Attachment 2 to Item 10.3.1.

Draft Macdonald River, Colo River, Webbs Creek and Greens Creek Floodplain Risk Management Study – Report

Date of meeting: 18 February 2025
Location: Council Chambers
Time: 6:30pm

Macdonald River, Colo River

Macdonald River, Colo River, Webbs Creek & Greens Creek

Flood Risk Management Study

DRAFT

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Cover photo – photo of the Colo River near the Upper Colo Gauge, June 2020.

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Report Structure

The reporting for the Macdonald River, Colo River, Webbs Creek & Greens Creek Flood Study and Flood Risk Management Study and Plan has been presented in four key documents:

- **Flood Study** – establishes the existing flood behaviour and function within the study area.
- **The Flood Risk Management Study** – details the assessment undertaken on existing flood risk and investigates flood risk management options .
- **Flood Risk Management Plan** – presents an implementation strategy for Council to prioritise flood risk management options.
- **Map Compendium** – a set of A3 maps as referenced in the Flood Study, Flood Risk Management Study and Flood Risk Management Plan.

Foreword

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

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

The *NSW Flood Risk Management Manual* (NSW Government, 2023a) is provided to assist councils to meet their obligations through the preparation and implementation of flood risk management plans, through a staged process. **Figure F1**, taken from this manual, documents the process for plan preparation, implementation and review.

The *NSW Flood Risk Management Manual* (NSW Government, 2023a) is consistent with Australian Emergency Management Handbook 7: *Managing the floodplain: best practice in flood risk management in Australia* (AEM Handbook 7) (AIDR 2017).

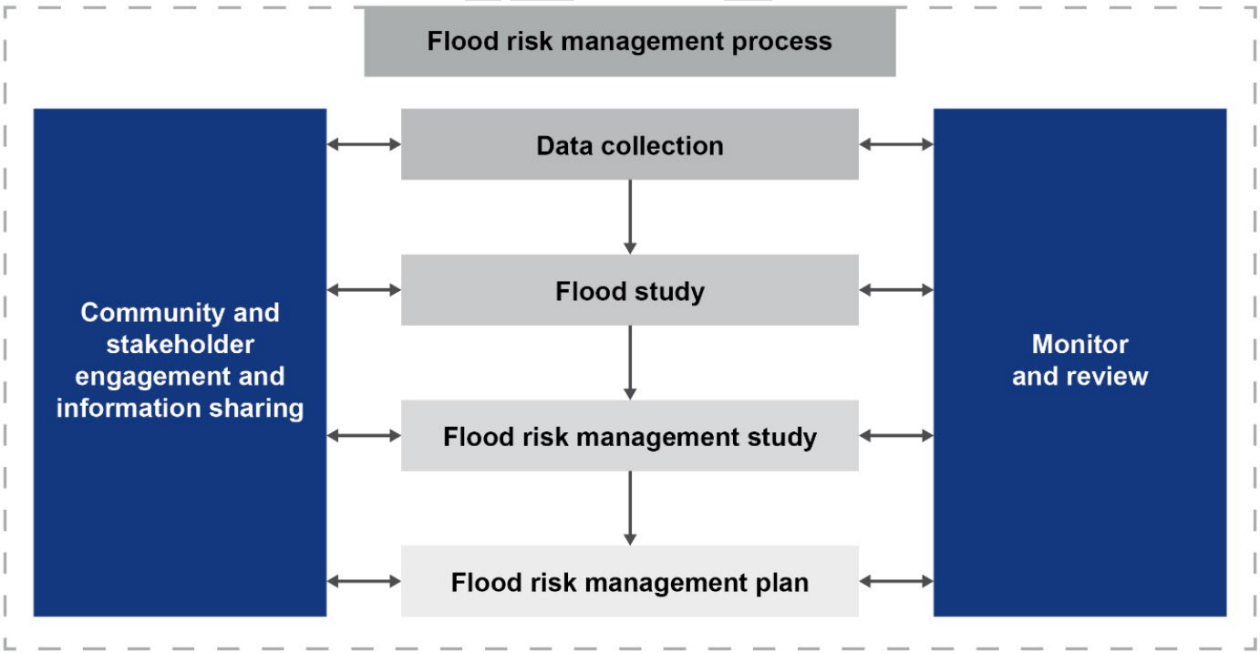

Figure F1. The Flood Risk Management Process (source: NSW Government, 2023a)

Executive Summary

The Combined Macdonald River, Colo River, Webbs Creek and Greens Creek Flood Study has been prepared for Hawkesbury City Council (Council) to refine the understanding of flood risk in the study area.

Flooding is a known risk within the study area, affecting private and public property and access during and after flood events. The flooding of key crossings also restricts the response of emergency personnel during emergencies. Each catchment is also affected by backwater flooding from the Hawkesbury River, which can also exacerbate the isolation risk.

Study Area

The study area includes four catchments: the Macdonald River, Colo River, Webbs Creek, and Greens Creek. Each catchment discharges into the Hawkesbury River. The catchments within the study area are varied, with the Colo River covering 4,640 km², the Macdonald River 1,845 km², Webbs Creek 363 km², and Greens Creek 10 km².

The topography throughout the study area is predominantly steep, with the river flowing through valleys that are semi confined by sandstone. Due to the semi-confined valley topography, flood levels, particularly in the Colo and MacDonald Rivers, can reach significant heights.

Objectives

The overall objective of this study is to improve understanding of flood behaviour and impacts, and better inform management of flood risk in the study area in consideration of the available information, and relevant standards and guidelines. The project will also assist Council with planning for future development and will provide flood intelligence to the SES to enable them to progress their emergency management planning for the region.

The flood risk management study will provide an understanding of the impacts of floods on the existing and future community. Testing and investigation of practical, feasible and economic management measures to treat existing, future, and residual risk has also been undertaken. Recommendations for the implementation and staging of these measures will be detailed in the flood risk management plan (FRMP).

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

Property Flooding and Flood Damages

A damages assessment has also been undertaken to quantify the existing flood damages based on design flood events within the study area. The results are summarised in **Table i**.

The average annual damage (AAD) for the study area under existing conditions is **$3,378,798**. Over a 50-year assessment period and under a five per cent discount rate, this is equivalent to a Net Present Value (NPV) of **$95 million**.

Table i Existing Damages Assessment Results

Event	Over-ground Flooding	Over-floor Flooding	Max Over-floor Depth (m)	Total Damages ($2024)[1]
PMF	509	508	35.9	$166,624,453
0.1% AEP	276	264	13.0	$80,494,966
0.2% AEP	243	236	11.5	$71,900,818
0.5% AEP	206	199	9.7	$59,819,742
1% AEP	182	170	8.2	$48,502,900
2% AEP	155	149	7.4	$40,834,358
5% AEP	89	85	5.9	$21,091,314
10% AEP	49	39	4.0	$8,151,039
20% AEP	20	8	1.3	$1,488,619

Flood Risk Management

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

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

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

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

A total of 11 management options were recommended for inclusion in the Flood Risk Management Plan (FRMP), comprised of:

- Nine emergency response modification options; and,
- Two property modification options.

Details of the implementation strategy are included in the FRMP component of this study.

Outcomes and Recommendations

This report presents the findings of the Flood Risk Management Study stage of the Flood Risk Management Process for the study area, in accordance with the NSW Flood Risk Management Manual (2023). Based on the identified flood risks, a series of floodplain management options were developed.

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

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

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

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Abbreviations

1D	One Dimensional
2D	Two Dimensional
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
ARR87	Australian Rainfall and Runoff 1987
ARR2019	Australian Rainfall and Runoff 2019
BoM	Bureau of Meteorology
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DCP	Development Control Plan
DPHI	Department of Planning, Housing and Infrastructure
DEM	Digital Elevation Model
FRMP	Flood Risk Management Plan
FRMS	Flood Risk Management Study
FPRMSP	Flood Risk Management Study & Plan
ha	Hectare
IFD	Intensity Frequency Duration
km^2	Square kilometres
LEP	Local Environment Plan
LGA	Local Government Area
LiDAR	Light Detection and Ranging
m	metre
m^2	Square metres
m^3	Cubic metres
mAHD	metres to Australian Height Datum
mm	millimetres
m/s	metres per second
NSW	New South Wales
OEH	Office of Environment and Heritage (NSW)
OEM	Office of Emergency Management
PMF	Probable Maximum Flood
RMS	Roads and Maritime Services
SES	State Emergency Service (NSW)

1 Introduction

The Macdonald River, Colo River, Webbs Creek and Greens Creek Flood Study and Flood Risk Management Study and Plan (FRMSP) has been prepared for the Hawkesbury City Council (Council) in accordance with the New South Wales (NSW) Flood Prone Land Policy and the Flood Risk Management Manual (NSW Government, 2023a) and its supporting guidelines.

The overall objective of this study is to improve the understanding of flood behaviour and impacts to inform the management of flood risk in the study area.

The project incorporates three key components:

- **The Flood Study.** The flood study defines flood behaviour to better inform flood risk management. The flood study considers available information, previous studies and relevant standards and guidelines including Australian Rainfall and Runoff (2019) and the latest climate change guidance. The flood study considers mainstream flooding only and does not consider local overland flow.
- **Flood Risk Management Study.** The FRMS evaluates a range of measures (including emergency response, property modification and flood modification measures) to address the flood risk and inform the development of a Flood Risk Management Plan.
- **Flood Risk Management Plan.** The FRMP provides a strategic level plan for Council to manage the flood risk in the study areas moving into the future.

The overall objective of these documents is to improve understanding of flood behaviour and impacts, and better inform management of flood risk in the study area in consideration of the available information, and relevant standards and guidelines. These documents include investigations across all aspects of flood risk management and can continue to be used for this purpose into the future.

The FRMS (this document) provides an increased understanding of the impacts of floods on the existing and future community. It also develops, tests and assesses new practical, feasible and economic management measures to treat existing, future and residual risk. This study provides the basis for informing development of a FRMP.

The Flood Study, FRMS and FRMP, together provide an understanding of, and information on, flood behaviour and associated risk to inform:

- relevant government information systems
- government and strategic decision makers on flood risk
- the community and key stakeholders on flood risk
- flood risk management planning for existing and future development
- emergency management planning for existing and future development, and strategic and development scale land-use planning to manage growth in flood risk
- decisions on insurance pricing (for the insurance industry)
- selection of practical, feasible and economic measures for treatment of risk
- development of a flood risk management plan
- development of a prioritised implementation strategy.

The outputs of the studies and plan will assist this by:

- Providing a better understanding of the:

  - variation in flood behaviour, flood function, flood hazard and flood risk in the study area
  - impacts and costs for a range of flood events or risks on the existing and future community
  - impacts of changes in climate on flood risk
  - emergency response situation and limitations
  - effectiveness of current management measures.
- Facilitating flood risk information sharing across government and with the community.

The Flood Study, FRMS and FRMP also inform decision making for investing in the floodplain; managing flood risk through prevention, preparedness, response and recovery activities, and informing and educating the community on flood risk and response to floods.

The intended end user groups which the Flood Study, FRMS and FRMP aim to support include:

- high level strategic decision makers
- the local community
- flood risk management professionals
- engineers involved in designing, constructing and maintaining mitigation works
- emergency management planners
- land-use planners
- hydrologists and meteorologists involved in flood protection and forecasting
- insurers.

1.1 Study Area

The study area incorporates four key catchments:

- Macdonald River;
- Colo River;
- Webbs Creek; and,
- Greens Creek.

An overview of the catchments and corresponding study areas is provided in **Figure 1-1**. Each catchment drains in a general south easterly direction into the Hawkesbury River and is described in further detail below. The study areas cover the lower reaches of each catchment and encompass most of the developed and rural land relevant to the Hawkesbury City Council LGA.

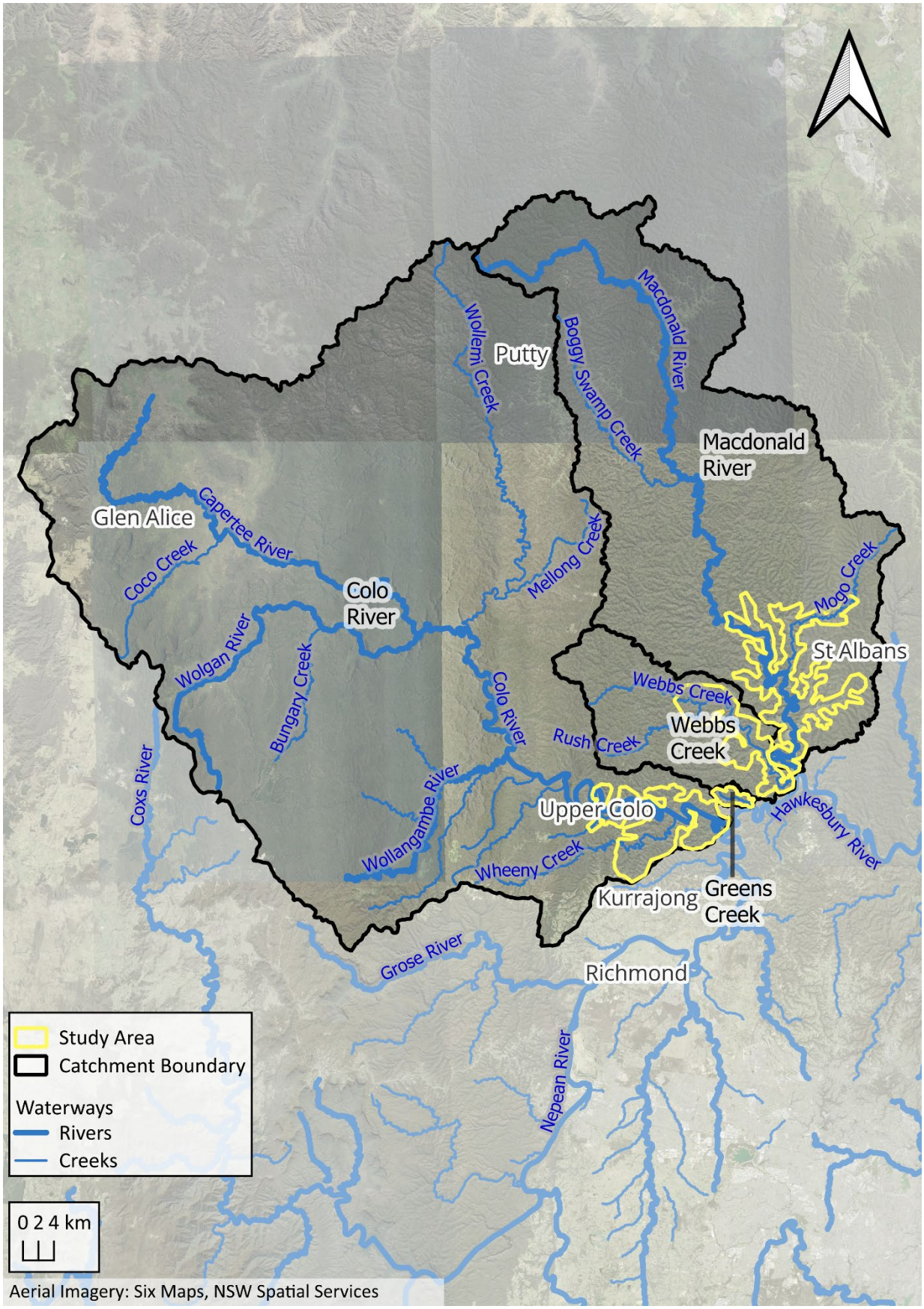

Figure 1-1 Study area

1.1.1 The Macdonald River

The Macdonald River is a tributary of the Hawkesbury River and drains a catchment area of approximately 1,845 km^2 and a length of approximately 150 km. The Macdonald River channel has a dynamic nature that is geomorphologically very active. The catchment consists of steeply vegetated slopes up to elevations of around 800 m. The upper portions of the catchment consist predominantly of natural bushland. Downstream of the Mogo Creek confluence, the Macdonald River floodplain is constrained within a steep valley that is typically 300-500 m wide. The majority of development within the catchment consists of scattered free-standing dwellings located on rural acreages, typically zoned C4 – Environmental Living.

Figure 1-2 Macdonald River at Higher Macdonald (18 February 2022)

St Albans is the only village within the catchment and has a population of around 300 people. The density of development increases in the downstream reaches of the valley. The highest concentration of residential development is located approximately 1-2km upstream of the Hawkesbury River junction, along the eastern side of the Macdonald River floodplain.

Flooding within the valley is primarily a consequence of surface runoff generated in the upper reaches and from local catchments. The lower reaches of the Macdonald River are also affected by backwater effects from the Hawkesbury River. Significant recent flooding occurred in 2021, March 2022 and July 2022.

There is also an established history of flooding with significant events known to have occurred in 1978, 1964, 1949 and as far back as 1867.

1.1.2 The Colo River

The Colo River begins at the confluence of the Wolgan River and the Capertee Rivers, north of Lithgow. The river flows eastwards and then south through a deep gorge in the northern Blue Mountains and ultimately flows into the Hawkesbury River at Lower Portland. The Colo River is approximately 97 km in length and has a catchment area of 4,640 km^2. A majority of the catchment is undeveloped. Within the study area, development consisting of scattered free-standing dwellings located on rural acreages on land zoned C4 – Environmental Living. The study area also supports a significant ecotourism and outdoor education sector that at times supports large groups of tourists and school groups. There are no towns or villages within the Colo River study area.

Figure 1-3 Colo River at Upper Colo Bridge (17 February 2022)

Flood behaviour in the Colo River catchment is comparable to the Macdonald River. Flooding results from surface runoff generated in the upper reaches and from local catchments. The lower reaches of the Colo River are also affected by backwater effects from the Hawkesbury River. The catchment has experienced significant recent flooding with major flooding recorded in 2020, 2021, March 2022 and July 2022. The March 2022 event was the largest recently recorded event.

1.1.3 Webbs Creek

Webbs Creek is approximately 40 km in length and has a catchment area of 363 km^2. Webbs Creek flows generally south-east before reaching its confluence with the Hawkesbury River, around 500 m upstream from the Webbs Creek Ferry crossing.

The lower reaches of Webbs Creek are tidal and subject to backwater effects from the Hawkesbury River when the Hawkesbury is in flood.

The majority of development within the Webbs Creek catchment is found in the lower portions of the catchment. The developed area consists of scattered free-standing dwellings located on land zoned C4 – Environmental Living. The remainder of the catchment is heavily vegetated bushland with steep slopes. The catchment also supports a significant ecotourism sector including outdoor retreats. There are no towns or villages in the catchment. There is limited information relating to historic flooding in the catchment.

Figure 1-4 Webbs Creek, looking upstream from Chaseling Road North Bridge (17 February 2022)

1.1.4 Greens Creek

Greens Creek is a small (6 km long) perennial watercourse located at Lower Portland, with a catchment area of 10 km^2. The creek flows in general in the south-east direction to join the Hawkesbury River. Flooding in the catchment is dominated by backwater from the Hawkesbury River.

Development in the catchment includes low density rural residential properties within land zoned C4 – Environmental Living.

