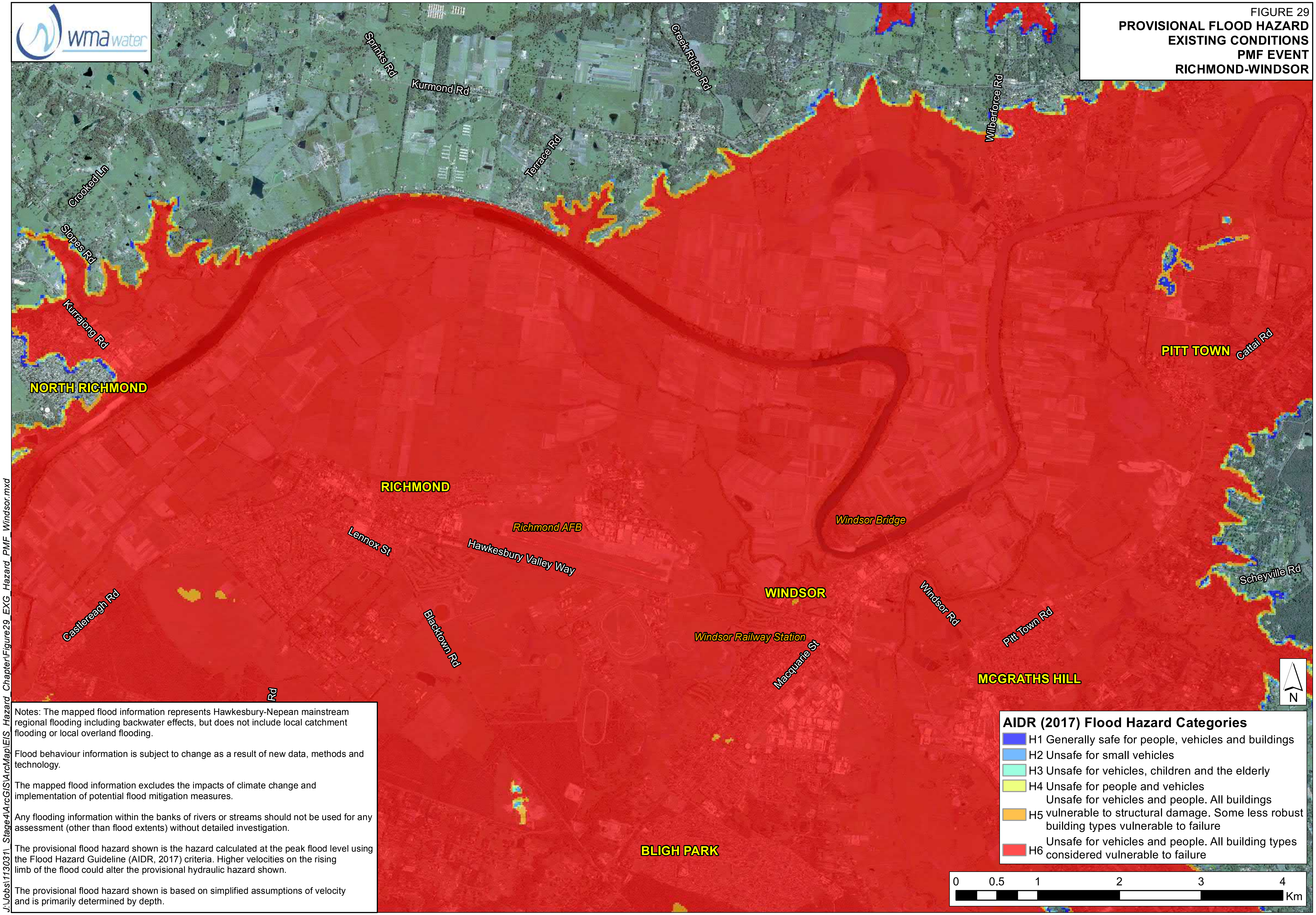
FIGURE 29
PROVISIONAL FLOOD HAZARD EXISTING CONDITIONS PMF EVENT RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

AIDR (2017) Flood Hazard Categories

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

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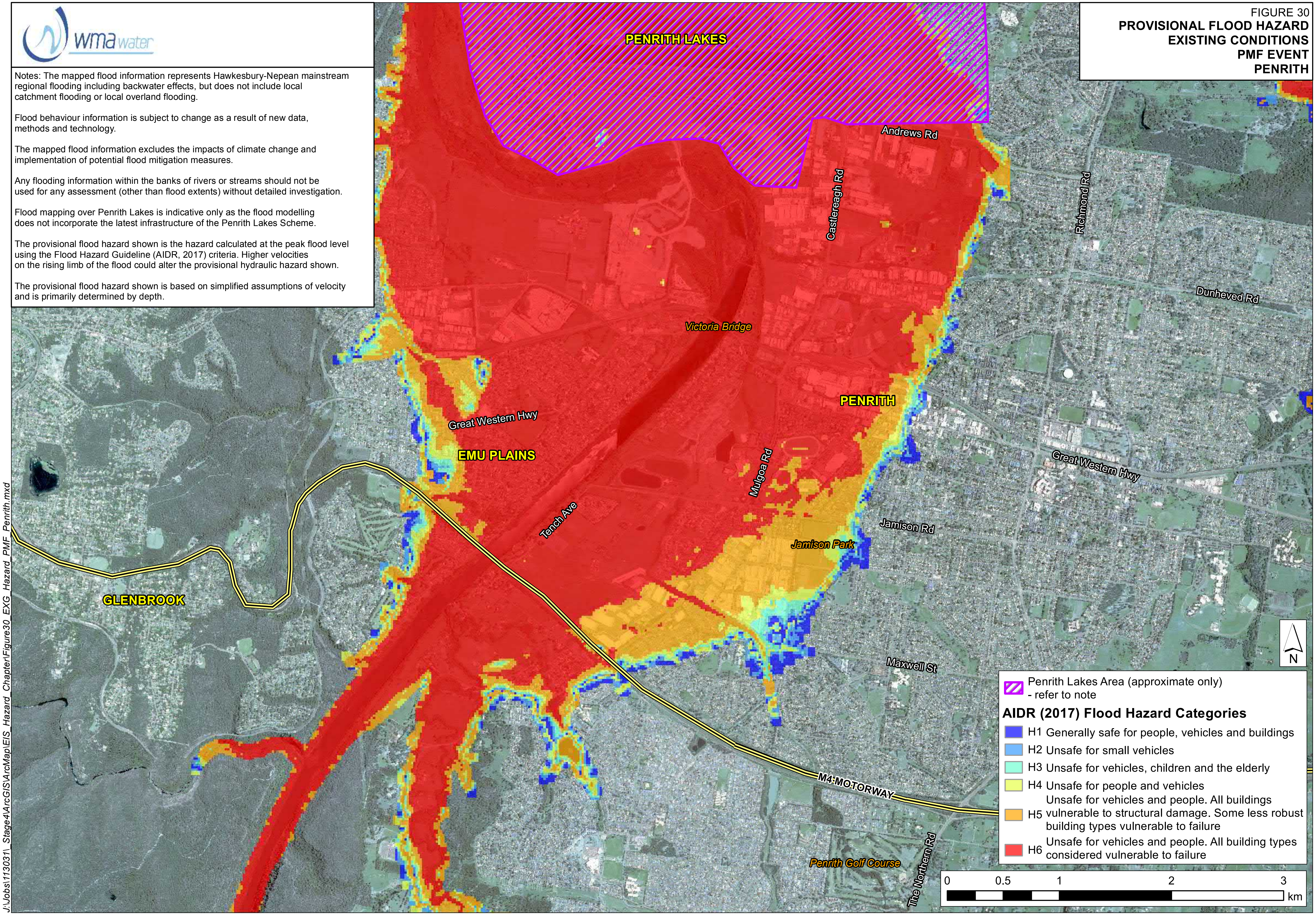
FIGURE 30
PROVISIONAL FLOOD HAZARD EXISTING CONDITIONS PMF EVENT PENRITH



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

Penrith Lakes Area (approximate only) - refer to note

AIDR (2017) Flood Hazard Categories

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

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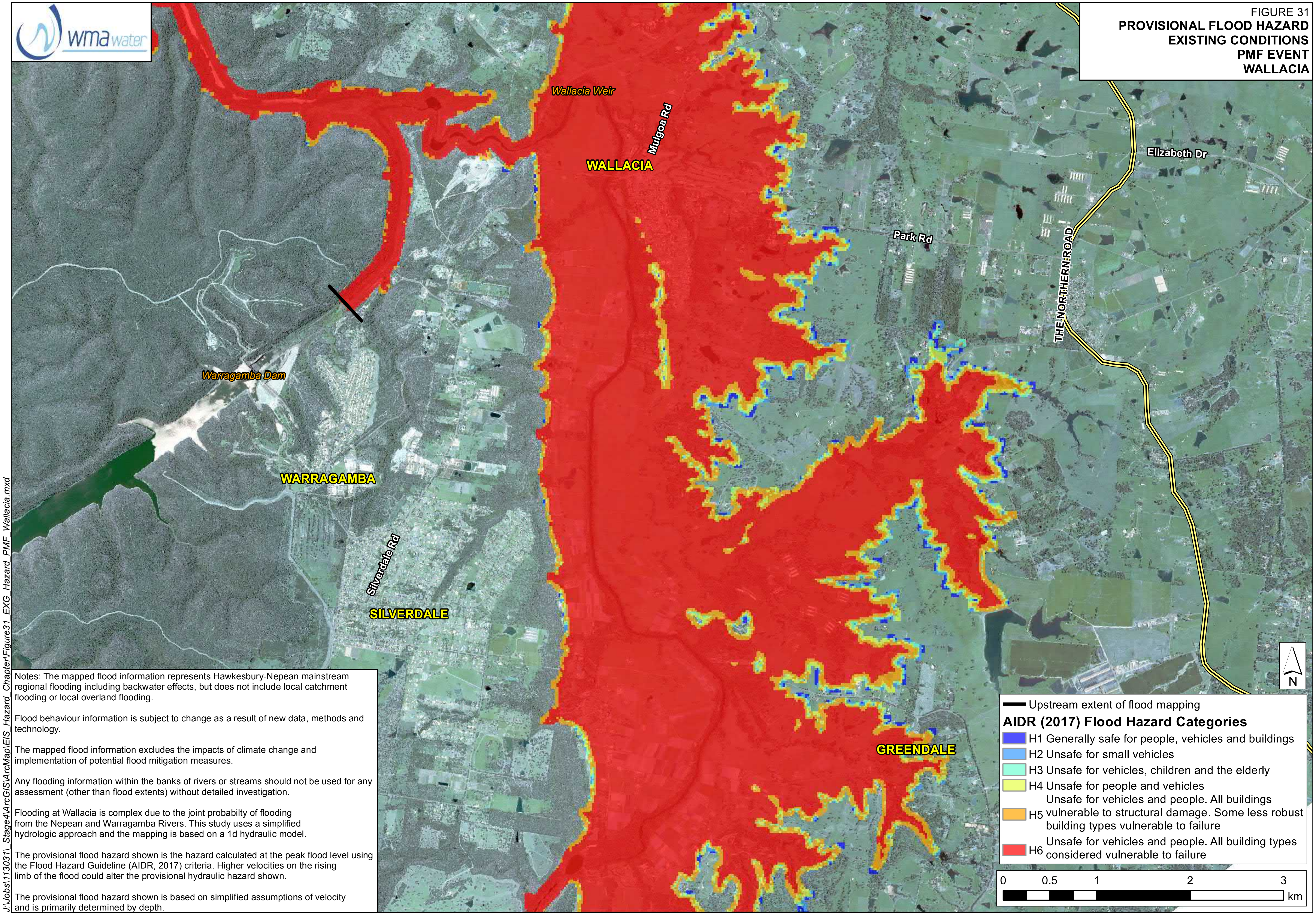
FIGURE 31
**PROVISIONAL FLOOD HAZARD
EXISTING CONDITIONS
PMF EVENT
WALLACIA**



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

Upstream extent of flood mapping

AIDR (2017) Flood Hazard Categories

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

0 0.5 1 2 3 km

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FIGURE 32
HYDRAULIC CATEGORISATION EXISTING CONDITIONS 1 IN 100 AEP EVENT FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).

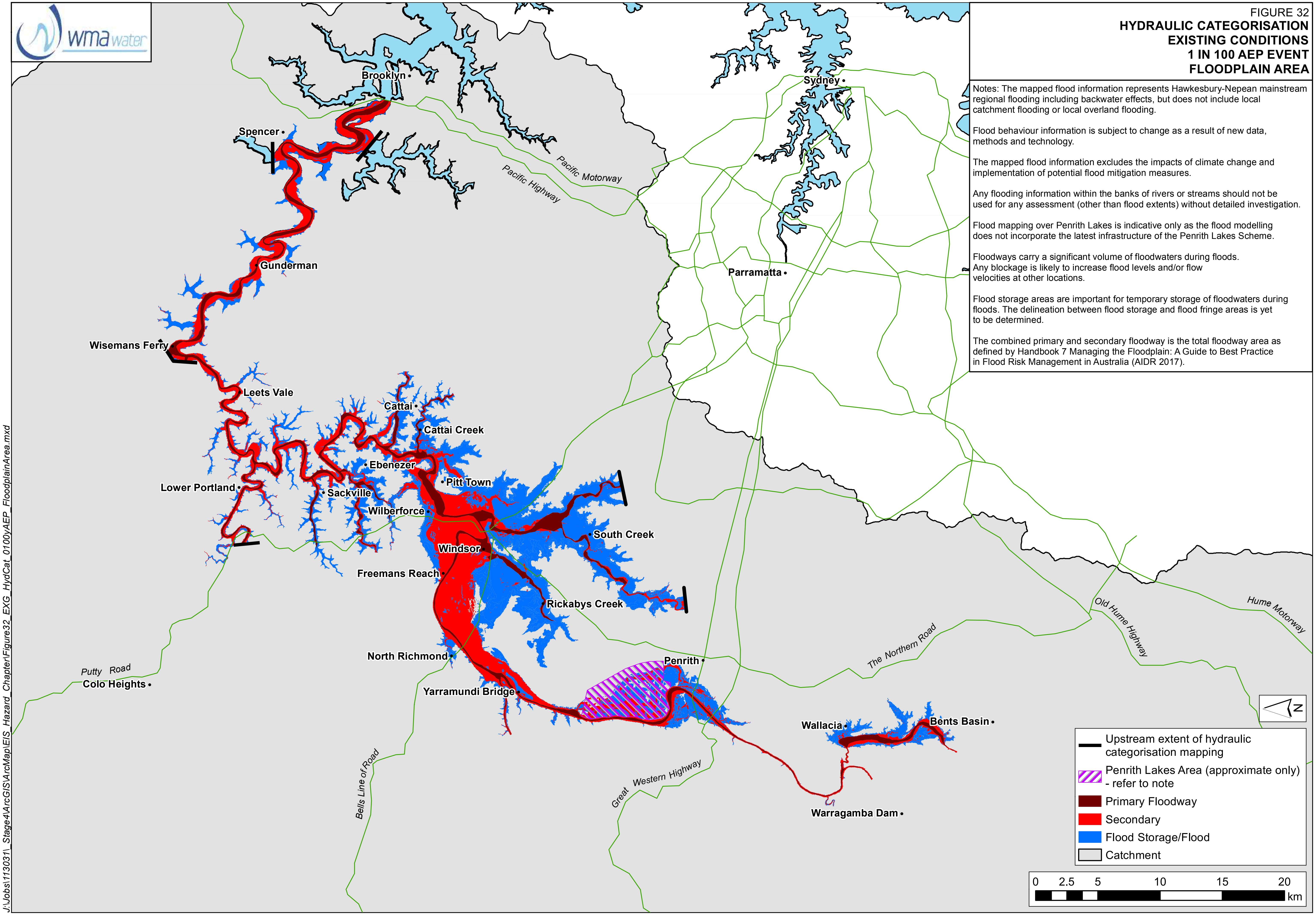

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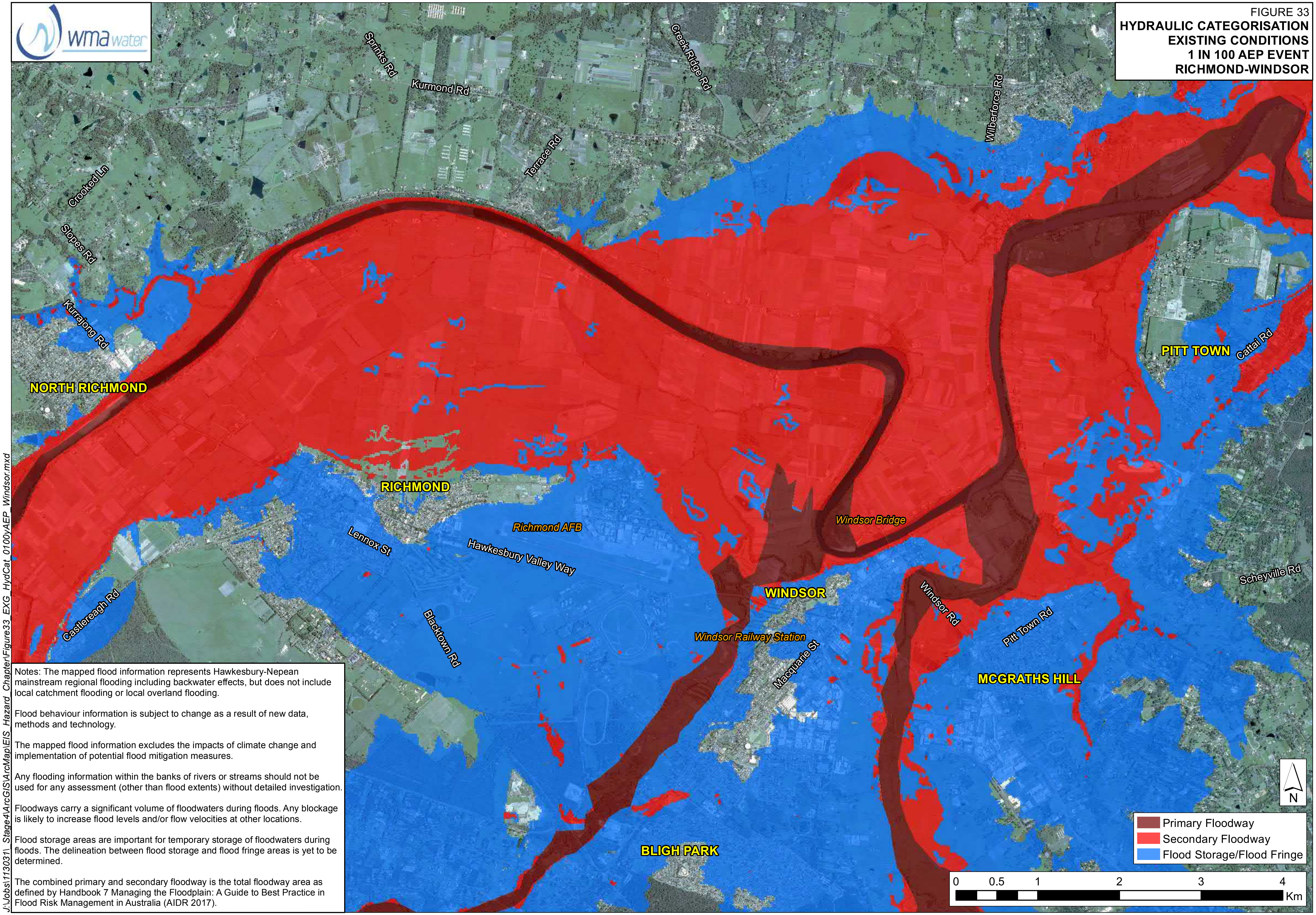
FIGURE 33

HYDRAULIC CATEGORISATION EXISTING CONDITIONS 1 IN 100 AEP EVENT RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).

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FIGURE 34

HYDRAULIC CATEGORISATION EXISTING CONDITIONS 1 IN 100 AEP EVENT PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).

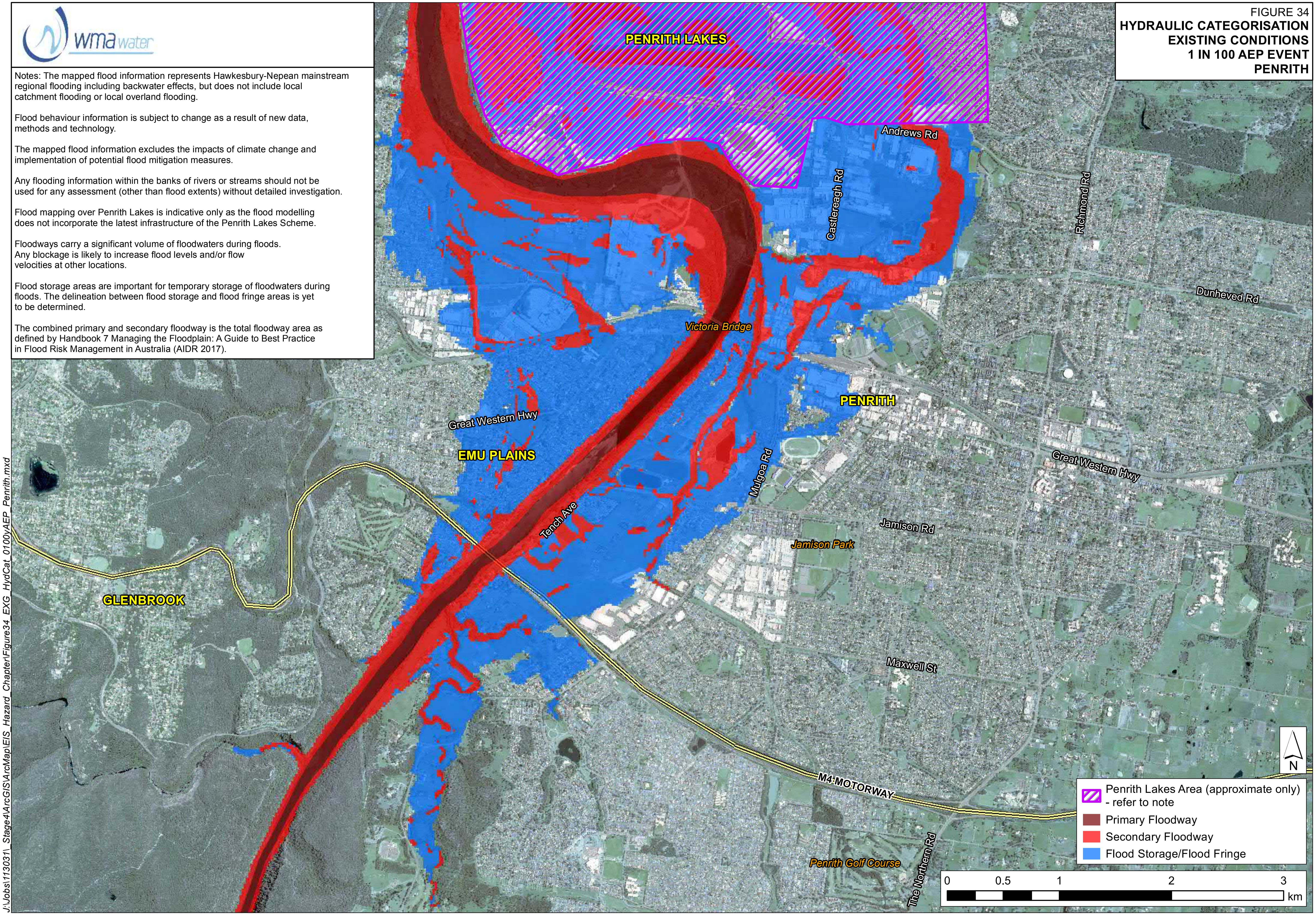

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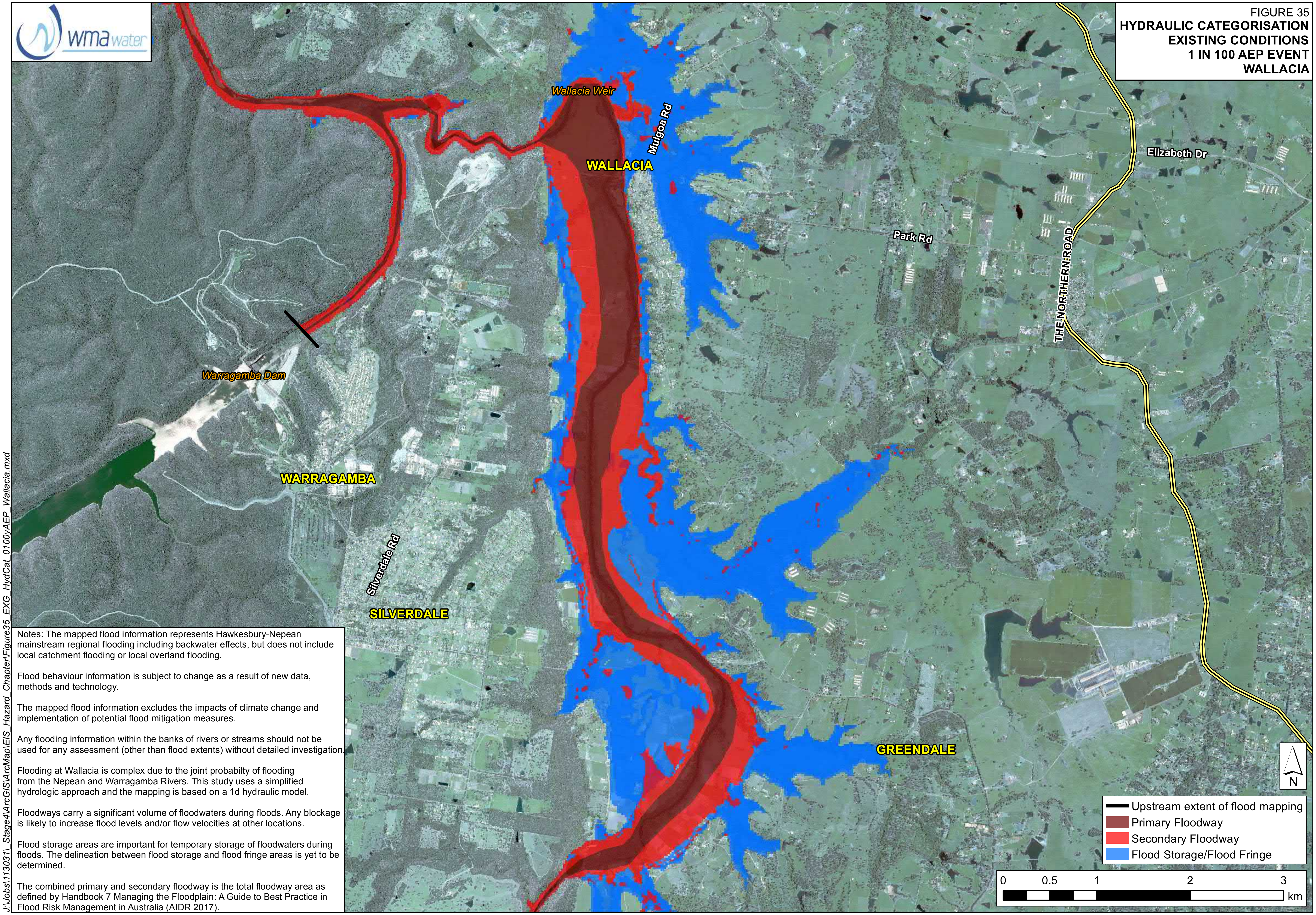
FIGURE 35
HYDRAULIC CATEGORISATION EXISTING CONDITIONS 1 IN 100 AEP EVENT WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).

