

SUPPORTING LAND USE PLANNING BY PROVIDING IMPROVED INFORMATION FROM THE FLOODPLAIN MANAGEMENT PROCESS

D McLuckie¹, A. Toniato², E Askew³, M Babister³, M Retallick³

¹Chair, National Flood Risk Advisory Group

²University of Technology, Sydney – Masters Student

³WMA Water Pty Ltd Sydney

Abstract

Floods result in hazardous conditions which create a flood risk where the community interacts with flooding. Introducing or intensifying development in the floodplain creates a flood risk to the new development and its users. New development can also impact upon the flood risk to the existing community by altering flood behaviour or impacting upon emergency management arrangements. The scale of these affects will vary depending upon how the floodplain is developed.

Land use planning can play a key role in limiting the growth in flood risk by reducing the likelihood of floods impacting upon communities and the consequences of floods to the growing community. To achieve this access to timely information on the constraints that flooding may place on landform in a readily useable is needed to inform planning activities.

Flood investigations provide a very detailed description of flooding as they aim to communicate the variation in flood behaviour across a floodplain to assist in managing the associated risks. However, this level of detail can make this information difficult to use in land use planning activities.

This paper outlines work on improving accessibility to timely information by combining information on different flood constraints to inform land use planning activities and support management of flood risk as communities grow.

Introduction

Flood is an important constraint to consider upfront or as early as possible in land use planning activities. Decisions on where and how to develop the floodplain are important to manage the growth in flood risk due to new development. Mitigating the consequences poor decisions on locating development in the floodplain may not be feasible, or can be difficult and expensive. Applying development conditions only has a limited ability to manage the growth in flood risk.

Therefore early consideration of flood constraints on land can steer development can encourage development on land that is less exposed to flooding where flood constraints can be more readily managed. It can discourage development in areas with flood constraints that are difficult, costly or impractical to manage. This approach can result in a growing community that is more resilient to flooding. Achieving this requires timely access to better flood information that can enable the development and implementation of community growth strategies to be better informed on how flood related constraints impact upon land within the floodplain.

Australian Emergency Management Handbook 7 - Managing the floodplain: A guide to best practice in flood risk management in Australia (AEM Handbook 7) outlines the importance of land use planning activities in managing the growth in flood risk due to new development. The National Flood Risk Advisory Group (NFRAG) is finalising development

of the *Technical flood risk management guideline: Flood information to support land use planning* to support AEM Handbook 7. The guideline aims to improve the availability of timely flood information that is more readily useful in land use planning activities. The guideline is designed to be used in consideration of, rather than to circumvent, jurisdictional legislation, regulation, directions, policies or land use planning systems. It promotes the extension of the flood study to provide information to support land use planning activities rather than to go directly into planning systems.

The guideline outlines how the often complex flood related constraint information can be developed into a single map or map set that breaks the floodplain down into 4 degrees of flood planning constraint categories (FPCCs). This makes information on flood constraints and the relative suitability of land for development easier to interpret. This information can assist in identifying: areas which are unsuitable for more intense development, locations suitable for development, the types of land uses suitable for different areas of the floodplain, and the development conditions and treatment measures needed to support development.

Key information informing categorisation

Flood investigations produce a large number of maps, each focusing on a particular design event and element of the flood behaviour. Collectively they provide a very detailed description of flooding and how this varies across the floodplain. This includes:

- Flood extents for a range of flood events.
- Flood function variation within the floodplain.
- Flood hazard variation within the floodplain.
- The range of flood behaviour and how this influences emergency management of flooding and flow conveyance and hazard.

This information relies upon an understanding of the full range of flood behaviour and how this interacts with the landscape, transport links and key infrastructure facilities.

This paper uses an example to show how FPCC information can be developed and inform land use planning activities. This example involves a town that is cut off from other major centres during floods that can last for weeks. There are weeks of warning time from a flood warning system. The existing township is protected by several levees (north and south of the river). The levees create some internal flooding issues if a local storm occurs whilst the river is in flood which can be limited by pumping stormwater into the river. There is an ongoing commitment to the maintenance of the existing levees and flood warning system. These along with local flooding are considered in strategic planning decisions.

Flood Extent Mapping

Flood extents identify areas subject to inundation for a particular flood or a range of flood events up to and including extreme floods considering the mitigation measures, such as existing levees, in place. They inform a range of land use planning activities and therefore are incorporated in FPCC development. However, flood extents alone are of limited value. They cannot provide an indication of the variation in flood behaviour or constraints. Figures 1 and 2 show the flood extents and depths for the defined flood event (DFE) and an extreme flood for the continuing example.

Flood Function

Adding flood function can assist in understanding areas where flow conveyance and flood storage may be a constraint on development. These are areas where changes in

topography or development may alter the existing flood behaviour. Therefore development in these areas can impact upon flood behaviour and risk to the existing community. Flow conveyance and flood storage areas are defined in AEM Handbook 7. Flood fringe areas make up the remainder of the flood extent for the particular event. These are the areas where impacts on flood function is not a constraint. Figure 3 shows the hydraulic categorisation for the ongoing example.



