Notice of Meeting

TUMBARUMBA FLOODPLAIN RISK MANAGEMENT COMMITTEE

Monday, 25 September 2023 at 4:00 PM
Meeting Room 2 Tumbarumba Office / Via Video Link

AGENDA

1. COMMENCING AT:

2. PRESENT:

3. ACKNOWLEDGEMENT OF COUNTRY:

Snowy Valleys Council proudly acknowledges the traditional owners and custodians of this land and water and pay respects to their Elders past and present.

4. APOLOGIES:

5. DECLARATION OF PECUNIARY INTEREST:

Pursuant to Section 4 of the Code of Conduct, Members are required to declare any direct or indirect pecuniary interest in any matters being considered by the Committee.

6. MINUTES OF PREVIOUS MEETING:

Nil

7. BUSINESS ARISING:

No previous minutes.

8. AGENDA ITEMS:

8.1. TUMBARUMBA FLOODPLAIN RISK MANAGEMENT COMMITTEE MATTERS - 25 SEPTEMBER 2023

REPORT AUTHOR: CO-ORDINATOR GROWTH AND DEVELOPMENT

RESPONSIBLE DIRECTOR: MANAGER GROWTH AND ACTIVATION

EXECUTIVE SUMMARY:

Council was successful in 2022/23 in obtaining a grant to undertake a flood study of the Tumbarumba catchment given the current development pressures being experienced within the catchment area. As part of the terms of the funding agreement, Council is required to form a steering committee to assist in providing direction to the Council on the proposed Tumbarumba Flood Study. At Council's ordinary meeting of February 2023, Council resolved to formally establish a Tumbarumba Floodplain Risk Management Committee being an advisory committee of council.

The Committee reports to Council after each meeting.

RECOMMENDATION:

THAT THE COMMITTEE:

1. **Receive the report on the Tumbarumba Floodplain Risk Management Committee Matters as at 25 September 2023.**

REPORT:

4.1 Floodplain Risk Management Committee -Terms of Reference - Attachment 1

Tabling the Terms of Reference (ToR) for the Tumbarumba Floodplain Risk Management Committee. The ToR was adopted at Council's Ordinary Meeting of April 2023.

4.2 Flood Risk Management Committee Handbook - Attachment 2

This handbook has been prepared by the NSW Department of Planning, Industry and Environment (DPIE) to provide committee members with a basic understanding of flood risk management in New South Wales. The handbook explains some of the key areas of flood risk management such as:

- what is flood risk and what is involved in managing flood risk
- the flood risk management framework, principles, aims and the various responsibilities
- some technical procedures
- some key options in managing flood risk and how they are evaluated

The Handbook can also be used as a quick reference guide to the issues that may arise during committee meetings.

4.3 Tumbarumba Flood Study - Draft Technical Brief - Attachment 3

The objective of this study is to improve understanding of flood behaviour and impacts, better inform management of flood risk in the study area in consideration of the available information and relevant standards and guidelines as outlined within this brief.

The study will be overseen and guided by Snowy Valleys Council and its Flood Risk Management Committee. The study will be guided technically by Council and a technical committee. The council will be the day to day contact for the study.

The overall project provides 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
- flood risk management planning for existing and future development
- emergency management planning for existing and future development, strategic and development scale land-use planning to manage growth in flood risk
- other key stakeholders (including providers and the insurance industry) on flood risk

4.4 Floodplain Risk Management Process

The Department of Planning and Environment's representative on the Floodplain Committee, Steve Manwaring, will be addressing the Committee on 25 September 2023.

4.5 Tumbarumba Flood Study - Scope of Works

WMA Water's representative, Erin Askew, will be addressing the Committee on the scope of works.

4.6 Nomination of Dates for 2023 Meetings

The Committee is to determine the dates for the Tumbarumba Floodplain Risk Management Committee 2023 as per the frequency outlined in the ToR.

4.7 General Business

ATTACHMENTS:

1. Attachment 1 - Tumbarumba Floodplain Risk Management Committee - Terms of Reference
2. Attachment 2 - Flood Risk Management Committee Handbook
3. Attachment 3 - Tumbarumba Flood Study - Draft Technical Project Brief

Attachment 1 - 20230913 - Tumbarumba Floodplain Committee - Terms of Reference

Tumbarumba Floodplain Risk Management Committee
Terms of Reference

ToR No: SVC-TofR-040-01

1. NAME

The name of the committee is the Tumbarumba Floodplain Risk Management Committee.

2. LEGAL STATUS

Council delegates its authority to the committee to act on its behalf in line with the Committee's *Terms of Reference*. As a result, legally, the committee is part of "Council" and any action the committee undertakes is conducted under Council's authority. Committees do not act in their own right and their actions are not legally independent of Council. Council delegates its authority to the committee to act on behalf of the Council and can withdraw this delegation at its discretion.

The committee cannot change this name and/or title without advising the Council of the intention to adopt a new name and/or title, nor can a committee merge with another party/committee without prior notice and input from Council.

Committee members must act in the interests of Council. This includes not:

- Acting contrary to any direction from Council, which includes a direction from the General Manager,
- Director, Manager or appointed delegate
- Acting contrary to Council's policies
- Advising any person that they may have a legal right or action against Council or any
- Councillors, Council employee or Council contractor exercising a function of Council
- Making any admission of liability or accepting liability on behalf of Council or the committee
- Acting contrary to Council's *Code of Conduct*
- Acting outside the limits of the committee's delegation
- Acting or presenting the committee as independent of Council.

3. DELEGATION

The Tumbarumba Floodplain Risk Management Committee will provide advice, feedback, and support to Council in developing, implementing and monitoring flood studies and floodplain risk management plans and associated projects.

4. PURPOSE

The purpose of the committee is to:

- Assist Council to develop Floodplain Risk Management Plans studies and associated plans in accordance with the New South Wales Floodplain Development Manual and adopted guidelines.

- Monitor and evaluate the implementation of Floodplain Risk Management Plans
- Assist in the development of suitable strategies to address floodplain management issues, communication and access to flood information and education by community members.
- Develop a better understanding of floodplains and identify issues that may be required to be addressed through development of strategies, studies, plans or works.

5. OBJECTIVES

The objective of the Tumbarumba Floodplain Risk Management Committee is to support the completion of the Floodplain Studies including the implementation and review of these studies where appropriate for catchments within the Snowy Valleys Local Government Area.

6. MANAGEMENT AND OPERATION OF THE COMMITTEE

a) MEETINGS

The committee should meet on a regular basis quarterly as required. Meetings shall be held within the Local Government Area of the Snowy Valleys Council. To ensure ongoing accountability and accessibility meetings can be in person or via video link.

b) MEMBERSHIP

The membership shall consist of:

- A maximum of two (2) Councillors, one of which will be elected as the Chair by the elected Council.
- Council staff from engineering / planning / environmental disciplines to service the committee and oversee the technical requirements of the study.
- Representatives from State Government Departments and Agencies including the Office of Environment and Heritage, State Emergency Services, Transport for New South Wales and the Department of Planning and Environment.
- One (1) Representative from the community with knowledge of historical flood behaviour in the catchment.
- One (1) representative from flood action groups or neighbourhood forum groups.

Guest are deemed necessary to:

- Provide specialist advice outside of the capabilities of the committee members (for example the Bureau of Meteorology).
- Sharing of experiences of flood impacts (for example local residents or businesses that have been impacted by floods.

A quorum will normally consist of members equal to the number that is half the committee plus one. If a quorum is not present within half an hour after the appointed starting time, the meeting will be adjourned and rescheduled to a later date.

Voting rights should only be for Councillors and local community representatives on the committee. Council staff and external agencies are in attendance only in a technical/advisory capacity.

c) CHAIRPERSON

The elected Council shall resolve to appoint a chairperson to the committee being one of the two Councillors appointed to the committee. In the absence of the Chairperson, the other Councillor on the committee shall be the acting Chairperson for the duration of the absence of the Chair.

d) SECRETARIAT

A staff member from the Snowy Valleys Council shall perform the Secretariat duties for the committee.

e) PECUNIARY INTERESTS AND CONFLICTS OF INTEREST

Members of the Committee when becoming aware of a conflict of interest can arise when a member of the committee has other involvements or interests, which make it difficult for them to always remain impartial when involved in discussions and decision-making. If a conflict of interest arises, the Chairperson and staff delegate must be notified. In addition to the Code of Conduct there is the *'At a Glance' guide for Council Committee Members and Delegates'* guide published by the Office of Local Government that can be used as a reference.

Members of the Tumbarumba Floodplain Risk Management Committee in performing their duties shall:

- Act honestly and in good faith
- Declare all actual and perceived conflicts of interest
- Perform their duties in a manner that ensures public trust in the integrity, objectivity and impartiality of the committee.
- Comply with Council's code of conduct

f) ATTENDANCE OF NON-MEMBERS

Staff and other professionals / members of the community may be invited to attend and participate at meetings as required.

g) CONFIDENTIALITY

Members of the Committee should appreciate that the working group may, from time to time, deal with sensitive matters of a confidential nature. The confidentiality of such information should be respected by all members.

7. AMENDING THE TERMS OF REFERENCE

Recommendations for amendments to the Terms of Reference can be made at any time. Any amendments to the Terms of Reference must be adopted by Council.

8. HISTORY TABLE

Version No	Approval Date	Resolution Number	Date to be Reviewed
1	20 April 2023	M54/23	30.09.2025

Attachment 2 - 20230113 - Flood Risk Management Committee Handbook - Committee Member Guidelines

Flood Risk Management Committee Handbook

A guide for committee members

Published by:

Department of Planning Industry and Environment
59 Goulburn Street, Sydney NSW 2000
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Phone: 1300 361 967 (DPIE and national parks enquiries)
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Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

Report pollution and environmental incidents
Environment Line: 131 555 (NSW only) or info@environment.nsw.gov.au
See also www.environment.nsw.gov.au

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DPIE 2019/XXXX
July 2019

Find out more about your environment at:

www.environment.nsw.gov.au

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1. WELCOME

Enjoy being part of your flood risk management committee. Your input into the flood risk management process is valuable, and it is hoped that it will also be a rewarding personal experience.

This handbook has been prepared by the NSW Department of Planning, Industry and Environment (DPIE)[1] to provide committee members with a basic understanding of flood risk management in NSW.

The handbook explains some of the key areas of flood risk management, such as:

- what is flood risk and what is involved in managing flood risk (Section 2)
- the flood risk management framework, principles, aims and the various responsibilities (Section 3)
- some of the technical procedures (Section 4), and
- some of the key options in managing flood risk and how they are evaluated (Section 5).

The handbook can be used as a quick reference guide to the issues that may arise during committee meetings.

Should you have any questions about flood risk management, do not hesitate to ask the relevant Council staff, DPIE or other State Government representatives.

The NSW Government's Floodplain Development Manual and supporting publications provide advice to local councils on how to most effectively understand and manage their flood risk. These can be viewed and/or downloaded from https://www.environment.nsw.gov.au/topics/water/floodplains/floodplain-manual and https://www.environment.nsw.gov.au/topics/water/floodplains/floodplain-guidelines.

Definitions and abbreviations used in this guide have the same meaning as those in the NSW Government's Floodplain Development Manual.

Note

[1] The Department of Planning Industry and Environment (DPIE) was formerly the Office of Environment and Heritage (OEH) up until 30 June 2019. References to DPIE documents may relate to documents labelled OEH.

2. MANAGING FLOOD RISK IN NSW

2.1 What is flooding and what causes it?

Flooding is a natural phenomenon that occurs when water covers land which would normally be dry. Floods generally come from catchment flooding due to prolonged or heavy rainfall (severe thunderstorms, tropical cyclones, monsoonal rains in the tropics and east coast lows) or coastal inundation or a combination of these. Catchment flooding may result in flooding from water leaving waterways (riverine flooding) or from water on the way to waterways (overland flooding). In coastal areas, flooding may also be influenced by water levels in the oceans, tides as well as the same rainfall events that result in flooding.

Floods vary greatly in size and frequency. Small floods may cause local nuisance flooding in an area each year, or more regularly. Larger floods causing significant community impacts may occur at the same location a few times in an average lifetime, or in some cases, not at all.

Studies under the Program generally look at larger floods. They will look at what happened in historical floods but also consider what may happen when floods larger than historical floods and outside the experience of the community occur. It is important to understand the potential impacts so that ways to manage these can be considered. Studies will also consider extreme floods to help understand the upper limit of potential impacts as this is important to understand in emergency management.

2.2 What is Flood Risk?

A flood event can create dangerous or damaging conditions on the floodplain. These hazardous conditions can exist whether or not there are people, infrastructure or assets in the floodplain.

It is the human interaction with a flood that results in a flood risk to the community. Flooding can affect the health and safety of individuals and communities living in the floodplain. It can also affect the built environment and other interests that support them.

Floods can be fatal, cause significant damage to public and private infrastructure and utilities, and have devastating impacts on communities that can require extended recovery time. They can cause considerable stress and concern in the community and on average, floods in New South Wales cause damage well in excess of $150 million a year.

Flood risk involves a combination of both the likelihood that a flood event causes a consequence to the community and the scale of the consequences of that event when it occurs. 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 (Figure 1). For example, a frequent storm likely to flood an area but only results in minor consequences is of low risk, whereas a frequent storm likely to flood an area that results in significant consequences would be a high risk.

Figure 1 Risk Triangle

There are generally three types of risk to be managed in flooding. These are:

- Existing flood risk – risk associated with the existing development in the floodplain. This can be limited by mitigation actions
- Future flood risk – risk associated with the future development of the floodplain. This can be limited by considering flooding when deciding where and how to develop within the floodplain
- Continuing flood risk – the risk remaining in both existing and future development areas, after all practical and justifiable management measures such as works, land-use planning, and development controls are implemented.

2.3 What is Flood Risk Management?

Flood risk management (FRM) is the management of flood risk to both existing and future people and property in the floodplain.

Effective consideration of flood risk requires both an understanding of the impacts of floods and the ways that it can practically be managed at a local level.

Flood risk is managed in NSW through the development of a FRM framework and undertaking studies through the FRM process. These are discussed in Section 3.

For more information on the general benefits of undertaking FRM refer to videos developed by Gosford City Council, Part A (before FRM) and Part C (after FRM).

3. FLOOD RISK MANAGEMENT FRAMEWORK

3.1 Background

To address the community's concerns with flooding, the State Government released the Flood Prone Land Policy (the Policy) in 1984 with the primary objective of reducing the impact of flooding and flood liability on individual owners and occupiers, and to reduce private and public losses resulting from flooding. The Policy has since been updated but its primary objective remains the same.

To support delivery of the Policy, the State Government released the first NSW Government Floodplain Development Manual in 1986 which provides councils with advice on a recommended framework and approach to better understand and manage their flood risk.

The 1986 Manual and Policy have since been updated with the gazetted 2005 Floodplain Development Manual (the Manual) and incorporates the Policy. A suite of guidelines also support the implementation of the Policy and Manual.

Councils can apply for subsidised funding under the State Floodplain Management Program (the Program) managed by DPIE to develop and implement FRM plans to manage their flood risk in accordance with the Policy and Manual.

The Manual is currently being reviewed and updates are available from DPIE's representative on the committee. When complete, the updated Manual will be available on the relevant government website. Supporting publications are regularly reviewed and updated and made available through the relevant government web page. During the update of the Manual some of the information or diagrams provided in this document may be slightly different than in the Manual.

3.2 Responsibilities in Flood Risk Management

Managing flood risk to the community requires cooperation across all levels of government, and between the government and non-government sector. The National Strategy for Disaster Resilience outlines that flood resilience is a shared responsibility between government and the community.

FRM is complex, and therefore requires access to a range of different skills and disciplines, which reside in a variety of agencies and across government levels.

3.2.1 Government

In NSW, FRM is a partnership between all levels of government with local councils primarily responsible in their local government area (Table 1). Additional details on key local, state and federal government roles are provided below.

All councils are strongly encouraged to call on the local community and state government agencies to assist them with this responsibility. This is best achieved by the establishment of a management committee and technical working group (Section 3.3).

Table 1 Government Roles and Responsibilities

Local Government	State Government	Federal Government
Flood risk management, land-use planning, development and infrastructure provision and maintenance	Leading, monitoring and maintaining legislative, policy and administrative framework for flood risk management.	
	Supporting management of flood risk by councils.	
	Supporting effective land-use planning, and development and building controls.	
	Technical and financial support to councils for studies and infrastructure under the management process	Financial support to councils under the management process (via the state government)
Supporting flood emergency management	Lead flood emergency management planning	
Local flood recovery	Leadership of regional and statewide disaster recovery and support for local disaster recovery	Support for disaster recovery
Providing information on flood risk to the community and to support local decision making	Information systems to support state government decision making	
Considering flood risk in decision making	Considering flood risk in decision making	Considering flood risk in decision making
		Conservation of natural resources and environmental values of national significance.
Roles and Responsibilities Shared across all Government levels		
Flood prediction and warning		
Managing gauges and supporting infrastructure to inform flood warning		
Funding coordination and management		
Recovery after a flood		
Research and training		
National coordination and cooperation in best practice		

Local Government

The Policy outlines that the management of flood prone land is primarily the responsibility of local government. Managing flood risk at a local level involves understanding flood risk and supporting practical management options across the local government service area (LGA).

Local responsibilities include:

- FRM – establishing a local FRM framework and developing and implementing FRM plans to understand and manage flood risk
- providing information on flood risk to the community and government
- considering flood risk in land use planning decisions
- developing, operating, maintaining and asset management for FRM infrastructure
- leading the local emergency management committee and support for flood emergency management planning

- local flood recovery

Many decisions are made at a local government level. These may involve prioritising efforts to understand and manage flood risk across different catchments within the LGA, including catchments shared with other LGAs. These decisions may be informed by flood studies, management studies and management plans in different catchments within the LGA, including those derived from studies undertaken in partnership with other LGAs in the same catchment.

State Government

The State Government provides local councils with technical and financial assistance to undertake studies to understand their flood risk, examine options to manage this risk, and to decide on and implement plans to manage this risk through the Program managed by DPIE. Under the Program funding may be available for the preparation of the various studies, and the implementation of FRM plans including the construction of mitigation works.

Funding under the Program (State and sometimes Federal Government funding) is provided on a priority basis considering annual applications from local councils across NSW for all stages of the FRM process. The priorities are determined by the relevant Minister considering the advice of the State Floodplain Management Assessment Committee led by DPIE.

Local government usually contribute its share (generally 1/3rd) of funding through its budgetary processes. However, low financial capacity councils can access better funding ratios requiring lower local contribution for some projects. In some cases, a council may seek to raise a specific levy to support implementation of major works.

DPIE technical staff assist councils with managing their flood risk and developing and implementing FRM plans.

The NSW State Emergency Service (SES) also has a key role in emergency management of flooding including:

- establishing, maintaining local flood plans and activating these plans in response to a flood threat.
- educating the community on response to flood threats and advising them of how to respond to an imminent flood threat.

3.3 The Flood Risk Management Committee

The formation of a FRM Committee is a key step in the management process to develop and implement management plans.

3.3.1 The Role of the Committee

The Committee assists Council in developing and implementing a FRM plan by contributing ideas, professional expertise, experience, and local knowledge.

Community members contribute their knowledge of historical information, local problems, and possible solutions. They also channel input from the wider community.

While it is important that key aspects of the FRM process are addressed, members are encouraged to contribute widely to the Committee's deliberations to produce the best possible outcomes for managing the flood problem. This involves seeking solutions to the existing, future and continuing flood risk issues, not solely on addressing the past.

The Committee should operate as a team with the community's interests being foremost.

Committee members may be required to vote to determine the majority opinion on different issues. Because the FRM plan should be a local based process, State Government representatives abstain from voting.

It is crucial that the Committee actively directs the course of the studies to ensures studies represent the views of the Committee, not only those of the consultant and Council.

3.3.2 Membership of the Committee

The FRM committee may be stand alone or the role of the committee may be given to a broader council committee which may already exist.

If flood risk is to be considered as part of a broader committee, both a technical working group (to facilitate agency input) and a community reference group (to support community input) should be established to ensure the community is included in the FRM process. FRM issues should also be a clear part of meeting agendas.

Committee (including technical working and community reference group) members are generally a mix of elected, community, and professional members, whose collective skills and interests are suited to addressing the flooding problem of a particular catchment. Typically, membership is:

- elected members of council;
- council staff from engineering, planning and environmental disciplines;
- an appropriate number of representatives of the local community (for example, local flood affected landholders (residential and business), relevant industry bodies (e.g. the chamber of commerce), and environmental groups);
- officers from the DPIE; and
- representative(s) from the State Emergency Service (SES).

Depending on the nature of the flooding problem at hand, the Committee may choose to co-opt other individuals or agencies as required.

3.3.3 What is expected of Committee Members

The FRM process is neither short nor simple, nor is it the singular responsibility of council officers, consultants or government officers to have input to the process.