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FIGURE 36
HYDRAULIC CATEGORISATION EXISTING CONDITIONS 1 IN 500 AEP EVENT FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

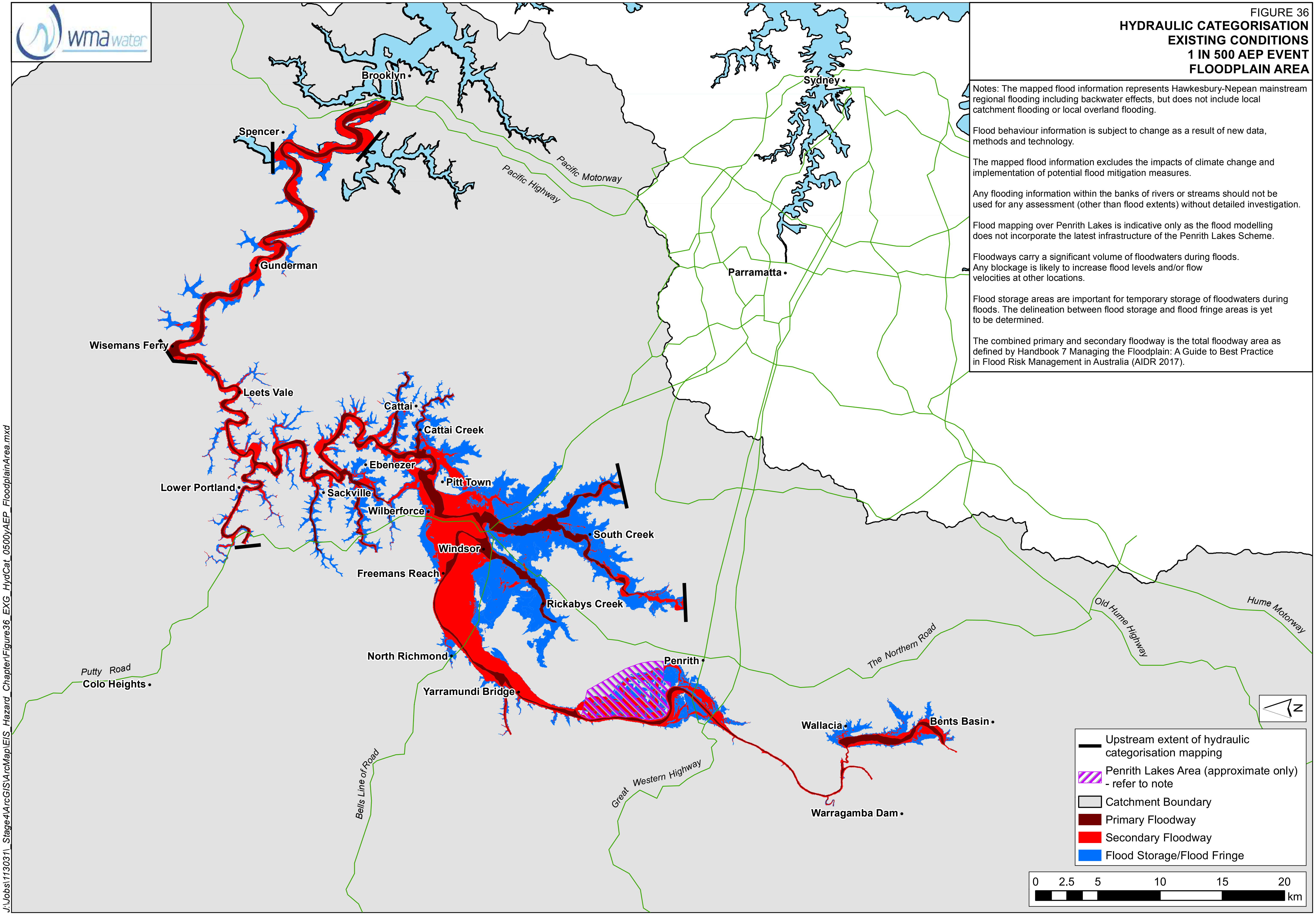
Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

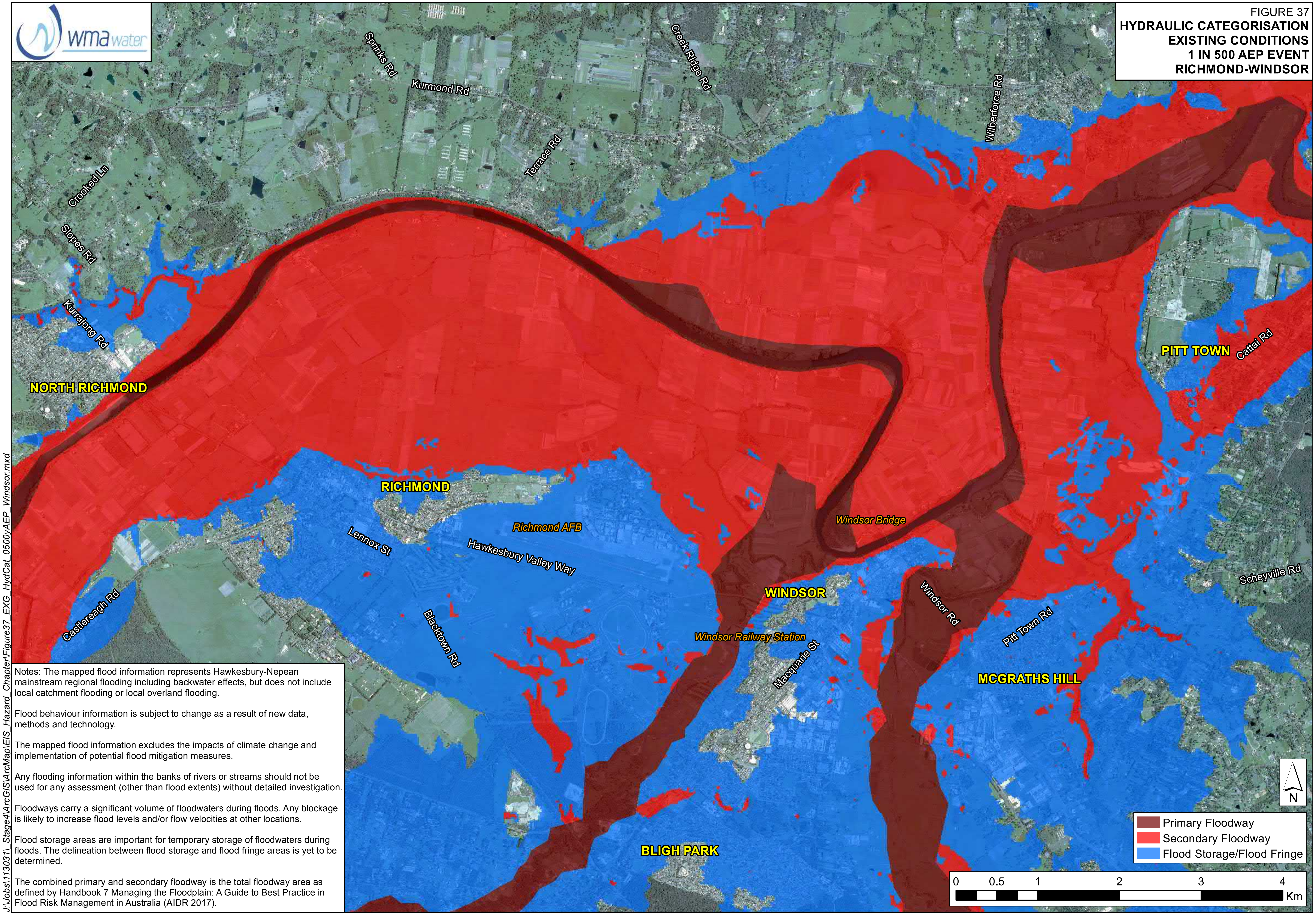
Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).



J:\Jobs\113031_Stage4\ArcGIS\ArcMap\EIS_Hazard_Chapter\Figure36_EXG_HydCat_0500yAEP_FloodplainArea.mxd

FIGURE 37
**HYDRAULIC CATEGORISATION
EXISTING CONDITIONS
1 IN 500 AEP EVENT
RICHMOND-WINDSOR**



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).

FIGURE 38

HYDRAULIC CATEGORISATION EXISTING CONDITIONS 1 IN 500 AEP EVENT PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

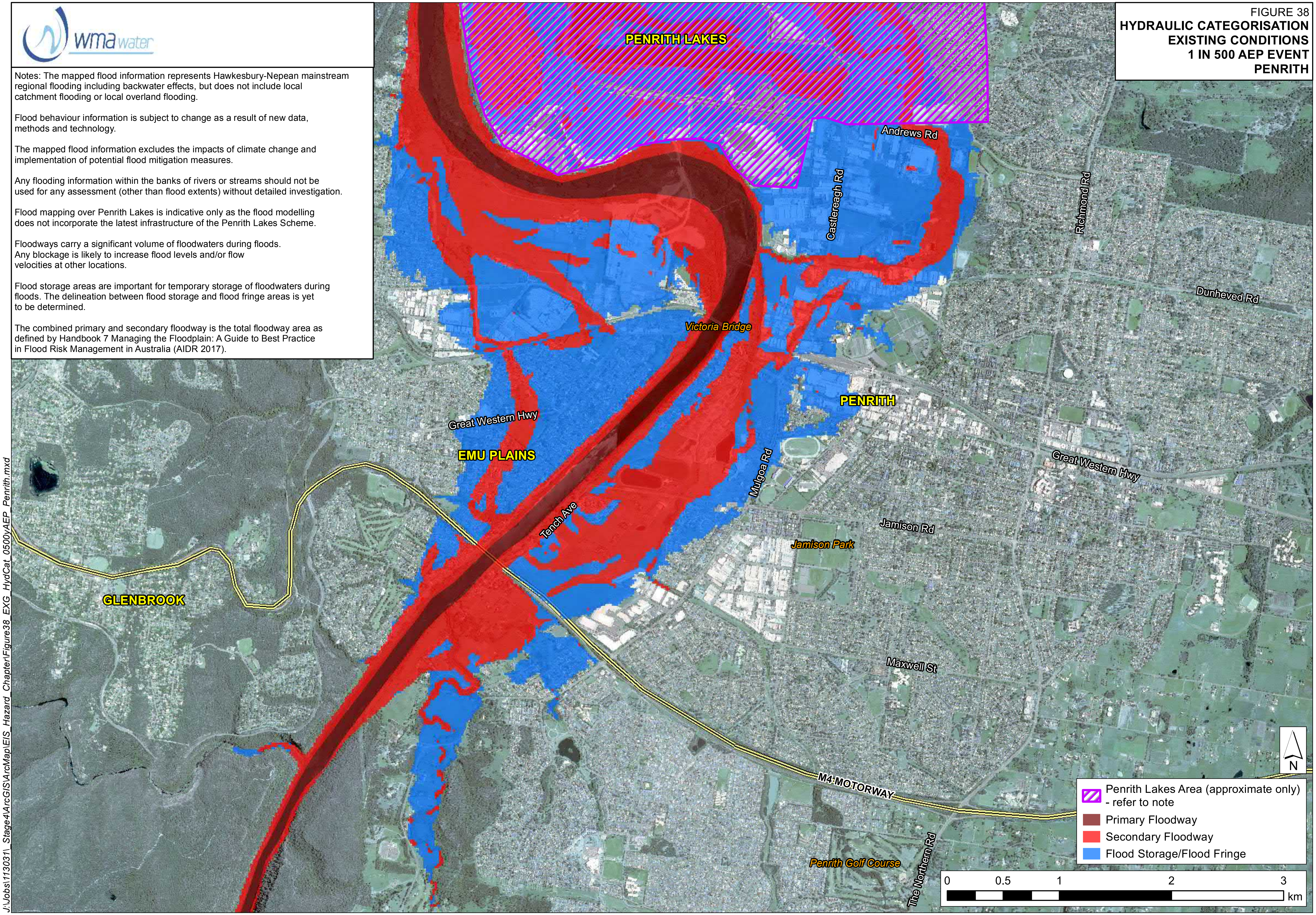
Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

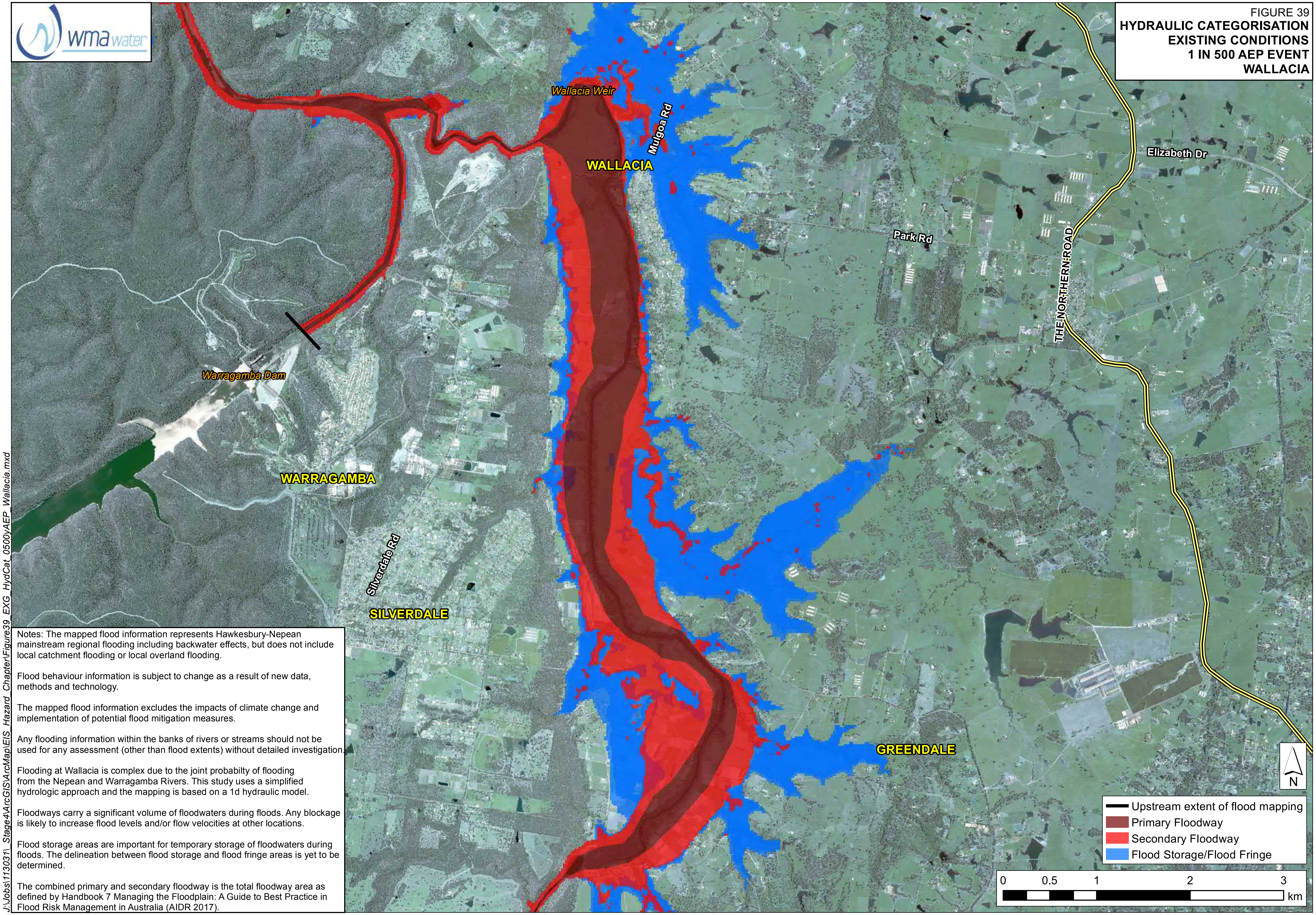
Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).



J:\Jobs\113031_Stage4\ArcGIS\ArcMap\EIS_Hazard_Chapter\Figure38_EXG_HydCat_0500yAEP_Penrith.mxd

FIGURE 39
HYDRAULIC CATEGORISATION
EXISTING CONDITIONS
1 IN 500 AEP EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).

J:\Jobs\113031_Stage4\ArcGIS\ArcMap\EIS_Hazard_Chapter\Figure39_EXG_HydCat_0500yAEP_Wallacia.mxd

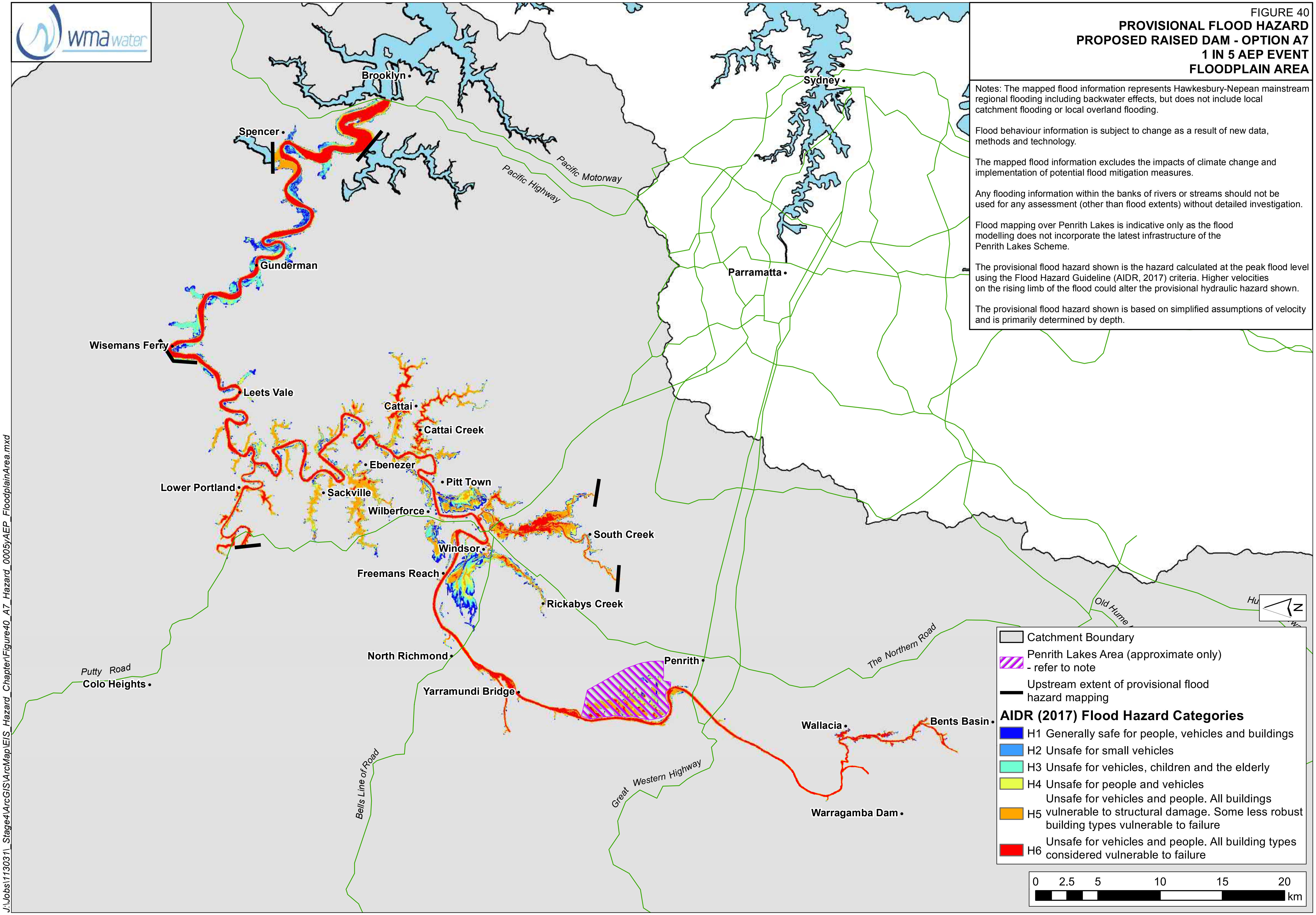
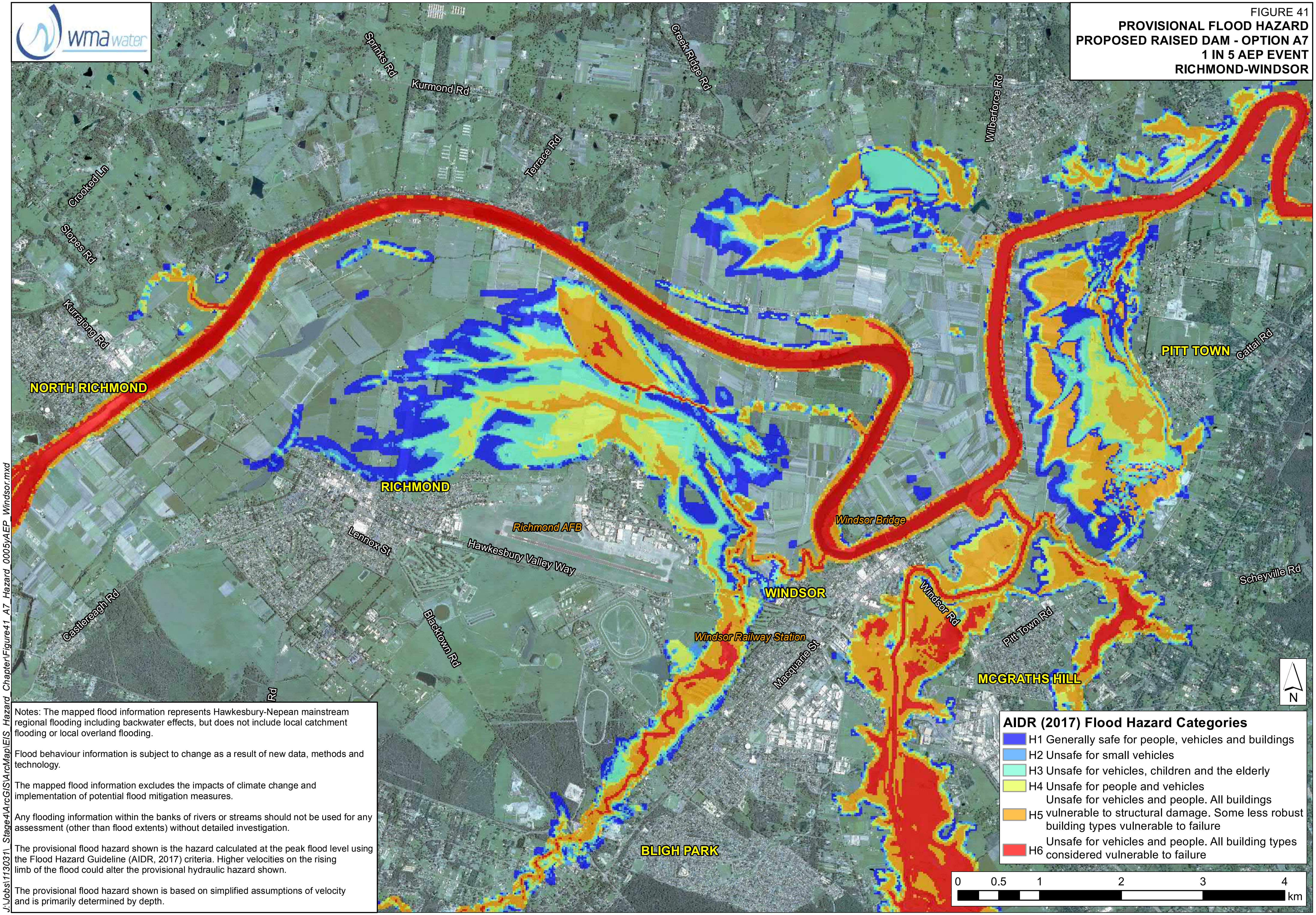


FIGURE 40
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 5 AEP EVENT
FLOODPLAIN AREA
Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.
Flood behaviour information is subject to change as a result of new data, methods and technology.
The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.
Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.
Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.
The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.
The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.
Brooklyn
Sydney
Spencer
Pacific Motorway
Pacific Highway
Gunderman
Parramatta
Wisemans Ferry
Leets Vale
Cattai
Cattai Creek
Ebenezer
Pitt Town
Lower Portland
Sackville
Wilberforce
South Creek
Windsor
Freemans Reach
Rickabys Creek
North Richmond
Penrith
Putty Road
Colo Heights
Yarramundi Bridge
The Northern Road
Old Hume
Wallacia
Bents Basin
Bells Line of Road
Great Western Highway
Warragamba Dam
Catchment Boundary
Penrith Lakes Area (approximate only) - refer to note
Upstream extent of provisional flood hazard mapping
AIDR (2017) Flood Hazard Categories
H1 Generally safe for people, vehicles and buildings
H2 Unsafe for small vehicles
H3 Unsafe for vehicles, children and the elderly
H4 Unsafe for people and vehicles
H5 Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 Unsafe for vehicles and people. All building types considered vulnerable to failure
0 2.5 5 10 15 20 km
J:\Jobs\113031_Stage4\ArcGIS\ArcMap\EIS_Hazard_Chapter\Figure40_A7_Hazard_0005yAEP_FloodplainArea.mxd

FIGURE 41

PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 5 AEP EVENT
RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

AIDR (2017) Flood Hazard Categories

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

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FIGURE 42
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 5 AEP EVENT
PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

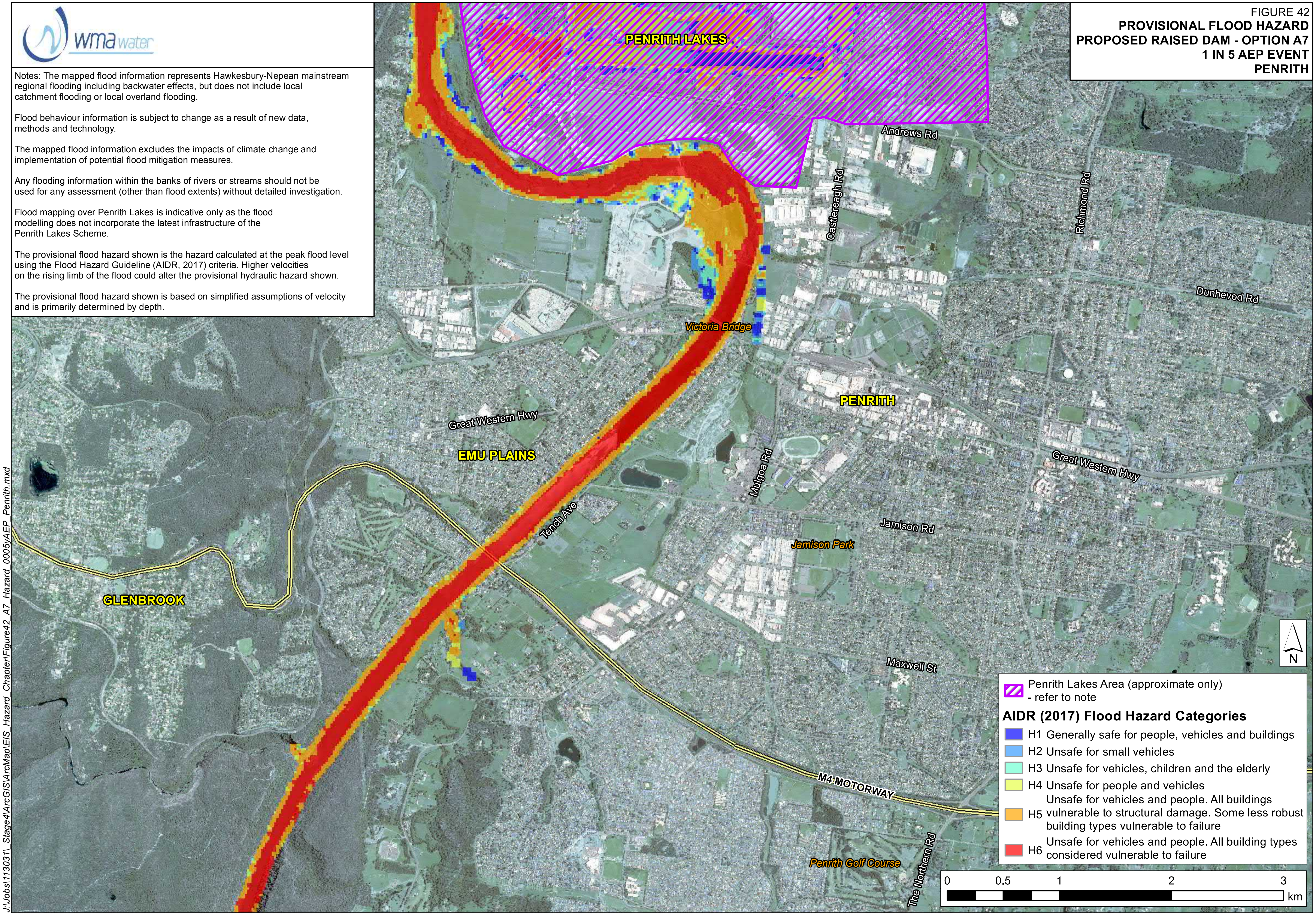
The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.



