A part of BMT in Energy and Environment

Burrill Lake Floodplain Risk Management Study and Plan

Final Report

R.N1777.001.04.FinalReport.docx

February 2013

Shoalhaven City Council

Burrill Lake Floodplain Risk Management Study and Plan

Offices

Brisbane
Denver
Mackay
Melbourne
Newcastle
Perth
Sydney
Vancouver

Prepared For:	Shoalhaven City Council
Prepared By:	BMT WBM Pty Ltd (Member of the BMT group of companies)

DOCUMENT CONTROL SHEET

BMT WBM Pty Ltd BMT WBM Pty Ltd 126 Belford Street BROADMEADOW NSW 2292 Australia PO Box 266 Broadmeadow NSW 2292 Tel: +61 2 4940 8882 Fax: +61 2 4940 8887 ABN 54 010 830 421 www.bmtwbm.com.au	***Document :*** R.N1777.001.03.Final.docx ***Project Manager :*** Darren Lyons ***Client :*** Shoalhaven City Council ***Client Contact:*** Isabelle Ghetti ***Client Reference***

Title :	Burrill Lake Floodplain Risk Management Study and Plan
Author :	Darren Lyons, Daniel Williams
Synopsis :	This report documents the Burrill Lake Floodplain Risk Management Study and Plan which investigates and presents a flood risk management strategy for the catchment. The study identifies the existing flooding characteristics and canvasses various measures to mitigate the effects of flooding. The end product is the Floodplain Management Plan, which describes how flood liable lands within the Burrill Lake catchment are to be managed in the future.

REVISION/CHECKING HISTORY

REVISION NUMBER	DATE OF ISSUE	CHECKED BY		ISSUED BY	
0	19 March 2012	DJL		DJL	
1	21 April 2012	DJL		DJL	
2	29 May 2012	DJL		DJL	
3	03 January 2012	DJL		DJL	
4	19 February 2013	DJL		DJL	

DISTRIBUTION

DESTINATION	REVISION				
	0	1	2	3	4
SCC BMT WBM File BMT WBM Library	electronic	electronic	electronic	electronic	electronic

EXECUTIVE SUMMARY

What is this Plan about and how has it been developed?

The Burrill Lake Floodplain Risk Management Study and Plan (FRM Plan) has been developed to direct and co-ordinate the future management of flood prone lands beside Burrill Lake. It also aims to educate the community about flood risks around Burrill Lake, so that they can make more appropriate and informed decisions regarding their individual exposure and responses to flood risks. The FRM Plan sets out a strategy of short term and long term actions and initiatives that are to be pursued by agencies and the community in order to adequately address the risks posed by flooding.

The FRM Plan covers the Burrill Lake floodplains incorporating the main urban developments of Dolphin Point, Burrill Lake, Bungalow Park and Kings Point. Emphasis is placed on the flood prone parts of the villages around the Burrill Inlet.

This FRM Plan is the culmination of many years of studies and on-going research that have aimed to understand the nature and extent of flooding across the Burrill Lake catchment. Development of the FRM Plan has been guided by the NSW Government's Floodplain Development Manual (2005).

The structure of this FRM Plan is presented in Figure A1. In essence this Plan assessed the current management of risks to life and property from floods in Burrill Lake against the principles for floodplain management as outlined in the Floodplain Development Manual. Current floodplain risk management is a legacy of past works and actions, and also the flood environment of Burrill Lake – that is, flooding can occur as a result of flooding from the local catchments, ocean flooding from elevated water levels in the ocean (tide and storm surge) and low-level persistent flooding from elevated Lake levels during periods of closure. Low-level persistent flooding may also become more frequent when the entrance is open with typically higher tidal levels associate with potential sea level rise. Based on the considered gaps and short-comings of current risk management, this FRM Plan reviews potential alternative risk management options and then formulates a future flood management strategy. The strategy includes both short term works and actions as well as longer term initiatives.

The short term works and actions have been chosen to give maximum priority benefit while also being readily implementable within envisaged affordable budgets. Implementation is still, however, subject to this albeit limited funding - customarily allocated year by year.

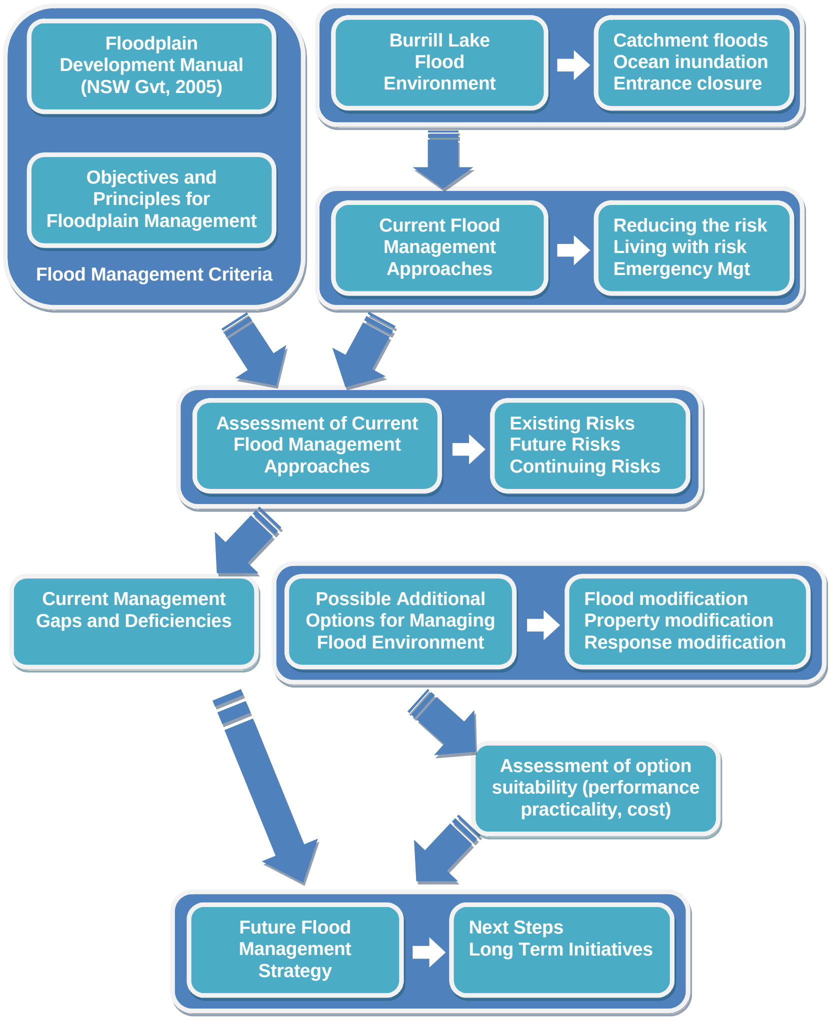


Figure A1: Structure of the Burrill Lake Floodplain Management Study & Plan

The longer term initiatives are still needed - to address the limitations of current risk management. The definition of these longer term initiatives is subject to future review while the short term works and actions are completed. Implementation of reviewed longer term floodplain risk management initiatives for areas around Burrill Lake would be subject to available future funding

It is very important to acknowledge that it is impractical to immediately eliminate all flood risks from the existing development beside Burrill Lake. Instead, the aim of future floodplain risk management is to ensure that existing and future development is exposed to an 'acceptable' level of risk, consistent with other risks that people live with on a day to day basis. Most importantly, this Plan seeks to minimise Risks to Life, as there can be no more serious loss during a flood event.

Flooding on the Peninsula, Burrill Lake, 1991

Why is flooding in Burrill Lake a problem?

Many parts of the Burrill Lake floodplains have been developed over time, taking advantage of the environmental and recreational values of the Lake side environment. Significant parts of this development occupy relatively low-lying lands which in times of non-flood offer the lifestyle opportunities that make the region attractive. However, the occupation of such low-lying land provides for significant flood risk given the potential for frequent and severe inundation from a number of flooding sources.

There are three causes of flooding: significant catchment rainfall, oceanic inundation and low-level persistent flooding from elevated Lake levels when the lake entrance is closed. There have been few occurrences of significant catchment or ocean flooding events in recent times. Flooding experiences in Burrill Lake over the last 20years have largely been related to low-level persistent flooding from an increased incidence of closure, partly related to long periods of low rainfall.

However, major flooding has occurred many times previously, most recently in June 1991, and will inevitably return. Recent flood experiences across Australia have demonstrated the devastating impacts of flooding with many "never seen before" or "worst flood on record" events that highlight the susceptibility of development on flood prone land to levels unlikely to have been experienced by many residents.

Quick Definitions

Existing Risk: Flooding risks that affects existing development

Future Risk: Flooding risks that will affect future development, once built

Continuing Risk: The risk remaining after all management works and initiatives have been implemented. This is the risk that people just have to live with, and therefore it must be at an acceptable level

Low-level Persistent Flooding: Flooding of the lowest parts of the foreshore areas from gradual rises in Lake level during periods of entrance closure or under potentially higher tidal conditions with sea level rise and an open entrance.

