Department of Environment & Climate Change NSW

WAGGA WAGGA CITY COUNCIL

WAGGA WAGGA FLOODPLAIN RISK MANAGEMENT PLAN

FINAL

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MAY 2009

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Project WAGGA WAGGA FLOODPLAIN RISK MANAGEMENT PLAN	**Project Number** 22033
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Date 1 May 2009	**Verified by**

Revision	Description	Date
1	Final	MAY 09

WAGGA WAGGA
FLOODPLAIN RISK MANAGEMENT PLAN

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FOREWORD

The State Government's Flood Prone Land Policy is directed at providing solutions to existing flooding problems in developed areas and to ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the Government through the following four sequential stages:

1. Flood Study
   - determines the nature and extent of the flood problem.

2. Floodplain Risk Management Study
   - evaluates management options for the floodplain in respect of both existing and proposed development.

3. Floodplain Risk Management Plan
   - involves formal adoption by Council of a plan of management for the floodplain.

4. Implementation of the Plan
   - construction or implementation of floodplain risk management measures to protect existing development,
   - use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

The Wagga Wagga Floodplain Risk Management Plan constitutes the third stage of the management process. This plan has been prepared by Webb, McKeown & Associates for Wagga Wagga City Council and provides the basis for the future management of flood prone lands in the Murrumbidgee River floodplain around Wagga Wagga.

This plan should be reviewed every two to five years or following any significant flood.

The Wagga Wagga Floodplain Risk Management Plan has been jointly funded by Wagga Wagga City Council and the Department of Environment and Climate Change.

SUMMARY

The Murrumbidgee River is a major tributary of the Murray River system and drains some 100,000 km^2 in the southern inland area of New South Wales. The catchment area at the city of Wagga Wagga is some 26,400 km^2.

Since early European settlement in the 1840's, the city of Wagga Wagga has experienced flooding on numerous occasions causing considerable damage and inconvenience. These events have shaped the past and will continue to shape the future development of the city and the region. The original settlement of North Wagga Wagga is situated on the northern floodplain but the majority of the city and recent developments are now located on the high ground of the southern bank. Industrial development has also occurred on the southern floodplain spreading east from Wagga Wagga along the Sturt Highway towards the township of Gumly Gumly and the airport (referred to as the Eastern Industrial Area).

Estimated records of river levels are available at Hampden Bridge from 1838 to 1886, and official records continue from 1886 to present day. Floods over 10 metres at the Hampden Bridge gauge were recorded in 1891, 1925, 1950 and 1974. It is likely that flood events in 1844, 1852, 1853 and 1870 also exceeded this height. The flood record is extremely variable with five floods occurring in 1974 and frequent flooding experienced in the period from 1950 to 1956. There have also been long periods where no significant flooding has occurred where river levels during floods remained below 9 metres, such as from 1939 to 1949, 1960 to 1970 and 1992 to 2006.

Wagga Wagga City Council initiated the development of this Plan to address the management of the flood problem on the Murrumbidgee River floodplain area around Wagga Wagga. The development of this Plan completes the th
ird stage of the Floodplain Risk Management Process, with the following reports constituting Stage 1 and 2 respectively:

- Wagga Wagga Flood Study (September 2004) and its Addendum (October 2006) which defined design flood levels, flows and velocities within the floodplain,
- Wagga Wagga Floodplain Risk Management Study (July 2007) which categorised the risks and hazards for the floodplain and also considered the various issues associated with existing flood affected properties as well as potential future development of the floodplain by the assessment of various floodplain management options.

Based on the findings of the Wagga Wagga Floodplain Risk Management Study, this Plan sets out the actions to be adopted for the future management of the Murrumbidgee River floodplain area around Wagga Wagga. A summary of the management measures recommended for implementation is presented in Table(i).

Table i): Recommended Floodplain Risk Management Measures for Wagga Wagga

Measure	Recommendation	Indicative Cost and Benefit	Responsibility
HIGH PRIORITY:			
F1: INVESTIGATE THE FEASIBILITY OF RAISING MAIN CITY LEVEE	Within the cost constraints and technical issues associated with raising a levee, a best practical compromise should be reached for a level of protection between the 100y ARI plus 0.5m freeboard and 100y ARI plus 1.0 m freeboard for concrete wall and earth embankment, respectively. Consideration should also be given to maintaining a 20y ARI level of protection for the North Wagga Wagga levee. A cost estimate for the levee upgrade is likely to be in the order of $7 -12 Million.	Cost up to $150,000 (eng. & geotechnical study only) Estimated to reduce AAD in the area by 55%.	Wagga Wagga City Council
F4: IMPLEMENT VEGETATION MANAGEMENT PLAN FOR PARKEN PREGAN LAGOON AND OVERBANK AREAS	From the current results, a 300m maintenance strip would be desired, however, 2D modelling is required to assess the full impact of particular maintenance scenarios. Sensitivity of design flood levels to vegetation management plan should be taken into account during the design of the Main City Levee upgrade.	Approx. $10,000 Ensures the management of regrowth to minimise any potential hydraulic impacts.	Wagga Wagga City Council
P3: ADOPT APPROPRIATE FLOOD PLANNING LEVEL	Adopt a flood planning level which is consistent for different types of development (based on risks) across the floodplain. The Flood Planning Level should incorporate the appropriate design flood level and a freeboard allowance. For Wagga Wagga, a level of 100y ARI plus 0.5m freeboard is recommended for residential development. The adopted 100y ARI design flood level should be based on the assumption that the main city levee will be upgraded.	Cost to development Assists in the management of future development to minimise the flood-related risk and damages.	Wagga Wagga City Council
P4: REVIEW AND UPDATE WWCC CURRENT FLOOD POLICY	Formalise Council policy documentation to include findings from this Floodplain Risk Management Process.	$20,000. Assists in the management of future development to minimise the flood-related risk and damages.	Wagga Wagga City Council
P5: ADOPT A CONSISTENT FREEBOARD OF 0.5 m ABOVE THE DESIGN FLOOD LEVEL	A consistent freeboard of 0.5 m shall apply for all new development within the flood planning area.	Cost to development Assists in the management of future development to minimise the flood-related risk and damages.	Wagga Wagga City Council
P6: REVIEW AND UPDATE SECTION 149 CERTIFICATES	Updated flood information and the floor level survey need to be included on Section 149 certificates.	$10,000. Informs residents about flood-related development controls and assists in ensuring future development is flood compatible.	Wagga Wagga City Council
P8: REVIEW AND UPDATE LEP	Update the current LEP to incorporate the latest flood terminology and policies.	$20,000. Assists in the management of future development to minimise the flood-related risk and damages.	Wagga Wagga City Council
P9: ADOPT & IMPLEMENT UPDATED DEVELOPMENT CONTROLS FOR FLOOD PRONE LAND	Council should adopt and implement a generic Flood DCP with reference to a specific planning matrix tailored to assist with development planning of flood prone lands on the Murrumbidgee River (Wagga Wagga) floodplain.	Cost to development Assists in the management of future development to minimise the flood-related risk and damages.	Wagga Wagga City Council