Penrith Lakes Area (approximate only) - refer to note

AIDR (2017) Flood Hazard Categories

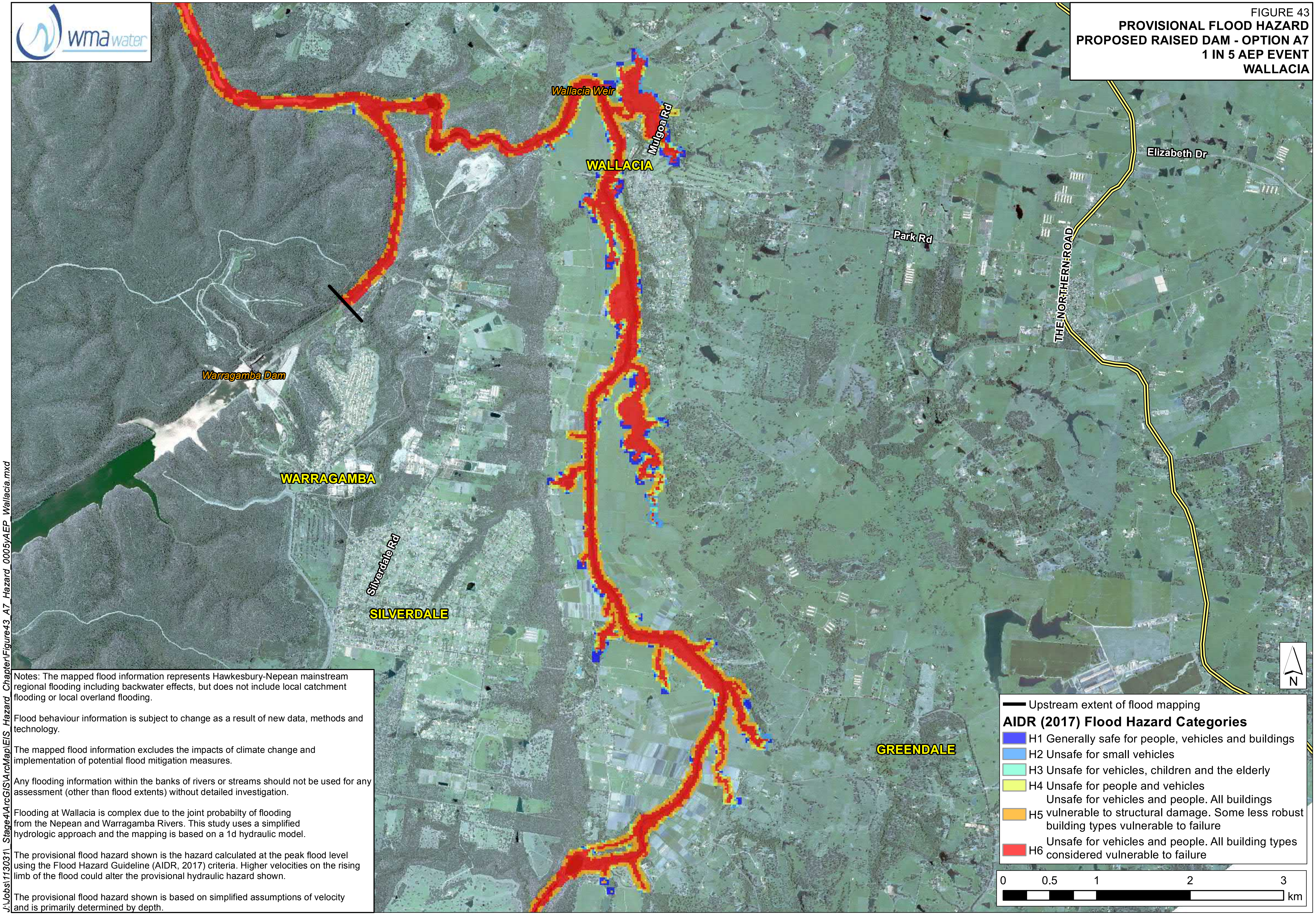
- H1 Generally safe for people, vehicles and buildings
- H2 Unsafe for small vehicles
- H3 Unsafe for vehicles, children and the elderly
- H4 Unsafe for people and vehicles
- H5 Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to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

0 0.5 1 2 3 km

J:\Jobs\113031_Stage4\ArcGIS\ArcMap\EIS_Hazard_Chapter\Figure42_A7_Hazard_0005yAEP_Penrith.mxd

FIGURE 43

PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 5 AEP EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 44
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 20 AEP EVENT
FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

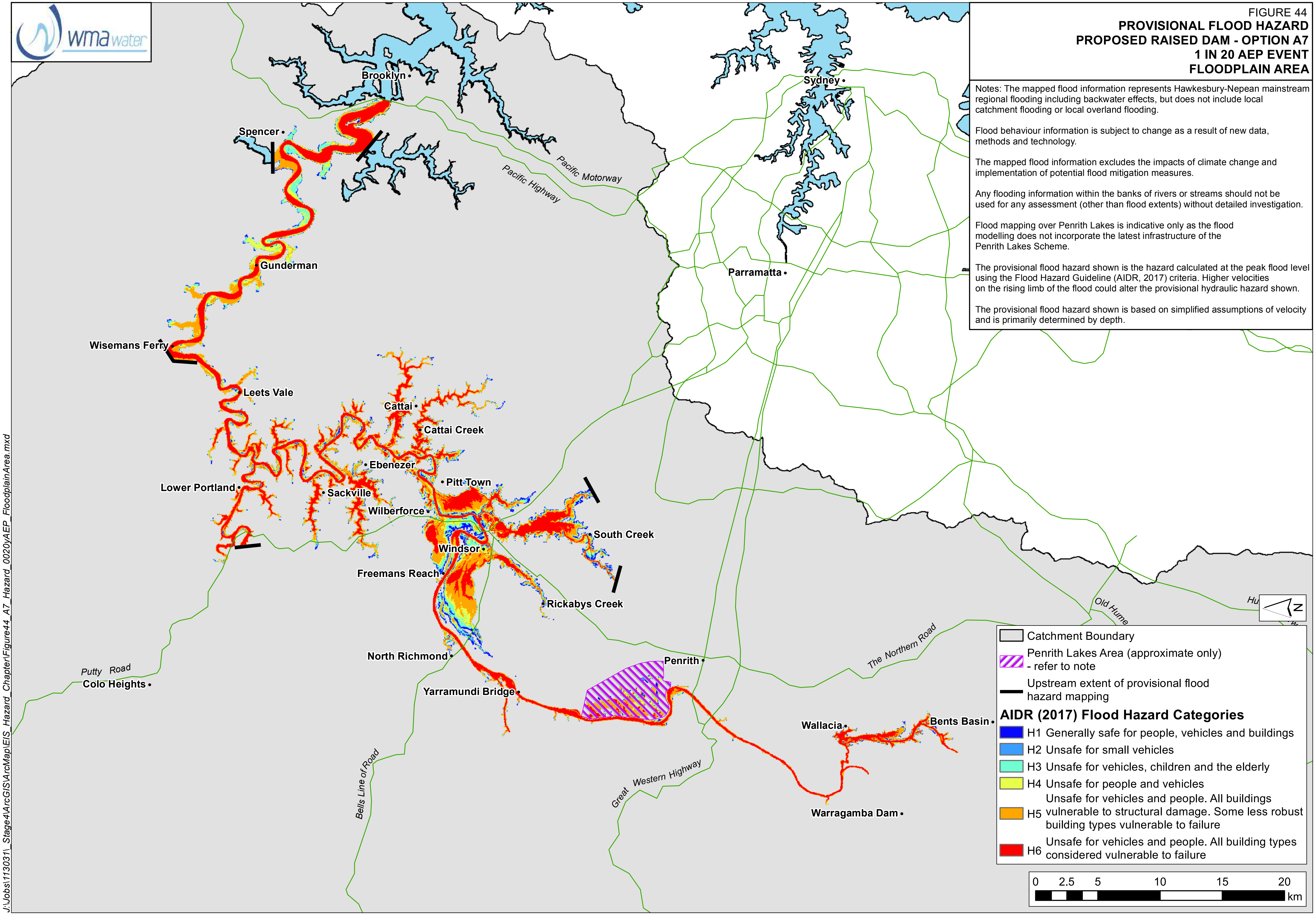

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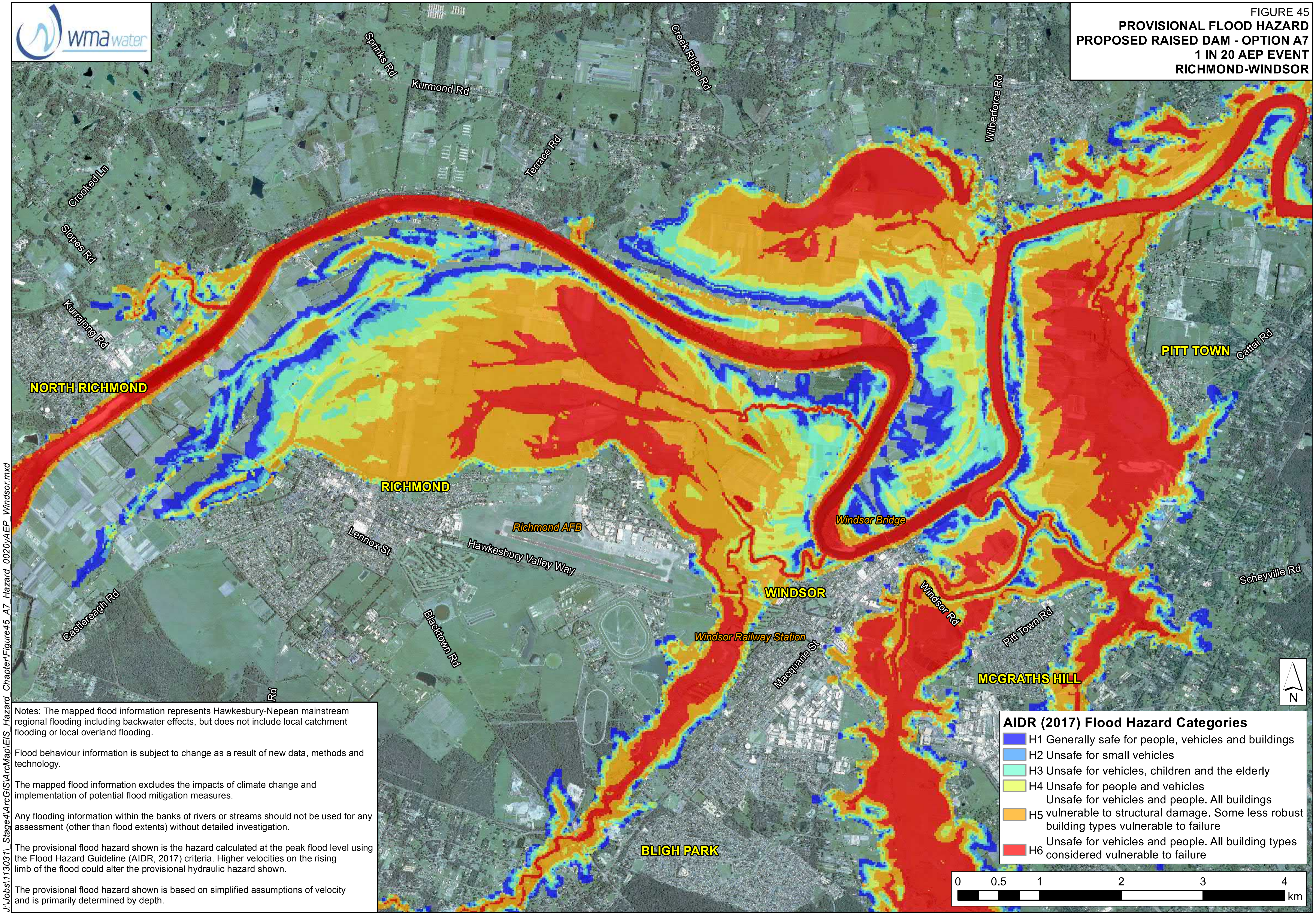
FIGURE 45

PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 20 AEP EVENT
RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

FIGURE 46

PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 20 AEP EVENT
PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

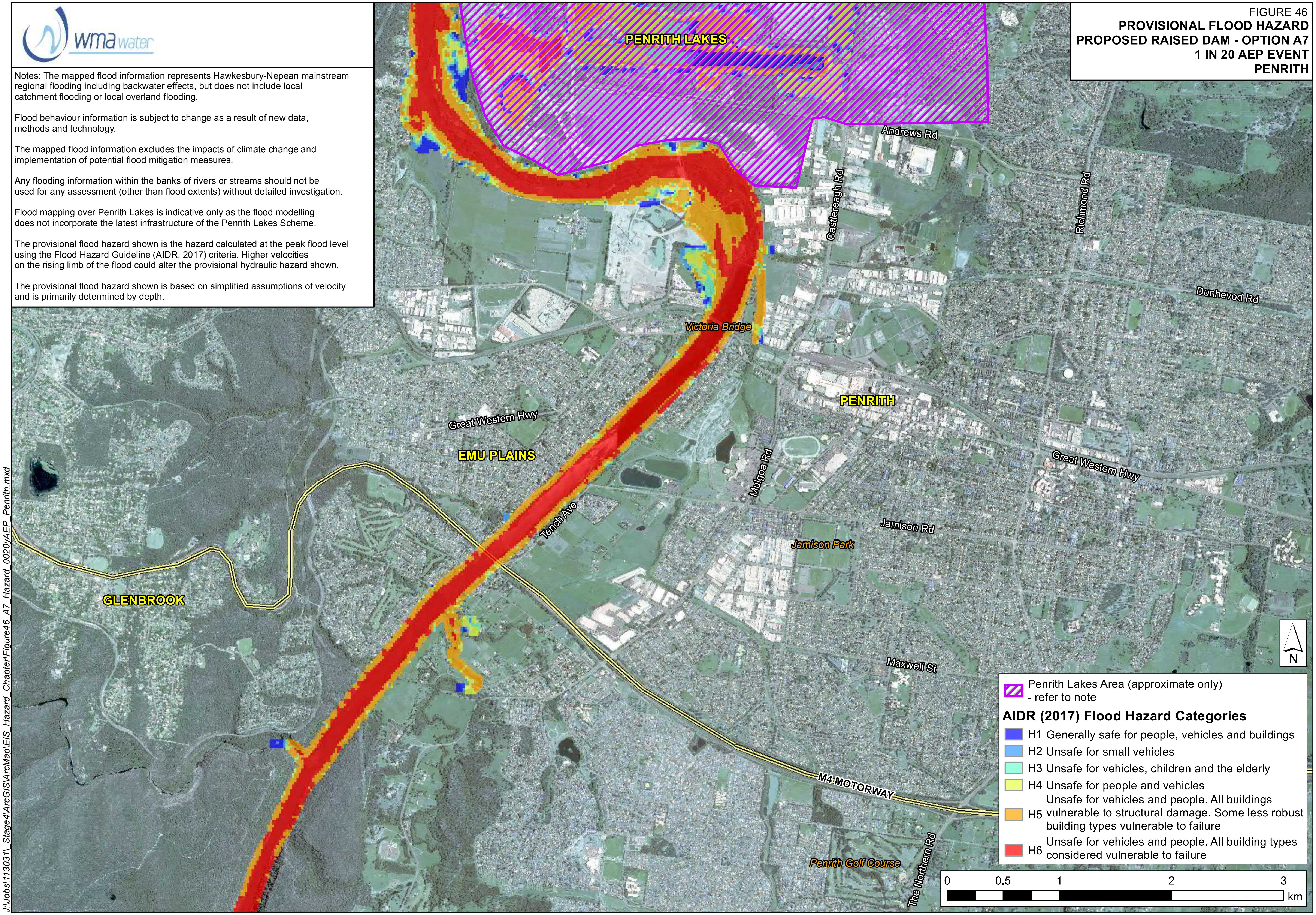


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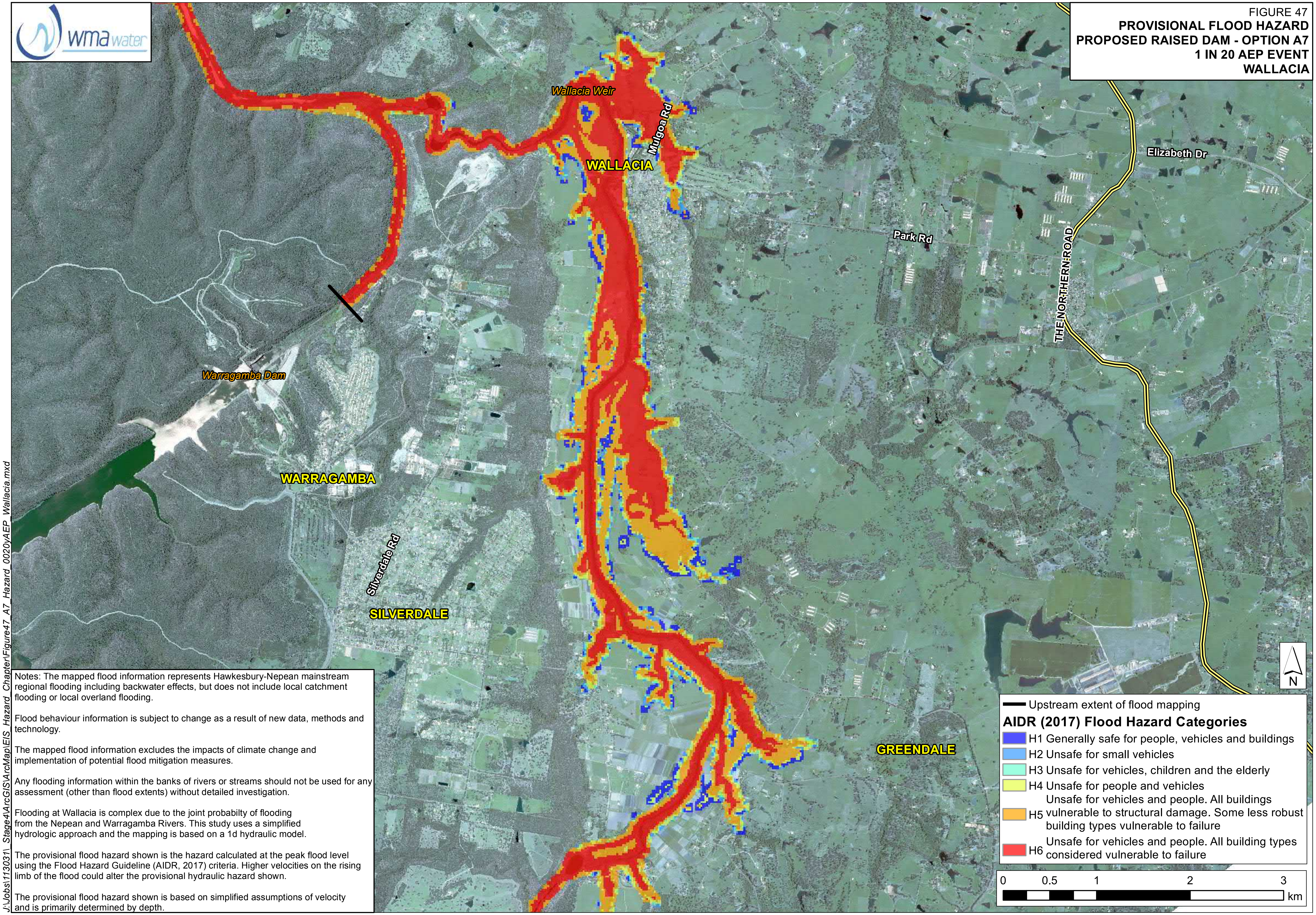
FIGURE 47
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 20 AEP EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

FIGURE 48
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 100 AEP EVENT
FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

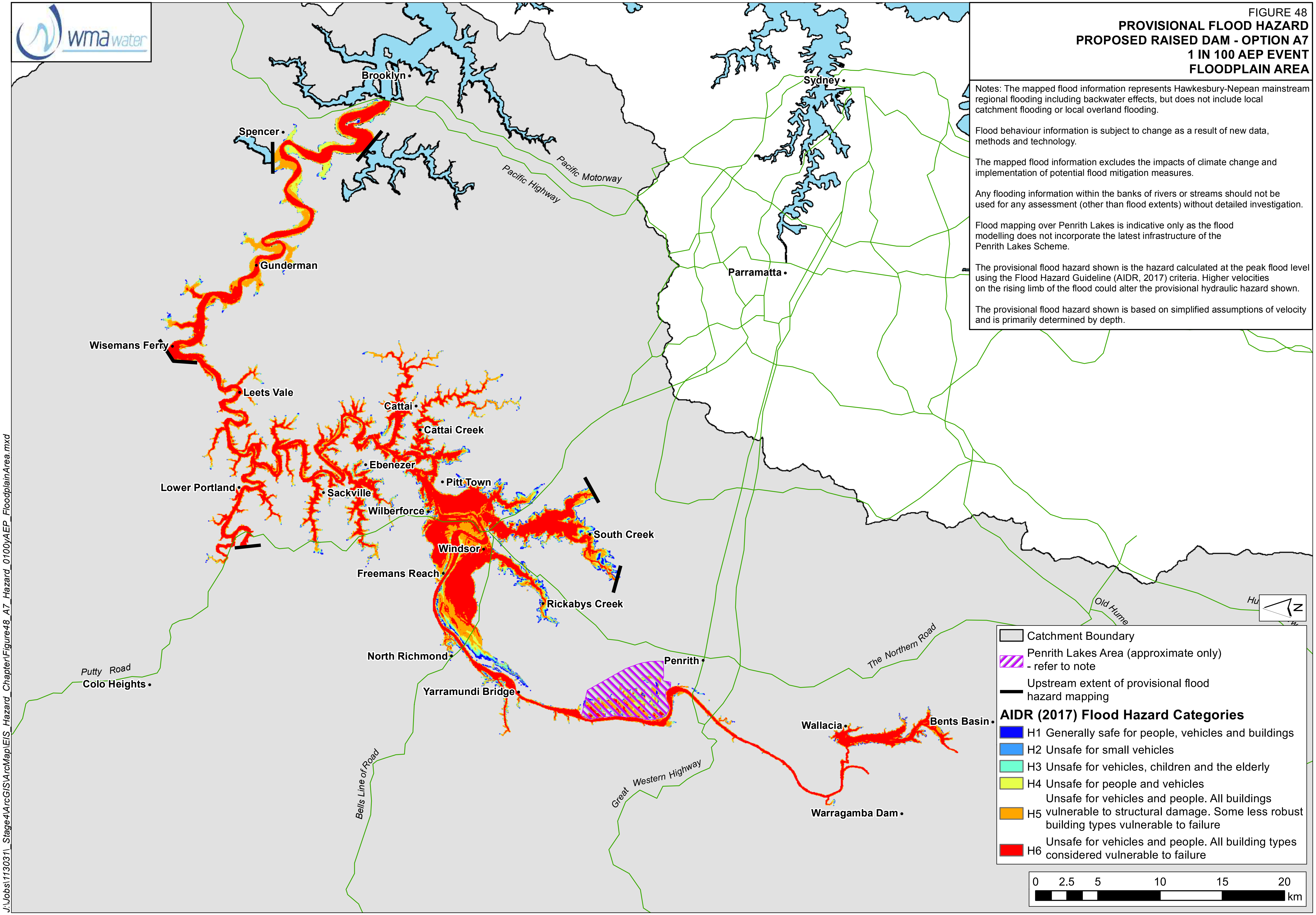


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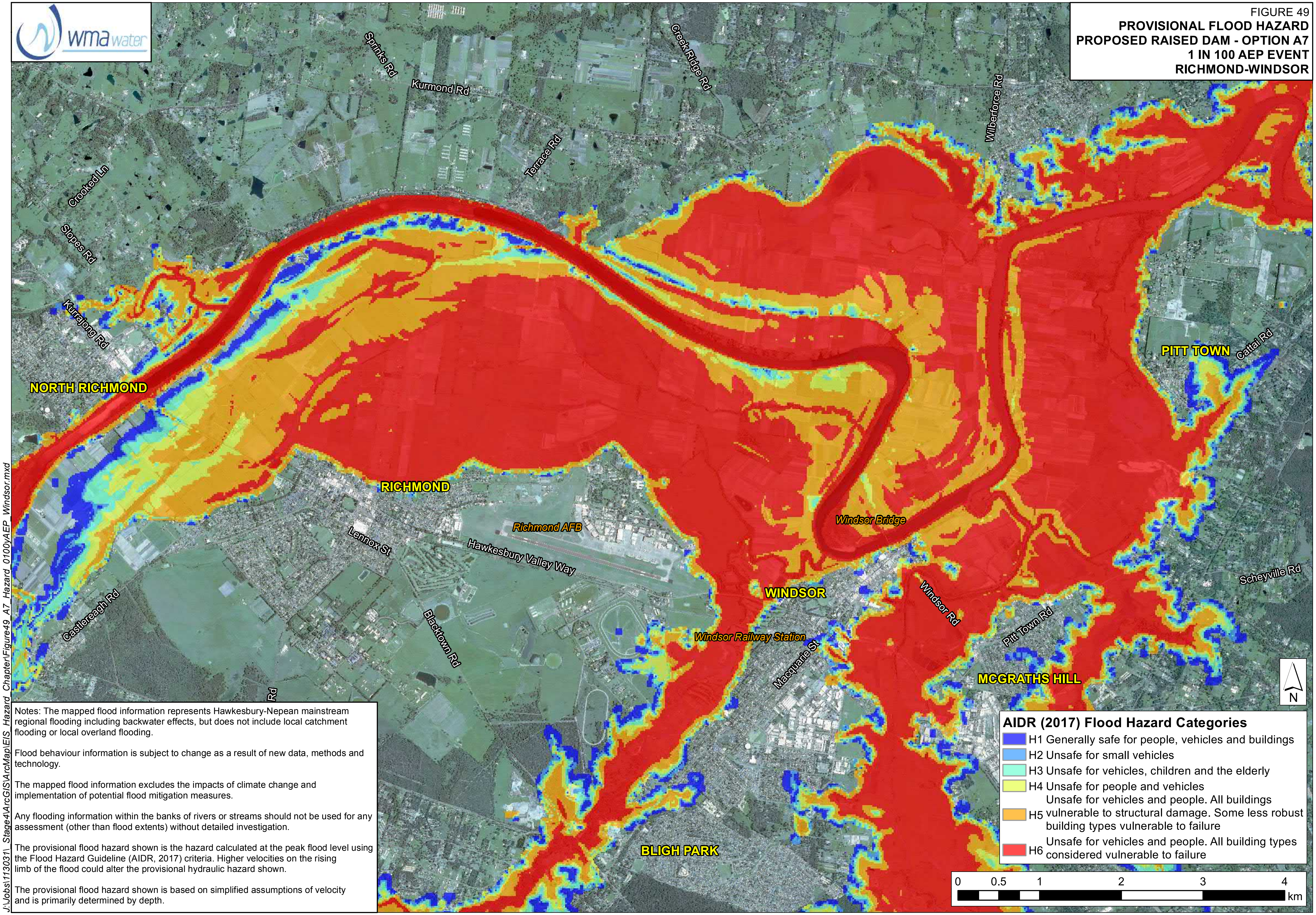
FIGURE 49
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 100 AEP EVENT
RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 50

PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 100 AEP EVENT
PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

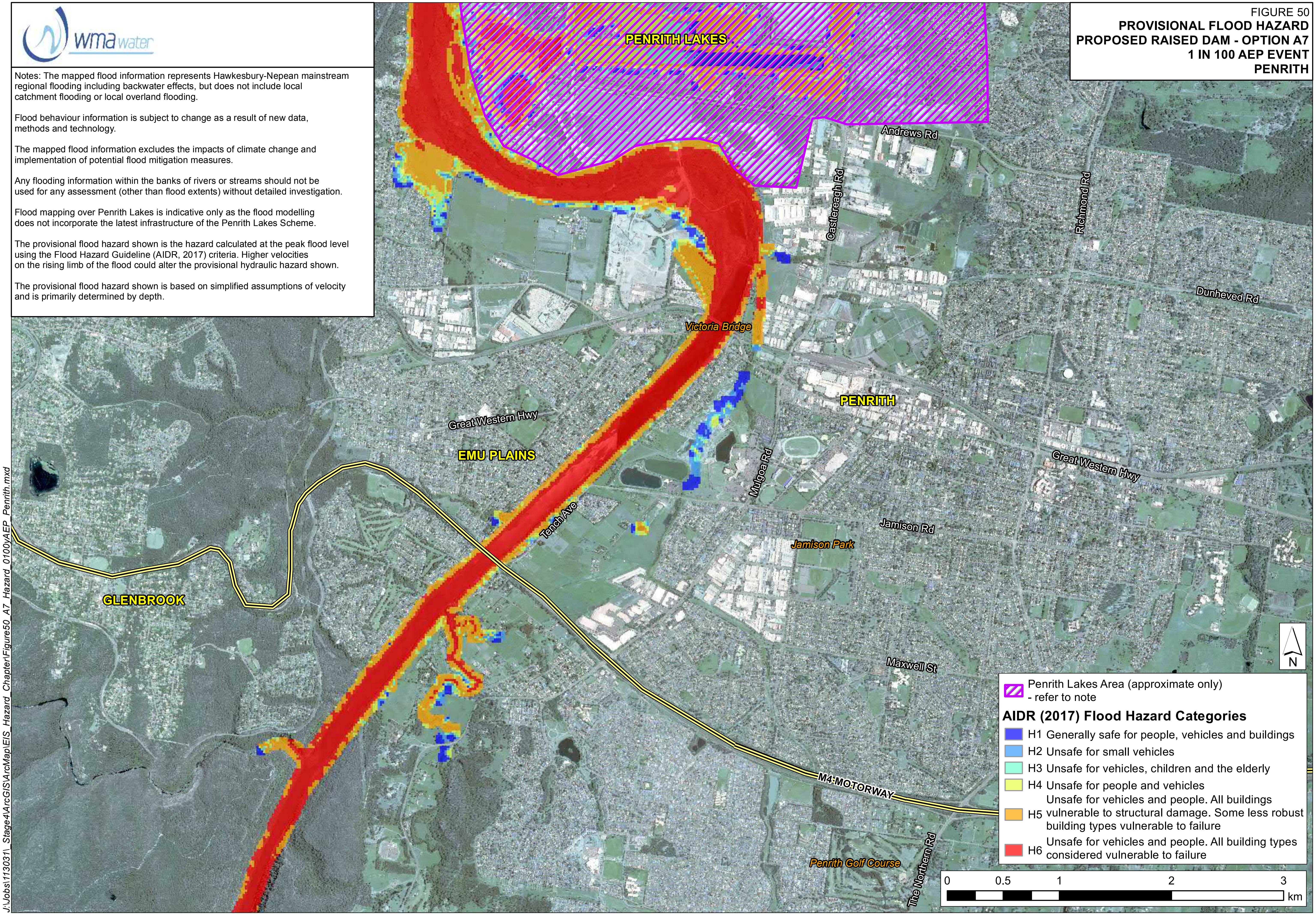

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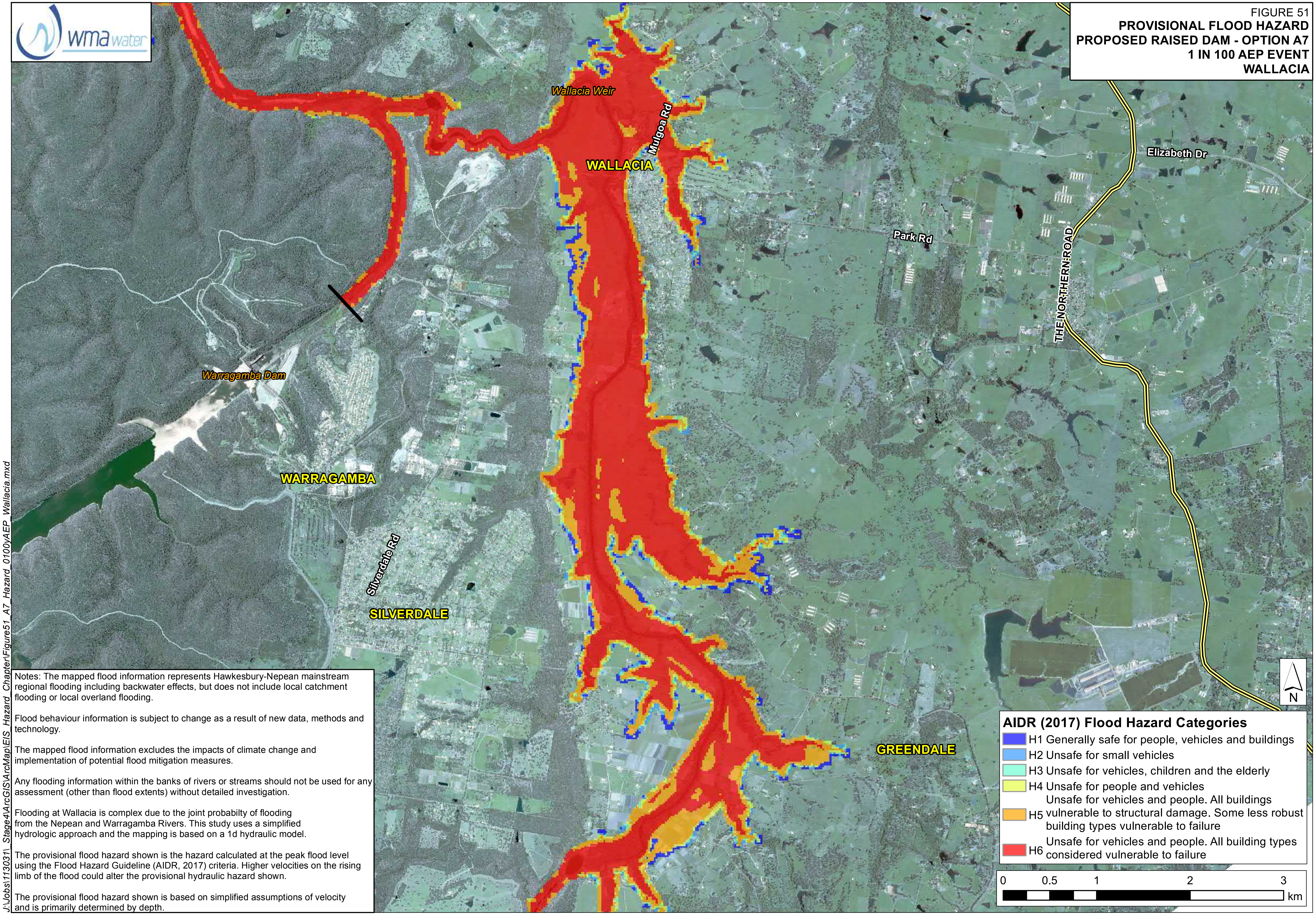
FIGURE 51
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 100 AEP EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 52
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 200 AEP EVENT
FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

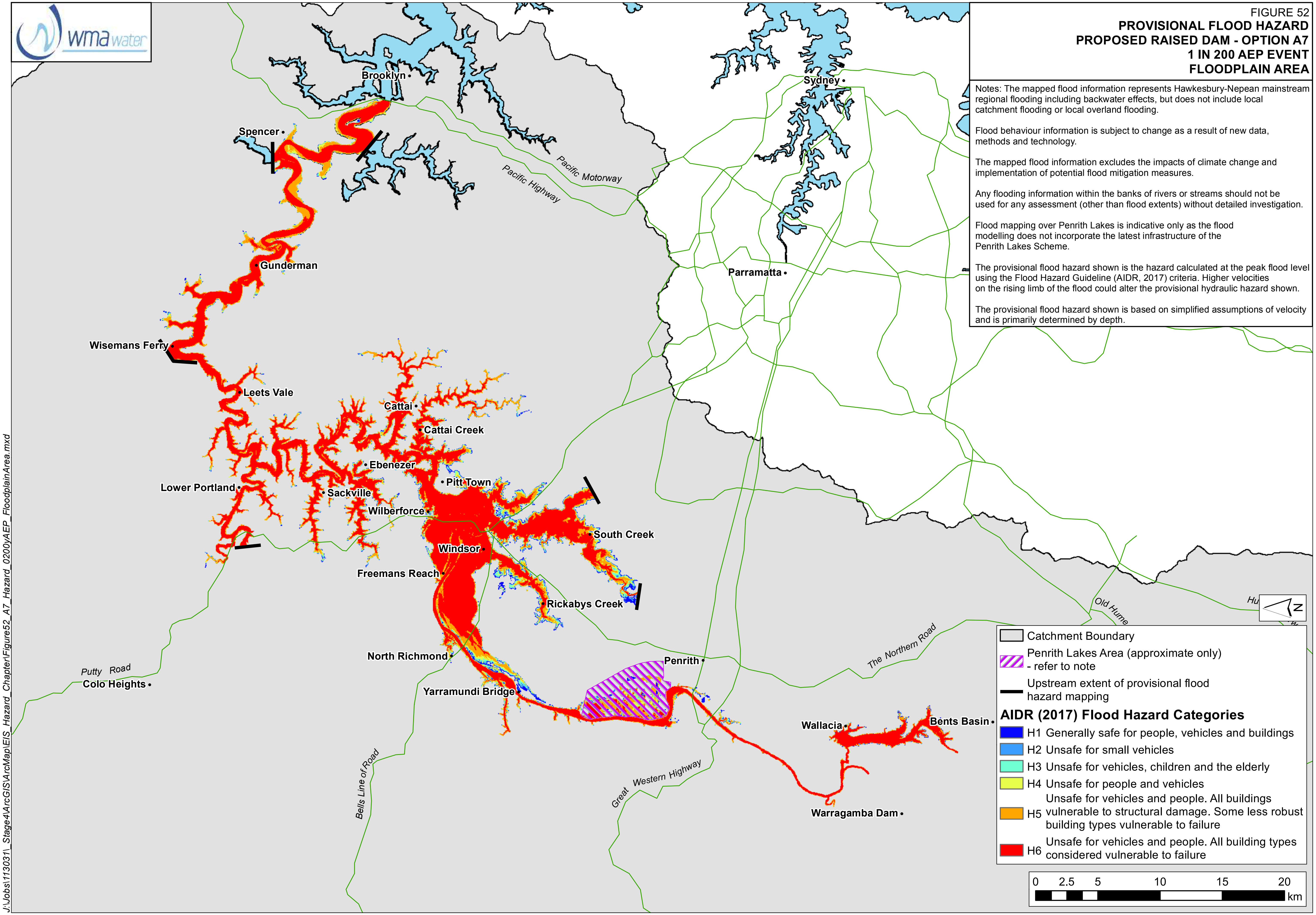

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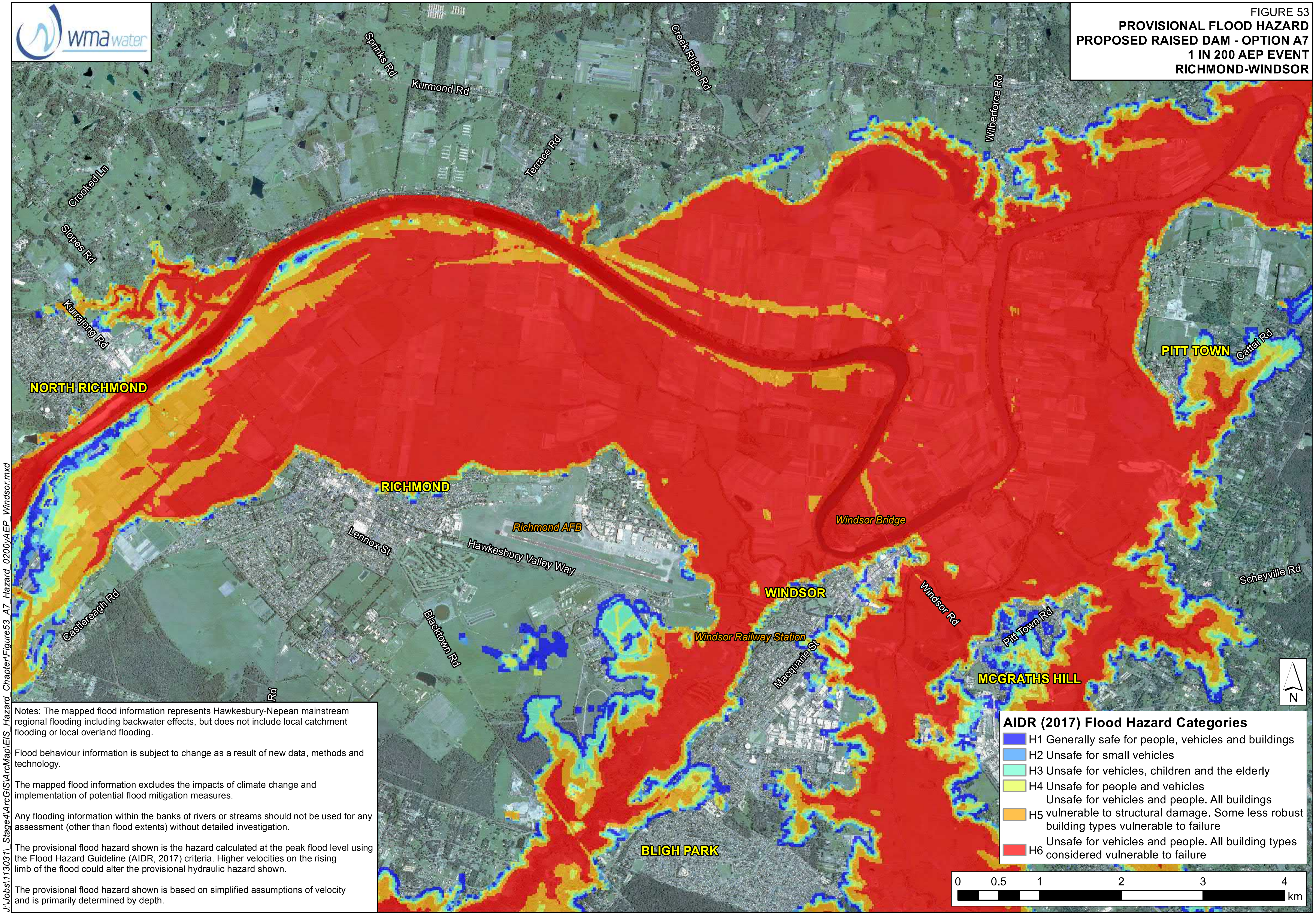
FIGURE 53

PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 200 AEP EVENT
RICHMOND-WINDSOR



AIDR (2017) Flood Hazard Categories

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

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 54

PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 200 AEP EVENT
PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

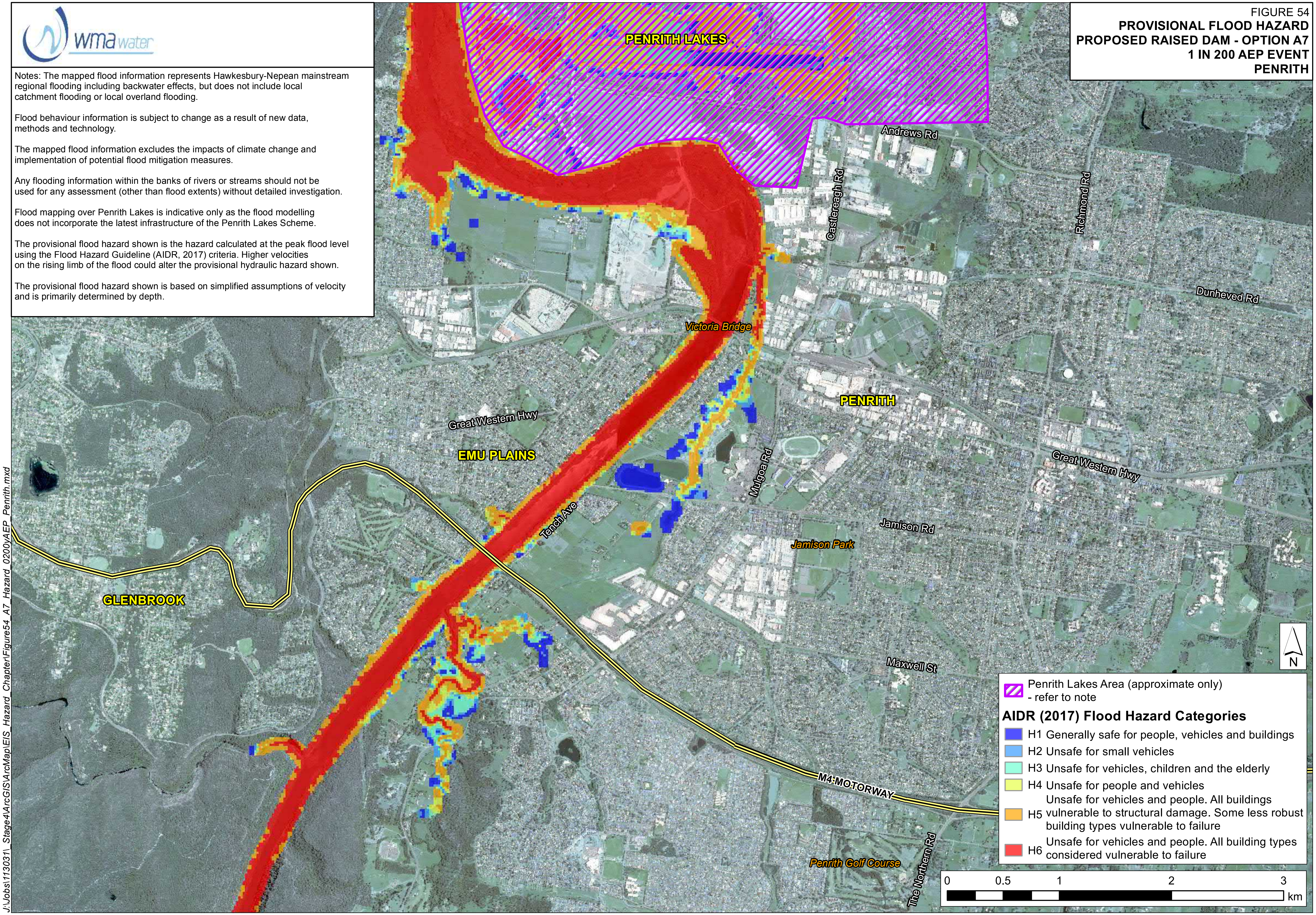
The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.



Penrith Lakes Area (approximate only) - refer to note

AIDR (2017) Flood Hazard Categories

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

0 0.5 1 2 3 km

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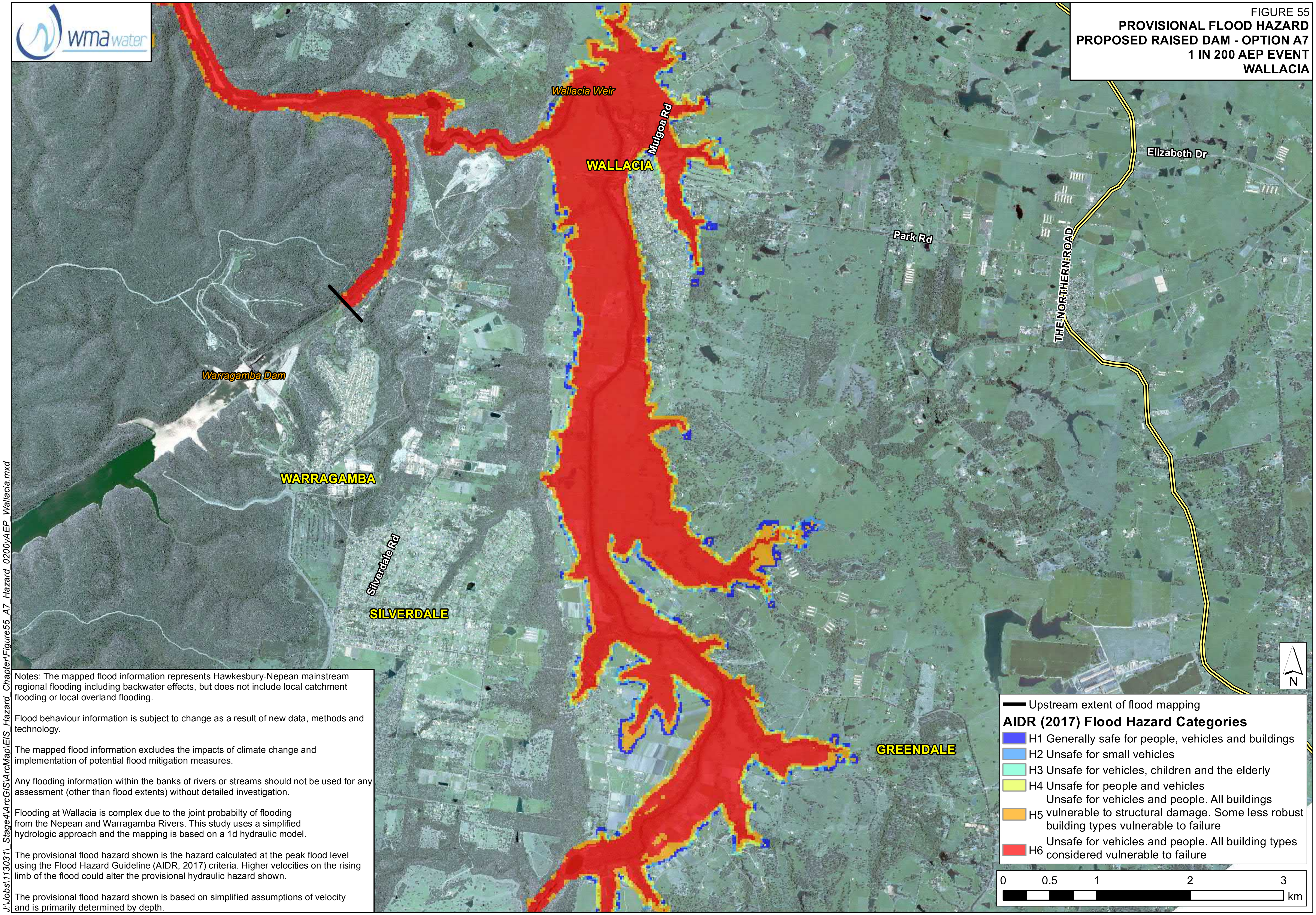
FIGURE 55
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 200 AEP EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 56
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 500 AEP EVENT
FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

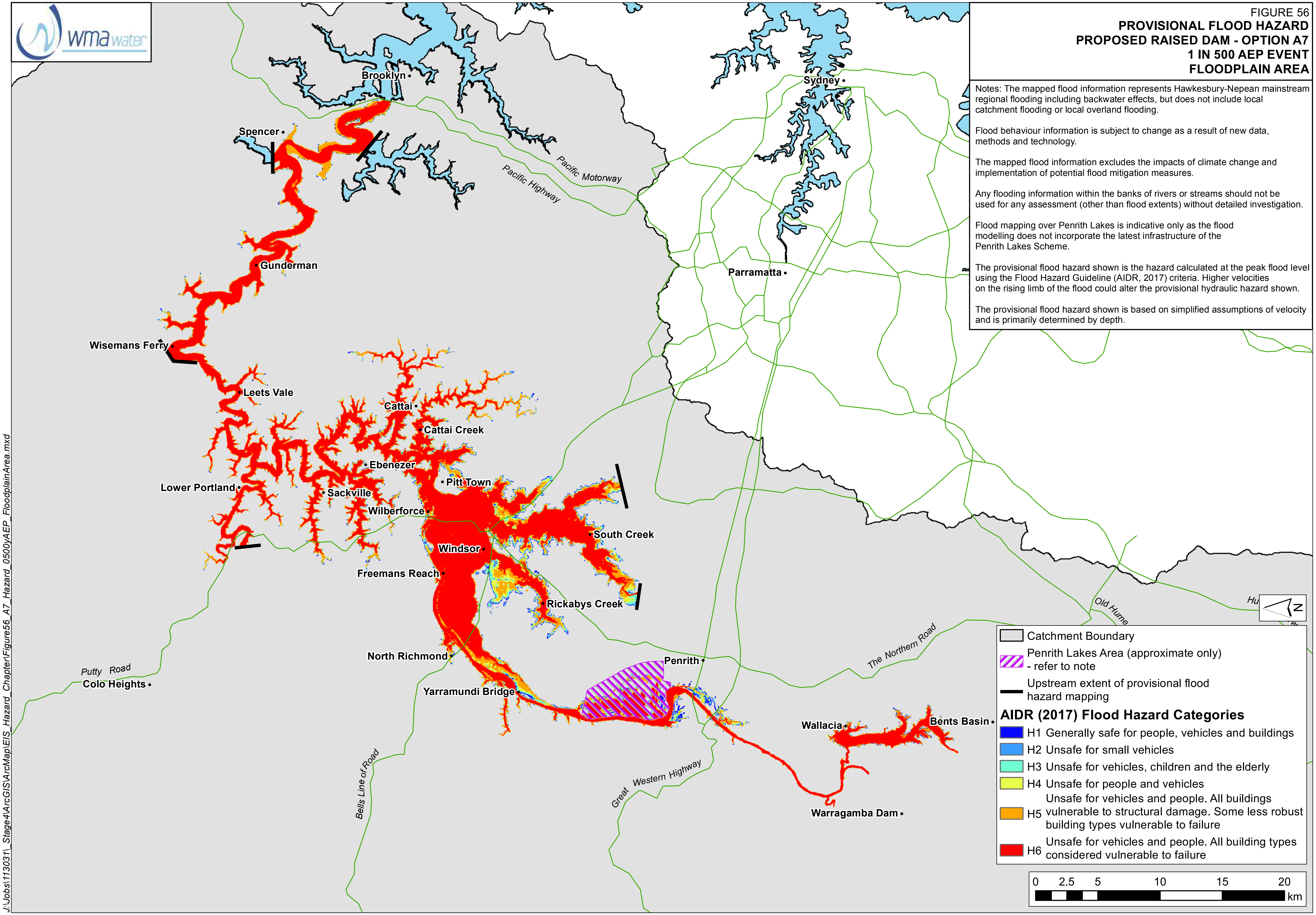
The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.