The FRM Committee must comprise members who are committed to and actively involved in the preparation and implementation of the FRM plan. It may take 2 to 5 years from the start of a flood study to the development of the FRM plan and the implementation of all recommendations may take much longer (typical lengths of time are shown in Table 2). Local community members who are enthusiastic and energetic are more likely to ‘see the distance’ to complete the FRM plan.

Committee members are expected to attend meetings at critical points in the project stages, on average this is every 3 months. Meetings are generally held at a convenient time for all committee members, most likely at night to accommodate work schedules. Committee members are expected to read and review the documents provided prior to meetings. This guide can be referred to in order to get an overview of the relevant stage in the project and a background on what may be discussed in the meetings.

In view of the length of time involved, the turnover of committee members, including both council staff and elected representatives, can be a problem. Whilst little can be done with respect to the potential turnover of council and government officers, the structure of the committee should be decided with consideration of its long-term viability and relationship with other committees in operation in the local area.

Table 2 Flood Risk Management Process Time Frames

Stage	Typical timeframe	Typical steps
Flood Study	1-1½ yrs.	Data collection. Engage consultant/s. Study very complex.
Flood Risk Management Study	1-2 yrs.	Committee/consultant examines management options. Involves widespread community consultation.
Flood Risk Management Plan	½ - 1 yrs.	Finalise options. Committee plans implementation.
Plan Implementation	1-15 yrs.	Flood warning systems, development controls, rezoning, levee construction, voluntary purchase etc.

3.3.4 The Role of the Consultant

In most cases, consultants will be engaged to prepare the necessary studies and reports in accordance with Council's study briefs. The Committee should contribute to the development of these briefs.

Consultants will undertake a range of investigations to enable Council to make management decisions with the Committee's assistance. The consultant will often be required to make presentations to the Committee to help with their deliberations.

Whilst it is expected the consultant will contribute initiative to the study, it is important that the Committee direct the consultant so that local issues are considered.

3.3.5 Community Involvement

If FRM is to be successful, it is important that the local community accepts the need for effective management practices, recognises that the finalised FRM plan has considered all factors of concern to the community, and that flood prone members of the community accept their individual responsibilities to reduce flood risk.

This requires the support of the community covered by the plan. Community involvement is a key component of the development of the plan through both membership of the Committee and through consultation at key points during studies. The Committee should represent the wider community and ensure that it acts in the interests of the whole community.

An important role of the management committee will be to assist in the presentation and resolution of conflicting desires and requirements on the part of various community groups and individuals. Public meetings, often spirited, are an important part of this process.

The community can be actively involved in the process by engaging in the community consultation activities and providing information on their local experiences with flooding.

The FRM plan will be a compromise involving trade-offs. Certain individuals may be disadvantaged, others advantaged, but the community will be better off.

3.4 The Flood Risk Management Framework

The FRM framework in NSW is outlined in Figure 2. It sets out a series of logical steps that if followed are likely to produce the best possible FRM outcomes for the community, allowing for variation in flood behaviour and impacts. Councils can provide local advice on the way in which they manage flood risk within their organisation. The keys steps in flood studies and FRM study and plan projects are described in Section 3.4.1 to 3.4.5.

FRM plans comprehensively consider flood risk and outline practical measures that can address the flood problems in the area covered by the plan. The area covered by a plan may be a town or locality or specific river catchment. The development of the FRM plan involves the application of a merit-based approach to management options that considers the variation in flood behaviour and impacts on the community rather than the application of a blanket rule.

For FRM to be successful, it is important that the local community accepts the need for effective FRM practices, recognises that the effective management plan has taken into account all factors of concern to the community, and that flood prone members of the community accept their individual responsibilities to reduce hazard. Community consultation and input is a major component of the development of the plan.

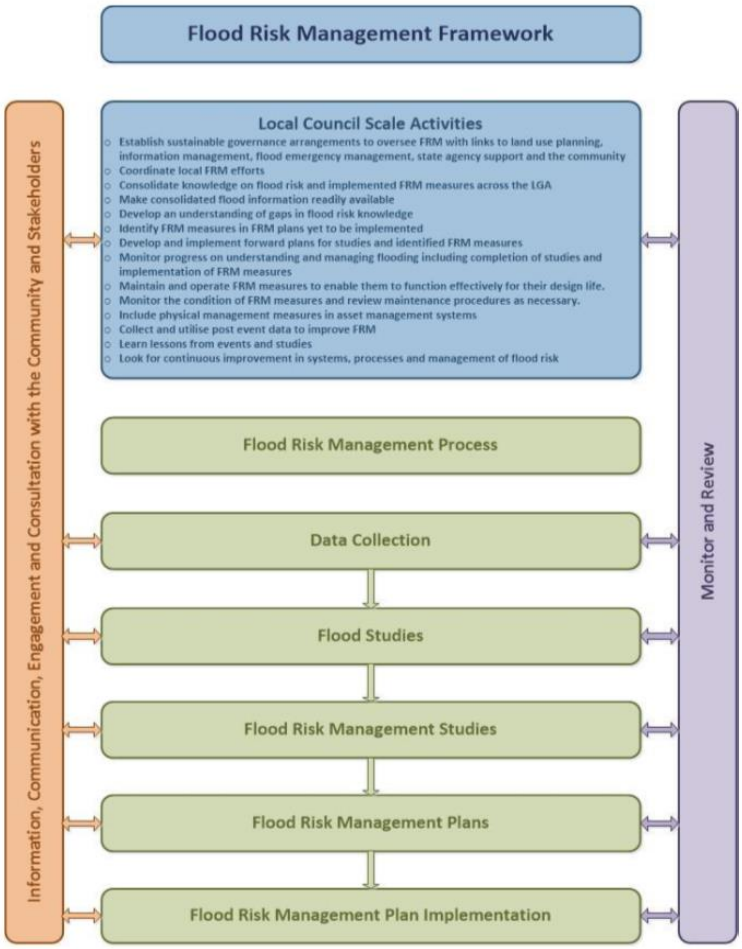


Figure 2 **Flood Risk Management Framework**

3.4.1 Flood Study

The flood study is generally the first stage of the FRM process as it involves defining flood behaviour and provides the main foundation of a robust management plan. It aims to improve the current understanding of the full range of flood behaviour and consequences.

Typically, a flood study considers the local flood history and available collected data, to develop flood models that are calibrated and verified, where possible, against significant historic flood events. These models are then used to determine the full range of potential flood behaviour and impacts. The community is to be consulted at key milestones throughout the development of the flood study.

Study outputs can include:

- a description of the historic floods,
- a description of existing flood mitigation measures,
- hydrologic and hydraulic models that are calibrated and validated considering historic flood events where possible,
- a description of the existing flood situation, and flood extent and level, depth, velocity information,
- the scale and variation in flood impacts, which can include the number of properties affected and the potential flood damages,
- breakdown of the floodplain considering:
  - variations in flood functions of flow conveyance and flood storage in the floodplain
  - variation in flood hazard (based on velocity and depth) across the floodplain
  - emergency response management limitations, including a breakdown of the floodplain to identify areas with different types and severities of response limitations
  - development of mapping to identify how flood related constraints on land vary across the floodplain for consideration in land use planning
- updated and consolidated information on flooding and its management, including the report, updated flood mapping, emergency management and land-use planning information, and community flood awareness information,
- an explanation of the degree of uncertainty in flood estimates.

The study, developed with Committee input, is provided to Council for consideration and adoption. Information in the study should be considered in FRM, land use planning activities and emergency management planning and associated decisions.

3.4.2 Flood Risk Management Study

The FRM study extends the flood study to increase understanding of the flood risk to the existing and future community and test management options. It provides a basis for developing the FRM plan.

Community engagement is vital to the successful development of the management study. The community should be consulted to allow their concerns, suggestions and comments about management options to be considered. Study outputs include:

- a description of existing flood mitigation measures
- the scale and variation in flood impacts, including the number and types of properties affected, and the potential flood damages
- An understanding of future development directions and consideration of the cumulative impacts of future development on flooding
- An assessment of FRM options to address risks to the existing and future community

- the outcomes of community consultation
- recommendations on options
- updated information and consolidated information on flooding and its management – this should include the report, flood mapping, information to assist with emergency management planning, land-use planning, and understanding the climate change impacts and the degree of uncertainty in flood estimates
- sufficient information on options to provide an understanding of their capabilities, limitations, interdependencies, costs and practical feasibility to inform implementation or further investigation.

Information in the study should be considered in FRM, land use planning activities and emergency management planning and associated decisions.

3.4.3 Flood Risk Management Plan

The FRM plan forms the basis of FRM in the study area into the future and details the final management options that have been agreed upon. It should be developed in consultation with the community and in consideration of relevant legislation, policies and guidance that may influence its implementation and the viability of the various management measures.

The plan generally involves a range of measures to manage existing, future and continuing risk, which will vary between different locations in the floodplain. It needs a prioritised implementation strategy, which outlines the commitment to implement, its staging and provides sufficient detail to facilitate implementation.

Management plans need to consider the cumulative impact of changes in the catchment on flooding behaviour due to both incremental development of the floodplain and a changing climate.

The plan developed by the committee is provided to the Council for consideration and adoption. Once a plan has been finalised and adopted by the council, it should be used to update and consolidate information on flooding and its management and communicate to relevant agencies and the community to update them on the flood risk.

3.4.4 Flood Risk Management Plan Implementation

The plan needs to be implemented to manage risk, and this implementation monitored. This requires commitment, coordination and communication within government and with the community.

The recommendations from the FRM plan would generally feed into the broader consideration and prioritisation of recommendation from FRM management plans from across the whole LGA. It should be reviewed every 5 years, if possible, or after a significant event has occurred.

Implementation of major mitigation works that significantly changes flood behaviour or the response of the community to a flood event can lead to a need to review the management study and plan to ensure that information is up to date and available to the community. It can also involve education of the community of how flood impacts or community response has changed.

Implementation is generally led by council and overseen by the Technical Working Group, led by the Council and involving relevant agencies.

3.4.5 Key Steps in Projects under the Process

Although there may be some variations, typically the major steps involved in producing these reports and who is involved in these steps are outlined in Table 3.

Table 3 Flood Study Key Steps Example

Step	Council	DPIE	Consultant	FRM Committee	Council decision making Committee
All projects					
Application for funding	x	x			
Scoping	x	x		x	
Prepare Brief	x	x			
Call for Proposals	x				
Review Proposals	x	x			
Engage Consultant	x				
Inception Meeting	x	x	x		
Data collection and review	x		x	x	
Model setup or review, calibration and validations	x		x	x	
Design results and mapping	x		x	x	
Draft flood study report	x		x	x	
Final flood study report			x		
Adoption of flood study					x
Update and consolidate information on flooding and its management	x				x
Updated information available to the community	x				x
Incorporation into decisions (FRM and land use planning)	x				
Incorporation into Emergency Management planning	x				x

4. UNDERSTANDING FLOOD BEHAVIOUR

4.1 Introduction

Councils may use in-house or consultancy hydrology and hydraulics skills to provide information on flood behaviour. This information is used to:

- understand the impacts of floods on the community
- analyse mitigation and management options
- investigate, design, construct and maintain mitigation works
- facilitate informed decisions on treating flood risk
- consider constraints on land use planning to facilitate informed decisions for floodplain development
- improve flood predictions and warnings
- support updated emergency management planning
- provide information to the community on flood risk and emergency response.

4.2 Flood Modelling

Flood modelling allows the computation of complex mathematical equations and procedures to provide simulations of river and flood behaviour and are most commonly performed by computers. Computer models can be developed to represent the whole or part of the catchment. There are two main types of computer models used in flood studies; hydrologic models convert rainfall to flows and hydraulic models route flows across the catchment. More recently, direct rainfall models allow for rainfall to be directly input onto the hydraulic model (i.e. bypassing the hydrologic model). There are various benefits and limitations to these models, some of which are discussed in the following sections.

4.2.1 Hydrological Models

Hydrological models convert rainfall over catchments into flow(s), see Figure 3.

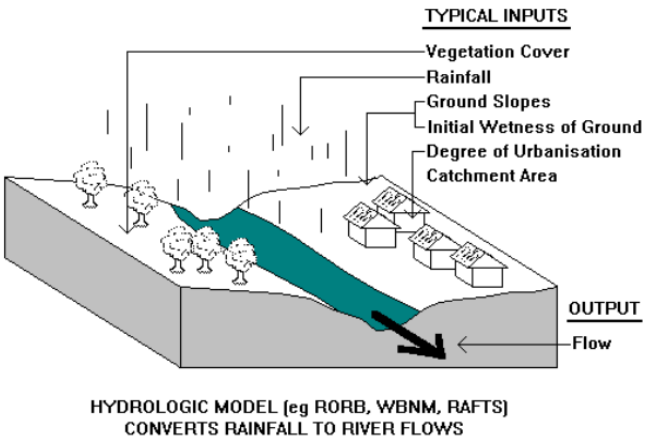


Figure 3 Hydrologic Computer Model

Typical examples of hydrologic model setups are shown in Figure 4.

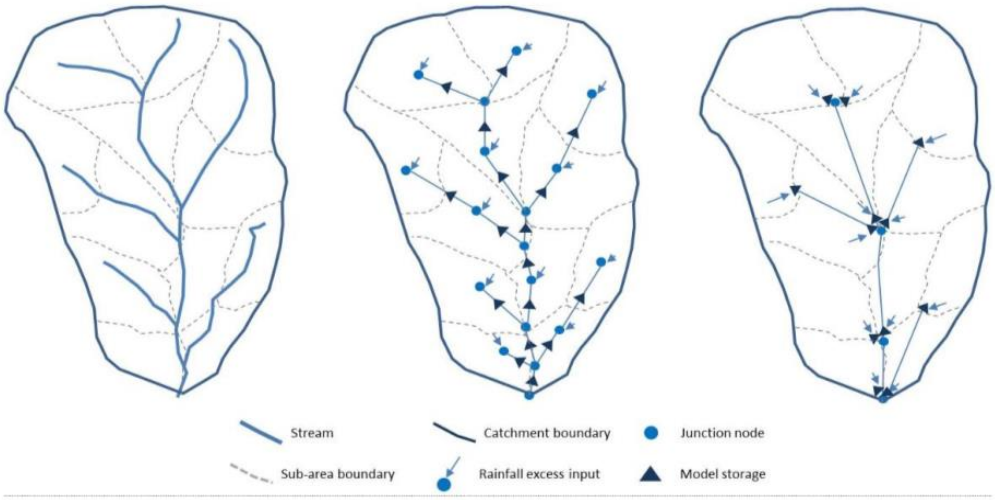


Figure 4 Examples of hydrologic runoff-routing models (ARR 2019)

The output from hydrologic models is normally in the form of flow hydrographs. As storm duration and patterns vary, hydrologic computer models run a range of different storm patterns for the same storm duration (see Figure 5) and compare representative patterns for different storm durations in selecting a design hydrograph(s) (see Figure 6) that are used in hydraulic modelling.

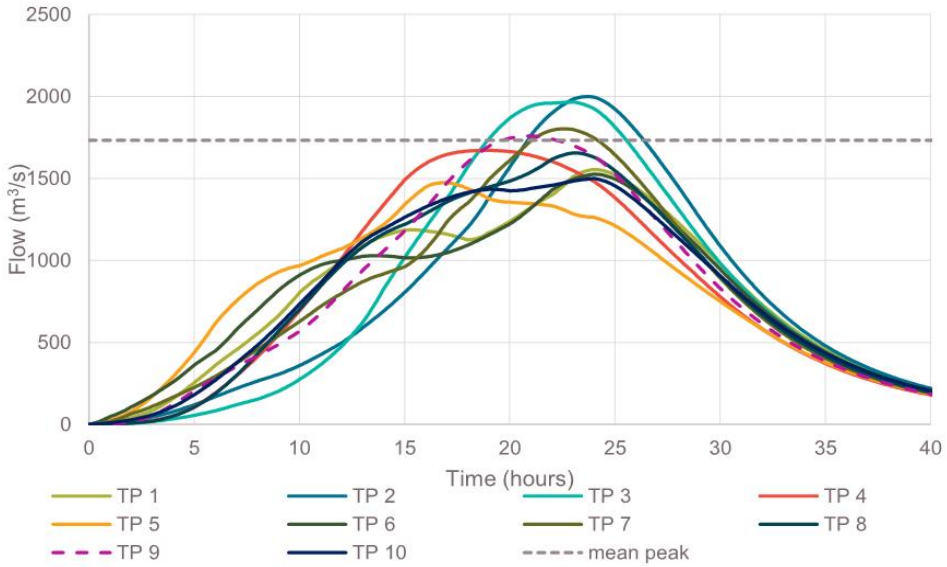


Figure 5 Sample of variations in Flow Hydrograph for different storm patterns (DPIE 2019)

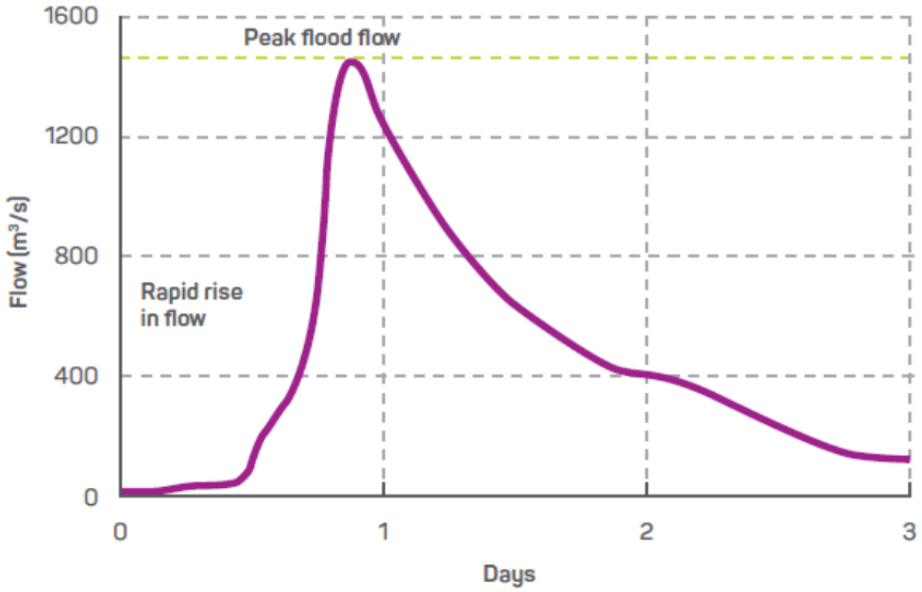


Figure 6 Sample Selected Design Flow Hydrograph (AIDR 2017a)

4.2.2 Hydraulic Models

Hydraulic models take the flow produced from hydrologic models and produce outputs such as flood levels, depths and velocities (see Figure 7).

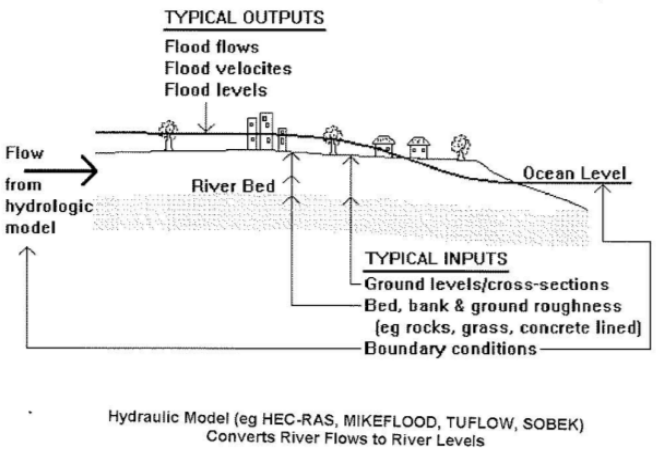


Figure 7 Hydraulic Computer Model

1D Hydraulic Model Examples

Hydraulic models can be 1D (see Figure 8 and Figure 9) to allow analysis of flooding in a channel, for example a river.

