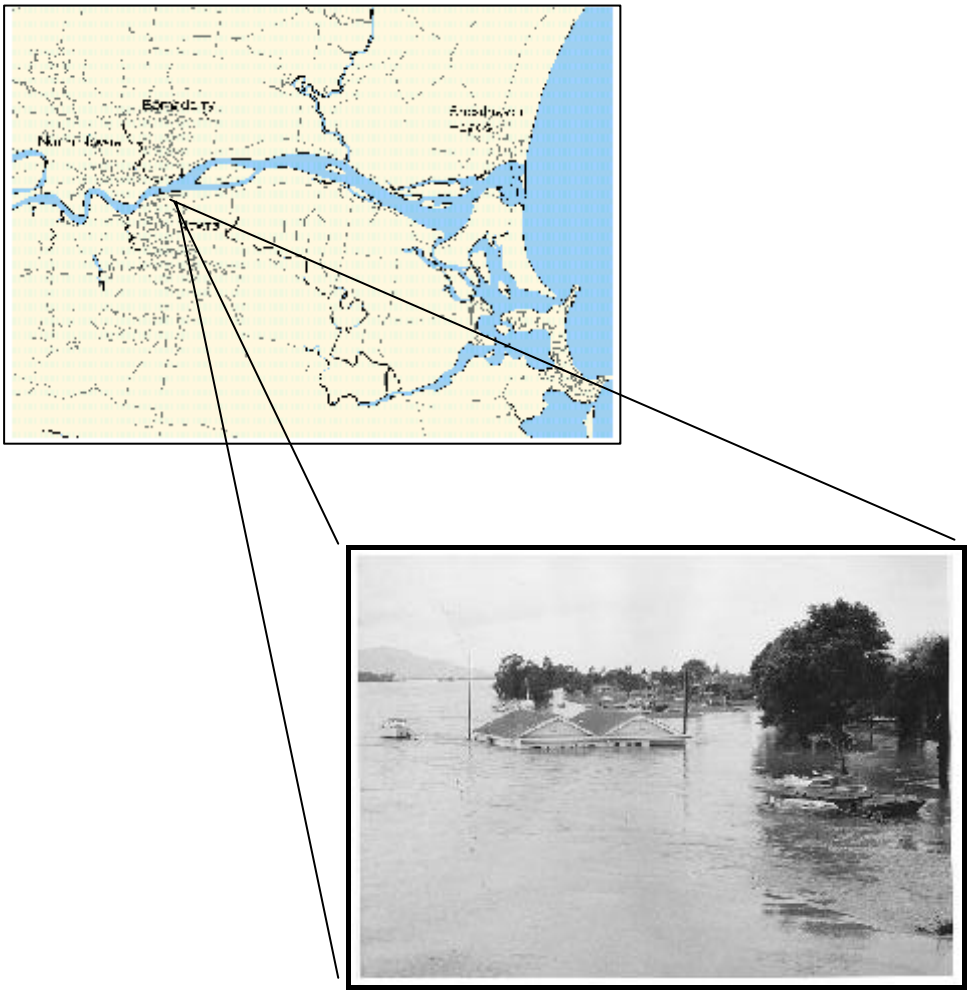
RIVERVIEW ROAD AREA - NOWRA FLOODPLAIN MANAGEMENT STUDY



Nowra Sailing Club, 1978 Flood

FEBRUARY 2002

SHOALHAVEN CITY COUNCIL

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FOREWORD

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

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

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

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

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

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

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

The Riverview Road Area - Nowra Floodplain Management Study constitutes the second stage of the management process and has been developed by the Shoalhaven Floodplain Management Committee. It was prepared for the committee by Webb, McKeown & Associates and provides the basis for the future management of flood liable lands in the Riverview Road area east of the Princes Highway and north of Moss Street.

The terminology used in this report is in accordance with the NSW Government's Floodplain Development Manual (1986 edition) and draft Floodplain Manual (1999 edition). Subsequently the final Floodplain Management Manual was released in January 2001. This latter document provided several changes in terminology which have not been included in this report.

SUMMARY

The land on the south bank of the Shoalhaven River downstream of Nowra Bridge has had a history of flooding. This Floodplain Management Study examines flooding issues relating to the area east of the Princes Highway (Figures 1 and 2) generally bounded by the Shoalhaven River, the Shoalhaven Caravan Park and Moss Street (generally known as "The Riverview Road Area"). The area is occupied by approximately 190 residential buildings (single dwellings and flats), two caravan parks, the sailing club/restaurant, the Leagues Club, and approximately 23 hectares of vacant land west of Ferry Lane. Some of the vacant land is approved for subdivision and there is pressure for further infill development.

The study was initiated by Shoalhaven City Council to address the management of the flood problem in the Riverview Road area. The primary objectives of the Study were to define the nature and extent of the hazard; to identify, assess and optimise measures aimed at reducing the impact of flooding on both existing and future development; and to make recommendations for future development in the study area.

The Floodplain Management Study builds on the Lower Shoalhaven River Flood Study, which was completed in April 1990 and defines design flood levels within the Lower Shoalhaven floodplain, including the Riverview Road area. Once a preferred scheme is adopted, an overall Floodplain Management Plan can be prepared.

A summary of the measures considered in the course of the study is provided in Table i).

Table i): Summary of Floodplain Management Measures

MEASURE	PURPOSE	COMMENT
FLOOD MODIFICATION:		
FLOOD MITIGATION DAMS (Section 4.2.1)	Reduce flooding downstream.	Not viable on economic grounds. Must be considered on a catchment wide basis.
FLOODWAYS (Section 4.2.2)	Provide a defined overbank area where a significant volume of water flows during floods.	Not applicable due to the size of the floodplain, the lack of a suitable location and the volume of water involved.
CATCHMENT TREATMENT (Section 4.2.3)	Reduce runoff from catchment.	Negligible impact on a large catchment but the general principles should still be applied.
RIVER IMPROVEMENT WORKS (Section 4.3.1) • Desnagging • Dredging • Realignment • Reconstruction • Remove hydraulic restrictions	Increase hydraulic capacity of the Shoalhaven River to reduce flood levels.	More applicable on smaller rivers. For the Shoalhaven River these measures provide only marginal hydraulic benefit, are not economically viable, and would raise significant environmental concerns. • Not applicable. • Limited benefit and high cost. • Not applicable • Environmental concerns. • Not applicable high cost, environmental impacts, limited benefit.
SHOALHAVEN HEADS ENTRANCE WORKS (Section 4.3.2)	Permit floodwaters to exit to the ocean through Shoalhaven Heads and so reduce flood levels upstream.	May lower levels for runoff dominated events but may raise them for ocean dominated events. Any changes resulting from entrance works would be insignificant at the study area. Previous studies have shown that it is not viable to maintain a permanent entrance.
MONITOR LOCAL DRAINAGE SYSTEM (Section 4.3.3)	To reduce the incidence of local runoff ponding.	Flooding in this manner does not inundate buildings and cannot be justified on flood mitigation grounds.
LEVEES (Section 4.3.4)	Prevent or reduce the frequency of flooding of protected areas.	Raising or constructing levees is not economically justifiable and will probably not be supported by the community. A management and maintenance audit of the existing levee should be undertaken.
PROPERTY MODIFICATION:		
VOLUNTARY PURCHASE (Section 4.4.1)	Purchase of the most hazardous flood liable properties.	High cost per property. Applicable for isolated high hazard residential buildings but cannot be economically justified to purchase all buildings. No suitable buildings were identified.

MEASURE	PURPOSE	COMMENT
PLANNING REGULATIONS (Section 4.4.4)	Reduce potential hazard and losses.	Already in place. Can be updated to clarify outstanding issues and include land within IDO No. 1 under the current LEP framework.
HOUSE RAISING/FLOOD PROOFING (Sections 4.4.2 & 4.4.3)	Prevent flooding of existing buildings.	All flood damages cannot be prevented using these measures. House raising may not be practical for social and heritage reasons. House proofing should be considered.
RESPONSE MODIFICATION:		
FLOOD INSURANCE (Section 4.2.4)	Offset a random cost with a series of payments.	Not readily available at the present time for residential buildings.
FLOOD WARNING (Section 4.5.1)	Enable people to evacuate and reduce actual flood damages.	System currently in place but could be enhanced.
EVACUATION PLANNING (Section 4.5.2)	To ensure that evacuation can be undertaken in a safe and efficient manner.	The SES has a Local Flood Plan. This could be enhanced to provide more detail on the particular problems of the area.
AWARENESS AND PREPAREDNESS PROGRAM (Section 4.5.3)	Educate people to minimise flood damages and reduce the flood problem.	A cheap effective method but requires continued effort. Examples of methods are provided.
OTHER MEASURES		
MONITOR CONTROLS FOR CARAVAN PARKS (Section 4.4.5)	To ensure that the existing controls are being carried out.	No new controls are proposed but the existing ones must be enforced.
BANK EROSION/COLLAPSE (Section 4.6.1)	To prevent erosion/collapse of the levee.	Should be monitored as part of the Estuary Management Program.
DEVELOPMENT MEASURES		
CONTROL DEVELOPMENT OUTSIDE THE STUDY AREA (Section 5.1)	To ensure that the flood hazard is not increased.	Should be adequately addressed under Council's existing development controls.
GREENHOUSE EFFECT (Section 5.2)	May increase design flood levels.	The effect is likely to be minor within the normal planning timeframe but must be closely monitored.

1. INTRODUCTION

The Shoalhaven River catchment (Figure 1) covers an area of 7000 square kilometres with approximately 120 square kilometres of floodplain downstream of Nowra. The Riverview Road area (Figure 2) is located on the floodplain immediately downstream of Nowra Bridge.

This area was first developed in the early 1960's with the Riverview Road subdivision initiated in the 1970's. The area experienced minor flooding in the 1970's. In 1986/87 the river bank levee was upgraded to provide protection up to the 1% AEP event (no freeboard allowance included). There is continuing pressure to develop the remaining vacant land and in 1995 a 55 lot subdivision to the south of Riverview Road was approved. Council has a proposal to develop part of the vacant land as a recreation area. There are approximately 190 residential buildings (single dwelling and flats) in the area, the majority of which are brick and less than 30 years old.

1.1 The Flood Problem

Historical flood records are available since 1860 and Table 1 lists floods for which some information is available.

Table 1: Flood Events

Month	Year	Month	Year
February	1860	February	1934
June	1864	September	1938
April	1867	April	1945
June	1867	May	1948
March	1870	June	1949
April	1870	June	1951
May	1871	May	1955
February	1873	February	1956
June	1891	July	1956
February	1898	October	1959
July	1899	March	1961
July	1900	November	1961
July	1904	June	1964
January	1911	September	1967
October	1916	August	1974
December	1920	June	1975
July	1922	October	1976
11 May	1925	March	1978
27 May	1925	April	1988
April	1927	August	1990
January	1934		

Note: Data prior to 1988 were obtained from the *Lower Shoalhaven River Flood History at Nowra Bridge 1860-1980* (Reference 1).

The local newspaper, the "Shoalhaven News", was produced in Terara (approximately 2.5 km downstream of Nowra bridge) in the period 1860-1873 and a good description is available of the eight major floods which occurred in that time. The flood of April 1870 was probably greater than a 1% AEP event. It inundated the township of Terara by over a metre and swept away approximately one third of the village. Five lives were lost in rural areas along the Shoalhaven River.

> *".....The spot where once stood the post office, the telegraph office, the steam company's store and wharf, where all was life, business and activity, is now one vast vacant blanket and forms part of the Shoalhaven River. The streets turned into innumerable fullies, sand banks and creeks, fences were washed away and the whole formation of the town completely destroyed....."* Quotation taken from Shoalhaven - History of the Shire of Shoalhaven by W A Bailey.

According to some accounts the earlier 1860 flood was even more devastating and carried away over 50 buildings. Several lives were lost as well as some 79 acres (32 hectares) of land.

A major feature of both these floods was erosion of the river bank at Terara. Historical plans indicate the bank may have migrated south by up to 400 m (Reference 4). None of the floods since 1870 have matched these two events for destruction of property or loss of land.

More recent significant floods occurred in August 1974, June 1975, October 1976 and March 1978. The August 1974 flood covered the ground over the study area causing minor disruption and inconvenience, very few buildings were inundated above floor level. The March 1978 flood was slightly higher than August 1974 and caused similar flooding problems.

Flood levels have been recorded intermittently since 1860 at Terara and regularly at Nowra Bridge since approximately 1960, however, despite a rigorous investigation of all available data, the peak levels of many historical events are not precisely known. A series of eight automatic water level recorders have now been installed along the river and all future events should be accurately recorded.

Table 2 lists the known or estimated heights of the major historical events and compares them with the design flood levels derived in the Flood Study (Reference 2).

Table 2: Peak Levels of Major Floods (mAHD)

	Historical Events				Design Events				
	1860	**1870**	**1974**	**1978**	**5%**	**2%**	**1%**	**0.5%**	**Extreme**
Nowra Bridge	5.5E	6.55E	4.9*	5.3*	5.3	5.8	6.3	6.8	8.9
Shoalhaven River at Terara	4.8E	5.7E	4.4*	4.7*	4.7	5.0	5.4	5.7	7.4
Terara (Hyams Hotel - at the intersection of Forsyth and South Streets)	4.6*	5.5*	3.7*	3.9*	3.6	3.9	4.7	5.1	7.2
Vacant Land/Moss Street	U	U	2.8#	4.3#	LR	3.7	4.5	5.1	8.0
Estimated AEP at Nowra Bridge	3%	0.7%	8%	5%					
Estimated Average Recurrence Interval at Nowra Bridge	30 years	150 years	12 years	20 years					

NOTES:
- * Recorded level taken from the Lower Shoalhaven River Flood History at Nowra Bridge 1860-1980.
- E Estimated level based on other historical flood data taken from the Lower Shoalhaven River Flood History at Nowra Bridge 1860-1980.
- U Unknown
- LR Subject to inundation from local runoff which has not been accurately determined.
- # Taken from Reference 2.
- Note 1: The more recent floods show a much greater difference in level between Terara (Hyams Hotel) and the river at Terara than the 1860 and 1870 events. This is due to the different heights of the river bank levee.
- Note 2: The design levels at Ferry Lane near Terara Road for floods smaller than a 0.5% AEP event reflect the benefit provided by the Riverview Road levee and are the result of backwater flooding.
- Note 3: The levels for the 1860 and 1870 floods at Nowra Bridge and in the Shoalhaven River at Terara are estimated as no actual levels were recorded.
- Note 4: Residents on the riverbank at Terara have provided levels of 4.3mAHD and 4.6mAHD for the 1974 and 1978 floods respectively.

1.2 Floodplain Management Process

Shoalhaven City Council has commissioned the following studies in accordance with the guidelines of the Floodplain Development Manual (Reference 3):

Stage 1: Flood Study - completed in April 1990

Stage 2: Floodplain Management Study - initiated June 1998

Stage 3: Floodplain Management Plan - initiated June 1998

The Flood Study (Stage 1 of the process) established the design flood levels, as shown in Table 2. The “1%” AEP or “1 in 100" flood has a 1 in 100 chance of being equalled or exceeded in any year. On a LONG TERM average it will happen once in every 100 years, but it is wrong

to think it can only happen once in a century. Because floods are random events, there is still a 1 in 100 chance of the flood occurring next year no matter what happens this year.

The Floodplain Management Study (Stage 2) seeks to fully identify the flood problem and canvass various measures to mitigate the effects of flooding. The end product is the Floodplain Management Plan (Stage 3) which will describe how flood liable lands are to be managed in the future. This process requires community interaction to ensure that the proposals are fully understood and supported.

1.3 Council's Interim Flood Policy

1.3.1 General

Council adopted an interim flood policy in September 1987 which was last revised in August 1996. The main points are:

- the 1% AEP flood is the Standard Flood,
- the freeboard to the floor levels of habitable rooms of commercial and residential developments is 0.5 m in a floodway and 0.3 m elsewhere. Local rules may apply in some areas,
- where the proposed development could be damaged by flooding, the structure is to be suitably designed to meet the guidelines,
- materials used in construction below the minimum floor level are to be compatible with immersion in floodwaters,
- for proposed dwelling extensions, where it is impractical to raise the floor level, the minimum floor level requirement will be treated on its merits,
- creation of new residential lots by subdivision will not be permitted in floodways.

Further discussion on Council's flood policy is provided in Section 4.4.4.

1.3.2 Caravan Parks

Council's interim flood policy for caravan parks on flood prone land was last updated in August 1995. The main features of the policy are:

- the floodplain is assessed according to the hydraulic and hazard category,
- three types of parks are considered:
    - new parks or extensions,
    - existing parks - authorised at June 1988,
    - existing parks - unauthorised at June 1988,
- guidelines are provided for each floodplain category and type of park,
- new unregistered moveable dwellings are to have floor levels at least 0.3 m above the standard flood level (1% AEP),
- quick release tie downs are to be equipped to each van and rigid annexe in high hazard areas,

- in all high hazard floodway situations the annexes are to be of rapid knock down design,
- an evacuation strategy is to be prepared, displayed and provided to each patron,
- a flood action plan is required to ensure that patrons are advised that a flood alert is current,
- park managers should ensure that they receive adequate flood warning**.**

Further discussion of Council's flood policy for caravan parks is provided in Section 4.4.5.

2. BACKGROUND

2.1 Catchment Description

The Shoalhaven River rises approximately 50km inland of Moruya and follows a northerly direction for 170km before turning east for a further 90km to reach the Pacific Ocean at Crookhaven Heads. Two hundred years ago the main entrance was at Shoalhaven Heads. This entrance is now intermittent following the construction of the Berry's Canal link to the Crookhaven River in 1822.

The valley can be categorised into three broad regions:

- upstream of Welcome Reef where the terrain is rolling plateau,
- between Welcome Reef and Nowra where the catchment consists of steep forested country with the main streams entrenched in deep gorges,
- downstream of Nowra where an expansive floodplain has developed.

The floodplain area was formed by the infilling of an old coastal lagoon. The southern part of the floodplain is drained by the Crookhaven River, which rises near Nowra, while the northern section is drained by Broughton Creek, which rises upstream of Berry. Flood behaviour in the area has been extensively modified since European settlement through the construction of flood mitigation and bank protection works. The excavation of Berry's Canal has also had a major impact by opening up a second entrance at Crookhaven Heads.

2.2 Riverview Road Area

2.2.1 Description

The Riverview Road area (Figures 1 and 2) comprises:

- approximately 160 residential lots in Riverview Road, Elia Avenue, Lyrebird Drive, Hawthorn Avenue and the northern part of Ferry Lane. The majority of these lots carry a single or two storey brick detached residential building with 141 buildings in total. The ages of the buildings vary from over 25 years to very recent,
- 10 residential lots on the western side of Ferry Lane and south of Riverview Road. Seven lots carry a residential building, consisting of either a single dwelling or a block of flats,
- 9 residential flats in Campbell Place and Brereton Street,
- approximately 30 residential buildings along Moss Street and Terara Road. These buildings are a mixture of brick and non-brick construction and are generally older than 20 years,
- a motel at 8 Pleasant Way,
- approximately 23 hectares of vacant land within the area generally bounded by Lyrebird Drive, Ferry Lane, Moss Street and the high ground near the Princes Highway,

- the Shoalhaven Caravan Park located immediately east of Ferry Lane comprising 117 cabins or van sites of which 85 are permanently occupied; 13 casual van sites; 50 tent sites; a manager's house and an amenities block,
- the Willows East Caravan Park at the southern abutment of Nowra bridge off The Pleasant Way. This park is protected to approximately the 1% AEP flood level by an extension of the Riverview Road levee. It has 60 permanent cabins or van sites; 10 easily moved permanent vans; 10 casual van sites; 10 tent sites; a house; an office and a shop.

There are approximately 190 residential buildings in the study area of which some 70% are single storey and 85% of brick construction.

The area is currently protected (to the height of the levee bank) from direct inundation from the Shoalhaven River by an earthen grassed levee which is generally up to 2 m above natural surface. The levee crest is at approximately 6.4 mAHD and will not be overtopped until greater than a 1% AEP event. The levee was raised to its present height in 1986/87. A longitudinal profile from Nowra Bridge to Terara (1992/93 survey) together with the design flood profiles determined in the Flood Study are shown on Figure 4.

The ground level within the area varies from approximately 2.0 mAHD to 4.7 mAHD and the majority of the ground will be inundated by backwater flooding across Ferry Lane in a 2% AEP event or greater. The lowest floor level is at 3.3 mAHD. Details of the number of buildings flooded in different events are given in Section 3.4.

2.2.2 History of Development

The Riverview Road subdivision was initiated in the early 1970's and a 12 hectare area along Riverview Road was largely developed by the early 1980's. It has a complex history with regard to flooding and planning. This is summarised chronologically as follows:

- At the time of approval for the initial subdivision in November 1959, the last major flood was in October 1959 and this did not overtop the river bank (0.3 m below). Little accurate data were available about design flood levels on the Shoalhaven River and no minimum floor level or fill levels were required. Available records at the time indicated that the last major flood prior to 1959 was in May 1925 and this was probably 1 m higher than the 1959 flood at Nowra Bridge. Subdivision approval was provided in good faith by Council based on this information, and fill levels were set at 4.3 mAHD with floor levels set at 4.9 mAHD.
- In approximately 1974 a large quantity of fill (approximately 100 000 m^3 to 150 000 m^3) was placed by the owner on part of the vacant land south of Lyrebird Drive. This raised the level of the land to approximately 4.0 mAHD.

- According to local residents the floods in August 1974 and June 1975 flowed into the area over the section of road leading to the wharf but did not overtop the river bank at Riverview Road. Elsewhere on the Lower Shoalhaven floodplain the river bank was extensively overtopped causing inundation of rural properties.

- The Public Works study indicated that the river bank would be overtopped in approximately a 5% AEP event. As a result of this finding a levee bank was constructed along the southern bank of the river from near the sailing club to Ferry Lane. Silt deposited on Nowra Golf Course during the 1974 flood was used to build the bank up to approximately 5.5 mAHD which was estimated to be the 1% AEP flood level prior to the March 1978 flood.

