Queensland Floods Commission of Enquiry

Submission

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1. INTRODUCTION

Flooding should be the easiest natural disaster to manage effectively: we know where floods will occur and through the use of numerical flood simulation models we can assess the potential impacts of floods of various severities. What we don't know is when a flood of a given severity will occur.

The effective management of flood risk is difficult because it requires integrated and coordinated actions from all levels of government and from the community at large; the roles and responsibilities of all parties affecting or affected by flood risk need to be clearly and transparently defined.

In the late 1990s, the federal government established a working group to review how flood risk could be better managed in Australia. All States and Territories were represented, and a manual of best practice guidelines was produced[1]. Most States and Territories have incorporated aspects of this manual into their respective State and Territory floodplain (or flood risk) management manuals. A central finding of the best practice guidelines was the need to adopt an 'integrated' approach to flood risk management, (integrated flood risk management or IFRM). The concept of integration, as embodied in the IFRM process, encompasses integration of the various flood risk management measures and integration of the efforts/activities of all parties that affect or are affected by flood risk.

This submission to the Queensland Floods Commission of Inquiry describes the IFRM process and framework and uses the latter to reflect on the management of flood risk associated with the January 2011 Floods in SE Queensland.

2. FLOOD RISK

Before describing the 'IFRM Process', a number of basic flood risk concepts are briefly discussed and described:

- We do not 'manage' floods *per se*. Rather, we manage flood risk.
- Flood risk depends upon the *likelihood* (probability) of flooding and the *consequences* of flooding (flood impacts).
- We generally cannot reduce flood risk by reducing the likelihood of a flood occurring, which is defined by the nature and severity of the underlying physical phenomenon (rainfall, storm surge, tsunami, etc). However, we can reduce flood risk by 'managing' the *nature* of flooding through the construction of *flood mitigation measures*, such as flood protection embankments, flood control dams, etc, and by reducing the *impact of flooding*.
- The impact of flooding depends upon the *nature of the flood* itself (peak flood height, duration, rate of water level rise, etc), any *flood mitigation measures* in place, and the *socio-economic vulnerability* of the flood-prone community.
- Community vulnerability depends upon the *population at risk*, *land-use and infrastructure* in flood-prone areas, and *community flood resilience*.
- Community resilience can be strengthened through the development of *flood preparedness, response, relief and recovery plans* (PPRR plans).

[1] 'Floodplain Management in Australia, Best Practice Principles and Guidelines', Standing Committee on Agriculture and Resource Management, SCARM Report No. 73, 2000. (CSIRO Publishing)

Thus, we can represent 'flood risk' by the following equation:

$$\text{Flood Risk} = \text{Function } (L_f, N_f, Pop_r, LU, CR)$$

Where: L_f is the likelihood of flooding,
N_f is the nature of flooding,
Pop is the population at risk,
LU is land-use, and
CR is the community resilience to flooding.

As noted above, we cannot reduce the likelihood of flooding, but we can reduce flood risk (i) by moderating the nature of flooding (use structural flood control works to '*keep the water away from the people'* with structural works), (ii) by reducing the population at risk (use appropriate land-use controls to '*keep people away from the water'*), and (iii) by increasing community resilience to flooding (acknowledge that '*the water will flood communities on flood-prone land' from time to time*, but seek to limit the ensuing socio-economic damage and disruption by ensuring that land-use is appropriate to flood hazard and risk, that buildings and infrastructure are flood resilient, and that PRRR Plans are prepared by federal, state and local government agencies contributing to the management of flood risk and by flood-prone communities.

Flood risk depends upon with the severity of a flood (as measured by its likelihood of occurrence). It also depends on the nature of flood behaviour: deep, fast flowing floodwaters are more hazardous and cause more damage than shallow, slowly moving floodwaters; the greater the area of flooding, the more people affected, and the greater the flood damage.

3. THE INTEGRATED FLOOD RISK MANAGEMENT PROCESS – AN OVERVIEW

Integrated flood risk management (IFRM) is a ***planning process*** that attempts to better manage flood risks by means of formulating an ***IFRM Plan*** that integrates and coordinates the actions of all parties that affect or are affected by flood risk.

IFRM identifies *three flood risks*, *five risk management measures* (one structural and four non-structural) and *four supporting or ancillary risk management measures* (all non-structural) *that need to be considered together to define an integrated and coordinated 'plan' to manage flood risk. Summary details of these risks and risk management measures are shown in*

Table 4.1.

The three flood risks, five flood risk management measures and four supplementary flood risk management measures are now described in some detail, including their expression in relation to flooding in SE Queensland in January 2011.

4. THE THREE FLOOD RISKS

The '*existing flood risk'* to a (flood-prone) community consists of two components: the *'controlled risk'* and the *'residual risk'*.

4.1 CONTROLLED FLOOD RISK

The *controlled flood risk* refers to the risk that is controlled by any structural flood risk management measures currently in place (existing measures). The principal existing structural flood measure providing protection against Brisbane River flooding in Ipswich and Brisbane City is Wivenhoe Dam (see Section

5.1).