Measure	Recommendation	Indicative Cost and Benefit	Responsibility
R1: CONTINUE TO IMPROVE PUBLIC ACCESS TO FLOOD WARNING INFORMATION	Continue to develop and upgrade warning information systems in consultation with BOM and SES.	$20,000. Assists in reducing the flood-related damages to the community (both tangible and intangible).	Wagga Wagga City Council, SES and BOM
R2: REVIEW AND UPDATE LOCAL FLOOD PLAN	The SES Local Flood Plan should be regularly reviewed and updated. It was last updated September 2004. Contents of the Local Flood Plan should be communicated to the community.	$5,000. Ensures that current best practice is employed and the approaches are the most appropriate.	SES
R4: DEVELOP AND IMPLEMENT A FLOOD EDUCATION PROGRAM	An ongoing Flood Education program will help to maintain/enhance the awareness of the community, particularly, the transient non-permanent “holiday makers”.	$50,000. Assists in reducing the flood-related damages to the community (both tangible and intangible).	Wagga Wagga City Council
R5: OBTAIN MORE DETAILED TOPOGRAPHIC INFORMATION	More detailed topographic information will allow a more reliable and rigorous foundation for the WaterRIDE program, will increase the accuracy within any future hydraulic modelling and can be used to better assess any flood modification measures.	$150,000. Enable more accurate flood information to pe provided.	Wagga Wagga City Council
MEDIUM PRIORITY:			
F2 & F3: REMOVE THE EASTERN INDUSTRIAL LEVEE PROPOSAL FROM COUNCIL’S LONG TERM PLANNING AND CONTINUE WITH COUNCIL’S CURRENT 20 YEAR ARI LEVEL FILLING POLICY.	Levees are a potential means of reducing the flood hazard and damages for existing development. However a similar effect can be achieved without the additional loss of floodplain storage under Council’s current filling policy.	$5,000 (to updated Council’s long term planning). Cost to development. Assisting in the management of flood-related risk and damage.	Wagga Wagga City Council
P1: ALLOW HOUSE RAISING FOR SUITABLE PROPERTIES	Raising these houses will reduce flood damages but it will not change the hazard categorisation for the property. Notification of the eligibility for house raising should be provided on the Section 149 certificate. Council will need to review the suitability of individual houses for house raising.	Approx. $50,000 per property. Reduces /eliminates property damage during a flood.	Wagga Wagga City Council
P7: NOTIFY EXISTING PROPERTY OWNERS OF CURRENT S149 CERTIFICATE DETAILS	As part of a flood awareness/education program and to ensure all existing property owners are made aware of any potential flood affectation encoded as a result of this FRMP process, notifications should be mailed to all flood prone property owners, also notifying them of suitable property modification measures.	$5,000. Raises resident awareness and assists in the successful implementation of development controls.	Wagga Wagga City Council
R3: MONITOR CHANGES TO THE FLOODPLAIN	Changes to the floodplain (such as filling, new development or re-development) occur on an ongoing basis. Such changes can alter (increase or decrease) the number of people at risk, the level of risk or evacuation needs and this information may require the Local Flood Plan to be updated.	Nominal. Ensures that the best available information is obtained.	Wagga Wagga City Council
LOW PRIORITY:			
P2: ALLOW FLOOD PROOFING	Flood proofing should be encouraged for existing flood affected buildings, particularly in the commercial/industrial sectors.	Approx. $10,000 per building Reduces the property damage caused by flooding	Wagga Wagga City Council

1. INTRODUCTION

The Murrumbidgee River is a major tributary of the Murray River system and drains some 100,000 km^2 in the southern inland area of NSW. The catchment area at Wagga Wagga is some 26,400 km^2 (Figure 1). The original settlement of the town was at North Wagga Wagga which is situated on the northern floodplain but the majority of the city and recent developments are now located on the high ground of the southern bank.

The majority of the Murrumbidgee River floodplain in the Wagga Wagga Local Government Area is used for agricultural purposes and contains numerous rural homesteads. There are small pockets of industrial and urban development in Central and North Wagga. Industrial development has also occurred on the southern floodplain spreading east from Wagga Wagga along the Sturt Highway towards the township of Forest Hill and the airport.

1.1 Floodplain Risk Management Process

Wagga Wagga City Council has commissioned the following studies in accordance with the guidelines of the Floodplain Management Manual (Reference 1), which has been recently updated as the 2005 Floodplain Development Manual (Reference 2):

Stage 1: Flood Study,
Stage 2: Floodplain Risk Management Study,
Stage 3: Floodplain Risk Management Plan,
Stage 4: Implementation of the Plan

The Flood Study (completed in 2004 with an addendum completed in October 2006, Reference 3) analysed all historical flood height data (Table 1) and established the design flood levels for the study area with selected values presented in Table 2. The Floodplain Risk Management Study (completed in July 2007, Reference 4) identified the flood problem in terms of risks to floodplain occupants and their assets, and then canvassed various measures to mitigate the effects of flooding. This Floodplain Risk Management Plan constitutes the third stage and sets out the implementation program for future management of the floodplain. Wagga Wagga City Council will complete the process through implementation of the actions identified in the Plan depending on financial, timing and other constraints.

2. STUDY AREA

2.1 Description

This study covers the Murrumbidgee River floodplain area depicted on Figure 2, stretching from Braehour around 10 km east (upstream) of Wagga Wagga to Kallewanda and the Malebo Range around 9 km west (downstream) of Wagga Wagga. A detail map of the study area is provided in Figure 3.

The original settlement was at North Wagga Wagga, which is situated on the northern floodplain. Today, the majority of the city and recent developments are located on the high ground of the southern bank. A large part of the city remains on the floodplain and is protected to varying degrees from flooding by levee banks, known as the North Wagga Wagga levee and the main city levee (south).