Figure 1 - Flood extent and depth for the defined flood event for the ongoing example

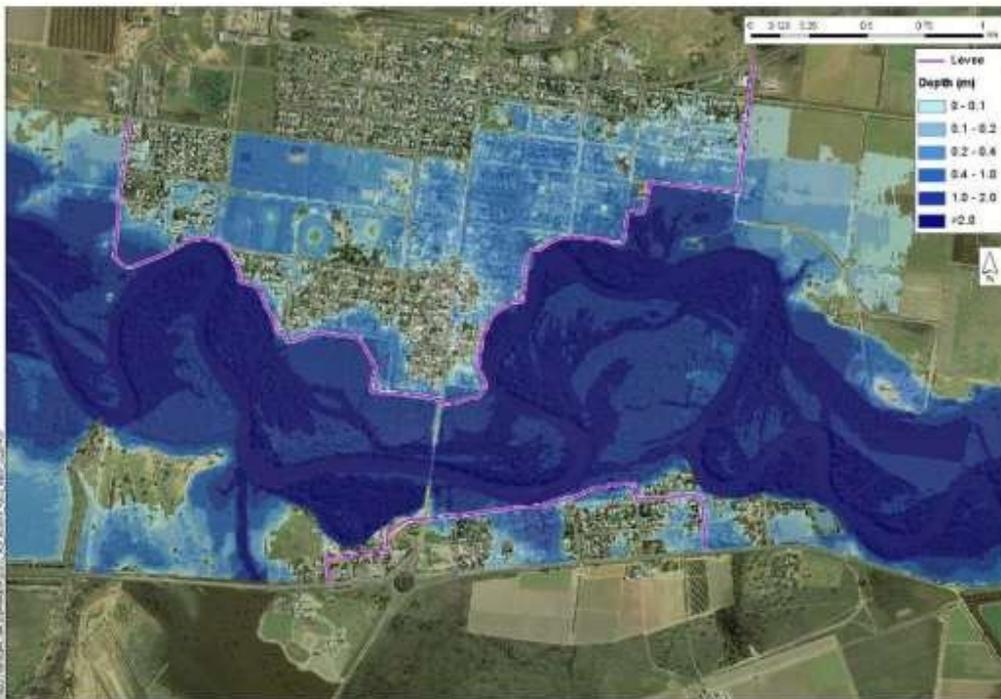


Figure 2 - Flood extent and depth for an extreme flood for the ongoing example

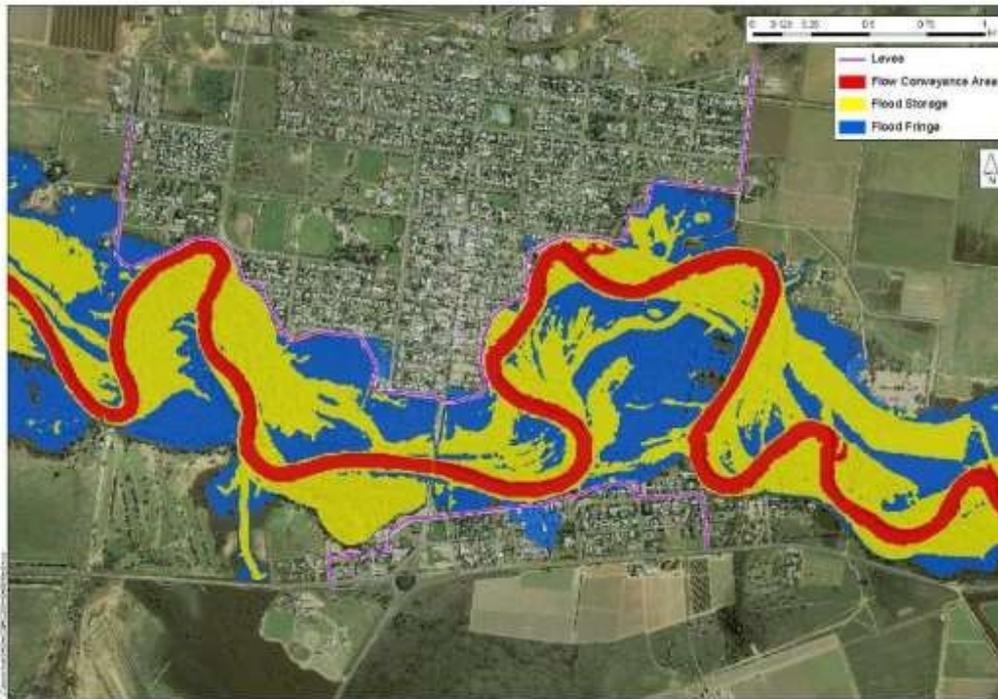


Figure 3 - Flood Function for the Defined Flood Event for the ongoing example

Flood Hazard

Flood hazard classification provides a description of how hazardous the physical conditions produced by a flood can be, independent of the population at risk. Depth and velocity of the floodwaters are categorised against thresholds to determine how hazardous this combination may be to people, cars, infrastructure and buildings, if they were exposed to the flooding. It can vary according to the magnitude of the flood event and can influence the suitability of a location for development. *AEM Handbook Series - Technical Flood Risk Management Guideline: Flood Hazard* supports this delineation recommending the categorisation of the floodplain into six categories dependent upon the consequences of people, vehicles and buildings with H2 to H4 sometimes combined. Figure 4 shows flood hazard categorisation for the ongoing example.