Table 4.1 Flood Risks and Flood Risk Management Measures

Item	Name	Details
Flood Risks	1. Controlled Risk	The flood risk to existing developments on flood-prone land that is 'controlled' by current structural flood protection works (eg dams, flood protection embankments).
	2. Residual Risk	The flood risk to existing developments over and above the controlled risk. It is generally impossible to completely eliminate flood risk. A residual risk associated with the overwhelming of structural flood protection works or with the failure of these works generally (always) remains.
	3. Future Risk	The risk exposure of flood-prone communities at some time in the future. Future risk relates to new developments and is generally (inevitably) higher than the current residual risk because of population growth in flood-prone areas and increased future community vulnerability of communities because of a higher future standard of living and likely increases in the vulnerability of future land-uses.
Flood Risk Management Measures	1. Structural Works	Aim at 'keeping the water away from the people'. In Assam structural works typically consist of flood protection embankments.
	2. Land-Use Zoning	Aims at 'keeping people away from the water'. Aims to ensure that land-use is appropriate to flood risk and hazard by defining flood hazard zones and regulating land-use within these zones.
	3. Building and Development Controls	Recognizes that flooding will occur (residual risk) and aims to limit the damage caused to buildings and infrastructure by 'flood-proofing'.
	4. Regional Flood Emergency Planning	Recognizes that flooding will occur (residual risk) and aims to limit socio-economic impacts on flood-prone communities by the provision of flood emergency services (preparedness, response, relief and recovery services). Regional flood emergency services are delivered by federal, state and local government agencies.
	5. Community-Based FRM	Recognizes that flooding will occur (residual risk) and aims to increase the flood resilience of flood-prone communities by developing a community-based flood risk management (FRM) Plan comprising local preparedness, response, relief and recovery arrangements.
Supplementary Flood Risk Management Measures	1. Land-Use Planning	Land-use planning provides a foundation for land-use zoning. In zoning flood-prone land, land-use factors additional to flood risk also need to be taken into account: the socio-economic needs of the community, together with ESD, NRM and RBM considerations.
	2. Flood Simulation Modelling	Enables the impacts of structural works and floodplain developments on flood risk and flood behaviour to be assessed. Also used for flood forecasting purposes. Flood simulation modelling is an essential tool of modern flood risk management.
	3. Flood Forecasting	Flood forecasting enables flood-warning time to be increased. Simple statistical-based manual methods or complex computer-based methods can be used.
	4. Flood Warning	If flood warning is to be effective, ie to significantly reduce flood risk, warnings must be accurate and timely and warning recipients must know how to respond appropriately (response plans).

4.2 RESIDUAL FLOOD RISK

The *residual flood risk* is that risk that is not controlled by structural flood measures, ie the risk over and above the existing controlled risk. Residual risk can be realized in two ways: through the occurrence of a flood larger than the design flood adopted for the design of the structural flood management measures (eg by the overtopping of a flood protection embankment); or by the physical failure of structural measures against a flood that should have been 'controlled' (eg through the breaching of a flood protection embankment or flood control dam). In the January 2011 Flood, Wivenhoe Dam did not fail in a physical sense (although on the basis of press reports the operators were apparently concerned about the structural integrity of the flood gates when fully open), but it may have failed to deliver the expected degree of flood protection, which on the basis of press reports was apparently commonly believed to be up to that of the 1974-Flood Event (see Section 5.1).

4.3 FUTURE FLOOD RISK

Future flood risk is associated with the future development of a flood-prone community. In general, future residual risk is greater than the existing residual risk (unless additional structural measures are built) because of population growth and development in flood-prone areas (more people, more assets and more

infrastructure at risk), because of a rising standard of living (more expensive assets and infrastructure at risk) and possibly because of changes to land-use (from more flood-resilient to more flood-sensitive land-uses, eg rural to urban). How well has the future flood risk along the Brisbane River and its tributaries been managed over the intervening period between 1974 and 2011. The existing residual risk in 1974 was substantially reduced by the construction of Wivenhoe Dam. However, future residual risk (ie today's residual risk) will have also increased substantially because of the additional development of flood-prone areas over the intervening period.

5. THE FIVE FLOOD RISK MANAGEMENT MEASURES

Figure 5.1 shows the five FRM measures, which are described below. Typically, these measures are categorized as 'structural' (structural works) or 'non-structural' (the remaining four measures). Financial measures, PRRR plans and flood education measures are important elements of flood emergency management and have been shown separately.

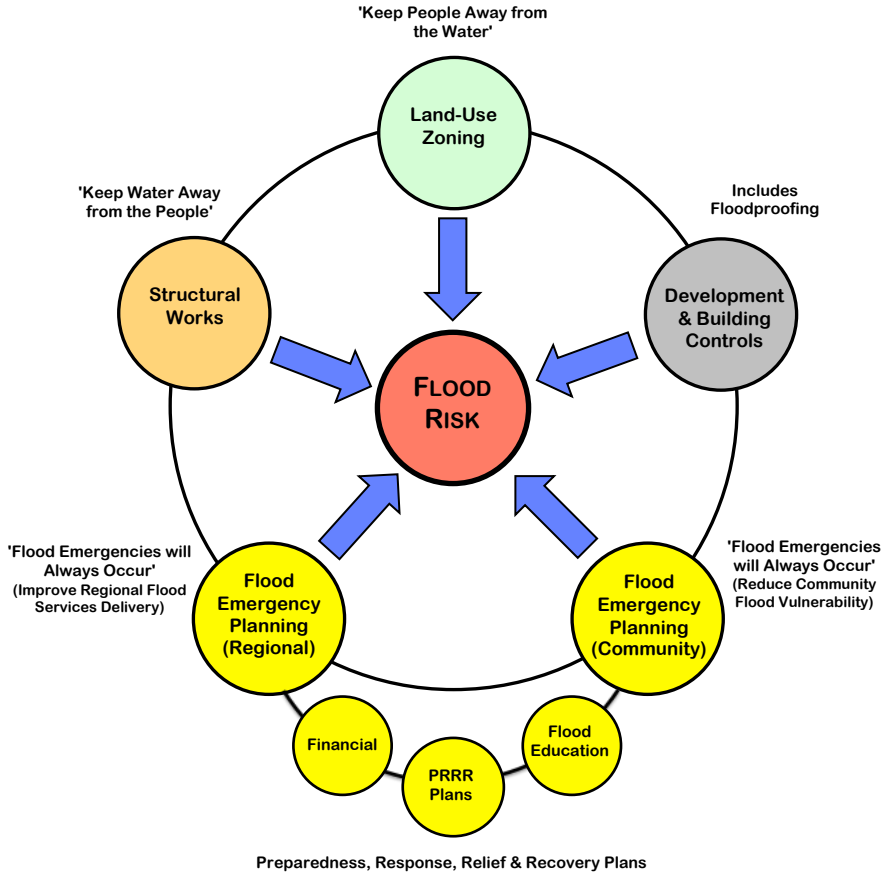

Figure 5.1 The Five Principal Flood Risk Management Measures

5.1 STRUCTURAL WORKS

The aim of structural works, which include flood protection dikes, flood control dams, sacrificial flood basins, river improvements, etc., is to protect existing and future development from flooding, ie to '*keep floodwaters away from the people'*. It is generally impossible to provide total protection against flooding, but structural works, provided they are well designed, constructed and maintained, *eliminate* (control) flood

risk up to the design flood event and the associated existing flood risk.

