

HAWKESBURY'S FLOOD RISK MANAGEMENT PLAN: 15 YEARS IN THE MAKING

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Abstract

The Hawkesbury-Nepean Valley has one of the most significant flood risk exposures in the nation. In 1997 the NSW Government established the Hawkesbury-Nepean Flood Management Advisory Committee and recommended the preparation of detailed floodplain risk management studies and plans (**FRMS&Ps**) for each of the six major councils in the Valley.

Now almost two decades later, Hawkesbury City Council, which has a lion's share of the Valley's flood problems, has produced a FRMS&P.¹ None of the other Councils has yet prepared their FRMPs.

The Hawkesbury FRMS&P was adopted in late 2012 after a three year period of preparation and public consultation. It has provided key strategic planning direction for the Council including:

1. recommended changes to the City's planning controls in keeping with the Valley's unique flood characteristics including its huge flood range. Some of these planning controls are unique across NSW Local Government Areas (**LGAs**), e.g.:
 - (a) no freeboard;
 - (b) 200 year residential Flood Planning Level (**FPL**);
 - (c) mandatory two storey development including controls on building materials for those developments wishing to continue with the previous 100 year residential FPL;
2. guidance on the evacuation risk of new release areas when carrying out strategic planning of these areas; and
3. support for construction of community-based evacuation shelters on low flood islands in case for whatever reason residents to do not evacuate when directed.

Uniqueness and Severity of the Hawkesbury's Flood Risks

Flood Risks to Property

Many buildings in Hawkesbury LGA have significant flood exposure (**Figure 1**). About 350 houses would be inundated in the 20 year flood, rising to 1,600 in the 50 year flood, 3,200 in the 100 year flood and over 13,000 in the Probable Maximum Flood (**PMF**). In the 100 year flood, almost 1,400 dwellings would be inundated to depths exceeding 2 metres.²

The exposure of housing to flooding varies between suburbs (**Figure 2**). McGraths Hill is severely affected in a 50 year flood and virtually entirely inundated in a 100 year flood. South Windsor also presents a serious flood risk exposure in the 50 year and 100 year floods, and is progressively more affected up to the PMF. A large number of houses are affected in Windsor, Pitt Town and Wilberforce in the 50 year and 100 year events. Houses in Bligh Park, Richmond, Hobartville and North Richmond are little affected in events up to and including the 100 year flood, but are significantly exposed at Bligh Park and Richmond in the 200 year and rarer events.

The annual average cost of flood damage to houses in the LGA was calculated as about \$18 million, whilst the present value of damages over a 50 year period is calculated as about \$261 million (**Table 1**). These estimates do not include damages for actual building failure (which is expected to be significant where depths are large) or estimates for damages to the commercial/industrial sector, to infrastructure, to motor vehicles or to special uses including caravan parks, the RAAF Base Richmond or the UWS Hawkesbury campus.

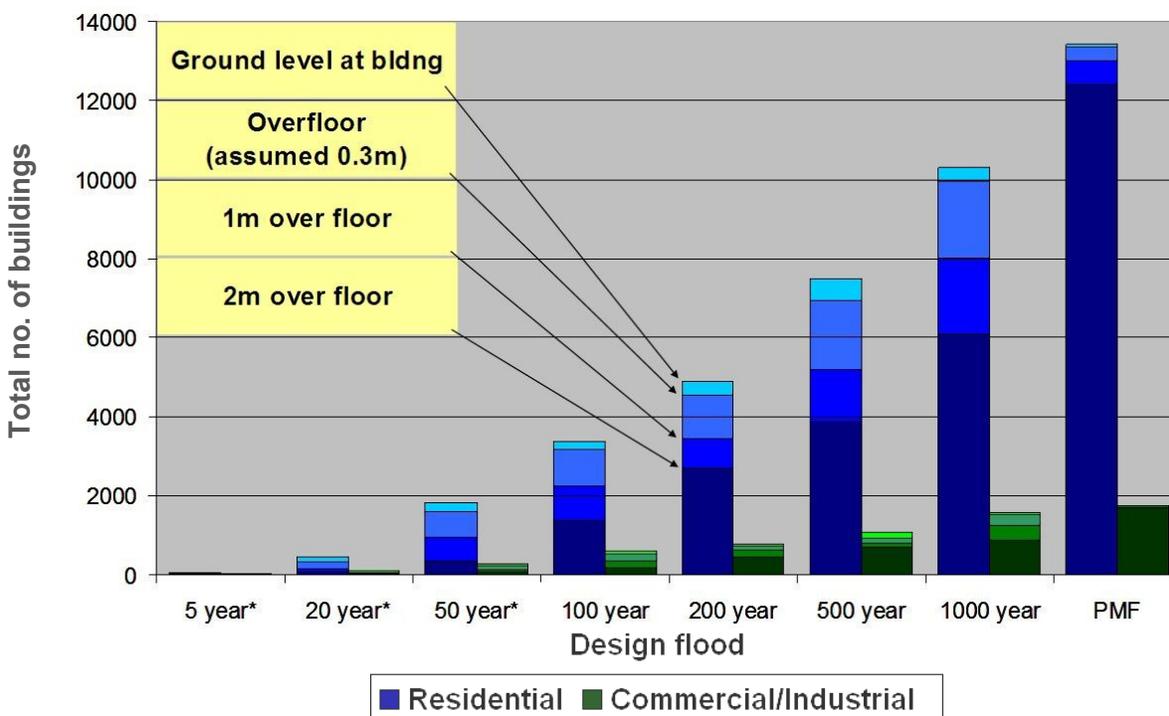


FIGURE 1 – Estimated Number of Buildings Flooded by Design Event, Depth and Land Use, Hawkesbury River within Hawkesbury LGA³

