

A GUIDE TO BEST PRACTICE IN FLOOD RISK MANAGEMENT IN AUSTRALIA

McLuckie D.

*For the National Flood Risk Advisory Group
duncan.mcluckie@environment.nsw.gov.au*

Introduction

Flooding is a natural phenomenon that occurs when water covers land that is usually dry. Flooding can have devastating impacts upon communities.

Effective flood risk management can enable a community to become as resilient as practicable to floods. This is achieved through planning and preparing for, responding to and recovering (PPRR) from floods. This requires a coordinated, multidisciplinary approach across all levels of government and between agencies with different responsibilities and the support of non-government organisations, a range of industry professionals and the active engagement of the community.

The goal of increased resilience to floods requires the management of the flood impacts to both existing developed areas of the community, and in areas that may be developed in the future. Generally this involves a combination of flood mitigation, emergency management, flood forecasting and warning measures, land-use planning, and infrastructure design considering the local flood situation and the associated hazards. Decision makers in these areas, insurers and the general public need access to information on flood risk to make informed management and investment decisions.

The *National strategy for disaster resilience*, adopted by the Council of Australian Governments on 13 February 2011 (COAG 2011) recognised that a national coordinated and cooperative effort is required to enhance Australia's capacity to withstand and recover from emergencies and disasters. A disaster resilient community is one that works together to understand and manage the risks it confronts. Disaster resilience is the collective responsibility of all sectors of society, including all levels of government, business, the non-government sector and individuals. If all these sectors work together with a united focus and a shared sense of responsibility to improve disaster resilience, they will be far more effective than the individual efforts of any one sector.

The National Flood Risk Advisory Group (NFRAG), a reference group of the Australian and New Zealand Emergency Management Committee, instigated a review of a series of five inter-related documents on floodplain management in the Australian Emergency Management (AEM) series. The manuals are *Managing the Floodplain* (AEM19), *Flood Preparedness* (AEM20), *Flood Warning* (AEM21), *Flood Response* (AEM22) and *Emergency Management Planning for Floods Affected by Dams* (AEM23). They provide guidance on best practice principles as presently understood in Australia, rather than describing current practice. The term 'best practice principles' is used in its broadest sense to mean the underlying principles that need to be considered when formulating management plans, leading to effective and sustainable land use across Australia's floodplains.

NFRAG is finalising the update of the last of these documents, *AEM19* which provides broad advice on all important aspects in managing flood risk in Australia. It is designed to be able to be used, where desired, to provide a basis for best practice within a State or Territory when used within a framework of administrative and technical guidance. This provides flexibility in practice that considers the issues faced within jurisdictions. This framework will replace:

- *Managing the floodplain*, its predecessor.
- *Floodplain management in Australia: best practice principles and guidelines*, prepared for the Standing Committee on Agriculture and Resource Management (SCARM) of the Agriculture and Resource Management Council of Australia and New Zealand (SCARM Report No. 73, 2000).

Application of Managing the Floodplain AEM19

AEM19 provides advice on management of flooding within the floodplains and catchments of waterways due to the following type of flood events:

- Catchment flooding from prolonged or intense rainfall. This can come from rivers and other watercourses, local overland flowpaths and groundwater systems.
- Coastal flooding in lower coastal waterways can be due to tidal or storm-driven coastal events, including storm surge. This can be exacerbated by wind-induced wave generation. Tsunamis are out of scope as they are dealt with in *Tsunami emergency planning in Australia (AEM46)*.
- Combinations of catchment and coastal flooding in the lower portions of coastal waterways where both can be produced by the same storm or a series of storms. Interaction and dominance of these sources will vary with location and configuration of the catchment, floodplain and waterway, and the storm cells.

The advice in *AEM19* can be used in managing floods in urban and rural areas, including water flowing overland to waterways. Its use in different locations should consider the varying issues, for instance:

- In rural floodplains, the scale of flood-dependent ecosystems means that environmental issues and maintenance of flow to these areas needs additional consideration and advice beyond *AEM19*.
- In local overland flood catchments that respond quickly to rainfall, no specific flood warnings may be possible and there may be little or no time to evacuate. Flowpaths are often ill-defined and may flow through private property and be inhibited by buildings and fences. These problems often require specific local rather than more general management measures.

Best Practice Vision and Principles

Managing the floodplain aims to encourage practice that works towards the following vision for flood risk management in Australia.

