Understanding and managing flood risk

Flood risk management guideline FB01

Department of Planning and Environment

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1. Introduction

Flood risk to communities is created by human interaction with flooding. This occurs primarily through the occupation and use of land that is affected by flooding. Studies under the flood risk management (FRM) process outlined in the *Flood risk management manual: the policy and manual for the management of flood liable land* (the manual; DPE 2023) provide the basis for understanding flood behaviour, constraints and risks and managing these risks.

Understanding flood behaviour, constraints and risks is fundamental to decisions on how best to manage risk into the future. To support effective consideration of flooding in management this guideline provides advice on:

- **understanding flood risk** (Section 2)
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  - understanding how these aspects may change into the future due to climate and catchment changes and future development (Section 2.6)
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  - using this information to understand flood risk and consider uncertainty (Section 2.8)
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- **Appendix B** provides examples of flood related planning controls and matrices for application in development control plans (DCPs).

1.1 Relationship to the manual and guidelines

This guideline builds on the advice provided in the manual. It supports councils in their role in delivery of the *NSW Flood prone land policy* (the policy) through the FRM process outlined in the manual.

This guideline refers to other FRM tools and guidelines, relevant state agencies and legislation. Details on these are provided in the current version of *Administration arrangements: flood risk management guideline AG01* (FRM guideline AG01). Links to FRM guidelines and relevant websites can be found in the 'More information' section below.

Information on the terms used in this guideline are available in the manual and FRM guideline AG01.

1.2 Audience

This guideline is written to support local council staff, state agencies and their consultants in understanding flood constraints and risks and how these may vary, and using this information to inform the management of flood risk to local communities.

2. Understanding flood risk

Risk is a combination of the consequences of flooding (Section 2.1 and Table 1) and the likelihood of these consequences occurring (Section 2.2).

The consequences to the community and the flood risk varies with the key constraints flood places on land (see Section 2.3 and Table 2), and a range of additional factors that can add to this risk (Section 2.4).

Flood risk to the community is not static over time. It can be influenced by FRM measures, climate change and future development. It is therefore important to understand risks with existing conditions (Section 2.5) and how these risks may change over time through future scenarios (Section 2.6) so that this change can be considered in management and broader decision-making.

Studies under the FRM process include the development and use of fit-for-purpose models (hydrologic and hydraulic models) that simulate flood behaviour which are:

- calibrated and validated against historic floods using best available information
- able to provide a reliable understanding of the full range of flood behaviour for the types of storms that drive flooding at the location
- able to be used to establish an understanding of flood behaviour and constraints with existing FRM measures and levels of development at the time of a study
- able to be used to understand changes in flood behaviour and constraints considering climate change, development and catchment changes (see Section 2.6)
- able to be used to assess the range of FRM options that may be needed to manage flood risk to the community through FRM, EM and land-use planning.

The importance of, and advice on, selecting the right scenario(s) to consider in decisions is discussed in Section 2.7.

The post-processing and interpretation of information from models can be used to inform the understanding of flood constraints and other factors that influence flood risk and how they vary across the floodplain. This can assist in understanding (Section 2.8) and managing flood risk and considering flood risk in broader decision-making. It can help to focus risk management (Section 3) efforts to the specific risks faced by the community or a section of the community in different areas in consideration of how these may change over time.

2.1 Consequences of floods to the community

Flooding may result in consequences to the community or varying elements of the community as indicated in Table 1. These consequences and the associated risks will vary:

- due to varying exposure to flooding
- across the full range of flood events
- between different areas of the floodplain and with the varying constraints flood places on the land (see Section 2.3 and Table 2) between and within the different elements, for example, situations that do not result in significant damage to property can be dangerous to people
- depending on the scale of the flood event – larger flood events will typically have more impacts than smaller events

- depending on the FRM measures in place – existing FRM measures such as levees and flood related land-use planning controls limit, but don't remove, flood exposure
- with a range of additional factors outlined in Section 2.4 and Table 3 and vulnerability (discussed in Section 2.8.3). Many of these factors are more important in areas of land with particular flood constraints. For example, evacuation limitations and effective flood warning systems and warning time are particularly important in areas that may become isolated and fully inundated by floodwaters.

The FRM process and advice in *Flood risk management measures FRM guideline MM01*, which provides advice on flood damage assessment) can assist in determining the consequences of floods on the community.

Table 1 Consequences to different community elements

Element	Description of issues
People in the community	Floods can cause fatalities, injuries and psychological impacts. The vulnerability of people in the community varies with aspects including knowledge of flooding and how to respond, age, fitness and ability. Both vulnerability and the degree of exposure to flooding influence risk.
The economy	Floods can have significant impacts on the community that may have implications, depending on scale, for the local or broader economy.
Social and cultural aspects	Floods can impact on social and cultural aspects in the community.
Service continuity	Floods can impact on the short- and long-term ability to maintain services to the community.
The natural environment	Floods can have significant impacts and benefits for the environment. FRM measures may have direct impacts (adverse and beneficial) on the environment, including ecosystems that depend on floods or flows for sustainability.

2.2 Likelihood of consequences

The consequences and risks of floods can change substantially between events of different scales. In addition, many FRM measures have a design height, tipping point or threshold at which their benefits diminish significantly or they no longer provide the intended protection. For example, the aim of FRM measures, such as levees, is to reduce impacts in events up to the levee design flood (see Section 3.3.1); and the aim of development controls, such as minimum floor levels, is to reduce impacts in floods up to the defined flood event (DFE) (see Section 3.4.2). The benefits provided are reduced where FRM measures, such as levees, are not fully implemented, effectively operated, maintained, upgraded or updated where needed.

The FRM process can provide information on the full range of flood behaviour (see Section 2.6.1). This can provide the basis for understanding the likelihood of the consequences of flooding occurring to the community with the existing conditions (see Section 2.5) and how this may change over time (see Section 2.6).

Example of how tipping points for an FRM work can vary

A levee provides flood protection from a river to a community up to a certain threshold or tipping point, generally a design flood. This tipping point is generally lower than the crest level of the levee by a freeboard allowance (see Section 3.3.2). Protection to this limit may rely on:

- the operation of the levee, including erecting temporary components or closing floodgates in the lead-up to an event, and operation of pumped drainage systems during an event
- effective maintenance of the levee so deterioration is limited and it can perform its intended function over its lifecycle. This involves regular inspections of assets, maintenance, testing and upgrading (where necessary) that is proactively responsive to changes in asset condition
- effective development controls to manage development in the vicinity of the levee. Any development in the vicinity of the structure may impact on its integrity and the protection it provides. It may also warrant additional development controls.

The protection provided by the levee may change over time if its condition deteriorates. This may mean the community needs to respond differently, in less time or more frequently, to flood threats. The protection provided may also be reduced due to:

- climate change impacts on sea levels and flood-producing rainfall events that can impact on flood behaviour
- changes in catchment characteristics
- impacts of development.

These implications need to be considered in decisions on asset management and upgrade and may also influence land-use planning and EM decisions.

2.3 Key constraints on land

Flood behaviour places constraints (including key constraints outlined in Table 2) on land that can influence management. There are also a range of additional factors that can influence consequences to the community and management (see Section 2.4). Studies under the FRM process can provide key information on flood constraints across the full range of flooding. Information may also be developed for different scenarios, including future scenarios (Section 2.6) and management options. The consideration of this information provides a basis for identifying the drivers for flood risk and can assist in focusing management efforts (Section 3). The flood constraints below can be mapped to provide a spatial awareness of their location and intersection with the community:

- flood extents indicate the areas impacted by a range of events of different probabilities, up to and including the probable maximum flood (PMF), which may have different consequences to the community
- flood function (see *Flood function FRM guideline FB02*) involves defining floodways and flood storage areas. The location of these areas varies across the extent of flooding in a particular event and across the full range of flood events (see example below)

- flood hazard classification (see *Flood hazard FRM guideline FB03*). This provides information on the relative degree of hazard the physical flood conditions can present for people, vehicles and buildings
- the range of variation of flood behaviour between events. Understanding the full range of flooding can assist in identifying where flood behaviour, particularly flood function and flood hazard in rarer events than the DFE (see Section 3.4.2), may warrant additional consideration
- flood emergency response classification of communities (FERCCs). These are derived considering the full range of flooding (see *Support for emergency management planning FRM guideline EM01*). They consider isolation of areas from places of community safety during a flood and the potential consequences to people who remain in these areas, considering the potential for inundation of the isolated area.

Table 2 Key constraints that flood behaviour places on land

Constraint	Description
Flood extents of different floods	Deriving flood extents for floods of different frequencies provides a basis for understanding the relative frequency of exposure of different areas to flooding.
Flood function See FRM guideline FB02	In any flood, flood affected areas perform different flood functions. These include flow conveyance in floodways (and flowpaths) and flood storage in flood storage areas. The remainder of the flood affected area outside floodways and flood storage areas is the flood fringe. Understanding where these key functions occur in the floodplain is important because changes in vegetation, topography and development in these areas can significantly affect flood behaviour. Floodways are important to convey floodwaters through the floodplain. Partial blockage of these areas due to changes in topography, installation of structures or intensification of development can cause a significant redistribution of flood flow. This can potentially result in the development of new flowpaths, increases in flood levels, extents or the length of time of inundation. Flood storage areas are important for storing water in the floodplain during a flood. If they are removed, the loss in storage will remove their ability to attenuate flood flows. This can result in an increase in flood flows that continue downstream with resultant impacts on flood behaviour and levels. Floodways and flood storage areas change with the scale of event. As floods get larger the extent of the existing floodways and flood storage areas will expand, new areas will fall into these categories, and some areas will change between these categories.
Flood hazard See FRM guideline FB03	This changes across the floodplain, during a flood event, and between floods of different sizes as the combination of peak flow velocity x flood depth change. Understanding the variation in flood hazard allows areas where floods are particularly hazardous to people, vehicles, people in vehicles, and may result in structural damage to or destruction of buildings to be identified.
Flood range	This considers how flood extents, flood function, depths, velocities and hazard can change with the scale of the flood event relative to the DFE. It can identify: • new areas affected by flooding in floods rarer than the DFE • where new floodways or flowpaths develop (in events such as the 0.2% annual exceedance probability [AEP] event, where the 1% AEP event is the DFE) • changes in flood depth, velocity and hazard. Interpreting these differences may benefit from the production of difference maps to support constraint mapping.
Flood emergency response classification of communities (FERCCs) See FRM guideline EM01	Flooding and terrain can isolate areas of the floodplain from safety and community support. People located in isolated areas are at additional risk from flooding than those who are in areas where they can readily retreat during floods to safe areas with community support. Areas that are isolated by flooding and then completely inundated as floodwaters rise can have additional adverse consequences for those who have not evacuated, and put their lives at risk. Determining FERCCs enables the variation in evacuation issues and consequences to be considered in management.

Example of variation in flood function with the scale of event

Flood function typically varies with the magnitude of the flood. This can be particularly important when areas with relatively benign flood conditions can develop into important floodways, resulting in more hazardous conditions in rarer floods. An example of this effect can be seen in Figure 1 for flooding in Dungog. The aerial images show outputs from modelling at this location for 3 different sized floods. These are:

- the 1% AEP flood (Figure 1a)
- the 0.2% AEP event (Figure 1b) – an event slightly larger than this washed away a number of houses and resulted in significant structural damage to another house and an industrial building
- an extreme event (Figure 1c) – this shows how the hazardous conditions within the newly created floodway across the road increase further compared to the 0.2% AEP event.

Without examining more severe events than the 1% AEP event, the circled location may have been considered suitable for development with the same controls generally applied to properties affected by the 1% AEP event. However, examining the 0.2% AEP event and an extreme event shows that a new floodway forms in centre of circle and creates significant risks to the development and its users, and these impacts increase as floods get larger. Understanding this potential for change in behaviour between the 1% AEP event and rarer events may lead to consideration of additional FRM measures in the affected area or in decisions to develop other areas of town in preference to this location.

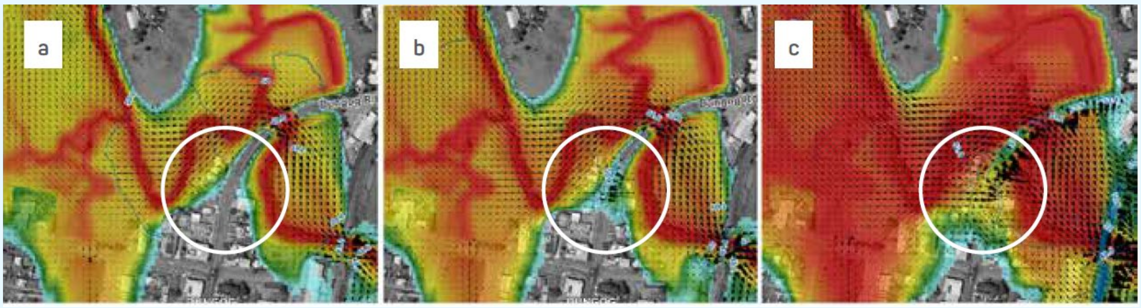

Figure 1 **Example of changing flood function with event scale: a) 1% AEP, b) 0.2% AEP, and c) extreme event**

2.4 Additional factors that influence risk

Additional factors that can influence flood risk are outlined in Table 3. These factors relate to the varying vulnerability of the community to flooding, how the community responds to flooding, and the impacts of flooding on the community and its ability to recover. These are all important issues to consider in management as they may influence decisions.

Table 3 Additional factors that may influence consequences to the community

Factor	Description of how it may influence community consequences
Vulnerability	Different types of development and their users have different degrees of vulnerability to the impacts of flooding (as discussed in Section 2.8.3). At the same level of exposure, the more vulnerable the development or its users the worse the consequences.
EM planning arrangements	EM planning arrangements (such as in local and state flood plans) can identify how different areas of the community may need to respond to a flood event.
Evacuation limitations	The availability of effective flood access that remains trafficable for long enough to allow evacuation to a place of community safety can directly influence the consequences of flooding on the community. Evacuation may have limitations due to: • the inability of individuals to self-evacuate • the suitability of the evacuation route, for example, the provision of all-weather road access • having to use non-trafficable routes for evacuation on foot – this is typically limited to able-bodied adults • flooding of the evacuation route – evacuation routes may be cut by floodwaters or local drainage, which can limit the available evacuation time • capacity of the evacuation route until it is cut, that is, the capacity of the road or pedestrian access within the available window for evacuation.
Flood timing, rate of rise and duration	• Timing of the flooding to reach key levels at critical locations (such as a low point on an evacuation route) can influence how the community needs to respond to a flood. Faster rising floods can leave little time for flood warning and response and may result in different EM decisions than if more time were available. • Situations where water rises more rapidly may impact on the consequences of floods, as people are more likely to be caught unaware or fail to evacuate before access is lost. In fast responding catchments there is often limited flood warning, which increases the potential for people to be quickly isolated and locations inundated. This increases the potential for them and rescuers to face a life-threatening situation. • The longer the duration of flooding, the higher the potential for people isolated from community services (including communication) and support to: experience medical emergencies; have shortages of medicines, potable water and food; and be exposed to secondary risks, such as fire. An extended period of isolation can also lead to decisions to venture into floodwaters or to request rescue (where communication channels exist). It can also exacerbate post-event anxiety and trauma-related disorders.
Effective flood warning	Flood warning is most effective in riverine situations where time is available before the onset of flooding. Well-developed flood warning services that are reliable, understood and acted on by the community contribute significantly to saving lives and protecting property. However, the ability to deliver

Factor	Description of how it may influence community consequences
	effective flood warning to communities can be limited by a range of factors, including the response time of the catchment and the availability of a total warning system for flooding for the area (from rainfall and water level gauges through to the ability to effectively deliver messages to the community).
Effective warning time	This is the actual time available to people in the community to undertake appropriate actions (e.g. evacuate or reduce damage). It is always less than the total warning time available, which includes time for emergency services to activate, warn the community, travel time to the point of safety, and a traffic safety factor.
Availability of evacuation centres and alternative accommodation	Evacuees may stay with family or friends outside the flood affected areas, but some may require access to a suitable evacuation centre with adequate community facilities and services that can house evacuees in the short term. In some cases, this may be required for an extended period and alternative accommodation may be required until floodwaters recede, and repairs to services, homes and businesses can be made.
Community flood awareness	Community awareness of the range of flooding and its consequences, and the need to respond to a flood threat and where to get advice on how to respond can influence readiness to respond and reduce complacency (often due to lack of experience with major floods).
Disruptions to community services	Services to the community (such as power, communications and water and wastewater services) may be disrupted in areas directly affected by flooding, and in indirectly affected areas. Disruption may occur during a flood event and impact on emergency response, however, depending on the scale of impact on services and the ability to re-establish them, disruption may continue for extended periods after floodwaters have receded. This can hamper the ability of the community to recover from the flood event.