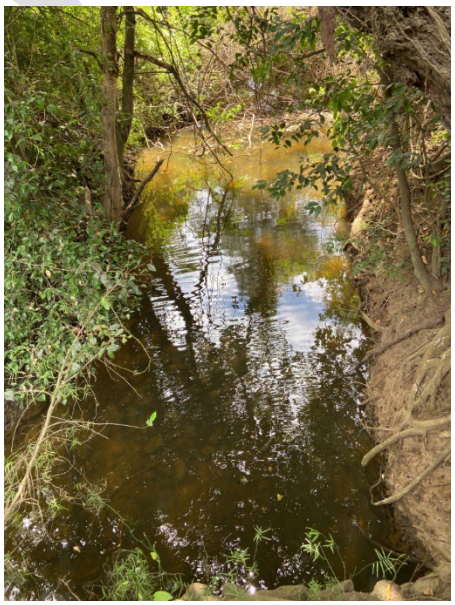

Figure 1-5 Greens Creek, looking upstream from Greens Road (17 February 2022)

1.2 Data Review

A comprehensive data review was undertaken as part of the Macdonald River, Colo River, Webbs Creek & Greens Creek Flood Study. The data review encompassed:

- Relevant studies and reports;
- Rainfall and stream gauge data;
- Available terrain (LiDAR) and bathymetric survey;
- Structure survey;
- GIS data;
- Historical flooding information.

2 Consultation and Engagement

Engagement with the community is essential for developing a well-informed, collaborative, and actionable floodplain risk management plan that aligns with local conditions and ensures long-term resilience for the community. Consultation with the community and key agencies has occurred throughout the project through committee meetings, digital and mail out surveys and drop in sessions. Additional consultation will occur through the public exhibition period.

2.1 Committee Meetings

Updates on the Combined Macdonald River, Colo River, Webbs Creek, and Greens Creek Flood Study and Floodplain Risk Management Study and Plan were provided to the Hawkesbury City Council Floodplain Management Sub-Committee throughout the project. Key presentations were delivered to the Floodplain Risk Management Sub-Committee on 21 February 2024 and 21 August 2024.

At the 21 February 2024 meeting, preliminary flood modelling results were presented. Following discussions, the Committee resolved:

> *"the consultants investigate the feasibility of extending the flood modelling further along the Macdonald River in Upper Macdonald in consultation with the Macdonald Valley Association."*

The subsequent investigation led to an extension of the flood model by approximately 9 km up the valley. This extension was based on the following considerations:

- Scope and constraints: Alignment with project objectives, timelines, and budget;
- Risk prioritisation: Focus on higher risk areas, including villages;
- Data Availability: Use of LiDAR (light detection and ranging) technology to create detailed Digital Terrain Models (DTMs) and Digital Elevation Models (DEMs). The diminishing accuracy of LiDAR data beyond certain areas was taken into account;
- Resources: Balancing costs and available timeframes; and
- Grant Requirements: Compliance with funding milestones, deadlines, and limitations.

At the 21 August 2024 meeting, preliminary flood management options were presented and workshopped with the Sub-Committee to explore actionable strategies as discussed further in **Section 8**

2.2 Drop in Sessions and Engagement

Community consultation for the Combined Macdonald River, Colo River, Webbs Creek, and Greens Creek Flood Study and Floodplain Risk Management Study and Plan Project was conducted from 31 July 2023 to 27 August 2023. Drop-in sessions took place on 2, 3, and 4 August 2023 in Wilberforce (**Figure 2-1**)**,** Colo Heights, and St Albans.

These sessions provided an opportunity for community members to share their experiences from recent flood events and offer insights to inform the development of preliminary management options.

Figure 2-1 Drop in session at Wilberforce School of Arts

The consultation aimed to gather local knowledge and firsthand accounts of recent and historical floods, as well as to collect suggestions for addressing flooding concerns in the Macdonald River, Colo River, Webbs Creek, and Greens Creek areas. The early engagement provided the following key insights:

- Community Ties: Most respondents reported a long-standing association with the Macdonald River, Colo River and Webbs Creek catchments. There were no responses from the Greens Creek Catchment.
- Flood Impacts: During recent flooding, the majority were isolated by floodwaters for up to three weeks.
- Preparedness and Evacuation: Respondents were generally aware of flooding risks, but most indicated they would not evacuate in future flood events, as they believed their properties were outside of the floodplain.

- Information Sources: Websites, social media, and radio were equally relied upon for information during flood events.

At the drop-in sessions and through additional questionnaire responses, participants highlighted several concerns in relation to flood events and emergency management:

- Communication Challenges:
    - Limited or no mobile phone coverage, making it difficult to access flood-related and welfare information;
    - Insufficient notice regarding ferry and road closures, as well as electricity shutdowns; and
    - Delays in restoring electricity, internet, and phone services after flood events.
- Infrastructure and Isolation:
    - Extended road, bridge, and ferry closures, often taking significant time to repair or reopen; and
    - Flood Warnings: Participants noted the absence of adequate flood warning systems in the study area.

2.3 Public Exhibition

To be updated with public exhibition details

2.4 Post Exhibition

To be updated post exhibition

3 Flood Behaviour

The flood behaviour in the study area was defined in the Macdonald River, Colo River, Webbs Creek & Greens Creek Flood Study (2024). Inundation extents are generally contained close to each of the main waterways, even during events as large as the PMF. A comparison of the inundation extents also shows that the extent of inundation does not vary dramatically between events, which is a product of the incised nature of most of the catchment areas. However, the confined topography does produce a significant flood height range. This produces some significant increases in water depth as the severity of flooding increases. For example, at St Albans, the peak 20% AEP water level within the Macdonald River channel is predicted to reach about 6.5 mAHD. During the 1% AEP flood, this is predicted to exceed 13.5 mAHD and during the 1 in 2000 AEP flood, the peak depth is predicted to exceed 17 mAHD. Therefore, although a significant area of additional floodplain is not necessarily activated as flood severity increases, the flood depth increases significantly in all catchments.

Along the Colo River, peak velocities along the river during the 20% AEP flood are typically contained well below 2 m/s. During the 1% AEP flood, peak velocities are commonly more than 2 m/s with localised areas (primarily river bends) exposed to velocities of more than 3 m/s.

As a result of the high-water depths and velocities, the flood hazard along each watercourse and floodplain is also predicted to be high. This includes:

- Colo River: H6 hazard is predicted across most low-lying areas during floods as frequent as the 5% AEP event. This includes the significant backwater area of Wheeny Creek
- Green Creek: H5 hazard is predicted across most of the inundated area during a 10% AEP flood. This is predicted to increase to H6 hazard during the 2% AEP flood.
- Webbs Creek: H5 hazard becomes prominent across the floodplain during the 5% AEP flood. This escalates quickly with much of the floodplain becoming exposed to H6 hazard during the 2% AEP flood:
- Macdonald River: H5 and H6 hazard areas are typically contained to formal watercourses during events up to and including the 5% AEP flood. Similar to Webbs Creek, the hazard escalates quickly in the 2% AEP flood, with much of the floodplain adjoining the Macdonald River exposed to H5 and H6 hazard. This includes parts of St Albans.

The water level profiles also show that the PMF is significantly higher than each of the other design events along all four watercourses. This includes the PMF typically being 10 metres higher than the 1% AEP flood level. Although the chance of a PMF occurring is very rare, the significant increase in flood depths and velocities associated with this event must be considered as part of the flood risk management process.

4 Flood Damages

4.1 Damage Categories

To quantify the economic impacts of flooding, a flood damage assessment has been undertaken. A property may suffer economic impacts from flooding through several ways. These are broadly grouped into three categories, as summarised in **Table 4-1**.

Table 4-1. Types of flood damages

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

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

In addition to tangible damages, there are also a category of damages referred to as intangible damages. Intangible costs relate to social impacts, such as insecurity and depression, that arise as a result of major flood events, risk-to-life impacts, or general inconveniences that occur during the post-flood stage. The intangible costs are difficult to calculate in economic terms. However, the latest guidance does provide some methods for incorporating a conservative estimate of this, and this estimate has been included in the damages assessment (see *Flood Risk Management Measures: Flood Risk Management Guideline MM01* (NSW Government, 2023c).

4.2 Property Floor Levels

Floor level and ground level survey was not available for the study. To ensure damages could be calculated in a fit-for-purpose manner, LiDAR and aerial imagery were used to determine ground elevations for properties within the study area. Points were placed in the vicinity of 509 PMF-affected properties where structures are affected to enable ground level extraction from LiDAR and vacant lots were not included in the analysis.

Limitations derived from the use of aerial imagery include the potential mislabelling of structures (e.g. sheds) as residential structures. To offset uncertainties which arise from this limitation, each of the 509 lots identified with structures was assumed to contain a maximum of one residential structure. Where available, Google street view was also used to assist in the validation of the building classification.

To determine the floor level, an aboveground height of 0.3m was assumed for each structure. This was added to the high side of the structure to ensure floor level estimates were not unrealistically low on steep properties. All structures were assumed to be single storey.

This approach was undertaken to allow for a broad understanding of the economic damages and likely property impacts across the study area. It represents only an approximate estimate of the floor levels. Should specific overfloor flooding estimates be required, then it is recommended that floor level survey be undertaken to verify the levels provided in this report.

4.3 Assumptions and Inputs

The damage assessment undertaken for this study was based on the methodology outlined by the *Flood Risk Management Measures: Flood Risk Management Guideline MM01* (NSW Government, 2023c).

Table 4-2 provides a brief description of the flood damages categories considered in this assessment. The general assumptions and inputs adopted in the analysis are listed in **Table 4-3**. It should be noted that the values adopted in this assessment correspond to the default parameters recommended by the flood damages spreadsheet.

Figure 4-1 illustrates the recommended damage curves for residential single storey and double storey buildings. For the purposes of this assessment, an assumption was made that all buildings were residential single-storey structures. This assumption is considered appropriate given the purpose of the damages assessment and uncertainty in the floor level estimates and building types.

Table 4-2 Flood damage categories considered in this assessment

Flood Damage Categories	Examples of components / items that may experience damage
Structural	Footings, piers, walls, roofing
Internal	Appliances, electronics, carpets, cabinetry
External	Gardens, sheds, outdoor furniture, landscaping
Infrastructure	Roadways, drainage structures, bridges, pump stations, electrical substations

Table 4-3 List of assumptions and inputs in the damages assessment

Assumption / Input	Value
Actual to Potential Ratio	0.9
Regional Uplift Factor	1.00
Infrastructure Damages Uplift	10%
Average contents ($)	$550
External Damages Depth Threshold (metres)	0.30
External Damages	$17,000
Typical size of residential buildings(m^2) (Recommended Default)	220
Replacement Value per m^2 for Detached Dwelling (Single Storey House) (Recommended Default)	$2,280

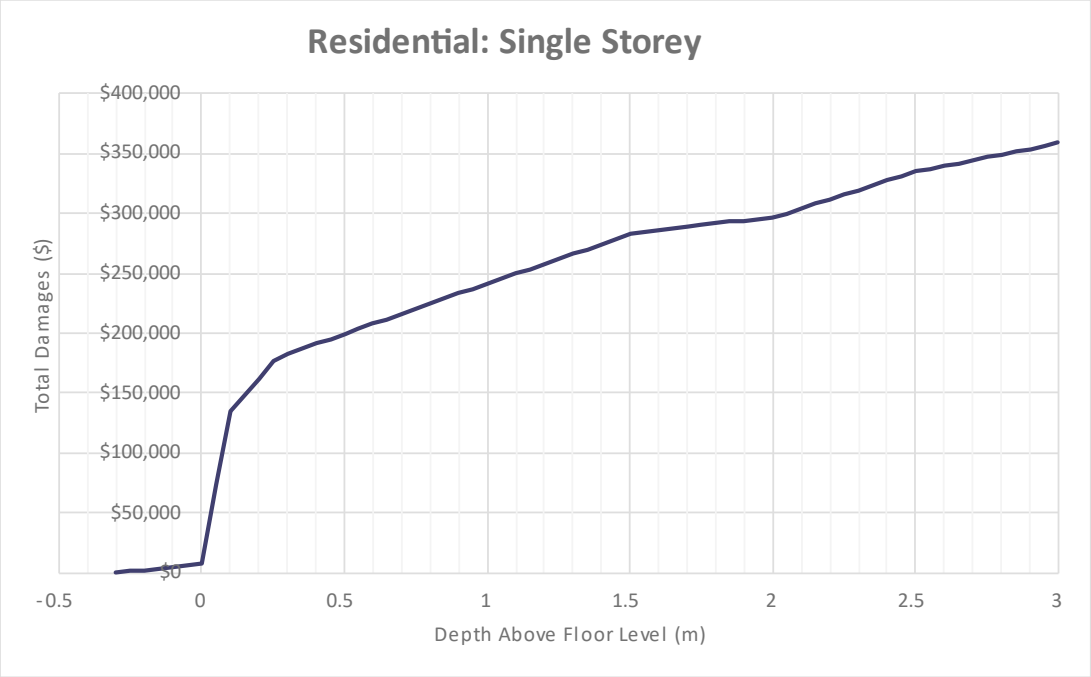

Figure 4-1 Recommended Damage Curves – Residential (NSW Government, 2023c)

4.4 Results

The results from the damage assessment are summarised in **Table 4-4**. The table reports the number of properties affected, the maximum overfloor flood depth occurrence and the total damages for a given design flood event.

The average annual damage (AAD) for the study area under existing conditions is **$3,379,823**. It was assumed that there are no damages in 1 in 4 year event or smaller.

Over a 50-year assessment period and under a five per cent discount rate, this is equivalent to a Net Present Value (NPV) of **$95 million**.

Map RG-00-701 shows the event in which flood affected buildings are first flooded above floor level.

Table 4-4 Existing damages assessment results

Event	Over-ground Flooding	Over-floor Flooding	Max Over-floor Depth (m)	Total Damages ($2024)[1]	Contribution to AAD
PMF	509	508	35.9	$166,624,453	$122,349
0.1% AEP	276	264	13.0	$80,494,966	$76,198
0.2% AEP	243	236	11.5	$71,900,818	$197,581
0.5% AEP	206	199	9.7	$59,819,742	$270,807
1% AEP	182	170	8.2	$48,502,900	$447,880
2% AEP	155	149	7.4	$40,834,358	$958,322
5% AEP	89	85	5.9	$21,091,314	$761,108
10% AEP	49	39	4.0	$8,151,039	$502,938
20% AEP	20	8	1.3	$1,488,619	$42,640

[1]Total Damages includes Infrastructure damage uplift which is 10% of residential damages.

By catchment the AAD is:

- Macdonald River $2,624,425
- Colo River $511,648
- Webbs Creek $243,634
- Greens Creek $116

The Macdonald River catchment accounts for nearly 80% of the AAD, largely due to the higher number of structures impacted during frequent flood events in the area. This concentration of affected structures amplifies the overall AAD for the catchment.

5 Flood Planning Review

5.1 Flood-related Planning Provisions and Development Controls

Land use planning assists with:

- Addressing legacy development issues in the floodplain; and
- Ensuring that future development is compatible with the various objectives of relevant planning instruments and directions.

This section provides a review of the relevant environmental planning instruments (EPIs), development controls and other planning provisions relevant to the management of flood risk in the floodplain. The purpose of the review is to identify gaps, overlaps or deficiencies in the planning provisions and to make recommendations to ensure future land use and development is compatible with flood risk.

The focus of this review has been on those EPIs relevant to the development of private land, which is regulated under Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). Recommendations for strategic flood risk management through the planning system are provided below.

It is noted, however, that parts of the study area catchments and floodplain (e.g. for the Colo River) comprise National Park Estate gazetted under the NSW *National Parks and Wildlife Act 1974* (NP&W Act) or other land tenures for which development would be regulated under Part 5 of the EP&A Act and a different planning approvals pathway applies. It is beyond the scope of this FRMS to consider planning controls for Part 5 developments, although it is noted that some of the EPIs discussed in this section also apply to such developments.

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

5.1.1 Environmental Planning and Assessment Act 1979

In accordance with Section 10.7 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), Councils can issue planning certificates which describe planning and development matters relating to a piece of land. A planning certificate issued under Section 10.7(2) discloses matters relating to the land, including whether or not the land is affected by a policy that restricts development of the land (e.g. development controls in a DCP). A planning certificate may also include information under Section 10.7(5) about other relevant matters affecting the land that Council is aware of but is not disclosed in a Section 10.7(2) certificate.

Obtaining a Section 10.7 certificate is required under the Conveyancing Act 1919 and Conveyancing (Sale of Land) Regulation 2010 when land is bought or sold.

The Objects of the EP&A Act are set out in Section 1.3 and can guide strategies to ensure future development appropriately addresses flood risk by emphasizing sustainable, risk-informed planning and decision-making. The objects of the EP&A Act are as follows:

> *(a) to promote the social and economic welfare of the community and a better environment by the proper management, development and conservation of the State's natural and other resources,*
>
> *(b) to facilitate ecologically sustainable development by integrating relevant economic, environmental and social considerations in decision-making about environmental planning and assessment,*
>
> *(c) to promote the orderly and economic use and development of land,*
>
> *(d) to promote the delivery and maintenance of affordable housing,*
>
> *(e) to protect the environment, including the conservation of threatened and other species of native animals and plants, ecological communities and their habitats,*
>
> *(f) to promote the sustainable management of built and cultural heritage (including Aboriginal cultural heritage),*
>
> *(g) to promote good design and amenity of the built environment,*
>
> *(h) to promote the proper construction and maintenance of buildings, including the protection of the health and safety of their occupants,*
>
> *(i) to promote the sharing of the responsibility for environmental planning and assessment between the different levels of government in the State,*
>
> *(j) to provide increased opportunity for community participation in environmental planning and assessment*

5.1.2 Environmental Planning and Assessment Regulation 2021

The Environmental Planning and Assessment Regulation 2021 (EP&A Regulation) addresses flood-related development controls primarily through Schedule 2, Clause 9, which pertains to planning certificates issued under Section 10.7 of the EP&A Act. This clause mandates that planning certificates specify whether the land in question is:

(1) If the land or part of the land is within the flood planning area and subject to flood related development controls.

(2) If the land or part of the land is between the flood planning area and the probable maximum flood and subject to flood related development controls.

These disclosures aim to ensure that prospective buyers, developers, and property owners are informed about flood risks and any applicable development constraints.

5.1.3 State Environmental Planning Policy (Housing) 2021 (the Housing SEPP)

Under Housing SEPP, complying development for purposes of a secondary dwellings or group homes proposed to be located on a flood control lot must comply with the development standards detailed under Clauses 58 and 65 respectively. The development standards relate to the siting of the secondary

dwelling, floor levels, flood compatible material and other design aspects appropriate to management of flood risk.

Part 5 of State Environmental Planning Policy (Housing) 2021 (the Housing SEPP) relates to Housing for seniors and people with a disability. Within the study area, it applies to land zoned RU5 Village. Clause 81 of the Housing SEPP permits development for the purposes of seniors housing on land to which this Part applies subject to meeting the requirements of this Part.

