3. POTENTIAL FLOODPLAIN MANAGEMENT MEASURES

3.1 Range of Available Measures

A variety of floodplain management measures can be implemented to reduce flood damages.

Flood modification measures change the behaviour of floods in regard to discharges and water surface levels to reduce flood risk. This can be done by the construction of levees, flood mitigation dams and channel improvements. Such measures are also known as "structural" options as they involve the construction of engineering works.

Property modification measures reduce risk to properties through appropriate land use zoning, specifying minimum floor levels for new developments, voluntary purchase of residential property in high hazard areas, or raising existing residences in the less hazardous areas. Such options are largely planning measures, as they are aimed at ensuring that the use of floodplains and the design of buildings are consistent with flood risk. Property modification measures could comprise a mix of structural and non-structural methods of damage minimisation.

Response modification measures change the response of flood affected communities to the flood risk by increasing flood awareness, by the installation of flood warning systems and the development of emergency management plans for property evacuation. These options are wholly non-structural.

3.2 Community Views

Comments on potential flood management measures were sought from the local community by way of a Questionnaire. *Question 20* in the Community Questionnaire outlined a range of potential measures. The responses are shown on **Table 3.1**, together with initial comments on the feasibility of the options, which are discussed in more detail in later sections of this chapter.

TABLE 3.1
COMMUNITY RESPONSES ON POTENTIAL FLOOD MANAGEMENT MEASURES FOR NARROMINE

Flood Management Option		Classification			Comments
			Yes	No	
a)	Construction of Permanent Levees	FM	76	5	The existing 800 m long town levee between Dandaloo Street and Manildra Street was constructed in 1950 and subsequently raised after the 1955 flood.
b)	Raising of existing Levees	FM	56	10	Although crest levels on the existing levee are above the 1% AEP flood level along most of its length, the freeboard is less than the minimum accepted value of 500 mm and an isolated section is below that flood level. The levee could be raised and extended upstream (see (c) below) as part of a scheme to exclude 1% AEP floodwaters from Narromine.
c)	Building of temporary levees during flood times by sandbagging	FM	46	16	Sandbagging has been used in previous floods to raise local low spots in the levee. This is feasible as there are several days warning time of imminent flooding at Narromine. However, a scheme comprising permanent levee works would be more desirable than having to rely on temporary works. Raising the existing levee by a modest amount (generally less than 1 m) in conjunction with upstream levee works to River Drive would achieve a 1% AEP level of protection for the town.
d)	Enlarging bridges to allow more water to flow under them	FM	30	23	The only bridge crossing of the Macquarie River is the Timbrebongie Bridge on the Eumungerie Road. This bridge does not impose a significant restriction, as major flood flows surcharge the channel and are conveyed on the floodplain.
e)	Increasing the capacity of flood mitigation storage in Burrendong Dam	FM	45	15	Burrendong Dam already has a large flood mitigation storage component amounting to 480 GL out of the total storage volume of 1,680 GL. Hydraulic studies have shown that the mitigating effect of the dam extends downstream to Narromine.
f)	Changing gate operation procedures at Burrendong Dam	FM	28	16	The gate is presently operated so as to ensure the safety of the dam is maintained against overtopping, whilst achieving the maximum practicable mitigation of downstream floods.
g)	Removal of floodplain obstructions	FM	44	8	There are no man-made obstructions in the river channel apart from the weir, a low level structure which was included in the *Narromine Flood Study, 2006*. That study demonstrated that the weir did not have a significant effect on upstream flood levels during major floods.
h)	Voluntary purchase of the most severely flood affected residences	PM	8	39	The community has a negative reaction to this option, which is often adopted to remove residential property in High Hazard areas of the floodplain. This option is reviewed in **Section 3.8.3.**

Legend: FM = Flood Modification Option PM = Property Modification Option RM = Response Modification Option

TABLE 3.1
COMMUNITY RESPONSES ON POTENTIAL FLOOD MANAGEMENT MEASURES FOR NARROMINE
(Continued)

Flood Management Option		Classification	Yes	No	Comments
i)	Raising floor levels of houses above 1% AEP flood levels	PM	19	35	The community does not favour this option. House raising is generally applicable to timber residences only, located in Low Hazard zones. This option is reviewed in **Section 3.8.4**.
j)	Flood proofing of individual properties by water proofing walls, shutters across doors, etc	PM	19	35	Individual properties may be flood proofed by diversion banks (which may adversely affect flow patterns), water proofed doors and shutters across entrances. This option was not favoured by community, but may be applicable to commercial development.
k)	Planning controls on future development in flood liable areas (minimum floor levels, controls over filling of sites, etc)	PM	54	10	Controls over development in flood prone land are strongly supported by the community. This issue is covered in the *draft Flood Policy* summarised in **Section 3.8.2** and **Appendix C**.
l)	Improvement to flood warning and emergency management procedures	RM	61	7	There is presently a flood warning system operated by BOM and SES for the Macquarie River catchment. Improvements to the system would be strongly favoured by the community.
m)	Public education, participation and flood awareness programs	RM	56	3	Promotion of awareness of the flood risk would be strongly favoured among the community. This option is reviewed in **Section 3.9.2**.
n)	Ensuring information on flood risk is available to residents and business owners	RM	58	5	The revised Narromine Flood Study, 2006 provides information on the depths of inundation of floods ranging between 1% AEP and the Extreme Flood. This information is included in **Appendix D** of this present Study.
o)	Providing a certificate to all residents stating whether their property is flood affected	RM	81	0	Provision of information on flood affection of properties is strongly favoured by the community. This is presently achieved by Council's notation on Section 149 Certificates.
p)	Ensuring residents and business owners have Flood Action Plans	RM	54	11	SES has recently published a ToolKit Manual to allow commercial and Industrial businesses to prepare individual Business Floodsafe Plans. This option is reviewed in **Section 3.9.3**.
q)	Installing flood markers (for example on telegraph poles)	RM	67	10	This option probably as part of an integrated flood awareness program combining options m) and n) above would be strongly favoured by the community.

Legend: FM = Flood Modification Option PM = Property Modification Option RM = Response Modification Option

3.3 Flood Modification Options – Levees

3.3.1 General

Levees are an effective means of protecting flood affected properties up to the chosen design flood level. In designing a levee it is necessary to take account of three important factors: potential redistribution of flood flows, the requirements for disposal of internal drainage from the protected area and the consequences of overtopping the levee in floods greater than the design event.

Levees are usually constructed of compacted soil won from local sources and carefully placed to strict engineering standards. Specifications for levees typically include the following recommendations:

- Design and construction supervision to be undertaken by a professional engineer.
- Crest width sufficient to allow the passage of vehicles.
- A freeboard for the crest level above the design flood of at least 500 mm.
- Geotechnical investigation required to determine side slopes, assess material suitability and foundation conditions.
- Spillway sections for the controlled overflow of floodwaters in the event of flooding greater than the design flood.

Reinforced concrete and concrete block walls are often used in situations where there is insufficient land available for earth banks. Such walls are provided with reinforced concrete footings of sufficient width to withstand overturning during flood events.

A major issue to consider when evaluating levee proposals, is that unless the levee is built to exclude the Extreme Flood, there will be a residual chance of its being overtopped over its life. Adoption of the Extreme Flood as the design flood is usually not feasible due to the large increase in peak flood level usually experienced compared with the lesser floods, for example the 1% AEP. At Narromine designing for the Extreme Flood, as opposed to the 1% AEP event, would require an increase in crest levels of around 1m.

When a flood smaller than the Extreme Flood is adopted for design, provision will need to be made for controlled overtopping of the crest. It is usual practice to have the downstream end of the levee set lower than the average flood gradient along its extent, so that overtopping commences at its downstream end and continues progressively upstream as river levels rise. This allows the overtopping to take place into a pool of water on the protected side of the levee and minimises the risk of erosion of its face.

Stormwater generated from the local catchment on the "protected" side of the levee must also be catered for over the duration of the flood. In the western flowing streams in NSW, flooding generally lasts for periods of several days and during that time any runoff generated locally must either be stored behind the levee for later drainage to the river as flood levels recede, disposed of by pumping over the levee, or conveyed downstream to a location where it can be discharged by gravity to the river.

A preliminary review of options for protecting Narromine by levees is given below.

3.3.2 Alternative Levee Routes

The existing levee extends upstream from west of Dandaloo Street to Manildra Street, a distance of 800 m. It generally would contain 1% AEP flooding over this extent, although it is deficient in freeboard allowance. There is a low spot in the levee which would need to be raised to exclude floodwaters from entering the town. There are also several low points in the river bank upstream of the existing levee between River Drive and Manildra Street which would also need to be raised in any levee upgrading proposal.

Two alternative routes for an upgraded levee were examined in the *Floodplain Management Study for the Macquarie River Valley* (SKM, 1983).

The first route was an extension of the existing levee by a 90 degree turn to run southwards along Manildra Street to the Mitchell Highway. This levee route would not prevent flows leaving the Macquarie River at the low points and inundating the floodplain between Crossley Drive and the Mitchell Highway. All of the developing areas to the east, i.e. upstream, of Manildra Street would be unprotected. Flows would still be conveyed beneath the Main Western Railway line via the culverts on the Town Cowal, with consequent inundation of residential development in the southern side of town. This route would not prevent damaging flooding in Narromine and is therefore, not considered viable.

The second route continues along the river bank about 4 km upstream of Manildra Street to River Drive. Upstream of Manildra Street the route would run parallel with Crossley Drive. There are several options for locating the levee along the frontage of existing residential properties in that street:

- Raise Crossley Drive to achieve the required level of protection. However, with this option, the properties on the river side of Crossley Drive would not be protected. Several of these properties have floors slightly below the 1% AEP flood level. The levee may appear to be a dam to these residents, acting to restrict the escape of flows onto the floodplain. This route has not been considered further in this assessment.

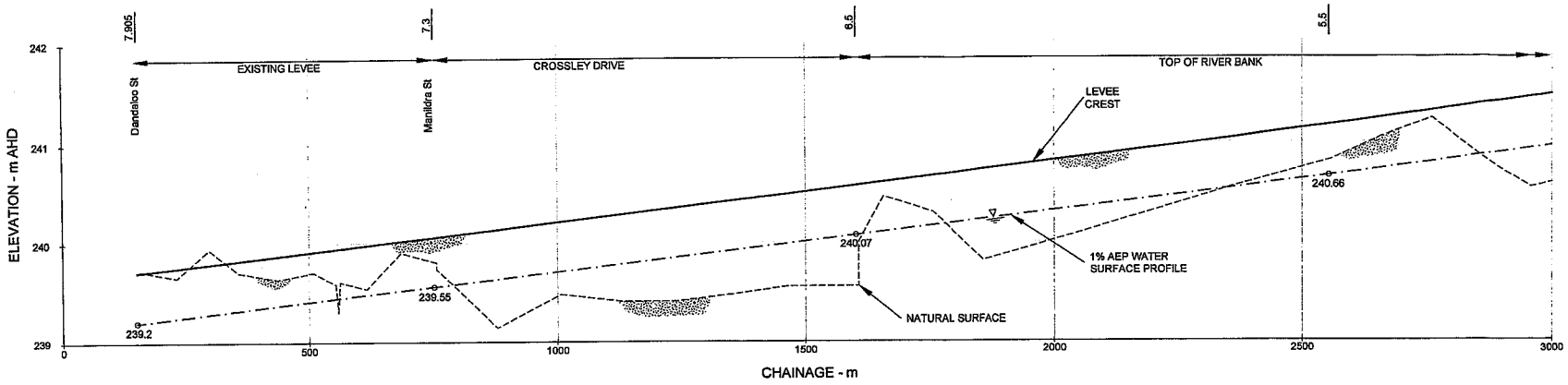
- Locate the levee on the river side of the properties fronting that street. Locating the levee on the boundary of the allotments near the river bank would require a high levee, as the land falls steeply towards the river. This would not be acceptable to residents as the levee would be very obtrusive and would also be expensive to construct. This route has not been considered further.

