GOSFORD CITY COUNCIL

AVOCA LAGOON
FLOODPLAIN MANAGEMENT PLAN

FINAL

(Adopted by Council 27 May 2008)

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POLICY BACKGROUND

NSW Government Policy

The New South Wales Government's Flood Policy (Reference 1) is directed at providing solutions to existing flooding problems in developed areas as well as ensuring that new development is compatible with the flood hazard and that it does not create additional flooding problems in other areas.

Under the policy, the management of flood-prone land remains the responsibility of local government. The state government subsidises flood mitigation works to alleviate existing problems, providing specialist technical advice to assist councils in the discharge of their floodplain management responsibilities.

The flood policy provides for technical and financial support by the government through the following four sequential stages:

* *Stage 1 - Flood study:*

  Determines the nature and extent of the flood problem.

* *Stage 2 - Floodplain management study:*

  Evaluates management options for the floodplain in respect of both existing and proposed development.

* *Stage 3 - Floodplain management plan:*

  Involves formal adoption by council of a plan of management for the floodplain.

* *Stage 4 - Implementation of the plan:*

  Involves construction of flood mitigation works to protect existing development and includes use of local environmental plans to ensure new development is compatible with the flood hazard.

The Avoca Lagoon Floodplain Management Plan constitutes completion of the third stage of the management process for Avoca Lagoon and its associated catchment and has been prepared for Gosford City Council to determine an appropriate floodplain risk management strategy.

Gosford City Council's Approach

Avoca Lagoon is one of the four major coastal lagoons in the Local Government area. The others are Wamberal, Terrigal, and Cockrone. All the lagoons face similar issues and are affected by:

- NSW Government Floodplain Management Policy;
- NSW Rivers and Estuaries Policy;
- NSW Coastal Policy.

The coastal, estuarine and floodplain management issues overlap to varying degrees in each lagoon.

Council established a Coastal Lagoons and Coastal Planning Committee, which concurrently undertook:

- floodplain management studies for Wamberal, Terrigal, Avoca and Cockrone Lagoons;
- estuarine and water quality investigations of the four lagoons;
- coastline management investigations for the coastline and beaches on the seaward sides of the four lagoons.

Council adopted:

- a Coastline Management Plan in 1995;
- a policy for opening of the various lagoons in 1999 (reviewed March 2005).

The work on the Avoca Flood Study, Floodplain Management Study and Plan were essentially completed over the period 1993 to 1995. However, their publication was delayed until similar projects at Terrigal and Wamberal were completed and the Coastline Management Plan was in place.

Publication Structure

The Floodplain Management Process comprises three stages (viz: Flood Study, Floodplain Management Study, Floodplain Management Plan). Each stage provides data for the Floodplain Management Plan. The most likely users of the reports on each stage are seen as differing. For example, the Plan will be of principal interest to Councillors, individual property owners and developers, while the Flood Study will be of principal interest to hydrologists, riverine and coastal engineers as providing the technical background to the Plan.

Accordingly, the Flood Study, Floodplain Management Study and Plan have been produced as three separate documents with the object of making the Plan as simple to use as possible.

The three stages of the floodplain management process have been completed (to "draft" stage) over a number of years as follows:

- Avoca Lagoon Flood Study – 1994
- Avoca Lagoon Floodplain Management Study – 1995 to 2003)
- Avoca Lagoon Floodplain Management Plan (1996 to 2007)

Thus, the monetary sums quoted in each report represent the Australian dollar values at the time of preparation of the report.

Floodplain Management Principles

Gosford City Council adopted the one percent annual exceedence probability event (1% AEP) as the Designated or Standard flood for consideration of floodplain management options throughout the council area under the 1986 Floodplain Development Manual. The 2001 Floodplain Management Manual supersedes the 1986 version. The 2001 Manual moved from a Flood Standard approach to specification of Flood Planning Levels for various types of development. The 2001 Manual has been superseded by the 2005 Manual (Ref. 5), which explicitly classifies flood liable land as the land inundated by the Probable Maximum Flood (PMF).

Thus, Council's adoption of the one percent flood plus freeboard is a defacto adoption of a Flood Planning Level.

Gosford City Council, in application of floodplain management plans in their administrative area identifies flood-liable land by hydraulic categories as "Floodway" or "Flood Storage".

In Avoca Lagoon and its environs, the hydraulic categories of "Floodway" and "Flood Storage" are applicable to particular portions of land.

Floodways

Floodways are those areas where a significant volume of water flows during floods. They are often aligned with obvious naturally defined channels.

Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, which may, in time, affect other areas. They are often, but not necessarily, the areas with deeper flow or areas where higher velocities occur.

Land use in floodways must be carefully controlled to ensure that the conveyance of the floodway is not reduced. Neither buildings nor hazardous uses or obstruction operations likely to impede floodwaters should be permitted in floodways. Only land use that is flood compatible or likely to enhance floodway capacity should be allowed.

The provision of floodways has added benefits as follows:

- floodways allow retention of the existing stream environment;
- they can accommodate floods larger than the designated flood; and
- a clearly visible floodway constantly provides flood awareness to the local community.

In the distant future, the floodway may provide the opportunity for improvement to the stream conveyance if it is necessary following ongoing development. However, once defined, the floodway should never be compromised. Small changes occurring progressively would, in time, cause a significant change to the flow capacity.

Flood Storage

Flood storage areas are not as sensitive to change as floodways. Essentially, flood storage provides ponding and temporary storage of floodwater. They are generally not categorised by high velocity flows but may involve significant flood depths. It is important to maintain flood storage as loss of such storage may create higher flood levels in the storage area and higher flood levels downstream of the storage area.