Hampden Bridge provided the main crossing of the Murrumbidgee River until it was closed and replaced by the nearby Wiradjuri Bridge. A second crossing has recently been constructed at Gobbagombalin. At Hampden Bridge the floodplain is approximately 3 km wide but this reduces to approximately 1.4 km at Gobbagombalin Bridge. Upstream of Wagga Wagga the river is crossed by the main southern railway and Eunony Road Bridge.

2.2 Existing Flood Behaviour

Official historical flood records for the Hampden Bridge gauge date back to 1886 and are available from Pineena (Reference 5). Prior to this the record is not complete however a compilation of flood heights from 1838 was made by R. J. E. Gormly, a former alderman and resident of the City of Wagga Wagga (Reference 6). Based on these records there have been seven flood events greater than 10 metres at the Hampden Bridge as shown in Table 1. Between 1886 and 2005, 76 floods (events separated by at least two days) occurred with peak heights over 8 metres at the Hampden Bridge gauge. In recent times the most significant floods (>9.3 mAHD) occurred in 1974, 1975, 1976 and 1991 with peak gauge heights of 10.74, 9.58, 9.38 and 9.61 metres respectively.

As part of the Wagga Wagga Flood Study (Reference 3) a rigorous flood frequency analysis of all past flood records was undertaken to determine the magnitude of the design events. A RUBICON hydraulic (computer) model was established, calibrated to historical data and used to determine design flood levels.

Table 1: Flood Events Greater than 10 m

Month	Year	Gauge Height *
June	1852	10.67 (1)
July	1853	11.04 (1)
April	1870	10.67 (2)
June	1891	10.47 (2)
May	1925	10.11 (2)
March	1950	10.06 (2)
August	1974	10.74 (2)

Notes:
(1) Source Gormly (Reference 6)
(2) Source Pineena (Reference 5)
* Gauge zero is equivalent to 170.05 mAHD.
Note: The main city levee was constructed following the 1956 flood and subsequently upgraded following the 1974 flood.

Design flood behaviour was established for the 100, 50, 20 and 10 year ARI events and the PMF. The Flood Study provides detailed peak height profiles, design flood contours, flow and velocity information. A summary of peak design levels (October 2006 Flood Study update) at key locations is provided in Table 2. Following the completion of the flood study, two updates were undertaken in light of new information during April 2005 and October 2006. These updates are reported as an Addendum to the Flood Study. Flood levels reported in this plan are based on the most current (October 2006) update.

Table 2: Selected Design Flood Levels (mAHD)

Flood (ARI) / Location	10y	20y	50y	100y	PMF
Gobbagombalin Bridge	177.8	178.5	179.3	179.9	185.7
Narrung Street	179.2	179.8	180.6	181.3	186.1
Hampden Bridge	179.3	180.0	180.8	181.4	186.1
Railway Bridge	179.9	180.5	181.3	181.9	186.4
Gumly Gumly (River)	182.0	182.6	183.2	183.8	188.3
Braehour	182.9	183.7	184.5	185.2	189.6

The Flood Study also examined the location and extent of overtopping of the Main City Levee at Wagga Wagga. It was determined that the August 1974 flood, previously considered to be a 90 year ARI event, is now considered to be a 60 year ARI event. The Main City Levee was designed to provide protection up to the August 1974 event.

The Flood Study provides an indicative classification of the hydraulic and hazard characteristics of the Murrumbidgee River floodplain for the 100y ARI and PMF events (Figures 3 and 4 respectively). The hydraulic and hazard categories are to be used for assessing the potential suitability of future types of land use and areas of possible development, rather than the assessment of individual or isolated development proposals. For the 100 year ARI, three hazard classifications were defined in the study area:

- **High hazard floodway** - areas where a significant volume of water flows during floods with high velocities and large depths.
- **High hazard flood storage** - those parts of the floodplains that are important for temporary storage of floodwaters, floodwaters tend to rise slowly, have low velocities but large depths.
- **Low hazard flood storage** - as for high hazard flood storage except depths and velocities tend to be less.

2.3 Flood Damages

The assessment of flood damages is an important part of the floodplain risk management process. By quantifying flood damages for a range of design events, appropriate cost effective management measures can be analysed in terms of their benefits (reduction in damages) versus the cost of implementation.

The estimation of flood damages tends to focus on the physical impact for the human environment in the floodplain but there is also a need to consider the ecological costs and benefits associated with flooding of the floodplain. Flood damages are often defined as being “tangible” or “intangible”. Tangible damages are those for which a monetary value can be assigned. This is in contrast to intangible damages which cannot easily be attributed a monetary value.

Table 3 presents the total number of buildings inundated for different regions of the study area. Due to the large volume of properties within the Main City Levee, a detailed survey of properties inundated during flood events was not undertaken. It is estimated, however, that if the Main City Levee was to fail or overtop in a major flood event (>50y ARI), the CBD area would be subject to an average flooding depth of 1.4 m over an area of 2.5 km^2. This accounts for approximately 2000 properties, of which around 75% are residential. This estimation has been used in damages calculations for the Wagga Wagga CBD.

Additionally, damages have been calculated with assumptions based on DECC formally DNR guidelines (References 16 and 17), that is that the main city and north Wagga levees partially fail once the design height is reached (that is, floods greater than 50y ARI for the main city levee and a 20y ARI for the north Wagga levee).

Table 3: Total Buildings Inundated

Area	20y ARI	50y ARI	100y ARI	200y ARI	500y ARI
Gobbagombalin	13	13	13	13	13
Northern Floodplain	1	6	10	12	13
Gumly Gumly	7	47	88	92	92
East Wagga	22	27	29	32	33
North Wagga	91	166	167	167	167
Oura	0	11	31	35	36
Area within main city levee	0	0	2000+	2000+	2000+
TOTAL	**134**	**270**	**>2300**	**>2350**	**>2350**

The standard way of expressing flood damages is in terms of Average Annual Damages (AAD), that is the total damages experienced by a community over a long period of time converted to an equivalent annual amount. An indication of the average annual damages apportioned to the different areas of existing development in the study area is provided in Table 4.