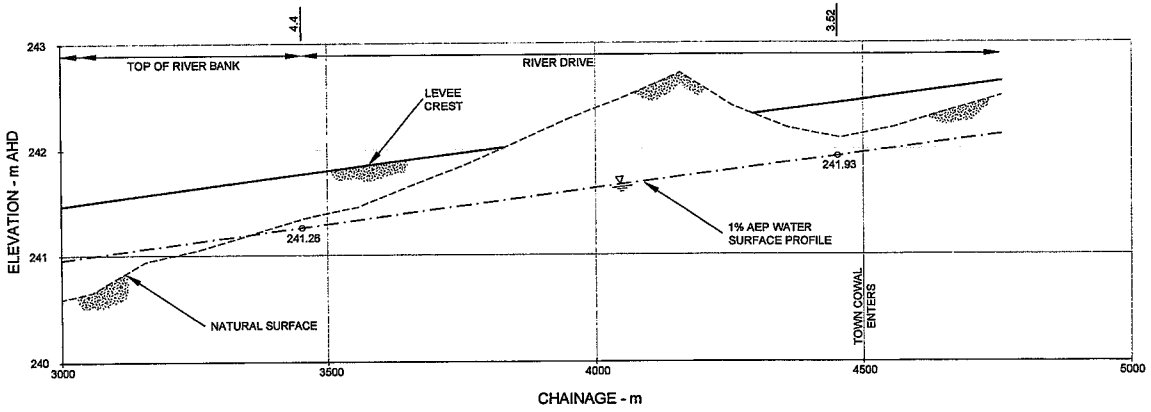
- The levee could be significantly reduced in height by locating it on the river side of the respective residences, but near the end of the building platform where natural surface levels are considerably higher than further down the river bank. This route has been adopted for further consideration below.

3.3.3 River Bank Levee

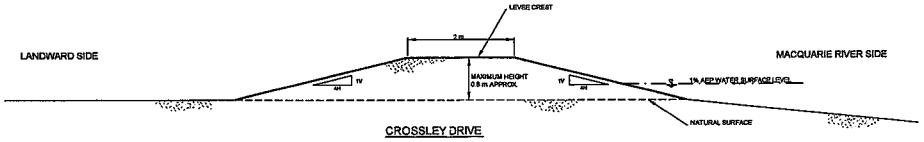
Figure 3.1 shows the potential route of the river bank levee. **Figure 3.2** is a longitudinal profile along its extent. For the purposes of this analysis it is assumed that the crest of the levee would be 500 mm above the level of the 1% AEP flood. This 500 mm of freeboard is a factor of safety which allows for wave action, uncertainties in the assessment of 1% AEP flood levels, construction tolerances and potential settlement of the levee.

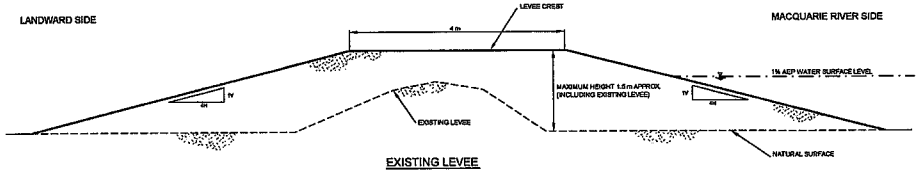
To achieve the design crest level, the existing levee would need to be raised by up to 600 mm. It has been assumed for costing purposes that the existing levee will be incorporated in the new works.

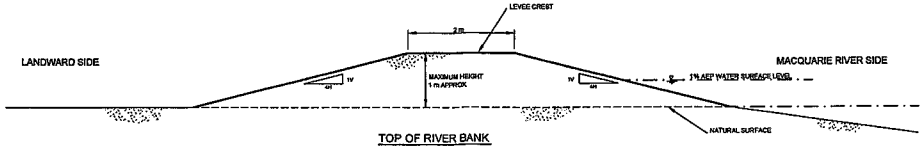




LONGITUDINAL SECTION
RIVER LEVEE







TYPICAL LEVEE CROSS SECTIONS

NARROMINE FLOODPLAIN RISK MANAGEMENT STUDY

Figure 3.2

LONGITUDINAL SECTION AND TYPICAL CROSS SECTIONS
RIVER BANK LEVEE

However, this assumption is subject to geotechnical testing at the design stage, as the engineering properties and compaction of the fill material are presently unknown.

Along the rear of the residential allotments in Crossley Drive, the height of the levee would range between 700 mm and 1 m. Although the preliminary costings were based on an earthen embankment, the footprint of the levee could be reduced by constructing it as a low block wall covered with earth and grassed. The visual effect of the levee would then be a low mounding in the backyards of the properties.

East of Crossley Drive, the route would follow the top of the river bank across rural land extending to the western end of River Drive. Survey information in this area is sparse with information on natural surface levels being confined to a line of levels taken along the estimated top of bank, together with the three cross sections of the river and floodplain incorporated in the hydraulic model of the floodplain developed for the flood studies. The maximum height of levee over the 3 km extent from the end of Crossley Drive to River Drive would be about 1 m.

Within town it would be necessary to cater for stormwater runoff from the local catchments on the "protected" side of the levee. This could be achieved by retaining the runoff in temporary storage areas pending its gravity drainage back to the river as flood levels recede. Alternatively it may be possible over the duration of the river flood to discharge stormwater runoff under gravity flow conditions along the route of the Town Cowal. This would reduce the requirements for storage of stormwater runoff. The feasibility of this latter alternative is subject to a survey which would be required as part of more detailed consideration of the levee scheme.

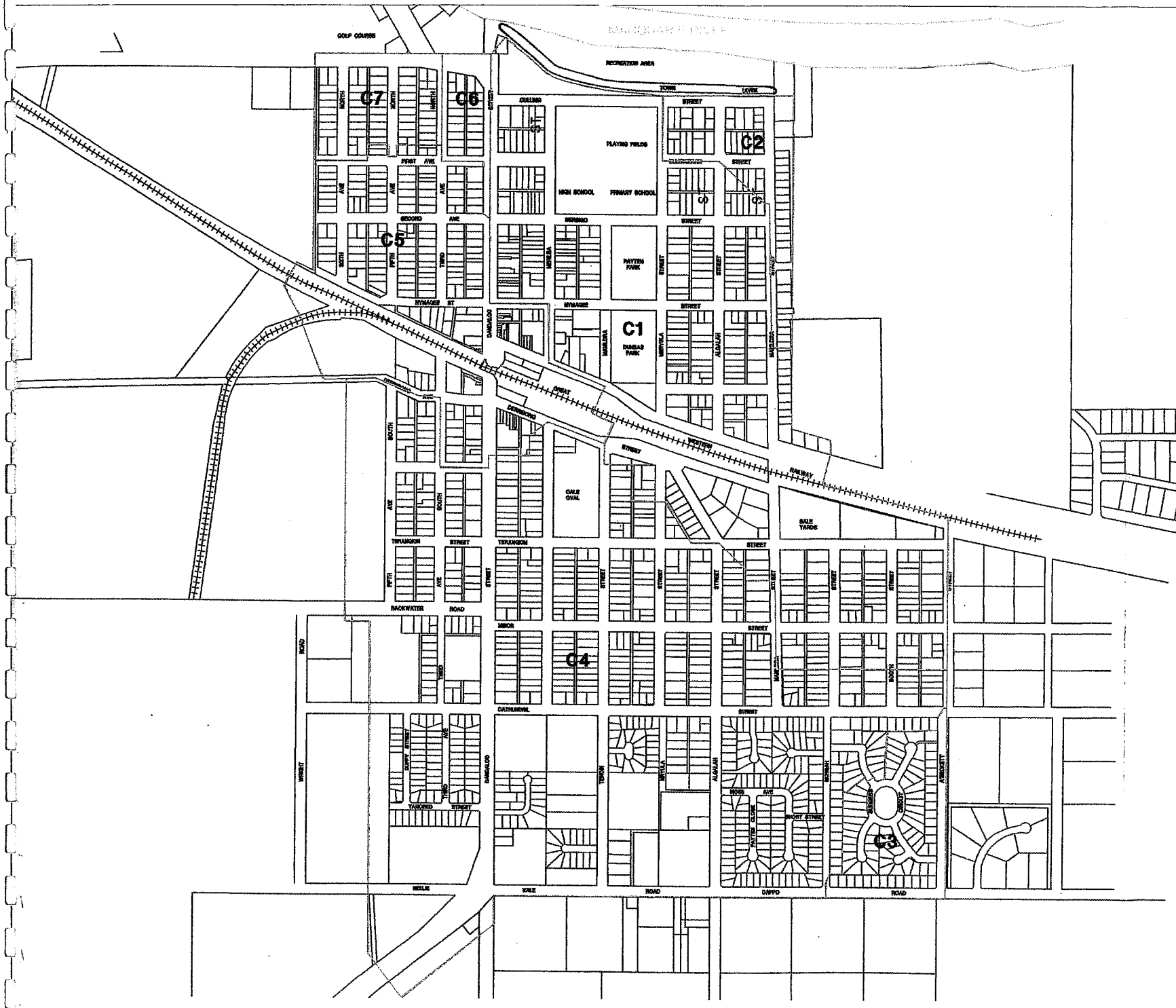
It is also possible that the levee may need to be extended west (i.e. downstream) of the commencement of the existing levee to exclude floodwaters from the Macquarie River which potentially overtop Warren Road between the intersection with the Mitchell Highway and the irrigation canal which crosses Warren Road near the bridge. Flows overtopping Warren Road from the river could flow into the downstream reach of the Town Cowal, cross the Mitchell Highway and enter the town in the vicinity of Sixth Avenue. It may be necessary to exclude floodwaters by constructing a low bank from the western end of the existing levee, along the river bank to high ground. A survey of natural surface levels along the high point of the river bank west of Dandaloo Street would be required to clarify this matter.

3.3.4 Provisions for Internal Drainage

The provision of facilities for the temporary detention and release of runoff from the protected areas of town whilst river levels are maintained is an important issue in planning for the levee. During major floods, river levels will be maintained near their peak level for a period of up to 5 days. The internal stormwater system will need to be capable of storing runoff from local storm events which occur over this duration.

The following discussion is an introduction to potential storage requirements assuming that gravity discharge of local runoff via the Town Cowal is not possible and it would be necessary to provide a dedicated storage area between the levee and the urban area of town.

The existing stormwater drainage system of Narromine comprises seven major sub-catchments shown on **Figure 3.3** (PPK Consultants Pty Ltd, 1994). The individual sub-catchments and their directions of discharge are summarised in **Table 3.2**. Four sub-catchments, C1, C2, C6 and C7, drain northwards and discharge via pipelines to the Macquarie River in the north, while the remaining sub-catchments discharge either to the town common in the south west sector of town or via open channels to the surrounding countryside.



LEGEND

	CATCHMENT BOUNDARY
C1	NORTHERN (CULLING St)
C2	NORTHERN (MANILDRA St)
C3	EASTERN (CATHUNDARL St)
C4	SOUTHERN (TOWN COMMON)
C5	WESTERN (NYMAGEE St)
C6	NORTHERN (DANDALOO St)
C7	NORTHERN (GOLF COURSE)

Taken from
Narromine Drainage Study, 1994

NARROMINE FLOODPLAIN RISK MANAGEMENT STUDY

Figure 3.2

EXISTING SUBCATCHMENT BOUNDARIES

Runoff collected in the street gutters flows via gravity into open channels which in turn discharge to open country to the east of the town and to the town common in the south. In the northern catchments, the street gutters flow to a number of large diameter pipelines which in turn discharge to the Macquarie River.