Ecologically Sustainable Development

Ecologically sustainable development (ESD) principles are now embodied through government policy (in particular the Environment, Planning and Assessment Act, Regulations 1994).

The Plan seeks to satisfy ESD principles of:

* Intergenerational equity, that is the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;

* Conservation of biological diversity and ecological integrity;

* Active and meaningful community participation in identifying issues, responses and strategies and decision making;

* Precautionary principle in that lack of scientific certainty is not a reason for the lack of amelioration measures to prevent environmental degradation where a threat of serious or irreversible environmental damage exists; and

* Inclusion of valuations of environmental costs of activities and the costs of changes to biodiversity, ecological and cultural values.

This Plan seeks to promote the adoption of an integrated approach to the management of all lands within the Avoca Lagoon catchment.

EXECUTIVE SUMMARY

Avoca Lagoon has a catchment of 11.4 sq kilometres, while the surface area of the lagoon is some 97.7 hectares.

Avoca Lagoon is a relatively small shallow lagoon, located behind Avoca Beach. The entrance is normally closed due to the action of dynamic coastal processes that create a beach berm across the entrance. The lagoon is perched some 2 metres above mean sea level.

The Flood Study of the lagoon was completed essentially in 1994. The flood study indicated that flood levels in Avoca Lagoon are essentially controlled by the beach berm and the break-out of the lagoon through the beach berm.

Gosford Council's existing floodplain management program in Avoca Lagoon comprises essentially:

- to mechanically assist break-out through the beach berm once water levels reach RL 2.09 m AHD; and

- to require minimum building floor levels of RL 3.7 m AHD (within the lagoon storage area).

The Avoca Lagoon Floodplain Management Study was conducted in 1995 and examined a range of structural and non-structural measures to limit and/or reduce existing and future damages from flooding.

The principal measures examined were:

- maintenance of the beach berm at various levels;
- levees at Lake Street;
- house raising;
- flood warning systems;
- voluntary acquisition.

The Avoca Floodplain Management Plan (the subject of this report) follows the Floodplain Management Study.

The Floodplain Management Plan divides the Avoca Lagoon area into four management areas, as below and shown on Figure 2.

Floodplain Management Areas

Management Area	Category
Avoca Lagoon - Beach Berm	High Hazard – Floodway/Investigation
Avoca Lagoon - Entrance	High Hazard / Low Hazard - Floodway
Saltwater Creek	High Hazard – Floodway
Avoca Lagoon and Foreshore	Low Hazard - Flood Storage

Essentially, the Floodplain Management Plan involves:

- maintenance of Council's existing let-out policy;
- maintenance of the beach berms;
- adoption of the design one percent AEP flood plus 0.5 m freeboard as the "Flood Planning Level" through the study area. This follows Council's existing practice.
- building and planning controls to set minimum floor levels and "allowable" building locations.

A summary of the measures is attached.

The Plan allows for a review of its contents every 5 years.

A timetable for implementation of the measures is seen as:

- High priority works and measures: 2007 to 2008 inclusive
- Medium priority works and measures: 2008 to 2009 inclusive
- Low priority works and measures: 2009 to 2012 inclusive

Summary - Broad Measures
Avoca Lagoon Floodplain Management Plan

Item		Comment	Cost to Council [2]	Priority[1]
Works and Measures				
1.	Maintenance of Council's current "let-out" policy	Maintain existing situation	Variable, depends on rainfall recorded	H
2.	Maintain beach berm at RL 2.7 to 2.8 m AHD	Required to enhance break-out	Variable, allow $5,000 per annum	H
3.	Installation of flood gauges to indicate "let-out" levels	Required to assist in public education	Allow $5,000 capital cost	H
4.	Additional investigations of lagoon entrance	Required to define induced levels and forces	Allow $48,000 capital cost	H
5.	Development controls (See summary below)			H
6.	Improved rainfall data collection	Required to give better correlation to Avoca Lagoon water levels	$20,500 capital cost	M
7.	Distribution of simple brochures on flood issues	Required for public education	Allow $5,000 per annum	M
8.	Improved water level prediction	Required to reduce chance of unnecessary opening of lagoon	Allow $3,000 per annum	L
Development Control Measures				
1.	Setting of minimum floor levels	Required to ensure that new buildings and additions are at least 0.5 metres above 1% AEP flood levels	None	H
2.	Raising of existing buildings to be encouraged	Required to provide all buildings to be above 1% AEP flood plus freeboard	None, owner funded	H

Item	Comment	Cost to Council [2]	Priority[1]
3. Filling under floor plan of buildings to be permitted	Required to provide minimum floor levels, subject to adjoining properties not being adversely affected	None	M
4. No filling of environmentally sensitive areas or modification of foreshore	Required for environmental protection	None	H
5. Filling of properties to 200 millimetres above "let-out" level be permitted	Required to reduce regular inundation of properties	None	M

Note: 1. Priorities: H High Priority
M Medium Priority
L Low Priority

2. Dollar values quoted as 2007 dollars (from earlier estimates adjusted by CPI figures)

1. INTRODUCTION

Avoca Lagoon is a coastal lagoon which is formed behind the beach dunes at Avoca Beach, Gosford. Avoca Lagoon is the largest of the four coastal lagoons within Gosford. The lagoon has a cruciform shape with a surface area of 97.5 hectares and average depth of 1.3 metres. The lagoon entrance is normally closed due to the action of coastal dynamic processes which result in the formation of a beach berm across the lagoon entrance, linking Avoca and North Avoca beaches.