Table 4: Geographical Apportionment of Average Annual Flood Damages

Area	Average Annual Damages	Percentage of Total AAD
Gobbagombalin	$48,300	2.3%
Northern Floodplain	$12,800	0.6%
Gumly Gumly	$85,200	4.1%
East Wagga	$99,000	4.8%
North Wagga	$381,800	18.5%
Oura	$29,600	1.4%
Area within main city levee (1)	$1,406,900	68.2%
TOTAL	**$2.1 million**	**100%**

1. Inundation levels and damages calculations within main city levee are based on estimates only

A new Guideline released by DECC (Reference 15) following completion of the damage assessment above if applied would result in much higher damages than those outlined above. The new guideline includes a revised stage-damage curve and assumes flood damage is based on level of protection rather than floor levels (that is, a freeboard is removed from the surveyed floor level). The second part of the update that is based on level of protection has been applied to the above assessment.

3. ASSESSMENT OF FLOODPLAIN RISK MANAGEMENT MEASURES

3.1 Introduction

An assessment of potential floodplain risk management measures was undertaken in the Floodplain Risk Management Study (Reference 4). The measures were assessed against the legal, structural, environmental, social and economic conditions or constraints of the local area. The potential floodplain risk management measures can be separated into three broad categories as follows:

- *Flood modification measures* modify the flood's physical behaviour (depth, velocity). Typical measures include flood mitigation dams, retarding basins, on-site detention, channel improvements, levees, floodways or catchment treatment.

- *Property modification measures* modify the existing land use or buildings and development controls for future development. This is generally accomplished through such means as re-zoning, development control plans, flood access, flood proofing (house raising or sealing entrances), or voluntary purchase.

- *Response modification measures* modify the community's response to the potential hazards of flooding. This is achieved by informing flood-affected property owners as well as the wider community about the nature of flooding so that they can make better informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

Table i) summarises the management measures recommended as a result of this assessment. The following sections provide a brief discussion of each of the recommended measures (Reference 4 provides details of the complete assessment).

3.2 Flood Modification Measures

F1: Main City Levee

Discussion

The Main City Levee that surrounds the central business district of the city of Wagga Wagga currently provides protection for up to the magnitude of the August 1974 flood (estimated as a 60y ARI flood - Reference 3). There are a few minor areas along the levee that are slightly below this level but these are sandbagged during flood events.

It is proposed that the Main City Levee should be raised to a 100y ARI level of protection and include a combination of 0.5 m and 1.0 m allowance for freeboard, depending on the construction type. This would provide increased protection to the leveed areas with minimum adverse impacts across the floodplain. Raising the Main City Levee to the 100y ARI level of protection with an allowance for freeboard will reduce the Annual Average Damages (AAD) for the leveed area by up to 55% of the current estimate of approximately $2.1 million.

There are other issues (besides the level of freeboard) to take into consideration with regard to upgrading the levee, including cost and localised impacts. The final amount of freeboard provided will be a design parameter based on the type of levee construction and material used.

Recommendations

It is recommended that the feasibility of raising the Main City Levee to a uniform level of protection be investigated further. Within the cost constraints and technical issues associated with raising a levee, a best practical compromise should be reached for a level of protection between the 100y ARI plus 0.5 m freeboard and 1.0 m freeboard based on construction and materials used. Consideration should also be given to providing a controlled failure point. Should the 100y ARI level of protection not be achieved due to practical constraints, appropriate controls for properties behind the levee will be required.

Consideration should be given to maintaining a 20y ARI level of protection to North Wagga Wagga following the levee upgrade and the sensitivity of design flood levels to any floodplain vegetation management plans.

The detailed design stage of the levee upgrade should also give consideration to measures for offsetting any adverse impacts flooding or otherwise resulting from the upgrade.

Actions

F1: Undertake further detailed investigation of the feasibility of upgrading the Main City Levee to a 100y ARI level of protection with an appropriate allowance for freeboard.

Priority
High

F2 & F3: Eastern Industrial Levee

Discussion
The majority of Wagga Wagga's industrial development has occurred on the southern floodplain, spreading east from Wagga to the township of Gumly Gumly. The proposed eastern industrial levee would surround the areas near Tasman Road, Hammond Avenue and Kooringal Road and would prevent the continual disruption of important commercial services. A levee designed for 20y ARI level of protection was assessed during the Floodplain Risk Management Study. Another two options were also considered, which involved the addition of a finger extension running along the Sturt Highway providing 20y and 100y ARI levels of protection.

The proposed location of the eastern industrial levee would result in loss of additional floodplain storage width compared to development under Council's current filling policy.

Flood level increases, particularly in Gumly Gumly, and additional lost floodplain storage width make any level of protection greater than a 20y ARI unacceptable. The smaller flood level impacts resulting from the 20y ARI levee are likely to occur due to Council's filling policy which requires only localised filling for developments in this area. However, any protection greater than this results in adverse impacts in larger floods in areas of the floodplain surrounding east Wagga Wagga. The effects will also have significant impacts on access and evacuation routes for many residences in the east Wagga Wagga and Gumly Gumly areas.

Recommendations
The proposal for a levee providing a 20y ARI level of protection, protecting the eastern industrial area should be removed from Council's long term planning as Council's current filling policy will produce a similar effect without the additional loss of floodplain storage width. Further the costs of Council's filling policy will be borne by the landholders who benefit from the filling.

Actions
F2: Remove the eastern industrial levee from Council's long term planning.
F3: Continue Council's current 20 year ARI level of protection filling policy for development in the eastern industrial area.

Priority
Medium

F4: Vegetation Management

Discussion

A major concern raised by the Committee and the community was the possibility of thick vegetation (trees) growing on the overbank areas of the Murrumbidgee River in the vicinity of North Wagga Wagga impacting on flood levels in all areas. A number of different scenarios and compensatory measures were modelled during the Floodplain Risk Management Study, including the use of 'maintenance strips' to negate the impacts of increased vegetation. As a result of the preliminary assessment, it was recognised that vegetation needs to be managed, while taking into consideration any environmental impacts that may incur.

Recommendations

It is recommended that the management of regrowth vegetation on the overbank areas be built into all future floodplain management planning given the significance of potential changes to flood levels. Based on the current results, a 300 m maintenance strip would be desired, particularly to reduce impacts on North Wagga Wagga associated with excessive vegetation regrowth. However, 2D hydraulic (flood) modelling is the only effective means of assessing the full impact of particular maintenance scenarios. Consideration should be given to the results of this assessment during the main city levee upgrade design. Sensitivity of design flood levels to the vegetation regrowth could significantly affect the crest height required to achieve the 100y ARI level of protection or the amount of freeboard allowance required.

Actions

F4: Implement a vegetation Management Plan for Parken Pregan Lagoon and overbank areas. Undertake 2D modelling to fully assess the impacts of particular maintenance scenarios and give consideration to these results during the main city levee upgrade design.

