Australian Disaster Resilience Handbook Collection

2020

Flood Emergency Planning for Disaster Resilience

Australian Government
Department of Home Affairs

Australian Institute for Disaster Resilience

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AUSTRALIAN DISASTER RESILIENCE HANDBOOK COLLECTION

Flood Emergency Planning for Disaster Resilience

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Australian Disaster Resilience Handbook Collection

The Australian Disaster Resilience Handbook Collection provides guidance on national principles and practices for disaster resilience.

The Handbook Collection:

- provides an authoritative, trusted and freely available source of knowledge about disaster resilience principles in Australia
- aligns national disaster resilience strategy and policy with practice, by guiding and supporting jurisdictions, agencies and other organisations and individuals in their implementation and adoption
- highlights and promotes the adoption of good practice in building disaster resilience in Australia
- builds interoperability between jurisdictions, agencies, the private sector, local businesses and community groups by promoting use of a common language and coordinated, nationally agreed principles.

The Handbook Collection is developed and reviewed by national consultative committees representing a range of state and territory agencies, governments, organisations and individuals involved in disaster resilience.
The collection is sponsored by the Australian Government Department of Home Affairs.

Access to the Handbook Collection and further details are available on the Australian Disaster Resilience Knowledge Hub: **www.knowledge.aidr.org.au/handbooks**

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This handbook is available on the Australian Disaster Resilience Knowledge Hub:
https://knowledge.aidr.org.au/resources/handbook-flood-planning/

For feedback and updates to this handbook, please contact AIDR: **enquiries@aidr.org.au**

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Executive Summary

Flooding poses a significant risk to Australian communities and it is essential that proactive flood emergency plans are developed to guide responses. Average annual economic losses for floods have been estimated to be greater than cyclones, storms, bushfires and earthquakes, costing Australia $8.8 billion annually (Australian Business Roundtable for Disaster Resilience and Safer Communities 2017).

Without plans, decision makers are forced to be reactive in their decision making and can be left to deal with avoidable consequences. For example, the *2011 Victorian Floods Review* found that the absence of plans directly reduced the capacity to implement emergency response functions (Comrie 2011).

Future flood risk is changing as cities expand and our climate changes. As the atmosphere warms, its capacity to hold moisture increases, enhancing the potential for extreme rainfall events and the risk of flooding. Sea level rise will increase flood risk in coastal and estuarine areas.

A flood emergency plan is a set of agreed arrangements that provide a framework for the management of a flood. A flood emergency plan provides a robust and adaptable framework that outlines the progression of emergency management functions and the parts that each actor will play. This includes defining the roles and responsibilities of different agencies and outlining the strategies for the performance of key flood management capabilities. Plans serve as a common reference for decision makers, ultimately contributing to the resilience of our communities.

Plans need to be based on flood risk and provide scalable and flexible frameworks to inform the management of all forms and magnitudes of flooding. The process of planning needs to include all the stakeholders likely to be involved in implementing the plan. Planning must also allow for active approaches to community engagement.

Depending on the flood risk, consider specific arrangements for flood prediction and warnings, evacuation, resupply, property protection, flood rescue, road closures and management and transition to recovery. Special environments also need to be considered including: flash flooding, dams, coastal flooding, levee protected communities and vulnerable developments and events.

Flood emergency planning links directly with wider floodplain risk management strategies through the management of residual risk and is supported by information produced through flood studies and risk analysis.

This handbook provides guidance to inform the development of flood emergency plans by outlining a series of principles and processes. Key considerations are outlined for specific capabilities and environments. The handbook is applicable to all communities across Australia and all levels of planning. It will also assist to provide guidance and information applicable to total warning systems and community engagement.

Introduction

Flood risk in Australia

Australia has a long history of flooding with communities, infrastructure and industries exposed to the effects of flooding. Effects of flooding may be direct (i.e. the flooding of homes or businesses, environmental and cultural damage, death and injury) and indirect (i.e. business disruption or mental health impacts).

Average annual economic losses from floods have been estimated to be greater than cyclones, storms, bushfires and earthquakes, costing Australia $8.8 billion annually (Australian Business Roundtable for Disaster Resilience and Safer Communities 2017).

There were 1,859 flood deaths that occurred between 1900 and 2015. Only heatwaves have a higher death toll. Flood fatalities have, however, been decreasing since the 1950s. This decrease may be attributed to the implementation of flood warning systems, advances in communications, construction of flood mitigation and the establishment of organised flood response agencies such as State Emergency Services (Haynes et al. 2017).

Several different types of flooding are possible, some of which are:

- large, regional scale floods that occur as water rises and falls as floods move from catchment headwaters
- floods occurring in small catchments that are fast to rise and fall
- local flash flooding in urban areas which can occur in a matter of minutes
- coastal flooding as a result of storm tides
- overland flooding resulting from rainfall runoff.

Significant flood events that have occurred in the last decade are depicted on the timeline in Figure 1.

Given the significance of the flood risk, it is essential that proactive emergency plans and warning systems are developed between authorities and communities to prepare to manage the occurrence of flooding.

Flood risk in the future is changing as cities expand and our climate changes. As the atmosphere warms, its capacity to hold moisture increases, enhancing the potential for extreme rainfall events and the risk of flooding. Sea level rise will increase flood risk in coastal and estuarine areas.

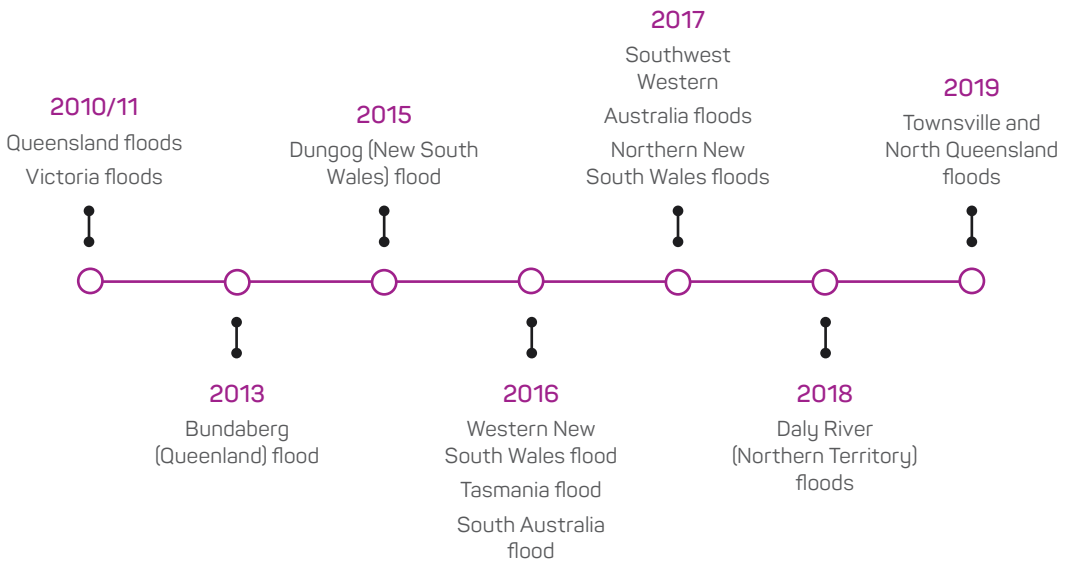


Figure 1: Timeline of significant Australian flood events in last decade

Purpose of the handbook

This handbook provides national principles and broad guidance to inform the development of flood emergency plans in Australia. Companion documents to this handbook provide guidance on flood warnings systems and community engagement.

The handbook draws on, and complements, current and ongoing activity in flood preparedness, warning and response and builds on the capability and knowledge of organisations and individuals across the disaster risk reduction and resilience sector.

The handbook supersedes a review of four Flood Manuals originally developed in the 1990s and last updated in 2009:

- *Flood Preparedness* (Manual 20)
- *Flood Warning* (Manual 21)
- *Flood Response* (Manual 22)
- *Emergency Management for Planning for Floods Affected by Dams* (Manual 23).

The handbook acknowledges that emergency management arrangements for each state and territory are well defined in existing legislation and plans. The handbook is intended to guide and assist those that play a role in flood emergency planning, community engagement and flood warning.

Readers interested in specific jurisdictional arrangements are encouraged to source relevant state legislation and planning arrangements.

The audience for the handbook includes:

- emergency service workers
- floodplain managers
- government departments and agencies
- dam owners and operators
- the community including businesses, community sector organisations, primary producers and individuals involved in community-based emergency planning
- local government
- recovery and reconstruction agencies
- infrastructure operators
- researchers.

Context

Flood Emergency Planning for Disaster Resilience is part of the Australian Disaster Resilience Handbook Collection. It fulfils a critical role in ongoing improvement to the sector's disaster preparation, response, and recovery under the policy framework established by the *National Strategy for Disaster Resilience* (Council of Australian Governments 2011). As such, the handbook recognises that emergency management for flooding is a shared responsibility that requires government investment in partnering with communities to develop flood emergency plans.

The handbook reflects increasing national and international focus on the need to reduce disaster risk and build disaster resilience, as considered in the:

- *Sendai Framework for Disaster Risk Reduction* (United Nations Office for Disaster Risk Reduction 2015)
- *National Disaster Risk Reduction Framework* (Australian Government Department of Home Affairs 2018)
- *Profiling Australia's Vulnerability: The Interconnected Causes and Cascading Effects of Systemic Disaster Risk* (Australian Government Department of Home Affairs 2018)
- *Australian Disaster Preparedness Framework* (Australian Government Department of Home Affairs 2018).

The *Sendai Framework* states that to strengthen resilience, countries must prevent new and reduce existing disaster risk.

Over the last decade, post flood reviews and inquiries have identified lessons learnt that are incorporated into this handbook. Key themes of reviews have included:

- command, control and coordination
- interoperability between organisations
- flood prediction
- flood intelligence
- timeliness and effectiveness of warnings
- vulnerable people
- community participation and local knowledge
- flood rescue
- flood mitigation including levee and dam operation
- relief and recovery.

This handbook addresses changes to flood emergency planning and the broader issues that have emerged and that are understood more clearly since publication of the manuals in 2009, including:

- the nature of flood risks, improvements in flood information
- development of a *National Framework for Flood Warning Infrastructure*
- changes in technology that facilitate improved information and its sharing
- risk assessment
- critical importance of community engagement
- shift in consequence based thinking
- focus on interoperability
- scenario modelling.

Scope

The scope of this handbook includes flood emergency planning related to riverine, coastal, flash and dam failure flooding. Its primary focus is on the development and application of flood emergency plans for community safety. It is not designed to guide private flood emergency plans for businesses or households, though some information contained in this handbook may be useful.

Flood emergency planning, community engagement, and warning systems are a component of broader floodplain risk management and are focused on the management of residual and/or continuing flood risk. That is the risk that remains after treatments are implemented to reduce flood consequences. Flood studies and management plans that are developed as part of the floodplain risk management process help to inform flood emergency planning. More on floodplain risk management can be found in *Managing the Floodplain* (AIDR 2017).

The handbook integrates with knowledge available in other handbooks from the Australian Disaster Resilience Handbook Collection including:

- *Australian Emergency Management Arrangements* (AIDR 2019)
- *Public Information and Warnings* (AIDR 2018)
- *Land Use Planning for Disaster Resilient Communities* (AIDR 2020)
- *National Emergency Risk Assessment Guidelines* (AIDR 2020)
- *Evacuation Planning* (AIDR 2017)
- *Emergency Planning* (AIDR 2020)
- *Community Recovery* (AIDR 2018)
- *Community Engagement for Disaster Resilience* (AIDR 2020).

The handbook is supported by two companion documents:

- *Application of the Total Warning System to Flood*
- *Emergency Management Engagement of Flood-Prone Communities*

The integration of these handbooks is illustrated in Figure 2.

Refer to the Australian Disaster Resilience Glossary for key terms utilised in this handbook: **www.knowledge.aidr.org.au/glossary/**.

Figure 2: Relationship with the Australian Disaster Resilience Handbook Collection

Chapter 1: Principles of flood emergency planning

Floods occur often in Australia and in some areas, according to a regular seasonal rhythm. Their location is mostly predictable and the flooding of rivers usually comes with some warning. However, flash flooding associated with thunderstorms is not as predictable.

It is possible to determine who is likely to be affected and what problems could be encountered as far as warning, evacuation, property protection, rescue, resupply and other issues are concerned for an event, or for events of different scales. Much can be known about a flood and its likely consequences before it occurs. Because of this, the opportunity exists to plan how a flood can be best managed in an emergency in the interests of maximising public safety and minimising property, environmental, cultural, social and other intangible forms of damage.

Flood emergency planning aims to improve the resilience of communities to flooding by supporting effective community response to floods. The principles of flood emergency planning for disaster resilience are described in Table 1.