Catchment Flooding: Flooding from runoff generated from significant rainfall in the catchment contributing to flows into Burrill Lake

Ocean Flooding: Flooding from very high ocean water levels, typically as a combination of big tides and storm surge

Risk to Life: Flooding risks that threaten life. This is the worst type of flood risk

Risk to Property: Flooding risks that threaten to damage or destroy property

10% AEP flood: There is a 10% (1 in 10) chance that a flood of this size or bigger will occur in any year

1% AEP flood: There is a 1% (1 in 100) chance that a flood of this size or bigger will occur in any year

Probable Maximum Flood (PMF): This is an extreme flood that is many times larger than the 1% AEP. Whilst it can potentially occur, it has a very low chance of occurring

The majority of developed properties in the suburbs around Burrill Inlet are located on the floodplain

Flood event	Approximate number of properties affected (ground inundated)	Approximate number of properties flooded above floor level
10% Annual Exceedence Probability (AEP)	380	70
1% Annual Exceedence Probability (AEP)	460	310
Probable Maximum Flood (PMF)	540	510

How have flood issues been addressed in the past?

Artificial opening of the entrance (June 2007)

Efforts to control flooding have largely been limited to intervention at the entrance. From the very early days there was a lot of pressure to keep the entrance channel open to relieve inundation on low-lying land fringing the Lake.

In more recent times, Council has imposed Flood Planning Levels (FPLs) on all new developments. These are minimum floor level standards, typically taken as 0.5 metres freeboard above the predicted 1% AEP flood level. The FPLs have varied over time as the flood level estimates they are based on have been refined. These levels have only recently (within the last 10 years) been able to be calculated using computer modelling of flooding, and are currently based on probabilities of catchment rainfall and ocean water levels.

Whilst Council has controlled development through FPLs, there still remains significant flood risk associated with existing development approved on the basis of past flood level estimates. Of serious concern is the large 'Risk to Life' during an extreme event (many times larger than the 1% AEP event), wherein potentially people would not have time to evacuate to safety, and would be either stuck on roads that turn into hazardous floodways, or are taking refuge within buildings that could conceivably collapse under the weight and force of floodwaters.

The nature of flooding in Burrill Lake is such that severe flooding problems can occur with very little warning. In most cases, emergency services such as the SES would not have the time or access from remote stations to help people in need during a major flood. Therefore, the Burrill Lake community needs to know what to do, and more importantly, what not to do, when faced with a flood situation.

A focus on entrance management works to reduce flooding only has some value in association with managing low-level persistent flooding. However, for major catchment flood events, the starting condition of the entrance, being in a heavily shoaled state or an open channel has minimal impact on the peak flood water levels reached in Burrill Lake.

The threat posed by ocean flooding to Burrill Lake is as significant as major catchment flooding. Under ocean flooding scenarios an open entrance allows for a greater penetration of ocean water through the inlet into the Lake. As such a wide open entrance condition may in fact exacerbate the ocean flooding risk for some event conditions.

Foreshore areas are susceptible to permanent inundation with future sea level rise (photo courtesy J Booler)

Coastal flooding in lowland areas such as Burrill Lake will be of increasing concern as sea level rises. This will increase the frequency, duration and height of flooding and consequent emergency evacuations as well as associated property and infrastructure damage. The NSW Government has made a concerted effort to incorporate climate change into relevant planning. The NSW Sea Level Rise Policy Statement (NSW Government 2009) was prepared to support consistent adaptation to projected sea level rise impacts. This policy statement included sea level rise planning benchmarks, which have since been revoked as formal benchmarks but remain the best currently available scientific advice for assessing potential impacts of sea level rise in coastal areas, including flood risk and coastal hazard assessments. The benchmarks are a projected rise in sea level, relative to the 1990 mean sea level, of 0.4 metres by 2050 and 0.9 metres by 2100.

At some time in the future with sea level rise, the majority of the existing areas of Bungalow Park Village and Burrill Lake Village will be subject to permanent inundation from normal Lake levels. Even before permanent inundation however, the increased frequency of flooding and high groundwater levels will become an issue. It is expected that under a sea level rise of about 0.4 metres, roads, structures and even ground vegetation would start to become detrimentally impacted by high groundwater levels, while a sea level rise of 0.9 metres would lead to deep inundation within many streets and yards on a frequent basis. Even under existing conditions, low-level persistent flooding presents problems to the community, noting the current entrance management trigger level of between 1.0 and 1.2m AHD.

The continued occupation of currently affected land in Burrill Lake would require raising of existing ground level through extensive land filling to combat the risk of rising lake levels and associated inundation and groundwater problems. If adaptation of existing developed areas cannot be achieved in an economically, socially and environmentally acceptable manner, then a planned retreat of current occupied flood prone land may be an appropriate land use strategy.

What is proposed to improve flood management in Burrill Lake and how it will help?

The outcomes of the study provide the basis for the Floodplain Risk Management Plan, containing an appropriate mix of management measures and strategies, to help direct and coordinate the responsibilities of Government and the community in undertaking immediate and future flood management works and initiatives.

Completion of the study and ultimately adoption of the recommended FRM Plan represents a major step in ongoing floodplain risk management in Burrill Lake with a number of positive outcomes including:

- that a number of options have been identified and recommended that would alleviate the impacts of a flood on the community at Burrill Lake;
- once adopted The FRM Plan will open the doors to funding for council and property owners to implement a number of actions such as flood warning, voluntary house raising, etc.;
- the recommended actions will inform council’s capital works program;
- the plan recommends further investigations that will require active community involvement and engagement; and

- there are no recommended actions that will impose any modifications to existing dwellings at risks.

A summary of what is proposed for Burrill Lake is provided in the Table below.

Summary of Proposed Actions, Works and Initiatives
Education Initiatives
Undertake community education, facilitated through a flood liaison officer
Flood Prediction & Warning
Provide water level forecasting for Burrill Lake gauge
Development of improved Flood Warning System for Burrill Lake(covering Catchment and Ocean Flooding), including effective broadcasting of warnings and relevant information through multi media and social media channels
Emergency Management
Update and implement as required the SES Local Flood Plan for Burrill Lake to include catchment and ocean flood risks and issues
Investigate a road raising program to provide suitable emergency access routes for low-lying development at Bungalow Park and Burrill Lake Village for small to medium flood events recognising that suitable emergency routes for the highest flood events may not be achievable.
Initiate discussion with the Roads and Maritime Service to upgrade the Princes Highway causeway and bridge (+Racecourse Creek near Ulladulla) to a 1% AEP or better service standard so as to facilitate emergency response operations
Property Works
Continued implementation of the Interim Entrance Management Policy to address low-level flooding issues recognising that mechanical entrance intervention may not be achievable in the long term should sea level rise manifest
Investigate Voluntary House Raising Program through prioritisation of eligible properties and establishment of funding model
Encourage redevelopment and renovations with more flood resilient materials and design
Planning Controls
Existing generic planning controls in DCP 106 Amendment 1(including Flood Planning Levels) have been confirmed appropriate with additional local controls recommended relating to no intensification of development, control on land filling, triggers for FPL review relating to climate change information and entrance management.
Other Initiatives
Undertake appropriate technical, social and economic investigations to establish a Strategic Position that will decide between abandoning or rescuing low-lying areas/suburbs in the long-term (50-year horizon). Technical investigation to include investigation of alternative building forms, review of the provision and maintenance of infrastructure and services and feasibility of a voluntary house purchase scheme.

What can the community do to help?

During floods, people will need to be responsible for their own personal safety. Appropriate actions such as early evacuation, not driving/wading through floodwater and preparing property for potential inundation can directly reduce the damages of flooding. This Plan aims to help people make the right decisions when faced with flooding through an extensive Community Education Program. The Program will provide people with a greater understanding of local flooding conditions, including flooding that has not been experienced to date. The Program also aims to arm the community with knowledge about what to do during a flood event, and more importantly, what not to do in a flood.

From a community perspective, it is important to understand flooding in Burrill Lake, and be prepared to act appropriately should flooding occur. In essence, the community needs to become ‘flood ready’. This can include preparing a personal emergency plan for a house or business, which should include options for evacuation, emergency contact numbers, and arrangements for post-flood recovery.

The community should also be ‘tuned in’ to possible flood warnings, thus giving themselves the maximum possible opportunity to prepare and respond to the flood. Once set up, a Warning System will allow community members to be included on automatic notifications of flood warnings (such as subscriptions to SMS or email alerts, or connected to facebook or twitter accounts used to disseminate warnings).

Overall, the best thing that community members can do is to take an interest in flooding issues in Burrill Lake. This way, they will be more aware and better prepared if a flood strikes suddenly.

Effective management of flooding in Burrill Lake will require significant investment in long term outcomes. It is expected that effective flood management will not be achieved unless there is strong political support for such actions, and this will only occur if the community are active and engaged in the issues.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

This document is the end product of considerable financial and personal contribution from a variety of organisations, individuals and the community over several years. Financial assistance through the State Floodplain Management Grant program, complemented by Council funding support, has made this document possible. Our gratitude extends to those agencies, council officers, councillors and community representatives, who have contributed both to the day to day requirements of such studies but also the past and present members of the Far South Natural Resource and Floodplain Management Committee, established to oversee and ultimately support this Study and Plan.

Finally, we wish to thank the community who have willingly contributed to discussions and voiced their concerns, opinions and support throughout the whole process.

GLOSSARY

annual exceedance probability (AEP) AEP (measured as a percentage) is a term used to describe flood size. It is a means of describing how likely a flood is to occur in a given year. For example, a 1% AEP flood is a flood that has a 1% chance of occurring, or being exceeded, in any one year. It is also referred to as the '1 in 100 year flood'. The AEP terminology has been used primarily in this document.

10% AEP flood There is a 10% (1 in 10) chance that a flood of this size or bigger will occur in any year (sometimes called the 1 in 10 year flood)

1% AEP flood There is a 1% (1 in 100) chance that a flood of this size or bigger will occur in any year (sometime called the 1 in 100 year flood).

