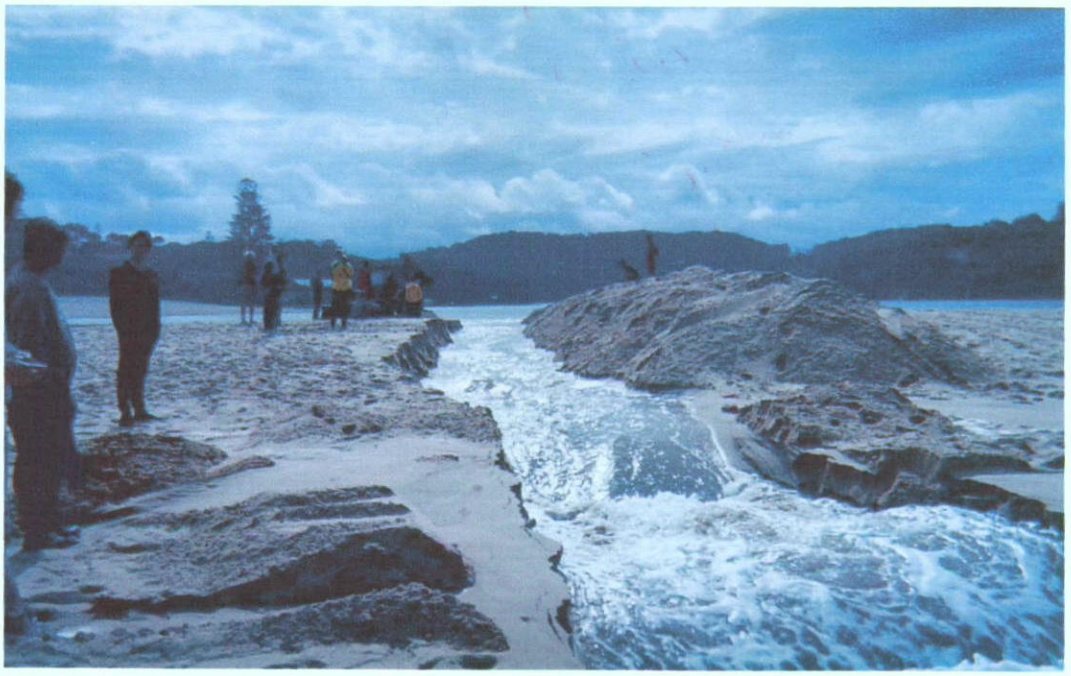
GOSFORD CITY COUNCIL

WAMBERAL LAGOON
FLOODPLAIN MANAGEMENT PLAN



NOVEMBER 2001

WEBB, McKEOWN & ASSOCIATES PTY LTD

GOSFORD CITY COUNCIL

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FOREWORD

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

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

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

1. *Flood Study*
   - determines the nature and extent of the flood problem.
2. *Floodplain Management Study*
   - evaluates management options for the floodplain in respect of both existing and proposed development.
3. *Floodplain Management Plan*
   - involves formal adoption by Council of a plan of management for the floodplain.
4. *Implementation of the Plan*
   - implementation of flood mitigation works and measures to protect existing development,
   - use of development controls and planning measures to ensure new development is compatible with the flood hazard,
   - amendments to relevant Local Environmental Plans to reflect Council's flood policy and development controls.

The Wamberal Lagoon Floodplain Management Plan constitutes the third stage of the management process for Wamberal Lagoon and its catchment area. This study has been prepared for Gosford City Council by Webb, McKeown & Associates and provides the basis for the future management of flood prone lands adjacent to Wamberal Lagoon.

This Plan was largely undertaken in accordance with the NSW Government's 1986 Floodplain Development Manual. This manual was superseded by the Floodplain Management Manual which was introduced in January 2001 when this report was nearing completion. The terminology and approach used in this present report largely relate to the 1986 manual. In some places the updated terminology has been introduced, and carried through to the Plan.

SUMMARY

Wamberal Lagoon has a catchment area of approximately 6.6 square kilometres, the majority of which lies within the boundaries of Gosford City Council. The remainder lies within the boundaries of Wyong Council. The area of the lagoon is approximately 0.5 square kilometres. Flooding of roads and residential areas within the catchment has occurred on a number of occasions in the last 20 years.

In the Wamberal Lagoon Flood Study (Stage 1 of the floodplain management process) a WBNM hydrologic model and a RUBICON hydraulic model were established and used to determine the design flood levels in the lagoon and adjoining floodplain. The design flood levels are a combination of rainfall induced and ocean induced inundation. The Wamberal Lagoon Floodplain Management Study (Stage 2 of the management process) used the design flood levels determined in the Flood Study to define the extent of the existing flood problem within each of the following floodplain management areas (shown on Figure 1).

	Floodplain Management Areas
1.	The lagoon water body
2.	Remembrance Drive
3.	Loxton Avenue
4.	Wamberal Park and Blue Bell Drive
5.	Lavinia Street and Malkana Avenue
6.	North Arm (downstream of The Entrance Road)
7.	North Arm (upstream of The Entrance Road)
8.	Upstream Catchments

Approximately eight buildings would be inundated above floor level in a 1% AEP rainfall induced event. Three are in Remembrance Drive and five at Lavinia Street/Malkana Avenue. A range of floodplain management measures were canvassed to mitigate the effects of rainfall induced inundation. In addition a range of development options were evaluated and criteria for future development of the catchment defined. The effects of ocean induced inundation cannot be realistically mitigated.

Following detailed consideration of the social, economic, environmental and hydraulic factors it was concluded that protection would not be provided to all buildings inundated above floor level in the 1% AEP rainfall induced event. Apart from the high cost of mitigation works and the likely social impact, the main reasons for this are that Council is not preventing further development or redevelopment in these areas, the area is low hazard with relatively easy access to high ground and in time redevelopment will reduce the number of affected buildings.

This Floodplain Management Plan represents Stage 3 of the floodplain management process and provides an overall plan of management for the floodplain. It incorporates the principles of Rivercare and Ecologically Sustainable Development as well as the results of recent estuarine and coastal studies. This Plan incorporates a range of floodplain management measures to provide the optimal degree of protection within the constraints of practicability and cost effectiveness. Some components of the Plan apply to the whole floodplain within the study area while others relate to the specific areas.

Floods larger than the 1% AEP will occur and these floods should be considered in assessing access to new developments and in developing local emergency plans. Notable recent examples of historical floods larger than the 1% AEP in NSW are Dapto in 1984, Coffs Harbour in 1996 and North Wollongong in 1998.

An indicative cost to Council for implementation of the Wamberal Lagoon Floodplain Management Plan is $8 000 per annum (some components have not been costed). The net present worth of the reduction in flood damages cannot be accurately quantified for all the proposed works as many of them do not result in a tangible benefit. Intangible flood damages (anxiety, flood hazard, etc.) will also be reduced, and would therefore increase the benefit/cost ratio if quantified.

The key features of the Plan are:

- the 1% AEP flood was adopted as the Flood Standard in the Floodplain Management Study. This term has now been superseded with the introduction of the 2001 Floodplain Management Manual and the Flood Planning Level (or the **minimum** floor level for buildings) adopted as the 1% AEP level plus 0.5 m. As noted above, larger floods will occur and it is recommended that, if possible, floors are raised above this minimum requirement,
- definition of the 1% AEP and 1% AEP + 0.5 m flood extents and identification of properties subject to minimum floor level requirements,
- criteria for the future development of the upper catchment determined. These will ensure that the volume of runoff and peak flows are not increased significantly downstream and the impact on water quality and sedimentation is minimised,
- Council will implement a procedure for increased maintenance at the entrance and a more formal system of opening the entrance. The objective will be to ensure that the beach berm is maintained at a maximum of 2.6 mAHD,
- a priority listing of floodplain management measures for the overall catchment (Table 1),
- seven separate floodplain management areas were defined (Table 2) and a priority listing of floodplain management measures developed (Table 3). The eighth area - Upstream Catchments, has not been examined in detail as part of this Plan. However, controls on the development of land within this area have been included,
- limited filling of the floodplain surrounding the lagoon will be permitted subject to adherence to Council's guidelines,
- Council will provide information and education to the local residents in order to ensure that flood damages in the future are minimised,

- further data are to be collected and studies conducted to increase our understanding of the system behaviour and improve the accuracy of the design flood levels,
- the possible impact of the Greenhouse Effect will be monitored and works and measures undertaken if required,
- Council supports any measures undertaken by public authorities which will increase the amount of flood warning time available to the residents,
- Council will introduce design standards and provide advice to new developments regarding the effects of ocean inundation,
- floods up to the Extreme Flood (or event of unknown AEP greater than the 1% AEP and less than the PMF) have been considered.

Table 1: Measures which Apply to the Entire Study Area

Measures	Comment	Cost	Benefit/Cost Ratio	Priority
Amend S149 Planning Certificate Database	Council will update the S149 Planning Certificate database to include the latest information regarding flooding.	Undertaken by Council	Not quantifiable	High
Provide Information/Education	Will ensure future damages are minimised (examples provided in Appendix B).	$2000 p.a.	High (not quantifiable)	High
Design Floor Level Policy	Floor levels of all new residential buildings are to be at a minimum of 0.5 m above the 1% AEP flood level.	Undertaken by the Developer	Not quantifiable	High
Limit Increase in Density of Development on the Floodplain	Dual occupancies, granny flats, subdivision or medium density use would increase the number of residents on the floodplain and thus the number of people at risk.	Nil	Nil	High
Flood Warning and Evacuation	The Local Emergency Management Committees are to review and update their procedures based on the information provided in this study.	Low	High	Medium
Review Flood Policy	A number of issues have been raised in the Floodplain Management Study. These will be reviewed and if appropriate the Flood Policy and LEP revised.	Undertaken by Council	Not quantifiable	Medium
Collect more Data	Install and maintain additional water level recorders. The data from future floods should be collected and analysed to increase understanding of the system behaviour and ensure accuracy of the design flood levels.	$1000 p.a.	Nil	Medium
Alterations to the Floodplain	Council will ensure that the effects of alterations to the floodplain (such as filling, fencing, buildings) are considered during the approvals process (to be documented in the Flood Policy). Generally fill up to 0.2 m above the let out level and for building pads will be permitted.	Undertaken by Council	Nil	Medium
Incorporate Floodplain Management Plan within the Integrated Planning Framework	This Plan should be adequately incorporated into Council's land use planning process.	Undertaken by Council	Nil	Medium
Greenhouse Effect	Council will prepare a bi-annual report outlining the current state of knowledge and potential impacts upon flooding. If appropriate the Flood Policy will be amended.	Undertaken by Council	Nil	Low
Catchment Treatment	Will not reduce the existing flood problem. Advice can be provided by Council to ensure that future works do not exacerbate the flood problem.	Undertaken by the Developer	Low	Low
On-Site Detention	The use of OSD to control increases in flows on small creeks and drains, as well as limit water quality degradation, is supported where it can be applied in a cost effective manner.	Undertaken by the Developer	Nil	Low
Impact of Flooding on Flora and Fauna and the Ecological Regime of the Lagoon	Council is to review relevant local information as it becomes available.	Undertaken by Council	Nil	Low
Maintenance of Creek System	Council will review their maintenance program to address the issues raised.	Undertaken by Council	Nil	Low
Hazard Reduction at Road Crossings	Council will liaise with the relevant authorities regarding a reduction in flood hazard at all road crossings. This may include provision of depth indicators.	Unknown	Not quantifiable	Low
House Raising	No catchment wide system is proposed but if applications are made these will be processed.	Approximately $40 000 per house	Low	Low