The lagoon, as illustrated on Figure 1, is a significant landscape and recreational resource in the Gosford area. Gosford City Council has frequently opened the lagoon to release impounded water. The let-out-level is approximately 2 metres above mean sea level.

The catchment of Avoca Lagoon is some 11.4 square kilometres. Ninety percent of the catchment is natural bushland or under rural development. Urban development is essentially confined to the beach front to the South Pacific Ocean and the slopes around the northern and southern arms of the lagoon.

Three distinct modes of flooding occur in the study area:

- inundation by ocean storm waves near the lagoon entrance;
- inundation by floodwaters ponded in the lagoon around the lagoon foreshores; and
- inundation by local runoff on the floodplain upstream of the lagoon and adjacent to drainage flowpaths.

Ocean inundation levels adjacent to the lagoon entrance are higher than the equivalent lagoon flood levels. Thus management of the entrance area is considered to be a coastal management issue and is not related to lagoon flood management.

Flooding in the tributary creeks to Avoca Lagoon occurs from short duration, intense storms (durations of 3 hours or less) while the lagoon itself floods in longer duration events (durations in the order of 12 hours). The magnitude of flood water level rises in the lagoon is determined by conditions at the beach front and beach berm levels.

Investigations in the Flood Study (Reference 2) and the Floodplain Management Study (Reference 3) indicate that the historical beach berm levels are variable (between 2.5 and 3.6 m AHD) and that design one percent AEP flood levels are some 300 millimetres above the beach berm level prevailing at the time of the flood.

Design one percent AEP flood levels within Avoca Lagoon are RL 3.2 m AHD for a beach berm level of RL 2.8 m AHD. The berm level is some 0.1 metres below the average berm level deduced from Council records available since 1972 and, under the current opening regime, represents a level that is reached or exceeded some 60 percent of the time.

At the upstream end of the study area, design one percent AEP flood levels reach RL 5.6 m AHD.

The flood-liable land around Avoca is comprised of:

- open space, public reserve around the shoreline of the lagoon;
- residential development abutting the above open space public reserve; and
- rural development of the floodplain upstream of the lagoon.

The catchment area of Avoca Lagoon is not developed to the capacity permitted under the current zonings. There are no known plans to intensify development densities permitted within the study area.

There is a significant area of land around the lagoon foreshore which is zoned for open space or public reserve.

Some redevelopment within the current urban areas is likely as holiday cottages are replaced by permanent residences and home unit blocks. There is some evidence of this redevelopment occurring at a number of locations around Avoca Lagoon.

It is also possible that some expansion of the existing urban areas may take place in the future in response to development pressures. However, the catchment characteristics are unlikely to change to a significant degree in the foreseeable future.

2. SPECIFIC COMPONENTS

2.1 Overview

Seven flooding precincts have been identified around the lagoon foreshore. These have been sub-divided into four management areas.

These management areas have been classified for flood hazard as:

High Hazard - Floodways

- Avoca Lagoon beach berm;
- Saltwater Creek, from the upstream study boundary to its confluence with Avoca Lagoon (identified as Saltwater Creek floodway); and

High Hazard – Low Hazard Floodway (Floodway Investigation area)

- Avoca Lagoon at its entrance to the ocean (Floodway/Investigation area);

Low Hazard - Flood Storage

- Avoca Lagoon and foreshores excepting high hazard areas above.

These management areas are illustrated on Figure 2, while Figure 3 provides more detailed information for the Avoca Lagoon entrance area and Figure 4 tables the specific provisions applicable to each of the management areas.

Council has adopted a policy of opening the lagoons when water level reaches RL 2.09 m AHD (identified as the let-out-level). Council has, in the past, also adopted a policy that requires new buildings to have floor levels above RL 3.7 m AHD. These two policies effectively constitute Council's current floodplain management practice around Avoca Lagoon.

Specific components of the Floodplain Management Plan are outlined below.

2.2 Avoca Lagoon Beach Berm

In this area, coastal and ocean processes dominate. Management of the beach berm is covered by a separate Council policy.

Essentially, Council's policy covers:

- management of the beach berm to maintain levels in the range 2.7 to 2.8 m AHD; and
- let-out of the lagoon once water levels reach RL 2.09 m AHD.

The investigations in the Flood Study (Reference 2) showed that maintenance of the beach berm in the range of RL 2.7 to 2.8 m AHD will produce one percent AEP flood levels of RL 3.2 m AHD. The target range of berm level (RL 2.7 to 2.8) is 0.1 metres below the average level maintained over the past 20 years by Council's "let-out" policy.

The community should be aware that severe weather conditions may prevent the "let-out" process and these management provisions may have to be delayed until work conditions are safe. Whilst "best endeavours" can be made to start the "let-out" process, the start cannot be guaranteed. Thus, the Floodplain Management Plan adopts a minimum floor level which matches the existing practice and assumes beach berm management, but also urges use of higher floor levels for new developments to provide a measure of security should the "let-out" process not be successful.

Current practice is to initiate the lagoon "let-out" on the falling tide. However, members of the community have questioned if the degree of scour through the beach berm during "let-out" is mitigated during a rising tide. The effectiveness of "let-out" on a rising tide would be best evaluated by field testing.