Runoff is conveyed across major roadways via short sections of underground pipelines or box culverts. On some of the minor roads raised box culverts with their invert levels set to existing street gutter levels have been constructed.

The majority of the local drainage problems associated with these catchments are due to the capacity of the street gutters and road crossings being exceeded in the lower areas of the sub-catchments. This is mainly due to the lack of underground stormwater drainage pipelines and kerb inlet pits, particularly in the commercial areas of the town.

When the capacity of the street gutters is exceeded, the runoff tends to collect and pond in natural low points within the town such as Payton and Dundas Parks and adjacent to the school located at the corner of Derribong and Manildra Streets (immediately south of the railway line).

For initial planning it was assumed that the lines on the existing stormwater systems discharging to the Macquarie River will be flap gated to prevent backflooding of protected areas. Assuming that runoff would need to be stored for up to 48 hours prior to gravity release to the river, a total volume of runoff of about 50,000 m^3 would need to be stored if, say, a 5% AEP local storm occurred in conjunction with a 1% AEP river flood. As there appears to be insufficient room available on the town side of the levee for the storage of that volume of runoff, it may be necessary to direct stormwater flows westwards to a location where gravity discharge to the river or floodplain is feasible.

As part of progressing the concept design for the levee, survey will be required to assess the volume available for the temporary storage of runoff. It will also be necessary to confirm the hydraulic gradient available for the conveyance of runoff generated by the local stormwater catchments as overland flow around the western side of town via the Town Cowal.

TABLE 3.2
SUMMARY OF LOCAL STORMWATER SUB-CATCHMENTS

Sub-Catchment Number	Sub-Catchment Description	Development Type	Discharge Outlet Location	Outlet Description	Sub-Catchment Area (ha)
1	Northern (Culling St)	Residential, Business, Commercial, School	Culling Street to Macquarie River.	825 mm pipeline	83.8
2	Northern (Manildra St)	Residential	Manildra Street to Macquarie River	825 mm pipeline	10.8
3	Eastern (Cathundril St)	Residential	Cathundril Street to Open Country	Open Channel	9.2
4	Southern (Town Common)	Residential, Hospital	Nellie Vale Road to Town Common at South Western sector of town.	Open Channel	142.7
5	Western (Nymagee St)	Residential	Nymagee Street to Open Country	825 mm pipeline	40.0
6	Northern (Dandaloo St)	Residential	Dandaloo Street to Macquarie River	2000 x 300 mm box culvert	4.2
7	Northern (Golf Course)	Residential	Trangie Road to Macquarie River	1200 x 300 mm box culvert	7.2

3.3.5 Economic Analysis of River Bank Levee

Table 3.3 gives an indicative cost of the levee and **Table 3.4** is a preliminary economic assessment. The levee has a 1% AEP design standard and would therefore prevent damages for floods ups to that magnitude. The present worth values of those damages therefore become the economic benefits of the scheme. The economic analysis has been undertaken for the three discount rates nominated by NSW Treasury Guidelines and a 20 year economic design life.

TABLE 3.3
INDICATIVE COST OF RIVER BANK LEVEE
1% AEP DESIGN STANDARD

Item	Cost $
Land Acquisition/Easements	125,000
Preliminaries (Establishment, Geotechnical Testing, Sediment Control)	35,000
Clear and Grub Foundation	80,000
Strip and Store Topsoil for later re-use	50,000
Supply, Place and Compact Fill	600,000
Place topsoil on levee faces; spray, seed, hydromulch.	210,000
Provide drainage from local catchments behind levee	50,000
Contingencies 25%	300,000
Survey, Investigation, Detail Design and Community Consultation	150,000
Total Estimated Cost	**1,600,000**

TABLE 3.4
ECONOMIC ANALYSIS OF
LEVEE SCHEME FOR NARROMINE
1% AEP DESIGN STANDARD

Discount Rate %	4	7	10
Present Worth Value of Benefits (Damages Prevented) $ x 10^6	2.9	2.2	1.8
Cost of Scheme $ x 10^6	1.6	1.6	1.6
Benefit/Cost Ratio	1.8	1.4	1.1

3.3.6 Refining the Levee Concept

The development of flood management concepts outlined in this report is necessarily constrained by budget and data limitations, as the study is of a strategic nature. The main objective of the benefit/cost analyses described in this Chapter of the report was to determine an economic priority for projects, rather than determine their final costs. Further investigation of the levee concept, with the benefit of additional survey data along its route would be required to prepare a preliminary design. The benefit/cost analysis would also need to be refined before the feasibility of the project could be confirmed.

A feasibility study of the levee has been included as a project in the draft *Floodplain Risk Management Plan*. The study activities would include survey, engineering analysis and community consultation. An outline of the scope of work required for the study and preparation of a submission for Government funding is given below:

- Survey: Preparation of cross sections normal to the line of the levee to confirm the location of the top of river bank; determine top of river bank levels downstream of Dandaloo Street; as well as invert levels of the Town Cowal to the west of Dandaloo Street.
- Engineering Analysis: Preparation of Levee profiles and cross sections; assess requirements for disposal of local stormwater drainage; refine costs and benefits. Prepare submission for Govt. Funding.
- Community Consultation: Presentation of levee proposal to residents (particularly in Crossley Drive area.)

3.4 Increase Hydraulic Capacity of Culvert at Parkes Narromine Railway

As noted in the *Narromine Flood Study, 2006*, reductions in flood levels in the ponding area on the eastern side of the Parkes Narromine Railway could be achieved by increasing the hydraulic capacity of the culverts, which presently comprise twin 600 mm diameter Armco pipes. These pipes do not have sufficient capacity to carry flood flows, resulting in a backwater forming upstream of the railway embankment. The area affected by ponding includes the potential development area on the eastern side of the embankment, as well as existing residential areas extending to Manildra Street, where damaging flooding would be expected in the event of a 1% AEP flood.

Improvements in the hydraulic capacity of the culverts at their present location would increase the peak discharge in the existing drainage line on its downstream side between the railway and Town Cowal. The impacts of the works on urban development on the western side of the railway would need to be evaluated, as flood levels may be increased in the drainage line. To mitigate this impact, it would be advisable to locate several new culverts spaced along the line of the railway embankment and discharging to un-developed areas.

There is insufficient survey available to undertake a detailed assessment of this project. For the purposes of the study an indicative costing has been prepared assuming improvements in culvert capacity from the

present capacity of 1.5 m^3/s to 23 m^3/s, sufficient to convey the 1% AEP flow without surcharging the railway embankment. A total of four waterway openings in the embankment has been provided, giving a total width of opening of 24 m. An allowance has also been made for channel improvements to direct overland flow to the new culverts.

Table 3.5 shows indicative costs and benefits of the culvert improvement scheme. The scheme may not be required to reduce damages to existing residential property in Cathundril Street and surrounding streets arising from breakouts from the Macquarie River if the river bank levee scheme outlined in the previous section were implemented. With the river levee in place, flows on the Town Cowal generated from breakouts of the river between Manildra Street and River Drive would be eliminated for floods up to the design standard of the levee.

However, improvements in culvert capacity may still be required if development in the open space area to the east of the Parkes Narromine Railway embankment were to proceed. This area is located on low ground and may be vulnerable to flooding derived from overflows of the drainage systems of the local stormwater catchments in the south – west sector of town, or backwater flooding from the Parkes Narromine Railway arising as a result of blockage of the existing culverts.

TABLE 3.5
ECONOMIC ANALYSIS
INCREASED HYDRAULIC CAPACITY AT CULVERTS
IN PARKES NARROMINE RAILWAY
1% AEP DESIGN STANDARD

Discount Rate %	4	7	10
Present Worth Value of Benefits (Damages Prevented) $ x 10^6	1.3	1.0	0.8
Cost of Scheme $ x 10^6	0.88	0.88	0.88
Benefit/Cost Ratio	1.4	1.1	0.9

A feasibility study of the culvert improvement scheme has been included as a project in the proposed Floodplain Risk Management Plan. The study activities would be similar to the levee scheme, requiring survey, engineering analysis and community consultation. An outline of the scope of work required to prepare a submission for Government funding is given below:

➢ Survey:	Preparation of creek cross sections and property levels on the downstream side of the culverts; determine top of rail levels; determine natural surface levels along prospective overland flow route from Cathundril Street to culvert entrance.
➢ Engineering Analysis	Preparation of hydraulic model of overland flow route, culvert and downstream channel; assess requirements for culverts and resulting flood levels; confirm no adverse impacts to property on the downstream side of railway line; refine costs and benefits.
➢ Community Consultation	Presentation of culvert improvement scheme proposal to residents (particularly on downstream side of railway line)

Should development to the east of the railway proceed in the near future, it would be appropriate for Council to seek a contribution from the developer to fund the feasibility study. A Flood Study of the area would be required in any case before the development were allowed to proceed.

3.5 Removal of Bank of Irrigation Canal on Western Side of Narromine

The irrigation canal is located on the western side of the golf course and runs in a southerly direction from the river towards the Mitchell Highway (**Figure 2.4**). The banking on both sides of the canal reaches elevations between 1.5 and 2 m above natural surface level.

From site inspection it appeared that the banking may block flows travelling downstream on the floodplain and may result in a backwater effect in town. However, hydraulic modelling showed that there would be no significant reductions in flood levels in town if the banking were removed.

The modelling showed that there was sufficient conveyance capacity available in the existing Town Cowal branch for the escape of flows and that flood levels in the Aerodrome area would be marginally increased by removing the banking.

Accordingly removal of the banking is not required and has not been recommended in this study.

3.6 Channel Improvements

The hydraulic capacity of a river may be increased by widening, deepening or straightening the channel and by clearing the banks of obstructions. The scope of such improvements can vary from minor works such as de-snagging and bank clearing, which do not increase the waterway area but reduce hydraulic roughness to major channel excavations.

Careful attention to design is required to ensure stability of the channel is maintained and scour or sediment build up is minimised. A degree of sinuosity is often provided in the channel route for these and aesthetic reasons. The potential for channel improvements to increase downstream flood peaks also needs to be considered. In general, channel improvements need to be carried out over a substantial stream length to have any significant effect on flood levels.

The existing channel of the Macquarie River is a deeply incised channel with a large hydraulic capacity. It is capable of containing flows up to the 2% AEP level without significant overbank flows.

The hydraulic model used in the *Narromine Flood Study, 2006* assigned values of hydraulic roughness of around 0.05. These values are characteristic of a hydraulically efficient channel which would not be significantly improved by stream clearing, which in any case would require a continuing program of maintenance to remain effective. Efforts at increasing channel capacity whether by clearing and removal of woody debris, or channel enlargement would not be supported by the Catchment Management Authority for environmental reasons.

Whilst significant stream clearing is not warranted, Council should consider being pro-active in managing vegetation along the banks of the Macquarie River to maintain recreation and habitat values and ensure that hydraulic capacity is maintained:

- The vegetation along the riverine corridor should be managed to maintain hydraulic conveyance capacity. Invasion of exotic trees such as willows and shrubby vegetation on the higher banks would increase the hydraulic roughness compared to the original riverine vegetation. Whilst the effect of invasive exotic species is unlikely to have a major effect because of the size of the channel, maintenance of hydraulic capacity should be an important consideration in the future management of this area.

- The riverine corridor provides a natural pathway for the movement of native animals and birds through the urban area. Enhancement of the habitat value would also provide a haven and encourage native bird populations within the town. The Macquarie River corridor appears to have retained some of its original vegetation which could form a basis for reintroduction of a wider diversity of native plants to the area.

3.7 Flood Mitigation Storage in Burrendong Dam

Figure B4.1 of **Appendix B** shows the pre-dam and post-dam probability distributions of flood peaks at Narromine. These data were prepared from the results of the analysis of peak discharges at Narromine for the periods 1909 – 1964 (pre-dam) and 1966 – 1998 (post-dam).