As stated in Clause 8 (1), unless otherwise stated in the policy, the Housing SEPP overrides the provisions of any other EPI, whether made before or after commencement of the SEPP. Hence, the flood related planning provisions and development controls in the HLEP 2012 and DCP would not apply to housing for seniors and people with a disability, where proposed for land located within the study area that is zoned RU5 and the development is permitted without consent. While the Housing SEPP incorporates provisions relating to the risk from development of bushfire prone land, there are no such provisions relating to development of flood prone land.

Where Housing for Seniors and people with a disability is proposed to be developed with consent under another EPI, Clause 97(1) requires that the consent authority consider the *Seniors Housing Design Guide* (DPE, 2023a). Chapter 3.0 Site analysis – environmental response requires considerations relating to environmental sensitivities, including flooding. Relevant Objectives include:

- 3.1.1 To fully understand the **natural and physical characteristics** of a site in order to formulate an appropriate built response for the development of the land.
- 3.1.2 To provide increased protection from **extreme climatic or environmental events** in buildings occupied by people who are particularly vulnerable because of age, illness and acute disability.
- 3.1.3 To manage and preserve existing natural features such as trees, **overland flow paths**, riparian corridors, and sensitive environments.

The associated design guidance includes:

- 3.1.6 Engage expert consultants for specific advice (bushfire, **flooding,** riparian, arborist, heritage and traditional knowledge holders, etc.), reports and actions affecting and informing the initial design as part of the primary site analysis.
- 3.1.7 **Identify and map the size and required protection zone for flood** and bushfire safety.
- 3.1.10 Consider existing stormwater systems and **overland flow paths** and provide robust stormwater management strategies to protect ecosystems, manage run-off and pollutants, and **protect vulnerable residents from flooding**.

While this Design Guidance does provide some requirements with respect to managing flood risk to occupants of the site, it does not provide specific provisions that would otherwise be addressed through the DCP (e.g. minimum floor levels) or impose requirements with respect to evacuation. Further, the Design Guidance relates only to seniors housing, and does not relate to housing for people with a disability.

The Housing SEPP does not include any provisions restricting development on flood prone land for any other types of housing permitted under the SEPP. In addition, it contains no provision for emergency management or appropriate engineering standards to manage the risk from coastal hazards for housing development. This means that, as the Housing SEPP overrides all other EPIs, there is no mechanism to refuse housing that is permitted with consent or complying development under the Housing SEPP, other

than for development under Parts 5 – Housing for seniors and people with a disability. Further, any provisions of the Hawkesbury LEP or DCP, or under the Resilience and Hazards SEPP, that relate to management of risk from coastal hazards would most likely not be enforceable.

5.1.4 Transport and Infrastructure SEPP

Clause 2.56 of the State Environmental Planning Policy (Transport and Infrastructure) 2021 (T&I SEPP) states that '*development for the purpose of flood mitigation work may be carried out by or on behalf of a public authority without consent on any land*'. The T&I SEPP overrides any provisions of the LEP.

'Flood mitigation work' is defined in the Standard Instrument as '*work designed and constructed for the express purpose of mitigating flood impacts. It involves changing the characteristics of flood behaviour to alter the level, location, volume, speed or timing of flood waters to mitigate flood impacts. Types of works may include excavation, construction or enlargement of any fill, wall or levee that will alter riverine flood behaviour, local overland flooding, or tidal action so as to mitigate flood impacts.*'

Under Clause 2.56(2) flood mitigation work is said to include '*a reference to development for any of the following purposes if it is in connection with flood mitigation work-*

(a) Construction works,
(b) Routine maintenance works,
(c) *Environmental management works*.'

5.1.5 Hawkesbury LEP 2012

The HLEP 2012 sets the direction for land use and development in the Hawkesbury LGA by setting out land use zonings and providing controls for different types of development. It determines what can be built, where it can be built, and what activities may be undertaken on the subject land.

The HLEP 2012 adopts the Standard Instrument template, as required by DPHI. The key elements of the HLEP 2012 that are of relevance to floodplain management are:

- Land use zonings which define different land use types and the associated objectives and lists of development permitted without consent, development permitted with consent and prohibited development;
- Flood planning clauses, which can be found in Part 5 of the Standard Instrument; and
- 'Build Back Better' clauses, which can also be found in Part 5.

Land Use Zones

The applicable land use zonings for the study area are shown in **Map RG-00-801**. The main land use zonings in each of the study area catchments are:

- Macdonald River floodplain – the two main land use zonings are C4 – Environmental Living (which is generally located adjacent to the river) and C1 – National Parks and Nature Reserves. The area also includes small areas zoned RU5 – Village at St Albans and Lower Macdonald;
- Colo River floodplain – The main land use zonings are RU1 – Primary Production, C4 – Environmental Living, and C1 – National Parks and Nature Reserves;
- Webbs Creek floodplain – The predominant land use zoning is C4 – Environmental Living with some areas of C1 – National Parks and Nature Reserves; and
- Greens Creek - the two land use zonings are C4 – Environmental Living and C1 – National Parks and Nature Reserves.

'*Flood mitigation works*' are permitted without consent in land use zones RU1 – Primary Production, RU5 - Village and C4 – Environmental Living.

The following types of development that are permitted with consent in zones RU1 – Primary Production, RU5 - Village and C4 – Environmental Living may be incompatible with the flood risk in some parts of the study area due to the type of development or vulnerable nature of occupants:

- Boarding houses;
- Camping grounds and caravan parks;
- Centre-based and home-based child care facilities;
- Community facilities;
- Hospitals (zones RU1 and C4 only);
- Schools (zone RU5 only);
- Respite day care centres; and
- Eco-tourist facilities and tourist and visitor accommodation.

Flood Planning Clauses of the LEP

The key flood planning clause in the LEP is Clause 5.21, which relates to development proposed in the Flood Planning Area (FPA) mapped in the HDCP 2023.

The objectives of clause 5.21 (1) are as follows:

(a) 'to minimise the flood risk to life and property associated with the use of land,
(b) to allow development on land that is compatible with the flood function and behaviour on the land, considering projected changes because of climate change,
(c) to avoid adverse or cumulative impacts on flood behaviour and the environment,
(d) to enable the safe occupation and efficient evacuation of people in the event of a flood.'

Clause 5.21(2) states that '*development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:*

(a) is compatible with the flood function and behaviour on the land, and
(b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and
(c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and
(d) incorporates appropriate measures to manage risk to life in the event of a flood, and
(e) *will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses*.'

Clause 5.21(5) defines the '*flood planning area*' as having the same meaning as it has in the Flood Risk Management Manual 2023, which defines the FPA

Optional Clause 5.22 Special flood considerations of the LEP Standard Instrument was not adopted by Council in the HLEP 2012. The objectives of the clause are as follows:

(a) 'to enable the safe occupation and evacuation of people subject to flooding,
(b) to ensure development on land is compatible with the land's flood behaviour in the event of a flood,
(c) to avoid adverse or cumulative impacts on flood behaviour,

(d) to protect the operational capacity of emergency response facilities and critical infrastructure during flood events,

(e) *to avoid adverse effects of hazardous development on the environment during flood events.'*

As per clause 5.22(c), the '*clause applies to:*

(a) Sensitive and hazardous development - land between the flood planning area and the probable maximum flood, and; and

(b) for development that is not sensitive and hazardous development - land the consent authority considers to be land that, in the event of a flood, may-

(i) cause a particular risk to life, and

(ii) *require evacuation of people or other safety considerations.'*

There is potential for small communities within the study area to be isolated in flood events, potentially for considerable periods of time, and for there to be difficulty evacuating such areas. Further, there may be hazardous or sensitive development (e.g. critical infrastructure) in such areas. As such, there may be value in preparing a planning proposal to amend the LEP to include Clause 5.22.

Clause 4.2B of the HLEP 2012 applies additional requirements '*to the subdivision of land-*

(a) under clause 4.1, 4.1AA, 4.1A, 4.1C, 4.1Em 4.1G or 4.2, and

(b) that creates a lot other than for use for a public purpose, and

(c) in the following zones-

(iii) Zone RU1 Primary Production,

(iv) Zone RU2 Rural Landscape,

(v) Zone RU4 Primary Production Small Lots,

(vi) Zone R5 Large Lot Residential,

(vii) *Zone C4 Environmental Living.'*

Hence, the clause applies to the study area.

Sub-clauses under clause 4.2B include:

'*(2) Development consent must not be granted for a subdivision to which this clause applies unless the consent authority is satisfied that there is an area of land on the lot that is above the FPL and is sufficient for the erection of a dwelling house.*

(3) For the purpose of subclause (2), an area of land is above FPL if the land is above the level of a 1:100 ARI (average recurrent interval) flood event (whether the level is a natural surface level or a level achieved by filling carried out with a previous development consent.'

Optional Clause 5.9 Dwelling house or secondary dwelling affected by natural disaster of the LEP Standard Instrument is not adopted in the HLEP 2012.

The objective of this clause, which was introduced following the devastating 2019/2020 bushfires, 'is to enable the repair or replacement of lawfully erected dwelling houses and secondary dwellings that have been damaged or destroyed by a natural disaster' and may under clause 5.9(2) be applied to specific land use zones.

While the consent authority is still required to complete a merit assessment of the development, may still be permitted even if it does not comply with all development standards in the LEP. The term 'natural

disaster' is not defined in the Standard Instrument but it would be reasonable to assume that a flood event could be classified as a natural disaster.

There is currently no provision within the clause for imposing controls, such as setbacks or engineering standards, to improve the resilience of the dwelling and reduce the risk from flooding (e.g. house raising). However, the FAQ that accompanies the Natural Disasters Clause[1] states 'The replacement or repair of a dwelling does not have to be identical to the original dwelling which was destroyed or damaged. Changes to the design and location of a proposed dwelling may be required to meet the relevant provisions of development control plans or other relevant planning instruments and associated legislation.' This provides an avenue for application of development controls to provide improved resilience through the re-construction of the subject land.

As such, the requirements of any relevant LEP or DCP provisions could still be applied to a development where the clause operates, so providing these standards and planning controls are regularly updated to reflect best practice when re-building for resilience, then building back better (i.e. to contemporary risk-based building design standards, which would most likely be better than those that the building that was damaged or destroyed) would be anticipated to occur provided the LEP and DCP provisions are implemented by Council in its merit assessment.

In the event that HCC determines to adopt Clause 5.9 of the Standard Instrument, an associated update of the DCP would be required to ensure appropriate, supporting development controls are in place.

5.1.6 Hawkesbury City Council Flood Policy 2020

HCC's Flood Policy 2020 gives effect to clause 5.21 Flood Planning of the HELP 2012 by setting out the development controls that apply to land located in the FPA. Under the Policy, the FPA is defined as 'the area of land below the FPL and thus subject to flood related development controls', which corresponds to the land falling within the 1:100 year ARI flood extent (i.e. within the 1% AEP flood extent).

It is noted that the Policy does not apply to overland flow flooding or local drainage inundation and that freeboard is not applied to the FPA.

The Flood Policy 2020 is supported by the 'Schedule of Flood Related Development Controls'.

5.1.7 Hawkesbury City Council Schedule of Flood Related Development Controls (2021)

The Schedule of Flood Related Development Controls provides flood related development controls based on flood hazard categories H1-H6 in a 1:100 ARI flood event. The Schedule of Flood Related Development Controls do not consider flood hazard or flood function in events between the 1% AEP and PMF. For each flood hazard category, controls are provided for:

- Permissibility
- Land Levels
- Flood Levels
- Cut and Fill
- Building
- Emergency Management

Table 5-1 provides general recommendations for future updates for the Schedule of Flood Related Development Controls. Council may also consider adopting the Flood Planning Precinct Categories

[1] https://www.planning.nsw.gov.au/sites/default/files/2023-03/natural-disaster-recovery-faq.pdf

(FPCCs) presented in **Section 6.4.** The FPPCs consider flood risk in the full range of flood events and provide broad flood controls.

Table 5-1 Recommendations for future updates for the Schedule of Flood Related Development Controls

Item	Recommendation
General	Currently, there are separate controls for all six hazard categories. There is an opportunity to consolidate the controls into broader categories. Providing controls based on flood planning constraint categories (FPCCs) may simplify the Schedule and reduce duplication. The FPCC approach also aligns with the best practice guidance provided in the Manual.
Permissibility	Council consider the flood compatibility of *Critical Uses and Facilities* and *Sensitive Uses and Facilities* land use types in events larger than the 1% AEP up to the PMF.
Land Levels	Consider decoupling controls from hazard categories. Control can be linked to use type rather than hazard. This approach would better align with guidance in the Manual and potentially reduce duplication of controls.
Flood levels	Control H2.19 and H3.28 effectively allow habitable floors to be constructed below the flood planning level. This should not be permitted. Under-croft controls could be a stand alone control in a new section "Other Controls".
Cut and Fill	Cut and Fill controls could be a stand alone control in a new section of the Schedule, "Other Controls".
Building	Links to flood compatible materials guidance should be provided.
Emergency Management	The appropriateness of shelter in place for future development within the study area should be reviewed due to the potential long periods of isolation during and following a flood event. This includes during periods of Hawkesbury River Flooding. The review should also consider the *Shelter-in-place guideline for flash flooding* (DPHI, 2025) Council should consider if an Evacuation Capability Assessment must be provided for all developments and alterations and additions. This may be overly onerous for small scale developments and alterations and additions. The Site Flood Emergency Response Plan should consider events up to the PMF. Specific emergency management requirements for tourist and visitor should be included.
Impact Assessment	Criteria for flood impact assessment should be clarified. Council could consider incorporating the requirements of Flood Risk Management Guideline LU01 into a revised DCP Chapter or schedule of controls.

5.1.8 Planning Proposals and Local Planning Direction 4.1 Flooding

A planning proposal is a document that explains the intended effect of a proposed LEP or proposed amendments to an LEP and is required under Division 3.4 of the EP&A Act (DPE, 2023b). It explains the intended outcomes, identifies and assesses the potential impacts that the changes to the LEP may have and provides justification for making the LEP. It describes how the amendments to an LEP will give effect to strategic and site-specific planning outcomes, providing a link between strategic plans and amending an LEP.

The Minister for Planning and Public Spaces can issue Local Planning Directions (otherwise referred to as Ministerial Directions) to planning authorities under section 9.1(2) of the EP&A Act. These Directions provide guidance on the preparation of planning proposals prepared on or after the date of issue and commencement of the subject Direction.

Local Planning Direction 4.1 Flooding applies when an authority prepares a planning proposal that applies to land that is within the floodplain. The objectives of Direction 4.1 '*are to:*

(a) ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005 [now superseded by the Flood Risk Management Manual 2023]*, and*

(b) *ensure that the provisions of an ELP that apply to flood prone land are commensurate with flood behaviour and includes consideration of potential flood impacts both on and off the subject land*.'

Directions 4.1(3) and (4) set out the requirements for planning proposals. 4.1(3) relates to planning proposals within the flood planning area. 4.1(4) apply to areas between the flood planning area and probable maximum flood to which Special Flood Considerations apply.

Direction 4.1(3) states '*A planning proposal must not contain provisions that apply to the flood planning area which:*

(a) permit development in floodway areas,
(b) permit development that will result in significant flood impacts to other properties,
(c) permit development for the purposes of residential accommodation in high hazard areas,
(d) permit a significant increase in the development and/or dwelling density of that land,
(e) permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,
(f) permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent,
(g) are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities, or
(h) permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event.'

Direction 4.1(4) states '*A planning proposal must not contain provisions that apply to areas between the flood planning area and probable maximum flood to which Special Flood Considerations apply which:*

(a) permit development in floodway areas,
(b) permit development that will result in significant flood impacts to other properties,
(c) permit a significant increase in the dwelling density of that land,
(d) permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,
(e) are likely to affect the safe occupation of and efficient evacuation of the lot, or
(f) are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities.

Further, Direction 4.1(5) requires that the Flood Planning Area (FPA) '*must be consistent with the principles of the Floodplain Development Manual 2005* [now superseded by the Flood Risk Management Manual 2023] *or as otherwise determined by a Floodplain Risk Management Study or Plan adopted by the relevant Council*.'

In this regard, definition of the FPA from the Manual is provided below along with definitions for other related terms:

- The Flood Planning Area (or FPA) is '*The area of land below the FPL*';
- The Flood Planning Level (or FPL) is '*The combination of the flood level from the DFE and freeboard selected for the FRM purposes*';
- The Defined Flood Event (or DFE) is '*The flood event selected as a general standard for the management of flooding risk to development*'; and
- FRM abbreviates Flood Risk Management, defined as '*The management of flood risk to communities*'.

5.1.9 NSW Planning Circulars

There are two key planning circulars (planning system) that were in force at the time of preparation of this review:

- PS 21-006 Considering flooding in land use planning: guidance and statutory requirements; and
- Its companion document, PS 24-001 Update on addressing flood risk in planning decisions.

PS 21-006 states that the Department recommends planning authorities adopt a risk-based approach to the assessment of planning proposals, local and regional Development Applications, and State Significant Development (SSD) and State Significant Infrastructure (SSI) applications. This should include taking into account the flood risk profile of each proposal. PS21-006 discusses requirements for planning certificates (refer **Section 5.1.1**) and planning proposals (refer **Section 5.1.1**).

PS 24-001 supplements guidance on considering flood risk in land use planning, as outlined in PS 21-006, and offers additional support for planning authorities in managing flood risk under the Environmental Planning and Assessment Act 1979. It further recommends that planning authorities take a risk based approach when assessing planning proposals, local and regional Development Applications, and State Significant Development (SSD) and State Significant Infrastructure (SSI) applications.

The requirements of these circulars and the supporting guideline, *Considering flooding in land use planning guideline* (DPE, 2021) have been considered in this review.

5.1.10 Hawkesbury-Nepean Valley Disaster Adaptation Plan

The NSW Reconstruction Authority is developing a Disaster Adaptation Plan (DAP) for the Hawkesbury-Nepean Valley. The DAP will bring together hazard information and analysis on risk reducing options for Hawkesbury-Nepean Valley, that will help protect communities flooding. There may be some overlap with this study area and options developed in the DAP.

6 Defining Areas to Support Land Use Planning

6.1 Defined Flood Event

The flood planning level for the Hawkesbury LGA is currently the 1% AEP with no freeboard. The 2021 flood prone land planning package allows Councils to set local FPLs based on the flood behaviour and risk identified in Flood Studies and Flood Risk Management Studies and Plans.

This allows Councils to adopt appropriate flood planning levels in response to updated flood risk information. It is noted that unless the PMF is adopted as the DFE, there remains a residual risk even when development is undertaken in line with all relevant controls, due to the possibility of floods larger than the DFE occurring.

Factors informing the selection of the DFE include:

- Consequences of floods to the community
- Likelihood of consequences
- Key constraints on land
- Additional factors that influence risk including extreme ranges in design flood levels
- Existing conditions
- Future conditions:

These factors are discussed with respect to the study area below.

6.1.1 Consequences of Flooding to the Community

A flood damages assessment was undertaken for the study area the results of which indicate the consequences to the community of various flood events.