The Management Plan in this area thus covers:

- maintenance of Council's current "let-out" policy;

- maintenance of the beach berms at a level between RL 2.7 m to RL 2.8 m AHD to enhance let-out of the lagoon in accordance with Council's "Opening of Coastal Lagoons, Policy"; and

- undertaking a series of measures to optimise the break-out process.

Measures to optimise the break out process are:

- improvement to rainfall data collection systems to allow an improved co-relation between catchment rainfall and lagoon water levels;

- development of improved water level prediction methods for Avoca Lagoon to reduce the chance of unnecessary opening of the lagoon;

- development of an improved flood prediction method to assist timely opening of the beach berm; and

- field trials of opening the lagoon during rising tide conditions to confirm if this strategy effectively reduces the width and depth of scour through the beach berm.

2.3 Avoca Lagoon Entrance Area

This area lies between the Avoca Lagoon Flood Storage area and the beach berm area as shown on Figure 3.

This area is affected by both flooding and coastal processes (principally ocean waves overtopping the beach).

Specific interim land use controls are:

- the area identified shall be treated as "Floodway";
- the areas within the lagoon have been classed as High Hazard Floodway, while the surrounding foreshore areas have been classified as Low Hazard – Floodway (with regard to Lagoon catchment flooding);
- new buildings and major extensions to be encouraged to have floor levels above RL 4.2 m AHD (as protection against the possibility that the beach berm cannot be effectively managed or should the "let-out" process be prevented by prevailing weather conditions);
- all new buildings and major extensions to be above the minimum floor level;
- raising of existing buildings from below minimum floor levels is to be encouraged;
- all buildings and major extensions are to be subject to special design provisions to dissipate forces from inundation by ocean waves in accordance with Council's "Coastal Frontage - Development and Building" Policy;
- all buildings and major extensions are to be subject to special design conditions to address flood flows and velocities. Such flood forces are expected to be less than those created by ocean waves.
- new buildings, re-development or extensions should not project into the floodway more than present buildings. This provision has been specifically addressed by Council's DCP No. 155 "Single Dwellings and Ancillary Structures".
- filling will be considered under the floor plan of buildings to achieve minimum floor levels, subject to the requirement that such filling have no adverse affects on overland flow on adjacent properties; and
- no further sub-division within the area or development that increases the population density. This provision is intended to limit the population at risk and thus in need of evacuation should a major flood or ocean event occur.

2.4 Avoca Lagoon Flood Storage Area

This precinct covers the bulk of Avoca Lagoon and its environs, as outlined on Figure 2.

The Floodplain Management Plan allows for the Avoca Lagoon beach berm to be maintained at about RL 2.7 m AHD and the current practice of assisting "let-out" once water levels reach RL 2.09 m AHD. However, the "let-out" process may be delayed by severe weather conditions.

Thus, the Plan provides for enforcement of minimum floor levels which assume the "let-out process" is effective and encourages higher floor levels as additional protection against uncertainty of the "let-out" process.

Specific provisions in this precinct are:

- all new buildings and major extensions are encouraged to be located outside the 1% AEP flood extent where possible;

- all new buildings and major extensions to be encouraged to have floor levels above RL 4.2 m AHD (as protection against the possibility that the beach berm cannot be effectively managed or should the "let-out" process be prevented by prevailing weather conditions);

- all new buildings and major extensions in or adjacent to the flood storage area are to be above the minimum floor level of RL 3.7 m AHD;

- raising of existing buildings to above minimum floor levels is to be encouraged;

- filling will be considered under the footprint of buildings to achieve minimum floor levels, subject to the requirement that such filling having no adverse affects on overland flow on adjacent properties;

- filling of properties up to 200 millimetres above the "let-out" level will be considered, provided side slopes do not exceed 1:6 (vertical to horizontal) and provided such filling does not affect overland flow on adjoining properties;

- filling of environmentally sensitive areas, or modification of the foreshore, will not be permitted; and

- proposed large scale filling will be treated on its merits, including assessment of drainage of overland flow patterns. Fill batters should not exceed 1:6 (vertical to horizontal).

- developments below the PMF level should have purposes that are compatible with the extreme flood risk and developments that are not compatible with flood recovery planning should be excluded (eg schools, hospitals, aged care facilities).

2.5 Saltwater Creek Floodway Area

This precinct represents the major tributary inflow into Avoca Lagoon as outlined on Figure 2.

Specific provisions in this precinct are:

- floodway to be maintained in perpetuity for the passage of floodwaters;
- no works that impede the passage of floodwaters along the floodway are permitted;
- no new construction of buildings in the floodway is permitted;
- filling is prohibited;
- all land use to be flood compatible;
- raising of existing buildings from below minimum floor levels is to be encouraged;
- fences, structures, landscaping and plantings likely to collect debris and/or impede the floodway are not permitted;
- all new buildings and major extensions are to be constructed outside the 1% AEP flood area and are to be constructed above the minimum floor level; and
- proposals to cross the floodway for services are permitted provided the proposals are adequately investigated and do not significantly affect flood capacity or flood levels.

2.6 General Provisions

Section 2.2, "Avoca Lagoon Beach Berm", contains a number of general provisions relating to improved management of the beach berm.

These management provisions, in summary, are:

- improved rainfall data collection;
- improved water level prediction; and
- improved flood prediction methods.

The object of the above is improvement of the prediction of lagoon levels to ensure that the beach berm is not opened unnecessarily.

Additional general provisions are proposed.

They are:

- preparation and distribution of simple brochures outlining flood issues and the responses contained in this Plan; and

- construction of two staff gauges at convenient locations to indicate "let-out levels", design 1% AEP flood levels and Council's "Let-out" Policy. Suggested locations are on Avoca Drive (at the Avoca Lagoon bridge crossing) and Bradleys Road. Some access provisions may be required at the Bradleys Road site.

It is noted in the Floodplain Management Study that upstream development has the potential to impact on flood behaviour and thus impact on the provisions of this Plan.

Accordingly, development controls are required upstream of Avoca Lagoon to:

- restrict flood flows to current levels (to prevent an increase in design flood levels);

- restrict the sediment generation and transport to Avoca Lagoon as increases can increase siltation of the Lagoon and subsequently increase flood levels.

2.7 Review Process

It is accepted that the Floodplain Management Process is not "fixed". The provisions of this Plan can be expected to change in response to:

- recorded flood occurrences;

- changes in community perceptions and requirements; and

- changes to Government legislative frameworks (for example, the introduction of new State Environment Planning Policies (SEPP).

Review Process should be triggered by either:

- flood reaching greater than RL 2.8 m AHD within the lagoon storage area; or
- passage of 10 years after adoption of the Plan.

Each review should identify:

- if catchment changes have modified runoff and flow volumes;

- the adequacy of the berm maintenance operations and any changes to the frequency of required operations;

- recorded rainfalls, flood levels and berm openings;

- the adequacy of public education and flood warning system; and

- the adequacy of measures to deal with floods larger than the design one percent AEP flood level.

- the magnitude of any ocean level rises or climate change that would affect the provisions of the Plan.

GLOSSARY

GLOSSARY - TERMS AND ABBREVIATIONS

Average Annual Damage (AAD): depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time. Refer Appendix H of Floodplain Management Manual (Ref. 1).

Annual Exceedence 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).

Anti-dunes: erodible channels have bed forms. Anti-dunes are wave like bed forms which migrate upstream. They require high velocities to create the particular bed form.

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

Average Recurrence Interval: 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.

Critical flow: flow lies between sub-critical and super-critical flow conditions. Critical flow usually occurs at flow controls eg. at a weir.

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

> *infill development:* refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development.
>
> *new development:* refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.
>
> *redevelopment:* refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.

Direct Damage: damage caused by contact with flood water eg. structural damage to building, water damage to furniture or house contents or damage caused by silt and debris.

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).

DST: Day Light Saving Time (East Coast).

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

EST: Eastern Standard Time.

Flash flooding: flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.

Flood education, awareness and readiness:

> *Flood education* seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
>
> *Flood awareness* is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
>
> *Flood readiness* is an ability to react within the effective warning time.

Flood fringe areas: the remaining area of flood prone land after floodway and flood storage areas have been defined.

Flood liable land: is synonymous with flood prone land (ie) land susceptible to flooding by the probable maximum flood (PMF) event. 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 (Ref. 4) (see flood planning area).

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 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 (Ref. 4).

Flood risk: potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in the Floodplain Management Manual is divided into 3 types, existing, future and continuing risks. They are described below.

> *existing flood risk:* the risk a community is exposed to as a result of its location on the floodplain.
>
> *future flood risk:* the risk a community may be exposed to as a result of new development on the floodplain.
>
> *continuing flood risk:* the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.

Flood storage areas: those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.

Floodway areas: those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.

Freeboard: a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted flood planning level and the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such and wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change. Freeboard is included in the flood planning level.

Hazard: a source of potential harm or a situation with a potential to cause loss. In relation to the Floodplain Management Manual (Ref. 1), the hazard is flooding which has the potential to cause damage to the community. (Definitions of high and low hazard categories are provided in Appendix G of Floodplain Management Manual).

Hydraulics: term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.

Indirect Damage: damage caused by flooding though not directly eg. loss of trade, cost of alternative accommodation or loss of wages.

Intangible Damage: damage that occurs but is difficult to quantify eg. increased ill-health in the community or disruption to community life.

Let-out-level: the water level in the lagoon used by Gosford City Council to initiate a mechanical break-out of the beach berm.

Mainstream flooding: inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

Mathematical/computer models: the mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.

Modification measures: measures that modify either the flood, the property or the response to flooding.

Peak Discharge: the maximum discharge occurring during a flood event.

Phreatic Line: free water surface line reached within the beach berm.

Probable Maximum Flood (PMF): the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with the PMF event should be addressed in a floodplain risk management study.

Probable Maximum Precipitation (PMP): the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to the estimation of the probable maximum flood.

Probability: a statistical measure of the expected chance of flooding (see annual exceedance probability).

Reduced Level (RL): a measured height above Australian Height Datum.

Risk: chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the Floodplain Management Manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

Runoff: the amount of rainfall which actually ends up as streamflow, also known as rainfall excess.

Sub-critical flow: flow in the channel is characterised by "mild" conditions featuring low velocities and reasonable depths.

Super-critical flow: flow in the channel is characterised by "unstable" conditions featuring high velocities and low depths.

Tangible Damage: damage that can be quantified in monetary terms.

Top Water Level (TWL): water level in the lagoon referenced by Council's opening records as existing prior to lagoon break-out.

REFERENCES

REFERENCES

1. "Floodplain Management Manual: The Management of Flood Liable Land", New South Wales Government, January 2001.

2. "Avoca Lagoon Flood Study", Paterson Consultants Pty Limited, April 1994.

3. "Avoca Lagoon Floodplain Management Study", Paterson Consultants Pty Limited, March 1995.

4. "Floodplain Development Manual", New South Wales Government, Public Works Department 86010, ISBN 724030115, Dec. 1986.