2.5 Existing conditions

Many communities rely on existing FRM measures and practices, such as those outlined in FRM guideline MM01, to reduce the likelihood or consequences of flooding to limit the flood risk.

Understanding the flood behaviour with existing measures in place provides the basis for understanding existing flood constraints on land (see Section 2.3 and Table 2) and the additional factors that influence risk (see Table 3) and how these may vary across the community.

This can provide a basis for understanding the residual risk to the community with existing conditions and making informed management decisions. It also provides a foundation for considering how risks may change into the future (as discussed below) so that these changes can be considered in management.

2.6 Future scenarios

Flood behaviour changes over time. It can be influenced by climate change, and changes within the waterways, catchment and floodplain.

Changes can be natural, such as those occurring over time to the waterways and floodplain; can be due to development, resulting in changes to topography, reduction in vegetation and increased impervious areas; and be due to the implementation of new FRM works (see Section 3.3).

These changes can impact on the constraints that flood behaviour places on land (Table 2) the consequences of flooding (Section 2.1) and the likelihood of these consequences occurring (Section 2.2), and flood risk (Section 2.8). Understanding these changes and how they may vary over time can provide the basis for more robust decisions. Future scenarios that may need to be analysed include future climate scenarios (Section 2.6.2), future catchment scenarios (Section 2.6.3), future development scenarios (Section 2.6.4), and the combination of these scenarios (Section 2.6.5).

An additional aspect that can be considered in future scenarios is the deterioration in the condition of FRM measures. FRM measures such as levees, if not effectively managed, may fail to provide the desired level of protection to the community even if flood behaviour remains static over time which may increase the flood risks to the existing community. Understanding the potential impacts of failure can be achieved by modelling realistic levee failure scenarios or examining flood risks without a levee in place (for long duration floods). Comparing it to the base case can highlight the benefits of the levee to the community and importance of maintaining and upgrading these key FRM assets.

2.6.1 How the FRM process can assist

Understanding the influence of future scenarios on flood risk relative to existing conditions can enable these changes to be considered in FRM decisions (see Section 3).

The FRM process provides knowledge of flood behaviour so that it can be considered in decision-making. The tools used for understanding existing flood behaviour can be adapted to consider the range of changes discussed in this section. Other factors, such as changes to antecedent conditions can also be considered, where relevant information exists that is fit for purpose for FRM. It can assist in assessing the range of future scenarios as discussed in this section so that the implications of changes that occur in these scenarios can be considered.

The sensitivity of flood behaviour and consequences for the community of future scenarios should be documented in studies.

Issues to consider when examining changes in flood behaviour include understanding where there is a significant change in:

- flood behaviour in the DFE. This may include changes to flood behaviour and the constraints it places on land, such as the development of new floodways and changes in:
  - flood hazard in the DFE
  - flood levels in the DFE
  - flood extents in the DFE
- flood frequency, for example, due to sea level rise in an estuary where water levels more frequently reach a tipping point which results in impacts to the community
- flood behaviour in the PMF event, particularly as it may impact on EM arrangements
- the frequency of isolation and inundation of isolated areas
- the flood emergency response classification of communities (FERCCs, see FRM guideline EM01 for advice on their derivation) for different areas.

Understanding these impacts allows them to be considered when making decisions that have long-term implications, for example, decisions on where to focus future development in the community, how to manage major redevelopments, implications for EM planning and decisions to put in place or upgrade FRM measures such as levees.

2.6.2 Future climate scenarios

Future climate scenarios can provide an understanding of the potential impacts of climate change on flood behaviour so they can be considered in management.

Climate change can influence the following factors that can, where relevant, impact on flood behaviour. These include the:

- frequency and severity of flood-producing rainfall events
- antecedent catchment and floodplain conditions in the lead-up to floods. These are different to average conditions
- downstream boundary conditions to the ocean and in the tidal portions of coastal waterways due to sea level rise
- impacts of sea level rise on water levels in the ocean and coastal waterways. This may include both a rise in the mean and in some cases an increase in tide range. Higher water levels reduce the flow capacity and available 'air space' volume available to absorb floodwaters before overbank areas are inundated
- condition of the waterway–ocean interface or entrance. Sea level rise can affect entrance conditions. This is particularly important in coastal waterways with intermittently closed and open lakes and lagoons (ICOLLs) and untrained entrances. Sea level rise is likely to directly affect berm height and change the frequency of entrance breakouts in ICOLLs
- ocean storminess and wave setup. Changes to these may influence flooding in some areas of lower coastal waterways.

The sections below provide advice in relation to flood-producing rainfall events and sea level rise that are to be considered in studies under the Floodplain Management Program.

Flood-producing rainfall events

Climate change is expected to impact flood-producing rainfall events. Research continues into the scale of these impacts, therefore advice on how we consider changes to flood-producing rainfall events will need to be updated over time.

The Australian Rainfall and Runoff (ARR) Data Hub and *Australian rainfall and runoff 2019* (Ball et al. 2019) provide the interim climate change factors as both temperature increases and per cent rainfall increases based on the CSIRO's Climate Futures Tool. The ARR Data Hub can provide values applicable to a specific location.

ARR2019 recommends the use of representative concentration pathway (RCP) or shared socioeconomic pathway (SSP) values of 4.5 and 8.5. The ARR Data Hub uses temperature scaling to provide values for factoring of rainfall.

Table 4 shows the general changes to the intensity and volume of flood-producing rainfall events. This is based on a 7% change in the intensity and volume of flood-producing rainfall events for every 1°C change in mean temperature for the recommended scenarios of RCP4.5 and 8.5 from the CSIRO work. Using this multiplier with temperature changes identified on the ARR Data Hub indicates that for the year 2090, percentage changes in rainfall across NSW regions are between 10.6% and 14.4% for RCP4.5, and 22.5% and 30.0% for RCP8.5 (Table 4).

This information can be compared to trends in changes in temperature using other data sources, such as on the AdaptNSW website. This includes the NSW and ACT Regional Climate Change Modelling (NARCliM) project, which provides a range of climate scenarios.

Studies under the Floodplain Management Program are to take a practical approach for consideration of how changes in flood-producing rainfall events impact on flood behaviour. These studies generally consider the full range of floods, including rare events (such as the 0.5% [1 in 200 year] AEP and 0.2% [1 in 500 year] AEP floods) and the PMF to understand the impacts of these events on the community.

Table 4 Typical changes in rainfall for different representative concentration pathways (RCPs) in different locations

Year	% change in rainfall (based on 7% change in intensity and volume for every 1°C change in mean temperature)									
	Central Slopes		East Coast South		Murray Basin		Rangelands		Southern Slopes	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
2030	6.9	7.4	6.3	6.9	6.0	6.9	7.1	7.7	5.0	5.7
2040	8.5	10.4	7.8	9.5	7.6	9.4	8.8	10.8	6.4	7.8
2050	10.4	13.7	9.4	12.3	9.1	12.2	10.6	14.0	7.8	10.1
2060	11.8	17.2	10.6	15.7	10.4	15.5	12.0	17.8	9.0	13.0
2070	12.9	21.3	11.6	19.2	11.3	19.3	13.3	22.0	9.8	16.4
2080	13.9	25.3	12.5	22.7	12.2	22.8	14.1	26.0	10.4	19.5
2090	14.3	29.1	12.7	26.0	12.6	26.2	14.4	30.0	10.6	22.5

The 0.5% and 0.2% AEP events are in the order of 15% and 30% more rainfall than the current 1% AEP flood event respectively, although the actual difference varies with location and should be considered in individual studies. These events are considered to provide reasonable proxies for the scale of change to the 1% AEP event for changes to flood-producing rainfall events under RCP4.5 and RCP8.5 at 2090 respectively, with the 0.5% AEP event also similar to RCP8.5 between 2050 and 2060. They can be used for understanding the scale of impacts of change on flood behaviour and the community in the 1% AEP for these scenarios and time periods.

Reporting should discuss the changes in flood behaviour and compare these proxies to the actual changes for the different RCPs at the location and the time period of interest for the decision, for example 2090. The percentage change in rainfall intensity for these events relative to the 1% AEP flood event can also be compared to the estimated climate change projections from the methods discussed above for the desired time period.

Alternatively, the actual percentage changes in rainfall derived for the location and the time period of interest for the type of decisions being made could be modelled. This approach is appropriate where a rarer flood to the 1% AEP event is being considered for the DFE.

The impacts of climate change of flood-producing rainfall events should be analysed both separately and in combination with changes to sea level rise, discussed below, where relevant.

Sea level rise

Advice on modelling the interaction of coastal inundation (including storminess), catchment flooding and waterway outlets and the impacts of climate change on these factors are provided in *Modelling the interaction of catchment flooding and oceanic inundation in coastal waterways FRM guideline FB05*.

Flood risk management should examine the likelihood and consequences of sea level rise based on the latest locally relevant and broadly recognised projection. Consideration should be given to both near terms and ongoing sea level rise and its implications for flood risk in and around coastal waterways. Table 5 provides advice on projected changes to New South Wales mean sea level (MSL) from the International Panel on Climate Change's (IPCC) *Sixth assessment report* (AR6) (Garner et al. 2021) for medium confidence modelling. The medium confidence modelling includes ocean/atmosphere interaction but excludes ice sheet processes. This estimates that the very likely range of the highest projection (SSP5–8.5 or RCP8.5) is from 0.5 to 1.3 m by 2100 for the 95% confidence interval.

Table 5 **IPCC *Sixth assessment report* (AR6) New South Wales mean sea level (MSL) projections to 2150 (in millimetres)**

Year	SSP2–4.5		SSP5–8.5	
	Median	Likely range [5% - 95%]	Median	Likely range [5% - 95%]
2020	54	[−1–114]	57	[5–113]
2030	100	[37–176]	108	[43–187]
2040	148	[74–250]	168	[92–274]
2050	212	[114–353]	247	[149–394]
2060	270	[148–456]	329	[199–533]
2070	341	[196–577]	430	[266–701]
2080	416	[244–707]	545	[346–888]
2090	486	[284–835]	678	[438–1,111]
2100	564	[331–983]	814	[523–1,342]
2110	645	[353–1,136]	920	[528–1,578]
2120	722	[392–1,281]	1,052	[605–1,811]
2130	797	[430–1,425]	1,178	[680–2,039]
2140	872	[466– 1,567]	1,297	[749– 2,263]
2150	945	[502–1,708]	1,408	[812–2,481]

Source: IPCC AR6 (Garner et al. 2021).

Selected projections can be used to derive an understanding of flood behaviour with the changed conditions in waterways and at entrances, as outlined in FRM guideline FB05. Different amounts of sea level rise may need to be assessed to consider different time periods and different RCPs (or SSPs), based on these projections.

Reporting can discuss the potential for flood behaviour to change and the associated impacts for the period of interest for the decision, for example, for 2100.

The impacts of sea level rise on water levels and outlet berms should be analysed for the full range of flood events as these may all be influenced by the impacts of permanent sea level rise and it can significantly impact on the frequency of flooding in low-lying coastal areas. These impacts should also be modelled in combination with changes to flood-producing rainfall events as both will influence flood behaviour in the tidal reaches of coastal catchments.

2.6.3 Future catchment scenarios

Future catchment scenarios may consider the variation in land use in the catchment (including floodplain and waterway vegetation) over time. This may occur naturally or can include changes due to catchment management measures, which are sometimes referred to as nature-based solutions, or for other reasons including development or fires.

These measures may involve changes in vegetation through the introduction of increased native vegetation and removal of exotics in a combination of the waterway, floodplain and catchment. These changes have the potential to alter flood behaviour.

Changes in riparian vegetation in the waterway can result, over time, in an increase in the density of vegetation in the area. This has the potential to increase the travel time for flows along this corridor. This may result in slightly lower downstream flood levels but increased upstream flood levels. This may also extend the time of upstream inundation and result in more water flowing outside the waterway, limiting any potential benefits of extending flow times.

Where catchment management or nature-based solutions are being proposed as FRM measures it is important to consider that any increase in vegetation is not going to result in instantaneous changes to the catchment. There will also be a natural variability (including the impacts of floods and fires) in vegetation levels which limit their reliability as an FRM measure.

Flood modelling of future catchment scenarios needs to consider this natural variability and its implications on critical flood behaviour when making FRM decisions. A precautionary approach should be taken such that a range of potential outcomes are modelled so these can be considered in decisions. These may include:

- a scenario which represents only those benefits that will be realised and reliably maintained into the future. For example, the minimum density of riparian vegetation that can reasonably be expected to occur within natural variability (including floods and fires) would have the least benefit for the downstream community. However, this case would also present the least adverse impact on the upstream community
- a scenario which represents the impacts of the worst case on the upstream community. For example, within natural variability, the density of riparian vegetation that would have the highest impact on the upstream flood behaviour (potentially resulting in more flow bypassing the corridor) and the upstream community.

The impacts of any timing changes on flood behaviour need to be considered. This may alter the critical storm patterns or durations in the catchment. In addition, where different tributaries of a river have different times to the flood peak at a downstream location, slowing the flow of one tributary may bring its peak flow closer to that of the peak flow off another area resulting in adverse impacts on downstream communities.

The implications of environmental enhancements including introduced structures such as artificial weirs (and their failure during a flood) on flood behaviour should also be considered.

Developing an overall understanding of the variability of impacts, benefits and reliability of measures requires a number of model runs and configurations, and needs to consider how factors such as critical storm duration may be impacted. Understanding this variability is essential to being able to effectively consider potential changes in the catchment in decisions about flood risk to the existing and future community. FRM guideline MM01 provides advice on some of the typical aspects to consider in FRM plan development.

2.6.4 Future development scenarios

The cumulative impacts of development on flood behaviour and the risks to the existing community will vary with the exposure of the existing community to flood risk, and development patterns (i.e. the location, type, scale and configuration of the development).

Understanding the flood related constraints on land (Table 2) and the additional factors that can influence risk (Table 3) can provide an indication of the areas that are more sensitive to change and the issues that need to be considered in managing the impacts of change.