In addition to properties, flooding also has significant impacts on local roads and ferry operation, restricting movement though and out of the study area during flood events.

Recent events in March and July 2022 demonstrated that communities in the study area, in particular in the Macdonald Valley, can be isolated for several weeks after a flood event due to damages to crossing, road surfaces and ferry closures.

6.1.2 Likelihood of Consequences

Summarised in **Table 6-1** are the probabilities of experiencing a flood of various magnitudes at least once and at least twice in a 70 year period.

The table shows that a 2% AEP, 1% AEP and 0.5% AEP have a 75%, 50% and 30% chance respectively of occurring in a 70 year period.

Given this potential, it is reasonable to set the FPL at the 1% AEP or greater from a risk management perspective, to limit people's exposure to flood events, and to assist in ensuring their safety when these events occur.

Table 6-1 **Probability of Experiencing a Given Size Flood or Higher in Lifetime (70yrs)**

Likelihood of occurrence in any year (AEP)	Probability of at least one event in 70 years (%)	Probability of at least two events in 70 years (%)
10%	99.9	99.3
5%	97	86
2%	75	41
1%	50	16
0.5%	30	5

6.1.3 Key Constraints on Land

The study area is largely undeveloped, with limited potential for significant amounts of new development due to restrictions placed on land use. Future development is likely to be restricted to residential redevelopment, agricultural related development or the construction of tourist accommodation facilities.

6.1.4 Future Conditions

Within the study area, land availability is limited, and significant large-scale development is not anticipated. Changes in development are unlikely to result in substantial alterations to regional flood behaviour. While smaller-scale developments may lead to localised impacts, for the purposes of assessing future conditions, it is assumed that any future development will not contribute to widespread changes in flood behaviour.

Future climate change has the potential to alter existing flood behaviour, through both increased rainfall intensity and increased sea levels. Climate change impacts were assessed in the Flood Study (2024). The assessment found that climate change has the potential to significantly impact flooding in the study area.

The Climate Change Calculator (ccc.wmawater.com.au) was used to assess how the study area may be impacted by future climate change. The Flood Study (Rhelm and CSS, 2024) provides further details on the climate change assessment. .

Figure 6-1 shows how the 2 day 1 % AEP catchment average rainfall at the Macdonald River outlet will change under the various climate change pathways. By 2100 rainfall is expected to increase by 21% to 32% under the most likely SSP2 and SSP3 pathways.

Section 6.6.2 of the Flood Study summarises the climate change impacts to 2050 and 2100 under SSP3 for the study area. Typical increases in flood levels in a 1% AEP event as estimated in the flood study in 2100 under SSP3 are:

- Colo River: 1 - 4m
- Macdonald River: 1-2 m
- Webbs Creek: 0.5 - 1m
- Greens Creek: 0.3 - 0.4 m

Changes in flood behaviour in the Hawksbury River due to climate change may cause additional increases in flood levels for relevant downstream reaches of the watercourses.

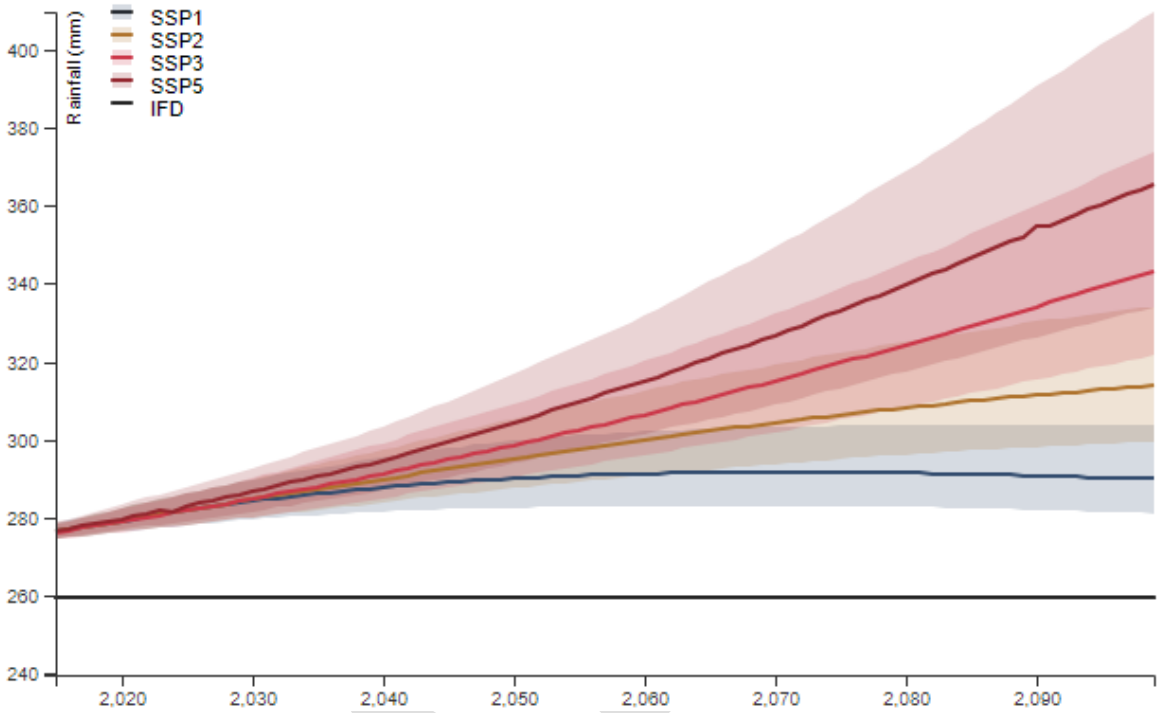

Figure 6-1 Change in Catchment Average Rainfall under Climate Change – 1% AEP – Macdonald River

Figure 6-2 is based on the updated guidance and shows the number of predicted exceedances over a 70 year period from 2024 to 2100 of the historical 1% AEP design level under various scenarios. **Figure 6-2** shows that the chance of experiencing an event equivalent to a historic 1% AEP event will increase under each SSP scenario. The figure shows that the likelihood of experiencing one event under historical conditions would be increased to up to three events under future conditions.

Under SSP3, the peak flow associated with a 1% AEP event is projected to increase by approximately 20% by 2050 and by 40–50% by 2100. Consequently, a 1% AEP event in 2050 is expected to align with he magnitude of a current 1-in-200-year event, while a 1% AEP event in 2100 is projected to align with present-day 1-in-500-year event.

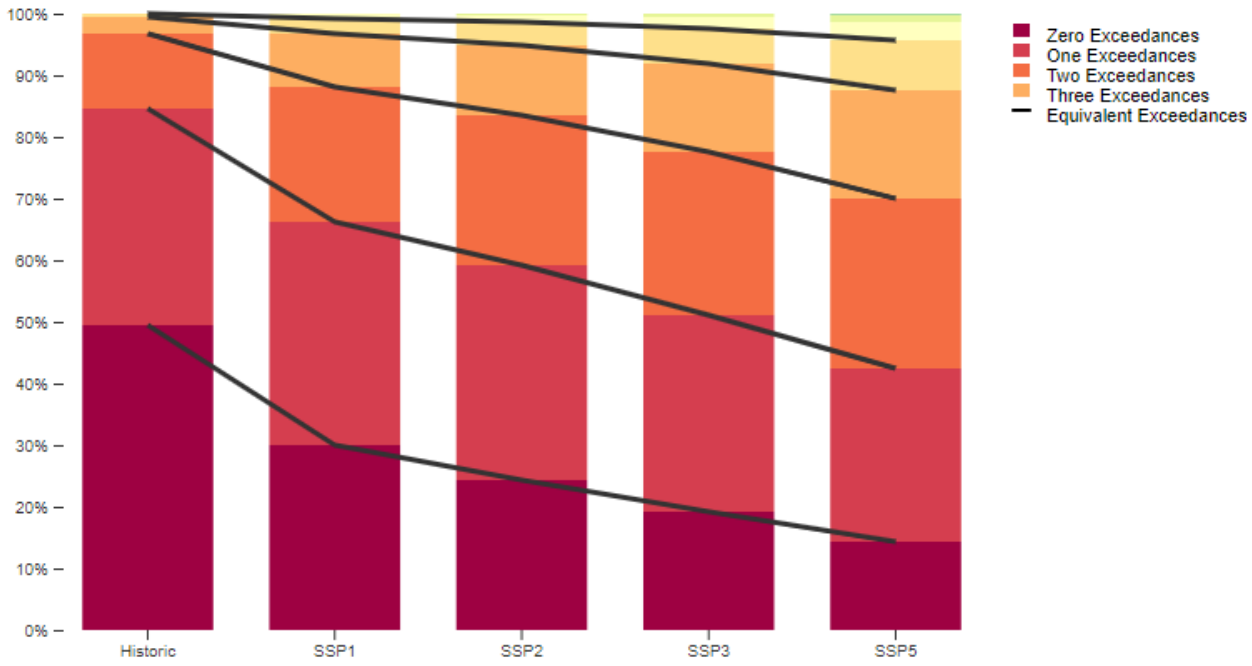

Figure 6-2 Expected Exceedances over 70 year period – St Albans

Given the long term nature of likely development projects (50 – 100+ years depending on the nature of the development), it is prudent to adopt a DFE that considers future climate change, to ensure that the catchment retains a reasonable level of flood protection.

6.1.5 DFE Recommendation

It is recommended that the defined flood event be defined as the 0.5% AEP (1 in 200 AEP) event to ensure a robust level of protection now and into the future. This recommendation is consistent with the recommendation from the draft Hawkesbury Floodplain Risk Management Study and Plan (2025). Hawkesbury City Council's current planning documents set the Flood Planning Level to the 1% AEP level without freeboard. The steep confined valleys in the study area means that the additional area affected by an increase in flood planning level is small. Based on the flood range and climate risk it is recommended that Council adopt the 0.5 % AEP (1 in 200 AEP) as the defined flood event.

6.2 Freeboard

DPE (2023b) provides guidance regarding determining a suitable freeboard. The typical freeboard used in New South Wales is 0.5 m. A freeboard higher than this may be necessary in some cases. This may be due to local circumstances, such as where estimated DFE levels are particularly sensitive to modelling assumptions or other local factors that significantly influence flood behaviour.

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

Freeboard accounts for such factors as:

- Inherent uncertainties in flood prediction
- Wave action
- Changes in catchment development and vegetation following the flood modelling;

- Afflux (local increase in flood level due to small obstructions below the level of the model grid resolution.

The contribution of these factors to a potential increase in flood level over that reported by the hydraulic model is summarised in **Table 6-2**. The total variation from these factors is estimated to be up to 0.5m.

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

Freeboard was utilised to manage uncertainty around climate change for a period in NSW. However, the DFE incorporates both sea level rise and increased rainfall intensities, and so freeboard is not required to address this aspect.

6.3 Flood Planning Area

The FPA is usually defined as the area below the Flood Planning Level (FPL). The FPL is set by the DFE, plus an appropriate freeboard.

The DFE event is defined in **Section 6.1.5** and the freeboard in **Section 6.2.**

The resulting FPA, based on the DFE plus 0.5m is shown in **Map RG-00-802**.

Table 6-2. Factors Incorporated in Freeboard Estimate

Factor	Flood Level Variation (m)	Consideration for this study	Comment
Catchment changes	0	0	It has been assumed that future development would be required to not adversely affect flood behaviour. Changes to vegetation have been incorporated through the model roughness sensitivity below.
Wave action	0-0.2	0.1	Includes wind and boat/vehicle generated waves.
Accuracy of ground survey used in the model	+/- 0.3	0.1	General accuracy of LiDAR data on vegetated surfaces.
Sensitivity of the model	Varies, up to +-- 4m in the Colo River.	0.3	Sensitivity testing of model parameters undertaken in the Flood Study (2024). The models sensitive is also considered in the DFE selection.
Afflux	0-0.1	0	Advice provided in *Determining Freeboard* (Gillespie, 2005)

6.4 Flood Planning Constraint Categories

The *Understanding and Managing Flood Risk Guide FB01 (2023)* presents the Flood Planning Constraint Categories (FPCCs) as a tool for managing development across flood prone and flood affect land. The FPCC approach divides the floodplain into four categories based on flood behaviour and risk, and with reduced development potential applied to higher risk categories.

The categories used for FPCC in the study area are based on the guidance in FB01.

The FPCC mapping is shown in **Map RG-00-803.**

The categories were defined as:

- **FPCC1**: DFE floodway and key storage areas, or H6 hazard in the DFE

- **FPCC2**: New floodways in larger floods than the DFE or H5 hazard in DFE, H6 hazard in floods larger than the DFE, isolated in events up to the PMF. The PMF was chosen as the event for mapping floodways in larger events.
- **FPCC3**: Outside FPCC2. Usually below the FPL
- **FPCC4**: Outside FPCC3, but within the PMF or extreme flood.

While some limited areas in the study area have rising road access, due to the loss of access in flood events, all land within the study area is considered isolated. The ability to evacuate the study area is further complicated by coincident flooding in the Hawkesbury-Nepean River.

As such, the FPCC mapping only includes FPCC1 and FPCC2, as FPCC2 incorporates high and low flood islands and trapped perimeters.

Table 6-3 provides land use categories that council could consider if adopting an FPCC's or another approach. While the potential FPCC mapping and controls have been designed for the study area, it is recommended that Council consider an LGA wide approach when updating flood planning documentation.

Table 6-3 Land use categories

Land Use Category	Land uses	
Sensitive and hazardous development	• boarding houses • caravan parks • early education and care facilities • eco-tourist facilities • educational establishments • emergency services facilities • group homes • hazardous industries • hazardous storage establishments	• hospitals • hostels • information and education facilities • respite day care centres • seniors housing • sewerage systems • tourist and visitor accommodation • water supply systems.
Subdivision	Subdivision of land which involves the creation of additional allotments	
Residential	• Attached dwellings • Dual occupancies • Dwelling houses • Multi dwelling housing • Residential flat buildings • Home based child care	• Home businesses • Home industries • Home occupations • Secondary dwellings • Semi-detached dwellings
Commercial or Industrial	• Agriculture • Amusement centres • Business Premises • Car parks • Crematorium	• Passenger transport facilities • Places of public worship • Public administration buildings (other than essential uses and facilities) • Pubs

Land Use Category	Land uses	
	• Depots • Entertainment facilities • Food and drink premises • Freight transport facilities • Funeral homes • Function centres • Hardware and building supplies • Health consulting rooms • Heavy industries • Hotel accommodation • Industries • Industrial retail outlets • Kiosks • Landscape and garden supplies • Light industries • Markets • Materials recycling or recovery centres • Medical centres • Mixed-use development • Mortuaries • Sex services premises	• Recreation facilities (indoor) • Recreation facilities (major) • Registered clubs • Restricted premises • Retail Premises • Service stations • Shop top housing; • Specialised retail premises • Storage premises • Transport depot • Truck depot • Vehicle body repair workshops • Vehicle repair stations • Vehicle showrooms • Veterinary hospitals • Warehouse or distribution centres • Waste or resource management facilities • Wholesale supplies
Recreational & Non-urban	• Animal training establishments • Boat launching ramps • Boat repair facilities • Boat sheds • Cemetery; • Charter and tourism boating facilities • Environmental facilities • Helipad	• Water recreation structures • Recreation areas and minor • Ancillary structures (e.g. Toilet blocks or kiosks) • Recreation facilities (outdoor)
Concessional Development	• Concessional development is any development or redevelopment that would normally not be permitted but may be permitted as a concession provided it: • i) involves an acceptably small (see below for limits) addition or alteration to an existing development that will not cause a significant increase in potential flood damages, risks or have an adverse impact on adjoining properties; or	

Land Use Category	Land uses
	• ii) redevelopment for the purposes of substantially reducing the extent of flood affectation to the existing building; provided that such redevelopments incorporate to the fullest extent practical, design features and measures to substantially reduce the existing potential for flood losses and risk to life, and avoid any adverse impacts on adjoining properties – especially obstruction or diversion of floodwaters and loss of flood storage. • In the case of all types of residential development, the maximum size of a concessional development is: • i) a once-only addition or alteration to an existing dwelling of no more than 10% or 40m² (whichever is the lesser) of the habitable floor area which existed at the date of commencement of this Policy or Plan; or • ii) the construction of an outbuilding with a maximum floor area of 20m². • In the case of other development categories, the maximum size of a concessional development is a once- only addition to existing premises of no more than 10% of the floor area which existed prior to 2025.

Table 6-4. presents flood related development controls that be applied to flood planning constraint categories. The controls have been adapted from the flood risk management manual for the study area.

Table 6-4. Flood related development controls. Adopted from the Flood Risk Management Manual Guideline FB02

Management Consideration	No.	Controls
Floor level		
Allows for varying floor levels for different development types and parts of a development considering flood constraints well as the cost of future flood damages and disruption	F1	All floor levels to be equal to or greater than the 5% AEP plus 0.5 m freeboard unless justified by site-specific assessment
	F2	Habitable floor levels to be equal to or greater than the DFE plus 0.5 m freeboard
	F3	All floor levels to be equal to or greater than the PMF level or DFE plus 0.5 m, whichever is higher
	F4	Floor levels to be as close to the DFE plus 0.5 m level as practical & no lower than the existing floor level when undertaking alterations or additions
	F5	Floor levels of commercial premises to be as close to the DFE plus 0.5m freeboard as practical. Where below the DFE plus 0.5m freeboard, more than 30% of the floor area to be above the DFE plus 0.5 m freeboard or premises to be flood proofed below the DFE plus 0.5 m freeboard
	F6	Garage floor level to be no lower than 300 mm above existing ground level

Management Consideration	No.	Controls
	F7	Garage floor level to be no lower than the DFE minus 300 mm or 300 mm above the finished adjacent ground (whichever is the greater)
	F8	Habitable floor levels to be equal to or greater than the DFE flood level plus 0.3 m freeboard
	F9	Garage floor level to be no lower than the DFE minus 300 mm or 300 mm above the existing ground level (whichever is the greater)
Building component		
Flood compatible building considerations for varying development types Encourages a means of reducing flood damages to individual properties	B1	All structures to have flood compatible building components below or at the DFE plus 0.5 m freeboard
	B2	All structures to have flood compatible building components below or at the DFE plus 0.5 m freeboard or PMF level, whichever is higher
	B3	All structures to have flood compatible building components below or at the DFE plus 0.3 m freeboard
Structural soundness		
Identifies the scale of assessment required to demonstrate structural soundness to minimise cost of future damages and potential for development components to become floating debris	S1	Suitably qualified civil engineers report required to certify that any structure can withstand the forces of floodwater, debris and buoyancy up to and including the DFE..
	S2	Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a DFE (and applied to the FPL) or PMF if required to satisfy emergency response criteria (see below)
	S3	Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a PMF event
	S4	Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a DFE flood level (and applied to the DFE flood level plus freeboard (FB2))
Flood affectation		
Identifies how the impacts of the development are to be managed and the risks to the development and its users are to be assessed and considered	FA1	The development must not increase flood affectation elsewhere beyond the permissible impacts outlined in the DCP. A FIRA required to demonstrate this outcome
	FA2	The impacts of the development on flooding are to be addressed through a FIRA or other appropriate analysis
Emergency response		

Management Consideration	No.	Controls
Considers the availability of existing EM arrangements including flood warning, evacuation routes, evacuation capacity, etc. and potential impacts of the development on evacuation capability of existing development	E1	Reliable access and egress for pedestrians required during a DFE flood, or a flood refuge area required within the development above the PMF level
	E2	Reliable access for pedestrians and vehicles required during a PMF event
	E3	Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest habitable floor level to an area of refuge above the PMF, or a minimum of 20 sq m of the dwelling/premises to be above the PMF level
	E4	The development is to be consistent with any relevant flood evacuation strategy or similar plan
	E5	Applicant to demonstrate that evacuation of any proposed development can be undertaken in accordance with the relevant local or state flood plan developed by SES
Management and design		
Considers additional factors needed to manage ongoing flood risk	M1	Applicant to demonstrate that potential development as a consequence of a subdivision or development proposal can be undertaken in accordance with the relevant DCP, policy and / or FIRA
	M2	Site flood guides (home or business or farmhouse) to address safety and property damage issues (including goods storage and stock management) considering the full range of flood risk
	M3	Goods must be stored above the FPL
	M4	Goods must be stored above the higher of the FPL and PMF
	M5	No external storage of materials below the DFE plus 0.5m freeboard which may cause pollution or be hazardous during any flood

Table 6-5 provides the prescriptive controls for the FPCCs that council could consider when updating the Schedule of Flood controls and/or DCP controls.