Australian Height Datum (AHD) National survey datum corresponding approximately to mean sea level.

attenuation Weakening in force or intensity

catchment The catchment at a particular point is the area of land that drains to that point.

continuing risk The risk remaining after all management works and initiatives have been implemented. This is the risk that people just have to live with, and therefore it must be at an acceptable level

design flood A hypothetical flood representing a specific likelihood of occurrence (for example the 1% AEP flood).

development Existing or proposed works that may or may not impact upon flooding. Typical works are filling of land, and the construction of roads, floodways and buildings.

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).

existing risk Flooding risks that affects existing development

flood Any significant flow within channel or waterway as well as concentrated overbank flow or temporary storage / ponding of water resulting from rainfall within local catchments, or backwater inundation from elevated downstream waters

Local street drainage is not considered a flood in the context of this report.

flood behaviour The pattern / characteristics / nature of a flood.

flood fringe Land that may be affected by flooding but is not designated as floodway or flood storage.

flood hazard The potential for damage to property or risk to persons during a flood. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.The degree of flood hazard varies with circumstances across the full range of floods.

flood level The height of the flood described either as a depth of water above a particular location (eg. 1m above a floor, yard or road) or as a depth of water related to a standard level such as Australian Height Datum (eg the flood level was 2.6 mAHD).

flood liable land see flood prone land

floodplain Land susceptible to flooding up to the Probable Maximum Flood (PMF). Also called flood prone land. Note that the term flood liable land now covers the whole of the floodplain, not just that part below the flood planning level.

floodplain risk management study Studies carried out in accordance with the Floodplain Development Manual (NSW Government, 2005) that assesses options for minimising the danger to life and property during floods. These measures, referred to as 'floodplain risk management measures / options', aim to achieve an equitable balance between environmental, social, economic, financial and engineering considerations. The outcome of a Floodplain Risk Management Study is a Floodplain Risk Management Plan.

floodplain risk management plan The outcome of a Floodplain Risk Management Study, which provides specific implementation details on actions, works and initiatives to improve floodplain management.

flood planning levels (FPL) The combination 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 designated flood or the flood standard used in earlier studies..

flood prone land Land susceptible to inundation by the Probable Maximum Flood (PMF) event. Under the merit policy, the flood prone definition should not be seen as necessarily precluding development. Floodplain Risk Management Plans should encompass all flood prone land (i.e. the entire floodplain).

flood storage Floodplain area that is important for the temporary storage of floodwaters during a flood.

flood study A study that investigates flood behaviour, including identification of flood extents, flood levels and flood velocities for a range of flood sizes.

floodway Those areas of the floodplain where a significant discharge of water occurs during floods. Floodways 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 usually expressed as a height above the adopted flood level thus determing the flood planning level. Freeboard tends to compensate for factors such as wave action, localised hydraulic effects and uncertainties in the design flood levels.

future risk Flooding risks that will affect future development, once built

high flood hazard For a particular size flood, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.

hydraulics The term given to the study of water flow in rivers, estuaries and coastal systems.

hydrology The term given to the study of the rainfall-runoff process in catchments.

low flood hazard For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.

m AHD metres Australian Height Datum (AHD).

m/s metres per second. Unit used to describe the velocity of floodwaters.

m^3/s Cubic metres per second or 'cumecs'. A unit of measurement for creek or river flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.

overland flow path The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as 'overland flows', may or may not re-enter the main channel from which they left; they may be diverted to another water course.

peak flood level, flow or velocity The maximum flood level, flow or velocity that occurs during a flood event.

probable maximum flood (PMF) The largest flood likely to ever occur, many times larger than the 1% AEP. The PMF represents extreme flooding conditions and defines the extent of flood prone land or flood liable land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with the PMF event are addressed in the current study. The PMF is primarily used in the management of Risk to Life. Whilst it can potentially occur, it has a very low chance of occurring

probability A statistical measure of the likely frequency or occurrence of flooding.

ocean flooding Flooding from very high ocean water levels, typically as a combination of big tides and storm surge

risk Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

risk to life Flooding risks that threaten life. This is the worst type of flood risk

risk to property Flooding risks that threaten to damage property

runoff The amount of rainfall from a catchment that actually ends up as flowing water in the river or creek.

topography The shape of the surface features of land

velocity The term used to describe the speed of floodwaters, usually in m/s.

water level See flood level.

PART A – FLOODPLAIN RISK MANAGEMENT STUDY

1 INTRODUCTION AND FRAMEWORK FOR FLOODPLAIN MANAGEMENT

1.1 Background and Purpose

Floodplains are low-lying areas adjacent to waterways that are periodically inundated by floodwater. Whilst supporting a multitude of environmental values they are also often the focus of a variety of human activities such as a residential, commercial, industrial, agricultural and recreational land use. Major transport infrastructure such as highways and railway lines, and community facilities such as schools, are also often situated in low lying areas so as to service these communities.

Flooding of such land is a natural process that can occur at any point in time with the cause, extent and potential impact of such events highly variable and complex. In the majority of instances, flooding truly is a force of nature that can never be completely controlled or eradicated. Because of the multiple uses of floodplains, we will always need to accept and adapt to flooding events if communities wish to continue to utilise them as they currently do.

Floodplain risk management is a broad concept, encompassing the continuous process of making decisions about whether and how floodplain lands are to be used in light of the obvious impact of flooding events. It incorporates the decisions made at all levels of government and choices made by the community. Floodplain risk management is not typically about radical movement of populations away from floodplains but rather is concerned with minimising or abating existing and future flood risks. The goal of floodplain risk management is to reduce risks such that all on-going, or continuing, flood risks are considered acceptable to the communities that are at risk, whilst ensuring that the communities are still fully aware of these on-going risks.

The primary guiding document for floodplain risk management in NSW is the State Government's Floodplain Development Manual (2005). The Floodplain Development Manual (the 'Manual') embodies current thinking that has evolved over the last 50 years, and requires a strategic merit based approach to the management of the full range of possible flood risks considering risk management, economic, social and environmental issues.

The Manual highlights that the primary responsibility for management of flood prone land rests with Councils. To assist in this role, Council's are provided with financial and technical support by the State and Commonwealth Governments. By managing flood risks in accordance with the Manual, Council's are afforded indemnity from liability arising from flooding. While Council's have the primary responsibility for the management of flood prone land, it is still recognised that many other agencies and the community have important roles.

Currently, flooding around Burrill Lake can occur from three mechanisms (and combinations thereof):

- Catchment flooding, as a result of intense rainfall within the local catchments (e.g. June 1991);
- Oceanic inundation, as a result of high ocean tides, storm surge, wave penetration. (e.g. king tides and 1974); and
- Low-level persistent flooding, occurring through a gradual and prolonged rise in lake levels during periods of entrance closure.

In future if sea level rise occurs, low-level persistent flooding could also be experienced under regular tidal cycles when the lake entrance is opened.

Risks associated with these forms of flooding in Burrill Lake are primarily a legacy of historical floodplain development. There has been extensive development on relatively low-lying foreshore area established before the current awareness and understanding of potential flooding extent and likelihood. As a result of detailed studies undertaken in recent years, it is now understood that approximately 500 properties are potentially affected by flooding around Burrill Lake. This flooding can range from slow-moving shallow backwaters with long warning time to fast flowing torrents that pose a risk to life and buildings within potentially short timeframes from the event commencing.

This document, the Burrill Lake Floodplain Risk Management Study and Plan (FRM Plan), is intended to form the basis for the immediate and future management of flood prone lands around Burrill Lake. The FRM Plan aims to help direct and coordinate the responsibilities of Governments and the community in undertaking immediate and future flood management works and initiatives. The FRM Plan aims to manage risks associated with the 'legacy development' on the Burrill Lake floodplains, as well as guiding appropriate future development on these floodplains (i.e. minimising any further flood risks without unreasonably precluding development from within the floodplain). The document also considers future challenges such as climate change and associated changes in sea levels and rainfall events.

1.2 Locality

Burrill Lake is located on the New South Wales south coast, about 180 km south of Sydney within the Local Government Area (LGA) of the City of Shoalhaven. The Lake entrance is around 5 kilometres south-south-west of Ulladulla. The main Lake water body has a surface area of some $4km^2$ and is fed by a catchment of approximately $78km^2$. The main tributary of the Lake system is Stony Creek which flows into the northern end of the Lake. Land use within the catchment area is predominantly agricultural grazing and forest, with smaller urban settlements around the Lake foreshore area. A locality plan of Burrill Lake and the area of interest for this Flood Plan is shown in Figure 1-1.

The major settlements in the catchment include the predominantly residential areas of Dolphin Point, Burrill Lake Village, Bungalow Park and Kings Point. Burrill Lake supports a vibrant tourist trade, being a popular holiday destination focused on access to the Lake, estuary and coastal environs. Accordingly, during peak holiday seasons the transient population increases the local population considerably.

Burrill Lake is connected to the Tasman Sea through Burrill Inlet, a tidal inlet channel of some 3km in length. The entrance channel is subject to periodic closure dependent on the level of sand build up at the ocean entrance. These types of systems are classified as Intermittently Closed and Open Lakes and Lagoons (ICOLLs).