Priority

High

Other Flood Modification Measures:

The possibility of raising the North Wagga Wagga levee level of protection was considered during the Floodplain Risk Management Study. It was agreed however that it was not appropriate to raise the level of protection of this levee due to the economic costs and social implications such as reduced flood awareness. It is recommended that the existing levee be maintained to a 20y ARI level of protection with an appropriate allowance for freeboard however. Consideration should be given to the North Wagga Wagga levee during the main city levee upgrade design assessment. Consideration should also be given to the incorporation of a controlled failure point such as a spillway.

3.3 Property Modification Measures

P1: House Raising

Discussion

House raising involves lifting an affected house so that the minimum habitable floor level is raised above a specified planning level. House raising does not alter or reduce the flood hazard for a property and in fact residents will tend to remain within their house rather than be evacuated early in an event. The main benefit of house raising is the reduction in flood damages experienced by the individual property.

Recommendations

House raising is a viable measure for those properties satisfying the criteria. Its adoption for implementation is however dependent on individual resident acceptance and funding availability. An indication of the property's eligibility for house raising could be recorded on the Section 149 Certificate to ensure future potential purchasers are made aware of their options. It must be made clear that this measure will not completely protect the occupants or the house in large events, evacuation may still be necessary which could pose some hazard or risk. Council will need to review the suitability of individual houses for house raising.

Commercial stock losses could also be reduced if businesses raised the level of their storage areas or stored stock above the Flood Planning Level.

Actions

P1: Allow house raising for properties satisfying the criteria and add notification to Section 149 certificates.

Priority

Medium

P2: Flood Proofing

Discussion

Flood proofing involves the sealing of entrances, windows, vents etc. to prevent or limit the ingress of floodwaters. An existing house could be sealed whilst new houses and extensions allow the inclusion of flood appropriate materials and design. Additionally, flood proofing can involve the raising of easily damaged/high cost items such as commercial stock, equipment and/or machinery. This method is only suitable for existing buildings as new buildings should have floor levels above the Flood Planning Level (FPL) and should be built in a manner which reduces the risk of flood damage for events greater than the design flood level that forms the basis of the FPL.

This measure is rarely used in NSW for residential buildings and is more suited to commercial premises where there are only one or two entrances and maintenance and operation procedures can be better enforced. It will not reduce the flood hazard and in fact the hazard may be increased if the measure results in occupants staying in their premises and a large flood eventually inundates the building to high depths above floor level. There are no other significant environmental or social problems associated with this management measure.

Recommendations

This measure generally costs much less than house raising and it is therefore worthy of further detailed consideration particularly for regularly flooded commercial properties where the damages can be greater.

A public awareness program should be initiated to inform owners of commercial and residential properties about the potential of this measure and allow them to undertake the works at their own convenience. It must be made clear that this measure will not completely protect the occupants or the house in large events, evacuation may still be necessary which could pose some hazard or risk.

Actions

P2: Inform and educate floodplain occupants about flood proofing measures. Promote flood proofing of existing affected commercial or industrial developments.

Priority

Low

P3, P4 & P5: Flood Planning Level and Flood Policy

Discussion

Flood Planning Levels (FPLs) are an important tool in floodplain risk management. Appendix K of the Floodplain Development Manual, 2005 (Reference 2) provides a comprehensive guide to the purpose and determination of FPLs. The FPL provides a development control measure for measuring future flood risk and is derived from the combination of a flood event and a freeboard.

Selecting the appropriate FPL for a particular floodplain involves trading off the social and economic benefits of a reduction in the frequency, inconvenience, damage and risk to life and limb caused by flooding against the social, economic and environmental costs of restricting land use in flood prone areas and of implementing management measures. In considering the suitable FPL for Wagga Wagga and the surrounding villages, Council and the Floodplain Risk Management Committee took into consideration the following key development controls:

- appropriate development,
- flood level,
- structural soundness,
- flood affectation,
- flood evacuation,
- management and design.

Recommendations

Following assessment of the above development controls for a variety of land use categories, it is recommended that Council adopt a 100y ARI plus 0.5m freeboard (assuming the main city levee will be upgraded) as the Flood Planning Level for the overall Murrumbidgee River floodplain. This level is considered to incorporate an appropriate level or balance of risk versus cost to the community for general residential development and is in accordance with accepted standards which have been implemented in similar situations throughout NSW.

Variations to the FPL may be adopted for local areas depending on the nature of the development and the level of flood risk. A planning matrix which could be adopted to assist in determining FPLs can be found in Appendix A.

Council's Flood Policy should be updated to include details regarding the FPLs and all other relevant information as part of this Floodplain Risk Management Process. Given Council's current planning to limit new development to beyond the 100y ARI extent, Council's flood policy will essentially better manage the current risk exposure rather than applying to future flood risk.

Actions

P3: Adopt an appropriate Flood Planning Level of 100y ARI plus 0.5 m freeboard, assuming the main city levee is upgraded.

P4: Review and update WWCC Flood Policy.

P5: Adopt consistent freeboard of 0.5 m.

Priority

High

P6 & P7: Section 149 Certificates

Discussion

Section 149 Planning Certificates provide information on the planning controls and policies that apply to a particular parcel of land. Currently, Section 149 Planning Certificates in Wagga Wagga are marked simply as "flood affected" where appropriate. There is no standard way of conveying the information relating to flood affectation, however the 2005 Floodplain Development Manual provides a number of examples.

It should be noted that the Section 149 Planning Certificate should not be the only form of acknowledgment that a property is flood prone. The community should be adequately informed about the extent of flood prone land and why the flood classification can change from one property or area to another. This is particularly relevant for the rural zoned areas of the floodplain.

Recommendations

The flood affected properties identified by this Study will require their Section 149 Planning Certificates to be updated as part of the floodplain management process. At the same time, the wording or description included on the certificate should be revised to better describe the flooding implications and/or planning/building restrictions which may apply as a result of the outcomes from the Floodplain Risk Management Study. Details of flood level information should be continually updated as more accurate survey and flood level information becomes available.

A means of appropriately notifying the flood prone rural zoned lands should also be implemented to ensure potential purchasers are fully informed of the flood risks and hazards.

It is also recommended that a public awareness program be developed to inform all flood prone properties, identified in the Floodplain Risk Management Study, of their current flood affectation and any development constraints imposed by their Section 149 status.

Actions

P6: Review and update Section 149 Certificates. Update and maintain database of floor and ground levels for all properties, within the floodplain.