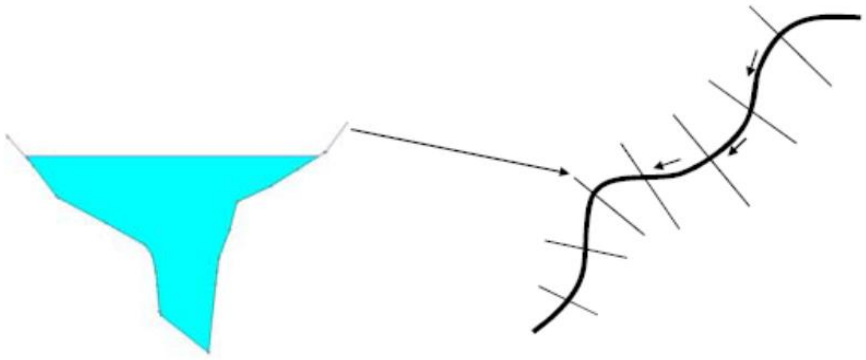


Figure 8 1D hydraulic model typical cross-section

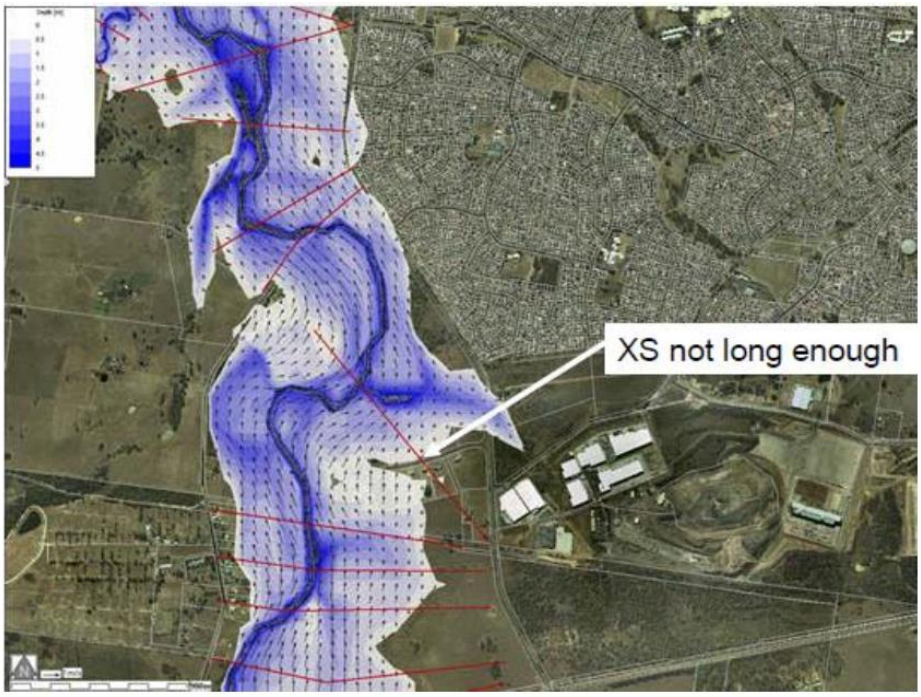


Figure 9 Example 1D hydraulic model results

2D Hydraulic Model Examples

Hydraulic models can be a 2D grid or mesh (see Figure 10) to analyse flooding from channels that extends into the floodplain and overland flows from catchment flooding.

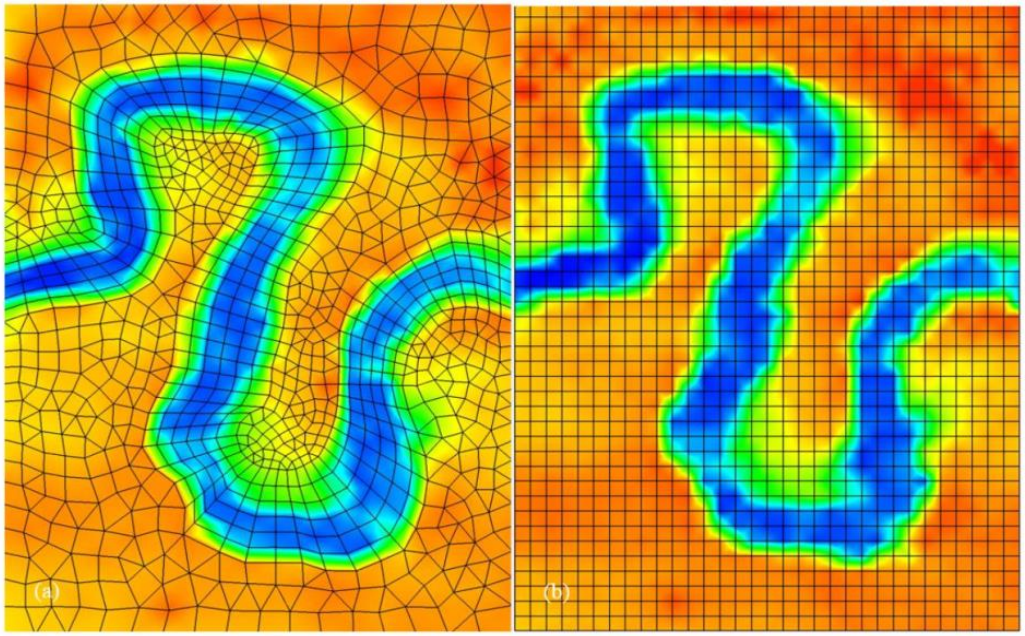


Figure 10 2D hydraulic model examples (a) is a flexible mesh (b) is a grid (ARR 2019)

1D/2D Hydraulic Model Examples

Hydraulic models can be a combination of 1D and 2D to allow the combination of riverine and overland flows to be modelled at the same time (Figure 11 and Figure 12).

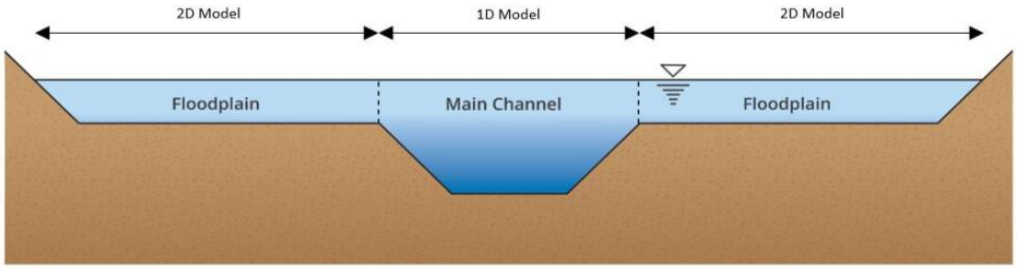


Figure 11 Cross-section of 1D/2D interface

Figure 12 1D/2D Hydraulic Model results showing flow patterns

The output from hydraulic models comes in a number of forms e.g. stage hydrographs, flood profiles, flood contours (Figure 13).

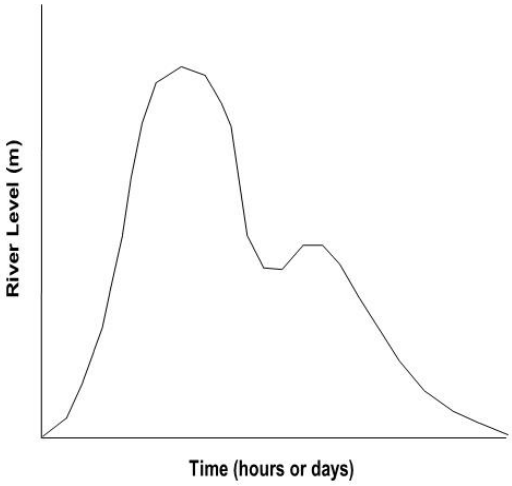


Figure 13 Sample Stage Hydrograph at a Particular Site

The output at different locations can then be used to produce flood profiles or contours along the river showing the maximum water level, depth and velocity at each location for either an actual or design flood (Figure 14 and Figure 15).

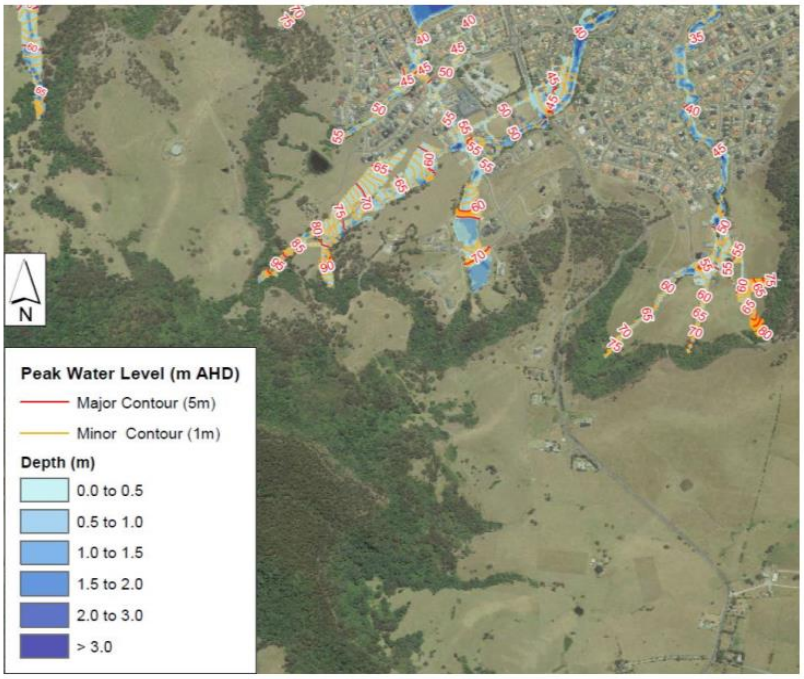


Figure 14 Flood Depths and Flood Level Contours (WMAwater 2017)

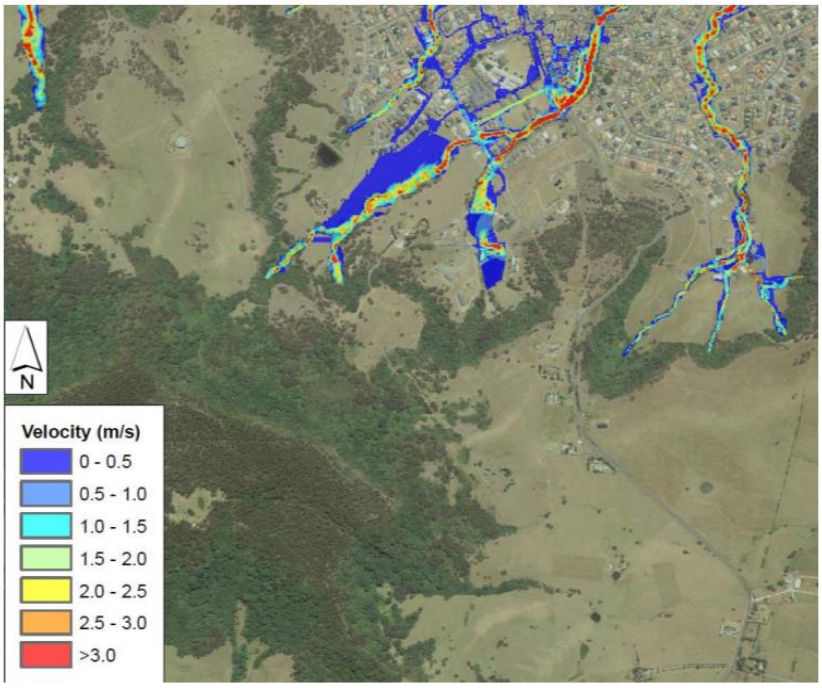


Figure 15 Flood Velocities (WMAwater 2017)

4.2.3 Direct Rainfall Models

Direct rainfall models, known as “rainfall on the grid” take rainfall directly onto the hydraulic model (Figure 16) to generate flow and produce outputs such as flood levels, depths (Figure 14) and velocities (Figure 15).

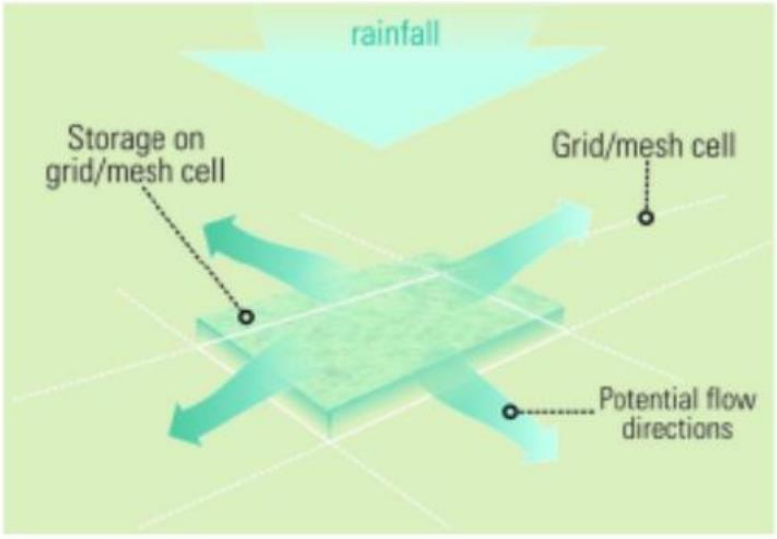


Figure 16 Conceptualisation of Direct Rainfall

4.2.4 Modelling Process

Modelling usually follows the process below, including:

- Calibration – Local historical data recorded during an actual flood event is used in the models to calculate river flows and levels and compare these to recorded levels. These are then compared with the recorded river flows, levels and extents for that flood event. It is normal to have to adjust some of the catchment characteristics to get a match between actual and modelled flows and levels.
- Validation – After calibration of the model is achieved, a check of the ability of the model to predict flood behaviour is carried out. Here the models are run for perhaps 2 or 3 other known flood events to ensure that the model results compare with the recorded flood levels from those events within an acceptable degree of accuracy.
- Design Modelling – After the models demonstrate they can satisfactorily represent actual flood events via calibration and validation, design rainfall data are used to enable the models to produce design flood flows and levels, depths and velocities along the river or floodplain. This is used as a baseline for looking at management options in the management study phase.
- Models are then used to develop the information required from design floods which can vary between studies. This information is then used to derive information to assist in future flood risk management, emergency management and land use planning.

In the FRM study phase, the model is run to assess:

- Development impacts – the effect that development has on flood behaviour and impacts can be assessed.
- Management options – to examine the effect flood mitigation works can have flood behaviour and impacts.

4.2.5 Accuracy of Computer Modelling

Even with powerful computers and programs, flood modelling still needs to be based on a number of assumptions. Accordingly, it would be unrealistic to believe that modelling can exactly replicate the river behaviour at every location.

However, with experienced operators, using proven modelling software to develop the models, reliable estimation of flood behaviour can be provided. This reliability is improved by the calibration and validation of model results (discussed above) with the information available in historical floods and the communities experience of these floods.

It is important to remember that the calibration and validation process demonstrates that the models can satisfactorily predict flood levels within acceptable limits of accuracy. Models can also predict the impact of floodplain changes such as development or mitigation works.

4.3 Design Floods

4.3.1 What Are Design Floods?

To fully appreciate the flood hazard, it is desirable to have a consistent procedure to assess how often floods will reach different levels. The concept of design flood levels achieves this. For example, a 1% AEP (annual exceedance probability) design flood level has a 1% (or 1 in 100) chance of being reached or exceeded in any one year. Historically, this flood was referred to as the 100 year ARI (Average Recurrence Interval) flood as it can be expected to occur, on average, once every 100 years over a very long period, say 10,000 years. Common design floods used in flood risk management shown in Table 4.

Table 4 Common design floods used in flood risk management

PMF	PMF
0.2% AEP	500 year ARI
0.5% AEP	200 year ARI
1% AEP	100 year ARI
2% AEP	50 year ARI
5% AEP	20 year ARI
10% AEP	10 year ARI
20% AEP	5 year ARI

Although a 10% AEP flood is likely to occur once every 10 years on average, it is important to note that there is nothing preventing two 10% floods (or even 1% floods) from occurring only weeks or months apart. This is similar to a lottery where the odds suggest you have a chance of winning a prize say once every 50 tickets you buy, but there is nothing stopping you winning a prize twice in a row or purchasing 200 tickets without a win. Figure 17 shows how likely you are to experience a given size flood at a location in an average person's life time.

Annual exceedance probability (%)	Approximate Average recurrence interval (years)	Probability of experiencing a given-sized flood in an 80-year period	
		At least once (%)	At least twice (%)
20	5	100	100
10	10	99.9	99.8
5	20	98.4	91.4
2	50	80.1	47.7
1	100	55.3	19.1
0.5	200	33.0	6.11
0.2	500	14.8	1.14
0.1	1,000	7.69	0.30
0.01	10,000	0.80	0.003

Figure 17 Probability of experiencing a given-sized flood one or more times in 80 years (AIDR 2017a)

4.3.2 Estimating Design Flood Levels

There are three accepted methods of estimating design flood levels:

- Physical Modelling: A scale model of the catchment is built, flooded, and water levels measured. Whilst they have some benefits, physical models are expensive and, as they occupy large amounts of space, are normally dismantled after use making unplanned subsequent studies costly. These are rarely undertaken today.
- Computer Modelling: This is the most common method (see Section 4.2 for explanation). It is used in conjunction with other techniques, such as flood frequency analysis, to determine design flood levels.
- Flood Frequency Analysis (FFA): This method involves performing a statistical analysis on known historic flood flows to draw a graph of flood flows against probability of occurrence, see Figure 18. Generally, creek and river flows are not measured directly. They are estimated from water levels using rating curves that relate water level to estimated flow based upon gauge measurements and hydraulic analysis, see Figure 19. FFA is often used as a check of the computer modelling results at sites where a sufficient length of record exists. FFA is site specific and can only be applied at the gauge location.

FRM Committee Handbook

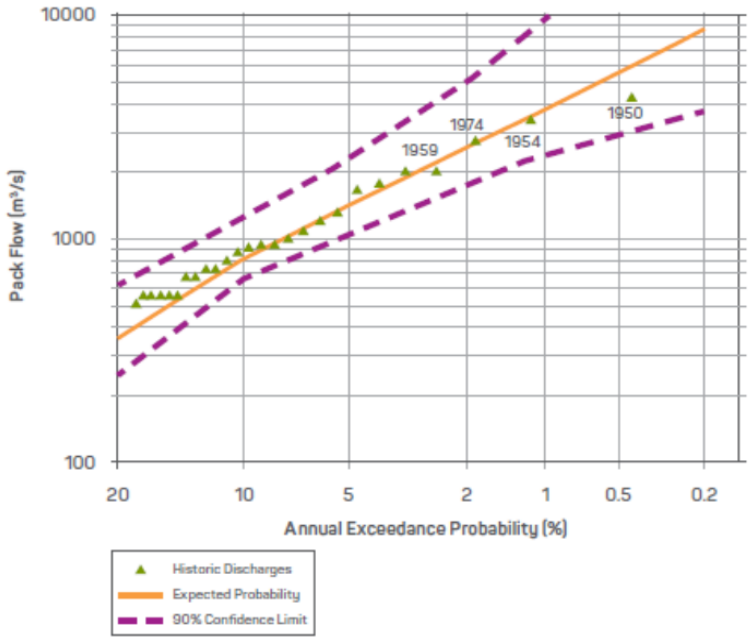


Figure 18 Sample frequency distribution for a stream gauging station (AIDR 2017a)

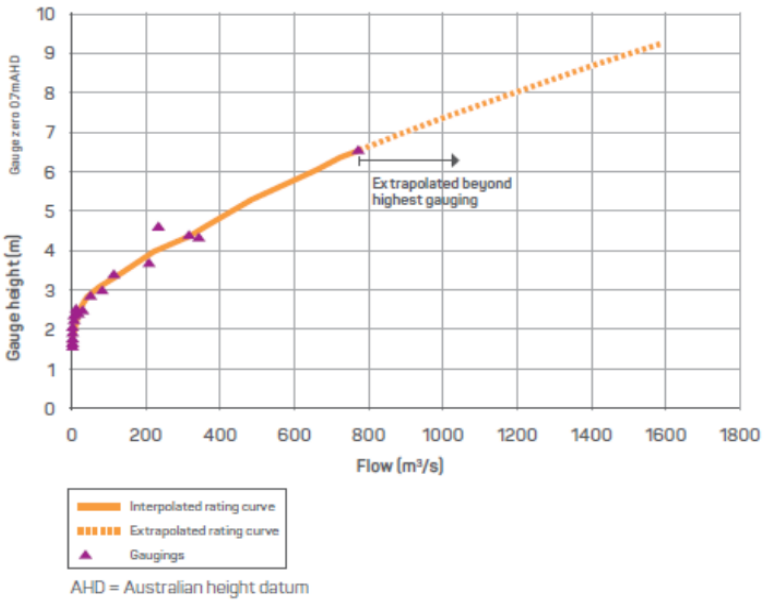


Figure 19 Example rating curve for a stream gauging station (AIDR 2017a)

4.3.3 Defined flood event or planning flood

The defined flood event (DFE) or planning flood is a large flood that is selected and used to determine where to apply minimum development standards, see Figure 20.

Selection of a DFE should consider the full range of flood events and take into account standards and guidance from government and industry. It can reflect what government and the local community may accept as a general standard that allows for a reasonable compromise between living on the floodplain and accepting the consequences of this choice. DFEs are the key floods used to derive information to inform management and land-use planning.

In NSW the 1% AEP flood is often used to define the DFE, a freeboard is then added to the DFE to determine the Flood Planning Level (FPL) (see Section 4.4.2) in which general development controls are applied to new standard residential and commercial development to limit growth in risk.

DFEs are initially determined in flood studies and may be refined in management studies, they are then incorporated in management plans.