Catchment Boundary

Penrith Lakes Area (approximate only) - refer to note

Upstream extent of provisional flood hazard mapping

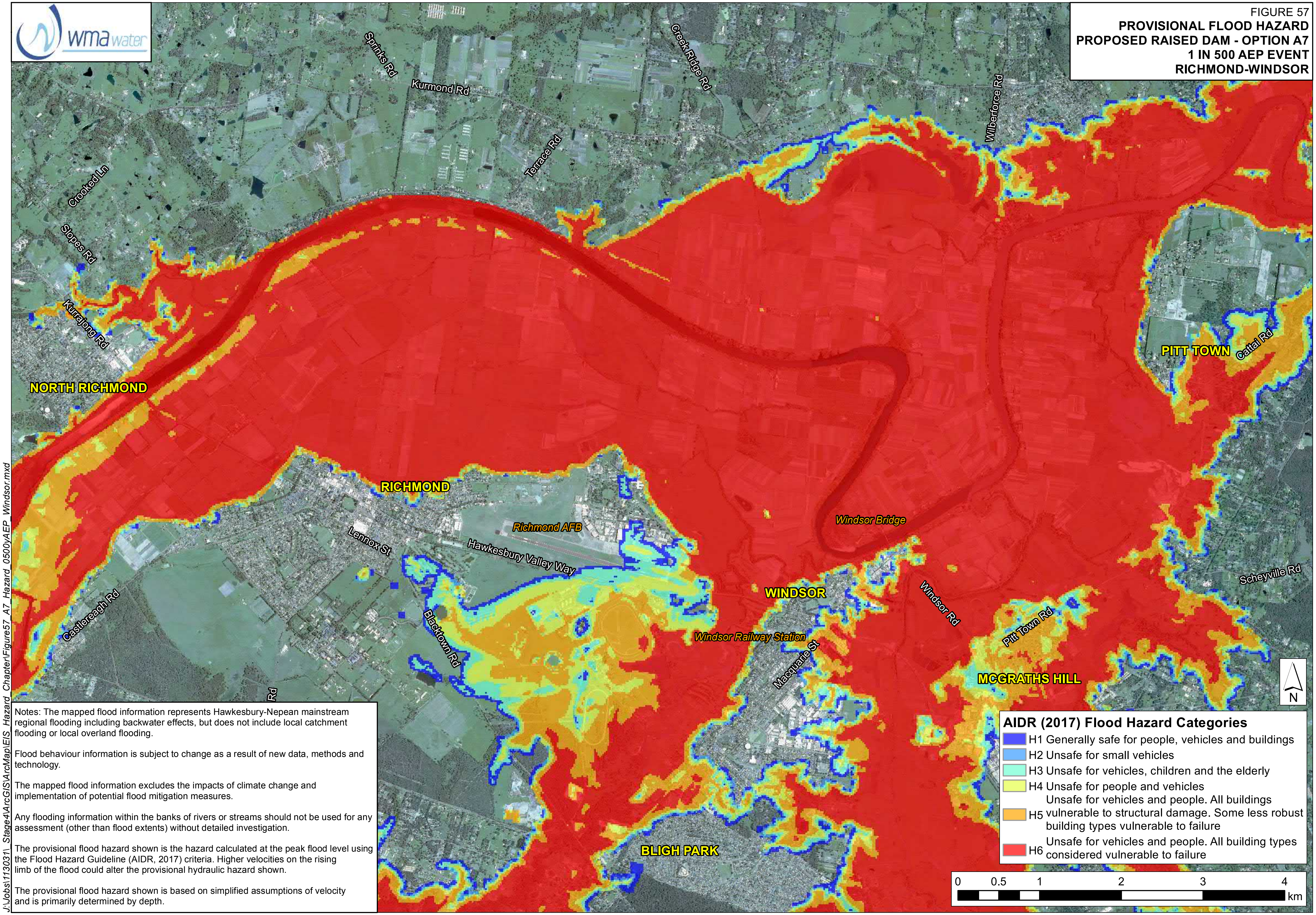
AIDR (2017) Flood Hazard Categories

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

0 2.5 5 10 15 20 km

J:\Jobs\113031_Stage4\ArcGIS\ArcMap\EIS_Hazard_Chapter\Figure56_A7_Hazard_0500yAEP_FloodplainArea.mxd

FIGURE 57
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 500 AEP EVENT
RICHMOND-WINDSOR



AIDR (2017) Flood Hazard Categories

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

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 58
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 500 AEP EVENT
PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

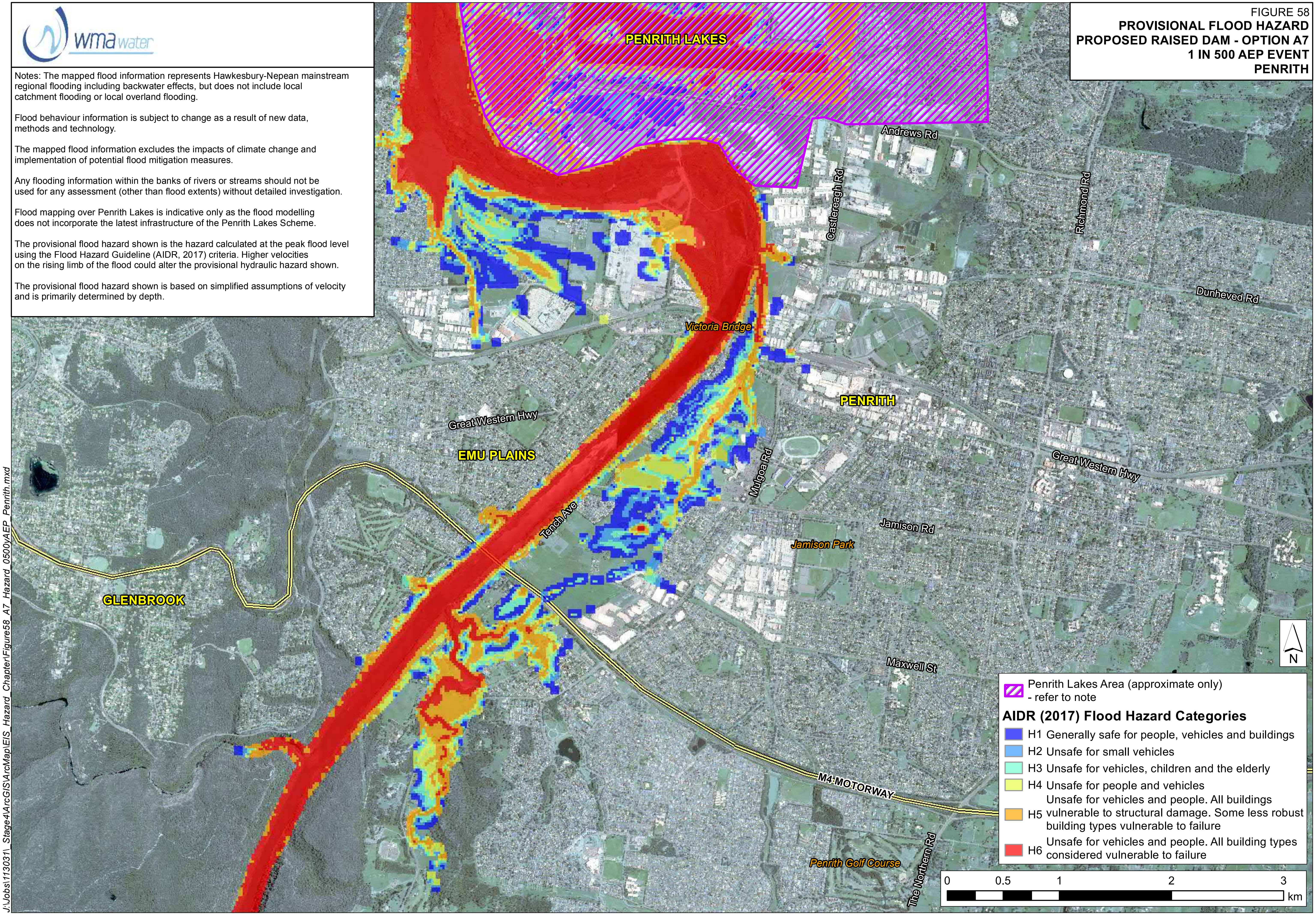

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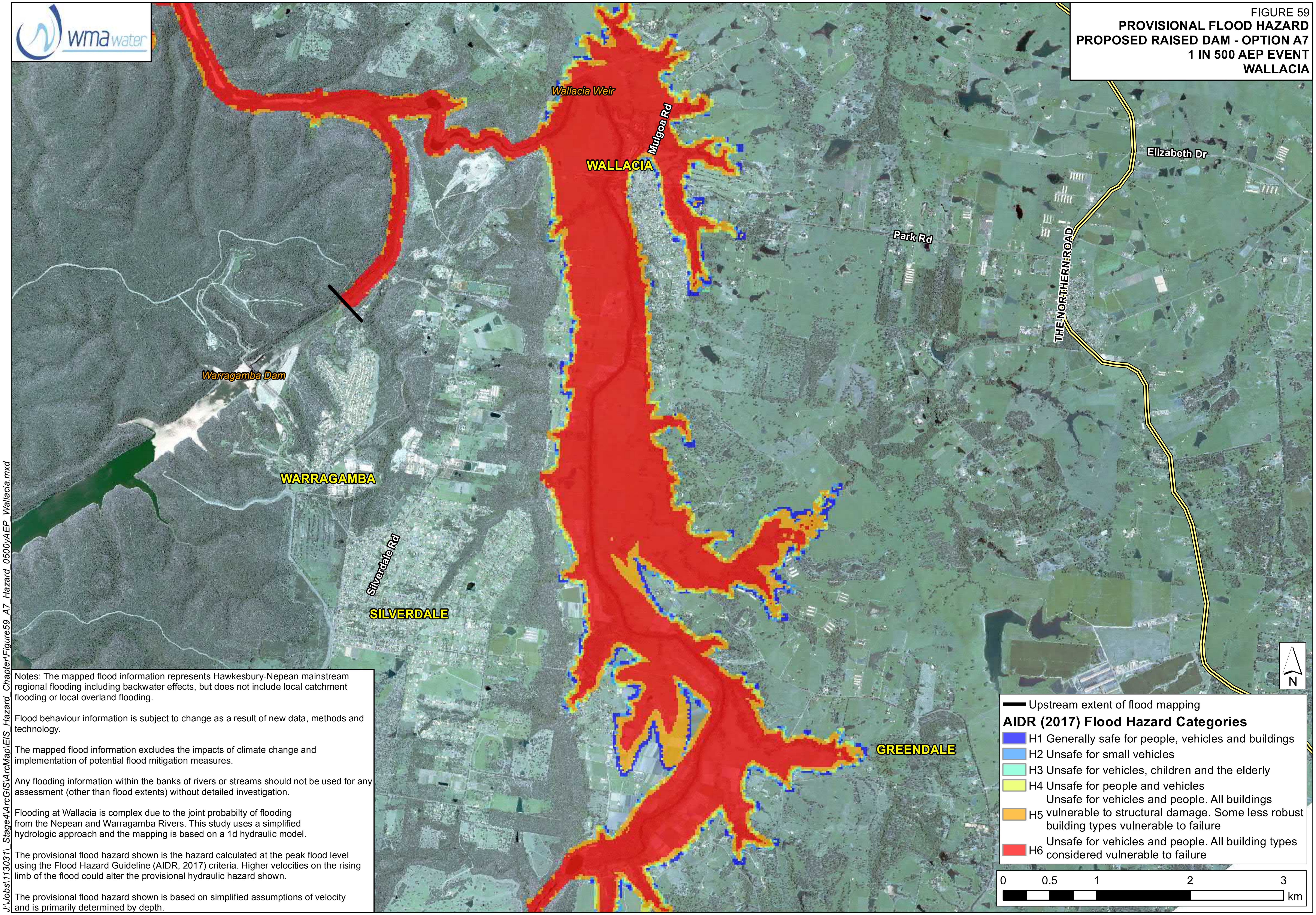
FIGURE 59
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 500 AEP EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

Upstream extent of flood mapping

AIDR (2017) Flood Hazard Categories

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

0 0.5 1 2 3 km

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FIGURE 60
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 2000 AEP EVENT
FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

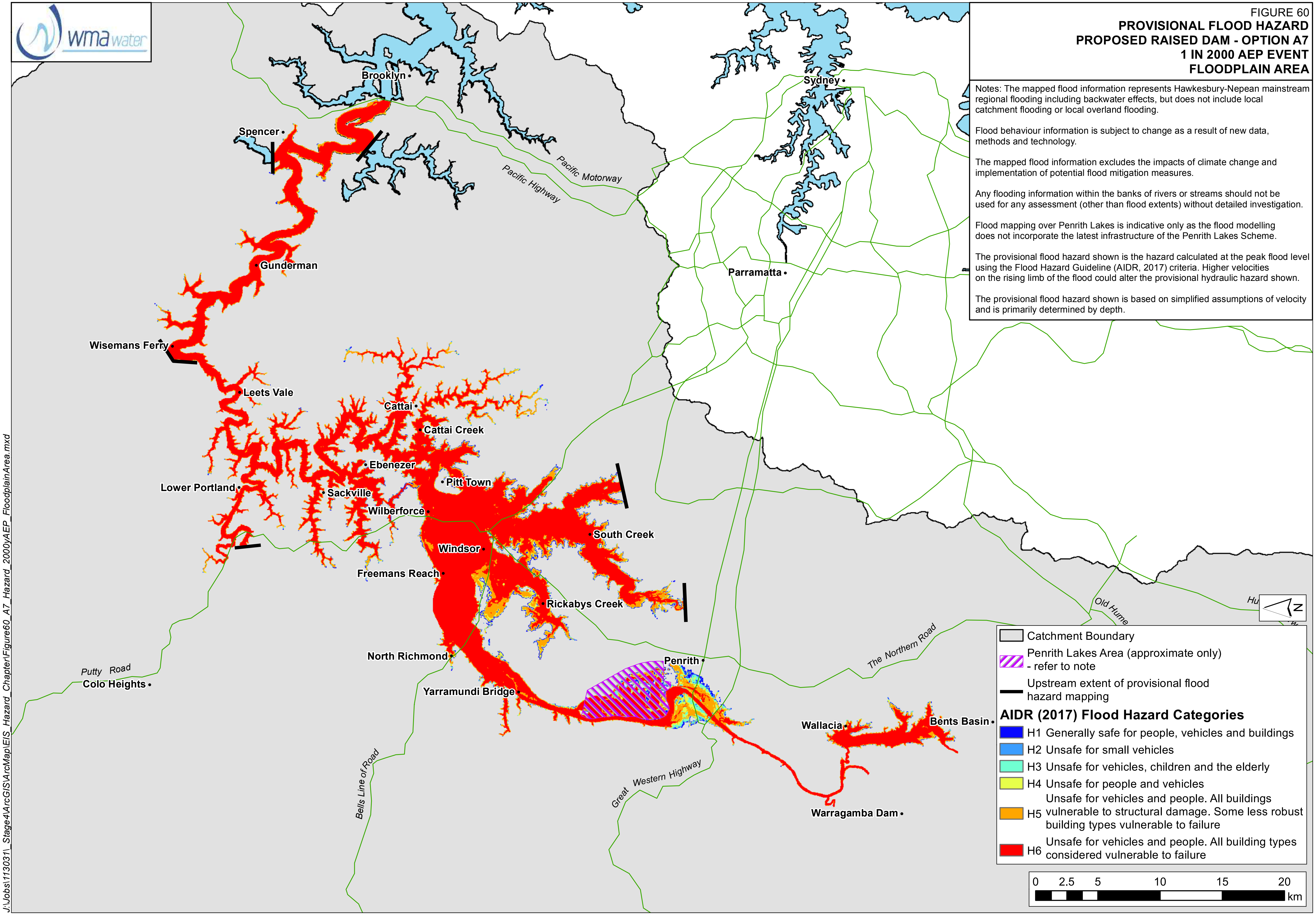

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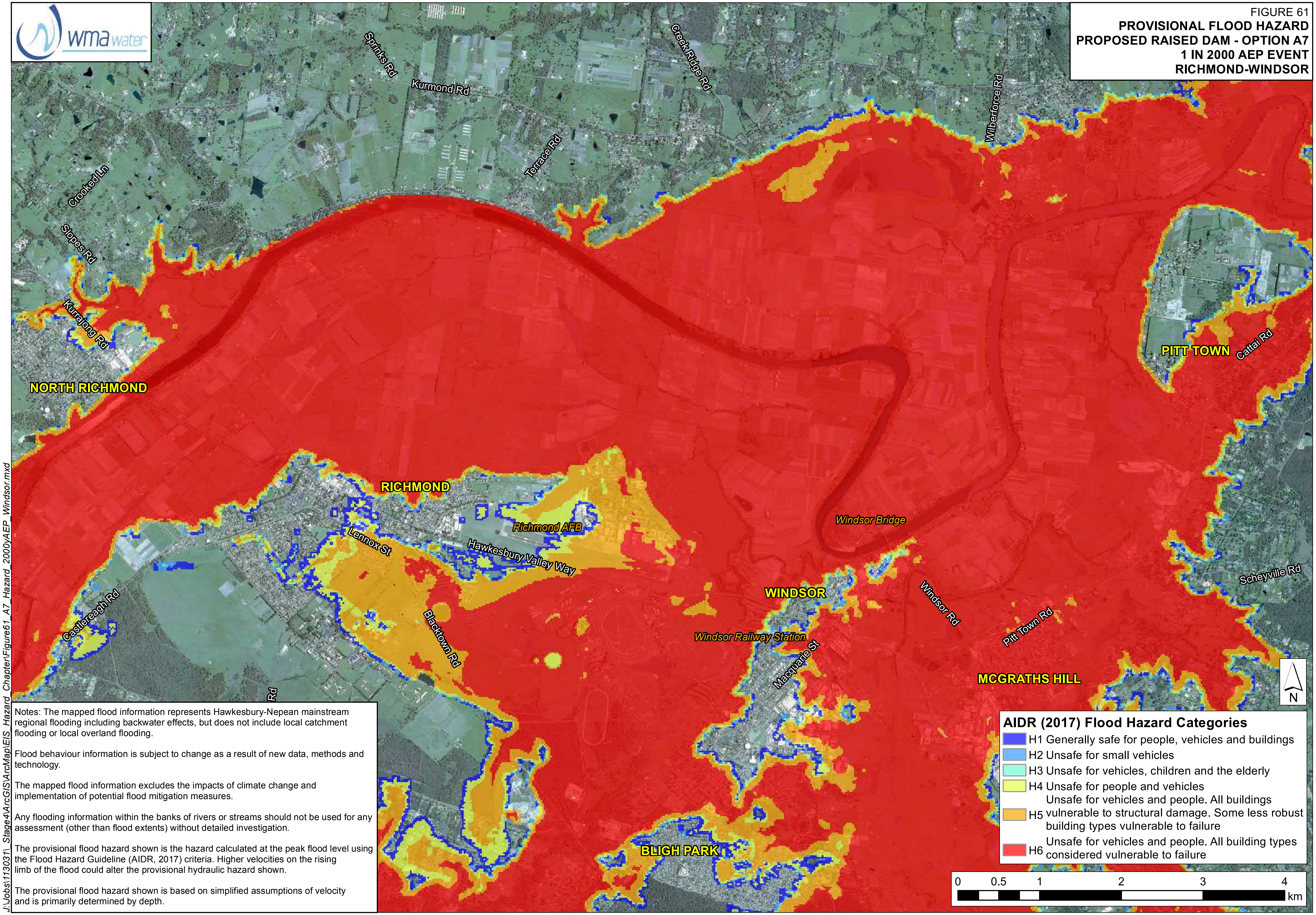
FIGURE 61
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 2000 AEP EVENT
RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

AIDR (2017) Flood Hazard Categories

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

0 0.5 1 2 3 4 km

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FIGURE 62
PROVISIONAL FLOOD HAZARD PROPOSED RAISED DAM - OPTION A7 1 IN 2000 AEP EVENT PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

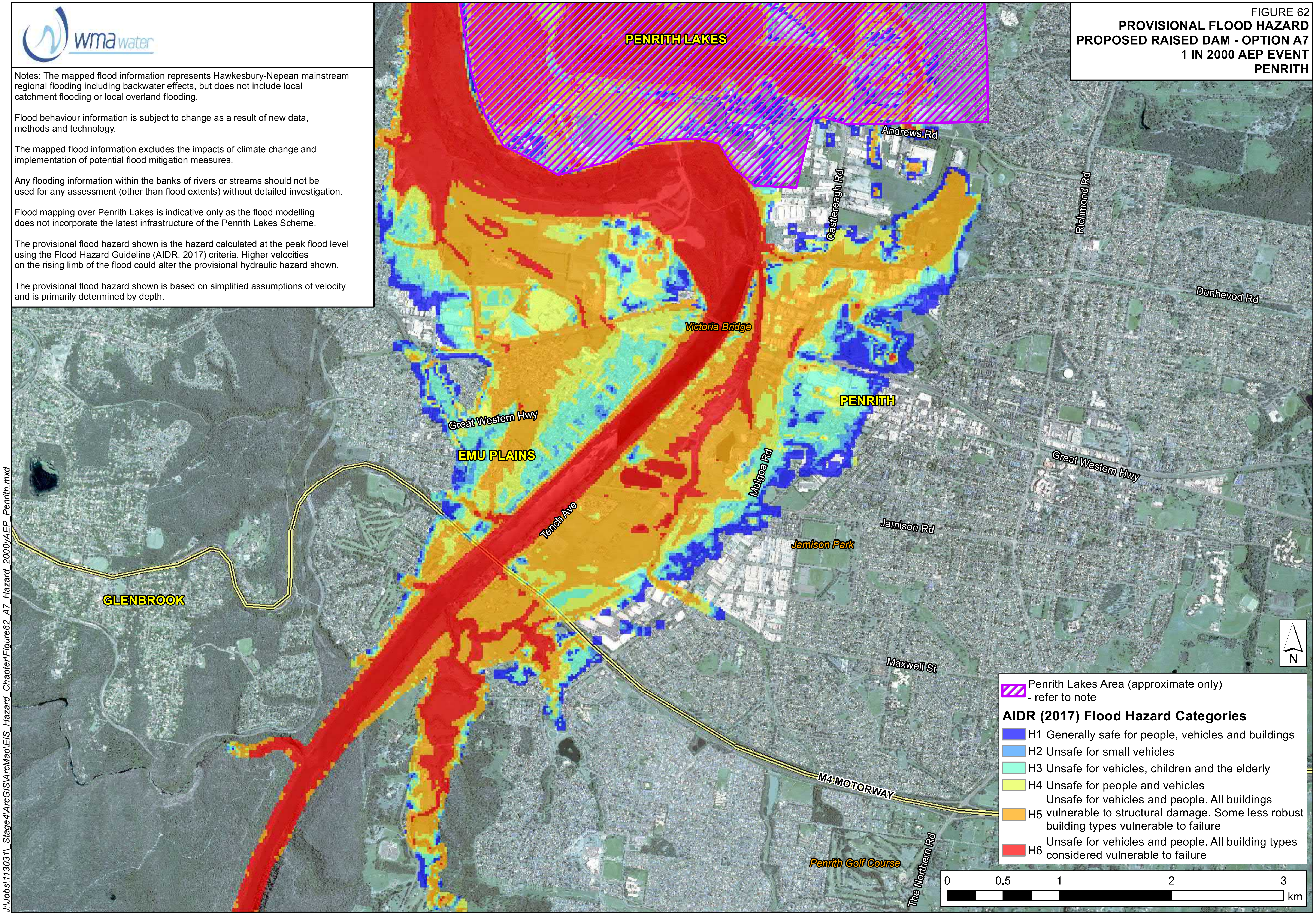

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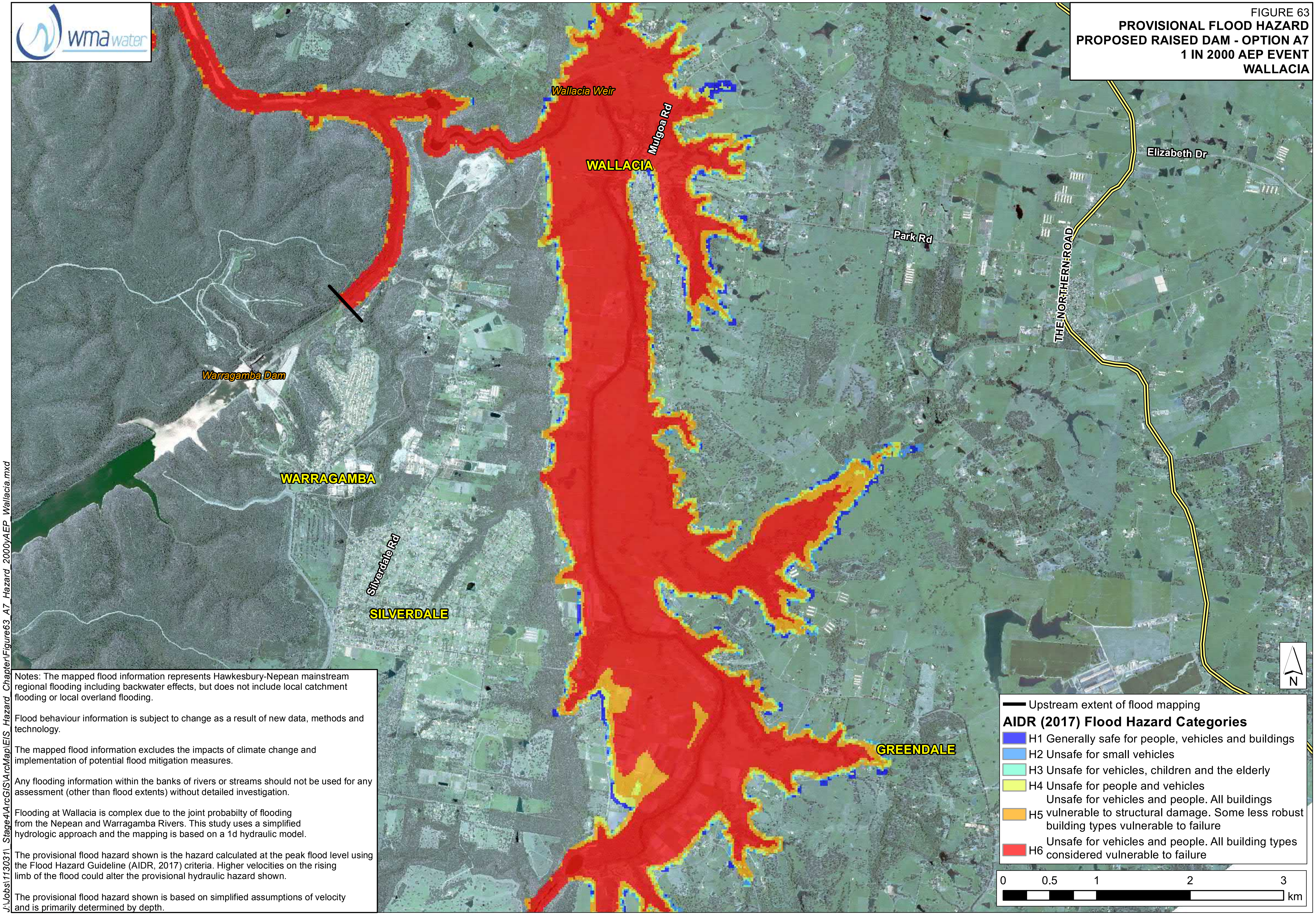
FIGURE 63
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
1 IN 2000 AEP EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 64