Future development scenarios should be selected to suit the needs of the location and the community. Options to consider when selecting scenarios may include one or more of the following:

- all identified future development proposals (both infill and greenfield development and assumptions on associated infrastructure)
- areas where pressure is expected for rezoning of land for more intense uses
- a time-related scenario, such as development expected within the next 20 to 40 years
- examination of full development of all land zoned for more intense development.

Future development scenarios should clearly identify the changes to the floodplain and catchment that are associated with the development and incorporate these changes into analysis. They may also identify expected works to offset development impacts in the DFE. For example, the use of community-scale detention basins to offset increase in peak flood flows due to development, and consider this is in a fit-for-purpose way in modelling.

This may involve a range of model runs that need to consider the implications of development on aspects such as critical storm duration.

Section 3.4 provides advice on limiting growth in risk through land-use planning.

Assessment of cumulative development impacts

Cumulative assessment of development impacts in studies under the FRM process may include analysis of various factors that influence flood behaviour, including:

- the frequency of flooding
- flood flows, volumes, levels, depths, velocities, hazard
- the flood function of different areas of the floodplain, for example the development of new floodways
- the timing of flooding and the length of inundation.

These changes may individually or incrementally result in detrimental impacts on flood behaviour and alter the flood risks to the existing and growing community. for example, new development increasing population in an area where evacuation route capacity and timing are limiting factors for a community EM strategy. This increase in population may further reduce the ability to evacuate the community within the available time window during an event. Where these impacts are significant, management options may need to be considered to address them, for example, evacuation road capacity could be increased.

To assess and manage the cumulative impacts of development on the existing community, councils may look to set acceptable limits for change. These limits consider the consequences of changes in flood behaviour to the flood risk of the existing community. As such they may vary between locations within the floodplain and between different floodplains.

In an area where the flood risk to the community is sensitive to change, lower acceptable limits may be set, relative to areas where risks are not sensitive to change. For example, for the same degree of change:

- the area affected by the change is likely to be significantly smaller in areas where flood gradients are steeper compared to flatter floodplains or areas where water ponds, such as upstream of waterway structures
- the scale of impacts of the change on the risks to a sparsely populated rural community may be different from a densely populated urban area.

Councils may develop advice on acceptable limits through the technical working group through the FRM process. This advice should outline the basis for setting these limits and the different areas they apply to. These limits can aid in setting the extent of floodways and flood storage areas, as discussed in FRM guideline FB02.

Table 6 provides advice on key considerations in assessing cumulative impacts and links these to the reason for considering this aspect. It also provides some initial values for allowable cumulative changes in flood behaviour (level, flow, inundation time and velocity) for councils to consider in the initial determination of floodway and flood storage areas and in subsequently setting acceptable limits for change. These values **should not** be used without testing, evidence and understanding the impacts of the change on the existing flood regime and on existing development.

The limits set for cumulative impacts are **not suitable** to use as limits for impacts for specific development or infrastructure projects. The limits for specific developments and infrastructure projects should be significantly lower (more conservative) as each project will have an impact that compounds to result in cumulative impacts that will be significantly higher. Development assessment is discussed in Section 3.4.9.

Table 6 Key considerations in assessing cumulative impacts

Key considerations in determining allowable cumulative impact	Reasons for consideration	Starting point for determining allowable cumulative impact through the FRM process, *not* for specific developments or projects
Flood level change	May identify: • a change in flood behaviour • increased inundation and damage to existing development • inundation of additional existing development • the creation of new or larger floodways or flowpaths • isolation of new areas	e.g. 0.1 m
Change in duration of flooding	May identify increased damage or increased duration of isolation	e.g. 10% increase
Velocity change	May identify increased scour potential and/or damage to structures and waterways	e.g. 10%
Flood extents	May identify increased extent of area inundated and more properties impacted	
Warning and evacuation time	May identify a decrease in available warning time and in the time available for evacuation	
Change in frequency of inundation	Properties may become flood affected in more frequent events Access may be cut more frequently Areas may be isolated more frequently	
Flood function categorisation change	May change flood function (e.g. flood storage to floodway) and change impacts of flooding on existing development	e.g. change of category
Hazard categorisation change	May reduce safety of vehicles, people or buildings	e.g. change of category

2.6.5 Combined future scenarios

An understanding of the combined impacts of the chosen climate change (Section 2.6.2), future catchment (Section 2.6.3) and development (Section 2.6.4) scenarios can inform FRM decisions that have long-term implications. This may involve a number of model runs to examine the variability of impacts so they can be understood and considered in FRM, EM, land-use and catchment management planning.

For example, the level of protection provided by an existing or proposed FRM work, such as a levee, may reduce in the combined future scenario relative to the existing case. This may lead to a decision to adapt the works (now or in future) to maintain or improve the protection they provide due to the potential changes in flood behaviour or impacts.

Different scenarios may be used for different time-related decisions. For example, emergency management planning needs to understand current condition, decisions on FRM works should consider the life of the assets, and land-use planning may use different timeframes for infill development in existing zoned areas compared to major new development areas or major redevelopment areas. The latter examples generally involve a permanent change in land use or density of use and increases the scale of community at risk.

2.7 Selecting the right scenario for your decisions

In selecting scenarios to inform different decisions, the likelihood of change should be considered. For example, while the magnitude of sea level rise by a given time is subject to uncertainty, ongoing sea level rise is considered virtually certain.

Depending on the decision being made, it may require information from flood modelling scenarios related to different time periods and assumptions. Whilst these will change with location and the issues being considered, Table 7 provides advice on the scenarios that should be considered to inform decisions.

This considers the planning horizons for, and consequences of, different decisions.

Table 8 provides examples of the scenarios that may be used to inform EM planning, FRM, land-use planning and infrastructure planning for the planning horizon relevant to the decisions being made. For example, EM planning needs current information. Whereas land-use planning may use different planning horizons for different decisions (i.e. 2050 for infill development and 2100 and potentially beyond for large-scale rezoning and major development and redevelopment projects).

This highlights that flood information will be developed for both the existing case and a range of future scenarios. Information from different scenarios needs to be clearly identifiable and separated and available to inform different decisions. This allows the information and any associated recommendations to be used to inform decisions in the right situation and context.

Table 7 Example of scenarios that may be considered to inform decisions

Scenario	Description	Range of flood events to model	Sea level rise	Flood-producing rainfall events	Catchment	Development	Infrastructure failure
Existing case (includes coast/ catchment coincidence)	E1. Existing base case E2. Current with infrastructure (e.g. levee) failure	All	Nil	Existing	Current	Current	Nil Yes
Sea level rise (SLR) (where relevant)	S1. 2050 S2. 2100 S3. 2100	Wide range to address frequency change due to SLR	2050 (median) 2100 (median) 2100 (95%ile)	Nil Nil Nil	Current	Current	Nil
Flood-producing rainfall events	F1. 2090 low F2. 2090 high	DFE (if 1% use 0.5% proxy) DFE (if 1% use 0.2% proxy)	Nil Nil	2050 2090	Current	Current	Nil
Combined coast and catchment flood coincidence change	CI1. Low change CI2. High change CI3. 5%ile High	See FRM guideline FB05	2050 (med) 2100 (med) 2100 (95%ile)	F1 F2 F2	Current	Current	Nil
Future catchment scenarios	CM1. Minimum for reliability CM2. Max. upstream impacts	Selected including DFE and PMF	Nil	Existing	Min. reliable Max u/s impacts	Current	Nil
Cumulative development	D1. Selected development scenario	Selected including DFE and PMF	Nil	Existing	Development only changes	Selected scenario	Nil
Combined future scenarios – development/ climate focus	CF1. 2050 CF2. 2100 CF3. 2100 (95%ile)	Wide range to address frequency change due to SLR	CI1 CI2 CI3	CI1 CI2 CI3	Current	D1	Nil

Table 8 Examples of use of scenarios to inform different types of decisions

Use of information	Description of case	Range of scenarios	Discussion
EM planning	• Current situation	E1	EM planning needs to consider current flood behaviour for the full range of events.
	• Current with infrastructure (e.g. levee) failure	E2	Advice on infrastructure failure can support understanding of ramifications for EM planning.
Flood risk management (for both base case and FRM options, such as levee upgrades)	• Current situation	E1	Understand existing behaviour and risk.
	• Current with infrastructure (e.g. levee) failure	E2	Understand consequences of infrastructure failure.
	• Future climate (tidal areas)	CI2, CI3	Understanding the impacts of climate change.
	• Future climate non-tidal	F1, F2	Understanding the impacts of climate change.
	• Development	D1	Understand the cumulative impacts of development.
	• Combined scenarios	CFS1, CF2 and CF3	Understand the future with development and climate change across a range of climate change impacts.
Land-use planning	Infill development in existing zoned areas and rezoning for small-scale redevelopment	E1, D1, CF1	To support understanding of the cumulative impacts of development and consideration of development controls for infill development and rezoning for small-scale redevelopments (2050).
	Rezoning for large-scale new development and redevelopment	E1, D1, CF2 and CF3	To support understanding of the cumulative impacts of development and consideration of development controls for major development and large-scale rezoning (2100).
Critical infrastructure	Current situation Combined scenarios	E1, CF1, CF2 and CF3	This provides a range of information to inform strategic decision-making on critical infrastructure considering the life of different assets.

2.8 Understanding flood risk to the community

Knowledge of the consequences of flooding for the community (Section 2.1) and the likelihood of these consequences (Section 2.2) provide the basis for understanding relative flood risk and how it may:

- vary between events of different scales
- vary across the floodplain
- vary between the different elements at risk, such as those in Table 1
- change over time with future scenarios
- be altered with the implementation of FRM measures.

Understanding these relative risks and their distribution across the floodplain and between the elements can focus management efforts. One way to show this variation in risk is to use a qualitative relative risk diagram, such as Table 9.

Table 9 allows relative risks (from very low to extreme) to be plotted for different elements (such as those in Table 1) for combinations of different likelihoods of flooding (from likely to extremely rare) and their consequences (from insignificant to catastrophic). This supports consideration of the full range of flood behaviour in understanding risk.

The scale of relative consequences used needs to be fit for purpose and can be tailored to the community. The *Australian disaster resilience handbook 10: national emergency risk assessment guidelines* (AIDR 2020a) provides some advice on consequence indicators that may assist.

Table 9 Simplified qualitative relative risk matrix

Likelihood of consequence	AEP range %	Level of consequence				
		Insignificant	Minor	Moderate	Major	Catastrophic
Likely	>10	Low	Medium	High	Extreme	Extreme
Unlikely	>1 to 10	Low	Low	Medium	High	Extreme
Rare to very rare	0.01 to 1	Very low	Low	Medium	High	High
Extremely rare	<0.01	Very low	Very low	Low	Medium	High

Example: Use of the relative risk matrix to plot average risks to different elements in the community

An existing town situated on a river suffered regular flooding resulting in the decision to construct a levee to provide protection to low-lying areas of the town. The levee is 20 years old, and some development has been permitted outside the levee. The levee reduces the likelihood of some flood consequences to development within the levee to events in excess of a 5% AEP flood.

The town is isolated from surrounding areas as floodwaters cut all the key roads from the area in a 10% AEP flood event. The nearest town that is not flood affected and has services to manage evacuees is 100 km away. The local flood plan identifies that there are areas in town where people can be safe and supported with community services (water, wastewater treatment) and resupplied in floods up to a 0.5% AEP event. However, some community services can be compromised in a 1% AEP flood.

The whole town would be inundated in the PMF. The PMF also affects the community hospital, impacts on community services that are critical for national communications, and floods council facilities, affecting service delivery. The environmental and cultural impacts of flooding are not considered significant in this case.

There are no formal flood warning arrangements in place for the town. The community is considered to have low flood awareness. Council requires consideration of historic flooding to new development but does not require any specific flood related development controls within the levee due to the level of protection it provides. The current risks are shown in the relative qualitative risk assessment matrix below.

An assessment of future scenarios has identified the impacts that climate change effects on flood-producing rainfall events are likely to have on the community. In this case it would change the frequency of major impacts of flooding on the community and in particular, on property, the economy and community services.

Likelihood of consequence	AEP range %	Level of consequence				
		Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Likely	>10	Community services People Property/ economy Social/cultural Environment (Low)	(Medium)	(High)	(Extreme)	(Extreme)
Unlikely	1 to 10	Social/cultural Environment (Low)	(Low)	Community services (Medium)	People (High)	(Extreme)
Rare to very rare	0.01 to 1	(Very low)	Social/cultural Environment (Low)	(Medium)	People Property/ economy (High)	Community services (High)
Extremely rare	<0.01	(Very low)	Social/ cultural Environment (Very low)	(Low)	Property/ economy (Medium)	Community services People (High)
Legend	**Extreme**	**High**	**Medium**	**Low**	**Very low**	

The council has considered the existing risks and how these may change over time, relevant government standards and the outcome of community consultation that low and very low risks are generally considered acceptable, medium risks are considered more tolerable, and that the focus of FRM investigations should be on managing high risks to people, property, the economy, and community services. Management of these issues needs to consider approaches to address risks to the existing community, and new development and redevelopment. It also needs to consider how these impacts vary across the floodplain and how they may change over time to adapt to the impacts of climate change on flood behaviour and the flood risks to the town.

Other important aspects to consider in understanding and managing flood risk are acceptability of risk (see Section 2.8.1), uncertainty (see Section 2.8.2) and the varying vulnerability of development to flooding (see Section 2.8.3).

2.8.1 Acceptability of risk

Decision-makers often use the risk evaluation process to understand risk and determine if further analysis is required to improve confidence in their understanding of risk and decide if action is needed to change current FRM practices to manage the risk.

The need to manage risk will depend on whether the current level of residual risk is acceptable to the community. However, as discussed in the manual this can vary. Accordingly, in the public interest, the NSW Government may provide advice on general standards for new development and redevelopment through the land-use planning system. Local councils then make decisions on local standards consistent with this advice. Councils may come to a decision on local standards in consultation with the community, and in consideration of NSW Government advice and guidance and general practice.

Standards are often linked to the likelihood of flooding as a statistical probability. For example, selecting the design flood (see Section 3.3.1) for a mitigation work such as a levee, or the DFE for land-use planning measures (see Section 3.4.2) is generally based on a flood of a particular AEP, or may relate to a historic flood event.

An example of using relative risk levels to consider the elements on which FRM investigations should focus is provided in the earlier example in Section 2.6.5, noting that risks will also vary across the community, and this variation needs to be considered when making decisions on the need to manage flood risk and in managing this risk.

2.8.2 Considering uncertainty

Uncertainty is an important consideration in FRM. Uncertainty in flood behaviour and its impacts comes from the variability of flood events and conditions in the catchment and floodplain, and a limited understanding of:

- flood history due to limited knowledge of historic flood events and the conditions in the catchment and floodplain during these events
- flood events and how catchment and floodplain parameters may affect flood behaviour
- the effectiveness of FRM measures to limit exposure of the community to flooding
- the ongoing effects of climate change on flood behaviour as discussed in Section 2.6.2.