Table 2: Floodplain Management Areas

Area (excluding Area 8)	No. of Buildings Inundated Above Floor * Level in the		1% AEP Flood Level (mAHD)	Property Type	Hazard Rating at the 1% AEP Level
	1% AEP Flood	20% AEP Flood			
1. The lagoon water body	nil	nil	3.1 to 3.8 (3.1 - rainfall) (3.8 - ocean)	Water	High
2. Remembrance Drive	3	nil	3.6 to 3.8 (ocean induced)	Residential	Low but High for ocean inundation
3. Loxton Avenue	nil	nil	3.1	Residential	Low
4. Wamberal Park and Blue Bell Drive	nil	nil	3.1	Residential	Low
5. Lavinia Street and Malkana Avenue	5	1	3.1 to 4.2	Residential	Low
6. North Arm (downstream of The Entrance Road)	nil	nil	3.1 to 7.0	Open Space	High in floodway Low elsewhere
7. North Arm (upstream of The Entrance Road)	nil	nil	4.2 to 8.8	New residential development and open space	High in floodway Low elsewhere
	8	1			

* Based upon the flood levels prior to introduction of Council's proposed entrance management policy. Appendix B of the Floodplain Management Study lists the surveyed floor levels.

Table 3: Measures for each Floodplain Management Area

Area	Measure	Cost	Benefit/Cost Ratio	Priority
1. The lagoon water body	Implementation of an entrance management policy (Appendix A).	$5,000 p.a.	approx. 0.8	High
2. Remembrance Drive	Ocean inundation effects are to be addressed by a qualified engineer experienced in coastal matters.	Borne by the Developer	Unknown	High
	Special design provisions regarding ocean inundation.	Borne by the Developer	Unknown	High
	Review of local drainage problem.	Provided by Council	n/a	Low
3. Loxton Avenue	Monitor the local drainage situation.	Provided by Council	n/a	Low
4. Wamberal Park and Blue Bell Drive	A local drainage study will be programmed in Council's Forward Plan of Works.	Provided by Council	Unknown	Low
5. Lavinia Street and Malkana Avenue	A local drainage study will be programmed in Council's Forward Plan of Works.	Provided by Council	Unknown	Low
6. North Arm (downstream of The Entrance Road)	None	n/a	n/a	n/a
7. North Arm (upstream of The Entrance Road)	Undertake hydraulic investigations for all future development.	Borne by the Developer	n/a	High
	Flood free access along The Entrance Road.	At this stage all costs will be borne by Council.	n/a	Low
8. Upstream Catchments	Development will be considered in the upstream catchments subject to detailed evaluation of the possible impacts on water quantity and water quantity	n/a	n/a	High
	Total Cost	**$5 000p.a.**		

Artificial Opening of
Wamberal Lagoon
1st July 1994

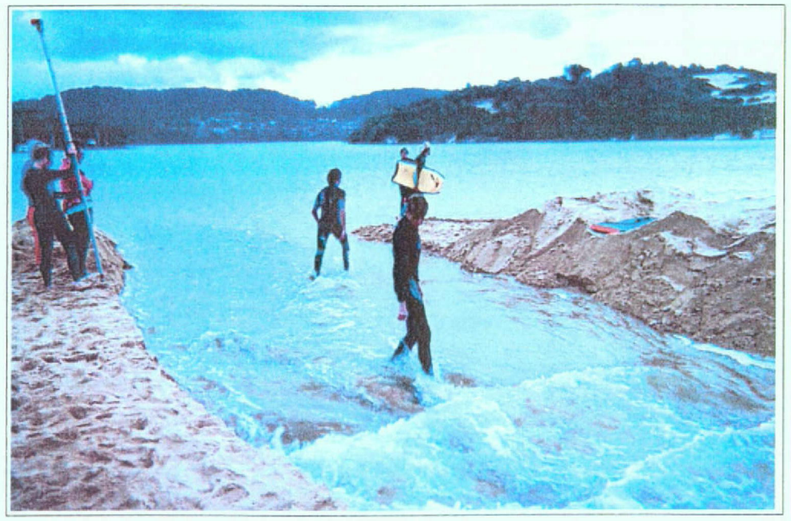
A bulldozer excavates a channel.

The start of runoff entering the ocean.

The channel quickly widens and deepens.


Approx. 2pm


Artificial Opening of
Wamberal Lagoon
13th September 1993




Approx. 5pm

GLOSSARY

Taken from the 2001 Floodplain Management Manual

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 (see average recurrence interval).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
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).
Flood	Relatively high streamflow 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.
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.
Flood Fringe Area	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 (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land now covers the whole of the floodplain, not just that part below the flood planning level, as indicated in the 1986 Floodplain Development Manual (see flood planning area).
Flood Planning Area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the "flood liable land" concept in the 1986 Floodplain Development Manual.

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 the NSW Government's Floodplain 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 (PMF) event. Flood prone land is synonymous with flood liable land.
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 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 as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change. Freeboard is included in flood planning levels.
Hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
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.
Local Overland Flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
Local Drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
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 streamflow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, streamflow and the distribution of flows across the floodplain.
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.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.

WAMBERAL LAGOON
FLOODPLAIN MANAGEMENT PLAN

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GENERAL MEASURES FOR THE FLOODPLAIN

Proposed floodplain management measures applicable to all flood prone lands within the study area are discussed below and listed in Table 1.

Amend S149 Planning Certificate Database

Council will ensure that all S149 planning certificates are issued in accordance with the design flood level data contained in the Flood Study (as amended to take into account the Entrance Management Policy - Appendix A).

The notification will include all properties with land inundated in the 1% AEP flood + 0.5 m (Flood Planning Level). Council will amend the notification if the resident can provide information from a Registered Surveyor to show that the land is above the designated level. Council will also consider notifying all flood prone landowners (up to the PMF, or Extreme flood if the PMF is not known) advising them that their property is flood prone. If additional flood or ground level data become available these will be used to update the database where appropriate. Council will review the extent of land affected after any works (filling) that might change the design flood level.

Provide Information/Education

Providing information and education to floodplain users has been shown to reduce damages and the risk to life. The costs and resulting benefits are difficult to quantify, however it is generally accepted that these measures have a benefit/cost ratio greater than one. The cost to provide a notice with Council rates is $2000 per annum.

The ways and means of disseminating information should be documented by Council. Examples of the possible types of procedures are provided in Appendix B and the established database of flood affected owners can be used to distribute material. It is proposed that Council and the relevant State Government authorities will be involved.

Design Floor Level Policy

All future residential floor levels will be a **minimum** of 0.5 m above the 1% AEP flood level. The freeboard (0.5 m) is to allow for wave action, local hydraulic effects and uncertainties in the understanding of flood behaviour. At this time the freeboard does not include an allowance for a possible rise in flood levels due to the Greenhouse Effect. Council is to monitor the available information and advice from the relevant bodies. Consideration will be given to increasing the freeboard if predictions for a sea level rise are verified. Larger floods than the 1% AEP will occur and if possible a higher floor level should be adopted. This policy will ensure that all future residential buildings do not experience above floor inundation in a 1% AEP event. Design floor level requirements for extensions to existing residential developments will be considered on their merits. Proposed non-habitable residential floor levels, such as laundries or garages, below the 1% AEP flood level + 0.5 m will be assessed on their merits.

There will be an additional cost to developers to implement this measure but it is considered that this will be outweighed by the elimination of most future tangible flood damages up to the 1% AEP flood level.

The design floor level requirement for residential buildings is to be specified by Council in Australian Height Datum to the nearest 0.1 m.

Council will review its requirements for non-residential buildings as it is not always economic, practical or necessary to construct these above the 1% AEP level. The adopted policy should be documented by Council.

Limit Increase in Density of Development on the Floodplain

An increase in the density of development on the floodplain (dual occupancies, granny flats, subdivisions, medium density) will increase the number of residents "at risk" during a flood. This will place additional strain on the emergency services which cannot be justified.

Flood Warning and Evacuation

Flood warning can provide sufficient time for residents to minimise flood damages and risk to life. The more warning time available the greater the benefit. There is no specific flood warning system for Wamberal Lagoon and such a system could not be justified because of the short response time of the catchments. Council supports the continued investigation of the "Ready-Set-Go" or any other such state or local flood warning procedure and will supply any information which will assist in this regard.

The Local Emergency Management Committee's Local Disaster Plan (Flood Sub-Plan) is to be reviewed and updated to include the latest information on design flood levels and roads, houses and other facilities which will be flood affected.

Revise Flood Policy

Council will review its Flood Policy in the light of the findings of the Floodplain Management Study. The main issues include:

- design floor level policy (discussed previously),
- floor levels for extensions,
- floor levels for non-habitable residential rooms,
- flood evacuation plans,
- controls on fencing, garages and other minor structures which affect the free flow of runoff across the site,
- controls on filling on the floodplain (discussed in later paragraph).

Collect More Data

The understanding of flood behaviour relies heavily on information obtained from previous floods. To date in the study area this has largely come from people's recollections and from debris marks

picked up after the event and Council's record book. There are several pluviometers within or near to the catchment and these provide an adequate definition of the rainfall but there is a need to better define future flood levels.

An automatic height recorder and a maximum height recorder (MHR) are located near the mouth of the lagoon and there is another MHR on Malkana Avenue. These need to be complemented by other recording sites to obtain an adequate profile along the creeks. It is proposed that Council and/or other public authorities install and maintain additional flood monitoring equipment. The most cost-effective procedure is to install approximately 3 maximum height recorders located at regular intervals along the system. These are relatively inexpensive and easy to install and maintain. An indicative cost of the program is $1000 per annum.