These results show that on a long term basis, the dam results in a considerable reduction in flood impacts even as far downstream as Narromine. For example, a peak flood level of RL 239.1 m under present day conditions has an annual chance of exceedance of 0.5% (**Figure 2.3**). However, prior to construction of the dam, this level, which approximates the peak of the February 1955 flood, had an annual probability of exceedance of 1%. That is, it was a much more frequent event.

The 1% AEP flood under present day conditions would reach a level of RL 238.7 m. By definition, this flood has an annual chance of exceedance of 1%. The analysis presented in **Appendix A** predicted damages at Narromine for that flood, would be of the order of $ 44 Million. Prior to construction of the dam, a peak of this magnitude would have a 2% annual probability of exceedance.

The above data indicate that the dam has halved the annual probability of exceedance of major floods. It may be possible to achieve further reductions in the probability of major flooding downstream of the dam by increasing the storage devoted to flood mitigation, but this would be at the expense of the water conservation storage component.

Since construction of the dam in 1965, large scale irrigation development has taken place in the Macquarie Valley in response to the resulting increased security of water supply. Although there would be increased flood mitigation benefits if the flood mitigation component were increased, the reduction in the volume of regulated flow available for irrigation may result in an adverse impact on the overall economic performance of the dam. Optimisation of the water conservation versus flood mitigation roles of the storage is, however, outside the scope of this present investigation.

3.8 Property Modification Measures

3.8.1 Considerations for Setting Flood Planning Level

Flood Planning Level – Selection of the Flood Planning Level (FPL) for an area is an important and fundamental decision as the standard is the reference point for the preparation of floodplain management plans. It is based on adoption of the peak level reached by a particular flood with an appropriate allowance for freeboard. It involves balancing social, economic and ecological considerations against the consequences of flooding, with a view to minimising the potential for property damage and the risk to life and limb. If the adopted FPL is too low, new development in areas above the FPL (particularly where the difference in level is not great) may be inundated relatively frequently and damage to associated public services will be greater. Alternatively, adoption of an excessively high flood planning level will subject land that is rarely flooded to unwarranted controls.

In the Narromine floodplain, there are a number of land use classes which need to be considered in terms of setting appropriate flood planning levels (FPL's):

- Residential
- Commercial and industrial
- Essential community facilities, critical utilities (electricity, water supply and sewage treatment facilities) and special uses which require special consideration, such as schools, hospitals, retirement and nursing homes.

Councils are responsible for determining the appropriate FPL's within their local government area. Whilst the flood used to determine the residential FPL is a decision of the Council, the *Floodplain Development Manual, 2005* highlights that FPL's for typical residential development would generally be based around the 1% AEP flood, plus an appropriate freeboard (typically 500 mm).

The Circular issued by the Department of Planning on 31 January 2007 contained a package of changes concerning flood related development controls on land above the 1 in 100 year flood and up to the Probable Maximum Flood. The package included an amendment to the Environmental Planning and Assessment Regulation 2000 in relation to the questions about flooding to be answered in Section 149 planning certificates, a revised ministerial direction (Direction 15) regarding flood prone land (issued under Section 117 of the EP&A Act, 1979) and a new Guideline concerning flood-related development controls in low flood risk areas.

The Circular advised that Councils will need to follow both the *Floodplain Development Manual, 2005* as well as the Guideline to gain the legal protection given by Section 733 of the Local Government Act.

The Department of Planning Guideline confirmed that unless exceptional circumstances applied, Councils should adopt the 1% AEP flood with appropriate freeboard as the FPL for residential development. In proposing a case for exceptional circumstances, a Council would need to demonstrate that a different FPL was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood.

Unless there were exceptional circumstances, Council should not impose flood-related development controls on residential development on land with a low probability of flooding, that is land above the residential FPL (denoted low flood risk areas in the Guideline).

Nevertheless, the safety of people and associated emergency response management needs to be considered in low flood risk areas, which may result in:

- Restrictions on types of development which are particularly vulnerable to emergency response, for example, developments for aged care.
- Restrictions on critical emergency response and recovery facilities and infrastructure. These aim to ensure that these facilities and the infrastructure can fulfil their emergency response and recovery functions during and after a flood event. Examples include evacuation centres and routes, hospitals and major utility facilities.

Consideration of the data on flooding patterns and the economic impacts of flooding supports retaining the 1% AEP flood (with freeboard) for setting the FPL of residential development in Narromine. For commercial and industrial development a lower FPL could be adopted, with the provision of a "mezzanine area" at a higher level for the temporary storage of goods. For essential services and uses requiring special consideration as identified above, a higher FPL should be adopted.

3.8.2 Outline of draft Flood Policy

Features of the proposed *Flood Policy* for Narromine, as set out in **Appendix C** are outlined below:

The floodplain, or extent of flood prone land, has been defined as the area inundated by the Extreme Flood, which is a flood with a peak discharge equal to three times the 1% AEP peak. The flood prone land has been divided into six flood risk precincts using the depth and flow velocity data derived in the *Narromine Flood Study, 2006* and subsequent hydraulic studies outlined in **Section 2.7**. The extents of the precincts, shown on **Figure 5.2,** have been identified using existing sources of survey data (see **Note D** below). The precincts are:

- The *"Macquarie River Floodway"*. This is the area conveying most of the flow in the Macquarie River in the event of a 1% AEP flood. The Flood Policy does not permit development in this area.

  The "*Town Cowal Floodway*" was zoned as a floodway in the Narromine LEP, 1997, but as noted in **Section 2.4** of this report under *Item 7,* may have been defined on imprecise survey data. **Section 2.7** identified the extent of the floodway in a hydraulic sense using existing sources of survey data. (The hydraulic floodway is the area where significant flow velocities would be expected at the 1% AEP flood and which should be kept clear of future development). It is suggested that when assessing developments, Council adopt the dashed lines as representing the extent of the floodway and therefore the limit of encroachment. In the future upgrading of the LEP, the dashed lines could be revised using any additional survey data available and should then replace the presently zoned "*Town Cowal Floodway*".

- The "*Manildra Street/River Drive Precinct*" is the area on the southern floodplain between the river and the Mitchell Highway. This Precinct includes two flow paths which act as conveyances for floodwaters breaking out from the low points in the river bank between Manildra Street and River Drive. Some of the flow travels eastwards to Manildra Street via the Manildra Floodway flow path and the remainder is conveyed via the Town Cowal through the railway culverts to the southern side of town. These flow paths are shown dashed on **Figure 5.2**. Based on depth and velocity criteria and interpretation of available survey, these flow paths are low hazard zones even though they convey significant rates of flow. **Note A** provides further commentary on proposed development controls.

- The "*High Hazard Ponding Area*" is the precinct on the eastern side of the Parkes Narromine railway embankment. There are sparse data on natural surface levels available in this area. However, on the basis of available information it appears that although flow velocities would be low, peak depths of inundation in excess of 1 m would be expected in the event of the 1% AEP flood. In this area in-fill residential development would be permitted, subject to minimum floor level requirements (1% AEP flood level plus 500 mm freeboard). However, prior to consideration of any sub-division development proposal, Council would require the applicant to demonstrate that the area could be developed without an increase in the overall flood risk to the population. As a minimum, Council would require a site survey and a Flood Study of the area, which would specifically consider the potential backwater effects resulting from surcharge of culverts in the Parkes – Narromine Railway embankment and incorporate suitable measures to mitigate any resulting flood affectation.

- The "*Intermediate Floodplain*" is the remaining land inundated by the 1% AEP flood and not falling in the above categories of flood prone land. Within this land, there would only be the requirement for minimum residential floor levels to be set at 1% AEP flood levels plus 500 mm. All land uses would be permitted in this zone. Refer **Note B** and **Note C** for requirements of other classes of development.

- The "*Outer Floodplain*" is the remainder of the floodplain between the 1% AEP flood extent and the Extreme Flood. In this area the same controls would apply over minimum floor levels as for the *Intermediate Floodplain*. The purpose of the *Outer Floodplain* would mainly be to define the potential flooded area, i.e. the extent of the "Floodplain".

Note A. Assessing Developments in "*Manildra Street/River Drive Precinct*"

Two residential sub-divisions have been approved in this area, with minimum floor levels equal to the 1% AEP flood plus 500 mm freeboard (based on *Narromine Flood Study, 2006*). In order to maintain a flow path for the conveyance of floodwaters within the confines of the dashed lines representing the Manildra Floodway, residences should be set on individual fill platforms extending over the footprint of the building, with the balance of the allotment remaining at existing natural surface level.

Alternatively, (and more desirably) the buildings could be constructed on piers with the area beneath left open for the conveyance of flow. No more than 50 per cent of the width of the allotment normal to the general east to west direction of flow across the sub-divisions should be developed so that it obstructs the flow. There should also be controls on inter-allotment fences. "Impermeable" fences should not be permitted as they would tend to block the flow and may adversely re-direct it to adjacent areas, or be subject to sudden failure due to the build up of water on the upstream side.

Note B. Assessing Commercial and Industrial Development Proposals

Most of the commercial and industrial development in Narromine is located in the "*Intermediate Floodplain,*" with an industrial area in the southern portion of the "*Manildra Street/River Drive Precinct*" in a location where flooding is of a ponding nature. Data presented in **Appendix A** (ref. **Figure A4.1**) shows that the median depth of above-floor inundation of existing properties in the event of a 1% AEP flood would be 200 mm. The maximum depth of flooding would be 900 mm.

The policy recommends the same FPL as for residential development (i.e. minimum floor levels set at the 1% AEP flood level plus 500 mm). However, where it is not practicable to achieve this level, Council may approve a lesser level commensurate with the local streetscape. However, in this eventuality, the applicant is to provide an area within the development for the temporary storage of goods at a minimum level equal to the 1% AEP flood plus 500 mm of freeboard. This area should be the larger of 20 % of the gross floor area, or 20 m^2.

Note C. Developments Requiring a Higher Level of Protection

Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential Development (which include nursing homes, aged care facilities and the like) require a higher degree of protection to reduce the risk to individuals and, in the case of essential infrastructure, to ensure that they are capable of continuing to function during major flooding.

The present Flood Policy of 2005 nominates a minimum floor level equal to the 0.5% AEP flood level for this category of development (but without a freeboard allowance). The *Narromine Flood Study, 2006* showed that on the southern side of town the 0.5% AEP flood level is less than 500 mm above the 1% AEP level. Therefore, unless a freeboard allowance were incorporated, the floor levels of this category of development could be lower than the residential FPL at that location.

The draft *Flood Policy* adopts the 0.5% AEP flood level plus 500 mm as the FPL for Essential Community Facilities and Critical Utilities and for these classes of development to be designed to be able to continue to function in the event of an Extreme Flood.

The policy recommends the same FPL for Flood Vulnerable Residential Development (i.e. minimum floor levels set at the 0.5% AEP flood level plus 500 mm). However, where it is not practicable to achieve this level, Council may approve a lesser level commensurate with local site conditions. However, in this eventuality, the applicant is to ensure that valuable equipment necessary for the operation of the facility is located at or above the recommended FPL, either permanently or via relocation to a temporary storage area of an area suitable for this purpose.

Note D. Limitations of Currently Available Survey for Presenting Flood Data

The survey available to construct the maps showing flood related information in this study and the *Narromine Flood Study*, 2006 are based on 2 m contour survey, plus isolated cross sections of the floodplain and some private surveys of parcels of land. The maps are therefore to be used as "indicators" as to whether land may be subject to flood related controls, with actual site survey accompanying development proposals to confirm the flood affectation of individual allotments and their location within the flood risk precinct system.

As directed by the Department of Planning in the Guideline of 31 January 2007, notification on S149 Certificates that properties are subject to flood related development controls should only apply for land

lying within the extent of the respective Flood Planning Levels (FPL's) for the various categories of land use. Unfortunately, the indicative nature of the flood mapping available to Council does not presently allow the extents of the FPL's to be defined with confidence and as a consequence it is possible that some properties near the flood fringe may be incorrectly identified as floodprone on S149 Certificates. This situation could be rectified by carrying out aerial mapping of the town which would allow definition of natural surface levels to 100 – 150 mm accuracy.