Understanding uncertainty and limitations is inherent in FRM and flood modelling. Flood behaviour and model estimates have a range of uncertainties and limitations including:

- the estimates of flood behaviour and levels. Calibration and validation of models against flood flows, levels and timing of historic events by experienced modellers can improve confidence in models but does not remove these uncertainties. These models can then be transitioned to the appropriate scenario
- local factors that can result in differences between observed and modelled water levels across the floodplain. These factors are often not included in flood modelling because they are too difficult, complex or expensive to incorporate
- that wave action is not considered in one-dimensional (1D) or 2-dimensional (2D) hydraulic models. Models assume flat water surfaces and do not replicate the undulations in surface levels occurring in floods. Waves can result from local factors such as wind from meteorological events (which may be independent of the flood-producing rainfall event), movement of boats and vehicles through flooded areas, and coastal processes. In areas with long flood durations, the potential for a separate wind event to the flood resulting in wind waves is increased. Open coastal waterways with broad, deep entrances can also allow a high degree of coastal wave penetration.

To inform decision-making, models should:

- consider the full range of flood events up to and including the PMF

- examine the variability of design storm patterns and durations considering the nature of the flooding and the risks to the community, and the types of storms that drive flooding
- test the sensitivity of key modelling parameters (e.g. FRM infrastructure reliability, climate and vegetation) to change. Testing should focus on the key factors that affect flood behaviour and FRM decisions
- examine both existing and future scenarios as discussed in Sections 2.5 and 2.6.

Understanding uncertainty associated with modelling and modelling results is extremely important for decision-making. The issue being managed and the degree of uncertainty can influence whether FRM practices and approaches should be maintained or changed.

In general, FRM decisions that relate to a flood of a specific magnitude or AEP are more likely to be sensitive to uncertainty. This sensitivity may relate, in part, to a step change in the impact of flooding on the community once flood levels exceed a tipping point related to the chosen event. Examples of tipping points are provided in Section 2.2.

One way of addressing these limitations and the associated uncertainties is to apply a freeboard above the design flood for an FRM work such as a levee (see Section 3.3) or the DFE for land-use planning controls (see Section 3.4). The application of freeboard in these instances provides more certainty that the desired reduction in frequency of exposure to flooding, or level of protection, is achieved as discussed in sections 3.3.2 and 3.4.3.

FRM decisions that consider the full range of flood behaviour including the PMF, and provide for a range of responses relative to the scale of flooding, are generally less vulnerable to uncertainty in relation to the scale of flooding.

EM planning (see FRM guideline EM01) provides an example of where response may vary with the scale and timing of the flood. It still has tipping points, however, the critical aspects of these may relate to the timing of an evacuation route being cut by floodwaters rather than the peak flood level in the event. This requires consideration of uncertainty in relation to a range of factors as outlined in the example below. Considering this uncertainty supports the development of robust and adaptable EM plans by the NSW State Emergency Service (NSW SES).

Example: Considering uncertainty in the time available for a community to respond to a flood

Time to respond, that is, time to mobilise, issue a warning to the community and for the community to accept the message and evacuate before access is lost may be a key FRM consideration in some communities. Where this is the case, it is important to understand:

- the tipping points at which community response needs to change and what drives the tipping point, for example, is it the cutting of an evacuation route isolating the community once it reaches a particular level?
- the consequences to the community of failed evacuation before, for example, the tipping point is reached. Is the community likely to have somewhere to shelter above the PMF as a last resort if required?
- how critical the timing of closure of the evacuation route is to the emergency response of the community. The more time constrained the circumstances, the more sensitive outcomes are likely to be to change
- the range of historic flood behaviour and how the effects on the evacuation route have varied and how this affects community response
- a wide range of design storm patterns and sizes to provide an understanding of the scale of potential variation in the time for the community to respond. The event that results in peak flood levels may be different from the event that results in the critical time for evacuation before the evacuation route is cut. The time-critical event may still reach peak flood levels that have significant consequences for the community
- the uncertainty involved. This enables it to be considered in EM planning, perhaps through modelling of evacuation using timeline assessments (Opper 2004; Opper et al. 2009), or agent-based models (different approaches are discussed in Molino et al. 2014).

More advice on EM planning is provided in FRM guideline EM01.

2.8.3 Considering vulnerability of development and its users

Vulnerability of developments and their users to flooding should be considered in decision-making as it can influence risk to the community. Vulnerability to flooding can vary between development types and their typical users. Table 10 provides examples of relative vulnerability of users, buildings and their contents.

Table 10 Examples of relative vulnerability of land uses for the same flood exposure

Type of use	Relative vulnerability compared to low-density residential development			Comment
	Users	Buildings	Contents	
Low-density residential	Base	Base	Base	This is used as a baseline for considering relative impacts in other land uses.
Medium/high density	Higher	Lower	Lower	Higher density means more people are involved but the buildings may be more structurally resistant to flooding. Contents may be over multiple levels so less exposed.
Large lot residential	Lower	Lower	Lower	Lower density of development and people.
Community hospital	Higher	Lower	Higher	Patients more vulnerable in evacuation. Buildings can be stronger. Contents can be valuable and vulnerable if exposed.
EM facility	Lower	Lower	Lower	Lower density of development and people.
Aged care facility	Higher	Lower	Higher	Users generally more vulnerable in evacuation. Building may be structurally stronger. Potential for high-value medical equipment.
School	Higher	Lower	Lower	Users on average more vulnerable in evacuation. However, evacuation arrangements likely to be in place. Buildings and contents generally lower value.
Community facility	Varies	Lower	Lower	Users are generally itinerant and the type of users and their exposure to flooding will depend on the nature of the development. Buildings and contents expected to be of lower vulnerability or value in general.
Correctional facility	Higher	Lower	Lower	May have challenges in the relocation of users therefore continued operation preferable. This relies on accessibility for staff and utility services. Buildings and contents expected to be less vulnerable.
Service club	Higher	Lower	Lower	Employees may be able to be trained to assist in response to flooding. Higher density of customers, who are likely to be unfamiliar with location or flood issue and therefore more vulnerable. Buildings and contents expected to be generally of less vulnerable.
Commercial	Higher	Lower	Varies	Employees may be able to be trained to assist in response to flooding. Higher density of customers, who are likely to be unfamiliar

Type of use	Relative vulnerability compared to low-density residential development			Comment
	Users	Buildings	Contents	
				with location or flood issue and therefore more vulnerable. Buildings expected to be lower vulnerability. Contents varies substantially depending on the business.
Industrial	Lower	Lower	Varies	Employees may be able to be trained to assist in flood response. Customer density low, but they are likely to be unfamiliar with location or flood issue. Buildings expected to be less vulnerable. Contents varies substantially depending on the business.
Hazardous/ offensive industry	Lower	Lower	Higher	Employees may be able to be trained to assist in response to flooding. Customer density low, but they are likely to be unfamiliar with location or flood issue. Buildings expected to be generally of lower vulnerability. However, the impacts of released hazardous or offensive materials on the community and environment could be significant and need to be considered. This may require management measures such as avoidance of flood affected areas or effective containment of hazardous or offensive materials to limit impacts.
Agricultural	Lower	Lower	Varies	Lower density development and people. Agricultural buildings expected to be generally of lower vulnerability but this can vary. Contents varies substantially.
Recreation	Lower	Lower	Lower	Occupied less and may be weather influenced, but could be higher density of people when in use. Users often unfamiliar with flooding in the location. Buildings and contents expected to be generally of lower vulnerability or value.
Manufactured home estate	Higher	Higher	Higher	Higher density of building (including commercial and residential). Generally, homes are at a higher density but are smaller with lower levels of contents. Therefore, more people and more individual developments on the same land area.
Caravan park, camping ground or moveable dwelling	Varies	Varies	Varies	Vulnerability varies substantially. Higher density of users who may be itinerant and not flood aware. Generally, less buildings and contents. They may incorporate moveable assets (whose mobility can vary). The ability to relocate people and moveable assets in response to a flood varies substantially.

Notes:

1. All developments are assumed to be at the same level of exposure to flooding.
2. Relative assessment considers the varying development density.

Considering vulnerability in land-use planning (see Section 3.4) involves considering impacts on people and property as outlined in Table 10. This may lead to a decision to locate developments whose typical users are more vulnerable in emergency response to areas that are less constrained from an EM perspective. These may be areas where emergency response is relatively straightforward and achievable considering the additional factors outlined in Table 3, such as with available warning and within the available warning time. An example is provided below.

Example: Why location and type of development are important

All new development in the floodplain creates additional flood risk. Locating a development whose users are particularly vulnerable during flooding, such as residents of a high care aged care home, in an area that needs to be evacuated but is difficult to evacuate within the available warning time, results in a higher increase in risk and demand on limited EM resources than if it were located in an area where it could be easily evacuated in the time available or where evacuation is not required.

3. Risk management

Risk management is achieved through a hierarchy of:

- risk avoidance or prevention measures that reduce exposure to flooding and/or limit the frequency or scale of flooding
- risk reduction measures that mitigate the consequences or likelihood of flooding
- risk acceptance, accepting the residual risk that exists.

Effective FRM relies on understanding the full range of flooding and how flood behaviour and functions vary between events and across the floodplain, and over time and a range of activities, as outlined in the manual.

The FRM process provides the basis for understanding flood risk with existing conditions and how this may change over time with climate change and catchment and development changes through future scenarios (Section 2). This can provide a basis for considering whether current FRM approaches are sufficient (see Section 3.1) or they need to be modified to better manage flood risk (see Section 3.2).

As the nature of flood behaviour and the exposure of the community to flooding varies greatly between and within catchments and communities, the best way to manage risk will vary. Flood behaviour and drivers for flooding in the area, the vulnerability and exposure of the community to flooding, and factors including the flood constraints on land (Table 2) and the additional factors that may influence consequences to the community (Table 3) all need to be considered.

3.1 Is current flood risk management adequate?

Management of flood risk needs to consider whether existing management practices are adequate to manage flood risk to the existing community and future development. Considering flood risks under both existing conditions and future scenarios (see Sections 2.5 and 2.6), can provide the basis for understanding if current FRM is adequate to address risks today and into the future. The outcomes of this assessment may be that current FRM is:

- adequate for current and future conditions and no FRM modifications are required
- not adequate for existing and future conditions and modifications to FRM measures should be considered now
- adequate for current conditions but will not be adequate for future conditions and modifications to FRM measures should be considered now or in the future.

Adequacy may also vary between locations within the floodplain and between the different elements of risk (e.g. people relative to the built environment).

Examining the effectiveness of existing FRM measures and practices involves assessing whether they achieve their intended objectives both now and into the future, considering what is acceptable to the community (discussed in Section 2.8.1 and the manual). For example:

- Does a levee effectively reduce the frequency of flooding to the existing community to limit exposure of people and property to flooding, and will this benefit diminish over time?
- Does a flood warning system support effective EM arrangements so the community can safely and effectively respond to the full range of floods, and will this change over time?

- Do existing land-use planning arrangements, zonings and controls effectively limit the growth in flood risk due to new development to both the existing community and to the new development and its users? Is new development compatible with flood behaviour and risk and will this change over time?

An example of some of the issues that may be considered in relation to land-use planning controls is given below.

Example of considering whether land-use planning controls are adequate

The following questions may assist in determining whether existing land-use planning controls are effective or whether consideration of adjustment or additional measures may be warranted:

- **Cumulative impact of development on flood behaviour.** Is more intense development excluded or significantly limited in floodways and flowpaths in the DFE? Is any allowable development in these areas compatible with flood function? Could allowable development significantly alter flood behaviour, and could this adversely affect the flood risk to the existing development or community? If so, have effective and efficient measures been put in place to offset these impacts? Are controls adequate to address this issue?
- **Impacts of flooding on new development and its users.** What are the impacts of flooding on new development and its users with conditions in place? Are these impacts managed to an acceptable level?
- **Flood hazard.** Is new development located in an area where, if development conditions are met, it is compatible with flood hazard?
- **Risk to people in emergency response in events up to extreme events such as the PMF.** Has isolation from community safety and support been considered? Does a flood warning system exist and what are its limitations? Can the users of new development effectively self-evacuate to safety in the available flood warning time in extreme floods? Does the emergency response of the new development impact adversely on the existing community and can this be effectively addressed?
- **New development with a role in emergency response** (e.g. evacuation management headquarters). Is it able to fulfil its role in extreme floods or are other arrangements in place, and if so what are these alternative arrangements?
- **Consideration of climate change impacts on flood risk.** Does climate change have a significant impact on flood behaviour? Is this risk adequately managed? If not, what additional considerations are needed for new development?

This assessment may be done broadly and if there are particular concerns, changes or new FRM measures should be considered to address them. For example:

- If a particular type of development is not compatible with the flood constraints on the land (See Table 2) and cannot meet the associated FRM objective in a particular flood planning constraint category (FPCC) (see Appendix A), consider restricting that development to FPCCs where it can meet these objectives or introduce additional controls to address these constraints.
- If objectives cannot be met for all types of development in a range of FPCCs consider the need for broad changes to controls. For example, where there is a

broad issue relating to excessive damages or exposure of structures to flooding for all development, consideration could be given to raising the DFE and associated development controls. However, this needs to be balanced against the implications of this change.

3.2 Assessing existing flood risk management measures

Managing flood risk needs to consider the flood risk to the community and how this varies between events of different scales, in different areas and to different elements (Table 1). It also needs to consider how this risk may change into the future.

Where current FRM measures are considered inadequate to address the flood risk faced by the community (discussed in Section 3.1), changes to current measures should be considered to manage flood risk into the future.

Management of flood risks to the community can involve a combination of prevention, preparedness, response and recovery (PPRR) activities, as described in FRM guideline MM01. These measures may be suitable for use to address flood risk to the existing community, to the future community, and to reduce residual risks by managing continuing risks.

The FRM process provides the basis for understanding flood risk, making informed decisions on how to manage flood risk, and managing flood risk through implementation of FRM measures.

Examining how best to manage flood risk involves the assessment of FRM measures.

The suitability of different FRM measures to address the risks faced by a community will be specific to the community and their flood and development circumstances. FRM measures that are effective to address risk at a location will vary depending on:

- the risks that require management (e.g. risks to people or to the built environment)
- whether risks are dispersed or concentrated
- whether risks are to the existing community (Section 3.3), or the aim is to manage growth in risks being created by new development and redevelopment (Section 3.4), or whether continuing risk (Section 3.5) needs to be addressed
- whether climate change or other factors such as the cumulative impacts of future development, will significantly influence risks and the ability of FRM measures to manage flood risk
- what aspects influence flooding in the area, for example, waterway structures or entrance conditions
- the constraints flooding places on land (Table 2). For example, the natural flood functions of flow conveyance in floodways and flood storage identify where flood behaviour is particularly sensitive to waterway, topography, development, and in some cases vegetation changes. Changes in these areas may alter flood flows, velocities, levels, flood extents, inundation time, or result in the development of new floodways to the detriment of the existing community
- the additional factors that influence risk (Table 3). These include EM limitations that may relate to evacuation limitations, rate of rise of floodwaters, availability of effective flood warning and the effective flood warning time. These issues may impact on the effectiveness of FRM measures, EM planning and land-use planning measures in addressing flood risks.

Identification and analysis of FRM measures and the issues to consider in management include their:

- practicality and feasibility
- flood and emergency response impacts or benefits to the existing community
- effectiveness, efficiency and reliability in reducing flood risk to the different elements at risk across their lifecycle relative to their costs and disbenefits, including any environmental impacts
- acceptability to the community and decision-makers
- alignment with government legislation, regulation, policies and standards, and industry standards
- potential to attract funding where community affordability may be limited
- robustness to provide benefit considering the potential for changes into the future.