Following a future flood the data should be evaluated and used (if appropriate) to adjust design flood levels. A Post Flood Evaluation and Review Program is presented in Appendix C.

Alterations to the Floodplain

Filling or other works on the floodplain can affect flood levels. Filling below the let-out level of 2.4 mAHD will result in minimal loss of temporary floodplain storage and for this reason is permitted subject to environmental considerations. In order to allow these low lying properties to adequately drain when the water level is near the let-out level, filling will be permitted to a level of 0.2 m above the let-out level.

Filling apart from that described above is not recommended. However, it may be permitted if the proponent provides plans which satisfy the following requirements:

- a cut and fill approach is preferred whereby there is no reduction in the temporary floodplain storage capacity,
- the fill does not impact upon environmentally sensitive areas,
- the fill does not affect the pattern of local runoff and/or divert flow elsewhere,
- the filling is not within a defined floodway,
- modification of the foreshore is not permitted,
- the filling does not act as a levee, i.e. the loss of floodplain storage volume is not greater than the volume of the fill. Filling to construct a levee will require a detailed hydraulic investigation,
- any large scale filling project (greater than 1000 m^3) will require a detailed hydraulic investigation and will be treated on its merits taking into account the cumulative effects from all developments,
- there is suitable justification for the importation of fill. For example fill to raise the floor level will generally be permitted under the floor area of the building, including the garage and laundry,
- the batter slopes should not be flatter than 1 vertical to 6 horizontal,
- minor importation of fill for landscaping or such like is acceptable and does not require Council approval,

- filling will generally not be permitted if it is to be used to increase the density of residential development or on an access road. The latter will only be considered if it results in flood free access (1% AEP event) to the main road and beyond.

Council should carefully record, monitor and control future development on the floodplain and request that the proponent (including Council or any public authority) submit appropriate technical information on the hydraulic and environmental impacts of the proposal. Detailed consideration must be given on the possible impacts on local runoff and flow paths. Any proposed development in a Floodway will require a rigorous hydraulic investigation. Council has copies of the hydrologic and hydraulic models used in the Flood Studies and where possible these should be utilised to evaluate potential impacts. Council will monitor the cumulative effects of filling and development on the floodplain and the possible impact on the frequency of lagoon openings. There is no cost to Council from this policy.

Integrated Planning

The Floodplain Management Plan should be incorporated into the land use planning process. Specific recommendations include:

- Development control and approval policies relating to flood prone land should refer to the Plan as a matter to be taken into consideration when determining applications under the Environmental Planning and Assessment Act 1979 and the Local Government Act 1974,
- the Plan should be considered when preparing Management Plans for community land as required under the Local Government Act 1979.

Council should also consider its policy with regard to flood prone land above the Flood Planning Level.

Greenhouse Effect

There is concern that the increasing amounts of greenhouse gases in the atmosphere may be raising the average earth surface temperature. As a consequence, this may affect the climate, the mean sea level and the entrance conditions.

The impact of a Greenhouse induced sea level rise on the estimated floor levels is discussed in Section 6.4.4 of the Floodplain Management Study. The best estimate of the projected sea level rise by the year 2050 is 0.2 m with a range between 0.07 to 0.39 m. A rise in sea level of say 0.3 m in the absence of a change in the design beach berm level would be unlikely to impact on the 1% AEP level in the lagoon. However, a rise in sea level may translate to a similar rise in the beach berm level. If this was to occur there would be a corresponding rise in the 1% AEP design flood level (rainfall induced). This would impact on development around the lagoon foreshore unless the beach berm could be lowered. This would require Council to implement an "entrance opening" procedure similar to that adopted for Terrigal Lagoon.

Under the present policy floor levels are required to be 0.5 m above the 1% AEP flood. A small increase in the flood levels due to Greenhouse could be accommodated in the present 0.5 m freeboard. However, if the sea level continued to rise as predicted over the next fifty years then at some point in time consideration would need to be given to including an additional "Greenhouse" freeboard allowance. Alternatively, a freeboard allowance of say 0.2 or 0.3 m in addition to the present freeboard of 0.5 m could be considered in anticipation of any predicted sea level rise.

Rather than increase the freeboard allowance at this stage Council is to monitor the available information and advice from expert bodies and prepare a bi-annual summary report. The Flood Policy should be revised in light of this information. Any future change in policy would particularly apply to the areas near the lagoon entrance. This review will be carried out by Council officers and has not been costed. Consideration should be given to including an additional "Greenhouse" freeboard allowance of say 0.3 m.

Catchment Treatment

Developments over a catchment have the potential to increase runoff and flood levels downstream as well as sedimentation, erosion and water quality problems. Council should ensure that, as far as possible, future development in the catchment occurs in a manner which will minimise the increase in runoff and affectation on water quality, sedimentation and other processes.

On-Site Detention

Council may impose on-site stormwater detention and retention (OSD) requirements on land which is being developed or redeveloped. This policy ensures that future development will not increase flood levels downstream. The policy will not reduce existing flooding or drainage problems.

Impact of Flooding on Flora, Fauna and the Ecological Regime of the Lagoon

There is concern in the community that management (or not) of the lagoon entrance is detrimental to the flora and fauna. Council should monitor the situation and review any relevant information as it becomes available.

Maintenance of Creek System

Council will review its maintenance program in the light of issues raised in this study. Attention will be given to clearing culverts, drainage lines and inlet pits and controlling noxious vegetation.

Hazard Reduction at Road Crossings

The potential high hazard at the road crossings cannot be addressed immediately by structural means because of the high costs involved. In the interim Council will review signposting. The hazards will also be highlighted in educational material.

House Raising

Council supports the use of house raising to reduce flood damages. However, because of the large number of houses involved within the floodplain of the four coastal lagoons (Wamberal, Terrigal, Avoca and Cochrane) and the fact that very few houses have been inundated in the last 20 years or so, a catchment-wide raising policy is not proposed. Should residents wish to make an application for State or Federal funding of their works this will be considered by Council and forwarded to the appropriate authorities. Preliminary investigation indicates that only three of the eight houses inundated in the 1% AEP event are suitable for raising. None would provide a benefit/cost ratio greater than 0.2.

AREA 1: THE LAGOON WATER BODY

1.1 Description of the Problem

This area covers approximately 60 hectares and includes the areal extent of the lagoon at normal water level (say 1.5 mAHD) and the Wamberal Lagoon Nature Reserve. As there are clearly no buildings and no proposals for future development within this area there are no flooding problems. The major issues in this area are water quality, sedimentation, visual quality and the possible impacts of development, including dredging and recreational usage. Part of the Nature Reserve is designated as SEPP. 14 Wetland Nos. 909 and 907.

The lagoon is classified as high hazard floodway.

1.2 Discussion

The peak flood levels in the lagoon are influenced by a number of factors relating to rainfall, ocean conditions and entrance berm conditions. The berm conditions at the outlet and in particular the height of the berm are the dominant factors. The entrance is normally closed but opens naturally or as a result of Council intervention following heavy rain. Council has a policy (since the 1970's) of lowering the entrance berm and initiating lagoon openings to limit the extent of inundation. In summary it says that Council will employ an excavator to "open" the entrance when the lagoon level reaches the let-out level (2.4 mAHD). Council generally does not monitor the build up of sand at the berm. However if heavy rain is forecast an excavator may be employed to lower the berm to near the let-out level.

The Greenhouse Effect has the potential to impact upon the design flood levels by elevating ocean levels and raising the long term berm level. Flood levels (rainfall induced) will rise if the design berm level rises in response to the Greenhouse Effect.

Reducing the impact of ocean inundation is not realistically achievable as it would involve some form of barrier at the entrance. This would increase rainfall induced flood levels and be socially and environmentally unacceptable.

1.3 Description of the Proposal

It is proposed that Council will introduce a more formal policy for maintaining and opening the entrance berm. This will include:

- introducing an entrance opening/maintenance procedure to be adhered to by Council's overseers,
- ensuring that the berm is generally maintained at 2.7 mAHD or below,
- maintaining a comprehensive record of all berm lowerings and openings,
- undertaking further studies to assess the adequacy and efficiency of the adopted opening/maintenance procedure and the accuracy of the design flood levels,

- ensuring that any factors (man-made or natural) which may affect the hydraulics of the opening are adequately monitored,
- consideration should be given to installing a water level rise alarm system to reduce the delay from the time the lagoon reaches the let-out level to the time of the mechanical opening of the lagoon,
- undertaking a bi-annual review of the latest information regarding the Greenhouse Effect and the implications for floodplain management.

1.4 Social, Economic, Environmental and Hydraulic Appraisal

Design flood levels for the lagoon (rainfall induced) were calculated in the Flood Study assuming a berm level of 3.0 mAHD at the time of the event, providing a 1% AEP level of 3.5 mAHD. This level is higher than the "normal" level of the berm and reflects the impact of coastal process during the build up of berm height in a major rainfall event. It is assumed that the berm level at the time of the flood can be reduced to 2.7 mAHD by introduction of Council's improved berm management policy (included as Appendix A). This results in approximately a 0.4 m reduction in the 1% AEP flood level (i.e. to 3.1 mAHD) and 0.2 m in a 10% AEP event (rainfall induced) as shown in the table below.

If the annual cost of monitoring and maintaining the beach berm is (say) $5 000 this provides an indicative benefit/cost ratio of approximately 0.7. The system only benefits flood levels resulting from rainfall induced flooding. The effect on ocean inundation flood levels is difficult to quantify and will have to be monitored. Further research is required in this area. The social and environmental concerns associated with this measure have been addressed at public meetings and with community groups. Overall the benefits outweigh the disbenefits. However, the system must be continually monitored to ensure that if any issues arise these are quickly addressed.

	Flood Level (mAHD)			
	Rainfall Induced #		Ocean Induced *	
Event	Existing	Proposed	0 m - 200 m upstream of the entrance	200 m - 350 m upstream of the entrance
Extreme	3.7	3.1	Unknown	Unknown
1% AEP	3.5	3.1	3.8	3.6
2% AEP	3.4	3.1	3.7	3.5
5% AEP	3.3	3.1	3.6	3.4
10% AEP	3.3	3.1	3.5	3.3

\# The **Existing** rainfall induced level data were taken from the *Wamberal Lagoon Flood Study - Table 8* and the **Proposed** from the *Wamberal Lagoon Floodplain Management Study - Section 5.2.3.*

* The ocean induced levels were taken from a report titled *The Entrance Dynamics of Wamberal, Terrigal, Avoca and Cockrone Lagoons* produced by Australian Water and Coastal Studies Pty Ltd in November 1994 (refer Figure 11) of the report.