PROVISIONAL FLOOD HAZARD PROPOSED RAISED DAM - OPTION A7 PMF EVENT FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

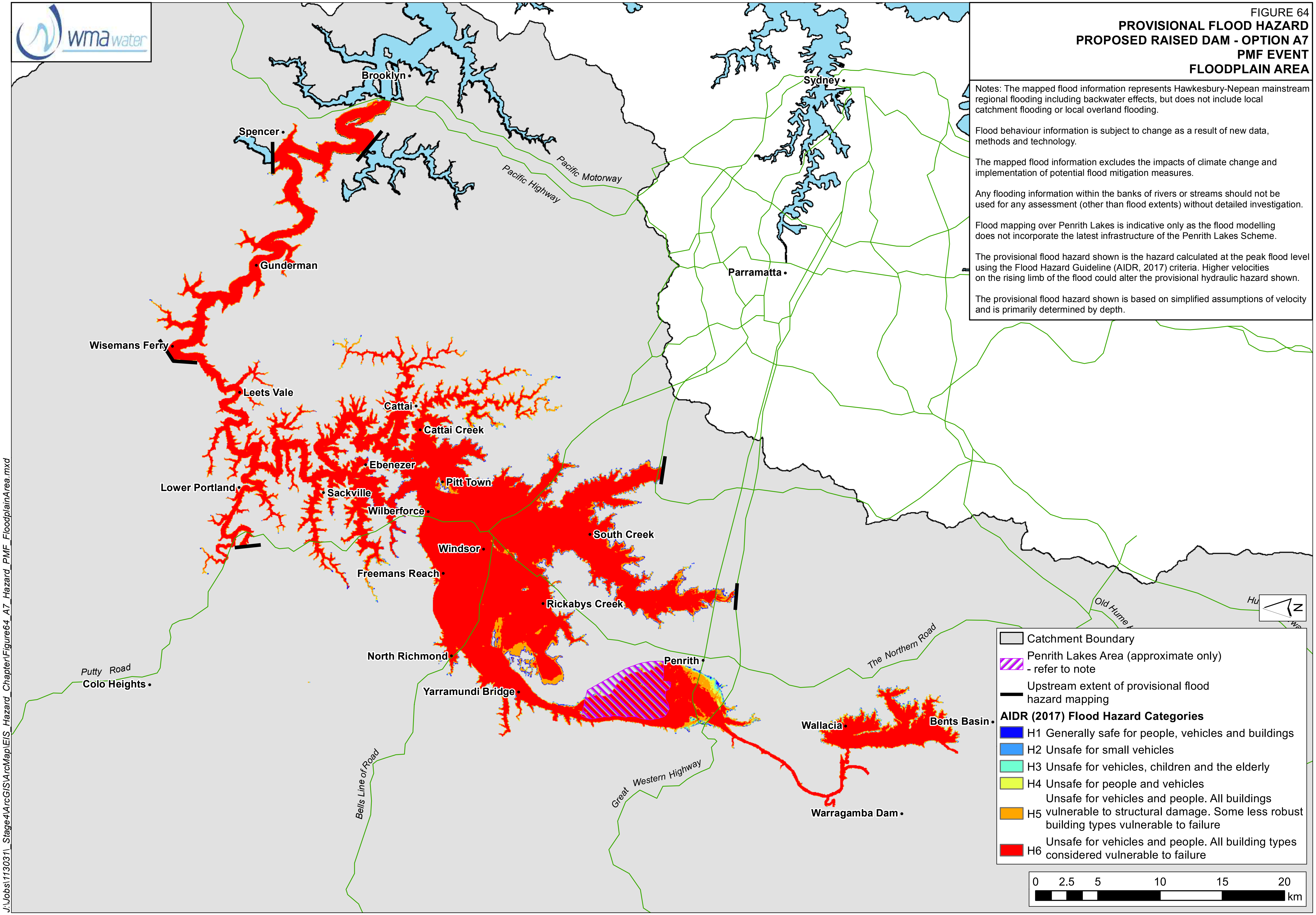

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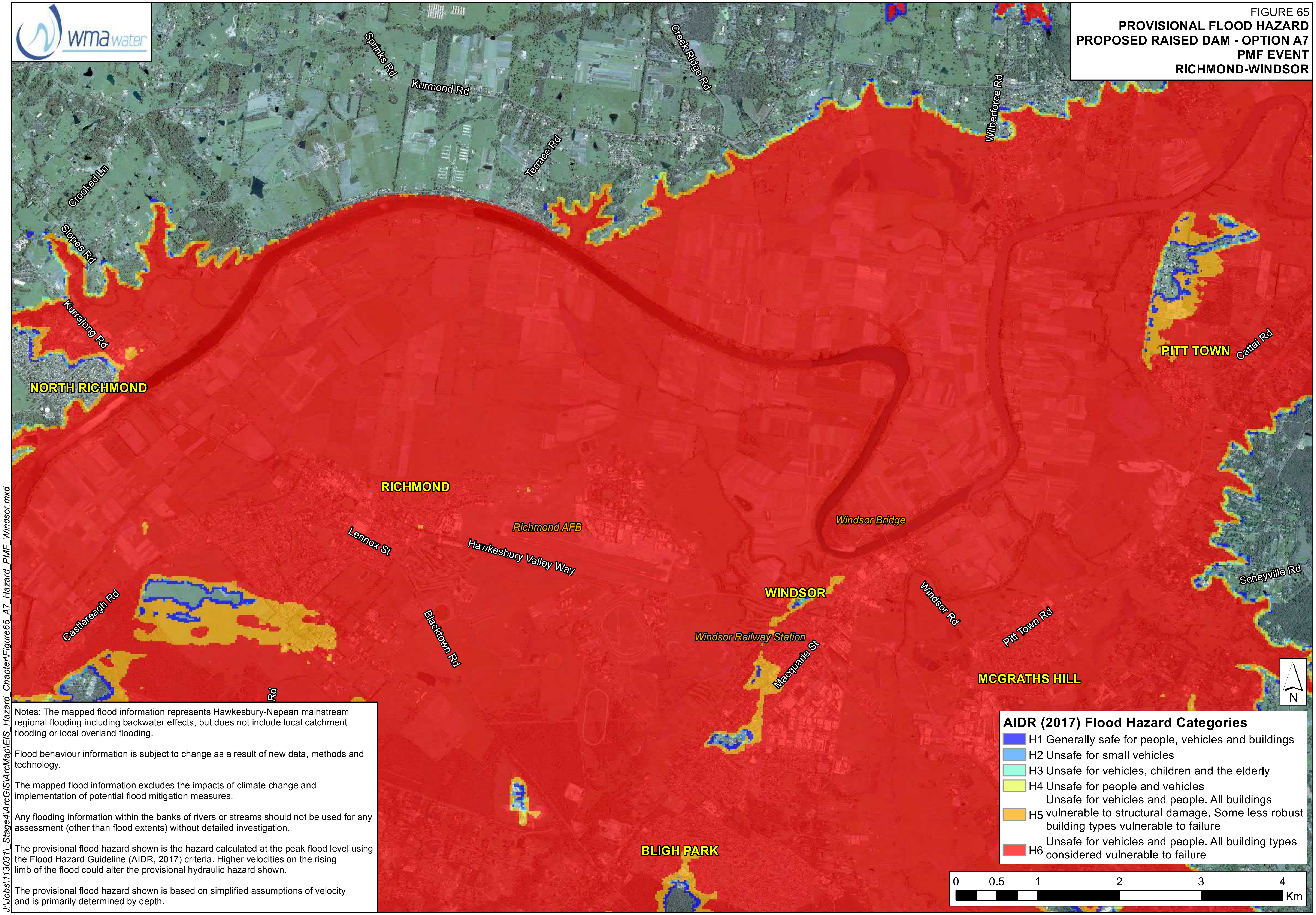
FIGURE 65
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
PMF EVENT
RICHMOND-WINDSOR



AIDR (2017) Flood Hazard Categories

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

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 66
PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
PMF EVENT
PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

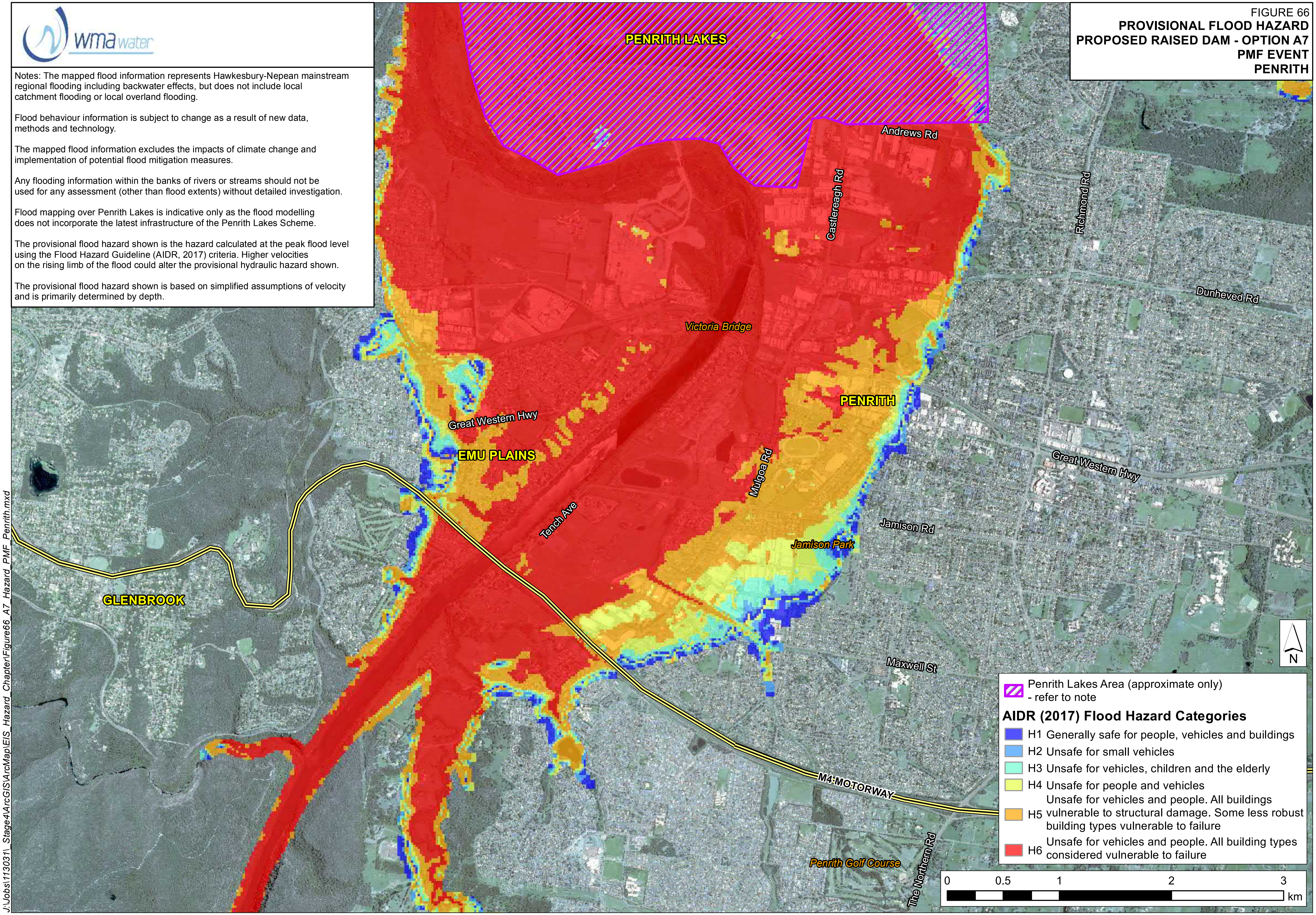
The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.



Penrith Lakes Area (approximate only) - refer to note

AIDR (2017) Flood Hazard Categories

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

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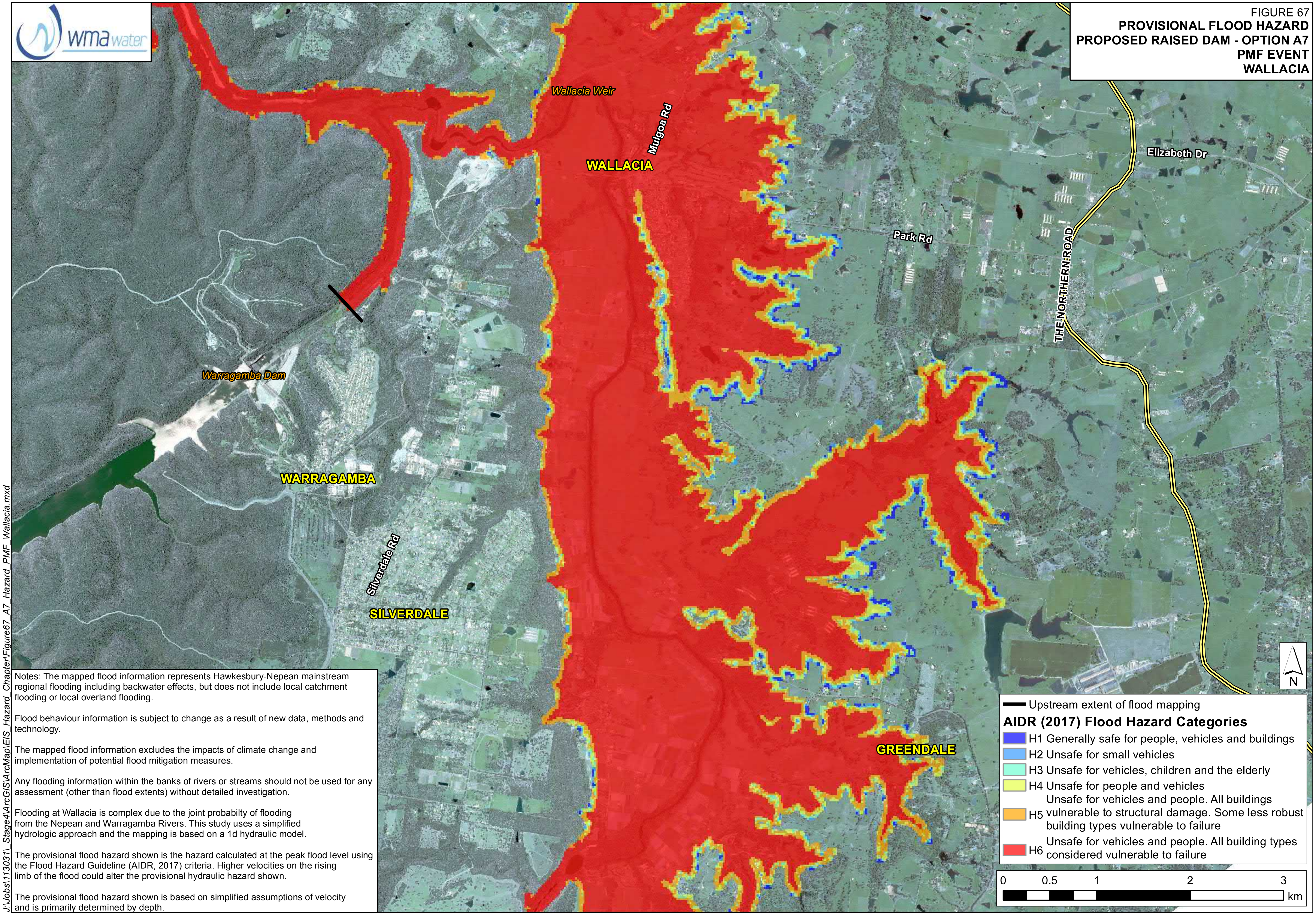
FIGURE 67

PROVISIONAL FLOOD HAZARD
PROPOSED RAISED DAM - OPTION A7
PMF EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

FIGURE 68
HYDRAULIC CATEGORISATION PROPOSED RAISED DAM - OPTION A7 1 IN 100 AEP EVENT FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).

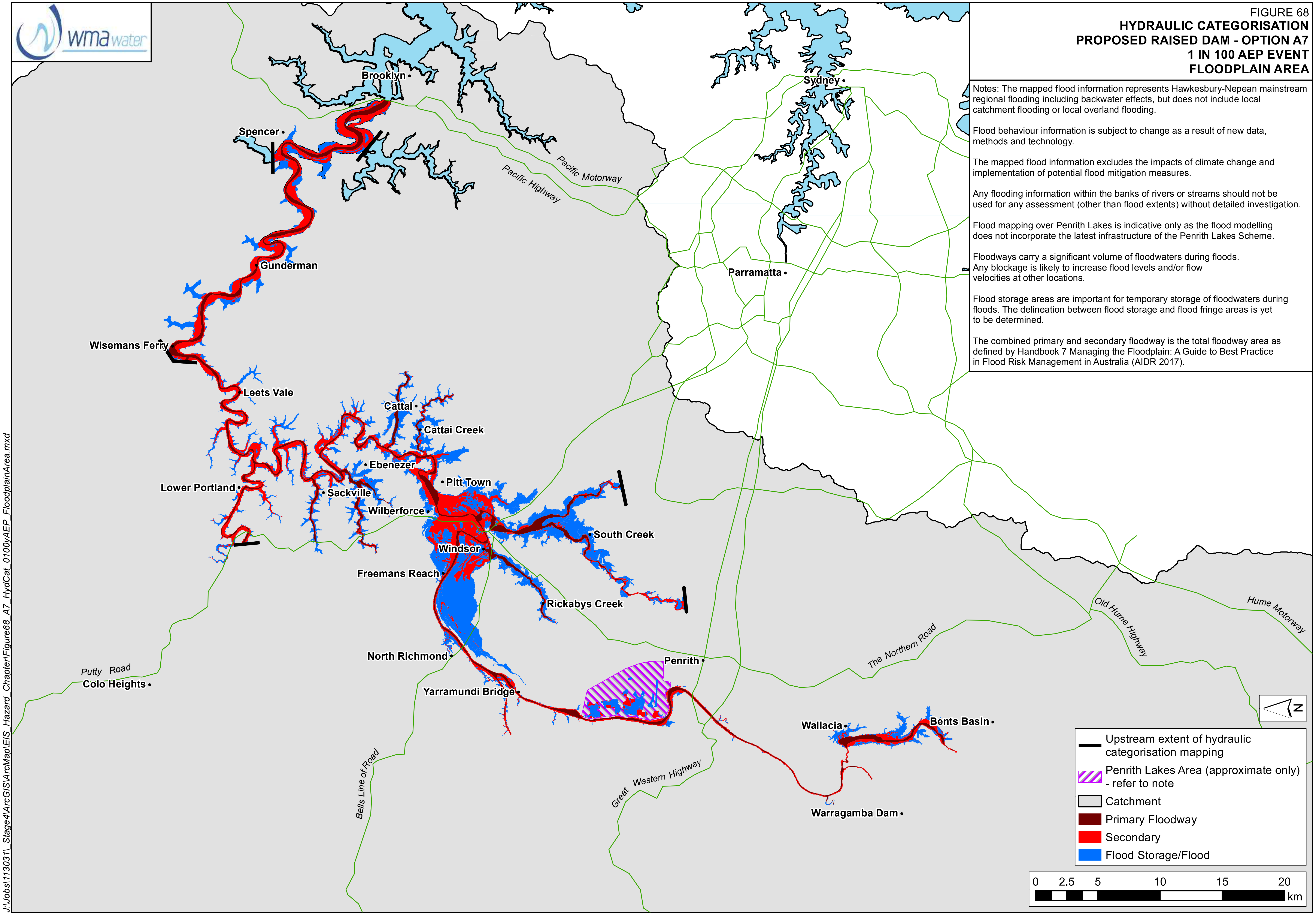


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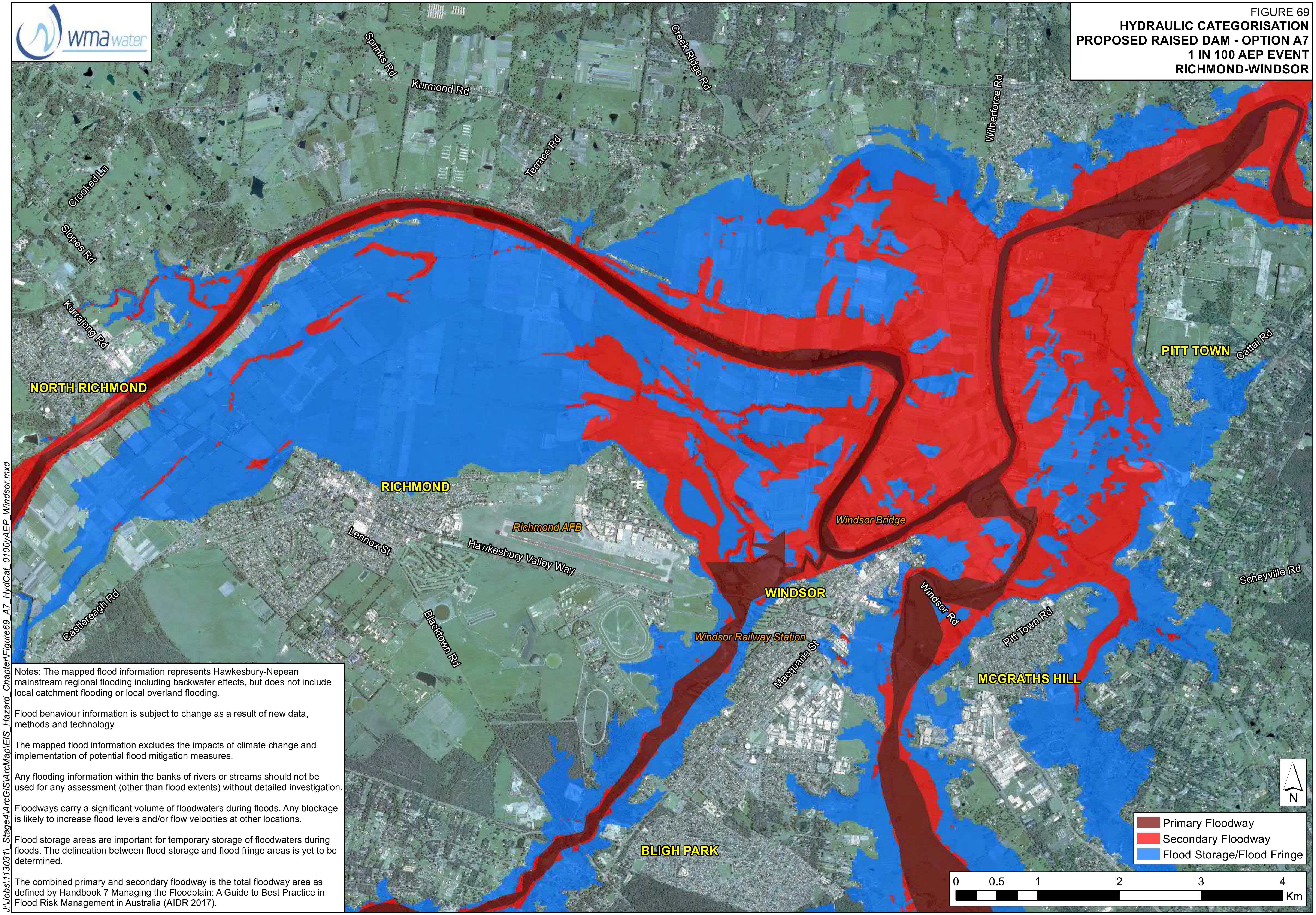
FIGURE 69
HYDRAULIC CATEGORISATION PROPOSED RAISED DAM - OPTION A7 1 IN 100 AEP EVENT RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).

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FIGURE 70

HYDRAULIC CATEGORISATION
PROPOSED RAISED DAM - OPTION A7
1 IN 100 AEP EVENT
PENRITH

wmawater

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

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Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).

