Report to
Queensland Floods Commission of Inquiry
Addressing Town Planning Issues

Statement of

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Introduction

1.0 Commission

1.1 This report has been prepared by Paul Grech, Principal of Grech Planners, on instructions from the Queensland Floods Commission of Inquiry.

2.0 Purpose of the Report

2.1 This report provides an opinion in regard to town planning issues that were identified for my comment by the Commission. These issues generally relate to Item (g) of the terms of reference, being:

> *"(g) All aspects of land use planning through local and regional planning systems to minimise infrastructure and property impacts from floods."*

2.2 My brief specifically requires that I address town planning considerations associated with the following:

A. Mapping for risks;

B. The appropriate risks to be taken into account in land use planning;

C. The use of building codes in the floodplain for existing and future development;

D. Appropriate development in the floodplain;

E. Catchments Authorities as regulators of the floodplain versus local Councils;

F. Appropriate minimum standards for development in flood prone land; and

G. Use of flood mitigation engineering solutions, e.g. levees.

2.3 My instructions provide that I may deal with the above issues in a report that is structured so that information is presented in a way which I consider will be most helpful to the Commission.

3.0 Qualifications

3.1 I am a town planner with the qualifications and experience as summarised in **Appendix A**. In summary I have 27 years experience working as a town planner. During this time I have been involved in a broad range of planning projects including development assessment, environmental impact statements, residential estate developments, rezoning proposals, environmental studies and floodplain risk management studies for the development industry, local councils, state government departments and commonwealth agencies.

3.2 Over the past 15 years I have gained specialist knowledge and experience in flood risk planning. This has involved the provision of the town planning input into

Floodplain Risk Management Studies and Plans covering over 25 Local Government Areas and the town planning component of the *Hawkesbury-Nepean Flood Risk Management Strategy* (prepared for an advisory committee established by the NSW State Government). I have undertaken other projects associated flood risk management issues and policy preparation for a number of Councils and the NSW Department of Planning and Infrastructure. I have contributed to a number of papers presented at conferences and published in the Australian Journal of Emergency Management. I also present the town planning component of the Floodplain Risk Management course currently run by the University of Technology.

4.0 Investigations Undertaken

4.1 In order to provide the input required I have undertaken the following tasks:

- reviewed documents provided to me in a brief from the Commission;
- relied on my existing experience and information sources, and undertaken further research as required;
- liaised with Mr Mark Babister of WMAwater to principally identify further available information relevant to this report, and
- perused the Queensland Floods Inquiry Interim Report and a number of submissions received by the Commission to date.

5.0 Limitations

5.1 This report will be limited to my areas of expertise, which is that of a town planner with specialist knowledge and experience in flood risk planning. The report is a desktop production, and so does not involve direct enquiries with local or state planning agencies. My knowledge and experience relates primarily to New South Wales, however the concepts and practices discussed are generally considered universal.

5.2 Due to the limited time available to prepare this report, the description of concepts is brief and sometimes simplified. Additionally, where examples are provided or reference is made to current practice, these are intended to illustrate a point and not to provide an exhaustive inventory.

5.3 This report does not review recent draft policies released during the conduct of Commission of Inquiry, such as “Temporary State Planning Policy – Planning for Stronger, More Resilient Floodplains” and associated “Part 1 – Interim Measures to Support Floodplain Management in Existing Planning Schemes” prepared by the Queensland Reconstruction Authority.

6.0 Outline of Report

6.1 The first sections of the report, sections 1.0 to 5.0, deal with the purpose and scope of the report. The following sections cover the matters required to be addressed within a structure that allows for an understanding of the principles associated with flood risk management and how they can relate to town planning. The report then

leads to the more specific questions of the specific topic areas identified by the Commission. In each section I endeavour to:

- identify general principles;
- provide a review of Queensland policies (both state and local)[1] using Brisbane City Council ("BCC") as a case study; and
- Outline general observations of the Queensland approach against key principles, which may assist the Commission.

Consideration of flood risks in land use planning

7.0 Principles

Understanding Flood Risks

7.1 Before undertaking a consideration of flood risk in land use planning, it is important to have a fundamental understanding of how to identify and analyse risk in general. In basic terms, risk can be defined as a function of both the likelihood of an event and the consequence of that event. It is generally accepted that the level of risk is proportional to each of these two components (consequence and likelihood) and therefore can be shown mathematically as follows:

Risk = Consequence x Likelihood[2]

7.2 For the purposes of identifying and analysing risk it is important to consider both the likelihood (i.e. probability) and the consequence (i.e. what is affected and how). As discussed further below, planning traditionally has considered only probability when considering flooding which may or may not provide a level of risk management acceptable to the community, if the actual risk associated with flooding were known.

7.3 Traditionally, for the purposes of flood risk management there has been a focus on identifying and mapping a flood based on a flood of a singular probability, typically the 100 year flood ("Q100")[3] or an actual flood that has been recorded. The restriction of development in the floodplain will inevitably provide some reduction in risk. However, the reliance solely on the imposition of flood restrictions based on the probability of a singular flood, without understanding the consequences associated with floods of a full range of probabilities, cannot ensure that an acceptable level of risk is being planned for.

7.4 For the purposes of flood risk management considerations relevant to planning, the second component of the flood risk equation, that is consequence, requires an understanding of both the nature of the flood hazard and the land use and

[1] This is not intended to be an exhaustive review of all flood related planning policies in Queensland, but only a review of select policies briefed to us by the Commission or identified as part of my research. The intention is for such reviews to provide examples to illustrate the conclusions reached.
[2] AS/NZS:4360-2004, page 49.
[3] These and related terms are discussed within the Queensland Floods COI Interim Report 2011, pages 135 – 136.

infrastructure that could be impacted. Factors which may be relevant to determining the hazard associated with flooding include:

- Depth of inundation;
- Flood velocities;
- Duration of inundation;
- Rates of rise of flood waters;
- Warning times;
- Evacuation capabilities (either vehicle or pedestrian) given potential closure of routes due to flooding or traffic congestion on available routes.

7.5 Those factors which may influence the consequences for buildings and infrastructure potentially affected by floods may include:

- Damage to building/structure and contents due to the physical form and structural adequacy of the building/structure.
- The capacity for the building/structure to be restored to a state suitable for reoccupation/reuse or reconstructed within a reasonable time.
- The economic capability of the occupants (and the community where assisting the occupants) to recover after a flood.
- The extent of the community affected which if substantial could have multiple impacts on individuals with loss of alternative accommodation opportunities, place of employment, access to community facilities and the like.

7.6 Similarly, the characteristics of floods and their different chances of occurring can impose a range of hazards to life. This is dependent on the physical capability of occupants to evacuate to a safe refuge, if required, during a flood.

7.7 Following on from the above, identification and analysis of flood risk therefore requires a consideration of both the probability and consequences of flooding over the full spectrum of flood frequencies that might occur at a location. This can be expressed mathematically as follows:

$$\textit{Flood Risk} = \int_{\textit{all floods}} \textit{Probability x Consequence}$$

7.8 The full spectrum of flood frequencies include floods up to and including the Probable Maximum Flood (PMF). The consequences of the flood hazard that are to be considered include both property damage (private and public) and personal danger (loss of life and injury) resulting from the site's flood characteristics.

7.9 From a practical perspective, a select number of floods can be identified for the purposes of assessing flood risk, ranging from frequent nuisance floods to large but

rarer extreme floods. The types of floods that could be expected can vary between floodplains. For example, a coastal floodplain with typical geomorphologic conditions may experience minimal height variations between floods such as the Q100 and the PMF. However on occasion specific geomorphologic conditions and catchment sizes could result in substantial variations in the behaviour of floods from a Q100 to a PMF[4]. Additionally, different floodplains can contain a range of development.

7.10 It is conceivable that floods that are only slightly rarer than the Q100 could have significantly greater consequences if for example the depths of inundation were substantially greater and the ability to safely evacuate is suddenly lost.

7.11 An understanding of the relevance of a risk management approach to addressing flood issues in planning was highlighted within the work undertaken as part of the Hawkesbury-Nepean Floodplain Management Strategy[5]. In such floodplains there are substantial variations in flood depths between the Q100, flood of record and PMF which contrast with that which would be experienced in other coastal floodplains and inland areas. **Figure 1** illustrates the consequences of floods rarer than the Q100, upon dwelling houses constructed in different locations, to comply with a minimum floor level equal to the Q100.

Figure 1 *- Comparative flood risks in 3 different floodplains t*[6]

7.12 A 200 year flood[7] is equivalent to the 1867 flood of record for the Hawkesbury-Nepean River and would reach levels more than 2 metres above the Q100 flood level in Windsor. While only half as likely to occur as the Q100 a repeat of the flood

[4] A town planner would be reliant on hydrologic and hydraulic engineering advice to determine such characteristics of a floodplain, the range of floods that might be considered and the behavioural characteristics of those floods.
[5] HNFMAC, November 1997.
[6] HNFMSC, June 2006(a), page 31, Figure 15.
[7] I.e. a Q200 or a flood with a 1 in 200 year chance of being reached or exceeded in any one year.

of record today would cause severe damage and possible total destruction of many existing houses and buildings.

7.13 The analysis undertaken for the Hawkesbury-Nepean Floodplain Management Strategy also identified that if the flood of record was to reoccur some 40,000 people would need to be evacuated to safety[8]. The understanding of this risk led to improvements to roads and emergency management procedures, and influenced future planning for expansions to urban areas in that floodplain. An analysis of flood issues which focused only on the Q100 would not have provided the same understanding of flood risk and response provided by land use planning.

Determining what is acceptable flood risk

7.14 Traditionally the Q100[9] has been considered to be an acceptable level of risk for most forms of development in jurisdictions across Australia. My experience is that while minimising risk to life is typically considered by planners, decision makers and the community to be paramount, there are varying attitudes as to whether simply restricting development in the Q100 achieves an acceptable level of risk to human life as well as property. While such an approach based on the probability of a singular flood may acceptably manage risk, there is no certainty of this without at least some consideration of the full range of risks associated with all potential floods and the consequences arising, using a risk management approach.

7.15 Flooding is only one form of risk that property or persons could be subjected to. Other risks include exposure to other natural hazards such as cyclones or manmade hazards such as house fires or traffic accidents. The imposition of standards that remove all flood risks may not be acceptable in most cases because of the economic and social implications associated with land sterilisation and/or flood risk mitigation construction costs. However, the imposition of no restrictions on development subject to flood risks is likely to be equally unacceptable.

7.16 A risk management approach provides a mechanism to identify and analyse risks, but does not specify what level of risk is acceptable. Determining how to decide on what is an acceptable level of risk is not an easy task. In general, risk can be dichotomised into those which relate to either personal danger or property damage. The acceptable level of risk associated with each of these categories, would normally differ, and in my experience risk to life is tolerated less.

What are Acceptable Risks to Life from Flooding?

7.17 A risk management approach provides a process to identify and minimise these risks to a level ultimately determined acceptable to the community. As outlined above, for the purposes of planning it is relevant to consider risks to both property and to life. However, as the terms of reference of the Commission of Inquiry are limited with respect to risks to life, I do not discuss this aspect of flood risk management further.

[8] HNFMS, 1997 page 18.
[9] In addition to the adoption of a singular flood standard such as the Q100, a safety factor is typically added (referred to as “freeboard”). Freeboard is added to deal with factors such as uncertainties in calculations and wave action but should not be considered as changing the probability of the flood.

What are acceptable risks to property from flooding?

7.18 As discussed above, the potential damage to buildings and infrastructure can vary significantly depending on both the likelihood of a certain flood, and the characteristics of that flood. However, damages to buildings and infrastructure arising from flooding fundamentally results from the depth and duration of inundation and the velocity of the water[10].

7.19 In my experience, there are various ways of analysing and determining what is an appropriate level of risk to buildings and infrastructure. Inevitably such considerations focus on the financial capability of coping with the costs of such damage. For example, would a private property owner with no insurance be capable of repairing or reconstructing a dwelling house affected by a flood, and what is the probability of that occurring?

7.20 The application of a risk management approach enables the consideration of both the probability and consequence of such damages. By using the example provided by Figure 1, the risk of property damage in a 200 year flood in one location is 25 times more severe than a similarly likely flood in another location. On this basis and assuming that the communities in both locations accept a similar level of exposure to risk, there is a clear requirement to impose substantially more stringent controls to minimise risk of damages to a building in a floodplain where the flood depth range is extreme.

7.21 Equally a similar approach would be relevant to assessing what acceptable risks should be applied to public infrastructure. However, the implications regarding such infrastructure extend, beyond the public costs to replace or restore infrastructure damaged by floods, and includes the need to have the infrastructure operable for emergency management purposes during a flood, and the ability of an area to function and be restored after a flood.

What is the Role of Planning in Reducing Risks?

7.22 The measures available for managing flood risk to life and property can be grouped into 3 categories in the following order of importance**:**

- **property modification measures** — these comprise controls on future development of property and community infrastructure;
- **response modification measures** — these modify people's response to flooding and usually include measures that provide additional warning of flooding, improved public awareness of the flood risk and improvements to emergency management during floods; and

[10] HNFMSC, 2006(c), page 2.