January 2011 Floods:

The principal structural flood management measure used to control flood risk along the Brisbane River is Wivenhoe Dam (or more correctly, the Wivenhoe/Somerset Dam combination). The degree of flood protection provided by a flood control dam depends on the peak discharge, the volume and the 'shape' of the incoming flood wave, and will differ from flood to flood. Peak flood levels along the lower reaches of the Brisbane River were less than 1974-Flood levels; peak flood levels along the lower reaches of the Bremer River and Lockyer Creek may have been substantially higher than 1974 levels (I do not have this information to hand). This outcome provides a mixed message as to the effectiveness of the dam. Certainly, releases from Wivenhoe Dam (dam release flooding) were the major factor in flooding along the Brisbane River and along the lower reaches of tributaries immediately downstream from the Dam (backwater flooding), although the flooding situation along the lower reaches of the Bremer River and Lockyer Creek was compounded by 'natural floods' attempting to move downstream when releases from the dam were at their greatest (see ICA 2011b, 2011c and 2011d). To objectively resolve the issue of the effectiveness of the dam during the January 2011 Floods, it is necessary to know (i) what downstream flood levels would have been in the absence of the dam; (ii) what flood levels would have been if the lowest fuse-plug had of breached because of rising dam levels[2] (presumably a major point of concern to the dam operators); and (iii) on the basis of the information available at the time to the dam operators, could releases from the dam have been better managed to reduce downstream flood levels.

> ***Recommendation No. 1:*** The operation of a dam under extreme circumstances is a difficult exercise. Given the contention surrounding the operation of Wivenhoe Dam during the January 2011 Flood, The Commission could consider seeking information from other States and Territories as to the operational plans for their major dams under extreme circumstances, which may provide insight into the operational plan for Wivenhoe Dam and the operational response during the 2011 Flood.

5.2 LAND-USE CONTROLS

Land-use controls or floodplain zoning is aimed at '*keeping people away from floodwater'*, ie attempting to ensure that land-use is appropriate to flood hazard and that flood-sensitive land-uses are shepherded into less hazardous areas of the floodplain. Land-use controls can limit flood risk exposure to community infrastructure, assets and the population at risk, and are the most cost-effective means of reducing the growth in future flood risk. There is always pressure to develop flood-prone land for urban purposes. The land is generally easy to develop: it is flat, often relatively inexpensive and is often in close proximity to existing urban developments and infrastructure. Flood-prone land is a valuable public and private resource. The object of land-use controls (floodplain zoning) is not to prohibit the development of such land, but to ensure that land-use is appropriate to flood risk and hazard, and that the residual flood risk associated with development of the land is appropriately addressed in associated development and building controls and flood emergency planning.

A variety of infrastructure and other land-use developments across floodplains can affect flood behaviour and the associated flood risk. Road and railway embankments can interfere with and redirect flood flows and increase flood levels, as can the filling of flood-prone land for property development. Inadequate waterway openings in bridges and culverts also increase flood levels. It is usual to use flood simulation models to assess the impact of proposed floodplain developments on flood behaviour (see Section 7.2).

January 2011 Floods:

At the time of writing, information is not to hand concerning (i) land-use controls for the development of flood-prone land in the various LGAs covering the Brisbane River catchment, (ii) the relative number of properties flooded above floor level in 1974 and 2011, and (iii) relative flood levels in 1974 and 2011 along Brisbane River, Bremer River and Lockyer Creek. As such, I cannot quantitatively comment on the relative success of land-use controls in limiting the annual growth in properties at risk of flooding. However, experience elsewhere indicates that the number of properties exposed to a given level of flooding

[2] The breaching of a fuse plug would have created a controlled breach in the dam embankment and would have substantially increased the discharge from the dam.

(eg the 100-Year ARI flood event) inexorably grows over time. In the aftermath of the January 2011 Floods, a close examination of the nature and effectiveness existing land-use controls for the development of flood-prone land in SE Queensland (and Queensland generally) is warranted. Such controls are the key to reducing the growth in future flood damage.

With regard to the influence of infrastructure on flood behaviour, it is noted that according to the operational plan for Wivenhoe, outflows are initially constrained in an attempt to keep two downstream low-level road crossings of the Brisbane River trafficable. Perhaps these crossings need to be raised to provide more operational flexibility for dam releases?

> ***Recommendation No. 2.*** In the aftermath of the January 2011 Floods, a close examination of the nature and effectiveness existing land-use controls for the development of flood-prone land in SE Queensland (and in Queensland generally) is warranted. Such controls are the key to reducing the growth in future flood damage.

5.3 DEVELOPMENT AND BUILDING CONTROLS

Along with regional and community flood emergency planning, development and building controls recognize that flooding cannot be eliminated and aim '*to minimize flood damage to infrastructure and assets'* by 'flood proofing', so reducing residual flood risk by enabling the ready return to use of infrastructure and assets in the aftermath of a flood.

January 2011 Floods

Given that flood-prone areas are to be developed for residential purposes, a common building control is to set *minimum floor levels* dictated by some nominated design flood event (typically the 100-Year ARI level for urban residential development) plus an allowance for freeboard. This should prevent above-floor flooding for floods up to and including the design flood event. On the basis of press reports, it appears that the owners of many properties flooded above floor level in Brisbane and Ipswich City LGAs thought their properties were protected up to the 100-Year ARI flood level. That above-floor flooding occurred at such properties indicates that (i) the design flood event was less severe than property owners thought (ie less than the 100-Year ARI flood level) or was incorrectly calculated or enforced (local council responsibilities), or (ii) that the January 2011 flood was greater than the design flood level in these areas (see Section 5.1).

Flood-proofing refers to the use of flood-resilient materials and building practices to minimize flood damage to flood-prone buildings and the to enable the ready return to service of flooded infrastructure in the aftermath of a flood. Flood-proofing is most easily incorporated in new buildings and infrastructure; elements of flood-proofing can be installed, albeit with some difficulty, in existing buildings and infrastructure via retrofitting. Many modern building materials have little if any resilience to flooding, gyprock wall linings and chipboard cabinets and fittings being two obvious examples, as was again demonstrated during the January 2011 Floods. The typical 'Queenslander' with its wooden single skin internal walls weathers flooding far better than modern buildings. It appears that there are no specific building regulations for flood-prone buildings in the State and local government building codes.