P7: Notify all existing property owners of the flood affection relating to their property. This should include the estimated flood levels and planning/development controls or restrictions which may apply.

Priority

High for P6 and Medium for P7.

P8 & P9: Review And Update LEPs & DCPs

Discussion

Clear and up-to-date planning controls are an essential part of the Floodplain Risk Management Process. They ensure that all members of the community are fully aware of what is allowed on flood prone land. The LEP usually specifies the nature of development allowable on any area of land and whether Council consent is required. A DCP usually applies to a particular issue or locality where specific development controls are imposed.

Recommendations

Council's Local Environment Plans (LEP 1991, RLEP 1991 and various related Development Control Plans) were reviewed as part of the Floodplain Risk Management Process. The relevant plans should now be updated to incorporate the latest terminologies and approach to controlling development within the floodplain.

The update should reference and incorporate the development controls identified for the Wagga Wagga floodplain as part of the Floodplain Risk Management Study (Reference 4). The proposed planning matrix included in Appendix A demonstrates the potential interaction of development categories with applicable controls/requirements and relevant Flood Planning Levels. It is recommended that Council adopt the planning matrix presented in Appendix A for application to the particular characteristics and issues associated with development on the Wagga Wagga floodplain.

Actions

P8: Review and update LEP to incorporate latest flood terminology and policies.

P9: Adopt and implement updated development controls for flood prone land.

Priority

High

3.4 Response Modification Measures

R1: Flood Warning

Discussion

Flood warning, and the implementation of evacuation procedures by the State Emergency Services (SES), are widely used throughout NSW to reduce flood damages and protect lives. The Bureau of Meteorology (BOM) is responsible for flood warnings on major river systems. The local SES also has their own system for monitoring Murrumbidgee River heights, which are clearly identified in the Wagga Wagga Local Flood Plan (Reference 7).

The SES Wagga Wagga Local Flood Plan endeavours to provide a comprehensive system of flood warning and intelligence communication. The SES monitor local gauges in times of flood and maintain a database of flood intelligence records to assist in providing the community with the best possible flood warnings. There is also a network of SES flood wardens, who are community members on the Murrumbidgee River who regularly report on flood levels and effects.

Recommendations

The Wagga Wagga SES has developed a comprehensive flood warning (and evacuation) plan that is detailed further in the Wagga Wagga Local Flood Plan. The group are highly motivated and committed to providing the most up-to-date information and ongoing education on flooding, flood warning, flood risk and evacuation planning to the surrounding community. However, it should be noted that the bigger the events, the greater the uncertainty in accurately predicting the peak and timing of flood events, and hence safe evacuation time required.

Actions

R1: Continue to develop and upgrade warning information systems in consultation with BOM and SES.

Priority

High

R2 & R3: Review And Update Local Flood Plan And Monitor Changes to the Floodplain

Discussion

A comprehensive Local Flood Plan was prepared by the SES in September 2004 as a sub-plan of the Wagga Wagga Local Disaster Plan.

In small and moderate floods in areas surrounding the town, most people will evacuate in a calm and orderly manner, due primarily to their experience and high flood awareness. The level of awareness in the CBD itself is relatively low and of significant concern, should the main CBD area require evacuation. The SES and Council should focus on educating the property owners in this area on the evacuation procedures.

Recommendations

The local Flood Plan should be reviewed and updated to include surveyed floor level information and flood affection produced as part of the Floodplain Risk Management Study. A workshop should be held to update the SES, Police, Fire Services and other authorities to ensure that all relevant flood response authorities are fully informed of the flood hazard and extent of flood affectation.

The current SES Flood Plan is scheduled for review no later than September 2009. It is standard policy to review a plan in the aftermath of an actual flood event where direct lessons may be learnt from the implementation of the Plan to real life situations.

The majority of information required to updated the local Flood Plan has already been made available as part of the Floodplain Risk Management Process. Additional information on the changes to the floodplain will need to be compiled.

Actions

R2: Review and update the Flood Plan based on the latest available information. Communicate the contents of the Flood Plan to the community.

R3: Monitor changes to the floodplain and their potential implications for the Local Flood Plan.

Priority

High for R2 and Medium for R3.

R4: Flood Awareness and Preparedness

Discussion

A community with high flood awareness will suffer less damage and disruption during and after a flood because people are aware of the potential situation and listen carefully to official warnings on the radio and television. The level of trauma or anxiety may be reduced as people have "survived" previous floods and know how to handle both the immediate emergency and the post flood rehabilitation phase in a calm and efficient manner.

In Wagga Wagga, the community outside the main city area is very aware of the risk and dangers associated with flooding, particularly in areas such as North Wagga Wagga and Gumly Gumly. The SES has a strong presence in the community, and flood education events are held to help maintain the level of awareness throughout the community.

The level of flood awareness for residents and businesses in the area protected by the Main City Levee is significantly lower than the rest of the community. This is primarily due to the sense of security that landholders in this area feel due to the presence of the levee. It is imperative that the impacts that may occur, were the levee to fail, be communicated to residents in this area.

Recommendations

As discussed earlier in R1, R2 and R3, the Wagga Wagga SES has developed a comprehensive flood warning and evacuation plan that is detailed further in the Wagga Wagga Local Flood Plan (Reference 7). The group are committed to providing ongoing education on flooding, the potential flood risks and evacuation planning to the surrounding community. Table 10 in the Wagga Wagga Floodplain Risk Management Study (Reference 4) provides examples of possible further education methods that may be developed and supported by Council.

Actions

R4: Develop and implement an ongoing flood education program.

Priority

High

R5: More Detailed Topographic Information

Discussion

In order to fully assess the impacts of a number of the proposed management options individual detailed assessment is required. The current RUBICON model does not have sufficient detail to fully assess these options. The acquisition of detailed topographic information such as ALS (Airborne Laser Survey) would benefit the investigation and development of these measures.

Recommendations

It is recommended that more detailed topographic information of the floodplain be acquired and incorporated into future flooding assessments as well as the WaterRIDE program.

Actions

R5: Obtain more detailed topographic information.

Priority

High

4. REFERENCES

1. NSW State Government
Floodplain Management Manual (2001)
January 2001.

2. NSW State Government
Floodplain Development Manual (2005)
April 2005.

3. Wagga Wagga City Council
Murrumbidgee River Wagga Wagga Flood Study
Webb, McKeown & Associates, September 2004

4. Wagga Wagga City Council
Murrumbidgee River Wagga Wagga Floodplain Risk Management Study
Webb, McKeown & Associates Pty Ltd, August 2007.