Floodplains are strategically managed for the sustainable long-term benefit of the community and the environment, and to improve community resilience to floods

Best practice promotes the consideration and, where necessary, management of flood impacts to existing and future development within the community. It aims to improve community flood resilience using a broad risk management hierarchy of avoidance, minimisation and mitigation to:

- reduce the health, social and financial costs of occupying the floodplain
- increase the sustainable benefits of using the floodplain
- improve or maintain floodplain ecosystems dependent on flood inundation.

Best practice promotes understanding flood behaviour so that the flood risk to the community can be understood, effectively communicated and, where practical and justifiable, mitigated. It facilitates informed decisions on managing risk, and economic investment in development and infrastructure on the floodplain.

This does not require a sophisticated or consistent understanding of flood behaviour across all areas of Australia, as this is neither practical nor necessary. The degree of effort required and approaches used will vary depending upon the complexity of the flood situation, and the information needs of government and the community to understand and manage risk. These techniques can vary within a catchment, with more sophisticated techniques used in areas with concentrated exposure to risk or more complex flood behaviour and simpler techniques used in areas where flood behaviour is more simplistic or development less concentrated.

Flood risk management efforts may be prioritised considering the scale of potential growth in risk, primarily due to new development in the floodplain, and the scale of existing risk to the community. This may promote sustainable urban and rural land use planning practices that are cognisant of flooding, and limit growth in residual risk. It may also facilitate the treatment of risk (where practical, feasible and cost-effective) to limit the exposure of the existing community to flooding. Treatment may involve a combination of flood mitigation, emergency management, flood warning and community awareness – together with infrastructure design, and strategic and development scale land-use planning.

The flood risk management framework

The framework (Figure 1) was established to promote a risk management approach that facilitates the effective understanding and management of flood risk within a floodplain management entity (FME) service area. An FME is the government entity with primary responsibility for managing flood risk at a location.

The framework encourages the FME to collect, improve and disseminate the best available information on flood behaviour, and associated risks to the community, decision makers and other agencies with a responsibility for managing flood risk. This information may be derived from a floodplain specific studies and other sources (eg. historic events), and by applying approaches of different degrees of sophistication that are fit-for-purpose for the situation. The framework and its knowledge hub support the availability of this information so that flood risk can be better understood and managed.

The framework builds upon the floodplain management process. It provides flexibility for FMEs, which have different levels of resources and information, to manage flood risk and

work to improve their knowledge and management practices considering the scale and complexity of the flood threat faced by their community. Key principles of a best practice approach on which the framework is based are discussed below.