A commonly overlooked development control (or consideration) is the existence of *safe evacuation routes* should sudden, severe flooding (flash flooding) occur. The people of Grantham were most fortunate that most had ready access to the railway embankment as a means of evacuation/safety. If there was no embankment in Grantham, the loss of life would have been much higher.

Recommendation No. 3: **(a)** Property owners should be unambiguously informed of the degree of protection they have against over-floor flooding. In the case of Wivenhoe Dam, this will involve an assessment of the joint likelihood of the peak discharge and volume of the incoming flood and the volume of water stored in the dam at the start of a flood event. **(b)** It is suggested that state and/or local building codes be reviewed with the object of identifying more flood-resilient building materials, assessing their effectiveness in minimizing resultant flood damage, quantifying any additional building costs, and possibly requiring their use in flood-prone buildings, eg the use of marine ply rather than chipboard for cabinets and fittings. **(c)** In light of the flash flooding that occurred down the upper and middle reaches of Lockyer Creek and its tributaries, local councils should assess areas potentially prone to flash flooding in their communities and townships, identify (construct?) safe evacuation routes, prepare evacuation plans (part of community flood response), and ensure that this information is provided to and understood by communities/people at undue risk. Isolated landholders should also be encouraged to prepare individual flood response and evacuation plans[3].

5.4 REGIONAL FLOOD EMERGENCY PLANNING

The provision of regional flood emergency services by federal, state and local government agencies is aimed at assisting flood-prone communities better prepare for, respond to, endure, and recover from floods, ie reducing the residual flood risk. To this end, federal, state and local government Preparedness, Response, Relief and Recovery Plans (PRRR Plans) need to be developed.

January 2011 Floods:

A basic question The Commission could address is the effectiveness of federal, state and local government PRRR Plans during the 2011 Floods. I make the following observations on the basis of newspaper reports and discussions with senior council staff during the preparation of the ICA Reports:

(i) There were a number of federal and state agencies, along with local councils, involved in RRR activities during the 2011 Floods. The coordination of RRR activities and effort is generally a major issue and this would appear to have been the case during the 2011 Floods.

(ii) Local councils, especially councils with a smaller rate base, may be under-resourced with regard to PRRR planning. During interviews with local councils, which were undertaken as part of the ICA Report preparation process, councils still did not know the actual number of properties flooded above floor level some 2-3 weeks after the actual flood events. A number of different agencies were doing house counts; different agencies were using different criteria to include or exclude flooded properties. Such an approach does not bode well for the smooth implementation of recovery and relief operations. We asked one local council why council officers were not doing property counts and were informed that council didn't have the necessary resources. It seems that immediate post-flood information useful for future flood risk planning was 'lost' because of a lack of council resources.

Recommendation No. 4: The Commission could review State and local government PRRR Plans to assess the nature of these plans and their effectiveness in reducing flood risk during the 2011 Flood Event. Local councils should be the main player in the management of local flood risk. It is also suggested that The Commission review the minimum resourcing needs of local councils to effectively develop and implement local government and community-based PRRR Plans. In passing, it is noted that the management of flood risk has been strongly devolved to local councils in Victoria and New South Wales. There may be insights for the Commission on the way things are done in these States**.**

5.5 COMMUNITY FLOOD EMERGENCY PLANNING

Flood-prone communities should be encouraged to accept responsibility for their residual flood risk. Local councils, in conjunction with the flood-prone communities, should develop Community Flood

[3] Many isolated landholders are farmers, who by their nature are more flood-aware and more independent than many urban dwellers. It is expected that many isolated landholders will have thought out their 'flood response', including evacuation if necessary. The role of council in this case is more one of reminding them of the need to have planned their flood response and informing them of sources of information during the onset, duration and aftermath of a flood event.

Preparedness, Response, Relief and Recovery Plans to reduce flood impacts. Again, these activities are aimed, in the most direct sense, at reducing residual flood risk and community vulnerability.

It needs to be constantly kept in mind that local flood-prone communities are the *target* of flood risk management planning. If we fail to achieve a reduction in flood risk and an increase in flood resilience at the local community level, the flood risk management exercise has failed.

January 2011 Floods:

I have no concrete information on the existence or nature of community-based FRM Plans or how plans were during the 2011 Flood Event. As discussed in Section 5.3, evacuation planning is a fundamental component of a community-based FRM Plan and was found wanting during the 2011 flash flood down Lockyer Creek.

Experience with past floods and media reports during the 2011 Floods indicate that many 'flood damaged' items from flooded properties were unnecessarily discarded, when in many cases they could be relatively easily and inexpensively repaired.

> ***Recommendation No. 5*: (a)** It is suggested that The Commission review with local councils the nature and effectiveness of activities undertaken by the latter in relation to community-based FRM Planning, including flood awareness and flood readiness (see below) with the aim of reducing flood risk at the local community level. Guidelines to assist local councils in these matters could be prepared. **(b)** Consideration could be given to the preparation of state-wide guidelines regarding the repair and restitution of flood-affected items in the aftermath of a flood.

5.6 ELEMENTS OF FLOOD EMERGENCY PLANNING

5.6a Flood Education

Flood Education should be part of flood preparedness planning. There are two elements to flood education: *flood awareness*, ie knowing local flooding behaviour and the local flood risk, and *flood readiness*, ie knowing what to do when a flood eventuates. Flood education is important at all levels of management (federal, state, local and community), but especially at the community level and is a fundamental element of a community-based FRM Plan.

5.6b Financial Measures

Financial measures form part of relief and recovery planning, and include government grants to meet immediate needs, donations and flood insurance.