Table 1: Principles of flood emergency planning

01	**Plans are risk based** and informed by studies of flood behaviour, previous flood history and knowledge of community exposure and vulnerabilities. Plans should consider possible compounding and cascading impacts, in addition to the flood hazard. Plans should be based on current day risk but be regularly updated to reflect the changing nature of risk.
02	**Plans are holistic** and consider the full range of causes (e.g. heavy rainfall, dam failure, storm surge and tsunami), the full range of flood events including worst-case scenarios and provide for coordination across prevention, preparedness, response and recovery.
03	**Plans are scalable, flexible and adaptable to all forms of flooding and the differing nature of floods.**
04	**Plans are based upon realistic assumptions concerning social behaviour** during floods.
05	**Plans are consistent with relevant legislation, regulations and governance arrangements.** This includes consideration of cross-jurisdictional considerations and arrangements.
06	**Plans are linked to required capability and capacity** to achieve desired outcomes and priorities. Planning identifies the demands different flood scenarios may have on resourcing and informs capability development strategies.
07	**Plans are concise, principles-based, simple to interpret and define priorities and desired outcomes.**
08	**Plans are contemporary; provide an authorising environment for decision makers and written from an operational perspective.**
09	**Planning is most effective when it is integrated rather than fragmented.** This involves inter-agency planning and designing plans to ensure responses are integrated across agencies and with those of volunteers and community groups.
10	**Planning is proactive** and enables better decisions to enact forward leaning responses based on warning systems, flood intelligence and pre-considered arrangements and strategies.
11	**Planning is a shared responsibility.** Communities are involved throughout the planning process and have significant buy-in. Plans are written to enable a whole-of-community response as well as emergency services and broader government responses.
12	**Planning is adequately resourced,** is central to the culture of flood emergency management organisations and embedded into all aspects of organisational structures, policies, practices.
13	**Plans are regularly exercised, and stakeholders are aware of their contents.** Plans are part of the process that educates, trains and exercises an organisation so they are well understood and embed into the process of what to do into its culture and its core business.
14	**Plans are living documents and planning is an ongoing process.** They are maintained and regularly updated to ensure they remain relevant in the context of the community risk profile.

Chapter 2: Flood emergency planning process

2.1 What is a flood emergency plan?

A flood emergency plan is a set of agreed arrangements that provide a framework for the management of a flood. A flood emergency plan provides a robust and adaptable framework that outlines the progression of emergency management functions and the parts that each actor will play. This includes defining the roles and responsibilities of different agencies and outlining the strategies for the performance of key flood management capabilities. Plans serve as a common reference for decision making. Planning seeks to build community resilience against the flood risk, ultimately reducing the impacts of floods when they occur.

Plans may be supported by a wider range of documents such as dam safety emergency plans (also known as emergency action plans), levee operating manuals or standard operating procedures.

Flood emergency plans are typically developed at different levels reflecting the different tiers of the incident management structure, for example, communities, local government areas, regions, zones and state level.

Guidance in this handbook deals with deliberate plans that are developed outside of operational response activities rather than incident action plans developed during a flood event. Flood emergency plans should act as an essential reference in the development of incident action plans.

2.2 Flood emergency planning process

The key steps in developing a flood emergency plan are illustrated in Figure 3 and further described in *Emergency Planning* (AIDR 2020).

Key outcomes of the flood planning process should include a documented plan and a strong understanding and ownership of arrangements by all stakeholders that may be necessary to manage a flood emergency.

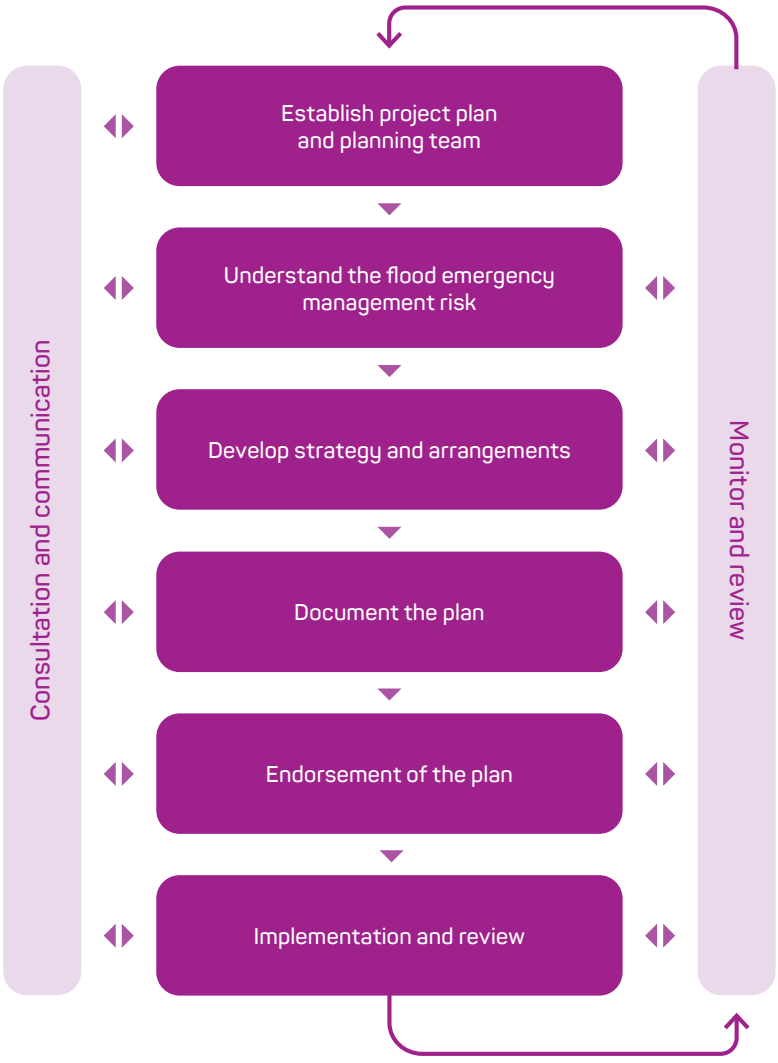


Figure 3: Key steps in developing a flood emergency plan

2.2.1 Establish a project plan and team

Developing an emergency plan is a project and a project plan should be established to guide the planning process. Project planning allows emergency planners to scope the entire process, so they have an understanding of what key stages are involved. Project management methodologies can be utilised to scope the project plan.

People who are involved in the planning process are more likely to understand, accept and use an emergency plan than those who did not participate. Therefore, it is important that key stakeholders are involved in the planning process – either by including them on the flood emergency planning team or through consultation.

Stakeholder analysis should be performed to ensure that key stakeholders are involved. These would typically include the flood control agency, local government, flood hazard leaders, floodplain managers, dam operators, emergency services and community and business representatives. Stakeholders will typically vary for different levels of planning (i.e. local, zone/region or state).

The flood emergency planning team can have a core membership that takes responsibility for the preparation of the plan. However, it should be possible to include outside expertise as necessary and to engage with particular interest groups including people who live, work or have interests in flood-prone areas. A flood emergency planning team would typically be governed by the relevant emergency management, disaster management or counter disaster committee and led by the lead agency for flood emergency management. It is essential that flood emergency planning team members are sufficiently senior and knowledgeable to contribute to the committee. In cases where a plan covers more than one community, it may be necessary to establish separate committees for each community.

In most circumstances the flood emergency planning process will require consultation with a range of people. They include technical specialists who can supply information on the nature of the problem, as well as agencies responsible for managing particular tasks before, during and after flooding.

Involvement of flood-prone communities is also vital. Opportunities should be provided for members of the community to participate in the planning process. Consultation and active participation build community ownership of the flood emergency plan.

2.2.2 Understand the flood emergency management risk

Flood risk is generated by the potential for flooding to interact with valued elements of the community and/or the physical environment. The flood behaviour, its consequences, likelihood and the associated risk must be thoroughly understood to inform the development of emergency management strategies. It is essential to develop an understanding of the risk posed by all magnitudes of flooding, including risk generated as a result of dam failure or by storm surge. This involves utilising existing information to inform flood emergency management strategies and working closely with flood risk management, dam management agencies and professionals.

To understand the emergency management risks of flood on the community, planners should perform a risk analysis. Guidance on developing an understanding of emergency management risks of floods is contained in Chapter 3. *Managing the Floodplain* (AIDR 2017) provides further details on the flood study process.

A summary of flood information and flood emergency management risk analysis should be summarised in flood emergency plans in a manner that is easily understood by incident management teams. This may include the use of tables, maps and flood intelligence records.

2.2.3 Develop strategies and arrangements

Operational objectives and priorities should be defined in flood emergency plans. Strategies and arrangements to achieve operational objectives and priorities are then to be identified, including roles and responsibilities for implementation.

Specific strategies should be based upon an analysis of required action. This analysis may be based on brainstorming by the flood emergency planning team of feasible options for addressing identified risks and the associated plan objectives. The most practical ideas are then further analysed by considering the operational realities that flooding will pose. Exercising the plan may assist to assess the viability of different strategies. Where different strategies are proposed, criteria can be utilised to decide which strategy is best suited to meet operational objectives.

Strategies require consideration of key capabilities and, in some cases, special flood environments. These aspects are discussed in Chapters 4 and 5.

Capability analysis should be undertaken to assess the extent that resources will be available to undertake required tasks. This should include consideration of capability constraints. Typical capabilities related to flooding include warning, control and coordination, property protection, rescue, resupply, infrastructure restoration, relief and recovery.

Gaps identified from the capability analysis should be documented, including trigger points for when to request additional resources. Consider alternate sources of capability such as businesses and to escalate control arrangements. Where resources are outsourced

associated logistics requirements should also be considered.

Flood emergency plans must define what capabilities are to be prioritised to best achieve operational objectives that support wider community efforts, effectively triaging responses based on risk. This may mean altering of typical service delivery standards and mechanisms (Gissing et al. 2018).

As planning occurs at different levels including community, local government, region/zone, state and national levels, the level and detail of planning will differ. For example, local level plans focus on arrangements for the implementation of tactical strategies, whilst higher level plans are more strategic in nature.

Extreme flood events will stretch resources, meaning response strategies that routinely work in smaller events will be quickly overwhelmed and ineffective. Planning for extreme events requires consideration of how capabilities nationally and internationally may be drawn upon. This requires consideration of capabilities outside of government including those that exist within the business, non-government, community sectors and internationally (Gissing et al. 2018, Australian Government, 2018).

2.2.4 Document the plan

Plans should be documented so that they are clear to their audience. They should be concise and mindful of those who will utilise them.

Templates will assist in this process and ensure consistency in format and arrangements across plans. It is important to ensure such templates are flexible in content so that users can adapt them to the circumstances of individual areas covered by the plans.

A list of content that typically comprises a local flood emergency plan is provided at Appendix A.

2.2.5 Endorsement of the plan

Plans should be endorsed by an appropriate authority, for example, emergency management, disaster management or counter disaster committees. Legislation or emergency management policy in each jurisdiction may outline the endorsement process.

Prior to a plan being tabled for endorsement, consultation with key stakeholders including consideration of comments and a quality assurance process, should be conducted to finalise the plan.

2.2.6 Implementation and review

Flood emergency plans and associated intelligence records are designed to inform operational decision making. They should form a key reference document for incident management teams and wider stakeholders to refer to regarding arrangements and strategies. The plan should be used to inform the development of incident action planning. Plans should be available to the public to inform them of likely strategies, arrangements and risk information.

Unless a plan is implemented regularly, it is likely that it will be ineffective. Any plan needs to be kept alive to ensure it remains fit for purpose and up to date. This can be done through exercising, review, training and community engagement.

Exercises provide opportunities to ensure that plans are workable and effective. They can be used as tools in plan revision, by identifying required strategies and responsibilities and inadequacies in procedures and communication flows. They also help to educate emergency services' personnel and community members about emergency management arrangements.

Exercising should be conducted regularly and be varied in its content and extent, since no single test can adequately simulate all aspects of a flood response. All stakeholders need to be involved in the process, practising their designated roles and responsibilities as specified in the plan. Training helps emergency personnel to become familiar with their responsibilities and to acquire the skills necessary to undertake them. A simple way of ensuring emergency personnel are familiar with their responsibilities is to run briefings that detail arrangements contained within a plan.

To ensure that flood emergency plans remain relevant and accurate it is essential that they are regularly reviewed. The flood threat information and arrangements contained in plans should be reviewed:

- after each flood operation
- when significant changes in land use or community characteristics occur
- when new information from studies regarding flooding becomes available
- when flood warnings systems are established or altered
- when flood control or mitigation works are implemented or altered
- when there are changes which alter agreed plan arrangements
- when there are significant changes in the personnel who will have to manage a flood, and when inquiries or research recommend new practices.

2.2.7 Consultation and communication

Communication and consultation are important considerations in each step of the planning process. Participation by stakeholders including the community builds ownership. It is essential that project planning includes effective strategies for communication and consultation between agencies and stakeholder groups in the community. Specifically, it is important that communities are involved in the planning process.

