LISMORE FLOODPLAIN RISK MANAGEMENT PLAN 2014

GLOSSARY AND APPENDICES

lismore
city council

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GLOSSARY

Australian Height Datum (AHD)	a common national surface level datum approximately corresponding to mean sea level.
Annual exceedance probability (AEP)	the chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage, for example, if a peak flood discharge of 500m^3/s has an AEP of 5%, it means that there is a 5% chance (ie 1 in 20 chance) of a 500m^3/s or larger events occurring in any one year (see ARI).
Average Recurrence Interval (ARI)	the long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
Catchment	the land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Development	is defined in Part 4 of the *Environmental Planning and Assessment Act 1979 (EP&A Act).* Infill development refers to the development of vacant blocks of land that are generally surrounded by developed properties. Conditions such as minimum floor levels may be imposed on infill development. New development refers to development of previously undeveloped land, for example, the urban subdivision of an area previously used for rural purposes. Redevelopment: refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale.
Disaster plan (DISPLAN)	a step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
Flood	relatively high stream flow which 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 compatible materials	materials used in building construction that can withstand inundation without suffering any form of damage and which can be readily cleaned when floodwaters subside.
Flood liable land	is synonymous with flood prone land (ie) land susceptible to flooding by the probable maximum flood (PMF) event. Note that the term flood liable land now covers the whole of the floodplain, not just that part below the flood planning level (FPL). (See flood planning area).
Floodplain	area of land that is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
Flood planning area	the area of land below the FPL and thus subject to flood related development controls. The concept of flood planning area generally supersedes the 'flood liable land' concept in the 1986 Manual.
Flood planning levels (FPLs)	are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.
Flood storage areas	those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
Freeboard	a factor of safety typically used in relation to the setting of floor levels, levee crest levels etc. It is usually expressed as the difference in height between the adopted flood planning level and the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as 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.
Probable maximum flood (PMF)	the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain.

Reduced Level (RL)	refers to the height of a point above the Datum Surface. RL refers to reducing (or equating) levels (elevations) to a common datum, which is either a real or imaginary location with a nominated elevation of zero. The most common convenient datum was mean sea level. On small surveys that require the collection of elevation data the datum can be assumed and for practical purposes it simply needs to be far enough below the survey area to avoid negative numbers, thus the starting point of a survey might be nominated to be RL 100.00
Risk	chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

APPENDIX 1: BACKGROUND DOCUMENTS

The following documents were referred to in the preparation of the Lismore Floodplain Risk Management Plan 2013:

- *Lismore Floodplain Management Plan 2002,* Lismore City Council
- *Lismore Floodplain Management Plan, Issue No. 1*, Patterson Britton & Partners, November 2000
- *Floodplain Development Manual,* New South Wales Government, 2005
- Various Flood Modelling reports prepared by Worley Parsons 2007-2010
- *Lismore Local Environmental Plan 2000*, Lismore City Council, 2000
- *Lismore Development Control, Chapter 8 - Flood Prone Lands*, Lismore City Council
- *Draft Lismore Local Environmental Plan 2010,* Lismore City Council
- *Lismore Local Environmental Study 2010*, Lismore City Council
- *Peer Review – Lismore Floodplain Risk Management Plan 2011,* GeoLINK 2011

APPENDIX 2: FLOOD BEHAVIOUR AND HISTORY OF FLOOD POLICY IN LISMORE

2. FLOOD HISTORY

A number of factors are responsible for flooding in Lismore. Its latitude and proximity to the coast make it liable to the effects of extreme weather mechanisms, viz tropical cyclones from January to April, and east coast lows from April to July.

The catchment above Lismore is fan-shaped and the valleys and streams are steep providing a relatively quick transfer of rainfall to runoff. The whole of the runoff from the 1,400km^2 catchment squeezes through a narrow section of floodplain at Lismore, which is located at the confluence of Wilsons River and Leycester Creek. The floodplain lies at approximately 9.5m AHD with significantly lower levels near Lismore Park in Central Lismore.

At the confluence, the Leycester Creek floodplain is approximately 2 to 2.5m higher than the upper Wilsons River floodplain. This causes the upper section of the Wilsons River to act as a natural detention basin. During the very early rising stages of a flood it is not uncommon for floodwaters from Leycester Creek to back up into the Wilsons River, and once the storage is filled the flow reverses and discharges into the lower, southerly section of the Wilsons River.

2.1 PEAK FLOOD LEVELS

The graph below shows the history of flood events and peak flood levels in Lismore since 1870 as measured at the Police Station and, from 1955, the rowing club gauge. The rowing club is located at the end of Magellan Street some 500 metres downstream from the junction of Leycester Creek and Wilsons River. Prior to the construction of the CBD flood levee wall in 2005, peak flood levels above 9.0m AHD exceeded the general level of the river banks and caused significant inundation of residential and commercial areas.

The prospects for mitigating the effects of flooding are complicated by the city being centred around the confluence of Leycester Creek and Wilsons River, either of which may dominate in a flood event. The April 1989 flood was an example where a 1 in 100 year ARI flood occurred in Leycester Creek with only a minor flood occurring in the Wilsons River. The combination of floods from these two branches resulted in a peak height of 11.28m AHD (estimated to be a 1 in 20 year ARI flood level at the rowing club gauge).

Observers noted that, in the rising stages of this flood the direction of flow in Wilsons River, upstream of its confluence with Leycester Creek, was in an upstream direction. Flood water initially overtopped the South Lismore levee at Kyogle Road partially due to the railway embankment. There were also reports that the South Lismore levee was overtopped in the vicinity of Snow Street, initially by water from the airport floodway.