Flood insurance is always a contentious issue, the major concern being the nature of the flood risk being insured against and the associated terminology. Most if not all insurance companies will unambiguously provide cover against 'Storm and Tempest Damage', which includes damage caused by rainfall entering a building via physical damage to the building itself or as stormwater flows arising from an overloaded stormwater drainage system as the stormwater makes its way to a receiving waterbody. Some insurance companies provide cover against 'waterway floods' of a particular nature, ie after the stormwater has arrived in a waterway. A few companies provide unconditional cover against 'flood damage', irrespective of the origin of the 'floodwaters'. The type of flood cover provided by insurance companies is a commercial decision. However, waterway flooding is not a risk that conforms to the standard conditions of insurability. If you live in a flood-prone property, it is *certain* that you will get flooded; the only uncertainty is when and to what extent. Thus, insurance against waterway flooding is unlike automobile insurance (say), where accidents are random in nature – as far as car owners are concerned – or storm and tempest damage, which is also random in nature. Further, it can be difficult to assess the risk of flooding (and hence the insurance premium), but this is less so today with information provided from flood simulation models. Yet again, even if the premium can be objectively assessed, it may be too expensive for the property owner to afford. Insurance companies providing general flood cover would appear to be using the premiums of non-flood-prone clients (or other clients) to subsidize flood-prone clients. If flood cover premiums reflected true flood risk, it would send a message to property owners and help sustain flood awareness. Subsidization hides the true cost of flood cover.

Grants and donations are a de facto form of flood insurance (admittedly of a limited amount) for the

uninsured. Again, this does not promote flood awareness.

January 2011 Floods:

It seems there was contention surrounding all three of the above financial measures during recovery operations in the aftermath of the 2011 Floods. Regarding government grants, both federal and state funds were made available; on the basis of press releases, there were delays in the disbursement of these funds and some contention regarding the selection of people to receive grants. Similar criticisms were levelled against funds collected by the Premier's Flood Appeal.

Criticisms were levelled against some insurance companies for the lack of transparency in the terminology of flood risks covered under 'flood insurance' and delays in assessing claims. The Insurance Council of Australia (ICA) opted to have 'plain English' regional flood studies made by an independent panel of hydrologists to facilitate the assessment of insurance claims. The work of the panel was delayed for some 2-3 weeks because of the initial refusal of agencies to release basic hydrometeorological data (these agencies included the Bureau of Meteorology, the Department of Environment and Resource Management, SEQWater and local councils). Possibly it was fear of litigation or a lack of staff resources to check the data before it was released that occasioned the delays. The required data are collected by public agencies, ie they are public data, and it is suggested that in future such data should be released as quickly as possible, even if accompanied by conditions and reservations from the agency in charge.

> ***Recommendation No. 6:*** It is apparent that there is a need for a standard, plain English terminology to unambiguously define the type of flood cover provided by an insurer[4]. The Commission could discuss the feasibility of such a terminology with representatives of insurance companies**.**

6. EFFECTIVENESS OF FLOOD RISK MANAGEMENT MEASURES

Table 6.1 indicates the effectiveness of the principal risk management measures in managing the three flood risks.

Table 6.1 Effectiveness of Flood Risk Management Measures in Relation to the Three Flood Risks

Flood Risk Management Measure	Controlled Risk (Existing Development)	Residual Risk (Existing Development)	Future Risk (New Development)
1. Structural Measures	✓		
2. Land Use Controls			✓
3. Development and Building Controls		✓ (Retrofit)	✓
4. Flood Emergency Planning (Regional)		✓	
5. Community-Based Flood Risk Management		✓	

- *Structural works* define the level of controlled risk for an existing development situation. As additional structural works are built, the level of controlled risk increases and the level of residual risk becomes smaller, ie there is less residual risk to manage.
- *Flood emergency planning* (at both the regional and community level) is the principal instrument used to manage residual flood risk; the retrofitting of flood-proofing measures to existing buildings and infrastructure at risk can reduce damage and the resulting service and socio-economic disruption.

[4] As part of the ICA Reports, the Hydrology Panel defined the various types of 'standard' floods in hydrological terms – see ICA 2011a to 2011d.

- *Land-use Controls* and *Building and Development Controls* (including the flood-proofing of new developments and infrastructure) are the most cost-effective means of controlling future flood risk.

7. ANCILLARY FLOOD RISK MANAGEMENT MEASURES

In addition to the five principal flood FRM measures, there are four ancillary or supplementary FRM measures, all of a non-structural nature. They are termed ancillary because they are more tools for the better management of flood risk rather than FRM measures per se. The four ancillary measures are:

1. Integrated Land-use Planning;
2. Flood Simulation Modelling;
3. Flood Forecasting; and
4. Flood Warning.

Flood forecasting and warning are commonly treated as principal flood risk management measures in their own right, although they are better regarded as part of regional and community-based flood emergency response planning.

7.1 INTEGRATED LAND-USE PLANNING

Integrated land-use planning is necessary to define land-use controls for flood-prone areas. Along with flood risk, the integrated land-use planning process for flood-prone lands needs to embrace other factors affecting land-use, such as the socio-economic needs of the community, together with ecologically sustainable development and natural resource management considerations.

January 2011 Floods:

No comments on the integrated land-use planning process in relation to the 2011 Floods, except to note that land-use planning is essentially a local government responsibility and that floodplain zoning based on land-use planning considerations is essential to control the growth in future flood risk.

7.2 FLOOD SIMULATION MODELLING

Flood simulation modelling via mathematical models provides an understanding of flood behaviour across the area of interest, eg the extent, depth and velocity of floodwaters across the floodplain, the rates of rise and fall of floodwaters and the duration of flooding, and so enables flood risk and hazard to be assessed quantitatively. Flood simulation models can be quite complex and are routinely used to assess the impact of proposed floodplain developments on flood behaviour and flood risk.

January 2011 Floods:

Again, no comments on the use of flood simulation models in relation to the 2011 Floods, except to note that SEQWater will have used such a model to plan the real-time operation of Wivenhoe Dam during the 2011 Flood Event and the Bureau of Meteorology will have used such a model to provide forecast flood levels for the Brisbane and Bremer Rivers.

7.3 FLOOD FORECASTING

Flood forecasting allows the future behaviour of an actual flood event to be simulated (predicted), analysed and used for warning purposes. Typically, real-time rainfall and water level data recorded at upstream locations are used, possibly in conjunction with forecast rainfall data, to forecast flood discharges and water levels at downstream locations of interest. These days, flood simulation models are generally used to simulate downstream flood behaviour and assist in the making of forecasts.