Considering the Range of Potential Flooding

Flood studies examine how flood behaviour varies between and during events. Some planning activities may consider the full range of flooding, whilst others relate to the DFE. Considering floods larger than the DFE provides information on emergency management constraints and how flood function (particularly conveyance) and hazard can change.

Flood function in different areas can vary with the magnitude of the flood event. This is particularly important when the relatively benign conditions develop into important flowpaths in rarer floods (Figure 5). At this location the 1% AEP flood (Figure 5a) shows benign conditions. If more severe events were not examined the location may be considered suitable for development. However the 0.2% AEP flood (Figure 5b) identifies a new flowpath forming that creates significant risks to the development and its users. In the extreme event, (Figure 5c) these conditions worsen. Considering this additional flowpath in planning activities can support decisions to steer development to other available land not exposed to this additional constraints during rarer flood events and more compatible

with the flood behaviour. Note houses at this location were destroyed in a large flood event. In the ongoing example comparing Figure 1 (DFE) to Figure 2 (extreme flood) indicates that flood behaviour and hazard generally remain similar, though categorisation considers that the levees are overtopped and some areas behind inundated.

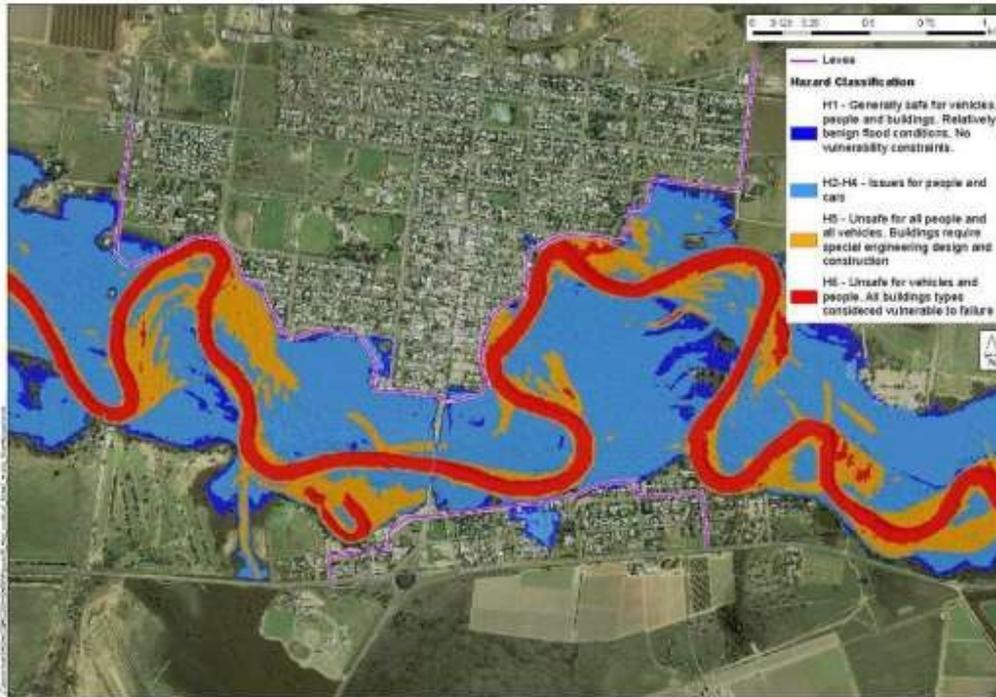
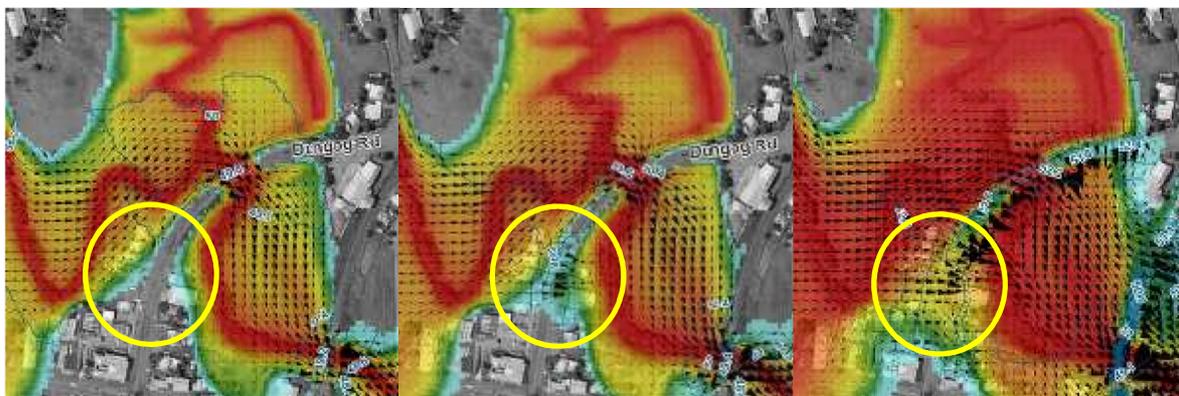