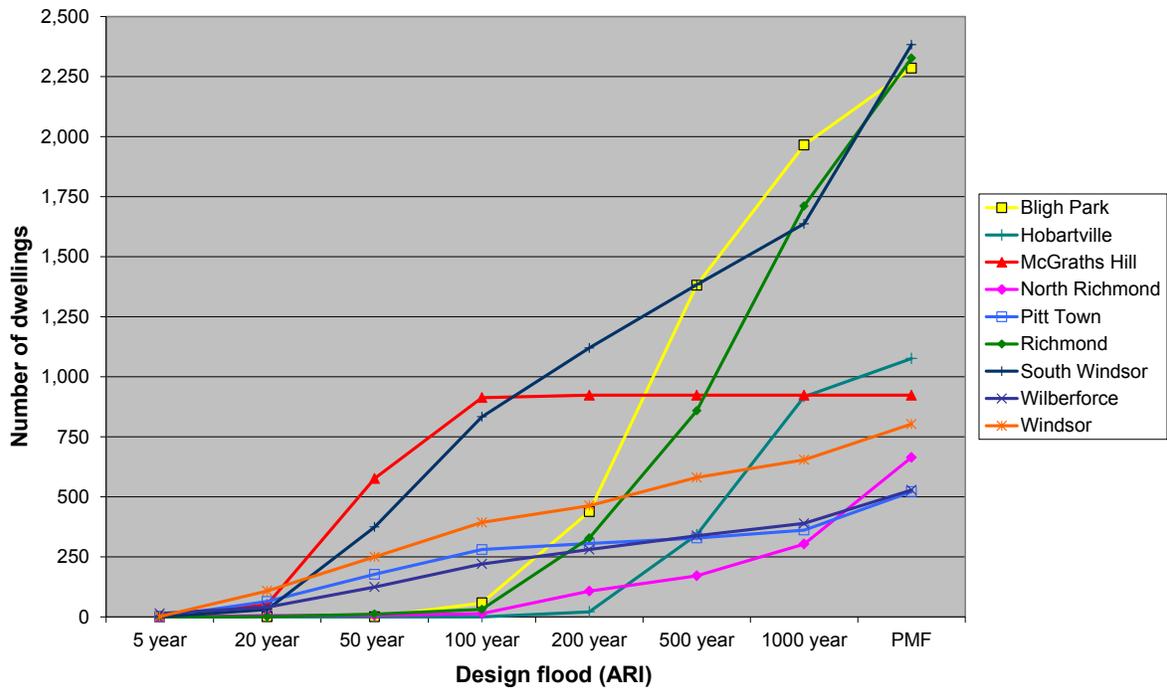


FIGURE 2 – Dwellings Flooded to Ground Level by Design Event and Suburb⁴

TABLE 1 – Summary of Residential Flood Damages by Event, Hawkesbury LGA

Design Flood (ARI)	Predicted Actual Damage in Flood Event (\$2010)	Contribution to Average Annual Damage (AAD) (\$2010)		Present Value of Damage over 50 Years (\$2010)
5 year	\$3M	\$0.5M	3%	
20 year	\$38M	\$3.1M	18%	
50 year	\$184M	\$3.3M	19%	
100 year	\$403M	\$2.9M	16%	
200 year	\$613M	\$2.5M	14%	
500 year	\$947M	\$2.3M	13%	
1000 year	\$1,408M	\$1.2M	7%	
PMF	\$2,214M	\$1.8M	10%	
TOTAL	–	\$17.7M	100%	\$397M (4% discount rate) \$261M (7% discount rate) \$177M (11% discount rate)

Flood Risks to Life

Flooding presents very serious risks to life within Hawkesbury LGA.

In most rivers in NSW, the differences between the 100 year flood level and the PMF are relatively small (i.e. nearly always less than 2m). However within the study area, the water levels in the Hawkesbury River during an extreme flood can rise up to three building storeys above the 100 year flood level. During these major flood events, significant areas of land are inundated.

Most critically in regard to risks to life, 'islands' of higher land can form as flood waters rise, isolating the communities on the island who, for whatever reason, may have failed to evacuate prior to the onset of the flood. As waters continue to rise during extreme floods, there is the potential for these low flood islands to be overwhelmed with disastrous loss of life.

Consequently the flood evacuation constraints of existing and future developments were a principal focus of the study.

The 1867 Flood

Flooding along the Hawkesbury River in the Windsor and Richmond districts has been problematic from the earliest settlement. The first flood fatality is reported in 1795 when a settler drowned as the river rose 25 ft above its usual level.⁵ Five fatalities occurred in the March 1806 flood and eight in the August 1809 flood.⁶ Severe losses to agriculture were reported for most of the early flood events.

The largest flood in the historical record peaked at Windsor at 5 a.m., Sunday 23rd June 1867. The peak level of 19.7m AHD is based on the observation of astronomer John Tebbutt.⁷ Newspaper articles of the day provide an insight to the flood's causes and characteristics. The weather conditions suggest that an east coast low pressure system was the cause of the flood-generating rains, which were likely to be higher in the catchment than the few gauge records indicate.

Reported rates of rise at Windsor vary from about 0.8m/hour early in the event to about 0.2m/hour closer to the peak. The flood was higher than 14.0m AHD for about four days. High flow velocities were described for the Sackville Reach where the valley floor is narrow. A number of reports describe the effect of the easterly gale creating waves on the surface of the water body, which was very extensive around Richmond and Windsor.

Reports from Windsor give a vivid description of the 'shrinking island' to which most inhabitants fled:

Saturday 22nd, noon: The town is divided into islands, which are gradually and terribly diminishing. The greater portion of the town is now inundated... The people themselves are every hour being driven closer and closer together as the mighty flood encroaches on the land. Houses are giving way before the sweeping current... Unless a change takes place very soon... the whole town will be deluged. Hairbreadth escapes are heard of from all points, and at best nothing but utter ruin and desolation stares us in the face.⁸

Twelve flood fatalities were recorded at Cornwallis, mostly children.⁹ The loss of life from this record event is much lower than it could have been, with reports of many 'near misses' as boat rescues were accomplished just in time.

A flood of the magnitude of the 1867 flood has been estimated to have an average recurrence interval (**ARI**) of between 200 and 300 years and would reach a height of about 19.3m AHD with the mitigating effects of Warragamba Dam.