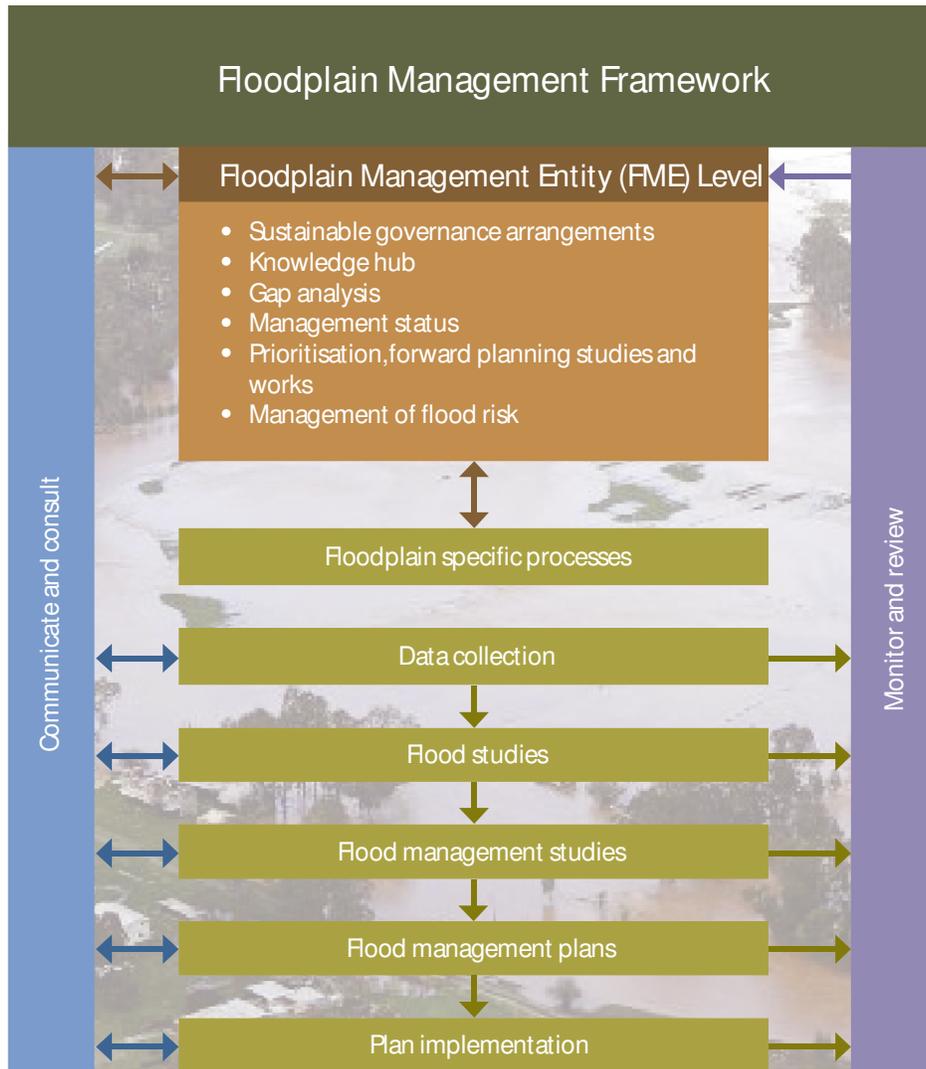


Figure 1: The flood risk management framework

A cooperative approach to manage flood risk

All levels of government need to work together actively to develop and implement integrated strategies to manage flood risk by providing clear and continuous governance arrangements, and legislative, financial, logistical and technical support to FMEs. Each State/Territory should develop and promote a comprehensive flood risk management policy supported by appropriate legislation, regulations, standards, guidelines and planning policies that clearly and unambiguously define the responsibilities and liabilities of agencies. Decision makers need to be aware of their duty of care for decisions on use of the floodplain, and for developing and implementing plans to manage flood risk.

AEM19 supports this approach by providing the framework which can be supplemented with administrative and technical guidance developed by jurisdictions, either independently or cooperatively. It supports co-operation in understanding and managing flood risk within a catchment which is important where land use or flood risk management practices in one FME may influence the flood risk in another FME.

A risk management approach

AEM19 outlines a risk management approach consistent with ISO31000:2009 *Risk Management*. It focuses investment on understanding and managing flood risk where it is needed most. Effort can be targeted considering current knowledge, the scale of flood risk to existing development, and the potential for growth in flood risk through increased development within the floodplain. Plans to manage risk are 'live documents' and need to be regularly reviewed to ensure they are current, able to be implemented and consider lessons learnt from any recent flood events.

A proactive approach

This involves considering the full range of flood risk early in the process of developing strategic land-use plans and in managing risk to the existing community. This aids development and implementation of sustainable plans to manage flood risk so that the community is more resilient to flooding. Being proactive also means that future communities are more resilient to flooding, where strategic land-use plans consider flood risk. Areas may be set aside for flood function, and where flood hazard is high and cannot be effectively managed. In areas suitable for development, risk is managed by limiting the types of development and using conditions considering the risk. Design standards can limit vulnerability of infrastructure to flooding so impacts are more manageable.

The community is encouraged to contribute to the understanding of flood behaviour and how risks are managed. This in turn improves resilience, because the community is better informed on risks and how to respond to the flood threat. Risks may also be reduced by treatments where these are practical, feasible, economic, and a priority within an FME service area.

A consultative approach

Public consultation is an important part of developing an understanding of flood behaviour, informing the community of the flood threat they face and producing sustainable floodplain management plans that have broad community support.

An informed approach

Previous flood events mean that there are few inhabited areas of Australia where there is no knowledge of flooding. This information is a starting point for understanding flood risk.

However, using this information without understanding the potential range and severity of flood events can result in poor management decisions – leaving the community unsustainably exposed to risk. Information from historic floods can be improved using investigative techniques and modelling to: increase understanding of these events; extrapolate to understand the range of flood behaviour; and assess treatment options to inform management decisions.