Figure 4 – Flood Hazard for the Defined Flood Event for the ongoing example



(a) 1% AEP

(b) 0.2% AEP

(c) Extreme Event

Figure 5 An example of changing flood function with event scale

Emergency response classification

Identifying areas with difficult evacuation problems can identify if these locations need to be treated differently in land use planning activities. Where an area can be readily evacuated to flood free land with appropriate facilities within the available warning time it is unlikely to require significant additional considerations. However, where an area is isolated from flood free land as a flood rises and then is totally inundated, it presents a much more difficult emergency management issue with more serious consequences that warrant consideration. This information can inform decisions on whether a location is more or less suitable for more intense development, and where considered more suitable,

what constraints should apply. It can also influence the location of facilities, such as community hospitals with an emergency response function, and land uses whose occupants may be more vulnerable in, or need significant support in, an evacuation. These uses are more suitable in areas with relatively straightforward evacuation where the consequences of a failed evacuation are limited. Where there is ample warning time and safety of the community can be demonstrated, emergency evacuation during a flood may not be a significant issue. However, locating communities in areas which are isolated for extended periods without essential services and ready access to community facilities places an additional burden on emergency response agencies during a flood event.

Technical Flood Risk Management Guideline: Flood emergency response classification of the floodplain (AEM 2014) classifies the floodplain based upon emergency response difficulties and consequences of failed evacuation. This considers whether the area is flooded in an extreme flood (flooded or not flooded), whether the area has access to evacuation facilities which remain flood free (isolated or has an exit route) and the potential consequences of flooding in the area (fully submerged, partially elevated or has indirect consequences). The overall classifications are: flooded isolated submerged (FIS), flooded isolated elevated (FIE), flooded exit route (FER), not flooded, indirect consequences (NIC). Figure 6 shows the categorisation for the ongoing example.

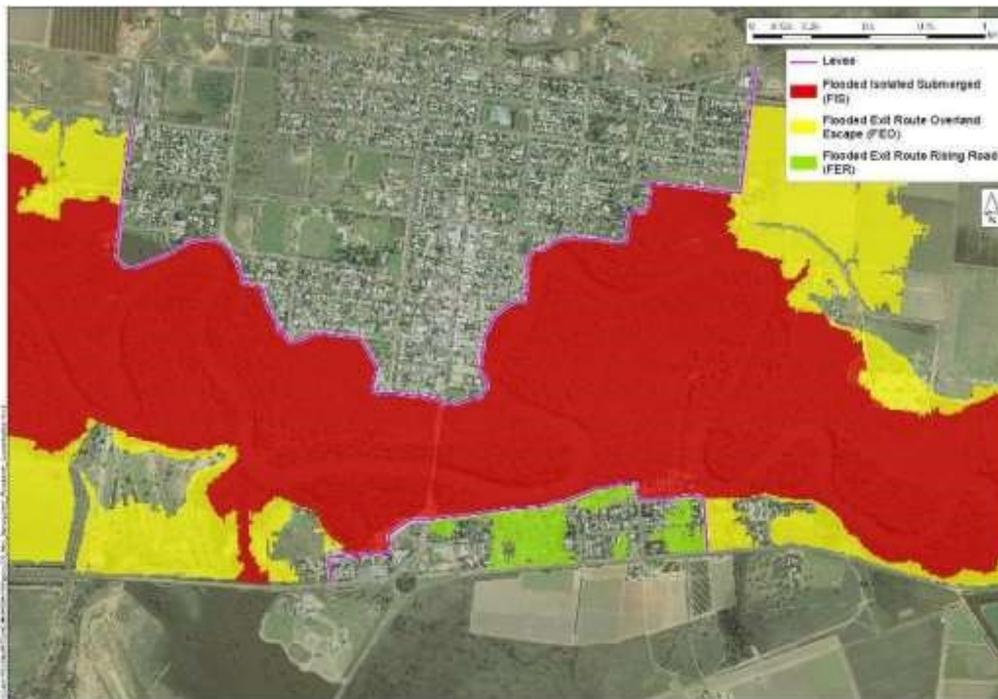


Figure 6 - Flood Emergency Response Classifications for the ongoing example

Flood planning constraint categorisation

Table 1 outlines how this information is combined into FPCCs. Figure 7 shows the combined base information and Figure 8 shows categorisation.