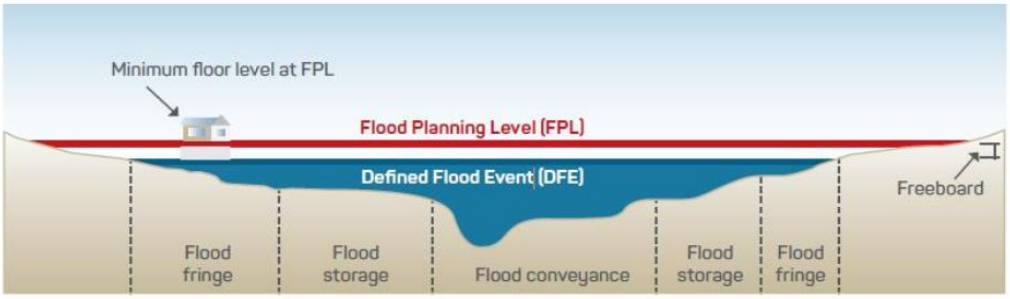


Figure 20 Defined flood event and other key terms (AIDR 2017a)

4.3.4 Probable Maximum Flood

The probable maximum flood (PMF) as defined in the Floodplain Development Manual provides the upper limit of flooding to inform flood risk management for communities. Estimation of the PMF provides a basis for understanding the extent of the floodplain and the upper scale of the flood problem faced by communities.

Depending on a number of factors, the PMF or an equivalent extreme flood can range from less than 1 metre to more than 10 metres higher than the 1% AEP flood levels (Figure 21). The PMF is likely to be higher than levels considered for minimum floor levels or for the crest of a levee.

It is a key event to consider in emergency management and should be considered with regard to the location of resources critical during floods such as evacuation centres and, hospitals with an emergency response function, disaster management centres and those whose occupants may be placed at more risk in evacuation (i.e. critical care patients in hospitals).

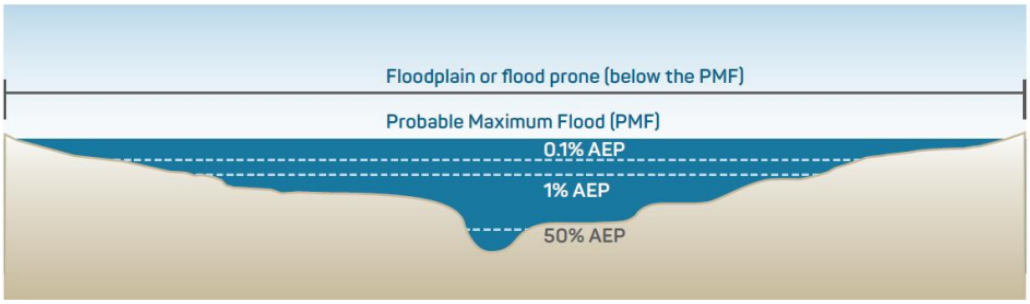


Figure 21 Floodplain and probable maximum flood (PMF) (AIDR 2017a)

4.3.5 Consideration of Climate Change

Consideration of climate change in flood studies is important as it can lead to altered flood behaviour and increased community exposure to flood risks and impacts. Climate change is expected to have adverse impacts upon sea levels (relevant in the lower portion of coastal waterways) and flood producing rainfall events (relevant across NSW).

Depending on the local flood situation both can have significant impacts on flood behaviour that is assessed as part of the studies.

Guidance on how to assess climate change impacts on flood behaviour and its impacts on the community is available within NSW Government FRM Guidance.

4.4 Categorisation of the Floodplain

The area flooded during a flood event (or events) can be further categorised based on different criteria depending on what information is required. These include the flood planning area, flood function (also call hydraulic categorisation), flood hazard, flood emergency response classifications and flood planning constraint categorisation. The categorisation of the flood behaviour in these ways can better inform processes such as land use planning and emergency planning, discussed in the sections below.

4.4.1 The Floodplain or Flood Prone Land

The floodplain or flood prone land is the area that is inundated by the PMF. Land above the PMF level may sometimes be referred to as flood-free although it should be remembered that some land above the PMF level could still experience local drainage problems or water flow across the ground or may be indirectly affected by flooding due to loss of services or power from facilities that are inundated.

4.4.2 Flood Planning Areas (FPAs) and the Flood Planning Levels (FPLs)

Flood planning areas are a type of flood planning constraint category. They are areas where councils apply flood planning controls for all types of development. The FPA is generally determined based on the areas inundated by the DFE or planning flood and includes a freeboard and therefore below the flood planning level (FPL) (Figure 20). Freeboards can vary depending on the type of flooding and the certainty of the modelling process, typical freeboards for riverine flooding are generally 0.5m and for overland flow flooding are generally 0.3m.

FPAs should be based on an understanding of flood behaviour and the associated hazards and risks. Choosing an FPL is a matter of assessing and balancing the social, environmental and economic consequences of adopting that FPL.

4.4.3 Flood Function (Hydraulic Categorisation)

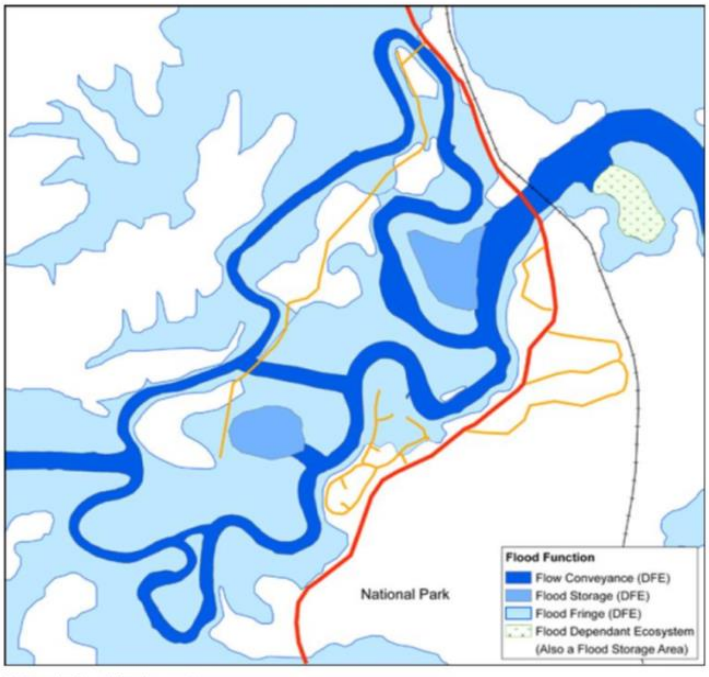
The determination of flood function (hydraulic categorisation) of flood prone land is an essential element of flood studies and management studies as it assists in determining appropriate flood risk management strategies for both existing and future development.

To identify areas that perform an essential flood function it is necessary to divide the floodplain into areas that reflect different flood functions or hydraulic categories. These are:

- Floodway - areas where a significant volume of water flows during flood and are often aligned with obvious natural channels. They are areas which, if only partially blocked, would cause a significant increase in flood levels and/or a significant redistribution of flood flow.
- Flood Storage - areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
- Flood Fringe - is the remaining area of land affected by flooding, after the floodway and flood storage have been derived.

The extent of flooding and floodways and flood storage areas will generally increase as the scale of flood increases. They are usually mapped for a minimum of the DFE (see Figure 20 and Figure 22), plus a smaller and larger event, and the PMF. This enables an understanding of how the flood function varies to be considered in management decisions.

Floodways and flood storage areas would have additional development controls that aim to support the flood function of the floodplain.



DFE = defined flood event

Figure 22 Breakdown of the DFE flood into flood functions (AIDR 2017a)

4.4.4 Flood Hazard

The extent of flooding in an event can be categorised based on the varying degree of hazard that flood poses to the land.

Hazard vulnerability curves (Figure 23) classify hazard based on the consequences of the flood hazard on people, vehicles and buildings. This information can be used to highlight where the flood is hazardous to these different elements (Figure 24).

This provides important information for FRM, emergency management planning and land use planning

Hazard Categories

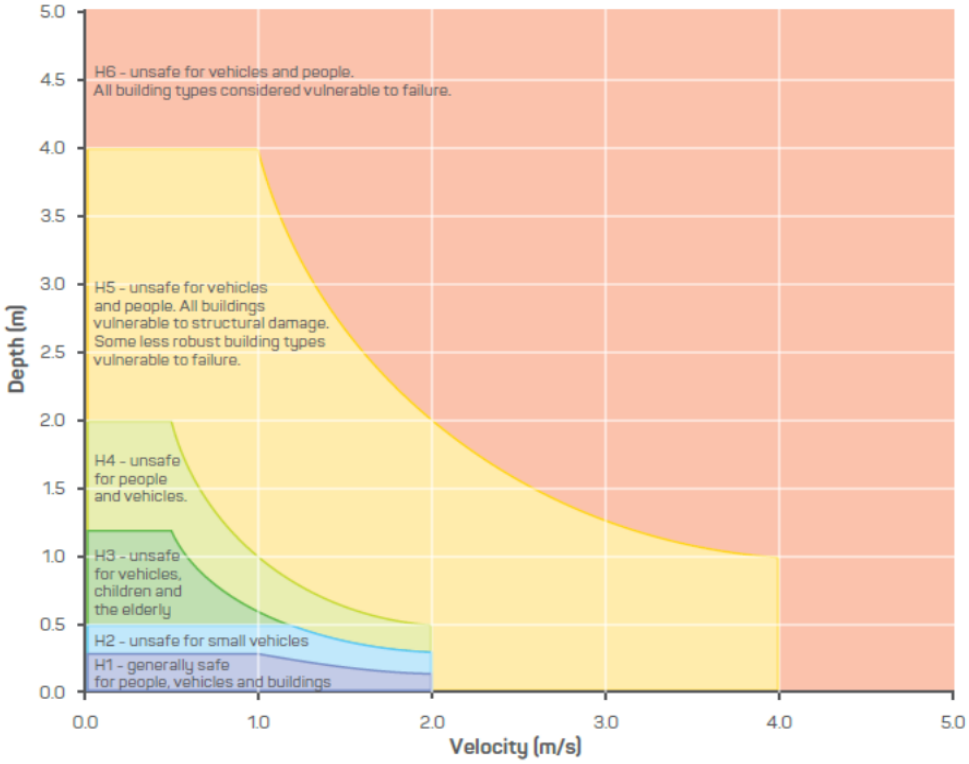


Figure 23 General flood hazard vulnerability curves

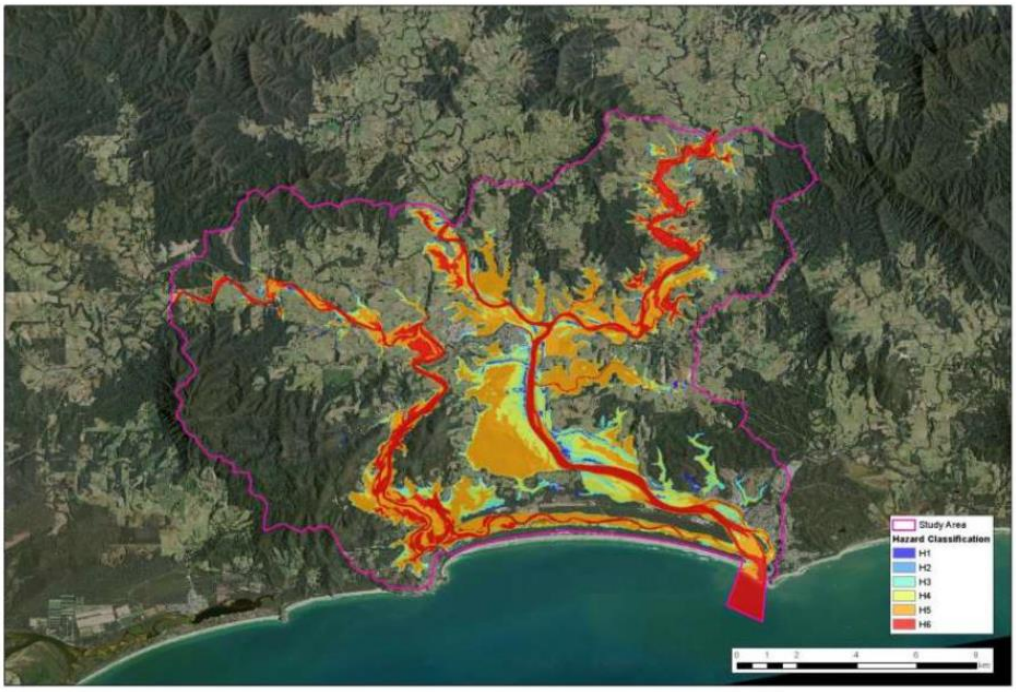


Figure 24 Example breakdown of the floodplain into hazard categories (AIDR 2017b)

4.4.5 Flood Emergency Response Classification

Flooding can isolate parts of the landscape and cut-off evacuation routes to flood-free land or locations where community facilities are available to support evacuated residents in a flood event. This can result in a dangerous situation, because people may see the need to cross floodwaters to access services, employment or family members. Any situation that increases people's need to cross floodwaters increases the likelihood of an injury or fatality.

The floodplain can be classified in relation to isolation and access considerations in a way that informs emergency response management (Figure 25). This classification provides the basis for understanding the nature, seriousness and scale of isolation problems.

It provides important information for emergency management planning, FRM and land use planning

Further information can be found in the Guide on Flood Emergency Response Planning Classification of Communities.

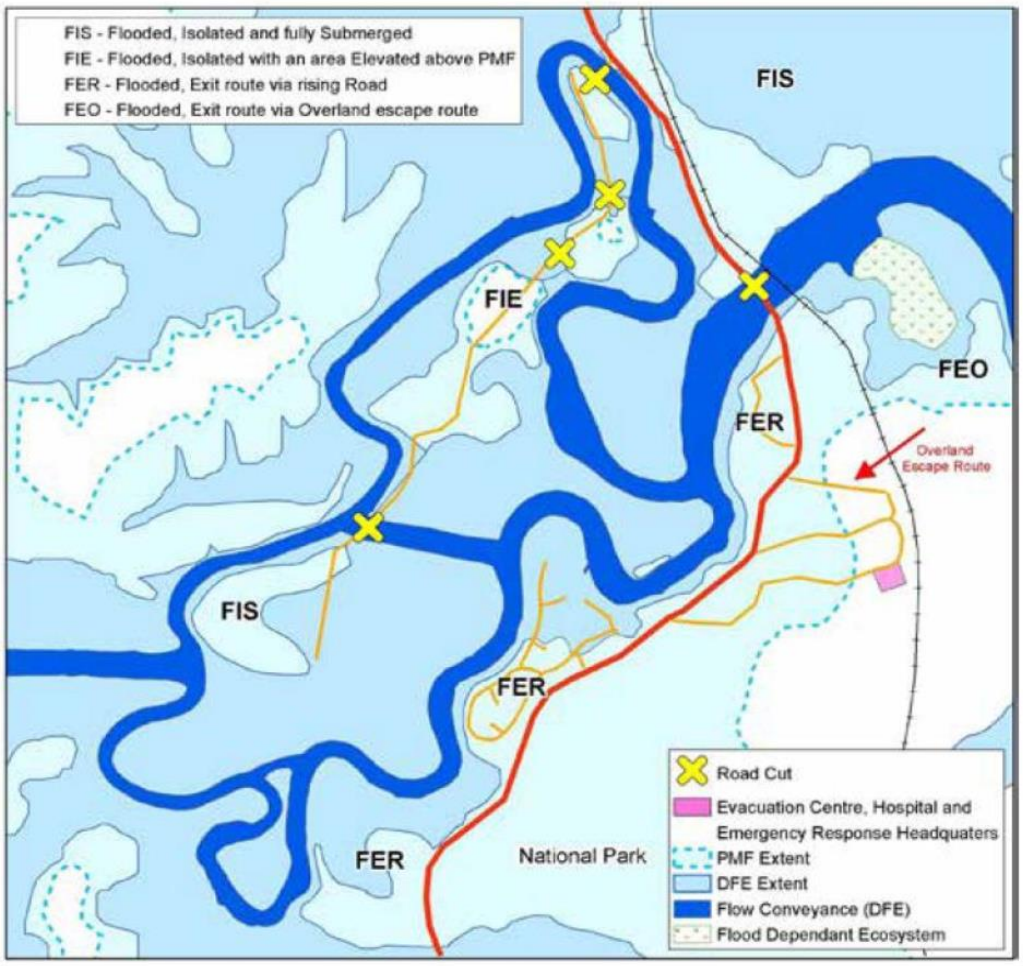


Figure 25 Example of flood emergency response classification of the floodplain (AIDR 2017c)

4.4.6 Flood Planning Constraint Categories

Flood studies typically produce many maps, each focusing on a particular design event and element of flood behaviour. Collectively, they provide a very detailed description of flood behaviour and the issues that are important in different areas of the floodplain.

Combining all elements of flood behaviour can produce a succinct set of information that breaks the floodplain down into areas with similar degrees of constraint – Flood Planning Constraint Categories (FPCC). FPCCs can better inform and support land-use planning activities by identifying where flood-related constraints can be treated similarly.

Deriving flood planning constraint categories involves using information derived from modelling including varied flood function (see section 4.4.3), flood hazard (section 4.4.4), flood emergency response classification (section 4.4.5) and considering the range of flood events. An example of FPCCs is shown in Figure 26, for further detail of the mapping components used to develop this example refer to Australian Disaster Resilience Guideline 7-5 Flood Information to Support Land-use Planning (AIDR 2017), Appendix A.

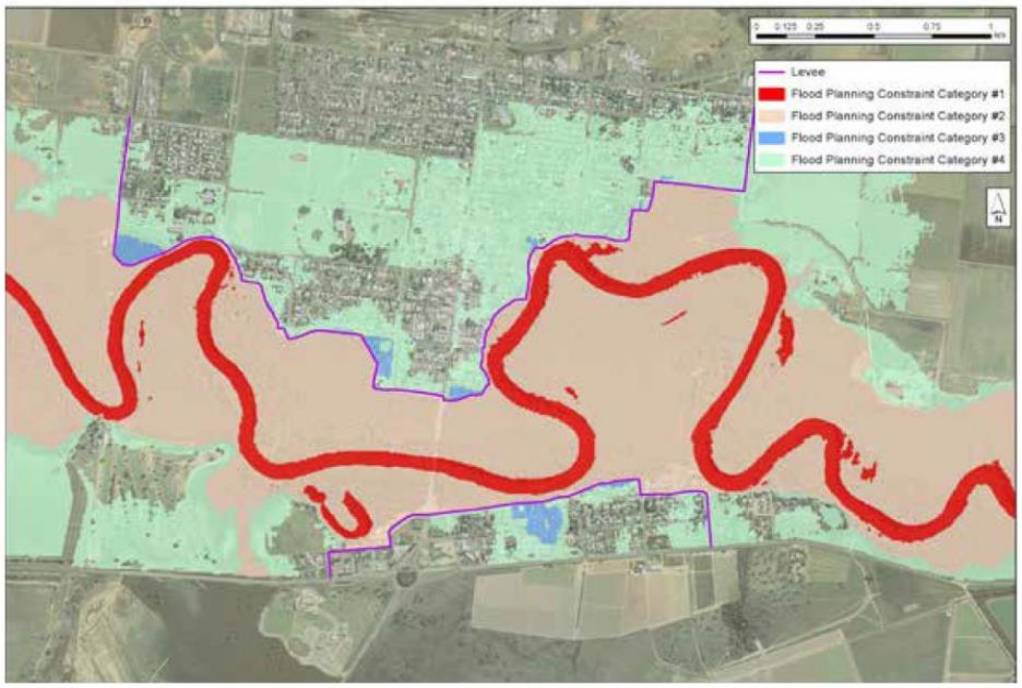


Figure 26 Example flood planning constraint categories (AIDR 2017c)

FPCCs can come in different forms. For example, Table 5 shows four FPCCs that have been developed to separate areas of the floodplain from the most constrained and least suitable for intensification of land use or development (FPCC1) to the least constrained and more suitable for intensification of land use or development (FPCC4). Other examples of FPCCs include flood risk precincts where the floodplain is broken down into areas of low, medium and high risk and the breakdown of the floodplain into floodway areas, the flood planning area and the flood risk management area.

Table 5 Flood Planning Constraint Categories – Implications and Key Considerations

FPCC	Level of constraints
1	Severe limitations on usage due to impacts on flood behaviour and hazard
2	Significant controls on development due to emergency response limitations, flood behaviour in rare events and the level of flood hazard
3	Standard land-use and development controls aimed at reducing damage and the exposure of the development to flooding in the DFE are likely to be suitable. Consider the need for additional conditions for emergency response facilities, key community infrastructure and vulnerable users.
4	Consider the need for conditions for emergency response facilities, key community infrastructure and land uses with vulnerable users.

5. MANAGEMENT MEASURES

5.1 Types of Measures

There are various ways of managing floodplains to reduce flood losses which include:

- modifying the response of the population at risk
- imposing controls on property and infrastructure development
- modifying the behaviour of the flood itself

The first two measures can be referred to as non-structural options or measures (Table 6). The third measure is often referred to as a structural option (those measures which modify flood behaviour by reducing flood levels or excluding floodwaters from areas at risk).