Readers are advised to consult *Community Engagement for Disaster Resilience* (AIDR 2020) for the national principles of community engagement for disaster resilience, detailed guidance on the core elements of community engagement, and a spectrum of approaches and styles for engaging with communities.

Good practice for engaging communities in the planning process includes:

- **Understand the community** – understand the diversity of needs, vulnerabilities and strengths of the community. Considerations are detailed in Chapter 4.
- **Engage early and often** – commence engagement at the start of the process and continue throughout.
- **Allow sufficient time** – consider time frames in partnership with the community.
- **Be flexible and tailor approaches** – tailor engagement methods to the community. Ensure flexibility in the community engagement approach.
- **Agree on the objectives from the outset** – enable discussion and agreement on objectives at the beginning of the planning process.
- **Acknowledge the community as equals** – empower the community to participate equally.
- **Engage in two-way dialogue** – engagement should be based on mutual respect and trust, involving two-way dialogue. Decision making is negotiated between all relevant stakeholders in a transparent manner. Community expectations must be managed. Where community members are unable to influence decision making their participation is not appropriate and they should be told why.
- **Use skilled facilitation expertise** – the facilitation of the planning process should be independent, open to differing views and across technical issues.
- **Use expert and local knowledge** – integrate institutional, scientific and local knowledge into the process. There may be a need to raise community flood awareness prior to initiating community-based planning processes.
- **Use and build social capital** - local relationships and local capacity are critical enablers. Enhance social capital when engaging with communities.
- **Evaluate** – evaluate community involvement to ensure future improvement. Involve communities in the evaluation process.

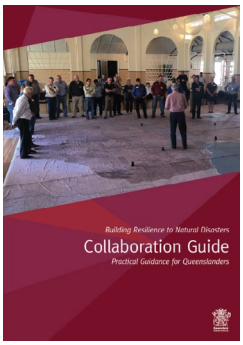
Further information on engaging communities can be found in the companion document: *Emergency Management Engagement of Flood-Prone Communities* (AIDR 2020), and *Community Engagement for Disaster Resilience* (AIDR 2020).

Building Resilience to Natural Disasters Collaboration Guide

Collaboration, partnerships and learning through knowledge sharing are fundamental to the disaster management tenet of shared responsibility. The *Building Resilience to Natural Disasters Collaboration Guide* provides advice on how to establish collaborative groups across stakeholders to advance locally led resilience in Queensland.

It draws on some theory and links activities to Queensland's disaster resilience policy framework. It reflects 'on the ground' experiences and learnings in designing and preparing Queensland's regional resilience strategies in partnership with local stakeholders under Resilient Queensland.

Although this guide is drafted with a 'resilience to natural disaster' lens, the principles and actions can be used to build resilience in any network. Closer bonds enhance preparedness and long-term



resilience, bolster a sense of unity, expedite recovery and facilitate smoother disaster management.

Collaboration is fundamental to success in prevention, preparedness, response and recovery. Everyone in the community has a role to play, however, we have learned that despite collaboration being critical, many people do not know how to reach out and feel vulnerable, uncertain and lack empowerment. Local knowledge is fundamental to continuous improvement in resilience. The greatest benefactors of good collaboration are those affected the most in disasters – the people of our communities.

https://www.qra.qld.gov.au/resilient-queensland

Walking the 'Big Map' – a collaboration tool

The pilot project 'regional resilience strategies' under Resilient Queensland, stemmed from a co-design process for the Queensland Reconstruction Authority (QRA) Resilience Team. The team started with the premise that the people who lived in a catchment — long-time residents, people with a good knowledge of floods and other natural disasters, emergency responders or business owners — had much greater knowledge than anything a policy document could produce.

The issue was how to capture this local knowledge to create a fit-for-purpose resilience strategy.

Visiting a catchment and asking what the strategy should look like was not going to work. The team settled on the 'Big Map' methodology, which allowed participants to walk their country and share intimate knowledge of the catchment characteristics and experiences from natural events. Sticky notes were written for places of interest. The team recorded every comment and a profile of experiences in natural disasters was built. Commentary was captured using the five pillars of resilience: social and people; roads and transport; economy; environment; and infrastructure.

The result was the basis for a resilience strategy which was effectively designed by the participants, their stories, shared knowledge and experiences.

Image: Central West Queensland Regional Resilience workshop with the big map, Longreach, 2019.

Knowledge and learning travelled both ways during these workshops, with participants gaining an appreciation of event characteristics in other parts of their catchment and the interplay between areas of expertise. The workshops were informal, often unstructured and allowed participants to speak freely about impacts and effects without steering the conversation. This gave rise to maximum participation.

Using this technique, a strategy can be devised that is recognisable as truly local. A locally led and state-facilitated, co-designed strategy can be co-delivered in a mutually agreed way as a shared responsibility.

Chapter 3: Understanding flood emergency management risks

The process of flood emergency plan preparation begins with the collation of available information and ends with an appreciation of plausible flood scenarios supported by risk analysis to appreciate flood emergency management risks. Risk analysis is defined as the systematic process of understanding the nature of and to deduce the level of risk (Attorney General's Department 2015). Flood risk is a function of the flood hazard, exposure, vulnerability and capacity.

- **Hazard** refers to a flood or a series of floods which are defined by a certain magnitude and probability.
- **Exposure** refers to elements that are prone to flooding (the people and things on floodplains) (Australian Government Department of Home Affairs, 2018a).
- **Vulnerability** is the condition determined by physical, social economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of floods (Australian Government Department of Home Affairs, 2018b).
- **Capacity** is the ability of people, assets and systems to survive and adapt (Australian Government Department of Home Affairs, 2018a).

A range of flooding should be considered up to and including extreme events such as the Probable Maximum Flood (PMF). Information about flood behaviour and the consequences of flooding should be built into the planning process to ensure operational decisions are informed and warnings targeted effectively. This includes consideration of:

- sources of flood risk information
- information on flooding including its behaviour and impacts
- analysis of the potential elements at risk of flooding in different events
- the vulnerability of the threatened community to flooding.
- local knowledge.

3.1 Information on flooding

Information produced to inform flood emergency planning for an area is derived from flood studies and plans. The information considered and produced in a study can vary depending on the type and purpose of the study. Typically, studies consider the physical and geographical characteristics of an area, compile data on historic flood events, develop models to simulate hydrologic and hydraulic characteristics of the area, describe the modelling results, post process data and produce a series of outputs based on the results of this work.

The following describes the typical information and considerations used to inform a flood study, the information that these flood studies produce and emergency management specific information.

3.1.1 Typical flood study considerations

- The types and sources of flooding which could occur (e.g. riverine, dam failure, coastal, storm surge, flash flooding).
- The shape and extent of the floodplain (i.e. whether it is wide, narrow, steep, flat, well defined with identifiable benches and escarpments).
- Stream characteristics (whether the watercourses are single-channelled, braided, convergent or divergent, with steep or mild bed-slopes and escarpments, etc.) or coastline characteristics (sand beaches, headlands etc.).
- Any bridges, embankments or other flow-restricting structures.
- The location and nature of any mitigation or control works.
- The location of any dams, their size, details of control structures and operating rules for releases, and any known physical or structural deficiencies or potential for failure under severe flood conditions.
- Sources of floodwaters (sub-catchment contributions).
- Tidal conditions at the time of the onset and peak of the flood and the impact of tidal fluctuations on river flood conditions.
- Analysis of available data to identify causes of floods, in terms of:
  - rainfall characteristics (e.g. depth, intensity, incidence of thunderstorms)
  - seasonal characteristics (e.g. unusually wet/dry, winter/spring, rain on snow)
  - antecedent conditions (e.g. flood one week earlier, rain for preceding week, drought)
  - typical pre-flood conditions, i.e. weather or synoptic conditions that usually precede or lead to a flood; and times (in terms of season or month) of greatest vulnerability to or likelihood of flooding i.e. post fire catchment behaviour.
- typical ground and floor levels of properties.

3.1.2 Typical information produced in studies

- Spatial extents and flood behaviour of different recurrence interval storm events.
- The rate of rise of floods (e.g. rapid rise of the order of x metres per hour initially, then slow rise to peak) and their progress (e.g. areas first affected, incidence and location of 'flood islands', identification of low points on evacuation routes, etc.). This should include variations in timing.
- The duration of flooding in particular areas, including the length of time the river stayed at its peak and/or above critical levels and the time it took to drain away.
- The incidence of stormwater back-up and/or entrapment and drain blockages.
- The influence (and contribution) of stormwater on the speed of rise and progress of floods.
- The significance (if any) of backwater effects or impacts on flood behaviour of structures.
- Water velocities and depths (including identification of areas where velocities and/or depths are likely to be high) and their impact.
- Timing characteristics such as the time between rain starting/stopping and the river rising for the first areas being flooded, and the time taken for floods to travel between significant and easily referable locations.

3.1.3 Emergency management information

- Emergency response classification of communities. See *Managing the Floodplain* (AIDR 2017).
- Details of key mitigation structures and their influence on flood behaviour such as levees.
- Spatial output of a flood warning gauge reference area.
- Evacuation routes and centres and access to emergency services.
- The makeup and the reliability of the flood warning gauge network that provides data to the Bureau of Meteorology and others.

Information collated during the study will assist to establish flood emergency response classifications. These classifications can be used to identify evacuation challenges such as communities located on low flood islands where evacuation routes will be flooded early during a flood before homes and businesses are inundated (refer to *Managing the Floodplain, Guideline 2: Flood emergency response classification of the floodplain* (AIDR 2017). In some circumstances, studies may specify key emergency management analysis and outputs as part of the scope of work in which case this information would be available to inform emergency planning.

3.2 Understanding exposure to flooding

Key elements of exposure include people, communities, settlements, the environment, infrastructure and the economy. Specific considerations for flood emergency planning include:

- land use, i.e. whether the flood-liable areas are under rural, urban, industrial, commercial, service or infrastructure uses, their density and the changes that are occurring with time
- impact and severity of flooding as indicated by spatial extent at particular heights at key or referable locations
- collation of data on possible flood consequences:
  - the number, type and location of properties flooded (and to what depths)
  - whether the residents were surrounded by water or experienced access difficulties at various gauge heights
  - the length of time the communities are likely to be isolated, together with estimates of likely needs for evacuation or resupply
  - number and location of potential evacuees
  - the extent to which essential infrastructure (e.g. roads, transport corridors, evacuation routes), services (e.g. energy, telecommunications, water and sewerage) or buildings (e.g. schools, childcare centres and hospitals) are vulnerable and any compounding cascading impacts (e.g. transport to schools)
  - any indirect consequences to the community
  - any environmental consequences
- number of casualties or deaths recorded in past events
- the threshold flood frequency which results in community isolation (e.g. rivers or creeks break their banks, key roads are inundated (resulting in isolation) and rail and airports are closed)
- prior preparation (or lack thereof) in past events.

Refer to *Land Use Planning for Disaster Resilient Communities* (AIDR 2020) for further guidance on vulnerability and land use planning considerations.

3.3 Understanding vulnerability and capacity

This involves establishing a community profile, identifying the elements at risk and their vulnerability. This should occur with involvement from the community. Community leaders have the capability to assist in the

planning process including to identify what sections of the community may be most vulnerable and what the community values.

Each community has capabilities to manage their flood response and recovery. Often such capabilities lie in community groups, community service organisations, businesses and community leaders. When developing an understanding of the community, identify such capabilities and ensure they are incorporated into flood emergency planning. This will enable a strengths-based approach.

Engage infrastructure operators to understand the vulnerability of essential infrastructure. Infrastructure includes gas, electricity, water, telecommunications, transport etc.

***Community Engagement for Disaster Resilience Handbook* (AIDR 2020) provides further guidance on how to develop an understanding of communities.**

3.3.1 People vulnerable to flooding

Some members of the community are especially vulnerable to flooding because of:

- where they live in relation to essential and emergency services and evacuation routes
- variations in personal characteristics and systemic vulnerabilities (e.g. age, disability, language, access to information and services, socio-economic factors, personal and social relationships).

The consequences of a flood may be more pronounced if the needs of individuals with specific support requirements are not met. If support needs are met and people are well informed and prepared, they may be no more vulnerable than others and could potentially provide support to others in their community.