ICOLLs open and close naturally in a constant but irregular cycle. The frequency of closure and opening of the entrance to an ICOLL is related to the condition of the entrance berm, waterway storage, contribution of runoff from upstream catchment areas and downstream coastal conditions including waves, tides and storm surge. During wetter times, ICOLLs tend to remain constantly open to the ocean. In periods of drought and low rainfall, some ICOLL's may stay closed for an extended period of time, sometimes years.

Title:
Locality Plan for Burrill Lake

Figure: 1-1

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_025_120330_Locality.WOR

1.3 Historical Context of Flooding and Flood Management in Burrill Lake

Prior to European settlement in the Shoalhaven region, traditional aboriginal peoples (in this area Budawang) would have experienced a wide range of floods over time. Despite settlement in the region from the late 1800's, historical flood reports are few. Perhaps the relative isolation of the locality in earlier times and limited residential development until the 1950's, provided for few personal experiences of flooding, particularly for inundation of the lower foreshores areas of the Lake and entrance channel.

Nevertheless, significant flood events have occurred in recent times. The largest floods recorded (albeit over a relatively short period) with peak flood water level information available occurred in February 1971, with the next largest event occurring in June 1991, and a third smaller event recorded for February 1992.

The flood event of June 1991 represents the last significant catchment flooding event in Burrill Lake resulting in extensive inundation of foreshore areas and properties. The two decades subsequent were relatively dry periods with no major flood producing rainfall. Given this prolonged period of no major flood activity, community perceptions of the flood risk may have changed. A common sentiment is flooding is more of an inconvenience than a danger.

These views are perhaps exacerbated by recent flooding experiences in Burrill Lake being largely related to low-level persistent flooding as a result of elevated Lake levels during periods of entrance closure.

These types of flooding experiences put a focus on entrance management policies, which are a key component of the current flood risk management, particularly for managing this low-level nuisance type flood inundation. Entrance management clearly was of interest to local government and communities even in the early 1900s. For example, within the Sydney Morning Herald on the 19 August 1909 it was written:

"*A public meeting last night decided to approach the Government with a view to opening the mouth of Burrill Lake, which of late years has been blocked, and in consequence large areas of good farm land on the shores have been submerged and rendered practically useless. … Mr. Bloomfield, of the Harbours and Rivers Department, in response to a request from the Clyde Shire, inspected the place last week, and recommends blasting a channel through the bar of rock, which at present is the principal barrier."*

Whilst entrance management may be effective in addressing low-level persistent flooding, there is a common misconception that major catchment flooding will be relieved if the entrance is kept open. This view has often formed the basis for calls for a permanent entrance opening through construction of groynes or breakwaters or continuous dredging programs. However, for major flood events, the condition of the entrance has less influence on peak flood water levels, and an open entrance does not provide for the protection perceived. The flood events of February 1971 and June 1991 occurred during periods the entrance was open.

In recognition of the need for advancing floodplain risk management in Burrill Lake, Council oversaw the completion of the Burrill Lake Catchment Flood Study in 2007, which established the existing flood risk and provided the basis for subsequent floodplain risk management. Previous to completion of the flood study, however, a number of planning policies considering floodplain management aspects were in existence guiding development in Burrill Lake. Some of these key policies include the City Wide Interim Flood Policy first adopted in 1987, and Development Control Plan 106 – Floodplain Management adopted in 2006.

Table 1-1 shows a timeline of significant flood events during the recent history of Burrill Lake. Also shown in this timeline are the efforts that have been made by Council and others to try and better understand and manage the risks to people and property arising from floods.

Table 1-1 Timeline of Significant Events in Burrill Lake's Flood History

Flood Event	Year	Planning Event
	1880s	Princes Highway causeway over Burrill Lake constructed
Major flood event	1911	
Major flood event	1915	
Major flood event	1927	
Major Flood Event	1959	
	1960s	Burrill Lake causeway raised
Major Flood Event	1971	
Major Ocean Flood Event	1974	
	1984	NSW Flood Prone Land Policy (First Release)
	1985	NSW Floodplain Development Manual (First Release) – Merit based – not prescriptive.
	1987	Interim Flood Policy – General Conditions for the Whole City and Specific Areas
	1988	Interim Flood Policy – Caravan Parks on Flood Prone Land
Major flood event	1991	
	1991	Continuous water level recorded installed upstream of the Causeway
Moderate flood event	1992	
	2001	NSW Flood Prone Land Policy and revised Floodplain Management Manual (not gazetted)
	2005	NSW Floodplain Development Manual. The Management of Flood Liable Land gazetted - (give consistency in the management of floods up to the most extreme).
	2006	Development Control Plan 106 – Floodplain Management adopted by Council
	2007	Floodplain Risk Management Guideline: Practical Consideration of Climate Change Burrill Lake Catchment Flood Study
	2008	Burrill Lake Interim Entrance Management Policy
	2009	NSW Sea Level Rise Policy Statement
	2010	NSW Flood Risk Management Guide. Incorporating sea level rise benchmarks in flood risk assessments

1.4 Framework for Floodplain Management

The development of this FRM Plan has been fundamentally guided by the NSW Government's Floodplain Development Manual (2005). The objectives of the Manual and the broad principles of floodplain risk management advocated within the Manual have been used as the "criteria" against which the current management approaches in Burrill Lake have been assessed.

Current approaches to floodplain risk management have evolved over the period that the Burrill Lake floodplain has been progressively developed. The current approaches aim to address the unusual flood environment of Burrill Lake, although in many respects, the totality of the flood environment has not been historically appreciated (due to a lack of firsthand experience). Only in recent years have computer models been developed that provide the full picture of flood risks across Burrill Lake (right up to the extreme but very rare Probable Maximum Flood [PMF] event).

Gaps or deficiencies of the current approaches to flood management in terms of meeting the fundamental objectives and key management principles of the Floodplain Development Manual have been identified through an assessment process. The new and additional measures have been assessed and prioritised according to the practicalities of implementation, within short and long term horizons. The floodplain risk management measures comprise a broad mix of approaches, including structural works, community education, improvements to emergency management, and future development controls.

It is important to recognise that not all flood risks can be eliminated. The framework adopted for this FRM Plan aims to ensure that the residual risks are manageable and acceptable to the community. On-going development controls that are more cognisant of the total flood risks than in the past means that overall flood risks across Burrill Lake should gradually reduce, as existing houses and buildings are progressively replaced and redeveloped. Residual risks therefore are expected to reduce in the future over a timeframe of 100 years or so (the expected design life of most buildings and urban developments). Notwithstanding, this timeframe is too long to manage flood risks purely through development controls. The mix of measures proposed as part of this FRM Plan therefore incorporates a range of measures that can be implemented in the short to medium term, which will supplement on-going development controls, to provide an integrated suite of management actions.

A schematic overview of the framework that underpins the structure of this FRM Plan is given in Figure 1-2.

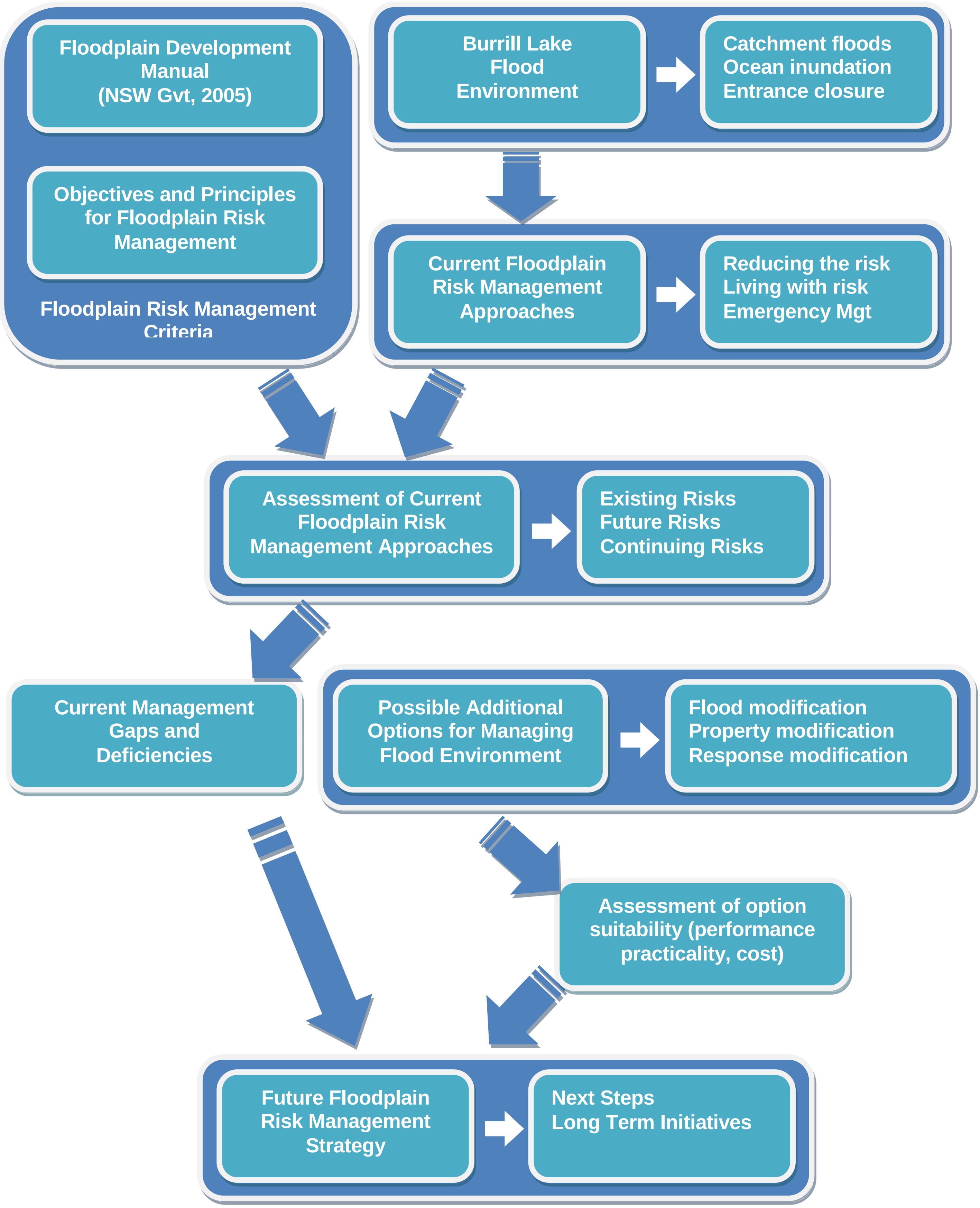


Figure 1-2 Conceptual Framework for Development of Floodplain Risk Management Plan

1.5 Community Consultation

Community involvement is essential to the effective management of flood risks across Burrill Lake and in all phases of the floodplain risk management process, particularly in the development, acceptance and implementation of such planning. Community involvement is relied on for effective management measures in aspects such as flood warning, flood awareness and flood response.