More information on FRM measures and their assessment is provided in FRM guideline MM01.

3.3 Managing flood risk to the existing community

Having examined the effectiveness of existing FRM measures and made a decision that the flood risk to the existing community needs additional management, options to manage this risk need to be considered.

Management of flood risk to the existing community aims to reduce the likelihood and/or consequences of flooding on the community. The ability to manage these risks can be constrained by the existing circumstances including the built and natural environment. This can limit the practical scale of risk reduction able to be achieved through mitigation. For example, for a flood warning system, the needs of the community, and system viability and effectiveness will vary with the speed of onset of flooding and the way the community needs to respond to a flood event.

As flood risks vary within the community and between different communities, the combination of FRM measures needed to address these risks will also vary. For example, FRM may involve considering upgrading, updating or implementing:

- FRM measures to reduce the frequency or scale of flood impacts on the existing community
- flood warning systems and evacuation routes that support community EM
- EM arrangements such as those outlined in local flood plans
- land-use planning arrangements to limit the impacts of development on the existing community and consider the varying flood constraints on land
- voluntary purchase schemes to remove the substantial safety risks to the users and their potential rescuers that cannot be otherwise managed.

Studies under the FRM process provide a mechanism for:

- understanding the full range of flood behaviour and associated risks to the community and how these may change in future due to climate change and development
- understanding where existing flood risk may warrant the consideration of additional FRM measures
- identifying, assessing and making informed decisions on FRM options that can address the risks faced by the community and are suitable for the specific circumstances of the community.

3.3.1 Determining a design flood for a mitigation work

An indication of the level of service of an FRM work is the design flood used for the work to mitigate impacts on the community.

Investigations into FRM works generally aim for these works to provide protection against a particular scale of flood.

The starting point for examining the design flood for a mitigation work may be the DFE or a similar scale historic flood as this is the same level of service that would be provided to new development in the community.

However, due to practical limitations, the costs of works, or other factors, it may not be possible to provide this level of protection to a community and compromises may result in acceptance of a lower level of protection. A higher level of protection can also be considered depending on the relative costs to benefits of the increased protection, where this is practical and feasible. It is not generally practical, cost-effective or feasible for flood mitigation works to provide protection for the PMF.

Multi-criteria assessment can inform decisions on FRM options and their service levels in consideration of the complementary and ongoing work associated with the various options. Advice on these aspects is available in FRM guideline MM01.

3.3.2 Freeboard for a mitigation work

Flood mitigation works such as levees use a freeboard above their design flood level to set crest levels of embankment structures. This freeboard is added to the design flood to provide reasonable certainty of achieving the desired level of protection. In effect, freeboard acts as a factor of safety that considers uncertainties and other factors identified below. It should not be relied on to give additional protection beyond the design flood to which it is applied.

The freeboard should be estimated in studies considering the following factors:

- uncertainties in the estimates of flood levels. These can arise from the relatively short record of past floods (and storm surges in coastal waters), together with uncertainties and simplifications in the models used to predict flood flows and flood levels
- local factors that can result in differences in water levels across the floodplain. Flood modelling can often not determine these factors, because they are too complex or expensive to model
- wave action is not considered in hydraulic models. Models assume flat surfaces and do not replicate the undulations in surface levels that occur in floods. Waves can result from local factors, wind from meteorological events, movement of boats and vehicles through flooded areas, and coastal processes. In areas with long flood durations, the potential for a wind event separate to the flood event resulting in wind waves is increased. Open coastal waterways with broad, deep entrances can also allow a high degree of coastal wave penetration
- the cumulative effect of subsequent infill development of existing zoned land in relevant areas outside the area protected by the levee. Modelling future development scenarios (see Section 2.6.4) can assist
- where the future climate has the potential to significantly increase risk within the life of the structure. An allowance for climate change may be built into the design, or the design may be constructed to be adaptable to allow for upgrade at a later date. For example, the land acquired for the construction of a levee allows for its future raising and widening to allow for climate change impacts on flood behaviour

(see Section 2.6.2), however, the levee is constructed based on existing flood conditions with a plan to upgrade it in future

- an additional allowance to offset uncertainties due to their nature and construction. For example, earthen mitigation works also need to consider:
  - post-construction settlement, which reduces the long-term level of the embankment
  - surface erosion due to vehicles, animals or pedestrians crossing, reducing the level of the embankment
  - the potential for significant surface shrinkage, cracking and associated additional risk of failure where good grass cover and appropriate moisture content cannot be maintained
  - the additional erosion caused by earthen structures overtopping that can lead to embankment breaches. This can result in fast-rising flooding and difficult evacuation, which is exacerbated when there is no vehicular access to flood-free land. Design of structures with appropriate reinforcement of spillways can reduce this potential.

The assessment of freeboard should be documented and included in reporting.

3.4 Limiting growth in flood risk through land-use planning

Effective consideration of flooding in land-use planning can limit the increase in flood risk as communities grow. It can lead to urban growth decisions, including permissible land uses and development requirements, that effectively consider flooding and are compatible with flood behaviour and hazard. This may result in recommended zonings of permissible development and development controls that aim to limit the growth of flood risk to the community due to new development and redevelopment. This supports community flood resilience.

New development can create additional flood risks due to the:

- impacts that flood events can have on development and its users
- impacts, including cumulative impacts, new development can have on flood behaviour and the flood risk to the existing community
- cumulative impacts of new development and its users on the flood emergency response of the existing community.

Flood risk may also be altered through:

- redevelopment including modification to existing development. This has the potential to have both positive and negative impacts on flood risks. Flood risks can be reduced where a more flood compatible new development replaces a development of the same or higher density. However, flood risk may increase where redevelopment affects the flood risks of the existing community or introduces more people into the floodplain at a similar level of risk to the existing development
- rebuilding after a flood considering current knowledge of flooding and associated development controls. This provides the opportunity to build back better and make the development more flood resilient than the original development.

Example: Building back better requirements

An FRM study and plan in an area has identified that flooding has significant impacts on existing development in an area. This resulted in the flood related development control requirements in council's DCP being updated. Meeting these criteria would result in new development or redevelopment that is more compatible with flooding and therefore more flood resilient.

A house in the area that was built to the older standards sustains significant structural damage in an extreme flood but is in an area where continued occupation is considered appropriate given available flood warning and evacuation capability. The owner decides to rebuild and upgrade the house. Building this house back according to new development standards would improve its compatibility with flooding and reduce its vulnerability to future floods. It would not remove all risk.

Decisions relating to land-use planning controls should also include consideration of future scenarios as discussed in Section 2.6, including cumulative impacts of future development (see Section 2.6.4).

Strategic land-use planning can support the development of land that is compatible with flood behaviour, constraints and risk in consideration of how these may change with development and future climate (as discussed in Section 2.6). It can limit the growth of flood risk due to development by effectively considering the:

- impacts of development and supporting infrastructure on flood behaviour and the flood risks to the existing community as outlined above
- full range of flood behaviour, the flood constraints on land (Table 2) and the additional factors (Table 3) that influence flood risks to the community as early as possible in the planning process
- vulnerability of different types of developments and their typical users to flooding, as discussed in Section 2.8.3 and Table 10
- roles of different community facilities in community flood response and recovery as discussed in Section 3.6
- advice from flood risk managers (as discussed in Section 3.4.1) and flood emergency managers (on EM arrangements and issues in the area) to ensure flood behaviour and risks are effectively understood and can be considered in decisions
- principles for land-use planning for disaster resilient communities (AIDR 2020b).

Developing and implementing land-use planning arrangements in local environmental plans (LEPs) and DCPs should be undertaken considering the:

- need to limit growth in flood risk due to new development, as discussed above
- flood related requirements of any relevant regional or district plans, state planning policies or planning circulars or directions
- local context of the:
  - land-use demands of the local community
  - land available within the community to meet these demands
  - other non-flood related constraints on land
  - full range of flood risk and the flood related constraints on the land (Table 2) and the additional factors that influence consequences to the community (Table 3) in different areas of the floodplain
  - the infrastructure needed to support the development.

This can support development that is more compatible with flood behaviour, constraints and risks that effectively considers and can limit the impacts of development on flood risks to the existing community. It can identify and influence:

- permissible land uses (through zonings, discussed in FRM guideline MM01) in different areas of the floodplain
- the controls necessary to support development and limit impacts of development on the community and the impacts of flooding on the development and its users. FRM guideline MM01 provides advice on typical development controls.

Outcomes of effective consideration of flood risk in strategic land-use planning

Strategic land-use planning that effectively considers the full range of flood behaviour, constraints and risks, and how these may change into the future (see Sections 2.5 and 2.6) can limit the increase in flood risk as the community grows.

It can inform decisions on where to develop, the type of development that is suitable in different areas of the floodplain, along with the flood related controls needed to manage the growth in risks to the development and its users, and due to the development.

The development and implementation of land-use planning strategies that consider flooding effectively can support sustainable community growth and community flood resilience through:

- the development of land compatible with flood behaviour, constraints and risk through appropriate zonings supported by development controls
- planning of road and transport infrastructure that supports public safety in large to extreme floods, including considering emergency access
- use of building design and materials that limit flood damage
- redevelopment or rebuilding after floods in a way that can reduce or limit the growth in flood risk relative to the existing situation
- LEPs and DCPs that effectively consider flood behaviour, constraints and risks.

3.4.1 Flood information to support land-use planning

Strategic land-use planning and development decisions should connect with the best available information and advice on flooding and the constraints flooding places on land. The flood information available can vary. It may have been developed for a range of different purposes and to different qualities. This information needs to be used within its limitations.

Flood risk managers can provide advice on:

- the best available fit-for-purpose information considering the full range of flooding and any relevant future scenarios. Local councils have been active in FRM for many decades, and there is a wide range of information available to support consideration of flooding in decisions. The best available flood information may come from a range of studies and from historic flood events. However, gaps exist in knowledge of flooding, including for areas where flooding has not been previously investigated. The suitability of available information will vary depending on the purpose and scale of the study and when the study was undertaken
- how this information should be used (including any limitations)
- where the information available to support decisions is lacking or needs improvement. This is particularly important where strategic decisions are being made to:
  - increase development density
  - change permissible land use to allow more flood vulnerable development in areas where it can impact on the existing community or result in significant future government spending on mitigation or recovery
- scoping of flood investigations to address knowledge gaps or to examine future scenarios (see Section 2.6)
- where development proposals may be required to derive flood information in a format required by the consent authority and undertake a flood impact and risk assessment (FIRA). A FIRA aims to determine the impacts of the development on the existing community and the flood risks to the new development and its users. *Flood impact and risk assessment FRM guideline LU01* can assist councils with scoping FIRAs.

3.4.2 Selecting a defined flood event

The selection of the DFE for an area is a key FRM decision and an important step in deriving information to support risk-based strategic land-use planning. The DFE is a large flood used as a general local standard for development controls. It is generally a design flood but key historic floods are used in some cases.

The selection of a DFE is a risk-based decision involving a merit-based approach consistent with the policy. The policy aims for compatibility of land use with flooding and limiting the risk of flooding to the development and its users. It does not aim to remove all risk to the community but rather to set a reasonable level of service that limits the frequency of exposure to and the consequences of flooding but does not unnecessarily sterilise land. Therefore, the use of extreme events such as the PMF as a DFE cannot generally be justified.

Studies under the FRM process provide the basis for making an informed decision on an appropriate DFE for the location or local government area, or for assessing whether the current DFE applied to the area remains appropriate for FRM into the future.

Selecting the DFE for typical residential development should generally start with the 1% AEP flood or a similar scale historic flood, but then consider rarer floods. The DFE provides a level of service that limits the exposure and growth of flood risk due to new development and redevelopment. Therefore, by adopting a particular magnitude of flood as the DFE it is accepted that rarer floods will cause more significant impacts. For example, in setting the current 1% AEP flood as the DFE, we are accepting that the development and its users will be exposed to significant impacts of flooding in events rarer than the 1% AEP flood and that their exposure may increase with climate change and development. Future scenarios (see Section 2.6) provide the basis for understanding the impacts of changes. Selecting scenarios for consideration in decisions is discussed in Section 2.7, with examples in Table 8.

As land-use planning decisions may result in rezoning, with new development and redevelopment expected to last into the future it is recommended that decisions on the DFE selected consider future scenarios for an appropriate time scale.

For example, for major developments or redevelopments this time scale should be long-term (2100 or longer) as land is generally rezoned for more intensive use. Increasing the density of development and number of people will generally result in significant additional risk. For smaller developments and infill developments in existing areas where the land is already zoned for the intended use, climate change impacts could be considered over a shorter duration, relative to the life of the structure where redevelopment over time is likely.

The selection of the DFE involves balancing the risks to the new development and the costs of living with them, against the benefits of occupying the floodplain. Selecting a DFE should consider:

- industry and government standards, guidance, directions and strategic planning instruments
- the current practice of the council. Most councils have an established flood event or DFE they use as a general minimum standard for the application of most flood related controls to development. The 1% AEP flood or a similar scale of historic flood event is often used for this purpose.
- the full range of flooding, up to and including the PMF and the associated constraints flood places on land and risks to the community. The scale of these risks can vary greatly with the consequences of flooding on the community from more extreme floods
- to the impacts of climate change and the cumulative impacts of future development on flood behaviour and the associated implications for the community (see Section 2.6)
- other FRM measures in place to reduce risks to the community that are relevant to the location. These may include:
  - measures to reduce the residual risks to people. These can involve flood warning, EM infrastructure, EM planning and arrangements, and associated community awareness. These considerations are relevant to all areas within the floodplain
  - the management of residual risks to property. This involves considering low probability events with high consequences to property. It can identify areas where it may be worth considering additional development controls to reduce damage. The FRM process can provide the basis for assessing the implications and costs relative to the benefits of a local or broad change in the DFE and allow for informed community input. This can support informed decisions, which will also be influenced by the scale of area affected. For example, where the identified area is:
    - localised, additional local controls may be recommended to address issues. The area to which these controls apply needs to be clearly identified
    - broadscale, a rarer flood may be considered for the DFE to identify both changed development standards and the area to which these will apply (flood planning area, FPA).

Where the DFE is considered inadequate to effectively address residual risks, recommendations on additional controls needed to limit residual risks and their application should be outlined in project reports.

Once selected, the DFE is generally used to inform management and land-use planning processes and controls. However, the full range of flood behaviour also influences decisions and land-use planning controls may apply outside the flood planning area.

3.4.3 Freeboard for land-use planning

Freeboard is added to flood levels to provide reasonable certainty of achieving the desired level of service expected from setting a DFE. Freeboard is added to the DFE to determine the flood planning levels (FPL).

Freeboard should be estimated in studies considering the factors outlined in Table 11. Where future scenarios (see Section 2.6) have not been considered in the DFE, freeboard may also consider how these scenarios may alter flood behaviour and the need to incorporate an additional freeboard allowance to maintain the desired protection level into the future.