3.8.3 Voluntary Purchase of Flood Prone Residential Property

This flood management measure involves the purchase of properties by Council for subsequent rezoning for more appropriate land use. These properties which are usually located in high hazard areas would be purchased at an equitable price and only where voluntarily offered. Where a property is considered to qualify for a voluntary purchase (VP) scheme the owner is notified that the body controlling the scheme (the Council in the case of Narromine) is prepared to purchase the property when the owner is ready to sell. There is no compulsion whatsoever to sell at any time. The price is determined by independent valuers and the Valuer General, and by negotiation between Council and the owners. Valuations are based on equivalent properties that are not affected by flooding.

It would be expected that the properties subject to the greatest inundation would be the most likely to be incorporated in a voluntary purchase scheme. In the event of a 1% AEP flood, there would be about 26 properties that would be subject to above floor inundation of 1.0 m or more, with a maximum depth of inundation of 1.2 m in the low-lying area on the southern side of town in the Fifth Avenue area, which lies within the backwater influence of the Parkes Narromine Railway embankment. No properties in this area or other areas in Narromine would be flooded in the event of a 2% AEP flood.

Individual valuations have not been carried out but, on the assumption of an average market price of $300,000, the capital cost of a voluntary purchase scheme could amount to $7.8 million. The benefits of a voluntary purchase scheme are represented by the long-term average annual damages in the affected properties brought back to a present worth value using an appropriate discount rate. **Table 3.6** shows the economic analysis. The benefit:cost ratio would only amount to 0.025 for a 7% discount rate and is therefore not economically justifiable on a scheme-wide basis.

It must be recognised however, that the principal objective of a VP scheme is to remove residents located in the most dangerous and frequently flooded areas of the floodplain. Consequently, there could theoretically be properties in flood prone areas that would qualify for VP on the grounds of public safety, even though they would not qualify on strictly economic grounds. In the case of Narromine, although there are residential properties located in a nominally high hazard zone on the basis of depth of inundation for the 1% AEP flood, the long warning time available and the fact that there are no difficulties likely to be experienced regarding evacuation, mean that there are no public safety grounds for initiating a VP scheme. The measure was also not favoured by the Community (**Table 3.1**).

Accordingly a VP scheme is not recommended as a flood management measure for Narromine.

TABLE 3.6
ECONOMIC ANALYSIS OF VOLUNTARY PURCHASE SCHEME FOR NARROMINE

Discount Rate %	4	7	10
Present Worth Value of Benefits (Damages Prevented) $ x 10^6	0.3	0.23	0.19
Cost of Scheme $ x 10^6	7.8	7.8	7.8
Benefit/Cost Ratio	0.04	0.03	0.02

3.8.4 Flood Proofing by House Raising

This term refers to procedures undertaken, usually on a property by property basis, to protect structures from damage by floodwaters. The most common process is to raise the affected house by a convenient amount so that the floor level is at or above the FPL. For weatherboard and similar buildings this can be achieved by jacking up the house, constructing new supports, stairways and balconies and reconnecting services. Alternatively, where the house contains high ceilings, floor levels can be raised within rooms without actually raising the house. It is usually not practical to raise brick or masonry houses.
Most of the costs associated with this measure relate to the dis-connection and re-connection of services. Accordingly, houses may be raised a considerable elevation without incurring large incremental costs.

The State and Federal Governments have agreed that flood mitigation funds will be available for house raising, subject to the same economic evaluation and subsidy arrangements that apply to other structural and non-structural flood mitigation measures.

In accepting schemes for eligibility, the Government has laid down the following conditions:

- House raising should be part of an adopted Floodplain Management Plan
- The scheme should be administered by the local authority.

The Government also requires that Councils carry out ongoing monitoring in areas where subsidised voluntary house raising has occurred to ensure that redevelopment does not occur to re-establish habitable areas below the design floor level. In addition, it is expected that Councils will provide documentation during the conveyancing process so that subsequent owners are made aware of restrictions on development below the design floor level.

Council's principal role in subsidised voluntary house raising would be to:

- Define a habitable floor level, which it will have already done in exercising controls over new house building in the area

- Guarantee a payment to the builder after satisfactory completion of the agreed work
- Monitor the area of voluntary house raising to ensure that redevelopment does not occur to re-establish habitable areas below the design floor level

However, assuming that it was feasible to raise half the 26 residences inundated by 1 m or more at the 1% AEP level of flooding and the cost per raising above the extreme flood level was $50,000, the total cost would be $650,000. **Table 3.7** shows the economics of the scheme.

Clearly, house raising is not an economically viable flood management measure at Narromine and for the reasons stated previously, could not be justified on grounds of increasing public safety. This strategy is also not favoured by the Community (**Table 3.1**) and has not been considered further.

TABLE 3.7
ECONOMIC ANALYSIS OF HOUSE RAISING SCHEME FOR NARROMINE

Discount Rate %	4	7	10
Present Worth Value of Benefits (Damages Saved) $ x 10^6	0.145	0.115	0.092
Cost of Scheme $ x 10^6	0.65	0.65	0.65
Benefit/Cost Ratio	0.22	0.18	0.14

3.9 Flood Response Modification Measures

3.9.1 Flood Forecasting, Warning and Evacuation Planning

Flood forecasting and warning can be an effective flood management measure if there is sufficient warning time for the community to react to the warning. An effective flood warning system has three key components, i.e. a flood forecasting system, a flood warning broadcast system and an evacuation plan. A system has been implemented by BOM which monitors meteorologic conditions and is also capable of predicting flood behaviour in real time during intense storm conditions. It forms the first stage of the flood warning/emergency response system for the Macquarie River catchment.

From the information on flooding characteristics presented in **Section 2.4**, the flood response to major storms on the Macquarie River catchment is expected to be up to a week (i.e. from the occurrence of the peak rainfall to the occurrence of the peak discharge in the lower reaches of the Macquarie River).

Response to flood warnings by SES and police follows procedures set out in the *Narromine Local Flood Plan, 2007*. The *Plan* was prepared by the Narromine Local Emergency Management Committee in accordance with the State Emergency Management Act and incorporates the results of the *Narromine Flood Study, 2006*. The plan aims to ensure co-ordinated and efficient management of the prevention, preparation of response and recovery arrangements for emergencies within the Narromine area.

The SES should review and if necessary update their emergency management procedures based on the information contained in this present study in regard to extents of inundation and flooded properties (in particular the information on the locations of flooded properties shown on **Figure 2.7** and in data supplied to Council).

3.9.2 Public Awareness

Community awareness and appreciation of the existing flood hazards in the floodplain would promote proper land use and development in flood affected areas. A well informed community would be more receptive to requirements for flood proofing of buildings and general building and development controls imposed by Council.

One aspect of a community's preparedness for flooding is the "flood awareness" of individuals. This includes awareness of the flood threat in their area and how to protect themselves against it. It is fair to assume that the level of awareness drops as individuals' memories of previous experience dim with time.

Means by which community awareness of flood risks can be maintained or may be increased include:

1. Permanent marks in the area showing the levels reached by previous floods (eg. the 1955 flood).
2. Teaching about floods in schools.
3. Sending out regular information with rates notices. The information contained in this Study and Plan could be edited and used for this purpose.
4. Displays at Council offices using the above information.
5. Educational videos and photographs of historic flooding in the area.
6. Talks by SES officers with participation by Council and longstanding residents with first hand experience of flooding in the area.

The benefits of a regular flood-preparedness campaign would extend to more than just reducing monetary losses. The campaign would also have social benefits by improving people's feeling of control, since they would have a better idea of how to respond to a flood emergency. However, given the lack of significant flooding in the area since the last major floods in 1955 and 1990, it may be difficult to generate the interest and co-operation required. These difficulties will need to be considered in planning any public awareness exercise.

3.9.3 Business Floodsafe Plans

SES has recently published a Toolkit manual to allow commercial and industrial businesses to prepare a *Business Floodsafe Plan* based on their individual risk. These Plans are intended to assist commercial and businesses reduce the risks of flooding to people, property and profits. The Plans would incorporate information on:

- The frequency and nature of the flood risk.
- What steps to take in advance of flooding to minimise risk.
- Developing procedures for lifting and evacuating goods and property.

Following acceptance of this *Floodplain Risk Management Study* and *draft Plan*, it would be appropriate for Council and SES to inform owners of the risk and for SES to introduce the Toolkit at seminars with the business community.

3.10 Summary

This Chapter has reviewed a number of potential floodplain management measures which are summarised on **Table 3.8**. The review supports the feasibility of:

- Planning and Building Controls, as set out in the form of a draft *Narromine Flood Policy.*
- Improvements to the Flood Response System by the incorporation of data from this study in the SES's *Narromine Local Flood Plan*, as well as community education on the nature of the flood risk.
- Structural flood mitigation works (river bank levee and improvements to capacity of drainage system at Parkes Narromine Railway embankment).

TABLE 3.8
SUMMARY OF POTENTIAL FLOODPLAIN MANAGEMENT MEASURES FOR NARROMINE

MEASURE	PURPOSE	COMMENT
PROPERTY MODIFICATION		
Planning and building controls	Reduce potential flood hazard and losses	• Mainly applies to re-development of existing sites and future developments in floodplain; adoption of controls based on Flood Planning Level applied according to land use is supported for inclusion in draft *Floodplain Risk Management Plan*. (Upgrading of existing mapping base would allow a more accurate definition of flood extent and assist administration of *Flood Policy* (***Appendix C***).
Voluntary Purchase Scheme	Purchase and removal of residential properties in the most flood prone areas	• Mainly applies to high hazard area. A VP scheme is not economically justified and not justified on social grounds. The Narromine community did not support this measure in the Questionnaire.
House Raising	Prevent flooding of individual buildings	• Mainly applies to low hazard area and wooden frame residences only. A house raising scheme is not justified economically or on social grounds. The Narromine community did not support this measure in the Questionnaire.
RESPONSE MODIFICATION		
Flood Response	Allow rapid appropriate actions to be taken during a flood	• Incorporate data from the *FRMS* in SES's Narromine Local Flood Plan.
Public Awareness Program	Educate the public on the nature of the flood risk	• Cheap, effective method, which should be incorporated in the draft *FRMP*. Council and SES to co-ordinate activities.
FLOOD MODIFICATION		
Levees	Prevent flooding of urban part of Narromine.	• 1% AEP river bank levee appears technically feasible, and economically justified. • Scope of investigation possible is presently limited by lack of survey. Further work is required with benefit of survey to confirm project feasibility and prepare a submission for Government funding.
Increase capacity of culverts in Parkes Narromine Railway embankment	Reduce flood levels in residential properties in south-west area of town.	• Scale of investigation possible is presently limited by lack of survey. Further work is required with benefit of survey to confirm project feasibility. • Would not be required to protect existing residential development from river flooding if river bank levee scheme is adopted, because the levee would reduce flows entering the southern side of town via the Town Cowal; but may be required to protect future residential development adjacent to railway from local stormwater catchment flooding.
Channel Improvements Works	Increase hydraulic capacity of river to reduce flood levels	• Does not reduce levels enough to substantially reduce damages. Environmentally not feasible.
Flood Mitigation Dams	Reduce downstream flood levels	• Burrendong Dam presently acts as an effective flood mitigation dam. • Any increase in storage volume dedicated to flood mitigation would reduce role of dam for water conservation. • The river bank levee option is a more cost-effective flood mitigation measure for Narromine.