Supporting informed decisions

It is important that flood information is readily accessible to government (including decision makers, flood risk managers, land-use planners, and emergency managers), non-government entities (including infrastructure providers, insurers) and the community to provide the basis for informed decisions on investing in floodplains and managing flood risk.

Recognition that all flood risk cannot be eliminated

The community and government need to recognise that living in the floodplain has an inherent risk, and a residual risk will always exist. The level of this risk will vary depending on how exposed the area of the floodplain is to flooding, the development controls in place when the area was developed, and the measures implemented to manage flood risk.

Recognition of individual responsibility

Individuals within the community are responsible for informing themselves about flood risks, being aware of how to respond to a flood threat considering community response plans, and heeding the advice of relevant government and emergency management personnel during events.

Achieving best practice in flood risk management

The effort required to achieve best practice will vary depending upon the area of interest and current management practice. It begins with bringing together knowledge of flood risk and its management and communicating this to decision makers and the community. Where necessary, it then identifies and fills gaps in knowledge and management practice, so that risk can be better understood and managed.

The degree of sophistication necessary to improve knowledge and inform management will vary depending upon the current level of knowledge, the complexity of the flood behaviour in the area and the exposure of the community to flood risk. Improvements are likely to occur over time, depending on need and available resources. Efforts are likely to be concentrated where knowledge is insufficient to understand and manage risk and

where growth is planned which may alter flood behaviour and/or increase risk exposure or current exposure requires management.

This provides a robust, fit-for-purpose approach that works towards achieving the vision and best practice management. To help accomplish this, five key objectives should be met:

- Develop sustainable governance arrangements
- Make flood information readily available
- Understand flood behaviour and risk
- Understand and maintain the natural flood functions
- Manage flood risk to the existing and future community.

Developing sustainable governance arrangements

State and Territory governments are responsible for the management of the flood risk to local communities within their jurisdictions. As administrative arrangements vary responsibilities for land-use planning, flood warning, flood mitigation, and emergency response and recovery are assigned differently between government agencies and levels in different jurisdictions.

AEM19 encourages each State and Territory to develop, maintain and make readily available guidance that outlines these arrangements, relevant government legislative and policy direction. These arrangements need to:

- provide clarity on the legislative and policy framework across the PPRR phases of managing floods. This includes effective links between flood risk management, flood forecasting, flood warning, emergency management and land-use planning
- provide clarity about and communicate the management roles, responsibilities and liabilities of government, the community, industry and non-government organisations
- encourage a proactive and cooperative approach across governments to manage flood risk before events happen (e.g. by land-use planning, mitigation works, flood warnings and emergency management planning) rather than focusing on response and recovery
- encourage the local community and individuals to take responsibility for their actions when developing the floodplain and responding to flood events
- outline the support available to local communities to help with management.

Making flood information readily available

Information is essential to facilitate informed decisions by government, industry and the community on managing risk and investing in the floodplain. To achieve this, it is important to:

- make the best information on flood risk openly, transparently and inclusively available.
- collect and maintain data to achieve a better understanding and management of flood risk into the future
- encourage use of consistent terminology and mapping standards to help achieve a better understanding of flood risk

- develop information to aid the understanding and strategic management of flood risk and provision of this information to end users and decision makers
- support initiatives that inform education and engagement measures that will enhance community resilience to flood
- highlight that the local community and individuals are responsible to inform themselves about their flood risks.

The degree of flood knowledge required for effective management varies with the:

- exposure of the community to flooding
- complexity of the flood situation
- potential for growth in risk due to new development
- potential for change in flood behaviour
- information needs of different end users.

AEM19 suggests the use of a hub to develop and communicate knowledge on flood risk and its management to the community and decision makers. At an FME scale, the best available information is likely to be derived from different sources developed using different methodologies and standards. An FME can then, by considering the knowledge necessary to manage flood risk in their community, identify knowledge gaps and examine ways to fill these gaps. Developing a knowledge hub may be as simple for example as:

- Bringing the best available flood data into one location with a simple plan outlining where information exists, its sources and the quality and limitations of the data
- Developing an understanding of community vulnerability to the flood threat, and how this varies in a floodplain and between catchments (based on studies and historic data)
- Developing an understanding of the current measures to manage flood risk, so that these can be considered in decision making. These may include mitigation measures, and land-use and emergency management planning
- Maintaining a register of data, sources and quality, so that updates and changes can be tracked and communicated as necessary and reliability can be understood.