The statutory responsibility for flood forecasting in Australia lies with the Bureau of Meteorology (BoM). A number of agencies operate real-time telemetering rainfall and water level recorders that can be used for flood forecasting purposes: BoM, the Department of Environment and Resource Management (DERM), SEQWater, Sunwater and local councils. It is unclear whether BoM relies only on its own stations for

making flood forecasts or incorporates data from stations operated by DERM and other agencies.

BoM enters into commercial arrangements with local councils to install, operate, maintain and supply the data from real-time monitoring stations (so-called Alert stations). As part of this service, BoM will set up and operate an Alert flood forecasting system for council. However, only some councils can afford this service. It is by no means clear that councils have the technical resources to make the best use of Alert data and forecasts supplied by BoM.

BoM provides rainfall forecasts to SEQWater for use in the planning of real-time operational releases from Wivenhoe Dam.

BoM has a regional office in Brisbane and eight field offices throughout Queensland. All flood forecasts for the Brisbane River catchment are made from the Brisbane regional office. There appears to be no formal mechanism for BoM to incorporate flood observations from on-the-spot private individuals into their flood forecasting and warning process. These days, flood forecasts often involve the use of sophisticated mathematical models that simulate the hydraulics of flood flow. It is by no means clear that this is the core business of BoM, which relates more to meteorological forecasting, or that BoM has the necessary technical resources to provide flood forecasts using hydraulic simulation models at a number of locations simultaneously across Queensland.

DERM is a modern collection of fashionable resource management agencies that includes the former Queensland Department of Water Resources. DERM has no statutory flood-forecasting role in Queensland and it is not known what technical resources the agency has in relation to water and flood management. In addition to the monitoring of hydrometeorological data, the water section of DERM may be able to play a support role to BoM's flood forecasting activities, perhaps by vetting local flood observations from private individuals. (It is thought that DERM has a better coverage of field offices across the State addressing water issues than BoM).

January 2011 Floods:

Exceptionally intense localized rains fell over the upper reaches of Lockyer Creek and its tributaries and over Toowoomba on the afternoon of 10 January 2011 (see ICA 2011b and 2011d for details) causing flash flooding (as defined in the ICA Reports) in Toowoomba and along the upper and middle reaches of Lockyer Creek. Most real-time rainfall and water level monitoring stations failed under these extreme rainfall and runoff conditions. Thus, much of the instrumentation used to generate flood forecasts failed during the storm and flood event of 10 January 2011. The only raingauge that continued to operate throughout the storm was the Prince Henry Drive gauge, which is located to the immediate east of Toowoomba and is operated by Toowoomba City Council. It is not known whether this information was available to BoM.

It appears that BoM does not provide local flash flood warnings; BoM warnings in relation to flooding down Lockyer Creek arrived too late to be of any use. (See Section 7.5 in relation to Flash Flood Guidance).

There appears to have been some contention between BoM and SEQWater about the accuracy of the rainfall forecasts the former provided to the latter over the period 10-12 January 2011. BoM forecasts for flood levels in the Bremer River fluctuated widely over the key flood period (from 15 m to 22 m). The nature of the flood simulation model BoM used to make these forecasts is not known, but the forecasts will depend on real-time and forecast releases from Wivenhoe Dam, as determined by SEQWater. Issues in relation to forecast rainfalls and the fluctuating nature of the Bremer River forecasts would seem to indicate a need for greater cohesion and coordination between the two agencies during the management of flood events. The wildly fluctuating flood forecasts for the Bremer River made the planning of real-time flood response activities difficult for Ipswich City Council.

Recommendation No. 7: **(a)** The roles and responsibilities of the various agencies in the flood forecasting and warning process need to be clearly defined and understood, including the monitoring and use of real-time data. **(b)** The Commission could enquire into the adequacy of BoM's technical resources to make flood forecasts based on sophisticated hydraulic models. In passing, it is noted that a number of proprietary flood management software packages are available. These systems could be applied to the whole of the Brisbane River catchment. Is such a system appropriate? Has BoM considered the use of such systems? **(c)** On-the-spot people who have reliable experience in local flooding behaviour have a role to play in local flood forecasting. The Commission could enquire as how these on-the-spot observations can be checked for reliability and incorporated in the Brisbane-based flood forecasting systems of BoM.

7.4 FLOOD WARNING

Flood warning is an essential component of regional and community-based flood emergency management response plans. Ideally, flood warnings should be accurate and delivered in a timely fashion to those at risk, who should know how to respond appropriately and reduce their vulnerability. As noted in Section 5.5 on community-based FRM, it is essential that the flood-prone community (i) knows how they will receive future flood warnings, and (ii) knows what to do to effectively evacuate themselves (and their possessions if time is available) when they receive a flood warning (flood readiness).

The issue of responsibility for the issuing of flood warnings (as opposed to forecasts) is not clear. Under Section 6 (c) of the Meteorology Act 1955, BoM is responsible for

> "the issue of warnings of gales, storms and other weather conditions likely to endanger life or property, including weather conditions likely to give rise to floods or bush fires;".

Thus, it would appear that BOM is responsible for issuing of warnings only in relation to *'weather conditions'* likely to cause flooding rather than flood warnings per se. Presumably, the issuing of flood warnings is the responsibility of Emergency Services Queensland (EMQ). If this understanding of the responsibilities of BoM and EMQ is correct, the decoupling of the flood forecasting and flood warning processes has potential pitfalls, something The Commission may wish explore.

January 2011 Floods:

My experience with flood warnings for the 2011 Floods is limited to three observations: (i) there was no flash flood warning for Toowoomba or the upper and middle reaches of Lockyer Creek (see Section7.5), (ii) widely fluctuating forecasts/warnings were given for Bremer River flooding (see Section 7.3), and (iii) forecasts/warnings for Brisbane River flooding in the City of Brisbane also fluctuated, but over a much smaller range. Flood forecasts and warnings are usually more reliable for larger catchments; floodwaters take longer to move downstream, there is more scope for the real-time correction of forecasts and warnings. The effectiveness of warnings in allowing people to shift their goods and possessions to flood-free locations is not known and is something The Commission could address. If this process was not effective, it may be because the warning time was too short, the warning was inaccurate or the people shifting the goods and property did not know what to do. Again, an evacuation plan for goods and possessions is something that should be included in community-based FRM Plans.