Geomorphologists have found geological evidence for substantially higher floods than the 1867 flood in the Nepean River.¹⁰

Consequences of Major Flooding Today

A repeat of the 1867 flood in the Hawkesbury-Nepean Valley today is estimated to have the following consequences (described for the entire Valley including Penrith):¹¹

- a need for the evacuation of 50,000 people because of the risks associated with isolation and further rises in river levels;
- considerable loss of life if evacuation were not completed before houses were inundated;
- emotional and medical trauma with perhaps thousands requiring medical treatment;
- inundation over floor level of about 7,000 houses, accommodating about 22,000 people;
- damage bills exceeding \$80,000 (an estimated 'threshold of affordability') for more than 5,000 houses, causing severe financial stress;
- significant structural damage for about 1,200 houses, accommodating about 3,500 people, who would require alternative accommodation;
- inundation over floor of about 1,600 businesses, employing about 4,000 people (based on 1988 development);
- loss of electricity supply for up to 67,000 premises (most located outside the floodplain) for periods between two days and three months;
- restricted water supply;
- flow of untreated sewage into the river;
- severely disrupted telecommunications, with inundation of telephone switching centres and exchanges;
- direct damages of about \$1.7 billion and indirect damages of about \$1.3 billion, for a total tangible damage bill exceeding \$3 billion.¹²

Flood damages above the FPL become extremely high because of the large flood depths and the fact that few measures have been taken to minimise impacts for the rarer events. This highlights the problem of basing planning mainly on probabilities with minimal consideration of consequences. The average annual damage of flooding in the Hawkesbury-Nepean Valley is today estimated at about \$70 million.¹³ This excludes the cost of complete building failure.

Issues in Progressing a Floodplain Risk Management Study and Plan (FRMS&P)

Hawkesbury-Nepean Floodplain Management Strategy (HNFMS)

In 1997 the three NSW Ministers with responsibilities for water, planning and emergency services established the Hawkesbury-Nepean Flood Management Advisory Committee. The Committee's purpose was to address the serious flood problem in the Hawkesbury-Nepean Valley downstream of Warragamba Dam.

The Committee's assessment of flood issues and its recommendations for remedial action related to the six LGAs comprising Penrith, Hawkesbury, Blacktown, The Hills, Hornsby and Gosford. A wide range of studies were initiated including planning studies, emergency management, flood damages, regional flood mitigation works, changes to Warragamba Dam, flood insurance, flood awareness and education.

The primary task of the Committee was to oversee preparation of a comprehensive strategy for management of the flood risks within the Hawkesbury-Nepean Valley.¹⁴ As far as the authors are aware, together with the Georges River FRMS&P and the Upper Parramatta River Catchment FRMS&P, the HNFMS is one of very few truly regional FRMPs prepared in NSW.

A key recommendation of the Strategy was that each of the six local councils including Hawkesbury, prepare their own FRMPs and policies. To assist in this task the Committee recommended that best practice *Subdivision Guidelines*¹⁵, *Building Guidelines*¹⁶ and *Land Use Guidelines*¹⁷ be prepared. Over the following decade considerable efforts were made in the preparation of these guidelines which were subsequently published in June 2006. These documents provide an excellent resource for councils in the Hawkesbury-Nepean Valley and in fact across all floodplains in NSW and the nation. The guidelines have received recognition including an Engineering Excellence Award from Engineers Australia. In the opinion of the authors of this paper, the guidelines represent current best practice floodplain risk management in Australia and are extremely valuable in underpinning the preparation of FRMS&Ps in the Valley and elsewhere.

These guidelines together with the Strategy developed by the Committee, provided the key foundation for preparation of the Hawkesbury FRMS&P. The authors have prepared in excess of 20 major flood risk management plans and found significant benefit in having a regional strategy in place prior to the undertaking of this project. In our experience, a key benefit of the 1997-2004 Strategy and the 2006 Guidelines was the establishment of a definitive position on how to approach the production of planning controls and a step by step approach for preparing a planning matrix with graduated controls based on land use.¹⁸

Role of Flood Risk Management Advisory Committee

Under the flood risk management process set out within the NSW Floodplain Development Manual, a council's floodplain committee performs a key role in overseeing and coordinating the preparation of the FRMS&P. Without an effective committee a successful study and plan cannot be prepared.

Hawkesbury City Council's committee was uniquely composed of both state and federal government politicians, a number of councillors and community representatives who had

lived in the LGA for many decades and had long experience with its flood problems. The committee was also served by representatives from the State Emergency Service (SES), NSW Office of Environment and Heritage (OEH), Department of Defence, Council staff and consultants.

There were a number of committee factors that were pivotal to the successful preparation of the Hawkesbury FRMS&P:

- (a) Organisation: – the organisation and operation of the Committee was the responsibility of the Director of City Planning and the management of the FRMS&P was the responsibility of Council's Strategic Planning Coordinator. It is our experience that many committees across the State are dominated by engineers or otherwise fail to properly engage town planners within Council. As a large part of any FRMS&P involves strategic planning, we have found that committees and FRMSs that are run by strategic planners are the most effective.
- (b) Chairman: – strong leadership of the Committee was provided by a Councillor with local practical experience in the floodplain and a thorough understanding of the flood risk management process. As there are often competing political tensions within a committee, a skilful chairman fulfils an important role in ensuring that tensions created within the committee are directed towards production of a practical FRMS&P.
- (c) Brief: – the FRMS&P was undertaken in accordance with a well prepared brief. (This brief deviated considerably from the standard brief commonly used within NSW for FRMS&Ps). The brief was written jointly by OEH and Council over a considerable period of time. Its writers had a very good understanding of the FRMS&P process as well as the local issues that would be important for the success of the FRMS&P. For example the brief specifically excluded investigation of regional structural flood mitigation works. These matters had been well canvassed in the Regional Study and while many still viewed them as a panacea, it was recognised that if the study's resources were directed towards consideration of these regional schemes, the result would be a lack of attention to local matters, and in particular, appropriate land-use planning and development controls.
- (d) Meeting Focus / Interest: – The Committee met regularly (either monthly or bimonthly) and the meetings were relatively short (i.e. one and a half hours). Meeting content was kept focussed on the preparation of a FRMP. Invitations to key personnel (e.g. Bureau of Meteorology) were made to provide advice on the FRMS&P to the Committee. Matters of an intensely technical nature were discussed by a technical working group with only the key outcomes being reported to the Committee.
- (e) Regional Strategy: – The Committee had the benefit of an existing flood study and regional strategy (including the 2006 Guidelines). Consequently the Committee could focus on the key issues relating to the appropriateness of future development and the specifics of the planning controls. Although some members of the Committee still took issue with the accuracy of the flood study, strong leadership by the chairman and the clear direction provided by the study brief, ensured that the Committee's focus remained centred on the key strategic planning and development control issues.