If the FME considered it necessary, the hub could be more sophisticated, such as a spatially based database of information.

The hub should be updated where improved knowledge on flood risk and/or its management becomes available, and as treatment measures are implemented. It should reference current investigations. Updating the hub's information may trigger the need for updated advice to the community and stakeholders, see Figure 2.

Communication is fundamental for sharing flood information within government and to the community, to inform flood risk management, emergency management, land-use planning and investment decisions. A communication plan may facilitate this by outlining how and when different stakeholders are informed and identify key points where proactive communication is important.

Conveying information is best achieved through spatial tools with supporting information. The ability to aggregate, convey and use this information for monitoring understanding and management of risk can be improved if:

- the information is transparent and openly available
- the basis, limitations and context are clear
- consistent terminology and formats are used

- output is generally tailored to broad end-user needs
- there is differentiation between degrees of impact
- treatment measures and their limitations are considered
- the information is monitored, maintained and continually improved
- the information avoids inadvertently giving the impression that no flood risk exists in an area when risk may exist above an arbitrary design standard
- it considers factors that may affect risk significantly into the future.

The information in the hub could be used for a range of strategic purposes, such as developing an FME or broader understanding of flood risk and management. This provides an opportunity to identify and assess gaps in knowledge and management (both in coverage and adequacy) so consideration can be given to how these can be managed. This can inform forward planning and resource allocation to improve knowledge and management of flood risk.

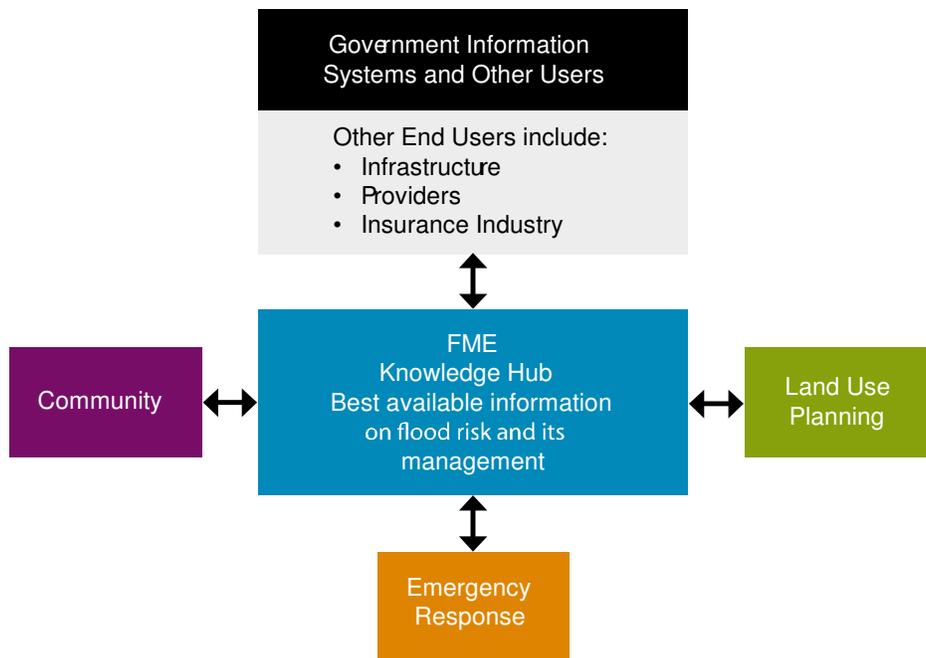


Figure 2: Communication from the knowledge hub

Understand flood behaviour and risk

Flood behaviour depends upon a range of factors, including the source of flooding, and catchment and floodplain location, size, shape, topography, vegetation, underground geological features and development.

AEM19 identifies understanding flood behaviour as essential for making informed management decisions. This includes comprehending the:

- range of potential flooding
- flood function of the area

- variation in flood hazard in the floodplain
- long-term changes in catchment and floodplain use (land use, rural practices, topography, environment, water table levels and flood mitigation and other infrastructure) which may adversely affect flood behaviour.