- **flood modification measures —** being structural measures such as the construction of levees and detention basins, channel widening/deepening, etc.

7.23 Planning's role relates primarily to the implementation of property modification measures, and to a lesser extent response modification measures particularly in regard to the manner in which it informs the community of flood risks through planning policies. Accordingly, the role of planning can be summarised as follows:

- **Strategic Planning**: Directing strategic planning as to the location of new areas or the redevelopment of areas in a manner which does not expose people and property to unacceptable flood risk;

- **Development and Building Controls**: Where development is permitted in locations where flood risk remains, to ensure that planning and building controls are applied in a manner which minimises risk to acceptable levels;

- **Communication of Flood Risk**: Ensuring that the planning policies and controls and associated documentation communicates flood risk in a responsible manner to allow the community to make informed decisions where discretion exists and to complement emergency management education and preparedness programs.

7.24 The determination of an appropriate planning response should ideally form part of a broader flood risk management plan informed by comprehensive flood risk management study.

7.25 A flood risk management study extends beyond a flood study that focuses on modelling flood behaviour, to address the economic, social and environmental consequences of both existing and possible future flood risks, in recognition that a balance between the use of land and minimising flood risks to property and persons needs to be achieved.

7.26 A flood risk management plan should have an integrated mix of management measures that address existing, future and continuing risk. Such measures may include structural engineering solutions (although these can be limited due to cost, environmental impact and practicality in removing all risks), voluntary acquisition and house raising programs, flood awareness and preparedness campaigns, emergency management strategies and planning responses as outlined above.

8.0 Queensland Policies

State and Regional Policies

8.1 The primary planning legislation in Queensland is the Sustainable Planning Act 2009, which superseded the Integrated Planning Act 1997. A hierarchy of planning policies may be prepared under this Act, basically being State Planning Policies (SPPs), Regional Plans and Local Planning Instruments.

8.2 Under Section 77 of the Sustainable Planning Act 2009 a local planning instrument can include:

"(a) a planning scheme;

(b) a temporary local planning instrument;

(c) a planning scheme policy."

8.3 Clause 3 of the Act outlines its purpose as follows:

"The purpose of this Act is to seek to achieve ecological sustainability by:

(a) managing the process by which development takes place, including ensuring the process is accountable, effective and efficient and delivers sustainable outcomes; and

(b) managing the effects of development on the environment, including managing the use of premises; and

(c) continuing the coordination and integration of planning at the local, regional and State levels."

8.4 Section 5 outlines what advancing the Act's purpose includes, which are principles such as decision making which is *"accountable, coordinated, effective and efficient"* considers short and long term environmental effects, applies the precautionary principle and achieves equity between generations. Subsection 5(1)(f) includes applying standards of *"safety in the built environment that are cost-effective and for the public benefit"*.

8.5 State Planning Policy 1/03 *'Mitigating the Adverse Impacts of Flood, Bushfire and Landslide'* (SPP1/03) was adopted on 19 May 2003 under the previous Integrated Planning Act 1997. SPP 1/03 took effect on 1 September 2003.

8.6 Clause 3.5 of SPP1/03 refers to the SPP1/03 Guideline: *Mitigating the Adverse Impacts of Flood, Bushfire and Landslide* ("the SPP Guideline") as providing implementation details. The SPP Guideline is declared to be "extrinsic material" under the Statutory Instruments Act 1992. SPP 1/03 and the SPP Guideline establish a number of concepts and an approach to managing flood risk through the planning process. It is beyond the scope of this report to provide an exhaustive analysis of this approach, but key matters are outlined as follows.

8.7 The following definitions outline the extent of land that could be subject to any flood risk[11]:

*"**Floodplain**: an area of land adjacent to a creek, river, estuary, lake, dam or artificial channel, which is subject to inundation by the Probable Maximum Flood (PMF).*

***Probable Maximum Flood (PMF)**: the largest flood that could reasonably occur at a particular location, resulting from the Probable Maximum Precipitation. The PMF defines the extent of flood-prone land. Generally, it is not physically or financially possible to provide general protection against this event."*

[11] See Clause 9 Glossary of SPP1/03 and Clause 9 Glossary of SPP Guideline.

8.8 SPP1/03 aims to minimise flood risk by *"ensuring that the potential adverse impacts of natural hazards are adequately considered when development applications are assessed, when planning schemes are made or amended and when land is designated for community infrastructure."*[12]

8.9 In recognition that it is unlikely to be appropriate to restrict all development within the whole of the floodplain, the SPP identifies a process of identifying "*natural hazard management areas*" which in effect would be a part of the floodplain which would be subject to planning controls. Natural hazard management areas are defined as follows:

> ***"Natural Hazard Management Area:*** *an area that has been defined for the management of a natural hazard (flood, bushfire or landslide) but may not reflect the full extent of the area that may be affected by the hazard (e.g. land above the 1% AEP flood line may flood during a larger flood event). Natural Hazard Management Areas for flood, bushfire or landslide are described in Annex 3".*[13]

8.10 Clause A3.2 of Annex 3 of SPP 1/03 provides the following:

> *"The Queensland Government's position is that, generally, the appropriate flood event for determining a natural hazard management area (flood) is the 1% Annual Exceedance Probability (AEP) flood. However, it may be appropriate to adopt a different DFE depending on the circumstances of individual localities. This is a matter that should be reviewed when preparing or undertaking relevant amendments to a planning scheme. Local Governments proposing to adopt a lower DFE in their planning scheme to determine a natural hazard management area (flood) for a particular locality will be expected to demonstrate to the satisfaction of the Department of Emergency Services (DES) and the Department of Natural Resources and Mines (NR&M) that the proposed DFE is appropriate to the circumstances of the locality."*

8.11 A process is recommended for identifying natural hazard management areas in a Planning Scheme and the adoption of other measures to provide for achievement of the outcome specified within the SPP. In general terms this would include the identification of a flood natural hazard management area as a map overlay to the Planning Scheme and the incorporation of planning controls[14] as specified by Outcome 6 of the SPP. In order to implement the above approach, best practice would require the undertaking of a broad flood risk management study, as I have discussed above. The SPP Guidelines provide direction as how to undertake this task.

8.12 Clause A3.2 provides a footnote that Councils are encouraged to adopt a natural hazard management area in a planning scheme "*as soon as possible to enable the application of the SPP to development in flood-prone areas*". Clause 6.6 of SP1/03 specifies that the natural hazard management area for flood hazard is dependent on adopting a flood event for the management of development in a particular locality and identifying this in a Planning Scheme. Until this occurs the SPP does not take

[12] Clause 4.7 SPP1/03.
[13] Clause 9 Glossary SPP1/03.
[14] Described as including a *"combination of development assessment tables, code(s) and other assessment measures in the planning scheme"* (Clause 7.6 SPP1/03).

effect for development assessment in relation to flood hazard in that locality." Clause 5.7 of the SPP Guideline explains that there is no default mechanism for "flood hazard management" due to unreliable State wide flood data and accordingly the SPP applies only where a Local Government has defined a DFE. It is suggested that a temporary approach could be followed involving the adoption of a "*Temporary Local Planning Instrument*" prior to making or amending the planning scheme.

8.13 A key requirement of SPP1/03 is the achievement of Outcome 2, which while basic is consistent with the fundamental objective of risk management. Outcome 2 provides that other than where a proposal is a "*development commitment*"[15] or there is an overriding public interest, development should:

- *"Minimises as far as practicable the adverse impacts from natural hazards; and*
- *Does not result in an unacceptable risk to people or property"*

8.14 SPP1/03[16] defines unacceptable risk as:

*"**Unacceptable risk:** a situation where people or property are exposed to a predictable hazard event that may result in serious injury, loss of life, failure of community infrastructure or property damage that would make a dwelling unfit for habitation."*

8.15 Clause 6.29 of the SPP Guideline provides further explanation as follows:

"An unacceptable risk may be thought of as one where an informed community would decide not to accept the consequences and the likelihood of a particular risk. The key characteristic of unacceptable risk is that it is determined by the community rather than an individual or particular group within the community. The best way to determine a community's risk threshold is through a natural disaster risk assessment study using the process outlines in Appendix 1."

8.16 Similarly, Outcome 4[17] requires that the process of making or amending Planning Schemes should wherever practical identify natural hazard management areas *"through a comprehensive and detailed natural hazard assessment study"*.[18] The SPP Guideline provides Appendix 2 to advise on an appropriate study process.

8.17 The SPP Guideline in general, and Appendices 1 and 2 in particular, specify a process for undertaking a natural hazard assessment relating to floods (also referred to as a flood risk management study). The key components are summarised by **Figure 2**.

[15] This is defined in the Glossary to SPP1/03 and generally relates to where there is some preliminary approval or the development is minor or consistent with a designation for community infrastructure.
[16] SPP 1/03, pg.12.
[17] Outcome 4 is *"natural hazard management areas are identified in the planning scheme"*.
[18] Clause 7.2 SPP Guideline.

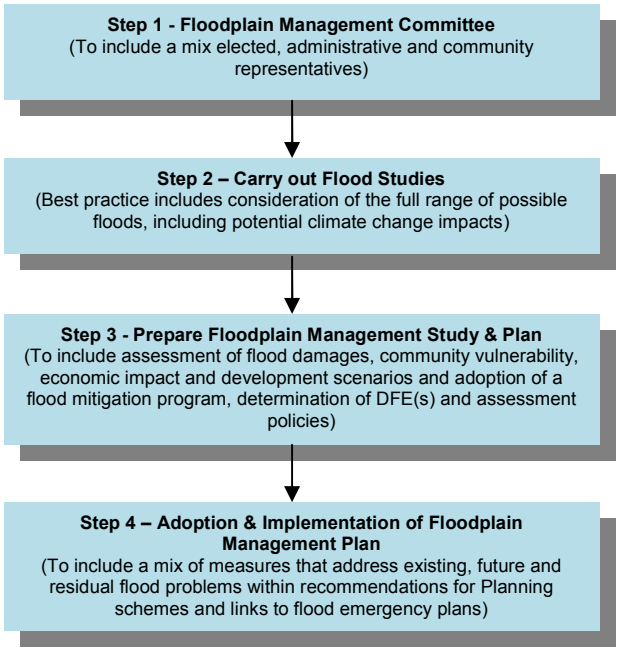

Figure 2: *Queensland Flood Risk Management Process (Adapted from Appendices 1 & 2 of the SPP Guideline)*

8.18 My general conclusion is that the SPP1/03 and SPP Guideline provide a substantial and sound basis for preparing flood risk management planning controls. That is, this process provides an appropriate framework for the management of flood risks through "flood modification measures" being one of the three categories of flood risk management outcomes most relevant to planning. However, SPP1/03 is primarily designed to achieve outcomes associated with the assessment of development applications. Consequently, the process does not appear to robustly address how planning measures should integrate with response and flood modification measures as part of an overall Flood Risk Management Plan.

Brisbane City Council

8.19 Brisbane City Plan 2000 ("City Plan") was originally adopted under the preceding Integrated Planning Act 1997 and amended on 1 July 2009. The City Plan is the primary local planning instrument for BCC. This plan is said to draw upon a number of other documents including various regional planning strategies[19]. Clause 4.3 specifically states that the *"Plan explicitly recognises, and is consistent with"* a number of SPPs, including SPP1/03.

8.20 In addition to City Plan, Council has adopted a *"Temporary Local Planning Instrument – 01/11 Brisbane Interim Flood Response (TLPI01/11) effective from 16 May 2011"*. TLPI01/11 has a number of stated purposes including the application of an interim residential flood level and identification of additional technical standards to supplement the *Subdivision and Development Guidelines*.

8.21 Whilst there are ranges of planning measures which are directed to minimising flood risk (as discussed below), there is no clear supportive information within these

[19] Clause 3 BCP 2000.

documents that indicate the basis for determining the level of risk which the planning controls seek to manage. That is, my investigations to date have not revealed a broader flood risk management study such as that encouraged to be prepared by SPP1/03 and the SPP Guideline. It could be argued that there is unlikely to be an area in Queensland for which such a study would be more appropriate than Brisbane City having regard to the extensiveness of the urban area focused on the Brisbane River with consequential potential risk to property and life.

8.22 Notwithstanding the above, I note that City Plan was originally prepared prior to the commencement of SPP1/03 and the Brisbane City Joint Flood Task Force[20] subsequently identified the need to undertake a complete flood risk management analysis that investigates a range of flood events up to and including the PMF. Further, it is important to understand that the application of a comprehensive risk management approach to inform the preparation of planning strategies and controls in a floodplain is a relatively new practice in Australia.