Table 6 Types of Modification Measures

Property Modification Measures	Response Modification Measures	Flood Modification Measures
Zoning	Community Awareness	Flood Control Dams
Voluntary Purchase	Community Readiness	Retarding Basins
Voluntary House Raising	Flood Prediction and Warning	Levees
Building and Development Controls	Local Flood Plans	Bypass Floodways
Flood Proofing Buildings	Evacuation Arrangements	Channel Improvements
Flood Access	Recovery Plans	Flood Gates

A FRM study will examine a wide range of management options for selection in the management plan and may include measures which:

- change the community's response to the next flood event;
- change the impact of floodwaters on development;
- change where the floodwaters go; and
- change the way we currently plan for future development and apply controls to current development.

5.2 Evaluation of Measures

The implementation of management measures is likely to have economic, social and environmental implications. The benefits of each measure need to be weighed up against their costs to justify their implementation.

When examining management options, the focus of looking at benefits and costs should be on aspects that will change due to the management option and effort should not be wasted on aspects that do not change.

Management option, especially structural options, need to consider whether the option impacts on the environment. For example, the construction of levees and floodgates may impact on wetlands which require tidal flows for efficient operation. Whilst such as examination should be sufficiently thorough to determine whether the option is environmentally viable, it does not extend to undertaking an environmental impact assessment. These more detailed assessments which will if needed be undertaken as part of detailed investigation and design before construction commencing. Where possible,

opportunities for enhancement of the environment via the implementation of FRM measures should also be investigated and promoted.

While it is possible to identify tangible costs e.g. the financial costs of implementing structural works or development controls, it is not practical to ascribe a monetary value to intangible costs e.g. social dislocation caused by flooding. This does not mean, however, that intangible costs are any less important in considering whether management options are justifiable. They are generally examined in a qualitative way so that this can inform decisions.

When examining management measures and development proposals, it is very important that consideration be given to the impact of the development or measure on flood behaviour as well as the impact of flooding on the measure or development.

5.3 Flood Damage

The assessment of damages can help focus FRM efforts by providing important information on the severity and location of impacts. Any reduction in impacts resulting from the implementation of mitigation measures provides advice on their relative cost-efficiency through cost-benefit analyses including qualitative assessments of benefits and costs where relevant.

The severity of consequences of flooding on the community can be assessed based upon the frequency and scale of tangible and intangible impacts.

5.3.1 Types of Damage

Flood damages are traditionally divided into tangible and intangible damages. Tangible damages are also sub-divided into direct and indirect damages (Figure 27).

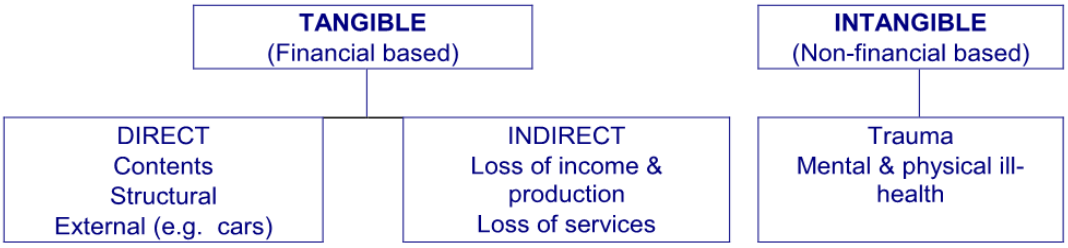


Figure 27 Types of Damage

5.3.2 Stage – Damage Curves

Direct damages are normally calculated using stage-damage curves. These curves show the damages that can be expected to occur for a range of depth of water over the floor. A sample stage-damage curve is shown in Figure 28.

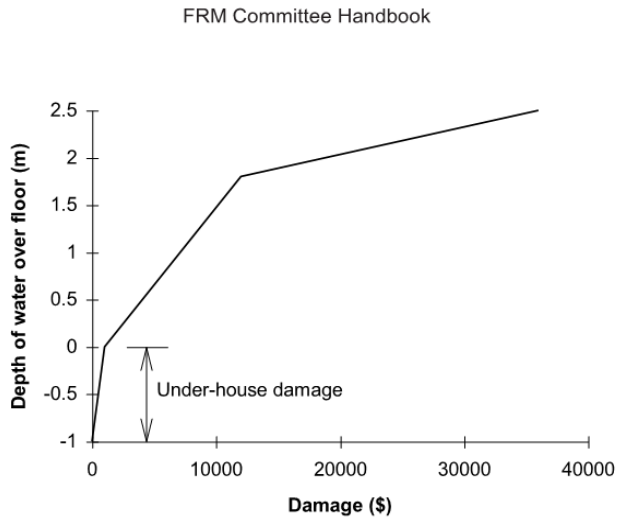


Figure 28 Sample Stage-Damage Curve

5.3.3 Average Annual Damage

The average annual damage (AAD) is the total damage caused by all floods over a long period of time divided by the number of years in that period. It represents the amount of damage that can be expected to occur every year on average. A sample curve relating damages to various design floods is shown in Figure 29. Such curves can be used to calculate the area under the curve to give AAD.

Examining the change in AAD is a convenient way to compare the economic benefits of various proposed mitigation measures.

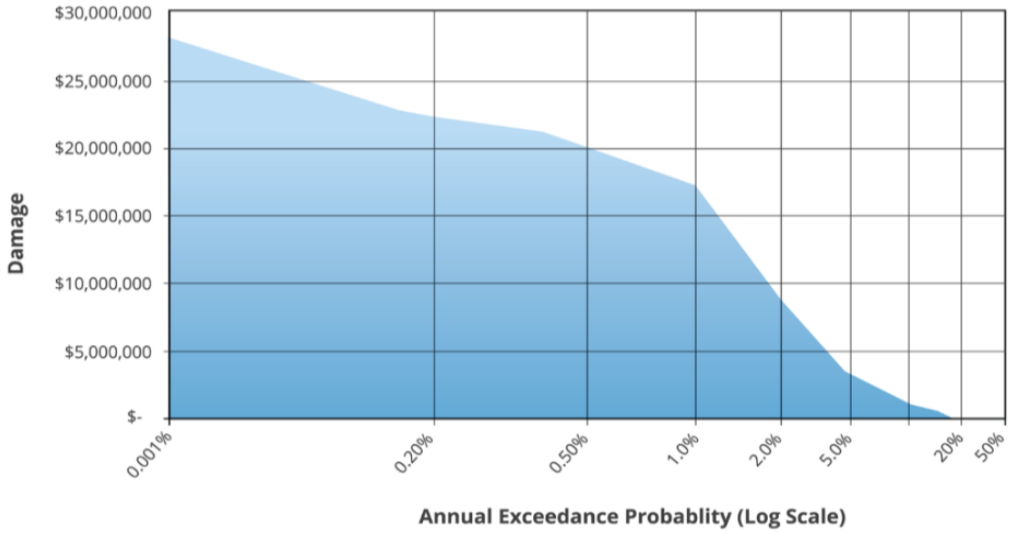


Figure 29 A Sample of a flood damage curve for a range of AEP events (ARR 2019)

5.3.4 Benefit/Cost Ratio

A convenient method of assessing the economic viability of proposed mitigation measures is the benefit/cost ratio. Here the net present worth of the benefits associated with the measure (e.g. the reduced AAD) (Figure 30) is divided by the cost of the measure (e.g. construction cost, on-going maintenance costs and financing costs). If the B/C ratio is greater than 1 this implies the works have more tangible benefits than cost, and vice versa for a B/C ratio less than 1. However, works with a lower B/C ratio may still be viable when social, environmental and similar benefits and costs considerations are also considered.

The level of economic appraisal of an option varies with cost, impacts etc. Economic appraisal can be an iterative approach with cursory analysis needed in the initial phases of a study to detailed analysis for final decisions.

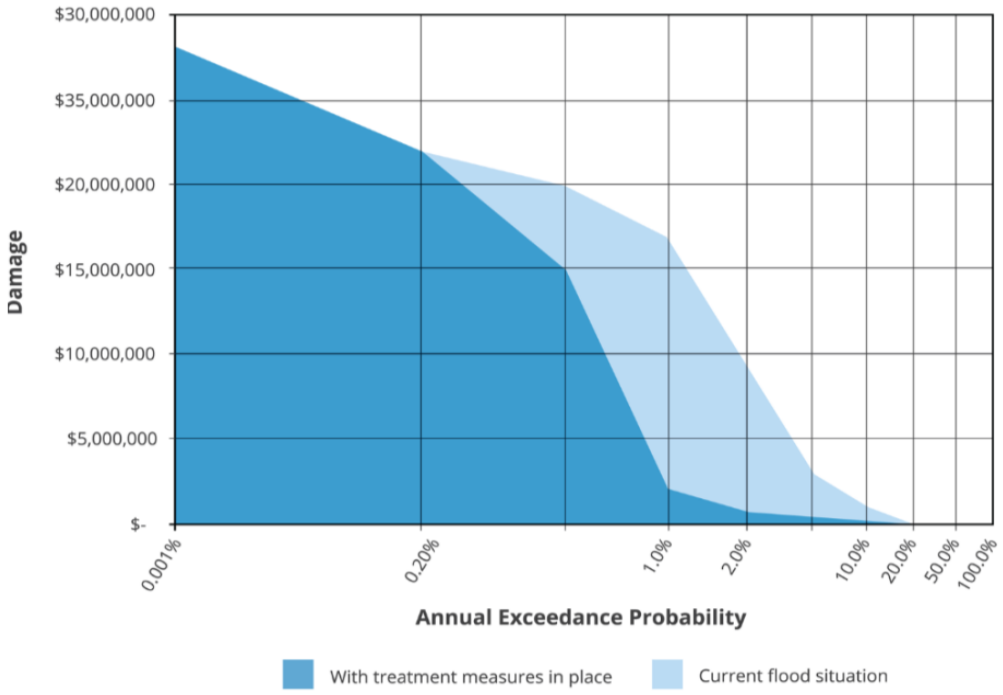


Figure 30 Sample Damage Curve with and without treatment options (ARR 2019)

6. REFERENCES

This handbook only provides basic information on flood risk management issues. The following publications and videos can assist in obtaining more comprehensive information.

AIDR 2017a, Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia, https://knowledge.aidr.org.au/media/3521/adr-handbook-7.pdf

AIDR 2017b, Australian Disaster Resilience Guideline 7-3 Flood Hazard, https://knowledge.aidr.org.au/media/3518/adr-guideline-7-3.pdf

AIDR 2017c, Australian Disaster Resilience Guideline 7-5 Flood Information to Support Land-use Planning, https://knowledge.aidr.org.au/media/3519/adr-guideline-7-5.pdf

ARR 2019, Australian Rainfall and Runoff: A Guide to Flood Estimation, Geoscience Australia, http://arr.ga.gov.au/arr-guideline

Managing Flood Risk (Video Series) Gosford City Council (2013), https://www.youtube.com/playlist?list=PLjDIzhwADz3YsX_Wb-B9JUsEI9PEiX0-Y

NSW Government (2005), *Floodplain Development Manual*, Department of Infrastructure Planning and Natural Resources, DIPNR 05_020, https://www.environment.nsw.gov.au/research-and-publications/publications-search/floodplain-development-manual

NSW Department of Planning Industry and Environment (DPIE), Floodplain Risk Management Guidelines, https://www.environment.nsw.gov.au/topics/water/floodplains/floodplain-guidelines

NSW Department of Planning Industry and Environment (DPIE), Floodplain Risk Management Guidelines, *Incorporating 2016 Australian Rainfall and Runoff in studies*, 2019, https://www.environment.nsw.gov.au/topics/water/floodplains/floodplain-guidelines

Shellharbour City Council, *Macquarie Rivulet Flood Study*, WMAwater, 2017

Note

[1] The Department of Planning Industry and Environment (DPIE) was formerly the Office of Environment and Heritage (OEH) up until 30 June 2019. References to DPIE documents may relate to documents labelled OEH.

Attachment 3 - 20230913 - Tumbarumba Flood Study - Draft Technical Project Brief

Technical project brief for Tumbarumba Flood Study

Commissioned by Snowy Valleys Council

PREFACE

This generic brief has been designed to be used in partnership with your local DPE flood risk management specialist and in conjunction with the associated guideline (*Guideline for using the national generic brief for flood investigations to develop project-specific specifications, NSW DPE*). This aims to generate a brief that is consistent with the:

- Floodplain Development Manual (FDM) 2005
- supporting guidelines
- national best practice as outlined in Australian Institute of Disaster Resilience Handbook Series, Handbook 7: Managing the Floodplain: A Guide to Best Practice in flood risk management in Australia and its accompanying guidelines and materials.

In some cases, such as for flood hazard, more recent national technical guidelines provide the opportunity to provide more specific advice on hazard to support management without being inconsistent with NSW guidance.

Also, the finalisation of the revised FDM (*Flood Risk Management Manual*) and its associated toolkit is likely within the timeframe of this study which needs to be considered.

CONTENTS

Tables

Figures

1 INTRODUCTION

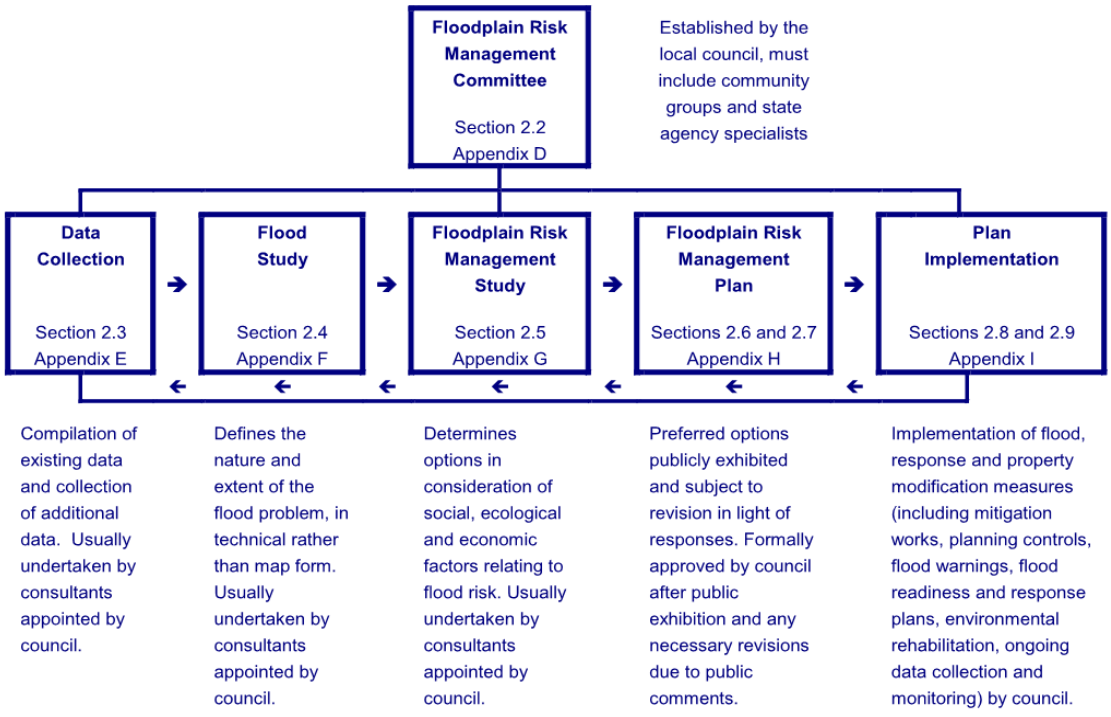
Snowy Valleys Council (the Council) has received financial support from the State Floodplain Management program, managed by the NSW Department of Planning and Environment (DPE), to undertake a flood investigation for the township of Tumbarumba and its environs.

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

The *Floodplain Development Manual* (NSW Government 2005) is provided to assist councils to meet their obligations through the preparation and implementation of floodplain risk management plans, through a staged process. Figure 1, taken from this manual, documents the process for plan preparation, implementation and review.

The *Floodplain Development Manual* is consistent with Australian Institute of Disaster Resilience Handbook 7: *Managing the floodplain: best practice in flood risk management in Australia* (AIDR Handbook 7) (AIDR 2017).



Note: sections refer to the source document
Source: NSW Government (2005)

Figure 1 **The floodplain risk management process in New South Wales**

2 STUDY OBJECTIVES

The 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 as outlined in Sections 4 and 5, respectively.

The study will be overseen and guided by Snowy Valleys Council (Council) and its Floodplain Risk Management Committee (FRMC), which may include representatives from key stakeholder and end user groups. The study will be guided technically by Council and a technical committee, which may include representatives from the Council and other organisations (such as NSW Government agencies). The Council will be the day-to-day contact for the study.

This project involves conducting a flood study, which is a comprehensive technical investigation of flood behaviour that provides the main technical foundation for the development of a robust floodplain risk management plan. It aims to provide an understanding of the full range of flood behaviour and consequences in the study area. It involves consideration of the local flood history, available collected flood data, and the development of hydrologic and hydraulic models. Where possible, models are calibrated and verified against historic flood events and then extended to estimate the full range of flood behaviour.

The overall project provides 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
- 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
- other key stakeholders (including utility providers and the insurance industry) on flood risk

The degree of sophistication of the study should be commensurate with the scope of the study, the outcomes and outputs required from the study and the complexity of the flood situation.

Depending upon the degree of sophistication of the study the outputs of the study outlined in Section 7 may be able to 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 development and climate on flood risk
  - emergency response situation and limitations
  - effectiveness of current management measures
- facilitating information sharing on flood risk across government and with the community.

The study outputs can also inform decision making for investing in the floodplain; managing flood risk through prevention, preparedness, response and recovery activities. Each of these areas has different user groups, whose needs vary. The key end-user groups that this study aims to support are identified in Table 1.

Table 1 Project End Users

Potential end user group
High-level strategic decision makers
Community
Flood risk management professionals

Potential end user group
Engineers involved in designing, constructing and maintaining mitigation works
Emergency management planners
Emergency services (i.e. SES, OEM)
Land-use planners (strategic planning and planning controls)
Hydrologists and meteorologists involved in flood prediction and forecasting
Insurers

Meeting the requirements of the identified end user groups, which have been tailored to the context of the flood situation, is a key objective of this study.

3 BACKGROUND AND STUDY AREA

Key drivers for the study

This project encompasses an assessment of riverine and major overland flow flooding at the subject town of Tumbarumba and its environs (see Figure 2).

There is significant development pressure in and around Tumut and Council intend to update the Floodplain Risk Management Study and Plan following the development of a state-of-the-art detailed two-dimensional flood model to define the existing flood risks due to both riverine and major overland flow flooding.

Study area overview

Tumbarumba Creek rises in the Bago Range at an elevation of about 1,290m. It flows 30km in a generally SSW direction to the town of Tumbarumba, where the elevation is about 630m. The catchment area to Tumbarumba has been measured at 139 km^2 at the Albury Street Bridge. Figure 3 shows that the catchment has a relatively elongated shape, which is generally conducive to flatter, longer duration hydrographs compared to a rounder catchment where flow from sub-catchments would arrive at the same time.

The town of Tumbarumba has a population of 1,487 people at the 2006 Census. Most of the town is located on a hillslope on the eastern side of Tumbarumba Creek and is not exposed to flooding from the creek (but may be at risk from overland flows). Several commercial premises and a caravan park are exposed to mainstream flood risks.

Development pressures

There is has been some development pressure in Tumbarumba in recent times both within the township and in the surrounding area. The flood study will involve the development of a detailed two-dimensional flood model to define the existing flood risks due to both riverine and major overland flow flooding for use in the development of appropriate planning strategies.

Study area political context

The study area is located within Snowy Valleys Council, within the Federal Electorate of Eden-Monaro, currently represented by Kristy McBain. Snowy Valleys Council lies within the Wagga Wagga electoral district of the Legislative Assembly of New South Wales and is currently held by Dr Joe McGirr who is an Independent member.

Flood Behaviour
Inundation problems in Tumbarumba may be generally attributed both to local overland flow during heavy local rainfall and to flooding from Tumbarumba Creek and its tributaries. Although generally most of the town is located off the floodplain a series of major floods occurred in 2010 that resulted in the inundation of the local caravan park, showgrounds and various camp grounds causing much inconvenience and damage.

Flood history
There are records of numerous major floods going back to 1889. More recently a series of major floods occurred in 2010 with 5 major peaks occurring between September and December that year. The Town was again impacted by a major flood in March 2012 again flooding the caravan park and other low lying properties.

Extreme flood events
Now previous flood study has been completed for the Study Area so the extent of the PMF (Extreme) flood event is unknown.

This flood study is expected to assess the PMF (Extreme) flood event across the study area with consideration for the probability of coincident flooding events. The exact method of PMF assessment is to be defined in consultation with Council and the FRMC as the project progresses.