4. SELECTION OF FLOODPLAIN MANAGEMENT MEASURES

4.1 Background

The *Floodplain Development Manual, 2005* requires a Council to develop a *Floodplain Risk Management Plan* based on balancing the merits of social, economic and economic considerations which are relevant to the community. This chapter sets out a range of factors which need to be taken into consideration when selecting the mix of works and measures that should be included in the draft *Floodplain Risk Management Plan.*

The community will have different priorities and, therefore, each needs to establish its own set of considerations used to assess the merits of different options. The considerations adopted by a community must, however, recognise the State Government requirements for floodplain management as set out in the *Floodplain Development Manual, 2005* and other relevant policies. A further consideration is that some elements of the *Plan* may be eligible for subsidy from State and Federal Government sources and the requirements for such funding must, therefore, be taken into account. Typically, State and Federal Government funding is given on the basis of **merit as judged by a range of criteria**:

- Degree of flood hazard and number of properties affected
- Damage caused by flooding and the benefit/cost ratio of proposals
- The importance given to strategic planning in the overall Plan
- Compatibility of proposals with TCM and other government policies
- Community involvement in plan preparation
- Availability of local funding for proposed works

The **issues which need to be considered** in developing a *Floodplain Risk Management Plan* typically fall under the following broad headings:

- Community Expectations and Social Impacts
- Natural Resource Management and Environmental Impact
- Economic and Financial Feasibility
- Technical Merit

The next section of this chapter presents a review of a range of considerations under the four headings listed above. An analysis is then presented which assesses the performance of the available options against the factors to be considered.

4.2 Community Expectations and Social Impacts

Community expectations are an important consideration in selecting appropriate floodplain management measures. These expectations may encompass a range of issues which are not directly economic or environmental in character such as:

- Community acceptance and expectations
- Compatibility with planning objectives
- Administrative and political issues

4.2.1 Community Acceptance

Flood related works and measures can have a range of effects on the community and individuals. These effects, if strongly negative, are often enough to deter the implementation of a proposal which might otherwise have significant merit. The issues impacting upon acceptance of a proposed measure are likely to include:

- Potential for individual financial loss/gain
- Disruption to daily life during and after floods
- Perception of fair play
- Public safety and welfare

4.2.2 Compatibility with Planning Objectives

Narromine Council has developed a set of planning policies for future development which reflects the long term goals of the community. These policies are embodied in the Local Environmental Plan, 1997 and the *Flood Policy* which has been reviewed and for which a number of suggested amendments are detailed in **Appendix C**. The new *Flood Policy* will be a key element of the *Floodplain Risk Management Plan* for the town. The recommended amendments are designed to ensure that policies for future land use on the floodplain are consistent with the *Floodplain Development Manual, 2005*, and current government thinking.

Proposals for other works and measures to be included in the Floodplain Management Plan must be assessed for consistency with Council's overall planning policy relating to floodplain management.

4.2.3 Administrative/Political Issues

Effective floodplain management involves the coordinated action of the community, Council and state government agencies. Clearly, any recommendation contained in the Floodplain Management Plan will have more chance of success if it fits within current administrative structures and allocation of responsibilities. On the other hand, should an alteration to the administrative system be clearly beneficial to the Plan, it should be so stated and the implications accepted.

The majority of the parties with responsibilities for floodplain management and emergency response in the event of a flood are represented on the Floodplain Management Committee and have been consulted in the course of this study. None of the options evaluated in **Table 4.1** involves any radical changes to the existing administrative structures and responsibilities.

4.3 Natural Resource Management and Environmental Impact

4.3.1 Total Catchment Management

Total Catchment Management (TCM) involves the coordinated and sustainable use and management of land, water, vegetation and other natural resources on a catchment basis. It allows for a cooperative forum where decisions may be made at both the community and government level. This is typically achieved through a Catchment Management Committee which consists of both community and government representatives.

Aspects of a *Floodplain Risk Management Plan* which could have implications for TCM include any proposals for flood mitigation storage basins, major levees or large scale channel enlargement works. As outlined in **Chapter 3**, only the levee proposal is economically viable. Provided the levee construction does not adversely affect riparian vegetation, then this proposal would be consistent with TCM objectives.

4.3.2 Other Relevant Government Policies

The NSW Government has developed a number of policies which are of direct relevant to floodplain management. The first of these are the policies enshrined in the *Floodplain Development Manual, 2005,* which forms the basis for the formulation of *Floodplain Risk Management Plans*. The second is the State Rivers and Estuaries Policies (NSW Water Resources Council, 1993) which is the umbrella policy for subsidiary policies including the Wetlands Policy; the Stream Management Policy; and the Riparian Zone Policy. The policy suggests that the overall objective should be to manage the estuarine and riparian zones of NSW in ways which:

- Slow, halt or reverse the overall rate of degradation
- Ensure the long term sustainability of essential biophysical functions
- Maintains the beneficial use of these resources

For the purposes of floodplain management, these zones may be taken as the area above the tidal and low flow level to the inner edge of the floodplain. In practice, the riparian zone merges into the floodplain and any management policies or actions should not stop at artificially defined boundaries. Any activities to manage these zones within the study area would be consistent with this policy by improving:

- Stream stability
- Ecology and habitat
- Buffer strip functioning
- Scenic amenity
- Recreational amenity

4.3.3 Environmental Impact

Few floodplain management measures could be considered seriously if the impact on the environment was extremely adverse. On the other hand, there are often opportunities for environmental enhancement in association with floodplain management works or measures. The most likely activity to have environmental impacts would be the levee scheme aimed at preventing flooding from the Macquarie River.

4.4 Economic and Financial Feasibility

4.4.1 Economic Feasibility

There is a range of procedures available to judge the economic worth of making an investment in floodplain management works and measures. The most common is the benefit/cost ratio (B/C) which has been used in this study. On a purely theoretical basis, no investment should be made in a measure if the benefits do not exceed the costs. However, many public projects are undertaken where this is not the

case because the intangible benefits, which are not able to be quantified, are considered important. Not all of the measures considered for Narromine in this study lend themselves to meaningful B/C analysis.

The results the economic analysis for the measures assessed in **Chapter 3** are considered in the evaluation of proposals in **Table 4.1**.

Chapter 3 has shown that:

- The option with the highest B/C ratio is the provision of a levee along the southern bank of the Macquarie River. At a 7% discount rate, the benefit/cost ratio for this measure is about 1.4. This scheme will give a 1% AEP level of protection against flooding in Narromine.

- Another structural measure examined included improvements to the hydraulic capacity of the culverts in the Parkes – Narromine railway. A preliminary assessment indicated that this option may be technically and economically feasible.

Property modification measures which were considered included planning measures, voluntary purchase schemes and house raising schemes. Flood response modification measures such as flood warning, preparedness and awareness were also reviewed. Of these non-structural measures, only the planning measures and response modification options are considered justified (although their B/C ratios cannot readily be quantified).

4.4.2 Financial Feasibility

Measures proposed for the *Floodplain Risk Management Plan* for Narromine must be capable of being funded over the proposed period of implementation. The sources of funding are traditionally:

- Council
- NSW Government
- Commonwealth Government

Contributions from these three sources are such that, where the costs are attributable to approved floodplain management activities, Council will bear one third of the overall cost, with the balance being equally shared by NSW and Commonwealth Governments.

The limitations on Council funding will be related to the magnitude of Council income in any one year, its borrowing capacity and existing commitments. The total allocation and sources of funds will vary in any one year and are dependent on special grants. In any one year, the funds available for floodplain management measures will be dependent on Council priorities.

Any State Government contribution is limited by the allocation to flood mitigation programs on an annual basis. The commencement/completion of flood mitigation projects would depend on the availability of Council's funds and/or limited Government funding. Flood mitigation projects can take up to 5 years to complete because of funding considerations. Since Council has many demands for drainage/road works, the financial feasibility is likely to be a significant constraint to the rate at which works can be undertaken.

4.5 Technical Merit

4.5.1 Engineering Feasibility

Floodplain management works, as distinct from measures, must be readily constructible and free of major engineering constraints to become an acceptable element of any plan. Maintenance requirements should also be considered in this assessment.

4.5.2 Performance in Exceedance Floods

Any proposed floodplain management measures must be assessed assuming that at some future time they will be exposed to floods that exceed the FPL. It is imperative that, should an extreme flood occur, the works and measures under consideration do not expose the community to unacceptable risks far beyond those experienced without the work or measure.

A key consideration for extreme floods must be the provision of escape routes which allow for evacuation as a flood develops. The most important requirement for this is that islands surrounded by deeper floodwater should be avoided.

4.6 Ranking of Options

The considerations discussed above must be assessed in terms of their relative importance to the community as well as the likelihood of attracting government subsidy. Although multi-objective assessment methods are now well accepted by Government for selecting from a range of options, the decision to provide state funds is still linked closely to economic and financial factors. The Floodplain Management Committee and the Community, however, have expectations which give more weight to social, environmental and planning issues.

A suggested approach to assessing the merits of various options is to use a subjective scoring system. The chief merits of such a system are that it allows comparisons to be made between alternatives using a common "currency". In addition it makes the assessment of alternatives "transparent" (i.e. all important factors are included in the analysis). The system does not, however, provide an absolute "right" answer as to what should be included in the plan and what should be left out. Rather, it provides a method by which the Council can re-examine its options and, if necessary, debate the relative scoring given to aspects of the plan.

Each option is given a score according to how well the option meets the considerations discussed in **Sections 4.2** to **4.5** In order to keep the scoring simple the following system is proposed:

+2	Option rates very highly
+1	Option rates well
0	Option is neutral
-1	Option rates poorly
-2	Option rates very poorly

The scores are added to get a total for each option.

Based on considerations outlined in this chapter, **Table 4.1** presents a scoring matrix for the options review in **Chapter 3**. This scoring has been used as the basis for prioritising the components of the draft

Floodplain Management Plan. It must be emphasised, however, that the scoring shown in **Table 4.1** is not "absolute" and **Council should carefully review the proposed scoring and weighting as part of the process of finalising the overall *Floodplain Risk Management Plan.***

Table 4.1 indicates that there are good reasons to consider including the following elements into the Floodplain Management Plan:

- River bank levee scheme
- Improvements to the culverts in the Parkes Narromine Railway (if the levee option is not implemented or prior to residential sub-division development adjacent to the railway embankment)
- Planning Controls
- Flood Awareness
- Review of Warning Emergency Management Procedures in the light of information on flooding in properties presented in this Study.

Property modification measures such as voluntary purchase or house raising schemes are not viable.

TABLE 4.1
FLOODPLAIN MANAGEMENT OPTIONS ASSESSMENT

Option	Impact on Flooding/ Reduction in Flood Risk	Community Acceptance	Planning Objectives	Environ. Impacts	Economic Justification	Financial Feasibility	Extreme Flood	Government Policies	TCM Objectives	Administrative Arrangements	Score
Property Modification											
Planning Controls & Public Awareness	2	2	2	1	1	1	1	2	1	1	14
Voluntary purchase residential	1	-1	1	1	-2	-2	1	1	1	1	2
House Raising	1	-1	1	1	-2	-2	1	1	0	1	1
Response Modification											
Flood Warning	2	2	1	0	1	1	1	1	1	1	11
Flood Modification											
River Bank Levee	2	2	1	0	2	1	0	1	1	1	11
Augmentation of culverts in Parkes-Narromine Railway	2	0	1	0	2	1	0	1	1	1	9
Channel Improvements	0	0	0	-2	-2	-2	0	0	0	0	-6

5. THE DRAFT FLOODPLAIN MANAGEMENT PLAN

5.1 The Floodplain Risk Management Process

A draft *Floodplain Risk Management Plan* (*FRMP*) has been prepared for Narromine as part of a Government program to mitigate the impacts of major floods and reduce the hazards in the floodplain. The *FRMP* has been prepared as part of the Floodplain Risk Management Process, in accordance with NSW Government's Flood Prone Land Policy.