5. "Floodplain Development Manual, the Management of Flood Liable Land", New South Wales Government, Department of Infrastructure Planning and Natural Resources, ISBN 07347 5476 0, April 2005.

FIGURES

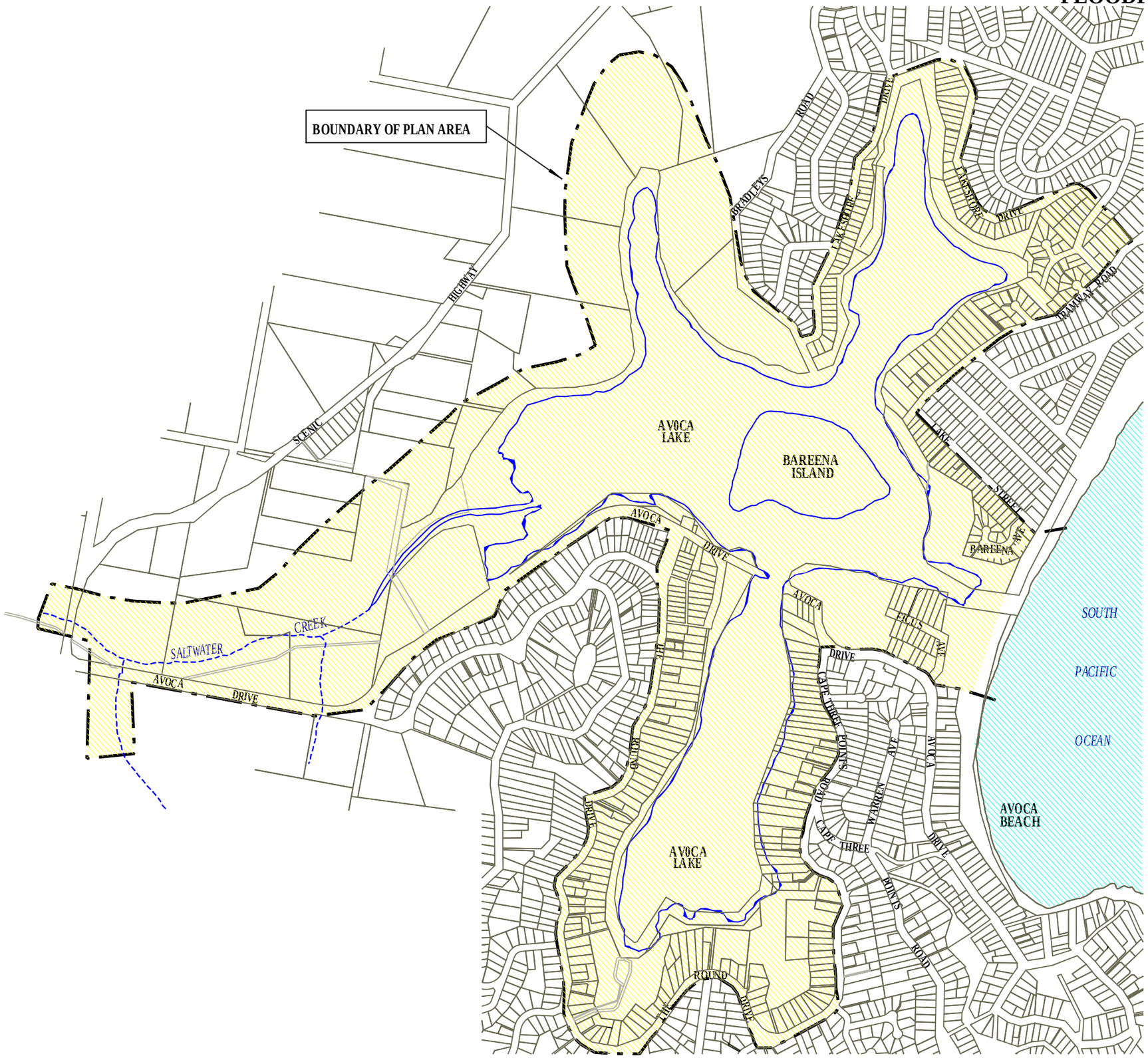

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FIGURE 1
STUDY AREA

AVOCA LAGOON
FLOODPLAIN MANAGEMENT PLAN

GENERAL MEASURES & GENERAL DEVELOPMENT CONTROLS

1. "Let-out Level" RL 2.09 m AHD
2. Develop an improved water level prediction method to reduce an unnecessary opening of the beach berm.
3. Improve rainfall data collection and improve correlation of rainfall to lagoon water level.
4. Develop an improved flood prediction method to assist timely opening of the beach berm.
5. Public information program by brochures
6. Construction of two staff gauges at convenient locations to improve public awareness.
7. Development controls upstream to restrict flood flows to current levels
8. Development controls upstream to restrict sediment generation and transport to Avoca Lagoon
9. New developments and major extensions to have flood free access up to 1% AEP flood event where possible.
10. All new developments and major extensions to to be above the minimum floor level

AVOCA LAGOON FLOOD STORAGE AREA
(For Specific Provisions see Table 1 on Figure 4)

SALTWATER CREEK FLOODWAY AREA
(For Specific Provisions see Table 2 on Figure 4)

AVOCA LAGOON ENTRANCE AREA
(See Detail on Figure 3 and for Specific Provisions see Table 3 on Figure 4)

AVOCA LAGOON BEACH BERM
(See Detail on Figure 3 and for Specific Provisions see Table 4 on Figure 4)