Table 6-5 Example of Flood Planning Constraint Categories for FPCC1 and FPCC2. Note - no areas were mapped as FPCC3 and FPCC4 due to the isolation risk in the study area.

Flood Risk Precinct	Land-use category	Prescriptive controls					
		Floor level	Building component	Structural Soundness	Flood Affectation	Emergency response	Management and design
FPCC1	Sensitive and hazardous development	U	U	U	U	U	U
	Subdivision	U	U	U	U	U	U
	Residential	U	U	U	U	U	U
	Commercial or Industrial	U	U	U	U	U	U
	Tourist Related	U	U	U	U	U	U
	Recreational & Non-urban	F1	B1	S1	FA1	E1	M2,M3,M5
	Concessional Development	F2,F4,F6	B1	S1	FA1	E1	M2,M3,M5
FPCC2	Sensitive and hazardous development	U	U	U	U	U	U
	Subdivision	N	N	N	FA1	E5	M1
	Residential	F2, F7	B1	S3	FA1	E3,E4	N
	Commercial & Industrial	F2, F5	B1	S2	FA1	E1,E4	M2,M3,M5
	Tourist Related	F2,F6	B1	S2	FA1	E3,E4	M2,M3,M5
	Recreational & Non-urban	F1	B1	S1, S2	FA1	E1	M2,M3,M5
	Concessional Development	F2,F4	B1	S2	FA2	N	M2, M3, M5
Notes:							
N	Not relevant	U	Unsuitable land use				

7 Information to Support Emergency Management Activities

7.1 Emergency Response Classification

Flood Emergency Response Classification aims to categorise the floodplain based upon differences in isolation due to the potential for entrapment of an area by floodwaters, potentially in combination with impassable terrain. It also considers the possible ramifications for an isolated area based upon its potential to be completely submerged in the probable maximum flood (PMF) or a similar extreme flood (AIDR, 2017). Flood Emergency Response Classification mapping is a useful tool to assist emergency services in planning and undertaking evacuation for a floodplain.

The NSW Flood Risk Management Manual (2023) provides guidance on undertaking emergency response classification mapping, which is intended to be undertaken at the community or precinct scale (i.e. not at the lot scale). A summary of the classifications is provided in **Table 7-1**. Classifications are taken from the Flood Risk Management Manual.

Table 7-1 Emergency Response Classifications (Source: DPE, 2023c)

Primary Classification	Description	Secondary Classification	Description	Tertiary Classification	Description
Flooded or Surrounded by Floodwater	The area is flooded or surrounded by floodwater in the PMF	Isolated	Areas that are isolated from community evacuation facilities (located on flood-free land) by floodwater and/or impassable terrain as waters rise during a flood event up to and including the PMF.	Low Flood Island	Where all the land in the isolated area will be fully submerged in a PMF after becoming isolated.
				High Flood Island	Where there is a substantial amount of land in isolated areas elevated above the PMF.
				Low Trapped Perimeter	In these areas, the ability to retreat to adjacent higher ground does not exist due to topography and/or impassable structures. Inhabited area is lower than the PMF
				High Trapped Perimeter	The ability to retreat to adjacent higher ground is limited due to topography and/or impassable structures. Inhabited area is higher than the PMF
		Exit Route	Areas that are not isolated in the PMF and have an exit route to community evacuation facilities (located on flood-free land).	Overland Escape	Evacuation from the area relies upon overland escape routes that rise out of the floodplain.
				Rising Road	Evacuation routes from the area follow roads that rise out of the floodplain.
Not Flooded	The area is not flooded in the PMF	-	-	Indirect Consequence	Areas that are not flooded but may lose electricity, gas, water, sewerage, telecommunications, and transport links due to flooding.
				Flood Free	Areas that are not flood affected and are not affected by indirect consequences of flooding.

Map RG-00-901 shows the emergency response classification for the study area. Much of the study area is classified as low or high trapped perimeter areas. The ability to retreat to adjacent higher ground does not exist due to the lack of roads and steep valley topography. Evacuation on foot may be possible in some locations and may reduce risk to life, however most locations do not have flood free access to a suitable evacuation centre or facility. It is noted that during a Hawkesbury-Nepean River flood event, regional access will also become flood affected, limiting evacuation potential and access for emergency services across the study area.

Figure 7-1 shows a high trapped perimeter area for the PMF. During a flood event the area is isolated by floodwater and property may be inundated, however, there is an opportunity for people to retreat to higher ground above the PMF and therefore the direct risk to life is limited. The area may require resupply by boat or air if not evacuated before the road is cut. If it will not be possible to provide adequate support (such as community and medical facilities) during the period of isolation, evacuation will have to take place before isolation occurs. Isolation without these services is more likely to result in fatal decisions to cross floodwaters.

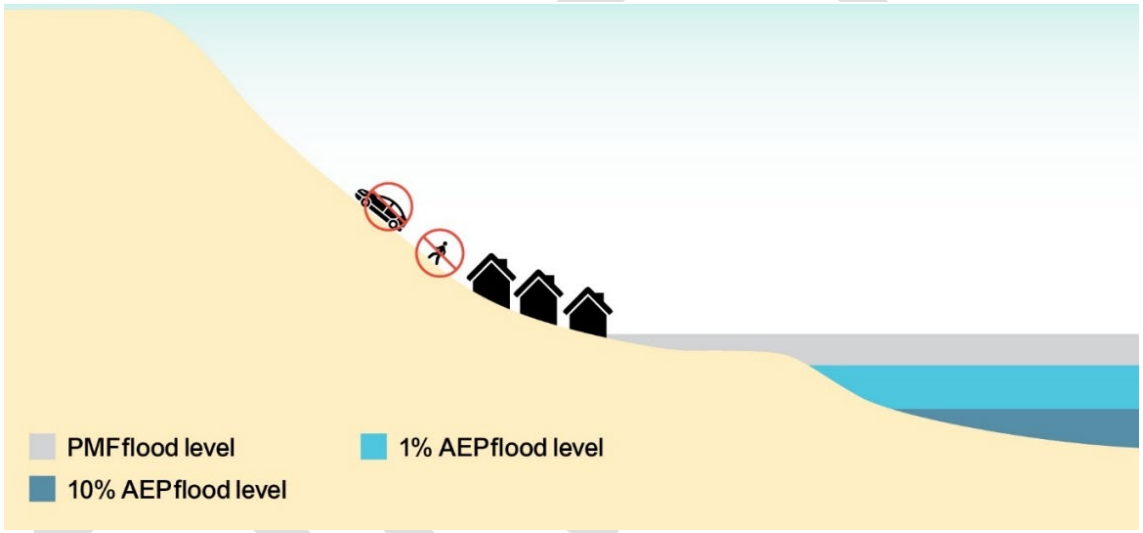

Figure 7-1 High trapped perimeter (NSW Government, 2023)

Figure 7-2 shows a low trapped perimeter area. The inhabited or potentially inhabited area is lower than the PMF. During a flood event the area becomes isolated by floodwater and property will be inundated. If floodwater continues to rise after it is isolated, the area will eventually be completely covered. People trapped in the area may drown.

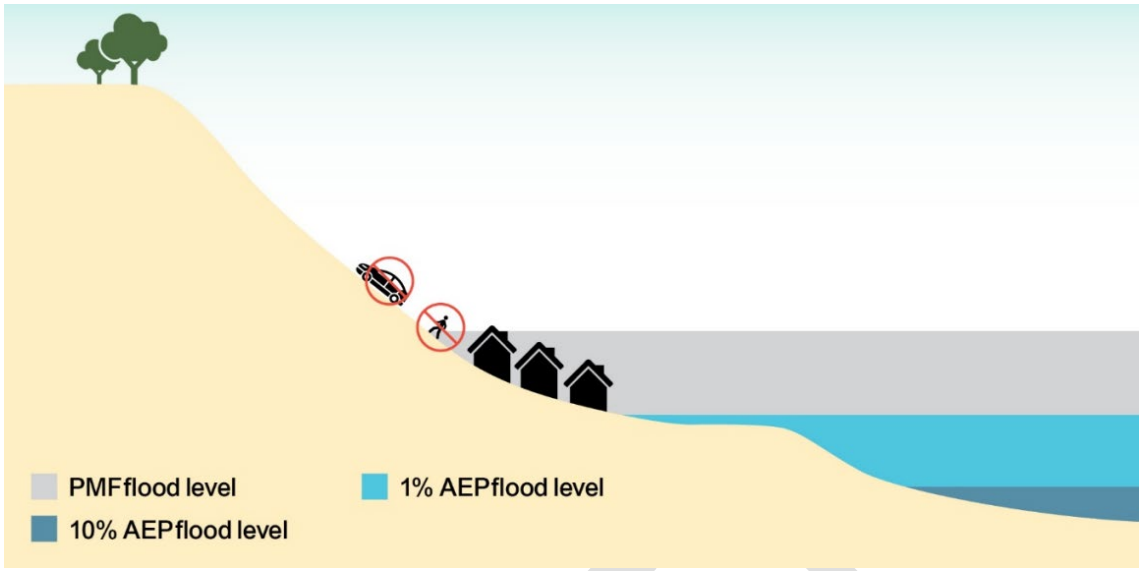

Figure 7-2 Low trapped perimeter (NSW Government, 2023)

7.2 Flood Impacts on Transport

Road access in the study area is limited and can be affected by flooding at multiple locations. There are multiple low level crossings throughout the study area. Additionally, due to the steep valleys within the study area, many of the roads have been constructed within the floodplain.

For effective emergency response planning, it is critical to identify the timing of overtopping events and the duration for which transportation routes remain inundated. An analysis of road overtopping during the design flood events was conducted, with roads considered overtopped when the flood hazard exceeded the H1 threshold.

The location of the river crossings investigated in the study area are provided in **Map RG-00-702.** A summary of peak overtopping depths for existing flood scenarios is provided in **Table 7-2.** Flood depth (rather than flood hazard) has been reported in **Table 7-2** as flood depth indictors are likely to be the only feasible flood risk management options for many of the low lying crossings.

Most crossings in the study area are low and are overtopped in a 20% AEP event or smaller. This is a significant challenge as communities become isolated early in a flood event.

The Putty Road bridge over the Colo River is overtopped between a 10% AEP and 5% AEP event. The St Albans Bridge is overtopped between a 2% AEP and a 1% AEP event.

The combined catchment and backwater flooding causes widespread road inundation across the study area which results in large areas of the study area becoming isolated in even minor flood events.

The time to overtopping and period of inundation for the 10% AEP, 1% AEP, and the PMF, are provided in **Table 7-3** The time to overtopping is estimated from the start of the design storm, and may be used as a guide for estimating warning times. However, it is important to note that during an actual flood event, roads may become overtopped more quickly and for longer durations than indicated in **Table 7-3.**

Table 7-2 Inundation depth over road (m)

Road#	Watercourse/ Location	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	1 in 500 AEP	PMF
Macdonald River								
Upper Macdonald Rd	Macdonald River/ Upper Macdonald	2.2	3.2	6.1	8.8	9.7	12.0	25.5
Settlers Rd	Wellums Creek	2.5	3.3	5.7	8.4	9.2	11.4	23.3
Settlers Rd	Wrights Creek	<0.1	0.9	2.5	5.3	6.2	8.5	20.3
Macdonald Rd	Upper Macdonald River	3.3	4.5	7.4	10.0	10.9	13.0	26.6
St Albans Rd	Flemings Creek	-	0.4	2.0	4.9	5.7	8.0	19.9
St Albans Rd	Bakers Gully	-	-	1.8	4.6	5.4	7.4	19.3
Wollombi Rd	Macdonald River – St Albans Bridge	-	-	-	-	0.5	2.8	15.6
Colo River								
Near McDougall Dr	Whatley's Creek	3.1	6.0	7.9	9.4	10.1	13.5	34.7
Upper Colo Rd	Wheeny Creek	3.7	6.9	9.0	10.7	11.4	14.9	37.0
Putty Rd	Colo River/ Putty Road Bridge	0.0	0.0	0.5	2.2	2.9	6.4	28.3
Upper Colo Rd	Gosper's Creek	3.3	6.9	8.7	10.2	10.9	14.2	38.9
Greens Rd*	Colo River	0.0	0.0	0.0	0.0	0.0	0.0	8.0
Colo Heights Rd	Colo River	6.8	10.3	12.0	13.5	14.2	17.5	41.8
Webbs Creek*								
Barry Rd	Webbs Creek	-	-	-	-	-	-	-
Chaseling Rd*	Webbs Creek	-	-	-	-	-	-	4.0
Greens Creek*								
Greens Road	Greens Creek	-	0.3	0.4	1.0	1.2	1.5	4.7

#This analysis is based on LIDAR data and does not include detailed survey of road levels

*Will also be affected by flooding from the Hawkesbury River, which is not covered by this table

Table 7-3 Rate of rise and inundation duration of key crossings

Location	Watercourse/ Location	10% AEP (Time to overtopping) (Period of inundation)	1% AEP (Time to overtopping) (Period of inundation)	PMF (Time to overtopping) (Period of inundation)
Macdonald River				
Upper Macdonald Rd	Macdonald River/ Upper Macdonald	2 days 1 - 2 days	12 hours 2 - 3 days	<6 hours 3 - 4 days
Settlers Rd	Wellums Creek	2 days 2 - 3 days	12 hours 3 - 4 days	<6 hours 4 - 4 days
Settlers Rd	Wrights Creek	3 days 1 - 2 days	18 hours 3 - 3 days	12 hours 3 - 4 days
Macdonald Rd	Upper Macdonald River	3 days 2 - 3 days	12 hours 2 - 3 days	12 hours 3 - 4 days
St Albans Rd	Flemings Creek	3 days 0.5 - 1 day	18 hours 2 - 3 days	12 hours 3 - 4 days
St Albans Rd	Bakers Gully	-	1 day 2 - 3 days	<6 hours 3 - 4 days
Wollombi Rd	Macdonald River – St Albans Bridge	-	1 day 0 - 1 days	18 hours 1 - 4 days
Colo River				
Near McDougall Dr	Whatley's Creek	< 6 hours More than 7 days	< 6hours More than 7 days	< 6 hours More than 7 days
Upper Colo Rd	Wheeny Creek	<6 hours More than 7 days	< 6 hours More than 7 days	<6 hours More than 7 days
Putty Rd	Colo River/ Putty Road Bridge	-	3 days More than 7 days	24 hours More than 7 days
Upper Colo Rd	Gosper's Creek	3 days 1 - 2 days	2 days 2 - 3 days	<6 hour More than 7 days
Greens Rd*	Colo River	-	-	2 days 2-3 days
Colo Heights Rd	Colo River	4 days 2 - 3 days	6 days More than 7 days	<6 hours More than 7 days
Webbs Creek*				
Barry Rd*	Webbs Creek	-	-	-
Chaseling Rd*	Webbs Creek	-	-	1-2 days
Greens Creek*				
Greens Road	Greens Creek	More than 7 days	More than 7 days	<6 hours More than 7 days

*Will be affected by flooding from the Hawkesbury River

7.3 Flood Impacts on Infrastructure and Facilities

Flood impacts on infrastructure and facilities has been assessed. The specific infrastructure and facilities included in the assessment are shown in **Map RG-00-703.** The assessment has considered emergency management facilities such as rural fire service (RFS) infrastructure as well as schools and campsites in the study area. The location of the emergency management facilities was obtained from Geoscience Australia (2023) and the campsite locations was obtained from Open Street Map. **Table 7-4** provides the flood hazard affecting infrastructure and facilities for key design flood events. Low lying land within campsites will be affected in more frequent events than what is shown in **Table 7-4.**

It should be noted that the **Table 7-4** does not consider flood events driven by Hawkesbury Nepean Valley flooding. For areas lower in the study area, Hawkesbury Nepean Valley flooding must also be considered. **Table 7-4** reports flood hazard rather than depth as the hazard relates to potential impacts on people and buildings directly affected by flooding.

Electricity in some parts of the study area is cut off prior to flooding, and power may net be switched back on for weeks after a flood event. Flood risk to electricity assets has not been assessed, however it is recognised that loss of power before, during and after flooding is a significant challenge within the study area.