- The March 1978 flood inundated the subdivision and subsequently the Public Works Department (now Department of Land and Water Conservation) re-examined the design flood levels.

- Following the 1978 flood, but prior to the re-examination of the design flood levels, Shoalhaven City Council prepared a draft Local Environmental Plan which made a commitment to the residential development of the vacant land south of Riverview Road. In September 1980 the Minister for Planning and Environment issued a notice to Council under Section 342 V(3) of the Local Government Act, taking planning control of vacant areas away from Council (Section 101 Notice). This was subsequently revoked in July 1988.

- In January 1981 Council prepared a "Riverview Road Strategy Report" and also formed a "Flood Mitigation and Coastal Engineering Steering Liaison Committee" comprising Council, the Public Works Department, the Department of Environment and Planning and local representatives. The majority recommendation of the Committee was that some infill development be permitted and, for major areas, development "rights" be transferred out of the floodplain to flood free land set aside by Council and the Lands Department. The report was submitted to the NSW Government.

- In February 1983 an Inter-Departmental Committee (IDC) was established to investigate "Floodway Development in the Vicinity of Riverview Road, Nowra". The IDC unanimously agreed that, contrary to the Liaison Committee's recommendations, there should be no further infill development if the existing levee was retained in its present condition. However the construction of a new levee, designed to resist a Probable Maximum Flood, and the use of other engineering works may make additional development of the area acceptable. It was proposed that either a voluntary purchase scheme or construction of a levee should be investigated by Council.

- From December 1983 to January 1984 a Commission of Inquiry (Commissioner W Simpson) was held pursuant to Section 119 of the Environmental Planning and

Assessment Act 1979. This Inquiry examined three Development Applications to construct dwellings on:

Lot 87 and Lot 90, DP 255834, Lyrebird Drive, and
Lot 5, DP 13888, Riverview Road.

The Inquiry concluded that consent for construction of the three dwellings should be refused by reason of the land being liable to flooding, located in a floodway, likely to place the lives of occupants at risk and re-direction of flood flows. The report stated:

"I do not accept that it would be acceptable or in the public interest to construct levees for the purpose of assisting or promoting further residential development in the Riverview Road area."

- Since 1984 the NSW Government has reviewed its guidelines for development in the floodplains and formulated a "merits" based approach.

- In approximately 1986/1987 the Riverview Road levee was raised to the existing estimated 1% AEP flood level. No freeboard allowance was included, although the levee is up to 0.3 m higher than the 1% AEP level in parts. The levee cost over $600 000 at the time and consists of a grass covered earthen embankment designed and built to engineering specifications with the crest level at approximately 6.4 mAHD. A stainless steel gabion mattress was placed below the surface of the back slope to minimise scouring during overtopping. An irrigation system was installed to maintain the high quality of the grass cover but this is rarely (if ever) used. In an extreme flood the levee will be overtopped by a depth of 2.5 m.

- Council commissioned a study in 1989 (the exact source is not available but is referred to in Council's resolution of 21 February 1989) to define the extent of "existing development" protected by the levee in accordance with Commissioner Simpson's Statement. The study also specified structural requirements for future dwellings and extensions to withstand floodway conditions.

- Approximately 20 new residential buildings have been constructed on vacant lots (mainly on Lyrebird Drive) since 1989. The conditions of approval were as defined by the 1989 study and included:

    - A minimum floor level of 4.9 mAHD. This is 0.5 m above the Public Works 1981 1% AEP flood level of 4.4 mAHD. The April 1990 Flood Study subsequently revised the 1% AEP level to 4.5 mAHD.

    - New construction, extensions and reconstruction on lots fronting the levee shall be two storey with load bearing walls to the ground floor or lower storey structurally designed in double brick or equivalent. Materials of construction

throughout the lower storey, excluding the ceiling, shall be compatible with immersion.

- New construction, extensions or reconstruction on other lots (e.g. Lyrebird Drive), not fronting the levee need not be two-storey. Load bearing walls of single storey dwellings and load bearing walls of the lower storey of two storey dwellings shall be double brick (which need not be specifically designed), or alternative construction such as brick veneer, designed by a practising structural engineer to resist the loads specified.

  Materials of construction throughout single storey or the lower floor of two storey dwellings, excluding the ceilings, shall be compatible with immersion.

  [Note: The requirement of "double brick" in the development conditions refers to the walls which form part of the structural support, usually the outer walls only. Other walls which are merely partitions need not be double brick, but must be of materials compatible with immersion, e.g. single brickwork.]

- In July 1995 Council approved a subdivision Development Application (No. 7956) for Part Lot 2, DP557644 (now Lot 1, DP 131820) Brereton Street, Nowra, for a 55 lot residential subdivision. The land is required to be filled to 5.1 mAHD (approximately the 0.5% AEP level) with minimum floor levels at 5.6 mAHD. Certificates of structural soundness for the buildings are required. The consent will lapse if the development is not commenced by July 2000. The land has subsequently been sold.

  The recommendations of Council included:
  - It be noted that, in supporting the application, the Shoalhaven Floodplain, Coastal and River Estuary Management Committee recognises the existing use rights in that the Leitz Subdivision has been substantially commenced by the filling of the land.
  - *It be acknowledged that no other development rights exist on adjacent allotments as no valid Development Applications were pursued by the owners prior to the change in flood status in 1980.*

- In March 1996 Council received an enquiry regarding a proposed subdivision of Lot 3, DP 513553.
- Council has prepared a concept plan for a proposed botanical garden on the vacant land surrounding the proposed residential subdivision on Lot 1, DP 131820.

- Council is at present reviewing the Structure Plan for Nowra-Bomaderry. The draft revision will not be available for some time, however the following comments foreshadow the directions being investigated.
  - *There is land available outside the floodplain for the short to medium term, i.e. approximately 10 years.*

- *Any new areas will exclude flood prone land.*
- *The only development being considered on the floodplain is infrastructure support, i.e., roads and recreation facilities, etc.*

2.2.3 Local Environmental Plan

The Riverview Road area residential subdivision was proposed to be zoned Residential 2(a4) (restricted residential) under the major Draft LEP of 1985. Subsequently Council recommended a change to 2(a1) subject to showing the flood line. In formulating the major Draft LEP there was no resolution on the most appropriate zoning and the May 1985 Local Environmental Plan does not apply to the majority of the study area, as it was excluded pursuant to Section 68(5) of the Environmental Planning and Assessment Act, 1979. The land is presently administered under Interim Development Order No. 1 (IDO No. 1). Properties on Moss Street are zoned 2(b2) or 2(b1). Land near the Leagues Club is zoned 6(b) and 2(b2).

A Rural Environmental Plan was gazetted in July 1999. This plan amends the 1985 LEP. The main features of the Rural Environmental Plan as they relate to flooding are:

> *The policy position of minimising development and settlement in flood prone areas has been retained..... The 1(g) zone remains the principal control in conjunction with Clauses 29 and 30. Zone objectives and provisions have been redrafted as a result of Council's 1993 working party debate.*

Clause 29 states:

Development of flood liable land:

29. *(1)* *Subject to subclause (2), the Council must not consent to the carrying out of development on land which, in its opinion, is flood liable.*

(2) *The Council may consent to the carrying out of development on flood liable land if:*

a) *the development is for a purpose ancillary or incidental to the use of land for the purpose of agriculture; or*

b) *the development comprises the extension or alteration of an existing dwelling house; or*

c) *the land is in any urban zone under this plan; or*

d) *the Council has received a flood assessment report, in relation to the land, that addresses each of the matters referred to in subclause (3), and the Council is of the opinion that the development is feasible despite the land being flood liable.*

(3) *In considering an application to which subclause (2) applies, the Council must make an assessment of:*

a) *the likely levels, velocity, sedimentation and debris carrying effects of flooding;*

b) the structural sufficiency of any building the subject of the application and its ability to withstand flooding;

c) the effect which the development, if carried out, will or is likely to have on the flow characteristics of floodwaters;

d) whether or not access to the site will be possible during a flood; and

e) the likely increased demand for assistance from emergency services during a flood.

(4) In granting consent to a development application made pursuant to subclause (2), the Council may impose conditions that set floor levels, require filling, structural changes or additions or require other measures to mitigate the effects of flooding or assist in emergency situations.

The objectives of the 1(g) Rural zone are:

- *to limit the erection of structures on land subject to periodic inundation,*
- *to ensure that dwelling houses are erected on land subject to periodic inundation only in conjunction with agricultural use,*
- *to ensure that the effect of inundation is not increased through development,*
- *to restrict development and how it is carried out so that its potential to have an adverse impact on site and off site on acid sulfate soils is reduced or eliminated; and*
- *to conserve and maintain the productive potential of prime crop and pasture land.*

The only development permitted without development consent in the 1(g) Rural zone is agriculture.

2.2.4 Heritage

There are six heritage listed items in the Draft Heritage LEP identified within the study area (Figure 2), namely:

- Graham Lodge and a Cemetery on Hawthorn Avenue,
- Moss Cottage at 3 Ferry Lane,
- timber slab cottage at 19 Ferry Lane,
- Elyard's boatshed and the Nowra Wharf on Wharf Road.

This Draft LEP has been publically exhibited and comments are being reviewed ahead of a report to Council (July 2001). The area east of Ferry Lane and Wondalga Crescent (Figure 2) is identified as a pastoral landscape in the Shoalhaven Heritage Study. There may be other heritage items in the study area, which have not been identified in these plans.

Any flood mitigation works which may affect these buildings will require detailed consideration of the impacts on heritage quality.

There are no identifiable Aboriginal sites within the study area.

2.2.5 Environmental

A preliminary review of the environmental qualities of the area has indicated that:

- the presence of acid sulfate soils and the release of acid into the river system is becoming of increasing importance and is currently being investigated. Some floodplain management measures (levees, drains) may upset the existing regime,
- at this point in time, no record of threatened or endangered species of flora or fauna has been identified within the study area.

2.3 Lower Shoalhaven River Flood Study

2.3.1 Review

The Lower Shoalhaven River Flood Study (Reference 3) was completed in 1990. The draft Compendium of Data (Reference 4) documented the data used in the Flood Study.

In the Flood Study a computer based hydrologic model, termed the Watershed Bounded Network Model, was established. This model converted rainfall data to estimates of streamflow which were input to the hydraulic model, called the Cell Model. This model covered the area from a point approximately 12 kilometres upstream of Nowra Bridge to the Pacific Ocean at both Shoalhaven Heads and Crookhaven Heads and produced information on flood levels, velocities and flows for the river and floodplain. The Cell Model layout for the study area is shown on Figure 3.

Both models were calibrated and verified to data recorded for the floods of August 1974, June 1975, October 1976, March 1978 and April 1988.

Design rainfall data were obtained from Australian Rainfall and Runoff (1987 edition) and input to the models to produce design flood information for the extreme, 1%, 2% and 5% AEP floods. The extreme flood provides an indication of the likely effects of the Probable Maximum Flood (PMF).

The Flood Study also considered:

- appropriate design ocean levels,
- the effects of the relative timing of the ocean peak and flood peak discharge,
- the effect of closure of the Shoalhaven Heads Entrance and subsequent scouring during the flood,
- variation in adopted width and friction values at the Shoalhaven Heads entrance.

The study concluded that, for a 1% AEP flood, the peak level at Shoalhaven Heads would be 0.75 m higher if the entrance was closed rather than open at the beginning of the flood. The difference would reduce to 0.01 m at Nowra Bridge.

The models used in the Flood Study were "state of the art" at the time of the study (1986 to 1988). Little has changed in hydrologic modelling since that time, but a new generation of hydraulic models has appeared. These new models still rely on calibration against historical flood levels to produce accurate replication of flood events. Given the amount of historical data used to calibrate and verify the Cell Model (and the lack of recent major floods) it is considered that the use of an "up to date" hydraulic model would not significantly alter the design flood levels at locations where historical levels are available. The results from the Flood Study are thus considered suitable for use in the Floodplain Management Study.

2.3.2 Design Flood Levels

Design flood levels were established in the Flood Study for the 1%, 2% and 5% AEP events and the extreme event. As part of the present study levels for the 0.2%, 0.5% and 10% AEP design floods were also established using the same procedure as in the Flood Study. Peak design levels are shown in Table 3 and on Figure 4.

Table 3: Design Flood Levels (mAHD)

Flood (AEP) / Location	Extreme	0.2%	0.5%	1%	2%	5%	10%
Nowra Bridge	8.9	7.3	6.8	6.3	5.8	5.3	4.8
Sailing Club	8.8	7.2	6.7	6.3	5.7	5.2	4.8
Riverview Rd West (River)	8.5	7.0	6.5	6.1	5.6	5.1	4.7
Riverview Rd East (River)	8.2	6.8	6.3	6.0	5.5	5.1	4.6
Pig Is West	7.4	6.1	5.7	5.4	5.0	4.7	4.4
Pig Is East	6.9	5.7	5.3	5.0	4.6	4.3	4.0
Willows Caravan Park	8.7	6.8	5.5	LR	LR	LR	LR
Riverview Rd West (land)	8.4	6.6	5.2	4.4	LR	LR	LR
Riverview Rd East (land)	8.2	6.5	5.1	4.6	4.4	LR	LR
Vacant Land/Moss St	8.0	6.2	5.1	4.5	3.7	LR	LR
Shoalhaven Caravan Pk	7.5	6.0	5.2	4.9	4.8	3.7	LR
Terara	7.2	5.8	5.1	4.7	3.9	3.6	LR
Worrigee Swamp	7.0	5.6	5.0	4.5	3.8	LR	LR

Note: LR Subject to inundation from local runoff which is not accurately simulated in the Cell Model.

As the design flows were determined using a runoff routing approach, as opposed to frequency analysis of historical flood records, any change in the estimates of the 1860 and 1870 flood levels at Nowra Bridge, or elsewhere, will not alter the design flood results.

Appendix E provides a post flood evaluation and review program which should be undertaken following each flood.

2.4 Stream Morphology

The Shoalhaven River channel below Nowra Bridge has experienced major changes in the period since European settlement. These include:

- the construction of Berry's Cut in 1822 and the scouring of Berry's Canal. This has resulted in shoaling of the Shoalhaven Heads entrance and subsequent periodic closure as the main river entrance has shifted to Crookhaven Heads,
- bank recession of up to 700 m has occurred over 150 years in the vicinity of the confluence of Berry's Canal and the Shoalhaven River,
- from 1822 to the early 1900's the river was dredged to maintain navigability. Over 1.1 million tons were removed in the period 1893 to 1911. The dredged material was either dumped on Old Man Island or taken out to sea,
- there has been a major retreat of the northern river bank (except near the downstream end of Pig Island) with maximum erosion near Broughton Creek,
- Pig Island has increased in width (650 m to 850 m) and in length (1680 m to 2400 m),
- the south channel around Pig Island has migrated to the south-east causing retreat of the Terara foreshore by up to 400 m,
- Numbaa Island may possibly not have existed prior to 1800,
- an 1822 survey plan indicates that the southern bank at Riverview Road has moved northwards by up to 150 m.

A study by the Public Works in 1988 (Reference 5) could not establish the fundamental reasons why the river morphology in the vicinity of Terara and upstream has changed since European settlement. Further downstream, much of the change can be attributed to Berry's Cut and the diversion of flow to Crookhaven Heads.

The main agents of erosion are flood scour, tidal scour and wind waves. To some extent the natural processes have been countered by scour protection works, but these works are under increasing pressure as the banks on which they rest are undercut. In places there has been a total loss of some protection works.

Overall the Public Works study concluded that the rate of river bank erosion is not slowing (except locally where protection works have been employed) and states:

"There is no end in sight to the erosion pattern in the study area, necessitating further understanding of the processes and leading to a management strategy that will combine remedial measures (where economically justifiable) with appropriate land use planning. The results of this report should be used in determining set back distances for all developments near river banks (including levees) in the interim period pending the devising of a management strategy."

2.5 Public Consultation Program

2.5.1 Components

A rigorous public consultation program (Appendix B) was carried out as part of this study and included:

- a letter of introduction and questionnaire,
- floodplain management committee meetings which included public representatives,
- newsletters,
- public meetings,
- public exhibition of material.

The direction of the study, and the degree of emphasis placed upon the various management measures, was influenced by feedback from the public consultation program. A summary of the responses to the program is given below.

2.5.2 Riverview Road Questionnaire (July 1998)

There were 98 responses from approximately 400 questionnaires sent out.

- The average length of residency was 12 years (ranging from 46 to one year).
- Only two houses had experienced above floor inundation but 19% had experienced inundation of yards.
- Previous floods had caused residents to leave their houses (4%), move their car (10%), and miss work (6%).
- Only 5% had experienced a financial loss.
- 18% had received a flood warning; of these 44% considered the warning useful.
- Only 4% (4 respondents) claimed that they suffered trauma resulting from flooding.
- 74% consider themselves flood aware with 14% having an action plan and 11% considering there was a risk to life.
- When asked to estimate the amount of warning time for a flood 24% had no idea, 18% said 1 day, 19% said 12 hours, 12% estimated 6 hours and 14% less than 6 hours.
- 52% considered flooding was of concern and 33% considered it was not a concern (15% did not respond).
- The majority (98%) considered some form of flood mitigation measures should be carried out. 49% saw dredging or enlarging Shoalhaven Heads as a priority. Other

measures suggested were dredging the river (30%), better flood warning (30%), more flood information (26%) and flood insurance (24%).

- Few suggested raising their houses (3%), voluntary purchase (3%) or sealing of buildings (3%).
- Answers from the question concerning how deep the water would be in major floods is not reported as the majority of respondents did not answer.
- A number of additional comments were made including:
    - maintenance of flap gates and drains,
    - stopping erosion of the river bank,
    - provision of sandbags and bricks,
    - prevention of wash from vehicles,
    - construct dams and control outflow to minimise sedimentation of the river,
    - more information on past floods,
    - effect of future development on flood levels,
    - low brick fences,
    - more assistance during floods.

2.5.3 Public Meeting (October 1998)

The following issues were raised during the course of the meeting (20 attendees).

- The area was first subdivided in around 1959 and some houses are 40 years old.
- The Easter 1973 flood came from Broughton Creek and entered across Ferry Lane.
- Council has a policy of maintaining a “low” spot at the mouth of the Shoalhaven River to ensure that a flood can “blow” it out. Council has also sent bulldozers to open the mouth prior to the flood peak.
- Shopping trolleys and other debris are affecting local drainage in the small creek running through the area, possibly raising flood levels and inundating garages.
- Small floods last for only 24 hours. Opening the Heads and a falling tide caused flood levels to drop quickly at Nowra Bridge.
- The August 1998 examples from flooding at Wollongong are not relevant as they were from “flash floods”.
- Why build on floodplains at all?
- What is the impact of Tallowa Dam?
- How will water be drained from the proposed 55 lot subdivision?
- The levee banks should be maintained to a high standard.
- Why is Riverview Road a high hazard area?
- This study will cause a reduction in land values and affect building approvals.
- Could brick fences be constructed on Riverview Road properties? They are presently banned by a covenant imposed by the original developer but it can be challenged.
- The floor level data seems to indicate that a new building has a floor level “below” the older buildings.
- Will development of the 55 lot subdivision proceed?
- What is the effect of a proposed Welcome Reef dam?

- Support for educating the public about flood risk.
- At present there is sufficient warning to enable residents to evacuate.

All of these comments, and others not listed, have been considered in developing management strategies.

3. EXISTING FLOOD PROBLEM

3.1 Flooding Mechanism

Flooding in the area can result from one or both of:

- flow from the Shoalhaven River over the Riverview Road levee,
- backwater flooding from the floodplain (Worrigee Swamp) which initially occurs as a result of local runoff but in larger events is augmented by flow over the river bank elsewhere.

The relative significance of the two mechanisms depends on flow in the river, local rainfall and the height of the river bank levees.

3.2 Hydraulic Classification

The classification of the study area has changed significantly in the last three decades due to construction of the Riverview Road levee and the subdivision and construction of buildings. The studies carried out prior to the levee upgrade in 1986 determined the area to be a floodway.

The Floodplain Development Manual defines three hydraulic categories which can be applied to areas of the floodplain.

> "*Floodways* are those areas where a significant volume of water flows during floods. They are often aligned with obvious naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant increase in flood levels and/or a significant redistribution of flood flow, which may in turn adversely affect other areas. They are often, but not necessarily, the areas with deeper flow or areas where the higher velocities occur.
>
> *"Flood storage* areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. If the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas will rise and the peak discharge downstream may be increased. Substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.
>
> *"Flood fringe* is the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels."

The hydraulic classification for the Riverview Road area varies depending on magnitude of the flood. There is little inundation in floods up to a 1% AEP event. In larger floods there will be

overtopping of the levee and significant depths of floodwater and high velocities as shown in Table 4.

Table 4: Depths and Velocities

Flood Levels	River	Riverview Road	Vacant Land	Shoalhaven Caravan Park
5% AEP event RL(mAHD)	5.1	LR	2.2	LR
depth (m)	n/a	LR	n/a	LR
2% AEP event RL(mAHD)	5.6	LR	3.7	4.8
depth (m)	n/a	LR	0.3	0.2
1% AEP event RL(mAHD)	6.1	4.4	4.5	4.9
depth (m)	n/a	0.1	1.1	0.3
0.2% AEP event RL(mAHD)	7.0	6.6	6.2	6.0
depth (m)	n/a	2.3	2.8	1.4
Extreme event RL(mAHD)	8.5	8.4	8.0	7.5
depth (m)	n/a	4.1	4.6	2.9

n/a not applicable - depths for a typical ground level of 4.3 mAHD (Riverview Road), 3.4 mAHD (vacant land) and 4.6 mAHD (Caravan Park).

LR subject to inundation from local runoff which is not accurately simulated in the Cell Model.

Velocity (m/s)	River	Elia Avenue	Lyrebird Drive	Shoalhaven Caravan Park
5% AEP event	3.6	LR	LR	0.5
2% AEP event	4.4	LR	LR	0.8
1% AEP event	5.2	<0.1	<0.1	0.5
0.2% AEP event	6.6	1.2	0.9	0.7
Extreme event	8.3	1.7	1.5	1.1

Note: Velocities are the section average velocity at the peak level. Local velocities may be higher by up to three times.