Floodplain Management Objectives and Controls

Land use planning activities should aim to support development that is compatible with the floodplain management objectives and the varying flood constraints on land. This will involve varying types and degrees of treatment to manage the varying constraints in FPCCs 1 to 4. Table 2 provides an example for planning and building controls for different

FPCCs consideration objectives. This should be used within the context of jurisdictional and local flood policies and in consideration of:

- The availability of other land where development could occur that has less impact on the flood risk to the existing community.
- The availability of other land whose flood function and exposure to flood hazard is more compatible with this type of development.

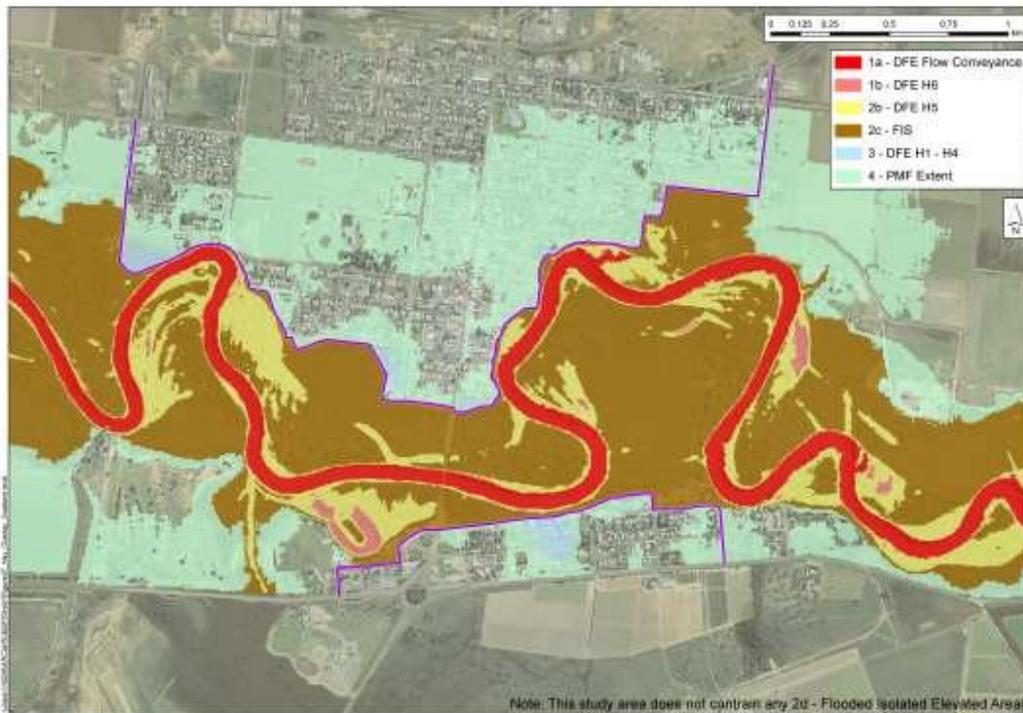


Figure 7 - Summary of elements making up FPCC mapping for ongoing example

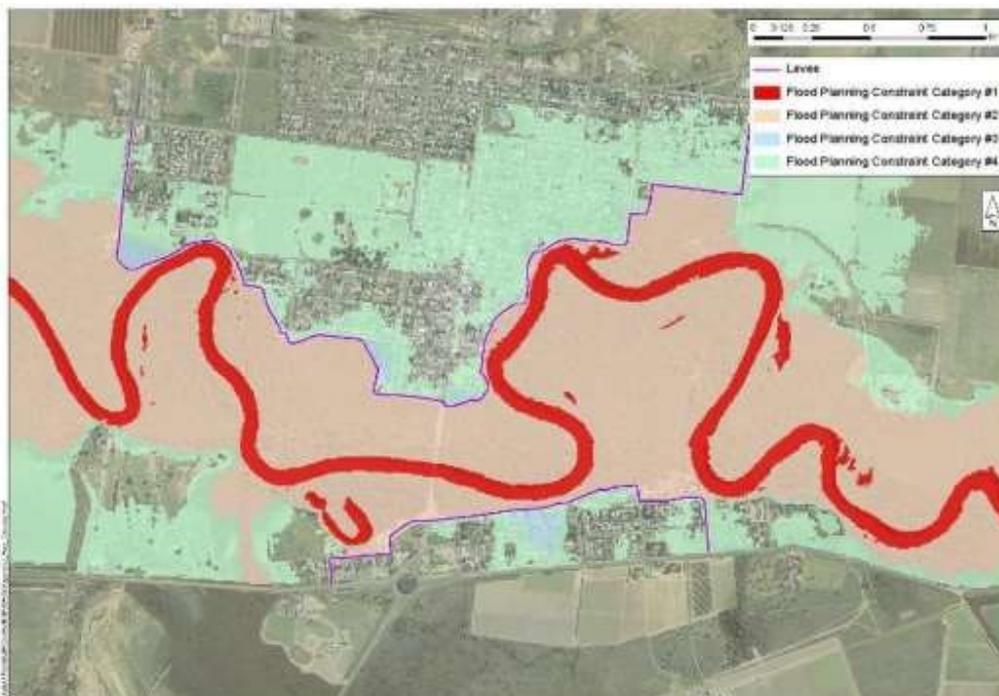


Figure 8 - Flood planning constraint categories for ongoing example

Table 1 Flood planning constraint categories (FPCCs)