9.0 Observations

Principle	*Observations*
The identification and analysis of flood risk requires a consideration of both the probability and consequences of flooding over the full spectrum of flood frequencies that might occur at a location.	The Queensland planning process does provide for the consideration of flood risks on this basis. There is no evidence that this has occurred to date. For example, flood maps which systematically identify a broad spectrum of floods leading to the adoption of the Design Flood Event by BCC have not been identified. Such an analysis would typically form part of a broader flood risk management approach which is a relatively new practice in Australia and a recent recommendation of the Brisbane City Joint Flood Task Force.
The determination of what is an acceptable flood risk for planning purposes is best determined through a comprehensive flood risk management study involving the community and leading to the preparation of a plan that outlines: • Property modification measures; • Response modification measures; and • Flood modification measures.	The Queensland planning process does provide for the consideration of flood risks on this basis. There is no evidence that this has occurred to date in Brisbane City Council but is a specific recommendation of the February 2011 Task Force Report. There is a need to ensure that whatever flood risk management process is adopted that all 3 categories of measures form part of a consistent and integrated strategy.
Planning's role relates primarily to the	The Queensland planning process does potentially provide for the implementation

[20] BCC Joint Flood Taskforce 2011, pages 37 - 38.

Principle	*Observations*
implementation of property modification measures, and to a lesser extent response modification measures, in particular: • Strategic planning; • Development and building controls; and • Communication of Flood Risk.	of these measures.
The flood risk management process should be integrated with the planning process.	The Queensland planning process does provide for the effective integration of the flood risk management process with planning outcomes. However, the process does not appear to robustly address how planning measures should integrate with response and flood modification measures as part of an overall flood risk management plan.
The process of undertaking of a comprehensive flood risk management study and adoption of a plan can be complex, resource demanding and lengthy. Therefore priority should be given to locations where potential risks are greatest. That is, flood prone areas with substantial existing development and pressure for growth. The absence of existing flood information or a flood risk management plan should not be an excuse to not consider flood risks where evident.	The statutory process allowing for the introduction of an Interim Policy, such as the Brisbane City TLPI01/11 provides an effective mechanism to deal with new information associated with flooding quickly. However, this should not be seen as a definitive solution that delays the preparation of a comprehensive flood risk management plan, based on a program that would have otherwise applied. The absence of an explicit process in the Queensland planning legislation that allows for the consideration of flood risks until the adoption of a Defined Flood Event should be reviewed. Flexibility should be incorporated to allow a planning authority to consider flood risks when suspected. Typically this would involve requiring a site specific flood study at the development application stage if in the absence of reliable data a suitably qualified professional considered that there were likely flood risks. The flood study could determine the level of risk and allow the application of controls that would otherwise apply.

Mapping Flood Risks

10.0 Principles

10.1 The mapping of flood risks is an essential tool in the flood risk management process. Flood behaviour modelling has become increasingly sophisticated since the 1980's with the aid of computers and geographical information systems (GIS). However, it is not a straight forward task to determine what and how to map flood risk.

10.2 The concept and application of flood risk mapping has been addressed in a relatively recent paper[21] which I co-authored. As outlined within this paper, flood risk mapping could be undertaken for a number of purposes, in particular to identify any or all of the following:

- **Existing flood risk** – which reflects the exposure of existing land use and infrastructure to flood risk;
- **Continuing flood risk** – the risk to existing land uses and infrastructure that would remain after the implementation of any proposed flood risk management measures such as improved evacuation capacity, construction of a levee, etc;
- **Flood risk for land use planning purposes** - that identifies the flood risk to future development.

10.3 The third type of flood risk mapping is that which is of primary relevance to this report and accordingly is the focus of the following discussion.

10.4 Traditionally, flood mapping for planning purposes would depict the extent of inundation occurring as a result of a singular flood, commonly the Q100. Such maps are often included within planning policies to reflect what is commonly misrepresented as the area affected by potential flood risk, where actually they typically relate to areas subject to a flood of a particular probability and related development controls. Unless flood related development controls extend to the PMF extent (which is unlikely for the majority of types of land uses) then such mapping could not correctly identify the extent of land potentially subject to flood risk.

10.5 It is emphasised that the purpose of flood risk mapping should not initially be to identify the extent of land that should be subjected to flood related development controls, but rather to identify where flood risks exist that could be managed by such controls. The process of identifying a range of floods during the preparation of a flood risk management study enables the community and decision makers to be fully informed in regard to flood risks. This is important because as discussed above it is commonly accepted that flood related development controls are unlikely to remove all flood risks which will inevitably mean that some newly approved development will remain subject to potential inundation and associated effects from flooding albeit in rarer occurrences.

[21] Bewsher & Grech, February 2009.

10.6 Providing full information to the community of known flood risks can have the advantage that personal decisions can be made on an informed basis and individuals may be less surprised when a rarer event occurs. Consequently, such information can assist in flood education and preparedness and the ability to implement emergency management measures during extreme floods. Additionally, individuals may choose to implement non-mandatory property modification measures where acceptable and practical or to live in a location that reflects personal choice and capability to deal with all risks associated flooding. An extensive study of the risk tolerance of the community[22] identified a reliance on responsible authorities like Councils to ensure that appropriate controls are in place to address risks associated with natural hazards such as floods.

10.7 There can be a considerable variety in the manner in which flood risks are mapped. One approach which may achieve reasonably comprehensive flood risk maps for planning purposes is described within the paper referred to above. Some key aspects of this approach include:

- The whole of the floodplain (i.e. up to the PMF) is mapped as being subject to some level of flood risk.
- The mapped extent is divided into different "precincts" of different levels of flood risk. Simple and commonly understood terminology such as low, medium and high flood risk precincts are used, consistent with approaches to mapping other natural hazards.
- The delineation between different precincts is determined based on an assessment of risk to human life and property across a broad range of floods.
- To facilitate production and reproduction of such maps, a combination of a number of typically modelled flood data such as a single flood (such as the Q100) or flood behaviour characteristics (such as hazard determined as a product of flood velocity and depth) may be used. These data should only be used after it is determined that they reflect relative grades of flood risk after examining potential consequences associated with a broad range of potential floods.
- Other data relevant to understanding the consequences of flooding should also be considered such as areas identified as being evacuation constrained.[23]
- Typically such mapping may undergo a "smoothing" process to remove anomalies created through a computer generated process.
- Ultimately the flood risk maps need to be useful in the application of planning controls. For this reason, the mapped precincts ideally need to relate to the types of planning controls that would be applied, such as:
    - where most development would be prohibited;
    - where most development controls would be applied; and

[22] GHD and Cox Consulting, 2001 pg.3.
[23] This would typically be determined by the carrying out of an Evacuation Capability Assessment.

- the remaining area of the floodplain where only very sensitive and critical uses may be subject to control (such as hospitals, aged care accommodation, etc) and some public recognition is provided of the residual risk which may be relevant for emergency management purposes in the case of rare but extreme floods.

- **Figure 3** depicts the typical outcomes for flood risk mapping planning purposes using this approach. Note the use of the Q100 (100 year flood) to delineate a risk precinct is an example of a typical outcome but this could appropriately vary between floodplains depending on the findings of a flood risk management study.

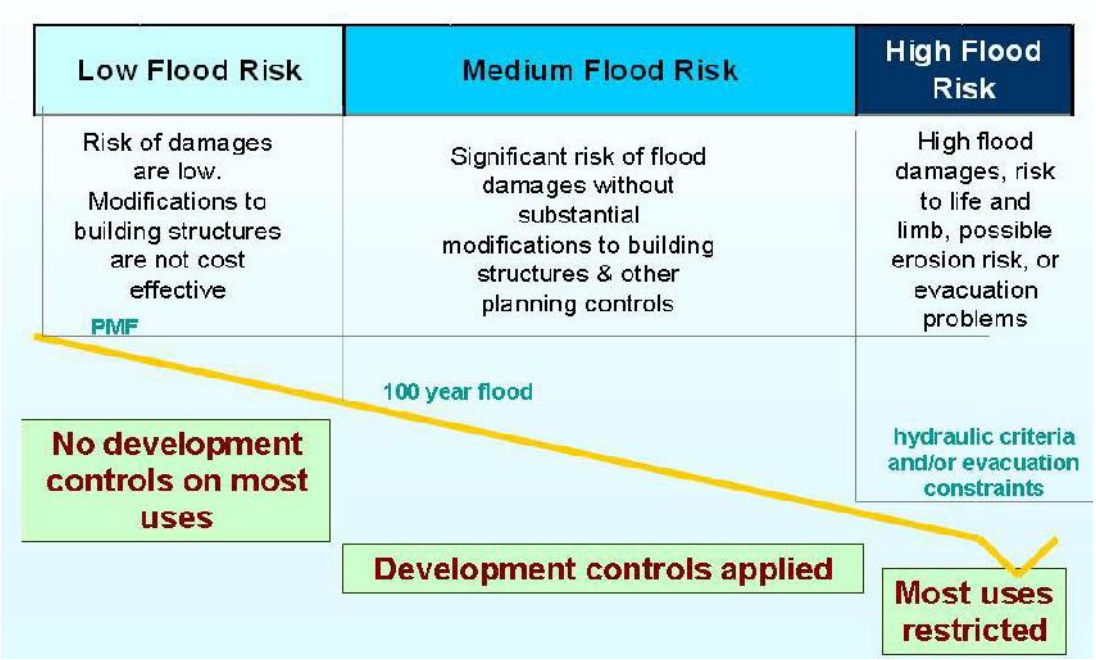

***Figure 3**: Possible Outcomes for Flood Risk Mapping for Planning Purposes*[24]

10.8 It is recognised that the above approach to flood risk mapping is a relatively recent practice compared to the mapping of a singular flood event. However, such an approach, or equivalent approaches are becoming more common practice. An example of such mapping is provided by **Figure 4**.

[24] Bewsher & Grech, February 2009, pg.8.

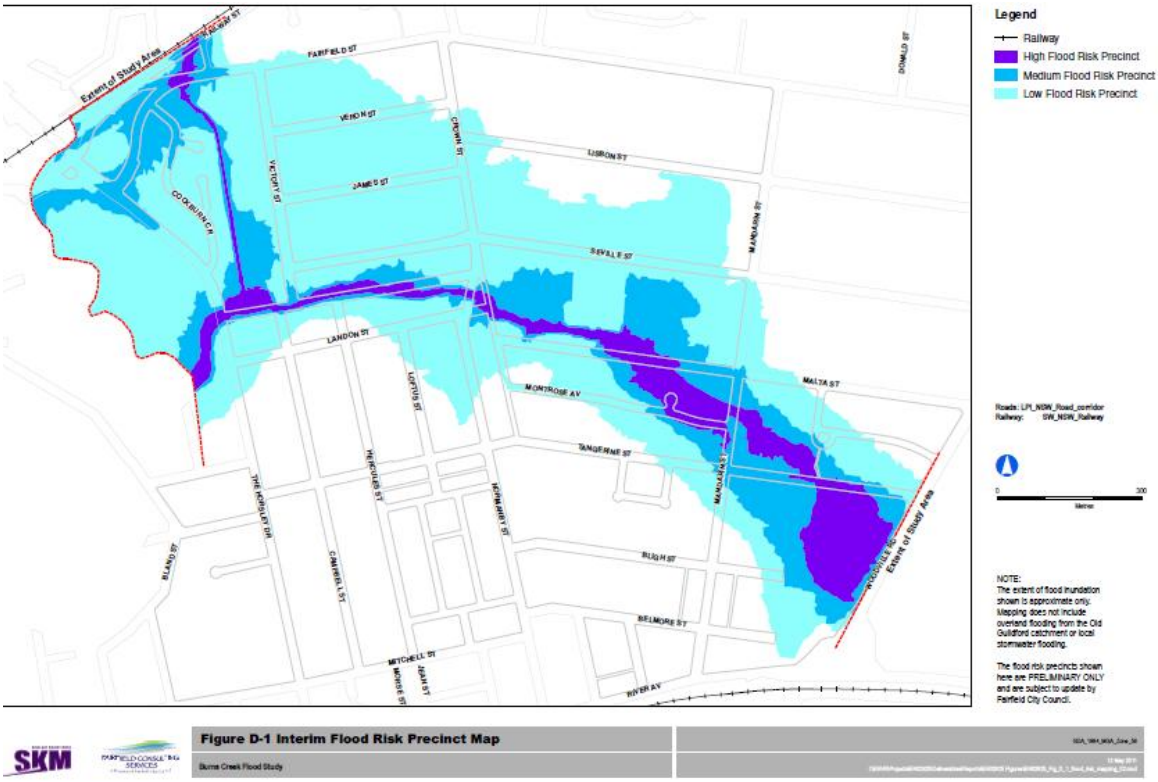

Figure 4: *Burn's Creek Interim Flood Risk Precinct Map (Fairfield City Council)*

10.9 Flood risk maps for planning purposes may also vary depending on the scale of planning for which they are intended. For example a regional planning strategy might more simply identify the whole of the floodplain (i.e. up to the PMF) as individual properties are not identifiable and the difference between the extents of different flood risk precincts may not be perceptible. Also regional strategies typically inform the production of planning controls rather than impose planning controls. At the other extreme, local planning instruments would need to be specific so that individual properties can be identifiable and provide clearer guidance as to what planning controls should apply.