Ground levels fall from approximately 4.7 mAHD on Riverview Road, adjacent to the levee to 4.0 mAHD on Lyrebird Drive. Within the vacant land south of Lyrebird Drive and north of Moss Street the ground levels vary from 2.2 mAHD to 4.2 mAHD. Prior to filling the majority of the land was at about 2.5 mAHD.

There is no absolute division between each hydraulic category but on the basis of the above results, the following categories were delineated:

- The Shoalhaven Caravan Park is floodway for the 2% AEP and greater events on account of the depth and velocity of floodwater.
- For events smaller than the 1% AEP, the area west of Ferry Lane is flood fringe.
- For events larger than the 1% AEP when overtopping of the Riverview Road levee occurs, the entire study area is floodway.

3.3 Flood Hazard Classification

Flood hazard is a measure of the overall adverse effects of flooding. It incorporates threat to life, danger and difficulty in evacuating people and possessions and the potential for damage, social disruption and loss of production.

Land is classified as either *low* or *high* hazard for a range of flood events. The classification is a qualitative assessment based on a number of factors as listed in Table 5.

Table 5: Hazard Classification

Criteria	Weight [1]	Comment
Size of the Flood	Medium	Up to a 1% AEP event there is no direct inundation from the Shoalhaven River over the Riverview Road levee but overtopping will occur in 5% AEP and greater events adjacent to the Shoalhaven Caravan Park. In events greater than a 1% AEP event the majority of the floodplain is inundated.
Flood Awareness of the Community	Low	Based upon the results of the questionnaire.
Depth and Velocity of Floodwaters	High	Velocities will be moderate (over 1 m/s) near the river bank but will slightly reduce near Ferry Lane . The depth of floodwaters (in events greater than the 1% AEP) is the main concern (refer Table 4).
Effective Warning and Evacuation Times	Medium	The existing ALERT system should provide adequate warning (Section 4.5.1).
Rate of Rise of Floodwaters	High	Residents will be aware that the river is rising but may be surprised at how rapidly the floodplain becomes inundated following overtopping of the levee.
Duration of Flooding	Low	The duration of inundation is of the order of 20 hours and the flood will generally have receded in approximately two days.
Evacuation Difficulties	Medium for residential properties. High for Shoalhaven Caravan Park	These are likely to be medium/high on account of: • the distance to high ground (0.5 km for the Shoalhaven Caravan Park), • the number of people using the routes, • all roads are lower than the building floor levels. Thus residents will have difficulty in evacuating if they wait until their floor is inundated, • the emergency services (SES, Police) will be "stretched" answering calls throughout the area.
Effective Flood Access	Low	The access route for the Moss Street properties is easy. For the remainder of the area there are two access routes (Pleasant Way and Ferry Lane).
Additional Concerns such as Bank Erosion, Debris, Wind Wave Action	Low (Riverview Rd) High (Shoalhaven Caravan Pk)	The risk of bank erosion is low for the majority of the study area but will increase as the flood magnitude increases. The high river velocities (>5 m/s) will cause erosion at weak spots. Debris and wind wave action will also cause damage to structures (Shoalhaven Caravan Park) and increase the risk to life.

Note 1: Relative weighting

Based on the above, the flood hazard classification for the area west of Ferry Lane is low for flood events up to the 1% AEP event and high for larger events. It is high for the 2% AEP and greater events at the Shoalhaven Caravan Park (east of Ferry Lane).

3.4 Flood Damages

The cost of flood damages and the extent of the disruption to the community depends upon many factors including:

- the magnitude (depth, velocity and duration) of the flood,
- land usage and susceptibility to damage,
- awareness of the community to flooding,
- effective warning time,
- the availability of an evacuation plan or damage minimisation program,
- physical factors such as erosion of the river bank, flood borne debris, sedimentation.

Flood damages can be defined as being "tangible" or "intangible". Tangible damages are those for which a monetary value can be assigned, in contrast to intangible damages, which cannot easily be attributed a monetary value. A summary of the types of damages with details of how the costs were calculated for this study is provided in Appendix A.

Table 6 indicates the number of buildings likely to be flooded in various events and shows the corresponding tangible damages. Likely damages to public utilities are provided in Appendix A.

Table 6: Riverview Road Area - Damages to Buildings and Caravan Parks

Flood	Number [1]	Caravan Park Damages ($1999)	Total Tangible Damages ($1999) [2]
Extreme	177	3 600 000	13 300 000*
0.2% AEP	167	3 200 000	10 500 000*
0.5% AEP	119	1 100 000	3 800 000*
1% AEP	7	480 000	940 000
2% AEP	2	370 000	430 000
5% AEP	nil	1 000	11 000
10% AEP	nil	nil	10 000

Notes: (1) Assumes only one building per property (i.e. a block of units is taken as one building). The number of caravans inundated is not shown.

(2) Includes the total tangible damages to private property within the study area including caravan parks and unit developments.

* Damages will be higher if buildings are completely destroyed.

While the total likely damages figure in a given flood (as shown on Table 6) is useful to get a "feel" for the magnitude of the flood problem, it is of little value for economic evaluation. When considering the economic effectiveness of a proposed mitigation option, the key question is what are the total damages prevented over the life of the option? This is a function not only of the high damages which occur in large floods but also of the lesser but more frequent damages which occur in small floods.

The standard way of expressing flood damages is in terms of average annual damages. These are calculated by multiplying the damages that can occur in a given flood by the probability of the flood occurring in a given year and summing across the range of floods. By this means the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods.

Based on Table 6, the average annual tangible damages (AAD) for the Riverview Road area are estimated to be approximately $70 000 ($1999). This figure excludes damages to public property and intangible damages.

4. FLOODPLAIN MANAGEMENT MEASURES

4.1 Introduction

Measures which can be employed to mitigate flooding and reduce flood damages can be separated into three broad categories:

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

Property modification measures modify land use including development controls. This is generally accomplished through such means as flood proofing (house raising or sealing entrances), planning and building regulations (zoning) or voluntary purchase.

Response modification measures modify the community's response to flood hazard by informing flood-affected property owners about the nature of flooding so that they can make informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

A number of the measures mentioned above were clearly not applicable to the situation at Riverview Road and were deleted from consideration at an early stage of the study process. Section 4.2 briefly canvasses these. Measures which were subjected to more detailed consideration are discussed in Sections 4.3 to 4.5.

A number of methods are available for judging the relative merits of competing measures. The benefit/cost (B/C) approach has long been used to quantify the economic worth of each option on a relative basis enabling ranking against similar projects in other areas. The benefit/cost ratio is the ratio of the Net Present Worth of the reduction in flood damage (benefit) to the cost of the works. Generally the ratio expresses only the reduction in tangible damages as it is difficult to accurately include intangibles such as anxiety, risk to life, ill health and other social and environmental effects. In this study the reduction in tangible damages to public utilities has not been included.

The potential environmental or social impacts of any proposed flood mitigation works are of great concern to society and these cannot be evaluated using the classical benefit/cost approach. The public consultation program (Appendix B) has ensured that all identifiable social and environmental factors were considered in the decision making process.

4.2 Measures Not Considered Further

Early in the study a report was provided to the Floodplain Management Committee with a list of all possible floodplain management measures which could conceivably be applied in the study area. The measures were classified with regard to reduction in flood level, social effect, environmental impact, cost to implement and benefit/cost ratio.

The Committee identified a number of measures that were not worthy of further consideration. These are summarised in Table 7 and the following sections.

Table 7: Floodplain Management Measures Not Considered Further

Measure	Impact				
	Reduction in Flood Level	**Social Effect**	**Environ-mental Impact**	**Cost to Implement**	**Benefit/Cost Ratio**
FLOOD MODIFICATION MEASURES:					
Flood Mitigation Dams etc	Yes	Nil	Very High	Very High	Low
Floodways	Non Applicable	-	-	-	-
Catchment Treatment	Minimal	Nil	Low	Low	Nil
RESPONSE MODIFICATION MEASURES:					
Flood Insurance	Nil	Some	Nil	Not Available for Residential	

4.2.1 Flood Mitigation Dams, Retarding Basins, On-Site Detention

Special purpose flood mitigation dams, or dams which have significant flood storage capability, such as Burrendong Dam (approximately 1 million megalitres of flood storage), can significantly reduce downstream peak flood levels. However dams are extremely expensive and can generally only be justified for flood mitigation in economic terms if combined with a water supply or power generation capacity. Construction of large dams will also have a significant environmental effect and should be evaluated on a catchment wide basis.

Tallowa Dam was constructed in the early 1970's downstream of the Shoalhaven River/Kangaroo River confluence as part of the Shoalhaven Water Supply Scheme. The dam was constructed to maintain a water supply for Bendela Pumping Station and has an active storage capacity of approximately 36 000 megalitres. As the volumes of each of the 1974, 1975 and 1978 floods were in excess of 1 million megalitres, the mitigating capacity of the dam is negligible.

Stage 2 of the Water Supply Scheme would involve construction of a major dam at Welcome Reef, which could have a capacity in excess of 2 million megalitres. At this time there is no certainty that Welcome Reef Dam will be constructed, and even if it were built, it would only control 50% of the catchment to Nowra. Floods originating in the Kangaroo Valley or Yalwal Creek would be unaffected.

There is little opportunity for reducing flood peaks at Nowra or downstream by constructing new dams or upgrading existing dams. The flood mitigation benefits of Welcome Reef should be considered when evaluating the viability of the dam, but would be a minor component of the decision making process given its primary function.

Retarding basins and on-site stormwater detention systems are increasingly being used in developing catchments. Both these measures are appropriate for controlling flooding in small catchments (say up to 20 km^2) or to mitigate the effects of increased runoff caused by development. However, they would have a negligible impact on flood levels in the Shoalhaven River and are not appropriate for flood mitigation at Riverview Road.

4.2.2 Floodways

Floodways are lower overbank areas which can carry significant flow in times of flood. In some instances, on smaller streams, an artificial floodway can be created in an environmentally sensitive manner to achieve reductions in upstream levels. However, given the size of the Shoalhaven floodplain, and the lack of a suitable location and the volume of water involved, artificial floodways are not viable.

4.2.3 Catchment Treatment

Catchment treatment modifies the characteristics of the catchment to reduce runoff to the river. For an urban catchment, this involves planning to maximise the amount of pervious area, maintaining natural channels where practical and the use of on-site detention. For a rural catchment, this involves limiting deforestation or contour ploughing of hill slopes.

Again it is a measure which can be effective on small catchments but has negligible impact on the volumes of water involved in a Shoalhaven River flood. As a general concept, catchment treatment techniques should be encouraged along with water quality and erosion/sedimentation controls but these will not affect flooding at Riverview Road.

4.2.4 Flood Insurance

Flood insurance (Reference 6) does not reduce flood damages but transforms the random sequence of losses into a regular series of payments. Many residents regard flood insurance as a preferred flood mitigation measure. At present, flood insurance is not readily available for houses, although it is available for some commercial and industrial properties. There are a

number of potential implications with flood insurance, such as rebuilding in a floodway and these need to be addressed.

4.3 Flood Modification Measures

4.3.1 River Improvement Works

Description

River improvement works, such as desnagging or removal of hydraulic restrictions, reduce flood levels by increasing the hydraulic capacity of the river. Dredging could also improve the hydraulic capacity by increasing the inbank flow area.

Discussion

Desnagging and removal of vegetation may reduce flood levels on small creeks but would provide negligible benefit on the Shoalhaven. Vegetation removal is likely to further destabilise the banks. Realignment or reconstruction of the channel and removal of hydraulic restrictions such as the islands (Pig, Numbaa, Old Man) were considered but rejected due to:

- high cost,
- land ownership and compensation issues,
- likely impact on the erosional and sedimentation regime,
- unlikely to be sustainable (i.e. will require ongoing maintenance dredging),
- environmental concerns,
- bank stability concerns,
- loss of agricultural land.

"Terara Sand and Gravel" has operated a dredge since 1992 to extract approximately 35 000 m^3 (or 50 000 tonnes) per annum. Currently the dredge only works within a limited area upstream of the village and provides minimal hydraulic benefit as it creates localised holes rather than reducing the bed level by a uniform amount over a large distance.

The hydraulic model was used to evaluate the effect of increasing the dredged area to enable a reduction in the general bed level. Three scenarios were analysed for both the 5% and the 1% AEP events

- Scenario A - 260 000 m^3 removed,
- Scenario B - 550 000 m^3 removed,
- Scenario C - 1 000 000 m^3 removed.

Dredging was assumed to extend over a 4.5 km length of the river from approximately midway along the Riverview Road levee to approximately midway between Pig Island and Numbaa Island. The resulting changes in peak flood level are shown in Table 8. The indicated reductions in flood level will have an insignificant effect on the flood hazard at Riverview Road. Dredging further upstream or downstream would have no additional benefit.

Table 8: Dredging - Reduction in Flood Level (m)

Dredging Scenario	A		B		C	
Location/Flood	**1%**	**5%**	**1%**	**5%**	**1%**	**5%**
Terara	0.02	*	0.03	*	0.07	*
Pig Island	0.02	0.02	0.04	0.04	0.07	0.08
Ferry Lane	0.03	0.03	0.06	0.06	0.11	0.12

NOTE: * values are not provided for the 5% AEP event at Terara as the land is only just inundated at this level and the peak levels relate more to local drainage, or backwater levels in the swamp than the river levels.

The cost of dredging largely depends on the size of the dredge and the land-based operation. An indicative range is \$8/m^3 to \$10/m^3. Assuming \$9/m^3 the scenario costs would be:

- Scenario A - \$2.3 million,
- Scenario B - \$5.0 million,
- Scenario C - \$9.0 million.

On top of these costs there is currently a royalty of \$1.20/m^3, although this might be renegotiated if the work was solely for flood mitigation purposes with no financial gain.

A preliminary estimate of the present worth of the reduction in annual average damages for Scenario B is only \$4 600, which implies a very low B/C ratio unless the material removed has commercial value.

Potential use of the extracted material depends on the quality of the material and the local market. The existing dredge operation provides sand for local concrete manufacturing and filling at approximately \$12/m^3 to \$20/m^3. Preliminary investigation suggests that decreasing the price will not significantly increase demand. In fact the current operator adjusts the extraction rate to meet the demand and could easily produce up to twice the current volume of material. Most of the material removed in the three scenarios would, therefore, not find a market and disposal sites would need to be found. This would add to the economic cost and also have significant environmental implications.

A dredging operation normally extracts approximately 30% solids and 70% liquid, and legislation requires that the liquid be settled before returning to the river. The present operator uses a trench on Pig Island for settling but this is already a source of contention and preliminary investigations suggest that this issue will be a significant problem for a larger operator.

Dredging is an extractive industry and requires an EIS to be prepared as part of the approval process. An EIS would cost of the order of \$100 000 and would require an evaluation of a range of environmental and social issues.

Further investigation would also be required to determine the long term effectiveness of dredging. It is possible that a subsequent flood would simply deposit material in the dredged area, thus negating the benefit. There is also the possibility that large scale dredging may induce local bank failure as a result of affecting the sedimentation/erosional regime of the area.

Conclusions

Large scale dredging will marginally reduce flood levels but will not greatly affect the inundation of buildings in large floods. It is not an effective floodplain management measure as it provides only marginal hydraulic benefit, is not economically viable and would raise significant environmental concerns.

4.3.2 Shoalhaven Heads Entrance

Description

The entrance at Shoalhaven Heads has closed on a number of occasions since the construction of Berry's Cut in 1822. It experiences rapid closure between flood events by shoaling of the entrance due to coastal processes. More recently the entrance was closed from late 1980 until it opened during the April 1988 flood. The entrance closed again in September 1989 and subsequently opened during the August 1990 flood (possibly it opened again between 1990 and 1998). The entrance opened in August 1998, closed in January 1999 and opened again in October 1999.

Floods are the only mechanism which open the entrance and the length of opening is related to the subsequent river flow and coastal and estuarine processes. Not all floods result in the entrance opening.

Some residents believe that providing a permanently open entrance will lead to significant reductions in flood levels in the vicinity of the study area.

Discussion

In the Flood Study (Reference 2) two entrance scenarios were examined for the design floods:

- *Closed* - as existed prior to the April 1988 flood with a beach dune at 2 mAHD and the flats behind the dune at 0 mAHD. This dune scoured during the passage of the flood.
- *Open* - the entrance was assumed to be a rectangular opening 400 m wide with an invert at -2 mAHD. This is the likely maximum size of channel and would only occur following a major flood.

The Flood Study adopted the *entrance closed* scenario for design but also considered the impacts on flood behaviour of assuming an *entrance open* condition. The scenarios were modelled for the 1% and 5% AEP floods and various ocean levels. The results are reproduced in Table 9:

Table 9: Impacts of Entrance Conditions at Shoalhaven Heads (mAHD)

Condition	Shoalhaven River at Terara		Shoalhaven Heads	
	5% AEP	1% AEP	5% AEP	1% AEP
Entrance Closed with Elevated Ocean	4.68	5.43	2.60	3.23
Entrance Open with Elevated Ocean	4.67	5.41	2.18	2.65

The table indicates that an open entrance will slightly decrease the 5% and 1% AEP levels adjoining Terara (by up to 0.02 m).

A number of other investigations (References 7 to 12) have examined the feasibility of a permanent ocean entrance at Shoalhaven Heads. Overall it would appear that the disadvantages of having a permanent entrance outweigh the advantages. Council has a policy of maintaining a low level beach berm at the Shoalhaven Heads entrance. When a flood occurs in future the beach berm will be quickly overtopped and the floodwaters will scour out the entrance. Council has also provided equipment in the past to "open" the dunes if sufficient warning is available and unsuccessfully trialed a "wet notch" in 1995/96.

Conclusions

Maintenance of an open entrance at Shoalhaven Heads would marginally reduce 1% AEP flood levels in the vicinity of Riverview Road. The impacts would be small, and a permanent open entrance cannot be justified solely on the grounds of reducing flood levels at Riverview Road.

4.3.3 Local Drainage

Description

Residents have reported that runoff ponds in the vacant land south of Lyrebird Drive. They are also concerned that the piped drainage system which enters the river under the levee is not working efficiently.

Discussion

Ponding is caused by runoff entering the area from west of the Princes Highway and from local rain over the area. It is a natural phenomenon on floodplains and causes no tangible damage to the residents. The efficiency of the piped drainage system was not investigated as part of this study.

Conclusions

The drainage system in the Riverview Road area and under the levee should be regularly inspected to ensure that it is functioning as designed. Measures to limit ponding within the vacant land cannot be justified on flood mitigation grounds.

4.3.4 Levees

Description

A levee was built along the southern bank of the Shoalhaven River from Nowra Bridge to Terara in the mid 1970's. In 1986 the levee from Nowra Bridge to Ferry Lane was increased to the 1% AEP flood level, approximately 2 m above the adjacent natural ground surface. The crest of the levee is approximately horizontal at 6.4 mAHD. The adequacy of the present levee and possible measures to upgrade protection to the area were considered.

Discussion

The benefits of levees in floodplain management have long been recognised, however in recent years a number of significant disbenefits have also become apparent.

They are expensive, for example the Riverview Road Levee cost approximately $600/m length in 1986. A levee to exclude large floods from the area would require raising of the existing levee and an additional levee to prevent inundation across Ferry Lane. A number of residents already regard the existing levee as visually obtrusive and detracting from the aesthetic qualities of the area.

Increasing flood protection for Riverview Road would marginally increase levels in the river and may deflect flows towards the north bank near the Paper Mill.

Unless the levee was to the PMF level, which would be unacceptable both economically and socially, it would eventually be overtopped in a very large flood event. When this inevitably happened, initial velocities would be high and substantial flood damages would occur. The situation would probably be exacerbated by the fact that the levee has engendered a false sense of security in the local population and substantially lowered flood awareness. This was the case at Nyngan in 1990.

Construction of a levee around the entire area may also lead to a pressure to alter Council's Flood Policy and allow further development. Previous reports on flooding at Riverview Road considered that levees should only be used to protect existing dwellings and should not be promoted to facilitate further development on the floodplain.

Conclusions

Raising the existing levee or constructing new levees are not likely to be economically justifiable and will probably not be supported by the local community on social grounds. A management and maintenance audit of the levee should be undertaken by Council. This would include a survey of the levee and an assessment of whether minor changes to the crest level should be made to control where overtopping will first occur.

4.4 Property Modification Measures

4.4.1 Voluntary Purchase

Description

Voluntary purchase of the entire area cannot be economically or socially justified but can be used as a long term strategy to reduce the number of flood liable properties.

Discussion

Voluntary purchase is not favoured by a large part of the community. Among their concerns are:

- it can be difficult to establish a fair market value,
- in many cases residents may not wish to move for a reasonable purchase price,
- progressive removal of properties may impose stress on the social fabric of the area,
- it may be difficult to find alternative equivalent priced housing in the nearby area with similar aesthetic values.

No buildings were identified as suitable for inclusion in a voluntary purchase scheme.

Conclusions

In view of the reservations listed above voluntary purchase is not considered to be a viable means of reducing the number of flood liable buildings.

4.4.2 House Raising

Description

House raising costs approximately $40 000 per house and is suitable for most non-brick single storey buildings on piers.

Discussion

This measure could be applicable for three buildings on Ferry Lane but the remainder of the buildings are probably unsuitable due to the construction material used. The benefit/cost ratio varies for each building depending on the floor level and the relative height of flooding but a typical ratio is less than 0.4. This is low because the buildings are not flooded until events larger than the 1% AEP. The buildings that are suitable for raising are older buildings which have some heritage quality.

The questionnaire showed a low level of acceptance for house raising. Individual streetscapes may be significantly impacted. House raising would not reduce the flood hazard in the area, and in fact may encourage residents to stay with their house rather than be evacuated when a major flood is predicted.

Conclusions

This measure could be considered further but social and heritage issues would seem to make it unacceptable.

4.4.3 Flood Proofing

Description

Flood proofing involves the sealing of entrances, windows, vents, etc., to prevent or limit the ingress of floodwaters. It is only suitable for brick buildings with concrete floors and can prevent ingress for outside depths up to approximately one metre. Greater depths may cause collapse of the structure unless water is allowed to enter. An existing house could be sealed for approximately $10 000 while the cost for new houses or extensions would be much less. The majority of buildings in the study area are suitable for flood proofing.