Table 11 Typical factors that influence freeboard for land-use planning

Factor	Description
Uncertainties in the estimates of flood levels	These can arise from the relatively short record of past floods (and storm surges in coastal waters), together with uncertainties and simplifications in the models used to predict flood flows and flood levels.
Local factors	Local factors that can result in differences in water levels across the floodplain. These factors may not be determined in flood modelling, because they are too difficult, complex or expensive to incorporate.
Wave action	This is not considered in hydraulic models. Models assume flat surfaces and do not replicate the undulations in surface levels occurring in flood events. Waves can result from: local factors, wind from meteorological events, movement of boats and vehicles through flooded areas, and coastal processes. In areas with long flood durations, the potential for a wind event separate to a flood resulting in wind waves is increased. Open coastal waterways with broad, deep entrances can also allow a high degree of coastal wave penetration.

Freeboard should not be relied on to give protection beyond the DFE to which it is applied.

Example: Level of protection when adopting reduced freeboard

Where the 1% AEP flood event is selected as the DFE the intent is to provide protection from floods of this scale. However, if this is used with a zero (0) metre freeboard (negating the factors in Table 11), the effective protection provided to the community may only be from a 5% AEP flood or similar. This would result in the community being impacted 5 times more frequently by floods than intended and to a worse degree in a flood of the magnitude of the 1% AEP flood.

The typical freeboard used for flooding from waterways in New South Wales is 0.5 m. A freeboard higher than this may be necessary in some cases. This may be due to particular local circumstances, such as where estimated DFE levels are particularly sensitive to modelling assumptions or other local factors that significantly influence flood behaviour. For example, properties around a lake foreshore may be exposed to wind wave attack during a flood and a higher freeboard may be warranted to reduce the additional potential for above floor level flooding and associated impacts in areas exposed to these conditions.

A lower level of freeboard, 0.3 m, is generally only considered acceptable where there is very shallow water and where the influence of the factors identified in Table 11 is limited. This is generally limited to some areas affected by local overland flooding.

3.4.4 Setting flood planning levels

FPLs will generally be determined by government through the FRM process. FPLs are based on the DFE (see Section 3.4.2) plus a freeboard (see Section 3.4.3).

Different FPLs may apply in different areas as the DFE and freeboard selected for an area may be different due to the varying flood behaviour (e.g. shallow flooding from local overland flooding rather than deep flooding from waterways) and risks. In addition, different FPLs may be selected for different types of development, given the varying vulnerability of developments and their users to flooding (see Section 2.8.3) and the use of community facilities during a flood (see Section 3.6).

In areas where FPLs have not been determined or are being reviewed, studies under the FRM process may examine different DFEs and freeboards to support making an informed strategic decision in setting FPLs.

On some new land release areas subject to a planning proposal, council may require additional flood information to be developed as part of a FIRA (see FRM guideline LU01). This is typically required where the area hasn't been subject to a study undertaken through the FRM process, or the consent authority could not adequately assess the proposal with the available information, or to update out-of-date information. This may involve the examination of a range of key events including the DFE and the development of information on flood behaviour and constraints.

3.4.5 Setting the flood planning area

The flood planning area (FPA) is the area below the FPL for typical residential development (see Section 3.4.4). It is the area in which the majority of flood related development controls apply to most types of development. Different FPLs may be applied to different types of developments or for different purposes within the FPA.

Decisions may also be made to apply controls outside the FPA or to rarer events than the DFE to developments that are, or whose users are, more vulnerable to flooding.

Local overland flooding can vary substantially in an area and therefore a combination of mechanisms, freeboard and setbacks (sometimes referred to horizontal freeboard) may be applied in deriving the FPA. This provides the flexibility to address the different circumstances that occur in local overland flood areas. For example, the application of a nominated setback or horizontal freeboard from the extent of a flowpath in the DFE event may be used where depths are shallow and controls are aimed at maintaining flow conveyance in the flowpath and limiting impacts on development adjacent to it. The use of this approach for this specific case negates the need for development controls in areas further away from the flowpath where flow in the DFE is unlikely to impact on properties significantly.

3.4.6 Local strategic planning statements

Local strategic planning statements (LSPSs) assist councils to implement the priorities set out in their community strategic plan and actions in regional and district plans. Examples of some typical actions in these plans are also given below. They should set out the 20-year vision for land use in the local area and provide advice on how growth and change will be managed into the future. To meet these commitments, LSPSs should consider that councils are primarily responsible for FRM in their local government area and the example FRM actions in Table 12 when reviewing or updating their LSPS.

Example: Typical flood related actions in regional and district plans

These generally include a requirement to increase resilience to natural hazards and may involve flood related actions such as:

- locating more intense development, including new urban release areas, in locations where they are compatible with flood behaviour and constraints. This may result in more intense development located outside of highly constrained areas and development controls that vary with location and the flood constraints of the land
- developing, updating and implementing flood studies and FRM studies and plans consistent with the manual
- considering the best available flood information in LEPs and DCPs consistent with current flood studies, FRM studies and plans that are fit for purpose
- updating and sharing current flood information to allow decisions to be informed
- managing risks associated with future urban growth in flood prone areas as well as risks to existing communities.

Table 12 Examples of how local strategic planning statements actions can be implemented

LSPS action	Implementation
Review best available flood information and identify gaps and limitations. Undertake priority studies and develop FRM plans to address identified gaps and limitations	Collate and review the best available flood information in consideration of any FRM measures in place to reduce flood risks. Identify studies and data required to address gaps and limitations and improve knowledge and management of flood risk, including future scenarios and the impacts of climate change (see Section 2.6). Undertake priority studies and FRM plans to address gaps in knowledge or management of flood risk and fulfil FRM responsibilities in accordance with the policy. Update best available information (including flood mapping) to incorporate any new information, including changes in flood behaviour due to management actions or other development or activities.
Review and update planning instruments (LEPs and DCPs) and certificates to enable effective consideration of flood risk	Review and update LEPs and DCPs to limit the impacts of development on flood risk and EM risks to the broader community. Review and update LEPs and DCPs in consideration of flood and EM constraints to manage development so it is compatible with flood behaviour, hazard and EM. Review council's planning certificates to ensure notations incorporate best available flood information and accurately reflect flood related development controls.
Consideration of flood related constraints in areas identified for development, including in the LSPS	Consider the best available flood information and where necessary do studies to improve information or examine flood impacts to ensure: • any development in these areas is compatible with the flood behaviour, flood constraints, and flood FRM and EM measures • any land use or development in these areas does not impact on flood behaviour, flood risk and EM risk to the detriment of the existing community.

3.4.7 Local environmental plans

LEPs are environmental planning instruments usually prepared by councils, to regulate and guide development (permissible land uses and development densities) within their area of application. LEPs are available online through the NSW legislation website.

The development, update and implementation of LEPs should consider:

- state-level FRM, land-use planning and EM guidance
- local planning directions, statutory instruments and any associated orders and regulations issued under the *Environmental Planning and Assessment Act 1979* and any associated standard and non-standard planning controls in LEPs
- regional and district plans and other relevant state plans
- any specific legislative requirements of government
- recommendations from existing FRM plans
- the full range of flood behaviour and the flood constraints based on the best available flood information
- the impacts of climate change on flood behaviour (see Section 2.6.2)
- the impacts of catchment changes on flood behaviour (see Section 2.6.3)
- the flood risk to new developments and their users and the cumulative impacts of development on the existing community (Section 2.6.4)

- the availability and adequacy of flood information. Where adequate flood information is not available, informed decision-making may involve:
  - undertaking studies under the FRM process to address information gaps. These studies can provide broad strategic advice on flooding, including future flood scenarios (see Section 2.6) that can be considered in the update of LEPs and DCPs
  - additional requirements for FIRAs to provide information to support consent authority decision-making
- the requirement for a FIRA (see FRM guideline LU01) to be provided to identify local development impacts (see Section 3.4.9) to support the assessment of a development proposal. A FIRA is typically required where:
  - there is insufficient information on local flood behaviour and its impacts
  - the development may impact on flood behaviour and the flood risk to the existing community
  - the development may impact on the flood emergency response of the existing community
  - the development is outside the scope of future development scenarios that have been considered through the FRM process.

LEPs include a land-use table that identifies the land-use zones for the area covered by the LEP, the zone objectives, and the permissibility of various land uses within the zone.

Rezoning should consider the vulnerability of the different types of development to flooding (Table 10), flood related development constraints (Table 2), and the additional risk factors (Table 3). This can steer development to locations where it is more compatible with flooding (now and into the future) and limit the adverse impacts of the development on the existing community. For example, development that is not compatible with the flow conveyance function of a floodway should be located where it does not adversely affect flow conveyance, that is, outside of floodways.

As discussed in Sections 3.4.1 and 3.4.10, studies under the FRM process and advice from flood risk managers can support the development and implementation of LEPs.

3.4.8 Development control plans

DCPs provide detailed planning and design guidance to ensure the objectives of the LEP are achieved. The development, update and implementation of DCPs should consider the issues listed in Section 3.4.7.

DCPs can be documented in various ways, however, all DCPs should contain provisions that relate to areas within the floodplain where flood controls apply. In areas where flood related development controls are to apply, the DCP needs to identify: objectives for development to consider, the land uses compatible with the flood constraints or risks in different areas, the controls that are to apply to different types of development when located in different areas, FPLs and the FPA and relevant mapping.

To achieve this the DCP may break the floodplain down into different areas, such as:

- floodways (for techniques for determination see FRM guideline FB02), the FPA (see Section 3.4.5 of this guideline), and the floodplain. The floodplain is the area that is flooded in the PMF or an equivalent extreme flood. See Appendix B for an example
- flood planning constraint categories (see Appendix A.1 for more advice and Appendix B for an example)
- flood risk precincts (see Appendix A.2 for more advice and Appendix B for an example).

The approach councils decide to use may be influenced by the approach they currently use in their DCP, and the best available flood information (and its limitations). Studies under the FRM process can provide information in the relevant format.

3.4.9 Development assessment considerations

Development assessment considerations should link to the requirements of the consent authority, which may be outlined in the relevant state environment planning policy (SEPP), LEP, DCP or policies. The requirements identified by the consent authority may vary with the development type, location, flood behaviour, constraints, flood risk and the available flood information.

These requirements may also identify the need for a FIRA to support the assessment of the impacts of a development proposal, including those identified within a DCP as outlined in Section 3.4.8. A FIRA is typically required for:

- subdivisions or new developments in existing zoned areas
- to support new development through a rezoning process
- situations identified by the consent authority, including those outlined in a DCP. This may include areas where council has concerns in relation to the impacts of the development on flood behaviour, the flood risk (including EM risks) to the existing community, or in relation to the risks to the new development and its intended users.

FIRAs need to demonstrate consistency with the objectives and meet the associated flood related requirements of council's LEP, DCP (see Appendix B) and relevant policies. This may involve the provision of flood information, the assessment of the impacts of the development and its users on the flood risks and emergency response of the existing community. FIRAs may also need to identify how risks to the new development and its users have been considered. FRM guideline LU01 provides advice for consent authorities to consider in scoping FIRA requirements.

These assessments may require consideration of measures to minimise the impacts of development. Such measures include changes in infrastructure to support the development; changes to the scope, scale, location or type of development, or to development controls needed to manage risks to the development, or to manage the impacts and risks from the development to the existing community.

Acceptable impacts for individual projects

Modelling development projects as part of a FIRA enables their impacts on flood behaviour and flood risks (including EM risks) to the existing community to be understood and considered in development assessment. It should consider impacts at key hydraulic controls both upstream and downstream of the development site as well as key intermediate locations to clearly identify any changes due to development. FRM guideline LU01 may assist consent authorities in the scoping of a FIRA.

Wherever possible, development impacts should be contained within the development site or property being considered for development. Where this is not possible, consent authorities should consider whether the development maintains the continuity of floodways and links to critical storage functions of the floodplain (see Section 2.3 and Table 2), and whether impacts of the development are acceptable.

To do this councils may consider setting acceptable limits for the impacts of individual projects which:

- would be significantly lower than the limits used for assessing the reasonableness of cumulative impacts in strategic studies for future development scenarios (see Table 6 and Section 2.6.4)

- consider the key factors relevant to the site, such as those identified in Table 6.

These limits also need to account for the limited, less comprehensive modelling typically done in studies for development and infrastructure projects and associated uncertainty.

Other consent authorities should liaise with councils in relation to acceptable limits for developments in their local government areas (LGAs) when assessing projects.

Where impacts are assessed as being outside those considered allowable or acceptable by council, this may lead to the need to revise the development. For example, this may involve reducing the scale or density of development or excluding development not compatible with flood conveyance from floodways, or incorporating FRM works such as flood detention basins, as part of the development, to reduce the impacts of development on peak downstream flood flows and therefore flood behaviour.

3.4.10 How studies under the FRM process can assist land-use planning

Studies under the FRM process can provide information to support the development and implementation of strategic land-use planning for communities. They can also provide the basis for flood risk managers to work with and support land-use planners and emergency managers to facilitate better consideration of flood risk in land-use planning decisions.

Studies under the FRM process provide the basis for:

- understanding the full range of existing flood behaviour and risks to the community
- understanding the constraints that the full range of flooding may place on land (Table 2) and the additional factors (Table 3) that influence the consequences to the community and need to be considered in decision-making
- understanding how flood behaviour, risks and constraints may change into the future with climate change (see Section 2.6.2), catchment changes (see Section 2.6.3), development (see Section 2.6.4) and combined scenarios (see Section 2.6.5)
- assessing, deciding on and implementing FRM measures, including changes to land-use planning practices. FRM studies generally involve a review of the existing LEP and DCP and may make recommendations for improvements to address identified FRM issues
- deriving flood information to support the development and implementation of LEPs and DCPs
- identifying, from an FRM perspective:
    - areas suitable for more intense development. These are areas where development can effectively address the flood related constraints without causing unacceptable impacts to the community
    - areas less suited for more intense development. These are those areas where development will cause unacceptable impacts to the existing community or where development (with development controls in place) is not compatible with flood behaviour, constraints or risk
    - the types of development that are more compatible with the varying flood risk and are more suited to be permissible given the flood constraints in different areas
    - the types of development controls that may be needed for different types of permissible development in different areas of the floodplain

- the considerations that may influence the preferred location of community facilities with a role in flood EM for the community (see Section 3.6), and the various issues that may need to be considered depending on their location
- areas where flood constraints do not impact on development.

This information and advice can provide a sound basis for making flood-informed land-use planning decisions. It can assist in setting or reviewing the DFE, the freeboard, FPLs and the FPA; and in reviewing LEPs, DCPs, development assessment considerations and related flood information, including mapping. It can also inform decision-making for new development areas in the floodplain such as subdivisions, land release areas and urban renewal.

Information from the FRM process can be post processed to suit council's LEP and DCP. Many councils already use a particular approach or have a preferred approach to identifying and structuring flood related controls and information in their DCP. Approaches to derive information may include breaking the floodplain down into:

- floodways (see FRM guideline FB02), the FPA (see Section 3.4.5), and the floodplain
- flood planning constraint categories (see Appendix A.1)
- flood risk precincts (see Appendix A.2).

3.5 Limiting residual risk through emergency management planning

EM for floods is the primary tool to address the continuing flood risks faced by communities and thereby further reduce residual risks to the community. EM arrangements and infrastructure can have significant limitations due to the logistics and practicalities that need to be considered during an actual flood. These include:

- the scale of flooding, often over a large geographic area affecting many communities in different ways
- the nature of the driving weather system causing various types of impacts during an event that require response
- the resulting flood behaviour
- the mechanisms causing flooding including waterways, overland flooding, ocean inundation, or dam failure that can interact and influence community emergency response
- available warning and the time available to interpret and respond to a warning
- the number of resources necessary and those available to assist the community to effectively respond to a flood threat.