It is possible, using census data and other information held by councils and state and federal agencies, to identify the potential number and location of people in an area (or the proportion of the community's population) with specific support requirements during floods. Consider:

- the elderly, especially those living alone and/or frail, who can be unable to respond quickly or without assistance
- those from low socio-economic backgrounds (i.e. those on low incomes, including the unemployed and pensioners), who tend to lack resources which would give them independence of decision making and action
- single-parent families, large families or families with very young children: these may be characterised by unfavourable adult/child ratios making evacuation difficult
- those lacking access to a motor vehicle who frequently need special transport provision to facilitate escape from threatening floodwaters
- pet owners that may be reluctant to evacuate, instead wishing to stay and care for their animals
- newcomers (i.e. residents who have lived in their communities for a short period), who are unlikely to appreciate the local flood threat, may have difficulty understanding advice about flooding, and may need special attention in terms of education and communication of warnings and other information
- members of culturally and linguistically diverse (CALD) communities, who have specific support requirements with respect to the development of preparedness strategies as well as warnings and communications during flood events
- the ill or infirm who have specific support requirements with respect to mobility, special needs, medications, support and management to ensure they continue to receive appropriate care and information
- those whose homes are isolated by floods, creating a potential need for medical evacuation or resupply of essential items
- tourists that could have little understanding of the local environment and the associated flood risks
- remote isolated regions that may suffer from long duration isolation.

It is also necessary to take note of the needs of essential services, buildings with a high proportion of vulnerable occupants and institutions in flood-prone areas. Examples include, but are not limited to, schools, nursing homes, senior citizens' centres, hospitals, childcare centres, animal holding establishments, caravan parks, hostels, libraries, art galleries, museums, jails, sporting facilities, supermarkets, banks, business districts and industrial areas.

The 2009 Victorian Bushfires Royal Commission recommended that relevant facilities where vulnerable people are likely to be situated be documented in emergency plans and arrangements should be established to contact vulnerable residents to provide assistance to them if evacuation is required.

Specific resources for disability inclusive disaster risk reduction can be found at: https://collaborating4inclusion.org/disability-inclusive-disaster-risk-reduction/

Further guidance can be found in *Community Engagement for Disaster Resilience* (AIDR 2020).

3.4 Sources of flood risk information

Potential sources of information to inform the planning process are detailed in Table 2.

Table 2: Sources of flood risk information

INFORMATION SOURCE	AVAILABLE FROM
FLOOD STUDIES	Councils, catchment management authorities, natural resource management organisations, State Emergency Service, state/territory governments, libraries
FLOODPLAIN MANAGEMENT STUDIES	Councils, catchment/water management authorities, State Emergency Service, state/territory governments, libraries
COASTAL MANAGEMENT STUDIES	Councils, State Emergency Service, state/territory governments, libraries
DAM BREAK STUDIES	Dam owners or operators
LEVEE STUDIES	Councils, state water and floodplain management agencies, State Emergency Service, libraries
HISTORICAL RECORDS	Councils, catchment management authorities, State Emergency Service, media, historical societies, museums, community members, Bureau of Meteorology
PALEO-FLOOD ANALYSIS	Research institutes and universities
FLOOD MITIGATION DESIGN STUDIES	Councils, operators of flood mitigation schemes
FLOOD IMPACT/RISK ASSESSMENTS TO SUPPORT PLANNING PROPOSALS	State agencies, councils
ROAD AND INFRASTRUCTURE DESIGN STUDIES	Road, rail owners
CENSUS AND BUILDING INFORMATION (E.G. FLOOR LEVEL DATA)	Councils, catchment management authorities, Australian Government, commercial providers
LOCAL KNOWLEDGE	Local champions, personal histories and newspaper archives
FLARE (FLASH FLOOD GUIDANCE)	Bureau of Meteorology
EXPOSURE DATABASES (E.G. NATIONAL EXPOSURE INFORMATION SYSTEMS AND THE GLOBAL NATIONAL ADDRESS FILE)	Geoscience Australia, PSMA Australia and Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC)
HISTORICAL EMERGENCY CALLS FOR ASSISTANCE	Emergency services
HISTORICAL INSURANCE CLAIMS	Insurance companies
FLOOD WARNING INFRASTRUCTURE NETWORKS	Bureau of Meteorology, water authorities, local councils

The online Australian Flood Risk Information Portal (**www.ga.gov.au**), instigated and managed by the Australian Government, provides information on some flood studies. As flooding is a state responsibility and in some states this responsibility is partially placed on local government, state and local councils will have information that is not available nationally. Some states and territories have online portals that provide flood mapping and other information. Emergency planners should be consulted when flood risk and floodplain management studies are prepared to ensure that their information requirements are met.

The information available to inform flood planning is variable across different communities. Where critical information is missing this should be brought to the attention of local floodplain risk management authorities and disaster planning committees for prioritisation.

New South Wales Flood Data Portal

The portal is part of the joint flood data access program of NSW State Emergency Service (NSW SES) and NSW Department of Planning Industry and Environment, Environment Energy and Science (DPIE EES). It was launched in 2017 and primarily focused on the upload of reports and data from newly completed flood projects. However, some older reports and data are also available through the portal.

It provides for secure cloud-based storage of electronic studies and related spatial and non-spatial data and tools, and supports the sharing of flood information under arrangements managed by the information owners (generally local councils). Local councils undertaking studies under the NSW Governments Floodplain Management Program are required to handover study reports and data through the portal and make key information publicly available. Some state agencies are also using the portal to share information within government.

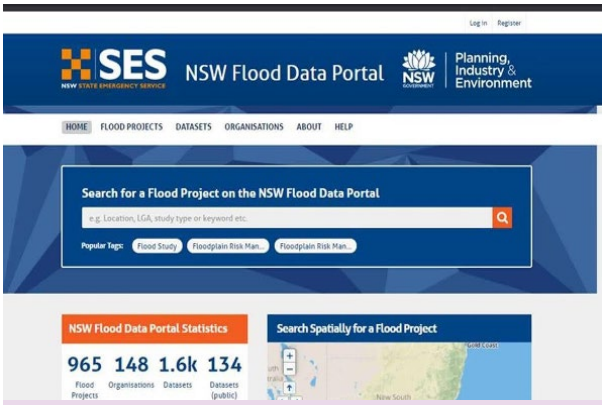


Image: NSW Flood Data Portal

The portal provides a platform to provide NSW SES direct access to newly completed studies to allow them to use this information to update their flood intelligence.

Information from studies to support flood emergency planning

The NSW Department of Planning Industry and Environment, Environment Energy and Science (DPIE EES) provides technical support to councils to assist their management of flood risk. Local council studies under the NSW Government's Floodplain Management Program are developed under the guidance of a local flood risk management (FRM) committee which includes DPIE EES and NSW State Emergency Service (NSW SES).

Through the FRM process, emergency management constraints are identified by developing flood emergency response classifications for communities that consider the full range of flooding. This provides a basis for understanding the emergency management difficulties in different areas of the floodplain, and helps to inform the development or refinement of emergency management strategies. For more information, see *Managing the Floodplain, Guideline 2: Flood emergency response classification of the floodplain* (AIDR 2017).

Developing other important information on flood impacts relevant to NSW SES supports emergency management.

Key components of flooding that studies support an understanding of include:

- flood behaviour and how it may vary
- flood warning time and how it may vary
- influence of combined flooding mechanisms such as ocean conditions and flooding in coastal catchments
- understanding how long evacuation routes may remain open, considering the varying rate of rise of floodwaters between events
- considerations relating to longer duration events which may isolate or inundate a community for an extended period of time
- influence of key structures that provide flood protection to the community, such as levees which can include advice on the consequences of levee over-topping or failure
- consequences of flooding based on a range of flood behaviour.

Image: Flood response classification

3.5 Local knowledge networks

Community members want to have input into local decision making. Local communities can provide valuable information to inform decision making such as river levels, levee conditions and historical flood behaviour, however this information must be assessed and validated. Previous historical knowledge may be of limited value when dealing with extreme floods that exceed previous historical levels (Comrie 2011).

Flood emergency plans should consider documenting the establishment of pathways and networks for local knowledge to be captured and considered in decision making before, during and after a flood. Local knowledge can be sourced from local emergency service volunteers, flood warden or observer networks, local government and community leaders (Sheehan 2014).

Local knowledge networks can provide a conduit for flood information to be communicated to communities. Such networks are particularly important if there is not a strong emergency service presence in a region (Sheehan 2014).

Refer to *Community Engagement for Disaster Resilience* (AIDR 2020) for guidance on engaging with local communities.

Victoria State Emergency Service, Local Knowledge Policy

The Victoria State Emergency Service (VICSES) developed a *Local Knowledge Policy* in 2013 to improve the information flow from the community to support operational activities, immediately before, during and after emergencies.

In recent years, the policy has been reinvigorated using new technology to improve how information is communicated from community observers to emergency management personnel.

VICSES achieved this by utilising an existing app the community already used to notify local councils about local issues that need to be reported by taking a picture and submitting it through the app.

The app has now been enhanced to include a bespoke function that allows community observers to capture images and submit flood reports through the app. The images and data are then displayed in an administration portal made available to the Intelligence Section during floods to improve knowledge about the impacts or real-time events and to maximise flood response efforts.

The project has targeted known information gaps during flood events, including the provision of information in flood-prone locations that do not have telemetered stream and rainfall gauge monitoring.

The app and portal are currently being released and implemented around the state as a pilot to test the functionality and efficiency of data being received during a flood event.

3.6 Presentation of information to inform flood emergency response risk analysis

3.6.1 Interactive spatial mapping tools

Interactive spatial mapping can be used to present and analyse flood risk using multiple different sources of spatial data examining flood hazard, exposure and vulnerability. Several case studies are provided on the use of such systems to present information.

The information presented in these tools is based on flood modelling and known behaviour of historical events. No two floods are the same, therefore flood behaviour may vary from that modelled when interpreting information within the tools to inform event decision making. This may require expert interpretation of all flood related intelligence, including modelling inputs and results, real time rainfall, water level and impact data during events to inform decision making.

The development of these tools needs to occur during business-as-usual conditions to allow time for understanding the ability and limitations of the tools, and to allow knowledge transfer and operational readiness through activities such as exercising plans for locations where the tools are available.

FloodZoom

Following state-wide flooding in 2011, the Victorian Government developed a web-based tool to provide flood information to inform decisions before, during and after floods. FloodZoom provides state-wide information relating to flood mapping, flood forecasts, river height gauges and property data.

A primary objective of FloodZoom is the collation and provision of access to flood spatial data. Spatial data is sourced from the Victoria Flood Database that contains spatial layers, including both historical and modelled floods. Information on flood mitigation infrastructure is also included.

A key focus of the platform is to provide flood consequence information to inform decision making.

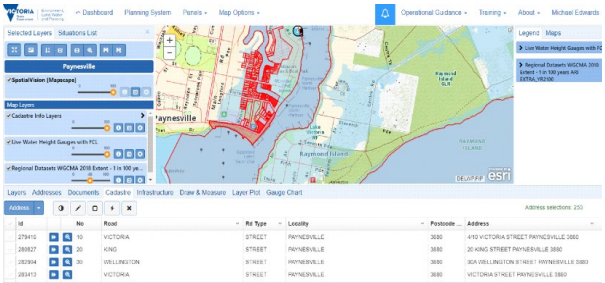


Image: FloodZoom screenshot

To do this, the system contains various asset and infrastructure layers which can be overlaid with flood extents. The system can also integrate live operational data, for example, the status of road closures, stream flow and rainfall data.

3.6.2 Flood intelligence records

Flood intelligence records attempt to provide information on flood consequences as they relate to specific stream heights and/or discharge recorded at a flood warning gauge. The records are useful to summarise the key consequences of flooding to inform strategies to be implemented based upon flood predictions that can be used as trigger levels.

Flood intelligence records are typically developed for a specific reference area in relation to a stream gauge. This is the area where heights at the gauge have meaning in terms of flooding, independent of local flooding or flooding from tributary creeks which may also occur at a location at the same or different time.

Flood intelligence records should describe key flood consequences related to the flooding of properties and infrastructure, farmland, isolation of properties and communities and any possible indirect impacts of infrastructure disruption. Entries can also include heights of historical floods and their impacts and design flood events for different frequencies. An example of a flood intelligence record is provided at Appendix B.

In drafting records, care should be taken to:

- correctly determine gauge heights as it is important not to include effects which did not relate directly to specified heights being reached during a particular event (e.g. effects on a tributary which occurred at the time a height was reached at a gauge on the main stem of the river but were not the result of that height being reached)
- note any dependencies or interdependencies, such as where an impact at a particular height at a gauge will occur only if some other effect, unrelated to that gauge, also occurs (e.g. a road cut at a certain height, necessitating a longer journey on an alternative route between two places but with the possibility of all access being lost when this route closes as a consequence of flooding on another stream)
- ensure that effects are noted in terms of types of impacts, e.g. roads closed to different classes of vehicles, or properties affected in different ways (by inconvenience; if additional distance is added to journeys; or by complete isolation which may require resupply; or by inundation)
- keep detailed lists of affected properties, by type (e.g. residential, farm, retail, industrial, caravan park).

Flood intelligence records are approximations. This is because no two flood events at a location, even if they peak at the same height at the gauge, will have identical impacts. The gradients of the floods or storm patterns may differ, the floods may be near their peaks for different durations, and the channel and floodplain environments in which they occur are unlikely to remain static.