No FRMS&P Starts with a 'Clean Slate'

When a committee embarks upon the process of preparing a FRMS&P, committee members come to the process with some preconceived ideas and are influenced by a range of existing political and community pressures. The Hawkesbury was no different and the following lists some of these issues with which the Committee was forced to grapple:

- (a) Doubts about the Flood Study: Prior to the mid-1990s the 100 year flood level at Windsor was around 16m AHD. The Hawkesbury Local Environmental Plan 1989 (**LEP 1989**) at that time consequently adopted this level as the floor height standard without reference to a particular flood frequency. During the 1990's there were failed attempts to amend the LEP and to change this level to reflect the findings of new studies. Ultimately the LEP was amended to refer specifically the 100 year flood as opposed to a specific level. The flood study which formed the basis of the FRMS&P raised this level to 17.3m AHD, which is the current 100 year flood level within the majority of the Windsor-Richmond area. Some committee members and sections of the community doubted the accuracy of the 'new' flood levels.
- (b) Regional Flood Mitigation Works: A number of major regional structural works were investigated during the preparation of the regional strategy. This included dredging of the River, raising of Warragamba Dam and excavation of Sackville Gorge. These regional works were seen by some as a panacea for all of the Hawkesbury's flood problems despite these schemes having been rejected during the preparation of the regional strategy. The desire to see these regional works re-examined during the FRMS&P impeded focus on local and non-structural measures (e.g. planning controls) in order to manage Hawkesbury's flood risks.
- (c) Freeboard: Hawkesbury City Council has had a long history of development without use of any freeboard. Both the previous 16m flood planning level (FPL) and the current 100 year flood standard have been applied without freeboard. Consequently there was strong resistance to the introduction of any freeboard despite the consideration of the very large flood range within the River compared with elsewhere within NSW.
- (d) Impact on Property Values: The perceived impact on property values resulting from comprehensive flood risk mapping and the introduction of amended development controls was a major consideration for the Committee, as it is for many other committees across the state.
- (e) Previous LEP: At the time of preparing the FRMS&P the principal planning instrument for the LGA (LEP 1989) included the following key provisions¹⁹ which some sectors of the community believed should be retained unchanged:
 - a definition of flood prone land was not provided. Whilst a definition of the 100 year flood level was provided this did not imply that this was the extent of potential flooding;
 - due to the above ambiguity evacuation issues were able to be considered for development on land up to the PMF;
 - subject to a number of qualified situations, the FPL for land upon which any building could be erected was 3m below the 100 year flood level;
 - subject to a number of qualified situations, the FPL for habitable residential floors was the 100 year flood level;
 - there was no freeboard provision;

- there was no stated FPL for the level of non-habitable residential uses or non-residential uses including commercial and industrial development (other than the land must first be no lower than 3m below the 100 year flood level); and
- any part of any building below the 100 year flood level was to be constructed of flood compatible materials.

A key difference between the planning controls in the LGA and other NSW LGAs was the differentiation of flood standards for floor levels (100 year flood) and for land upon which development could be approved (3m below the 100 year flood).

Key Outcomes of the FRMS&P

The following are some of the key outcomes of the FRMS&P. These are discussed in the remaining sections of the paper:

- application of a definitive approach to the formation of flood risk planning controls as established by the 1997-2004 Strategy and 2006 Guidelines;
- preparation of flood risk maps to be used to inform land use planning;
- development of revised planning controls;
- evacuation risk advice to inform strategic planning of new release areas and rezonings; and
- recommendations for community refuges.

Flood Risk Planning Approach

The Strategy and Guidelines provided clear recommendations for the adoption of graduated planning controls. The rationale underpinning this approach is diagrammatically depicted by **Figure 3**.

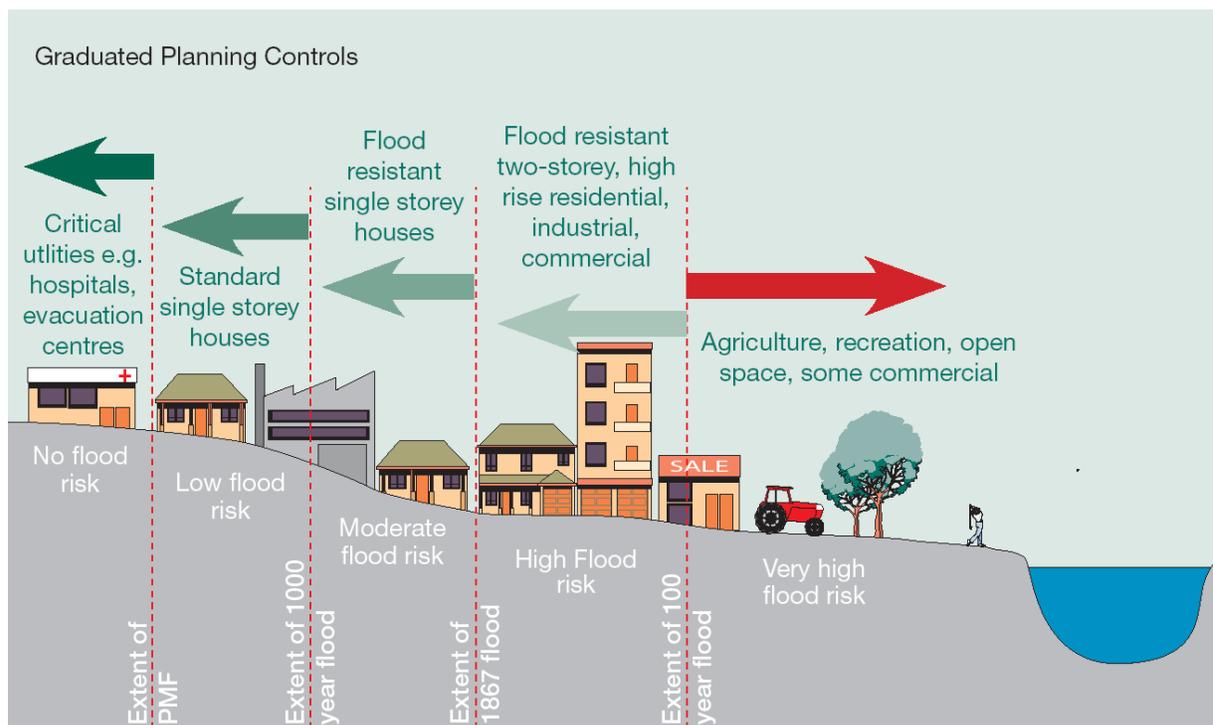


FIGURE 3 – Distribution of Land Uses on the Floodplain to Reduce Risk

Source: *Land Use Guidelines*

Flood Risk Mapping

Categorisation of floodplains into different grades of flood risk has been carried out in many NSW council areas, typically into flood risk bands of 'high', 'medium' and 'low'.²⁰ These bands have usually been derived from consideration of hydraulic characteristics as well as evacuation constraints. Given the special evacuation concerns in parts of the study area, it was decided for the purposes of the current study to prepare flood risk classifications based solely on hydraulic considerations and to provide a separate system for classifying evacuation risks.