COASTAL PROCESSES DOMINATE IN THIS AREA
(See Detail on Figure 3)

LIMIT OF STUDY
LIMIT OF STUDY
LIMIT OF STUDY
LIMIT OF STUDY
LIMIT OF STUDY
LIMIT OF STUDY

HIGH HAZARD FLOODWAY
LOW HAZARD FLOOD STORAGE
LOW HAZARD FLOOD STORAGE

SCENIC DRIVE
AVOCA DRIVE
AVOCA DRIVE
AVOCA DRIVE
FICUS AVENUE
CAPE THREE POINTS ROAD
WARREN AVENUE
AVOCA DRIVE
AVOCA BEACH
OCEAN STREET
LAKE STREET
THE ROUND

911
912
914

3.2 3.3 3.5 3.8 4.0 4.3 4.5 4.8 5.0 5.3 5.4 5.6

LEGEND

1. WETLANDS
SEPP 14 WETLANDS AREAS
WETLAND IDENTIFICATION
2. COUNCIL OWNED LAND
3. BUILDINGS (IF SHOWN)
EXISTING DEVELOPMENTS
BUILDING FOOTPRINT
IMPROVEMENTS FOOTPRINT

LEGEND - FLOODING

FLOOD LEVELS
1% AEP FLOOD LEVELS (m AHD)
FLOOD EXTENTS
1% AEP FLOOD LEVEL EXTENT
1% AEP FLOOD LEVEL + 0.5m ON PROPERTIES
PROBABLE MAXIMUM FLOOD
FLOODPLAIN MANAGEMENT PLAN
MANAGEMENT AREA BOUNDARY
LOW HAZARD, FLOOD STORAGE
HIGH HAZARD, FLOODWAY

0 100
METRES

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FIGURE 2
AVOCA LAGOON MANAGEMENT PLAN

AVOCA LAGOON
FLOODPLAIN MANAGEMENT PLAN

GENERAL MEASURES & GENERAL DEVELOPMENT CONTROLS

1. "Let-out Level" RL 2.09 m AHD
2. Develop an improved water level prediction method to reduce any unnecessary opening of the beach berm.
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4. Develop an improved flood prediction method to assist timely opening of the beach berm.
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6. Construction of two staff gauges at convenient locations to improve public awareness.
7. Development controls upstream to restrict flood flows to current levels
8. Development controls upstream to restrict sediment generation and transport to Avoca Lagoon
9. New developments and major extensions to have flood free access up to 1% AEP flood event where possible.
10. All new developments and major extensions to to be above the minimum floor level.