Flood emergency management situation.
Preparedness, response and recovery measures for flooding in Tumbarumba are detailed in the Tumbarumba Local Flood Plan (SES, Feb 2013). Currently no flood intelligence card exists for Tumbarumba to the knowledge of Council.

How the study outcomes of the study will be used.
The objective of this study is to develop a state-of-the-art flood model for the Township of Tumbarumba and its environs for the purposes of defining the flood risks due to both riverine and major overland flow flooding.

This project will provide information that will be used to:

- Reduce the impacts of existing flooding and flood liability on communities and to reduce private and public losses resulting from floods.
- Make informed decisions on managing flood risk by preparing floodplain risk management plans (and associated background studies) under the floodplain risk management process.
- Develop a FRM (Floodplain Risk Management) Plan leading to the implementation of floodplain risk management measures to reduce flood risk to both existing and future development, and reduce losses through a range of property, flood and response modification measures as outlined in the Floodplain Development Manual.

Provide essential information to the NSW State Emergency Service to enable the effective preparation and implementation of local flood plans to deal with flood emergency response.

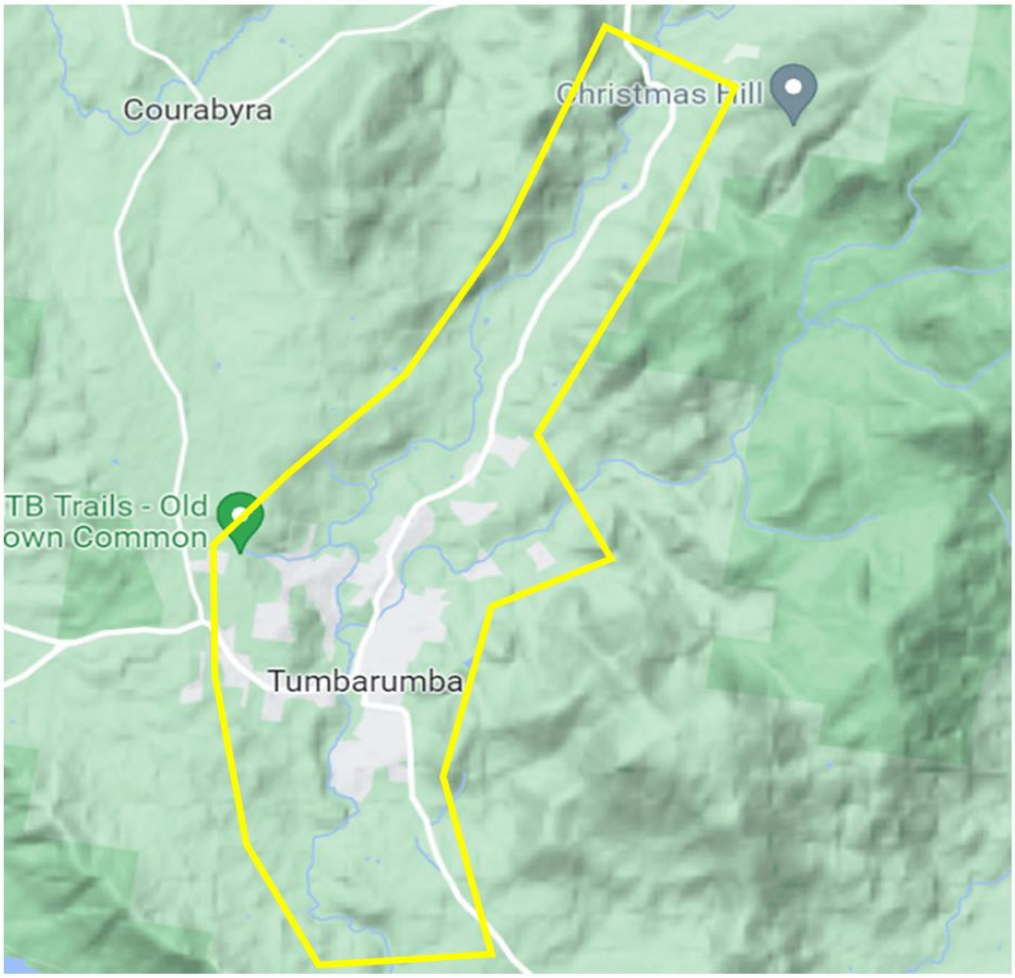


Figure 2 **Study Area**

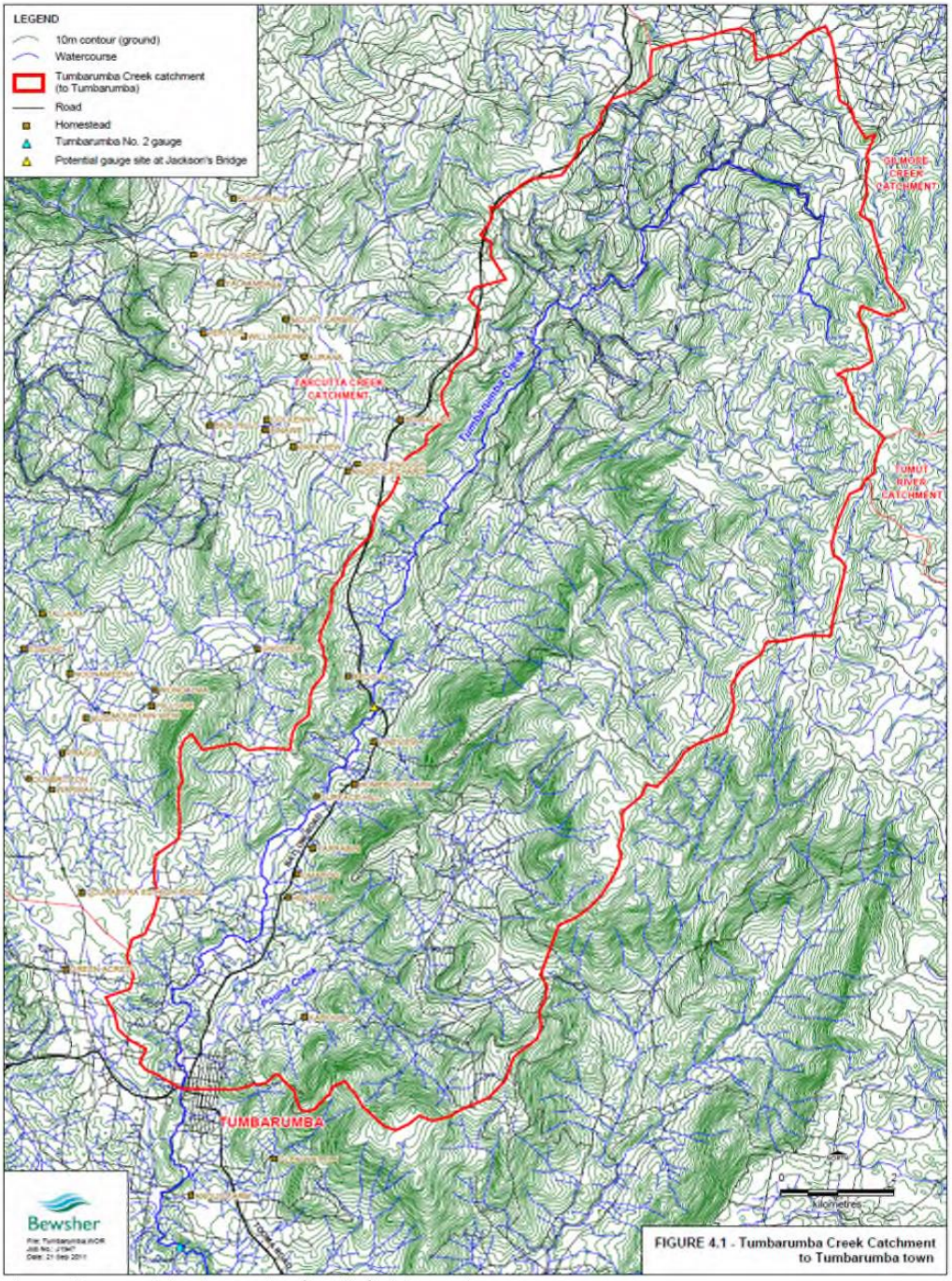


Figure 3 **Tumbarumba Creek Catchment**

4 AVAILABLE INFORMATION

The study is to draw upon:

- existing flood investigations in the area (Table 2)
- relevant local land-use planning policies, flood emergency management plans and local design standards (Table 3).

The study should use relevant existing data that are available from Council for use by the consultant during the study (Table 4) and other organisations that may have other relevant information – for example, road or rail authorities, and the Bureau of Meteorology (Table 5). The data listed in Table 4 will be provided or arrangements for access made at the start of the study.

Table 2 Summary of previous studies

Study name	Description (one paragraph summary)	Author	Year	Accessible for tendering and project
Flood Intelligence Collection and Review for Towns and Villages in the Murray and Murrumbidgee Regions following the October 2010 Flood	Following severe flooding in October 2010 in the South West Slopes and Riverina districts, the NSW State Emergency Service (NSW SES) commissioned a large flood intelligence collection and review exercise. Fourteen towns and villages across five local government areas were selected for the Investigation including Tumbarumba.	Bewsher Consulting	2012	Available post engagement from Snowy Valleys Council
Flood Intelligence Collection and Review for 24 Towns and Villages in the Murray and Murrumbidgee Regions following the March 2012 Flood	Severe flooding was experienced in March 2012 across similar areas as was experienced in October 2010. In order to capture the additional flood data, the NSW SES commissioned a project to conduct further investigations for 24 towns and villages including Tumbarumba.	Dr Stephen Yeo	2013	Available post engagement from Snowy Valleys Council
Adelong Flood Study	The study objective was to define flood behaviour in the adjacent Adelong Creek catchment at Adelong following the major floods in 2010 and 2012.	Lyall & Associates Consulting Water Engineers	2014	Available post engagement from Snowy Valleys Council
Adelong Floodplain Risk Management Study and Plan	The overall objectives of the Floodplain Risk Management Study were to assess the impacts of flooding, review existing Council policies as they relate to development of land in flood liable areas, consider measures for the management of flood affected land and to develop a Floodplain Risk Management Plan.	Lyall & Associates Consulting Water Engineers	2018	Available post engagement from Snowy Valleys Council

Table 3 Summary of local policies and emergency management plans

Document	Description (one paragraph summary)	Author	Year	Accessible for tendering and project
Land-use planning policies				
Tumbarumba Local Environmental Plan	The Local Environmental Plan (LEP) provides the rules and guidelines for the control of land (both private and public) through zoning. It aims to reduce possible conflict between adjoining land uses and ensures there is adequate land to meet diverse needs.	Snowy Valleys Council	2010	https://www.snowyvalleys.nsw.gov.au/Building-Planning/Planning/Local-Environmental-Plans
Snowy Valleys Development Control Plan 2019	The overall objectives of the Snowy Valleys Development Control Plan 2019 are to: achieve the aims and standards in Council's Local Environmental Plan by providing more detailed controls for development; outline Council policies, standards and identify the preferred future direction for development design within the Snowy Valleys Council area; and assist with the preparation of development proposals by providing proponents a guide to the community's expectation for development	Snowy Valleys Council	2019	https://www.snowyvalleys.nsw.gov.au/Building-Planning/Planning/Development-Control-Plans
Emergency Management Plans				
Tumbarumba Local Flood Plan (LFP)	The purpose of the LFP is to detail arrangements agreed for the planning, preparedness/prevention, response and recovery from flood incidents.	NSW SES	2013	https://www.ses.nsw.gov.au/media/1663/plan-tumbarumba-shire-lfp-feb-2013-endorsed.pdf
Flood Intelligence Cards	NSW SES maintain flood intelligence cards for key gauges across NSW detailing flood impacts at locations. There is currently no FIC for Tumbarumba to Councils knowledge.	NSW SES		.

Table 4 Available and compiled existing data

Document	Description (one paragraph summary)	Author	Year	Accessible for tendering and project
Data Collection Report	See NSW SES data collection reports post 2010 and 2012 events detailed in Table 2 above.			Available post engagement from Snowy Valleys Council
Historic flood information Including photos, satellite imagery and post event reports	See NSW SES data collection reports post 2010 and 2012 events detailed in Table 2 above.			Available post engagement from Snowy Valleys Council
Hydrologic data Stream water level gauges (station number and record length (years))				
Tumbarumba No. 1 gauge	Record length – 1946 to 1983	Owner Water NSW		Accessible by from Pineena software

Document	Description (one paragraph summary)	Author	Year	Accessible for tendering and project
Tumbarumba No. 2 gauge (401007)	Record length - since 2000 to present	Owner Water NSW		Accessible by internet and on Pineena software http://www.bom.gov.au/waterdata/
Survey data (ALS/topographic DEMs), existing floor levels, datum cross references, hydraulic structure details, aerial photos				
LiDAR	1 m grid DEM derived from LiDAR acquired in November 2014 for the Study Area.	NSW Spatial Services – Department of Customer Service	2014	Access via data download from: https://elevation.fsdf.org.au/
LiDAR	2 m grid DEM derived from LiDAR acquired in 2018 for the wider catchment.	NSW Spatial Services – Department of Customer Service	2018	Access via data download from: https://elevation.fsdf.org.au/
GIS Layers	None			
Hydrologic models	None			
Hydraulic models	None			

Table 5 Organisations with relevant existing data

Agency/Office	Relevant contacts – name, email, phone	Comments
Council Engineers	Andrew Vaz- Co-ordinator Survey & Design avaz@svc.nsw.gov.au	
Council Planners – Strategic and statutory planners	Nicholas Wilton - Manager Growth & Activation nwilton@svc.nsw.gov.au Mark Kirton – Co-ordinator Growth and Development mkirton@svc.nsw.gov.au Brad Allen- Development Assessment Planner ballen@svc.nsw.gov.au	Information regarding areas subject to development pressure and potential new release areas and the location of existing and/or proposed critical infrastructure which could impact on the pattern of flooding and/or may be critical for the viability of the community
Floodplain Risk Management Committee, the community and community groups (Historical Societies, Progress Associations)	Committee not yet formed	Information on past flood behaviour, flood photographs, specific problem areas, community concerns
Department of Planning and Environment (DPE)	Steve Manwaring SNRO Floodplain Management Steve.Manwaring@environment.nsw.gov.au	Best practice guidelines, policy, technical and project management advice.
WaterNSW	TBC	River gauging and tidal data, other relevant data from their

Agency/Office	Relevant contacts – name, email, phone	Comments
		records. Blowering Dam operations.
NSW State Emergency Service (SES)	Craig Ronan Coordinator Planning – Hazards Community Planning and Preparedness craig.ronan@one.ses.nsw.gov.au	Information on past flood behaviour, response planning and operation information requirements including potential impacts on emergency service and evacuation facilities as well as access/evacuation issues (closure of roads & access routes)
Bureau of Meteorology		Rainfall data and information on key historic storms
Roads and Maritime Services and State Rail Authority		Road, rail embankment and bridge details including flood damage
Land and Property Information		Existing topographic information (including LiDAR survey) and aerial photographs.
The Foundation Spatial Data Framework (ELVIS)		Topographic information http://elevation.fsdf.org.au/
Geographical Names Board		Gazetted geographical names of local features.
Geographical Names Board		Gazetted geographical names of local features.
Resilience NSW		

5 CURRENT GUIDELINES AND REFERENCES

The consultant should use current guidelines, manuals and technical reference documents during the study. Sources are outlined in Table 6.

Table 6 Guidelines and reference documents

Reference	Source/Link	Topic	Comment
National			
Australian Institute of Disaster Resilience Handbook Series, *Managing the floodplain: A guide to best practice in flood risk management in Australia* – AIDR Handbook 7	https://knowledge.aidr.org.au/resources/handbook-7-managing-the-floodplain/	Best practice	Adhere
AIDR Handbook Series, *AIDR Handbook 7, supporting document* Guideline 7-3 Technical flood risk management guideline – Flood Hazard	https://knowledge.aidr.org.au/resources/guideline-7-3-flood-hazard/	Flood hazard	Adhere
Australian Emergency Management Handbook Series, *AIDR Handbook 7, supporting document* Guideline 7-2 – Flood Emergency Response Classification of Communities	https://knowledge.aidr.org.au/resources/guideline-7-2-flood-emergency-response-classification-of-the-floodplain/	Emergency response	Consider
AIDR Handbook Series, *AIDR Handbook 7, supporting document* Guideline 7-5 – Flood risk information to support land-use planning	https://knowledge.aidr.org.au/resources/guideline-7-5-flood-information-to-support-land-use-planning/	Land use	Adhere
AIDR Handbook Series, *AIDR Handbook 7, supporting document* Guideline 7-6 – Assessing options and service levels for treating existing risk	https://knowledge.aidr.org.au/resources/guideline-7-6-assessing-options-and-service-levels-for-treating-existing-risk/	Mitigation options and service levels	Consider
AIDR Handbook Series, *AIDR Handbook 6*, National Strategy for Disaster Resilience – community engagement framework	https://knowledge.aidr.org.au/resources/handbook-6-community-engagement-framework/	Community engagement	Consider
Australian National Committee on Large Dams (ANCOLD) Guidelines	http://www.ancold.org.au/?page_id=334	Dams	Consider
Australian Rainfall & Runoff (ARR; this includes the current version of ARR and specific project reports, such as Project 5 – Regional flood frequency estimation, Project 15 – Two Dimensional modelling in urban and rural floodplains, Project 18 – Interaction of coastal processes and severe weather events and Project 11 – Blockage of hydraulic structures)	http://arr.ga.gov.au/arr-guideline also http://arr.ga.gov.au/downloads-and-software/revision-project-reports	Best practice	Consider
New South Wales			
Section 733 of the Local Government Act, 1993		Flood prone land policy	Consider
NSW Government's *Floodplain Development Manual – the management of flood liable land*, April 2005, incorporating the NSW Flood Prone Land Policy.	http://www.environment.nsw.gov.au/research-and-publications/publications-search/floodplain-development-manual	Flood prone land policy and industry practice	Adhere
Floodplain Risk Management Guidelines:	http://www.environment.nsw.gov.au/topics/water/floodplains/floodplain-guidelines		
Incorporating Australian Rainfall and Runoff 2016 into studies		Best Practice	Consider
Floodway Definition		Floodway	Consider
Temporary or relocatable flood barriers		Temporary barriers	Consider
Rainwater Tanks – limitations as flood risk management devices		Rainwater tanks	Consider

Reference	Source/Link	Topic	Comment
Drainage behind and through levees		Internal drainage	Consider
SES requirements from floodplain risk management process		SES requirements	Consider
Residential flood damage and supporting calculation spreadsheet		Flood damages	Consider
Practical consideration of climate change		Climate change	Consider
Coincidence of Coastal Inundation and Catchment Flooding		Coincidence	Adhere, where applicable
NSW Department of Planning, Industry and Environment Data Handover requirements	https://flooddata.ses.nsw.gov.au/dataset/flood-project-handover-template https://www.ses.nsw.gov.au/media/2503/fdp-uploading-project-guide_v1.pdf	Data handover	Adhere
NSW Government Elevation data product specifications and description: Source: Airborne Light Detecting and Ranging (LiDAR) Version 2 May 2015	Copy available from OEH on request	LiDAR	Adhere

6 SCOPE OF WORK

The proposal is to outline a methodology that will achieve the objectives of the study, listed in Section 2 for the identified key end users (Table 1). The proposed methodology is to be developed to meet the scope of work and to produce the required deliverables (Section 7) and comply with the guidelines and best practices (Section 5) in consideration of the available information (Section 4).
The tenderer's proposal is to have a section on limitations to specifically indicate the ability to comply with the full requirements of the brief or to specifically identify any limitations of their proposed approach in meeting the full requirements of this brief, including the defined deliverables for all end users.

The scope of hydraulic modelling work includes the following components:

- Tumbarumba Creek extending from the Jackson's Bridge crossing on Batlow Road to Tumbarumba Creek No. 2 Gauge (401007) downstream of Tumbarumba Township.
- Local inflows from Pound Creek from the upper extent that lies within the Study Area (see Figure 2) to the confluence with Tumbarumba Creek within Town.
- Major overland flows within the Tumbarumba Township.

It is envisaged that the flows used for the Tumbarumba Creek modelling work will be based on assessment of the available gauged flow data. However, the limited period of record may result in the need to use alternative AR&R methods.

Local inflows should also be considered including Pound Creek and overland flows throughout the Tumbarumba township. The major overland flow path assessment is not intended to comprise a detailed assessment of stormwater infrastructure. Major overland flow paths are described as significant natural conveyors of concentrated runoff from the town itself and any catchment areas adjoining the township areas which are discharging to the major overland flow paths. Culverts or stormwater pipes less than 525 mm in diameter (or equivalent) are to be excluded from the major overland flow path assessment. The catchment boundaries associated with the major overland flow assessment will need to be defined using the available terrain data, notably the available LiDAR data.