Flooding affects the health and safety of individuals and communities living in the floodplain and impacts upon the built environment. Risk results from the interaction of the community with flooding through occupation or use of the floodplain. Exposure to flood hazard varies significantly between and within floodplains, and between flood events of different magnitudes. People, buildings and infrastructure are not all the same, and their vulnerability to flood varies within these individual elements and between element types. There are generally three types of risk to be managed in flooding. These are:

- Existing flood risk is associated with current development in the floodplain. Understanding this risk informs decisions on whether to, and how to treat this risk.
- Future flood risk is associated with future development of the floodplain. Knowing the likelihood and consequences of flooding can inform decisions on where not to develop (where new development may affect flood behaviour, or where hazards cannot be managed), and where and how to develop the floodplain (to reduce risks to new development and its occupants to acceptable levels). This information can feed into strategic land-use planning.
- Residual flood risk. This is the risk remaining, in both existing and future development areas, after management measures (works, land-use planning and development controls) are implemented. It can vary significantly within and between floodplains. Emergency management and recovery planning, supported by systems and infrastructure, can assist to reduce residual risk.

Analysing risk involves understanding the likelihood of events and the severity of their consequences, which vary within the floodplain and between element at risk (community or built environment). It can inform decisions on the acceptability of residual risk, identify the need to improve confidence on estimates or understanding of risk, and inform decisions on where action to treat risk needs consideration.

Understand and maintain the natural flood functions

Flood behaviour is sensitive to changes in topography, development within the floodplain, and infrastructure crossing the floodplain, that may alter flood functions. Changes may lead to increased upstream flood levels and redistributed flood flows and/or increased downstream flood flows and levels, with the potential for adverse impacts upon the community and the environment. *AEM19* outlines that understanding the variation of flood function is important to identify those areas which are likely to be most sensitive to these changes. It is the first step to being able to maintain these functions and reduce the potential for changes in flood behaviour. It is generally determined in broader studies so it can be assessed at a strategic scale to allow for consideration of cumulative impacts. Maintaining flood function involves encouraging:

- maintenance or improvement of the capability of the floodplain to perform its natural function of conveying and storing floodwater, and supporting floodplain ecosystems dependent on inundation
- land uses that are compatible with the flood function

- infrastructure planning and design cognisant of flood function
- informed flood mitigation decisions
- floodplain and catchment management practices that are ecologically sustainable.

Managing or treating flood risk

Occupation of floodplains and management of the associated risks is a balancing act. It involves acknowledging that living on the floodplain comes with an inherent risk and understanding what adverse impacts the community is prepared to accept in return for the benefits of living on the floodplain.

Knowing the consequences of the full range of flooding can inform decision making on limiting the growth of risk resulting from new development and risk reduction to the existing community.

Although there is a common vision for managing flood risk, there is no single blueprint that can be applied in all flood environments. The most effective means of achieving sound management outcomes is to formulate and implement risk-based management plans through the floodplain-specific management process for a study area. This encourages balanced consideration of social, economic and environmental issues and consultation to inform decisions. Balanced management plans need to address risk to existing and future development, and residual risk in a manner that considers factors affecting floodplain use.

A plan should outline the recommended approach to managing flood risk. Existing risk is often managed by treatment measures that aim to reduce risk. Growth in future risk is principally limited through land-use planning in consideration of flood risk. Residual risk is limited by managing existing and future risk. It may be further reduced through effective community response to a flood threat, facilitated by evacuation infrastructure, flood warning, emergency management planning, education and assistance with recovery.

Achieving effective management involves encouraging and/or promoting the:

- management of existing, future and residual flood risk for communities using the range of treatments available
- engagement with, and active participation of the community in managing the flood threat they face
- inclusion of management outcomes in policies, planning instruments and forward plans
- strategic planning and use of floodplains as valuable and sustainable resources capable of multiple uses of benefit to the community. These uses should be compatible with the flood function and hazard, and aim to limit the impacts of flooding on property and infrastructure, and the wellbeing, health and safety of the community. It should consider long-term climate, cumulative land-use and demographic changes that are expected to influence risk
- identification, assessment and implementation of feasible, practical and effective options to treat intolerable risks to the existing community, considering their social, environmental and economic benefits and costs, and their sustainability.
- cross-catchment prioritisation of treatment efforts by FMEs to ensure efficient and effective allocation of scarce resources to treat risk

- sustainable emergency management practices that consider long-term climate variation, and cumulative land-use and demographic changes
- management of flood risk to infrastructure and the design of new infrastructure to limit its impacts on flood behaviour. Key infrastructure for emergency response and recovery needs to be fit-for-purpose when required
- continued aid to the community in recovering from the impacts of floods.