5. Department of Land & Water Conservation
Pineena, Version 6 - NSW Surface Water Data Archive
Approx. 1999

6. R J E Gormly
61 Floods at Wagga Wagga
Undated

7. State Emergency Services
Wagga Local Flood Plan
SES, September 2004 Edition

Figures

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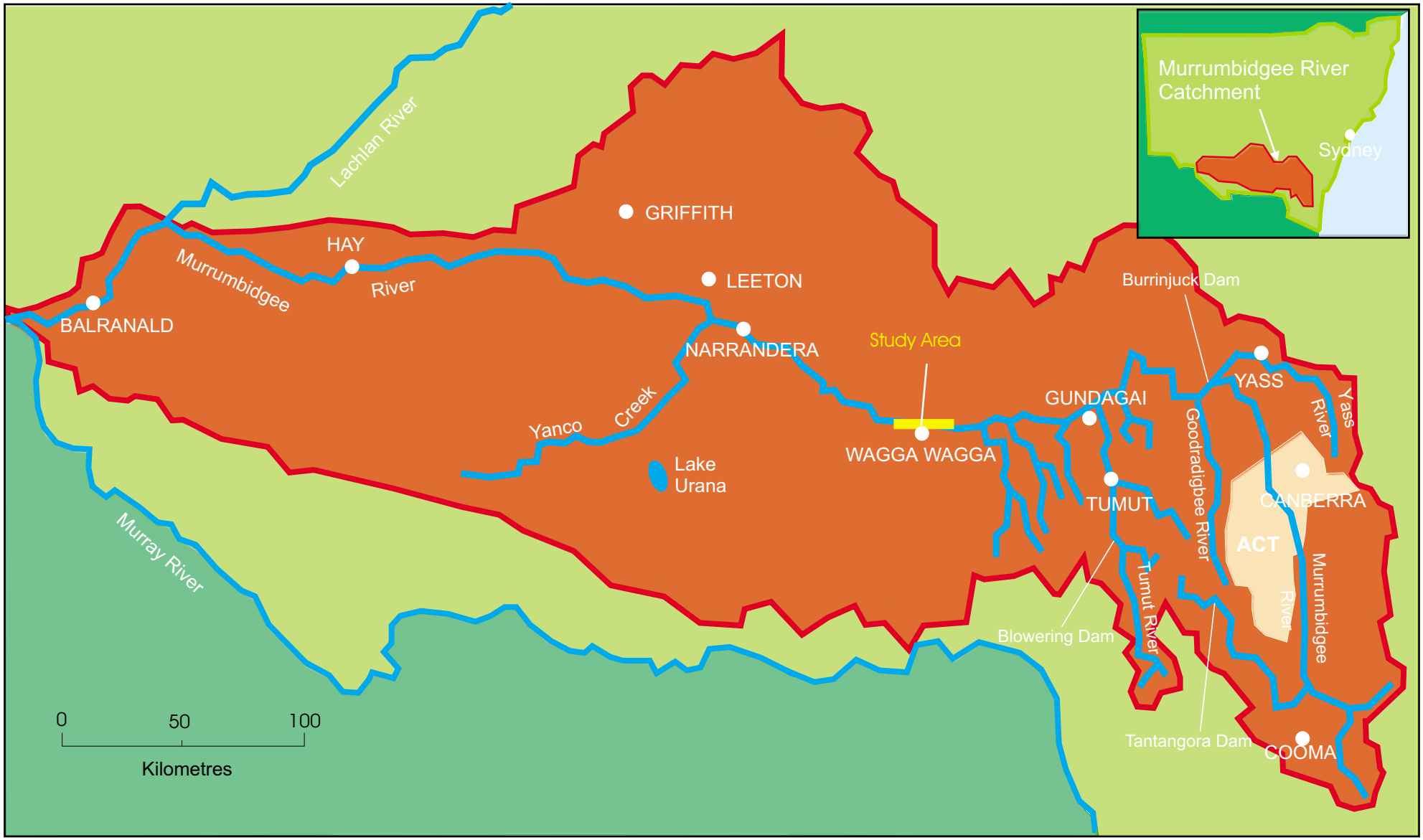

FIGURE 1
MURRUMBIDGEE RIVER CATCHMENT

FIGURE 2

STUDY AREA AND LOCATION OF MAJOR LEVEES

North Wagga Wagga Levee

Gobbagombalin Levee

Gobbagombalin Bridge

Gobbagombalin Weir

Malebo Range

Kallewanda

East Street/Mill Street Levee

Kurrajong Lagoon Levees

Murrumbidgee River

Hampden and Wiradjuri Bridges

Braehour

Marshalls Creek

Gumly Gumly Levee

City of Wagga Wagga

Main City Levee

Sturt Highway

Railway Line

Forest Hill

Legend

FloodplainAreas

- Eastern Industrial Area
- Gumly Gumly
- North Wagga Wagga
- Northern Rural Floodplain
- Wagga Wagga CBD

0 0.5 1 2 3 4 Km

FIGURE 3

100 YEAR ARI HAZARD MAP

High Hazard Flood Storage

High Hazard Floodway

Low Hazard Flood Storage

Limit of contour information

Levee

N

0 0.5 1 2 3 4 Km

FIGURE 4

PMF HAZARD MAP

N

High Hazard Floodway

Limit of Contour Information

Levee

0 0.5 1 2 3 4 Km

Appendix A

Table A1: Flood Policy Matrix

Flood Risk Precincts (FRPs)

Planning Consideration	Central Wagga Protected by Levee (Low Flood Risk)						
	Essential Community Facilities	Critical Utilities	Residential	Low Impact Commercial	Industrial & High Impact Commercial	Recreation & Agriculture	Other Development
Appropriate Development	1	1					
Floor Level		12, 13	11	11, 13	11, 13	11, 13	11, 13
Structural Soundness		20, 22	22	22	22	22	
Flood Affectation		23	23	23	23	23	
Evacuation		25	25	25	25	25	25
Management and Design		33					

Planning Consideration	Central Wagga (Outside of Levee) (High Flood Risk)						
	Essential Community Facilities	Critical Utilities	Residential	Low Impact Commercial	Industrial & High Impact Commercial	Recreation & Agriculture	Other Development
Appropriate Development		1	3-5				
Floor Level		12, 17	7,9,14 17	10, 17 18		11, 15-18	11, 16-18
Structural Soundness		20, 21	19, 21	19, 21		19, 21	19, 21
Flood Affectation		24	24	24		24	24
Evacuation		25-29	25-29	25-28		25-28	
Management and Design		31, 33	30, 33	31-33		31-33	31, 33

Planning Consideration	North Wagga Inside Levee (High Flood Risk)						
	Essential Community Facilities	Critical Utilities	Residential	Low Impact Commercial	Industrial & High Impact Commercial	Recreation & Agriculture	Other Development
Appropriate Development		1	4, 5	6			2
Floor Level		12, 17	8, 9, 14, 17	11, 17		11, 16-18	16-18
Structural Soundness		20-22	19, 21 22	19, 21 22		19, 21	19, 21
Flood Affectation		24	23, 24	23, 24		24	24
Evacuation		25-29	25, 26	25, 26		25, 26	
Management and Design		31, 33	30, 33	31, 33		31, 33	31, 33

Planning Consideration	Gumly/Oura/ Collingullie (High Flood Risk)						
	Essential Community Facilities	Critical Utilities	Residential	Low Impact Commercial	Industrial & High Impact Commercial	Recreation & Agriculture	Other Development
Appropriate Development		1	3-5				
Floor Level		12, 17	7,9,14 17	10, 17 18		11, 15-18	11, 16-18
Structural Soundness		20, 21	19, 21	19, 21		19, 21	19, 21
Flood Affectation		24	24	24		24	24
Evacuation		26-29	25-29	26-28		25-28	
Management and Design		31, 33	30, 33	31-33		31, 33	31, 33

Planning Consideration	Rural Floodplain (High Flood Risk)						
	Essential Community Facilities	Critical Utilities	Residential	Low Impact Commercial	Industrial & High Impact Commercial	Recreation & Agriculture	Other Development
Appropriate Development		1	3-5				
Floor Level		12, 17	7,9,14 17	10, 17 18		11, 15-18	11, 16-18
Structural Soundness		20, 21	19, 21	19, 21		19, 21	19, 21
Flood Affectation		24	24	24		24	24
Evacuation		26-29	25-29	26-28		25-28	
Management and Design		31, 33	30, 33	31-33		31, 33	31, 33

Planning Consideration	Rural Floodplain (Low Flood Risk)						
	Essential Community Facilities	Critical Utilities	Residential	Low Impact Commercial	Industrial & High Impact Commercial	Recreation & Agriculture	Other Development
Appropriate Development		1	3-5				
Floor Level		12, 17	7,9,14 17	10.17, 18	10,17, 18	11 15-18	11 16-18
Structural Soundness		20,21	19,21	19,21	19,21	19,21	19,21
Flood Affectation		24	24	24	24	24	24
Evacuation		25-29	25-29	25,27	25,27	25-28	
Management and Design		31,33	30,33	31-33	31-33	31,33	31,33

Planning Consideration	Eastern Industrial Area (Medium Flood Risk)						
	Essential Community Facilities	Critical Utilities	Residential	Low Impact Commercial	Industrial & High Impact Commercial	Recreation & Agriculture	Other Development
Appropriate Development		1					
Floor Level		12, 17		10, 17	10, 17		
Structural Soundness		20, 21		19, 21	19, 21		
Flood Affectation		24					
Evacuation		26-29		25, 27	25, 27		
Management and Design		31, 33		31-33	31-33		

Not relevant   Unsuitable Land Use

Appropriate Development
1 Existing essential community services and critical utilities to be moved to land above the PMF flood level where possible.
2 Extensions, garages and sheds to be allowed where it can be demonstrated they will not significantly impede the flow of floodwaters.
3 Habitable developments only on lots greater than 80ha where it can be demonstrated they will not significantly impede the flow of flood waters (< 80ha if viable).
4 Housing for aged or disabled persons not permitted.
5 No new dwellings to be built - replacement of existing dwellings only, however if dwelling is in “high hazard” area the dwelling must be relocated to a location where the overall flood risk is less, that is of lower hazard and/or better access, if available on the property.
6 Suitable low impact commercial development (See current North Wagga DCP).

Floor Level
7 All new habitable developments to have floor levels greater than the 100y ARI flood level (plus freeboard).
8 All new developments (replacements of old dwellings) or extensions, including habitable rooms, in excess of 50 m^2 to have habitable floor levels greater than the 100y ARI flood level (plus freeboard)
9 Additions to existing dwelling should be limited to < 50 m^2 (See current Local DCP for example).
10 All new developments to have floor levels greater than the 20y ARI flood level plus freeboard..
11 At ground level (plus 225 mm minimum floor height above the ground).
12 Floor levels greater than the PMF level (plus freeboard).
13 Developments to consider local drainage and ponding of stormwater within the levee.
14 Encourage house raising or flood proofing for existing residential developments below the 100y ARI flood level.
15 Farming shedding can be constructed at ground level.
16 Garages and sheds to be located on highest practical section of property.
17 New developments to be consistent with flood hazard and evacuation needs.
18 Storage of all chemicals and materials above the 100y ARI flood level plus freeboard.

Note: Reference to freeboard refers to an increased height of 0.5 metres.

Structural Soundness
19 Engineers report to certify that any new structure can withstand the forces of floodwater, debris and buoyancy up to and including the 100y ARI (excluding sheds <20 m^2).
20 Engineers report to certify that any new structure can withstand the forces of floodwater, debris and buoyancy up to and including the PMF.
21 Fencing to be constructed in a way, and of materials which permit flood waters to equalise on either side.
22 Development must be advised of the potential for and consequences of levee failure.

Flood Affectation
23 Development must be advised of the potential for and consequences of levee failure.
24 Engineers report required that the development will not increase flood affectation elsewhere.

Evacuation
25 Advise that SES has an evacuation plan.
26 Site to be evacuated in accordance with the SES Flood Plan.
27 Encourage the development of a Flood Plan by owner including evacuation of employees and storage of material above 100y ARI flood level plus freeboard.
28 Flood evacuation access should not to be worse than for the old dwelling being replaced.
29 Habitable developments to be sited on property to provide best possible evacuation access where access conditions allow.

Management and Design
30 A flood free area should be encouraged for all new developments.
31 Applicant for new non habitable developments to demonstrate that area is available to store goods above the 100y ARI flood level (plus freeboard).
32 No external storage of materials below the 20y ARI flood level which may cause pollution or be potentially hazardous during any flood.
33 Parts of building below the 100y flood level (plus freeboard) to be constructed from flood compatible materials.