It is envisaged that the hydraulic model for the rural floodplain reaches will be coarser in terms of terrain representation in comparison to the reaches through the urban areas of Tumbarumba.

6.1 Data collection and review

In the data collection stage, all data necessary for the completion of the study should be collated. It is typically begun at the outset of the study, when the majority of data are collected (or commissioned to be collected). The remaining data will be collected during the study, either as it is required or as it becomes available – for example, for a recent flood event.
Section 4 outlines the data collected prior to this study and its availability for review during the tender process. If not available during the tender process, this data will be supplied at the start of the study.
All available and collected data should be reviewed and considered in the development of the study. Reporting on data collection should consider the findings and any recommendations of this review.

Where the need for and availability of data additional to that listed in Section 4 could have reasonably been anticipated before the close of tenders, the consultant shall obtain the data as part of the project. The cost of obtaining these data is to be included in the proposal fee. If additional data become necessary during the study, and it can be shown the need or availability could not have been reasonably anticipated during the tender process, the consultant is to submit a brief to Council that outlines what data are required, and the cost and timing of acquiring them.
Following Council's approval, the consultant will undertake the additional data collection.

6.1.1 Topographic survey

It is expected that the 2013 NSW government acquired LiDAR data will be the principal terrain data source in defining the terrain surface of the areas subject to hydraulic modelling. The 2014 acquired LiDAR, including 1 m grid derived DEM, is available for download from the internet (http://elevation.fsdf.org.au/).

Validation of the existing LiDAR to ground survey points is required to be completed to ensure its accuracy prior to its use. If existing LiDAR data is deemed inadequate and additional LIDAR needs to be obtained, then it is to be captured in accordance with the relevant guideline listed in Table 6.

Additional survey of structures such as bridges and large culverts is required if they are likely to control or significantly influence flood behaviour, and up-to-date, detailed information for these structures does not exist.

Any survey deliverables should meet the requirements and be consistent with the format specified in Table 14.

Following engagement and the completion of the data review activities, the consultant shall submit to Council a Brief outlining details of the additional survey required (e.g. additional structures, additional LiDAR etc).

Following receipt of written approval from Council, the consultant shall arrange for the survey to be undertaken. This may include obtaining quotes from survey firms to undertake the survey in accordance with the Brief prepared by the consultant.

The consultant shall be responsible for the engagement and supervision of the approved subconsultant to complete the survey work. The consultant is also responsible for ensuring any data acquired is fit for purpose.

In relation to tendering price information, the scope of the additional survey work will not be known until the data review phase is completed. Tenderers are therefore instructed to nominate a provisional survey allowance in their pricing submission.

6.1.2 Survey for flood damages assessment

To assess the cost of flooding on the community, a realistic estimate of the associated survey requirements and costs must also be provided. The consultant should consider the proposed end use of this information and outline the proposed methodology and any limitations on the accuracy of this methodology relative to these uses. These limitations also need to be incorporated into the final report.
A floor level survey done as part of this study will be used to assess the relative cost of different events and flood situations. The data are not required by any other identified end users. Typical data to be collected include both survey information (lowest habitable floor level, ground level at dwelling, ground level at kerb near entry) and other property-specific information (type of house construction, number of floors, relative size, etc.).
Consultant's should base their tender proposals on the following approach:

• For properties within the identified 1% AEP flood extent. The floor level of the main building is to be based on a drive by assessment approach (i.e. estimate the height of the floor level above the adjoining ground surface by field visual assessment). The building floor level elevation is to be assigned based on the estimated height above the ground surface added to the LiDAR ground surface elevation. Tenderers to allow for a total of 50 buildings subject to the drive by assessment approach.
• All other properties. The floor level of buildings is assumed to be based on the adjoining LiDAR ground surface elevation plus a nominal amount (e.g. 200mm).
Deliverables should meet the requirements (including relevant coordinate system) and be consistent with the format specified in Table 14.

6.2 Site visit

During the initial stages of the project, the project team should undertake a comprehensive familiarisation field inspection of the study area. This should be conducted to enable an understanding of key features within the catchment and floodplain that may influence flood behaviour. Ideally, this would be undertaken with representative(s) from the Council and would be used to inform development of the survey brief (if required).

6.3 Consultation

Community consultation has an important role in all flood-related studies. The outcome goals for community consultation can be to:
- inform the community about the study
- identify community concerns
- gather information from the community by participation
- develop and maintain community confidence and collaboration with the study results
- inform the community about flood risks in the area
- seek input from the community on management options.

These principles are in line with those detailed in the relevant community engagement guideline listed in Table 6.
The consultant is to propose a consultation program considering the relevant guidance outlined in Table 6 that is suitable for the study, achieves each consultation point identified in Table 7 and, at a minimum, uses the tools identified in the same table. The consultant's proposal is to form the basis of a program community consultation with further discussion at the inception meeting for the project.

Table 7 Consultation points and tools

Consultation Point	Consultation tools	Comment/aim
Milestone 1 - Data Collection, and Review	FRMC inception meeting (meeting 1)	Update Committee and gather input into data collection and review activities
	Public information meeting	Inform on the project and gather flood information from the community
	FRMC meeting 2	Update Committee and gather technical feedback and input
Milestone 2 – Model Development and Calibration / Validation	FRMC meeting 3	Update Committee and gather technical feedback and input
Milestone 3 – Design Flood Modelling & Damages Assessment	Public information meeting	Inform on the project and gather feedback from the community on the preliminary modelling results
	FRMC meeting 4	Update Committee and gather technical feedback and input

Consultation Point	Consultation tools	Comment/aim
Milestone 4 – Draft Flood Study report & Public Exhibition	FRMC meeting 5	Update Committee and gather technical feedback and input
	Public Exhibition process - information meeting supporting the process	Seek feedback / public submissions on draft Flood Study report
Milestone 5 – Final Flood Study report	FRMC meeting 6	Report to Committee on response to public submissions
Milestone 6 – Completion of Contract		

As part of consultation:

- A community questionnaire is to be sent to flood affected landowners and residents in the study area, informing them about the study objectives and requesting any information they may have on historical floods. The survey is to be sent in the post and provided as an online questionnaire.
- A community newsletter is to be sent to flood affected landowners and residents in the study area, informing them about the study objectives or outcomes. The newsletter is to be sent in the post, available for download and available from Council's information centre.
- Three public community information sessions are to be held at key stages in the study, aimed at informing residents about the study progress and gathering information on historical flood events (this excludes the meeting held during the public exhibition period).
- As part of the consultation program, the draft Flood Study report should be placed on public exhibition and be available for viewing for a period of four weeks.
- The consultant is to hold a public information session during the public exhibition period.

Consultation with key stakeholders is an important aspect of the consultation process. Key stakeholder groups are identified in Table 8. This list is not exhaustive and other stakeholder may be identified throughout the study. The consultant is to demonstrate how they will engage with the identified and potential future stakeholders

Table 8 Key stakeholders for consultation

Stakeholder group	Comment
Planning staff at Snowy Valleys Council	Provide flood intelligence and historical information.
Engineering staff at Snowy Valleys Council	Provide flood intelligence and historical information and confirm flood effects.
Tumbarumba Caravan Park owners/managers	Provide flood intelligence and historical information.
WaterNSW	Provide information on stream gauges.
New South Wales State Emergency Service	Provide flood intelligence and historical information.

6.4 Hydrologic analysis

The purpose of the hydrologic analysis is to calculate all flows entering the hydraulic model, either as upstream or point inflows, rainfall or other hydrological model boundaries. The consultant is to provide details of their recommended methods of analyses. They must indicate how the methodology is fit for purpose for both the study area and the project scope and how it aligns with industry best practice as outlined in ARR. Possible methods of analyses may include flood frequency analysis and rainfall-runoff routing models. Features of the catchment that have a distinct influence on the catchment's hydrology are listed in

Table 9.

Table 9 Catchment features affecting hydrology

Catchment feature
• **Tumbarumba Creek catchment conditions have a large impact on runoff.**

Catchment feature
• Pound Creek is a major tributary of Tumbarumba Creek that converge within the township.

6.4.1 Model Selection

River Design Flow Estimates

It is unsure whether design flood estimates for Tumbarumba Creek are to be adopted based on the results of flood frequency analysis (FFA) at the existing downstream stream gauge or from rainfall-runoff modelling. Any rainfall-runoff model parameters should be adjusted to fit the adopted design flood estimates.

Historical records of gauged flows are available at the stream gauges detailed in Table 4 of this Brief. The FFA will draw on the extensive hydrologic records. The FFA should be undertaken in accordance with the procedures outlined in ARR.

Details of the rating curves used in the FFA should be documented. Particular attention needs to be paid to the upper end of the rating curves and discussions with relevant hydrographer staff to confirm the accuracy in major flood events.

The development of the Tumbarumba Creek design event hydrographs should take into account the shape of the historical event hydrographs for major creek flood events.

Pound Creek and Major Overland Flow

In relation to Pound Creek and the local major overland flows, an appropriate computer based rainfall-runoff routing model should be used. The chosen modelling software and approach should be detailed.

The hydrologic analyses are to use the ensemble hydrologic modelling approach outlined in ARR. This approach relies on selecting an ensemble of 10 and in some cases 20 temporal patters for each event duration. The design flow at key locations should be calculated by averaging the flow from the ensemble for each duration. These key locations should include inflow locations to the hydraulic model and those locations further downstream within the hydraulic model where for example tributaries combine.

Extreme Event Modelling

An agreed approach to extreme event modelling should then be sought with Council and the the FRMC.

6.5 Hydraulic model

The purpose of the hydraulic model is to simulate the behaviour of flood waters in the study area, including their depth, level and velocity as they vary across the study area. The model is to be able to represent all hydraulic processes and topographic features that significantly affect flood behaviour, including waterways, overland flow paths and trunk drainage systems structures. The study area for modelling including specific waterways to be modelled (refer to Figure 2).

The proposal is to nominate a software model and configuration that is suitable to achieve the required outcomes of this study, including the assessment of flood risk management measures as part of this or subsequent studies in a cost effective manner. The proposal should detail how it will achieve these outcomes and identify any limitations or shortcomings of the proposed approach. Features of the Tumbarumba Creek floodplain within the reach to be modelled that have a distinct influence on the hydraulic behaviour of the flooding are listed in **Error! Not a valid bookmark self-reference.**.

Table 10 Catchment features affecting hydraulic behaviour

Catchment feature
Jacksons Bridge on the Batlow Road over Tumbarumba Creek
Various low level road bridges and causeways within the Study Area.

Catchment feature
Numerous footbridges across Tumbarumba Creek through Tumbarumba
Albury Street Bridge
Murrays Crossing Road Bridge
Tumbarumba Quarry

The selection of hydraulic modelling technique is primarily governed by the complexity of the flood situation and flood risk present.

6.5.1 Model Selection

Given the scope of the study and outputs required, the size of the study area, and the nature of the waterways and their flood behaviour, a 1D/2D hydraulic model is suitable for this study. This model type will represent the floodplain and flow paths in sufficient detail to accurately simulate flow behaviour in the hydraulic model. Furthermore, a 2D hydraulic model will produce spatial and temporal outputs to a level of detail that is appropriate given the range of end users and their varying needs.

The proposed grid cell resolution should be sufficient to appropriately represent the features within the catchment. Guidance on this is provided in ARR and associated project report Project 15: Two dimensional simulations in rural and urban floodplains.

The hydraulic model grid cell size selection within the Tumbarumba township area should be suitable to define the overland flow in a relatively built-up environment. This may be limited by the accuracy of the topographic data, the stormwater drainage network and other hydraulic structures (and blockage of these), land use, and buildings. The consultant should consider these items when setting out their proposed methodology. Furthermore, a 2D hydraulic model will produce spatial and temporal outputs to a level of detail that is appropriate given the range of end users and their varying needs.

Consideration should be given to using a finer grid size in each of the urban areas to more accurately define the major overland flow paths, the effects of riverine flooding and the interaction between the two sources of flooding.

Information is needed on the variability of key indicators other than the peak flow or depth, such as rate of rise. For this case, the design flood levels should be determined from the ensemble. A representative design flood that is close to the mean should also be determined. The method for selecting the representative design flood will need to be documented.

If a tenderer supports using a different model type, reasoning should be given as to how this model is suitable, including how it will meet the objectives of the study and produce the deliverables as outlined in Section 7 for the full range of end users' needs, as well as any shortcomings the model type will have. The project schedule should be amended to clearly identify a specific item to include all the associated costs. This cost should be considered as part of the lump sum proposal.

6.6 Model calibration and validation

The models are to be calibrated and validated to a standard consistent with both the Council's expectations and with the guidelines on model calibration that form parts of the material listed in Table 6**, before any work on simulation of design flood levels is undertaken**.

The consultant shall review the available data and information and provide guidance on the possibility of undertaking a reasonable calibration and validation process.
Suitable hydrologic and hydraulic models to simulate flood behaviour in the study area are to be developed by calibration and subsequent validation of flood behaviour against available data from historical flood events. Historic events to be used have been listed in Table 11 or should be identified by the successful consultant in consultation with Council.
To appropriately reproduce calibration events, consideration should be given to how conditions on the floodplain have changed and what historical topographic features or structures are not represented in the current survey data. Following calibration, the model is to be validated against the historical events detailed in Scenario ID 1 in Table 11.
During the calibration and validation process, features of the catchment that have a distinct influence on flood behaviour should be considered. The calibration/validation process should guide the final model configuration and selection of hydraulic model grid cell resolution if undertaking 2D modelling. The significant features present in this catchment are listed in Section 6, 'Hydrologic analysis and hydraulic model'.
A report and supporting model data files are to be provided to outline calibration and validation for consideration and review by Council. The consultant shall not undertake any aspect of the design flood modelling until the Council has reviewed and provided written approval of the model calibration and validation. This report and the supporting model data files provided should meet the requirements of the relevant guideline as outlined in Table 6.

The calibrated model is to achieve a satisfactory fit to the historical data. The calibrated model is to be able to reliably reproduce flood behaviour in the Tumbarumba township and its environs in particular.

The consultant is to validate model results and assumptions made to ensure potential flow paths and obstructions are accurately represented within the model and model produced behaviour. This ground truthing exercise is to include field inspections of key locations.

6.7 Rating Curve Review

Where a hydraulic model has been established, the existing rating curves should be validated against the results of the hydraulic model, particularly in the high-flow zone above the highest ratings. In conducting the review, liaison should be undertaken with the gauge owner and the results of the review provided for their consideration.

6.8 Model parameter sensitivity

Sensitivity analyses shall be carried out to assess how much influence model parameter values have on the results of the calibration and validation. The main parameters are those simulating rainfall (spatial and temporal variation), rainfall losses, catchment storage and lag, friction, energy losses, and blockage at culverts, bridges and other structures. The sensitivity of the model results to downstream boundary conditions shall also be tested.
Sensitivity analyses shall also be carried out to assess the relative uncertainty associated with the design results. The consultant is to clearly state the proposed approach and methodology, along with nature and extent of sensitivity testing that will be undertaken.
For comparison purposes the 1% and 5% AEP events should also be developed using the procedures and design inputs including IFD outlined in Australian Rainfall and Runoff 1987. The cause of any significant differences from the estimates derived from this study using the methods outlined in Australian Rainfall and Runoff 2019 should be determined.

6.9 Modelling events

The study should consider flood behaviour for a range of events. The models are to be run for all the relevant scenarios and the results discussed in reporting and used to developed relevant deliverables.
Table 11 outlines the events that should be considered for this study. The events and scenarios included will depend upon the end use of this information.
For the design event runs outlined in The models are to be run for all the relevant scenarios and the results discussed in reporting and used to developed relevant deliverables.
Table 11 the calibrated model is to be modified as necessary to accurately represent the relevant conditions for the scenario, with model and modelling parameter changes clearly documented.
The blockage of structures can be an important factor in this catchment. Different combinations for degrees of blocked and unblocked scenarios can result in peak flood conditions in different areas. Design events may need to be derived using an envelope of different blocked and unblocked scenarios at different points in the catchment.
The study area includes the junction of major waterways. The coincidence of flooding in the vicinity needs to consider relevant guidance in Australian Rainfall and Runoff.
The models are to be run for all the relevant scenarios and the results discussed in reporting and used to developed relevant deliverables.

Table 11 Flood events or floodplain conditions to be assessed

Scenario ID	Event	Description/Information
1(A)	Historical calibration/validation flood events – historic conditions	October 2010/December 2010, March 2012 & a more recent event possibly November 2021 (to be confirmed with Council post engagement)
2(B)	Design flood events - existing conditions	20%, 10%, 5%, 2%, 1%, 0.5%, 0.2% AEP and PMF (or Extreme Flood event)
4(D)	Design flood event to test sensitivity to climate change	Compare 0.5% and 0.2% AEP and PMF (or Extreme Flood Event)
7(C)	Design events for model parameter sensitivity analysis	5%, 1% AEP & PMF (or Extreme Flood event)
8	Design events for assessment of flood hazard	5%, 1% AEP & PMF (or Extreme Flood event)
9	Design events for assessment of flood function	5%, 1% AEP & PMF (or Extreme Flood event)
11	Design events for assessment of flood warning and emergency management	5%, 1% AEP & PMF (or Extreme Flood event)
12	Design events for developing information to support land use planning activities	5%, 1% AEP & PMF (or Extreme Flood event)

The use of an extreme event instead of the probable maximum flood (PMF) is to be approved by Council, unless stated in The models are to be run for all the relevant scenarios and the results discussed in reporting and used to developed relevant deliverables.
Table 11.

6.10 Consequences of Flooding to the Community

This information is to be used to develop an understanding of the consequences of flooding to the community. This needs to be developed and included in the report as outlined below.

6.10.1 Flood emergency response classification of communities

The floodplain shall be categorised based upon the general classification of the flood emergency response classification guideline outlined in Table 6. This classification provides an indication of the relative difficulty of the flood emergency management situation at a

community or precinct scale. It may also assist in identifying the type and scale of information needed by the emergency managers to assist with emergency response planning.

6.10.2 Flood damages assessment

After the full extent of the floodplain has been determined, the study will incorporate an estimate of flood damages to assist in determining the impacts upon the community across the range of flood events. The flood damages are to be estimated in accordance with the relevant guidelines listed in Table 6.

The flood damages assessment shall produce, for each flood event, information on the number of properties affected and their category (residential, commercial, etc.), the tangible damages, and the average annual damage. For the purposes of tendering, it shall be assumed that the damages for the number of developed properties of all types, as detailed in Table 14, are to be assessed.

Depending on the method of floor level collection for flood damage assessment, it is essential that the accuracy and any limitations of the data should be outlined as part of the documentation associated with the flood damages assessment.

6.10.3 Assessment of the impacts of climate change on flood behaviour

Sensitivity analysis of climate change should be undertaken in accordance with events outlined in Table 11 and guidance in Table 6. The assessment should be undertaken in accordance with the recommendations in ARR. The report should outline how sensitive flood behaviour and consequences to the community are in relation to climate change.

6.11 Post processing of results

The information from the hydraulic modelling needs to be further processed to develop important information to inform a range of management and related activities as described below. Specific formats and outputs to be delivered as part of the study are discussed in Tables 12 and 13.

6.11.1 Flood hazard

Flood hazard is to be determined based on hydraulic considerations such as depth and velocity. The assessment is to be undertaken in accordance with guidelines relevant to hazard listed in Table 6 of the brief. The events to be considered are detailed in Scenario ID 8 of Table 11.

6.11.2 Flood function (hydraulic categorisation)

To provide an indication of the existing flood function, flood conveyance and storage areas should be determined based on a detailed assessment of their extents by modelling encroachments into the floodplain due to potential development or an agreed alternative methodology. The different floodplain areas should be confirmed via an alternative method. The events to be considered are included in Scenario ID 9 of Table 11.

6.11.3 Flood emergency response classification of communities

The floodplain shall be categorised based upon the flood emergency response classification guideline outlined in Table 6. This classification provides an indication of the relative difficulty of the flood emergency management situation at a community or precinct scale. It may also assist in identifying the type and scale of information needed by the emergency managers to assist with emergency response planning.

6.12 Information to support decisions on activities in the floodplain and managing flood risk

This section outlines specific activities to support decisions on developing in the floodplain and on managing flood risk.

6.12.1 Flood Planning Area

The study is to map a preliminary flood planning area (FPA) based on the defined flood event and an appropriate freeboard. It is required that the Preliminary FPA and Flood Planning Levels for the Study Area, incorporate both riverine and major overland flow components using best current practice procedures. This is required to allow Council to make informed decisions with regard to new and proposed development within the Study Area prior to the next phase of developing a Floodplain Risk Management Study and Plan for the Study Area. The precise method for completing this task is to be confirmed with Council before finalising the development of the Preliminary FPA.