Community consultation has been an important component of the current study. The consultation has aimed to inform the community about the development of the floodplain risk management study and its likely outcome as a precursor to the development of the floodplain risk management plan. It has provided an opportunity to collect information on their flood experience, their concerns about flooding issues and to collect feedback and ideas on potential floodplain management measures and other related issues.

The key elements of the consultation process have been as follows:

- Consultation with the Far South Natural Resource and Floodplain Management Committee through meetings, presentations and workshops;
- Distribution of questionnaires and information brochures;
- Two community information sessions, firstly to outline the study objectives following completion of the Flood Study Review and identify key community concerns, and secondly to workshop potential floodplain risk management options;
- A website was established to provide information to the community through various stages of the study (http://gis.wbmpl.com.au/BurrillLake/);
- Public exhibition of the Draft Floodplain Risk Management Study and Plan.

A detailed summary of the key outcomes of the community consultation undertaken is provided in Appendix B.

The study has been overseen by the Far South Natural Resource and Floodplain Management Committee (Committee). The Committee has assisted and advised Council in the development of the Floodplain Risk Management Study. Members of the Committee include representatives from the following:

- Shoalhaven City Council - Councillors;
- Staff from Shoalhaven City Council;
- Office of Environment and Heritage (formerly DECCW);
- NSW Land and Property Management Authority;
- Southern Rivers Catchment Management Authority;
- NSW Dept. Transport – Roads and Maritime Services;
- NSW Dept. Primary Industries – Fishing and Aquaculture;

- Jerrinja and Ulladulla Local aboriginal Land Councils;
- NSW State Emergency Service (SES); and
- Community representatives.

The Committee is responsible for recommending the outcomes of the study for formal consideration by Council.

1.6 Climate Change Considerations

The Intergovernmental Panel on Climate Change (IPCC) reports evidence of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea levels. Regardless of the cause, it very likely that these trends will continue well into the future.

The NSW Government has made a concerted effort to incorporate consideration of potential climate change impacts into relevant planning. The NSW Sea Level Rise Policy Statement (NSW Government 2009) was prepared to support consistent adaptation to projected sea level rise impacts. This policy statement included sea level rise planning benchmarks, which have since been revoked as formal benchmarks but remain the best currently available scientific advice for assessing potential impacts of sea level rise in coastal areas, including flood risk and coastal hazard assessments. The benchmarks are a projected rise in sea level, relative to the 1990 mean sea level, of 0.4 metres by 2050 and 0.9 metres by 2100. These benchmarks may change in the future as new information comes to hand.

Worsening coastal flooding impacts in lowland areas such as Burrill Lake will be of particular future concern as a consequence of sea level rise. This will include increased likely frequency, duration and height of flooding and consequent emergency evacuations and associated property and infrastructure damage.

Regional climate change studies (e.g. CSIRO, 2004) indicate that aside from sea level rise, there will also be an increase in the frequency of extreme rainfall events in the region in summer and autumn and an increase in the maximum intensity of extreme rainfall events. Rainfall projections indicate that average annual rainfall may increase in the region, especially during summer and winter. Such climatic changes are likely to change the future flood risk profile.

The NSW Floodplain Development Manual (2005) requires consideration of climate change in the preparation of floodplain risk management studies and plans, with further guidance provided in the Flood Risk Management Guide - Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments (DECCW, 2010). Key elements of future climate change (sea level rise, rainfall frequency and intensity) have been incorporated into the assessment of future flooding conditions and considered in the risk management framework.

2 BURRILL LAKE EXISTING FLOOD CONDITIONS

2.1 Physical Setting

Burrill Lake is a large and relatively deep water body with a surface area of some 4km^2 and is connected to the ocean by Burrill Inlet, a 3km long meandering channel. The main body of the Lake comprises two basins, one to the north and one to the south of the marine drop over where Burrill Inlet meets the Lake. The main tributary of the Lake is Stony Creek, which flows directly into the northern end of the northern basin.

The existing development in the study area is largely confined to small villages including:

- Kings Point – the most recently developed suburb located mostly on high ground on a peninsula extending into the northern basin of the Lake;
- Burrill Lake Village – located on the northern side of Burrill inlet;
- Bungalow Park – located on a peninsula on the southern side of Burrill Inlet and wrapping around the eastern end of the southern basin of the Lake; and
- Dolphin Point – located generally on high ground on the headland south of Burrill inlet.

The extent of the Burrill Lake catchment is shown Figure 2-1, with a detail of the topography in the vicinity of the inlet channel and surrounds shown in Figure 2-2.

The Burrill inlet channel is relatively shallow, with typical depths less than 3m, and potentially as shallow as 1m in some locations under low tide conditions. There are a number of shoals along the length of the Inlet. Aerial photography indicates that the channel positions and extents of the shoals at the upstream end have effectively remained unchanged for a number of decades, while downstream of the Causeway active shoals and channels are located towards the entrance.

The Princes Highway Causeway which traverses the inlet channel was originally constructed in the 1880's. The level of the causeway was raised in the 1960's to reduce the frequency of inundation and highway closure. The current level of the Causeway however remains relatively low at 1.6m AHD. The span of the causeway across the inlet channel is approximately 200m, with the waterway opening (provided at the southern end) is limited to approximately 45m.

The inlet channel at the ocean entrance largely remains fixed in general location between Dolphin Point and the vegetated dune to the north adjacent Burrill Beach. The entrance is subject to closure dependent on the level of sand build up in response to climatic conditions.

On the southern side of the entrance, the presence of a rock platform provides some level of control on water levels and build-up of the entrance berm. A gully exists in the rock just south of the inlet channel alignment that drains some flow from the Lake, even when the inlet channel is heavily shoaled.

Title:

Burrill Lake Catchment

Figure: 2-1

Rev: A

N

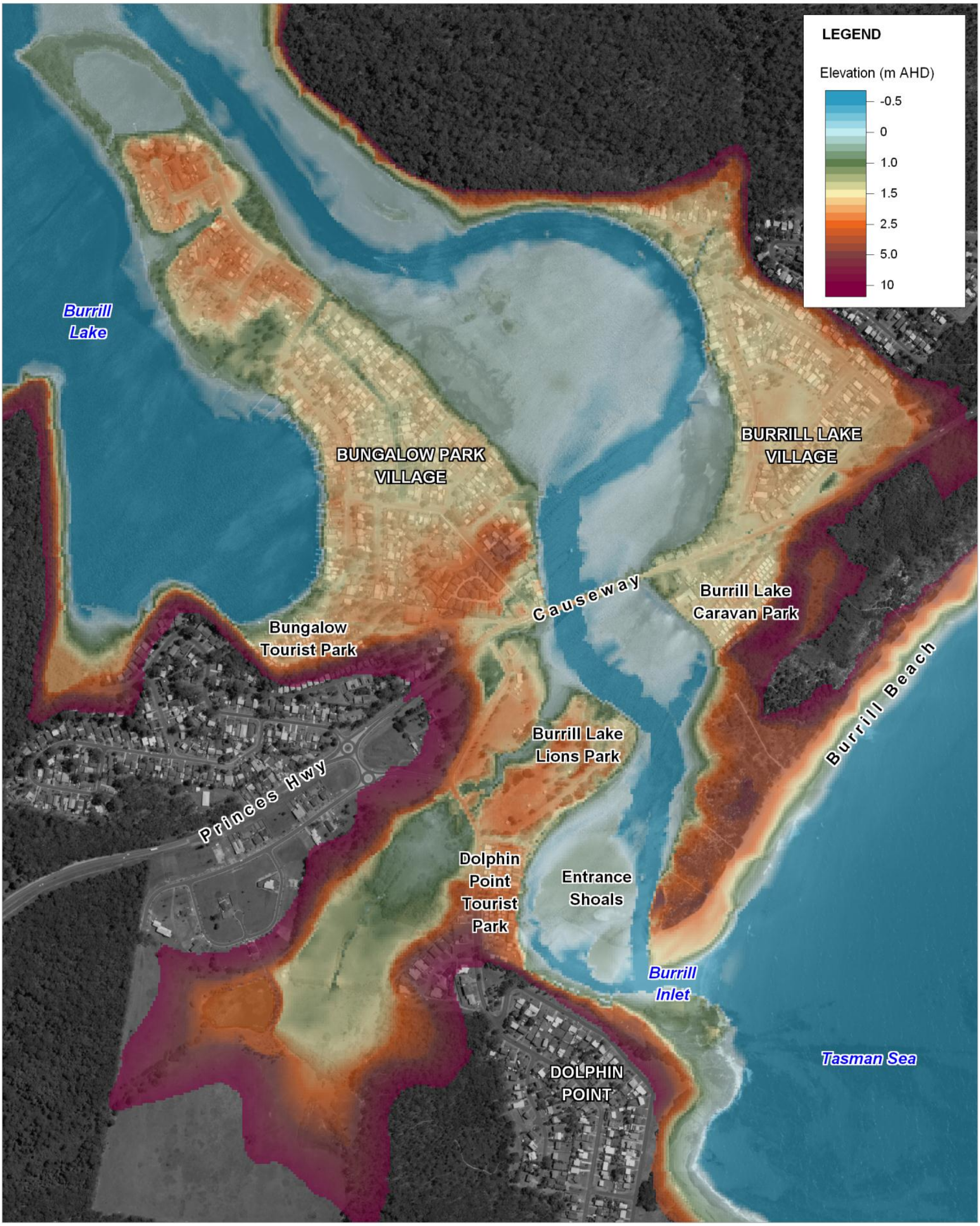
0 1.25 2.5km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N1778_Burrill_Lake_FRMS\MI\Worskpaces\DRG_026_120330_Catchment.WOR



Title:
Local Topography of Burrill inlet

Figure: **2-2**

Rev: **A**

N

0 200 400m
Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_022_120328_Inlet_Topography.WOR

2.2 Source of Flooding

Flooding within Burrill Lake can be the result of a number of very different mechanisms, including:

- Catchment flooding from the local catchment rainfall (e.g. June 1991);
- Ocean inundation (e.g. as a result of high ocean tides plus storm surge e.g. 1974, plus potential future sea level rise); and
- Low-level persistent flooding (due to elevated Lake levels during periods of entrance closure).

These flooding mechanisms and the resulting flood environments are further described within the following sections.

Figure 2-3 Flooding in Burrill Lake (June 1991), showing inundation of roads and property on the peninsula and North Burrill, and overtopping of the causeway

2.2.1 Catchment Flooding

Catchment flooding in Burrill Lake tends to emanate from major rainfall events within the catchment from falls of the order of hundreds of millimetres over 1-2 day periods. Given the size of the catchment and the storage of the Lake system itself, it is largely not prone to flooding from shorter more intense rainfall.

Details of historical flooding in Burrill Lake are somewhat limited, with the February 1971 and June 1991 acknowledged as the most significant events recorded in recent history. Comparison of long-term rainfall records provides further evidence of historical events in the catchment. Table 2-1 provides the highest recorded daily rainfall (24-hour total) at nearby gauges where an extended period of record is available.

Table 2-1 Highest Daily Rainfall Totals at Nearby Gauges

	Milton[1]		Ulludulla[2]		Woodburn[3]	
Rank	Date	Rainfall (mm)	Date	Rainfall (mm)	Date	Rainfall (mm)
1	30th Oct 1959	311	30th Oct 1959	353	7th Feb 1971	288
2	18th Apr 1927	289	6th Feb 1971	229	30th Oct 1959	262
3	12th Jun 1991	268	19th Jan 1950	226	11th Mar 1975	258
4	13th Jan 1911	264	4th Apr 1950	188	16th Oct 1976	207
5	10th Jun 1915	249	25th Sep 1951	188	18th Jan 1950	196

Notes 1) Milton period of record 1876 to 2004
2) Ulladulla period of record 1937 to 1974; and 1994 to 2010
3) Woodburn period of record 1938 to 1980

The October 1959 rainfall represents one of the most significant rainfall events in the locality, with high recorded totals at all gauges. There is some variation between the gauges with respect to other significant events, often due to periods of record not overlapping. For example, the next highest totals recorded at the Milton gauge for the years 1911, 1915, 1927 and 1991 are outside the period of operation of the other gauges. Nevertheless, the historical totals indicate that daily totals in excess of 250mm have been recorded on numerous occasions, with up to 350mm for some events.

The January 1911 event was noted in an article in Sydney Morning Herald on the 17th January 1911:

"*The recent rainfall for Milton totalled nearly 10 inches….Conjola, Burrill and Tabourie Lakes have broken out and relieved the situation in regard to surrounding properties.*"

An interesting observation from the rainfall records is that the highest daily rainfall recorded after the last significant flood event (which occurred in 1992) has only been 166mm at Ulladulla (March 1997) and 137mm at Milton (September 1996). Accordingly, rainfall events of the magnitude to generate significant catchment flooding have been sparse in the last two decades. This is expected to have impacted on the community's perception of flood risk.

It should be noted that these are 24-hour totals and within this duration there may be shorter bursts where the majority of rainfall fell, providing for more intense rainfall and subsequent flooding conditions. In some instances an event may span two or three recording days, such that significantly more rainfall than individual daily totals may contribute to the flooding event. The critical storm burst duration providing for the highest peak flood level conditions in Burrill Lake was identified from the flood study as 18 hours.

Table 2-2 presents the adopted design rainfall totals used to derive the peak flood levels for floods of various magnitudes. Comparison with historical totals as shown in Table 2-1 illustrate the representativeness of the adopted design conditions compared to observed conditions and the appropriateness for long term floodplain risk management planning.

Table 2-2 Adopted Design Rainfall Totals

Design Event	Rainfall Depth (mm)
20% AEP (1 in 5)	187
10% AEP (1 in 10)	220
5% AEP (1 in 20)	259
2% AEP (1 in 50)	315
1% AEP (1 in 100)	335

The design flood conditions for Burrill Lake have been estimated utilising the computer models developed as part of the Burrill Lake Catchment Flood Study (BMT WBM, 2007). These models were calibrated and tested utilising recorded flood data from the February 1971 and February 1992 flood events.

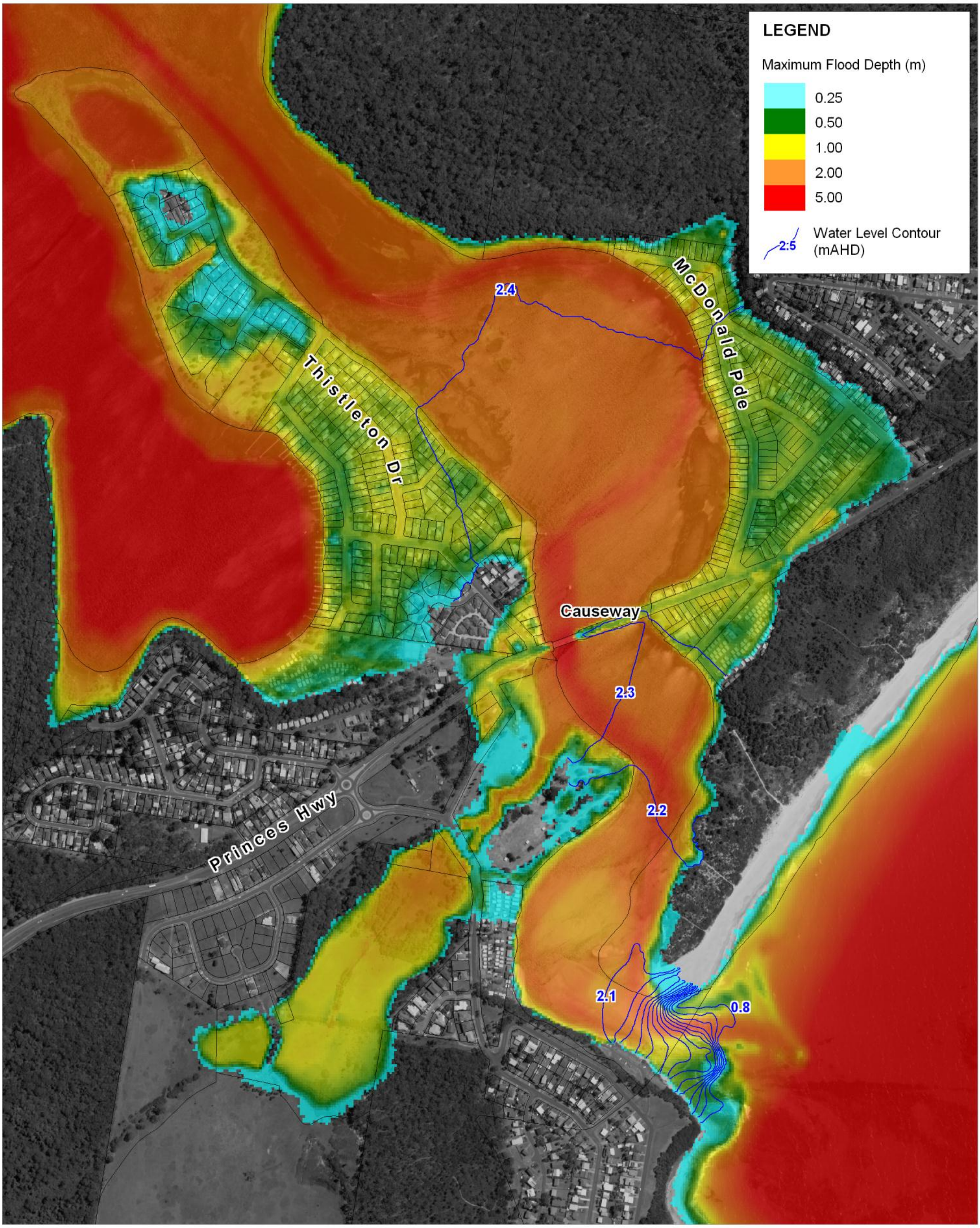
Design flood levels have been established for the 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP events and the Probable Maximum Flood (PMF). In deriving the design flood conditions for catchment flooding, consideration was given to:

- the impact of closure at the entrance; and
- coincident tidal conditions (levels and timing).