10.10 A further important consideration for the purposes of planning is to develop a system that allows for the application of flood related development controls where no mapping exists. Due to the extensive resources that may be required to undertake flood mapping there are occasions where a property may be suspected of being subject to flood risk but no mapping or other definitive information exists. In my experience, this can arise during the development application process whereupon identification of the potential for such risk, an applicant may be required to prepare a site specific flood study.

10.11 The definition of flood risk precincts (or any other categorisation technique) needs to provide a reasonably easy system to determine the appropriate flood risk category on a site by site basis in a consistent manner, where no mapping exists. While it may be expected that some flood mapping exists in areas of dense urban development, it may be unreasonable to expect that all land within Queensland that is subject to flooding has been mapped. This is particularly relevant when noting that flood modelling will typically be truncated at some point within the upper

reaches of a catchment and not always include minor tributaries, and major overland flow flooding would normally be identified through a separate mapping process.

10.12 Rather than an absence of flood mapping which normally would be an automatic trigger to require the assessment of flooding at the development application stage, it may be prudent to very broadly map "flood investigation areas." Such areas could be that land where on a very rudimentary review of topographic maps and creeks systems, an experienced flood engineer would not be confident that the potential for any flood risk could not be ruled out.[25] The concept of "flood investigation areas" that identify the need for further studies could also be extended to land known to be not flood affected based on current day conditions that could be affected in the future as a consequence of climate change[26]. The intention should be that such investigation areas are subject to broader comprehensive studies in the future as needed and resources become available.

11.0 Queensland Policies

11.1 There is no definitive description in regard to the format and content of flood risk maps prepared in accordance with the process outlined by SPP1/03 and the SPP Guideline. As discussed previously, the guidelines do specify behavioural information that can be documented and the desirability of analysing a range of floods up to and including the PMF.

11.2 I have obtained access to a number of flood studies relevant to those areas being investigated by the Commission of Inquiry, from WMAwater. I have perused a selection of these studies that appear most relevant and my general observations on the type of mapping provided are outlined below.

Study	Comments on Mapping
Brisbane River Flood Study (June 1999, prepared by City Design, BCC).	Primarily relates to the mapping of the Q100. Notes that significant floods have occurred six times in the last 160 years in Brisbane (pg.10).
Review of Brisbane River Flood Study (3 September 2003. Report to Brisbane City Council by Independent Review Panel).	Principally involved in reviewing estimates of the Q100, consistent with the terms of reference for the Panel.
Brisbane River Flood Investigations Final Report (November 1975, Prepared by SMEC for the Cities Commission).	This was a report prepared for the then Cities Commission focussing primarily on the January 1974 flood of the Brisbane River. This report does refer to a number of extreme historical floods dating back to the early 1800s.
Lota Creek Stormwater Management Plan (June 1999 prepared by SKM for BCC).	Maps the Q100.
Cubberla Creek Flood Study (1996	References modelling undertaken for "ultimate

[25] This is consistent with the *precautionary principle*.
[26] The issue of climate change flood risks is not discussed further as I am instructed that this is beyond the terms of reference of the Commission.

Study	Comments on Mapping
prepared for BCC by SKM).	conditions" in a 1, 2, 5, 10, 20, 50, 100 and PMP flood (see Appendices E & F).
Brisbane River Flood Study (December 2003 prepared by SKM for BCC)	The brief was to provide a best estimate of the 100 year flood.
Recalibration of the Mike11 Hydraulic Model and determination of the 1:100 AEP flood levels (05/02/2004 prepared by SKM for BCC).	Brief was to reassess the Q100. References made to the 1974 and 1955 floods as having reliable historic flood level data.
Calculation of floods of various return periods on the Brisbane River (6/07/2004, prepared for BCC by SKM).	Flood modelling undertaken for the Q10, Q20, Q50 and Q2000.[27]
Phase Three – Damage Mitigation Feasibility and Final Report for Brisbane Valley Flood Damage Minimisation Study (2007, prepared by City Design, BCC).	The aim of the project was "*to gain a greater understanding of the potential damage caused by a range of flood events in the Brisbane River Catchment and to consider, if applicable, reviewing the dam operating rules to improve flood mitigation*". A range of floods investigated – mapping not available.
Brisbane River Flood Study Review of Hydrological Aspects (December 1998, prepared for BCC by Monash University).	Reviews estimations of the Q100.
Further Investigations for the Brisbane River Flood Study (December 1999 prepared by BCC)	Primarily focuses on estimating the impact of the Wivenhoe Dam on Q100 flood levels.

11.3 As noted above, post the 2010/2011 floods, the Brisbane City Joint Flood Task Force[28] identified the need to undertake a complete flood risk management analysis that investigates a range of flood events up to and including the PMF. In the interim BCC has adopted TLPI0/11.

11.4 In terms of mapping that has been incorporated into City Plan prior to the commencement of TLPI0/11, BCC had prepared maps depicting the extent of the DFE. The extent to which this map corresponded with a particular flood frequency is a matter for other experts.

11.5 Clause 1.2 of TLPI0/11 states that the flood maps contained in that Policy have been determined based on the highest of:

- Brisbane River – January 2011 event;
- The Defined Flood Level (DFL) based on a Brisbane River Flood Event using a high profile 3.7m AHD at the City gauge.

11.6 An example of a map provided by TLPI0/11 is provided as **Figure 5**.

[27] Information made available to me included date outputs but not maps.
[28] BCC Joint Flood Taskforce 2011, pages 37 - 38.

11.7 I note that while the background definitions and information provided within the hierarchy of planning policies upon which TLPI0/11 is based provides a better understanding of the scope of such maps, it might not be clear to the general public that the full extent of land potentially subject to flooding[29] is not mapped.

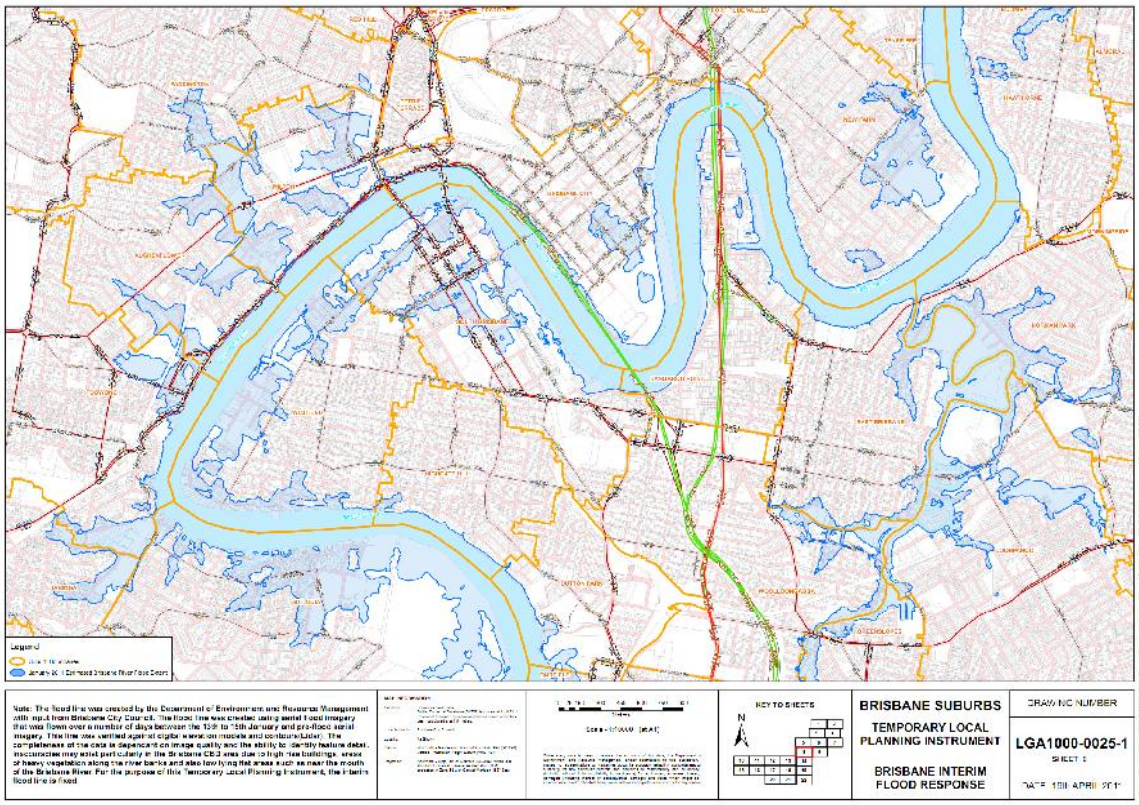

Figure 5: *Example flood map from Brisbane City TLPI0/11.*

11.8 The BCC has also developed "F*lood Flag Maps*" which provide information on flooding inclusive of overland flow paths. These are available on Council's website, an example of which is provided as **Figure 6**. This map also does not clarify as to what flood extent is mapped and whether residual flood risks remains. However the map does advise that further information can be obtained from various sources.

[29] I.e. up to the PMF in accordance with the definition of floodplain provided by SPP0/13.

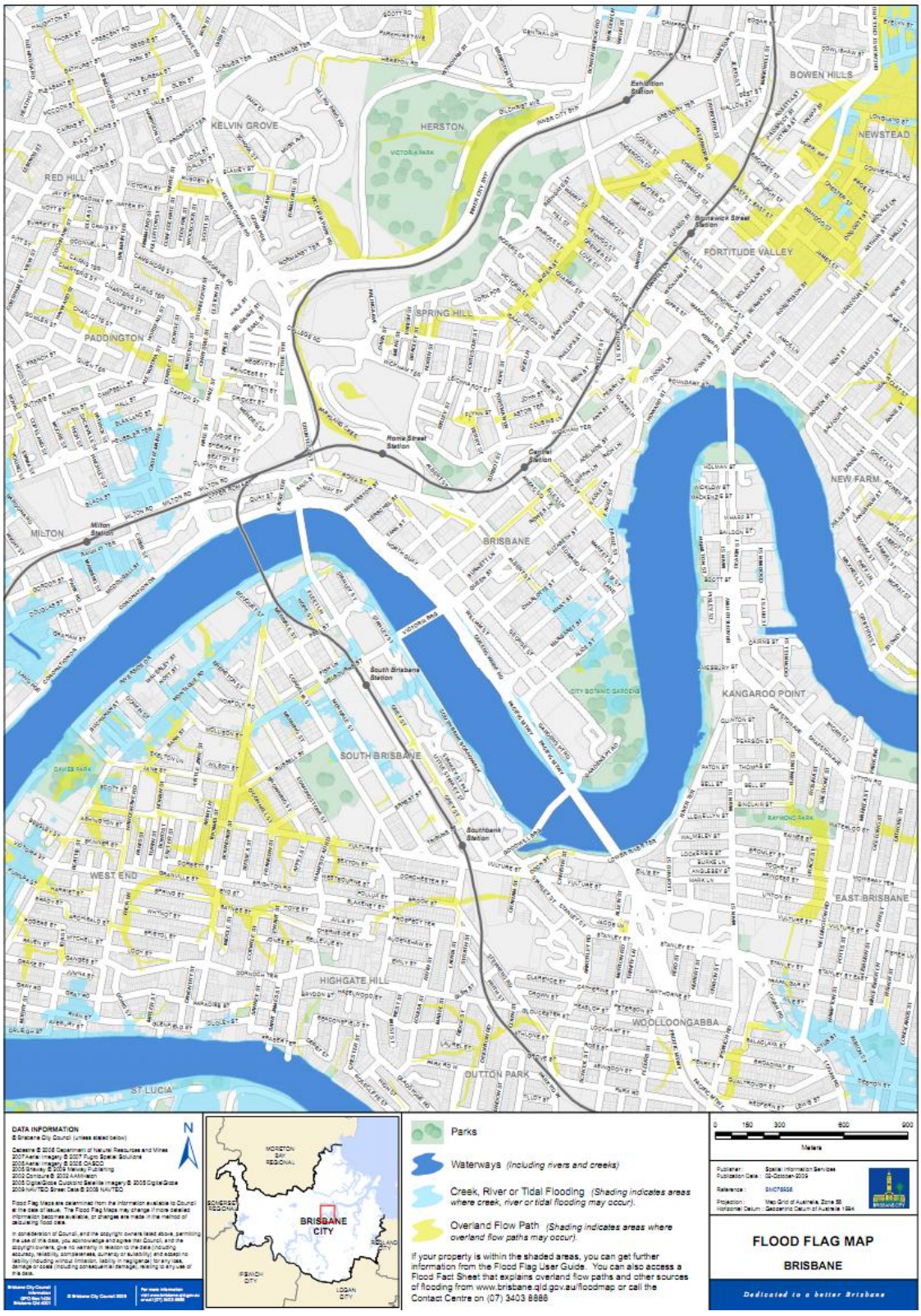

Figure 6: *Brisbane Flood Flag Map - CBD*[30]

[30] Brisbane City Council website accessed 9 September 2011.