The fact that height and consequence links are approximations (and in some cases may be estimates of likely occurrences) should not be of concern. Absolute precision cannot be expected and is not necessary for effective planning to be undertaken. Where substantial known variability exists in the heights at which particular effects can occur, the potential impacts can be noted by listing a range of heights. This can highlight the potential variation so that this can be considered in triggering a response based on the potential consequences identified in emergency planning.

Flood intelligence records can also include actions that need to be undertaken based upon predicted flood levels, for example, evacuations or road closures. In this sense they can act as operational checklists to inform incident management decision making.

Records may also be developed based on rainfall for areas impacted by flash flooding. In this case, potential consequences may be defined for triggers such as different rainfall intensities at various locations within a catchment. However, there are significant limitations on the known severity of flash flooding and its consequences during an actual event. Often gauge locations are dispersed and do not capture the localised intensity of rainfall and variation in storm patterns at the scale necessary to understand the specific areas impacted until flooding occurs.

Chapter 4: Planning for specific capabilities

This chapter outlines typical capabilities utilised during flood incidents. For wider capabilities, such as the management of spontaneous volunteers or donated goods, readers should refer to *Communities Responding to Disasters: Planning for Spontaneous Volunteers* (AIDR 2018). The *Australian Disaster Preparedness Framework* (Australian Government Department of Home Affairs 2018) provides an outline of capabilities that may be required to respond to severe and catastrophic events.

4.1 Command and control

Flood emergency plans must not only detail roles and responsibilities, but identify how command and control will be exercised to achieve priorities and objectives. Key planning considerations include:

- incident management structure
- locations for incident control centres
- likely divisions of control, for example, sector and divisional boundaries
- division and sector control arrangements particularly where a flood control agency may have little on-ground presence.

Further information on planning for command and control can be found in *Incident Management* (AIDR 2021) and the *Australasian Inter-service Incident Management System* (AIIMS).

4.2 Flood prediction and warnings

The development, maintenance and operation of flood warning systems, through the total warning system, is critical to unlocking the manageability of the flood threat. *Public Information and Warnings* (AIDR 2018) provides an overview of the total all-hazards warning system utilised across Australia and includes principles that can be utilised to plan for the flood warning function.

Specific guidance on the establishment and operation of total warning systems for flooding is provided in the companion document: *Application of the Total Warning System to Flood*.

4.3 Evacuation

Where practical, evacuation is the primary strategy for ensuring the safety of at-risk communities. The purpose of evacuation is for people to relocate temporarily from areas at risk of the consequences of flooding to places of safety. It is essential to assess risks involved in undertaking an evacuation, as evacuation may not always be the most appropriate action. This will ensure that people are not exposed to more hazardous environments as a consequence of their evacuation, for example, travelling through deep, fast-flowing floodwater.

All-hazards principles regarding the evacuation process and planning considerations are detailed in *Evacuation Planning* (AIDR 2017). Specific evacuation considerations for flooding will include:

- **Establishment of evacuation triggers** based on flood risk analysis. Evacuation triggers could include when:
  - properties are likely to become inundated
  - properties are likely to become isolated and occupants are unable to be self-sufficient and safe in isolated conditions
  - public health is at threat as a consequence of flooding
  - essential services have been damaged and are not available to a community.
- **Classification of floodplain types to identify evacuation challenges** (refer to *Managing the Floodplain, Guideline 2: Flood emergency response classification of the floodplain* (AIDR 2017).
- **Identification of the warning time, availability of official warnings and time available** for evacuations to occur.
- **Identification of suitable evacuation routes**. This will include identifying any likely locations where routes may flood and require closure. Identify the best evacuation route and record when it and feeder routes will close.
- **Identification of evacuation/relief centres**. Ideally evacuation centres will be located outside the extent of extreme floods such as the Probable Maximum Flood, however, this may not always be possible. In some instances, residents might need to move to a neighbouring town or city, in which case evacuation centres and reception details should be considered at these locations.
- **Planning for communication or warning** approach to facilitate evacuation and return the communication medium and message content need to be carefully considered.

Evacuation modelling can be utilised to inform evacuation planning and inform the length of time evacuations will take. Any, modelling will be based on assumptions and decision making will need to be aware of the assumptions used in formulating a strategy and adapting this during an event given the uncertainty associated with predictions and actual event conditions.

4.4 Resupply

Resupply is a frequently required function in rural and remote areas, though on occasions entire communities may become isolated. It can be difficult to manage because of the geographic dispersal of those who are cut off by flooding from normal means of supply. As a principle, normal supply chains should be supported to ensure their effective operations for as long as is possible.

Resupply requirements differ depending upon the likely duration of flooding and the likelihood of infrastructure damage. Where prolonged isolation is identified as a possible consequence of flooding, planning for the resupply of properties and/or communities should be undertaken. The purpose of this planning should be to ensure that arrangements are developed to provide supplies of essential items to properties and/or communities when they are isolated. The initial task in developing a plan to conduct resupply is to identify areas which are likely to lose road and/or rail access and the flood events that will result in the isolation of properties and/or communities. For each area the following information should be identified:

- location of the area
- key access routes to the isolated community or properties
- location and heights (relative to the relevant flood warning gauge) at which key access routes may be inhibited or closed by flooding
- the likely duration of isolation
- the size of communities and/or the number of properties requiring resupply
- locations where the community and/or properties normally purchase supplies
- whether or not a community have access to businesses to meet its needs or resupply the community
- whether or not any special-needs risk groups (e.g. families with young children) or institutions (e.g. hospitals, clinics and nursing homes) are likely to become isolated
- specific resupply needs (for example medication and infant formula) of people and animals (including farm livestock and domestic pets and companion animals)
- locations suitable as distribution points to which resupply items are delivered for distribution to isolated properties or businesses if whole communities are isolated
- most appropriate means of transport.

Locations from which resupply occurs are referred to as loading points. Resupply goods will be delivered to such points by suppliers and then transported to isolated communities and/or properties.

Loading points sites should be identified in advance. They should be established as close as possible to normal suppliers to facilitate ease of delivery. The choice of loading point location will also depend upon the chosen methods of resupply delivery. Priorities for resupply must be determined and detailed in the plan. Essential services like water, food and medications should be given the highest priority.

4.4.1 Property protection

Temporary property protection measures, like barriers and the removal or lifting of the contents of buildings can be used to prevent or minimise property damage to neighbourhoods or individual assets.

Temporary barriers (sandbagging, earthworks or commercial 'wall' barrier products) can be used to prevent water entering buildings or yards (e.g. containing essential infrastructure) or business premises or dwellings. Methods of protection are often ineffective against large floods, during which they may be overtopped or fail. Additionally, sandbags must be positioned correctly to be effective and minimise damage to property.

Temporary barriers should not be used nor relied on as an alternative to evacuating a community. When protecting essential infrastructure, it is preferable to invest in permanent measures rather than rely on temporary barriers.

The use of barriers may require the application of cost-benefit analyses to determine whether they are economically appropriate or have negative externalities and adversely impact flood behaviour elsewhere.

Such analysis should be considered in the planning phase as it is rarely possible to conduct such analysis during the response phase due to time constraints. To apply such analyses during the planning phase requires the early identification of the locations and circumstances of potential barrier use.

Managing the Floodplain (AIDR 2017) provides some advice on issues to consider in deciding if the use of temporary flood barriers are appropriate for a location, and the associated upfront, ongoing and operational issues to consider. For further information, see the AFAC guideline _Use of Temporary Flood Barriers_: https://www.afac.com.au/insight/doctrine/article/current/use-of-temporary-flood-barriers

Temporary levees

The town of Nathalia in Victoria has a long history of flooding, with notable floods occurring in 1916, 1939, 1974, 1993 and 2012. Earthen levees protect the town from flooding. The levees system was upgraded after 1993 and relies on demountable portable barriers for some sections. The levee provides protection to the 1 per cent AEP flood plus freeboard of between 450mm and 650mm. The portable barriers were used for the first time in 2012. They operated successfully, although there were some minor leakages between the base of the barriers and the roadway. Sandbags were used to shore up these areas. The Victoria State Emergency Service issued an evacuation order as some doubt existed as to the levee system's ability to contain the floodwaters. Rectification works have subsequently been undertaken. The case study illustrates the application of barrier systems and their limitations.

Image: Levee at Nathalia. Source: Moira Shire Council

Damage to building contents, infrastructure and equipment can be reduced or eliminated by lifting items or removing them to areas above the impacts of flooding where this is feasible. However, it is also important to recognise the potential range of flooding and likely magnitude of a given event to inform decision making, particularly where flooding results in depths above the level to which items can be lifted within buildings.

Key planning considerations include:

- identification of community priorities for protection, (e.g. significant buildings vital for community resilience such as hospitals and civic centres, and essential services like water supply pump stations)
- analysis of options for property protection and any limitations (e.g. impacts on others, cost, logistics of asset management, storage, installation)
- triggers for property protection (e.g. forecast flood heights)
- resources available to conduct property protection
- time frames available for conducting property protection
- strategies for conducting property protection (e.g. barrier such as sandbagging, and/or lifting or removal of goods). This should include strategies for encouraging community self help
- logistical support for property protection (for barriers: sources of sandbags, sandbagging machines and sand; for removal: transport, storage facilities, management of storage facilities and security of storage facilities).

4.5 Flood rescue

Flood rescue is a reactive strategy that is implemented once an area becomes flooded or isolated. It is significantly different from evacuation that is implemented in a proactive manner before flooding occurs.

The aim of flood rescue operations is to move people from immediate or potential harm to safety. The risk profile of rescues can vary from assisting to relocating individuals who have become trapped to removing individuals whose life is at imminent risk.

In some circumstances it may be necessary to conduct large scale coordinated rescue operations as a result of evacuation routes no longer being accessible. Where the potential need for large scale coordinated rescue operations are identified, arrangements should be contained within flood emergency plans. Since flood rescue is often related to evacuation arrangements, planning for these functions should be conducted concurrently.

An understanding of the likely issues associated with flood rescue should be established through the consideration of:

- areas where people are likely to require rescue, noting that a higher risk will apply to low flood islands
- the potential number of people likely to require rescue, including any groups with specific support requirements.

Flood rescue operations can be separated into the following phases:

Identification and deployment of rescue resources

This stage identifies available resources and mechanisms for their deployment. Key planning considerations include the identification of:

- accredited rescue units available
- other rescue resources (including material resources) available
- identification of arrangements for the management of aircraft
- evacuation triggers for the pre-deployment of resources: when ordering the evacuation of a large area
- areas suitable as staging areas, including areas for the landing of aircraft.

Rescue execution

The rescue execution stage encompasses the conduct of the rescue itself. Planning considerations include the identification of:

- the most suitable methods (flood rescue technicians, flood rescue boat, aircraft or high-clearance emergency service vehicle)
- rescue sectors (these are likely to be aligned with evacuation sectors)
- rescue priorities
- shelters of last resort where people may assemble and from which they can be rescued.

Shelter and welfare

Once people have been rescued, shelter and welfare need to be provided. Planning considerations include the identification of:

- likely drop-off points where rescued persons can be transferred to evacuation centres, hospitals or other locations (these may be the same location as staging areas for the deployment of rescue services, provided flood-free road access is available to medical facilities and evacuation centres)
- likely resources and staffing required at drop-off points e.g. transportation, decontamination, facilities for animals, registration, ambulatory care and logistics support requirements for rescue resources
- arrangements for the registration of rescued persons
- appropriate shelters (these are likely to be identified in evacuation planning).

4.6 Road closures and management

Road closure and information provision priorities should be documented in flood emergency plans given the significant proportion of flood deaths that have occurred due to motorists entering floodwaters (49 per cent of flood deaths between 1960 and 2015 were vehicle related (Haynes et al. 2017)).

In some instances, road operators may maintain automatic warning signage or road closure devices. The location of these should be included in plans. Road operators may also operate camera networks that can provide valuable intelligence to inform response operations.

Planning for road closures and management should be performed in consultation with relevant road operators and any key stakeholders that may utilise the roadway, such as local industry groups.

In establishing priorities for road closures and assessing risks along evacuation routes some roadways are clearly more dangerous than others (Gissing et al. 2019). Specific flood risk factors that must be considered include:

- Road alignment - a tight bend in a roadway directly before a floodway may limit chances for a motorist to act in order to avoid entering floodwater.
- Road grade - the falling grade of a road may mean a motorist entering shallow water quickly progresses into much deeper water or that floodwater may be difficult to observe on approach. Such conditions may give a driver a false impression of the degree of flood risk.
- Presence of lighting - lighting of a roadway allows motorists to observe floodwater during evening hours.
- Rate of rise - fast-rising floodwaters may limit the ability of vehicle occupants to escape.
- Presence of roadside barriers - roadside barricades provide protection against a motorist leaving a roadway.
- Depth and velocity of floodwaters - greater depth and flow velocities of floodwaters increase the likelihood of a vehicle being washed from a road.
- Flood depths downstream - vehicles will sink in deep floodwaters.
- Kerb and guttering - kerb and guttering provide some degree of protection against a motorist leaving a roadway.
- Ease of turning around - the width and lane structure of a road (i.e. one way or two way) influences the ability of a motorist to turn a vehicle around (Gissing et al. 2019).