6.12.2 Information to Support Emergency Management Activities

Information for emergency services should be provided in accordance with the relevant guideline noted in Table 6. A key consideration of this is timing of the flood event reaching critical levels such as cutting evacuation routes. This may result from shorter duration events rather than those generating peak design levels. Therefore, a range of shorter duration events should be modelled as outlined in Table 11 to determine the critical timing for emergency response. This information would generally be required where time to reach a critical level is an important factor in emergency response planning.

Where required, this should include information on the consequences of flooding for key transport and evacuation routes. Key infrastructure for community response and recovery from flooding should be identified. This should include information on what level/gauge height key transport links may become impassable, what level/gauge height key public infrastructure (e.g. hospitals, water supply, sewerage works, main electrical switchyards) are inundated, timing of structures overtopping (including levees and bridges) and gauge-related timing information. This information can be supplemented with historical or anecdotal evidence, including related timing information.

6.12.3 Advice on land-use planning considering flooding

A key objective of the study is to provide better flood information to support land use planning activities in the study area. This includes:

- improved information on how flood related constraints may vary across the floodplain. Advice relating to understanding and considering these constraints is provided in the guideline for developing flood information to support land use planning referred to in Table 6.
- advice on general planning controls within different flood planning constraint categories considering the varying constraints and Council's general requirements and relevant standards.

This information should be made available to inform land use planning activities until more detailed assessment is undertaken in a future floodplain management study.

6.12.4 Advice on land-use planning considering overland flooding

In local overland flooding areas where traditional flood planning area may not be fit for purpose, the consultant is to make recommendations for planning instruments on alternate development controls in consideration of state government directions to reduce the impacts of development on flooding and flood impacts on new development. This may include development controls to ensure maintenance of flow paths and to reduce damage to property in the vicinity of flow paths. The areas are to be identified separately to mainstream flooding and mapping provided where different controls are recommended.

6.13 Peer review

The consultant is to undertake a comprehensive internal peer review of the study including hydrologic and hydraulic modelling, reporting and outcomes. The peer review is to be documented and considered in finalising the outcomes of the report.

6.14 Reporting

The draft and final report is to cover the issues identified in the scope of work in sufficient detail to be fit for the intended purpose. As a minimum it is to contain the following information:

Executive Summary

1 Outlining the purpose of the study as well as its methodology, results and conclusions

Introduction

- Outlining the purpose of the study, the intended end users and the client

Background

(i) Study Area - description of the study area, its catchment(s) and the history of flooding in the area
(ii) Previous Studies - a summary of the previous studies completed in the area and their relevance to the current study
(iii) Discussion of relevant policies, legislation and guidance
(iv) Flood Behaviour - Written description of design and historical flood behaviour for a range of events for locations across the study area

Available Data

Provided and collected - description of all data collected (data and survey) and used for the study and their limitations and final ownership. This includes:

- Historic Data – including summary of historic events and available data
- Guidelines used
- Data collection
- Information from Site Visit
- Topographic and Aerial Survey and imagery
- Survey for Flood damage assessment

Community Consultation

- Methodology
- Materials developed
- Discussion on inclusive consultation undertaken and results for different stages

Hydrological analysis

Description of the hydrologic analyses, including any review of existing models and studies, and calibration and validation, and assumed catchment conditions.

- Hydrologic controls in catchment and changes overtime
- Model Selection
- Model Setup
- Model parameter selection
- Model results – reporting and presentation of results for all design runs identified in Table 11 including design flood hydrographs at gauges and key locations.

Hydraulic Analysis

Description of the hydraulic analyses, including any review of existing models and studies.

- Identification of hydraulic controls in the floodplain and any key changes overtime
- Model Selection
- Model Setup

Model Calibration and Validation

Description of model calibration and validation. Presentation of results showing model fit to calibration and validation flood events, if applicable

- Model parameter selection and assumed catchment conditions
- Model results - reporting and presentation of results for all design runs identified in Table 11 including design flood hydrographs at gauges and key locations.

Model sensitivity

Description of the results of sensitivity analysis and model checks.

Overall Model results

- written description of likely model accuracy and limitations such as domain extent compared with suitable study area for result use

Consequences of Flooding on the Community

- Identification of existing flood problem areas
- Flood Impacts - A preliminary assessment of flood impacts and risk in the study area.
- Written description (aided by figures if needed) to describe flood levels at which roads are cut and other relevant information
- Flood damages. Assessment and reporting on flood damages
- Impacts of climate change

Post Processing of Results

Reporting on and providing the following post processed model outputs.

- Flood Extents
- Flood function
- Flood hazard
- Flood Emergency Response Classification

Information to inform decisions on activities in the floodplain and managing flood risk

- Emergency Response
- Land use planning
- Cumulative Impacts
- Impacts of works on the floodplain.

Option Assessment

- Identification and preliminary assessment of options.

Peer Review

Conclusions

Figures

Acknowledgements

References

Appendices

Data Handover

- The report is to summarise the intellectual property of all study material (including outputs, models and input data), in consideration of the requirements of the brief.
- It is also to document the information handed over as part of the study, including all relevant model files and versions used in the study as outlined in Section 7.

Printing of the final report(s) shall not proceed without the written direction of the Council. The cost of all work associated with preparing the approved final report shall be included in the consultant's fee estimate.

6.15 Meetings

Meetings are to be held regularly throughout the duration of the study. The meetings shall be generally attended by representatives from the floodplain risk management committee (FRMC) comprising elected members of Council, community members, Council staff (typically land-use planning, engineering, disaster management, community engagement, etc.) and Agency Representatives (typically DPE, NSW SES, WaterNSW etc.). Meetings

will generally take place at the project inception and when progress milestones are reached. The meeting location, number of meetings (six FRMC meetings in total including the inception meeting and five subsequent meetings), their purpose and expectations of the consultant are shown in Table 12.
Consultants should advise in their proposals as to their intended approaches for the FRMC meetings (e.g. attending in person at Tumbarumba or participating remotely via MS Teams/or Zoom).

Table 12 Meeting requirements

Meeting Type/Purpose	Location	Number of Visits Required	Expectation of Consultant
Inception meeting with FRMC	Tumbarumba Council offices.	1	Finalising conditions of commission, handover of data etc.
Progress meeting and reports to the FRMC	Tumbarumba Council offices.	5	Reporting and presenting to FRMC, receiving and discussing feedback, clarifying technical matters.
Community meetings	Tumbarumba	2 community meetings pre public exhibition	To gather flood information and get feedback on modelling results
During Public Exhibition community information session	Tumbarumba	1	To present on the draft Flood Study report

6.16 Timing and hold points

The end of each stage represents a milestone. The study will also include significant hold points where a council review period should be allowed for. The consultant is not to commence works on any new stage beyond a hold point without written approval of acceptance of the previous stage from the Council's representative. Acceptance of the final report and handover of all relevant materials will mark the completion of the study. Key project stages for reporting and managing progress payments are shown in Table 13.

Table 13 Project stages

Phase/stage	Milestone	Comments/dates
Stage 1	Data Collection, Review and Community Consultation progress report	Hold point – 2 weeks
Stage 2	Model Development & Calibration/Validation progress report	Hold point – 2 weeks
Stage 3	Design flood modelling and damages assessment progress report	Hold point – 2 weeks
Stage 4	Draft Flood Study report & Public Exhibition	Hold point – 4 weeks
Stage 5	Final Flood Study report & Council adoption	Hold point 4 weeks
Stage 6	Completion of contract	

7 DELIVERABLES

Deliverables are to be produced in the formats specified in this section and provided to the Council in accordance with the milestones of the study as outlined in Table 13. They include progress, draft and final reports, survey data, model set-up files, model files, model results, and mapping products. Outputs will be used by a number of end users for a variety of purposes and therefore all deliverables should adhere to the formats specified in the following section, in accordance with any relevant guideline detailed in Section 5 and provided in GIS format, where possible.

Output deliverables are to be provided for the events listed in Table 11. Table 14 lists the required deliverables and indicates whether a hard copy figure is required as part of the final report. All mapping should be clear and legible. All deliverables are to be provided electronically (where applicable) to assist in provision of information to all study end users. Some deliverables are also required in hardcopy.

Table 14 provides a listing of the majority of deliverables required from this study, it aims to provide an indication of the scope and scale of deliverable requirements for this study.

At the completion of the project, all final deliverables are to be uploaded electronically through the NSW Flood Data Portal and provided to Council on a portable hard drive unless otherwise advised.

Table 14 Output deliverables

Deliverable	Specifics	Data Set ID*	IP*	Notes, Formats and Preferences
Document Transmittal Checklist	Completed and signed	1	2	
Data Schedule	A completed electronic list of all data handover and its formats	1	2	see https://flooddata.ses.nsw.gov.au/template/flood-project-handover-template
NSW Flood Database completed template		3	2	
Data	Study area	4	1	Spatial layer of the study area GDA94
	Survey data	10	2	Raw and Processed. Spatial Layer of locations GDA94 mAHD
	LiDAR	11	2	GDA94 mAHD
	Aerial Imagery	12	2	Catalogue of imagery
	Digital Elevation Model	10	2	GDA94 mAHD
	Flood data	5	2	Collected historical information, gauge/rain mAHD and BOM gauge
	Survey for flood damages assessment	9	1	Assume the floor levels of the main building on 50 properties are to be estimated by way of LIDAR and "drive by" methods. Provided as part of a cadastral GIS layer or as a .csv excel file in tabular form. Floor, ground and levels are to be tabulated with the properties' property number or address, coordinates.
	Hydrologic controls	10,4	2	Survey or description
	Hydraulic controls	10,4	2	Survey or description
Hydrologic Modelling	Advice of Model version used	6	n/a	RORB, XPRAFTS or WBNM etc
	Model set-up files	6	2	Description and components
	Model input files	6	2	All runs or scenarios
	Model output files	7	1	
Hydraulic Modelling	Advice of Model version used	6	n/a	TUFLOW or MIKE etc
	Model DEM	6	2	Consistent with model results
	Model set-up files	6	2	Description and components
	Model input files	6	2	All runs or scenarios
	Model output files	7	1	native format, ASCII, viewer (eg QGIS/waterRIDE)
Flood Damages model and assessment	Advice of Model version used	6	n/a	MS Excel
	Model set-up files	6	2	
	Model input files	6	2	All runs or scenarios
	Model output files	7	1	
Benefit Cost Assessment for options	Cost Estimates	15	2	
	AAD Calculations	15	2	
	NPV Calculations	15	2	

Deliverable	Specifics	Data Set ID*	IP*	Notes, Formats and Preferences
	BC Analysis	15	2	
Management Options Assessment	Multi Criteria Assessment	15	2	
	Environmental Assessment	15	2	
	Concept Design Drawings/Specification for recommended works	16, 4	2	
Reports	Monthly Progress Reports	2	2	1 electronic copy (MS Word/PDF)
	Survey Brief, where required	2	2	1 electronic copy (MS Word/PDF)
	Calibration and Validation Report	2	1	1 electronic copy (MS Word/PDF)
	Progress Reports	2	2	1 electronic copy (MS Word/PDF)
	Internal peer review report	2	2	1 electronic copy (MS Word/PDF)
	Draft report	2	2	2 hard copies of each report, 1 electronic (MS Word/PDF)
	Final report	2	1	5 hardcopies of each report, 2 electronic (MS Word & PDF)
	Figures	2	1	Figures of flood layers to be A3 unless otherwise stated. Flood layers to be overlaid on cadastral map or aerial photography, including a legend. Other figures.
Processed model results study area wide	Post processing software	6	2	Any software developed or acquired to interface or transfer data between models or to pre/post process
	Calibration and validation model results	4	1	ArcGIS (Shapefile) or MapInfo (MID/MIF, etc.) (grid) and figures To be provided at the calibration milestone and final data handover
	Maximum water level, water depth, velocity	4	1	ArcGIS (Shapefile) or MapInfo (MID/MIF, etc.) (grid) and figures Calibration/Design
	Flood extents	4	1	GIS layers (polygons/grid) and as figures (A3).
	Impacts on flooding of future conditions	17	1	GIS layers and figures
	Flood planning area/levels	14	1	GIS layers and figures
	Flood Function maps	4	1	GIS layers and figures
	Assessment of change in flood behaviour or levels as a result of mitigation works	7	2	GIS layers and figures
	Flood emergency response classification maps	13, 4	1	GIS layers and figures
	Flood hazard maps	4	1	GIS layers and figures
	Flood Impacts – Flood Damages	7	2	GIS layers and figures
	Mapping to support land use planning activities	14	1	GIS layers and figures
	Flood profiles/flood depths	7	1	Graphs (figures) and tables
Model results specific locations	Levels/AEP at which critical access roads/critical	13	1	Tables and figures

Deliverable	Specifics	Data Set ID*	IP*	Notes, Formats and Preferences
	infrastructure are affected			
	Levels/AEP at which properties are affected	4	1	Tables and figures
	Timing of structures overtopped, including levees and bridges	13	1	Tables and figures
	Gauge information (related timing)	13	1	Tables and figures
	Gauge height/elevations at which structures are overtopped	13	1	Tables and figures
	Link between gauge height and areas inundated	13	1	Tables and figures
	Inundation timing of properties/access roads	13	1	Tables and figures
Visualisation/ Animations	Video animation of flood progression in whole study area	8	2	viewer (eg QGIS/waterRIDE)

* Note: IP - Case 1: IP Clauses 1.1-1.7 and Schedule A apply
IP - Case 2: IP Clauses 1.1-1.6 apply
Data Set ID: refers to Dataset categories used in NSW Flood Data Portal. The Dataset categories are provided in Table 15.

Table 15 Dataset ID References

Dataset ID	Description
1	Checklist and summary of inclusions in Datasets
2	Report and all Figures
3	Completed NSW Flood Database Template
4	Spatial Layers
5	Collected Data
6	Hydrological, Hydraulic and flood damage model input files
7	Hydrological, Hydraulic and flood damage model output
8	Hydraulic modelling post processed files for AVIs
9	Base survey information for flood damage assessments
10	Survey information
11	LiDAR
12	Aerial Imagery
13	Emergency Response Planning
14	Land use planning
15	Management options and recommended management packages
16	Plans for works
17	All Other Required Data

7.1 Handover Material – Development, Delivery and Intellectual Property

The Consultancy Agreement should contain clauses including the following information or an equivalent which does not place any additional restriction on use by the State or use of specific information under creative commons. Table 14 column 4 identifies Intellectual Property Cases 1 and 2 which are defined as follows.
Case 1 -all clauses apply –which involves making information available under creative commons as outlined in Clause 1.7 and Schedule A below.

Case 2 – clauses 1.1 to 1.6 apply

2 *Intellectual property*

1.1 In this clause, Intellectual Property includes all statutory, legal, equitable and other proprietary rights and interests, including without limit, in copyright, patents, registered and unregistered trademarks, registered designs, circuit layouts, trade secrets, semiconductor or circuit layout rights, trade, business or company names, or other proprietary rights, or any rights to registration of such rights existing in Australia, whether created before or after this agreement.

1.2 The consultant indemnifies Council, the Department of Planning, Industry and Environment (NSW Government) and their employees and agents against any action, costs, expenses, losses or damages suffered or incurred by all, or any more of them, arising out of, or in any way in connection with:

- *any breach by the consultant or its employees or its agents of the consultant's obligations under clause 1.2, and*
- *any infringement by council or NSW Government of third party Intellectual Property rights in its use of the Project Materials.*

1.3 The consultant warrants that:

(a) in carrying out the Project, it will not infringe any Intellectual Property rights, and

(b) any report by the Recipient will not contain anything that, to its knowledge, is libellous or defamatory.

1.4 Subject to clause 1.5:

- *The consultant grants to the council and the State, at no cost, a perpetual, irrevocable, worldwide, royalty-free non-exclusive licence, including the right to sub-license, to use, reproduce, modify, adapt, publish and communicate to the public, the Project Materials (to avoid doubt, including for the purpose of making the Project Materials freely available to the public or any section of it, whether in hard copy or on-line and including use and modification of any models and copying photographs), and*
- *To ensure compliance by the consultant with clause 1.4(a), if the consultant engages a third party to create the Project Materials the consultant must ensure that the terms of its engagement provide that the third party:*
  - *assigns Intellectual Property in such materials to the council immediately on creation of the materials; and*

warrants that it has the legal authority to comply with the obligation referred to in clause 0□o.

1.5 To the extent that the consultant cannot take ownership of Intellectual Property in any Incorporated Existing Materials:

- *the consultant must ensure that relevant third parties grant to the council and State, at no cost, a perpetual, irrevocable, worldwide, royalty-free, non-exclusive licence, including the right to sub-licence, to use, reproduce, modify, adapt, publish and communicate to the public, the Incorporated Existing Materials for any Non-Commercial Purpose (to avoid doubt, including for the purpose of making the Incorporated Existing Materials freely available to the public or to any section of it, whether in hard copy or on-line and including use and modification of any models and copying of photographs); and*
- *if any of the Incorporated Existing Materials are included in the materials referred to in clause 1.7, the Recipient must ensure that*

relevant third parties make those Incorporated Existing Materials available to the public under a Creative Commons Attribution 4.0 licence.

1.6 This clause 1 survives termination or expiry of this agreement.

1.7 To make the required information available under a Creative Commons Attribution 4.0 licence the Consultant must insert a copyright notice into the deliverables indicated below in accordance with the form and instructions in Schedule A. The Consultant must particularise New Contract Material and Existing Contract Material, as specified in the instructions in Schedule A. The deliverables this refers to are as follows:

(v) project report(s) and associated figures (excluding any sections highlighted as confidential by the council);

(vi) spatial flood extent layers for key events; and

(vii) any other data and tools noted as IP Case 1 in Column 4 of Table 14 or otherwise advised by council to the consultant

SCHEDULE A

This copyright notice is to be incorporated into the Deliverable Services. It can be downloaded MS Word format from: https://goo.gl/dsuQD5. It should replace any other copyright notice in the document(s), which are generally located inside the front cover.

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6. *You are required to particularise the Existing Contract Material (this includes third party material and material provided by the Purchaser)that is **incorporated** into the Deliverable Services, in a Table of References.(See above and Clause 23) Each reference shall particularise the title of the material being reproduced, Author or Copyright Holder, Year of Publication, Page number (if appropriate), Copyright Licence(if any – E.g. CC Attribution Licence), or 'All Rights Reserved'*

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Attachment A – Cost Schedule

Consultants can expand this table to include additional Team Members.

	Team Member 1 **Name** **Role**	**Team Member 2** **Name** **Role**	**Team Member 3** **Name** **Role**	**Disbursement**	**Total**	
$/Hour	$ (excl. GST)	$ (excl. GST)	$ (excl. GST)			
	Hours	Hours	Hours	**$ (excl. GST)**	**Hours**	**$ (excl. GST)**
Familiarisation with Project (Sections 1-5)						
				Sub-total		
Data Collection and Review (Sections 6.1 and 6.2)						
Site inspection(s)						
Data Collection and Review						
Preparing and managing Survey Brief						
Additional survey - provisional fee allowance						
DEM Development						
Floor Level Survey – Drive by assessment for 50 buildings						
				Sub-total		
Community Consultation (Section 6.3)						
Community Questionnaire						
Community Newsletter						

Community information sessions – total of 2						
Public exhibition period						
Public presentation during public exhibition						
				Sub-total		
Hydrologic Analysis (Section 6.4)						
Flood Frequency Analysis – Tumbarumba Creek						
Establish Hydrologic Model(s) – Tumbarumba Creek (if necessary) and Pound Creek and major overland flow at Tumbarumba.						
Develop design hydrographs						
				Sub-total		
Hydraulic Analysis (Section 6.5)						
Establish Hydraulic Model(s)						
				Sub-total		
Model Calibration and Validation (Section 6.6 and 6.7)						
Calibrate/Validate Hydrologic/Hydraulic Model(s), reporting and data provision						
Sensitivity Assessment						
				Sub-total		
Modelling Existing Scenarios (Section 6.7)						
Model Design Events						
				Sub-total		

Impacts of Flooding on the Community						
Impacts on the Community and Emergency Response						
Flood Damages Assessment						
Climate Change Assessment						
				Sub-total		
Post Processing of Model Outputs						
Flood Hazard						
Flood Function						
Flood Emergency Response Classifications						
				Sub-total		
Information to Support Decisions						
Interim FPA						
Information to support emergency management						
Advice on Land use Planning - Riverine						
Advice on Land use Planning – overland flooding						
				Sub-total		
Peer Review						
Reporting						
Draft						
Final						
				Sub-total		
FRMC Meetings (6 No.)						
Data Handover						

SUB TOTAL (excl. GST)						
10% GST						
TOTAL (incl. GST)						
Additional Costs (not included in Total Cost)						
Additional FRMC meetings at Council (excl. GST)						
Additional FRMC meetings held remotely (excl. GST)						
Additional community information meetings (excl. GST)						
Cost of assessing damages using drive by method for additional properties (over and above first 50) (excl. GST)						
Re-familiarising with suspended project (excl. GST)						
Other						

9. GENERAL BUSINESS:

10. NEXT MEETING: