WALLAMBA RIVER
FLOODPLAIN RISK MANAGEMENT STUDY
For NABIAC, FAILFORD & MINIMBAH AREAS

DRAFT

Prepared for:
GREAT LAKES COUNCIL
Prepared by:
Department of Infrastructure, Planning and Natural Resources
June 2004

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

i Executive Summary

Nabiac, Failford and Minimbah are located in the Wallamba River catchment. This study concentrates on flooding from the Wallamba River and does **not** deal with flooding from the local urban area or the tributaries of the Wallamba River. It indicates the number of buildings affected by flooding and the approximate extent of flooding where sufficient survey information is available.

The total catchment area of the Wallamba River is 495km^2. The catchment upstream of the Pacific Highway lies within the local government area of Greater Taree City Council, while the catchment downstream of the highway lies within the local government area of Great Lakes Council.

Flooding at Nabiac has not occurred for a number of years. Significant local floods in records at Nabiac occurred in 1927, 1929, 1947, 1957, 1978 and 1983. A flood event also occurred in February 2002. This event was a more localised flood event with above floor flooding experienced due to tributaries to the Wallamba River, such as Town Creek, rather than from flooding from the Wallamba River. The influence of the Wallamba River was not significant as the flood levels in the river were lower than those in town and the peak of river flooding happened well after the peak flood levels in the township. This storm does, however, serve as a timely reminder that whilst well located, Nabiac does have flood problems that need to be effectively managed.

The effects of major floods at these areas are relatively contained to the areas in the vicinity of the river. Flooding from the Wallamba River in the study area in the 1% annual exceedance probability (AEP) flood event will inundate around 18 houses and 3 non residential buildings above floor level with 9 of these buildings in Nabiac, 6 in Failford, and 6 in Minimbah. The potential flood damage in the 1% AEP event is estimated to be in the order of $455,000 with the annual average damage for the full range of floods expected to be in the order of $34,000. The 0.2% and extreme flood events are likely to impact upon 79 and 220 buildings respectively. Very few properties are affected above floor level in floods of less than a 1% AEP. Therefore, whilst development is generally protected from the majority of flood events, extreme flood events can have a significant impact on Nabiac (141 buildings), Failford (61 buildings) and Minimbah (18 buildings).

The development of a bypass flowpath from the Wallamba River through the township of Nabiac occurs in events of around a 0.2% AEP and the scale of this increases in larger events. This is a very rare event, but is important from an emergency management perspective. It can result in areas being isolated, as roads are cut off, and as water levels rise further both the land and the buildings are inundated. This needs careful consideration in the emergency management section of the Great Lakes Local Flood Plan that deals with Nabiac and is an issue for flood education and awareness of the community.

The low number of properties affected above floor level by flooding in a 1% AEP flood event, and the associated relatively low level of average annual flood damages means that it is unlikely for flood mitigation measures, such as levees, to be economically viable. This is further compounded by the large length of river bordering Nabiac, Failford and Minimbah. In addition, works, such as levees, may also impact upon flood levels resulting from local drainage and the Town Creek tributary.

The preliminary findings of the study were presented to the community as part of the consultation undertaken for the project. There appeared to be little community interest in riverine flooding and no particular option for mitigation was supported.

Notwithstanding this council needs to manage three types of flood risk. Each of flood risk involves a component related to danger to personal safety and property damage. The findings of the study indicate that a number of different measures are needed to address all types of flood risk, namely:

- existing flood risk which relates to existing development in the floodplain. This could be reduced by the adoption of a voluntary house raising scheme. The raising of houses below the 2% flood level to 0.5m above the 1% flood level would have the most economic benefit with a return of around $0.87

for every local dollar expended (given a $2 State: $1 Local funding ratio). Local funding could be from Council, property owners or a combination of both. In addition voluntary purchase of worst affected properties unsuitable for raising should be considered.

- future flood risk which relates to the risk to future development in the floodplain. This can be dealt with by recommended changes to Councils Flood Policy and Development Controls.
- continuing flood risk is the risk remaining after management measures are implemented. The flood warning system needs to be accompanied by appropriate community warning methods and community evacuation planning in the local flood plan. Evacuation planning may highlight the need for access improvements in some key areas which may need to be added to the plan. Emergency planning relies on community education and awareness of the problems. It is recommended that Council and the State Emergency Service combine to undertake regular education and awareness campaigns in the community.

1. INTRODUCTION

1.1 Floodplain Risk Management in the Great Lakes Council Area

Council is responsible for land use planning, incorporating the management of flood prone land, within its local government area in accordance with the NSW Government's Flood Prone Land Policy. To support effective floodplain risk management Council has formed a Floodplain Risk Management Committee and is undertaking the floodplain risk management process in accordance with the NSW Government's Floodplain Management Manual (2001). Whilst the manual recommends council consider both mainstream and local overland flooding, this study only examines flooding from the Wallamba River. It does, however, provide essential information for future investigations of Pipeclay and Town Creeks and major drainage issues within the area. The process outlined in the manual aims at addressing the existing, future and continuing flood risks related to human occupation of the floodplain using a process of risk avoidance, minimisation and mitigation. This floodplain risk management study is the second of four steps in this process, described in the table below.

Table 1.1 Steps in the Floodplain Risk Management Process

1	Flood Study	-	Determines the nature and extent of the flood problem.
2	Floodplain Risk Management Study	-	Evaluates management options for the floodplain with respect to existing, future, and continuing flood risk.
3	Floodplain Risk Management Plan	-	Involves formal adoption by Council of a plan of management for the floodplain.
4	Implementation of the Plan	-	Involves construction of flood mitigation works, where viable, to protect existing development and reduce existing flood risk.
		-	Uses planning controls to ensure that future development is compatible with flood hazards controlling future flood risk.
		-	Uses flood education and awareness to promote flood readiness to minimise continuing flood risk

This study is one of a number that are being undertaken by Council for different locations within its service area. This study concentrates on the impacts of the Wallamba River on Nabiac, Failford townships and provides some information on flooding in the Minimbah area.

The existing measures for floodplain risk management at Nabiac, Failford and Minimbah are discussed in Section 3.

1.2 Wallamba River Floodplain Risk Management Study

The Department of Infrastructure, Planning and Natural Resources (DIPNR) was engaged by Council to undertake a Floodplain Risk Management Study for the Nabiac and Failford areas on the Wallamba River. This study was extended to consider flooding in Minimbah.

The Wallamba River flows in a generally easterly direction from the foothills of the Great Dividing Range to Wallis Lake, near the twin towns of Forster and Tuncurry, as indicated on Figure 1. The total catchment area of the Wallamba River is 495km^2. The catchment upstream of the Pacific Highway lies within the local government area of Greater Taree City Council, while the catchment downstream of the highway lies within the local government area of Great Lakes Council.

The largest urban centre in the catchment is the township of Nabiac, located to the north of the Wallamba River just downstream of the Pacific Highway, as indicated on Figure 2. The smaller community of Failford is located on the north side of the Wallamba River between Nabiac and Tuncurry, whilst Minimbah is on the other (south) side of the river from Failford.

Great Lakes Council, through its Floodplain Risk Management Committee, proposes to develop a strategy for management of the floodplain for Nabiac, Failford and Minimbah in accordance with the NSW Government's Floodplain Management Manual (2001). Whilst this study only examines flooding from the

Wallamba River it provides an essential platform for assessment of flooding for key tributaries, such as Town and Pipeclay Creeks, and examination of other local overland flooding issues in the area.

The plan and this study deal with the management of both danger to personal safety and damage to property as they relate to the 3 types of flood risk: existing, future and continuing flood risk:

- existing flood risk is the risk vested in current development in the floodplain. This may need to be managed by floodplain risk management options;
- future flood risk is related to new development within the floodplain. This risk is most effectively managed by the use of development controls; and
- continuing flood risk is the risk remaining after floodplain risk management and development controls are in place. Continuing flood risk needs to be managed by options such as evacuation planning.

This management considers the two separate components of risk, ie, the potential danger to personal safety and the potential damage to property resulting from flooding.

Council has adopted the 1% annual exceedance probability (AEP) flood as the basis for setting flood planning levels (FPL) for control of new development in the Council's Flood Management Policy. This report reviews the flood situation at Nabiac, Failford and Minimbah and addresses the development and assessment of floodplain risk management options in the following sections:

Section 2 The Wallamba River Floodplain – describes existing floodplain conditions including the extent of existing flood problems from the river

Section 3 Existing Floodplain Risk Management – describes floodplain risk management practices

Section 4 Options to Improve Floodplain Risk Management – identifies and assesses potential options

Section 5 Community Consultation – reports on the outcome of community consultation

Section 6 Government Funding – indicates the current government funding programs

Section 7 Conclusions and Recommendations

Section 8 Glossary - provides a definition of the terms used in this report

Section 9 Acknowledgments – indicates the participants in the report development

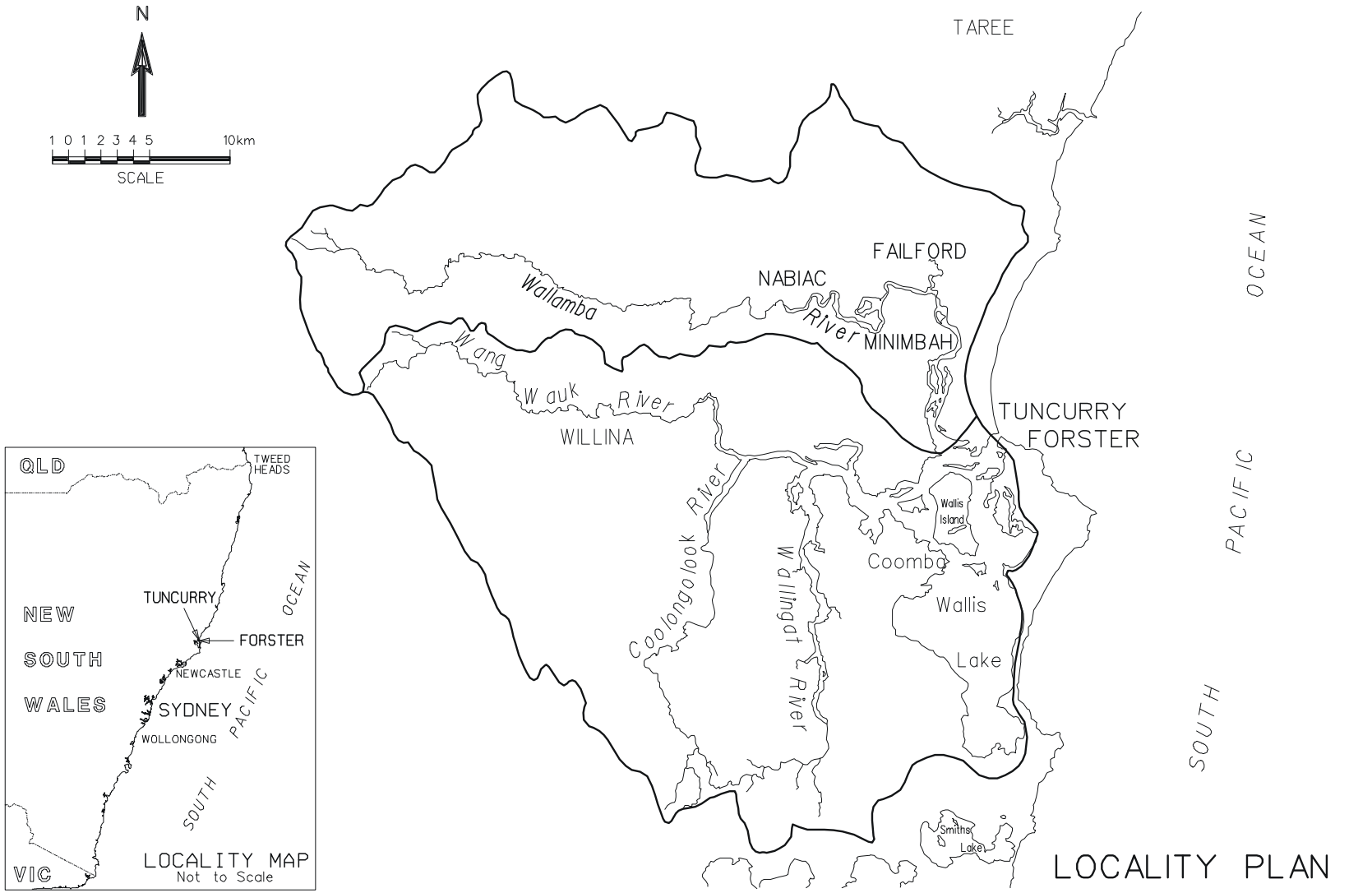
Section 10 References

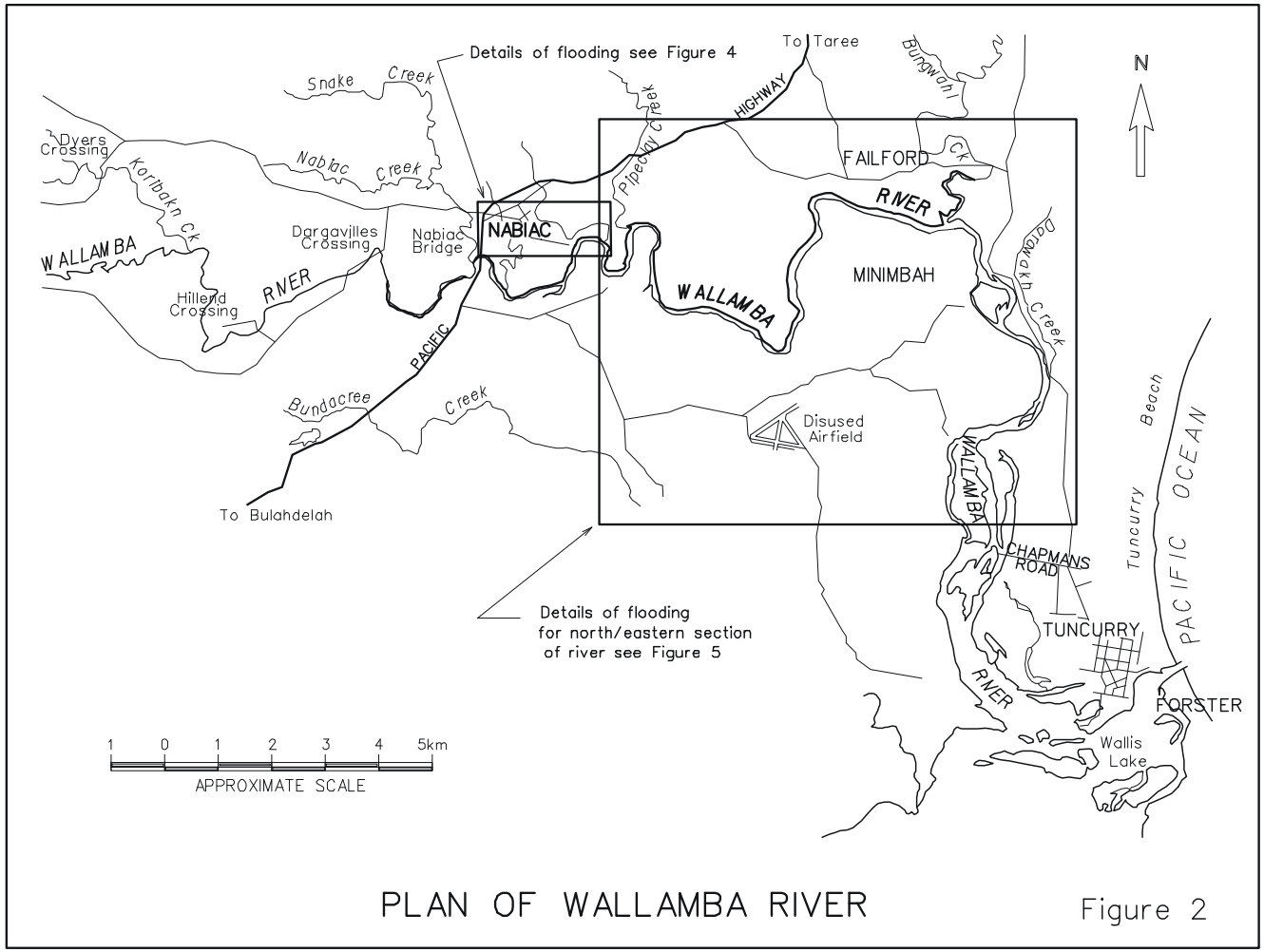
The recommended strategy will be documented in the draft floodplain risk management plan. The report is supported by the following appendices.

Appendix A - Historic Flood Information

Appendix B - Flood Study Review – review of the previous investigations

Appendix C - Flood Damages – assessment of flood damages


N
1 0 1 2 3 4 5 10km
SCALE
TAREE
FAILFORD
NABIAC
Wallamba River
MINIMBAH
Wang Wauk River
WILLINA
TUNCURRY
FORSTER
Coolongolook River
Wallingat River
Wallis Island
Coomba
Wallis Lake
Smiths Lake
PACIFIC OCEAN
SOUTH PACIFIC OCEAN
QLD
TWEED HEADS
NEW SOUTH WALES
TUNCURRY
FORSTER
NEWCASTLE
SYDNEY
WOLLONGONG
VIC
LOCALITY MAP
Not to Scale
LOCALITY PLAN
Figure 1



PLAN OF WALLAMBA RIVER

Figure 2

2. THE WALLAMBA RIVER FLOODPLAIN

2.1 PHYSICAL CHARACTERISTICS

The Wallamba River is a coastal river on the mid-north coast of New South Wales. It experiences a warm temperate climate with average annual rainfall of approximately 1300 millimetres per year. Highest rainfall is experienced from January to June with lower rainfall in late winter and early spring.

The Wallamba River flows in a generally easterly direction from the foothills of the Great Dividing Range to Wallis Lake, near the twin towns of Forster and Tuncurry, as indicated on Figure 1. The total catchment area of the Wallamba River is 495km^2. River channel form has been characterised by DIPNR in their stressed rivers assessment report for the Karuah River/Great Lakes catchment.

- intermediate and open valley setting with continuous floodplain and stable channel: to
- a tidal or coastal influenced style with multiple anabranches or channels of various dimensions within the tidal zone, though with one main channel.

The channel form of the Wallamba River is typical of many New South Wales coastal rivers with steep headwaters gradually moving into an open valley with a stable channel and continuous floodplain. Further downstream, the valley widens but the channel form is maintained. In the lower reaches the channel is influenced by the tidal influences with multiple anabranches or channels of various dimensions within the tidal zone, though with one main channel dominant. Nabiac, Failford and Minimbah are located in the open valley area with a stable channel and continuous floodplain. The floodplain is continuous until the Wallamba River drains into Wallis Lake, a coastal lake system with tidal influence.

2.1.1 Vegetation

The Great Lakes Greening Strategy identified natural vegetation characteristics within the Nabiac village area (Daintry Gerrand and Associates, 2001). Tree species occurring on the floodplain include forest red gum (*Eucalyptus tereticornis*), swamp mahogany (*E. robusta*), flooded gum (*E. grandis*), small-fruited grey gum (*E. propinqua*) and forest oaks (*Allocasuarina littoralis* and *A. torulosa*).

Habitat significance was assigned to remnant vegetation forming the Wallamba River riparian corridor. Nabiac Landcare has undertaken regeneration and restoration work in the area adjacent to 'Bullocky Wharf'.

Flora investigations have also been undertaken as part of the Bundacree Creek to Possum Brush Pacific Highway Upgrade Environmental Impact Statement (Sinclair Knight Merz, 2001). Two high priority habitat areas were identified in the vicinity of Nabiac village. They are described as follows:

- South of Nabiac between Glen Ora Road and Minimbah Road – open forest community comprising grey ironbark (*E. siderophloia*), blackbutt (*E. pilularis*), small-fruited grey gum (*E. propinqua*), blue-leaved stringybark (*E. agglomerata*), pink bloodwood (*Corymbia intermedia*) and spotted gum (*C. maculata*);
- North of Nabiac – from south of Brushgrove Park Road to south of Pipe Clay Creek Road – open forest with blackbutt and tallowwood (*E. microcorys*) and swamp forest dominated by swamp oak (*Casuarina glauca*), willow bottlebrush (*Callistemon salignus*) and a variety of Melaleuca species (*Melaleuca nodosa*, *M. quinquenervia* and *M styphelioides*).

Two threatened plants, *Allocasuarina defungens* and *Asperula asthenes*, have been identified within a 10 kilometre radius of Nabiac.

These locations are likely to represent remnants of native floodplain vegetation in the area. However, as no physical works are proposed as part of this study, there will be no impact on these communities of the recorded threatened flora species as a result of floodplain risk management measures proposed.

2.1.2 Fauna

A number of threatened fauna species have been identified in the vicinity of Nabiac (Sinclair Knight Merz, 2001 and Ecotone Ecological Consultants, 2000). These include:

- Squirrel glider (*Petaurus norfolcensis*);
- Koala (*Phascolarctus cinerus*);
- Eastern mastiff bat (*Mormopterus norfolkensis*);
- Brush-tailed phascogale (*Phascogale tapoatafa*);
- Masked owl (*Tyto novahollandiae*);
- Large bent-wing bat (*Miniopterus schreibersii*);
- Little bent-wing bat (*Minopterus australis*);
- Southern myotis (*Myotis macropus*); and
- Australian bittern (*Botaurus poiciloptilus*).

However, as no physical works are proposed as part of this Floodplain Risk Management Study, there will be no impact on recorded threatened fauna species occurring within the vicinity.

2.2 ABORIGINAL HERITAGE

Great Lakes State of the Environment Report for 1998/99 notes that according to the National Parks and Wildlife Service Aboriginal sites register, Great Lakes is rich in Aboriginal cultural values. A diverse range of sites have been recorded shire wide, including:

- Open camp sites;
- Bora/ceremonial;
- Scarred trees;
- Middens;
- Stone arrangements;
- Carved trees;
- Burials;
- Rock engraving;
- Axe grinding grooves; and
- Natural mythological (ritual) sites.

No specific information is available in relation to Aboriginal cultural heritage items within Nabiac or Failford itself. However, if any floodplain risk management works were proposed which disturbed the natural ground surface or required any clearing of vegetation, an archaeological survey would need to be undertaken.

2.3 FLOODING OF THE BUILT ENVIRONMENT

The reasonable portion of the land zoned for urban development within the floodplain at Nabiac and Failford has been developed, whilst Minimbah has a lower scale of development. Figure 3 provides an indication of the approximate flood extents as defined by an extreme event and an indication of the inundation in a 1% AEP flood event in Nabiac. Figure 4 provides an indication of the houses likely to be inundated in various flood events in the Failford and Minimbah areas. Table 2.1 indicates the number of buildings affected above floor level in various flood events.

Table 2.1 Buildings affected above floor level in different AEI's and areas

Location	5% AEP	2% AEP	1% AEP	0.2% AEP	Extreme Flood Event
Residential					
Nabiac	0	0	7	38	116
Failford	2	5	6	17	59
Minimbah	2	3	5	9	16
Total Residential	4	8	18	64	191
Non Residential					
Nabiac	0	1	2	13	25
Failford	0	0	0	0	2
Minimbah	1	1	1	2	2
Total Non Residential	1	2	3	15	29
Total Residential and Non-Residential					
Nabiac	0	1	9	51	141
Failford	2	5	6	17	61
Minimbah	3	4	6	11	18
Total	5	10	21	79	220

The annual average damage (AAD) due to flooding with current development levels in the study area is in the order of $34,000, with further details on the flood study review and damages provided in Appendix B.

Any future development is assumed to be in accordance with Council's development control requirements, including its Flood Management Policy, which sets the minimum floor levels at a minimum of 0.5m above the 1% AEP flood level.

Therefore, whilst the impacts of the 1% AEP flood maybe limited, the impacts of an extreme event are significant and can result in significant depths of water over roads throughout the study area, making key roads impassable around the peak of an event throughout the study area. Several rural roads will also have significant depths in the 1% AEP flood including Glen Ora and Willow Point Roads.

2.3.1 European Heritage

Schedule 2 of the Great Lakes Local Environmental Plan (LEP) indicates Heritage items in the Council area. One site is located in Failford and five in Nabiac. The Failford site, a house on the corner of Failford Road and Bullocky Way, is of regional significance. In Nabiac there is one item of state significance (Hancocks Store 7-9 Nabiac Street), one of regional significance (Showground cnr Nabiac Street and Showground Lane), and 3 of local significance (the former Hospital and former ES&A Bank and Dwelling, both in Nabiac Street and the house at 77 Clarkson Avenue).

Hancocks Store is likely to be affected by flooding above floor level in an extreme event, whilst other sites are likely to be flood free. Any proposed floodplain mitigation works would have to consider the impacts on these sites, though impacts are unlikely.

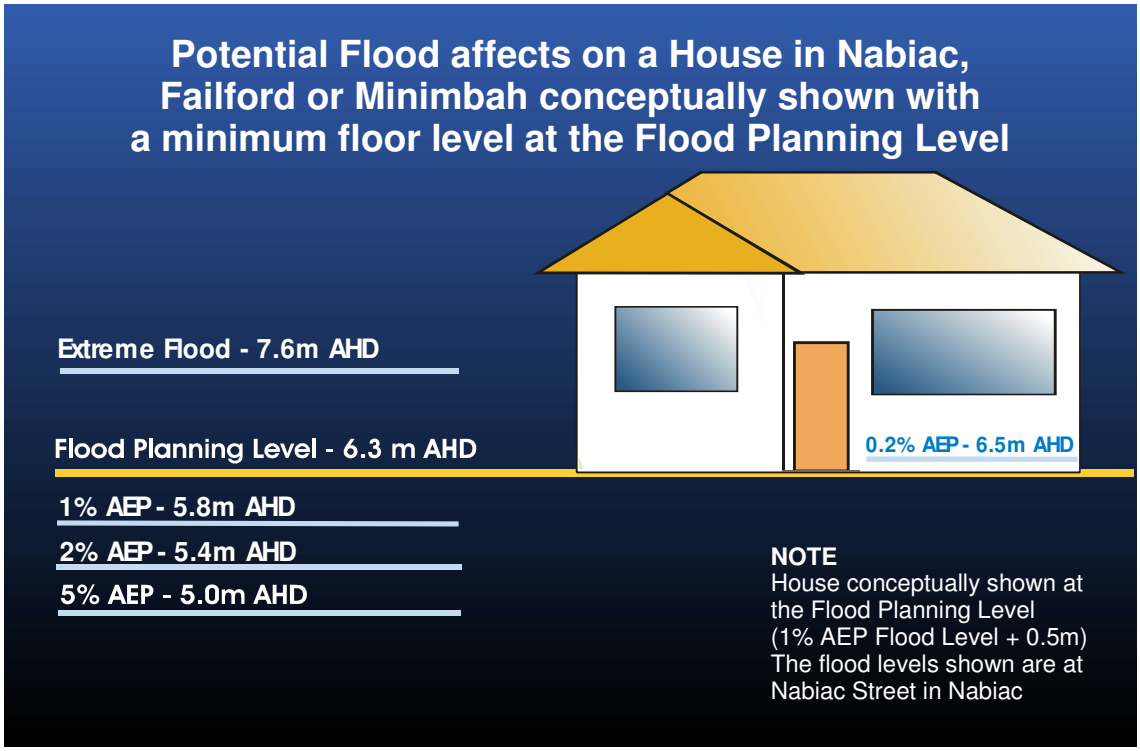
2.3.2 Planning Controls

Great Lakes Council has in place a number of planning instruments and policies that control development within the study area. These include the:

- Great Lakes Local Environmental Plan, gazetted December 1996, last amended June 2000;
- Subdivision Development Control Plan, adopted September 1999;
- Residential Development Control Plan for Urban Areas, adopted September 1999;
- Exempt and Complying Development Control Plan, adopted August 1999; and

- Flood Management Policy, adopted on 10 December 1985.

The relationship of planning measures to floodplain risk management is discussed in Section 3.



RELATIVE LEVEL OF FLOODS AT NABIAC, FAILFORD and MINIMBAH

Figure 3

2.3.3 Available Flood Free Land

Land in the Nabiac township area outside the indicative limits provided on Figure 4 are unlikely to be affected by flooding from the Wallamba River. However, some of this land may be affected by flooding from local tributaries due to local rainfall events, eg February 2002. A significant proportion of floodplain is not inundated by the 1% AEP event from the river. This event is the basis for development controls in the study area as outlined in Council's flood management policy.

Suitable sites for evacuation of people and their possessions during floods are discussed in Section 3.7 as part of discussion of flood response plans.

2.4 GREAT LAKES COUNCIL ENVIRONMENTAL PRIORITIES

Great Lakes Council's 1998/99 State of the Environment Report described progress made in relation to a series of high priority issues. High priority issues, first identified in 1994 are:

- determining the extent, flow, distribution, volume and quality of groundwater;
- lack of monitoring programs for a variety of surface and groundwater parameters;
- catchment management;
- mapping of stormwater outlets, drains and sewer overflows, including retention basins;
- mapping flood levels;
- vegetation loss;
- core habitat areas for biodiversity;
- protection and management of wildlife corridors;

- rates of vegetation loss;
- contaminated sites, solid waste management; and
- acid sulfate soils.

As part of consultation undertaken for the State of the Environment Supplementary report (Great Lakes Council 2001), Nabiac Landcare requested that Council prioritise cleaning out of Town Creek. The creek is currently overgrown and flow of water through the area is likely to be impeded due to the amount of debris in the creek. It is unclear whether the clean out was proposed because of drainage problems or to improve the general condition of the area. This report assists in determining flood levels in the Nabiac, Failford and Minimbah areas.

2.5 SOCIAL CHARACTER

Great Lakes Council area is made up of a number of distinctly separate communities, of which Nabiac is one. The population of Great Lakes grew at a rate of greater than 2% per annum from 25,997 in 1991 to 28,609 in 1996. During this period the population of Nabiac rose at 1% per annum from 509 to 536. The population in 2002 was estimated at 560.

Whilst the overall population of Nabiac was relatively static from 1991 to 1996, the age distribution of the population has changed. The population aged between 0 and 4 has decreased substantially, whilst the age groups between 5 and 29 (5-12, 13-19 and 20-29) remained relatively static, increasing only slightly. The population between 30-39 decreased, whilst the population aged between 40 and 49 substantially increased (over 30%). Older populations groups (50-59 and 60+) decreased. This data suggests that there has been movement in and out of Nabiac rather than a stable aging population subject to natural attrition. Although the overall increase in population was not great, it seems that new families are moving into the area, and this could support the need for release of further land for residential purposes within the village.

2.6 LAND USE AND PLANNING CONSIDERATIONS

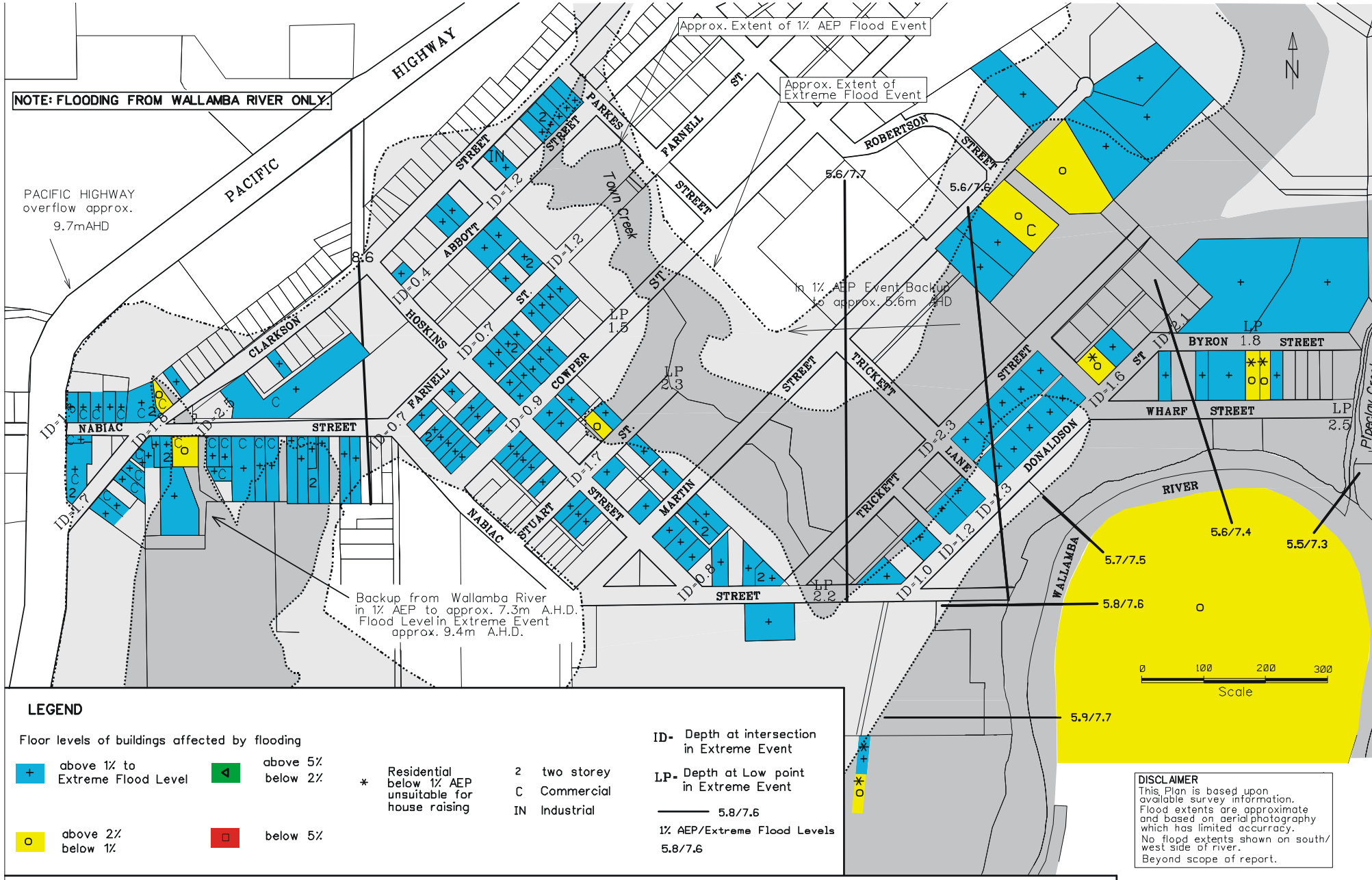
Great Lakes Council describes Nabiac as a village, and have indicated a preference for any further development to be concentrated within the existing urban area. A strategic planning investigation has identified that the most appropriate land uses for adjoining areas as the continuation of existing agricultural land uses (principally cattle grazing) with some rural residential subdivisions (Great Lakes Council, 2002).

Land use on the surrounding floodplain areas between Nabiac and Failford is predominantly vegetated land, with some areas of grazing, and small areas of intensive animal production. Rural residential subdivisions also occur on the floodplain with a rural residential rezoning approved on Minimbah Road, Nabiac approved in 1996/97 with development consent for a staged approval given in 2002.

Land use on the Wallamba River floodplain is controlled through the Great Lakes Local Environmental Plan (LEP) 1996, though some land is still under Manning LEP No.1. Zoning of these areas is mostly a 1(a) rural zone, with small sections of 1(d) small holdings zone and 1(d1) rural residential.

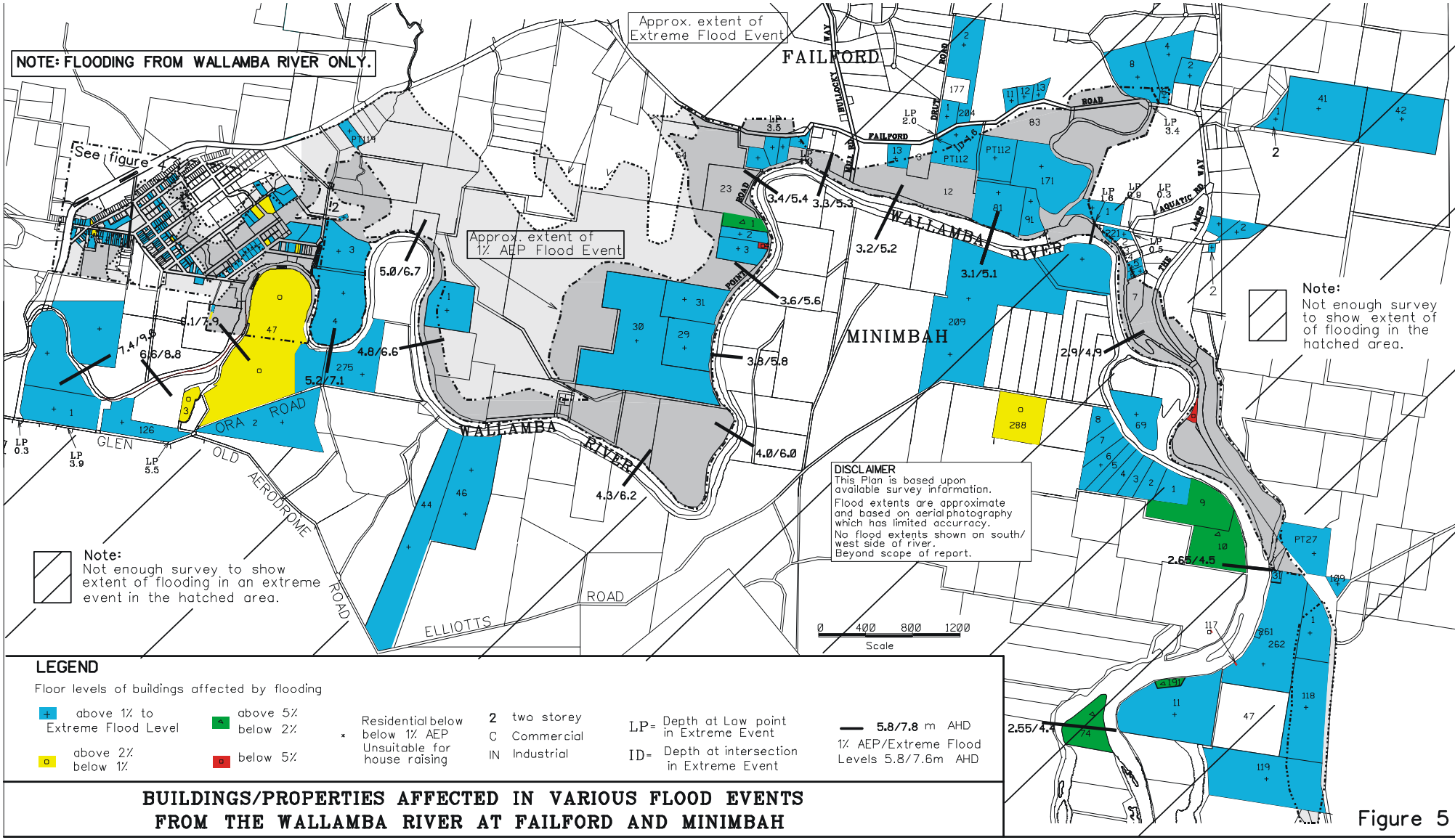
Great Lakes Council (2002) has estimated that there are 54 lots currently available within Nabiac for housing, equating to approximately 10 years supply based on current growth estimates. These lots are estimated to support an additional population of 130 people. Council predicts that Nabiac could support an additional 90 lots with a corresponding population increase of 215 people. Under this development scenario, the total population of Nabiac would be in the order of 905 people. At the current uptake rate for new lots, an additional 144 lots would be adequate for approximately 28 years of growth. The report identifies the potential development sites in Nabiac. The development of these sites needs to carefully consider the current flood situation. This is discussed in Section 4.7.

The development strategy for Nabiac is to consolidate the existing village area while maintaining its village character and dominance of the rural environment. As part of this strategy, the floodplain area should be protected and public access and links to the Wallamba River should be maintained (Great Lakes Council, 2002).



BUILDINGS/PROPERTIES AFFECTED IN VARIOUS FLOOD EVENTS FROM THE WALLAMBA RIVER AT NABIAC

Figure 4



BUILDINGS/PROPERTIES AFFECTED IN VARIOUS FLOOD EVENTS FROM THE WALLAMBA RIVER AT FAILFORD AND MINIMBAH

Figure 5

2.7 FLOOD BEHAVIOUR

2.7.1 Assessment of Flood Behaviour

Assessment of existing floodplain conditions was undertaken for the a range of flood events from the 5% AEP to an extreme event. The assessment was limited to flooding from the Wallamba River. The possible impact of flooding from local watercourses, such as Town Creek and Pipeclay Creek or urban drainage was not considered. Results of the flood analysis are discussed in detail in Appendix B and summarised below.

Figure 3 provides an indication of the relative levels of floods in the study area in relation to a house built at the Flood Planning Level, based upon Councils Local Flood Policy.

Nabiac

1% Flood Event

Floodwaters from the Wallamba River in the 1% AEP event may enter the Nabiac township area by the following mechanisms:

- Back up through a local creek which flows through the central business district of Nabiac, on the western side of the township. This creek enters the Wallamba River some 600m downstream of the Pacific Highway bridge.
- Overflow of the north bank of the Wallamba River at the eastern side of the township, together with back up through a local creek into low lying areas.

These two flooding mechanisms are shown in Figure 4. The western and eastern flood affected areas of Nabiac in the 1% AEP event are effectively separated by a ridge of relatively high ground extending north of the showground.

The back up of floodwaters into the western side of the township would be to an estimated level of 7.3m AHD in the 1% AEP flood. At this level, only three buildings in the vicinity of the Nabiac Street-Clarkson Street intersection would be inundated above floor level, as indicated in Figure 4.

The overflow of floodwaters at the eastern side of the township would reach a level of about 5.6m AHD in the 1% AEP event. Overflow would occur at the low point in Nabiac Street between Martin Street and Donaldson Street and downstream of the Donaldson Street-Wharf Street intersection and lead to above-floor inundation of three buildings near the river. The overflow would also affect low lying areas to the north and west, with above-floor inundation of two buildings in Martin Street and one building in Stuart Street.

The major flood flowpaths, known as floodways, would generally be confined to the river or the nearby low lying floodplain in the vicinity of Nabiac. Areas outside this area can be classified as flood fringe.

Flood hazards in the 1% AEP event in Nabiac is generally low. The land where inundation depths are sufficient to create high hazard conditions is currently open space. The hazard will generally be low in developed areas which will be affected by overflow and backup in the 1% AEP event.

Streets which will serve as evacuation routes in the 1% AEP event will generally experience limited or no inundation during the 1% AEP event. The greatest depths of inundation will occur near the east end of Wharf Street, where the depth will be about 1.0m, and on Nabiac Street east of Clarkson Street, where the depth will be about 0.5m. With the flood warning system in place and an appropriate flood emergency response plan, this area can be considered to remain low hazard.

Extreme Events

In events of greater than 0.2% AEP magnitude and up to the extreme flood event a significant flowpath develops through town which cuts off and potentially inundates a section of town, as indicated on Figure 4. Flooding in an extreme event would result in flow over Nabiac Street, between Clarkson and Farwell Streets flowing to the north east into Town and Pipeclay Creeks. This will result in significant inundation of existing development in Nabiac. Modelling indicates that this flowpath takes around 5% of the total flow from the system in an extreme event, but less in more frequent events. The removal of this flowpath would

have negligible impact upon flooding (around 0.1m maximum in an extreme event) and therefore it would not be classified as a floodway.

Modelling indicates that flow velocities in the high level flowpath through town in the PMF event would vary between 0.5 and 1.5m/s with depths in the order of 1 to 2m. Therefore this would be considered a high hazard area. However, with the recent instigation of a formal flood warning system and with the associated preparation of an appropriate emergency response plan, which includes flood awareness, this area could be considered low hazard, as people could be effectively evacuated prior to the hazardous situation occurring.

Local Flooding

Whilst local flooding is beyond the scope of this investigation, it should be recognised that flooding of local creeks in the Nabiac township area, including Town and Pipeclay Creek may occur due to local rainfall-runoff conditions, with or without coincident Wallamba River flooding.

This is evidenced in the localised flood event in February 2002 which resulted in above floor flooding due to tributaries to the Wallamba River, such as Town Creek, rather than from flooding from the Wallamba River itself. The influence of the Wallamba River was not significant as the flood levels in the river were lower than those in town and the peak of river flooding happened well after the peak flood levels in the township. This storm does, however, serve as a timely reminder that whilst well located, Nabiac does have flood problems that needs to be effectively managed. In addition, a more widespread storm would have resulted in more impacts from the much larger Wallamba River catchment.

This study concentrates on flooding from the Wallamba River and provides an essential basis for future assessment of flooding from local creeks. It does not, however, examine flooding from these local creeks, which will result in localised higher flood levels than the river in areas in the vicinity of these creeks. Council needs to consider the impacts of flooding from these tributaries in their land use planning and should therefore consider undertaking studies in these areas in the future.

Failford and Minimbah

The estimated 1% AEP flood levels in the Failford and Minimbah areas are shown in Figure 5. There will be overbank flow throughout this area, with inundation depths of up to around 2 metres. However most dwellings in this area are located on relatively high ground near Failford Road so they will not experience above-floor inundation in the 1% AEP flood.

The most flood liable properties are in the rural residential area off Willow Point Road, upstream of Failford, along with a property on Lakes Way, near Goswick Island and several properties in Manns Road.

Floodway in the vicinity of Failford may extend beyond the main river channel to low lying land near the banks of the Wallamba River. Most overbank areas can be considered flood storage areas.

Floodplain areas close to the river at Failford can be considered as high hazard areas due to flow depth, velocity and the potential for roads to be cut, and evacuation routes cut, at an early point in a flood event, such as Willow Point Road, which runs in the vicinity of the top of the river bank. Away from the river can be considered low hazard as evacuation to Failford Road can readily be achieved, an effective emergency management plan can be put in place, and flood depths and velocities are low relative to the vicinity of the river.

Some areas of Minimbah could also be considered high hazard, given the likely flow depths and velocities, however, insufficient information is available to determine the extents of flooding or hazards in this area. It is noted that the water depths over the Glen Ora Road, the main road into and out of this area, can be up to 3.3m in 1% AEP event, 2.5m in the 5% event and 5.5m in an extreme flood event, based upon available survey. This means that this road would be cut off early in a flood event and that Minimbah area would therefore need to be evacuated early in a flood event as it will be isolated and ultimately inundated. Without effective evacuation access and an effective emergency management plan the flood situation in the whole of Minimbah could be considered high hazard.

Properties in the Failford area may also be impacted upon be flooding from tributaries to the Wallamba River, including Bungwahl and Darawank Creeks which may result in higher flood levels than from the main river in some areas. However, flooding on these tributaries is outside the scope of this investigation.

3. EXISTING FLOODPLAIN RISK MANAGEMENT

Floodplain risk management in the study area involves a number of different measures aimed at addressing existing, continuing and future flood risk. These measures involve development control, using planning instruments and policies as indicated in Section 2.3.2, and emergency response planning as identified in the Local Flood Plan for Great Lakes Council.

The role of the individual documents in floodplain risk management are discussed separately below.

3.1 GREAT LAKES LOCAL ENVIRONMENTAL PLAN 1996

The Local Environmental Plan (LEP), last amended in June 2000, indicates that the urban areas of Nabiac and Failford allow construction of dwellings as compatible with this zoning. Areas within the floodplain outside the village are zoned as Zone 1(a) Rural with agricultural activities compatible with this zoning.

In relation to flooding, several provisions of the LEP are relevant. Clause 11 – Land Form Modification has the objective to control soil erosion, sedimentation and drainage impacts associated with land form modification. This clause indicates that filling or excavation is generally only permissible with the consent of Council. Consent may not be necessary, where in the opinion of Council the filling or excavation will not significantly affect the natural and existing built environments.

Clause 18 allows for the construction of 2 attached dwellings on a rural property with Clause 19 indicating that the minimum area of land upon which a dwelling can be built in a rural 1(a) zoning is 40 hectares unless a smaller parcel of land comprises the whole of the allotment.

Clause 25 – Waterways includes information on flood liable land. Flood liable land is not separately identified on an LEP map. This clause indicates that development on flood liable land requires Council consent and regard for Council's Flood Management Policy. Council may refuse development on flood liable land that, in Council's opinion, could significantly affect flood behaviour, increase flood hazard or damage, cause riverbank erosion, increase risk to human life, restrict the capacity of the floodway, or impose increased demand on agencies concerned with evacuation procedures.

Schedule 1 of the LEP indicates development not requiring consent. Section 11 enables Council or the Department of Infrastructure, Planning and Natural Resources (formerly Department of Land and Water Conservation) to undertake flood mitigation works other than the erection or substantial modification of buildings and the formation or alteration of any access road without requiring development consent.

3.2 SUBDIVISION DEVELOPMENT CONTROL PLAN, SEPTEMBER 1999

This DCP contains provisions for subdivision planning. Section 1.3.5 indicates the need for a Statement of Environmental Effects to demonstrate consideration has been given to the environmental impact of the development and sets out measures taken to mitigate any likely adverse environmental impact. This statement would need to address the potential impact of development on flood levels. Therefore flooding is one of a number of issues that requires consideration when determining the suitability of a site for subdivision.

Section 2 deals with general requirements for subdivisions in all zones. Section 2.3, identifies the need to address site hazards at the development application stage. If flooding is identified as a site hazard, subdivision design should minimise the risk of inundation to urban development. Section 2.3.2, Controls and Design Principles, provides requirements for flooding which include:

- the extent of development and minimum floor levels are to be in accordance with the recommendation of Council's most recent flood risk assessment;
- subdivision layouts are to be based on a strategy for surface water drainage which minimises the incidence of nuisance flooding.

Section 2.7.2 Drainage Controls and Design Principles also indicates consideration needs to be given to the likely effects of flooding in determining an application. This appears to mean that local overland flooding (or drainage) needs consideration.

3.3 RESIDENTIAL DEVELOPMENT CONTROL PLAN FOR URBAN AREAS, SEPTEMBER 1999

This DCP does not contain specific provisions relating to flooding. It does however contain provisions that enable solid front fences or walls to be built to at least 1.2m height, and up to 1.8m height in certain circumstances. This may have implications for the free flow of water in flood liable areas.

Council's Local Approvals Policy of May 1996 states that fences (other than for swimming pools) are to be constructed so that they do not prevent the natural flow of stormwater drainage. This would be a suitable provision to extend to fences in flood liable areas.

3.4 EXEMPT & COMPLYING DEVELOPMENT CONTROL PLAN, AUGUST 1999

This DCP identifies types of and specifies the requirements for developments to be considered exempt and complying and outlines the procedures for obtaining certification of exempt development.

3.4.1 Exempt Development

Exempt development is very minor development which does not require Council approval provided it meets the requirements set out in this DCP.

Most categories of exempt development are unlikely to have an impact on the flooding in Nabiac, Failford and Minimbah. In rural areas Machinery/Hay Sheds and stables are allowable in rural land. However the requirement for these to be located a minimum of 40m from the top of bank of a stream, creek or watercourse would mean, in the context of flooding at Nabiac, Failford and Minimbah, that they may be outside floodway areas and therefore are generally likely to have little impact on flood levels.

River and foreshore improvement works are permitted as long as their purpose is to repair damage caused by natural or human processes or activities to the river. These are exempt where a river care plan has been prepared on behalf of the local authority and a management plan for the public land has been prepared by or on behalf of the Public Authority managing the land. In addition, the approval of the NSW Fisheries and Department of Infrastructure, Planning and Natural Resources may also be required.

This would be applicable for any environmental improvements or enhancements being considered in the vicinity of the Wallamba River as part of this study.

3.4.2 Complying Development

Complying development is small scale low impact development which may be certified by an accredited private certifier or by Council if it meets the non-discretionary requirements set out in this DCP.

Development of land below the 1% AEP flood level is not considered to be complying development. Any filling of land below the 1% AEP level would require separate council consent. Therefore complying development is not applicable to flood liable land.

3.5 FLOOD MANAGEMENT POLICY

Council's Flood Management Policy was adopted on 10 December 1985, before the New South Wales Government's 1986 Floodplain Development Manual. Council's policy aims at providing the community with the basis of Council's assessment of development on flood liable land, recognises the existing development and resources in flood liable areas and their value to the community, and encourages flood compatible development of flood liable land.

The policy provides a list of definitions which need some revision to avoid confusion with the new Exempt and Complying Development DCP and to reflect current terminology in the floodplain risk management field. In this regard proposed development terminology needs to be revised to reduce confusion.

The policy does not require different floor height requirements for different land use categories but provides Council with the flexibility to allow for altered conditions in building extensions. The policy indicates that rezoning of flood liable land to uses incompatible with the flood situation will not be approved by Council.

Council considers the hazard, hydraulic, land use and development categories when assessing developments. The hazard categorisation methodology recommended in the policy is preliminary only and should be over ridden by assessments made in floodplain risk management studies for specific areas. Hazard categories for Nabiac and Failford are discussed in Section 2.6.

Tables 1 to 6 of the Council's Policy relate to the 1986 Floodplain Development Manual. This manual was replaced in March 2001 by the Floodplain Management Manual (2001). The revised manual limits the recommended use of these diagrams and provides additional special classifications for developments such as caravan and mobile home parks. The use of the tables should be limited to areas where studies are yet to be undertaken and care should be taken in their use. These issues should be considered in revision of the policy.

The 1% AEP flood levels for planning purposes in the Nabiac, Failford and Minimbah areas were reviewed as part of this management study.

One particular inconsistency in the flood policy relates to land filled to or less than 0.2m above the 1% AEP flood level. If a property was 0.1m below the 1% AEP flood level the required minimum floor level would be 0.5m above the 1% AEP flood level. However, if the property was at or above the 1% AEP flood level, a minimum floor level of only 0.3m above the ground level would apply. This situation means that freeboard above the 1% AEP flood level to account for wave action, local hydraulic effects and other factors is not being consistently applied.

3.6 FLOOD PLANNING LEVEL

Great Lakes has adopted the 1% AEP flood as the planning level flood for the Nabiac, Failford and Minimbah areas. Thus the area of land below the flood planning level (1% AEP plus adopted freeboard) is subject to flood related development controls. Review of this standard is discussed in Section 4.3.

3.7 FLOOD RESPONSE PLANNING

Flood response planning has been addressed by the Local Emergency Management Committee in a sub-plan of the Great Lakes Local Disaster Plan called the Great Lakes Local Flood Plan (draft September 1995).

The State Emergency Service (SES) has prepared a Local Flood Plan for the Great Lakes Council area. The plan covers preparedness measures, the conduct of response operations and the co-ordination of immediate recovery measures for flooding within the Council area, including Nabiac, Failford and Minimbah.

The plan includes a guide to the content of evacuation warning messages and identifies Nabiac Showground, Nabiac Street Nabiac as the site to be used as the evacuation centre. This site is located on flood free land on the east side of the Pacific Highway and is in close proximity to the inundated areas. The area, would however, be cut off during a flood event in excess of 0.2% AEP. Therefore arrangements need to be made for helicopter landing for medical emergencies and any logistics supplies to be bought to site. Even though the site is isolated the relative length of the flood should mean that the locality can be a viable evacuation centre. An alternative suggested by the SES is to evacuate to Taree, this would need to be undertaken relatively early in the event due to the potential for the Pacific Highway to be cut off.

No evacuation centre is identified for the Failford area. This needs to be developed. Evacuation centres should be identified for these areas. It may be logical to evacuate the eastern end of Failford to Forster and the western end to Nabiac, however, this needs to consider the relative levels of the bridges on the Failford

Road and evacuation may need to be undertaken early in an event as Failford is cut off. Failford Road is cut west of Bullocky Way and at Bungwahl Creek and the Lakes Way is cut for a large distance south of the Failford Road intersection. It may also be logical to consider a centre in the Failford township or alternatively evacuation up to Taree via the Bullocky Way. Bullocky Way has several low points which may be affected by local drainage, however, this access to the highway is generally high and would appear viable. The SES would need to consider this further to ensure that residents trapped between the Failford Road bridge and triple culverts could be effectively managed as these structures would be overtopped relatively early in a flood event.

Minimbah may be cut off from flooding from The Wallamba River in a number of places. Sections of Glen Ora Road and Elliots Road would be overtopped by significant depths of floodwater. In addition this area would be cut off from Nabiac when the Pacific Highway cuts. Therefore evacuation from Minimbah would need to be early in a flood event due to inundation of the access roads and could be either to the north to Nabiac or Taree, dependant upon flooding of the Pacific Highway or to the south to Wang Wauk or Coolongolook. The local flood plan does not currently, but needs to specifically address this issue.

Examination of evacuation from some areas of Failford and Minimbah as part of the local flood plan may highlight the need for upgrading works for access from Minimbah and Willow Point Road. If works are highlighted as necessary they should be considered for inclusion in the floodplain risk management plan.

3.8 FLOOD WARNING

The Bureau of Meteorology does not issue flood warnings for watercourses within the Great Lakes Council area. However, Great Lakes Council has put in place an ALERT flood warning system for Wallis Lakes which includes a water level gauge on the Wallamba River at Nabiac and another 6kms upstream of Nabiac. This system has been designed to provide council and the State Emergency Service (SES) warning of potential flood events in locations, including Nabiac.

This allows the SES personnel to monitor flooding developments on the Wallamba River in accordance with the Local Flood Plan. Wallamba River levels are gauge monitoring results are provided along with advice on actual and anticipated flood severity to the Lower Hunter SES Division Headquarters for broadcast over local radio stations in SES Flood Bulletins.

4. OPTIONS TO IMPROVE FLOODPLAIN RISK MANAGEMENT

This section considers options for changes to floodplain risk management practices in Nabiac and Failford to address existing, continuing and future flood risk.

4.1 OBJECTIVES

The objectives of floodplain risk management are aimed at:

- managing the danger to personal safety caused by flooding; and
- managing the damage to property resulting from flooding.

The management of these risks are necessary in both existing and future development areas.

In existing development areas, existing flood risk (the risk faced by existing development in the floodplain that can be managed by mitigation measures) and continuing flood risk (the risk remaining after adopted floodplain risk management options have been implemented) both need to be addressed.

In future development areas, future flood risk (the risk that would be faced by future development in the floodplain that can be managed by development controls) and continuing flood risk (the risk remaining after adopted floodplain risk management options have been implemented) need to be addressed.

Floodplain risk management options are available that can be used to manage these risks. These options can be broken down into the following three categories, namely property modification measures, response modification measures and flood modification measures. Options available under these categories provided in Table 4.1

Table 4.1 Typical Floodplain Risk Management Measures

Property Modification Measures	Response Modification Measures	Flood Modification Measures
Zoning and development control	Community awareness	Flood control dams & retarding basins
House raising	Community readiness	Levees and associated flood gates
Flood proofing of buildings	Flood prediction and warning	Bypass floodways
Voluntary purchase	Local flood plans	Channel improvements

Property modification measures aim at either altering existing development or in placing controls on future development to minimise the potential danger to personal safety and the degree of damage due to flooding. Therefore property modification measures would generally be used to deal with existing or future flood risk.

Response modification measures deal with making the community flood aware, developing an appropriate community response to flood events, and having local response agencies develop plans for dealing with a flood event. Response modification measures are generally used to deal with the continuing flood risk.

Flood modification measures, as the name implies, aim at modifying the flood through the use of structural works. These measures are generally aimed at dealing with existing flood risk, though may also consider future flood risk. However, Commonwealth and State government funding would only be available for these works where they are designed to deal with existing flood risk.

4.2 BASIS FOR ASSESSMENT OF ALTERED FLOODPLAIN RISK MANAGEMENT MEASURES

Assessment of management options is undertaken in relation to their effectiveness in meeting the objectives identified in Section 4.1 and to a number of additional relevant criteria indicated below:

- environmental impact in relation to the affects of any proposed works;
- opportunities for environmental enhancement;
- affect on the community and the associated community support and acceptance;
- economic efficiency; and

- ability and capacity to implement measures.

4.3 REVIEW OF THE FLOOD PLANNING LEVEL

As indicated in Section 3.6, the 1% AEP flood event forms the basis of existing development control at both Nabiac and Failford. In reviewing the flood planning level the following have been considered:

- The major flowpath for Nabiac is around the township in events up to the 1% AEP flood event. However, a major flowpath develops through town in events above a 0.2% AEP flood with flow through the township increasing as the magnitude of flooding increases.
- The ground level at the fringes of the floodplain increases steadily limiting any additional area of inundation. Therefore variation of the flood standard (eg raise to the 0.5% AEP flood or lower to the 2% AEP flood) would not have a major effect on the area of land subject to flood related controls.
- Given the limited impact of flooding of Nabiac from the Wallamba River, selection of the 0.5% or 2% AEP flood level instead of the 1% flood level would not have a major impact upon the area of land subject to flood related controls.
- There is land below the 1% AEP flood level that is available for development:
  - Development of the available land, considering controls related to the 1% AEP flood level will not significantly increase flood risk.
  - Developing this land to a reduced flood standard will be inconsistent with previous development control decisions. In addition it will increase the level of flood risk in Nabiac relative adopting the current development controls.
  - Developing with a higher flood standard will have only a minimal effect on flood damage potential and is unlikely to significantly alter levels of danger to personal safety.
- The flood behaviour in the extreme event does result in altered behaviour to that of the 1% AEP Flood in the area of Nabiac, due to the development of a flowpath through Nabiac, as shown on Figure 4, this flowpath starts to operate in events greater than a 0.2% flood event. This flowpath cuts off the eastern end of Nabiac, which would be ultimately inundated in an extreme event, with flood levels around 1.8m higher. Whilst this is an issue for consideration in assessing the Flood Planning Level, an appropriate warning system and associated emergency response plan is considered an appropriate method of managing the risk from these very rare events.
- The flood warning system for Nabiac is included in the overall system recently installed for the Wallis Lake catchment. This will provide assistance to the study area. However, a specific flood emergency response plan for Nabiac, Failford and Minimbah is needed in conjunction with flood warning to limit the hazard to existing and future development in floods greater than the 1% AEP flood.

In considering this information, there appears to be no valid reason to alter the current development control practice, as long as development is compatible with the level of flood risk and that self evacuation is practical and achievable in an extreme flood given the likely warning regime. Therefore it is recommended that development control remain linked to the 1% AEP flood event, but with consideration of evacuation in larger events, as appropriate.

One particular inconsistency in the flood policy, identified in Section 3.5 of this report, relates to land filled to or less than 0.2m above the 1% AEP flood level. If a property was 0.1m below the 1% AEP flood level the required minimum floor level would be 0.5m above the 1% AEP flood level. However, if the property was at or above the 1% AEP flood level only a minimum floor level of 0.3m above the ground would apply. This situation means that freeboard above the 1% AEP flood level to account for wave action, local hydraulic effects and other factors is not being consistently applied.

It is recommended that a flood planning level (FPL), of 0.5m above the 1% AEP flood, be adopted for development control. All land below this FPL would have a minimum floor level set at the FPL, overcoming this inconsistency.

This has impacts upon Council's Flood Management Policy. Review of the policy is discussed below.

4.4 REVIEW OF THE FLOOD MANAGEMENT POLICY

Council's Flood Management Policy, adopted in December 1985, is discussed in Section 3.5. This policy aims at providing the community with the basis of Council's assessment of development on flood liable land, recognises the existing development and resources in flood liable areas and their value to the community, and encourages flood compatible development of flood liable land.

The policy requires revision to address the following issues:

- A number of definitional changes to be consistent with the Floodplain Management Manual, 2001.
- Revision of definitions to avoid confusion with the new Exempt and Complying Development DCP and to reflect current terminology in the floodplain risk management field.
- Council considers the hazard, hydraulic, land use and development categories when assessing developments. The hazard categorisation methodology recommended in the policy is preliminary only and should be over ridden by assessments in floodplain risk management studies for specific areas.
- Tables 1 to 6 of the Policy are similar to those in the 1986 Floodplain Development Manual. This manual has been replaced with the Floodplain Management Manual (2001) which have revised tables that are to only be used in limited situations. In addition, special classifications for developments such as caravan and mobile home parks are included. Therefore the policy should limit the use of tables to areas where studies are yet to be undertaken and care should be taken in their use.
- The adoption of the 1% AEP plus 0.5m adopted freeboard as the Flood Planning Level for minimum floor levels for habitable development removes inconsistency in freeboard application. This criteria applies to all properties totally or partially below the FPL, ie, in the flood planning area.
- The basis for flood levels for development control in the study area should be the flood study review carried out as part of this management study and documented in Appendix B of this report.
- Appendix A of the Policy relates to the NSW Government's Flood Prone Land Policy. This should be deleted as much of the background information is not relevant some 16 years after adopted of the policy and can refer to the Floodplain Management Manual: The Management of Flood Liable Land (2001).
- The Policy also needs updating to make it consistent with the Floodplain Management Manual including the need to address issues such as major drainage, and flood awareness and education.
- The Policy should be been renamed the Flood Risk Management Policy to be consistent with the Floodplain Management Manual.

4.5 CHANGES TO DEVELOPMENT CONTROLS

There are currently a range of planning and development provisions in place for flood liable land within the Great Lakes local government area (LGA). These provisions are contained in various documents (Policy, Local Environmental Plan, etc.).

There appears to be a case for centralising flood provisions in one document; eg a flood specific Development Control Plan, to cover all developed areas of the LGA, including Nabiac, Failford and Minimbah. This would facilitate Council's administration of floodplain risk management controls, as well as the community's understanding. In the interim the revision of Council's Flood Management Policy, as discussed above, would improve the consistent control of development in Council's floodplains.

The LEP provisions are considered adequate in respect of flooding when used in conjunction with the relevant Development Control Plans (DCPs) and Flood Management Policy.

4.6 CHANGES TO FLOOD RESPONSE PLANNING

A detailed evacuation plan should be prepared to establish evacuation procedures for Nabiac, Failford and Minimbah, including identification of preferred evacuation routes based on the flood hazard and the difficulties in access due to flood depths. Figures 4 and 5 provide information on flood depths at specific

road locations in the extreme flood event. The extreme flood level is generally around 2.1 to 2.2m above the 1% AEP flood level. Key low points which will be subject to early flooding are indicated in Table 4.2.

Table 4.2 Key Low Points and Associated Issues

Location	Related Access Issues	Depth of Flooding (m)				
		Extreme Event	0.2% Event	1% Event	2% Flood	5% flood
Wharf Road at Nabiac	Local Only	2.5	1.4	0.7	0.3	0
Nabiac St in the low point near Clarkson St at Nabiac.	Affects access from eastern Nabiac & from highway to showground. Lower depth alternative available via Clarkson, Hoskins & Farnell Sts	2.5	1.1	0.4	0	0
Nabiac St in the low point between Trickett & Donaldson St.	Affects access from eastern Nabiac to highway & showground. No lower depth alternative available.	2.2	1.1	0.1	0	0
Willow Point Rd in Failford at the culvert	Affects access from Willow Point Rd area to Failford Road & Bullocky Way. No lower depth alternative available.	4.3	2.6	2.3	2.0	1.7
Failford Road at the bridge over Bungwahl Creek	Main access Failford Rd to The Lakes Way.	3.4	1.7	1.4	1.2	0.9
Failford Road at the 3 culverts west of Bullocky Way	Cuts Failford Road from Bullocky Way from West	3.5	1.9	1.5	1.3	1.0
Glen Ora Road 2nd low point from Highway	Access to Minimbah. No lower depth alternative available.	3.9	2.7	1.9	1.4	0.9
Glen Ora Road 3rd low point from Highway,	Access to Minimbah. No lower depth alternative available.	5.5	4.3	3.5	3.0	2.5

It is suggested that Council liaise with the SES in order to advance the development of a detailed local flood evacuation plan. The plan should recognise that floods greater than the 1% AEP event may occur. Some specific issues that should be addressed include:

- Annex A identifies the flood threat. A higher level of detail could be provided for the Wallamba River at Nabiac, Failford and Minimbah similar to the information on Wallis Lakes.
- Annex B indicates specific risk areas. Some additional information could be included for Nabiac, Failford and Minimbah relating to typical warning times, likely depths of water in some areas, evacuation routes and early road closures. In addition, the provision of depth indicators may improve safety in low points. In addition, emergency management planning for key areas cut off need to be carefully considered. Some key low points are identified in Table 4.2. Evacuation planning may highlight the need to consider upgrade of some of these low points.
- Annex D provides a guide to the content of evacuation warning messages. Map 1 indicates that the Nabiac SES Unit is designated as operating in Nabiac, Failford and Minimbah. It would be useful if maps of townships indicating critical areas such as evacuation routes and centres were included.
- The current procedures are informal and rely on empirical information and the decisions of individuals based upon general Bureau of Meteorology warnings. These warnings give no prediction of timing or specific severity to enable plans to be enacted. As apart of the development of the warning system for Wallis Lake more detailed procedures for information dissemination would be required including the timing of this, including expected river level triggers. The procedures would need to consider the differences in an extreme event resulting in faster rise of water, less evacuation time, longer flood duration.

4.7 SPECIFIC DEVELOPMENT AREAS IDENTIFIED BY COUNCIL

Great Lakes Council (2002) identifies 2 potential residential development areas in Nabiac which are shown in Council's report.

The smaller of the sites north of the Cowper and Parkes Street intersection is outside the approximate limits of extreme flooding from the Wallamba River and therefore no specific development controls relating to this

study apply. However, consideration should be given to any potential flooding from the local creek, named Town Creek.

The larger of the sites is between Cowper and Trickett Streets. This site is impacted upon by flooding from the Wallamba River in events of less than the 1% AEP event and will in part be a major overland flowpath in an extreme event. In addition, the site would be subject to flooding from Town Creek which may result in higher flood levels than from the Wallamba River.

Flooding from the Wallamba River in the 1% AEP event would be due to backwater flooding with the maximum depth at a surveyed point being 0.7m near the northern end of Martin Street. The flow velocity would be low and therefore the provisional hydraulic hazard in the area would be low.

However, in events of around 0.2% AEP, flows will develop through this area as floodwaters from the Wallamba River flow into Town Creek (within Nabiac) and back into the river to the south east of town. This flowpath will result in depths of up to a maximum of 2.3m deep in the surveyed point at the end of Martins Road in an extreme event.

Therefore the development of the site needs to consider the potential impacts of an extreme event and flowpaths need to be provided through the site to convey the flow to Town Creek. Localised filling to the 1% AEP flood level is unlikely to impact upon extreme flood levels from the Wallamba River. Filling above this level is likely to have an impact upon flood levels and flow distribution in the Wallamba River.

However, the impact of filling on flood levels from Town Creek would need to be investigated as this may impact upon upstream development. In addition riverine corridor and environmental issues need to be considered, which would limit the development in the vicinity of the banks of Town Creek.

It should be noted that Nabiac Landcare raised the issue of clearing of the banks of Town Creek in the State of the Environment Report (Section 2.4). This issue is understood to have generated from flooding issues on Town Creek following the February 2002 storm.

4.8 PRELIMINARY OPTION ASSESSMENT

Preliminary assessment of the floodplain risk management options indicated in Table 4.1 was used to narrow the options to be considered in more detail by examining their appropriateness and effectiveness. Preliminary assessment of options is discussed under the categories of property, response and flood modification measures.

4.8.1 Property Modification Measures

Potential property modification measures are indicated in Table 4.1. Their appropriateness for use in Nabiac, Failford and Minimbah, and therefore the need for detailed assessment is discussed below. In general, property modification measures have little adverse impact on the environment but offer little opportunity for environmental enhancement. However they do have implications in terms of economics and social issues and must be considered accordingly.

Zoning and development control can be used to control future flood risk to minimise the increase in potential flood damages and any additional danger to personal safety occurring due to increased development of the floodplain. These controls are already in place and are considered an appropriate management measure. These controls were examined in Section 4.4, which recommends consolidation of measures into a single Development Control Plan.

Voluntary house raising is a management option used to reduce existing flood damages. It does, however, have little impact upon the danger to personal safety resulting from flooding. There are a number of existing dwellings affected by flooding above floor level in a 1% AEP flood event which are suitable for raising. This option is considered in detail in Section 4.9.

Flood proofing of buildings usually relates to modifications to existing buildings or the use of particular construction materials in new buildings to reduce the structural damage that is likely to occur during a flood. Flood proofing of buildings does not address damage to contents or danger to personal safety resulting from flooding. Flood proofing is not as effective as house raising and therefore is not considered separately. It is however considered an appropriate development control for properties in the Wallamba River Floodplain and is incorporated into Councils flood management policy, discussed in Section 3.5.

Voluntary purchase is generally appropriate in high hazard floodway areas and may be appropriate in high hazard flood storage areas where houses cannot be raised due to their construction. It removes both the potential for flood damage and the danger to personal safety, by removing the people at risk and removing the need for others to rescue or assist in moving them. Voluntary purchase does, however, effectively limit land use to more flood compatible uses and should only be used where this is appropriate.

In general, the level of hazard of flood prone properties at Nabiac and Failford is not sufficiently high to warrant implementation of a voluntary purchase scheme. If a high degree of flood awareness is maintained and an appropriate flood warning system is implemented, evacuation of properties could be achieved during the early stages of a major flood without undue risk. It is therefore considered acceptable to continue the existing uses of all properties on the floodplain. However, where flooding is relatively deep and the house cannot be raised, voluntary purchase followed by demolition of the house and resale of the property with appropriate development conditions could be considered. This should therefore be considered in conjunction with voluntary house raising in Section 4.9.

4.8.2 Response Modification Measures

Potential response modification measures are indicated in Table 4.1. Their appropriateness for use in Nabiac, Failford and Minimbah and therefore the need for detailed assessment is discussed below. In general, response modification measures have little adverse impact on the environment, offer little opportunity for environmental enhancement and have little impact upon the social fabric of the community. However, they also have little impact on flood damages and therefore need to be considered in economic terms.

Community flood awareness involves the understanding that a flood problem exists and an understanding of what the community, as individuals, need to do in a flood event. This is desirable to reduce the danger to personal safety resulting from flooding. This will be assessed in conjunction with community flood readiness, discussed below.

Community flood readiness is understanding and being ready to react appropriately in a flood event when informed by the local emergency agency. This helps in reducing danger to personal safety resulting from flooding and may lead to reduced flood damages, where sufficient flood warning time is available to allow for the lifting or removal of house contents.

Flood prediction and warning from the existing flood warning system can be a valid floodplain risk management measure where the community is flood ready and the local emergency management committee has put in place appropriate plans to manage the communities response to a flood event. This option is considered in detail in Section 4.9.

Local flood plans are the plan developed by the local emergency management committee of how to respond to (and planning for recovery from) a flood event. They look at dissemination of warnings to the community and the roles and responsibilities of the different local authorities involved. These plans would include evacuation arrangements, where appropriate. The community is informed about these plans and any associated evacuation procedures as part of community awareness and readiness campaigns. The local flood plan prepared by the Local Emergency Management Committee for Great Lakes Shire, has been reviewed and is discussed in Section 3.7. The local flood plain forms part of the community flood readiness option being discussed in Section 4.9, as they are integrally linked.

Examination of flood access, shown in Table 4.2 along with emergency response planning may highlight a need to upgrade some key low points. This may result in some additional works that may need to be added to the plan.

4.8.3 Flood Modification Measures

Typical flood modification measures are listed in Table 4.1. Their appropriateness for use in Nabiac, Failford and Minimbah and therefore the need for detailed assessment is discussed below. Flood modification measures are likely to have adverse impacts upon the environment but may offer an opportunity for environmental enhancement. The options often have significant costs but can have significant benefits and therefore need to be considered in economic terms.

Flood control dams are, from experience, generally not cost effective for flood damage reduction in cases comparable to Nabiac. This is because expensive embankment construction and a substantial storage area are required in order to effect a significant reduction in downstream peak 1% AEP discharges. Preliminary assessment of the Wallamba River catchment indicates that this situation would also apply to the study area. A flood control dam is likely to have a significant environmental impact, effect upon a reasonably large area of land, both for the dam wall and due to temporary upstream storage (during an event), and is likely to significantly increase upstream flood levels. Therefore a flood control dam is unlikely to be environmentally or economically viable and as such is not considered in detail.

Levees could be constructed to protect existing properties with low floor levels from inundation by floodwaters from the Wallamba River. The extent of flooding from the Wallamba River in the 1% AEP event is not significant and the spread of development along the river means that the economic benefits of a levee would be low and is likely to be well below 0.1. A levee is also likely to impact upon the environment, have impacts on flooding from the local catchment and to impact upon extreme flood levels. These factors mean that the levee is not considered a viable flood modification measure.

In addition there is little scope for cost effective reduction of 1% AEP flood levels by means of hydraulic modifications involving construction of additional flow paths such as by-pass floodways or improving the river capacity. Both have significant environmental impacts and are not considered viable alternatives.

4.9 DETAILED OPTION ASSESSMENT

Following completion of the preliminary option assessment a list of options for detailed assessment was derived. This list includes:

- Property modification measures including zoning and development control, and a combined examination of house raising, flood proofing and voluntary purchase; and
- Response modification measures including community flood readiness, flood prediction and warning (combining local flood plans and community readiness).

There are no viable flood modification measures.

These measures are discussed individually below in relation to the criteria outlined in Section 4.2.

The State and Commonwealth Government provide funding for undertaking some floodplain risk management measures as discussed in Section 6.

4.9.1 Property Modification Measures

Zoning and Development Control

Planning and development controls are important floodplain risk management measures in areas with ongoing development or re-development. Council indicates that development pressures in Nabiac are not high and Council has not identified any broad-scale land filling options.

Provisions relating to flooding are currently contained within a number of plans, policies and related documents of Council. Flood related planning and development controls should be centralised in one document, ie a Development Control Plan (DCP). The provisions of this DCP could cover all developed areas in the LGA including Forster, Tuncurry, Bulahdelah, Tea Gardens, and Hawks Nest, as well as Nabiac, Failford and Minimbah.

Preparation of a flood-specific DCP would also provide an opportunity to update and add controls; eg specifying appropriate minimum floor levels according to land use, including design provisions to address privacy and drainage implications of filling to the flood level, appropriate fence construction methods, and emergency evacuation procedures. These issues have been considered in the revised flood management policy discussed in Section 5.4. This revised policy could be used to provide input into a DCP.

Voluntary House Raising and Voluntary Purchase

Voluntary house raising may be a practical measure to reduce the potential for flood damage to existing houses and their contents. It does not, however, address danger to personal safety. Council has identified 6 houses of timber or fibro-cement construction in the study area which would be inundated above their floor levels by the 1% AEP flood and which could be suitable for house raising. The voluntary raising of these houses would have a negligible effect on flood behaviour or on the community.

The estimated cost of raising a fibro-cement or weatherboard house is around $30,000. The costs and benefits of raising houses is outlined in Table 4.3.

Table 4.3 Benefits/costs of House Raising dependant upon regularity of above floor level flooding

Flooding Above Floor Level in AEP event	Number of Houses	Indicative Cost	Benefit. Reduction in flood damages if houses raised to above 1% AEP level	Benefit to Cost Ratio
All below 1%	9	$270,000	$44,000	0.17
Only those between 2% & 1%	5	$150,000	$9,000	0.09
Only those affected in events 2% or more frequent	4	$120,000	$35,000	0.29

The Committee and Council needs to consider the make up of any voluntary house raising scheme if it is selected as a floodplain risk management measure. The Council would also need to consider the make-up of the local component of any floodplain risk management funding as discussed in Section 6. Voluntary house raising schemes vary between Councils with some contributing toward the cost of damage reduction works in part or full and others not. The ability to implement the scheme may depend upon the option selected by Council and therefore the ability of the individual owners to contribute toward house raising. A part payment by Council may make implementation feasible.

Ensuring buildings being raised can withstand flood forces should be part of any house raising scheme. This may require special conditions on development applications relating to house raising and should incorporate the requirement for structural certification. A typical clause could be as follows:

> *House raising requires the raising of floor levels to 0.5m above the 1% AEP flood levels. In raising the house all the materials used should be flood resistant in accordance with Council's Flood Management Policy and considering flow velocities in the floodplain. In determining design flood loadings consideration should be given to the additional loadings caused by flood debris. Information on flood levels and flow velocities in the area based upon current studies is available from Council.*

As voluntary house raising does not deal with danger to personal safety it must be used in combination with another management method. This is most logically a response modification measure. The Local Flood

Plan for Great Lakes deals with the flood situation at Nabiac and Failford. However, this need to be extended to include Minimbah and may be improved as discussed in Section 3.7.

In addition, in Nabiac, Failford and Minimbah, there is scope for flood warning and evacuation prior to the peak of a major flood event. If a high degree of flood awareness and readiness is maintained and an appropriate flood warning system is implemented, evacuation of properties could be achieved during the early stages of a flood in order to further reduce this risk.

There are some 8 residential properties below the 1% AEP flood level that cannot be raised. Of these houses, 3 in Failford and 1 in Minimbah are all likely to be in high hazard areas. The Committee and Council needs to consider the make up of any voluntary purchase scheme if it is selected as a floodplain risk management measure. Table 4.4 provides some associated advice.

Table 4.4 Benefits/Costs of Voluntary Purchase dependant upon regularity of above floor level flooding

Flooding Above Floor Level in AEP event	No of Houses	Indicative Cost	Benefit. Reduction in flood damages if houses raised to above 1% AEP level	Benefit to Cost Ratio
All below 2%	4	$960,000	$86,200	0.09
Worst located properties	2	$480,000	$59,300	0.13

4.9.2 Response Modification Measures

Community Flood Readiness

Ongoing education is necessary to ensure that the community in the floodplain has a high level of both flood awareness (an accurate perception of the flood risk) and flood preparedness (knowledge of the appropriate course of action during a flood). Knowing what may occur and knowing what to do and being ready to do this is considered to be flood readiness.

The most recent severe flood at in study area occurred in the 1950's, though the recent February 2002 storm was a timely reminder of the need to consider flood issues. Given the time since the major events and considering the arrival of new residents, the general level of flood awareness will diminish over time in the absence of appropriate education campaigns. The Council in conjunction with the SES should conduct regular flood awareness campaigns, which could include measures such as the following:

- installation of permanent marks showing the levels reached by the largest historical floods;
- sending out regular information with rate notices; and
- SES displays and talks by SES officers to community groups.

Flood preparedness campaigns should educate the flood affected community on issues such as:

- storage or removal of important items, memorabilia and treasured items as high as practicable and, at least, above the 1% AEP flood level;
- procedures for lifting and evacuation of possessions;
- provide an understanding of the warning system;
- indicating what is expected of individuals; and
- indicating where to evacuate to and who to report to once you arrive at the evacuation centre.

The estimated cost of an initial flood awareness and public education program would be between $5,000 and $10,000. The cost of ongoing activities to maintain a high level of flood readiness would be about $2,000 per annum.

Local Flood Plans

Improvements to the local flood plan will be necessary to make the flood warning system effective. It is suggested that Council liaise with the SES in order to advance the development of a detailed local flood

evacuation plan. The plan should recognise that floods greater than the 1% AEP event may occur. Some further suggestions are provided in Sections 3.7 and 4.6.

Flood Warning and Predictions

As indicated in Section 3.8 the Bureau of Meteorology does not issue flood warnings for watercourses within the Great Lakes Council area. However, the Council in conjunction with the Bureau have installed a flood warning system for the Wallis Lakes which includes gauges in the Wallamba River above Nabiac. This system should be designed to provide information to the SES so that warnings can be issued for the Nabiac, Failford and Minimbah Areas.

The critical storm on the catchment for the 1% AEP event is the 36 hour storm. Analysing this design storm indicates that there is typically 5 hours for Nabiac and 6 hours for Failford and Minimbah between the occurrence of the maximum rainfall intensity in the upstream catchment and the peak flood level at Nabiac due to catchment runoff. However shorter times can occur due to:

- shorter storms producing water levels of a similar magnitude;
- more severe storm intensities will result in water levels approaching critical levels for action and evacuation more quickly; and
- different spatial distributions may result in quicker flood level increases.

To utilise the potential warning time the system being installed should consider the need for warnings to be issued at both Nabiac, Failford and Minimbah and incorporate the necessary equipment. Flood forecasting models would be required in order to provide predictions of flood heights using the data collected from the flood warning system together with meteorological forecasts. The hydrologic model (and possibly the hydraulic model) developed for this study could be of assistance for this purpose. The models could be used to develop general relationships between catchment rainfall, river heights and flood levels at Nabiac, Failford and Minimbah. These relationships could then be readily applied during actual flood events.

The system would provide economic benefits in reduction of damages and would benefit the SES by providing them with a better indication of the predicted flood levels assisting them in concentrating their efforts on the properties likely to be affected, either by isolation or inundation.

Flood warning, with an appropriate response plan enables a reduction of danger to personal safety due to flooding by providing a better indication of flood levels and more warning time for evacuation if used with a more formal flood response plan for SES.

Evacuation Access

Evacuation access upgrading should be considered where evacuation access is so limited that effective warning and evacuation planning do not enable effective self-evacuation of the community within the available warning time. Given the low lying nature of the access to Minimbah, the access from this area may need to be considered on this basis. In addition the Willow Point area in Failford would be a similar problem.

The typical depths of flooding in Nabiac and the alternative routes available mean that this is unlikely to be necessary in Nabiac.

- Detailed analysis of evacuation is outside the scope of this report and needs to be considered in the emergency response plan for the area. This may confirm the need for upgrading works in these areas, which should then be considered for inclusion in the floodplain risk management plan. Evacuation planning may highlight the need for access improvements on Old Aerodrome Road which services Minimbah area. The low point in the road is cut by up to 5.5m in an extreme event and 2.5m in a 5% flood event. This may result in the need for upgrading the low point in the management plan. Emergency planning relies on community education and awareness of the problems. It is recommended that Council and the SES combine to undertake regular education and awareness campaigns in the community.

4.10 EFFECTIVENESS OF MEASURES IN FLOOD RISK CONTROL

This section examines the effectiveness of the floodplain risk management alternatives discussed in Section 4.8 on existing, continuing and future flood risk. Each of these risks contains two components that require consideration, namely, danger to personal safety and flood damage. Table 4.5 indicates the effectiveness of options in dealing with risk. The table indicates the need to undertake different floodplain risk management measures to deal with existing, future and continuing risk.

Existing flood risk can be mitigated by either construction of a levee(s) or house raising and voluntary purchase and to some degree by response modification measures. Future flood risk is best dealt with by zoning and development control, as is the case under Council's existing Flood Management Policy. Improving community flood readiness and evacuation planning can reduce continuing flood risk. The addition of flood warnings and predictions will improve matters further.

Table 4.5 Effectiveness of Options in Dealing with Flood Risk

	Existing Development				Future Development			
	Existing Risk		Continuing Risk		Future Risk		Continuing Risk	
	Danger*	Damage #	Danger*	Damage #	Danger*	Damage #	Danger*	Damage #
Property Modification Measures								
Zoning and Development Control	-		-	-	High	High	-	-
Voluntary House Raising	Low	High	-	-	-	-	-	-
Voluntary Purchase	High	High	High	High	-	-	High	High
Flood Proofing	-	Low	-	-	-	-	-	-
Response Modification Measures								
Community Flood Readiness	Low	Low	Medium	Medium	-	-	Medium	Medium
Local Flood Plans	Low	Low	Medium	Medium	-	-	Medium	Medium
Upgrading Access	High@	-	High@		High@	-	High@	-
Flood Predictions and Warnings	Medium	Low	High	Low	-	-	High	Low

Danger* Danger to Personal Safety

Damage# Damage to Private Property

@ From specific areas, this is potential only. It depends upon evacuation planning as part of updating the local flood plan.

5. COMMUNITY CONSULTATION

Community consultation was undertaken at the draft study stage. This involved distribution of questionnaires and display of the draft report in early 2004. Information/Questionnaire sheets were prepared and distributed throughout the study area. Seventeen responses were received:

- Eleven (11) from Nabiac. Of these responses, seven were from residents whose houses were identified as flood prone in events up to the PMF, although all were above the 1% AEP flood level. Seven respondents identified that they had experienced flooding in the area . Three of these properties were toward the east end of town, cut off relatively early in an extreme event. The majority of respondents have a car available to evacuate during a flood. The one that indicated they didn't appears to be on the western flood fringe of flooding in the 0.2% riverine flood event so evacuation should be a relative short distance. Only one respondent was interested in voluntary house raising, though their house was above the 1% AEP flood event. Many indicated that local creeks need to be cleaned out to avoid local flooding. One suggested regarding Nabiac Street between Hoskins and Donaldson Street to remove the low point to improve evacuation. This low point is currently 2.2m below the Extreme flood level, 0.1m above the 1% AEP flood level and the low point appears localised.
- Six (6) from Failford and Minimbah. Four of these responses were from Failford whilst two did not indicate where they were from. Three respondents have experienced a flood in the local area with one indicating that flooding of Failford Road was frequent. Only one noted that the plan indicated their property was affected by flooding with the house currently being built 0.9m above the ground. The address of the house was not provided. All appear to have transport and none appear in favour of house raising. Two responses suggested restricting development until proper drainage is provided and one suggests stopping filling around watercourses whilst another is concerned that land filling and debris build up is making problems (particularly drainage) worse.

The majorities of these comments relate to the local drainage and localised creek systems which have resulted in flooding.

6. GOVERNMENT FUNDING

6.1 FUNDING SOURCES

Funding for floodplain risk management is available through the State Government's Floodplain Management Program administered by the Department of Infrastructure, Planning and Natural Resources. Funding is only available for works protecting existing. Because of its low priority protection or modification works specifically directed at existing commercial and/or industrial development is generally ineligible for Government funding.

The Floodplain Management Program includes two sub-programs called the Commonwealth Assisted and State Assisted Programs.

The Commonwealth Assisted Program is a partnership with the Commonwealth Government recently funded under it's Regional Flood Mitigation Program (RFMP) to approved floodplain risk management works. This program offers funding for works on $1 Commonwealth: $1 State: $1 Local basis. This program provides funds for the design and construction of works.

The State Assisted Program provides State Government subsidy to fund approved floodplain risk management works. This program offers funding for works on $2 State: $1 Local basis. This program provides assistance for the construction of modification works and associated designs and studies into works.

Therefore both sub-programs require the local component to be one-third (33.3%) of the project cost.

6.2 THE LOCAL COMPONENT OF FUNDING

The local component (33.3%) of funding can be from any local source. In most instances the Council provides the local input through either its general rates or by the levy of a special rate for floodplain risk management measures.

Some councils have adopted schemes which require the individual to pay the whole one-third or part thereof for voluntary house raising where house raising is not required because of the impacts of other mitigation works on flood levels. A partial payment of the local component may make this option more attractive to residents.

7. CONCLUSIONS AND RECOMMENDATIONS

Flooding from the Wallamba River, local tributaries and local overland flooding from drainage paths affect Nabiac, Failford and Minimbah. This study **only** deals with flooding from the Wallamba River.

Flooding from the Wallamba River has not occurred for a number of years, with the majority of recent problems due to flooding from local tributaries. This is reflected in the general low interest of the community found in consultation with the majority of interest being in local drainage issues.

The effects of major floods at these areas are relatively contained to the areas in the vicinity of the river. Flooding from the Wallamba River in the study area in the 1% annual exceedance probability (AEP) flood event will inundate around 18 houses and 3 non residential buildings above floor level with 9 of these buildings in Nabiac, 6 in Failford, and 6 in Minimbah. The potential flood damage in the 1% AEP event is estimated to be in the order of $455,000 with the annual average damage for the full range of floods expected to be in the order of $34,000. The 0.2% and extreme flood events are likely to impact upon 79 and 220 buildings respectively. Very few properties are affected above floor level in floods of less than a 1% AEP. Therefore, whilst development is generally protected from the majority of flood events, extreme flood events can have a significant impact on Nabiac (141 buildings), Failford (61 buildings) and Minimbah (18 buildings).

The development of a bypass flowpath from the Wallamba River through the township of Nabiac occurs in events of around a 0.2% AEP and the scale of this increases in larger events. This is a very rare event, but is important from an emergency management perspective. It can result in areas being isolated, as roads are cut off, and as water levels rise further both the land and the buildings are inundated. This needs careful consideration in the emergency management section of the Great Lakes Local Flood Plan that deals with Nabiac and is an issue for flood education and awareness of the community.

The low number of properties affected above floor level by flooding in a 1% AEP flood event, and the associated relatively low level of average annual flood damages means that it is unlikely for flood mitigation measures, such as levees, to be economically viable. This is further compounded by the large length of river bordering Nabiac, Failford and Minimbah. In addition, works, such as levees, may also impact upon flood levels resulting from local drainage and the Town Creek tributary.

The findings of the study and the potential management measures were presented to the community to canvass their opinion. There appeared to be little community interest in riverine flooding and no particular option for mitigation was supported.

Notwithstanding this council needs to manage three types of flood risk. Each of flood risk involves a component related to danger to personal safety and property damage. The findings of the study indicate that a number of different measures are needed to address all types of flood risk, namely:

- existing flood risk which relates to existing development in the floodplain. This could be reduced by the adoption of a voluntary house raising scheme as outlined in Section 4.9.1 of the report. The raising of houses below the 2% flood level to 0.5m above the 1% flood level would have the most economic benefit with a return of around $0.87 for every local dollar expended (given a $2 State: $1 Local funding ratio). Raising of all floor levels would have a return of around $0.51 for every local dollar expended. Local funding could be from Council, property owners or a combination of both. In addition voluntary purchase of worst affected properties but unsuitable for raising should also be considered as discussed in Section 4.9.1 of this report.
- future flood risk which relates to the risk to future development in the floodplain. This can be dealt with by recommended changes to Councils Flood Policy and Development Controls as outlined in Sections 4.4 and 4.5.
- continuing flood risk is the risk remaining after management measures are implemented. The existing flood warning system needs to be accompanied by appropriate community warning methods and community evacuation planning in the local flood plan. Recommendations are provided in relation to this study in Section 4.9.2. This plan relies on community education and awareness of the problems. It

is recommended that Council and the relevant emergency services groups combine to undertake regular education and awareness campaigns in the community.

Flood planning levels (FPLs) should be adopted as follows:

- The FPL for residential, commercial and industrial development in Bulahdelah should be the 1% AEP flood event plus the adopted freeboard of 0.5m.
- The FPL for flood awareness and emergency management should be the extreme flood level.

Council should consider adoption of the above recommendations and use these recommendations as the basis for the preparation of a floodplain risk management plan.

8. GLOSSARY

Following is a glossary of the terms used in this management study.

annual exceedance probability (AEP) — the chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a peak flood discharge of 500 m^3/s or larger occurring in any one year.

Australian Height Datum (AHD) — a common national surface level datum approximately corresponding to mean sea level.

average annual damage (AAD) — depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.

development — is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act).

infill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development.

new development: refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.

redevelopment: refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.

discharge — the rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).

effective warning time — the time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.

emergency management — a range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.

flood — relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.

flood education, awareness & readiness — **flood education** seeks to provide information to raise awareness of the flood problem so as to enable individuals to

	understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness. **flood awareness** is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures. **flood readiness** is an ability to react within the effective warning time.
flood fringe areas	the remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	is synonymous with flood prone land (ie) land susceptible to flooding by the probable maximum flood (PMF) event.
flood mitigation standard	the average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
floodplain	area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	the measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	a management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning area	the area of land below the flood planning level and thus subject to flood related development controls.
flood planning levels (FPLs)	are the combinations of flood levels and freeboards selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans. The concept of flood planning levels supersedes the “standard flood event” of the first edition of this manual.
flood proofing	a combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	is land susceptible to flooding by the probable maximum flood event. Flood prone land is synonymous with flood liable land.
flood risk	potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been

	implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
freeboard	a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted flood planning level and the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such and wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change. Freeboard is included in the flood planning level.
habitable room	in a **residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom in an **industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	a source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community.
hydraulics	term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	a graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
mainstream flooding	inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
mathematical/computer models	the mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
merit approach	the merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour

	implications, and environmental protection and well being of the State's rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into council plans, policy, and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain management policy and EPIs.
minor, moderate and major flooding	both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **minor flooding:** causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded. **moderate flooding:** low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **major flooding:** appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
modification measures	measures that modify either the flood, the property or the response to flooding.
peak discharge	the maximum discharge occurring during a flood event.
probable maximum flood (PMF)	the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with the PMF event should be addressed in a floodplain risk management study.
probable maximum precipitation	the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to the estimation of the probable maximum flood.
probability	a statistical measure of the expected chance of flooding (see annual exceedance probability).
risk	chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	the amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	equivalent to "water level". Both are measured with reference to a specified datum.

stage hydrograph	a graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
water surface profile	a graph showing the flood stage at any given location along a watercourse at a particular time.

9. ACKNOWLEDGMENTS

The study is being funded under a joint State and Commonwealth Government grant through the New South Wales Government's Floodplain Management Program administered by the Department of Infrastructure, Planning and Natural Resources (DIPNR).

The study has been prepared by the Ecosystems Branch Flood Unit of the Department of Infrastructure, Planning and Natural Resources in association with Great Lakes Council and Council's Floodplain Risk Management Committee.

10. REFERENCES

1. PUBLIC WORKS DEPARTMENT NSW
Wallamba River Flood Study PWD Report No. 84021, January 1985

2. PUBLIC WORKS DEPARTMENT
Forster/Tuncurry Flood Study Report No. 88036, September 1989

3. INSTITUTION OF ENGINEERS, AUSTRALIA
Australian Rainfall and Runoff A Guide to Flood Estimation,
Volumes 1 and 2 Revised Edition, 1987

4. NEW SOUTH WALES GOVERNMENT
Floodplain Development Manual December 1986

5. STATE EMERGENCY SERVICE
Great Lakes Local Flood Plan
A Sub-Plan of the Great Lakes Local Disaster Plan Draft, September 1995

6. DEPARTMENT OF LAND AND WATER CONSERVATION
Forster/Tuncurry Floodplain Management Study April 1998

7. WATER STUDIES PTY LTD
User Manual "FLDAMAGE" March 1992

8. NSW GOVERNMENT
Floodplain Management Manual: the management of flood liable land 2001

9. GREAT LAKES COUNCIL
State of the Environment Report 1998/99

10. GREAT LAKES COUNCIL
State of the Environment Supplementary Report 2000/01

11. GREAT LAKES COUNCIL
Great Lakes Community Profile 1999

12. GREAT LAKES COUNCIL
Forster/Tuncurry Conservation and Development Strategy 2002

13. SINCLAIR KNIGHT MERZ
Environmental Impact Statement – Bundacree Creek to Possum Brush Upgrade of the Pacific Highway 137.5km to 147.2km north of Newcastle. For RTA 2001

14. ECOTONE ECOLOGICAL CONSULTANTS
Threatened Species Assessment – Bundacree Creek to Possum Brush Section of the Pacific Highway Upgrade. Appendix M in Sinclair Knight Merz (2001) EIS Bundacree Creek to Possum Brush Upgrade of the Pacific Highway 137.5km to 147.2km north of Newcastle. Volume 3. Prepared for the RTA 2000

15. DAINTRY GERRAND AND ASSOCIATES
Great Lakes Greening Strategy. Prepared for Great Lakes Council 2002

APPENDIX A - HISTORICAL FLOOD INFORMATION

The following historical flood information for the Wallamba River downstream of the Pacific Highway bridge is taken principally from the Wallamba River Flood Study, PWD Report No. 84021, January 1985. Flood level records upstream of the Pacific Highway are not included.

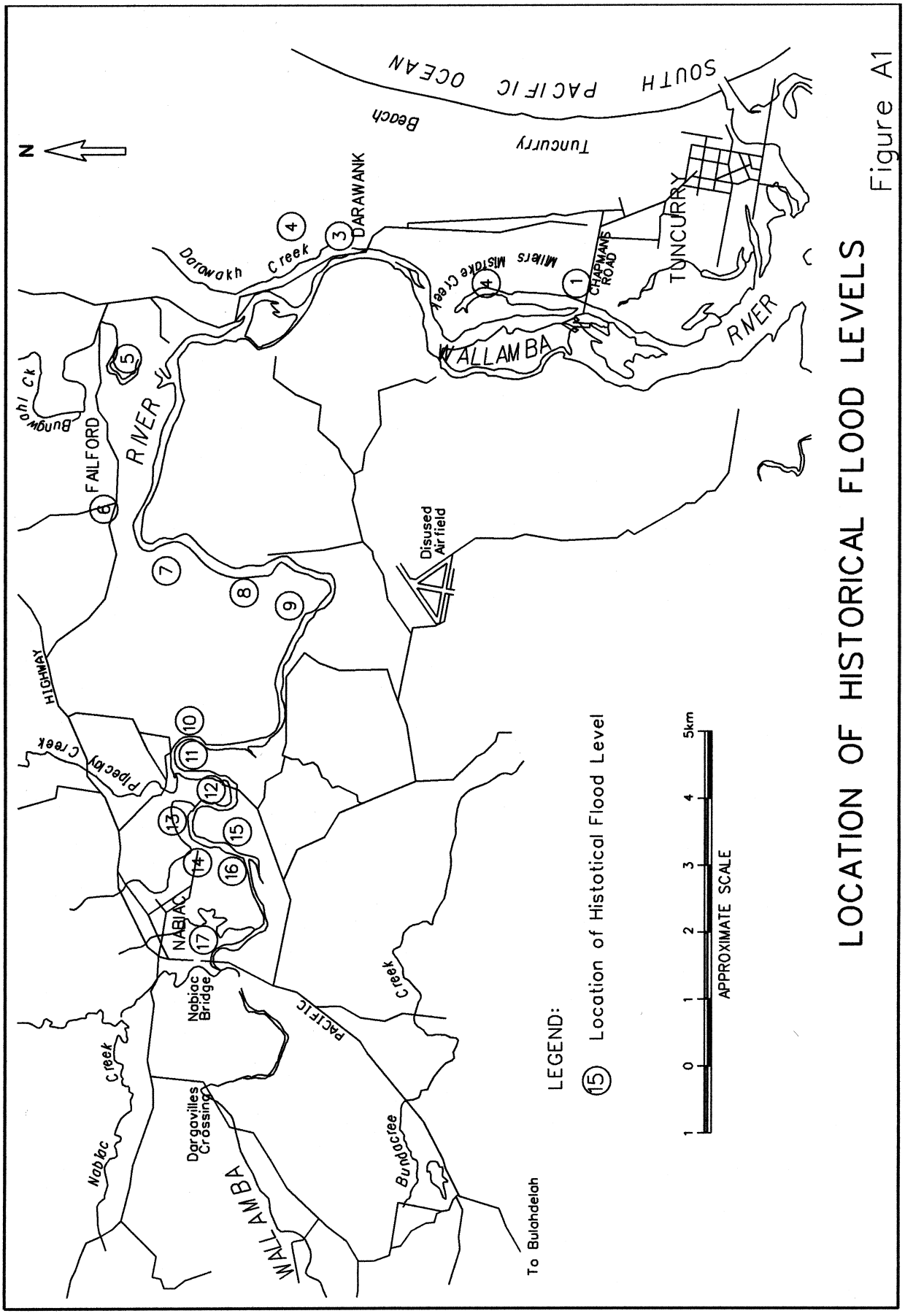
Some historical flood levels were taken from the Forster/Tuncurry Flood Study, PWD Report No. 88036, September 1989. These levels are denoted by an asterisk (*). Great Lakes Council was advised by local community groups that additional flood level records were not available, largely because of the absence of flooding in recent years and the long period of time since the previous major floods.

The locations of the historical flood levels are shown in Figure A1, and the data are plotted on a longitudinal profile of the Wallamba River in Figure A2. There is considerable scatter in the records for some flood events and uncertainty regarding the reliability of some records.

Table A.1 Historic Flood Information 1927 to 1957 Flood Events

Location No.	Flood Level (m AHD)	Source
1927 Flood		
3(*)	2.23	Mr A Mead, Darawank
11	5.56	Mr Elliot McMaster, occupier “Glen Ora”
12	5.84	Mr Elliot McMaster as told to Mr Hodges, house occupier
16	5.93	Mr Bob Campbell, Nabiac (former occupier)
17	7.30	Mr Norman Lulham, Nabiac - Local creek level
1929 Flood		
1	1.84	) Dwyer, D. J. & Associates Pty Ltd, 1978
2	1.74	) “Wallamba Peninsula Tuncurry Flood
3	1.92	) Investigation”, prepared for Civil Land and
3	1.88	) Real Estate Pty Ltd
17	7.86	Great Lakes Council - Local creek level?
1947 Flood		
7	3.35	Mr W Saxby, Willow Point Road, Failford
17	7.15	Mr Norman Lulham, Nabiac
1957 Flood		
11	4.96	Mr Elliot McMaster, occupier “Glen Ora”
15	4.81	Mr Clayton Everingham, Nabiac
16	5.63	Mr Bob Campbell, Nabiac (former occupier)

(continued)


LOCATION OF HISTORICAL FLOOD LEVELS
Figure A1
N
SOUTH PACIFIC OCEAN
Tuncurry Beach
TUNCURRY
RIVER
WALLAMBA
CHAPMANS ROAD
DARAWANK
Darawakh Creek
Mistake Creek
Mitars
FAILFORD
Bungwahl Ck
RIVER
Disused Airfield
HIGHWAY
Pipeclay Creek
NABIAC
Nabiac Bridge
Dargavilles Crossing
Nabac Creek
PACIFIC
Creek
Bungacree
WALLAMBA
To Bulahdelah
LEGEND:
(15) Location of Histotical Flood Level
APPROXIMATE SCALE
1 0 1 2 3 4 5km

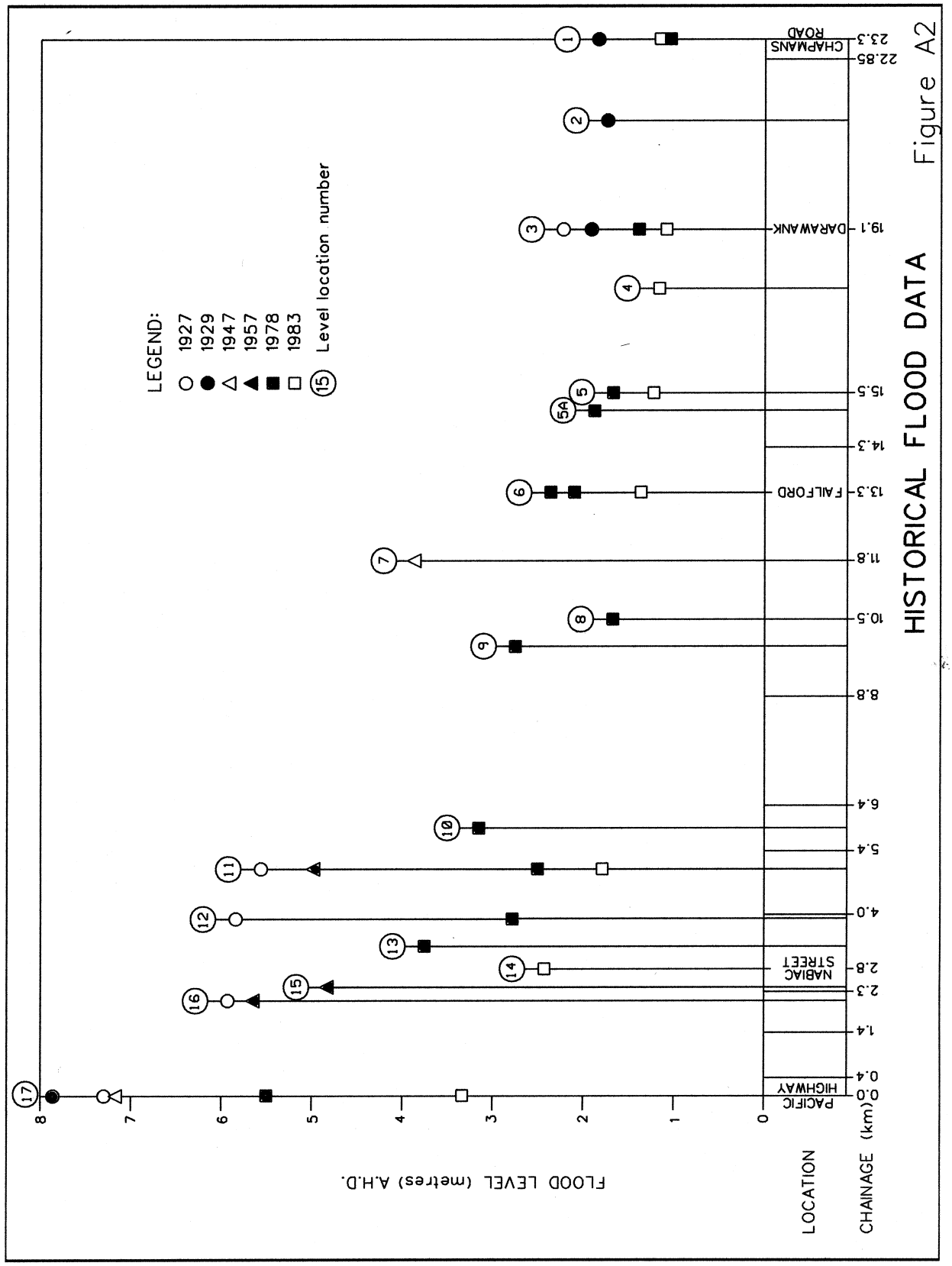

HISTORICAL FLOOD DATA
Figure A2
LEGEND:
1927
1929
1947
1957
1978
1983
Level location number
FLOOD LEVEL (metres) A.H.D.
LOCATION
CHAINAGE (km)
PACIFIC HIGHWAY
NABIAC STREET
DARAWANK
FAILFORD
CHAPMANS ROAD
0.0
0.4
1.4
2.3
2.8
4.0
5.4
6.4
8.8
10.5
11.8
13.3
14.3
15.5
19.1
22.85
23.3

Table A.2 Historic Flood Information 1978 and 1983 Flood Events

Location No.	Flood Level (m AHD)	Source
1978 Flood		
1	1.04	
3	1.39	
5	1.67	Mr Peter Johnson, resident Wallamba Ski Park
5	2.69	Proprietor, Shalimar Caravan Park
5A(*)	1.88	Mr W Eggink, Bungwahl Creek Bridge
6	2.10	
6(*)	2.36	Mr D Duncum, Failford Caravan Park
9	2.75	Great Lakes Shire Council
10	3.15/	Bayley, occupier "Belmont"
	4.24?	(Great Lakes Shire Council)
11	2.50	Mr Elliot McMaster, occupier "Glen Ora"
12	2.78	Mr David Hodges, occupier
13	3.75/	Mr Colman, occupier
	4.05?	(Great Lakes Shire Council)
17	5.5	Mr Northam, occupier (GLSC)
1983 Flood		
1	1.16	Chapmans Road PWD MHR
3	1.09	Darawank Bridge PWD MHR
4	1.17	Gowack Island PWD MHR
5	1.23	Wallamba Ski Park
5	2.06	Shalimar Caravan Park
6	1.37	Bullocky Way PWD MHR
8	1.68	Willow Point Road PWD MHR
11	1.79	Mr Elliot McMaster, occupier "Glen Ora"
14	2.43	Nabiac Street PWD MHR
17	3.34	Nabiac Bridge PWD MHR

Note: Maximum height recorders (MHRs) along the Wallamba River are currently under the control of the Department of Infrastructure, Planning and Natural Resources.

APPENDIX B - FLOOD STUDY REVIEW

B.1 PREVIOUS STUDIES

Previous studies of Wallamba River flooding include:

- Wallamba River Flood Study, Public Works Department NSW, January 1985 (Reference 1)
- Forster/Tuncurry Flood Study, NSW Public Works, September 1989 (Reference 2)

The Wallamba River Flood Study included hydrologic analysis to derive catchment runoff estimates and hydraulic analysis to derive design flood profiles along the Wallamba River. The Cordery-Webb synthetic unit hydrograph method was used for hydrologic analysis and the HEC2 computer program developed by the US Army Corps of Engineers was used for hydraulic analysis.

There have been some advances in hydrologic and hydraulic modelling techniques since the 1985 study. In addition, design rainfall intensities and temporal patterns were revised with the publication of the 1987 edition of Australian Rainfall and Runoff (ARR) (Reference 3).

The Forster/Tuncurry Flood Study included modelling of the Wallamba River which is the major tributary of Wallis Lake. The Watershed Bounded Network Model (WBNM) was used for analysis of catchment rainfall-runoff conditions and the Wallingford Hydraulic Model was used for analysis of river and lake behaviour.

The main emphasis in the 1989 study was on Wallis Lake and the incoming reach of the Wallamba River; namely, downstream of Darawank. The modelling of the Wallamba River was generally coarse and was not intended to provide reliable results for areas upstream of Failford.

In view of the limitations of previous studies, it was considered appropriate to undertake further investigation to derive reliable design flood profiles for the reach of the Wallamba River downstream of the Pacific Highway bridge near Nabiac.

B.2 METHODOLOGY

A linked hydrologic and hydraulic modelling approach was adopted for this investigation. The WBNM model from the 1989 study was refined to provide improved definition of runoff from the Wallamba River catchment, in particular the catchment downstream of the Pacific Highway.

Design rainfalls based on ARR (1987) provided the main input to the WBNM model.

The MIKE-11 software package developed by the Danish Hydraulics Institute was used for hydraulic analysis. MIKE-11 simulates one dimensional unsteady flow behaviour in river systems and is well suited to hydraulic modelling of the Wallamba River. The main inputs to the MIKE-11 model were the catchment runoff hydrographs derived using WBNM. The downstream boundary condition for the model was the stage hydrograph upstream of the confluence of the Wallamba River and Wallis Lake.

The linked hydrologic and hydraulic models were calibrated using recorded rainfall and river level data for a flood event which occurred in March 1978. The models were then applied using design rainfalls to derive flood profiles for the 1% and 5% AEP events. An extreme flood event was also assessed using 3 x the runoff peak and volume of the 1% AEP design event.

B.3 AVAILABLE DATA

Historical flood data were available for the Wallamba River, including recorded levels from flood events in 1927, 1929, 1947, 1957, 1978 and 1983. These levels are given in the 1985 Flood Study report. The

levels between Nabiac and Chapmans Road (which is just upstream of the confluence with Wallis Lake) are reproduced in Appendix A.

Great Lakes Council was advised by local community groups that additional flood level records were not available, largely because of the absence of flooding in recent years and the long period of time since the previous major floods. Accordingly the flood level records obtained in the past were used for this study.

Historical rainfall data for the March 1978 event are given in the 1985 report. This event is the most appropriate event for model calibration based on the availability of rainfall and flood level data. There is limited data for the earlier events, while the river levels in 1983 were considerably lower than in 1978.

In 1984, Public Works Department surveyed nineteen (19) cross-sections of the Wallamba River between Nabiac and Chapmans Road. Three (3) cross-sections were also obtained upstream of Nabiac. Details of the survey are provided in the 1985 report.

B.4 DESIGN RAINFALLS

The rainfall maps in ARR(1987) indicate that there is no significant gradient in design rainfalls over the Wallamba River catchment. The design rainfall intensities at Nabiac were used as the basis for estimation of average catchment rainfalls for various durations. Table B.1 shows the design rainfall intensities for Nabiac, derived using ARR (1987).

Table B.1 - Design Rainfall Intensities for Nabiac

Duration (hours)	Average Intensity (mm/hr)					
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
1	36.9	46.3	51.8	59.1	68.7	75.9
2	24.3	30.8	34.6	39.6	46.2	51.2
3	19.0	24.1	27.1	31.2	36.4	40.5
6	12.4	15.9	17.9	20.7	24.3	27.0
9	9.6	12.4	14.1	16.3	19.1	21.3
12	8.1	10.5	11.9	13.7	16.2	18.1
18	6.3	8.2	9.3	10.7	12.6	14.1
24	5.3	6.8	7.7	9.0	10.6	11.8
36	4.1	5.3	6.0	6.9	8.2	9.1
48	3.3	4.3	4.9	5.7	6.8	7.5
72	2.5	3.2	3.7	4.3	5.1	5.7

B.5 HYDROLOGIC MODELLING

The WBNM model was refined to provide catchment runoff hydrographs for the components of the Wallamba River catchment listed in Table B.2.

Table B.2 – WBNM Model - Catchment areas for Hydrograph Generation

Component	Area (km^2)
Area upstream of Pacific Highway	314
Area between Nabiac and Glen Ora (including Pipeclay Creek catchment)	25
Area between Glen Ora and Failford	28
Area between Failford and Gowack Island (including Bungwahl Creek catchment)	67
Area between Gowack Island and Wallis Lake (including Darawakh Creek catchment)	61
Total Area	**495**

WBNM was used to derive design runoff hydrographs from these areas. The adopted value of the storage coefficient was C=1.29, and the adopted values for initial loss and continuing loss rate were 21mm and 2.5 mm/hour respectively, as for the 1989 study. The adopted C value was supported by calibration of the linked hydrologic and hydraulic models to available data for the 1978 flood.

WBNM was run for a range of design storm durations and the 36 hour storm event was found to produce the highest peak discharges along the Wallamba River. This is consistent with the 1989 study which found that the 36 hour event generally resulted in the highest flood levels. The estimated peak discharges from the above areas for the modelled events, including the March 1978 event, are given in Table B.3.

Table B.3 Modelled Peak Discharges from Catchment Areas

Area	Peak Discharge (m^3/s)			
	1978	**1% AEP**	**2% AEP**	**5% AEP**
Upstream of Pacific Highway	794	1740	1515	1296
Nabiac to Glen Ora	67	169	147	128
Glen Ora to Failford	74	186	162	140
Failford to Gowack Island	170	398	347	300
Gowack Island to Wallis Lake	155	365	319	276

The modelled 1% AEP peak discharge for the catchment upstream of the Pacific Highway is about 4 per cent higher than the peak discharge derived for the Forster/Tuncurry Flood Study. An estimate of the 1% AEP peak discharge for this catchment was also made using the probabilistic Rational Method (Reference 3). This estimate was in good agreement with the peak discharge obtained using WBNM.

B.6 HYDRAULIC MODELLING

A MIKE-11 hydraulic model was set up for the Wallamba River from the Pacific Highway bridge near Nabiac downstream to near Chapmans Road, which is about 3 km from the confluence with Wallis Lake. The locations of the MIKE-11 model cross-sections are shown in Figure B.1.

The model cross-sections were generally the same as the cross-sections used in the 1985 Wallamba River Flood Study, as obtained in the 1984 PWD survey. The most downstream cross-section was taken from the hydraulic model developed for the Forster/Tuncurry Floodplain Management Study. Overbank extensions were applied to some cross-sections where appropriate to allow for floodplain flow in large events. Sensitivity analysis indicated that the flood levels for the 1% AEP event did not vary greatly for the modelled range of floodplain widths. The cross-sections are listed in Table B.4.

Table B.4 - MIKE-11 Model Cross-Sections

Location	Model Chainage (km)	1984 Survey Cross-Section No.	Manning's n Value	
			River	Overbank
Pacific Hwy	0.0	bridge	0.065	0.08
	0.2	1A	0.065	0.08
	0.4	1B	0.06	0.075
	0.6	1C	0.06	0.07
	1.4	2A	0.06	0.07
	2.3	3A	0.05	0.06
Nabiac Street	2.8	4W	0.05	0.06
	4.0	5W	0.04	0.05
	5.4	5A	0.04	0.05
	6.4	6W	0.035	0.045
	8.8	7W	0.035	0.045
	10.5	8W	0.035	0.045
	11.8	9W	0.035	0.045
Failford	13.3	10W	0.03	0.04
	14.3	10A	0.03	0.04
	15.5	11W	0.025	0.035
Darawank	19.1	12W	0.02	0.03
	22.85		0.02	

The locations of the inflow hydrographs to the MIKE-11 model are also shown in Figure B.1. These hydrographs were derived using WBNM. The downstream boundary condition for the model is represented by a stage hydrograph at the most downstream cross-section; ie near Chapmans Road. This hydrograph was adopted for the various modelled events based on the results of hydraulic modelling undertaken for the Forster/Tuncurry Floodplain Management Study.

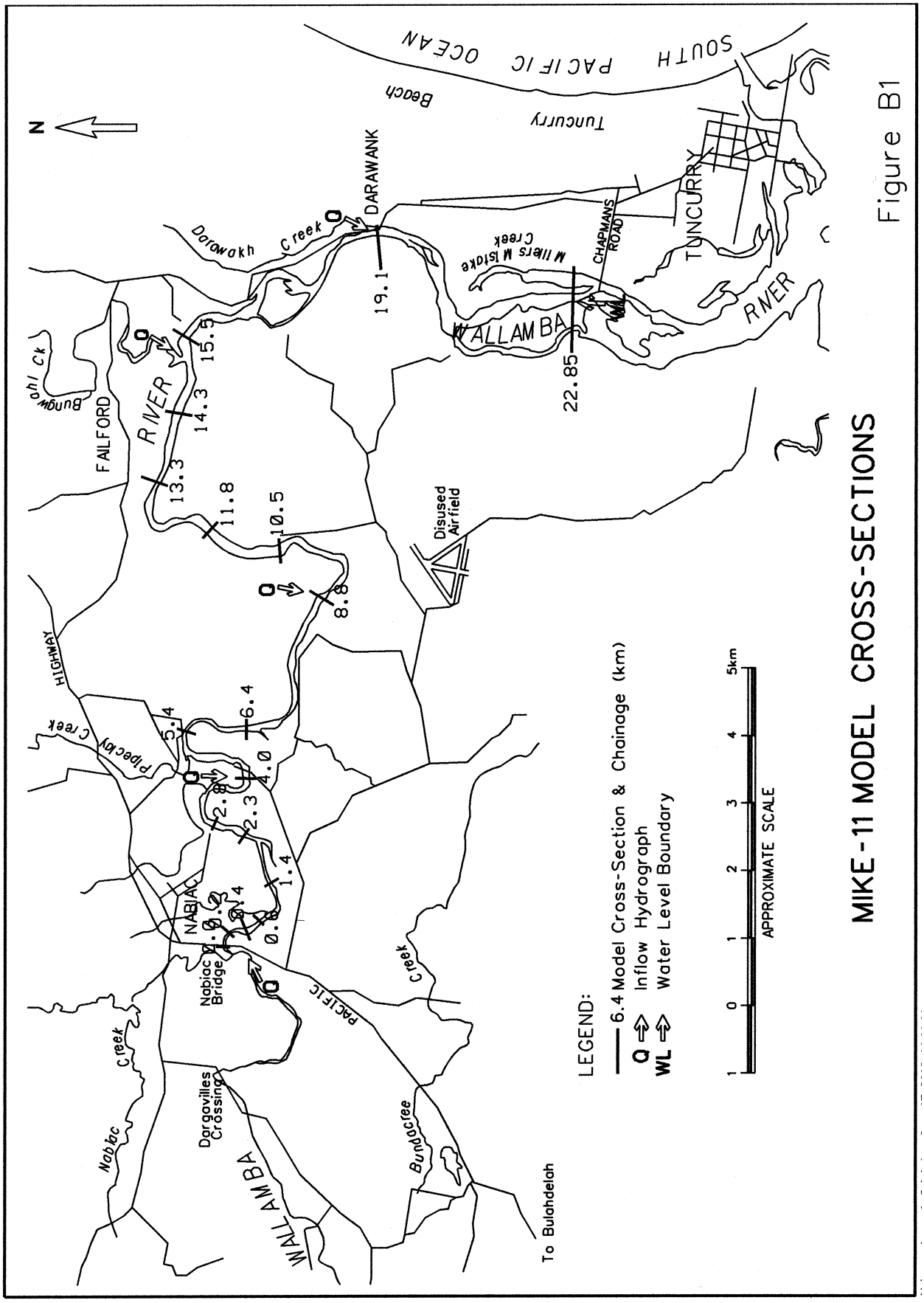
The MIKE-11 model was calibrated to the March 1978 flood event, with the modelled flood level profile shown in Figure B.2. The Manning's n values used in the calibration are shown in Table B.4. Given the scatter in the available data, the fit to recorded levels is considered reasonable.

The calibrated MIKE-11 model was used to derive flood profiles along the Wallamba River for the 1% AEP, 2% AEP and 5% AEP events. These flood profiles are shown in Figure B.3 with indicative flood extents provided on Figure 3, for Nabiac, and Figure 4, for Failford.

The model was also used to derive estimates of flood levels for an extreme flood event. For the purposes of this study, the extreme event was defined as an event with catchment runoff of three (3) times the magnitude of the runoff for the 1% AEP event. The computed flood levels for the extreme event are also shown in Figure B.2.

There was insufficient topographic data to model the full extent of overbank flow and floodplain storage for the extreme event. Hence the modelled flood levels for this event should be regarded as conservatively high.

The computed flood profiles for the design events are higher than the flood profiles given in the 1985 Wallamba River Flood Study. The 1% AEP flood level at Nabiac is about 0.4m higher than the 1985 estimate, and the 1% AEP flood levels at Failford is about 0.2m higher than the 1985 estimate. The revised 1% AEP flood level estimates in the Nabiac area are reasonably consistent with 1927 flood level records in the area.


MIKE-11 MODEL CROSS-SECTIONS
Figure B1
N
SOUTH PACIFIC OCEAN
Tuncurry Beach
TUNCURRY
RIVER
CHAPMANS ROAD
WALLAMBA
Millers Mistake Creek
DARAWANK
Darawakh Creek
FAILFORD
Bungwahl Ck
RIVER
Disused Airfield
HIGHWAY
Pipeclay Creek
NABIAC
Nabiac Bridge
Pacific
Creek
Nabiac
Creek
Dargavilles Crossing
WALLAMBA
Bungacree
To Bulahdelah
19.1
15.5
14.3
13.3
11.8
10.5
8.8
6.4
5.4
4.0
2.8
2.3
1.4
0.8
22.85
LEGEND:
6.4 Model Cross-Section & Chainage (km)
Q ⇨ Inflow Hydrograph
WL ⇨ Water Level Boundary
APPROXIMATE SCALE
1 0 1 2 3 4 5km

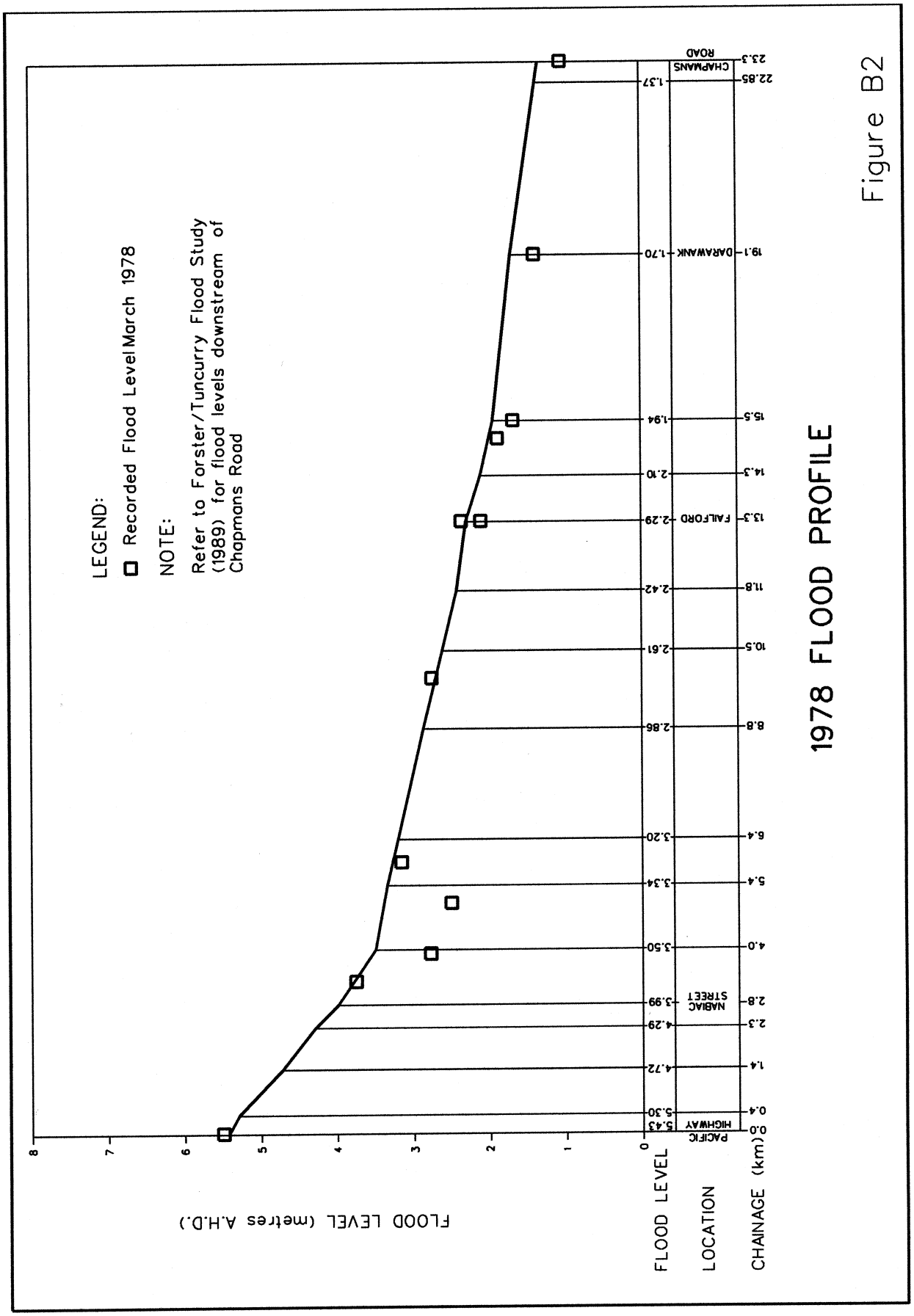

1978 FLOOD PROFILE
LEGEND:
Recorded Flood Level March 1978
NOTE:
Refer to Forster/Tuncurry Flood Study (1989) for flood levels downstream of Chapmans Road
FLOOD LEVEL (metres A.H.D.)
FLOOD LEVEL
LOCATION
CHAINAGE (km)
PACIFIC HIGHWAY
NABIAC STREET
FAILFORD
DARAWANK
CHAPMANS ROAD
5.43
5.30
4.72
4.29
3.99
3.50
3.34
3.20
2.86
2.61
2.42
2.29
2.10
1.94
1.70
1.37
0.0
0.4
1.4
2.3
2.8
4.0
5.4
6.4
8.8
10.5
11.8
13.3
14.3
15.5
19.1
22.85
23.3

Figure B2

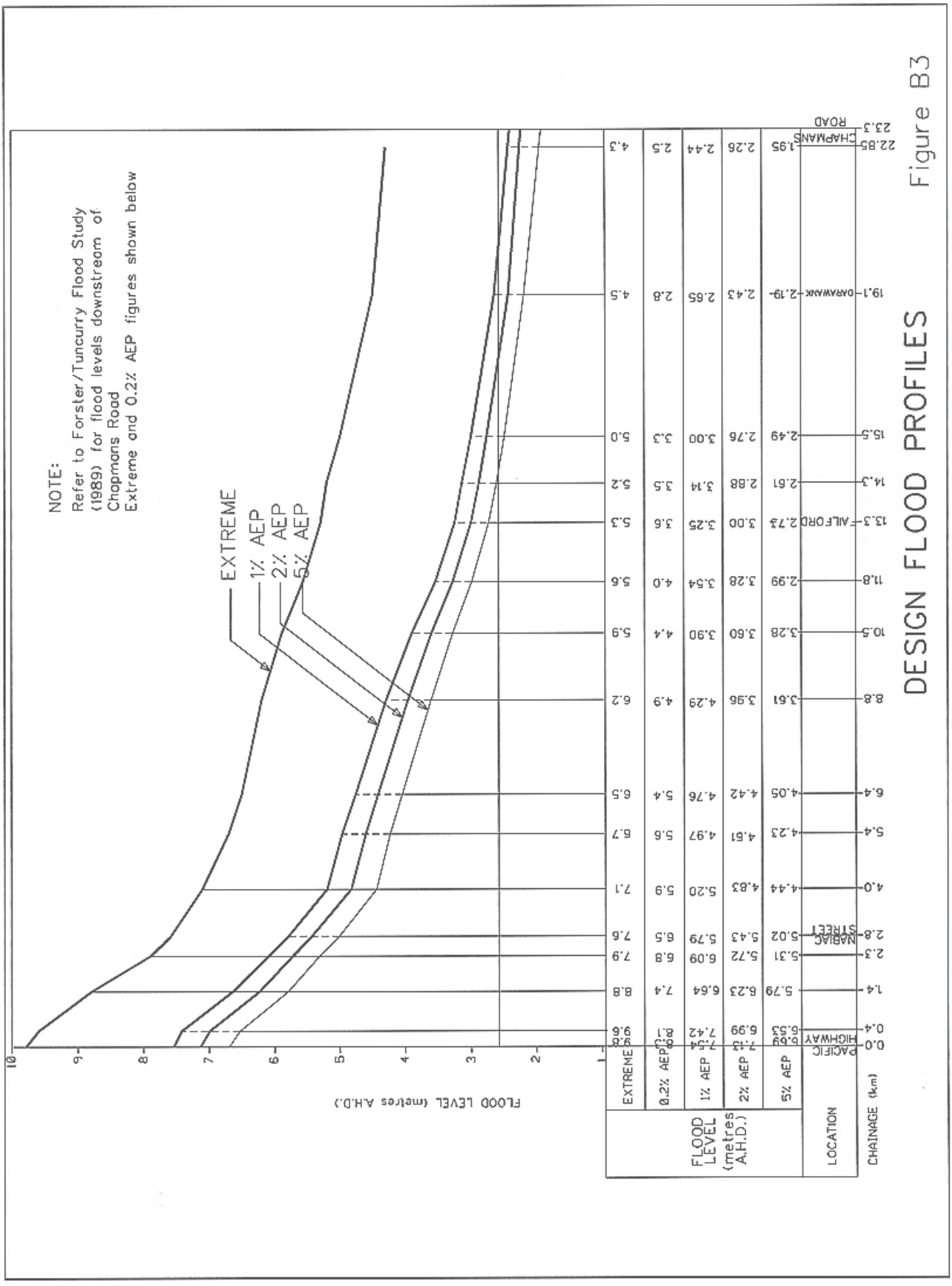

DESIGN FLOOD PROFILES
NOTE:
Refer to Forster/Tuncurry Flood Study (1989) for flood levels downstream of Chapmans Road
Extreme and 0.2% AEP figures shown below
EXTREME
1% AEP
2% AEP
5% AEP
FLOOD LEVEL (metres A.H.D.)
LOCATION
CHAINAGE (km)
EXTREME
0.2% AEP
1% AEP
2% AEP
5% AEP
PACIFIC HIGHWAY
NABIAC STREET
DARAWANK
ALLFORD
CHAPMANS ROAD

Figure B3

The principal factor contributing to the higher design flood levels is the increase in catchment runoff magnitudes resulting from the rainfall temporal patterns in Australian Rainfall and Runoff (1987). The temporal pattern for the 36 hour duration storm is a relatively severe pattern and the use of this pattern leads to substantially higher values of discharge than the values obtained using the previous edition of Australian Rainfall and Runoff (published in 1977).

B.7 FLOOD DAMAGES

Flood damages were estimated for the properties inundated above floor level in the 1% AEP flood. The basis for the assessment of flood damages is outlined in Appendix B. The estimated total damages are given in Table B.5.

Table B.5 Flood Damages in the 1% AEP Flood Event

1% AEP Flood Damage	Average Annual Damage Excluding Extreme Event	Average Annual Damage Including Extreme Event
$485,000	$12,300	$35,000

The above estimates indicate that the total economic losses due to flooding from the Wallamba River in the developed areas of Nabiac, Failford and Minimbah will be relatively low. A significant proportion of damage will occur in events in excess of the 1% AEP flood event.

B.8 HYDRAULIC CATEGORIES

There are three hydraulic categories of flood liable land:

- Floodways - areas where a significant volume of water flows during floods. They are areas, which if partially or fully blocked have a significant impact on flood behaviour.
- Flood storage - areas that are important for the temporary storage of floodwaters during the passage of a flood. Complete filling of flood storage areas would generally cause significant increases in peak flood levels and/or peak discharges.
- Flood fringe - the remaining areas of land affected by flooding. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

Nabiac

The main channel and parts of the adjacent low lying floodplain of the Wallamba River can be considered a floodway. Overbank areas in Nabiac township which are subject to inundation in the 1% AEP event can generally be considered as flood fringe areas.

Failford and Minimbah

Floodway areas in the vicinity of Failford and Minimbah may extend to include low lying land near the banks of the Wallamba River as well as the main river channel. Most of the overbank areas can be considered as flood fringe or flood storage areas.

B.9 HAZARD CATEGORIES

The flood hazard is a measure of the risk to individuals and property resulting from the effects of flooding. The flood hazard applying to a particular area is dependent upon the following factors:

- Depth and velocity of floodwaters;
- Effective evacuation time; and

- Evacuation difficulties, including isolation of some areas as floodwaters rise.

The preliminary determination of the flood hazard category is based on the hydraulic conditions. However, where hydraulic conditions are not dominant, provision is made for the consideration of other significant factors such as warning time, flood awareness, the rate of rise of floodwaters, evacuation difficulties and access problems.

In low hazard areas, people and their possessions would generally be evacuated from houses progressively as the floodwater level rises to the floor level. Able-bodied adults would have little difficulty in wading, and the damage potential and the risk to life and limb would be low.

In high hazard areas, the evacuation of flood affected people and their possessions may be difficult and potentially dangerous. There could be danger to life and limb, and social disruption and financial loss could be high.

Nabiac

The area of Nabiac township inundated in the 1% AEP event by Wallamba River will flood due to overflow of the back of the river and backup of local creeks, with indicative extent as shown in Figure 4. High hazard areas will only exist in the vicinity of the Wallamba River and creek channels.

The land where inundation depths are sufficient to create high hazard conditions is currently open space. The hazard will generally be low in developed areas which will be affected by overflow and backup in the 1% AEP event.

Streets which will serve as evacuation routes in the 1% AEP event will generally experience limited or no inundation during that event. The greatest depths of inundation will occur near the east end of Wharf Street, where the depth will be about 1.0m, and on Nabiac Street east of Clarkson Street, where the depth will be about 0.5m. With the flood warning system in place and an appropriate flood emergency response plan, this area can be considered to remain low hazard.

Failford and Minimbah

Floodplain areas close to the river at Failford can be considered as high hazard areas due to flow depth and velocity. Areas near the edge of the floodplain can be considered low hazard where inundation depths are low and where evacuation to Failford Road can readily be achieved. Areas adjacent to Willow Point Road are considered high hazard due to water depths and the potential need to evacuate along this road which is close to the river bank.

Some areas of Minimbah could also be considered high hazard, given the likely flow depths and velocities, however, insufficient information is available to determine the extents of flooding or hazards in this area. It is noted that the water depths over the Glen Ora Road, the main road into and out of this area, can be up to 4m in 1% AEP event and 5.5m in an extreme flood event, based upon available survey. This means that this road would be cut off early in a flood event and that Minimbah area would therefore need to be evacuated early in a flood event as it will be isolated and ultimately inundated. Without effective evacuation access and an effective emergency management plan the flood situation in the whole of Minimbah could be considered high hazard.

APPENDIX C - ASSESSMENT OF FLOOD DAMAGES

C.1 GENERAL

Damages will be incurred to urban properties in the Nabiac and Failford areas during major flood events. Flood damages can be divided into two major categories (Reference 7):

- Tangible damages, are the financial costs of flooding and are quantified in dollar terms; and
- Intangible damages, the social costs of flooding reflected in increased levels of mental stress, physical illness, etc.
- Tangible damages can be subdivided into two major sub-categories:
- Direct damage, is loss in value of property caused by direct contact with floodwaters; and
- Indirect damage, is production or revenue loss, wages loss, additional accommodation and living expenses and any other extra outlays that occur as a consequence of the flood.

Potential damage refers to the damage that would be sustained if nothing was done to attempt to reduce this damage. The actual damage is always less than the potential damage. Even in the absence of flood warnings, people will attempt to save items by lifting them, by shifting cars, etc. Estimates of actual damage were derived for Nabiac and Failford assuming no official flood warnings.

C.2 DEPTH-DAMAGE RELATIONSHIPS

The damages are related primarily to the depth of inundation. Estimates of actual flood damage at Nabiac and Failford were derived using depth-damage relationships based on information provided in the User Manual for the computer program FLDAMAGE (Reference 7). This information takes account of damage data obtained from the most recent large floods in New South Wales including floods at Nyngan and Forbes in 1990, and Inverell in 1991.

The depth-damage relationship for inundation of properties above floor level includes the following components of direct and indirect damage:

- Internal damage, which refers to damage to the contents of the building on the property;
- Structural damage, which refers to damage sustained by the fabric of the building (eg foundations, floors and walls) and by permanent fixtures such as built-in cupboards;
- Clean-up costs, which refer to the cost of labour and materials required to clean out a flooded building; and
- Indirect financial costs such as the cost of alternative accommodation in the post flood recovery phase.

The adopted depth-damage relationship for residential buildings is given in Table C.1. Depth-damage relationships were also defined for external damage which refers to damage to items external to the main building such as motor vehicles, fences and gardens. The adopted relationship for residential properties is given in Table C.2.

There are a several non-residential properties which will be inundated above floor level in the 1% AEP flood at Nabiac and Failford. The depth-damage relationships for these properties were based on the medium damage commercial category as defined in the FLDAMAGE User Manual, with an average floor area of $100m^2$. The adopted relationships for above floor damages and external damages for non-residential properties are given in Table C.3.

C.3 ESTIMATION OF TOTAL DAMAGES

Total damages were calculated for the extreme floods and floods of 1%, 2% and 5% AEP using the floor and ground levels from a property survey supplied by Council. A curve of total damage versus probability was determined, assuming zero damage for the 10% AEP flood with the area under this curve represents average annual damage.

The estimation of total damages and average annual damage was carried out for:

- Existing conditions
- Selected floodplain risk management options

For floodplain risk management options, the benefit is the reduction in damages compared with existing conditions. The present worth of benefits was calculated by multiplying the average annual benefit by a present worth factor of 15.8, based on a discount rate of 6% per annum and an analysis period of 50 years.

Table C.1 Above Floor Damage Values for Residential Properties

Depth of Flooding Above Floor Level (m)	Estimated Damage ($)
0	1,800
0.1	9,400
0.2	13,600
0.25	24,600
0.4	29,800
0.6	35,200
0.9	40,200
1.2	42,000
1.6	43,600
2.0 or more	45,400

Table C.2 External Damage Values for Residential Properties

Depth of Flooding Above Ground Level (m)	Estimated Damage ($)
0	0
0.2	1,500
0.25	2,000
>4	3,700