Discussion

This measure is rarely used in NSW for residential buildings and is more suited to commercial premises where there are only one or two entrances and maintenance and operation procedures can be better enforced.

Flood proofing requires sealing of doors (new frame, seal and door); sealing and re-routing of ventilation gaps in brickwork; sealing of all underfloor entrances and checking of brickwork to ensure that there are no gaps or weaknesses in the mortar.

It will not reduce the flood hazard and may increase the hazard if residents stay in their houses and a large flood eventually inundates the building. A typical benefit/cost ratio is 1.3 and there are no significant environmental or social problems.

Conclusions

This measure has a higher B/C ratio than house raising and should be investigated further. Preliminary work would include detailed inspection of buildings and interviews with the residents.

4.4.4 Planning Considerations

Description

The study area west of Ferry Lane is categorised as high hazard floodway for events greater than the 1% AEP. In smaller events there is no significant inundation. The Shoalhaven Caravan Park is a high hazard floodway for events greater than the 5% AEP. Removal of the existing population from the entire area cannot be justified as:

- it would cause significant social problems,
- many residents are likely to reject any reasonable offer of voluntary purchase.

Under the present zoning, applications for further development could be made.

The main categories of development which could be considered are:

- new residential buildings (single dwelling and unit development) as infill development within the existing subdivided area at Riverview Road,
- new non-residential buildings (commercial),
- new residential subdivisions,
- additions/extensions to existing structures,
- expansion of existing caravan parks.

Discussion

Appropriate planning restrictions involve consideration of the social, economic, environmental and risk to life and limb consequences associated with the occurrence and mitigation of floods of various sizes. This involves trading off the various benefits of reducing the impact of flooding on development against the costs of restricting land use in flood prone areas and of implementing management measures.

Issues to be considered in planning are shown in Table 10.

Table 10: Flood Related Issues Considered in Planning

ISSUE	COMMENT
Flood Behaviour up to the PMF	Depth, velocity. Change in behaviour over the full range of events.
Existing Flood Standard	Is it accepted by the community? How significant will any change be?
Land Use	Existing and potential. How will this be affected?
Availability of Land	Is there other land suitable for development in the area?
Impact of Floodplain Management Strategies	How will these impact upon existing and future development?
Land Values and Social Equity	Will changes affect other land owners?
Impact of Future Flooding	On existing and future development.
Impact of Future Development	On flood behaviour.
Resulting Change in Flood Damages	Percentage and absolute change.
Consequences of Larger Floods	Up to the PMF.
Flood Awareness and Preparedness of the Community	Present community. In the future.
False Sense of Security	Will this be created?
Flood Warning/Flood Evacuation	Effectiveness of emergency response.
Environmental and Ecological Issues	Will these be affected? Streetscape.
Duty of Care	How has this been taken into account?

The primary objective of the NSW Government Flood Policy is *to reduce the impact of flooding and flood liability on individual owners and occupiers, and to reduce private and public losses resulting from flooding.*

This present study has identified the study area as high hazard area and has examined a range of floodplain management measures to reduce the hazard. No viable flood modification measures are available, and whilst the response modification measures will reduce flood damages, they do not provide a long term solution to the problem. Voluntary purchase of the entire area cannot be socially or environmentally justified (Section 4.4.1).

Planning regulations offer the only long term solution by controlling further residential and commercial developments.

Conclusions

New Residential Buildings within the Riverview Road Subdivision: Infill development within the subdivision has already been approved by Council subject to the conditions provided in Council's Flood Policy. Approximately 15 new buildings could be approved in this manner within the already subdivided areas and a further 12 within Lot 7 DP 809132 (approved for subdivision).

The basis for Council's approval and conditions were developed over a number of years and took into account the history of the development, social factors and hydraulic considerations. No change is proposed.

Approved Residential Subdivisions yet to be Developed: Approval for the 55 lot subdivision on Lot 1, DP 131820 took into account the existing use rights of the owners and requires a floor level 0.7 m higher (5.6 mAHD) than that adopted for the Riverview Road subdivision (4.9 mAHD).

The land has been sold and the lot layout and type of development has changed with the new owner. Council has applied conditions to ensure that the proposed development is compatible with the approved conditions and will not be exposed to increased damages or flood hazard.

Council has concept plans for a proposed botanic garden on Lot 8, DP 809132 and the land outside the 55 lot subdivision on Lot 1, DP 131820.

New Residential Development on vacant land within IDO1 (except within approved subdivisions): There is pressure for further development on Lots 1 and 2, DP 714140 and others.

Approvals for the Riverview Road subdivision and the recent 55 lot subdivision were given using a merits based assessment taking into account the earlier approvals by Council to the development. An assessment of the development potential of the vacant land with the IDO1 area indicates:

- Council has determined that the land had no prior development commitment. The area is high hazard floodway in events greater than the 1% AEP (it would be high hazard floodway for events greater than the 5% AEP if the Riverview Road levee and the subdivision had not been constructed. This is relevant because the levee was constructed to prevent inundation to the existing subdivision and not to facilitate further development.).

- Council's planners have indicated that there is suitable land for development elsewhere which is not flood prone.

- Filling in the area would cause a minor adverse hydraulic impact (raising of flood levels and velocities) as a result of loss of temporary floodplain storage and loss of flow area. This would result in an increase in flood damages elsewhere.

- Whilst the damages to any future development can be minimised by raising the floor levels, even if they are raised above the extreme flood level (8.0 mAHD) evacuation would still be required during a large flood. This increases the demand on rescue services and the potential for risk to life.

- The social disbenefits (increase in noise and population density, reduction in amenity of the area) and benefits (additional development within an existing urban area) as well as environmental (unlikely to be significant) impacts have not been evaluated as part of this study.

- Council's policy is to limit development on flood prone lands.

On the basis of the above assessment, further subdivisions and residential development within the IDO1 area are likely to increase the future flood damages and must be weighed against the likely benefits of the developments. The only exceptions may be on Lots 1 and 2, DP 521592 near Moss Street/Wondalga Crescent. This land is near to high ground which may provide safe evacuation routes.

Any increase in the population of this area will increase the demand on the rescue services and the risk to life. Filling of lots may increase flood levels or redirect flows elsewhere.

New Subdivisions on Land outside IDO1: Land east of Ferry Lane is zoned Rural 1(g). The objectives of the zone are appropriate and adequately take into consideration the flood hazard.

Land south and west of IDO1 is zoned either 2 (b2, b1) or 6(b). This land is on the fringe of the floodplain with relatively easy access to high ground even in an extreme flood. Development of this land should not be prevented on account of flooding but must be done in a manner compatible with Council's flood policy and the State Government's Policy.

New Non-Residential Buildings (Commercial): At present there are no proposals for commercial developments within the study area. Should this situation change, the proposal should be considered on its merits taking into account the following:

- a few non-residential buildings (generally only very large companies) can be insured against flood damage,
- the amount of damage can vary from practically nil to very high depending on the usage,
- there is usually less risk to life as the building is not occupied at night and the occupants are more willing to move,
- the damage and risk to life can be minimised through preparation of a Flood Evacuation Plan,
- the building may be sealed to prevent the ingress of floodwaters,
- compliance with the floor level policy may severely limit the use of the site, e.g. truck loading, access,
- consideration should be given to the life span of the structure and of the equipment which may be damaged in a flood,
- generally there are less intangible damages than for residential buildings,
- a non-residential developer who has been fully informed on the flood risk should be in a position to assess the flooding risk against other commercial risks,

- damage can be minimised by ensuring that all services (electrical, sewer, water, air conditioning) are built at higher levels,
- the building can be made of flood compatible material (no gyprock or compressed wood cupboards).

Any non-residential usage should only be considered within the wider planning framework of the City of Nowra and the region.

The above considerations do not imply that there are lesser restrictions for residential than commercial buildings, only that there should be more flexibility in applying the restrictions to account for a range of commercial developments.

Extensions/alterations to existing Residential Development: The proposed requirements are summarised below:

ITEM	REQUIREMENTS
Floor Level	To be considered on its merits.
Building Components	To be considered on its merits.
Structural Soundness	To be considered on its merits.
Impact upon Others	Not to be considered unless the works are greater than 100 m^2 in area.
Flood Evacuation	No additional works required.

4.4.5 Caravan Parks

There are two caravan parks within the study area:

- the Willows East Caravan Park located at the southern abutment of Nowra bridge off the Pleasant Way (approximately 80 sites),
- Shoalhaven Caravan Park located east of Ferry Lane on Terara Road (approximately 130 sites).

Caravan parks present their own unique problems namely:

- there is poor access with a single entrance/exit which may be controlled by gates,
- only a poor (or no) site map is generally available to show the internal road system or the types of vans,
- fixed annexes which may contain high cost equipment such as freezers or stoves,
- there is poor internal lighting which may fail during a flood,
- there is no flood emergency plan or it has not been practised recently. A plan is available for The Willows East Caravan Park,
- there is a problem in communicating to the residents due to the lack of or failure of the public address system or telephone network,
- short term residents will have little flood awareness of the flood risk or damage minimisation measures,

- a large number of vans may be vacant thus increasing the workload and possible risk to life of the "rescuers" in removing vans,
- there is the risk that vans may float and crash into each other or obstruct exit routes,
- caravans have little structural integrity and thus can easily be damaged by flowing water,
- the internal fittings (cupboards, fridges, beds) are usually non-removable and quickly damaged by floodwaters.

Discussion

Both caravan parks are in high hazard floodway areas (The Willows East in events greater than the 1% AEP). Floodplain management issues relating to caravan parks are addressed in Council's *"Interim Flood Policy - Caravan Parks on Floodprone Land"* (Section 1.3.1) and the SES's *"Shoalhaven Local Flood Plan"*. The measures described in these documents include:

- tie downs and rapid knock down annexes,
- an evacuation strategy,
- flood action plan.

In the initial approval by Council for the Shoalhaven Caravan Park there were requirements to raise the levee and construct an elevated area to hold all vans in a flood. These measures are appropriate for minimising damages but depend upon adequate enforcement and maintenance for their continued success.

Conclusions

Caravan parks are areas of potential high risk and damages (Table 6) as a result of flooding. There should be no increase in the number of permanent or semi-permanent unregistered vans or cabins within the Rural 1(g) zone. Adequate measures have been incorporated into Council's policy to minimise these effects for existing vans/cabins but only if they are enforced. A program should be established to ensure that the policy is carried through.

4.5 Response Modification Measures

4.5.1 Flood Warning

Description

Flood warning, and the implementation of evacuation procedures by the State Emergency Services (SES), are widely used throughout NSW to reduce flood damages and protect lives. The Bureau of Meteorology (BOM) is responsible for flood warnings on major river systems such as the Shoalhaven River. A flood warning system is usually based on stations which automatically record rainfall or river levels at upstream locations and telemeter the information to a central location. Alternatively this type of information can be relayed manually.

Adequate flood warning gives residents time to move goods, stock and vehicles above the reach of floodwaters and to evacuate from the area. The effectiveness of a flood warning scheme depends on:

- the maximum potential warning time before the onset of flooding.
- the actual warning time provided before the onset of flooding. This depends on the adequacy of the information gathering network and the skill and knowledge of the operators,
- the flood awareness of the community responding to a warning.

Studies have shown that flood warning systems generally have high benefit/cost ratios if sufficient warning time is provided. Even with an effective flood warning system, some tangible and intangible flood damages will still occur.

Discussion

An ALERT system (Automated Local Evaluation in Real Time) has been operated in the catchment by Shoalhaven City Council and the BOM since 1989. It cost $120 000 to install which was shared between the two authorities. It consists of 15 rain and eight stream sensor stations and a number of repeater stations. The system has not been tested in a large flood but performed successfully in smaller events in the 1990's. Some operational problems (radio interference, battery life, software problems) have occurred but these have now been resolved.

Although Council monitors the situation during flood events the responsibility for preparing regional flood warning rests with the BOM. Based on this information the SES issues community level warnings. Council does not issue warnings but assists the SES with road closures and evacuations. Council uses the ALERT system to provide information to the SES for events below the minimum level at which the BOM issues warnings.

Council does not have a facility to forecast flood levels but is currently investigating this matter. If Council had its own forecasting model it would provide additional benefits such as:

- it would act as a fall back system if the BOM system failed,
- it may assist in minor and local flooding situations not monitored by the BOM,
- Council may wish to take action to protect its assets based upon its own forecasting rather than waiting for the official BOM warning.

The main improvement that could be made to the existing system is the use of computer based models to generate real time flow estimates and (ultimately) flood levels. Installation of an automatic gauge at Terara would also improve forecasting as well as a staff gauge at Grassy Gully.

Conclusions

The ALERT system is a suitable approach for providing flood warning advice for the Shoalhaven River. The system should be continually monitored and upgraded as required. More sophisticated computer modelling, installation of gauges at Terara and Grassy Gully and rectification of the minor existing system problems are the main limitations of the present system. Council should also prepare a Flood Warning Manual to ensure that the existing knowledge held by current Council and SES staff is adequately documented.

4.5.2 Evacuation Planning

Description

A comprehensive Local Flood Plan was prepared by the SES in November 1996. It includes sections on:

- Flood preparedness, including:
  - public education,
  - activation,
  - flood intelligence,
  - warnings.

- Response, including:
  - control,
  - operations centre,
  - liaison,
  - communications,
  - information,
  - road control,
  - flood rescue,
  - evacuation,
  - logistics and re-supply,
  - stranded travellers.

- Recovery, including:
  - welfare,
  - registration and inquiry,
  - all clear,
  - recovery co-ordination,
  - debrief.

Discussion

The effectiveness of the Plan to evacuate the Riverview Road area has not been tested. The main problems with all flood evacuations are:

- they must be carried out quickly and efficiently,
- they are hazardous for both the rescuers and the evacuees,
- residents are generally reluctant to leave their homes, causing delays and placing more stress on the rescuers,
- evacuation routes may be cut some distance from their home and people do not appreciate the danger.

As part of this study, discussions were held with the SES and Council to review the effectiveness of the Flood Plan and to provide recommendations for further enhancement. Key areas where improvements are possible include details on:

- when and where evacuation routes are cut,
- the number of buildings affected at various flood heights,
- road closures,
- the potential for overtopping of the Riverview Road levee.

The last point is critical as shown in Table 11. Whilst the river rises only 0.2 m once overtopping occurs (0.5% event), the level at Riverview Road increases by 0.6 m accompanied by high velocities presenting a significant threat to life.

Table 11: Rates of Rise - 0.5% AEP Flood

Elapsed Time from Start of Levee Overtopping (h)	Levels (m AHD)			Comment
	Nowra Bridge	Riverview Road	Shoalhaven Caravan Park	
-20.0	3.0	-	-	Local rain may have already inundated parts of the area.
-11.0	4.0	-	-	Residents will be aware of the possibility of flooding.
-8.0	5.0	-	-	Start of overtopping at Shoalhaven Caravan Park levee.
-4.0	6.0	-	4.0	Parts of Terara Road are up to 1 m deep. Access along Ferry Lane to Moss Street will start to become difficult. Motor vehicle access to the Pleasant Way will still be possible.
0.0	6.6	4.4	5.0	Start of overtopping of Riverview Road levee. Access along Ferry Lane will be limited to 4 wheel drive vehicles or trucks. Access to the Pleasant Way will become hazardous due to high velocities and there is the risk that some cars may float. Pedestrians risk being washed away in the high velocity flow.

Elapsed Time from Start of Levee Overtopping (h)	Levels (m AHD)			Comment
	Nowra Bridge	Riverview Road	Shoalhaven Caravan Park	
5.0	6.8	5.0	5.1	Peak at Nowra Bridge. Ferry Lane will be impassable for all vehicles. Access to the Pleasant Way will be hazardous and restricted to large trucks or boats. It will be difficult to move around (by boat or truck) as the overflow will be funnelled between buildings into high velocity streams.
9.0	6.6	5.1	5.2	Peak at Riverview Road and at the Shoalhaven Caravan Park. Vehicle access to the Pleasant Way may be cut. Water borne debris such as fences or sheds may have further restricted access.
11.0	6.5	5.1	5.1	End of overtopping of Riverview Road levee.

Table 11 is based on an idealised design flood hydrograph. The times may vary considerably in practice.

At present the SES Local Flood Plan only covers floods up to the 1% AEP event. Larger events up to the extreme or Probable Maximum Flood must be considered as these pose the greatest risk to life in this area.

Figure 4 indicates that the crest of the levee is generally horizontal at about 6.4 mAHD. The reasons for adopting this design rather than one parallel to the river gradient or one with a low point to permit "controlled overtopping" are unknown. There is no obvious place to locate a low point as Riverview Road is fully developed with houses. If the levee profile was parallel to the river gradient then overtopping would occur simultaneously over the full length of the levee. As it is, overtopping first occurs at the upstream end near the wharf. This issue should be reviewed as part of the management and maintenance audit for the levee (Section 4.3.4). Preliminary investigation suggests that the residents would be strongly opposed to any further work on the levee which raises the crest level.

Once overtopping occurs the risk of levee failure increases as flood waters cascade down the back slope. There is also an increased risk to life due to the rapid increase in flood depth and velocity of flow in the area. Table 11 indicates a peak drop in water level over the levee of up to 1.8 m. There is no section of the SES Local Flood Plan dealing specifically with the Riverview Road area. Possibly a section should be included detailing the particular requirements of this area and addressing the following key points:

- the need to evacuate the area prior to levee overtopping. A lot will depend upon the accuracy of the flood forecasting system (how much time will be available) and the effectiveness of the flood warnings,
- how will residents respond to an evacuation order? Can their response be improved?
- the possibility of failure of the levee and the sudden influx of floodwaters,

- where will the overtopping first occur? The overflow path must be identified,
- which access routes will be cut and when? This will provide an indication of how much time is available for evacuation,
- has the SES sufficient resources to undertake the evacuation given that they will have committed resources elsewhere?
- the mix of single storey and two storey properties in the area. Residents can at least go to the second storey of a two storey house and await rescue,
- which buildings will be most vulnerable to collapse if the levee fails?
- the SES response procedure needs to be regularly tested,
- should warning sirens or warning signs be placed in the area?
- how effective are the current flood awareness and preparedness programs for this area? Can they be improved?
- how aware are the community and the SES to the change in flood hazard that will occur once the levee is overtopped?
- will minor modifications to the levee crest assist the SES (e.g. by providing a more defined overtopping point)?

Conclusions

The SES Local Flood Plan should be updated to provide more detailed information on the response requirements in the Riverview Road area over the full range of flood events, and in particular those greater than the 1% AEP event. Detailed flood information is provided in the 1990 Flood Study and in this present study. Some specific issues to be addressed in the update are listed above. A special section on the Riverview Road area should clearly identify the flood hazard, the potential for overtopping of the levee and the need for early evacuation.

Floor level data contained in this Floodplain Management Study (Appendix D) should be provided to the SES to enable officers to accurately determine which houses require evacuation. These details can be linked to Council's GIS database to provide a map of the affected properties.

4.5.3 Flood Awareness and Preparedness

Description

The success of any flood warning system depends on:

Flood Awareness: How aware is the community to the threat of flooding? Has it been adequately informed and educated?

Flood Preparedness: How prepared is the community to react to the threat? Do they (or the SES) have damage minimisation strategies (such as sand bags, raising possessions) which can be implemented?

Flood Evacuation: How prepared are the authorities and the evacuees to evacuate households to minimise damages and the potential risk to life? How will the evacuation be done, where will the evacuees be moved to?

Discussion

A community with high flood awareness will suffer less damage and disruption during and after a flood because people are aware of the potential of the situation and listen to official warnings on the radio and television. There is often a large, local, unofficial warning network which has developed over the years and residents know how to effectively respond to the warnings by raising goods, moving cars, lifting carpets, etc. Photographs and other non-replaceable items are generally put in safe places. Often residents have developed storage facilities, buildings, etc., which are flood compatible. The level of trauma or anxiety may be reduced as people have "survived" previous floods and know how to handle both the immediate emergency and the post flood rehabilitation phase in a calm and efficient manner.

The level of flood awareness within a community is difficult to evaluate. It will vary over time and depends on a number of factors including:

- *Frequency and impact of previous floods.* A major flood causing a high degree of flood damage in the previous few years will increase flood awareness. However if no floods have occurred, or there have been a number of small floods which cause little damage or inconvenience, then the level of flood awareness may be low.

- *History of residence.* Families who have owned properties for generations will have established a considerable depth of knowledge regarding flooding and a high level of flood awareness. A community which predominantly rents homes and stays for a short time will have a low level of flood awareness.

- *Whether an effective public awareness program has been implemented.*

For floodplain management to be effective it must become the responsibility of the whole community. A public consultation program was incorporated into this present study to involve the public and various organisations in the decision making process. An important part of the program was simply to inform the community that there is a flood problem. It is difficult to accurately assess the benefits of an awareness program but it is generally considered that the benefits far outweigh the costs. The perceived value of the information and level of awareness, diminishes as the time since the last flood increases. Some residents may oppose an awareness program because they consider it reduces the value of their properties.

A major hurdle is often convincing residents that large floods will occur in the future. This is made easier by reference to the large historical events of last century at Terara.

Conclusions

Based on feedback from the questionnaire, public meetings and general discussions, the residents of the Riverview Road area have a low to medium level of flood awareness. Their level of preparedness is also probably low to medium.

The SES has a medium to high level of awareness of the problem and the requirements necessary to effect evacuations. As the time since the last major flood (1978) increases, the direct experience of the SES units with historical floods will diminish. More consideration should be given to the problems of evacuating the area.

A suitable Flood Awareness Program should be implemented using appropriate elements from Table 12. The details of the program and necessary follow up should be properly documented to ensure that they do not lapse with time.