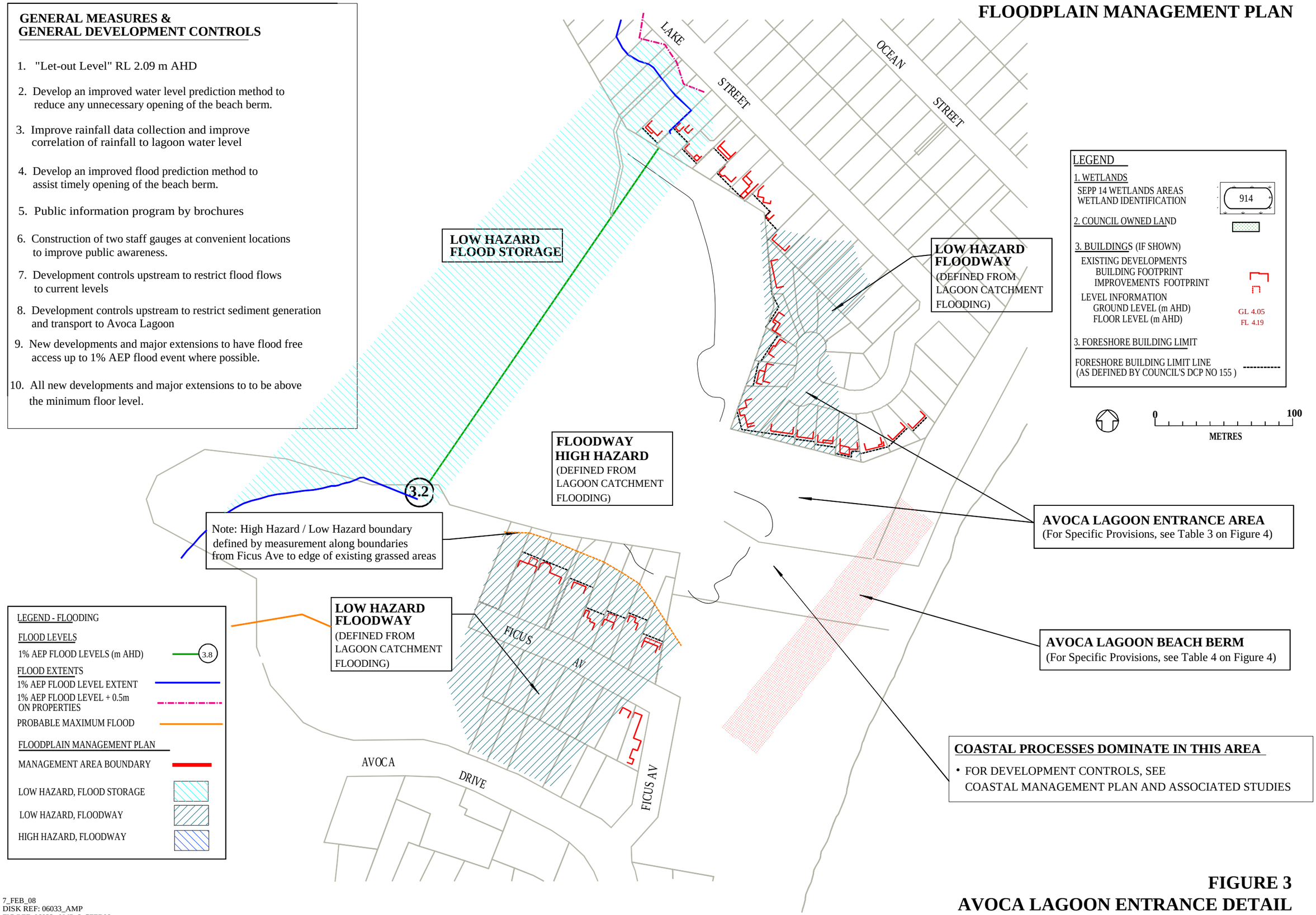

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FIGURE 3
AVOCA LAGOON ENTRANCE DETAIL

AVOCA LAGOON
FLOODPLAIN MANAGEMENT PLAN

TABLE 1

SPECIFIC PROVISIONS, AVOCA LAGOON FLOOD STORAGE AREA

- all new buildings and major extensions are encouraged to be located outside the 1% AEP flood extent where possible;
- all new buildings and major extensions to be encouraged to have floor levels above RL 4.2 m AHD (as protection against the possibility that the beach berm cannot be effectively managed or should the "let-out" process be prevented by prevailing weather conditions);
- all new buildings and major extensions in or adjacent to the flood storage area are to be above the minimum floor level of RL 3.7 m AHD;
- raising of existing buildings to above minimum floor levels is to be encouraged;
- filling will be considered under the footprint of buildings to achieve minimum floor levels, subject to the requirement that such filling having no adverse affects on overland flow on adjacent properties;
- filling of properties up to 200 millimetres above the "let-out" level will be considered, provided side slopes do not exceed 1:6 (vertical to horizontal) and provided such filling does not affect overland flow on adjoining properties;
- filling of environmentally sensitive areas, or modification of the foreshore, will not be permitted; and
- proposed large scale filling will be treated on its merits, including assessment of drainage of overland flow patterns. Fill batters should not exceed 1:6 (vertical to horizontal).
- developments below the PMF level should have purposes that are compatible with the extreme flood risk and developments that are not compatible with flood recovery planning should be excluded (eg schools, hospitals, aged care facilities).

TABLE 2

SPECIFIC PROVISIONS, SALTWATER CREEK FLOODWAY AREA

- floodway to be maintained in perpetuity for the passage of floodwaters;
- no works that impede the passage of floodwaters along the floodway are permitted;
- no new construction of buildings in the floodway is permitted;
- filling is prohibited;
- all land use to be flood compatible;
- raising of existing buildings from below minimum floor levels is to be encouraged;
- fences, structures, landscaping and plantings likely to collect debris and/or impede the floodway are not permitted;
- all new buildings and major extensions are to be constructed outside the 1% AEP flood area and are to be constructed above the minimum floor level; and
- proposals to cross the floodway for services are permitted provided the proposals are adequately investigated and do not significantly affect flood capacity or flood levels.

TABLE 3

SPECIFIC PROVISIONS, AVOCA LAGOON ENTRANCE AREA

- the area identified shall be treated as "Floodway";
- the areas within the lagoon have been classed as High Hazard Floodway, while the surrounding foreshore areas have been classified as Low Hazard - Floodway (with regard to Lagoon catchment flooding).
- all new buildings and major extensions to be encouraged to have floor levels above RL 4.2 m AHD (as protection against the possibility that the beach berm cannot be effectively managed or should the "let-out" process be prevented by prevailing weather conditions);
- raising of existing buildings from below minimum floor levels is to be encouraged;
- all buildings and major extensions are to be subject to special design provisions to dissipate forces from inundation by ocean waves in accordance with Council's "Coastal Frontage - Development and Building" Policy;
- all buildings and major extensions are to be subject to special design conditions to address flood flows and velocities. Such flood forces are expected to be less than those created by ocean waves.
- new buildings, re-development or extensions should not project into the floodway more than present buildings. This provision has been specifically addressed by Council's DCP No. 155 "Single Dwellings and Ancillary Structures".
- filling will be considered under the floor plan of buildings to achieve minimum floor levels, subject to the requirement that such filling have no adverse affects on overland flow on adjacent properties; and
- no further sub-division within the area or development that increases the population density. This provision is intended to limit the population at risk and thus in need of evacuation should a major flood or ocean event occur.

TABLE 4

SPECIFIC PROVISIONS, AVOCA LAGOON BEACH BERM

- maintenance of Council's current "let-out" policy;
- maintenance of the beach berms at a level between RL 2.7 m to RL 2.8 m AHD to enhance let-out of the lagoon in accordance with Council's "Opening of Coastal Lagoons Policy"
- undertaking a series of measures to optimise the break-out process:
  - improvement to rainfall data collection systems to allow an improved co-relation between catchment rainfall and lagoon water levels;
  - development of improved water level prediction methods for Avoca Lagoon to reduce the chance of unnecessary opening of the lagoon;
  - development of an improved flood prediction method to assist timely opening of the beach berm; and
  - field trials of opening the lagoon during rising tide conditions to confirm if this strategy effectively reduces the width and depth of scour through the beach berm.

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FIGURE 4
AVOCA LAGOON MANAGEMENT PLAN, SPECIFIC PROVISIONS