The condition of the entrance, being either open, closed or heavily shoaled, has some impact on peak flood conditions in the estuary. Detailed assessment of the sensitivity of the design flood conditions on the configuration of the entrance is presented in Appendix A.

For major flood events (e.g. 1% AEP event), significant scouring of the entrance channel by the catchment flows would be expected by the time the flood peak is conveyed through the system. Accordingly, the resulting impact of the starting berm condition on peak flood levels attained is relatively minor for large flood events. The impact of the starting berm condition is more pronounced for lower order flood events which produce less flow and hence less scour leading up to the peak of the flood. The adopted design flood conditions for catchment flooding assume a closed entrance at the start of the flood, with a minimum level of 1.0m AHD (approximate to current entrance management trigger levels).

The design 1% AEP flood inundation extent and depth of flooding in Burrill Lake is shown in Figure 2-5. A flood event of this magnitude would result in an extensive inundation of existing property, particularly on the Bungalow Park Village peninsula and Burrill Lake Village (north Burrill Lake). Typical flood depths of the order of 0.5m – 1.0m would result in above floor flooding of a large number of properties. Similar patterns of flooding are evident for other events, albeit with different severity dependent on flood magnitude. The relative inundation extents for the 5% AEP, 1% AEP and PMF events are shown in Figure 2-5. Significantly, the PMF flood extent does not increase substantially beyond the 1% AEP extent, given the steep nature of the topography at the edge of the floodplain.



Title:

Catchment Flood (Existing Conditions)
1% AEP Maximum Flood Depths and Water Levels

Figure: **2-4**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

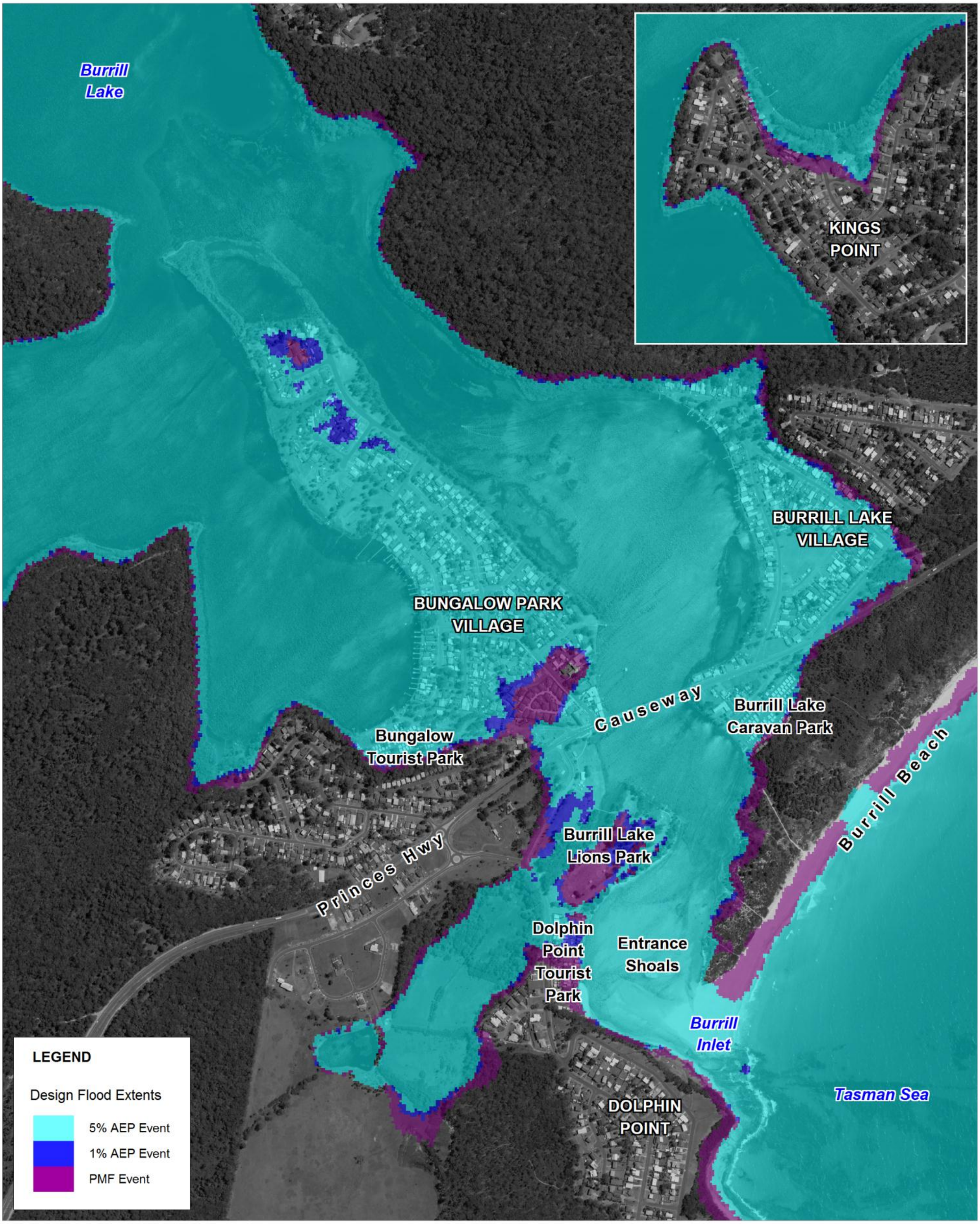
0 200 400m

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_017_111108 EX 1% Depths Catchment.WOR



Title:

Design Flood Inundation Extents
Catchment Derived Flooding Existing Conditions

Figure: 2-5

Rev: A

N

0 250 500m
Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_023_120329_Inundation_Extents.WOR

2.2.2 Ocean Flooding

The second flooding type that potentially affects Burrill Lake is inundation from elevated ocean water levels. In addition to normal astronomical tides, low air pressure causes ocean levels to increase (called inverse barometric set-up), while strong onshore winds can also 'pile-up' water against the coastline. These ocean storm conditions can cause elevated water levels considerably higher than normal tidal regimes.

As with catchment flooding scenarios, the entrance condition can impact on ocean flooding behaviour. Greater penetration of ocean water through the entrance and into the body of the lake system is afforded by an open unconstrained entrance. An open entrance also increases the susceptibility to wave penetration into the entrance channel with subsequent increases in foreshore inundation through wave run-up. Conversely, the penetration of ocean water into the Lake system is dampened by a closed or heavily shoaled entrance.

Details of historical ocean flooding events are limited for Burrill Lake. The most significant event in recent history was the extreme coastal storm of May 1974, which resulted in significant inundation and coastal erosion along the NSW South Coast. Specific details of the impact of this event on Burrill Lake are limited, however, it is understood the storm resulted in breaching of the entrance spit (Peter Spurway & Associates, 2008).

Design ocean water levels adopted in the study are in accordance with the recommendations in the Draft Coastal Risk Management Guide (DECCW, 2009). Peak ocean boundary water levels for various magnitude storm events are summarised in Table 2-3

Table 2-3 Peak Design Ocean Flooding Boundary Condition

Design Event	Ocean Water Level (m AHD)
20% AEP (1 in 5)	1.9
10% AEP (1 in 10)	2.1
5% AEP (1 in 20)	2.25
2% AEP (1 in 50)	2.45
1% AEP (1 in 100)	2.6

With no coincident catchment inflows, the tidal surge is considerably attenuated through the entrance channel and into the Lake system. For example, the 1% AEP peak flood level in the Lake body from the coastal event is approximately 1.8m AHD, and 1.5m AHD for the 5% AEP event.

Ocean flooding conditions are exacerbated when combined with any significant catchment rainfall. Significant runoff generated from the catchment is unable to be conveyed through the entrance when the ocean condition is high, indeed there is corresponding inflow from the ocean. Accordingly, flood water levels may be expected to build to levels similar to that observed in the ocean.

The levels of ocean inundation represent a significant risk to existing development in Burrill Lake, and can be just as severe in terms of peak flood levels as similar magnitude catchment flood events. This has particular implications for entrance management options for flood mitigation given that ocean flooding conditions are more severe for an open entrance condition, while minor catchment flooding conditions are more severe for a closed entrance.

2.2.3 Low-Level Persistent Flooding

Recent flood experiences in Burrill Lake have been as a result of a gradual and prolonged build up in Lake level during periods when the entrance has closed. Coupled with the fact there has been no significant catchment events, the perception of many in the community of “flooding” is solely related to this low-level persistent inundation.

Since European settlement in the late 1800’s the Burrill Lake entrance has tended to be more opened than closed. Left to natural processes, the frequency of closure and opening of Burrill Lake will be a function of the interaction of runoff from the catchment area sweeping sand out and downstream coastal conditions including waves, tides and storm surge pumping sand in. Recent decades have seen a relatively dry phase of the climate with limited sand removal so that the frequency of closure and degree of shoaling at the entrance has increased somewhat.