EM planning provides a sound basis for planning community emergency response. It is typically done using the best available flood information from sources such as historical events and studies under the FRM process, and considering the existing FRM measures and local flood planning in place.

FRM guideline EM01 provides further advice on EM planning for floods.

3.5.1 How studies under the FRM process can assist EM planning

Studies under the FRM process provide the basis for understanding flooding, flood impacts and flood related constraints on land (see Table 2), and provide information to support EM planning including the additional aspects outlined in Table 3.

FRM studies involve the review of existing FRM measures and associated EM infrastructure to assess their adequacy in managing risk to the existing community and where necessary, examine options and make recommendations to address the issues identified. Studies can also involve a review of local flood plans (and their EM arrangements) to assess the information on which they are based, to identify where this information is out-of-date and where updates may be required.

Where studies under the FRM process are considering future development scenarios (see Section 2.6.4), the cumulative impacts of development on EM can be examined under the FRM process. This may lead to recommendations in FRM plans to address the changing EM issues for the existing community through changes to local flood planning, changes to LEPs and DCPs to address risks, and the implementation of related FRM measures.

3.6 The role of community facilities in a flood

Some facilities can perform key functions for the community during flooding (see Table 13) and have an important role in reducing flood risk to individuals.

Table 13 Examples of facilities that can support community flood response

Type of facility	Use in emergency response	Comment
Community hospital with medical emergency facilities	Yes	Operation during an event relies on accessibility to staff and patients, and utility services. This can be significantly influenced by the design of the facility and utility services and any backup arrangements. If not, planning may be needed for evacuation of patients and alternative emergency medical facilities identified
Emergency response management facility	Yes	Facility needs to be able to operate and be accessible during an event or have alternative arrangements in place
School	Possible	May be an evacuation centre during an event
Community facility	Possible	May support emergency response or could be an evacuation centre or support evacuees during an event
Correctional facility	Possible, continue operation	May be challenges in relocation of users therefore continued operation preferable. This relies on accessibility for staff and utility services
Service club	Possible	Service clubs can support response as an evacuation centre or support centre

Where these facilities are known (such as those identified in local flood planning) their ability to perform this function and any associated limitations on achieving this across the full range of flood behaviour should be understood. If they cannot fulfil this role it is important for EM planning to identify:

- alternative arrangements for providing the services outlined in Table 13 to the local community during events
- arrangements for evacuating the facilities, if required
- efficient arrangements for return to operation after a flood to support recovery and return to business as usual.

It is also important to consider the EM role a community facility might be expected to perform when making decisions in locating and developing the facility. An example of this is provided below.

Example: Considering flooding when locating and developing community facilities with an EM function

Facilities such as community hospitals can play an important role in supporting the community during a flood. The design intent of these facilities may be to operate the emergency medicine facilities and hospital wards during disasters.

To do so they would ideally be located outside of the floodplain, however, even outside the floodplain they can be indirectly affected by flood impacts, such as loss of power and other utilities. Onsite backup services may be needed to support the hospital for the length of time the utility services are out of action. The ability of the community and staff to access the facility to support continued operation also needs consideration.

Where the facility cannot be located outside the floodplain it is best located in areas of limited flood impacts, such as flood planning constraint category (FPCC) 4 or potentially FPCC3, discussed in Appendix A. Additional considerations may be needed to limit flood impacts on operations. For example:

- floor levels of emergency medicine areas and patient wards above an extreme flood level (such as the PMF) may mean these do not need to be evacuated if services can be maintained
- the location and protection of backup utility services so they can be operational and accessible and are available during floods
- resupply of essential goods, equipment and materials during floods so the facility can continue to operate
- adequate room for storage of waste products away from floodwaters to avoid contamination
- design of the site to maximise accessibility of emergency and staff entries into the hospital during floods. This may affect the location and design of the entrance
- likelihood of some staff having their homes affected by flooding and their need to look after family members.

Where these requirements cannot be met operations during an event may be compromised. This needs to be considered in EM planning for the community and for the facility. There may need to be alternative arrangements in place in case of a flood of the scale that impacts on operations.

For example, if all other issues are addressed but accessibility to a community hospital with emergency medicine facilities remains an issue:

- alternative arrangements may be needed for emergency medical care for the community while it is not able to perform these operations
- arrangements to support staff getting to/from the facility may be needed
- alternative staffing arrangements may be needed while staff are managing flooding of their homes and associated family issues.

4. References

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More information

Flood risk management manual, guidelines and tools

See links on the following Department of Planning and Environment (DPE) webpages:

- Flood risk management manual
- Flood risk management guidelines
- Administration arrangements: flood risk management guideline AG01

Appendix A Defining areas to support land-use planning

A1 Flood planning constraint categories

The different types of flood constraints identified in Table 2 can be mapped individually. Informed decisions involve considering multiple map layers of constraints and can be complex. To reduce this complexity, *Australian disaster resilience (ADR) guideline 7-5: Flood information to support land-use planning* (AIDR 2017) provides advice on grouping flood related planning constraints into flood planning constraint categories (FPCCs) that can assist in FRM and strategic land-use planning. FPCCs consider the constraints outlined in Table 2.

Table 14 provides advice on the key considerations for development in areas within FPCCs 1 to 4. Figure 2 provides an example of FPCCs for a community. More detail and further examples are available in the ADR guideline (AIDR 2017).

FPCC1 and FPCC2 capture land that is highly constrained and may, in some cases, be unsuitable for intensification of development. This may be due to the:

- impacts development of these areas would have on flood behaviour and the flood risk and flood emergency response of the existing community
- degree of flood constraints that new development would need to address to manage the flood risks to the development and its users.

Developing in **FPCC1** areas, including in existing developed areas, should generally be limited to those uses that are compatible with the flood function and flood hazard in the area. This means that the majority of new development types and more intense development are likely to be excluded from FPCC1 due to their impacts on flood behaviour and their vulnerability to the degree of flood hazard.

FPCC2 is outside FPCC1. It is the next least suitable area for more intense development due to the impacts of flooding on the land and the consequences to the development and its users. Some FPCC2 areas are likely to be unsuitable for increased density of development and some types of development, whilst other areas have development potential but need to address the significant flood related constraints on the land. Consideration should be given to limiting redevelopment or infill development in these areas where the associated increasing risks cannot be effectively managed.

FPCC3 areas are outside FPCC1 and 2. They are more suitable for increased density of development and expansion of existing development when flood related development controls are met. Consideration may be given to restricting emergency response facilities and vulnerable land uses in some of these areas.

FPCC4 identifies areas outside of FPCC1 to 3 but below the extent of the PMF. Special flood considerations to certain types of development may apply to some areas in FPCC4.

In addition to considering the FPCCs, the additional factors outlined in Table 3, such as warning time, can also influence decision-making and the importance of the different flood related constraints that factor into decision-making. Advice from flood risk managers and emergency managers can support consideration of these additional factors in a fit-for-purpose way for the particular circumstances under consideration.

Table 14 Example of flood planning constraint categories (FPCCs) 1 to 4 and their key considerations for land-use planning

FPCC	Constraint	Implications	Key considerations for land-use planning
1	DFE floodway and key storage areas	Development or topography changes within flood conveyance and storage areas affect flood behaviour, e.g. alter flow depth or velocity in other areas of the floodplain. Changes can negatively affect the existing community and other property.	Most uses and developments have adverse impacts on flood behaviour. Consider limiting uses and development to those compatible with maintaining flood function.
	H6 hazard* in DFE	Hazardous conditions considered unsafe for vehicles and people. All building types are considered vulnerable to structural failure.	Most uses and developments are vulnerable to failure in this flood hazard category. Consider limiting developments and uses to those that are compatible with flood hazard H6.
2	Outside FPCC1		
	New floodways in larger floods than the DFE	Flood conveyance areas may develop during an event larger than the DFE. People and buildings in these areas may be affected by flowing and dangerous floodwaters.	Consider compatibility of developments and uses with rare flood flows in this area.
	H5 hazard in DFE	Hazardous conditions are considered unsafe for vehicles and people, and all buildings are vulnerable to structural damage.	Many uses and developments are vulnerable to flood hazard. Consider limiting new uses to those compatible with flood hazard H5. Consider treatments such as filling (where this will not affect flood behaviour) to reduce hazard to allow application of standard development controls. Alternatively, consider special development conditions.
	H6 hazard in floods larger than the DFE	Hazardous conditions may develop in an event rarer than the DFE, which may have implications for the development and its occupants.	Consider the need for additional development controls to reduce the effect of flooding on the development and its occupants.
	Low flood island	Area becomes isolated by floodwater or impassable terrain, with loss of evacuation route to the community evacuation location. The area will become fully submerged with no flood-free land in an extreme event, with	Consequences of isolation and inundation can be severe. Consider the consequences of evacuation difficulty or inundation of the area on the development and its users, which may include limitations on land use, or land use that has users who are more vulnerable to disruption and loss.

FPCC	Constraint	Implications	Key considerations for land-use planning
		ramifications for those who have not evacuated and are unable to be rescued.	Consider the impacts of the development on EM planning for the existing community (including the need for measures to offset impacts), community flood recovery, and disruption or loss of the development on the users and wider community.
	High flood island	Area becomes isolated by floodwater or impassable terrain, with loss of an evacuation route to a community evacuation location. The area has some land elevated above the extreme flood level. Those not evacuated may be isolated with limited or no services and will need rescue or resupply until floods recede and roads are passable.	Some developments and their users may be vulnerable to disruption or loss. Consider evacuation difficulty on the development and its users, which may include limitations on land use with users who are particularly vulnerable in EM (including evacuation). Consider the impacts of the development on EM planning for the existing community (including the need for measures to offset impacts), community flood recovery, disruption of the development on the users and the wider community, and additional support required to those isolated.
3	Outside FPCC2. Usually below the FPL	Hazardous conditions may exist creating issues for vehicles and people. Structural damage to buildings that meet building standards unlikely because of flooding.	Standard development controls aimed at reducing damage and the exposure of the development to flooding in the DFE are likely to be suitable. Consider the need for controls for EM facilities, key community infrastructure and developments with vulnerable users.
4	Outside FPCC3, but within the PMF or extreme flood	EM may rely on key community facilities such as emergency hospitals, EM headquarters and evacuation centres operating during an event. Recovery may rely on key utility services being able to be readily re-established after an event.	Consider the need for controls for emergency response facilities, key community infrastructure with an EM function, and land uses with vulnerable users.

* Flood hazard categories (e.g. H5 and H6) are explained in *Flood hazard FRM guideline FB03*.

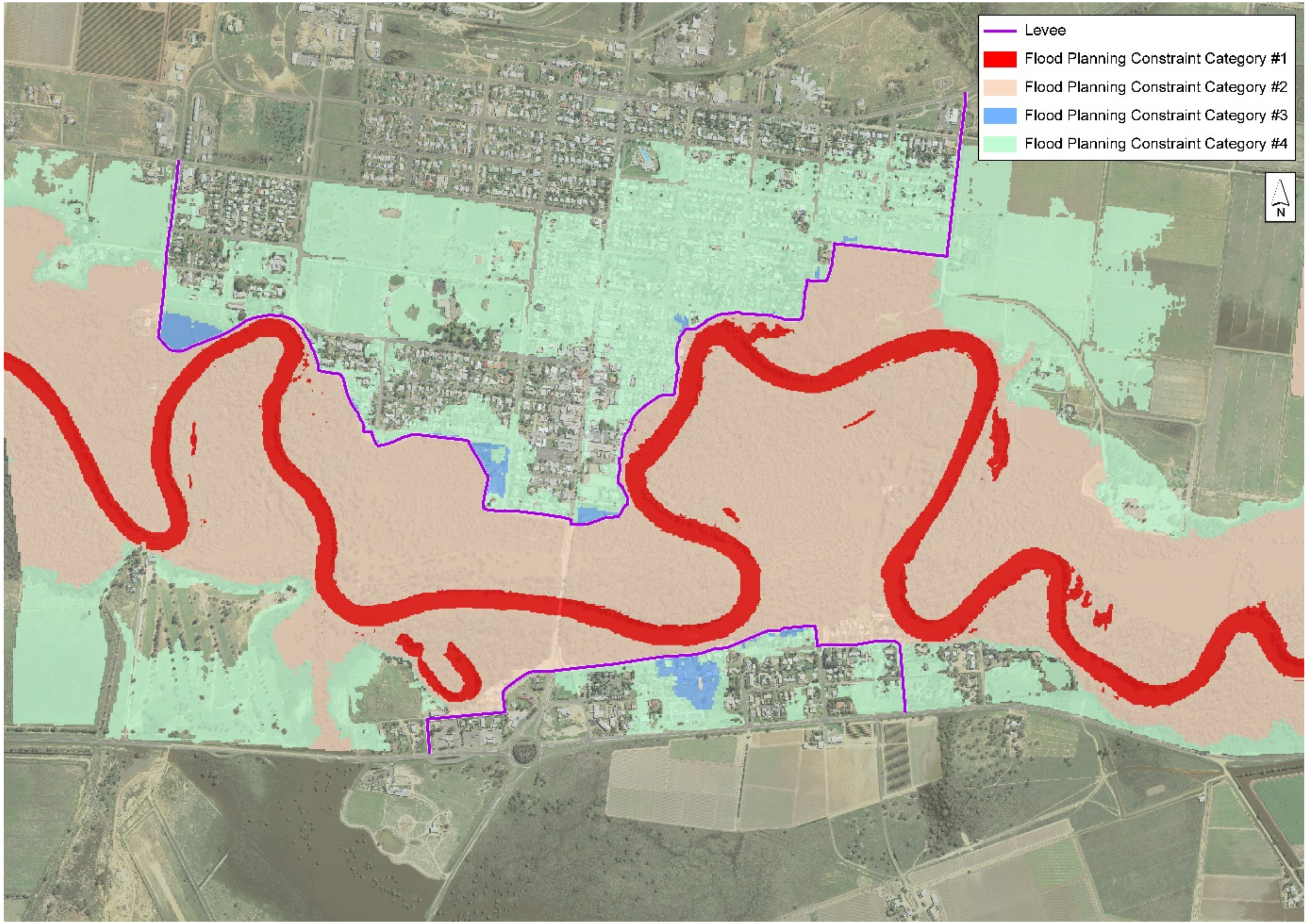

Figure 2 **Example of mapped flood planning constraint categories**

A2 Flood risk precincts

Flood risk precincts (FRPs) have been used in New South Wales and typically categorise the floodplain into high, medium and low risk areas, with the high risk precinct being the most constrained. While these precincts are typically determined based on likelihood considering the flood behaviour and potential consequences, the high risk precinct generally considers hazard and flood function in the DFE. Whilst their application varies, the following general definitions apply:

- high risk precinct – high hazard (from the *Floodplain development manual* [DIPNR 2005]) or H5 and H6 as determined through FRM guideline FB03 – and in some cases floodways in the DFE event. This is the most constrained area of the floodplain
- medium risk – low hazard (from the *Floodplain development manual* [DIPNR 2005]) or H1 to H4 as determined through FRM guideline FB03 in the DFE event and extending out to the FPA (based on the DFE plus freeboard)
- low risk – outside the FPA and potentially out to the extent of the PMF.

These definitions, whilst providing some breakdown of the floodplain, do not clearly link the precincts to all flood related development constraints described in the FPCC approach. This approach also requires consideration of the additional factors as outlined in Table 3, and discussed above in Section 2.4.