5.2 Purpose of the Plan

The overall objectives of the *Floodplain Risk Management Study and draft Plan* were to assess the impacts of flooding, review policies and options for management of flood affected land and to develop an *FRMP* which:

- Sets out the recommended program of works and measures aimed at reducing over time, the social environmental and economic impacts of flooding and establishes a program and funding mechanism for the *FRMP*.
- Proposes modifications to existing Council policies to ensure that the future development of flood affected land is undertaken so as to be compatible with the flood hazard and risk.
- Ensures the *FRMP* is consistent with local emergency management planning.
- Ensures that the *FRMP* has the support of the community.

5.3 The Study Area

This *FRMP* deals with the floodplain of the Macquarie River in the vicinity of Narromine. For the purposes of this Plan the study area comprises the reach of the Macquarie River between the Webbs Crossing to a point about 1 km downstream of the Timbrebongie Bridge across the river.

5.4 Relevant Investigations

The Study and Plan drew on the results of the recent investigations and flood related policy documents including:

- *Narromine Flood Study, 2006,* prepared by LACE.
- *Narromine Local Flood Plan, 2007*, prepared by State Emergency Service.
- *Narromine Flood Policy, 2005 prepared by Narromine Shire Council.*

5.5 Community Consultation

The Floodplain Management Committee provided valuable direction over the course of the investigations, bringing together views from key Council staff, other departments and agencies, and importantly, the views of the community gained through:

- The delivery of a Community Newsletter to occupiers and owners of property located in the floodplain.
- Meetings and consultation with Council over the course of the investigation.

5.6 Structure of Floodplain Risk Management Study and Plan

The report comprises the *Floodplain Risk Management Study* and *draft Floodplain Risk Management Plan* and is supported by Appendices which provide additional details of the investigations undertaken for the preparation of the *Study* and draft *Plan*.

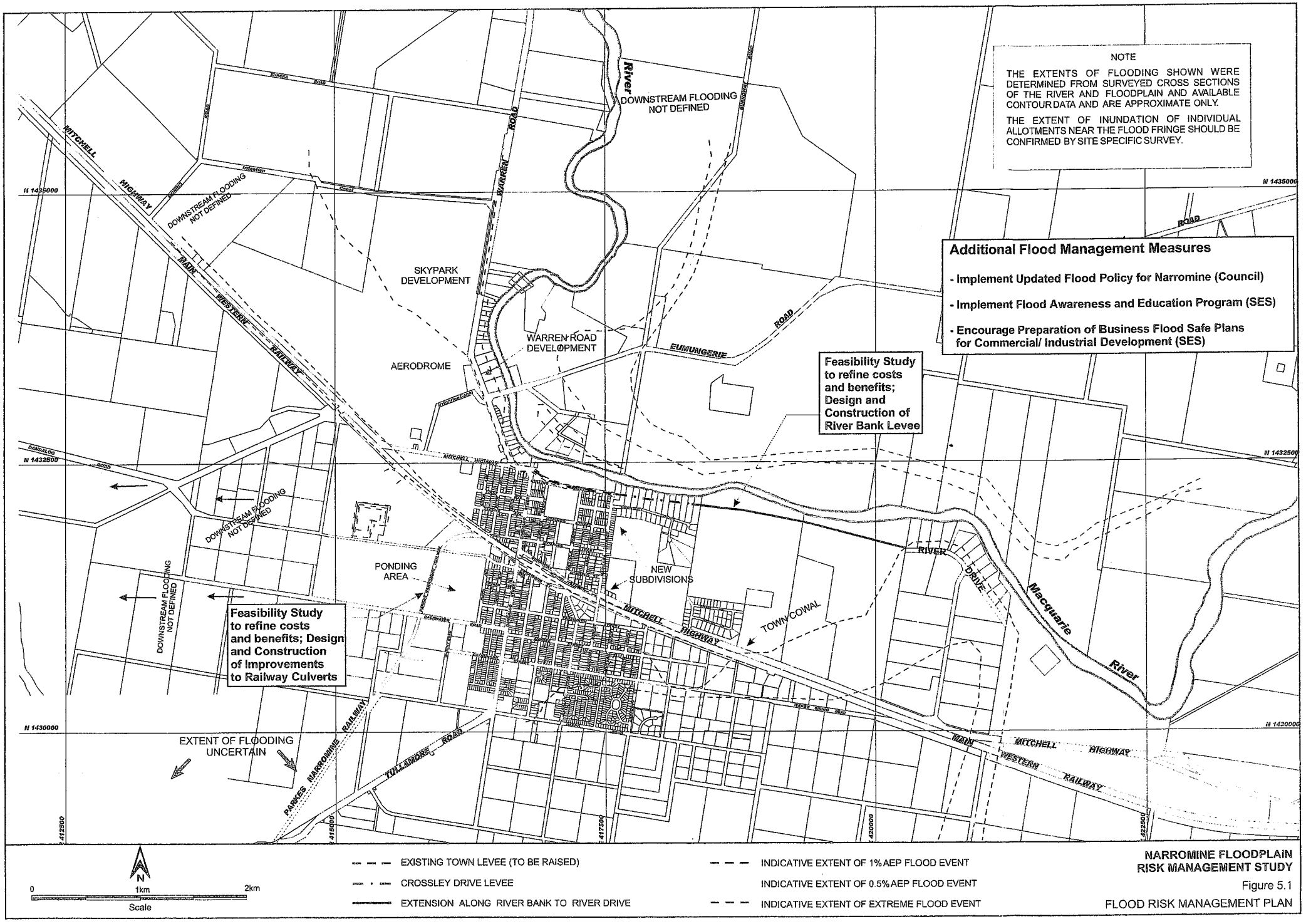
A summary of the *draft Floodplain Management Plan* proposed for the study area is shown on **Table 5.2** (at the end of this chapter). **Figure 5.1** shows the locations of the various elements of the Plan. The draft *Plan* is based on:

- The application of a graded set of planning controls that recognises both the type of development and the flood risk of the area, to be applied through a *Flood Policy* for Narromine (a draft *Flood Policy* is presented in **Appendix C**).
- Improved emergency management plans for Narromine, including incorporation of flood information determined from the current Study in the SES's *Narromine Local Flood Plan* and the preparation of individual *Business Floodsafe Plans* for commercial properties subject to flooding.
- Further investigation of the river bank levee concept developed in the *Study* to protect the town from river flooding (**Section 3.3**). The investigation would be based on better survey information than is currently available. It would refine the concept design and economic assessment prepared in this study and would provide documentation to support an application for Government funding for the levee.
- Preparation of detailed designs and implementation of the levee as funding becomes available, subject to the results of the above investigation.
- Further investigation of the proposal to augment the hydraulic capacity of the culverts in the Parkes Narromine railway embankment to reduce flood levels in the existing residential area in the south-west sector of Narromine (**Section 3.4**).
- Preparation of detailed designs and implementation of the railway culverts, subject to the results of the above investigation and the timing of construction of the river bank levee proposal. Following construction of the levee, the risk of flooding of the town from the river will be reduced and the main purpose of the culverts would be to discharge runoff generated on the local stormwater catchments.

5.7 Indicative Flooding Extents and Impact of Flooding

5.7.1 Indicative Flooding Extents

The extents of inundation shown on **Figure 5.1** are indicative only, being based on available 2 m contour mapping and limited cross sections of the floodplain comprising the hydraulic model developed in the *Narromine Flood Study, 2006*. Site survey would be required to confirm flood affectation and identify flood extents within individual properties. This level of accuracy in the flood mapping is supported by DECC, as the costs associated with undertaking detailed ground survey in each flood affected property presently lies outside the scope of the NSW Government's floodplain program. Under the program, it is Council's responsibility to identify the flood risk within the floodplain and prepare maps showing indicative flood extents, with the onus being on the property owner to carry out sufficient survey to allow a more accurate picture of flood affection to be described in his allotment.



NARROMINE FLOODPLAIN RISK MANAGEMENT STUDY

Figure 5.1

FLOOD RISK MANAGEMENT PLAN

To allow Council to assess individual development proposals, a detailed site survey would be required to allow the extent and depth of flooding to be evaluated using the results of the *Narromine Flood Study, 2006*. For this reason, applicants will be required to submit a detailed survey plan of sites for which development is proposed.

It would, however, assist Council with the operation of the draft *Flood Policy* if the extent and depths of inundation in the urban area of Narromine could be identified with greater accuracy than is presently possible. This could be achieved at comparatively modest cost by undertaking an Airborne Laser Survey of the study area, which would achieve accuracies in defining natural surface levels in the range 150-200 mm. This would be a vast improvement on the accuracy of existing mapping sources and would also assist Council in the planning and design of other engineering and town planning disciplines (roads, stormwater management, strategy studies and the like). However, the cost of the survey would be outside the scope of the NSW Government's floodplain program and would therefore be borne by Council.

Alternatively at a modest cost, Council could convert the Narromine Sewerage Plans which are currently in Imperial units to a Metric scale and with levels at Australian Height Datum.

5.7.2 Impacts of Flooding

Table 5.1 shows the number of properties which would be flooded and the damages experienced for the various classes of property in Narromine study area. Approximately half of the residential properties in Narromine would be flooded above floor level in the event of a 1% AEP flood. **Figure 2.7** shows houses and commercial properties which would be flooded in the event of a 1% AEP design flood.

TABLE 5.1
PREDICTED FLOOD DAMAGES IN NARROMINE STUDY AREA

Flood Event % AEP	No. of Properties with Floors Inundated			Total Damage ($ x 10^6)
	Residential	Commercial	Public	
2	0	0	0	0
1	747	58	20	44
0.5	1070	142	39	113
Extreme Flood	1174	144	40	162

5.8 Land Uses

The land uses currently located within the town of Narromine comprise residential, commercial, industrial, special use and recreational areas. Residential sub-division development is currently proceeding in flood prone areas, which has the potential to increase the flood risk in Narromine if appropriate flood related controls were not implemented; in particular in the area denoted the Manildra Floodway, which is located between the river and the Mitchell Highway to the east of Manildra Street. Further industrial development adjacent to the existing industrial area which borders the Mitchell Highway is also proposed.

5.9 Flood Modification Measures

Flood modification measures, also known as "structural measures" involve the construction of engineering works which modify the pattern of flooding on the floodplain. Measures investigated in **Section 3** of the Study, and recommended for further investigation and inclusion in the draft Plan include the river levee and augmentation of the hydraulic capacity of the culverts in the Parkes Narromine railway.

5.10 Property Modification Measures

5.10.1 Draft Flood Policy

The results of the Floodplain Management Study indicate that an important measure for Narromine Shire Council to adopt in the floodplain would be strong floodplain management planning applied consistently by all branches of Council. A *draft Flood Policy* has been prepared for the guidance of Council officers in the evaluation of development proposals and is included **Appendix C**. An outline of the Policy is given in **Section 3.8.2.**

Flood Risk Precincts

The floodplain, or extent of flood prone land, has been defined as the area inundated by the Extreme Flood, which is a flood with a peak discharge equal to three times the 1% AEP peak. The flood prone land has been divided into six flood risk precincts using the depth and flow velocity data derived in the *Narromine Flood Study, 2006* and subsequent hydraulic studies outlined in **Section 2.7**. The extents of the precincts, shown on **Figure 5.2,** have been identified using existing sources of survey data The precincts are:

- The *"Macquarie River Floodway"*. This is the area conveying most of the flow in the Macquarie River in the event of a 1% AEP flood. The Flood Policy does not permit development in this area.

  The "*Town Cowal Floodway*" was zoned as a floodway in the Narromine LEP, 1997, but as noted in **Section 2.4** of this report under *Item 7,* may have been defined on imprecise survey data. **Section 2.7** identified the extent of the floodway in a hydraulic sense using existing sources of survey data. (The hydraulic floodway is the area where significant flow velocities would be expected at the 1% AEP flood and which should be kept clear of future development). It is suggested that when assessing developments, Council adopt the dashed lines as representing the extent of the floodway and therefore the limit of encroachment. In the future upgrading of the LEP, the dashed lines could be revised using any additional survey data available and should then replace the presently zoned "*Town Cowal Floodway*".