The timing of management activities on the entrance berm will be determined by the weather and coastal conditions. For this reason Council may delay the activities until conditions are safe.

1.5 Concise Description of the Plan

- The beach berm is to be managed in accordance with the Council policy for Wamberal Lagoon (Appendix A). In severe weather conditions management provisions may have to be delayed until conditions are safe.
- The possible impacts of the Greenhouse Effect or other man-made or natural factors which may affect the hydraulics of the opening will be monitored (included under measures applicable to the entire study area - Table 1).

1.6 Priority of Work

Implementation of the berm management system is of high priority due to the relatively small cost and the consequent large reduction in flood level.

AREA 2: REMEMBRANCE DRIVE

2.1 Description of the Problem

There are approximately 14 residential properties in Remembrance Drive fronting the lagoon. The land rises gradually from the lagoon and the houses are located on the slope to capture the views of the lagoon and entrance. The residents all appreciate the aesthetic appeal of the lagoon and are concerned about the quality of the lagoon (pollution, odour). There is minimal risk to life from flooding as all the residents can easily escape to higher ground.

Flooding of the lots from elevated lagoon levels as a result of heavy rainfall and as a result of ocean inundation have occurred in the past. Local flooding causes inconvenience in their front yards and along Remembrance Drive but no above floor inundation.

There are three buildings with floor levels below the existing 1% AEP rainfall induced flood level (floor levels of 3.3, 3.3 and 3.5 mAHD). Reducing the rainfall induced 1% AEP flood level to 3.1 mAHD (refer Section 1.4) will mean that all three buildings in the future will not be inundated above floor level in this event (they will still be inundated in a 1% AEP ocean inundation event).

The area is classified as low hazard flood fringe. There is some pressure for further development and filling within the area.

2.2 Discussion

Remembrance Drive is inundated even in small floods (50% AEP event) resulting from a combination of inadequate local drainage and elevated lagoon levels (refer Section 1.4). The house floors are only inundated as a result of elevated lagoon levels or ocean inundation and are not affected by local drainage. Lowering the lagoon flood levels by introducing an entrance management system (refer Area 1) will eliminate the flood problem for existing development for rainfall induced flooding. House raising is possible for two of the three buildings inundated in the 1% AEP event but will have very low benefit cost ratios (less than 0.1). It is likely that redevelopment of these properties may occur in the future.

Flooding and inconvenience resulting from inadequate local drainage may be alleviated by local drainage works such as minor drains or filling of the land.

2.3 Description of the Proposal

Residents will be informed of the risk of ocean inundation and all new buildings will be designed accordingly.

Council and the local residents will undertake a review of the local drainage problem.

Further filling of the floodplain to provide building pads will be permitted subject to the guidelines provided in the general measures.

2.4 Social, Economic, Environmental and Hydraulic Appraisal

The additional cost to the resident to satisfy the ocean inundation requirements will be borne by the developer as will filling of any properties. The review of the local drainage problem will be undertaken by Council. There are no social, environmental or hydraulic impacts of the proposal.

2.5 Concise Description of the Plan

- The effects of ocean inundation are to be addressed by a qualified engineer experienced in coastal matters.
- All new buildings will be subject to special design provisions to dissipate forces from ocean inundation.
- A review of local drainage works will be undertaken by Council.
- General measures for the floodplain:
    - all new buildings and major extensions to be constructed above the minimum floor level (MFL). This is a minimum requirement and a higher floor level is encouraged (to prevent inundation in floods greater than the adopted standard),
    - raising of all existing buildings with floor levels below the MFL is encouraged,
    - where possible buildings should be constructed on the high part of the property outside the floodplain,
    - filling may be permitted under the plan area of the dwelling and possibly over the remainder of the lot (to 0.2 m above the let out level or higher) subject to the guidelines provided in the General Measures,
    - the entrance opening/maintenance procedure (Area 1) will reduce design flood levels by up to 0.4 m.

2.6 Priority of Work

Advice on ocean inundation and implementation of special design provisions are high priority items. A review of the local drainage problem is low priority.

AREA 3: LOXTON AVENUE

3.1 Description of the Problem

There are approximately 18 lots in Loxton Avenue and Ocean View Drive which may possibly be affected by an elevated lagoon. The lowest floor level is at 3.7 mAHD (No. 9) and this is 0.2 m above the existing 1% AEP design rainfall induced flood level of 3.5 mAHD (0.6 m above the proposed level). It is only in events greater than a 1% AEP flood that flooding of these buildings may occur. The buildings are all modern brick residences with the majority being slab-on-ground construction, they all enjoy views over the lagoon. The key features of this area are:

- there have been several reported drainage problems,
- ponding of local runoff has been a problem prior to 1992. It is expected that subsequent drainage works by Council have resolved the problem but there have been no major rainfall events to test their effectiveness,
- the proposed design lagoon levels will not cause direct inundation of the buildings but any elevated lagoon level will exacerbate the local drainage problems.

The area is classified as low hazard flood fringe and is not affected by ocean inundation.

3.2 Discussion

The extent of the existing local drainage problem can only be evaluated following the next period of heavy rain. If the existing works are not successful minor local levees and/or local building works may be applicable. Lowering the lagoon rainfall induced flood levels (refer Area 1) will reduce this problem. A local drainage study is not proposed but the situation should be monitored.

3.3 Description of the Proposal

No specific floodplain management measures are proposed for this area except a monitoring of the local drainage situation.

3.4 Social, Economic, Environmental and Hydraulic Appraisal

An appraisal is not required.

3.5 Concise Description of the Plan

- The local drainage situation will be monitored by Council.
- General measures for the floodplain:
  - all new buildings and major extensions to be constructed above the minimum floor level (MFL). This is a minimum requirement and a higher floor level is encouraged (to prevent inundation in floods greater than the adopted standard),
  - raising of all existing buildings with floor levels below the MFL is encouraged,

- where possible buildings should be constructed on the high part of the property outside the floodplain,
- filling may be permitted under the plan area of the dwelling and possibly over the remainder of the lot (to 0.2 m above the let out level or higher) subject to the guidelines provided in the General Measures,
- the entrance opening/maintenance procedure (Area 1) will reduce design flood levels by up to 0.4 m.

3.6 Priority of Work

Monitoring of the local drainage situation will be provided as a low priority item.

AREA 4: WAMBERAL PARK AND BLUE BELL DRIVE

4.1 Description of the Problem

This area encompasses the residential lots adjacent to Wamberal Park and along Blue Bell Drive. It also includes the lots in Tall Timbers Road fronting the lagoon. The lowest floor level of these buildings is 3.8 mAHD. Elevated lagoon levels have not inundated buildings in the past and are unlikely to even in an Extreme Flood. The residents all have pleasant outlooks across the lagoon and the adjoining Nature Reserve.

This area is classified as low hazard flood fringe area. According to the residents some minor local drainage problems have arisen in the past. Preliminary investigation suggests that these do no impact upon building floor levels and only affect the residents' yards.

4.2 Discussion

Further investigation into the causes of the local drainage problems is required before the appropriate works can be employed.

4.3 Description of the Proposal

A local drainage investigation will be initiated to assess the problem.

4.4 Social, Economic, Environmental and Hydraulic Appraisal

The local drainage study will be undertaken by Council and has not been costed.

4.5 Concise Description of the Plan

- A local drainage study will be programmed in Council's Forward Plan of Works.
- General measures for the floodplain:
  - all new buildings and major extensions to be constructed above the minimum floor level (MFL). This is a minimum requirement and a higher floor level is encouraged (to prevent inundation in floods greater than the adopted standard),
  - raising of all existing buildings with floor levels below the MFL is encouraged,
  - where possible buildings should be constructed on the high part of the property outside the floodplain,
  - filling may be permitted under the plan area of the dwelling and possibly over the remainder of the lot (to 0.2 m above the let out level or higher) subject to the guidelines provided in the General Measures,
  - the entrance opening/maintenance procedure (Area 1) will reduce design flood levels by up to 0.4 m.

4.6 Priority of Work

The local drainage study is a low priority item.

AREA 5: LAVINIA STREET AND MALKANA AVENUE

5.1 Description of the Problem

This area includes the residential developments located on the eastern bank of North Arm creek bounded by Lavinia Street, Malkana Avenue, Crystal Street and Noorong Avenue. The area can be subdivided into two parts separated by Binang Avenue. Upstream of Binang Avenue near Crystal Street, the ground is low-lying and there are approximately 40 lots which are flood prone including parts of John Street. The lowest building floor level is at 3.9 mAHD. Five buildings would be inundated above floor level in a 1% AEP event to a maximum depth of 0.3 m. Downstream of Binang Avenue there are approximately 20 lots with the lowest building floor level also being 3.9 mAHD.

Elevated lagoon levels do not cause inundation of buildings downstream of Binang Avenue, although the yards and driveways are affected. Upstream of Binang Avenue flooding has been reported as a result of overbank inundation from North Arm creek as well as from local drainage. Management of the entrance berm (Area 1) and consequent reduction of the rainfall induced flood levels will have no benefit upstream of Binang Avenue.

The area is designated as low hazard flood fringe except for North Arm creek which is high hazard floodway.

5.2 Discussion

Levees and house raising were examined as possible floodplain management measures for the properties upstream of Binang Avenue. Levees are not viable for aesthetic, access and internal drainage reasons (flooding of yards can occur as a result of local runoff without inundation from the creek). Local drainage works may alleviate the problem, but are unlikely to eliminate flooding of yards. House raising is discussed under general measures for the floodplain. One house may be suitable for raising with an indicative benefit/cost ratio of less than 0.3.

5.3 Description of the Proposal

A local drainage study will be undertaken to investigate the problem and suggest solutions.

5.4 Social, Economic, Environmental and Hydraulic Appraisal

The local drainage study will be undertaken by Council.

5.5 Concise Description of the Plan

- A local drainage study will be programmed in Council's Forward Plan of Works.
- General measures for the floodplain:
  - all new buildings and major extensions to be constructed above the minimum floor level (MFL). This is a minimum requirement and a higher floor level is encouraged (to prevent inundation in floods greater than the adopted standard),
  - raising of all existing buildings with floor levels below the MFL is encouraged,
  - where possible buildings should be constructed on the high part of the property outside the floodplain,
  - filling may be permitted under the plan area of the dwelling and possibly over the remainder of the lot (to 0.2 m above the let out level or higher) subject to the guidelines provided in the General Measures,
  - the entrance opening/maintenance procedure (Area 1) will reduce design flood levels by up to 0.4 m.

5.6 Priority of Work

The local drainage study will be undertaken as a low priority item.

AREA 6: NORTH ARM (Downstream of The Entrance Road)

6.1 Description of the Problem

This area includes all the flood prone land west of the North Arm and downstream of The Entrance Road. There are no buildings and no likelihood of development in this area. The concerns for this area are the same as for the lagoon itself (Area 1). One significant concern being the potential for erosion and pollution from the drain rising near Dalpura Road.

The area is classified as low hazard flood fringe with the exception that North Arm creek is a high hazard floodway.

6.2 Discussion

Flooding is not a problem within this area for the existing land users.

6.3 Description of the Proposal

No specific floodplain management measures are proposed for this area.

6.4 Social, Economic, Environmental and Hydraulic Appraisal

An appraisal is not required.

6.5 Concise Description of the Plan

- No specific measures are proposed.
- No development conditions required at this time.

6.6 Priority of Work

Not applicable as no specific measures are proposed.

AREA 7: NORTH ARM (Upstream of The Entrance Road)

7.1 Description of the Problem

Upstream of The Entrance Road there are no buildings which are flood prone within the study area (as at the time of the survey in 1994). The majority of the area consists of thickly vegetated rural land. The only exception is along Carbeen Road where a residential subdivision has been recently completed (1999).

The Entrance Road has been inundated on several occasions in the past at the bridge crossing.

7.2 Discussion

Development in Carbeen Road must comply with Council's flood policy and build to a MFL. Making The Entrance Road flood free would be expensive as it is inundated over a 200 m length. Upgrading cannot be justified solely on flooding grounds as there is an alternative flood free route along Tumbi Road. However it should be considered at the time of future road upgrading works.

7.3 Description of the Proposal

No specific floodplain management measures are proposed for this area. Developers must undertake hydraulic investigations to assess any impact on the existing floodplain. Flood free access for The Entrance Road will be considered as part of any future road upgrading work.

7.4 Social, Economic, Environmental and Hydraulic Appraisal

The costs to undertake any hydraulic investigations will be undertaken by the developer.

7.5 Concise Description of the Plan

- Flood free access for The Entrance Road will be considered by Council as part of any future road upgrading works.
- General measures for the floodplain:
  - all new buildings and major extensions to be constructed above the minimum floor level (MFL). This is a minimum requirement and a higher floor level is encouraged (to prevent inundation in floods greater than the adopted standard),
  - raising of all existing buildings with floor levels below the MFL is encouraged,
  - where possible buildings should be constructed on the high part of the property outside the floodplain,
  - filling will be permitted under the plan area of the dwelling subject to the guidelines provided in the General Measures.

7.6 Priority of Work

Any hydraulic investigations for future development must be undertaken as a high priority item. Flood free access along The Entrance Road is a low priority item.

AREA 8: UPSTREAM CATCHMENTS

8.1 Description of the Problem

Upstream of the immediate floodplain of the Lagoon there are a number of contributing catchments. There are pressures from private developers and Government bodies to develop parts of these catchments. Analysis undertaken as part of the Floodplain Management Study indicated that upstream development could affect flood levels and water quality in the downstream management areas, unless controls on upstream development were implemented.

8.2 Discussion

Urbanisation of the upper catchment is inevitable as the demands for development increase. However, controls on the type and extent of any such development will minimise the impact on downstream floodplain occupants. The controls should be used to limit any increase in the quantity of the flow and any adverse water quality implications from flows entering the Lagoon.

8.3 Description of the Proposal

Urbanisation of the upstream catchment will only be permitted if downstream flooding and water quality are not adversely affected. Prior to approval of a significant development, a Hydraulic Assessment report must be undertaken to demonstrate that these conditions can be achieved in an ecologically, social, environmentally and economically sustainable manner.

8.4 Social, Economic, Environmental and Hydraulic Appraisal

The proposed conditions will be implemented by the Developer in a manner which does not adversely affect others.

8.5 Concise Description of the Plan

- Development will be considered in the upstream catchments subject to detailed evaluation of the possible impacts on water quantity and water quality.

8.6 Priority of Work

This work is considered high priority and should be implemented immediately.

FIGURES

FIGURE 1
Floodplain Management Areas
Wamberal Lagoon

Wamberal Lagoon
Floodplain Management Areas

1. *The Lagoon Water Body*
2. *Remembrance Drive*
3. *Loxton Avenue*
4. *Wamberal Park and Blue Bell Drive*
5. *Lavinia Street and Malkana Avenue*
6. *North Arm (downstream of The Entrance Road)*
7. *North Arm (upstream of The Entrance Road)*
8. *Upstream Catchments*

Coastal Processes Dominate

N

100 0 100 200 300 400 500m
SCALE

APPENDIX A: COUNCIL'S ENTRANCE MANAGEMENT POLICY

OPENING OF COASTAL LAGOONS

E0.04

190.81.04

DEVELOPMENT AND ENVIRONMENT

POLICY OBJECTIVES

To mitigate flooding by opening the coastal lagoons in a manner which minimises the impacts on the environment of the coastal lagoons and the surrounding areas.

POLICY STATEMENT

1 This Policy relates to Terrigal, Wamberal, Avoca and Cockrone Lagoons.

2 Council will arrange the opening of the coastal lagoons in accordance with the requirements of the Coastal Lagoons Floodplain Management Plans and the Coastal Lagoons Management Plan.

3 Lagoons will be opened in accordance with the following procedure.

PROCEDURE FOR THE OPENING OF THE COASTAL LAGOONS

INTRODUCTION

Lagoon opening using mechanical means and the subsequent breakout and drainage of the lagoon has been developed as a management method following extensive study and consideration of lagoon ecology, flood behaviour and flood management and long term water quality issues.

Openings between July and October will have optimum benefits in regard to the recruitment of commercial fish species, however this will be weather dependent.

OPENINGS

Terrigal, Wamberal, Avoca and Cockrone Lagoons have marked level heights at various points around the shores. These levels show the critical heights above which local residences and property may be flooded. Once the water reaches these levels, the lagoons **must** be opened. The let out levels are shown on the attached schedule.

SANDBAR LOWERING

As heavy rain occurs, there is a possibility that lagoons can quickly fill and exceed the heights at which the lagoons are let out. In order to control this eventuality, the flood management plans for the lagoons have calculated levels at which the sandbars of lagoons should be retained in order to allow the lagoons to let themselves out should severe floods occur. The levels at which the sandbars should be kept are indicated in Table 1.

SAFETY

Suitable signs and barriers are to be erected at the time of opening and maintained during the initial run out period.

There will be times when the sandbars need to be excavated but the sea conditions are so large that working on the sandbars would be dangerous and contravene occupational safety provisions. In these circumstances the work shall be delayed until the tide and sea state have moderated to a point at which the work can be safely carried out. However, due to the flooding that is likely to occur, any delay should be kept to a minimum.

ENVIRONMENTAL FACTORS

The following environmental considerations have been identified by the Coastal Management, Lagoons Management and Coastal Planning Committee, and are included in the opening procedures.

* When opening Avoca Lagoon, Council should consider the time at which the lagoon is opened. It should reach a maximum run out velocity towards the top of the ocean tide so that the scouring of the opening is minimised. The purpose of this consideration is so that the width to which the entrance scours is kept to a minimum to enable the lagoon to quickly close and prevent the lagoon from being open for too long a period. This is considered reasonably critical at Avoca because of the huge extent of mud flats which are exposed with a high velocity run out. This can result in long term odour problems for the nearby residents if the lagoon does not close off quickly.

* When openings are made in the lagoons, they should be made in a central area of the sandbar. The intent is to try to avoid a meandering outlet which in the past has caused difficulty to either bank of the outlet channel if it tends to meander when it runs out heavily. Openings offset from the centre seem to encourage meandering or scouring which could be problematic to nearby property.

* Avoca Lake (at least) has a population of the endangered Green and Golden Bell Frog (*Litoria aurea*). Lagoon opening has the potential to disrupt breeding efforts of this species as the peripheral breeding sites prematurely drain when the lagoons are opened. Where possible, pending lagoon opening is to be notified to Council's Environment Program and NPWS with sufficient notice to ascertain breeding status and salvage strategies where necessary.

MONITORING OF LEVELS

During periods of rain, residents may telephone Council staff to request the lagoon to be let out, fearing flooding. Many of these calls may be premature but need to be checked . Listed below in this procedure are the contacts for the lagoon releases and the lagoon level telephone monitor numbers.

The Construction Section at Erina Depot monitors the lagoon levels continually and generally lagoon levels should not reach the "call out stage" via the "on call duty system" without responsible staff being aware of the water levels. However, each lagoon level may be checked if required by calculating the difference between the let out level listed below and the current lagoon level gained by telephoning the lagoon in question.

Example:

1 Telephone Terrigal and you are given a height of say 1.205.
2 Deduct 1.205 from the let out level height of 1.230.
3 The calculation gives you the measurement of 0.025 which informs you that the current lagoon level is only 25 mm below the let out level.

If the telephone monitoring system fails the responsible person shall arrange for visual monitoring to guard against water levels rising above the let out levels.

The sandbar heights will be monitored visually using sighting aids with a maximum interval between inspections of 2 weeks. More regular inspection shall be carried out in wet weather or heavy sea conditions.

WHO TO NOTIFY

Advice of the impending opening is to be given to:

A The local Fisheries Officer for any or all lagoons opened.

B The Central Coast District Office of National Parks and Wildlife Service for the impending opening of Wamberal Lagoon, and for Avoca Lake due to the presence of a population of the endangered Green and Golden Bell Frog (*Litoria aurea*).

C Lifesavers, if they are on duty at the time of the impending opening, shall be notified.

D Council's Environment Program in regard to which lagoons have been opened, and the time they were opened.

The details of the openings are to be recorded in the 'Lagoon Book' at Erina Depot.

DELEGATION

Arrangements for the carrying out of the opening of the Coastal Lagoons are delegated to the General Manager.

* *

TABLE 1

LET OUT LEVELS, SANDBAR HEIGHTS AND TELEPHONE NUMBERS FOR CURRENT WATER LEVELS			
LAGOON	**LET OUT LEVEL m AHD**	**SANDBAR HEIGHT m AHD**	**TEL NO (INTERNAL USE ONLY)**
TERRIGAL	1.230 m	1.7 m	4384 2992
WAMBERAL	2.400 m	2.6 to 2.7 m	4384 3561
AVOCA	2.090 m	2.7 to 2.8 m	4382 3247
COCKRONE	2.530 m	3.3 to 3.5m	4382 3263

OTHER INFORMATION

RELEASE OF LAGOONS - JOB NUMBERS

E0100.169 TERRIGAL LAGOON
E0110.169 COCKRONE LAGOON, COPACABANA
E0120.169 WAMBERAL LAGOON
E0130.169 AVOCA LAGOON

(Min No - 4 October 1968)
(Minute No 515/88 - 21 June 1988).
(Minute No 1085/89 - 26 September 1989)
(Minute No 547/94 - 14 June 1994)
(Minute No 322/96 - 23 April 1996 - Review of Policies)
(Minute No 201/99 - 26 October 1999)
(Minute No 239/00 – 26 October 2000 – Review of Policies)

APPENDIX B: METHODS OF DISSEMINATING FLOODING INFORMATION TO THE COMMUNITY

APPENDIX B: METHODS OF DISSEMINATING FLOODING INFORMATION TO THE COMMUNITY

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

APPENDIX C: POST FLOOD EVALUATION AND REVIEW PROGRAM

APPENDIX C: POST FLOOD EVALUATION AND REVIEW PROGRAM

C1. GENERAL

Design flood levels are provided in the *Wamberal Lagoon Flood Study*. Copies of this report are held by Gosford City Council and the Department of Land and Water Conservation. The design levels were largely obtained from hydraulic modelling and historical data. Due to the paucity of historical data the design levels have a stated accuracy of ±0.4 m. The accuracy of the design flood levels can be improved with further flood and rainfall data to confirm the calibration of the computer models. The following procedure has been developed to ensure that the information available from future floods is accurately obtained and analysed.

C2. PROCEDURE

Step 1 - Future Flood: If the lagoon level exceeds 2.0 mAHD data should be collected.

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

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

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

Step 4 - Reports from Authorities: Council should obtain written reports from various sections of Council, the SES and any other relevant public authority on the flood. Data should be obtained from the automatic water level recorder and peak water level recorders. These data can be obtained at any time although if they are collected soon after the event they can be used to identify and correct any gross errors in other data. If new gauges are subsequently installed, data should also be collected from these.

Step 5 - Major Floods: Flood levels which indicate an AEP of greater than 10% AEP should be used to re-examine the calibration of the hydrologic/hydraulic models. Data from any other floods which have not previously been analysed should be included in this re-examination.

Steps 6 and 7 only apply to floods with an AEP greater than 10% AEP.

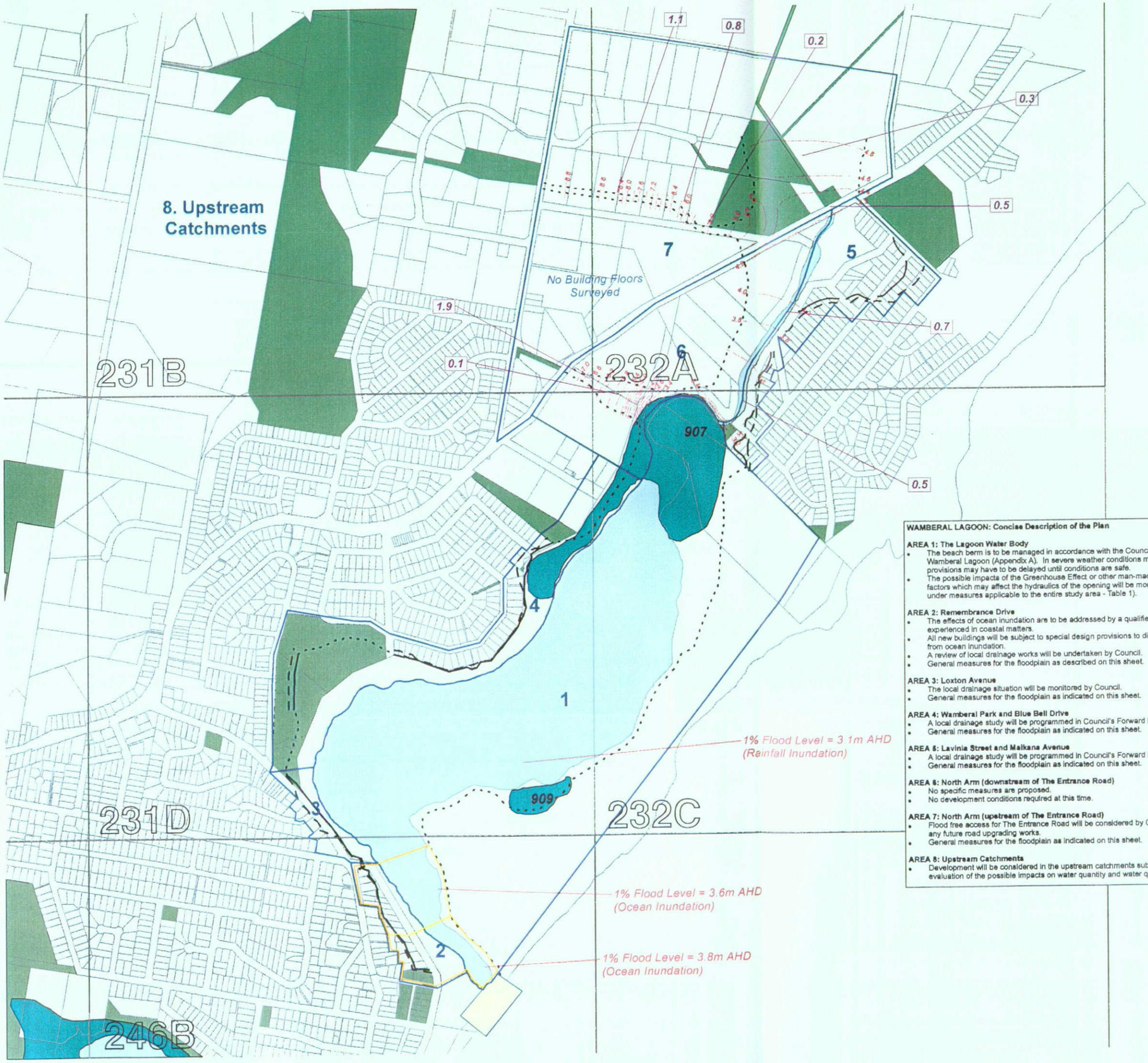
Step 6 - Rainfall Data: Council should make enquiries as soon as possible with Bowling Clubs, Golf Courses or any other possible sources to obtain all available rainfall data. Rainfall data from the Department of Land and Water Conservation and Bureau of Meteorology gauges is continuously recorded and can be readily obtained at any time. If warranted, additional rainfall information can be sought from residents at the same time as flood data are requested.

Step 7 - Hydrologic/Hydraulic Modelling: The new data should be run through the WBNM and RUBICON models. If the models do not produce satisfactory results then all available information (including that from floods used in the Flood Study) needs to be considered to see if the model parameters should be changed. Any changes would lead to a revision of design flood levels. A report should be produced documenting the results and any adjustments made to Council's Floodplain Management Plans and S149 Certificates.

FLOODPLAIN MANAGEMENT PLANS

WAMBERAL LAGOON
Floodplain Management Plan

KEY MAP



Wamberal Lagoon
Floodplain Management Areas

1. *The Lagoon Water Body*
2. *Remembrance Drive*
3. *Loxton Avenue*
4. *Wamberal Park and Blue Bell Drive*
5. *Lavinia Street and Malkana Avenue*
6. *North Arm (downstream of The Entrance Road)*
7. *North Arm (upstream of The Entrance Road)*
8. *Upstream Catchments*

Coastal Processes Dominate

LEGEND

- Surveyed 1% AEP Flood Extent
- Surveyed 1% AEP + 0.5m Flood Extent (Flood Planning Level)
- 1% AEP Flood Contour
- Not Surveyed 1% AEP Flood Extent (Based on 1:2000 Maps)
- 5 Floodplain Management Area
- Land Affected by Ocean Inundation
- 1.1 1% AEP Average Velocity (m/s)
- Council Owned Land
- 910 SEPP 14 Wetlands
- 246B Gosford City Council Map Reference (approx.)

MAP KEY

	231B	232A
231C	231D	232C
246A	246B	
246C	246D	

WAMBERAL LAGOON: Concise Description of the Plan

AREA 1: The Lagoon Water Body
- The beach berm is to be managed in accordance with the Council policy for Wamberal Lagoon (Appendix A). In severe weather conditions management provisions may have to be delayed until conditions are safe.
- The possible impacts of the Greenhouse Effect or other man-made or natural factors which may affect the hydraulics of the opening will be monitored (included under measures applicable to the entire study area - Table 1).

AREA 2: Remembrance Drive
- The effects of ocean inundation are to be addressed by a qualified engineer experienced in coastal matters.
- All new buildings will be subject to special design provisions to dissipate forces from ocean inundation.
- A review of local drainage works will be undertaken by Council.
- General measures for the floodplain as described on this sheet.

AREA 3: Loxton Avenue
- The local drainage situation will be monitored by Council.
- General measures for the floodplain as indicated on this sheet.

AREA 4: Wamberal Park and Blue Bell Drive
- A local drainage study will be programmed in Council's Forward Plan of Works.
- General measures for the floodplain as indicated on this sheet.

AREA 5: Lavinia Street and Malkana Avenue
- A local drainage study will be programmed in Council's Forward Plan of Works.
- General measures for the floodplain as indicated on this sheet.

AREA 6: North Arm (downstream of The Entrance Road)
- No specific measures are proposed.
- No development conditions required at this time.

AREA 7: North Arm (upstream of The Entrance Road)
- Flood free access for The Entrance Road will be considered by Council as part of any future road upgrading works.
- General measures for the floodplain as indicated on this sheet.

AREA 8: Upstream Catchments
- Development will be considered in the upstream catchments subject to detailed evaluation of the possible impacts on water quantity and water quality.

General measures for the floodplain:

- all new buildings and major extensions to be constructed above the minimum floor level (MFL). This is a minimum requirement and a higher floor level is encouraged (to prevent inundation in floods greater than the adopted standard),
- raising of all existing buildings with floor levels below the MFL is encouraged,
- where possible buildings should be constructed on the high part of the property outside the floodplain,
- filling may be permitted under the plan area of the dwelling and possibly over the remainder of the lot (to 0.2 m above the let out level or higher) subject to the guidelines provided in the General Measures,
- the entrance opening/maintenance procedure (Area 1) will reduce design flood levels by up to 0.4 m.

All levels in metres to AHD

Notes
Building floor levels are provided in Appendix B of the Floodplain Management Study.

The rainfall induced flood levels assume that the entrance berm is at 2.7m AHD at the onset of the event. The lagoon let out level is 2.4m AHD and Council maintains the sandbar at approximately 2.6m to 2.7m AHD.

Design flood levels were taken from the Wamberal Lagoon Flood Study and Floodplain Management Study. Ocean inundation levels were taken from a report, *The Entrance Dynamics of Wamberal, Terrigal, Avoca and Cockrone Lagoons*, prepared by AWACS in November 1994.

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13th August 2001

100 0 100 200 300 400 500m

SCALE

WAMBERAL LAGOON
Floodplain Management Plan

231B

WAMBERAL LAGOON: Concise Description of the Plan

AREA 1: The Lagoon Water Body
- The beach berm is to be managed in accordance with the Council policy for Wamberal Lagoon (Appendix A). In severe weather conditions management provisions may have to be delayed until conditions are safe.
- The possible impacts of the Greenhouse Effect or other man-made or natural factors which may affect the hydraulics of the opening will be monitored (included under measures applicable to the entire study area - Table 1).

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- A review of local drainage works will be undertaken by Council.
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AREA 3: Loxton Avenue
- The local drainage situation will be monitored by Council.
- General measures for the floodplain as indicated on this sheet.

AREA 4: Wamberal Park and Blue Bell Drive
- A local drainage study will be programmed in Council's Forward Plan of Works.
- General measures for the floodplain as indicated on this sheet.

AREA 5: Lavinia Street and Malkana Avenue
- A local drainage study will be programmed in Council's Forward Plan of Works.
- General measures for the floodplain as indicated on this sheet.

AREA 6: North Arm (downstream of The Entrance Road)
- No specific measures are proposed.
- No development conditions required at this time.

AREA 7: North Arm (upstream of The Entrance Road)
- Flood free access for The Entrance Road will be considered by Council as part of any future road upgrading works.
- General measures for the floodplain as indicated on this sheet.

AREA 8: Upstream Catchments
- Development will be considered in the upstream catchments subject to detailed evaluation of the possible impacts on water quantity and water quality.

Wamberal Lagoon
Floodplain Management Areas

1. *The Lagoon Water Body*
2. *Remembrance Drive*
3. *Loxton Avenue*
4. *Wamberal Park and Blue Bell Drive*
5. *Lavinia Street and Malkana Avenue*
6. *North Arm (downstream of The Entrance Road)*
7. *North Arm (upstream of The Entrance Road)*
8. *Upstream Catchments*

Coastal Processes Dominate

LEGEND

- Surveyed 1% AEP Flood Extent
- Surveyed 1% AEP + 0.5m Flood Extent (Flood Planning Level)
- 1% AEP Flood Contour
- Not Surveyed 1% AEP Flood Extent (Based on 1:2000 Maps)
- 5 — Floodplain Management Area
- Land Affected by Ocean Inundation
- 1.1 — 1% AEP Average Velocity (m/s)
- Council Owned Land
- SEPP 14 Wetlands
- 15/3 850426 — Property Street Number / Lot Number, Deposited Plan Number

MAP KEY

	231B	232A
231C	231D	232C
246A	246B	
246C	246D	

General measures for the floodplain:

- all new buildings and major extensions to be constructed above the minimum floor level (MFL). This is a minimum requirement and a higher floor level is encouraged (to prevent inundation in floods greater than the adopted standard),
- raising of all existing buildings with floor levels below the MFL is encouraged,
- where possible buildings should be constructed on the high part of the property outside the floodplain,
- filling may be permitted under the plan area of the dwelling and possibly over the remainder of the lot (to 0.2 m above the let out level or higher) subject to the guidelines provided in the General Measures,
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All levels in metres to AHD

Notes
Building floor levels are provided in Appendix B of the Floodplain Management Study.

The rainfall induced flood levels assume that the entrance berm is at 2.7m AHD at the onset of the event. The lagoon let out level is 2.4m AHD and Council maintains the sandbar at approximately 2.6m to 2.7m AHD.

Design flood levels were taken from the Wamberal Lagoon Flood Study and Floodplain Management Study. Ocean inundation levels were taken from a report, *The Entrance Dynamics of Wamberal, Terrigal, Avoca and Cockrone Lagoons*, prepared by AWACS in November 1994.

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13th August 2001

40 20 0 40 80 120 160 200m
Scale

WAMBERAL LAGOON: Concise Description of the Plan

AREA 1: The Lagoon Water Body
- The beach berm is to be managed in accordance with the Council policy for Wamberal Lagoon (Appendix A). In severe weather conditions management provisions may have to be delayed until conditions are safe.
- The possible impacts of the Greenhouse Effect or other man-made or natural factors which may affect the hydraulics of the opening will be monitored (included under measures applicable to the entire study area - Table 1).

AREA 2: Remembrance Drive
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- General measures for the floodplain as indicated on this sheet.

AREA 5: Lavinia Street and Malkana Avenue
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- General measures for the floodplain as indicated on this sheet.

AREA 6: North Arm (downstream of The Entrance Road)
- No specific measures are proposed.
- No development conditions required at this time.

AREA 7: North Arm (upstream of The Entrance Road)
- Flood free access for The Entrance Road will be considered by Council as part of any future road upgrading works.
- General measures for the floodplain as indicated on this sheet.

AREA 8: Upstream Catchments
- Development will be considered in the upstream catchments subject to detailed evaluation of the possible impacts on water quantity and water quality.

WAMBERAL LAGOON
Floodplain Management Plan

232A

Wamberal Lagoon
Floodplain Management Areas

1. *The Lagoon Water Body*
2. *Remembrance Drive*
3. *Loxton Avenue*
4. *Wamberal Park and Blue Bell Drive*
5. *Lavinia Street and Malkana Avenue*
6. *North Arm (downstream of The Entrance Road)*
7. *North Arm (upstream of The Entrance Road)*
8. *Upstream Catchments*

Coastal Processes Dominate

LEGEND

- Surveyed 1% AEP Flood Extent
- Surveyed 1% AEP + 0.5m Flood Extent (Flood Planning Level)
- 1% AEP Flood Contour
- Not Surveyed 1% AEP Flood Extent (Based on 1:2000 Maps)
- 5 — Floodplain Management Area
- Land Affected by Ocean Inundation
- 1.1 — 1% AEP Average Velocity (m/s)
- Council Owned Land
- 910 — SEPP 14 Wetlands
- 15/3 850428 — Property Street Number / Lot Number Deposited Plan Number

MAP KEY

	231B	232A
231C	231D	232C
246A	246B	
246C	246D	

General measures for the floodplain:

- all new buildings and major extensions to be constructed above the minimum floor level (MFL). This is a minimum requirement and a higher floor level is encouraged (to prevent inundation in floods greater than the adopted standard),
- raising of all existing buildings with floor levels below the MFL is encouraged,
- where possible buildings should be constructed on the high part of the property outside the floodplain,
- filling may be permitted under the plan area of the dwelling and possibly over the remainder of the lot (to 0.2 m above the let out level or higher) subject to the guidelines provided in the General Measures,
- the entrance opening/maintenance procedure (Area 1) will reduce design flood levels by up to 0.4 m.

All levels in metres to AHD

Notes
Building floor levels are provided in Appendix B of the Floodplain Management Study.

The rainfall induced flood levels assume that the entrance berm is at 2.7m AHD at the onset of the event. The lagoon let out level is 2.4m AHD and Council maintains the sandbar at approximately 2.6m to 2.7m AHD.

Design flood levels were taken from the Wamberal Lagoon Flood Study and Floodplain Management Study. Ocean inundation levels were taken from a report, *The Entrance Dynamics of Wamberal, Terrigal, Avoca and Cockrone Lagoons*, prepared by AWACS in November 1994.

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13th August 2001

40 20 0 40 80 120 160 200m
Scale

WAMBERAL LAGOON
Floodplain Management Plan

231D

WAMBERAL LAGOON: Concise Description of the Plan

AREA 1: The Lagoon Water Body
- The beach berm is to be managed in accordance with the Council policy for Wamberal Lagoon (Appendix A). In severe weather conditions management provisions may have to be delayed until conditions are safe.
- The possible impacts of the Greenhouse Effect or other man-made or natural factors which may affect the hydraulics of the opening will be monitored (included under measures applicable to the entire study area - Table 1).

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- General measures for the floodplain as indicated on this sheet.

AREA 6: North Arm (downstream of The Entrance Road)
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- No development conditions required at this time.

AREA 7: North Arm (upstream of The Entrance Road)
- Flood free access for The Entrance Road will be considered by Council as part of any future road upgrading works.
- General measures for the floodplain as indicated on this sheet.

AREA 8: Upstream Catchments
- Development will be considered in the upstream catchments subject to detailed evaluation of the possible impacts on water quantity and water quality.

Wamberal Lagoon Floodplain Management Areas

1. *The Lagoon Water Body*
2. *Remembrance Drive*
3. *Loxton Avenue*
4. *Wamberal Park and Blue Bell Drive*
5. *Lavinia Street and Malkana Avenue*
6. *North Arm (downstream of The Entrance Road)*
7. *North Arm (upstream of The Entrance Road)*
8. *Upstream Catchments*

Coastal Processes Dominate

LEGEND

- Surveyed 1% AEP Flood Extent
- Surveyed 1% AEP + 0.5m Flood Extent (Flood Planning Level)
- 1% AEP Flood Contour
- Not Surveyed 1% AEP Flood Extent (Based on 1:2000 Maps)
- 5 — Floodplain Management Area
- Land Affected by Ocean Inundation
- 1.1 — 1% AEP Average Velocity (m/s)
- Council Owned Land
- 910 — SEPP 14 Wetlands
- 15/3 850426 — Property Street Number / Lot Number Deposited Plan Number

MAP KEY

	231B	232A
231C	231D	232C
246A	246B	
246C	246D	

General measures for the floodplain:

- all new buildings and major extensions to be constructed above the minimum floor level (MFL). This is a minimum requirement and a higher floor level is encouraged (to prevent inundation in floods greater than the adopted standard),
- raising of all existing buildings with floor levels below the MFL is encouraged,
- where possible buildings should be constructed on the high part of the property outside the floodplain,
- filling may be permitted under the plan area of the dwelling and possibly over the remainder of the lot (to 0.2 m above the let out level or higher) subject to the guidelines provided in the General Measures,
- the entrance opening/maintenance procedure (Area 1) will reduce design flood levels by up to 0.4 m.

All levels in metres to AHD

Notes

Building floor levels are provided in Appendix B of the Floodplain Management Study.

The rainfall induced flood levels assume that the entrance berm is at 2.7m AHD at the onset of the event. The lagoon let out level is 2.4m AHD and Council maintains the sandbar at approximately 2.6m to 2.7m AHD.