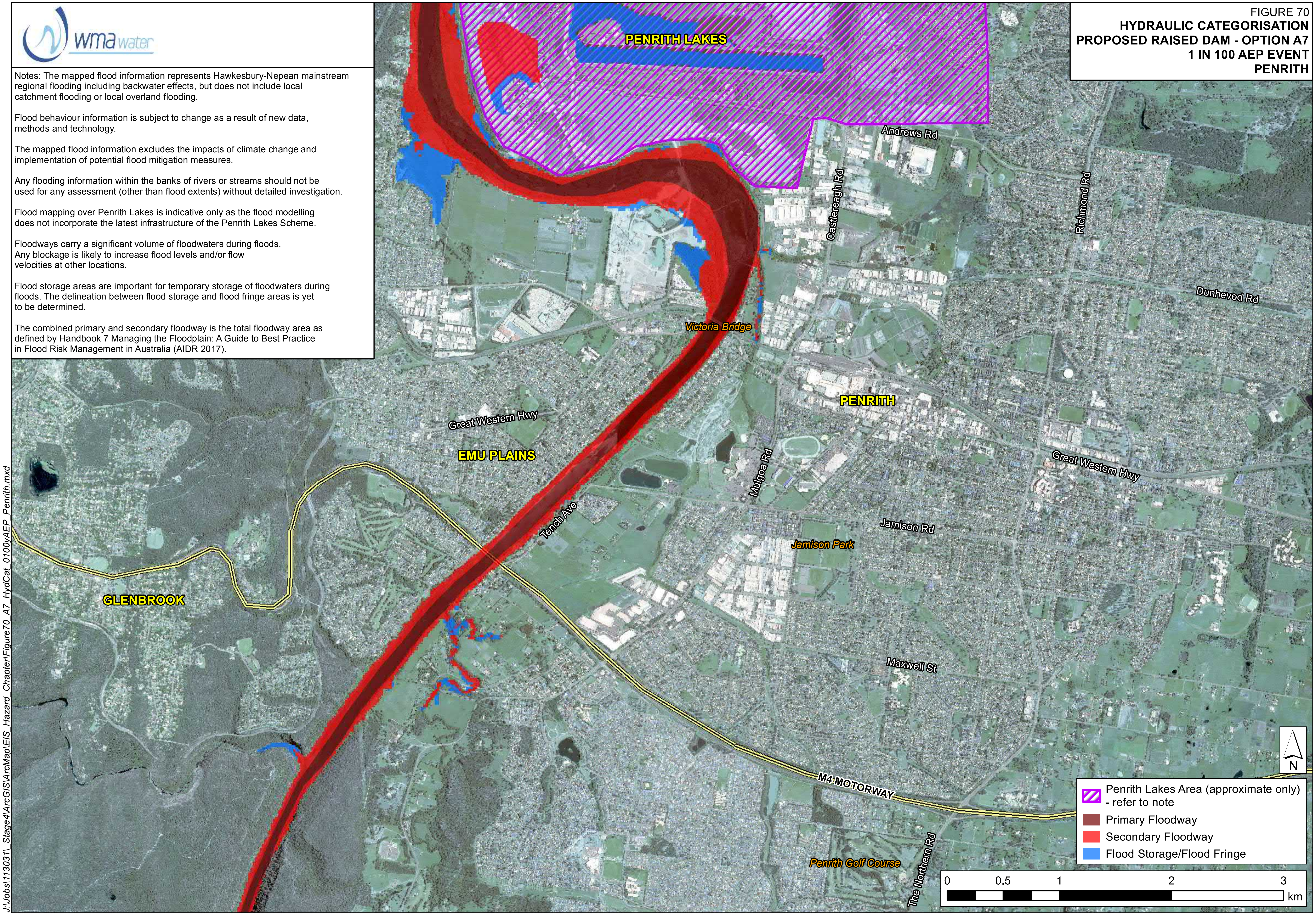

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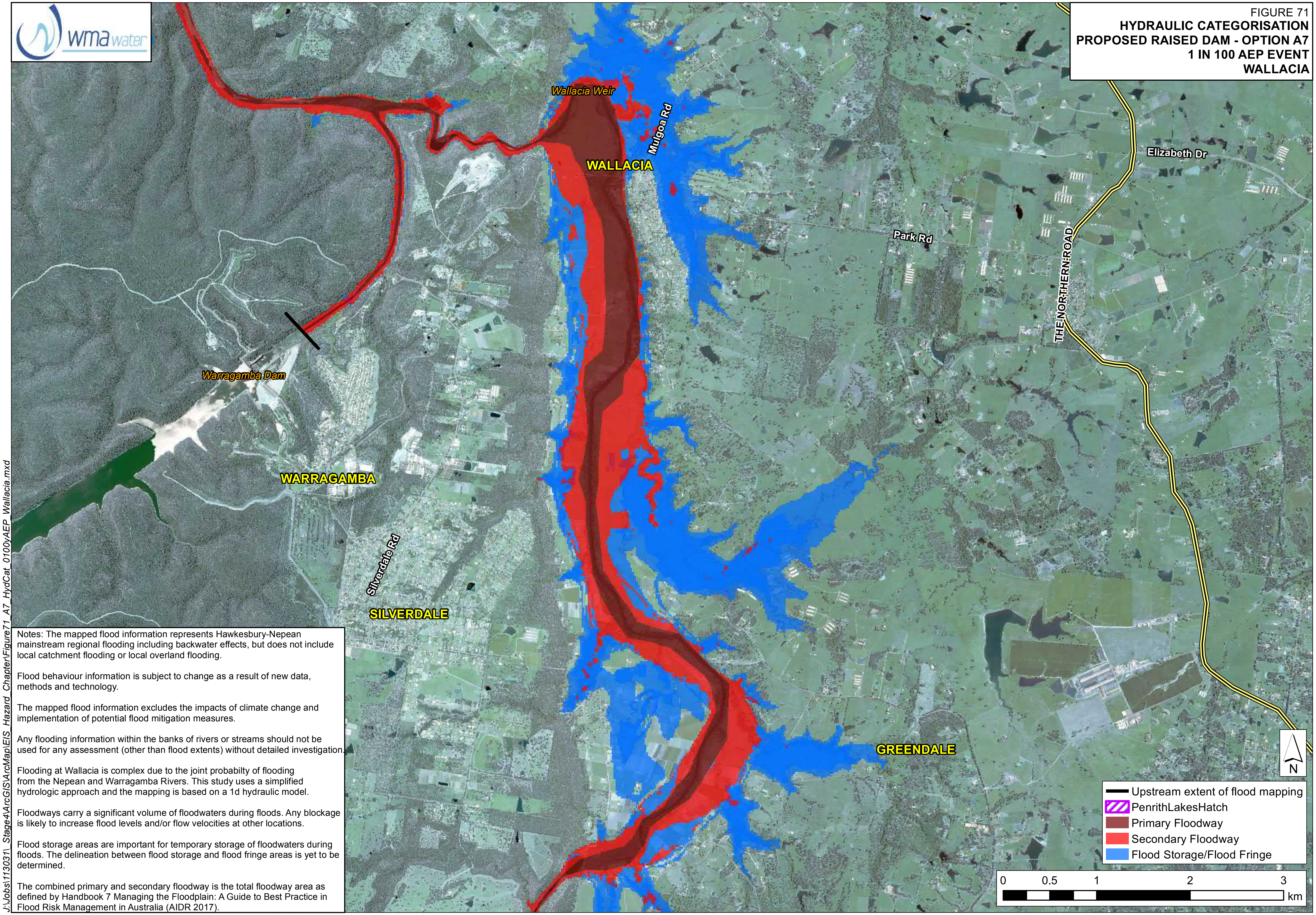
FIGURE 71
HYDRAULIC CATEGORISATION
PROPOSED RAISED DAM - OPTION A7
1 IN 100 AEP EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

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FIGURE 72
HYDRAULIC CATEGORISATION PROPOSED RAISED DAM - OPTION A7 1 IN 500 AEP EVENT FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

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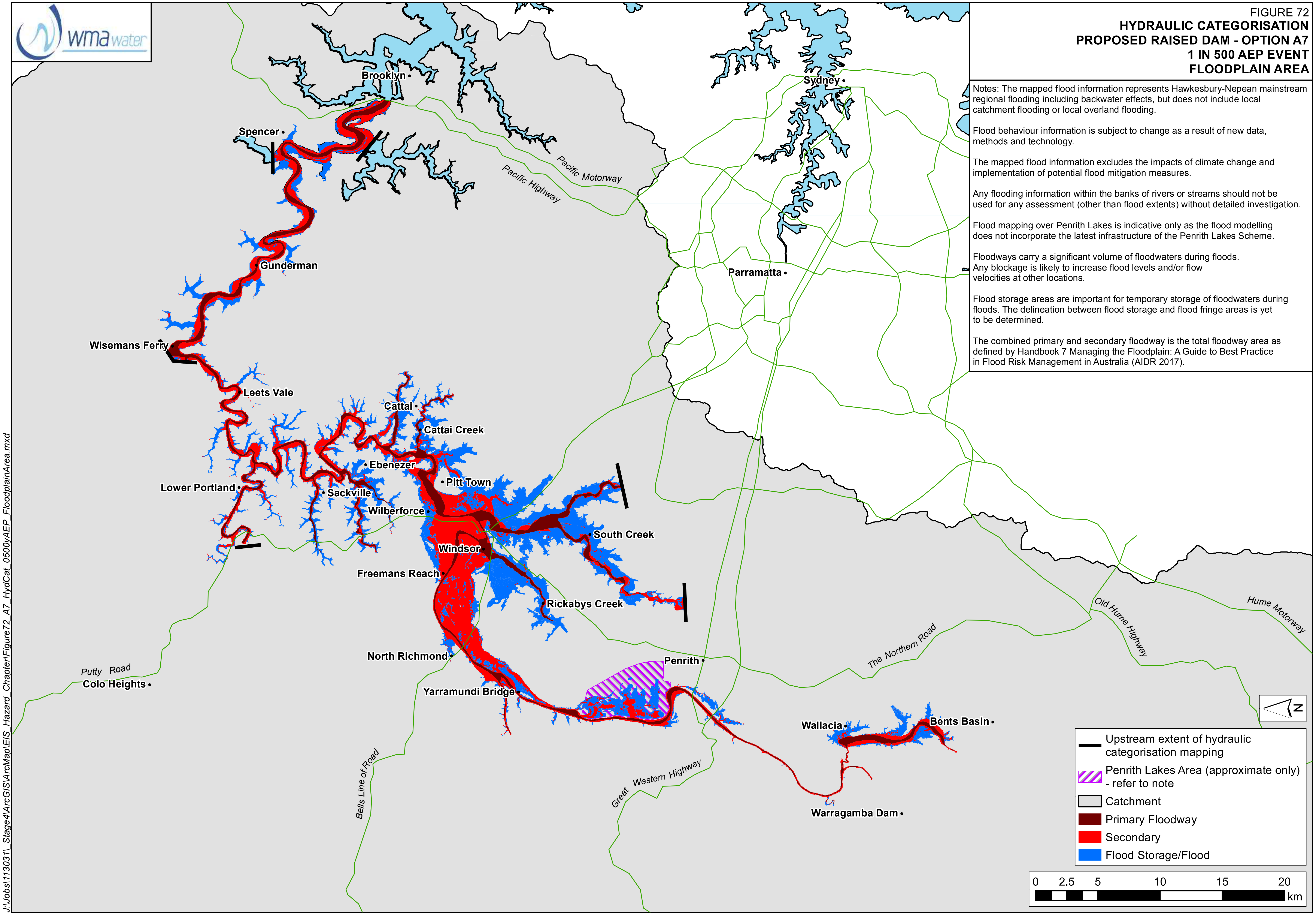

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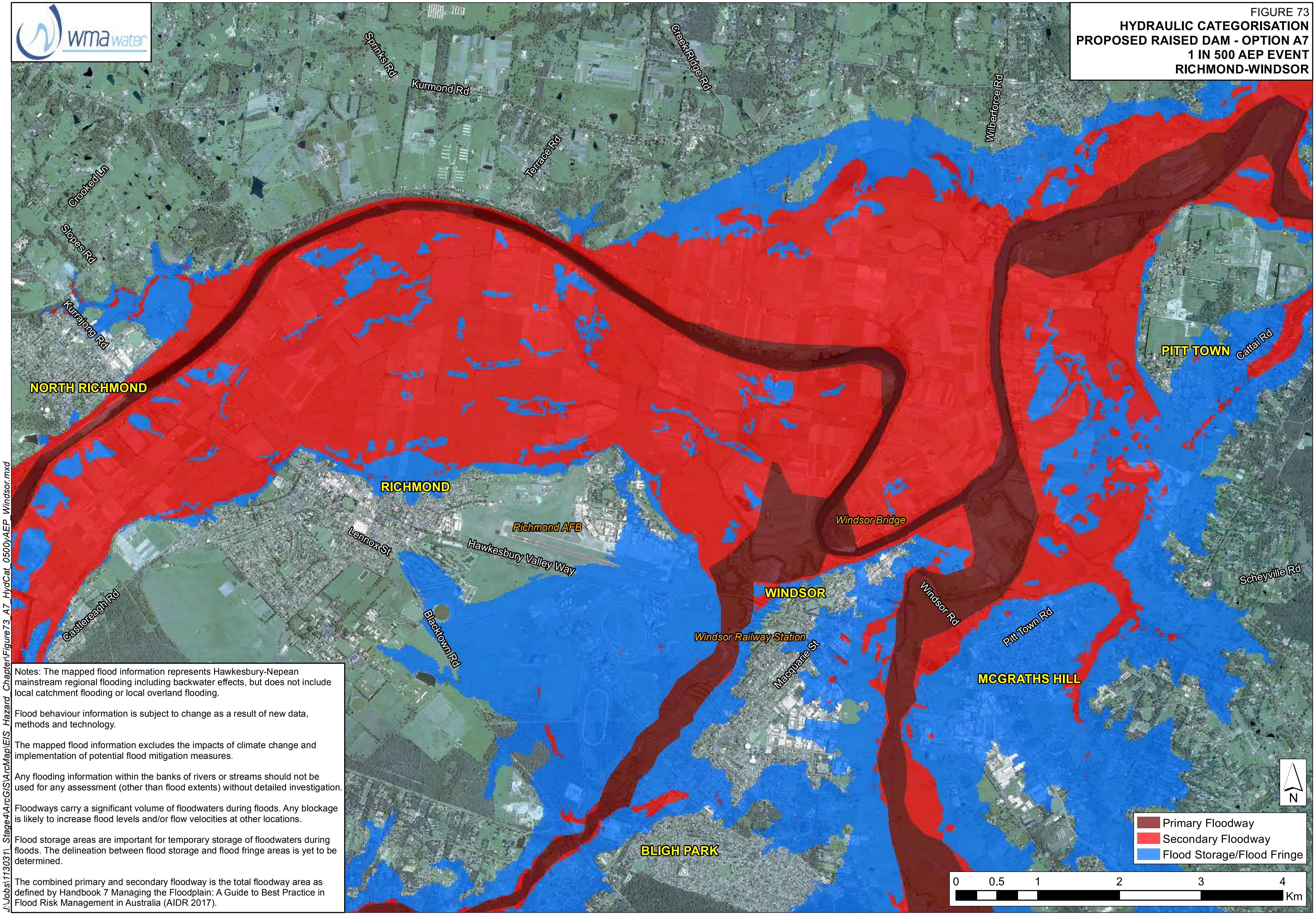
FIGURE 73
HYDRAULIC CATEGORISATION
PROPOSED RAISED DAM - OPTION A7
1 IN 500 AEP EVENT
RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

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Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).

FIGURE 74
HYDRAULIC CATEGORISATION PROPOSED RAISED DAM - OPTION A7 1 IN 500 AEP EVENT PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

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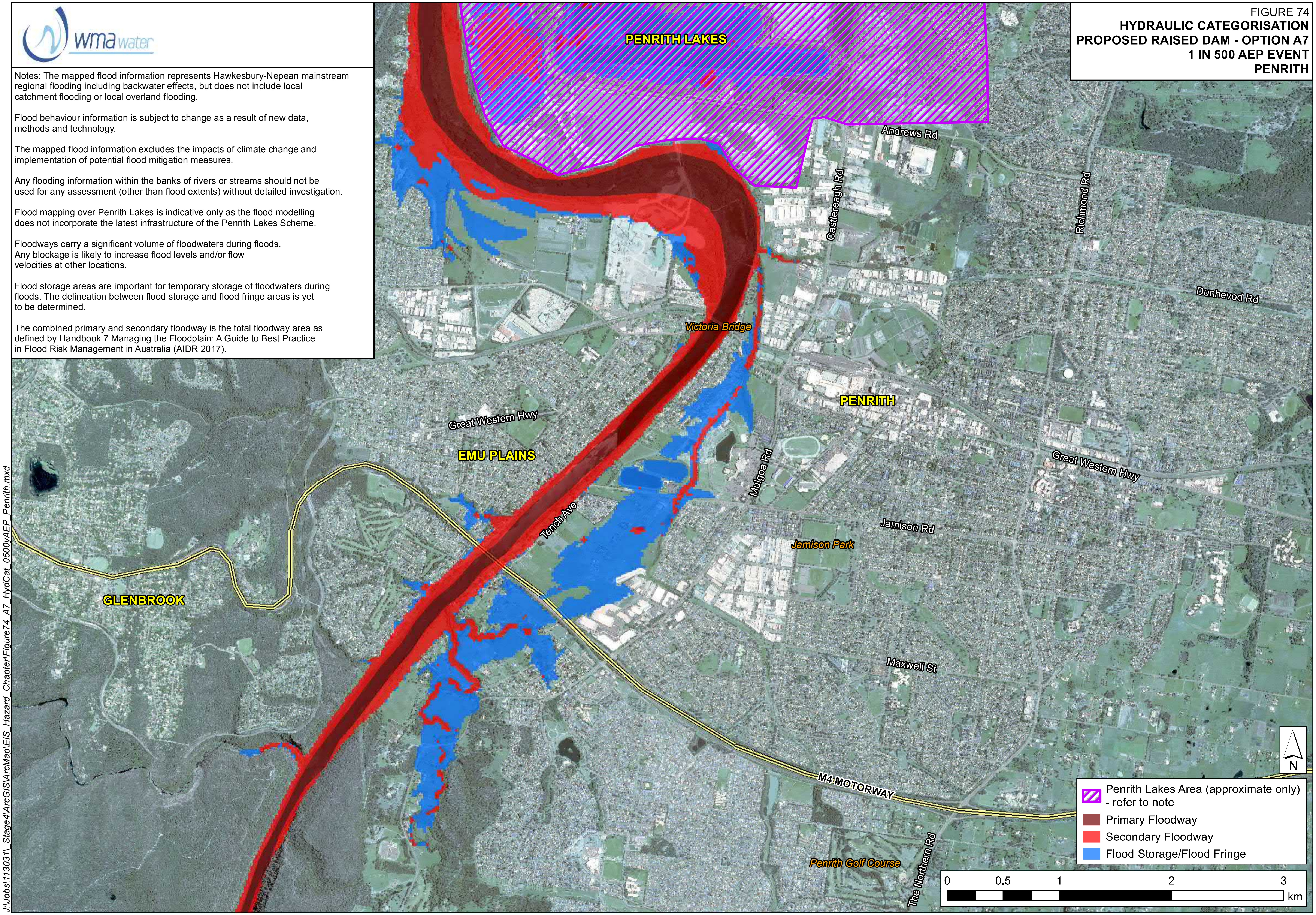

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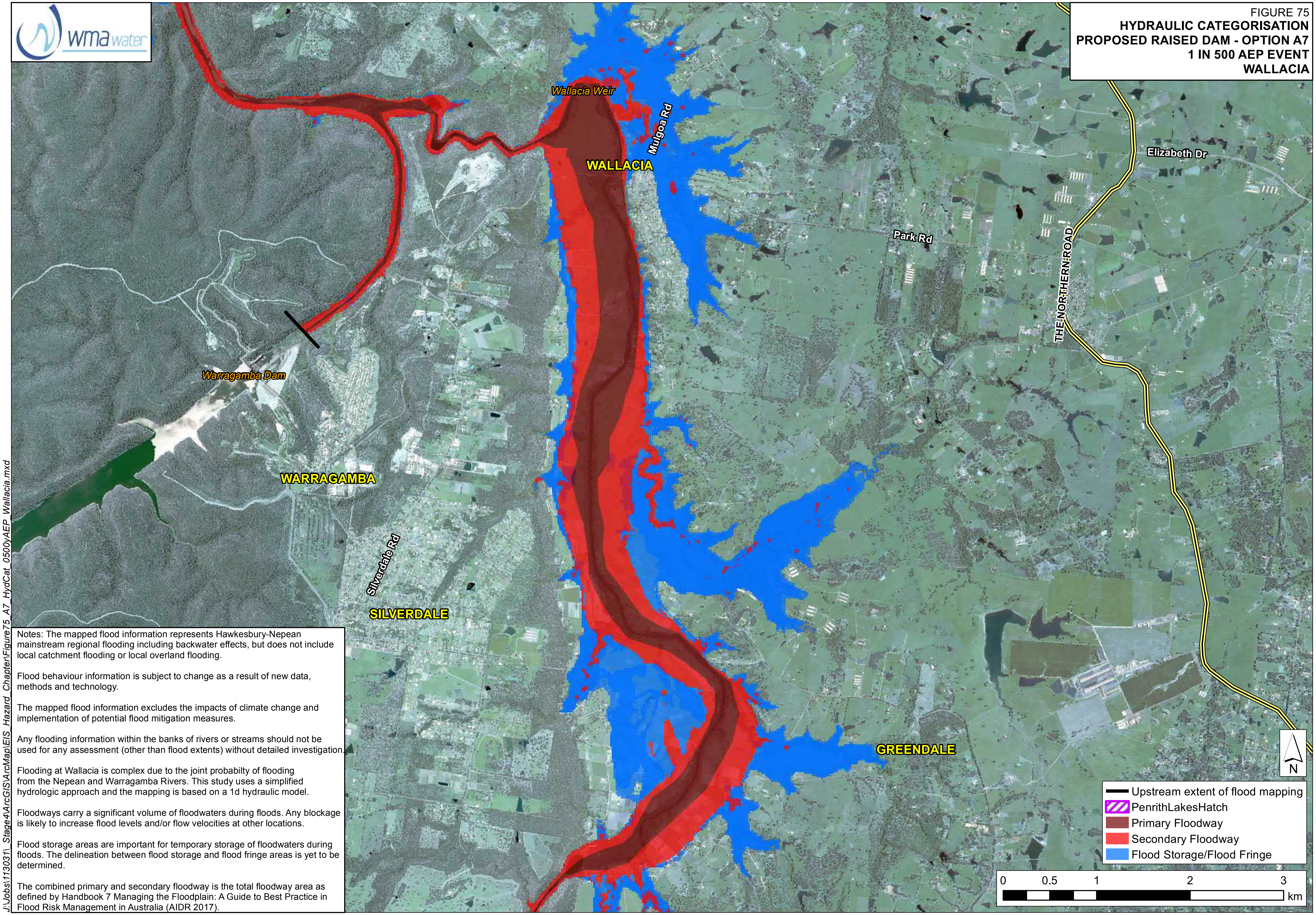
FIGURE 75
HYDRAULIC CATEGORISATION
PROPOSED RAISED DAM - OPTION A7
1 IN 500 AEP EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flooding at Wallacia is complex due to the joint probabilty of flooding from the Nepean and Warragamba Rivers. This study uses a simplified hydrologic approach and the mapping is based on a 1d hydraulic model.

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Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).

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FIGURE 76

PROVISIONAL FLOOD HAZARD STEADY STATE 100GL/D EVENT FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

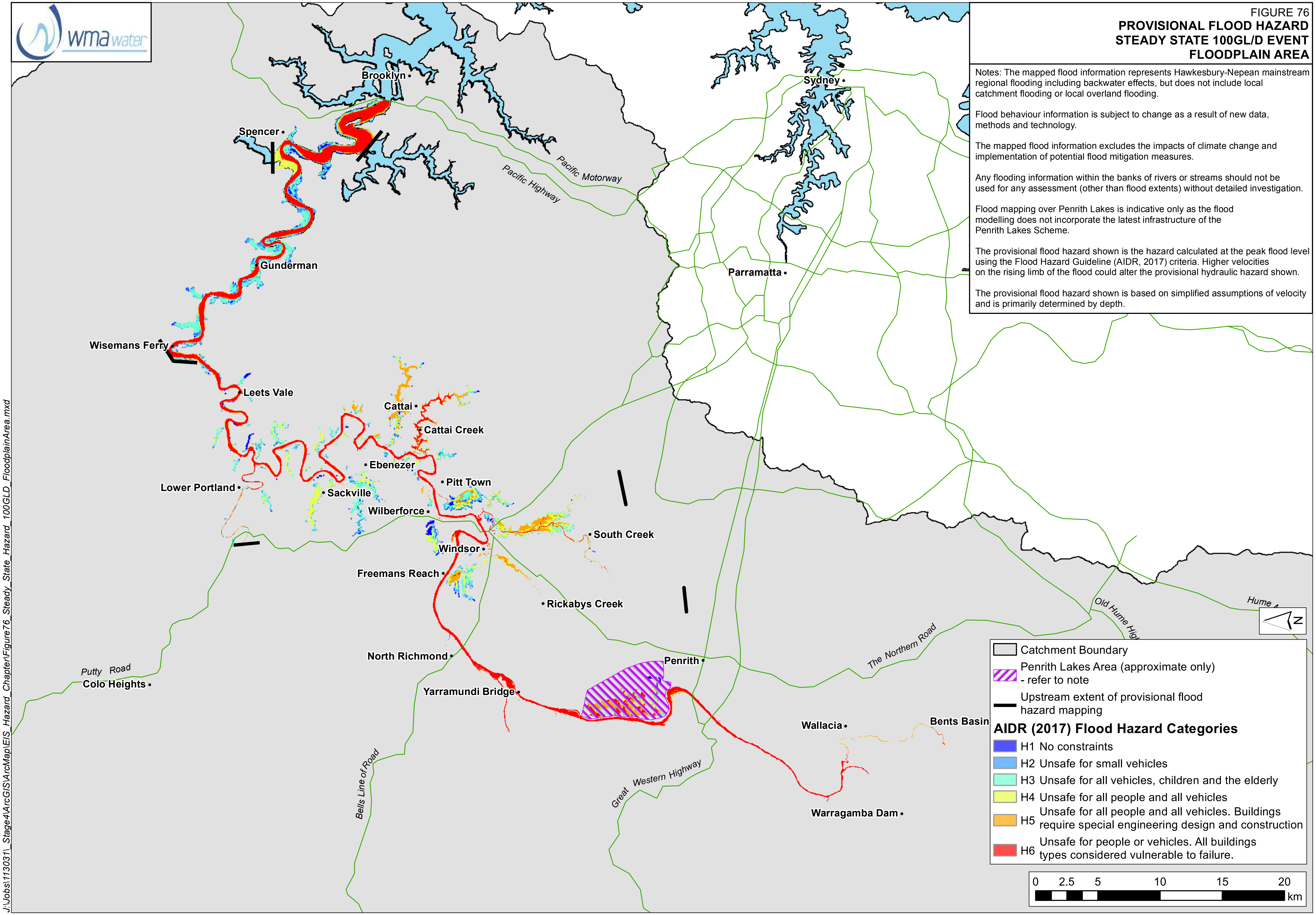

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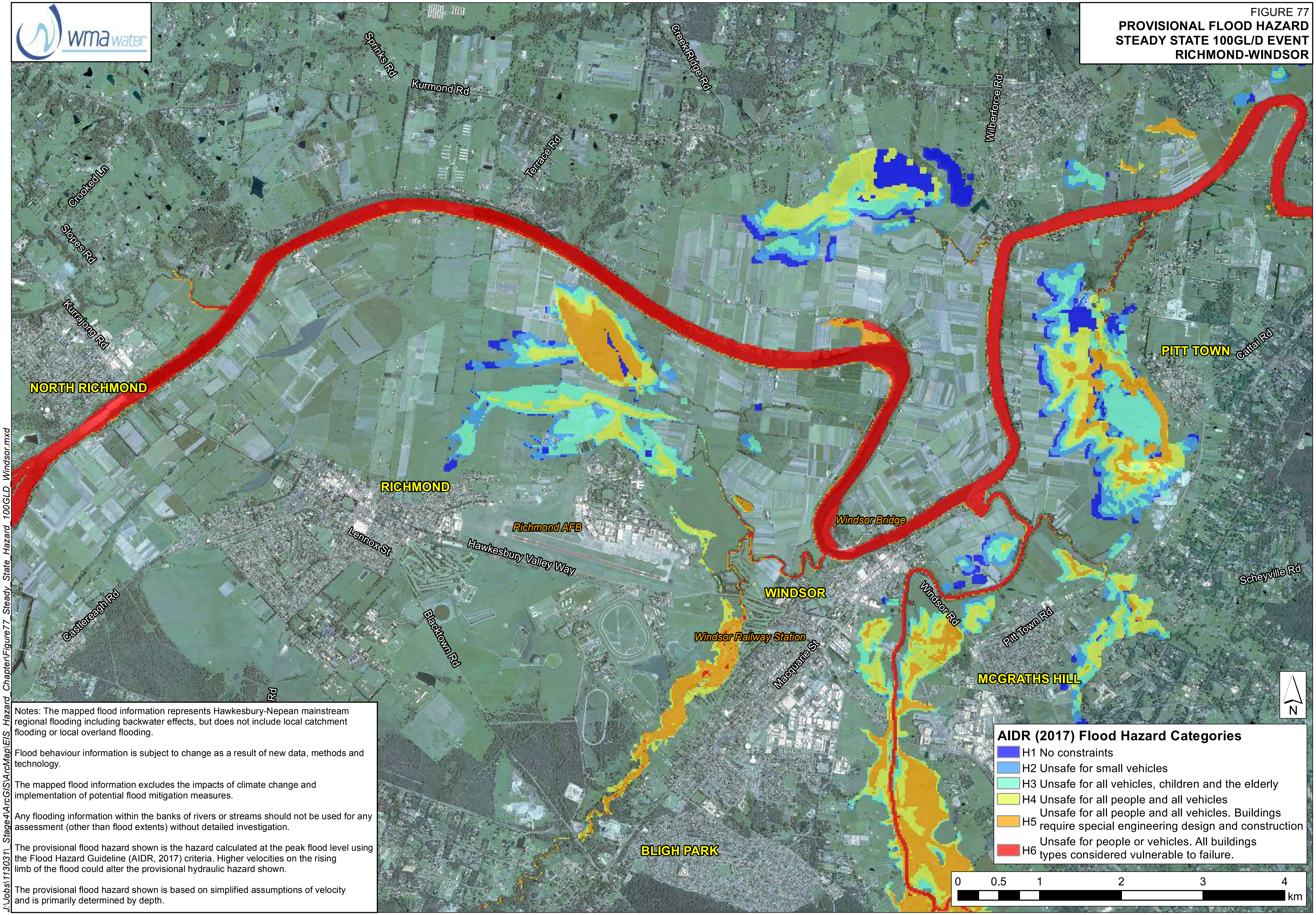
FIGURE 77
PROVISIONAL FLOOD HAZARD
STEADY STATE 100GL/D EVENT
RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 78
PROVISIONAL FLOOD HAZARD
STEADY STATE 100GL/D EVENT
PENRITH