The flood risks in the study area were then classified into five bands (**Figure 4**). These bands were chosen having regard to the detailed considerations undertaken during the preparation of the *Land Use Guidelines*, as well as the hydraulic considerations listed above and the large flood range in the study area.

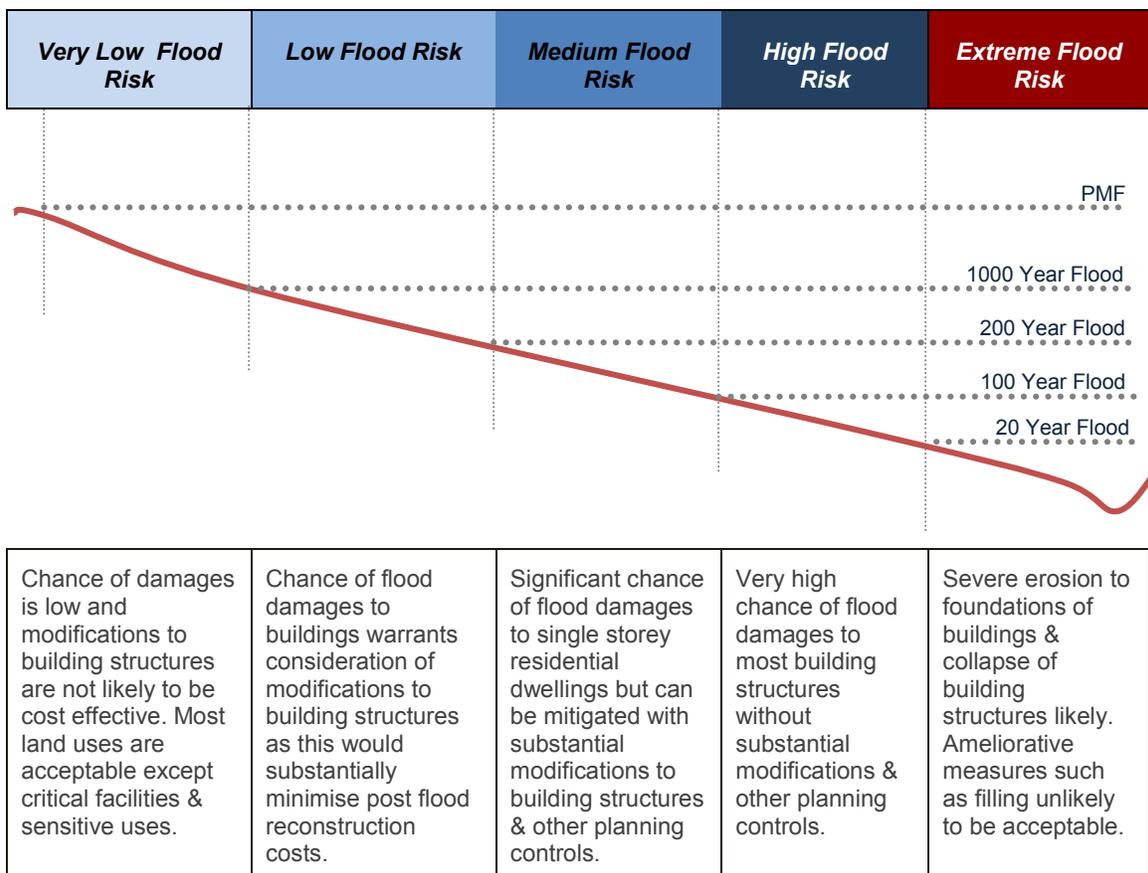


FIGURE 4 – Flood Risk Categories used for Development Control Purposes

Flood risk mapping for the LGA, which was prepared using the above classification system, is shown in **Figure 5**.

One of the most important consequences of the adopted mapping approach was to provide a way of differentially mapping flood risks over the whole of the floodplain. In this way even though residential development may not be subject to flood risk related controls, but still subject to flood risk, the land is mapped within a lower flood risk precinct.