Table 7-4 Flood hazard affecting key infrastructure in the study area

Road	20% AEP	5% AEP	2% AEP	1% AEP	1 in 500 AEP	1 in 2000 AEP	PMF	Comment
Macdonald River								
Saint Albans RFS	-	H2	H5	H5	H6	H6	H6	
Lower MacDonald Rural Fire Service	-	-	-	-		-	-	Affected by H6 hazard flooding in a Hawkesbury Nepean Valley PMF
Macdonald Valley Public School	-	-	-	-	-	H1	H6	
Heartbreak Hill Campground	-	-	-	-	-	-	-	Isolated during flood events
Colo River								
Upper Colo Rural Fire Service	-	-	-	-	H3	H6	H6	Access cut in earlier events
Colo Heights RFS	-	-	-	-	-	-	-	Not flooded. Access from RFS to properties on the northern side of the Putty Road Bridge Colo Heights Road
Lower Portland Hawkesbury RFS	-	-	-	-	-	-	H6	Affected by H6 hazard flooding in a Hawkesbury Nepean Valley PMF

Road	20% AEP	5% AEP	2% AEP	1% AEP	1 in 500 AEP	1 in 2000 AEP	PMF	Comment
Colo Heights Public School	-	-	-	-	-	-	-	Not flood affected. Access via Putty Road to the north. Access to the South becomes isolated at Putty Road between a 5% and 2% AEP event.
Colo River holiday Park			H2	H3	H6	H6	H6	Lower parts of the of the park are affected by higher hazard flooding
Upper Colo Reserve					H6	H6	H6	Lower parts of the of the reserve are affected by higher hazard flooding
Bielany Campsite		H3	H5	H5	H6	H6	H6	Lower areas within the campsite are affected by higher hazard flooding
Wheeny Creek Campground								The campground is around 2 km upstream of the model extent. The Campground is expected to be affected by hazardous flooding in all events.
Colo Meroo Campground								The campground is around 3 km upstream of the model extent. The Campground is expected to be affected by hazardous flooding in all events.
Somerset Outdoor Learning Center			H3	H4	H6	H6	H6	Lower areas within the learning centre will be affected by higher hazard flooding
Webbs Creek								
Lower MacDonald sub RFS	-	-	-	-	-	-	-	Outside of the Webbs Creek model domain. The sub RFS is significantly impacted by flooding from the Hawkesbury Nepean Valley and is H6 hazard in PMF.
The Grove Camp Ground			H1	H2	H3	H3	H6	Lower areas within the camp grounds will be affected by higher hazard flooding
Little River Campsite	H3	H4	H5	H5	H6	H6	H6	Lower areas within the campsite will be affected by higher hazard flooding

7.4 Flood Levels and Gauging

There are two flood gauges in the study are where gauge levels can be compared to the design flood levels from the Macdonald River, Colo River, Webbs Creek & Greens Creek Flood Study (2025). These are the Upper Colo Gauge (563033) and the St Albans Gauge (061353). Flood warnings are issued for the Colo River, however warnings are not currently issued for the Macdonald River. Often, the level reported at a gauge is related to a local datum, while a design flood level is reported in Australian Height Datum.

Figure 7-3 shows the locations of gauges within the study area. The Upper Colo Gauge (563033) and the St Albans Gauge (061353) provide real-time monitoring of water levels, enabling comparisons between observed gauge levels and the design flood levels established in the Macdonald River, Colo River, Webbs Creek, and Greens Creek Flood Study (2025). The Glen Davis and Howes Valley gauges are located outside the hydraulic model extent, whole the Putty Road gauge is not currently active.

A key consideration in interpreting flood levels is the reference system used. Gauge readings typically refer to a local datum, whereas design flood levels are expressed in the Australian Height Datum (AHD). This difference requires careful conversion to ensure consistency and accurate flood level assessments.

Table 7-5 compares the flood classification and gauge levels for the Upper Colo gauge. **Table 7-6** compares the flood classification and gauge levels for the Mcdonald Colo gauge.

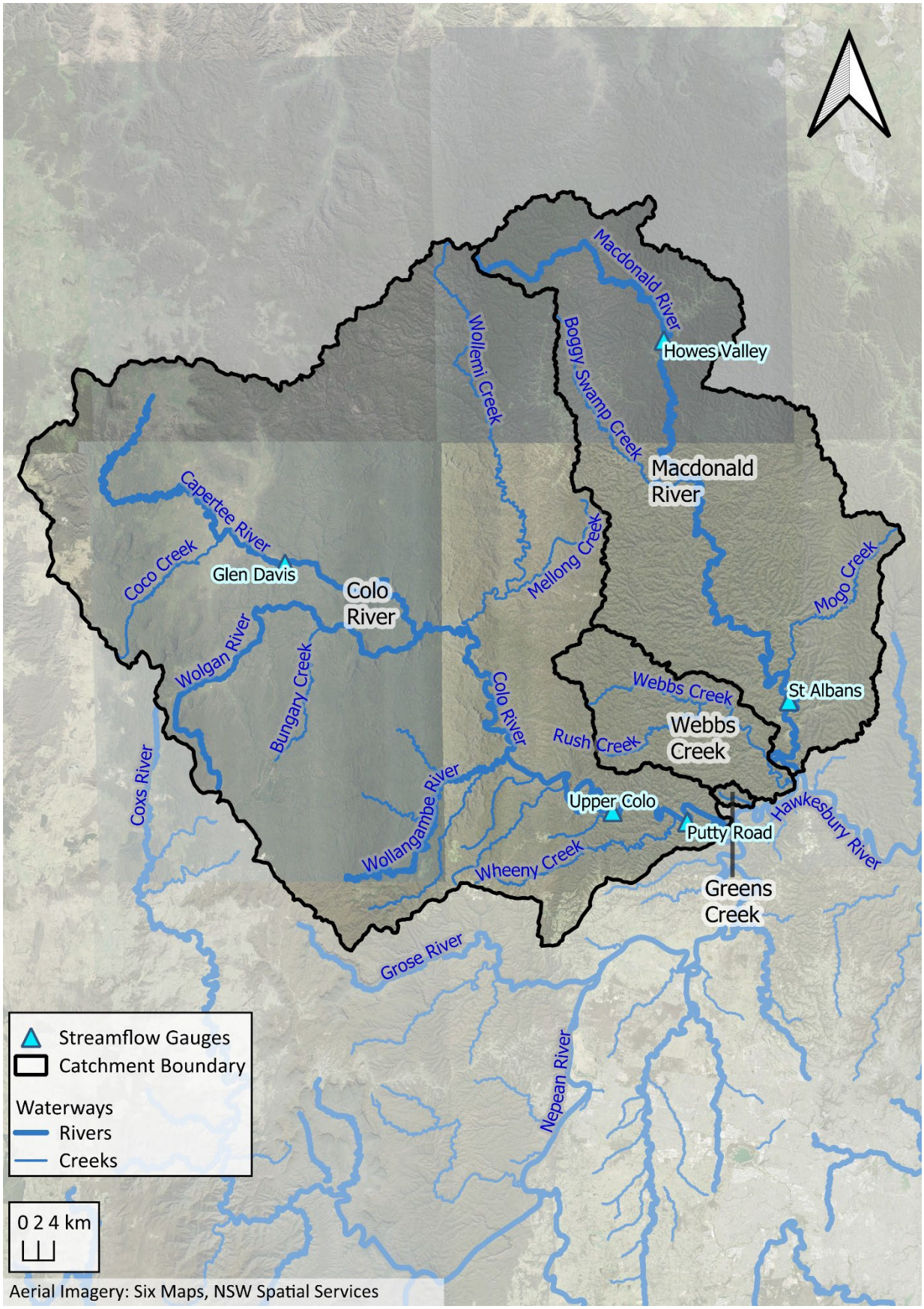

Figure 7-3 Flood gauges in the catchments

Table 7-5 Upper Colo Gauge Design Flood and Height

Classification	Gauge level (m)	Gauge Level (mAHD)	Approximate AEP
Minor	5.10	6.47	<20% AEP
Moderate	8.60	10.07	<20% AEP
	12.51	13.98	20%
Major	14.30	15.77	20% - 10% AEP
	16.16	17.63	10%
	17.91	19.38	5%
	19.4	20.87	2%
	20.13	21.60	1%
	21.4	22.87	0.5%
	23.41	24.88	0.2%
	24.95	26.42	1 in 1000
	26.26	27.73	1 in 2000
	47.9	49.37	PMF

Table 7-6 St Albans Gauge Design Flood and Height

Classification	Gauge level (m)	Gauge Level (mAHD)	Approximate AEP
Floods not classified at St Albans Gauge	6.22	8.98	20%
	7.11	9.87	10%
	9.52	12.28	5%
	12.19	14.95	2%
	12.72	15.48	1%
	14.02	16.78	0.5%
	15.12	17.88	0.2%
	15.98	18.74	1 in 1000
	16.82	19.58	1 in 2000
	27.98	30.74	PMF

7.5 Flood Warning, Public Awareness and Education

The sharing and distribution of the flood data developed as part of this study has the potential to reduce flood risk within the catchment through changing behaviours and flood responses of residents and emergency responders.

For this to be effective, the relevant flood information must be transferred in a manner that is consistent with the audience and intended purpose. Information transfer to the community and emergency responders may be undertaken through a range of programs including:

- Flood education programs for the community, and residents and operators of at-risk venues
- The development of flood awareness material (such as Flood Safe guides) for the community and businesses
- Weather and flood forecasting systems
- Updates to local flood plans based on study data
- Data handover to the SES
- Data handover to the SES flood data portal for public access.

These programs have been included as response and recovery measures options and are detailed in **Section 8.3.**

8 Flood Risk Management

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

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

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

Approaches to managing risk are outlined in **Table 8-1**.

Table 8-1. Flood risk management approaches

Flood Risk Management Approach	Examples
Preventing/avoiding risk	Appropriate development outside the flood extent
Reducing the likelihood of risk	Structural measures to reduce flooding risk such as drainage augmentation, levees, and detention
Reducing the consequences of risk	Development controls to ensure structures are built to withstand flooding
Transferring risk	Via insurance – may be applicable in some areas depending on insurer
Financing risk	Natural disaster funding
Accepting risk	Accepting and understanding that there is a residual risk

8.1 Options Identification

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

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

Table 8-2 provides examples of potential flood risk management measures.

Table 8-2 Potential Floodplain Risk Management Measures

Flood Modification	Property Modification	Response Modification
Levees	Land zoning	Community awareness/preparedness
Bypass channels	Voluntary purchase	Flood predictions and warnings
Detention basins	House raising	Evacuation planning
Flood control dams	Zoning and development controls	Evacuation access
Dredging	Flood proofing	Flood plan / recovery plan
Vegetation management	Property access improvements	Improved communications

8.2 Flood Modification Options

The feasibility of flood modification measures was initially assessed at a high level. A summary of the assessment of the potential modification measures is provided in **Table 8-2.** The preliminary modification measures were discussed with the Floodplain Management Committee on 21 August 2024.

Table 8-3 Preliminary assessment of flood modification measures

Flood Modification Measure	Details	Progress to detailed investigation
Levees	**St Albans Levee.** 1% AEP level would need to be up to 5m high. Due to the high cost and loss of amenity, a 1% AEP levee is not feasible for St Albans. A smaller levee proving protection up to the 5% AEP event may be feasible.	Yes
	Settlers Road Levee. Most floor levels are above the 1% AEP level. Some properties are flooded above floor in a PMF. Would require works on private property.	No
	Lower Macdonald Levee. Would require works on private land. Loss of amenity. Limited space for construction.	No
Bypass channels	No feasible location	No
Detention basins	No feasible location	No
Flood control dams	Significant environmental and economic impacts	No
Dredging	Unlikely to provide significant and long-term flooding benefits due to the high sand volume in the Colo and Macdonald Rivers. This option would require high ongoing costs. Environmental and biodiversity constraints. Potential geomorphological and bank stability constraints.	No
Vegetation management	Heavily vegetated reaches are typically national park.	No

8.2.1 Detailed Assessment of Flood Modification Options

Following the preliminary assessment presented in **Table 8-2,** only the St Albans levee with a protection level up to the 5% AEP progressed to detailed assessment. The levee was modelled with a freeboard of 0.1 m above the 5% AEP level. It is noted that the typical freeboard for such structures is 0.5 m above the designated protection level, allowing for uncertainties such as wave action, settlement, and hydraulic uncertainty. The reduced freeboard applied in this case reflects specific site conditions and assumptions adopted during the detailed modelling process.

Levee Layouts

Table 8-4 summarises the levee options modelled and provides some indicative cost estimates and key constraints. **Figure 8-1** shows the Levee A configuration. The green highlighted text shows the existing ground levels and the white highlighted text shows the modelled level crest levels. **Figure 8-2** shows the levee option B that is effectively a ring levee around the village of St Albans.

An order of magnitude ('ball park') cost estimate was prepared. The cost is based on a linear rate of $5,000 per metre based on estimates from Rhelm (2022) . Recognising the uncertainties in the estimates and the strategic nature of the option, a contingency of 50% has been adopted. Given the limited information available at this stage of the assessment, this contingency may represent a low bound estimate. It would not be unreasonable to adopt a higher contingency, for example, 80% given the uncertainties, lack of design.

Table 8-4 St Albans Levee Options Modelled

Option	Length (m)	Height	Cost	Considerations
Levee A	750	0.5-2m	$5.6 M plus land acquisitions	Loss of amenity, high construction cost, does not provide 5% AEP protection, upstream impacts
Levee B	1000	0.5-2m	$8.3 M plus land acquisitions.	Loss of amenity, high construction, upstream impacts. Limited protection provided. More complex design in comparison of Levee A.

Levee Option A provided some minor benefits but did not provide a 5% AEP flood immunity to St Albans due to backwater effects. Depths in parts of St Albans remained relatively high (up to 2 m in some places). A complete ring levee (Option B) was then tested and found to remove flooding in a 5% AEP event. **Figure 8-3** shows Levee B would protect the St Albans village in a 5% AEP event, however the levee does cause upstream impacts of up to 0.2m. **Figure 8-4** shows that in a 1% AEP event, the levee would cause flood levels to increase by 0.02 – 0.04m. The levee options have not considered any local drainage upgrades.

8.2.1.1 Economic Analysis St Albans Levee B

The economic assessment in **Table 8-5** is based a 50 year life span and a 5% discount rate. St Albans Levee B was found to have a very low benefit cost ratio of 0.13. Based on economic assessment alone, the levee is not recommended for inclusion in the Floodplain Risk Management Plan. Other considerations that would further limit the feasibility of Levee B include the need for land acquisitions, loss of amenity, upstream impacts and possible creation of a false sense of security that could reduce early evacuation. While the levee would protect the village in smaller events up to a 5% AEP flood, in larger events such as the 1% AEP event, flood levels would increase.

Table 8-5 Economic assessment of St Albans Levee

Option	Cost	Annual Cost*	NPV Costs	NPV Benefits	Benefit Cost Ratio
Levee B	$8.3M	$8,300	$ $8,451,524	$ $1,058,844	0.13