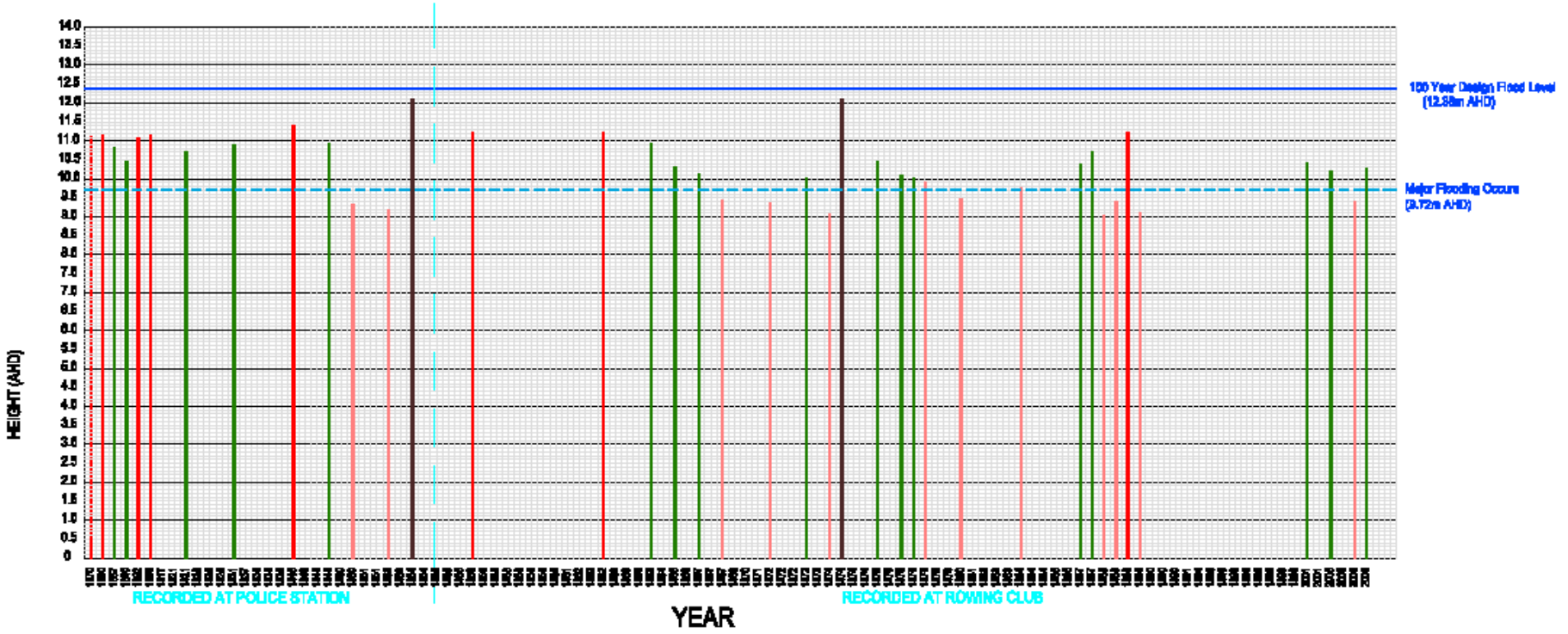
The highest recorded floods of 1954 and 1974 occurred from cyclonic rains. In the case of the 1974 flood, cyclone ‘Zoe’ was the cause. The peak water level of these floods at the rowing club gauge was 12.12m AHD. A frequency analysis of peak flood height data at the rowing club gauge indicated that the 1974 flood was a 1 in 70 year ARI flood. The 1 in 100 year peak flood height at the gauge is estimated at 12.4m AHD.

It is significant that Lismore has not experienced a 1 in 100 year flood or rarer, in European history. This is not to say that rarer floods have not occurred. Many coastal valleys in NSW have in recent years experienced floods greater than the predicted 1 in 100 year event.

NOTE: Pre 1955 flood levels were recorded at police station,
Post 1955 flood levels were recorded at rowing club gauge

HISTORY OF FLOOD EVENTS 1870 - 2009

FOR EVENTS HIGHER THAN 9.0M AHD



LEGEND

AHD HEIGHT OF FLOOD EVENT

- 9m to 10m
- 10m to 11m
- 11m to 12m
- 12m to 13m

LISMORE CITY COUNCIL
HISTORY OF FLOOD EVENTS
1870 TO 2009 - BAR GRAPH
1
1
CP2835

2.2 SIGNIFICANCE OF LEVELS

Figure A shows the significance of flood levels in Lismore as measured at the rowing club guage. The highest flood levels reached in recent times were:

- 12.09m AHD in February 1954,
- 12.12m AHD in March 1974,
- 11.28m AHD in April 1989,
- 10.42m AHD in February 2001,
- 10.2m AHD in June 2005, and
- 10.4m AHD in May 2009.

Figure A: Representation of flood levels at Lismore

Rowing Club Gauge AHD (m)	**Comments**
16.0	Probable maximum flood level for PMF (WBM 1998), which notionally represents 1 in 100,000 year ARI flood.
13.4	Probable maximum flood level for 1 in 500 year ARI flood.
12.4	Probable maximum flood level for 1 in 100 year ARI flood.
12.12	Level reached by 1974 and 1954 floods, the highest last century.
11.4	Probable maximum flood level for 1 in 20 year ARI flood.
10.9	Probable maximum flood level for 1 in 10 year ARI flood South Lismore levee overtopped and South Lismore flooded.
7.2	Low lying areas of North Lismore.
5.2	State Emergency Services “Danger Height” i.e. the height at which land holders in the vicinity are alerted.

Appendix 3 contains details of the range of design flood events.

2.3 FLOOD POLICY IN LISMORE

2.3.1 History of Flood Policy

Arising from repeated flooding in the 1940s, the Richmond River Flood Management Inter-Departmental Committee (IDC) was inaugurated in 1948. The terms of reference for that Committee were primarily to identify structural works that would alleviate/mitigate the severity and damage from flooding.

The IDC report, published in 1954, advocated a valley wide program of works, comprising mainly minor levees, drains and diversion channels.

The Richmond River County Council (RRCC) was established in 1960 to oversee the program. Improvements in Lismore were restricted to the South Lismore Flood Levee and the Brown Creek pump station and floodgate, which represented approximately 7% of the total works program at the time. The IDC rejected the notion of major structural works in Lismore on the basis that such works were not cost effective.

After the disastrous flood of 1954 (equal highest on record), Lismore City Council (LCC) recognised the risk to life associated with the depths and velocities of major floods and initiated a programme of voluntary acquisition of houses located in the more hazardous areas of the floodplain. The acquisitions were entirely funded by Council until 1978 when a subsidised Voluntary House Purchase Scheme *(*VHPS*)* was set up. This subsidy scheme is based on the costs being shared between the State Government (2/3) and Council (1/3) (refer to Section 3.5 of the FRMP).

As well as house acquisition, Council has supported the raising of houses in hazardous areas when approached by the owner (refer to Section 3.6 of the FRMP).

Another disastrous flood in 1974 (equal highest on record*)* rekindled community concern for flood protection measures for Lismore. After strong lobbying by the RRCC, the State Government established a second IDC with broad terms of reference "*to review the overall flood situation*" and recommend "*practical ways in which the flood situation could be improved*".

The RRIDC report *(*1982*)* reaffirmed that valley wide structural works would provide only "minor benefit". It concluded that major structural works were not cost effective and recommended that non-structural measures be pursued to mitigate the impacts of future floods.

These findings were consistent with the findings of the Lismore Floodplain Management Study (SKP, 1980*),* which examined thirteen structural flood mitigation proposals such as levee construction, river straightening and the construction of various dams above Lismore. SKP *(*1980*)* concluded that none of these structural proposals were economical and some proposals would be ineffective or deleterious to the Richmond Valley as a whole.

RRIDC *(*1982*)* concluded that Lismore required a comprehensive floodplain management policy based on a mix of land use and development controls, flood warning systems and evacuation planning and hazard reduction measures such as, "*property acquisition, clearing, flood free subdivisions, relocation assistance ….. and exchange of flood prone land for flood free level as well as flood proofing. A priority order to be established for application of the scheme to problem areas*".

Lismore's Flood Policies evolved from the foregoing major studies through a series of Council and Public Works Department (PWD) policy investigations into flood mitigation strategies and options:

- PWD 1983, *Lismore Floodplain Management Advice to Council*

- Lismore City Council 1983, *Pilot Study Flood Prone Land* and
- PWD 1984, *Lismore Flood Hazard Areas*.

The results of these studies culminated in the preparation of Development Control Plan No. 7 (DCP), which came into effect on 9 September 1985. The Lismore Local Environmental Plan (LEP) 1992 was gazetted on 27 March, 1992. The LEP defined permissible and non-permissible land uses on land zoned as flood prone and tightened the development controls in DCP 7. These provisions were carried over into the Lismore LEP 2000.

2.3.2 Lismore Levee Scheme

The investigation for an appropriate flood mitigation system to reduce the impacts of flooding in the Lismore floodplain examined a wide variety of options, including levees, diversion channels and improvements, river dredging, catchment improvement and retarding basins. The larger structural mitigation measures were found to be uneconomical, impractical and socially unacceptable.

After considerable public involvement, Council adopted the Lismore 1 in 10 Levee Scheme in 1996, which protects the Central Lismore area against floods up to the 1 in 10 year ARI. The Scheme also relocated 1.7kms of the South Lismore levee, originally constructed in 1975, to improve the flow capacity of the Lismore Airport floodway.

The construction of the levee was completed in the 2005 calendar year. The final construction costs associated with all works, including house raising, were approximately $20 million. Reference should be made to the LFMP 2002 for further detail on the levee scheme.

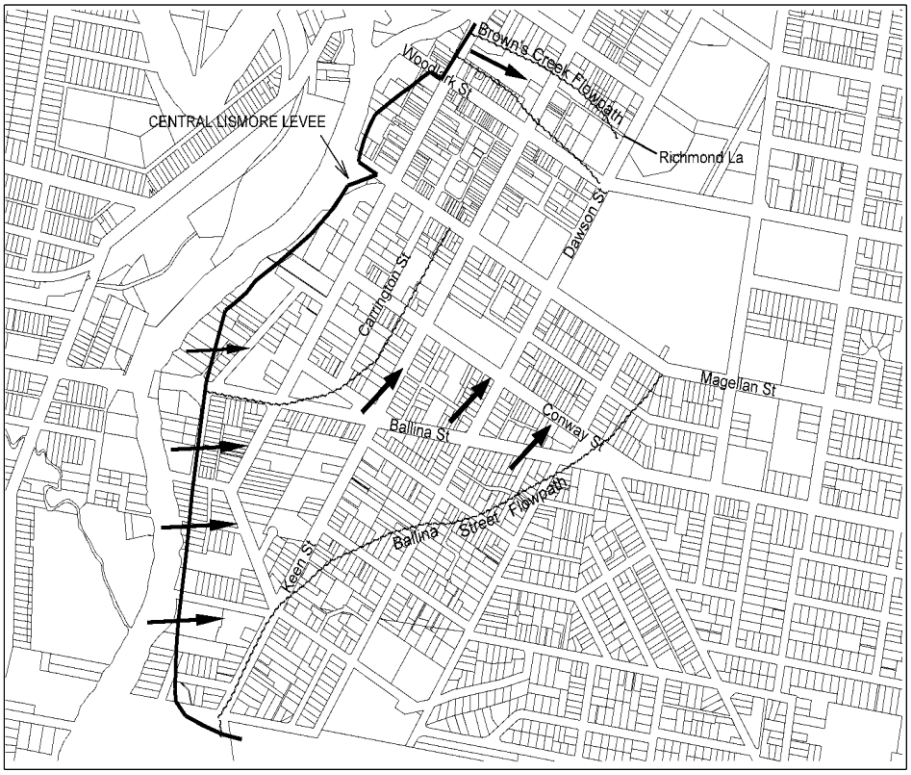
In 2005, 2007 and 2009 the levee has protected the Central Lismore area from flooding. Apart from reducing the frequency of nuisance flooding the levee provides a benefit in allowing greater time before the closure of Central Lismore evacuation routes. Therefore, the foreshadowed benefits of the levee have been realised.

Figure B on the next page shows how the floodwaters behave in the rising stage after the levee wall overtops. At the same time as the river is rising, runoff from the local catchment is filling the central basin. When the levee wall overtops, fast flowing floodwaters from the river will enter the basin via the Clyde Campbell car park (reference point 1). A second flow path (reference point 2) initially conveys floodwater from the south, across Ballina Road and Dawson Street into the central basin. The level at which the levee will overtop at Browns Creek will vary (between 10.6m and 10.95m according to the Rowing Club gauge) and is dependent on the river gradient. Floodwaters in the basin will exit through Browns Creek and Gasworks Creek once the river begins to recede.

North Lismore is not protected by the Lismore Levee Scheme due to the higher personal risks identified as likely in an overtopping flood event.

Reference can be made to the Lismore Levee Operations and Maintenance Manual for further details on the floodgates and pumps.

Figure B: Flowpaths into Central Lismore



2.3.3 Current Lismore Flood Policy

The Lismore Floodplain Management Plan 2002 outlines the current flood policy for Lismore. It comprises measures that address:

- existing and future land use and development on the floodplain, including the Voluntary House Purchase and Voluntary House Raising Schemes;
- flood response, including the warning and evacuation systems, and community awareness and education;
- flood mitigation measures, including the Lismore Levee Scheme.

The adoption of the LFMP 2002 led to amendments to the Lismore LEP 2000 and Development Control Plan 7 (now chapter 8 of the Lismore DCP). The LEP defines permissible and non-permissible land uses on flood prone land and includes development controls that allow the suitability of a land use or development to be assessed in accordance with the level of flood hazard. The LEP also places an onus on Council to consider risk to life and the need for evacuation of persons.

APPENDIX 3: DESIGN FLOOD EVENTS

3. FLOOD PROBABILITIES

3.1 AVERAGE RECURRENCE INTERVAL (ARI)

Two terms are commonly adopted for use when describing flood probabilities. They are 'average recurrence interval' (ARI) and 'annual exceedance probability' (AEP). A flood the size of the 1 in 20 year ARI flood or larger is expected to occur on average once every 20 years. This can similarly be described as a 5% AEP flood (means there is a 5% chance that a flood equal to or larger could occur in any one year).

The use of the term 'recurrence interval' has been criticised as leading to confusion because it can be interpreted as meaning that a flood of a certain magnitude will only occur at regular intervals (e.g. every 20 years). For this reason the word 'average' has been added to help minimise the misconception of a fixed interval. In other words, the 1 in 20 year ARI flood could occur this year and also again next year, but over the long term it is expected that a flood of this magnitude or larger would occur on average every 20 years (e.g. five times in a century).

The Floodplain Management Committee has adopted the ARI as the preferred term to describe flood probability. It is important to note that ARI floods are design floods, not actual floods. They are computer generated floods based on analysis of historical data, and may therefore change as time progresses and more data is collected.

3.2 1 IN 10 ARI FLOOD

Details of flood depths, average velocities and hazard factors at the peak of a 1 in 10 ARI flood, are given in **Table 1.**

North Lismore

- Flood water levels range from 11.1m AHD east of the railway to 11.5m AHD west of the railway.
- Overland flood depths are approximately 0.7m east of the railway and vary between 0.6m and 1.1m west of the railway
- Overland flow velocities are negligible to the east of the railway and 0.4m/s to the west.

South Lismore

- Water levels range from 9.4m AHD south of the Aerodrome to 12.1m AHD at the northern end of the STP wetlands. There is no flooding within the existing levee system.
- Outside of the levees, water depths vary from 0.4m south of the Aerodrome, to 0.7m immediately east of the STP wetlands and 0.2m immediately north. There is no flooding inside the existing levees.
- Flow velocities range from 0.8m/s at the STP wetlands to 0.2m/s south of the Aerodrome. Along the banks of Leycester Creek, velocities are about 2m/s.

Table 1: Peak of 1 in 10 ARI Flood – Depths, Velocities and Hazard Factors

General Location	Water Depth (m)	Velocity (m/s)	Hazard Factor (velocity x depth)
NORTH LISMORE			
East of Railway	0.7	0.0	0.0
West of Railway-Tweed St	1.1	0.4	0.5
SOUTH LISMORE			
Nesbitt Park	0.0	0.4	0.0

Casino St West of Hanlon St	0.0	1.1	0.0
Crown St at Newbridge St	0.0	0.0	0.0
Three Chain Rd East of Levee	0.0	0.0	0.0

Source: WBM (1999)

3.3 1 IN 20 ARI FLOOD

Details of flood depths, average velocities and hazard factors at the peak of a 1 in 20 ARI flood, are given in **Table 2.**

North Lismore

- Peak flood levels range from 12m AHD west of the junction of Wilson and Terania Streets to 11.5mAHD near the Greyhound Track at Colemans Point.
- Overland flow involves flood depths between 1.1m east of the railway and 1.5m west of the railway.
- Average velocities at the peak of the flood vary between negligible east of the railway to 0.5m/s to the west.
- During the rising phase of the flood, velocities *(at peak discharge)* vary around 0.5m/sec reaching approx. 1.5m/sec across Terania St and Wotherspoon St (SKM, 1995).
- Rates of rise in North Lismore are a little less than 1 m/hr.

South Lismore

- Flood levels across South Lismore range between 9.8m AHD south of the aerodrome and 12.7m north of the STP wetlands.
- Inside the levee system, flood levels range between 10.9m AHD at the southern end of Crown St and 11.7m AHD in the north west.
- Velocities within the levee reach up to approximately 1.5m/s in the north west and 0.6m/s south of three chain road.
- In South Lismore, rising phase velocities vary from 0.4m/s north of the railway to generally 0.2m/s south of the railway and 0.9m/s crossing the Bruxner Highway (SKM, 1995).
- South Lismore has rates of rise up to 1.5 m/hr.

Central Lismore

- Flood levels are approximately 11.3m AHD at the floodpath near Browns Creek and around 11.0m AHD at the floodpath close to Gas Works Creek.
- In the CBD area, flood depths exceed 2.3m.
- Velocities through the CBD vary from 0.3m/s to 1.4m/s.
- During the rising stage, fast flowing floodwaters enter the basin via the Browns Creek carpark. In the 1987 flood, high velocities caused scouring at Council's Dawson St carpark.
- A second flowpath initially conveys floodwater from the south, across Ballina and Dawson Streets into the central basin in the filling stage.
- Both flood depth and extent increase within the basin.
- Once the basin is filled floodwater flows through the basin exiting along Gas Works Creek Ballina Street flowpath.
- Velocities through the CBD range from 0.3m/s to more than 3.5m/s during the rising phase *(SKM, 1995)*.
- Central Lismore has rates of rise of the order of 0.6m.hr

Table 2: Peak of 1 in 20 ARI Flood – Depths, Velocities and Hazard Factors

General Location	Water Depth (m)	Velocity (m/s)	Hazard Factor (velocity x depth)
NORTH LISMORE			
East of Railway	1.1	0.1	0.1
West of Railway-Tweed St	1.5	0.5	0.8
SOUTH LISMORE			
Nesbitt Park	0.1	1.2	0.1
Casino St West of Hanlon St	0.2	1.5	0.3
Crown St at Newbridge St	0.9	0.6	0.5
Three Chain Rd East of Levee	0.8	0.6	0.5
CENTRAL LISMORE			
Molesworth St between Woodlark St and Magellan St	2.3	1.4	3.3
Ballina St at Victoria St	1.1	0.2	0.2
Dawson St at Conway St	1.3	-	-

Source: WBM (1999)

3.4 1 IN 100 ARI FLOOD

Details of flood depths, average velocities and hazard factors at the peak of a 1 in 100 ARI flood are given in **Table 3.**

North Lismore

- Water levels are fairly constant varying between 12.5m and 12.7m AHD.
- Overland velocities vary from 0.1m/s east of the railway to 1.0m/s to the west.
- In river velocities vary from 1.3m/s in Wilsons River to 2.2m/s in Leycester Creek, upstream of the junction of the two.
- Overland flow depths range from 2.2m east of the railway to 2.6m to the west.
- Rising phase velocities vary from 1.2m/s along Crane St to 0.7m/s across Terania St (SKM, 1995).
- Rates of rise in North Lismore are 0.5m/hr.

South Lismore

- Flood levels range from 11.3m AHD south of the Aerodrome to 13.0m AHD at the northern end of STP wetlands.
- South Lismore is isolated. Inside the levee, water levels range from a minimum of 12.3m to a maximum of 12.9m AHD.
- Depths range from 1.2m – 1.6m north of the railway to around 2.3m near Hollingsworth Creek, to 2.3m where Three Chain Road crosses the levee.
- Inside the levee, overland flow velocities differ locally, ranging between 2.2 m/s north of railway to 0.7m/s at the southern end of the levee.
- Velocities are reasonably uniform outside of the levee at approximately 0.5m/s.
- Rising phase velocities within the levee vary around 0.5m/s, north and south of the railway line (SKM, 1995).
- High velocities are expected crossing the levee at Three Chain Road *(1.2m/s)* and crossing Bruxner Highway *(2.2m/s)* (SKM, 1995).
- Rates of rise in South Lismore approach 1m/hr.

Central Lismore

- Central Lismore is flooded to between 12.3m AHD and 12.4 m AHD.
- The floodway at Browns Creek leading into the basin has a width of approximately 100m, the flood path crossing Ballina St conveying water out of the basin back into Wilsons River is approximately 600m wide – see **Figure B in Appendix 2**.
- Rising phase velocities through the CBD range from 0.4m/s to 4.5m/s (SKM, 1995).
- In Central Lismore, near Magellan St at Dawson St, flood levels rise at a maximum rate of up to 1.4m/hr.

Table 3: Peak of 1 in 100 ARI Flood – Depths, Velocities and Hazard Factors

General Location	Water Depth (m)	Velocity (m/s)	Hazard Factor (velocity x depth)
NORTH LISMORE			
East of Railway	2.1	0.1	0.2
West of Railway-Tweed St	2.6	1.0	2.0
SOUTH LISMORE			
Nesbitt Park	1.5	2.1	2.9
Casino St West of Hanlon St	1.4	2.2	3.2
Crown St at Newbridge St	2.3	1.5	3.5
Three Chain Rd East of Levee	2.3	0.7	1.6
CENTRAL LISMORE			
Molesworth St between Woodlark St and Magellan St	3.4	1.3	4.4
Ballina St at Victoria St	2.3	0.3	0.7
Dawson St at Conway St	2.4	-	-

Source: WBM (1999)

3.5 PROBABLE MAXIMUM FLOOD (PMF)

The Probable Maximum Flood or PMF is a theoretical flood derived from the maximum amount of precipitation the atmosphere could deliver to a catchment taking into account climatic systems appropriate to the region and local topography *(ie orographic effects)*. The probability of occurrence of a PMF is a notional concept and is generally considered to be 1 in 100,000 years.

Improvements in extreme climate data analysis and advances in the science of meteorology have led to an upward progression in the parameters used to calculate PMF rainfall. As a consequence, each generation of PMF estimates lead to increased estimates of the level of the PMF flood.

The current estimate of the PMF flood level is 16.0m AHD (SKM, 1998). Any PMF estimate is likely to be an underestimate. In the future as more is known about the meteorology of extreme events, PMF estimates are likely to be increased.

APPENDIX 4: DEVELOPMENT CONTROLS IN THE FLOOD RISK PRECINCTS

This Appendix summarise the development controls that are proposed to apply to development that is permissible in the Flood Risk Precinct areas. These are generally consistent with the existing Chapter 8 of the Lismore Development Control. However, amendments to Chapter 8 will be necessary to reflect changes to the description of the risk precincts in particular.

Flood Planning Level is defined as the level of a 1 in 100 ARI flood event plus 0.5m freeboard. For 1 in 500 year ARI flood levels ADD 1.03m to the 1 in 100 year ARI flood level.

4.1 FLOODWAY PRECINCT

In the Floodway Precinct, no new buildings or structures, will be permitted except:

1. Where such buildings or structures are to be used for the purpose of providing utility installations or small scale facilities associated with recreation space, such as amenities; or
2. Minor or ancillary development, such as small sheds, associated with an existing approved development (as at the date of adoption of the FRMP), subject to the development not adversely affecting flood behaviour or increasing flood impacts on adjoining buildings or properties; or
3. Replacement dwellings where a hydraulic study has been carried out that demonstrates that: (i) the flood impacts of the proposed building will not adversely affect flood behaviour or increase the flooding impact on any other land; (ii) habitable floors are at or above the Flood Planning Level; and (iii) the building is structurally adequate.
4. Where the building or structure is to be located within 10 metres of the boundary of the Floodway Precinct and a hydraulic study has been carried out for the land on which the building is proposed which demonstrates that the flood impacts of the proposed building or structure and any associated works will not adversely affect flood behaviour or increase the flooding impacts on adjoining land; or
3. Where the building or structure is located on land that forms part of the Lismore Airport and
    a) will form part of the commercial aviation area developed in the northern precinct of the airport and such development is consistent with the adopted plan of management for the Lismore Airport and maintains the cross sectional integrity of the respective floodway; or
    b) is development of a non-residential nature, located on the western side of the Bruxner Highway between Habib Drive and the Lismore Airport passenger terminal, that has been developed consistent with the concept plan for the development of airport land, as shown in Chapter 8 of the Lismore Development Control Plan and an evacuation plan has been prepared for each development. The area closest to the airport terminal is to be developed for uses that are ancillary to the airport only.

4.2 HIGH FLOOD RISK AND FLOOD ISOLATED (EVACUATION) PRECINCTS

4.2.1 Residential

- No new residential development unless it is the replacement of a dwelling or is a dwelling relocated from another site within the High Risk Precinct and no new dwellings will result.
- For extensions or additions to existing residential development – all habitable floor areas to be at or above the flood planning level, except where in the opinion of Council such a floor level requirement is impractical or unreasonable. As a general guide, extensions with a floor area greater than 25m^2 will be required to be at or above the flood planning level.

- For the replacement of existing residential development, all habitable floor areas to be at or above the flood planning level.
- New motels, and other forms of development providing temporary accommodation only, permitted where a minimum of 90% of the habitable floor area is at or above the flood planning level and a flood evacuation plan is approved for the development.
- No new caravan parks permitted.

4.2.2 Commercial

All new commercial development to provide:

- Equivalent of 25% of gross floor area to be at or above the Flood Planning Level
- A mezzanine level (with emergency exit for evacuation purposes) above the 1 in 500 ARI flood level as an emergency flood refuge for employees.
- Bulk fill to within 300mm of finished surfaced level is to be sourced from on-site, from the preferred excavation area or from another area on the floodplain. Minor increases in the depth of imported fill will be considered where it can be demonstrated that this is necessary to complement the design of the footings of a future building. If bulk fill cannot be obtained from these sources, imported fill may be approved by Council subject to a flood impact assessment that demonstrates no adverse effects on flood levels upstream or flood behaviour on adjacent properties.
- A risk analysis report is to be prepared by a structural engineer addressing the design criteria adopted for the building and its relative merits in the 1 in 500 ARI flood event.

4.2.3 Industrial - South Lismore (South of Hollingsworth Creek)

- Minimum floor level to be at or above the Flood Planning Level is preferred.
- All new buildings to provide a mezzanine level (with emergency exit for evacuation purposes) above the 1 in 500 ARI flood level as an emergency flood refuge for employees.
- All lots to be filled to the 1 in 100 ARI flood level, subject to maintaining existing flood flow paths.
- For infill development in existing industrial areas, Council prefers that lots be filled to a level equivalent to the 1 in 100yr ARI flood level but will consider on its merits a fill level equivalent to that of surrounding lots or in accordance with any previous Council consent for filling. Where buildings are constructed on land that has not been filled to the 1 in 100 yr ARI flood level, an equivalent of at least 10% of gross floor area is to be at or above Flood Planning Level and those parts of the building below the 1 in 100 yr ARI flood level are to be constructed of flood compatible materials. Grading of site fill to street and/or to adjoining property boundary levels will be permitted where appropriate.
- All bulk fill to within 300mm of finished surfaced level to be sourced from on-site, from the preferred excavation areas or from another area on the floodplain. If bulk fill cannot be obtained from these sources, imported fill may be approved by Council subject to a flood impact assessment that demonstrates no adverse effects on flood levels upstream or flood behaviour on adjacent properties.
- A risk analysis report is to be prepared by a structural engineer addressing the design criteria adopted for the building and its relative merits in the 1 in 500 ARI flood event.

4.2.4 Industrial - All other areas

- Equivalent of 25% of gross floor area to be at or above the 1in 100 year ARI flood level.
- All new buildings to provide a mezzanine level (with emergency exit for evacuation purposes) above the 1 in 500 yr ARI flood level as an emergency flood refuge for employees.
- All bulk fill to within 300mm of finished surfaced level to be sourced from on-site, from the preferred excavation areas or from another area on the floodplain. Minor increases in the depth of imported fill will be considered where it can be demonstrated that it is necessary to

complement the design of the footings of a future building. If bulk fill cannot be obtained from these sources imported fill may be approved by Council, subject to a flood impact assessment that demonstrates no adverse effects on flood levels upstream or flood behaviour on adjacent properties.

- A risk analysis report is to be prepared by a structural engineer addressing the design criteria adopted for the building and its relative merits in the 1 in 500 year ARI flood event.

4.2.5 Controls Applying To All Development

- Where a minimum floor level is specified, a certificate from a registered surveyor will be required certifying that the floor has been constructed to the required level.
- All applications are to be accompanied by a certificate of structural adequacy prepared by a qualified structural/civil engineer stating that the building has been designed to withstand structural damage from the forces of floodwaters and associated debris.
- For non-habitable floors constructed below the Flood Planning Level, the applicant will be required to demonstrate that:

  a) the new structure will not have an adverse affect upon the existing flow of floodwaters, and
  b) that all materials used below the Flood Planning Level are flood compatible.

4.3 MEDIUM RISK PRECINCT, CBD FLOOD LIABLE, EAST LISMORE FLOOD LIABLE AND SOUTH LISMORE FLOOD ISOLATION

4.3.1 Residential

- Permit site filling to the equivalent of the Flood Planning Level provided material is sourced from the preferred excavation area or on-site. If fill cannot be obtained from the preferred excavation area, imported fill may be approved by Council subject to a flood impact assessment that demonstrates no adverse effects on flood levels upstream or flood behaviour on adjacent properties.
- Habitable floor areas for new residential development to be at or above the flood planning level.
- New motels permitted where a minimum of 90% of the habitable floor area is above the Flood Planning Level and a flood evacuation plan is approved for the development.

4.3.2 Commercial

All new commercial development to have:

- Equivalent of 25% of gross floor area to be at or above the Flood Planning Level
- A risk analysis report prepared by a structural engineer certifying that the design criteria adopted for the building will withstand the impact of flood waters and debris up to the 1 in 500 ARI flood event. Such report to be submitted with the Construction Certificate.
- Bulk fill to within 300mm of finished surfaced level to be sourced from on-site, from the preferred excavation areas or from another area on the floodplain. If bulk fill cannot be obtained from these sources, imported fill may be approved by Council subject to a flood impact assessment that demonstrates no adverse effects on flood levels upstream or flood behaviour on adjacent properties.

4.3.3 Industrial - South Lismore (South of Hollingsworth Creek)

- Minimum floor level at or above the Flood Planning Level.
- All new buildings to provide a mezzanine level (with emergency exit for evacuation purposes) above the 1 in 500 ARI flood level as an emergency flood refuge for employees.

- Lots to be filled to the 1 in 100yr ARI flood level, subject to maintaining existing flood flow paths.
- For infill development in existing industrial areas, Council prefers that lots be filled to a level equivalent to the 1 in 100yr ARI flood level but will consider on its merits a fill level equivalent to that of surrounding lots or in accordance with any previous Council consent for filling. Where buildings are constructed on land that has not been filled to the 1 in 100 yr ARI flood level, an equivalent of at least 10% of gross floor area is to be at or above Flood Planning Level and those parts of the building below the 1 in 100 yr ARI flood level are to be constructed of flood compatible materials. Grading of site fill to street and/or to adjoining property boundary levels will be permitted where appropriate.
- All bulk fill to within 300mm of finished surfaced level to be sourced from on-site, from the preferred excavation areas or from another area on the floodplain. If bulk fill cannot be obtained from these sources, imported fill may be approved by Council subject to a flood impact assessment that demonstrates no adverse effects on flood levels upstream or flood behaviour on adjacent properties.
- A risk analysis report prepared by a structural engineer addressing the design criteria adopted for the building and its relative merits in the 1 in 500 ARI flood event.

4.3.4 Industrial - All other areas

- Equivalent of 25% of gross floor area to be at or above the Flood Planning Level.
- All new buildings to provide a mezzanine level (with emergency exit for evacuation purposes) above the 1 in 500 ARI flood level as an emergency flood refuge for employees.
- All bulk fill to within 300mm of finished surfaced level to be sourced from on-site, from the preferred excavation areas or from another area on the floodplain. If bulk fill cannot be obtained from these sources, imported fill may be approved by Council subject to a flood impact assessment that demonstrates no adverse effects on flood levels upstream or flood behaviour on adjacent properties.
- A risk analysis report prepared by a structural engineer addressing the design criteria adopted for the building and its relative merits in the 1 in 500 ARI flood event.

4.3.5 Controls Applying To All Development

- Where a minimum floor level is specified, a certificate from a registered surveyor will be required certifying that the floor has been constructed to the required level.
- All applications involving new building work are to be accompanied by a certificate of structural adequacy prepared by a qualified structural/civil engineer stating that the building has been designed to withstand structural damage from the forces of floodwaters and associated debris up to a 1 in 500 ARI flood event. Developments under $50 000 other than restumping of dwellings are exempt from this requirement.
- For non-habitable floors constructed below the Flood Planning Level, the applicant will be required to demonstrate that:
  a) the new structure will not have an adverse affect upon the existing flow of floodwaters, and
  b) all materials used below the Flood Planning Level are flood compatible.

4.4 LOW FLOOD RISK PRECINCT

No development controls apply to residential, commercial or industrial development; however the safety of people and associate emergency response management still needs to be considered and may result in:

- Restrictions on certain types of development that may be particularly vulnerable to emergency response such as aged care developments; and

- Restrictions on critical emergency response and recovery facilities and infrastructure such as evacuation centres, hospitals and major utility facilities to ensure such facilities and infrastructure can fulfil their emergency response and recovery functions during and after a flood event.

4.5 PREFERRED EXCAVATION AREAS

- No fill to be placed
- No structures to be built
- No agricultural activities that will have an adverse impact on flood flows.

APPENDIX 5: CRITERIA & PRIORITIES FOR VOLUNTARY HOUSE PURCHASE

Four (4) criteria were developed with input from the Floodplain Management Committee to allow priority to be allocated to properties eligible for the voluntary house purchase scheme. A total of 209 properties adjacent to Leycester Creek, Wilsons River and Hollingsworth Creek were considered and all properties were ground-truthed to ensure that the VHPS encapsulates all flood liable dwellings in the urban area of Lismore.

The four (4) criteria, listed below, resulted in the allocation of a total point score for each property considered.

Depth of Flooding above ground in a 1 in 100 year flood

The depth of flooding above ground indicates the severity of the flood risk. As such, dwellings with the ground inundated by more than 3 metres in the 1 in 100 year ARI flood receive 2 points, more than 1.5 metre receives 1 point and those less than 1.5 metre receives 0 points.

Depth of Flooding above Floor in a 1 in 100 year flood

In the past, the VHPS applied irrespective of floor level. Recognition is now given to floor level as the lower the floor level the more exposed is the dwelling to flooding. As such, dwellings with floor inundated by more than a metre in the 1 in 100 year recurrence flood receive 2 points, less than a metre receives 1 point and those not flooded above floor in a 1 in 100 year recurrence flood receives 0 point.

Evacuation Difficulty

This relates to the amount of time available and the difficulty the SES and residents face to evacuate a site. Residents in North and South Lismore have the greatest risk in this respect as they have the shortest evacuation time available and the longest evacuation route, via the CBD. In recognition of this, properties in North and South Lismore receive the highest point score of 2 whereas properties in East Lismore receive 0 point.

Flood Hazard Category

Dwellings must be located entirely within a floodway or high flood risk area. Dwellings in the floodway precinct receive 3 points and those in the high flood risk category 1 point.

Findings and Priorities

The allocation of points on the basis of the criteria above results in total point scores that range from 0 to 9 with a maximum of 9. Properties with scores of 8 and 9 are nominated as high priority, those with a score of 7 medium priority, and those with a score of 6 and less a low priority. This resulted in 15 dwellings being of high priority, 10 of medium priority and 177 of low priority.

Favourable consideration may be given to properties located in areas where a large number of properties are targeted for acquisition in order to consolidate the area. In this instance one main precinct was identified in North Lismore, with 15 high priority properties in the Baillie and Wotherspoon Street and Winterton Parade area..

APPENDIX 6: CRITERIA & PRIORITIES FOR VOLUNTARY HOUSE RAISING

The Floodplain Management Committee developed criteria to prepare a priority list of residential properties that will be eligible for assistance under the VHRS. The priority list excludes properties identified as suitable for the VHPS. The 3 criteria below were used to identify priorities and resulted in the allocation of a total point score for each property considered.

Floor Level Above Ground After Raising

Council requires the floor level to be at least 0.5m above the 1 in 100 year recurrence flood level should a dwelling be raised under the VHRS. For practical reasons the floor level of the dwelling above ground after raising should not exceed 4.0m. Otherwise the dwelling would be recommended for VHPS. In this instance the dwelling will be weighed against the VHPS for priority listing.

Current Floor Level Above Ground

The floor level of a dwelling above ground indicates its vulnerability to inundation. A dwelling with an existing floor level that already exceeds 2.0m above ground will not be recommended for house raising. However, a dwelling with a floor level of less than a metre above ground will receive 2 points, and 1 point for a dwelling with a floor level of more than a metre above ground.

Depth of Flooding Above Floor

A dwelling with its floor inundated by more than a metre in the 1 in 20 year recurrence flood receives 3 points whereas those inundated by less than a metre will receive 1 point. This is based on the extent of flood damage that occurs when the flood level exceeds 1m (roughly equivalent to table height).

Priorities

35 of the 99 dwellings considered were identified for Voluntary House Purchase due to the excessive height above ground if raised. Of these, five (5) have already been purchased or no longer exist, 16 are of high priority for Voluntary House Purchase, two (2) of medium priority and 6 of low priority. The remaining six (6) are categorised as 'do nothing' as the floors are already more than 2m above ground (with the exception of 105 Lake St).

The remaining 64 dwellings of the 99 considered were prioritised for VHRS. The total point score ranged from 1 to 5 with a maximum of 5. Scores of 4 and 5 are designated a high priority, a score of 3 medium priority and a score of 2 and less low priority. This resulted in 7 dwellings being high priority, 43 medium priority and 14 low priority.

Of the 7 dwellings identified as high priority for VHRS, one (1) has already been raised and six (6) cannot be raised as they are of slab on ground construction or are currently utilised as businesses.

Of the 43 dwellings identified as medium priority for VHRS, 24 will be given a higher priority due to the depth of flooding above floor level that would exceed 0.3m in a 1 in 20 year recurrence flood and 19 will be given a lower priority due to the depth of flooding above floor level not exceeding 0.3m in a 1 in 20 year recurrence flood.