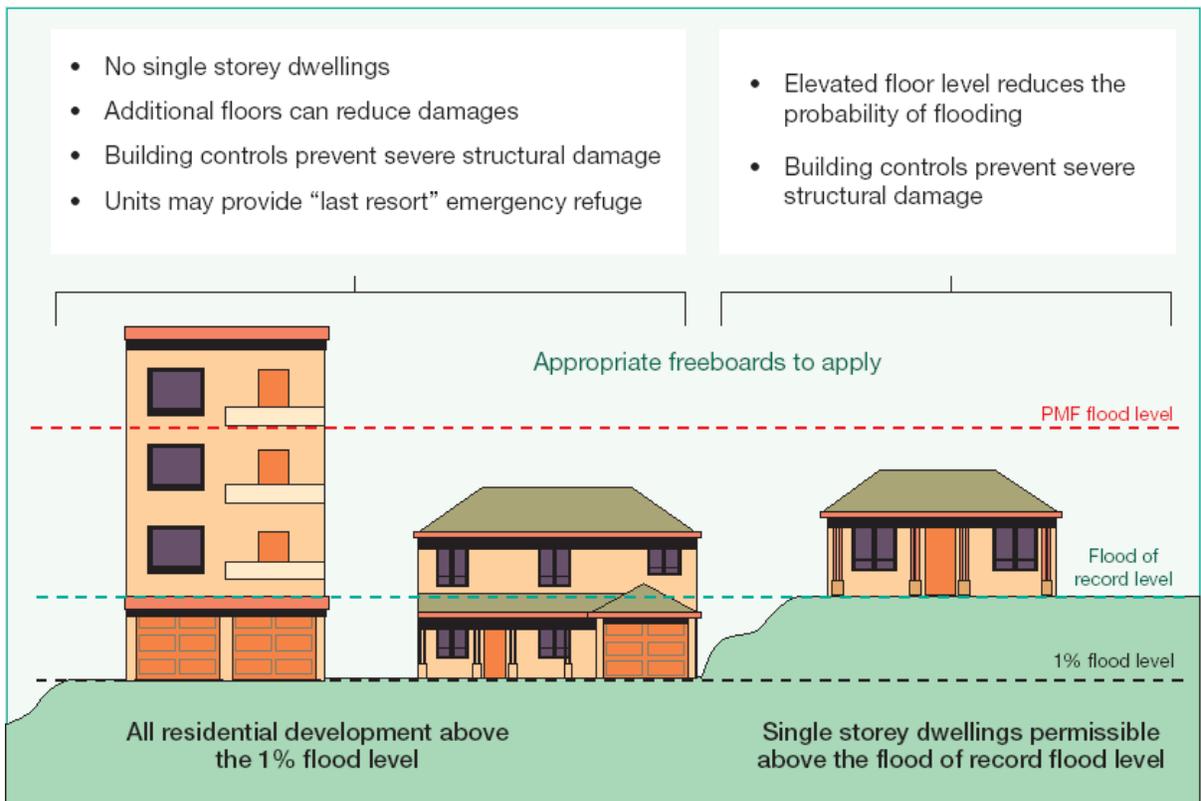


FIGURE 6 – Increased Property Protection through Development Controls
 Source: *Land Use Guidelines*

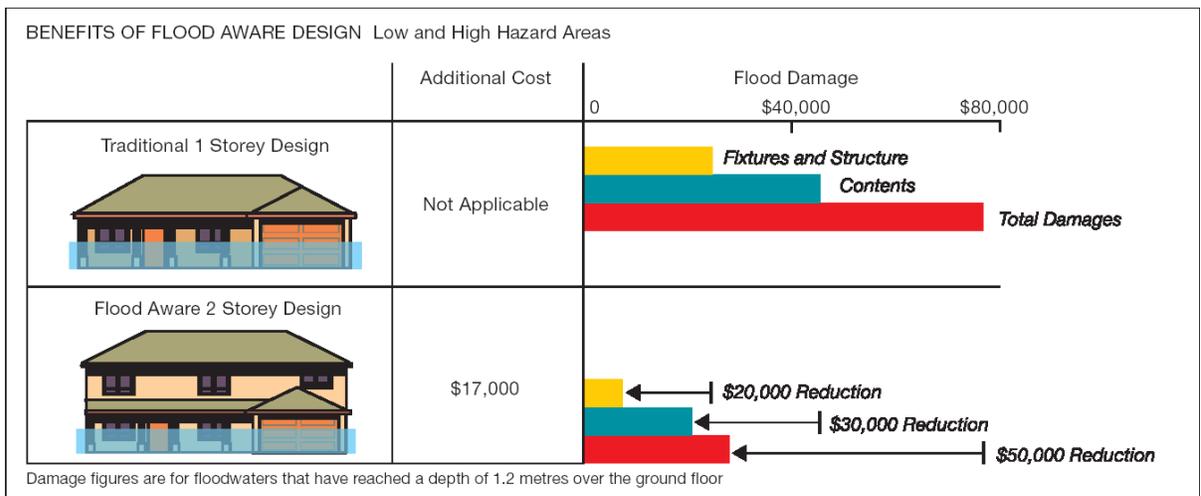


FIGURE 7 – Cost Benefits of Flood Aware Housing Design
 Source: *Building Guidelines*

It could be argued that higher increases in floor levels are appropriate when compared with other floodplains in NSW, given the very significant flood risks in the Hawkesbury. Nevertheless as there was pressure from some sectors to keep the existing FPLs, it was considered that the resultant FPL recommendations provide an appropriate balance.

The '3m below the 100 year flood level' standard was extensively used in the existing planning controls. Translation of this standard was considered useful where needed to provide for the integration of new development in existing areas. However the standard was related to a specific flood (i.e. the 20 year flood) to provide a consistent level of immunity across the floodplain.

A comprehensive assessment of Council's existing planning framework was prepared as discussed above. The relevant flood risk management controls within Council's consolidated DCP were reviewed and revised. The floodplains of the LGA were classified into different flood risk precincts (FRPs) and mapping prepared for incorporation within the DCP. The key recommended planning controls are diagrammatically depicted by **Figures 8 and 9** (with reference to flood levels in the Richmond-Windsor floodplain).