12.0 Observations

Principle	*Observations*
The mapping of flood risks is an essential tool in the flood risk management process. Mapping of flood risks for planning purposes should consider a full range of floods up to an including a PMF, the flood behaviour factors for each flood and emergency management issues such evacuation capability.	The Queensland planning process does provide for the consideration of flood risks on this basis but for the mapping of only a singular *defined flood event* and not all flood risks that may be relevant to planning decisions.
For the purposes of planning it is desirable to develop a system that allows for the application of flood related development controls where no mapping exists.	The Queensland planning process does not provide for this. The development of a process would be desirable. For example, rather than have no trigger for the automatic consideration of flooding it may be prudent to very broadly map "investigation areas." where on a very rudimentary review of topographic maps and creeks systems. The concept of "flood investigation areas" could also be extended to land that could be affected in the future as a consequence of climate change. The intention should be that such investigations areas are subject to broader comprehensive studies in the future as needed and resources become available.
Flood risk mapping may be undertaken for purposes other than the preparation of planning controls such as identifying areas with existing evacuation issues, and this information needs to be considered as part of the broader flood risk management Plan making process.	• This may be achievable in the Queensland planning process but more specific guidelines would be desirable.

Appropriate development in the floodplain

13.0 Principles

13.1 In my view, there is no single answer as to what represents appropriate development in the floodplain. As discussed above, this is best determined through a flood risk management approach that balances the social, economic and ecological considerations against all of the consequences of flooding in the aim of minimising the potential for damage to property and infrastructure and the risk to life, to a level acceptable to the community. Accordingly, the process of implementing a risk management approach is crucial to ensuring that the ultimate determination of what development is permitted in the floodplain reflects community expectations.

13.2 The process of balancing social, economic and ecological considerations to determine what development should be permitted in the floodplain, is best undertaken as part of the broader planning process. The planning process is required to address the totality of issues associated with the development of land, such as natural hazards, transport, heritage, ecological considerations, urban design and provision of services and infrastructure utilities. Flood risk is one consideration which needs to be balanced against other, often competing, factors.

13.3 It is difficult, if not impossible, to reach meaningful conclusions about what is appropriate development in a floodplain external to the planning process which determines how important it is to develop land for different uses, in different forms and in different locations. It is similarly difficult, if not impossible, to undertake a meaningful planning process to determine these things without some understanding of the consequent flood risk (as well as other planning considerations).

13.4 For example, consideration of flood risks as part of the planning process may ultimately determine that some development should be supported in a part of the floodplain that would traditionally not be supportable, because of the high demand and low supply of land for such development, the importance of such development to the local and regional economy, the absence of any ecological impacts and the ability to utilise existing infrastructure. I reiterate that the process is critical to making such a determination, as this provides for transparency in decision making so that such risks are clearly understood, and where development is permitted with exposure to flood risk, appropriate decisions can be made as to the need for application of other ameliorative measures such as building controls and emergency management.

13.5 Notwithstanding the above, there are typically considered to be some key principles that should be applied to provide some boundary as to what the flood risk management process may determine. Such principles, based on my experience would include:

- Minimising the potential for loss of life is paramount.
- The cost (direct and indirect) associated with potential damages to property and infrastructure is that which individuals and the community can manage.
- Individual developments within the floodplain should not increase the potential risk to others within the floodplain.
- There are parts of the floodplain that would be too hazardous for most development due a combination of factors such as the velocity and depth of flooding and evacuation constraints in most floods, and too impractical to ameliorate. This should be based on technical engineering advice.

13.6 Mitigation measures may be employed to reduce risks to acceptable levels, but not where this would result in ecological or amenity impacts that would otherwise be considered unacceptable. For example it may not be acceptable for a property to be filled if this results in the destruction of a ecologically significant riparian corridor.

13.7 The concept of applying a risk management approach to flood risk management in the manner described previously to determine what is appropriate development within the floodplain, was documented as part of the Hawkesbury-Nepean Flood Management Strategy[31] and later developed in greater detail within the document

[31] HNFMAC, November 1997, Appendix C

entitled *'Managing Flood Risk through Planning Opportunities'*[32]. The four step process is illustrated in **Figure 7** and described below.

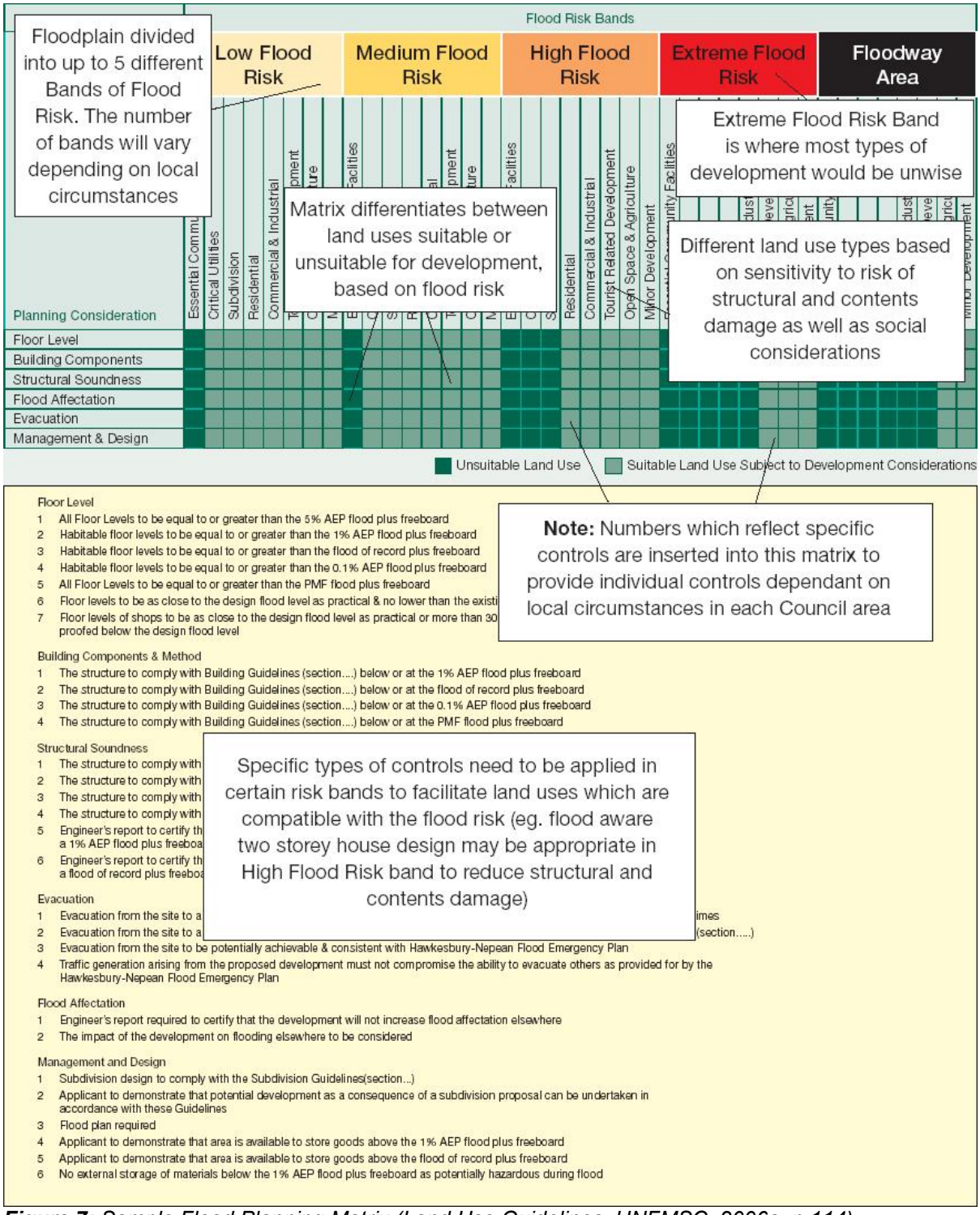

Figure 7: *Sample Flood Planning Matrix (Land Use Guidelines, HNFMSC, 2006a, p.114)*

[32] HNFMSC, June 2006(a), pages 113 – 136.

- **Step 1 - Mapping of flood risk precincts** – this involves dividing the floodplain (i.e. all land affected up to the PMF) into areas with similar levels of risk. The number of precincts may vary between different floodplains but as a general guide it is desirable to maintain the three tier category of low, medium and high for reasons discussed previously.

- **Step 2 – Categorising flood risk precincts** – identifying the risk to development, including both property and persons, associated with each of the flood risk precincts.

- **Step 3 – Prioritising land uses in the floodplain** – this involves identifying discreet categories of land uses with similar levels of vulnerability to the flood hazard and identifying what flood risk precincts within which they should be permitted or prohibited. Ideally this would be undertaken as part of the planning process as discussed above.

- **Step 4 – Identifying controls to modify building form and response to flooding** where the planning process determines land uses are appropriate, but still subject to flood risk. Different planning and building controls can be imposed to minimise potential damages and to maximise the ability of the community to respond (i.e. preparedness and capacity to evacuate) during a flood. The types of development controls that would typically be applied are discussed later.

13.8 In my view the above approach can provide planning outcomes consistent with a best practice risk management approach.

14.0 Queensland Policies

State and Regional Policies

14.1 As discussed above, SPP1/03 and the SPP Guideline provide an approach to determine appropriate development in the floodplain preferably based on a risk management approach. The approach outlined in Appendix 2 of the SPP Guideline (see in particular A2.31) provides an approach to determine what is an appropriate land use dependent upon the severity of the flood hazard across the floodplain. In my view, this approach is consistent with a best practice risk management approach.

14.2 SPP1/03 also provides for a merit assessment to determine whether some development otherwise considered unacceptable should be permitted due to an overriding public interest. This approach is not considered to be inconsistent with best practice flood risk management integrated with the planning process, provided that the decision to allow such development is undertaken in a transparent manner. That is, there needs to be an understanding of the true risks associated with allowing such development in order to properly balance that against the public interest.

14.3 While SPP1/03 and the SPP Guideline provide an approach to analysing flood risk based on best practice, it is difficult to understand how this could ultimately be translated in a meaningfully way to planning policy having regard to the expected

planning outcome of defining *Natural Hazard Management Areas* based on a singular *defined flood event*.

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14.4 As discussed above, BCC has effectively identified a defined flood event based on the combination of the Q100 and historical flood events, which forms a basis for determining appropriate development. We have not found information to confirm whether or not this has been based on a comprehensive flood risk management study.

15.0 Observations

Principle	*Observations*
There is no single answer as to what represents appropriate development in the floodplain. This is best determined through a flood risk management approach which balances the social, economic and ecological considerations against all of the consequences of flooding in the aim of minimising the potential for damage to property and infrastructure and the risk to life, to a level acceptable to the community.	The Queensland planning process does provide for this approach. However, it is difficult to understand how this could ultimately be translated in a meaningfully way to planning policy having regard to the expected planning outcome of defining Natural Hazard Management Areas based on a singular defined flood event.
Some key principles that should be applied to provide some boundary as to what the flood risk management process might determine include: •Minimising the potential for loss of life is paramount. •The cost (direct and indirect) associated with potential damages to property and infrastructure is that which individuals and the community can manage. •Individual developments within the floodplain should not increase the potential risk to others within the floodplain. •There are parts of the floodplain that would be too hazardous for most development due a combination of factors such as the velocity and depth of flooding in most floods and evacuation constraints.	It could be construed that the Queensland planning process does provide for these principles to be considered but the potential planning outcomes are constrained as outlined above. More definitive guidelines would be desirable.
Mitigation measures may be employed to reduce risks to acceptable levels,	• The Queensland planning process does provide for these principles to be considered.

Principle	*Observations*
but not where this would result in ecological or amenity impacts that would otherwise be considered unacceptable.	

Appropriate minimum standards for development in flood prone land

16.0 Principles

16.1 Determining appropriate minimum planning standards in the floodplain is ideally achieved through a comprehensive flood risk management study.

16.2 As previously outlined, the primary control that planning may impose, is a prohibition[33] through the land use zoning provisions. Most development should be prohibited or discouraged in high risk areas as these areas by definition pose significant risks to life and property and the scale of mitigation measures to reduce risk to acceptable levels are likely to be impractical or result in significant amenity and ecological impacts. However, where the flood risk management and planning processes determine that development should be permitted, but such development remains subject to some flood risk, controls can be imposed through the development application process.

16.3 Controls applied to development within a floodplain would typically relate to the following seven considerations:

- Site and Floor levels:
- Building components and method;
- Structural soundness;
- Flood affectation;
- Car parking and driveway access;
- Evacuation; and
- Management and Design

16.4 Consistent with the process outlined above the stringency of the controls should vary in proportion to the vulnerability of the land use and the level of flood risk affecting the site. This can lead to variations between different areas.

16.5 Standards applying to development on flood prone vary in my experience. This can be an appropriate reflection of the risk management approach applied to the individual circumstances of different floodplains However those considerations and type of standards that should be typically applied are outlined in the following table:

[33] This could also include being designated a “generally inappropriate” development under the Queensland planning system.