Risk treatment to new development

Growth in risks is traditionally managed by reducing the frequency of exposure of development and its inhabitants to hazardous flood situations. This is a risk management decision that balances the flood risk and the costs of living with this risk with the benefits of occupying the floodplain, in consideration of a reasonable level of service to the community. It is the community, not the land developer, who takes on this long-term risk, and the members of the community who may have their lives and their homes at risk.

It is generally reflected in the selection of the defined flood event (DFE) as the basis for general property protection. This should consider the full range of flood events, and take into account standards and guidance from government and industry. It can reflect what government and the local community may accept as a general standard allowing for a reasonable compromise between living on the floodplain and accepting the consequences of this choice.

In Australia, the 1 %AEP flood (plus a freeboard) is often used in government guidelines and policy instruments to define the standard for new residential development to limit growth in risk. A residual risk remains from floods larger than 1% AEP events. Suffering the economic impact of rarer events may have been seen as tolerable by default. However, the magnitude of residual risk varies, because the range of floods and the consequences of the same magnitude of flood can vary greatly between locations.

Therefore, there can be locations where adopting the general standard for development controls may result in a residual risk that is intolerable to the community. In these circumstances, additional localised development constraints may be warranted to further reduce residual risk. In addition, certain community groups and the types of development they inhabit may be more vulnerable to flooding and may need additional constraints. For example, aged care homes and hospitals can be difficult to evacuate and, therefore, may best be located where emergency response is relatively straightforward. Also, the likelihood of needing to react to a flood may be reduced by increasing protection levels.

The decision on an acceptable level of flood risk for general standards also depends upon the element at risk. Governments generally provide additional support or implement additional measures (e.g. flood warning systems, emergency management planning and infrastructure to support emergency management) to further reduce the threat to community members.

Key community infrastructure such as power supplies, communication centres, emergency response headquarters and evacuation centres may also require additional protection to ensure that they are fit for purpose in emergency response and recovery.

Risk treatment to existing development

The need to treat risk will depend upon whether the current level of residual risk is acceptable to the community and the availability of practical, feasible and cost effective solutions to manage this risk.

What level of risk is acceptable will depend upon who is asked, what their experience of floods has been and when they are asked. Accordingly, governments may make decisions in the 'public interest', yet remain mindful of the general need for a consistent standard. They may come to a decision in consultation with the community and in consideration of what may be considered reasonable general practice. In the flood context, this advice is often linked to flooding likelihood being a statistical probability.

When examining treatment options to reduce risk to existing development, it is not always practical, feasible or cost-effective to meet a general standard for protection applicable to new development. Lower standards of protection may provide significant reductions in the existing exposure of communities to frequent flood risk, and present a more feasible, practical and cost-effective solution. Treatment priorities should consider the current residual risk, and the relative benefits and costs of treatments of differing standards.

Conclusion

Managing the Floodplain, AEM19, when used by jurisdictions in conjunction with administrative and technical guidance, aims to provide the basis for best practice in flood risk management in Australia. *AEM19* is nearing completion and NFRAG is starting work on supporting guidelines to enable the handbook to be used, where desired, as part of the policy framework for flood risk management in individual States and Territories.

The handbook builds upon the sound foundation provided by SCARM Report 73 and other similar state based models, to promote a risk management framework that supports the allocation of scarce resources to understand and management flood risk to the community.

References

Emergency Management Australia (1999). *Managing the Floodplain: PART III Emergency Management Practice: Volume 3—Guidelines*. Emergency Management Australia: Canberra.

NFRAG Draft: *Managing the Floodplain Australian Emergency Management Series Manual*

NFRAG (2008) *Flood Risk Management in Australia*. *The Australian Journal of Emergency Management*. Vol 23, No. 4, November 2008

NSW Government (2005). *Floodplain Development Manual*. Department Of Infrastructure Planning and Natural Resources. DIPNR 05_020.

SCARM (2000) *Floodplain Management in Australia: Best Practice Principles and Guidelines*.

Agriculture and Resource Management Council of Australia and New Zealand, Standing Committee on Agriculture and Resource Management (SCARM). Report No 73. CSIRO Publishing, 2000.