Historical flood rescue data in any areas where vehicle rescues have occurred previously may also be considered.

4.7 Transition to recovery

Flood emergency plans should consider strategies and arrangements for initial relief and recovery arrangements and transition to longer term recovery. Important functions to consider include:

- public health
- clean-up
- disaster waste management
- restoration of infrastructure
- return of evacuees
- mental health support
- establishment of recovery centres
- making buildings safe for return
- information provision.

Further information on planning for recovery can be found in *Community Recovery* (AIDR 2018). Readers should also refer to the specific recovery arrangements that exist within their jurisdiction.

Chapter 5: Planning for special environments

Note the Bureau of Meteorology defines flash flooding as flooding occurring within about six hours of rain, usually the result of intense local rain and characterised by rapid rises in water levels.

5.1 Flash flooding

Flash flood environments are characterised by the rapid onset of flooding from when rainfall begins (ranging from within tens of minutes to a few hours) often with rapid rates of rise and areas of high hazard. The duration of flash flooding is often relatively short by comparison to riverine floods. Flash flooding can overwhelm streams and stormwater drainage. The ability to provide warning to people likely to be affected by flash flooding is also reduced.

At least 130 people died in flash floods in NSW, Victoria, ACT and south east Queensland from 1 January 2000 to 30 June 2017. Of these fatalities 85 per cent occurred outside of buildings. Fatalities that occurred inside buildings were associated with severe or record flood events (Coates et al. 2017). Outside of buildings the majority of victims were attempting to cross a watercourse by wading, swimming or driving (Coates et al. 2017). This evidence suggests that if evacuation has not occurred prior to the arrival of floodwater, taking refuge inside a building may generally be safer than trying to escape by entering the floodwater.

However, any evacuation strategy needs to be aware of the full range of flooding and its constraints to ensure strategies employed during events are compatible with these constraints. In some situations, the rate of rise, flood depths and behaviour can be destructive and/or overwhelm the occupants and buildings with the only advance notice of flooding being floodwater entering buildings. Fit for purpose warnings systems, such as an early warning system, may be one of the only mechanisms to provide advance notice of flooding to the community. However, given these are often based on forecast rainfall well before any rain, they can lead to false alarms, making response extremely difficult depending on the certainty of forecasts. Considering an approach such as this to assist in managing flood risk for the community requires a holistic approach through floodplain risk management, emergency management and community engagement strategies.

In addition to considerations already outlined, the following guidance should be applied when planning for environments where flash flooding is a risk:

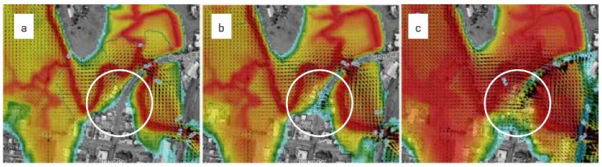
- The emergency management strategy must consider the context of the flood situation. For example, is there a warning system with time available to evacuate the at-risk community and is there emergency management capability to execute evacuation plans?
- Where sufficient warning time and emergency management capability are available, evacuation should be the primary strategy.
- Severe weather warnings, flood watches and weather forecasts should be used proactively to encourage

Dungog flash flooding, 2015

In April 2015, the NSW town of Dungog experienced destructive flash flooding resulting in the loss of three lives and the flooding of some 80 dwellings resulting in severe structural damage in others.

The three victims were aged over 65 and drowned at their residence. Residents were caught unaware of fast-rising floodwaters in the early evening hours trapping them in their homes some of which were flooded up to ceiling height. Responding to the event was challenging. The coroner's investigation recommended the development of an automated flash flood warning system for the township. This system was commissioned in 2020 and is now operational for the community.

Following the 2015 flood three vacant properties where houses were washed away were purchased in the township under the NSW Government's Floodplain Management Program. This removed



the potential for redevelopment and occupation of these properties.

These houses were in an area where flood conditions in smaller floods were less severe, but the 2015 flood developed a high hazard flow path (which was slightly larger than a 0.2% Annual Exceedance Probability (AEP) flood), resulting in hazardous conditions, such as those shown above.

This example highlights the importance of considering the full range of flooding (including more extreme floods), and the variation in flood behaviour and constraints.

residents to be ready when there is a risk of heavy rain that may lead to flash flooding. Areas where there is a high risk to life or that will be difficult or dangerous to evacuate or rescue people from should be prioritised.

- Where it is not possible to evacuate before the event, partial evacuation focused on high risk areas should be considered. Remaining residents should be advised to seek shelter in a safer place which may be in a higher storey, attic, highest point in the property or in a higher building nearby.
- Plans should identify high risk areas to inform the pre-deployment of rescue resources.
- Consideration should be given to the behaviour of building occupants who may attempt to escape a flooded building. Secondary risks, such as fire and medical emergencies that can impact on the safety of people surrounded by floodwater should also be considered.
- Risks faced by the itinerant population and motorists visiting the area should be considered and managed.
- Community awareness of flash flood risks and what to do in these cases is essential.

Further information can be found in the AFAC guideline, *Emergency Planning and Response to Protect Life in Flash Flood Events:* https://www.afac.com.au/insight/doctrine/article/current/emergency-planning-and-response-to-protect-life-in-flash-flood-events

5.2 Dams

Dams affect the natural stream flows and typically change the peak, timing and duration of floods. By how much depends on catchment size, dam storage capacity, rainfall intensity and how full the dam is.

The Australian National Committee on Large Dams (ANCOLD) specifically defines a large dam as:

> *One which is: (a) more than 15 metres in height measured from the lowest point of the general foundations to the crest of the dam. (b) more than 10 metres in height measured as in (a) provided they comply with at least one of the following conditions: (i) the crest is not less than 500 metres in length, (ii) the capacity of the reservoir formed by the dam is not less than 1 million cubic metres, (iii) the maximum flood discharge dealt with by the dam is not less than 2000 cubic metres per second, or (iv) the dam is of unusual design.*

– *(ANCOLD, 2012; p.1).*

Unlike many larger dams, small dam embankments may be highly variable structures. They are often constructed by landowners or local contractors without using the best practices of the large dams community. They may have unknown construction histories or be constructed to unknown, or unchecked design standards.

The embankment material used for the construction may be of poor quality. Additionally, the material may be poorly graded or not have been compacted sufficiently, which can lead to voids or cracking. There may be large regional variation in soil types and approaches to dam construction. Finally, they may have unknown or insufficient maintenance histories, for example addressing cracks and slumps, vegetation removal or animal burrows.

Although the consequences of failure may indeed be lower for smaller dams, the large number of unknown or unregulated dams in some locations means that it can be difficult to quantify their overall contribution in terms of dam safety risk.

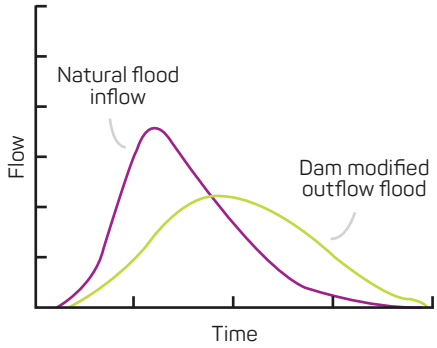
Most states and jurisdictions place legal or regulatory obligations on dam owners to manage the structures in a safe manner, irrespective of size and dependent upon the population at risk if the dam were to fail. Typically, a dam is designed to survive an extremely rare flood event. Flood behaviour during a dam failure event is not discussed in this handbook.

If any dam can significantly affect flood behaviour, and has an impact on downstream communities, consideration also needs to be given to flood emergency planning.

5.2.1 Uncontrolled versus controlled structures

Some dams have a means of controlling releases from the dam in response to inflows, for example with the use of gates. However, most dams have fixed spillways, meaning that there is no provision to manually control the release of flows to any significant degree during times of flood.

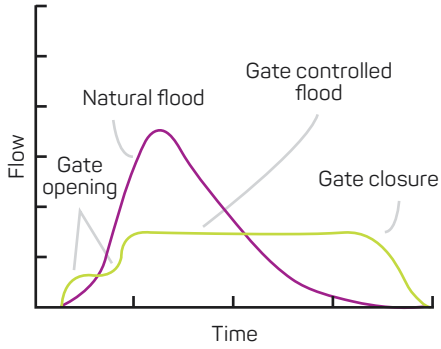
For uncontrolled dams with fixed spillways, outflows typically show a lessening of the flood peak accompanied by a lengthening of flood duration (see Figure 4). This flow attenuation is due to the storage effects of the dam before the inflows are released through the spillway.



FLOOD FLOW THROUGH UNCONTROLLED DAM

Figure 4: Flood flow through uncontrolled dam

Dams with the ability to control downstream outflows can do so through the use of air space, gates, or valves. In floods, releases are controlled in accordance with a particular strategy, either to minimise the rise in storage levels, to reduce downstream flood flows and heights or to optimise water supply capacity following the flood (or to achieve a combination of these effects). A flood peak may be deliberately stored for later release, or 'pre-released' because the dam operator needs to create extra air space in a reservoir to absorb some of the flood by letting out some of the stored water ahead of an approaching flood (see Figure 5).



FLOOD FLOW THROUGH CONTROLLED DAM

Figure 5: Flood flow through controlled dam

Dam operators for water supply dams often have protocols regarding the operation of the dam which considers various factors relating to the storage level of a dam. This typically includes an understanding of inflow into the reservoir and outflow routing through the dam to maintain a particular water storage level. This routing typically relies on actual known rainfall with some knowledge of forecast rainfall, then subsequent application of hydrologic and (sometimes) hydraulic modelling. However, there is significant uncertainty associated with forecast rainfall (timing and spatial extents) and surface hydrology which in turn can mean there is, at times, significant uncertainty in flooding downstream of a dam.

Each catchment responds differently to rainfall events. Therefore, it is important that all dam operators, and emergency response and support agencies, understand the unique behaviour of the catchment and operating requirements for each dam within their region. It is also important to ensure that the roles and responsibilities of managing floods are firmly established and understood. Typically, an emergency action plan (EAP), or a dam safety emergency plan (DSEP), is in place to describe this.

The following types of floods apply for flooding downstream of dams:

- Natural floods. The majority of floods passed through dams are natural floods caused by rainfall in the catchment which do not threaten the safety of the dam, but could endanger life, property, transport links or the environment downstream. They can be of concern to dam operators if they are large enough to exceed the capacity of the dam, increasing the risk of structural failure and/or overtopping.
- Man-made floods. This applies to dams which enable the release of water to be controlled by the dam operator. It could be to create additional airspace to absorb a forecast flood, for dam safety reasons or for environmental flows to flood natural wetlands and floodplains. Typically, a release from a dam will be less than what the natural flow would be if the dam did not exist.
- Dam failure floods which are caused by the unexpected failure of the dam. Such floods may happen at any time (called a 'sunny day' failure, e.g. the cause could be an earthquake or a pre-existing deficiency in the dam).
- Dam failure floods resulting from floodwaters overtopping the dam wall.

A range of floods up to the Probable Maximum Flood (PMF) needs to be considered in planning. The most extreme flood will likely be the PMF combined with dam failure.

5.2.2 Community and environmental impacts

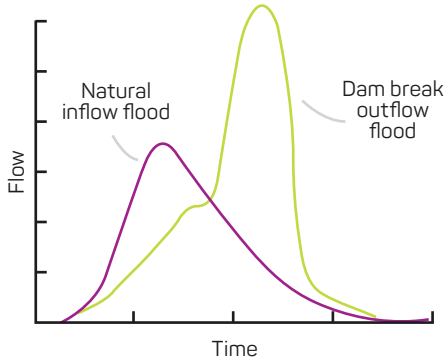
Dam releases can create difficulties if the people downstream are not expecting them or are not aware of the circumstances when releases need to occur.

Regardless of whether dam releases are controlled or not, the greater the flood volume relative to dam storage, the less is their potential flood mitigation effect. Furthermore, the potential mitigation effect of a dam decreases in a downstream direction, especially if there are significant inflows from catchments downstream. The mitigation capacity of a dam can be influenced by the available flood storage in the dam prior to a flood event. For example, a flood event occurring after a

period of sustained wet weather may generate higher downstream releases from a dam compared to the same event occurring after a dry period.

5.2.3 Dam failure

Dams also have the potential to fail and the subsequent dam-break floods can cause substantial damage downstream. The effect of dam failure on flood flows is illustrated in Figure 6. If managed through an appropriate dam safety management program, dam-failure floods involving a risk to life are rare events. However, if they happen, dam failures can lead to extremely rapid rises in downstream flood levels. These rises can occur with little or no effective warning especially if the population at risk is close to the dam.