Consideration	Typical Standards
Site and Floor levels	Standards for minimum site levels may not always be specified as the suitability of the site in principle should be reflected in the land use zone designation. Minimum site levels for fill pads on non-urban sites and minimum levels for private open space on urban sites could be imposed that relate back to prescribed floor levels. For vulnerable uses (where allowed in the floodplain) floor levels may be set as high as the PMF. For standard residential development habitable floor levels are commonly required to be no lower than the minimum Q100 level plus freeboard (typically 0.5m unless an alternate freeboard has been adopted by Council)[34]. For uses with lower vulnerability, such as certain industrial uses or recreational facilities, floor levels could be lower, relative to a residential floor level. A restriction may be placed on the title of the land, where the lowest habitable floor area is elevated (say more than 1.5m above finished ground level) confirming that the undercroft area is not to be enclosed or used for habitable purposes.
Building components and method	All structures below the habitable floor level to comprise flood compatible materials and methods.
Structural soundness	An engineer's report may be required to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including the design floor level or a PMF where on-site refuge is proposed in the building.
Flood affects	Council or a suitably qualified engineer would need to be confident that the development will not increase flood affects elsewhere in the floodplain. This could involve an engineering report for an individual site, but is best addressed in catchment wide flood risk management studies to ensure cumulative effects are fully considered.
Evacuation	Reliable access for pedestrians or vehicles could be required from the building, commencing at a minimum level equal to the lowest habitable floor level to a refuge area above the PMF. (The issue as to whether a refuge area must be located outside of the floodplain or whether it can be in the same building is discussed further below).
Car parking and driveway access	Open car parking spaces or carports could be required to be above a minimum level different to the floor level that reflects a desire to minimise damages or to ensure that the vehicle can be used for evacuation purposes if required. Driveways between car parking spaces and the connecting public roadway should not dip, to avoid people driving into water that could destabilise the vehicle (e.g. so that it would be inundated by depth of water greater than 0.3m during a Q100). Larger enclosed car parking areas (e.g. basement car parks) could require protection from inundation from floods such as the Q100, and to be provided with rising pedestrian evacuation paths and audible and visual alarms triggered

[34] This could vary depending on the outcome of the risk management process which considers the circumstances of a particular floodplain.

Consideration	Typical Standards
	by the overtopping of the entrance.
Management and design	These controls would typically relate to miscellaneous issues such ensuring newly subdivided lots can potentially be developed in compliance with the controls and providing for the storage of hazardous materials to avoid pollution spills during floods.

16.6 The above table illustrates the redundancy associated with the adoption of a singular design flood level as the risk management process can appropriately identify a multitude of levels to manage risk associated with the seven development considerations.

16.7 Evacuation issues would need to be carefully considered. It is a widely accepted principle that in the planning of new development, evacuation to a suitable refuge area above the PMF should be determined to be achievable within available warning time. This can be determined using time modelling techniques which consider the time required for emergency management agencies to mobilise and notify affected persons to evacuate, the number of people requiring to evacuate and the capacity of roads prior to being cut by flood waters[35]. However, there is currently debate amongst flood risk management professionals as to the acceptability of allowing new development to rely on a refuge area on site.[36]. Where on-site refuges are accepted, an appropriate floor area would need to be provided within a building above the PMF extent, and the building would need to be certified as structurally sound within a PMF.

16.8 Planning controls may typically also include filling and construction of fences. In principle, the filling of large areas needs to be comprehensively evaluated within a flood risk management study rather than on an ad hoc development application basis, to ensure that cumulative impacts are assessed. However, where this is not available typical planning controls would require an engineer's report to certify that the filling will not increase flood affectation elsewhere, with inclusion of cumulative impacts as best as possible. Normally filling of a floodway area or land that conveys an existing overland flow path would not be permitted. Similar principles are normally applied to fencing in the more hazardous parts of the floodplain.

16.9 Planning controls might also provide more lenient controls for alterations and additions to existing development. This would normally be on the basis that such minor development does not materially increase the level of risk associated with that development. Planning controls may also allow for more substantial changes to existing development, including rebuilding of existing dwelling houses, where it can be proven that the rebuilding of development would reduce flood risk. This is considered both appropriate and desirable in order to achieve the objective of reducing flood risk in the community where there is no existing or probable intention of the Government to acquire the flood affected property, or for the owner to abandon it.

[35] See Opper, S, et al, 2009.
[36] This has in the past been considered as acceptable in flash flood catchments where available warning time would not conceivably allow for evacuation.

16.10 Flood affects on others within the floodplain could arise due to filling undertaken in association with a dwelling house development. As a general rule land filing is acceptable where it has "no affect on others in the floodplain" (in addition to addressing other issues such as ecological and amenity impacts). Flood affects could also include loss of flood storage or redirection of flood flows. Loss of flood storage from a the construction of a single house would unlikely have a measurable effect in most floodplains but cumulative effects could be a concern.

16.11 Cumulative effects of filling and broader issues such as evacuation that require close liaison with other government agencies are best considered within a comprehensive flood risk management study rather than on an ad hoc basis through the assessment of individual development applications.

17.0 Queensland Policies

State and Regional Policies

17.1 The relevant State planning policies as discussed above do not directly mandate the application of any particular standards, but rather provide guidance for determining these standards.

17.2 Notwithstanding, I observe that the SPP Guideline defines "safe refuge" as:

"An area at least 300mm above the DFE flood level with sufficient space to accommodate the likely population of the development in safety for a relatively short time until flash flooding subsides or people can be evacuated."

17.3 Best practice would require that a safe refuge be in a location above the PMF, being an area removed from any risk to life directly arising from flooding. As discussed above there is debate as to whether there are circumstances where such a refuge could be allowed for in elevated levels of a building that would be sited within the floodplain, but in all cases a refuge would be required to be located above the PMF.

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17.4 All planning authorities across Australia have different processes for the determination of development that require approval or not, the method to assess those types of development that do require some form of consent, and the "rules" to apply in undertaking the assessment. It is recognised that in Queensland, there is a hierarchy of development categories and associated assessment levels. This report focuses only on assessable development for the purposes of providing a preliminary review of flood related development controls.

17.5 The City Plan provides the general overview of requirements, with the majority of detailed provisions being contained within a number of assessment codes, supplementary policies within Appendix 2 of the Plan, and the *Subdivision and Development Guidelines*. An additional layer to the above, are local plans which

may provide further controls that prevail. More recently, Council has also adopted TLPI0/11 which substantially overrides pre-existing flood related controls.

17.6 Clause 3 of City Plan outlines desired environmental outcomes and objectives which include "*reducing risk*"[37] and maintaining the flood carrying capacity of waterways[38]. It is important to note that the objective is to reduce risk.

17.7 Clause 9 of City Plan defines the following terms which have varying relevance to flood risk management:

- Adverse flooding.
- Emergency services.
- Flood regulation lines.
- Local Stormwater Management Plan (LSMP).
- Overland flow path.
- Waterway.
- Waterway corridors.
- Waterway Management Plan (WMP).

17.8 The definition of waterway corridor is:

*"**Waterway corridor**: The corridors along a waterway indicated on the Planning Scheme Maps. These corridors are defined by:*

- *The Brisbane River Corridor;*
- *A Flood Regulation Line (FRL);*
- *A Local Plan, Environmental Corridor or Waterway Corridor;*
- *A Waterway Corridor defined in a Stormwater Management Plan (SMP);*
- *A Waterway Corridor defined in a Waterway Management Plan (WMP);*
- *If more than one of these measurements is available for a particular waterway, the largest applies;*
- *If there is no FRL, Local Plan, SMP or WMP, a 30 metre distance measured on each side from the centre line of a waterway."*

17.9 The definition of Waterway Corridors and its individual components do not necessarily identify land that may be subject to the full extent of flood risks (i.e. up to the PMF). SPP1/03 provides a definition of the floodplain which would be encompassing of all flood risks (i.e. up to the PMF) from which a flood risk management study would determine what level of risks are to be managed through planning and development controls. The distinction between the two is not always understood by the general community, and in some cases assessment managers

[37] Clause 3.2.2.8
[38] Clause 3.6.2.1

and decision makers, assume that compliance with the relevant controls relating to flooding would address all known risk.

17.10 Flood related controls in the City Plan are spread across a number of development codes. The following table[39] provides a summary of key controls which apply under the various Codes and associated documents of City Plan.

Code & Clause	Provision[40]	Comment
	Site & Floor Levels	
House Code various performance criteria and acceptable solutions – Table 1	Minimum ground level for Brisbane River – Q100 plus 300mm (IRFL[41] plus 300mm). Minimum ground level creek or waterway Q100 plus 300mm. Minimum ground level overland flow path – Q50 plus 300mm.	It is assumed that there is an expectation that a site must be filled to this level. It is not clear as to how the cumulative impacts of such filling are addressed.
Habitable Floor Level	Habitable Floor Level for Brisbane River – Q100 plus 500mm (IRFL plus 500mm). Habitable Floor Level for creek or waterway – Q100 plus 500mm. Habitable Floor Level for overland flow path – Q50 plus 500mm.	Generally consistent with typically applied standards, with the exception that a flood of record would not normally be applied as a standard.
Community Use Code Clause 4-P9 & A9.1	Material change of use to a childcare facility – site not to be located in a Q5 storm event or within a Flood Regulation Line.	This part of the floodplain could typically be considered high hazard. Best practice would consider childcare centres as vulnerable uses due to potential evacuation difficulties. A risk assessment might determine such a standard inadequate.
Subdivision & Development Guidelines Part A Chapter 1 Clause 2	Minimum site levels for lots as described above for residential development. For other than residential development the same flood levels apply but with no additional freeboard height. Different floor levels assigned to the range of BCA classifiable buildings – the standards now being mainly superseded by TPLI01/11.	
Subdivision & Development Guidelines Part A	Flood immunity levels for various community infrastructure (e.g. emergency services, emergency	The application of such higher standards to such critical and flood sensitive uses is consistent with

[39] This is a summary of key development controls as referenced within various subordinate documents to the City Plan. This should not be considered an exhaustive list of all controls.
[40] Controls provided in (brackets) are those contained in TLPI0/11, and controls not in brackets are those which preceded TLPI0/11.
[41] Interim Residential Flood Level being the highest of the January 2011 flood for Brisbane River, or a Brisbane River Flood Event using a flood high profile of 3.7m AHD at the City Gauge.

Code & Clause	Provision[40]	Comment
Chapter 1 Table A1.4	shelters, Police facilities, hospitals and associated facilities, power stations, major switch yards, water and sewerage treatment plants) – various recommended flood levels including the Q200 and Q500.	best practice and an expected likely outcome of a flood risk management study.
Building Components and Methods		
(TPLI01/11 – Table 1)	(Performance criteria for building components and flood resilient design. Acceptable solutions include use of water resistant materials below IRFL, locating essential services above IRFL, use of corrosion free building components below IRFL - refer to "*Growth Management Queensland Facts Sheet January 2011 – Repairing your house after a flood*").	Refer to discussion further below in this report in regard to building codes.
(TPLI01/11 – Table 4(	(Introduces flood immunity requirements for essential electrical services defined to include various power and telecommunication facilities).	Consistent with best practice.
Structural Soundness		
Waterway Code Clause 4.7 – A3.1	Retaining walls to be designed to withstand "*flood conditions.*"	'*Flood conditions'* not defined (i.e. which flood event).
Flood Affects		
House Code – B5 & A5.1	Performance criteria require protection from "*adverse flooding*" and interference with passage of flood flows.	
(TPLI01/11 – Table 1)	(Any enclosure below IRFL to have openings that are at least 1% of enclosed area).	Principle consistent with best practice. Engineering adequacy beyond scope of this report.
Waterway Code Clause 4.6 P3 and A3.1	Fencing must not impede flow of floodwater. Fencing in the Brisbane River corridor is to be less than 2m in height, and restrictions on river walls in certain locations apply.	
Filling & Excavation Code Clause 4 – P3 & A3.1 – A3.5	Filling or excavation not to directly or cumulatively increase flooding. No filling or excavation permitted in Waterway Corridor or Q100 flood extent. Noted that a flood study may be required to demonstrate compliance.	Consistent with best practice. Not clear as to what prevails when such an assessment concludes filling to achieve minimum prescribed site levels will cause an impact.
Stormwater Management	No adverse flood impact on upstream or downstream properties.	Consistent with best practice. See also above.