wmawater

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

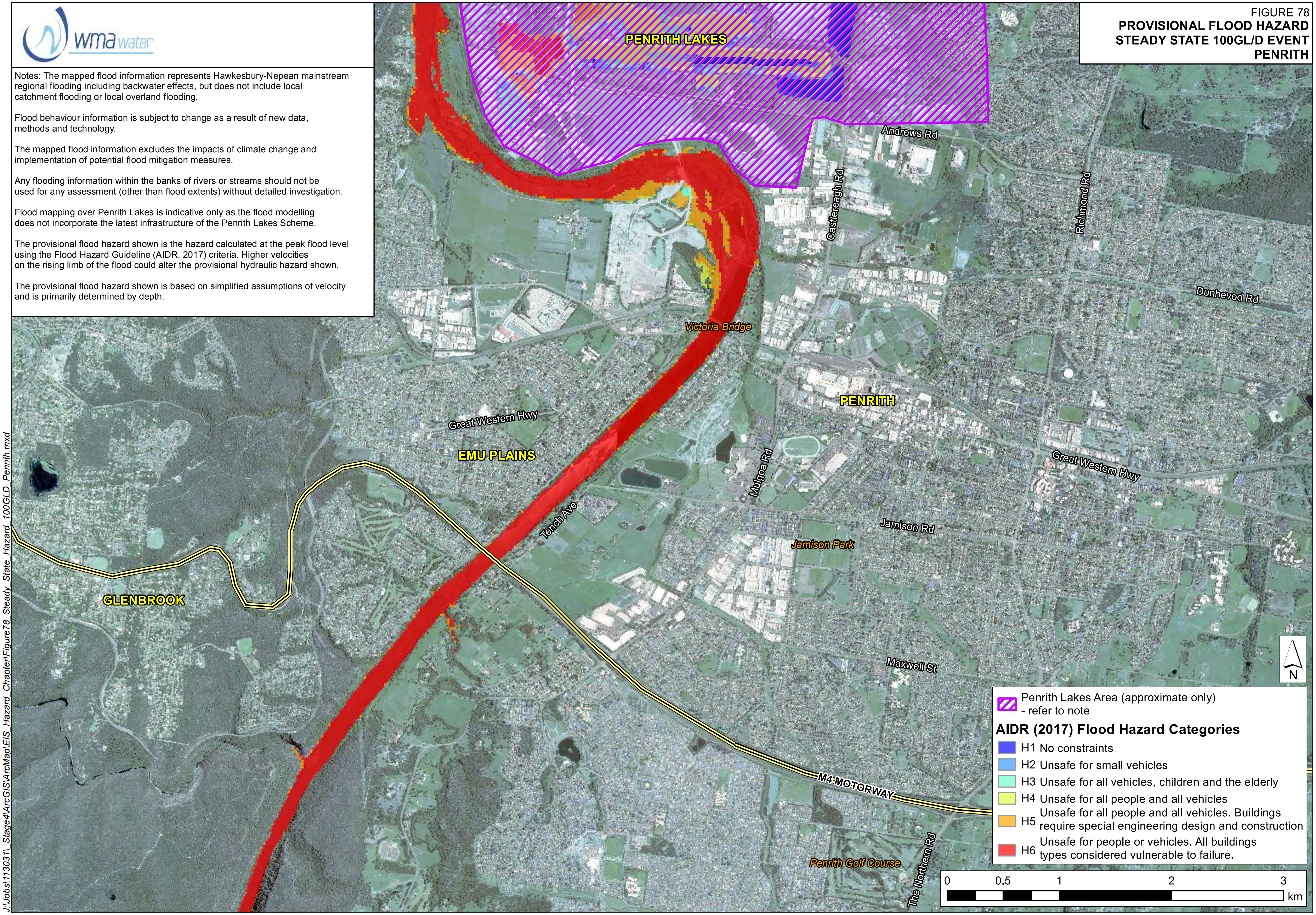
The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

The provisional flood hazard shown is the hazard calculated at the peak flood level using the Flood Hazard Guideline (AIDR, 2017) criteria. Higher velocities on the rising limb of the flood could alter the provisional hydraulic hazard shown.

The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.



Penrith Lakes Area (approximate only) - refer to note

AIDR (2017) Flood Hazard Categories

- H1 No constraints
- H2 Unsafe for small vehicles
- H3 Unsafe for all vehicles, children and the elderly
- H4 Unsafe for all people and all vehicles
- H5 Unsafe for all people and all vehicles. Buildings require special engineering design and construction
- H6 Unsafe for people or vehicles. All buildings types considered vulnerable to failure.

0 0.5 1 2 3 km

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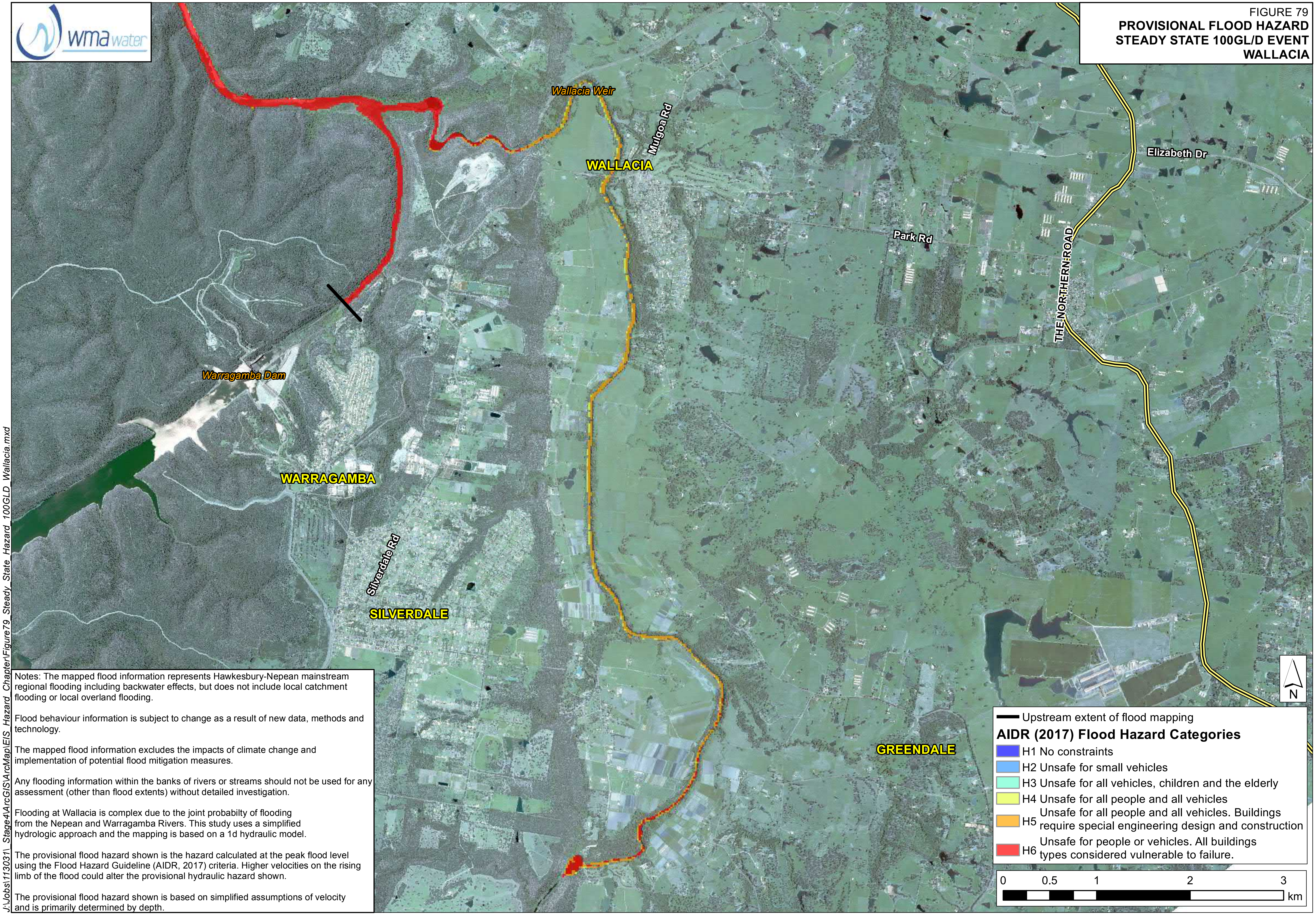
FIGURE 79
PROVISIONAL FLOOD HAZARD
STEADY STATE 100GL/D EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

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The provisional flood hazard shown is based on simplified assumptions of velocity and is primarily determined by depth.

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FIGURE 80
HYDRAULIC CATEGORISATION STEADY STATE 100GL/D EVENT FLOODPLAIN AREA

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

Any flooding information within the banks of rivers or streams should not be used for any assessment (other than flood extents) without detailed investigation.

Flood mapping over Penrith Lakes is indicative only as the flood modelling does not incorporate the latest infrastructure of the Penrith Lakes Scheme.

Floodways carry a significant volume of floodwaters during floods. Any blockage is likely to increase flood levels and/or flow velocities at other locations.

Flood storage areas are important for temporary storage of floodwaters during floods. The delineation between flood storage and flood fringe areas is yet to be determined.

The combined primary and secondary floodway is the total floodway area as defined by Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017).

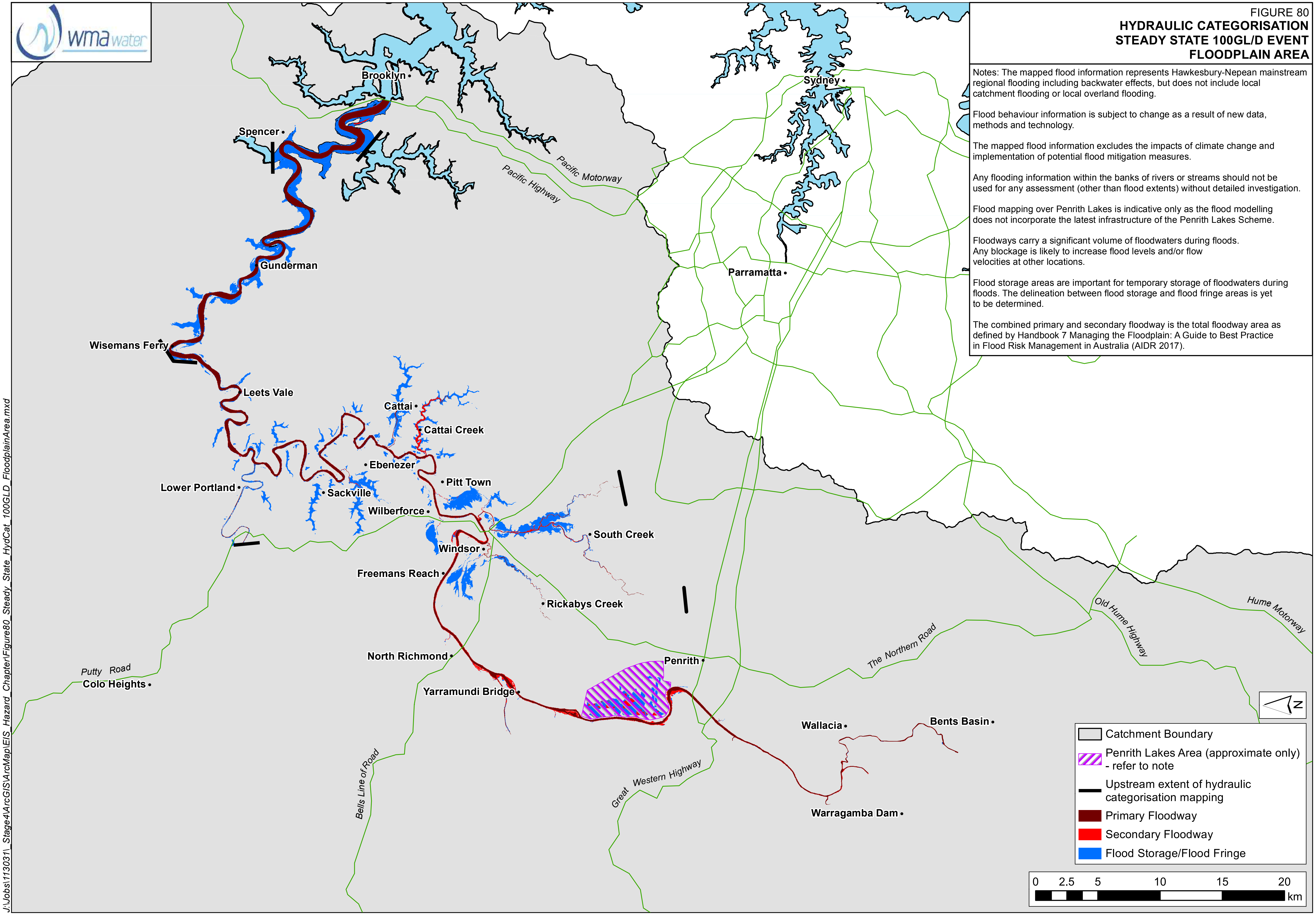
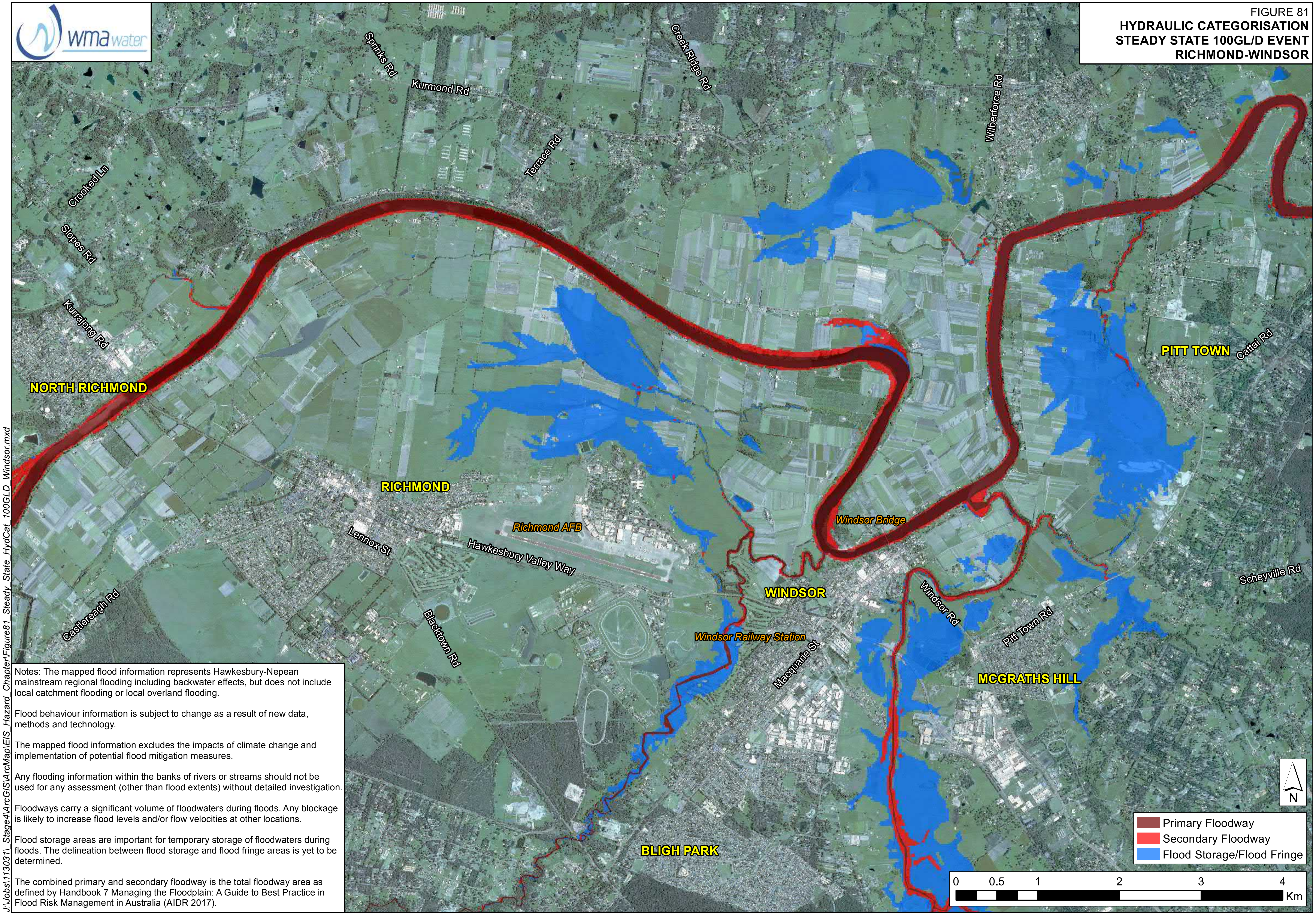


FIGURE 81
HYDRAULIC CATEGORISATION
STEADY STATE 100GL/D EVENT
RICHMOND-WINDSOR



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

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FIGURE 82
HYDRAULIC CATEGORISATION STEADY STATE 100GL/D EVENT PENRITH

Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

Flood behaviour information is subject to change as a result of new data, methods and technology.

The mapped flood information excludes the impacts of climate change and implementation of potential flood mitigation measures.

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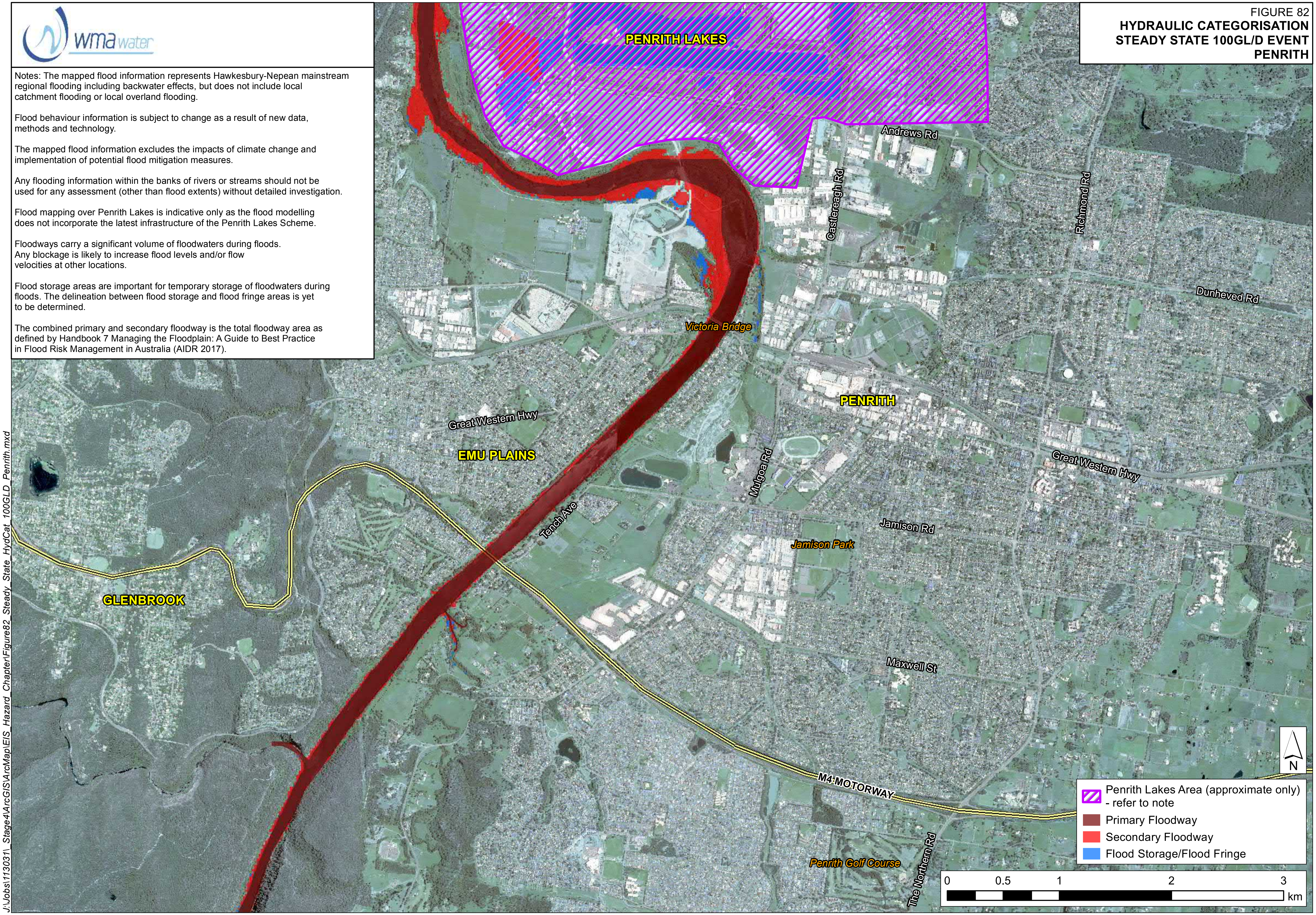

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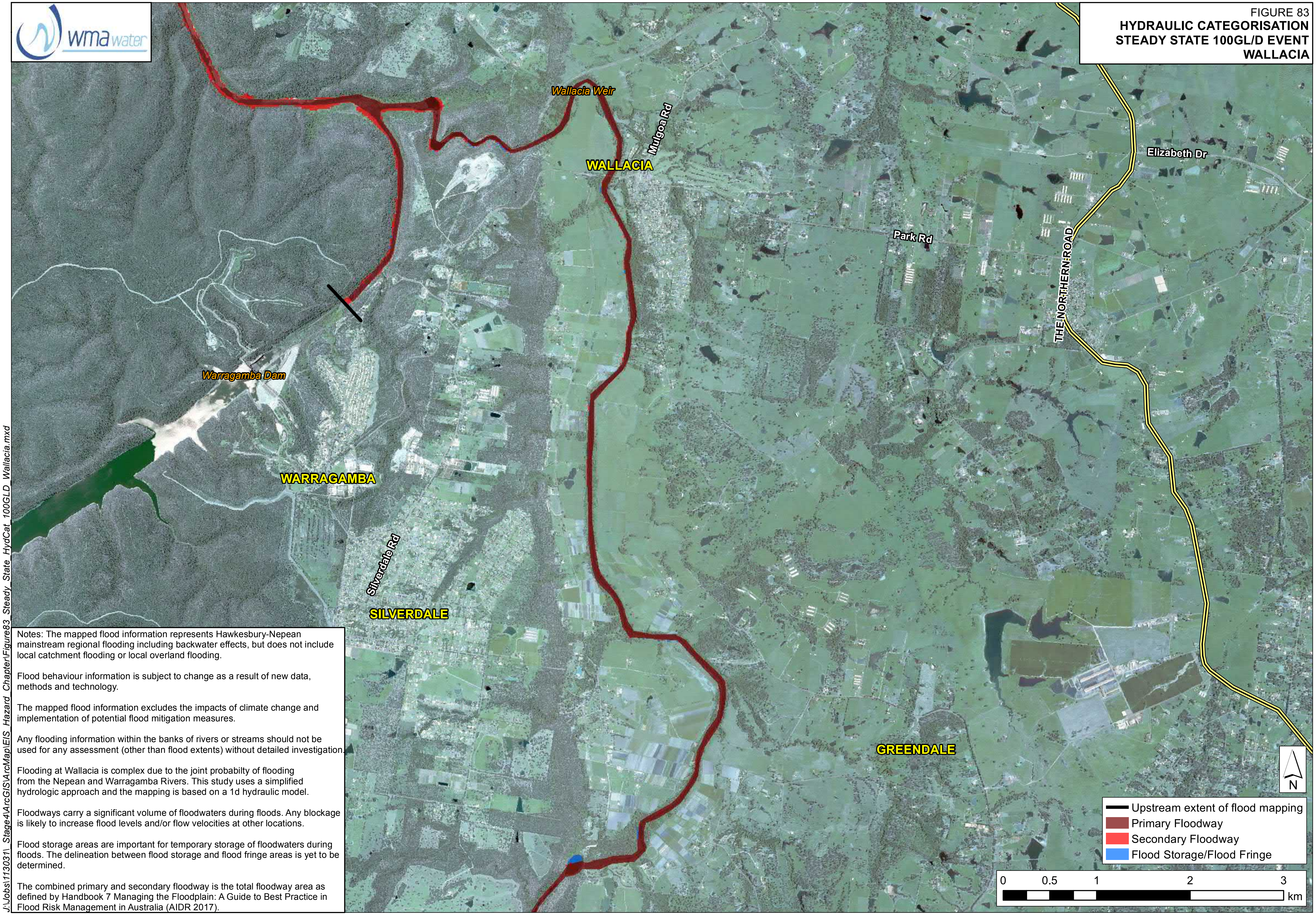
FIGURE 83

HYDRAULIC CATEGORISATION
STEADY STATE 100GL/D EVENT
WALLACIA



Notes: The mapped flood information represents Hawkesbury-Nepean mainstream regional flooding including backwater effects, but does not include local catchment flooding or local overland flooding.

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