EFFECT OF DAM BREAK

Figure 6: Effect of dam break

Dam failure can be caused by:

- flooding exceeding spillway capacity and overtopping a dam wall, resulting in structural failure of the dam
- earthquakes that cause damage to dams, resulting in their failure
- piping, cracking and seepage of water through the dam structure
- human-induced actions such failure of gate operations, structural deficiencies and terrorism.

'Sunny day' dam failures can result in downstream flooding at any time, regardless if there is a rainfall event. Meanwhile, dam failures which occur during floods can contribute to the flood event.

In some catchments the risk of cascade failure can be present when the flood wave released by an upstream dam failure results in the failure of a dam further downstream, further compounding the scenario.

Dam failure floods are typically much larger than any previous historical floods, can occur unexpectedly and behave in a manner that is different to a natural flood. Depending upon the effectiveness of emergency response measures, downstream communities located close to dams can have short warning times, though in the case of dam failures caused by extreme floods passing through the dam some downstream evacuations may have already occurred as a consequence of anticipated flooding of rivers or creeks. Often communities are evacuated early if a dam safety risk is identified.

5.2.4 Integrated planning for dams

An integrated approach to flood emergency planning is required. Communication and collaboration between the dam owner/operator and the emergency service agency, local government and relevant disaster planning groups are essential, along with agreement on the handover arrangements if required. There can only be one control agency, regardless of the number of agencies that may have control responsibilities for aspects of the response.

The identification of resources to manage an emergency event is an essential part of emergency management planning. Large dam owners/operators will usually have operational procedures to follow, including 24-hour contact information. Ensure that operational data and forward planning is provided to the emergency service agency. This will include joint definition of notification protocols based upon triggers for action.

Dam operators may maintain warning systems to warn communities immediately downstream of the dam. This is typically the case where the dam operator is most capable of providing warnings to residents directly downstream. It is essential that such warning systems are integrated with warning methods and procedures.

5.2.5 Dam safety emergency plans

Dam safety emergency plans (DSEPs), also known as emergency action plans (EAPs), should be prepared for all dams where there is the potential for loss of life in the event of a dam failure in consultation with emergency services. They are typically developed by the dam operator. ANCOLD and individual jurisdictions maintain legislation, requirements and guidelines for the development of these plans. Discussion in this section attempts to outline key principles and planners should refer to specific jurisdictional requirements for comprehensive guidance.

5.2.6 Considerations for incorporating DSEPs into flood emergency plans

The focus of flood emergency plans will be the management of flood consequences downstream of a dam. They should consider both 'operational' flooding, where there is dam discharge but the dam structure is

safe, and also dam failure flooding, which is likely to have far more serious consequences.

The dam owner/operator supplies information to the flood emergency planners regarding the likely discharges during floods as well as downstream consequences of dam failure. Types of information available include stage/discharge graphs, dam-break analysis reports, inundation maps and DSEPs.

Information relating to flood inundation includes:

- flood inundation maps for possible failure scenarios including sunny day failure and a range of flood events up to PMF, including the dam crest flood (DCF)
- flood inundation maps for a range of non-failure scenarios up to PMF
- the Annual Exceedance Probability (AEP) of the DCF
- the period over which dam failure might occur
- travel times for the flood wave to reach critical downstream locations (indicating both the front of the wave and its crest where possible)
- likely flood inundation durations, and flow velocities and depths.

General information includes:

- description of the dam
- any known defect or deficiency
- description of dam failure scenarios and description of likely downstream consequences and timings
- description of any special dam-failure alerting or warning systems, for example sirens or automatic-dialling telephone systems
- arrangements for the establishment and review of intelligence regarding the downstream consequences of dam failure (to identify/verify risk areas, action triggers, time frames and priorities), arrangements and responsibilities for the conduct of community education regarding dam failure
- arrangements and responsibilities for the establishment and maintenance of dam failure warning systems
- arrangements and responsibilities for notifying downstream residents of flood releases.

Information relating to failure mechanisms includes:

- a description of failure mechanisms for the dam, considering flood events exceeding capacity, structural failure (overturning, sliding and piping) and operational failure (gate operations or loss of communication)
- a description of the escalating triggers for action for each failure mechanism, with corresponding actions and communications protocols.

Considerations for response will include arrangements and responsibilities for:

- actions to be undertaken on receipt of dam alerts by dam operators
- the warning of at-risk communities
- the evacuation of at-risk communities, including the identification of suitable evacuation routes and shelters
- the restriction of access and security of evacuated areas
- reconnaissance of potentially affected areas
- the rescue of trapped and injured people
- communication arrangements between dam operators and emergency managers, and
- the resupply of potentially isolated communities.

5.3 Coastal flooding

Coastal flooding can occur in low-lying coastal and estuarine areas resulting from offshore storms such as tropical cyclones, and typically to a lesser extent, east coast low pressure systems and tropical lows. Intense storms generate storm surge that can be several metres above the highest astronomical tide and stretch for significant sections of coastline. Storm surges are most dangerous when they occur at hightide.

Coastal erosion is an associated risk but is outside the scope of this handbook. Emergency management planners may need to consider the potential impact of erosion on unstable shorelines as well as coastal flooding, as this may affect evacuation triggers and arrangements.

Minor coastal flooding can be caused by king tides. Coastal flooding may also coincide with riverine flooding in estuaries further exacerbating flooding. Risks associated with coastal flooding will increase in the future due to sea level rise.

The primary emergency management strategies for responding to coastal flooding include warning and evacuation away from low-lying coastal areas to high ground. Shelter in place in multi-storey buildings should not be considered an alternative and only adopted as a measure of last resort. Shelter in place is constrained due to the limitations of identifying suitable buildings and the possibility of discouraging earlier evacuation to high ground, as well as the potential for unsafe conditions outside a building.

Flood emergency plans should consider:

- identification and mapping of areas at risk of coastal flooding
- warning systems for storm surge

- evacuation arrangements including key triggers and transport arrangements for at-risk communities on the mainland and on islands
- identification of buildings of last resort where individuals may be able to shelter if they fail to evacuate
- arrangements for the protection of coastal assets such as ports and moorings
- identification of tide gauges and wave buoy locations to monitor coastal conditions.

Various evacuation zones may be defined and triggered based on key thresholds forecast in warnings. Evacuation triggers ensure evacuations are completed before the onset of strong winds which may pose risks to evacuees.

5.4 Levee protected communities

A levee is typically a form of embankment designed to reduce the frequency of flood damages by reducing the exposure of the protected part of the community. Levees in Australia are often constructed from compacted earth. Concrete walls or steel sheet piling is used in some cases, usually where space is limited.

The amount of protection that a levee is designed to provide protection for is linked to the magnitude or frequency of flooding for which the levee has been designed or constructed. Freeboard is added to allow for uncertainties in the estimation of the design flood level and various factors including wind and wave action, local anomalies or variations in flood behaviour. The freeboard allowance also includes provision for settlement of the levee embankment, traffic or stock wearing away the crest and possible surface defects in the levee.

This means that the top or crest of a designed levee is higher than the design flood level used as the basis for protection.

The typical cross-section of an earthen levee is shown in Figure 7.

There are circumstances where levees are built with no freeboard. Sometimes a section of levee might be intentionally lower to allow for water to enter the protected area in a controlled manner, reducing the likelihood of catastrophic failure of the levee. When a flood higher than the design flood occurs, zones within the protected area of first inundation and the associated consequences and their progression are known with some confidence and the impacts can be better managed.

In some cases, levees may have been constructed without a formal design process often in response to a threatening flood without full engineering design. Decision makers may need to be more conservative when planning for these levees and they may require close monitoring to ensure they perform their desired function during an event.

Unless the levee has been designed and maintained to protect against the Probable Maximum Flood (PMF), there is a chance that at some future time a flood will occur that exceeds the levee's design flood level, overtops the levee or causes the levee to fail. Floodwater will be able to enter the previously protected area, risking life and property. A residual risk of flooding remains.

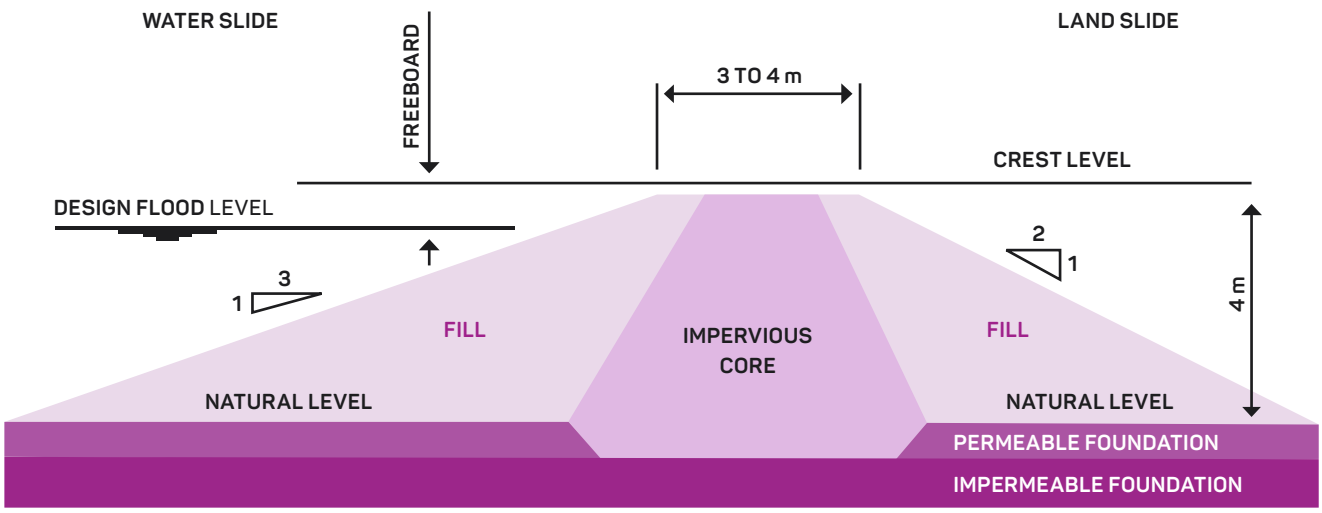


Figure 7: Typical cross-section of an earth embankment levee

(Source: NSW Levee Owner's Guideline: NSWPW Report No DC13140, NSW Public Works, 2015)

In Australia, very few levees have been constructed for a design flood level higher than the 1% Annual Exceedance Probability (AEP) flood. Many have been constructed to a lower design flood level.

The potential for overtopping or failure means flood emergency plans should be required for all communities protected by levees, with evacuation arrangements specified based on a range of considerations such as the condition of the levee and when floodwaters threaten the safety of the levee. For a designed levee this corresponds to the design flood levels. For a levee that has not been designed or maintained, levee experts should be engaged to estimate the potential failure levels by considering existing flow pattern, historic performance against floods, the condition of the levee and its maintenance history.

Portions of levees may also tie into roads or rail embankments (which may not have been designed as water retaining structures) and may also require temporary designed barriers to manage flood waters. All actions and temporary works or structures that make up the design level of protection need to be understood and documented in emergency plans. Flooding can happen within protected areas without levee failure or overtopping occurring if heavy rainfall causes stormwater flooding within the protected area with or without closure of stormwater gates or other barriers preventing excessive runoff to escape. Pumps can in some cases be established in low-lying areas to reduce the impact of such flooding.

Ring levees (i.e. a town encompassed fully by a ring levee) with design height less the PMF are vulnerable to severe and catastrophic inundation if the flood height exceeds the design level, or the levee fails. These environments are effectively low flood islands where evacuation routes are cut before flooding occurs. Such environments require an understanding of flooding on infrastructure within the levee and in particular inundation of roads outside the levee to enable early evacuation decisions where flooding is likely to threaten the safety of the community within the levee.

Flood emergency plans outline arrangements for monitoring the performance of levees throughout the entirety of a flood event.

Communities protected by levees should also receive ongoing community education to maintain their awareness of the residual flood risk.

5.4.1 Levee overtopping and breaching

Inundation scenarios associated with levee safety include:

- breach before overtopping
- overtopping with breach
- overtopping without breach
- malfunction of a levee system component.

Properly designed and located spillways or preferred overtopping locations are often built into a levee so that when a flood higher than the design flood occurs, zones within the protected area of first inundation and the associated consequences and their progression are known with some confidence and can be better managed. Though some confidence can be given to overtopping at these locations, varying flood gradient can lead to overtopping initially at other locations.