Code & Clause	Provision[40]	Comment
Code Clause 4.2 – P1 & A1		
Appendix 2 – Compensatory Earthworks.	Generally provides engineering requirements to ensure flood storage capacity and conveyance capability of waterways are not affected	Objectives consistent with best practice. Review of engineering requirements beyond scope of this report. See also above.
Evacuation		
Subdivision & Development Guidelines Part A Chapter 1 Table A1.4, Table A1.5, Table A1.6	In regard to state controlled roads no specific recommended level. For new local roads: ○ where serving essential development – the *defined flood level* or Q100 for river/waterways or Q50 for local flooding. Local roads ○ where serving industrial/ commercial development – Q50 for rivers, waterway and local flooding In regard to the construction of existing dedicated roads – varying standards depending on road and flooding type – including either a Q20 or Q50.	It is not clear as to whether the objective of these standards is to reduce potential damage to roads or to facilitate evacuation, or both.
Subdivision & Development Guidelines Part A Chapter 1 Section 3.2	Trafficable access satisfying two criteria: ○ Time of closure for the Q50 must not exceed 6 hours (except for Brisbane River); ○ Average annual time of closure must not exceed 2 hours.	It is not clear as to whether this is intended to provide for the evacuation of an area potentially affected by all floods up to and including a PMF.
Subdivision & Development Guidelines Part A Chapter 1 Section 4	Requires a risk management assessment in accordance with AS4360 for land affected by Brisbane River flooding. Brisbane River flooding has a secondary assessment method for certain Class 1A,, 1B, 2-4 BCA classifiable buildings.	The description of the risk management process required is not comprehensive. Some ambiguity as to whether the assessment relates to both property damages and evacuation (risk to life). It is also not clear as to all circumstances in which this approach is required or accepted.
Car Parking & Driveway Access		
As applicable	Generally driveways and car parking would be subject to meeting minimum site and non habitable flood levels – see above.	Further detailed provisions could be considered particularly for basement car parking associated with multi storey developments.
(TPLI01/11)	(Generally, levels of car parking relate to amended levels adopted for non habitable floors as per TLPI01/11. Includes additional requirements for parking located in the building undercroft of a multi unit dwelling	(Table 5 refers to Table 4 for applicable "*immunity*" however details in regard to Categories C and D are not evident?).

Code & Clause	Provision[40]	Comment
	(Category C), carports, unroofed car parks and vehicle manoeuvring areas (Category D). Basement parking entry to be Category C plus 300mm).	
Subdivision & Development Guidelines Part A Chapter 1 Clause 2.3	Car parking generally subject to non habitable floor level requirements. Specific note for basement car parking constructed below specified levels to be waterproofed and with entrances to be above the defined flood level for Brisbane River and 100 year flood for all other sources	Generally consistent with best practice. Could incorporate additional safety measures in case of over-topping of the driveway entrance.
Management & Design		
Clause 5.4.1 – P1 & A1.1 – A1.3	All lots to be designed to be able to accommodate future development in compliance with flood related development controls for buildings (i.e. adequate area of lots to the above minimum site levels for flood immunity).	Consistent with best practice.
Stormwater Management Code – Clause 4.1 – P1 and A1.1 – A1.3	Provide integrated management of stormwater that includes minimising flooding. Requires compliance with any SMP, LSMP and WMP	Consistent with best practice.
Brisbane River Corridor Planning Scheme Policy Clause 4	Outlines the guiding principles for the Brisbane River Management Plan including "*recognise and manage flooding risk through mitigation, planning and education.*"	Appropriate principle but not clear as to how this is expected to be achieved.
Subdivision & Development Guidelines Part A Chapter 1 Clause 2.3.2	In regard to development involving the intensification of the floodplain - filling of a site is preferred to achieve immunity, but may be allowed without filling where flood the flood hazard is acceptable. Acceptable hazard is described by reference to flood depths and velocity relevant for evacuation and flood damage purposes.	These criteria preface design floor levels and pavement levels for buildings and car parking described above. It is not clear as to whether they need to be separately addressed in an assessment.
Subdivision & Development Guidelines Part A Chapter 1 Section 7	Use of levees in new developments not permitted due to potential for failure and overtopping in extreme events	Consistent with best practice

18.0 Observations

Principle	*Observations*
Determining appropriate minimum planning standards in the floodplain is ideally achieved through a comprehensive flood risk management study. However, there are certain key outcomes that could be expected.	The Queensland planning process would allow for this but more specific guidelines would be desirable.
The primary planning measure that could be applied is to prohibit development in the floodplain. Most development should be prohibited or discouraged in high risk areas as these areas by definition pose significant risks to life and property and the scale of mitigation measures to reduce risk to acceptable levels are likely to be impractical or result in significant amenity and ecological impacts.	The scope of this report does not allow for the assessment of existing land use zones against flood risks. A useful exercise in a flood risk management study would be to review land use zonings against flood risk maps.
Controls applied to development when permitted within a floodplain would typically relate to the following seven considerations: •Site and Floor levels: •Building components and method; •Structural soundness; •Flood affectation; •Car parking and driveway access; •Evacuation; and •Management and Design.	• The BCC planning controls provide a range of Codes and associated documents that deal with each of these considerations in some way. • The controls are generally similar to those typically applied but there are some controls that are unclear and potentially inconsistent. • It could be beneficial to have all these controls contained in a discrete Flood Risk Management Code to provide a singular comprehensive reference for all flood risk management issues, which can ensure all controls are consistent.
The stringency of the controls should vary in proportion to the vulnerability of the land use and the level of flood risk affecting the site.	• There is evidence of this in the BCC controls.

Use of building codes in the floodplain for existing and future development

19.0 Principles

19.1 A development consent may condition compliance with various building codes (such as the Building Code of Australia or various Australian Standards) which would need to be addressed within subsequent construction approvals.

19.2 Such building codes could incorporate standards that are aimed at reducing the damage to a building when inundated by flood waters. The use of flood compatible building materials and appropriate structural techniques can reduce the extent of damage experienced by a building during a flood. This can have the effect of both reducing the cost of damages and the time required for a building to be reoccupied.

19.3 The extent of damage that may be experienced by a building would be primarily dependent upon the depth and velocity of flood waters during any particular flood. Having regard to the scope of this report and my expertise, I discuss only the type, availability and use of building codes that may typically be referred to within detailed planning controls.

19.4 Presently, while there are building codes for other natural hazards including bushfires, earthquakes and cyclones, there is currently no Australian Standard or specific provisions within the BCA for building on flood prone land. This fact was recognised by the *Hawkesbury-Nepean Flood Risk Management Strategy* which identified that substantial risks could be reduced by improving the resilience of buildings that would be affected by over floor flooding in events slightly rarer than the Q100. This led to the undertaking of substantial research documented within the publication entitled '*Reducing Vulnerability of Building to Flood Damage*'[42]. This document is widely acclaimed as the most comprehensive information available in regard to construction in flood prone areas. The document has recently been made accessible through the *Queensland Reconstruction* website.

19.5 Ideally the production of such building codes should be a task undertaken at a national level. Similar with other aspects of detailed design, appropriate building requirements in flood prone areas should apply universally in a manner similar to, for example, Australian Standards that apply for construction in cyclone regions. However, until such universal codes are adopted, it is reasonable to expect that some controls are incorporated within planning policies.

19.6 I understand that a draft national standard is being prepared through the Australian Building Codes Board, however I have not seen the document and I am uncertain as to when the standard may be introduced.

[42] HNFMSC, 2006(c).

20.0 Queensland Policies

20.1 Specification of flood compatible building materials and associated design considerations have been discussed above in the review of appropriate minimum planning standards in the floodplain.

21.0 Observations

Principle	*Observations*
The use of flood compatible building materials and appropriate structural techniques can reduce the extent of damage experienced by a building during a flood It is generally accepted that planning controls should contain a requirement to build using flood compatible building materials and methods in some situations.	Presently, there are no Australian Standards or specific provisions within the BCA for building on flood prone land. Ideally the production of such building codes should be a task undertaken at a national level which is understood to be underway. However, until such universal codes are adopted, it is reasonable to expect that some controls are incorporated within planning policies. The publication entitled 'Reducing Vulnerability of Building to Flood Damage' (HNFMSC, 2006(c)) is widely acclaimed as the most comprehensive information available in regard to construction in flood prone areas but is not in a format which allows it to be referenced as a technical specification for construction design purposes. Notwithstanding such a reference could be used to as a basis to augment existing local controls.

Use of flood mitigation engineering solutions

22.0 Principles

22.1 Traditionally, flood mitigation focused on identifying and delivering engineering solutions to mitigate flood risk. In my experience, over the last 15 to 20 years, there has been a redirection of focus to non engineering solutions such as improved emergency management strategies, improved planning controls and in some cases acquisition of significantly affected properties (i.e. reversal of past inappropriate planning decisions). There has also been a trend away from high cost engineering structures that alter natural flows, towards strategies that enhance natural systems.

22.2 In some cases, where consistent with broader planning strategies, the proactive encouragement of redevelopment of flood prone land by for example allowing more

intensive building forms subject to increased building setbacks from watercourses, higher floor levels, flood compatible building designs structurally certified to withstand the force of flood waters and improved evacuation measures could provide a substantial reduction in flood risk[43].

22.3 There is a reasonable expectation that broad scale engineered flood mitigation measures may be undertaken as part of greenfield development. This would potentially entail earthworks inclusive of filling, the construction of flood retention basins and where ecologically acceptable reconstruction of watercourses including piping and channelisation of minor water courses in some cases. However in areas of greater ecological sensitivity environmental works that affect watercourses are normally not accepted as appropriate in the planning process. Additionally, any such large scale engineering works could be cost prohibitive.

22.4 In existing established urban areas, the capacity to provide engineering works is diminished due to the lack of available land for works, the potential affect on existing properties that cannot be re-engineered by for example filling in association with such works, and higher costs associated with the acquisition of existing developed urban land. This is not to say that select engineering works cannot be undertaken in established urban areas in an acceptable manner that achieves an appropriate outcome. Additionally, there is of course larger scale catchment based engineering solutions that can provide substantial mitigation (at cost) such as that previously provided by the Wivenhoe Dam.

22.5 From a planning point of view, the principles that will determine the appropriateness of an engineering solution would include matters such as:

- The environmental impact of the development would need to be acceptable, with regards to general planning considerations such as ecological impacts, aesthetic acceptability and so on.

- The works should not cause an impact on other occupants within the floodplain, by for example increasing flood levels on other properties.

- Residual risk must be assessed within a broader flood risk management strategy. For example, the construction of a levee with the crest lower than the PMF level does not fully address potential flood risk and there remains the possibility of overtopping. Additionally, the failure of a levee is a possibility, which could result in devastating consequences[44]. Normally the principle associated with the construction of a levee as part of a flood risk management strategy is that it is intended to provide protection to existing development and not new development. New development would be assessed on the basis of the risks associated with the levee overtopping or failing.

22.6 The assessment of flood mitigation engineering solutions is best considered as part of a broader flood risk management study. This should involve the undertaking of a cost benefit analysis as well as assessing the broader environmental impacts and residual risk associated with such options.

[43] D Bewsher & P Grech, 2000.
[44] Such as that experienced with the failure of the ring levee around the western NSW township of Nyngan, in 1990 where almost every building was flooded and 2,500 people were evacuated.

23.0 Queensland Policies

23.1 As discussed above the Queensland planning process does provide for the preparation of broad flood risk management studies which would provide an appropriate basis for the consideration of engineering solutions. As this process is geared towards planning outcomes, the process may need to be refined to provide for the implementation of any engineering solution determined appropriate.

23.2 The review of existing BCC standards above did identify controls relating to the use of engineering solutions (such as levees) which are consistent with best practice principles.

24.0 Observations

Principle	*Observations*
The assessment of flood mitigation engineering solutions is best considered as part of a broader flood risk management study involving a cost benefit analysis as well as assessing the broader environmental impacts and residual risk associated with such options.	The BCC planning controls do incorporate appropriate considerations for some engineering works such as levees, but this would be relevant only at the development application level. The Queensland planning process does provide for the preparation of broad flood risk management Studies. These studies are prepared as part of the planning process which is considered desirable, but creates a need to ensure that any appropriate engineering solution is also identified and implemented. This may require a refinement of the existing process to incorporate the implementation of non-planning outcomes.

Catchment Authorities as regulators of the floodplain versus local Councils

25.0 Principles

25.1 I have not sourced any published literature that debates the issue of Catchment Authorities versus local Councils as regulators of the floodplain. My view is that there are advantages and disadvantages for the appointment of either of these two agencies depending upon the outcome intended to be achieved. As discussed above, flood risk management should involve a multifaceted strategy comprised of various components including:

- Property modification measures (i.e. generally planning controls).
- Response modification measures (i.e. flood education, improved flood warning systems and emergency management strategies).

- Flood modification measures (i.e. structural engineering solutions).