FPCC	Constraint	Implications	Key Considerations	Sub-Category
1	Flow conveyance and storage areas in DFE	Development or changes to topography within flow conveyance areas impact on flood behaviour which will alter flow depth or velocity in other areas of the floodplain. Adverse impacts can impact upon the existing community and other property.	The majority of developments and uses have adverse impacts upon flood behaviour. Consider limiting uses and development to those compatible with maintaining flood function.	a
	H6 Hazard in DFE	Hazardous conditions considered unsafe for vehicles and people. All building types are considered vulnerable to structural failure.	Majority of developments and uses are vulnerable to failure in this flood hazard category. Consider limiting developments and uses to those that are compatible with flood hazard H6.	b
2	Flow conveyance in larger events	Flow conveyance areas may develop in an event larger than the DFE. For example, 0.2% AEP if 1% AEP is DFE. People and buildings in these areas may be impacted upon by flowing and dangerous floodwaters.	Consider compatibility of developments and users with rare flood flows in this area.	a
	Flood Hazard H5 in DFE	Hazardous conditions considered unsafe for vehicles and people and all buildings vulnerable to structural damage.	Many uses and developments will be vulnerable to flood hazard. Consider limiting new uses to those compatible with flood hazard H5. Consider treatments such as filling (where this will not impact upon flood behaviour) to reduce the hazard to a level that allows for the application of standard development conditions. Alternatively consider a requirement for special development conditions.	b
	Emergency Response – Isolated and Submerged	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 ramifications for those who have not evacuated and are unable to be rescued.	Consequences of isolation and inundation can be severe to the development and its users. Consider: <ul style="list-style-type: none"> The consequences of evacuation difficulty or inundation of the area on the development and its users. The consequences of the development on emergency management planning for the existing community including the need for additional treatments. The consequences for the development on community flood recovery. The consequences of disruption or loss of the development on the users and wider community. 	c
	Emergency Response – Isolated but Elevated	Area becomes isolated by floodwater or impassable terrain with loss of evacuation route to community evacuation location. Area has some land elevated above the extreme flood level. Those not evacuated may be isolated with limited or no services and need rescue or resupply until floods recede and roads passable.	Some development and their users may be vulnerable to disruption or loss. Consider: <ul style="list-style-type: none"> The consequences of disruption or loss of the development on the users and the wider community. Limiting uses that are vulnerable, or which have occupants, that are vulnerable to disruption and loss. Requiring additional emergency management treatments. Issues associated with the level of support required during a flood, particularly for long duration flood events. 	d
	Flood hazard H6 in larger events	Hazardous conditions may develop in an event rarer than the DFE which may have implications for development and occupants.	Consider the need for additional development conditions to reduce impacts of flooding on development and uses.	e
3	Outside FPCC2. Generally below DFE + freeboard	Generally areas within the flood planning area but in the flood fringe. Hazardous conditions may exist creating issues for vehicles and people. Structural damage to buildings that meet building standards unlikely due to flooding.	Standard land use and development controls aimed at reducing damage and the exposure of development to flooding in the DFE are likely to be suitable. Consider the need for additional conditions for emergency response facilities, key community infrastructure and vulnerable uses.	
4	Outside FPCC3 but within PMF (or similar extreme event)	Emergency response may rely upon key community facilities such as emergency hospitals, emergency management headquarters and evacuation centres operating during an event. Recovery may rely upon key utility services being able to be readily re-established after an event.	Consider the need for conditions for emergency response facilities, key community infrastructure and vulnerable uses.	

Table 2

Example of Floodplain Management Objectives, Constraints and Possible Treatment Options and Controls