Recommendation No. 8**: (a)** The Commission could review the roles and responsibilities of the various agencies issuing flood warnings and the effectiveness of their interactions with BoM in relation to the forecasts on which the warnings are based. The forecasting/warning process needs to be integrated and consistent across agencies. **(b)** The Commission could review the effectiveness of flood warnings issued to flood-prone communities along the Bremer and Brisbane Rivers in relation to the success or otherwise in shifting goods and possessions to flood-free locations.

7.5 FLASH FLOOD GUIDANCE SYSTEM

It is difficult to provide effective warnings for flash floods: by their nature, flash floods are sudden and unexpected. However, flash flood guidance systems are available to provide an indication of the likelihood of flash flooding, based on soil moisture levels and likely future rainfalls. (The wet antecedent soil moisture conditions of the Toowoomba and Lockyer Creek catchments were an important factor in the

resultant flash flooding, as was the high intensity rainfall band apparent on BoM's radar images – see ICA 2011a, 2011b and 2011d).

The Hydrologic Research Center (HRC) of San Diego[5] was established in 1993 as a nonprofit research, technology transfer, and training organization. HRC was created to help bridge the large gap existing between scientific research in hydrology and applications for the solution of important societal problems that involve water. HRC has developed a flash flood guidance system that has been installed in Romania, Central America and lately in the Mekong Basin. This system proves and indication of the threat of flash flooding *before it occurs*, thus enabling flash flood alerts to be issued to areas at risk. The Commission should assess the reliability and effectiveness of this system; BoM should be queried on whether or not they have contemplated the introduction of such a system or a similar system.

> ***Recommendation No. 9:*** The Commission should consider contacting HRC in relation to their flash flood guidance system to explore the potential usefulness and effectiveness of such a system for the Brisbane River catchment.

8. INTERACTIONS BETWEEN THE PRINCIPAL AND ANCILLARY FLOOD RISK MANAGEMENT MEASURES

Error! Reference source not found. shows the five FRM measures, the four ancillary measures and interactions between them. They are seen to interact in a complex way, indicating a strong need for 'integration' of FRM responsibilities and activities across all relevant agencies that influence or are affected by flood risk. It is also seen that land-use planning plays a large role in IFRM. Not only does flood risk have to be taken into account in determining appropriate land-use across flood-prone areas, but also community needs, environmentally sustainable development considerations, natural resource management considerations and river basin management considerations need to be addressed.

In effect, Figure 8.1 provides a framework for the integrated management of flood risk.

9. IFRM CONCEPTS AND PRINCIPLES

IFRM embodies the following concepts and principles:

- The need to identify all parties affected by or affecting flood risk - at regional, national, provincial, local and community levels - and the need to integrate FRM actions and efforts by all parties into an agreed and cohesive IFRM plan.
- The need for a clear and transparent allocation of roles and responsibilities across the various parties affected by or affecting flood risk.
- The need for a participatory and consultative planning process at all levels to formulate an effective IFRM Plan.
- Recognition that flood risk is *but one factor* affecting the use of flood-prone land and that other considerations need to be included in the IFRM planning process, e.g. population growth, community aspirations, socio-economic needs, natural resources management considerations, river basin management issues, ecologically sustainable development needs, etc.
- The need to objectively evaluate the cost-effectiveness and cost-benefits of alternative FRM measures to ensure that an IFRM Plan delivers 'value for money'.
- Effective monitoring and evaluation of flood risk management outcomes, together with the regular reassessment of IFRM Plans to ensure that objectives are being met, the plan remains up-to-date, and that new circumstances are addressed as they arise.

Whilst IFRM concepts and principles are easy to define, their implementation is often difficult. IFRM considerations cut across the activities, roles and responsibilities of many government departments and

[5] Contact Robert Jubach, General Manager, HRC, at http://www.hrc-lab.org/index.php

agencies. Often cooperation is not forthcoming. One way of fostering cooperation and the integration of flood risk management efforts and activities is through the formation of an 'IFRM Committee' on which all parties that affect or are affected by flood risk are represented. Such a committee can oversee the formulation of an IFRM Plan. Such plans should be prepared for all levels of management. The contents of a local IFRM Plan to manage flood risk at the community level are described below.

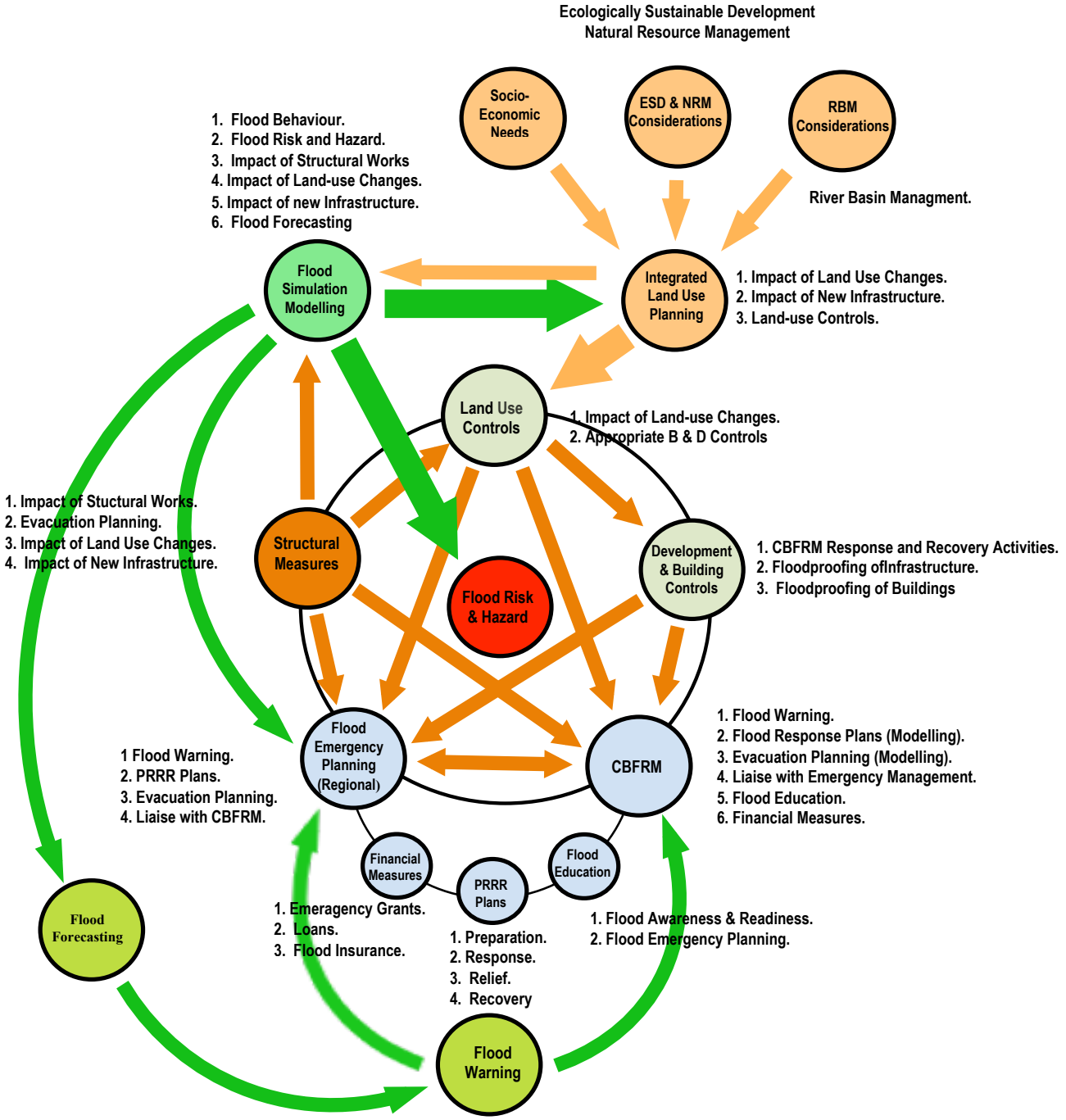

Figure 8.1 The IFRM Process and Framework – Interactions Between the 5 Flood Risk Management Measures and the 4 Ancillary Measures

10. IFRM PLANS

The most basic output of the IFRM process is an *IFRM Plan* that addresses flood risk in the area of interest (which may be regional, trans-boundary, national or local in scope). This plan states how residual and future flood risks are to be managed and is based on a number of component studies:

- An assessment of *existing and likely future land-use* in the area of interest, including population growth. This may involve national, trans-boundary and local land-use considerations across many national sectors, such as agriculture, transport, water resources development, industry, commerce, etc, i.e. the statutory planning process such as it is.
- An evaluation of *controlled, residual and future flood risks*. This requires the use of flood simulation models to investigate flood behaviour and flood risk under present day and future circumstances. Important factors affecting future flood risk are population growth, land-use change and infrastructure development.
- An evaluation of the *economic cost-effectiveness* and cost-benefits of the five flood risk management measures and four ancillary measures, together with the associated *social, environmental and natural resource management implications* of these measures. This is followed by a judicious selection of the most appropriate measures to manage flood risk. Included in these studies will be an assessment of the economic, social and environmental vulnerability of flood-prone communities and the impacts thereon of the proposed flood risk management measures.
- Identification of the any changes in existing or new stakeholder roles and responsibilities to effectively implement the IFRM Plan. This step addresses the integration of efforts across flood risk management measures and across federal, state and local government agencies and flood-prone communities.

Essential elements of IFRM planning include the identification and inclusion of all stakeholders and a willingness to undertake the necessary institutional changes.

Steps in the preparation of an IFRM Plan include:

1. *Establish an IFRM committee*. Such a committee should include representatives of all agencies that affect or are affected by flood risk, as well representatives from communities at risk. The purpose of the committee is to provide a consultative vehicle that directs the process of formulating the flood risk management plan.
2. *Collect relevant data*. A number of different data are required, including details of past flooding behaviour, the socio-economic basis and current flood vulnerability of flood-prone communities included in the study, expected population growth and land-use change over the planning period, current flood risk management practices and any deficiencies therein, survey details of waterway cross-sections and floodplain topography, etc. Likely change to future land-use is an important element of a flood risk management plan, as it defines future flood risk. Efforts should be made to obtain information from all agencies that affect land-use or the provision of infrastructure across the floodplain (such agencies should be represented on the IFRM committee).
3. *Conduct a flood study*. The purpose of a flood study is to evaluate the risk and hazard of flooding across the floodplain by providing information on the extent, depths and velocities of floodwaters and their distribution across the floodplain. This will normally require the use of numerical flood simulation models. Such models need to be developed and calibrated against historical flood data for the area of interest. The changing nature of hazard and risk across the floodplain can then be investigated for a range of ‘standard’ flood events. Such models are also used to investigate residual risk and the future risk,
4. *Conduct a floodplain risk management (IFRM) study*. The purpose of the risk management study is to determine the best means of managing the residual and future flood risk in the area of interest. This is where the IFRM risk management diagram of Figure 8.1 comes in. The feasibility, costs, effectiveness and benefits of all five flood risk management measures and four

ancillary flood risk management measures need to be carefully assessed and the most appropriate mix of measures selected. Land use planning is an especially important management measure. Note that land-use planning across flood-prone areas has to address community wants and needs, ecologically sustainable development, natural resource management and river basin management considerations. Note that if structural measures are included in the mix of flood risk management measures, the environmental impacts should be evaluated and managed.

5. *Prepare an IFRM plan*. Based on the results of the above studies, a floodplain risk management plan is drafted, which needs to account for a range of factors including changes to flood behaviour and risk associated with future changes to population and land-use, the economic and social consequences of the proposed risk management measures, the ecological and environmental consequences associated with the proposed plan, it being noted that the beneficial effects of flooding should be preserved as much as possible, and local planning needs, restrictions and opportunities need to be addressed.

6. *Implement the Plan*. The successful implementation of a floodplain risk management plan involves the coordinated actions of a number of federal, state and local government agencies and flood-prone communities. This is not an easy process. Floodplain risk management plans need to be evaluated at regular intervals to ensure that they are delivering the desired outcomes and to identify any major changes to the planning assumptions used in the preparation of the plan, eg flood behaviour, land-use, etc.

11. REFERENCES

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