*0.1 % of capital expenditure

Figure 8-1 St Albans Levee A

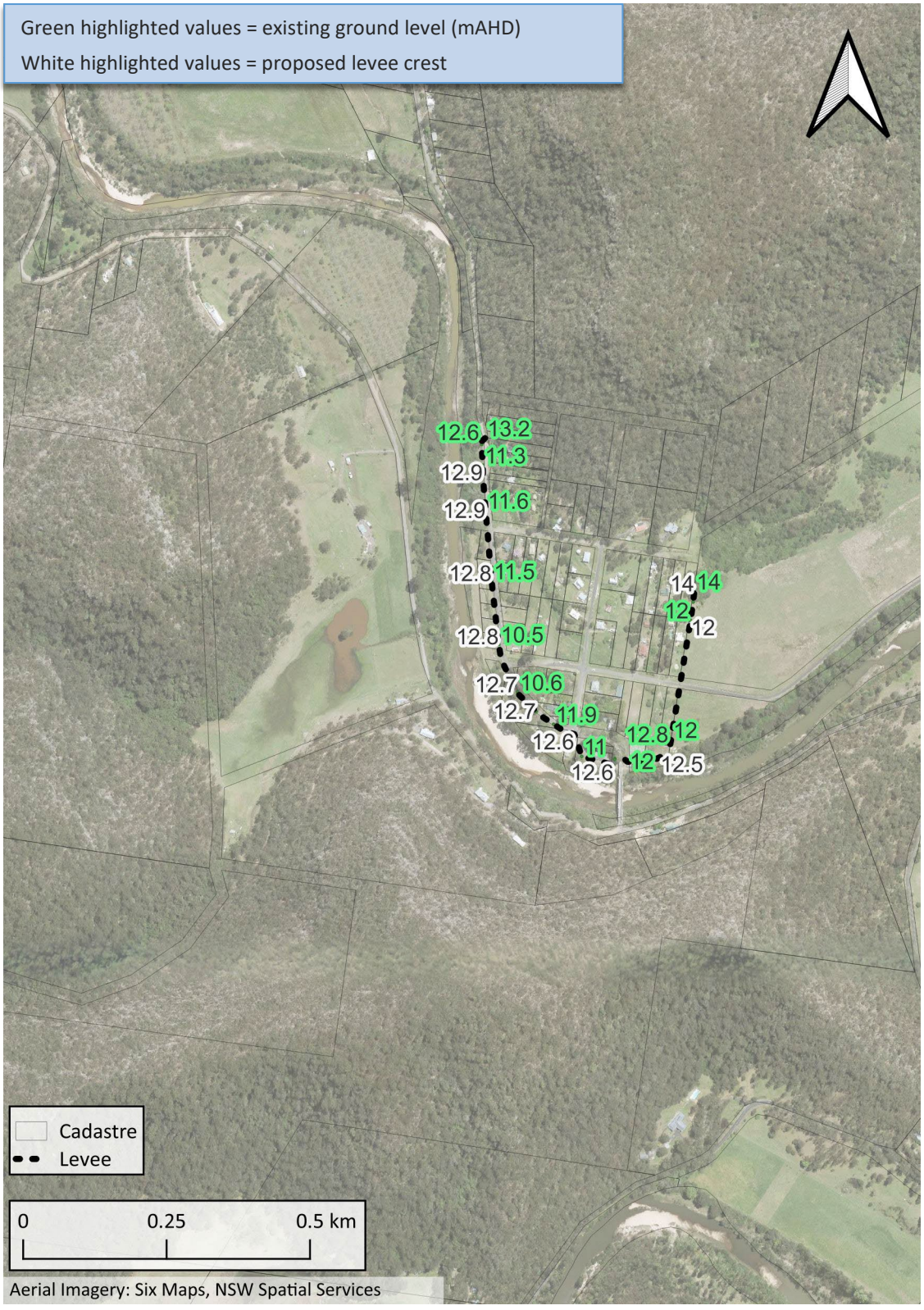

Figure 8-2 St Albans Levee B Extended Levee Option

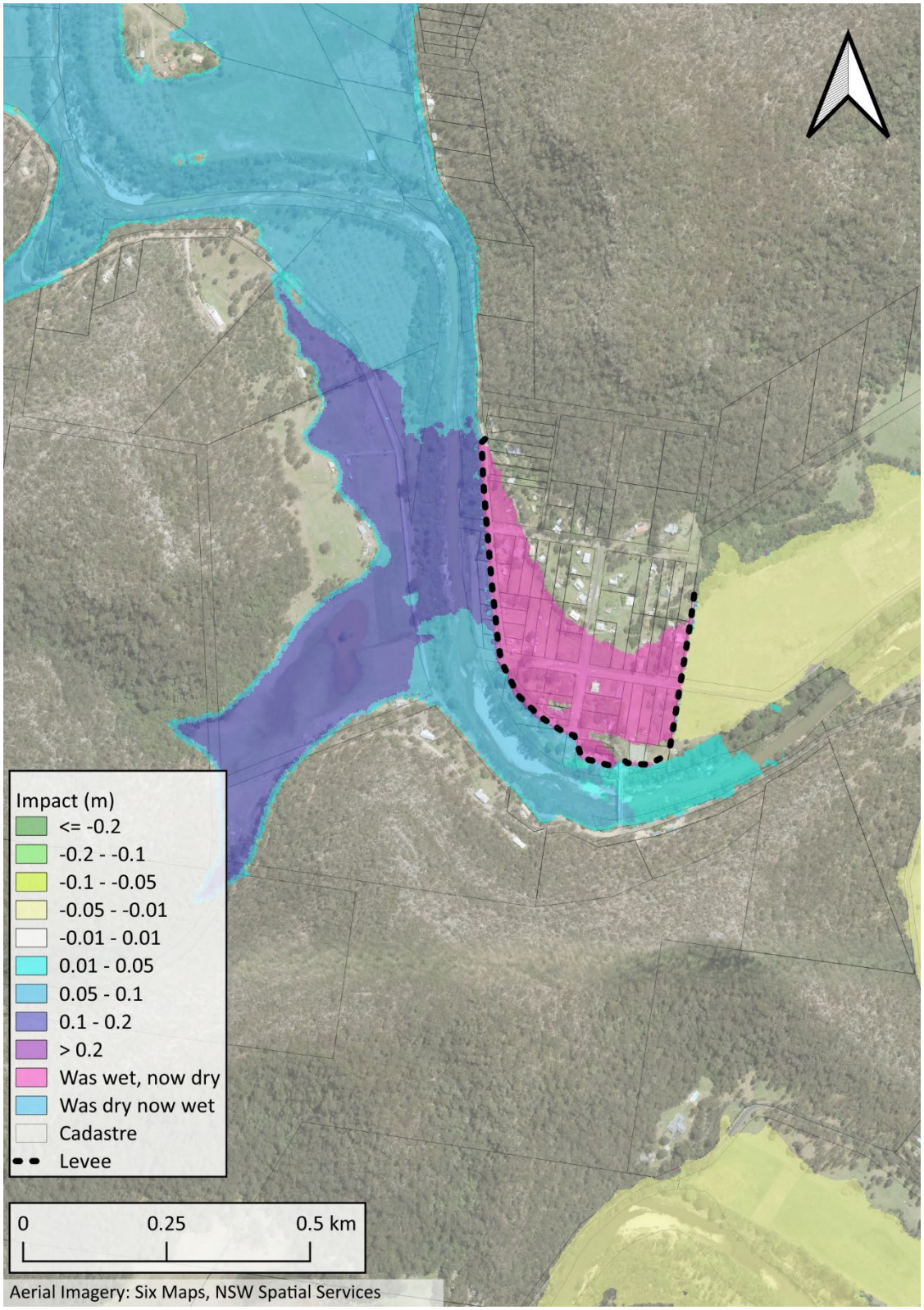

Figure 8-3 Levee Option B 5% AEP Flood Level Impact

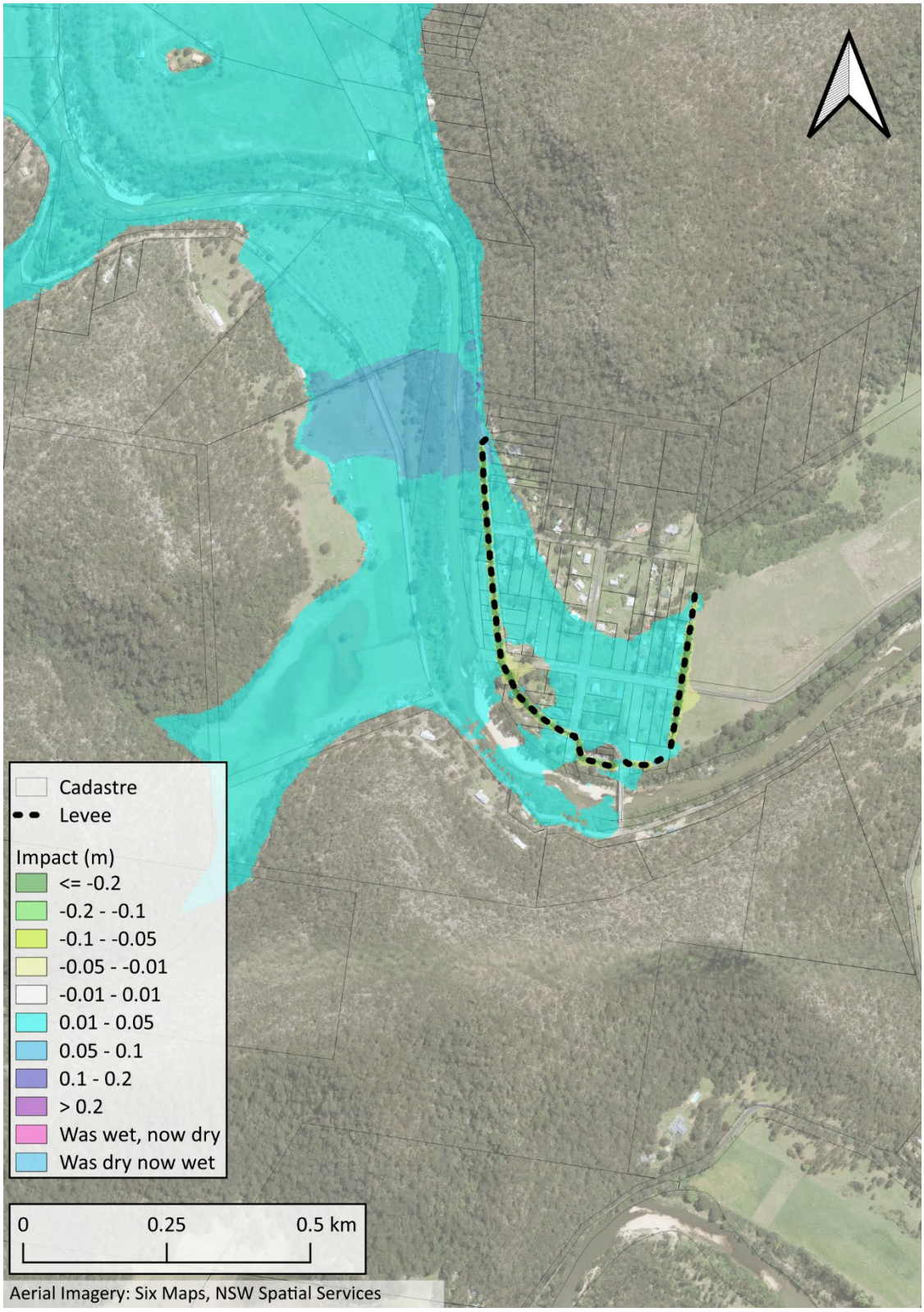

Figure 8-4 Levee Option B: 1% AEP Flood Level Impact

8.3 Response and Recovery Modification Measures

Response and recovery modification measures aim to reduce the consequences of flood risks by:

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

Many of these types of measures are typically incorporated into the NSW SES local flood plan, and education of the community on the contents of the plan is very important. As noted within the Flood Risk Management Manual (NSW Government, 2023) these measures effectively modify the response of the community at risk to better cope with a flood event.

Of all the floodplain risk management options available for consideration, it is only emergency management modifications (which includes community planning) that addresses the residual flood risk after all the flood and property modification options have been implemented.

For the Study area, a combination of structural and non-structural emergency response options has been identified. The structural options primarily involve the development of improved or new access to facilitate emergency evacuation and access during a flood event.

8.3.1 EM1 – Data Handover to SES

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

- Flood depth and extent maps for various events
- Hazard and flood function mapping
- Flood emergency response classifications
- Location and depth of road inundation within the study area for the modelled flood events
- Map of flooded properties, including the events in which the properties are inundated, and events in which over floor flooding occurs (if applicable).

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

All relevant data, mapping and reporting will be handed over to the SES through the SES Flood Data Portal consistent with the requirements outlines in *Support for emergency management planning Flood risk management guideline EM01* (DPE, 2023c).

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

8.3.2 EM2 – Update of Emergency Response Documentation

The Hawkesbury-Nepean Valley Flood Emergency Plan (2020) and the Hawkesbury City Local Flood Plan cover the Colo River, Webbs Creek and Macdonald River. Greens Creek is not mentioned in the Plan however evacuation is considered within the Webbs Creek and Colo Sectors, including the inundation of Greens Road.

Both Plans should be updated based on the design flood and emergency management information provided in this study and more specifically consider the communities within this study area.

8.3.3 EM3 –Flood Warning System and Gauges

Currently, flood warnings in the study area are restricted to the Colo River, with no warnings issued for St Albans on the Macdonald River. However, the Bureau of Meteorology (BOM) is leading an ongoing project to upgrade the gauge at St Albans. This upgrade should ensure that flood warnings can be issued for the area.

Furthermore, there is a valuable opportunity to enhance flood prediction and warning systems across the study area. The presence of rainfall and flow gauges within catchment areas significantly improves flood information for the community. At present, the study area is equipped with five pluviographic rainfall gauges—two in the upper catchment and three in the lower catchment—as well as three flood level gauges. Communities throughout the study area can become isolated during relatively small flood events. It is recommended that additional rainfall and water level gauges be placed at key crossings in the MacDonald River, Colo River and Webbs Creek catchments. It is also recommended the community be given access to additional live water level gauge data to allow more informed decision making during flood events. A recently installed flood warning system in the neighbouring Wollombi Brook catchment could be considered as a local case study when implementing a flood warning system. The Wollombi Brook flood warning system operates outside of the BOM official warning system but allows the community to better understand and share flood information. Community groups such as the Macdonald Valley Association would be well placed to share live flood information with the community.

It is recommended Council undertake a feasibility study in collaboration with the SES and BOM to enhance the flood warning system within the study area.

8.3.4 EM4 – Emergency Response Plans for Flood Affected Facilities and Organisations

As discussed in **Section 7**, a number of vulnerable locations are flood affected within the study area, including tourist and visitor accommodation and schools.

These locations contain demographics who may be more vulnerable to flood risk than the general population. In the case of tourism and visitor accommodation, these transient populations may not be familiar with the flood risk. Therefore, timely and appropriate flood response are critical to ensure the safety of those on-site.

It is recommended that flood affected tourist and visitor accommodation (including short term rentals), and schools prepare a flood response plan. This includes directly affected properties as well as properties that may become isolated during flooding. The Plans would include:

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

It is noted that the responsibility for the preparation of these plans lie with the site owner. However, it is recommended that Council communicate the outcomes of this study with the owners, and attempt to collaborate with them, and SES in developing flood plans for these sites. The SES website contains

tools to assist in the preparation of such plans including the emergency plan template: https://www.ses.nsw.gov.au/emergency-plan-template.

Education related to campgrounds within the study area are covered specifically in **Section 8.3.7.**

8.3.5 EM5 – Flood Warning Signs and Information

Flood warning and information signs may be used to educate the community on flood risk, or to provide them with flood information during a flood event (such as depth markers) to allow them to make safer decisions.

It is recommended that depth gauges be installed at road crossings and campgrounds that are subject to flooding in frequent events and/or experience high hazard flood conditions in larger events.

8.3.6 EM6 – Community Education and Awareness

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

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

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

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

8.3.7 EM7 – Campground Flood Education Program

There are several campgrounds located in the study area which present a significant risk during flood events as occupants (campers and/or tourists) are unlikely to be as familiar with the flood behaviour and risks as long term residents. The consequences of being flooded or becoming isolated while camping are significant.

Hawkesbury-Nepean Valley Flood Risk Management Directorate, in 2022, developed a flood emergency plan template for caravan parks along the Hawkesbury-Nepean River aimed to improve their flood preparedness and responsiveness. Central to this project was the development of a highly collaborative working group that involved all key stakeholders, including the local councils, communications and engagement specialists, NSW SES, local SES volunteers, and flood specialists.

It is recommended that Council adapt the flood emergency plan template developed in the Hawkesbury-Nepean project, or that a similar project be undertaken with camp ground operators in the study area.

The project would seek to develop a flood emergency plan template drawing on the latest flood data, communications principles, and the input of local SES units and campground operators. The development and implementation of a plan based on this template could be enforced by Council as a condition for an approval to operate in this region. Council could draw on the experience of the Hawkesbury-Nepean Valley Flood Risk Management Directorate to inform the development of this plan.

It is noted that a key component of this plan is the involvement of the campground operators in the development of the template and the completion of their plans. In particular, Council and the SES providing them with adequate support and training in the development of these plans.

8.3.8 EM8 – Flood Shelter at Camping Sites

As mentioned above, campgrounds present an increased flood risk to occupants during flood events. Notable amongst these risks is the lack of formal shelter and the risk of inundation.

This option would see the construction of a flood refuge above the PMF, and of a size to accommodate the maximum number of occupants in which the campground can host.

It is noted that this shelter would act as a last resort but would provide a dry and safe refuge for campers during a flood event until evacuation or rescue is possible. Due to the extreme flood depths during a PMF in some parts of the study area, it may not be feasible for some campsites to construct a PMF refuge. Alternatives may include formal arrangements with neighbouring properties or constructing flood resilient shelters as high as practical. The feasibility of this option could be discussed with camp site operators during the implementation of EM7 - Campground Education Campaign and Emergency Response Plan. As this option would be the responsibility of the campground owner, it has not been assessed through the multi criteria assessment.

Council may also need to consider revisions to flood related planning controls (See **Section 8.4.1)** to accommodate flood shelters.

8.3.9 EM9 – Data Collection following Flood Events

The availability of historical flood data provides numerous benefits to Council and the SES, namely:

- Identification of areas that experience frequent flooding issues
- Confirmation (or not) that Council and SES records of high-risk locations and road overtopping behaviour is correct
- Confirmation (or not) that the flood modelling undertaken to date accurately reflects flood behaviour observed during flood events
- Allows for a more comprehensive calibration and validation process when flood models are updated in the future.

In order to supplement the historical data already held by Council, the collection of flood data following flood events should be continuously undertaken. Depending on the size of the event, such data may include:

- Records of complaints or observations made by the community
- Photographs taken during or after the flood event
- Notes made of road inundation locations and durations
- Survey of flood marks following the event.

It is recommended that a formal process be developed within Council for this collection, which outlines the type of data required (location, level, etc.), the steps to collect the data, and the identification of safety measures surrounding collecting the data.

The condition of Council assets should also be systematically inspected following flooding. It is recommended that a post flood asset inspection checklist be developed for use by Council. The checklist should include a list of key structures to be inspected and a method for collecting and surveying reliable

flood marks. Post flood event data collected by other organisations such as the SES. There should be a coordinated approach to post event data collection.

8.3.10 EM10 – Gauge Data Reported in mAHD

Currently available stream gauge data at Colo and St Albans are reported to a local site datum. This may prove confusing to residents and members of the community when comparing gauge levels to ground and property levels. To make the data more accessible and less prone to misinterpretation it is recommended that the datum at these gauges be revised to be reported in mAHD or both the local datum and mAHD levels are reported.

It is understood that this is not a decision for Council to make. It is suggested that this recommendation be shared with the gauge operators, along with the reasoning behind it, to start a conversation with the relevant stakeholders about making this change. The involvement of the SES in these discussions would also be suggested.

Whilst the option is considered a viable means of improving flood awareness and communication, it has not been recommended for inclusion in the plan, due to its implementation being beyond Council's control.

8.3.11 EM11 – Scoping Study to Improve Flood Immunity at Crossings

This option focuses on prioritizing upgrades to road surfaces to facilitate the reopening of key access routes as quickly as possible following flood events. Upgrading road surfaces would not significantly improve access during a flood event but may allow key access roads to be opened sooner following flooding.

Targeted road surface upgrades could be considered for sections of Settlers Road, St Albans Road, and Upper Colo Road, which sustained damage during the April and June 2022 flood events. To ensure durability, upgrades should designed with concrete pavement or other materials resistant to hydraulic forces, as asphalt surfacing is prone to failure under flooding conditions.

Localised improvements adjacent to crossings may be achievable as part of future crossing upgrades and would serve to provide some road protection where depths and velocities are greatest, but widespread road and crossing upgrades are not considered feasible.

Updating all low-level crossings along the Macdonald River to standard to recently completed Gorricks Run Causeway shown in **Figure 8-5** would improve resilience and recovery post flood events. Upgraded crossings should be constructed as high as practicable. It is recognised achieving a specific flood immunity is not possible at many crossings due to the very high flood depths in events in frequent (e.g. 20% AEP) flood events.

Figure 8-5 The $1.25M Gorricks Run Causeway Replacement Completed in October 2024

8.4 Property Modification Options

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

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

The property modification options assessed for the study area are discussed below.

8.4.1 PM1 – Land Use Planning and Building Control Recommendations

Table 8-6 provides land use planning recommendations based on the outcomes of **Section 5** Flood planning review and **Section 6** Defining areas to support land use planning. The recommendations, provided in **Table 8-6** , have been made to assist Council in achieving best practice flood planning in the study area and across the LGA.

Table 8-6. Flood planning recommendations

Number	Issue	Recommendation
P1	Hawkesbury LEP does not include the optional clause 5.22 Special Flood Considerations	Council amend the HLEP (2012) to include S5.22 Special Flood Considerations. **Section 5.1.4** provides further detail.
P2	Flood Planning Level and Defined Flood Event (DFE)	Council adopt the 0.5% AEP (1 in 200 year) event as the DFE. Design flood levels in the study area, particularly in the Colo and MacDonald River catchments are sensitive to changes in flow. Future design rainfall is expected to increase with climate change. Adopting a 0.5% AEP event as the DFE will improve flood resilience for existing and future communities. **Section 6.1** provides further detail regarding the DFE recommendation. The flood planning level is recommended to be the DFE plus 0.5 m freeboard See **Section 6.2** for further details.
P3	Flood Planning Precinct Categories	**Section 6.4** presents Flood Planning Precinct Categories (FPCCs) and example controls for the study area. It is recommended Council adopt the FPCC approach across the LGA. Council could adopt the FPCCs presented in the study, or tailor the mapping criteria and controls to align with other study areas.
P4	Flood Policy (2020) and Schedule of Flood Related Development Controls (2021)	The Flood Policy (2020) and Schedule of Flood Related Development Controls (2021) will require updating to incorporate recommendations **P2** and **P3.** Alternatively, Council could create a new Floodplain Management chapter within Part C: General Guidelines for the DCP 2002. **Table 5-1** provides specific recommendations.

8.4.2 PM2 – Flood Proofing/ Flood Resilient Buildings

Flood proofing or flood resilient building is the process of undertaking changes to both the structure and operating procedures of flood affected properties to reduce the damages experienced by the property during flood events. Flood proofing can apply to either existing dwellings that are flood affected, or to new buildings. As Council's flood policies govern new development and have specific requirements for flood planning levels (effectively flood proofing future buildings), this FRMS option focuses on flood resilience for existing buildings.

For flood resilient or compatible materials, these focus on minimising the direct building damages[2], being protecting elements of the building such as walls or floorings. It does not provide any benefit for the external damages (e.g. fences etc.), contents damages or any significant reduction in intangible damages or risk to life.

[2] In the literature on flood damages, building damages can sometimes be referred to as structural damages. To differentiate structural elements of a building (such as the frame) from non-structural elements (such as insulation), they have been referred to as building damages in this report.