Floodplain Management Objectives	Land Use Planning Objectives	FPCC	Constraint	Possible Land use Planning and Building Treatment Options and Controls ^a for area
<p>1. Minimise new development impacts on</p> <ul style="list-style-type: none"> Flood behaviour Flood risk to the existing community Safety of the existing community responding to floods <p>2. Reduce the impacts of flooding on development and its users.</p> <p>3. Key community uses consider functionality in extreme events</p>	<p>1. Risks to life considered for events up to extreme events</p> <p>2. Key community uses consider function in events up to extreme events.</p> <p>3. The risks posed by flooding to existing development are not increased by new development likely to occur in the floodplain</p> <p>4. The risks posed to the existing community by flooding are not increased by new developments that are likely to occur in the floodplain</p> <p>5. Economic and social costs that may arise from damage to new property from flooding are not be greater than that which can reasonably be managed by community</p>	1	Overall	In addition to development controls in FPCC2.
			DFE event flow conveyance & storage areas	Development is discretionary provided it does not adversely affect flood function. This is likely to result in a significant restriction on intensification of development or new development.
			H6 Hazard in DFE	Intensification of existing and new key community, utility and vulnerable, residential and commercial uses may be prohibited. Intensification of other existing uses and new uses discretionary provided detailed risk assessment can demonstrate that an appropriate mix of planning, building and emergency management controls can effectively manage the risks to the use and occupants.
		2	Overall	In addition to controls in FPCC3
			Flow conveyance in larger events	Development discretionary provided development does not adversely affect, and is compatible with flood function.
			Flood Hazard H5 in DFE	New key community, utility and vulnerable uses may be prohibited. Intensification of existing key community, utility and vulnerable uses discretionary provided that a detailed risk assessment can demonstrate that an appropriate mix of planning, building and emergency management controls can effectively manage the risks to the use and the occupants. Intensification of other existing uses and new uses discretionary provided that a detailed risk assessment can demonstrate that an appropriate mix of planning, building and emergency management controls can effectively manage the risks to the use and the occupants.
			Emergency Response – Isolated and Submerged (FIS)	Consideration should be given as to whether to minimise more intense development in these areas. New key community, utility and vulnerable uses may be prohibited. Intensification of existing uses and new uses or developments discretionary provided that a detailed risk assessment can demonstrate that an appropriate mix of planning, building and emergency management controls can effectively manage the risks to the use and the occupants.
			Emergency Response – Isolated but Elevated (FIE)	Consideration should be given as to whether to minimise or prevent more intense development in these areas. Key community, utility and vulnerable uses discretionary provided a detailed risk assessment can demonstrate that an appropriate mix of planning, building and emergency management controls can effectively manage the risks and ensure continuity of service. Intensification of existing uses and new uses or developments discretionary provided that a detailed risk assessment can demonstrate that an appropriate mix of planning, building and emergency management controls can effectively manage the risks to the use and the occupants.
			Flood hazard H6 in larger events	All uses and developments including key community and utility uses discretionary provided a detailed risk assessment can demonstrate that an appropriate mix of planning, building and emergency management controls can effectively manage the risks and ensure continuity of service.
		3	Outside FPCC2. Generally below DFE+ freeboard	In addition to controls in FPCC4 All other uses and developments are permitted provided they meet flood specific planning conditions such as meeting minimum fill and floor level and specific building and access requirements.
			4	Outside FPCC3 but within PMF (or similar extreme event)

Table 2 provides some examples of typical treatment measures and development controls which should only apply where risks associated with specific conditions within the floodplain have been tested to show these control risk to acceptable levels. Treatment solutions for flash flood environments will be different to those for floodplains with sufficient flood warning time. Local and jurisdictional policies and planning instruments may override or restrict some of treatment options.

Using this information in land use planning activities

In considering the suitability of land for development the following should be considered:

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

FPCC1 captures land that is either unsuitable for development or on which development is highly constrained. The majority of new development types are likely to be excluded due to their impacts upon flood behaviour and their vulnerability to the degree of flood hazard. The exception is those limited uses that are compatible with the flood function and flood hazard in the area. Consideration should be given to limiting growth in exposure of existing development not compatible with flood function or hazard.

FPCC2 identifies the next least suitable area for new development due to the impacts of flooding on the land and the consequences to the development and its users. Some areas are likely to be unsuitable for new development whilst other areas have some development potential but with significant constraints. Consideration should be given to limiting growth in exposure of existing development where the associated risks cannot be effectively managed.

FPCC3 areas are more suitable for new development and expansion of existing development when flood related development conditions are met. However there may also be restrictions for emergency response facilities and vulnerable land uses.

FPCC4 identifies areas where only some types of new or expanded land uses, typically developments used in an emergency response, those with vulnerable development, are likely to have flood related development conditions.

Greenfield development should generally be targeted to FPCC3 or FPCC4 or outside the floodplain. However, where other suitable land is not available, development in FPCC2 could be considered, however additional flood investigations will be necessary to determine if the land is suitable for the development and with what limitations.

Using of Information in the ongoing example

Where to target new development

There are significant areas of land outside the floodplain and in FPCC3 and FPCC4 north of the river and connected with the existing commercial centre. Therefore, new greenfield development can be targeted to areas in FPCC3, FPCC4 and areas outside the floodplain. The available land will outstrip anticipated demand. Given the length of time the river is in flood and as land supply is not limited relative to demand, no new greenfield residential land releases would be recommended south of the river as this is isolated from many town services during a flood. However, as this area is close to a major transport route new light industrial or commercial development may be desirable in this area.

What types of development to target where

The next step is deciding how to use the available land by considering where different types of development would best be located in growing the township. This should consider both the use of different development types in response to a flood emergency and the relative vulnerability of the land uses and their users to flooding. Table 3 provides some advice.

An efficient way of doing this is to locate facilities used in community emergency response first as these need to operate during a flood event and therefore their exposure to flooding needs to be limited. The next step is to locate the land uses whose development or users are most vulnerable to flooding to locate these where flood exposure is limited. This continues down until the least vulnerable types of development are located. For example going from age care homes through to agricultural development.