Table 12: Flood Education Methods

Method	Comment
Letter/Pamphlet from Council	These may be sent (annually or bi-annually) with the rate notice or separately. A Council database of flood liable properties/addresses makes this a relatively inexpensive and effective measure. The pamphlet can inform residents of subsidies, changes to flood levels or any other relevant information.
School Project or Local Historical Society	This provides an excellent means of informing the younger generation about flooding. It may involve talks from various authorities and can be combined with water quality, estuary management, etc.
Displays at Council Offices, Library, Schools, Local Fairs	This is an inexpensive way of informing the community and may be combined with related displays.
Historical Flood Markers or Depth Indicators on Roads	Signs or marks can be prominently displayed in parks, on telegraph poles or such like to indicate the level reached in previous floods. Depth indicators on roads advise drivers of potential hazard.
Articles in Local Newspapers	Ongoing articles in the newspapers will ensure that the problem is not forgotten. Historical features and the remembrance of the anniversary of past events (1860, 1870) make good copy.
Collection of Data from Future Floods	Collection of data assists in reinforcing to the residents that Council is aware of the problem and ensures that the design flood levels are as accurate as possible. A Post-Flood Evaluation Program (Appendix E) documents the steps to be taken following a flood.
Notification of 149 Certificate Details	All property owners were notified that they were flood affected as part of the public consultation program. Future owners are advised during the property searches at the time of purchase through a 149 certificate.
Types of Information Available	A recurring problem is that new owners consider they were not adequately advised that their property was flood affected on the 149 Certificate during the purchase process. Council may wish to advise interested parties, when they inquire during the property purchase process, regarding flood information currently available, how it can be obtained and the cost.
Establishment of a Flood Affectation Database	A database would provide information on (say) which houses require evacuation, which roads will be affected (or damaged) and cannot be used for rescue vehicles, which public structures will be affected (e.g. sewage pumps to be switched off, telephone or power cuts). This database should be reviewed after each flood event. It could be developed by various authorities (SES, Police, Council).
Flood Preparedness Program	Providing information to the community regarding flooding informs it of the problem. However, it does not necessarily adequately prepare people to react effectively to the problem. A Flood Preparedness Program would ensure that the community is adequately prepared. The SES would take a lead role in this.
Foster Community Ownership of the Problem	Flood damage in future events can be minimised if the community is aware of the problem and takes steps to find solutions. For example, Council should have a maintenance program to ensure that its drainage systems are regularly maintained. Residents have a responsibility to advise Council if they see a maintenance problem such as a blocked drain. This process can be linked to water quality or other water related issues including estuary management.

4.6 Other Issues

4.6.1 Bank Erosion

Description

The channel morphology study (Reference 5) describes historical erosion rates along the river based on surveys and aerial photographs. The Riverview Road area is immediately upstream of the upper limit of that study. Terara (approximately 2.5 km downstream of Nowra Bridge) has a history of bank erosion (see Appendix C). In the 1860 and 1870 floods over 50 hectares of land were lost near the village. In each of these floods the bank receded by 50 m to 100 m and a number of buildings were lost. Subsequently there has only been a minor retreat of the river bank in this vicinity.

Several residents consider that construction of the levee bank in 1986 has been a benefit in reducing bank erosion and has caused a small accretion at the toe. However there is always the risk that a flood (not necessarily an overtopping flood) may cause erosion. Should this occur and the levee is breached the risk to life and potential damages would increase significantly.

The possibility of bank erosion cannot be dismissed and the potential impact on the area needs to be considered.

Discussion

The cost of bank erosion to the Riverview Road community is impossible to accurately quantify. In the 1860 and 1870 floods, bank erosion at Terara , as opposed to inundation by floodwaters, was probably the most significant factor contributing to damage. In subsequent floods bank erosion would appear not to have been a major factor (at Terara or at Riverview Road).

The extent of bank erosion is not necessarily linked to the magnitude of the flood and may even occur at non-flood times. The 1860 and 1978 floods appear to have reached similar levels at Terara and Nowra Bridge yet there was no significant damage to the bank in 1978. While 1860 and 1870 were both large events, serious erosion could still occur in a quite small flood given appropriate conditions.

The estimate of average annual damages (Section 3.4) has not taken account of the effects of bank erosion and a rigorous analysis of this problem is outside the scope of this study. Nevertheless it is reasonable to infer that in large floods, bank erosion could be a significant problem. If it does occur during a flood there will be a significant increase in the risk to life, particularly if residents remain with their properties.

Conclusions

Bank erosion has been controlled in recent times following construction of the Riverview Road levee. Further downstream at the Shoalhaven Caravan Park the risk may be higher as the levee bank was probably built to a lower design standard than the Riverview Road Levee. The situation should be closely monitored by Council's Estuary Management Committee and should include the possibility of a set back for development from the river bank for the area downstream of the Riverview Road Levee.

5. DEVELOPMENT MEASURES

This chapter discusses measures to deal with future development within or near the study area to ensure that it will not significantly affect the flooding regime, or if it does, that the impacts are addressed.

5.1 Control of Outside the Study Area

Developments outside of the study area have not been examined unless they were raised as part of the community consultation program. It is possible that developments outside the area may affect the erosional and sedimentational regime of the river, cause adverse hydraulic impacts or increase the amount of pollutants and sediments. However, it is Council's responsibility to ensure that any development applications adequately address these issues and that the flood hazard in the Riverview Road area is not adversely affected.

5.2 The Greenhouse Effect

Description

The Greenhouse Effect results from the presence of certain gases in the atmosphere which allow the sun's rays to penetrate to the earth but reduce the amount of energy being radiated back. It is this trapping of reflected heat which has enabled life to exist on earth.

Recently, there has been concern that increasing amounts of greenhouse gases resulting from human activity may be raising the average surface temperature. As a consequence, this may affect the climate and sea level. The extent of any permanent climatic or sea level change can only be established through scientific observations over several decades. Nevertheless, it is prudent to consider the possible range of impacts with regard to flooding and the level of flood protection provided by any mitigation works.

Discussion

The Bureau of Meteorology has indicated that there is no intention at present to revise design rainfalls to take account of the Greenhouse Effect, as the possible mechanisms are far from clear and there is no indication that the changes would in fact increase rainfalls in major storms. Even if an increase in total annual rainfall does occur, the impact on storm rainfalls may not be adverse.

It has also been suggested that the cyclone belt may move further southwards. The possible impacts of this on design rainfalls cannot be ascertained at this time as little is known about the mechanisms that determine the movement of cyclones under existing conditions.

Another possible consequence of the Greenhouse Effect could be a rise in sea level. This issue is complicated by other long term influences on mean sea level changes. The available literature suggests that a gradual increase in sea level is likely to occur with a rise of perhaps 0.3 m to

0.5 m within the next 50 years. This will have a significant impact at Shoalhaven Heads if it equates to a similar increase in the design ocean level, but modelling results demonstrate that any change in ocean levels will have minimal impact on flood levels in the Riverview Road area.

Of more significance would be any impact on the erosional and sedimentation regime at Shoalhaven Heads. The Greenhouse Effect may vary the frequency and length of closures but, at this stage, there is not enough information to allow any definite conclusions on this.

Conclusions

The Greenhouse Effect may affect design flood levels in the Lower Shoalhaven River, however, preliminary investigation demonstrates that the impact in the study area will be minor. The impact on the Shoalhaven Heads entrance may be more significant but there is no definitive information at this stage. Council should continue to monitor the available literature and reassess Council's Flood Policy as appropriate.

6. ACKNOWLEDGMENTS

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- Shoalhaven Floodplain Management Advisory Committee,
- Shoalhaven City Council,
- Department of Land and Water Conservation,
- State Emergency Services,
- Local residents of the Riverview Road area.

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FIGURES

FIGURE 1
CATCHMENT MAP

36°

35°

149° 30'

Jerrabattgulla Ck

Reedy Creek

SHOALHAVEN

BRAIDWOOD

GOULBURN

Nerrimunga Creek

MONGARLOWE RIVER

Welcome Reef

RIVER

MORUYA

BATEMANS BAY

ENDRICK RIVER

Ettrema Creek

Ck

Yalwal

Grassy Gully

KANGAROO RIVER

BURRIER

MITTAGONG

SOUTH PACIFIC OCEAN

NOWRA

TERARA

BERRY

Jervis Bay

WOLLONGONG

150° 30'

N

SCALE

10km 0 20km

DATE : 11-11-1998

WMA JOB No. : 98066-01

36°

35°

FIGURE 2

LOCALITY PLAN

SHOALHAVEN RIVER

TO BOMADERRY

NOWRA BRIDGE

NOWRA WHARF

SAILING CLUB

RIVERVIEW ROAD

LEVEE

RESERVATION 30.48M FROM H.W.M.

6(a)

RESERVE DP 634524

THE WILLOWS EAST VAN PARK

MOTEL

HAWTHORN AVE.

ELIA AVENUE

LYREBIRD DRIVE

RIVERVIEW RD.

SHOALHAVEN CARAVAN PARK

DP 505763

1(g)

DRAINAGE EASEMENT

SLAB COTTAGE

ELYARDS BOATSHED

PLEASANT WAY

LEAGUES CLUB

6(b)

CEMETERY

LOT 6 DP 713092

2(b)

VACANT LAND PRIVATE OWNERSHIP

VACANT LAND COUNCIL OWNERSHIP

LOT 8 DP 809132

LAND TO BE DEDICATED TO COUNCIL

DEFERRED UNDER SECTION 68(5) (IDO No.1)

LOT 2 DP 714140

VACANT LAND PRIVATE OWNERSHIP

FERRY LANE

DP 449102

MOSS COTTAGE

TERARA

TERARA ROAD

DP 634042

GRAHAM LODGE

PRINCES HIGHWAY

LAND TO BE DEDICATED TO COUNCIL

LOT 1 DP 1318200

APPROVED 55 LOT SUBDIVISION

PUBLIC RESERVE DP 802068

PUBLIC RESERVE DP 130989

CAMPBELL PLACE

STREET

MOSS STREET

BREETON

WONDALGA CRESCENT

2(a)

5(a)

NOWRA

TO SOUTH NOWRA

DP 616269

DP 186738 SEWAGE T'MENT WORKS GAZ.28/2/36

DP 500900 SEWAGE TREATMENT WORKS

LEGEND

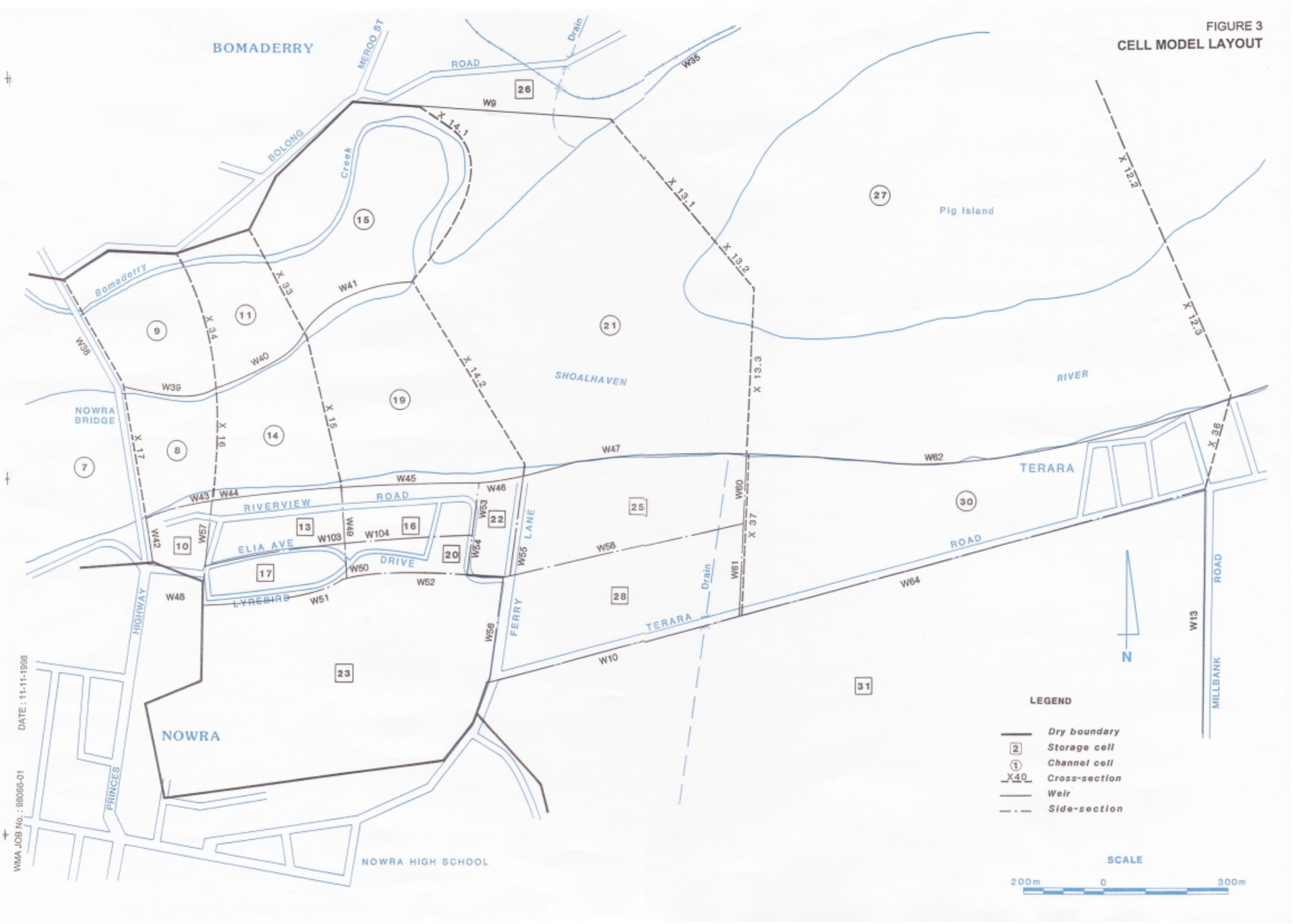
- HERITAGE ITEM
- UNITS
- STUDY AREA
- PASTORAL LANDSCAPE DRAFT DCP No.76 (DRAFT HERITAGE LEP)
- 53 HOUSE NUMBER
- 1(a) ZONE (LEP 1985)

0 40 80 120 160 200m

SCALE

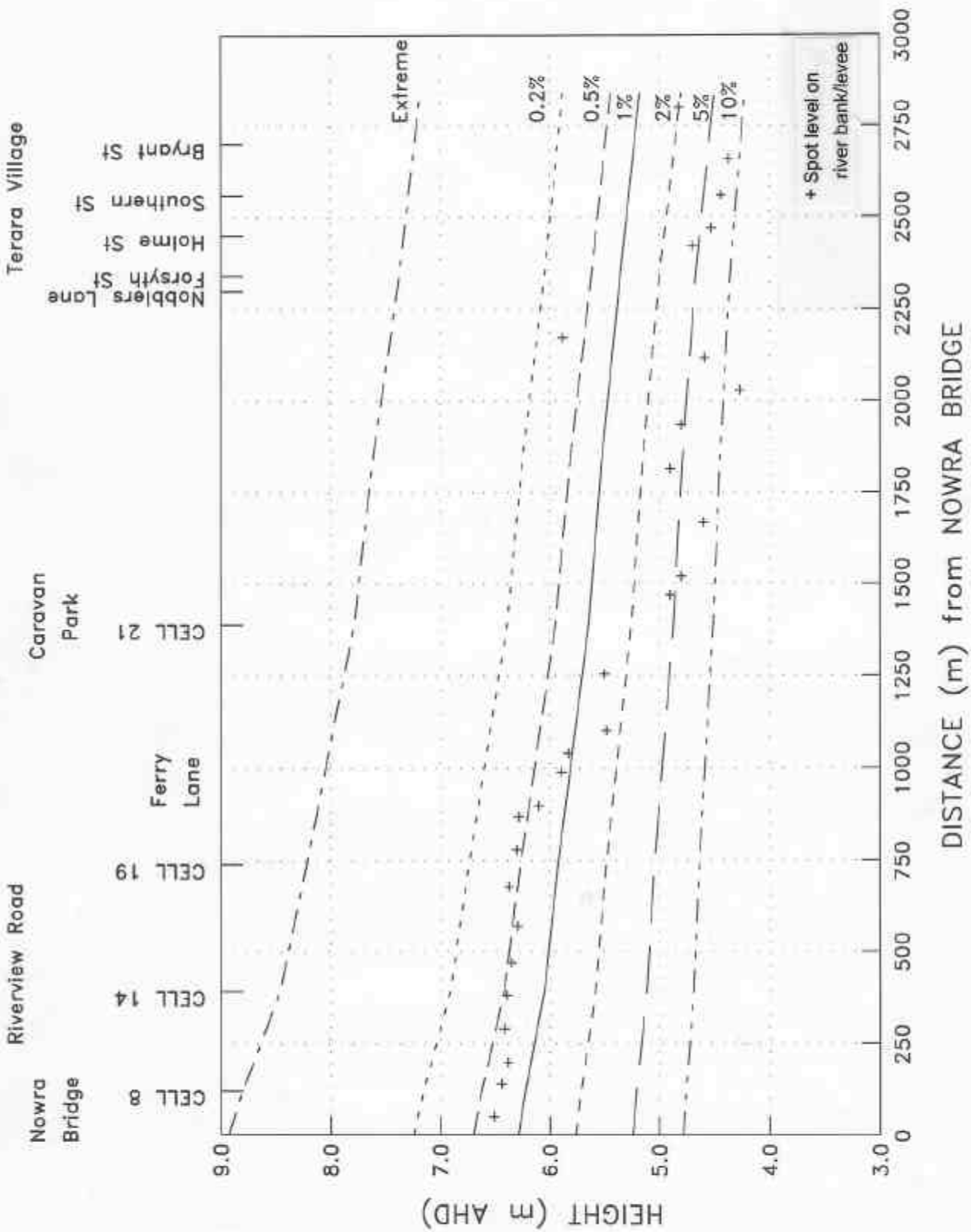
NOTE:
HOUSE NUMBERS ARE ONLY SHOWN WHERE A BUILDING EXISTS ON THE PROPERTY

FIGURE 3
CELL MODEL LAYOUT



WMA JOB No. : 98056-01 DATE : 11-11-1998

FIGURE 4
DESIGN FLOOD PROFILES



WMA JOB No. : 98066-01 DATE : 11-11-1998 15:00

04/11/98 15:17

FIGURE 5

BUILDINGS INUNDATED

SHOALHAVEN RIVER

TO BOMADERRY

NOWRA BRIDGE

NOWRA WHARF

SAILING CLUB

RIVERVIEW ROAD

LEVEE

RESERVATION 30.48M FROM H.W.M.

RESERVE DP 634524

SHOALHAVEN CARAVAN PARK

DP 505763

DRAINAGE EASEMENT

ELYARDS BOATSHED

THE WILLOWS EAST VAN PARK

MOTEL

HAWTHORN AVE.

ELIA AVENUE

PLEASANT WAY

LEAGUES CLUB

CEMETERY

LYREBIRD

VACANT LAND PRIVATE OWNERSHIP

VACANT LAND COUNCIL OWNERSHIP

LAND TO BE DEDICATED TO COUNCIL

SLAB COTTAGE

MOSS COTTAGE

GRAHAM LODGE

PRINCES HIGHWAY

VACANT LAND PRIVATE OWNERSHIP

LAND TO BE DEDICATED TO COUNCIL

APPROVED 55 LOT SUBDIVISION

DRIVE

RIVERVIEW RD.

LANE

FERRY

TERARA

TERARA ROAD

DP 634042

DP 616269

DRAINAGE EASEMENT

DP 186738 SEWAGE T'MENT WORKS GAZ.28/2/36

DP 500900 SEWAGE TREATMENT WORK

CAMPBELL PLACE

PUBLIC RESERVE DP 130989

DP 802068

PUBLIC RESERVE

STREET

MOSS STREET

BRERETON STREET

WONDALGA CRESCENT

TO SOUTH NOWRA

NOWRA

DP 616269

LEGEND

0.5% AEP OF FLOOD WHICH FIRST INUNDATES THE BUILDING

0 40 80 120 160 200m

SCALE

NOTE:
FOR CARAVAN PARKS, THE AEP IS SHOWN FOR THE MAIN RESIDENTIAL BUILDING

APPENDIX A: DESCRIPTION AND ASSESSMENT OF FLOOD DAMAGES

APPENDIX A: DESCRIPTION AND ASSESSMENT OF FLOOD DAMAGES

A1. DESCRIPTION OF FLOOD DAMAGES

A1.1 General

A database provided by Shoalhaven Council (Appendix D) has been used to identify the number of buildings inundated above floor level for various design events. For each property a habitable floor level (or work floor level for non-residential buildings) and a typical ground level were obtained. The ground level reflects yard damages to the grounds, garage, etc.

Flood damages can be defined as being *tangible* or *intangible* and a schematic breakdown of the damages categories is provided as Table A1. Tangible damages are those for which a monetary value can be assigned, in contrast to intangible damages, which cannot easily be attributed a monetary value.

There are few records of actual flood damages to buildings or private property although these undoubtedly occurred in the floods in the 1970's. A draft 1979 report into the feasibility of constructing the Riverview Road levee provided the following information.

August 1974 Flood

Riverview Road Area: No homes were flooded. Flooding was mainly confined to roads. The river broke its banks near the Nowra Sailing Club and the water was channelled along Hawthorn Avenue into Worrigee Swamp.

Terara: Four out of 21 owners interviewed indicated their homes were flooded.

June 1975 Flood

No indication of the number of homes inundated.