There are several guidelines and references for flood resilient buildings and materials, both nationally and internationally. The two key references for Australia are the Blue Book (HNFMSC, 2006), developed for the Hawkesbury-Nepean floodplain but applicable to NSW and wider, and the more recent Queensland flood resilient guide (QRA, 2019). Despite its age, the blue book, *Reducing Vulnerability of Buildings to Flood Damage – Guidance on building in flood prone areas* (HNFMSC, 2006), represents a milestone in the field of flood-resistant building design. The majority of contemporary standards and reviews (including guidelines overseas) reference this document. A more detailed review of the Blue Book and international guidance is provided in Collier et al (2021). In addition, Collier et al (2021) presents draft resilient development and building controls for new residential development in the Hawkesbury-Nepean floodplain.

The focus of Collier et al (2021) and the Blue Book are primarily on new build construction, rather than retrofitting. QRA (2019) includes retrofitting measures. Further guidance on improving flood resilience within buildings is provided in NSW RA (2024a and 2024b)

Retrofitting of buildings can be difficult, particularly integrating within older housing types. While resilient features such as flooring can be retrofitted to some degree, protection of walls and the building structure itself is more challenging. For example, retrofitting of walls needs to consider not only the wall cladding, but also the insulation. Both of these features can also generally be replaced for significantly less cost than their resilient alternatives.

Given these challenges, and the limited number of residential properties within the floodplain, it is suggested that this option may not be a focus for the floodplain for residential properties.

The flood proofing measures suggested by the SES business toolkit could be considered as and distributed as part of an educational program for any commercial buildings within the floodplain. As such, is recommended that this option be combined with EM6 – Community Education and Awareness.

8.4.3 PM3 – Voluntary Purchase

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

The main aim of VP is to permanently remove at risk people from high flood hazard areas (areas with high flood depths and velocities) by purchasing their properties. Once purchased, the dwelling is removed, and the property is generally reclassified as community or operational Council owned land.

The NSW State Government, through DCCEEW provides grants to councils under the Floodplain Management Program for eligible properties in defined VP schemes. Properties being considered for VP should be located in one or more of the following locations:

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

The criteria developed to determine if additional properties should be added to the VP list was based on the Floodplain Management Program Guidelines for voluntary purchase schemes (DCCEWW, 2024a)

- Only residential properties constructed prior to 1986 are eligible

- Overfloor flooding H4 hazard and above in a 1% AEP flood
- No internal refuge above PMF (e.g. second storey)
- The property is located within a floodway and the removal of a building may be part of a floodway clearance program
- No viable structural flood modification measure identified that would reduce the risk to life
- purchase of a property enables other flood mitigation works (such as channel improvements or levee construction) to be implemented because the property will impede construction or may be adversely affected by the works with impacts not able to be offset.

170 properties within the study area are affected by overfloor flooding in a 1% AEP event with 138 properties affected by H4 flooding and above. As highlighted in **Section 7.2**, these properties are also isolated for relatively long periods of time, with limited evacuation potential (representing a reasonable risk to life).

A further consideration in VP on rural properties is the impact on productive land. Specific consideration needs to be given in the appropriate development of a VHP scheme that ensures that productive rural land is not vacated. This might include, for example, the purchase of a small area around the dwelling, rather than the entirety of the property.

Noting the complexities around VP, and the considerations above, it is recommended that Council undertake a scoping study to prioritise potential properties for VHP. This could be at a study area scale or LGA wide scale.

8.4.4 PM4 – Voluntary House Raising

Voluntary house raising (VHR) is a flood risk management tool that involves raising a home above the minimum flood design level or relocating a home within its current lot to higher ground. Without detailed property survey data (including building material type), it is not possible to assess the suitability of properties for VHR. Council may consider a future VHR prioritisation study at a study area or LGA wide scale.

The Guidelines for the voluntary house raising schemes (DCCEEWb, 2024) include the following relevant criteria:

- Funding is only available for residential properties, not commercial or industrial properties.
- Funding is only available for properties with buildings that were approved and constructed prior to 1986.
- Properties that are benefiting substantially from other floodplain mitigation measures – such as houses already protected by a levee or those that will be – will not be funded for VHR.
- VHR should generally return a positive net benefit in damage reduction relative to its cost (benefit-cost ratio greater than 1). Consideration may be given to lower benefit-cost ratios where there are substantial social and community benefits, or VHR is compensatory work for the adverse impacts of other mitigation works.
- The VHR Scheme should involve raising residential properties above a minimum design level and must comply with the council's relevant development control plan.

It is noted that a number of the properties are on large rural lots, and therefore there may also be the potential for relocation of dwellings within the lot, depending on the dwelling type etc. This may be

a more appropriate measure to ensure that people remain on the land, while also reducing the flood risk.

It is recommended that Council undertake a scoping study to prioritise potential properties for VHR. This study could be combined with the scoping study recommended under PM3 - Voluntary Purchase.

9 Multi-Criteria Assessment

A Multi-Criteria Assessment (MCA) approach has been developed for the comparative assessment of all floodplain management options identified within the study area using a similar approach to that recommended in the Flood Risk Management Manual (NSW Government, 2023).

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

A scoring system was devised to subjectively rank each measure for a range of criteria considering the background information on the nature of the catchment and floodplain.

The categories and criteria adopted are:

- Flood Risk Reduction
    - Reduction in flood damages
    - Increased community flood awareness
    - Reduction in risk to life
    - Emergency response
- Feasibility
    - Cost (capital and ongoing)
    - Implementation complexity
- Social and Environmental
    - Likely community support. This assessment criteria will be updated following public exhibition.
    - Environmental. Considers potential environmental impacts of any works following scoping studies.

As no structural options have been identified that would require works in the floodplain, environmental constraints have not been considered in the MCA.

The options assessment undertaken in Section 8 has already filtered out mitigation options that are unsuitable for the study area. As such, the MCA has focussed on dividing the suitable options into levels of priority (high, medium and low) for inclusion in the FRMP.

The MCA approach undertaken adapts a "traffic light" system to indicate where the flood management options create value for Council and the community. The adopted lights were:

- Dark Green – High value, 2 points
- Light Green - Medium value, 1 point
- Yellow – Not applicable or neutral, 0 points
- Red – Low or negative value, -1 point

There was a total of 11 options assessed using the MCA. The results are presented in **Table 9-1.**

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

With respect to flood risk, the MCA indicates that the focus of the options is reducing risk to life and improving emergency response, with secondary benefits to flood awareness and reductions in flood damages. .

Table 9-1 Multi Criteria Assessment

Option ID	Option Description	Flood Risk Reduction				Feasibility		Social and Environmental		Outcome	
		Reduction in Flood Damages	Increased Community Flood Awareness	Reduction in Risk To Life	Emergency Response	Cost	Implementation complexity	Likely Community Support	Environmental	Score	Priority
Response and Recovery Modification Options											
EM1	Data handover to SES	0	1	1	1	2	2	2	0	9	High
EM2	Update of Emergency response documentation	0	1	1	2	2	1	2	0	9	High
EM3	Flood Warning System and Gauging's	1	1	1	2	2	-1	2	0	8	High
EM4	Emergency Response Plans	1	1	1	2	1	1	1	0	8	High
EM5	Flood Warning Signs and Information	1	2	1	0	2	2	1	0	9	High
EM6	Community Education and Awareness	1	2	1	0	1	1	2	0	8	High
EM7	Campground Education Campaign	1	2	1	0	2	1	2	0	9	High
EM9	Data Collection following Flood Events	0	2	1	1	1	2	2	0	9	High
EM11	Scoping Study to Improve flood immunity of crossings	1	0	1	1	-1	0	2	0	4	Medium
Property Modification Options											
PM1	Land Use Planning and Building Control	2	1	2	1	1	0	1	1	9	High

PM3	VP/VHS Scoping Study	2	2	1	0	0	-1	0	0	4	Medium

10 Conclusions

The Combined Catchments of Macdonald River, Colo River, Webbs Creek and Greens Creek FRMS has been prepared for Council to assess and address the flood risks present in the catchment. The FRMS provides an understanding of the flood risk within the study area, as well as mitigation strategies to address this risk, to ensure the safeguarding of residents, properties, and other infrastructure.

The overall objective of this study was to better inform the management of flood risk in the study area in consideration of the available information, and relevant standards and guidelines. The project will also assist Council with planning for future development and will provide flood intelligence to the SES to enable them to progress their emergency management planning for the region.

A comprehensive review of Council's current flood related planning and development controls was undertaken. The purpose of the flood planning review was to establish the existing flood planning context in relation to the study area.

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

The outcomes of the multi-criteria assessment provide a sound basis upon which Council can make informed decisions to reduce the impact of flooding on property and life. The implementation strategy associated with the outcomes of this study may not necessarily approach the options from "highest ranking to lowest ranking" but will also need to incorporate various other considerations such as existing works programs, availability of funding and other opportunities to combine floodplain works with other activities.

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

11 References

AIDR (2017). *Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*. Handbook 7: Australian Disaster Resilience Handbook Collection. East Melbourne.

DPE, 2023a *Seniors Housing Design Guide*, NSW Department of Planning and Environment. Department of Planning and Environment

DPE, 2023b *Understanding and managing flood risk*, *Flood risk management guideline FB01.* NSW Department of Planning and Environment.

DPE, 2023c *Support for emergency management planning*, *Flood risk management guideline EM01.* NSW Department of Planning and Environment.

Collier, L., Thomson, R., Schwecke, M., & Camroux, S. (2021). Flood Resilient Building Controls - next generation guidance for the Hawkesbury Nepean floodplain. *2021 Online Floodplain Management Australia National Conference.* Online: Floodplain Management Australia. Geoscience Australia (2023) Emergency Management Facilities Database. Available:

https://ecat.ga.gov.au/geonetwork/srv/api/records/015c1b8c-7b47-4780-8206-1bd39ad2120b

DCCEEW (2024a) Guidelines for the voluntary house purchase scheme. NSW Government. Department of Climate Change, Energy, the Environment and Water.

DCCEEW (2024b) Guidelines for voluntary house raising schemes. NSW Government. Department of Climate Change, Energy, the Environment and Water.

DPHI (2025) Shelter-in-Place Guideline for flash flooding. Department of Planning, Housing and Infrastructure. Available: https://www.planningportal.nsw.gov.au/draftplans/made-and-finalised/shelter-place-guideline-flash-flooding

Microsoft (2023). *Australian Building Footprints*. GitHub repository. Available: https://github.com/microsoft/AustraliaBuildingFootprints

NSW Government (2023*) Flood Risk Management Manual.*

NSW Government (2023a). *Flood Risk Management Manual: The policy and manual for the management of flood liable land*. Department of Planning and Environment.

NSW Government (2023b). *Flood Risk Management Guideline FB03: Flood Hazard*. Department of Planning and Environment.

NSW Government (2023c). *Flood Risk Management Measures: Flood Risk Management Guideline MM01*. Department of Planning and Environment.

NSW RA (2024a) Resilient Homes Program Guideline – Northern Rivers. NSW Reconstruction Authority. Version 3.

NSW RA (2024b) Resilient Homes Program - Central West Program Guideline. NSW Reconstruction Authority. Version 1

NSW Spatial Services (2023). *NSW Digital Cadastral Database Clip and Ship.* Available:

QRA. (2019). *Flood Resilient Building Guidance for Queensland Homes.* City East Queensland: Queensland Reconstruction Authority. Rhelm (2022) National Flood Hazard Mitigation Priorities Technical Report. IAG Available

Rhelm & CSS (2024). *Hawkesbury-Nepean River Flood Study*. NSW Reconstruction Authority.

SIX Maps - Clip & Ship (nsw.gov.au)

Road and Traffic Authority of NSW (1994). *Bridge over Colo River at 24.9 km North of Windsor*. Schedule of Drawings.

Webb, McKeown & Associates (2004). *Lower Macdonald River Flood Study*. Hawkesbury City Council.

Glossary

The following glossary was adapted from the NSW Flood Risk Management Manual (NSW Government, 2023a).

Term	Description	Context for use/additional information
Annual exceedance probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage	AEP is generally the preferred terminology. ARI is the historical way of describing a flood event; for example, a 1% AEP flood has a 1% or 1 in 100 chance of being reached or exceeded in any given year
Australian Height Datum (AHD)	A common national surface level datum often used as a referenced level for ground, floor and flood levels	0.0m AHD corresponds approximately to mean sea level
Average recurrence interval (ARI)	The long-term average number of years between the occurrence of a flood equal to or larger in size than the selected event	ARI is the historical way of describing a flood event. AEP is generally the preferred terminology; for example a 100-year ARI flood that has 1 in 100 chance of being reached or exceeded in any given year. It is equivalent to a 1% AEP flood
Catchment	The area of land draining to a specific location	It includes the catchment of the primary waterway as well as any tributary streams and flowpaths
Defined flood event (DFE)	The flood event selected as a general standard for the management of flooding to development	Used to define the flood planning levels
Design flood	Design floods are hypothetical floods used for planning and floodplain management investigations. They are based on having a probability of occurrence specified as Annual Exceedance Probability (AEP) expressed as a percentage.	The design flood may be considered the flood mitigation standard for works or planning. For example, a levee may be designed to exclude a 2% AEP flood, which means that floods rarer than this may breech the structure and impact upon the protected area. In this case, the 2% AEP flood would not equate to the crest level of the levee, because this generally has a freeboard allowance, but it may be the level of the spillway to allow for controlled levee overtopping
Development	May be treated differently depending on the following categorisation: **infill development**: the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under current land zoning **new development:** development of a completely different nature to that associated with the former landuse (e.g. the urban subdivision of a previously rural area)	New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power Redevelopment generally does not require either rezoning or major extensions to urban services

Term	Description	Context for use/additional information
	redevelopment: rebuilding in an area (e.g. as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale)	
Flood	A natural phenomenon that occurs when water covers land that is normally dry. It may result from coastal inundation (excluding tsunamis) or catchment flooding, or a combination of both	Flooding results from relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flowpaths associated with major drainage, and/or oceanic inundation resulting from superelevated ocean level
Flood awareness	An appreciation of the likely effects of flooding, and a knowledge of the relevant flood warning, response and evacuation procedures facilitating prompt and effective community response to a flood threat	In communities with a low degree of flood awareness, flood warnings may be ignored or misunderstood, and residents confused about what they should do, when to evacuate, what to take with them and where to go
Flood education	Seeks to provide information to raise awareness of flooding so as to enable individuals to understand how to manage themselves and their property in response to flood warnings	It can support a state of flood readiness
Flood evacuation	The movement of people from a place of danger to a place of relative safety, and their eventual return	People are usually evacuated to areas outside of flood prone land with access to adequate community support Livestock may be relocated to areas outside of the influence of flooding
Flood fringe areas	That part of the flood extents for the event remaining after the flood function areas of floodway and flood storage areas have been defined	
Flood function	The flood related functions of floodways, flood storage and flood fringe within the floodplain	Flood function is equivalent to hydraulic categorisation
Flood hazard	A flood that has the potential to cause harm or conditions with the potential to result in loss of life, injury and economic loss	The degree of hazard varies with the severity of flooding and is affected by flood behaviour (extent, depth, velocity, isolation, etc.)
Flood impact and risk assessment	A study to assess flood behaviour, constraints and risk, understand off-site flood impacts on property and the community resulting from the development, and flood risks to the development and its users	These studies are generally undertaken for development and are to be prepared by a suitably qualified engineer experienced in hydrological and hydraulic analysis for flood risk management
Flood plan (local or state)	A subplan of an emergency plan that deals specifically with flooding; they can exist at state, zone and local levels	The NSW Government develops flood plans as a legislative responsibility to determine how best to respond to floods. These community-based plans describe the risk to the community, outline agency roles and responsibilities, the agreed community

Term	Description	Context for use/additional information
		emergency response strategy and how floods will be managed. The relevant plan within the study area is the Hawkesbury-Nepean Valley Sub-Plan.
Flood planning area (FPA)	The combination of the flood level from the DFE and freeboard selected for FRM purposes	Different FPLs may apply to different types of development. Determining the FPL for typical residential development should generally start with a DFE of the 1% AEP flood plus an appropriate freeboard (typically 0.5 metres). This assists in determining the FPA
Flood planning levels (FPLs)	Flood planning levels selected for planning purposes are derived from a combination of the adopted flood level plus freeboard, as determined in floodplain management studies and incorporated in floodplain risk management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also consider the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plans.	The concept of FPLs supersedes the "standard flood event". As FPLs do not necessarily extend to the limits of flood prone land, floodplain risk management plans may apply to flood prone land beyond that defined by the FPLs.
Flood prone land	Land susceptible to inundation by the probable maximum flood (PMF) event. Under the merit policy, the flood prone definition should not be seen as necessarily precluding development. Floodplain Risk Management Plans should encompass all flood prone land (i.e. the entire floodplain).	
Flood prone land	Land susceptible to flooding by the PMF event	Flood prone land is also known as the floodplain, flood liable land and flood affected land
Flood storage areas	Areas of the floodplain that are outside floodways which generally provide for temporary storage of floodwaters during the passage of a flood and where flood behaviour is sensitive to changes that impact on temporary storage of water during a flood.	See also flood function, floodways and flood fringe areas
Floodplain	Land susceptible to flooding by the PMF event.	See the definition of flood prone land
Floodways	Areas of the floodplain which generally convey a significant discharge of water during floods and are sensitive to changes that impact flow conveyance. They often align with naturally defined channels.	See also flood function, floodways and flood fringe areas Floodways are sometimes known as flow conveyance areas

Term	Description	Context for use/additional information
Freeboard	A factor of safety typically used in relation to the setting of minimum floor levels or levee crest levels	Freeboard aims to provide reasonable certainty that the risk exposure selected in deciding on a specific event for development controls or mitigation works is achieved. Freeboards for development controls and mitigation works will differ. In addition, freeboards for development control may vary with the type of flooding and with the type of development
Gauging height	The height of a flood level at a particular water level gauge site related to a specified datum	The datum may or may not be the AHD
Hazard	A source of potential harm or conditions that may result in loss of life, injury and economic loss due to flooding	
Hydraulics	The study of water flow in waterways and flow paths; in particular, the evaluation of flow parameters such as water level and velocity	
Hydrology	The study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods	
Merit-based approach	Weighs social, economic, ecological and cultural impacts of land-use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and wellbeing of the state's rivers and floodplains	The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk, which are formulated into council plans, policy, and environmental planning instruments. At a site-specific level, it involves consideration of the merits of a development consistent with council LEPs, DCPs and local FRM policies, and consistent with FRM plans
Probability	A statistical measure of the expected chance of a flood	For example AEP
Probable maximum flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation (PMP), and where applicable, snow melt, coupled with the worst flood producing catchment conditions	This is equivalent to the probable maximum precipitation flood in Australian Rainfall and Runoff (ARR). The PMF in ARR is used for estimating dam design floods
Risk	'The effect of uncertainty on objectives' (ISO 2018)	See also flood risk. Note 4 of the definition in ISO31000:2018 also states that 'risk is usually expressed in terms of risk sources, potential events, their consequences and their likelihood'

Term	Description	Context for use/additional information
Stage	Equivalent to water level; measured with reference to a specified datum	Measurement may relate to AHD, a local datum or a local water level gauge
Velocity	The speed of floodwaters, measured in metres per second (m/s)	

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