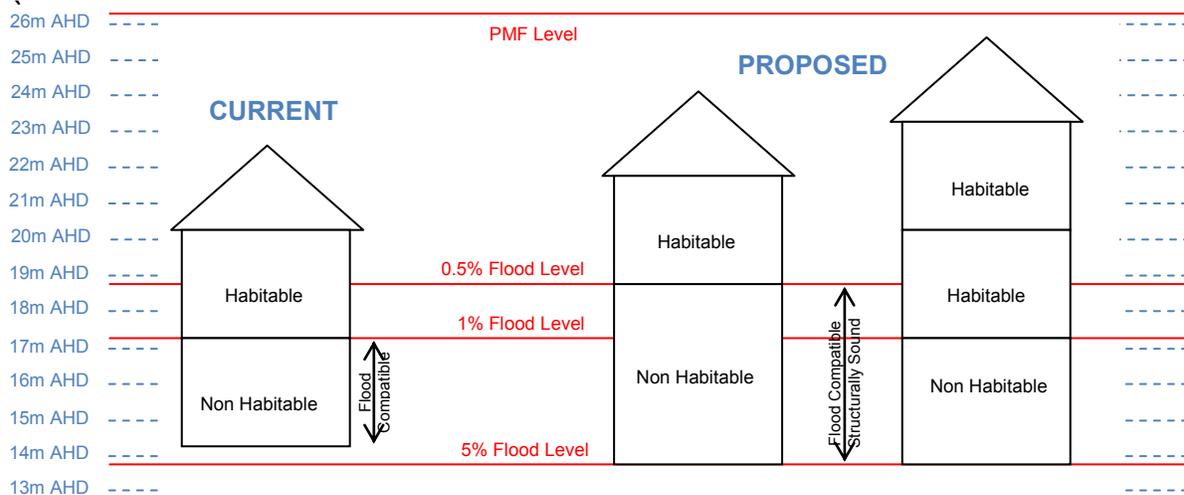


FIGURE 8 – Typical Controls for Residential Development²¹

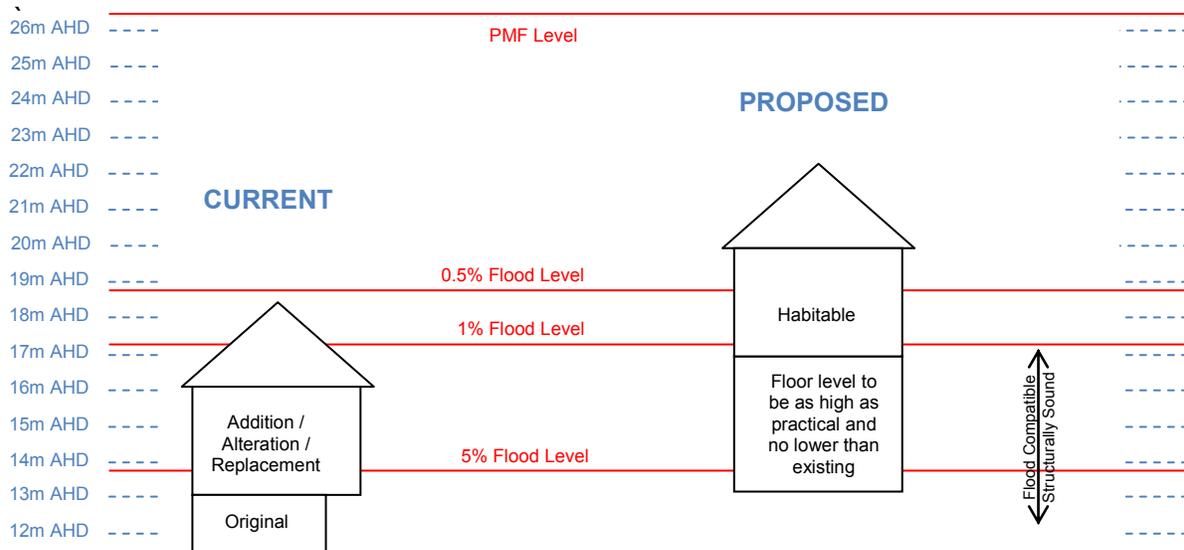


FIGURE 9 – Typical Controls for Concessional Development

A range of other planning related recommendations were made including preparation of mapping to ensure that complying development²² only occurs in areas of the floodplain with 'very low', 'low' and 'medium' flood risks. Recommendations to improve Council's system of Section 149 notations were also prepared.

It is noted that the draft DCP recommended in the FRMP will be subject to separate assessment and public exhibition under the Environmental Planning and Assessment (EPA) Act, before it can be adopted and implemented.

It was also recommended that an 'exceptional circumstances' application should be made to the relevant State Government departments to confirm application of residential controls above the 100 year flood level.

Providing Advice on Evacuation Risks of Future Developments

Arguably the most important outcomes of this study addressed the implications of flood risk management on future development within the LGA. In recent years, Council has had a number of requests to rezone flood prone land to allow additional development. Council has also prepared a Residential Land Strategy that identified potential development areas. In addition there is potential for infill and other development on existing zoned land within the major urban centres of the LGA. As many of the locations where future developments are proposed were identified during the HNFMS as being evacuation constrained, Council has had to seriously assess the potential flood risks before allowing further development either on existing zoned land or as part of future rezonings.

When considering the appropriateness of future development, flood risk constraints are but one of many constraints and other considerations that Council (or other consent authorities) must take account of. In this context therefore it is not appropriate for a FRMS to recommend the planning acceptability of specific developments but rather the study should provide advice to the planning process so that flood risk can be properly considered in the development decision. A four tiered approach to such advice was formulated as provided in **Table 2**.

TABLE 2 – Evacuation Risk Categories (ERCs) to Inform the Planning Process

Class A	Risks are Minor – Limited Consideration is Required
Class B	Risks are Moderate – Detailed Consideration is Required
Class C	Risks are Serious – Very Detailed Consideration is Required
Class D	Risks are Intolerable/Unacceptable – Development Should Not Proceed

In determining which class of evacuation risk advice should be provided to the planning process, a number of factors were considered including the results of evacuation capability assessments (**ECAs**), the availability of refuges (with or without support facilities), the topography of the land and the proposed land-use.

Community Refuges

There are a number of low flood islands scattered throughout the study area that present significant safety risks in the event of major or extreme flooding. The largest urban flood island exposed to frequent flooding is McGraths Hill with its population of about 2,500 people which becomes isolated in a 20 year ARI event and is overwhelmed in a 100 year ARI event.

There is a much greater population at risk on the other urban flood islands within the study area however most of these become inundated in much rarer flood events. These include Windsor which becomes isolated at the 100 year ARI flood level (when the Jim Anderson bridge access is cut) and overwhelmed in a PMF.

The NSW SES has confirmed that they will take every possible action to ensure the populations of all flood islands are evacuated. Nevertheless despite the diligent efforts of the NSW SES, there is a very real possibility that significant numbers of people will remain on flood islands as a result of their unwillingness to leave, their inability to evacuate before egress routes become cut by floodwater, meteorological uncertainty in forecasting the flood or for other reasons. The provision of elevated building floor levels located above the reach of floodwaters on the higher portions of flood islands, would provide locations where trapped people could take refuge. While such facilities might not necessarily provide comfortable conditions for the occupants until such time as they were rescued, they could serve as an option of last resort to avert many deaths by drowning.

It needs to be recognised that the frequency of the flood events when such refuges might be used, is rare or very rare. Whilst a refuge within McGraths Hill might be used every 50 years on average, the refuges on the higher parts of Richmond and Windsor would be vital less often than once every 1000 years on average. Consequently buildings purpose-built solely to service this refuge requirement, may be an unnecessary impost on the community. Rather refuges could be provided within public or private buildings such as schools, government offices, gymnasiums, etc, as an ancillary use to the main function of the building.