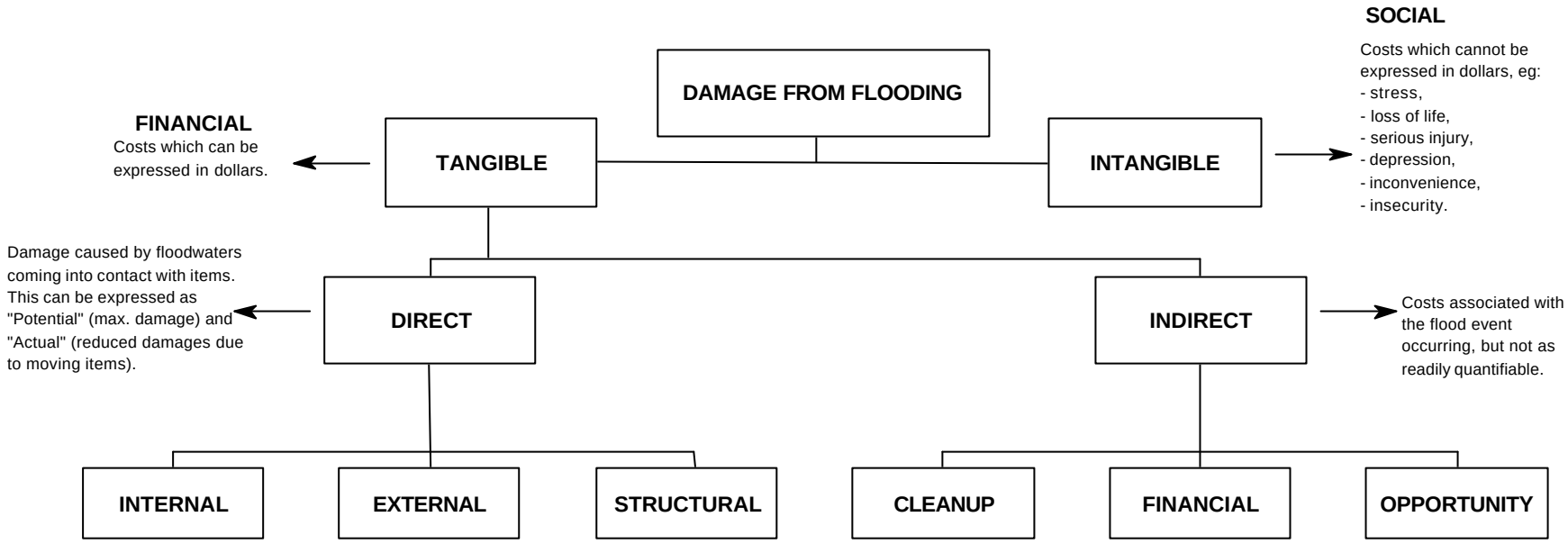
March 1978 Flood

Riverview Road Area: The river broke its banks at a number of places. The main area was opposite Hawthorn Avenue. The Willows Caravan Park was inundated as well as most of the surrounding land. Approximately 10 out of 94 homes were inundated.

Terara: Water flowed through the whole of the village. It was estimated that up to 10 buildings were inundated (probably an over-estimate).

Flood Damages:	Residential	$10,640	Nowra Boat Hire	$500
	Council	$2,800	Schadel's Sand	$17,000
	Telecom	$350	Market Gardening	$11,300
	Electricity	$670	Swimming Pool	$650
	Willow Caravan Park	$6,000	Sailing Club	$2,150
	Riverhaven Motel	$28,000	**Total**	**$80,060**

Table A1: Flood Damages Categories



RESIDENTIAL	Contents of Buildings: Clothes, Carpets, Furniture, Valuables, Fittings, Appliances	External Items: Vehicles, Laundries, Caravans, Sheds, Tools, Gardens, Fences	Physical Damage to Buildings: Gyprock, Cupboards, Scour of Footings, Houses becoming buoyant (floating off footings)	Clean Carpets, Walls, Clothes; Re-instate Furniture; Remove Mud and Debris	Loss of wages, Living costs (temporary accomodation and food), Time to repair/replace damaged items	Not Applicable
RURAL	Contents of Buildings: Clothes, Carpets, Furniture, Valuables, Fittings, Appliances	External Items: Vehicles, Sheds (stables/barns), Machinery, Tools, Fences, Feed storage, Saddles, Crops &/or Stock, Irrigation Systems	Physical Damage to Structures: Damage to Homestead, Sheds, Access tracks, Protection levees	Clean Homestead and Out-buildings; Remove Debris; Dispose of affected crops &/or stock	Loss of Farm Production and Income, Re-instatement of Pastures, Supplementary feeding of stock (by hand or outside agistment), Stock movement/ transport, Living costs (temporary accomodation and food)	Sowing or harvesting of Crops, Sale of Stock (at depreciated value or dependent on market influences)
COMMERCIAL	Contents of Buildings: Products, Stock, Fittings, Tools, Machinery, Raw Materials	External Items: Vehicles, Machinery, Display, Raw Materials/Stockpiles, Fences	Physical Damage to Buildings	Dispose of damaged products, stock, materials; Cleaning and Re-instatement	Loss of Productivity and Income, Bank Interest Charges	Loss of existing &/or Potential Trade
PUBLIC AUTHORITIES	Contents of Public Buildings and Facilities	Public Property and Facilities: Parks, Signs, Machinery, Equipment	Physical Damage to Infrastructure: Electricity, Water, Telephone, Gas, Road & Rail Transport Links	Remove Mud & Debris from Facilities, Public & Private Property Repairs (temporary & permanent)	Disruption of Services, Community Service Relief Grants	Provision of Public Service

A1.2 Tangible Damages

Tangible damages can be sub-divided into *direct* damages, which occur due to physical contact with the floodwaters, and *indirect* damages which occur as a result of the disruption of business, trade and other activities. Direct and indirect damages may be referred to as *Potential* or *Actual* damages. Potential damages are the assumed damages if no damage reduction measures are employed and are thus greater than the actual damages. The ratio of actual to potential damages depends upon a number of factors including:

- magnitude of the flood,
- prior flood experience of the community,
- length of warning time.

Direct Damages

Direct damages can be sub-divided between the rural and urban sector. Under direct urban damages there are three broad categories: *Residential, Commercial* and *Public Sector*.

The direct damages under these categories can be grouped under the following headings:

- *Internal* - building contents,
- *Structural* - structure and building fabric,
- *External* - yard, garage, vehicle and other machinery (air conditioning).

Damages to commercial and industrial buildings are much more difficult to quantify for two reasons:

- damages to a given property vary much more than with houses, as they are heavily influenced by the type of business being carried out and the amount of stock carried. This will also vary over time as different businesses use the building,
- industrial enterprises in particular cannot simply be averaged out. Where large factories or warehouses are involved, the only way to get a good estimate of potential damages is to do a site specific survey of the enterprise.

As flood damages can vary greatly between areas depending upon the type of buildings and contents, an average damages figure is estimated for each of the above categories (residential, commercial and public sector) following a flood. This is generally presented as a flood depth versus flood damages function.

Public sector (non-building) damages include:

- recreational/tourist facilities,
- water and sewerage supply,
- gas supply,
- telephone supply,

- electricity supply including transmission poles/lines, sub-stations and underground cables,
- roads and bridges including traffic lights/signs,
- railway line and associated structures,
- costs to employ the emergency services.

Damages to the public sector can contribute a significant proportion of the total flood costs. In the Inverell flood of February 1991, direct costs to the local Council accounted for 10% of the total direct damages. A single item such as a bridge or a sub-station may account for a large proportion of the damages bill in a particular flood.

Indirect Damages

Indirect damages are more difficult to quantify. They can be sub-divided into three broad cost categories:

- *Clean-up* - clean carpets, furniture, refrigerator, etc. It also includes the cost of alternative accommodation,
- *Financial* - loss of wages, loss of trade for the commercial/industrial sector,
- *Opportunity* - non-provision of commercial and public services.

In a particular locality it would require an extensive survey to evaluate the costs of lost working hours, disruption to business and trade. Nevertheless an indication of the damages can be obtained from previous studies. Generally the indirect damages have been expressed as a percentage of the direct damages. The figure varies greatly depending upon a number of factors including:

- magnitude of flood,
- time away from home/work,
- category (residential, commercial, industrial).

An average percentage (indirect as a percentage of direct) from a number of post flood surveys is:

- Residential - 15%,
- Commercial - 30%,
- Industrial - 50%.

It should be noted that there can be a considerable range (± 100%) around the above figures for commercial and industrial properties in different locations.

A1.3 Intangible Damages

Intangible damages are those flood damages which by their nature are difficult to quantify in monetary terms. An example of a *direct* intangible damage is the "loss of visual quality" of an

area or the "loss of a heritage item". Most intangible damages are *indirect* and commonly occur after the flood peak has passed.

Intangible damages can be categorised as follows:

- **Residential**

  Post flood damages surveys have linked flooding to stress, ill-health and trauma in the residents. For example the loss of memorabilia, pets, insurance papers, etc., may cause stress and subsequent ill-health. In addition, flooding may affect personal relationships by contributing to marriage breakdowns and lead to stress in domestic/work situations. Residents may worry each time heavy rain occurs and there is a threat of flooding. This may be reflected in increased sickness or depression requiring psychiatric help. These effects can induce a lowering in the quality of life of the flood victims.

  Flood victims may also suffer injuries during a flood or during the clean-up process. Whilst the direct costs of the injuries may be accounted for in the flood damages survey, the physiological effect or discomfort may last for a long time.

  The most extreme “intangible damage” that can arise from flooding is death, and unfortunately this is not a rare occurrence. There are many examples of deaths of local residents and rescue workers during floods.

- **Commercial/Industrial/Rural**

  Whilst a large number of businesses carry insurance for loss of trade during and following a flood until the clean-up is complete, they may still suffer a financial loss. For example the confidence in the business of regular clients may be reduced permanently. Clients may take their business elsewhere during the flood/clean-up period and may never revert to the original supplier.

- **Services**

  The loss of services to customers, e.g., transport disruption, loss of education, loss of power, etc., occur as a result of floods and these are generally not costed within the tangible damages category.

- **Environmental**

Environmental damage may occur as a result of flooding, for example flora and fauna may be lost. However the riverine environment is a natural system and it is difficult to quantify the effects of flooding on natural processes. Some flora and fauna can in fact benefit from flooding. Also in the short term there may be a deterioration in water quality or vegetation, which may recover in the long term. Wetlands develop over time as a result of flooding and require periodic flooding for their long term survival.

Probably the most significant potential environmental impact is the release of pollutants as a result of flooding. Generally this is as a result of flooding of commercial/industrial establishments.

The loss of man-made structures which have a "heritage" or non-replaceable value are a real cost which cannot be quantified. Modifications to the pattern of flooding through flood mitigation works may change the existing ecosystem. Although the changes can be beneficial or adverse.

In summary, there is a comprehensive body of available literature on intangible damages which provides many examples. However the costing of such damages in dollar terms is often not possible. These "costs" must not be ignored when determining floodplain management options. The literature suggests that the value of intangible damages may equal or exceed tangible damages. It is therefore often necessary to imply a value to the intangible damages to achieve a proper appreciation of proposed works and measures.

A2. ASSESSMENT OF FLOOD DAMAGES

A2.1 General

A2.1.1 Introduction

Quantification of flood damages is generally based upon post-flood damage surveys. An alternative procedure is to undertake a self-assessment survey of the flood liable residents. This latter approach is more expensive and may not accurately reflect what actually occurs in a flood. Floods by their nature are unpredictable and it is unlikely that a self-assessment survey would have predicted the scale of the damages which occurred in Nyngan in 1990. For this reason it was decided to use the post-flood damage approach in assessing flood damages. More recent information will become available from the November 1996 flood at Coffs Harbour. A listing of the most widely known post flood damage surveys is shown in Table A2.

Table A2: Residential Flood Damage Surveys

Location	Year of Flood	Comments
Brisbane	1974	400 residential properties.
Lismore	1974	100 properties. The data were obtained several years after the last major flood.
Forbes	1974	35 properties. The data were obtained several years after the latest major flood.
Sydney (Georges River)	1986	96 properties (2 studies undertaken)
Nyngan	1990	24 residential, 14 commercial and 6 public properties, 4-5 weeks after the flood.
Inverell	1991	4 residential, 20 commercial and 10 public properties, 2-3 weeks after the flood.

The most comprehensive surveys are those carried out for Sydney (Georges River), Nyngan and Inverell. Some of the problems in applying data from these studies to other areas can be summarised as follows:

- varying building construction methods, e.g. slab on ground, pier, brick, timber,
- different average age of the buildings in the area,
- the quality of buildings may differ greatly,
- inflation must be taken in account,
- different fixtures within buildings, e.g. air-conditioning units,
- change in internal fit out of buildings over the years or in different areas, e.g. more carpets and less linoleum or change in kitchen/bathroom cupboard material,
- external (yard) damages can vary greatly. For example in some areas vehicles can be readily moved whilst in other areas it is not possible,
- different approaches in assessing flood damages. Are the damages assessed on a "replacement" or a "repair and reinstate where possible" basis? Some surveys include structural damage within internal damage whilst others do not,
- varying warning times between communities means that the potential to actual damage ratio may change,
- variations in flood awareness of the community.

A2.1.2 Summary of Survey Data

Flood damages data from the following surveys are provided in Table A3:

- Inverell 1991 - Reference A1,
- Nyngan 1990 - Reference A2,
- Sydney (Georges River) 1986 - Reference A3.

References A1 and A2 were undertaken by Water Studies Pty Ltd and Reference A3 by the Centre for Resource and Environmental Studies (CRES) at the Australian National University, Canberra.

Table A3: Summary of Post Flood Damage Surveys
(Note: Costs quoted at the time of the flood)

	Nyngan	**Inverell**	**Georges River**
TOTAL FLOOD DAMAGES	$47 Million	$20.6 Million	$17 Million
Year	**1990**	**1991**	**1986**
Flooded Premises and Total Cost per section in $M (in brackets):			
Residences	717 ($18.9)	126 ($2.3)	1000
Commercial/Industrial Premises	98 ($11.3)	264 ($14.9)	215
Public Authorities/Utilities	42 ($17.0)	36 ($3.4)	Not Known
Total	857	426	
Damage ($M) per Category and % of Total Flood Damages (in brackets):			
Direct	28.6 (60%)	10.7 (52%)	16.9 (89%)
Indirect	18.7 (40%)	9.8 (48%)	2.1(11%)
Average Damages per Premise and % of Total Flood Damages (in brackets):			
Average Residential	$26 400(40%)	$18 000(11%)	$8 000(48%)
Average Commercial/Industrial	$117 000(24%)	$54 000(72%)	$40 000(52%)
Average Public	$400 000(36%)	$93 000(17%)	Not Known
Average Residential Damages by Category and % of Total Residential Damages (in brackets):			
Direct - Internal	$8 900(34%)	$8 100(42%)	Not Known
Direct - External	$4 500(19%)	$2 500(19%)	$3 500 (44%)
Direct - Structural	$5 200(20%)	$5 000(27%)	Not Known
Indirect - Financial	$4 800(20%)	$300(1%)	Assumed as 15%
Indirect - Clean Up	$2 200(7%)	$2 100(11%)	of Direct
Average depth of inundation above floor	0.8m	0.6m	Not Known
Average Commercial Damages by Category and % of Total Commercial Damages (in brackets):			
Direct - Internal	$28 600 (25%)	$17 100 (33%)	Not Known
Direct - External	$1 100 (1%)	$5 500 (12%)	Not Known
Direct - Structural	$3 000(3%)	$750 (1%)	Not Known
Indirect - Financial	$79 500 (70%)	$23 000 (45%)	Assumed as 55%
Indirect - Clean Up	$2 000 (1%)	$4 900 (9%)	of Direct
Average Annual Damage	$0.63M	Unknown	$14.4M

NOTES:
- 93% of all properties in Nyngan were flooded above floor level.
- The AAD figure for Sydney (Georges River) is $0.88M for residential and $13.5M for commercial/industrial.

A2.2 Tangible Damages - Residential Properties

Tangible direct damages are generally calculated under the following components:

- Internal,
- Structural,
- External.

Tangible indirect damages can be subdivided into the following groups:

- accommodation and living expenses,
- loss of income,
- clean up activities.

Damages may be calculated as either estimated actual damages or estimated potential damages. If potential damages are calculated an Actual/Potential (A/P) ratio is estimated based upon (as well as other factors) the likely flood awareness of the community and the available warning time.

The flood awareness of the community is likely to be high with the available flood warning time medium. For these reasons the A/P ratio will be relatively high (say 80%). At Nyngan (February 1990) the A/P ratio for average residential damages was 77%. It should be remembered that not all items can necessarily be saved (kitchen cupboards, carpets) and that many residents may be away. Based upon the available data it is considered that the A/P ratio for the study area will be similar to that at Nyngan or Inverell.

A2.2.1 Direct Internal Damages

- **Water Studies**

In the Water Studies approach internal damages are based upon the following formulae provided in Reference A1.

$$\frac{D}{D_2} = 0.06 + 1.42H - 0.61H^2 \quad \text{for } H < 1.0\text{m}$$

$$\frac{D}{D_2} = 0.75 + 0.12H \quad \text{for } H > 1.0\text{m}$$

where,

H	=	height of flooding above floor level (m)
D	=	damage at height (H) above floor level
D_2	=	damage at height of 2m above floor level

At Nyngan and Inverell D_2 was $12 500 for small houses and $14 500 for medium/large houses. These values are in $1991's. The reference states that *"Damages to individual properties scatter widely around the relationship, which can only be used to reliably estimate the*

aggregated damage to a collection of flood prone dwellings and not the damage to a single dwelling.". Structural damages are not included in the above figures.

- **CRES**

In the CRES approach (Reference A3) internal and structural damages are combined. Data are provided for three groups of buildings, namely Poor, Medium and Good. The data are shown in $1986's in Table A4.

Table A4: Residential Stage-Damage for Actual Direct Damage to Structure and Contents ($1986's)
(Taken from the Georges River Study: Reference A3 - Table A2.2.7)

Over floor Depth	Poor	Medium	Good	Average
0.0m	370	1045	2400	1270
0.1m	740	2090	4799	2540
0.6m	3012	5713	10360	6360
1.5m	7102	7595	13190	9300
1.8m	7210	7711	13391	9440

A2.2.2 Direct Structural Damages

In the CRES approach internal and structural damages are combined. In the Water Studies approach structural damage was adopted as approximately $5 000 at both Nyngan and Inverell.

A2.2.3 Direct External Damages

The majority of external damages is attributable to vehicles. However there is a high likelihood that a significant percentage of the vehicles can be moved to high ground even with minimal flood warning.

At Nyngan external damages were estimated as $4 500, mostly for vehicles, and at Inverell at $2 500 of which $1 500 was for vehicles. In the Sydney 1986 data obtained by CRES an external damages figure of $600 was adopted per property experiencing over ground flooding. In addition a sum of $2 000 per property experiencing over ground flooding in excess of 0.6m was included.

A2.2.4 Indirect Damages

In the Inverell study the indirect damages were taken as $200 for accommodation, $100 for loss of income and $2 100 for clean up activities. The total indirect damages ($2 400) therefore,

represented approximately 20% of the direct damages. At Nyngan indirect damages were high due to the extended period residents were away from their homes and were estimated at $7 700 per dwelling flooded above floor level. In this case the indirect damages amounted to approximately 40% of the direct damages. CRES adopted a figure for indirect damages of 15% of the direct damages (Georges River Study).

A2.3 Adopted Tangible Damages - Residential Properties

The adopted values used in this study are provided in Table A5 and documented in the following sections.

Table A5: Adopted Residential Depth/Damage Data ($1998)

Depth over Floor/Yard (m)	Total	Internal Damages	Structural Damages	External Damages	Indirect Damages
0.1	7018	3918	2000	300	800
0.3	17922	8622	6000	900	2400
0.5	27850	12350	10000	1500	4000
1.0	32900	17400	10000	1500	4000
1.5	34100	18600	10000	1500	4000
2.0	35300	19800	10000	1500	4000

A2.3.1 Direct Internal Damages

The Water Studies approach to the determination of internal damages was adopted for use in this study. As noted previously the A/P ratio for Nyngan is likely to be similar to that for the study area. A single D_2 value of $20 000 was adopted for all residential buildings regardless of the type of building.

A2.3.2 Direct Structural Damages

Structural damages were assumed to be a linear relationship from $0 at 0 m to $10 000 at 0.5 m. Above this value it was considered that there would be no additional structural damages.

In floods larger than a 1% AEP event there is the possibility that some buildings may collapse or have to be destroyed. The cost of these damages have not been included in the analysis.

A2.3.3 Direct External Damages

External damages (laundry/garage/yard/vehicle) were assumed to be a linear relationship from $0 at 0 m above ground level to $1 500 at 0.5 m.

A2.3.4 Indirect Damages

Indirect damages were assumed to be a linear relationship from $0 at 0 m above floor level to a maximum of $4 000 at 0.5 m.

A2.4 Tangible Damages - Public Utilities

The damages to public utilities include:

- water and sewerage supply,
- telecommunications,
- road/rail transport,
- other public assets.

Little data are available for establishing costs to public utilities, and the data from Nyngan and Inverell show that it can vary from 17% to 36% of the total damages bill.

The following is a summary of the likely damages to public property.

Sewerage

There is a public sewer system for the area. Flooding will cause inundation of the system and cause damage to the pumps electrics. Possibly there may be some release of sewerage.

There are very little tangible damages to the systems. The damages are largely intangible through the loss of supply of the system, such as inconvenience, disruption and health risk.

Recreational Facilities/Roads

There will be some direct tangible damages but the major factors are intangible damages to the community through the loss of use of the facilities.

Telephone, Electricity, Water Supply

These facilities should experience only minor (if any) flood damages. Telephone and electricity supplies may be severed at the time of the flood for other reasons (lightning).

Evacuation and Clean-Up Costs

It is estimated that the evacuation and clean-up costs to Council for each event is $40 000.

In this study damages to public utilities were not estimated.

A2.5 Annual Average Damages

It should be emphasised that these **figures include only tangible (direct or indirect) damages to buildings and residents, the cost of intangible damages has not been evaluated**. Available literature suggests that the extent of **intangible damages may equal or exceed the tangible damages. Damages to the public sector have not been accurately assessed in this study**. Recent studies show that **damages to public property can vary significantly but may comprise 50% of the private tangible flood damages**.

A3. REFERENCES

A1. NSW Department of Water Resources
Inverell Flood Damage Survey February 1991 Flood
Water Studies Pty Ltd - November 1991.

A2. NSW Department of Water Resources
Nyngan 1990 Flood Investigation - Chapter 9
October 1990.

A3. Public Works, Department of Water Resources
Losses and Lessons from the Sydney Floods of August 1986 Vol. 1 and Vol. 2
Centre for Resource and Environmental Studies, Australian National University, and Environmental Management Pty Ltd Sydney - September 1990.

APPENDIX B: PUBLIC CONSULTATION PROGRAM

APPENDIX B: PUBLIC CONSULTATION PROGRAM

The following text was provided to the Floodplain Management Committee at the start of the study.

Council has requested that the community be involved in the preparation of the Floodplain Management Studies (FMS) and Floodplain Management Plans (FMP) for the village of Terara and the Riverview Road area to ensure that affected persons are aware of the study and to ensure that the consultants have considered and reported on suggestions raised by the community.

To meet the requirements of the consultant's brief in this regard a public consultation program has been prepared for implementation during all stages of the study process.

B1. OBJECTIVES

The consultation program seeks to:

- increase community awareness of the findings of the 1990 Flood Study and of the ongoing process of preparing the FMS and FMP,
- encourage community participation in the FMS and FMP preparation,
- encourage feedback on the draft FMP document to assist Council in their consideration of the final outcomes.

B2. KEY CONSIDERATIONS

In developing the consultation program, the following considerations were regarded as important:

- The expected role of the community needs to be clearly established. This means that the ground rules for community involvement need to be clearly set out so that the community knows what is expected of them. In general a wide range of community views will be sought and discussed. Final decision making will rest with the Floodplain Management Committee (FMC) and Council.

- The program will focus on residents and property owners of the flood liable areas although advertisements in the local press will make the general community aware of the study.

- The consultation program closely follows the study work program and will be seen as an important element of that process. However it is not seen as an end in itself but rather as a means of ensuring that the final product has been prepared in full consideration of all issues raised by the community.

- The consultation program will be carried out by the consultants and thus will be seen to be somewhat independent of any vested interests in the area. An alternative is to engage an independent facilitator to conduct the meetings.

- Consultation methods will seek to provide an independent and impartial forum to ensure that the community fully understands the proposals being considered for inclusion in the study, and can exchange ideas and discuss the full implications of proposals with relevant technical experts in a friendly and non-intimidatory environment. It is not intended that the program be a forum for debate or argument, rather one for the exchange of ideas and the recording of community views.

B3. PROPOSED PROGRAM

The proposed consultation program has three distinct phases:

- **Phase 1** is a short inception period during which broad agreement to the details of the study are to be resolved including matters such as:
  - means of disseminating information,
  - determining the format of the newsletter, questionnaire and advertisements,
  - identifying the community to be consulted,
  - details of the dates and agendas and participants for public meetings.

- **Phase 2** includes the range of activities during the preparation of the FMS.

- **Phase 3** includes the range of activities associated with the exhibition of the draft FMP and the review of submissions.

The following main elements of the program are presented for consideration.

B3.1 Phase 1 - Inception

Means of Disseminating Information: It is proposed that the community be consulted initially via a Letter of Introduction and a Questionnaire which will be distributed by mail to the approximately 460 homes and businesses which occupy or own land within the study area. If people wish to respond or provide comment they will be asked to write to a Reply Paid Number at Webb McKeown's office. Subsequently two A4 newsletters will be provided.

The above material will be mailed to any other interested party nominated by the Committee. Council will distribute material to members of the Floodplain Management Committee.

Council will display the various material in local libraries, Council Offices, community centres and any other appropriate locations.

Advertisements will be placed by Council in the local and national papers at the time of distribution of the newsletter. Council will also issue press releases to local radio, television, and newspapers. These will also announce the dates of the public meetings.

The exact format of the newsletter and advertisements will be the subject of discussion but the broad issues to be covered are set out under Phase 2.

Agenda: The following dates are to be determined:

- 1st Floodplain Management Committee Meeting, 23 July 1998,
- Period of Investigation of Strategies by Consultant,
- Date of Distribution of 1st Newsletter,
- Date of 1st Public Meetings,
- Period for Preparation of Draft FMS and FMP by Consultant,
- Date of Distribution of 2nd Newsletter,
- Date of 2nd Public Meetings,
- Date of Draft FMP submitted to Council.

Other FMC meetings will occur at regular intervals.

Community to be Involved: Any residents occupying land (within the study area) which is below 8.0 mAHD will be invited to be involved in the process. Material will be provided to resident owners, non-resident owners and tenants. The advertisements will capture residents who have involvement in the area but do not occupy low lying land. All government and local progress associations will be contacted by direct mail.

Identification of Stakeholders: Any body which has a significant interest in the study should be identified and included in the mailing list. Depending on the number of groups they could be asked to attend the FMC meetings, attend meetings with the project group, or be talked to individually by the consultant.

How Public Interest will be Generated: The success of the study can be measured by how the outcomes of the study are supported by the community. To achieve a high level of support the community needs to be involved in the decision making process. The proposed program aims to generate public interest in the following ways:

- advertisements in local newspapers and press releases provided to local radio, television and newspapers,
- distribution of the letter of introduction and two newsletters,
- two public meetings,
- displays at Council,
- local progress associations and/or representatives on the Floodplain Management Committee should advise their members.

B3.2 Phase 2 - Preparation of the FMS

Preparation and Release of Newsletter: The newsletter will seek to:

- advise the community of the study, its purpose, timetable and expected outcomes,
- summarise the findings of the Flood Study,
- provide concise representations of the strategies proposed in the FMS,
- outline the consultation program and inform the community on how to become involved in the process,
- invite a submission on the draft FMS,
- advise of the forthcoming public meetings to discuss the findings of the FMS.

Discussions with Stakeholder Groups: It is expected that representatives of these groups will attend the FMC meetings. Alternatively it may be possible to meet with these groups prior to or following the FMC meetings.

Public Meetings: Two meetings will be held with residents (one for each area). Invitations to attend the meetings would be included in the newsletter and public advertisement. It is anticipated that both meetings will be held on the same day in Council Offices.

It is expected that the meetings would run for approximately 2 hours and be chaired by a Councillor. Each will be attended by Mr R Dewar. The meetings would address the following issues:

- a presentation of the study process,
- an outline of the flooding characteristics of the area,
- a presentation of the strategies,
- community response to those strategies,
- discussion of other strategies to be considered,
- where to from here?

The meeting will include display of graphical material including aerial photos, maps and the proposed strategies.

Technical Workshop: A technical workshop would be held with relevant officers of Council (from a range of relevant disciplines such as engineering, planning and recreation), and State Government departments with an interest in the outcome of the FMS. This workshop would discuss the strategies presented in the FMS and any others nominated by the group. This workshop may form part of a FMC meeting and should occur after the public meetings.

The results of the workshop, discussions and submissions will be reported to the Council and will be presented to the FMC for consideration and recommendation prior to proceeding with the completion of the draft FMP.

B3.3 Phase 3 - Preparation of the Draft FMP

Once a draft FMP has been prepared and approved for exhibition by the committee the following activities will occur:

- An exhibition of the draft FMS and FMP will be prepared by Council and exhibited at Council Chambers and major libraries. It is not expected that the exhibitions will be elaborate or space consuming. The consultants would provide maps, plans, etc.

- Advertisements will be placed in the state (SMH) and local newspapers advising of the availability of the draft FMS and FMP for comment. The advertisements will advise on where the draft study is exhibited and how comments can be made. The consultants would prepare the advertisements which would be placed by Council. Local radio, television stations and newspapers would also be issued with a press release from Council.

- A second newsletter will be prepared and circulated in a similar manner to the first newsletter with the addition of those who expressed an interest during the study process.

- Public meeting(s) will be held to discuss the draft and to hear comments of the community.

- Council and the consultants will review submissions on the Draft Reports and report to the FMC.

B3.4 Role of the Consultants

Webb, McKeown & Associates: Webb, McKeown & Associates (R Dewar) would participate in the meetings and workshop. He would provide technical support and present the findings of the study in a manner understandable by non-technical members of the public. WM would prepare the newsletters and format of the consultation program.

TERARA VILLAGE/RIVERVIEW ROAD AREA FLOODPLAIN MANAGEMENT STUDIES QUESTIONNAIRE

No. 1
3 July, 1998
Distribution Area: All Residents

Your response to this questionnaire will help Council in its investigation of the flooding issues along the south bank of the Shoalhaven River (Nowra Bridge to Terara). Please tick a box where requested.

1. Please provide your name and address details below.
   Name: _____ Telephone: _____
   Address: _____

2. How long have you been at this address? _____ Years

3. Type of development? House Commercial (specify) _____
   Residential Units Agricultural

4. Your status with regard to this property?
   Owner residing or conducting business at property. Tenant
   Owner not residing or conducting business at property.
   Other (please specify) _____

5. Have you ever experienced? Please tick more than one box.

	Yes	**No**	**Not Applicable**
Have floodwaters ever entered your house?			
Have floodwaters ever entered your yard?			
Has flooding ever caused you to leave your house?			
Has flooding ever caused you to move your car?			
Have you ever incurred a financial loss from flooding?			
If YES provide approximate amount (in $'s). _____			
Have you ever missed work during a flood?			
Have you ever received a flood warning?			
If YES was the warning useful?			
Have you ever received assistance during a flood?			
From whom - specify? _____			
Have you ever experienced any post flood emotional trauma?			
Do you have a flood action or emergency plan?			
Do you think there is a risk to life in your area from flooding?			
Do you think that you are flood aware?			

6. How deep (in centimetres) do you think the water would be above your lowest habitable (or work) floor level in the following events?

In a flood which occurs on average once in every 20 years _____ cms

In a flood which occurs on average once in every 100 years _____ cms

In the largest possible flood event _____ cms

7. How much time do you think you would have in a major flood to undertake emergency measures?

no idea 1 day 12 hours 6 hours less than 6 hours

8. Is the inundation of your land and/or building caused by flooding (from severe rain and ocean conditions) of concern to you? Yes No

If Yes indicate the means by which you would like the problem to be addressed.

Yes

do nothing

dredge, enlarge or maintain the Shoalhaven Heads entrance channel

better flood warning information

more information regarding damage minimisation or evacuation procedures

house raising

flood insurance

dredge the Shoalhaven River

voluntary purchase of building/land

sealing the entrances to the building

maintain or raise the levee on the southern bank from Nowra bridge to Terara

Other - specify: _____

_____

9. Please provide any further comments that you think appropriate.

_____

_____

After completing this questionnaire please check that you have answered every question. Put the completed questionnaire into an envelope and mail (no stamp required) within 7 days to:

REPLY PAID 1752
Webb, McKeown & Associates Pty Ltd
Level 2, 160 Clarence Street
SYDNEY NSW 2000
Attention: Mr Richard Dewar

Thank you for your assistance

RIVERVIEW ROAD FLOODPLAIN MANAGEMENT STUDY

COMMUNITY INFORMATION SHEET OCTOBER 1998

INTRODUCTION

This Community Information Sheet has been issued to inform you of the Floodplain Management Studies (FMS) being prepared for the Riverview Road area and the village of Terara.

Shoalhaven City Council has appointed Webb, McKeown & Associates Pty Ltd (Consulting Engineers) to develop a sustainable plan for floodplain management of these two areas.

An integral part of the study process is the implementation of a community consultation program and this newsletter constitutes part of this process. Previously a questionnaire and a letter of introduction were provided by Council in July 1998.

Your questions and/or comments are welcome at any time during the course of the study. Details on how to contact the study team are provided on the back of this sheet as well as details of the upcoming public meeting.

PROCESS

The implementation of sound floodplain management practice is an important process which can be used to optimise development potential, and to obtain social and economic benefits from the reduction in tangible and intangible flood damages.

The **first step** in the process is preparation of a Flood Study to establish design flood levels. (Design flood levels are levels which have a known likelihood of occurrence. For example the 1% annual exceedance probability event (AEP) has a 1% or 1 in 100 chance of being equalled or exceeded in any year.) This study was completed in 1990. The results indicate that a number of buildings would be inundated above floor level.

Event	Buildings Inundated above floor
Extreme	177
0.5% (AEP)	118
1% (AEP)	7
2% (AEP)	3
5% (AEP)	nil

The **second step** is preparation of this FMS which identifies various floodplain management measures. The **third stage** is preparation of a Plan which documents how the works identified in the FMS are to be implemented. The **final stage** is the undertaking of the works.

OBJECTIVES OF THE STUDY

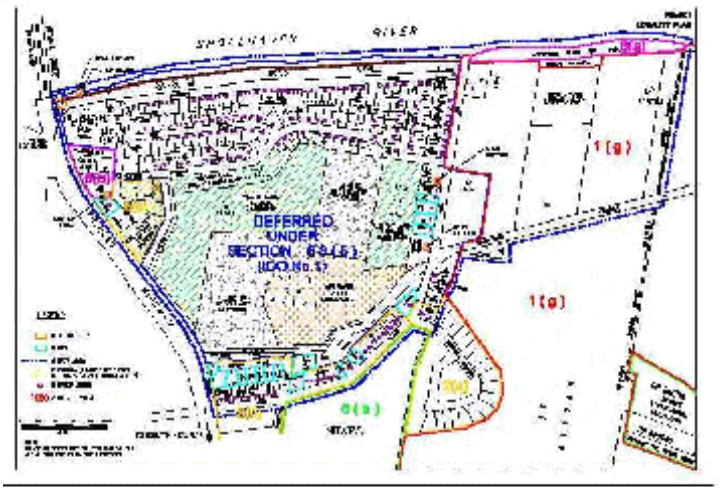
The objectives for this FMS are as follows:

- to manage flooding as an integral part of the planning and development process,
- to systematically identify and address flooding problems,
- to prepare a schedule of works to manage the existing flood problem and reduce future flood damages,
- to implement a unified approach,
- to ensure sustainable development principles are achieved,
- to maintain and enhance the quality of the Shoalhaven River.

THE STUDY AREA

The study area (Figure 1) incorporates the area from the Princes Highway east to the drainage easement.

FLOODPLAIN MANAGEMENT



THE FLOOD PROBLEM

Runoff from the 7000 square kilometre catchment of the Shoalhaven River enters the lower floodplain area at Nowra bridge, and enters the Pacific Ocean through Shoalhaven Heads or the Crookhaven entrance. Tidal conditions, wind wave activity and the build up of sand may restrict these outlets.

As the water level rises floodwaters overtop the river banks and inundates the floodplain. Flooding in the past (1860, 1870, 1974, 1978) has caused considerable damage and hardship to the community. A levee has been constructed from Nowra Bridge to Terara (it is at various levels) and provides protection up to the 10% level at Terara and the 1% level at Riverview Road.

The study area is designated as **High Hazard Floodway** and a summary of possible floodplain management measures is shown in the accompanying table and below.

Flood Modification - modifies flood behaviour.
Property Modification - modifies land use and development controls.
Response Modification - modifies the communities response to flood hazard.

HOW DO I GET INVOLVED?

Community input to the FMS is essential and a range of consultation activities are planned to coincide with the various stages of the study. Activities have or will include:

- your direct feedback to the project team or Shoalhaven City Council,
- individual discussions with residents, businesses and other stakeholders,
- input from your local representatives on the Floodplain Management Committee,
- questionnaire,
- public meetings,
- public exhibition of the draft FMS and Plan.

Submissions are welcome at any stage of the study process. Any interested party is invited to attend the first public meeting. The Terara public meeting is being held beforehand from 5 30pm till 7 30pm.

FIRST PUBLIC MEETING

For the RIVERVIEW ROAD AREA

7 30pm till 9 30 pm
Monday 26 October 1998
Training Room No 1
Shoalhaven City Council Offices
Bridge Road, Nowra

(You are requested to meet the security personnel at the southern entrance to gain access to the building)

WHO TO SPEAK TO?

The Project Manager is:
Mr Richard Dewar,
Reply Paid 1752
Webb, McKeown & Associates
Level 2, 160 Clarence Street
SYDNEY NSW 2000
Telephone: (02) 9299 2855
Facsimile: (02) 9262 6208
Email: Shoalhaven@webbmckeown.com.au

You may also wish to contact Mr Ajith Goonatilleke, Strategic Drainage Engineer, Shoalhaven City Council on (02) 44 293238 to discuss any aspects of the project.

Should you only wish to make a brief comment or seek clarification on any issue, or have any comments on the proposal, please respond in the format as shown below and return to the free Reply Paid address.

NAME: _____
ADDRESS: _____
_____
TELEPHONE: _____
COMMENT: _____
_____
_____
_____
_____

PLEASE ATTACH A LONGER SUBMISSION IF THERE IS INSUFFICIENT ROOM ABOVE.

APPENDIX C: BANK EROSION AND FAILURE

APPENDIX C: BANK EROSION AND FAILURE

C1. GENERAL

The terms bank erosion and bank failure are often used interchangeably. However, the two terms have different specific meanings. *Erosion* occurs when individual soil particles of the bank's surface material are removed. *Failure* occurs when a relatively large section of the bank fails and slides into the channel.

The major factors contributing to river bank erosion are:

- altered flow patterns, tidal currents and/or velocities,
- wave attack (from boats and wind waves),
- rainfall,
- seepage,
- overbank drainage,
- changes in land use (e.g. removal of native vegetation, introduction of livestock).

The major causes of river bank failure can generally be categorised as either an increase in the shear stresses in the bank or a decrease in the shear strength of the soil. These causes, which can individually or in combination lead to bank failure, are:

- increase in shear stress within the bank:
  - changes in channel shape due to bed scour or erosion of the bank face,
  - increase of load at the top of the bank,
  - rapid drawdown of water against the bank face,
- decrease in shear strength of soil:
  - swelling of clays due to absorption of water,
  - pressure of groundwater from within the bank,
  - creep, or minor movements of the soil,
  - removal of vegetation from banks.

C2. BANK EROSION

Soil particles carried away from a bank by flowing water are removed by a tractive force which tends to pull particles along with the flow. An *alteration in flow patterns, tidal currents and/or velocities*, whether natural (e.g. flooding) or caused by man (e.g. excavation) can increase the tractive force. The potential for erosion depends on the resistance of the river bank's soil particles, which is based on particle size and cohesive properties. Larger particles weigh more and are harder to move, thus gravel is more resistant to erosion than sand. Highly cohesive particles such as clay are more resistant.

Flow patterns vary across the width of a river, particularly at bends. The velocity (and correspondingly the tractive force) significantly increases towards the outside of a bend, causing a greater erosion potential on the outside bank. On the inside of a bend the velocity decreases allowing suspended sediments to deposit and build a point bar.

Local scour around obstacles in the bed or banks of the channel is caused by the turbulence of eddies and velocity concentrations in the flow generated by the obstacle. The extent of scour is related to the size and streamlining of the obstacle. Typical obstacles which cause scour are irregular bank lines, bridge piers, weirs, boat docks, rubble, and trees.

When *waves* set up by passing boats or wind reach the river bank, the repeated agitation caused by waves can dislodge soil particles. Waves will alter the exposed bank wherever the energy cannot be dissipated in non-destructive hydrodynamic turbulence, such as progressive breaking on a stable beach, movement through the interstitial spaces of a rip rap slope, or diffraction and transfer of momentum through vegetation or other fixed or floating bodies. Additional damage can be caused by boats which moor.

Raindrops striking an exposed river bank tend to loosen soil particles and reduce the infiltration capacity of the soil. With the infiltration capacity reduced, more and more of the rainfall will run down the bank, increasing the tractive force of the runoff and thereby increasing the potential for erosion.

Seepage effects can be either steady or unsteady. Steady effects relate to discharge from, and recharge to, the regional groundwater regime through the channel bank. Pressure from groundwater movement inside the bank forces water on to the face of the bank, loosening soil particles at the bank's surface. The resulting downslope movement of seepage water and loosened soil particles can further erode the bank. Groundwater seepage can be observed as a wet bank face or as piping flow from small holes on the slope.

Unsteady seepage effects relate to changes in pore water pressure in the bank due to fluctuations in the water level in the channel, and are independent of the steady seepage into or out of the bank. These result from long-period changes such as flooding and tidal activity, or short-period changes such as water level drawdown due to boat and surface waves. The flow of pore water within the soil depends on the rate of change of the water level in the channel, the permeability, and the drawdown or wave height. Silty and sandy soils are most at risk as they cannot respond quickly enough to avoid relatively high pressure gradients, yet the seepage velocity may be significant.

Overbank drainage is closely related to the problem of river bank surface erosion due to rainfall and seepage, and can be responsible for severe sheet and rill erosion. Whilst erosion due to overbank drainage can occur naturally, it is more likely to occur when the land near the top of the bank has been disturbed by clearing and ploughing and no provisions have been made for surface drainage control.

Changes in land use which influence river flow past the bank and the amount of sediment in the flow can cause an otherwise erosion-free bank to suffer severe erosion. Three major changes in land use which can increase the potential for erosion are vegetation clearing (e.g. for agricultural purposes), allowing livestock to trample banks, and urbanisation. The inevitable results of removing vegetative cover, disturbing surface soils, and decreasing the area available for rainfall infiltration are downstream flooding and increased sediment loads. In addition to

higher tractive forces during the flood, the sediment load deposited by the flood reduces the channel's flood-carrying capacity so that the river may attempt to widen itself to carry the flow, thus further eroding the banks.

C3. BANK FAILURE

Bank failure due to *changes in channel shape* such as toe scour is perhaps the most dramatic and serious cause of bank recession, resulting in sudden loss of the bank and its vegetation. Scour typically tends to occur at the toe of the bank, over steepening the slope and instigating collapse of the bank through slip circle failure or slumping. The resulting talus, which normally stabilises the toe is subsequently removed through sediment transport under strong river and/or tidal flows and the recession process is repeated.

An *increase in the load on top of the bank* causes an increase in shear stress within the bank, thereby increasing the potential for bank failure. Loads can be increased by man-made structures such as roads, bridges, buildings, etc., as well as by living things such as livestock.

Bank failure due to *rapid drawdown* (or a rapid drop in water surface elevation) is most likely to occur as floodwaters recede, or when the bank is subject to fluctuations in water surface elevations. During periods of high water, banks can become saturated by inflow from the river. When the bank face is covered by water, a pressure balance exists between the water in the channel and the weight of the saturated bank, helping to keep the bank in place. If the water elevation of the river is suddenly lowered and the soil cannot drain quickly, a pressure imbalance can occur (a pressure imbalance can also be caused by infiltration due to rainfall or runoff, or by groundwater sources deep within the bank). If the bank has insufficient shear strength to resist, the imbalance may cause bank failure.

The *swelling of clay materials* within banks due to the absorption of water can cause erosion by decreasing the shear strength of the bank. When the exposed wet clay and silt dry out, shrinkage and cracking can occur near the bank's surface, forming a layer of soil that can be easily eroded. The next time that water moves over the bank face, all or part of the layer may be removed. As the newly exposed material dries out, the cycle can repeat itself.

High *pore water pressure* in the bank material due to seepage or rapid lowering of the water level in the channel, will reduce the shear strength of the soil and can trigger a deep-seated rotational failure.

Soil creep can be observed as the development of bank cracks running generally parallel to a river. Wetting and drying cycles can cause swelling and shrinking of soils which contain clay. This encourages the generation of vertical fissures and the formation of soil blocks with desiccation cracks. This in turn encourages soil creep which can be responsible for bank failure.

The *root mat from vegetated banks* (mangroves have a particularly effective root mat) can modify the geotechnical properties of the soil, such that the shear strength of the bank can be increased and some tensile strength provided. Vegetation can therefore help to maintain the stability of river banks by helping prevent tension crack formation. Removal of the vegetation can cause the river bank to suffer mass failure.

APPENDIX D: FLOOR LEVEL DATABASE

APPENDIX D: FLOOR LEVEL DATABASE

No.	House No.	Street	Floor Level (mAHD)	Ground Level (mAHD)	Single Storey	Double Storey	Timber	Fibro	Mixed	Brick	Good	Poor	Large	Medium	Units	Comments	AEP which first Inundated the Floor
1	2	BRERETON ST	5.6	5.3		1				1			1		6	6 flats	0.2%
2	1	CAMPBELL PL	6.1	5.8	1					1			1		2	2 flats	0.2%
3	2	CAMPBELL PL	6.2	5.9	1					1			1		2	2 flats	Ext
4	3	CAMPBELL PL	6.4	6.1	1					1			1		4	4 flats	Ext
5	4	CAMPBELL PL	6.1	5.8	1					1			1		3	3 flats	0.2%
6	5	CAMPBELL PL	6.7	6.4	1					1			1		5	5 flats	Ext
7	6	CAMPBELL PL	6.1	5.8	1					1			1		8	8 flats	0.2%
8	7	CAMPBELL PL	5.8	5.5	1					1			1		6	6 flats	0.2%
9	8	CAMPBELL PL	5.6	5.3	1					1			1		3	3 flats	0.2%
10	2	ELIA AVE	4.9	4.4	1					1				1	1		0.5%
11	4	ELIA AVE	4.9	4.5	1					1			1		1		0.5%
12	5	ELIA AVE	5.3	4.9	1					1				1	1		0.2%
13	6	ELIA AVE	4.9	4.5		1				1			1		1		0.5%
14	8	ELIA AVE	5.0	4.7		1				1			1		1	Floor levels ; house	0.5%
15	9	ELIA AVE	5.2	4.9		1				1			1		1	Front door	0.2%
16	10	ELIA AVE	4.9	4.6	1					1				1	1		0.5%
17	11	ELIA AVE	5.1	4.8	1					1				1	1	Front door	0.5%
18	12	ELIA AVE	4.9	4.3	1					1			1		1		0.5%
19	13	ELIA AVE	5.0	4.7	1					1				1	1	Front door	0.5%
20	14	ELIA AVE	4.9	4.3		1				1			1		1		0.5%
21	15	ELIA AVE	6.1	4.9		1				1			1		1		0.2%
22	16	ELIA AVE	4.9	4.7	1					1				1	1		0.5%
23	17	ELIA AVE	5.3	4.9	1					1			1		1		0.2%
24	18	ELIA AVE	5.3	4.9	1					1				1	1		0.2%
25	19	ELIA AVE	5.1	4.9	1					1			1		1		0.5%
26	20	ELIA AVE	5.0	4.3	1					1				1	1		0.5%
27	21	ELIA AVE	5.4	4.9	1					1				1	1		0.2%
28	22	ELIA AVE	4.9	4.9	1					1			1		1		0.5%
29	23	ELIA AVE	4.9	4.9		1				1			1		1		0.5%
30	24	ELIA AVE	4.9	4.7	1					1			1		1		0.5%
31	25	ELIA AVE	4.9	4.9	1					1				1	1		0.5%
32	26	ELIA AVE	4.9	4.9		1				1			1		1		0.5%
33	27	ELIA AVE	5.3	4.9		1				1			1		1		0.2%
34	28	ELIA AVE	4.9	4.4	1					1				1	1		0.5%
35	29	ELIA AVE	4.9	4.9	1					1			1		1		0.5%
36	30	ELIA AVE	4.9	4.4	1					1				1	1		0.5%
37	31	ELIA AVE	5.3	4.9	1					1				1	1		0.2%
38	33	ELIA AVE	5.3	4.9	1					1				1	1		0.2%
39	2	FERRY LANE	5.3	5.0	1					1				1	1	Front door	0.2%
40	3	FERRY LANE	3.9	3.6	1			1						1	1	Front door	1%
41	7	FERRY LANE	4.9	4.6		1				1			1		5	5 flats	0.5%
42	9	FERRY LANE	5.8	4.3	1					1				1	6		0.2%
43	13	FERRY LANE	4.9	4.9		1				1				1	4		0.5%
44	15	FERRY LANE	4.9	4.9		1				1				1	6		0.5%
45	17	FERRY LANE	4.9	4.3	1			1						1	1		0.5%
46	19	FERRY LANE	4.9	4.5	1			1						1	1		0.5%
47	25	FERRY LANE	4.9	4.7	1					1			1		1		0.5%
48	27	FERRY LANE	4.9	4.9		1				1				1	1		0.5%
49	29	FERRY LANE	4.9	4.5	1					1				1	1		0.5%
50	31	FERRY LANE	4.9	4.3	1					1			1		1		0.5%
51	33	FERRY LANE	4.9	4.7	1					1				1	1		0.5%
52	35	FERRY LANE	5.4	4.9	1			1					1		1		0.2%
53	37	FERRY LANE	5.6	4.9		1				1				1	1		0.2%
54	39	FERRY LANE	5.4	4.9	1		1							1	1		0.2%
55	45	FERRY LANE	5.2	4.9	1					1				1	1		0.2%
56	1	HAWTHORN AVE	4.9	4.9		1				1				1	1		0.5%

No.	House No.	Street	Floor Level (mAHD)	Ground Level (mAHD)	Single Storey	Double Storey	Timber	Fibro	Mixed	Brick	Good	Poor	Large	Medium	Units	Comments	AEP which first Inundated the Floor
57	3	HAWTHORN AVE	4.9	4.9		1				1			1		1		0.5%
58	6	HAWTHORN AVE	5.3	5.0	1					1				1	1	Front Door	0.2%
59	22	HAWTHORN AVE	8.8	8.5		1				1			1		3	3 flats	
60	1	LYREBIRD DR	4.9	4.9	1					1				1	1		0.5%
61	2	LYREBIRD DR	4.9	4.9	1					1			1		1		0.5%
62	3	LYREBIRD DR	4.9	4.9	1					1				1	1		0.5%
63	4	LYREBIRD DR	5.4	4.9	1					1			1		1		0.2%
64	5	LYREBIRD DR	5.3	4.9	1					1			1		1		0.2%
65	6	LYREBIRD DR	5.2	4.9	1					1			1		1		0.2%
66	7	LYREBIRD DR	5.2	4.9	1					1			1		1		0.2%
67	8	LYREBIRD DR	4.9	4.6	1					1				1	1		0.5%
68	9	LYREBIRD DR	5.4	4.9	1					1				1	1		0.2%
69	10	LYREBIRD DR	4.9	4.9	1					1				1	1		0.5%
70	11	LYREBIRD DR	5.3	4.9	1					1				1	1		0.2%
71	12	LYREBIRD DR	4.9	4.3	1					1				1	1		0.5%
72	13	LYREBIRD DR	5.2	4.9	1					1			1		1		0.2%
73	14	LYREBIRD DR	4.9	4.3	1					1			1		1		0.5%
74	15	LYREBIRD DR	5.3	4.9	1					1			1		1		0.2%
75	16	LYREBIRD DR	5.1	4.3	1					1			1		1		0.5%
76	17	LYREBIRD DR	5.4	4.9	1					1			1		1		0.2%
77	18	LYREBIRD DR	5.0	4.7	1					1			1		1	Front door	0.5%
78	19	LYREBIRD DR	5.1	4.9	1					1			1		1		0.5%
79	20	LYREBIRD DR	4.9	4.3	1					1				1	1		0.5%
80	21	LYREBIRD DR	4.9	4.6	1					1			1		1	Front door	0.5%
81	22	LYREBIRD DR	4.9	4.5	1					1			1		1		0.5%
82	23	LYREBIRD DR	5.2	4.9	1					1			1		1		0.2%
83	24	LYREBIRD DR	4.9	4.4	1					1				1	1		0.5%
84	26	LYREBIRD DR	4.9	4.7	1					1			1		1		0.5%
85	27	LYREBIRD DR	4.9	4.6	1					1				1	1	Front door	0.5%
86	28	LYREBIRD DR	4.9	4.5		1				1				1	1		0.5%
87	29	LYREBIRD DR	4.9	4.5	1					1			1		1		0.5%
88	30	LYREBIRD DR	4.9	4.4	1					1			1		1		0.5%
89	31	LYREBIRD DR	5.0	4.7	1					1				1	1	Front door	0.5%
90	32	LYREBIRD DR	4.6	4.3	1					1				1	1	Front door	0.5%
91	33	LYREBIRD DR	4.8	4.5	1					1				1	1	Front door	0.5%
92	35	LYREBIRD DR	5.0	4.7	1					1				1	1	Front door	0.5%
93	37	LYREBIRD DR	5.0	4.7	1					1				1	1	Front door	0.5%
94	37A	LYREBIRD DR	5.0	4.6	1					1				1	1		0.5%
95	39	LYREBIRD DR	4.9	4.6	1					1			1		1	Front door	0.5%
96	43	LYREBIRD DR	4.9	4.6	1					1				1	1	Front door	0.5%
97	45	LYREBIRD DR	4.9	4.6	1					1				1	1	Front door	0.5%
98	49	LYREBIRD DR	4.9	4.6	1					1				1	1	Front door	0.5%
99	51	LYREBIRD DR	5.0	4.7	1					1				1	1	Front door	0.5%
100	47	MOSS ST	7.9	7.6	1		1							1	1	Front door	Ext
101	49	MOSS ST	8.4	8.1	1			1						1	1	Front door	
102	53	MOSS ST	8.1	7.8	1			1						1	1	Front door	
103	57	MOSS ST	8.1	7.8	1		1							1	1	Front door	
104	59	MOSS ST	8.2	7.9	1			1						1	1	Front door	
105	63	MOSS ST	8.2	7.9	1			1						1	1	Front door	
106	67	MOSS ST	7.9	7.6	1			1						1	1	Front door	Ext
107	69	MOSS ST	7.8	7.5	1			1						1	1	Front door	Ext
108	73	MOSS ST	6.7	6.4		1				1			1		4	4 flats	Ext
109	77	MOSS ST	6.6	6.3	1			1						1	1	Front door	Ext
110	79	MOSS ST	6.1	5.8	1			1						1	1	Front door	0.2%
111	81	MOSS ST	5.9	5.6	1			1						1	1	Front door	0.2%
112	83	MOSS ST	5.6	5.3	1			1						1	1	Front door	0.2%
113	85	MOSS ST	5.3	5.0	1			1						1	1	Front Door	0.2%
114	87	MOSS ST	5.3	5.0		1				1			1		3	3 flats	0.2%
115	89	MOSS ST	4.9	4.6	1					1				1	1	Front Door	0.5%
116	91	MOSS ST	4.4	4.1		1				1			1		3	3 flats	1%

No.	House No.	Street	Floor Level (mAHD)	Ground Level (mAHD)	Single Storey	Double Storey	Timber	Fibro	Mixed	Brick	Good	Poor	Large	Medium	Units	Comments	AEP which first Inundated the Floor
117	93	MOSS ST	5.0	4.7	1		1							1	1	Front door	0.5%
118	95	MOSS ST	4.5	4.2	1			1						1	1	Front door	1%
119	97	MOSS ST	5.0	4.7	1			1						1	1	Front door	0.5%
120	99	MOSS ST	5.0	4.7	1					1				1	1	Front door	0.5%
121	101	MOSS ST	5.3	5.0	1			1						1	1	Front door	0.2%
122	103	MOSS ST	5.1	4.8	1					1				1	1	Front door	0.2%
123	105	MOSS ST	5.1	4.8	1		1							1	1	Front door	0.2%
124	107	MOSS ST	4.8	4.5	1					1				1	1	Front door	0.5%
125	109	MOSS ST	4.1	3.8		1				1			1		12	12 flats	1%
126	112	MOSS ST	6.7	6.4	1		1							1	1	Front door	Ext
127	120	MOSS ST	5.0	4.3	1					1			1		1		0.5%
128	122	MOSS ST	4.9	4.4	1		1							1	1		0.5%
129	1	PLEASANT WAY	4.9	4.6	1			1						1	1	Home	0.5%
130	8	PLEASANT WAY	5.4	5.1		1				1			1		14	14 units	0.2%
131	2	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
132	6	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
133	8	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
134	10	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
135	12	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
136	16	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
137	18	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
138	18A	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
139	20	RIVERVIEW RD	4.9	4.9	1					1				1	1		0.5%
140	22	RIVERVIEW RD	4.9	4.9		1				1			1		1		0.5%
141	26	RIVERVIEW RD	4.9	4.9		1				1			1		1		0.5%
142	28	RIVERVIEW RD	4.9	4.9		1				1			1		1		0.5%
143	30	RIVERVIEW RD	5.1	4.8		1				1			1		1	Front door	0.5%
144	32	RIVERVIEW RD	4.9	4.9		1				1			1		1		0.5%
145	34	RIVERVIEW RD	4.9	4.9		1				1			1		1		0.5%
146	36	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
147	38	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
148	40	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
149	42	RIVERVIEW RD	5.2	4.9		1				1				1	1		0.2%
150	44	RIVERVIEW RD	6.1	4.9		1				1				1	1		0.2%
151	46	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
152	50	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
153	52	RIVERVIEW RD	5.3	4.9	1					1				1	1		0.2%
154	54	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
155	56	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
156	58	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
157	60	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
158	62	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
159	64	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
160	66	RIVERVIEW RD	5.2	4.9	1					1				1	1		0.2%
161	67	RIVERVIEW RD	5.1	4.8		1				1			1		1	Front door	0.5%
162	68	RIVERVIEW RD	4.9	4.9	1					1			1		1		0.5%
163	69	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
164	70	RIVERVIEW RD	5.1	4.8		1				1			1		1	Front door	0.5%
165	71	RIVERVIEW RD	4.9	4.9		1				1				1	1		0.5%
166	72	RIVERVIEW RD	5.2	4.9	1					1				1	1		0.2%
167	73	RIVERVIEW RD	4.9	4.9	1					1				1	1		0.5%
168	74	RIVERVIEW RD	5.2	4.9	1					1				1	1		0.2%
169	75	RIVERVIEW RD	5.3	4.9		1				1				1	1		0.2%
170	76	RIVERVIEW RD	5.3	4.9	1					1				1	1		0.2%
171	77	RIVERVIEW RD	5.0	4.3	1					1				1	1		0.5%
172	78	RIVERVIEW RD	4.9	4.6	1					1				1	1		0.5%
173	78A	RIVERVIEW RD	4.9	4.6	1					1			1		1		2%
174	79	RIVERVIEW RD	4.9	4.4	1					1				1	1		0.5%
175	81	RIVERVIEW RD	4.9	4.9	1					1			1		1		0.5%

No.	House No.	Street	Floor Level (mAHD)	Ground Level (mAHD)	Single Storey	Double Storey	Timber	Fibro	Mixed	Brick	Good	Poor	Large	Medium	Units	Comments	AEP which first Inundated the Floor
176	82	RIVERVIEW RD	4.9	4.5	1					1			1		1		0.5%
177	83	RIVERVIEW RD	4.9	4.6	1					1			1		1		0.5%
178	CP	TERARA RD	4.6	4.3		1				1			1		1	Downstairs office	0.5%
179	4	TERARA RD	3.6	3.3	1					1				1	1	Front door	2%
180	6	TERARA RD	3.3	3.0	1					1				1	1	Front door	2%
181	1	WHARF RD	5.1	4.8		1				1			1		1		0.5%
182	60	WONDALGA CRES	7.6	7.3	1					1				1	1	Front door	Ext
183	10	WHARF RD	4.8	4.5		1		1						1	1	Rest boat	0.5%
	1	Campbell Pl	6.4	6.1	n/a										2	1 Camp units	
	2	Campbell Pl	6.5	6.2	n/a										2	2 Camp units	
	Leagues	Hawthorn Av	8.7	8.4	n/a										3	Leagues Club	
		Sailing Club	2.8	2.5	n/a										1	Sailing Club	
	1	Pleasant Way CP	5.0	4.7	n/a										1	Office	
	1	Pleasant Way CP	4.9	4.6	n/a										1	Shop	
	1	Pleasant Way CP	5.5	5.3	n/a										65	Vans	
		Shoalhaven CP	3.9	3.5											3	Vans	
		Shoalhaven CP	4.1	3.7											0	Vans	
		Shoalhaven CP	4.3	3.9											5	Vans	
		Shoalhaven CP	4.5	4.1											17	Vans	
		Shoalhaven CP	4.7	4.3											25	Vans	
		Shoalhaven CP	4.9	4.5											31	Vans	
		Shoalhaven CP	5.1	4.7											26	Vans	
		Shoalhaven CP	5.3	4.9											8	Vans	
		Shoalhaven CP	5.5	5.1											9	Vans	
		Shoalhaven CP	5.7	5.3											5	Vans	

No.	No.	Address	FL RL	Gr RL	Sngl	Dbl	Tmbr	Fbro	Mixd	Brck	Good	Poor	Lrg	Med	Units	Comments
			Totals		125	58	8	19	0	156			70	113	263	
			Percent		68	32	4	10	0	85			38	62		

Note: The data shown in the above Table was collected and used for the purpose of the assessment of flood damages in the study and internal use of Council. It should not be used for any other purpose. Council will not take any responsibility for any loss or damage suffered due to any errors in the above data.

APPENDIX E: POST FLOOD EVALUATION AND REVIEW

APPENDIX E: POST FLOOD EVALUATION AND REVIEW

E1. GENERAL

Design flood levels along the Shoalhaven River are provided in the *Lower Shoalhaven River Flood Study* - April 1990. Copies of this report are held by Shoalhaven City Council and the Department of Land and Water Conservation. The design levels were obtained from computer models of the catchment which were calibrated to five historical floods (August 1974, June 1975, October 1976, March 1978 and April 1988).

The accuracy of the design flood levels can be improved with further flood and rainfall data to confirm the calibration of the computer models. The following procedure has been developed to ensure that the information available from future floods is accurately obtained and analysed.

E2. PROCEDURE

Step 1 - Future Flood: If the river level exceeds (say) 4.8 m at Nowra Bridge data should be collected. The design flood levels at Nowra Bridge are shown in Table E1.

Step 2 - Collect Peak Levels: River levels and times should be recorded during the event if possible by SES, Council employees or local residents. It is imperative that the peak height of the flood be marked immediately following the event either from debris marks or eyewitness reports. Debris marks can be lost within hours of the peak as a result of wind, rain or human activities.

Council should despatch personnel to cover the length of the river (on both banks) to identify, mark and photograph debris. The levels can be picked up later by a surveyor. The data should be recorded in a report showing the photograph, time of recording (if during the flood) and level to AHD. Council should consider if a circular or notice in local papers is warranted to obtain further information.

If possible velocity measurements should be taken from Nowra Bridge (by the DLWC or other authority).

Step 3 - Buildings Inundated: If floodwaters enter buildings, the occupier should be interviewed to provide a preliminary indication of the damages and peak level, and to obtain photographs. The floor level database used in the Floodplain Management Study indicates which buildings are likely to be flooded in a given event.

Step 4 - Reports from Authorities: Council should obtain written reports from various sections of Council, the SES and any other relevant public authority on the flood. Data should be obtained from the DLWC automatic water level recorders and Sydney Water and Bureau of Meteorology rain gauges. These data can be obtained at any time although if they are collected soon after the event they can be used to identify and correct any gross errors in other data.

Step 5 - Major Floods: Flood levels which indicate an AEP of greater than 5% AEP should be used to re-examine the calibration of the hydrologic/hydraulic models. Data from any other floods which have not previously been analysed should be included in this re-examination.

Steps 6 and 7 only apply to floods with an AEP greater than 5%.

Step 6 - Rainfall Data: Rainfall data from Sydney Water and Bureau of Meteorology gauges is continuously recorded and can be readily obtained at any time. If warranted, additional rainfall information can be sought from residents at the same time as flood data are requested.

Step 7 - Hydrologic/Hydraulic Modelling: The new data should be run through the WBNM and CELL models. If the models do not produce satisfactory results then all available information (including that from floods used in the Flood Study) needs to be considered to see if the model parameters should be changed. Consideration should be given to upgrading the hydraulic model. This will require a considerable amount of additional survey. Any changes in calibration parameters may lead to revised design flood levels. A report should be produced documenting the results and any adjustments required to Council's Floodplain Management Plans and S149 Certificates.

Step 8 - Shoalhaven Entrance Survey: The amount of sand that accumulates between openings at the mouth of the Shoalhaven Heads entrance has a significant influence upon flood levels in the local area. It is essential that as much information as possible is obtained on the pre and post flood topography at the entrance. Generally this will only be possible from aerial photography, but a post flood survey may be warranted. Such a survey was undertaken following the April 1988 flood and this proved very useful in calibrating the hydraulic model. These data should be obtained as soon after the flood as possible.

Table E1: Design Flood Levels (mAHD)

Event (AEP)	Nowra Bridge	Shoalhaven River at Terara
Extreme	8.94	7.39
0.2%	7.28	6.08
0.5%	6.76	5.70
1%	6.34	5.43
2%	5.79	5.04
5%	5.25	4.68
10%	4.78	4.36