- The "*Manildra Street/River Drive Precinct*" is the area on the southern floodplain between the river and the Mitchell Highway. This Precinct includes two flow paths which act as conveyances for floodwaters breaking out from the low points in the river bank between Manildra Street and River Drive. Some of the flow travels eastwards to Manildra Street via the Manildra Floodway flow path and the remainder is conveyed via the Town Cowal through the railway culverts to the southern side of town. These flow paths are shown dashed on **Figure 5.2**. Based on depth and velocity criteria and interpretation of available survey, these flow paths are low hazard zones even though they convey significant rates of flow.

- The "*High Hazard Ponding Area*" is the precinct on the eastern side of the Parkes Narromine railway embankment. There are sparse data on natural surface levels available in this area. However, on the basis of available information it appears that although flow velocities would be low, peak depths of inundation in excess of 1 m would be expected in the event of the 1% AEP flood. In this area in-fill residential development would be permitted, subject to minimum floor level requirements (1% AEP flood level plus 500 mm freeboard). However, prior to consideration of any sub-division development proposal in this area, Council would require the applicant to demonstrate that the area could be developed without an increase in the overall flood risk to the population. As a minimum, Council would require a site survey and a Flood Study of the area, which would specifically consider the potential backwater effects resulting from surcharge of culverts in the Parkes – Narromine Railway embankment and incorporate suitable measures to mitigate any resulting flood affectation.

- The "*Intermediate Floodplain*" is the remaining land inundated by the 1% AEP flood and not falling in the above categories of flood prone land. Within this land, there would only be the requirement for minimum residential floor levels to be set at 1% AEP flood levels plus 500 mm. All land uses would be permitted in this zone.

- The "*Outer Floodplain*" is the remainder of the floodplain between the 1% AEP flood extent and the Extreme Flood. In this area the same controls would apply over minimum floor levels as for the *Intermediate Floodplain*. The purpose of the *Outer Floodplain* would mainly be to define the potential flooded area, i.e. the extent of the "Floodplain".

Flood Planning Levels

The Flood Planning Level (FPL) is the minimum floor level for the various categories of development. For new residential, commercial and industrial development in Narromine the proposed FPL is the peak 1% AEP flood level at the particular development site, as defined in the *Narromine Flood Study, 2006* plus an allowance of 500 mm for freeboard.

Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential Development (which include nursing homes, aged care facilities and the like) require a higher degree of protection to reduce the risk to individuals and, in the case of essential infrastructure, to ensure that they are capable of continuing to function during major flooding.

The draft *Flood Policy* adopts the 0.5% AEP flood level plus 500 mm as the FPL for Essential Community Facilities and Critical Utilities and for these classes of development to be designed to be able to continue to function in the event of an Extreme Flood.

The policy recommends the same FPL for Flood Vulnerable Residential Development (i.e. minimum floor levels set at the 0.5% AEP flood level plus 500 mm). However, where it is not practicable to achieve this level, Council may approve a lesser level commensurate with local site conditions. However, in this eventuality, the applicant is to ensure that valuable equipment necessary for the operation of the facility is located at or above the recommended FPL, either permanently or via relocation to a temporary storage area of an area suitable for this purpose.

The *draft Flood Policy* is based on the recognition that individual developments should not be evaluated in isolation, but rather, should be considered in a strategic sense as if it were one of several developments in the area. Whilst individual developments in isolation may not have a measurable impact on flooding, the cumulative impacts of ongoing development could be significant.

New buildings, or additions to existing buildings would be subjected to these building controls with the long term objective of having all buildings in the area ultimately flood proofed. Controls need to be imposed on a merit basis, balancing restrictive development conditions with the impact of development on flood behaviour in the floodplain.

5.10.2 Voluntary Purchase of Residential Property

The economic analysis undertaken in the Floodplain Management Study showed that implementation of a voluntary purchase scheme was not economically viable and could not be justified on social grounds.

5.10.3 Raising Floor Levels of Residential Property

The economic analysis undertaken in the Floodplain Management Study showed that the implementation of a voluntary house raising program was not economically viable and could not be justified on social grounds.

5.11 Response Modification Measures

5.11.1 Flood Warning and Response

As part of the *Narromine Flood Study, 2006* water surface levels were computed for the 2, 1 and 0.5% AEP floods, as well as the Extreme Flood event. Plans have been prepared as part of this present study, showing the indicative extent of flooding, high hazard areas and the locations of flood affected properties. Information is also available on the depths of inundation of residential properties in town. Consequently there is sufficient information available to identify areas at risk from flooding for the full range of flood events likely to trigger flood response procedures.

The *Narromine Local Flood Plan, 2007* should be further developed by SES so as to produce a graded response plan involving:

- Ranking the threatened houses according to their hazard situation, taking account of depth of floodwaters, and means of access, as a flood develops.
- Preparing a detailed response plan which focuses on initial evacuations from the most hazardous locations, followed by further evacuations in descending exposure to hazardous conditions.
- Preparing a plan for traffic management, which takes account of the sequence of road flooding as a flood develops. This plan would aim to:
    - maximise opportunities for the community to evacuate,
    - prevent unnecessary traffic through the affected area,
    - ensure access for SES operations.

5.11.2 Flood Awareness

A number of measures are recommended to maintain awareness in the community of the threat posed by floods:

- The *draft Flood Policy* of **Appendix C** of the Study should be reviewed, amended as required and adopted by the Council.

- Council should continue to promote knowledge of the characteristics of flooding among property owners. These characteristics should include information on the frequency of flooding and the depths at various locations. This information could be included in a flood information booklet containing both general and site specific data and distributed with the rate notices. The information contained in the Community Newsletters prepared for the community consultation phase of this study will be of assistance in the preparation of suitable documentation. The community should also be made aware that a flood greater than historic levels or the Flood Planning Level can, and will, occur at some time in the future. The need for a flood response and preparedness plan to address such an occurrence should be clearly explained.
- The *Floodplain Risk Management Plan* should be publicised and exhibited in Council offices and at community gathering places to make residents aware of the measures being proposed.

5.12 Recommended Measures and Funding

Broad funding requirements for the recommended measures to be included in the *draft Floodplain Risk Management Plan* are given in **Table 5.2** below. The total estimated cost amounts to **$2.53 Million**. These measures comprise a program of engineering investigations and capital works, preparation of planning documentation by Council, community education on flooding by SES to improve flood awareness and response. They will over time, achieve the objectives of reducing the flood risk to existing and future development for the full range of floods. **Table 5.2** includes a priority ranking for implementation of the projects and discusses potential sources of funding.

TABLE 5.2
RECOMMENDED MEASURES FOR INCLUSION IN
NARROMINE DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Required Funding	Key Features of the Measure	Comments and Funding Source
Implement the recommended development controls based on *draft Flood Policy for Narromine.*	Council's staff costs	▪ Control development in floodplain as summarised in *draft Flood Policy* ***(Appendix C)***. ▪ Graded set of flood controls based on the type of development and their location within the floodplain, defined as land inundated by the Extreme Flood. ▪ Floodplain divided into six Flood Risk Precincts as shown on **Figure 5.2** ▪ Minimum floor levels for residential development to be 1% AEP flood plus 500 mm freeboard. ▪ Council may allow a lower floor level for commercial/industrial development, provided an area is available at 1% AEP flood plus 500 mm for the temporary storage of goods. ▪ Minimum floor levels for Essential Community Facilities and Critical Utilities Essential Services to be 0.5% AEP flood plus 500 mm freeboard and facility to be able to function in the event of the Extreme Flood. ▪ Minimum Floor levels for Flood Vulnerable Residential Development (e.g. aged persons, nursing homes) to be 0.5% AEP flood plus 500 mm freeboard. Council may allow a floor level equal to the residential FPL, provided an area is available at 0.5% AEP flood plus 500 mm for the storage of valuable equipment. ▪ Council's evaluation of development proposals to use data presented in *Narromine Flood Study, 2006 and site survey.*	This measure has a **high priority** in view of projected residential development in Narromine. It does not require Government funding.
Ensure flood data in this *Floodplain Risk Management Study and draft Plan* is available to SES for inclusion in flood emergency response procedures.	Council and SES costs	▪ SES's Narromine Local Flood Plan, 2007 is to incorporate information on locations of flood prone development presented in this *Floodplain Risk Management Study*. Flooded residences (inundated above floor level at 1% AEP) are shown on **Figure 2.7**.	This measure would improve emergency management procedures and has a **high priority**. It does not require Government funding.
Implement flood awareness and education program for residents and owners of commercial and industrial developments.	SES's and owner's costs	▪ SES to prepare Flood Information Brochure to advise residents of the flood risk, based on the information presented in the *Floodplain Risk Management Study*. ▪ Encourage preparation of a Business Floodsafe Plan for individual commercial and industrial developments based on the recently published SES Toolkit.	This measure would reduce flood losses and has a **high priority**. It does not require Government funding.
Feasibility Study of river bank levee.	$80,000	• Survey along proposed route of levee to define top of river bank. ▪ Prepare concept design; refine initial costing and economic analysis presented in this *Floodplain Risk Management Study*. ▪ Undertake Community Consultation. ▪ Prepare a submission for Council and Government funding.	This measure is the first step in providing the levee and has a **high priority** in view of the economic impacts resulting from the occurrence of a 1% AEP flood. It requires Council and Government funding.
Preparation of detailed design and construction of levee (dependent on the results of the above study)	$1.6 Million	▪ Prepare detailed design and documentation of levee. ▪ Works are to be implemented by Council when funding available.	This measure would depend on a favourable outcome from the Feasibility Study and the availability of Council and Government funding.
Feasibility Study of upgrading hydraulic capacity of culverts in Parkes Narromine Railway.	$50,000	• Survey natural surface levels in south-west sector of town upstream of the railway embankment. • Hydrologic and hydraulic analysis to assess requirements for control of both river flows and local stormwater runoff. ▪ Prepare concept design; refine the initial costing and economic analysis presented in this *Floodplain Risk Management Study*. ▪ Undertake Community Consultation. ▪ Prepare a submission for Council and Government funding.	This measure is the first step in providing the new culverts and reducing flood levels in the south-west sector of town. It has a **medium priority**. It requires Council and Government funding, or alternatively, contributions from developers of land on eastern side of railway embankment.
Prepare detailed design and construct culvert works (scheme is dependent on the results of the above study and whether river bank levee scheme is implemented. River bank levee would reduce ponding upstream of the Railway and possibly reduce the need for improved culverts.)	$0.8 Million	▪ Prepare detailed design and documentation of culverts. ▪ Works are to be implemented by Council when funding available.	This measure would depend on a favourable outcome from the Feasibility Study and the availability of funding.
Total Estimated Cost	**$2.53 Million**		

5.13 Implementation Program

The steps in advancing the floodplain management process from this point onwards are:

- Floodplain Management Committee to consider and adopt recommendations of this study. In particular, the Committee should review the basis for ranking floodplain management measures (as set out in **Table 4.1**) and confirm the proposed works and measures to be included in the proposed plan as set out in **Table 5.2**.
- Exhibit the *draft Plan* and *Study Report* and seek community comment.
- Consider public comment, modify the draft *Plan* if and as required, and submit the final *Plan* to Council.
- Council adopt the *Plan* and submit an application for funding assistance from the Floodplain Management Program administered by DECC and/or the Natural Disaster Mitigation Program administered by the State Emergency Management Committee and other agencies.
- As funds become available from DECC, other Government agencies and/or Council's own resources implement the measures in accordance with the established priorities.

The *Plan* should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change could include new flood events and experiences, legislative change, alterations in the availability of funding, reviews of the shire planning strategies and importantly, the outcome of some of the studies proposed in this report as part of the *Plan*. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the Plan.

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