A levee breach (i.e. an opening in the levee that water can flow through – a structural failure) can be triggered by several factors and can happen over a long period of time or very quickly:

- Overtopping of the levee crest - when floodwater reaches a level higher than the levee crest and overtops the levee. The flow of water can erode the crest of the levee, letting more floodwater into the protected area.
- Failure of the levee foundations – seepage of water through soils beneath the levee or scouring of levee foundations.
- Piping failure through the levee wall itself – seepage of water through the levee, e.g. through a poorly compacted zone or area adjacent to tree roots leading to internal erosion of the levee.
- Surface erosion – erosion of the embankment.
- Slumping of the levee embankment - slope instability.

The rapid and unexpected release of water or increase of water flow into the protected area resulting from a sudden levee breach could be expected to result in threat to life because of the likely volume, velocity and depth of that water, the rate of rise of ponding of water in the area and the short time available for evacuation. When a levee is overtopped, the crest and inside (dry side) bank can be eroded which in turn can lead to total structural failure.

5.4.2 Information about levees to be included in flood emergency plans

- Description of each levee, detailing location, purpose, construction type/material, size (length, height), age (date of construction/modification) and the communities protected. Ideally a map of the location of levees should be included.
- A summary of general levee conditions and any key areas of concern.
- Information about past floods and levee performance.
- The name, identification number and gauge zero for the flood warning gauge relevant to each levee.
- The design flood levels and freeboard.

Nyngan levee emergency

Nyngan was flooded on the 23rd of April 1990 after the ring levee system protecting the town was overtopped. It serves as one of the worst flood disasters involving a levee system in Australia.

Prior to the 1990 flood it was a popular belief amongst residents that the levee system protected the town entirely from flooding. Emergency levees had been built and protected the town from flooding in 1955 and 1976. Following flooding in 1976, permanent levees were designed to provide protection against floods similar in magnitude to the 1976 flood.

Residents defended their town by laying some 200,000 sandbags atop of existing permanent levees. Eventually, the sandbag levee failed, and the town became flooded. Once the levees failed flooding quickly occurred. All single storey buildings in the town were affected and infrastructure was significantly disrupted. That evening, residents were forced to flee their homes to seek shelter in areas of two storey buildings which were above the flood level. The next day the entire town of some 2500 people had to be rescued by helicopter and bussed to Dubbo.

The emergency committee had made decisions based on a belief that the combined levee and sandbag wall would be sufficient. These measures were overwhelmed when floodwaters rose higher than anticipated.

A key lesson from the flood was that emergency plans, including those for evacuation and rescue, need to be developed before flooding to guide responses to the inevitable scenario of levee overtopping. Sandbagging of the levees should not be relied on to ensure the safety of the community. In the case of communities protected by ring levees, early evacuation must be considered before evacuation routes are cut.

- An outline of how the levee needs to be operated in the lead up to and during an event and the associated responsibilities. This may include locations of any parts of each levee which need to be closed other than drains (e.g. gates for roadways and railways) and the height relative to the relevant flood warning gauge that action must be completed by and typical available timing. Consideration should also be given to the readiness of equipment and personnel to perform such tasks.
- Likely locations of levee overtopping and the sequence of overtopping and flooding.
- Requirements for monitoring performance.
- Triggers for initiating evacuation before imminent failure.
- Size of the population, the number of residential and commercial properties and critical infrastructure or environment affected by levee overtopping or failure. This output, if possible, should be expressed in relation to a variety of flood magnitudes, including a worst-case scenario.
- The height, relative to the relevant flood warning gauge, at which any controlled spillway built into the levee operates.
- Areas protected by the levee that are liable to flooding from other sources (e.g. stormwater runoff).
- The pattern of inundation or a description of any drainage issues behind the levee.
- Possible scenarios in terms of the length of time it might take to flood the area behind each levee and the pattern of inundation.
- Evacuation routes and considerations.
- Details of ground features (topography) inside (landside) of the levee or levee system and the height of potential high points of land relative to the relevant flood warning gauge that could be used as refuge of last resort.
- Details of any critical issues such as the structural integrity of the levee or maintenance history.

5.5 Vulnerable developments and events

All vulnerable developments and events need to be considered in flood emergency planning. Planning should refer to the *Australian Standard for Planning for Emergencies in Facilities* (AS 3745).

This section provides some further guidance specifically on caravan parks and camping areas, tourism events and schools that are frequently located in flood prone areas.

5.5.1 Caravan parks and camping areas

Many caravan parks and camping areas are located in low-lying areas close to streams or beach fronts making them susceptible to inundation. Whilst the loss of services including power, sewer and water creates significant issues the instability of caravans can place occupants at high risk. Even shallow flooding can cause significant damage. Caravans float easily and can be washed away. Often caravan park occupants can have special needs. Though originally developed to allow mobile caravans to be mobile and occupants to be short-term many caravan parks now consist of fixed permanent caravan and cabin structures occupied by long-term residents. Caravan parks can also be filled with tourists that may not be familiar with the flood risk or the general area (Yeo and Grech 2006).

Flood emergency plans need to consider evacuation arrangements for caravan parks and that caravan parks maintain onsite emergency plans.

Flood emergency planning should consider:

- the locations of at-risk caravan parks and camping areas and the nature of these areas in terms of the number of occupants and the structures present
- triggers for evacuation and evacuation routes
- sites for caravans to be relocated to and facilitates available at sites (e.g. parks)
- arrangements for liaison between emergency services and caravan park and camping ground operators
- arrangements for the return of occupants and caravans.

Caravan park operators amongst other items should consider:

- procedures for providing warnings to caravan park occupants
- actions for the relocation of caravans and to secure non-moveable caravans.

Victoria State Emergency Service maintains a Caravan Park Planning Toolkit: **www.ses.vic.gov.au/get-ready/caravan-park-information**

5.5.2 Tourist events

Tourist events may be held in areas that are flood liable. Detailed considerations for the development of emergency plans relevant to events are contained in *Safe and Healthy Crowed Places* (AIDR 2018). Flood emergency planners should work in partnership with event organisers to consider risks and appropriate strategies including possible inclusion in emergency management plans where these are held at frequent intervals in an area.

5.5.3 Schools

Schools located in flood-prone areas should be recorded in flood emergency plans and factored into wider strategies. The *Comprehensive School Safety Framework* (**https://www.undrr.org/publication/comprehensive-school-safety**) developed by the United Nations Office for Disaster Risk Reduction provides further guidance. Representatives of flood-prone schools should be engaged in the planning process.

Tamworth Country Music Festival

The NSW State Emergency Service in partnership with event organisers has developed and maintains a detailed flood emergency plan to manage the risk of flooding in low-lying areas of Tamworth where the annual Country Music Festival is held. The plan includes a description of the problem, and warning and evacuation arrangements. The plan is supported by communications with visitors to make them aware of the flood risk and evacuation arrangements. The plan has been successfully implemented during previous floods to evacuate campers to safety.

Appendix A: Typical local flood emergency plan structure

Some individual jurisdictions have developed local flood emergency planning templates. The structure described below is based on the local flood emergency planning template used in Victoria.

Introduction

- Approval and endorsement
- Governance
- Purpose and scope of this flood emergency plan
- Municipal/local flood planning committee (M/LFPC)
- Responsibility for planning, review and maintenance of this plan

BEFORE: Prevention and preparedness arrangements

- Community engagement and awareness
- Structural flood mitigation measures
- Non-structural flood mitigation measures
- Exercising the plan – education and training
- Flood warning
- Local knowledge

DURING: Response arrangements

- Introduction
- Activation of response
- Responsibilities
- Emergency coordination centre or equivalent
- Escalation
- Control
- Incident controller (IC)
- Incident control centre (ICC)
- Divisions and sectors
- Incident management team (IMT)
- Emergency management team (EMT)
- Actions on receipt of a flood watch/severe weather warning
- Actions on receipt of the first and subsequent flood warnings
- Initial impact assessment
- Preliminary deployments

- Response to flash flooding
- Evacuation for all flooding
- Flood rescue
- Aircraft management
- Resupply
- Essential community infrastructure and property protection
- Disruption to services
- Road closures
- Dam spilling/failure
- Waste water related public health issues and critical sewerage assets
- Access to technical specialists
- After action review

AFTER: Emergency relief and recovery arrangements

Appendix A: Description of Flood threats
Appendix B: Typical flood peak travel times
Appendix C: Arrangements for individual communities within the local government area
Appendix D: Flood evacuation arrangements
Appendix E: Public Information and Warnings
Appendix F: Maps and Schematics
Appendix G: Local knowledge arrangements
Appendix H: Local flood information

Appendix B: Sample flood intelligence card

Flood Intelligence Record
Nevagazunda Gauge – Station Number: 310065

Monday, 2 February, 2019

Accuracy

Use this information as a guide to the possible effects of a flood. The card is based on estimates of flood behaviour and particular effects may occur at heights different from those indicated here. They may also occur at slightly different heights in different floods.

Confidentiality

This card may contain sensitive information about the effects of flooding on private property. Specific reference to private addresses or businesses must be made directly to owners or other emergency services but not via broadcast or print media.

Stream: Stopper River

Gauge Zero: 0.0m

Location: Located on the Nevagazunda Bridge over the Stopper River

Datum Type: AHD

Minor: 1.5m **Moderate:** 2.5m **Major:** 5.0m **Levee height:** 5.0m

Note: The Bureau of Meteorology is generally able to predict flood heights 12 hours in advance of major flooding at Nevagazunda.

HEIGHT (M)	CONSEQUENCES
1.50	Water starts to break out of the Stopper River, flooding low-lying farmland to the south of Nevagazunda. Livestock and equipment need to be relocated to higher ground.
2.50	1 in 10 year flood level
	The town common is flooded. This is a popular spot for campers during the summer months and during the annual Knee Knockers festival held in the last week of February. At the peak of the festival, up to 1000 tent sites may be occupied.
	Deck height of the old bridge over Kneys Creek. During flooding on the Stopper River, water can back up along Kneys Creek, closing this bridge and isolating up to 20 rural acreages east of Nevagazunda. During past flood events, access from these properties into town has been lost for up to one week.

HEIGHT (M)	CONSEQUENCES
3.50	The Nevagazunda Caravan Park is flooded. The van park has a normal occupancy of 50 people, but this can rise during peak periods to over 300. The park consists of 40 van sites, 10 of which are permanent, and 70 tent sites. Note: tent sites are located close to the river bank.
5.0	Peak height, 3 October 1974. During this event, a flood runner crossed Bank Road closing it to all traffic.
	1 in 20 year flood level. This is the design height of the Old Nevagazunda levee. The overtopping or failure of this levee will result in over-floor flooding of 100 residential properties and approximately 40 businesses in Old Nevagazunda. A further 20 residences will have flooding in their yards. There is a large proportion of elderly persons living in this area.
	Widespread rural flooding occurs in the areas south of Nevagazunda and approximately 15 rural homesteads are inundated over floor level.
5.50	Crest height of the Old Nevagazunda levee. The western approach to the Nevagazunda bridge over the Stopper River (on Kings Road) is now closed.
6.50	1 in 50 year flood level.
	200 residential properties and 50 businesses flood over-floor in Old Nevagazunda. A further 40 residences experience flooding in their yards.
	Water breaks out of the eastern bank of the Stopper River and flows into the lower south-western part of the Nevagazunda Central Business District (CBD), inundating 20 to 30 business premises.
	The northern approach to the Kneys Creek Bridge closes at the intersection of the Central Highway and Bank Road.
	All access roads to and from the Swampy Heights area are now closed by floodwater except the Queens Road. This road stays open until the 1% flood height (7.0 metres).
7.00	1 in 100 year flood level.
	Queens Road is closed to all traffic. This is the last evacuation route from Swampy Heights. Swampy Heights becomes a flood island. Further river rises will result in the flooding of properties in Swampy Heights.
	300 residential properties and 70 businesses flooded over-floor in Old Nevagazunda. A further 20 residences experience flooding in their yards.
	Extensive rural flood downstream of Nevagazunda with up to 30 rural homesteads inundated and many more isolated.
7.10	Floodwaters begin to enter Swampy Heights. Approximately 500 properties experience flooding of their yards.
7.60	Approximately 500 homes in the Swampy Heights area have flooding over the floor up to 0.1 metres deep.
7.80	Approximately 1000 residential properties in Swampy Heights experience over-floor flooding up to 0.3 to 1 metre deep.
	A minimum of 9 hours is required to evacuate Swampy Heights (assumes 28 door knocking teams available).
9.50	90 businesses in the Nevagazunda CBD are flooded over floor by this height.
10.50	1 in 200 year flood level.
	400 residential properties and 90 businesses flooded over-floor in Old Nevagazunda. 1000 residential properties experience over-floor flooding (2.8 to 3.0 metres deep) in Swampy Heights. 160 businesses flooded over-floor in the Nevagazunda CBD.
11.20	Probable Maximum Flood (PMF) level.
	500 residential properties and 120 businesses flooded over-floor in Old Nevagazunda. 1000 residential properties flooded over-floor in Swampy Heights (3.5 to 3.7 metres deep). 250 businesses flooded over floor in Nevagazunda CBD.

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