It was the recommendation of the FRMS&P that Council and the State Government condition future development approvals to ensure that safe refuges be constructed on the higher points of the major flood islands within Windsor, Bligh Park, Richmond and McGraths Hill. If evacuation south along Llandilo Road becomes excessively congested, there is also opportunity for evacuees to take temporary refuge within a new facility on higher ground in the Windsor Downs area until the road congestion clears.

Summary and Conclusions

- (a) The recent preparation and adoption of the Hawkesbury FRMP is a testament to the wisdom of the flood risk management process within the NSW Floodplain Development Manual and its merit-based approach.
- (b) Given that the Valley has one of Australia's most significant flood risk exposures, it has not been unexpected that planning controls which vary from the 'default' 100 year ARI flood plus 0.5m freeboard have been recommended for adoption.

- (c) Flood risk mapping derived from consideration of the full spectrum of possible floods has been prepared which allows implementation of graduated planning controls based on land use type and floods risk exposure.
- (d) The significant evacuation risks within parts of the LGA have been identified. Noting that planning for new release areas and rezonings are based on a range of considerations of which flooding is but one, a system for informing this process of the severity of evacuation risks has been prepared. As many areas within the LGA are evacuation constrained, this advice has and will be useful as Council plans future release areas and considers infill options.
- (e) The FRMS&P have benefited from the excellent preparatory work undertaken as part of the 1997-2004 Hawkesbury-Nepean Floodplain Management Strategy and its subsequent Guidelines that were released in 2006. Few FRMS&Ps across the nation have had the benefit of such a regional strategy and the diligence of the numerous flood risk practitioners who contributed to its preparation.
- (f) The FRMP has been prepared in spite of many competing political pressures and a diverse range of views within the community and Council. The Council's Flood Management Advisory Committee has successfully considered and evaluated these views, due principally to the skilful oversight and direction provided by its Chairman and the personal involvement of the Director of City Planning and Council's Strategic Planning Coordinator.
- (g) Whilst a 200 year flood level standard has been proposed for new residential development, provision has been made for continuation of the 100 year floor level provided two storeys are constructed. This reduces potential damage to the building and provides opportunity to relocating goods to the upper storey in the event of a major flood²³.
- (h) Key components of the FRMP include mapping to limit the application of complying development from areas of the floodplain, support for construction of community refuges, recommendations for preparation of S149 notations and an application for 'exceptional circumstances' under the NSW 2007 Planning Guideline.
- (i) Because of the duplication of processes within the NSW system, the draft planning controls which have emerged from the FRMP following both Committee and community involvement, cannot yet be formally implemented until separate consideration, evaluation and consultation is completed under the EPA Act.

References and End Notes

¹ Bewsher Consulting Pty Ltd, December 2012, *Hawkesbury Floodplain Risk Management Study & Plan*, (3 vols.), prepared for Hawkesbury City Council.

² Field survey of most building floors was unavailable. Estimates of floor levels were obtained using a ground level digital terrain model assuming floors were approximately 0.3m over the ground (at the building). This will result in some over-estimation of floor inundation where buildings are elevated.

³ Results for 5 year, 20 year and 50 year floods are understated because of the limited extent of flood grids; commercial/industrial excludes 'special' uses such as schools, caravan parks and infrastructure.

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- ⁴ Only suburbs with >500 dwellings affected in PMF shown.
- ⁵ Stubbs, R., n.d., 'The Hawkesbury: early settlement'. In *Sydney's North-west Sector: Learning from History?* Accessed from www.hawkesburyhistory.org.au/stubbs/leaning.html 14 January 2011.
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- ⁸ Sydney Morning Herald, Tuesday 25th June 1867, p.2, 'The Floods – Windsor'.
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- ¹⁰ Saynor, M.J. & Erskine, W.D., 1993, 'Characteristics and implications of high-level slackwater deposits in the Fairlight Gorge, Nepean River, Australia', *Australian Journal of Marine and Freshwater Research*, 44(5), 735-747.
- ¹¹ Molino Stewart, September 2012, *Hawkesbury-Nepean Flood Damages Assessment: Final Report*, prepared for Infrastructure NSW.
- ¹² Note damages were previously estimated at nearly \$2 billion by Patterson Britton & Partners Pty Ltd, June 1993, *Towards a New Floodplain Planning Policy*, prepared for HCC.
- ¹³ Molino Stewart, September 2012.
- ¹⁴ HNFMSC (Hawkesbury-Nepean Floodplain Management Steering Committee), October 2004, *Hawkesbury-Nepean Floodplain Management Strategy Implementation*, HNFMSC, Parramatta.
- ¹⁵ HNFMSC (Hawkesbury-Nepean Floodplain Management Steering Committee), June 2006, *Designing Safer Subdivisions: Guidance in Subdivision Design in Flood Prone Areas*, HNFMSC, Parramatta.
- ¹⁶ HNFMSC (Hawkesbury-Nepean Floodplain Management Steering Committee), June 2006, *Reducing Vulnerability of Buildings to Flood Damage: Guidelines on Building in Flood Prone Areas*, HNFMSC, Parramatta.
- ¹⁷ HNFMSC (Hawkesbury-Nepean Floodplain Management Steering Committee), June 2006, *Managing Flood Risk through Planning Opportunities: Guidance on Land Use Planning in Flood Prone Areas*, HNFMSC, Parramatta.
- ¹⁸ *Land Use Guidelines*, pp.113-136.
- ¹⁹ Grech Planners, July 2012. *Hawkesbury Floodplain Risk Management Study & Plan - Volume 2: Planning Issues*. Report of Hawkesbury City Council's Floodplain Management Committee, prepared for Bewsher Consulting. Pp.19-22.
- ²⁰ Bewsher, D. & Grech, P., 2009, *Flood Risk Mapping — What, Why, How?* FMA Conference 2009.
- ²¹ The height of the buildings under proposed controls (as shown in Figures 8 and 9) could be moderated with the use of attic style upper levels if dictated by amenity considerations.
- ²² Complying development is a type of development within the NSW planning system which does not require a full development application. It must be issued a complying development certificate by Council or a private certifier subject to satisfying basic parameters.
- ²³ *Building Guidelines*, pp.48-50.