In the ongoing example, developments used in emergency response (for example a community hospital and evacuation centre) are ideally located in the northern part of town in areas outside of the influence of flooding or in the fringes of FPCC4, where they can still perform their emergency response roles during a flood event. The location of land uses whose occupants or users are vulnerable in emergency response (such as aged care homes) should be located in areas with limited consequences of failed evacuations. These would generally be located in areas where flood depths are relatively shallow and evacuation routes are relatively short. Therefore areas in the north of town within and toward the fringes of FPCC4 or outside the floodplain.

FPCC1 and FPCC2 areas are generally between the northern and southern sections of the town in the vicinity of the river and outside the protection provided by the levees. These areas are considered unsuitable for further intensification of use for residential purposes. They are suitable for agricultural activities that is compatible with maintaining flow conveyance and therefore unlikely to adversely impact on flood behaviour in the vicinity of the town. Any agricultural activities and works in these areas should also consider the degree of flood hazard and the limited ability to manage this hazard.

Table 3 Examples of relative vulnerability to flooding for the same exposure to flooding

Type of Use	Element at risk			Use in Emergency Response	Comment
	Building	Contents	Occupants		
	Base	Base	Base	No	
Standard Residential	Base	Base	Base	No	
Medium / High Density Residential	Lower	Higher	Higher	No	Higher density but buildings often stronger
Rural residential	Lower	Lower	Lower	No	Lower density
Community Hospital with medical emergency facilities	Lower	Higher	Higher	Yes	Occupants on average more vulnerable in evacuation. Facility needs to be able to operate and be accessible during an event or have an alternative and evacuation plan.
Aged Care Facilities	Lower	Higher	Higher	No	Occupants on average more vulnerable in evacuation
Schools	Lower	Lower	Higher	Possible	Occupants on average more vulnerable in evacuation
Community Facility	Lower	Lower	Varies	Possible	The type of occupants and their exposure to flooding will depend on the nature of the development.
Service Club	Lower	Lower	Higher	Possible	Employees may be able to be trained. Customers likely to be unfamiliar with location or flood issue
Emergency Response Facility	Lower	Lower	Lower	Yes	Facility needs to be able operate and be accessible during an event or have alternate arrangements
Commercial	Lower	Varies	Employees Lower Customers Higher	No	Employees may be able to be trained. Customer density high, likely to be unfamiliar with location or flood issue
Industrial	Lower	Varies	Lower	No	Employees may be able to be trained, customer density low. Customers likely to be unfamiliar with location or flood issue
Agricultural	Lower	Lower	Lower	No	

Development constraints in different areas of the floodplain

Table 2 provides a starting point for advice on the typical floodplain management objectives and examples of development controls that assist in achieving these objectives in different FPCCs. These should be used in conjunction with jurisdictional advice to develop controls to support development through planning systems in consideration of the floodplain management objectives.

Conclusion

Providing specific, timely and readily available information from the floodplain management process can support land use planning activities. This can be achieved earlier in the process by producing some specific outputs within a comprehensive flood study. These outputs include FPCC mapping developed consistent with the guide and jurisdictional advice an information on planning and development controls to meet floodplain management objectives for each of the FPCCs to support the guide. This should be developed in consideration of the advice provided in the guide and relevant jurisdiction legislation, regulation, policies and directions.

The information derived using the guide is designed for flood risk managers to inform land use planning activities rather than go directly into land use planning activities. It is aimed at a community or precinct scale rather than for individual developments. The guideline has been developed to deal with riverine flood issues where flood extents are readily defined. Care should be taken when using the guide where there are significant ranges in flooding between the DFE and extreme floods. The principles of the approach are sound, particularly in mainstream flooding but the application needs consideration to ensure that the results are fit for purpose and reasonable from a community perspective.

Land use planning professionals are encouraged to be involved in flood risk management from scoping to implementation. Getting involved in scoping of studies can ensure the necessary information is provided through outputs to support decision making. Land use planning, flood risk management and emergency management professionals are encouraged to work closely together to ensure that growth in flood risk is managed as communities grow.

Acknowledgements

This paper is based upon work for the guideline. The guideline had significant input from NFRAG members and a project working group from across Australia involving a number of land use planning professionals. The work of Angela Toniato as a Masters student at the University of Technology, Sydney was integral to project. Funding for this work was provided through the National Emergency Management Program managed by the Attorney General's Department. The NSW Office of Emergency Management administered the grant on behalf of NFRAG.

References

- Australian Emergency Management Institute (2013), Australian Emergency Management Handbook 7: Managing the Floodplain Best Practice in Flood Risk Management in Australia AEMI, Canberra.
- AEMI (Australian Emergency Management Institute) 2014a, Guideline for use of the national generic brief for flood investigations to develop project-specific specification, AEMI, Canberra.
- AEMI (Australian Emergency Management Institute) 2014b, Technical flood risk management guideline: Flood emergency response classification of the floodplain, AEMI, Canberra.
- AEMI (Australian Emergency Management Institute) 2014c, *Technical flood risk management guideline: Flood hazard*, AEMI, Canberra.
- AEMI (Australian Emergency Management Institute) 2014d, *Technical project brief template for flood investigations*, AEMI, Canberra.