Design flood levels were taken from the Wamberal Lagoon Flood Study and Floodplain Management Study. Ocean inundation levels were taken from a report, *The Entrance Dynamics of Wamberal, Terrigal, Avoca and Cockrone Lagoons*, prepared by AWACS in November 1994.

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13th August 2001

40 20 0 40 80 120 160 200m
Scale

WAMBERAL LAGOON: Concise Description of the Plan

AREA 1: The Lagoon Water Body
- The beach berm is to be managed in accordance with the Council policy for Wamberal Lagoon (Appendix A). In severe weather conditions management provisions may have to be delayed until conditions are safe.
- The possible impacts of the Greenhouse Effect or other man-made or natural factors which may affect the hydraulics of the opening will be monitored (included under measures applicable to the entire study area - Table 1).

AREA 2: Remembrance Drive
- The effects of ocean inundation are to be addressed by a qualified engineer experienced in coastal matters.
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AREA 4: Wamberal Park and Blue Bell Drive
- A local drainage study will be programmed in Council's Forward Plan of Works.
- General measures for the floodplain as indicated on this sheet.

AREA 5: Lavinia Street and Malkana Avenue
- A local drainage study will be programmed in Council's Forward Plan of Works.
- General measures for the floodplain as indicated on this sheet.

AREA 6: North Arm (downstream of The Entrance Road)
- No specific measures are proposed.
- No development conditions required at this time.

AREA 7: North Arm (upstream of The Entrance Road)
- Flood free access for The Entrance Road will be considered by Council as part of any future road upgrading works.
- General measures for the floodplain as indicated on this sheet.

AREA 8: Upstream Catchments
- Development will be considered in the upstream catchments subject to detailed evaluation of the possible impacts on water quantity and water quality.

WAMBERAL LAGOON
Floodplain Management Plan

232C

Wamberal Lagoon
Floodplain Management Areas

1. *The Lagoon Water Body*
2. *Remembrance Drive*
3. *Loxton Avenue*
4. *Wamberal Park and Blue Bell Drive*
5. *Lavinia Street and Malkana Avenue*
6. *North Arm (downstream of The Entrance Road)*
7. *North Arm (upstream of The Entrance Road)*
8. *Upstream Catchments*

Coastal Processes Dominate

LEGEND

- Surveyed 1% AEP Flood Extent
- Surveyed 1% AEP + 0.5m Flood Extent (Flood Planning Level)
- 1% AEP Flood Contour
- Not Surveyed 1% AEP Flood Extent (Based on 1:2000 Maps)
- 5 — Floodplain Management Area
- Land Affected by Ocean Inundation
- 1.1 — 1% AEP Average Velocity (m/s)
- Council Owned Land
- 910 — SEPP 14 Wetlands
- 15/3 / 850426 — Property Street Number / Lot Number / Deposited Plan Number

MAP KEY

	231B	232A
231C	231D	232C
246A	246B	
246C	246D	

General measures for the floodplain:

- all new buildings and major extensions to be constructed above the minimum floor level (MFL). This is a minimum requirement and a higher floor level is encouraged (to prevent inundation in floods greater than the adopted standard),
- raising of all existing buildings with floor levels below the MFL is encouraged,
- where possible buildings should be constructed on the high part of the property outside the floodplain,
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All levels in metres to AHD

Notes
Building floor levels are provided in Appendix B of the Floodplain Management Study.

The rainfall induced flood levels assume that the entrance berm is at 2.7m AHD at the onset of the event. The lagoon let out level is 2.4m AHD and Council maintains the sandbar at approximately 2.6m to 2.7m AHD.

Design flood levels were taken from the Wamberal Lagoon Flood Study and Floodplain Management Study. Ocean inundation levels were taken from a report, *The Entrance Dynamics of Wamberal, Terrigal, Avoca and Cockrone Lagoons*, prepared by AWACS in November 1994.

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13th August 2001

40 20 0 40 80 120 160 200m
Scale

TERRIGAL AND WAMBERAL LAGOONS
Floodplain Management Plan

246B

1% Flood Level = 3.1m AHD (Rainfall Inundation)

1% Flood Level = 3.6m AHD (Ocean Inundation) Affected by Ocean Inundation as well as Rainfall Induced Inundation

1% Flood Level = 3.8m AHD (Ocean Inundation) Affected by Ocean Inundation as well as Rainfall Induced Inundation

1% Flood Level = 2.9m AHD (Rainfall Inundation)

WAMBERAL LAGOON NATURE RESERVE

LEGEND

- Surveyed 1% AEP Flood Extent
- Surveyed 1% AEP + 0.5m Flood Extent (Flood Planning Level)
- 1% AEP Flood Contour
- Not Surveyed 1% AEP Flood Extent (Based on 1:2000 Maps)
- 5 — Floodplain Management Area
- Land Affected by Ocean Inundation
- 1.1 — 1% AEP Average Velocity (m/s)
- Council Owned Land
- 910 — SEPP 14 Wetlands
- 15/3 / 850426 — Property Street Number / Lot Number / Deposited Plan Number

MAP KEY

	231B	232A
231C	231D	232C
246A	246B	
246C	246D	

WAMBERAL LAGOON: Concise Description of the Plan

AREA 1: The Lagoon Water Body
The beach berm is to be managed in accordance with the Council policy for Wamberal Lagoon (Appendix A). In severe weather conditions management provisions may have to be delayed until conditions are safe.
The possible impacts of the Greenhouse Effect or other man-made or natural factors which may affect the hydraulics of the opening will be monitored (included under measures applicable to the entire study area - Table 1).

AREA 2: Remembrance Drive
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General measures for the floodplain as described on this sheet.

AREA 3: Loxton Avenue
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General measures for the floodplain as indicated on this sheet.

AREA 4: Wamberal Park and Blue Bell Drive
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General measures for the floodplain as indicated on this sheet.

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General measures for the floodplain as indicated on this sheet.

AREA 6: North Arm (downstream of The Entrance Road)
No specific measures are proposed.
No development conditions required at this time.

AREA 7: North Arm (upstream of The Entrance Road)
Flood free access for The Entrance Road will be considered by Council as part of any future road upgrading works.
General measures for the floodplain as indicated on this sheet.

AREA 8: Upstream Catchments
Development will be considered in the upstream catchments subject to detailed evaluation of the possible impacts on water quantity and water quality.

Wamberal Lagoon

General measures for the floodplain:

- all new buildings and major extensions to be constructed above the minimum floor level (MFL). This is a minimum requirement and a higher floor level is encouraged (to prevent inundation in floods greater than the adopted standard),
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All levels in metres to AHD

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Wamberal Lagoon Floodplain Management Areas

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6. *North Arm (downstream of The Entrance Road)*
7. *North Arm (upstream of The Entrance Road)*
8. *Upstream Catchments*

Coastal Processes Dominate

TERRIGAL LAGOON: Concise Description of the Plan

AREA 1: The Lagoon Water Body
- The beach berm is to be managed in accordance with the Council policy for Terrigal Lagoon (Appendix A of the Plan). In severe weather conditions management provisions may have to be delayed until conditions are safe.
- The possible impacts of the Greenhouse Effect or other man-made or natural factors which may affect the hydraulics of the opening will be monitored (included under measures applicable to the entire study area - Table 1 of the Plan).

AREA 2: Bundara Avenue
- A local drainage study is to be undertaken.
- General measures for the floodplain as indicated on this sheet.

AREA 3: Northern End of Ocean View Drive Bridge
- The effects of ocean inundation are to be addressed by a qualified engineer experienced in coastal matters.
- New buildings within 100 m of the northern shore of the lagoon are to be subject to special design provisions to dissipate forces from ocean inundation.
- General measures for the floodplain as indicated on this sheet.

AREA 4: Southern Shore of the Lagoon
- No specific measures for this area are proposed.
- General measures for the floodplain as indicated on this sheet.

AREA 5: West Arm (west of the Willoughby Road Bridge)
- No specific measures for this area are proposed.
- General measures for the floodplain as indicated on this sheet.

AREA 6: Farrand Crescent
- No specific measures for this area are proposed.
- General measures for the floodplain as indicated on this sheet.

AREA 7: Ogilvie Street
- No specific measures for this area are proposed.
- General measures for the floodplain as indicated on this sheet.

AREA 8: Golf Course
- No specific measures for this area are proposed.
- General measures for the floodplain as indicated on this sheet.

AREA 9: Windsor Road
- Implement the program of works for the levee as outlined in Appendix D of the Plan.
- Implement the measures to control flooding from local catchment runoff (Appendix D of the Plan).
- Initiate an audit and maintenance program for the levee.
- General measures for the floodplain as indicated on this sheet.

AREA 10: Upstream of Willoughby Road Causeway
- No specific measures for this area are proposed.
- General measures for the floodplain as indicated on this sheet.

AREA 11: Upstream Catchments
- Development will be considered in the upstream catchments subject to detailed evaluation of the possible impacts on water quantity and water quality.

Terrigal Lagoon

General measures for the floodplain:

- all new buildings and major extensions to be constructed above the minimum floor level (MFL). This is a minimum requirement and a higher floor level is encouraged (to prevent inundation in floods greater than the adopted standard),
- raising of all existing buildings with floor levels below the MFL is encouraged,
- where possible buildings should be constructed on the high part of the property outside the floodplain,
- filling may be permitted under the plan area of the dwelling and possibly over the remainder of the lot (to 0.2 m above the let out level or higher) subject to the guidelines provided in the General Measures,
- the entrance opening/maintenance procedure (Area 1) will reduce design flood levels by up to 0.1 m.

All levels in metres to AHD

Notes
Building floor levels are provided in Appendix B of the Floodplain Management Study.

The rainfall induced flood levels assume that the entrance berm is at 2.4m AHD at the onset of the event. The lagoon let out level is 1.23m AHD and Council maintains the sandbar at approximately 1.7m AHD.

Design flood levels were taken from the Terrigal Lagoon Flood Study and Floodplain Management Study. Ocean inundation levels were taken from a report, *The Entrance Dynamics of Wamberal, Terrigal, Avoca and Cockrone Lagoons*, prepared by AWACS in November 1994.

Terrigal Lagoon Floodplain Management Areas

1. *The Lagoon Water Body*
2. *Bundara Avenue*
3. *Northern End of Ocean View Drive Bridge*
4. *Southern Shore of the Lagoon*
5. *West Arm (west of the Willoughby Road Bridge)*
6. *Farrand Crescent*
7. *Ogilvie Street*
8. *Golf Course*
9. *Windsor Road*
10. *Upstream of Willoughby Road Causeway*
11. *Upstream Catchments*

Coastal Processes Dominate

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13th August 2001

40 20 0 40 80 120 160 200m
Scale

End of Report