Figure 3 provides an example of FRPs for the same community used in the example of FPCCs above.

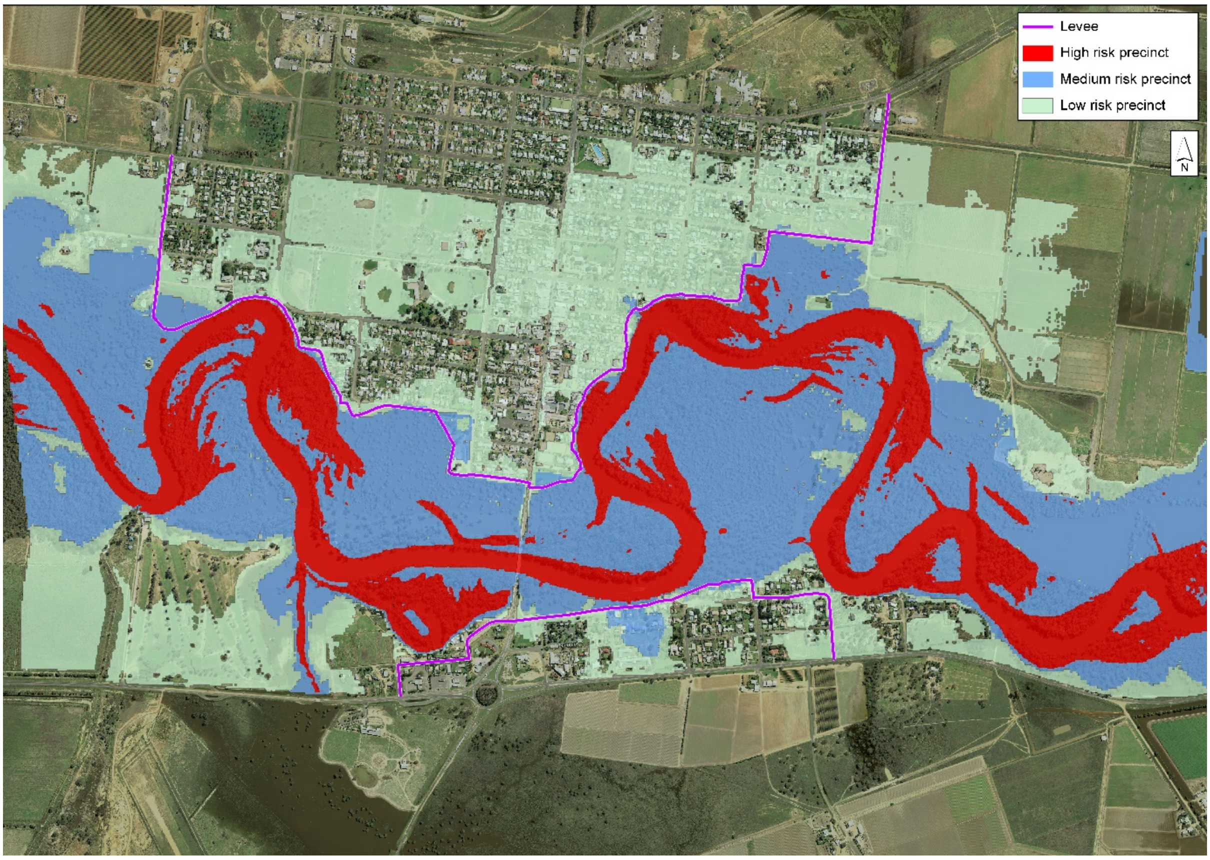

Figure 3 Example of flood risk precincts

Appendix B Example considerations for development control plans

DCPs are often used by councils to provide guidance on additional location and development type specific controls to consider in meeting the requirements of an LEP.

A DCP may contain advice on:

- the high-level FRM objectives of council. These objectives may be included to provide an understanding of the broad objectives that council is aiming to achieve within the floodplain. They generally relate to the LEP and policy
- the objectives of the specific development controls. These may include, for example, aspects such as minimising the risk to life due to flooding, maintaining the function and capacity of floodways, and allowing for adaptability to climate change
- considerations for the assessment of development applications in the floodplain, as discussed in Section 3.4.9
- the different types of flood related controls used in the DCP. Table 15 provides examples of the controls used to manage flood risks to development. Note that this is not exhaustive and may contain additional advice for particular categories of development as needed, for example, controls related to fencing or similar. General advice on controls is provided in FRM guideline MM01
- where different flood related development controls may apply. Application of controls may vary with:
    - land-use categories. The broad land-use categories used may require a separate land-use table that identifies the specific uses incorporated into the different categories considering land-use vulnerability to flooding as discussed in Table 10
    - the breakdown of the floodplain considering varying flood constraints on land. Different approaches may be used as discussed in Section 3.4.8. These can include: floodways, FPA and the floodplain (Table 16), or FPCCs 1–4 (Table 17) or different flood risk precincts, Table 18

  Table 16, Table 17, and Table 18 are only examples and should not be used directly without considering the latest government advice and testing whether they are fit for purpose for the intended use, the flood constraints in the area, and the information available.

- where to access related flood information and mapping. However, note that not all flood affected areas are generally mapped and controls may apply in unmapped areas. In these areas, development requirements may include the need to provide relevant flood information to enable council to apply the relevant controls to the proposed development.

Table 15 **Examples of flood related development controls**

Management considerations	No.	Example controls
Floor level		
Allows for varying floor levels for different development types and parts of a development considering flood constraints (Table 2), the additional factors (Table 3) as well as the cost of future flood damages and disruption	F1	All floor levels to be equal to or greater than the __% AEP flood level plus freeboard, unless justified by site-specific assessment
	F2	Habitable floor levels to be equal to or greater than the FPL
	F3	All floor levels to be equal to or greater than the PMF level
	F4	Floor levels to be as close to the design floor level as practical and no lower than the existing floor level when undertaking alterations or additions in excess of __ m^2
	F5	Floor levels of shops to be as close to the design floor level as practical. Where below the design floor level, more than __% of the floor area to be above the design floor level or premises to be flood proofed below the design floor level
	F6	Garage floor level to be above finished adjacent ground
	F7	Garage floor level to be no lower than the __% AEP flood level minus __ mm or __ mm above finished adjacent ground (whichever is greater)
Building components and method		
Flood compatible building considerations for varying development types Encourages a means of reducing flood damages to individual properties	B1	All structures to have flood compatible building components below or at the FPL
	B2	All structures to have flood compatible building components below or at the PMF level
Structural soundness		
Identifies the scale of assessment required to demonstrate structural soundness to minimise cost of future damages and potential for development components to become floating debris	S1	FIRA required that includes certification that any structure can withstand the forces of floodwater, debris and buoyancy up to and including the DFE and applied to the FPL
	S2	Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a DFE (and applied to the FPL) or PMF if required to satisfy emergency response criteria (see below)
	S3	Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a PMF flood
Flood affectation		
Identifies how the impacts of the development are to be managed and the risks to the development and its users are to be	FA1	FIRA required to certify the development will not increase flood affectation elsewhere
	FA2	The impacts of the development on flooding are to be addressed

Management considerations	No.	Example controls
assessed and considered based on the scale and type of development, its impacts on the existing community and the risk		
Emergency response		
Considers the availability of existing EM arrangements including flood warning, evacuation routes, evacuation capacity, etc. and potential impacts of the development on evacuation capability of existing development	E1	Reliable access and egress for pedestrians required during a __ flood
	E2	Reliable access and egress for pedestrians and vehicles required during a PMF
	E3	Reliable egress is required from the lowest habitable floor of the building to an area of refuge above the PMF level
	E4	The emergency response strategy of the development is consistent with any relevant local or state flood plan developed by the NSW SES
	E5	Applicant to demonstrate that evacuation of any proposed development proposal can be undertaken in accordance with the relevant local or state flood plan developed by the NSW SES
Management and design		
Considers additional factors needed to manage ongoing flood risk	M1	Applicant to demonstrate that potential development as a consequence of a subdivision or development proposal can be undertaken in accordance with the relevant DCP and/or FIRA
	M2	Site FloodSafe plan (home or business or farmhouse) to address safety and property damage issues (including goods storage and stock management) considering the full range of flood risk
	M3	Materials that may cause pollution or be potentially hazardous during a flood should be contained or not be stored below the ___flood level

Table 16 Example of applying controls from Table 15 using floodways, FPA and outside the FPA

Flood category	Land-use category	Planning controls					
		Floor level	Building components	Structural soundness	Flood affectation	Emergency response	Management and design
Floodway	Critical use and facilities	U	U	U	U	U	U
	Sensitive use and facilities	U	U	U	U	U	U
	Subdivision	U	U	U	U	U	U
	Residential	U	U	U	U	U	U
	Commercial and industrial	U	U	U	U	U	U
	Tourist related	U	U	U	U	U	U
	Recreation & non-urban	F1	B1	S1	FA1	E4	M2, M3
	Concessional	F2, F4, F6	B1	S1	FA1	E2 or E3	M2, M3
FPA	Critical use and facilities	U	U	U	U	U	U
	Sensitive use and facilities	U	U	U	U	U	U
	Subdivision	N	N	N	FA1	E4, E5	M1
	Residential	F2, F6 or F7	B1	S1	FA2	E3, E4	N
	Commercial and industrial	F2 or F5	B1	S1	FA1	E2, E4	M2, M3
	Tourist related	F2	B1	S1 or S3	FA1	E3, E4	M2, M3
	Recreation & non-urban	F1, F2	B1	S1, S2	FA1	E4,	M2, M3

Flood category	Land-use category	Planning controls					
		Floor level	Building components	Structural soundness	Flood affectation	Emergency response	Management and design
	Concessional	F2, F4, F6	B1	S1	FA2	E2 or E3	M2, M3
Outside FPA	Critical use and facilities	F3	B2	S3	FA1	E2 or E3, E4	M2, M3
	Sensitive use and facilities	F3	B2	S3	FA1	N	M2, M3
	Subdivision	N	N	N	FA1	E4, E5	M1
	Residential	N	N	N			M2
	Commercial and industrial	N	N	N	FA1	E4	M2, M3
	Tourist related	N	N	N	FA1	E4	M2, M3
	Recreation & non-urban	N	N	N	N	N	M2
	Concessional	N	N	N	N	E4	M2

Notes:

N	Not relevant
U	Unsuitable land use

See Table 15 for explanation of planning controls.

Table 17 **An example of applying controls from Table 15 using flood planning constraint categories (FPCCS) 1 to 4**

Flood category	Land-use category	Planning controls					
		Floor level	Building components	Structural soundness	Flood affectation	Emergency response	Management and design
FPCC 1	Critical use and facilities	U	U	U	U	U	U
	Sensitive use and facilities	U	U	U	U	U	U
	Subdivision	U	U	U	U	U	U
	Residential	U	U	U	U	U	U
	Commercial and industrial	U	U	U	U	U	U
	Tourist related	U	U	U	U	U	U
	Recreation & non-urban	F1	B1	S1	FA1	E4	M2, M3
	Concessional	F2, F4, F6	B1	S1	FA1	E2 or E3	M2, M3
FPCC 2	Critical use and facilities	U	U	U	U	U	U
	Sensitive use and facilities	U	U	U	U	U	U
	Subdivision	N	N		FA1	E4, E5	M1
	Residential	F2, F6 or F7	B1	S1	FA2	E3, E4	M2
	Commercial and industrial	F2 or F5	B1	S1	FA1	E2, E4	M2, M3
	Tourist related	F2	B1	S1 or S3	FA1	E3, E4, E5	M2, M3
	Recreation & non-urban	F1	B1	S1, S2	FA1	E4	M2, M3

Flood category	Land-use category	Planning controls					
		Floor level	Building components	Structural soundness	Flood affectation	Emergency response	Management and design
	Concessional	F2, F4, F6	B1	S1	FA2	E2 or E3	M2, M3
FPCC 3	Critical use and facilities	U	U	U	U	U	U
	Sensitive use and facilities	U	U	U	U	U	U
	Subdivision	N	N	N	FA1	E4, E5	M1
	Residential	F2, F6 or F7	B1	S1	FA2	E4	M2
	Commercial and industrial	F2 or F5	B1	S1	FA1	E4	M2, M3
	Tourist related	F2	B1	S1	FA1	E4	M2, M3
	Recreation & non-urban	F1	B1	S1, S2	FA1	E4	M2
	Concessional	F2, F4, F6	B1	S1	FA2	E2 or E3	M2, M3
Areas in FPCC 4	Critical use and facilities	F3	B2	S3	FA1	E2 or E3, E4	M2, M3
	Sensitive use and facilities	F3	B2	S3	FA1	N	M3
	Subdivision	N	N	N	FA1	E4, E5	M1
	Residential	N	N	N	N	N	M2
	Commercial and industrial	N	N	N	FA1	E4	M2, M3
	Tourist related	N	N	N	FA1	E4	M2, M3
	Recreation & non-urban	N	N	N	N	N	M2

Flood category	Land-use category	Planning controls					
		Floor level	Building components	Structural soundness	Flood affectation	Emergency response	Management and design
	Concessional	N	N	N	N	E4	M2

Notes:

N	Not relevant
U	Unsuitable land use

See Table 15 for explanation of planning controls.

Table 18 **Example of applying controls from Table 15 using flood risk precincts**

Flood category	Land-use category	Planning controls					
		Floor level	Building components	Structural soundness	Flood affectation	Emergency response	Management and design
High flood risk	Critical use and facilities	U	U	U	U	U	U
	Sensitive use and facilities	U	U	U	U	U	U
	Subdivision	U	U	U	U	U	U
	Residential	U	U	U	U	U	U
	Commercial and industrial	U	U	U	U	U	U
	Tourist related	U	U	U	U	U	U
	Recreation & non-urban	F1	B1	S1	FA1	E4	M2, M3
	Concessional	F2, F4, F6	B1	S1	FA1	E2 or E3	M2, M3
Medium flood risk	Critical use and facilities	U	U	U	U	U	U
	Sensitive use and facilities	U	U	U	U	U	U
	Subdivision	N	N	N	FA1	E4, E5	M1
	Residential	F2, F6 or F7	B1	S1	FA2	E3, E4	N
	Commercial and industrial	F2 or F5	B1	S1	FA1	E2, E4	M2, M3
	Tourist related	F2	B1	S3	FA1	E3, E4	M2, M3
	Recreation & non-urban	F1, F2	B1	S1, S2	FA1	E4, E5	M2, M3

Flood category	Land-use category	Planning controls					
		Floor level	Building components	Structural soundness	Flood affectation	Emergency response	Management and design
	Concessional	F2, F4, F6	B1	S1	FA2	E2 or E3	M2, M3
Low flood risk	Critical use and facilities	F3	B2	S3	FA1	E2 or E3, E4	M2, M3
	Sensitive use and facilities	F3	B2	S3	FA1	N	M2, M3
	Subdivision	N	N	N	FA1	E4, E5	M1
	Residential	N	N	N	N	N	M2
	Commercial and industrial	N	N	N	FA1	E4	M2, M3
	Tourist related	N	N	N	FA1	E4	M2, M3
	Recreation & non-urban	N	N	N	N	N	M2
	Concessional	N	N	N	N	E4	M2

Notes:

N	Not relevant	U	Unsuitable land use

See Table 15 for explanation of planning controls.