25.2 The following table summarises my views.

Outcome	Catchment Authorities		Local Council	
	Advantages	Disadvantages	Advantages	Disadvantages
Property Modification Measures.	Can provide a consistent catchment wide perspective integrated with broader water management strategies.	Catchment Authorities typically have minimal role in land use planning and regulation of development Would be reliant on local Councils to adopt and implement planning policies. Likely to provide an additional tier in the management system which may increase complexities and difficulties in decision making and implementation.	Can coordinate with other roles in the preparation of strategic plans and planning policies and development assessment planning policies. Existing expertise in understanding and implementation of controls that relate to property modification measures.	May result in inconsistent controls being applied across the same floodplain, where it straddles two or more Council areas Potential for planning strategies to conflict in achieving appropriate flood risk management objectives. For example landfill being undertaken in one Council area may impact upon flood levels in adjoining Council areas, or increased development in one area may exceed the evacuation capacity of the floodplain notwithstanding development expectations in an adjoining local Council area.
Response Modification Measures.	Potential to provide better coordination of measures for the whole of the floodplain unconstrained	Are unlikely to have existing expertise in this area. Possibly fewer established mechanisms to	May have expertise to analyse emergency management issues and produce	Are limited to Council boundaries which may not align with whole of floodplains. This can be

Outcome	Catchment Authorities		Local Council	
	Advantages	Disadvantages	Advantages	Disadvantages
	by Council boundaries.	notify and educate the community.	responsive planning policies but would require coordination with emergency management combat agencies such police and SES in the formulation of emergency management strategies Likely to have established mechanisms to provide Flood information and flood education (such as rates notes, Council planning information, etc). Greater potential to coordinate with requirements of existing and future development.	addressed by collaboration between adjoining local Councils however this may increase the organisational complexities of decision making and implementation.
Flood Modification Measures.	Integration of flood mitigation measures within broader water management strategies. Not confined to administrative boundaries – i.e. can undertake whole of catchment management works. Separate funding stream compared to local Councils which have	Need to understand existing and future development patterns in determining cost benefit of works.	Greater understanding of the need for flood modification works to reduce risks associated with existing and planned development.	Confined to administrative boundaries without collaboration with adjoining Councils. Limited funding stream and broader responsibilities which may not facilitate assigning high priority to flood risk management works.

Outcome	Catchment Authorities		Local Council	
	Advantages	Disadvantages	Advantages	Disadvantages
	broader. responsibilities Focused charter and responsibility relating to water management, providing greater certainty and commitment to the planning and delivery of works.			

25.3 In my view, the key is the determination of which should be the lead agency in the preparation of flood risk management strategies. Such strategies can then indentify the agency responsible for implementation of different recommendations, whether they relate to structural works, planning controls or flood education and emergency management measures. Irrespective of the lead agency, a range of agencies would need to have a role in the formulation and implementation of the flood risk management strategy and have statutory responsibilities and funding sources to ensure implementation of their nominated actions.

25.4 Statutory responsibilities imposed on the lead agency could be linked with indemnity from liability subject to acting in accordance with established principles. This can provide an effective incentive to ensure comprehensive flood risk strategies are prepared. Such indemnity can be important to both encouraging the preparation of such strategies and in ensuring reasonable outcomes are adopted, that do not seek to perfunctorily restrict all development in the floodplain (i.e. up to the PMF) in fear of the liability that the lead agency may be exposed to.

26.0 Queensland Policies

26.1 With regard to planning outcomes, the State Government is responsible for establishing broad planning policies and over arching legislation, while Local Government is the lead agency for the preparation and implementation of planning controls (in most cases). As discussed above, this should in principle entail the preparation of a flood risk management study and plan to inform the preparation of planning controls, with recognition that this may not always be achievable in the short to medium term by Councils who are poorly resourced and with minimal need due to low growth rates. Additionally, Local Government can be responsible for local structural mitigation works.

26.2 The preparation of an effective flood risk management study and plan would require coordination with other Government agencies responsible for the provision of emergency management services and other regional structural works (such as

dams). The role of these agencies and issues associated with Local Government responsibilities, is beyond the scope of this report.

27.0 Observations

Principle	*Observations*
There are advantages and disadvantages for the appointment of either of these two agencies depending upon the outcome intended to be achieved; i.e.: • Property modification measures; • Response modification measures; or • Flood modification measures. Irrespective of the lead agency, a range of agencies would need to have a role in the formulation and implementation of a flood risk management plan and have statutory responsibilities and funding sources to ensure implementation of their nominated actions.	With regard to planning outcomes, the State Government is responsible for establishing broad planning policies and over arching legislation, while Local Government is the lead agency for the preparation and implementation of flood risk management strategies and planning controls (in most cases). On balance, there seems to be many advantages with maintaining local government as the lead agency however this role could be strengthened but providing: ○ Greater specification as to the conduct of the flood risk management plan preparation process. ○ Statutory obligations for other key agencies to cooperate in the process. ○ Encouragement for adjoining Councils covering the same floodplain to jointly engage in the process. ○ Inducements through statutory indemnity from liability and funding programs.

28.0 Conclusion

28.1 Planning policies associated with development in the floodplain should be ideally based on a comprehensive flood risk management study and plan that apply a risk management approach in a process involving the community and other stakeholders. Such a study and plan would identify all risks associated with a range of floods before determining appropriate risk levels upon which to base planning policies.

28.2 A flood risk management plan should involve a multifaceted strategy comprised of various components including:

- Property modification measures (i.e. generally planning controls).
- Response modification measures (i.e. flood education, improved flood warning systems and emergency management strategies).
- Flood modification measures (i.e. structural engineering solutions).

28.3 Planning's role relates primarily to the implementation of property modification measures, and to a lesser extent response modification measures particularly in regard to the manner in which it informs the community through flood risk planning.

28.4 The preparation of a comprehensive flood risk management study and plan can typically require extended time and resources to prepare, adopt an implement. Systems to encourage the preparation of such studies could be encouraged by the State Government through measures such as statutory indemnity and funding where the flood risk management process is followed. It is recognised that not all Councils in Queensland with flood prone land have the same issues and the priority and scale of studies will vary depending on available resources and anticipated rates of development.

28.5 State Planning Policy 1/03 *'Mitigating the Adverse Impacts of Flood, Bushfire and Landslide'* (SPP1/03) and SPP1/03 Guideline: *Mitigating the Adverse Impacts of Flood, Bushfire and Landslide* ("the SPP Guideline") provide a substantial basis for preparing flood risk management planning controls, in a manner generally consistent with best practice. These instruments were introduced in 2003, and provide a process for the undertaking of such studies by local councils to inform the preparation of local planning instruments.

28.6 Notwithstanding the above, some refinement of SPP1/03 and the SPP Guideline including greater specification as to the process for preparing these flood risk management studies and the adopting and implementation of flood risk management plans would be beneficial. Such refined guidelines should clearly specify the need to consider the consequences of a range of all floods within the floodplain and the issues to consider in analysing risks to all land uses across the floodplain. The outcome of this assessment should ideally include the preparation of flood risk maps based on a consistent state wide format that identify all risks across the floodplain irrespective as to whether planning controls apply in all cases.

28.7 Greater specification of the flood risk management process to be followed by local councils could include:

- Guidelines for the preparation and presentation of flood risk maps.
- A model development code for flood risk management that could be adapted to suit local circumstances as determined through the study process.
- A standard building code for development in flood prone areas (ideally as a national code in cooperation with other states).

28.8 It is inconceivable that a comprehensive flood risk management process would result in all development being subjected to restrictions in all parts of the floodplain. However, the benefits of such a process include:

- improved decision making in regard to where to locate new areas in the floodplain;
- restrictions on select critical sensitive uses to minimise danger to vulnerable sectors of the community and to safeguard infrastructure that may be important during emergency management operations or post flood recovery;
- a better informed community that understands that compliance with development controls in most cases does not remove all flood risks; and
- providing a comprehensive basis for adopting a flood risk management strategy that is integrated with outcomes not directly related to planning such as emergency management, community flood education and preparedness programs and acceptable engineering solutions.

28.9 While local councils could be the preferred lead agency in the preparation of flood risk management studies and plans, there will be a need to ensure the cooperation of all relevant government agencies, particularly where flood risk management plans rely on organisations other than Councils to implement.

28.10 The above would take some time to implement. Any changes in the approach to flood risk management in Queensland would be expected to apply across the state and not only those communities significantly affected by the 2010/2011 floods. The introduction of interim measures would be desirable, particularly for lower priority Councils. This should include a requirement for a planning authority to consider suspected flood risks when assessing a development application prior to the adoption of a flood risk management plan.

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30.0 Glossary [45]

100 year flood ("Q100")	A **flood** that occurs on average once every 100 years. Also known as a 1% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
annual exceedance probability (AEP)	AEP (measured as a percentage) is a term used to describe **flood** size. It is a means of describing how likely a flood is to occur in a given year. For example, a 1% AEP flood is a **flood** that has a 1% chance of occurring, or being exceeded, in any one year. It is also referred to as the '100 year flood' or 1 in 100 year flood'.
Australian Height Datum (AHD)	A common national plane of level approximately equivalent to the height above sea level. All **flood levels**, floor levels and ground levels in this study have been provided in metres AHD.
average recurrence interval (ARI)	ARI (measured in years) is a term used to describe **flood** size. It is the long-term average number of years between floods of a certain magnitude. For example, a 100 year ARI flood is a flood that occurs or is exceeded on average once every 100 years. See also **annual exceedance probability (AEP)**.
Catchment	The land draining through the main stream, as well as tributary streams.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
Flood	A relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood hazard	The potential for damage to property or risk to persons during a **flood**. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.
flood level	The height of the **flood** described either as a depth of water above a particular location (eg. 1m above a floor, yard or road) or as a depth of water related to a standard level such as **Australian Height Datum** (eg the flood level was 3.8m AHD).
flood liable land	Land susceptible to flooding up to the **probable maximum flood (PMF)**. Also called **flood prone land**.
flood prone land	Land susceptible to flooding up to the **probable maximum flood (PMF**). Also called **flood liable land**.
Flood Study	A study that investigates flood behaviour, including identification of flood extents, **flood levels** and flood velocities for a range of flood sizes.

[45] The terms and definitions included below are substantially derived from the NSW Floodplain Development Manual (2005).

Floodplain	The area of land that is subject to inundation by floods up to and including the probable maximum flood event, that is, **flood prone land** or **flood liable land**.
Floodplain Risk Management Plan	The outcome of a **Floodplain Risk Management Study**. (Note that the term 'risk' is often dropped in common usage.
Floodplain Risk Management Study	Studies that assess options for minimising the danger to life and property during **floods** that may affect the **floodplain**. These measures, referred to as 'floodplain management measures/options', aim to achieve an equitable balance between environmental, social, economic, financial and engineering considerations. The outcome of a Floodplain Risk Management Study is a **Floodplain Risk Management Plan**.
Floodway	Those areas of the **floodplain** where a significant discharge of water occurs during **floods**. Floodways are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in **flood levels**.
Freeboard	A factor of safety expressed as the height above the **design flood level**. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the **floodplain**, such and wave action, localised **hydraulic** behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change.
high flood hazard	For a particular size **flood**, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.
Hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and **velocity**.
Hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of **peak discharges**, flow volumes and the derivation of hydrographs (graphs that show how the discharge or stage/flood level at any particular location varies with time during a flood).
low flood hazard	For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.
overland flow path	The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as 'overland flows', may or may not re-enter the main channel from which they left — they may be diverted to another water course.
probable maximum flood (PMF)	The largest flood likely to ever occur. The PMF defines the extent of **flood prone land** or **flood liable land**, that is, the **floodplain**.

Risk

Risk is measured in terms of consequences and likelihood. In the context of floodplain management, it is the likelihood and consequences arising from the interaction of floods, communities and the environment. For example, the potential inundation of an aged person's facility presents a greater flood risk than the potential inundation of a sports ground amenities block (if both buildings were to experience the same type and probability of flooding). Reducing the probability of flooding reduces the risk, increasing the consequences increases risk

APPENDIX A

Curriculum vitae

Paul Antony Grech

PRINCIPAL

Paul Grech has over 25 years experience working as a town planner. Paul aims to practice broadly within the town planning profession, believing that a breadth of knowledge and experience is important to providing balanced, comprehensive and practical input to projects. Paul has been involved in undertaking environmental studies, floodplain risk management studies, statutory planning and development assessment, preparation and review of development contributions plans, the preparation of environmental impact statements, statements of environmental effects and environmental assessment reports and presenting expert evidence for the development industry, local councils, state government departments and commonwealth agencies. His experience includes the management of multi-disciplinary project teams involved in a wide variety of residential, industrial, commercial and rural projects.

Paul also currently lectures in the Faculty of Engineering at the University on Technology, Sydney, delivering the town planning component of the Floodplain Risk Management course.

Qualifications

Certified Practicing Planner

Member of Planning Institute Australia

Bachelor of Town Planning (Class 1 Honours) University of NSW

Certificate in Horticulture (with Distinction)

Completed course work in Associate Professional Certificate in Expert Evidence for the Land & Environment Court (Joint API and Sydney University, 2005)

Academic Awards

Best Thesis in the Bachelor of Town Planning UNSW

Highest Achiever Award in the Certificate of Horticulture

Published Papers

Presentation of Papers to planning and development seminars and conferences inclusive of over 15 papers on the topic of Floodplain Planning

Employment

2010 to Present	Grech Planners, NSW, Australia, Principal
1993 to 2010	Don Fox Planning, NSW, Australia, Director and Town Planner
1989 to 1993	Don Fox Planning, NSW, Australia, Senior Town Planner
1988	Campbelltown CC, NSW, Australia, Environmental and Research Planner
1985 to 1987	Don Fox Planning, NSW, Australia, Associate Town Planner
1984 to 1985	Department of Leisure Sport & Tourism, NSW, Australia, Research Planner
1983 to 1884	National Capital Development Commission, ACT, Australia, Student Town Planner
1982 to 1983	Wyong Shire Council, NSW, Australia, Student Town Planner