Given the presence of low-lying development around the Burrill Lake foreshore, an entrance management policy has been adopted for Burrill Lake to breach the entrance barrier when the water level reaches specified trigger levels, to relieve potential flooding of public roads and private properties.

The Interim Entrance Management Policy (2008) provides for a staged trigger level between 1.0 – 1.2m AHD (as measured at the Burrill Lake gauge upstream of the causeway) dependent on climatic conditions and seasonal holiday periods. Accordingly, while the Interim Entrance Management Policy remains in force, the 1.2 m AHD level is expected to provide a typical upper bound for flood inundation under these conditions.

Figure 2-6 shows the typical pattern of inundation for the 1.2m AHD water level. To demonstrate the sensitivity to this level, the projected inundation at a 1.5m AHD level is also shown for reference. Even at the 1.2m AHD threshold there is extensive length of the public foreshore inundated particularly around Rackham Crescent and Ireland Street in Bungalow Park and MacDonald Parade in Burrill Lake Village. Parts of Thistleton Drive and Balmoral Road are subject to inundation around 1.1m AHD

No above floor flooding to existing residential property would be experienced at 1.2m AHD, however inundation of ground areas including under crofts of some low-lying properties would be experienced. Extended periods of inundation may cause stability issues for property foundations. Boat ramps, jetties and other public recreational infrastructure occupying the lowest points of the foreshore are obviously impacted.

Localised flooding may also be exacerbated by rainfall given the inability of stormwater drainage to function efficiently during periods of elevated lake level.

Title:

Burrill Lake Inundation - Low-level Persistent Flooding

Figure: **2-6**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 200 400m

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_003_101125 EX 1% Depths.WOR

2.3 Floodways, Flood Storages and Flood Fringes

Criteria set out in the Floodplain Development Manual (NSW Government, 2005), and replicated in Council's DCP 106 amendment 1, allow for the floodplain to be compartmentalised into different flood hydraulic categories, generally comprising:

- Floodway;
- Flood Storage; and
- Flood Fringe.

In simplified terms the Manual guides that:

- **Floodways** are 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.
- **Flood Storage** areas are 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.
- **Flood Fringe** areas are the remaining area of flood prone land after floodway and flood storage areas have been defined.

There are no prescriptive methods for determining what parts of the floodplain constitute floodways, flood storages and flood fringes. Descriptions of these terms within the Floodplain Development Manual are essentially qualitative in nature, given that flood behaviour and associated impacts is likely to vary from one floodplain to another depending on the circumstances and nature of flooding.

In accordance with the Floodplain Development Manual, Floodways are areas and flowpaths that convey the majority of flood flows. In simple terms, flood flow at any location can be approximated by the product of velocity and depth (v*d). Using the results of the computer modelling, a v*d threshold was able to be determined wherein approximately 80% of total floodplain flows were contained. For the 1% AEP catchment flood conditions, this threshold was approximately v*d=0.3.

Flood Fringes are non-floodway areas that, if filled, would not have a significant impact on flood levels, velocities and flowpaths. Computer model simulations were again carried out to iteratively assess the differentiation between Flood Storages and Flood Fringes. Based on these modelling results, it was established that for flash flood environments, Flood Fringes are areas where flood depths are less than 0.5m for a 1% AEP event. The resulting definition of flood impact categories are defined in Table 2-4

Table 2-4 Adopted initial classification of flood hydraulic categories

Floodway	velocity * depth > 0.3
Flood Storage	velocity * depth < 0.3 & depth > 0.5 m
Flood Fringe	Remainder of floodplain (up to PMF)

The hydraulic categories (Floodways, Flood Storages and Flood Fringes) across Burrill Lake are shown in Figure 2-7.

The general principle is to keep floodways free for flood flow and, in this regard, development is not encouraged. The 1% AEP floodways are exclusively contained within the channel.

Given the depth of flooding at the 1% AEP flood level, significant areas with existing development are classified as flood storage. In fact the majority of the floodplain area outside of the floodway extent is classified as flood storage, with flood fringe areas confined mostly to the very limits of the floodplain.

2.4 Flood Hazard

Hazard categorisation is carried out to establish how hazardous (i.e. dangerous) various parts of the floodplain are. Primarily the hazard is a function of the depth and velocity of floodwater, however, the hazard categorisation considers a wider range of flood risks, particularly those relating to personal safety and evacuation. These hazard factors are derived from both hydraulic risk factors (such as depths and velocities) and human / behavioural issues (such as flood readiness). These considerations are summarised below in the context of the Burrill Lake flood environment.

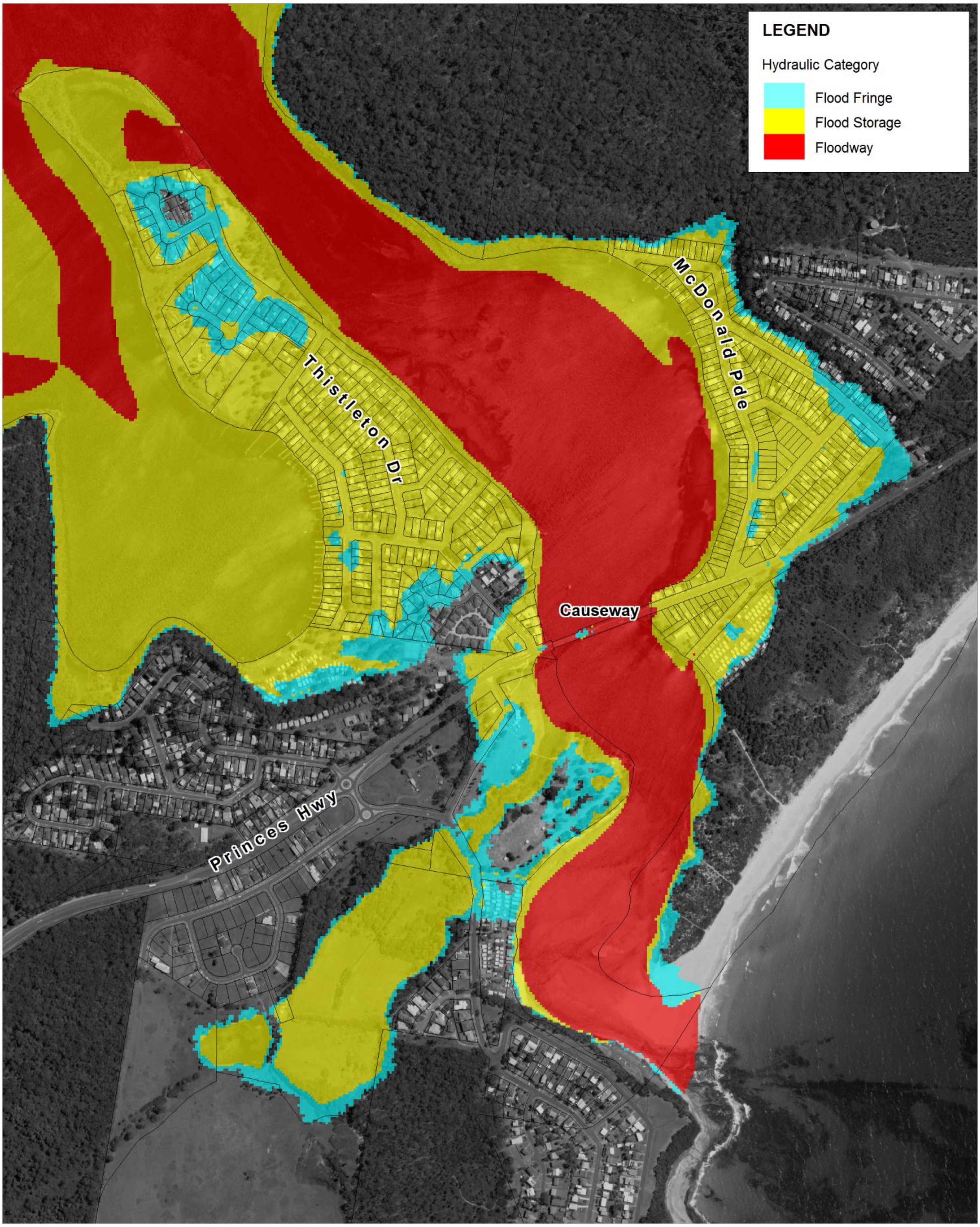
2.4.1 Size of Flood

The size of flood, as well as the origin (catchment rainfall and/or storm surge), will have an obvious and significant influence on the degree of flood risk. Relatively frequent or minor floods would typically be associated with a low flood hazard, whilst the major or rare flood events are likely to provide for high hazard flood conditions.

Whilst extensive inundation of existing developed areas primarily in Bungalow Park and Burrill Lake may be experienced for relatively frequent flood events (e.g. up to 10% AEP event), the depth of flooding and peak velocities are such that only low to medium hazard conditions are anticipated. The 1% AEP flood presents substantially greater risk and is the event magnitude primarily used for development planning.

2.4.2 Depth and Velocity

Depth and velocity hazards have been identified according to the provisional hydraulic hazard categories provided in the Floodplain Development Manual. This has been further sub-categorised to show the predominant 'type' of hydraulic hazard (i.e. high velocity, depth, or combination) as shown in Figure 2-8 below.



Title:

Hydraulic Categorisation Map - 1% AEP Event Catchment Flooding Existing Conditions

Figure: 2-7

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 200 400m

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_019_120314_HydCats.WOR

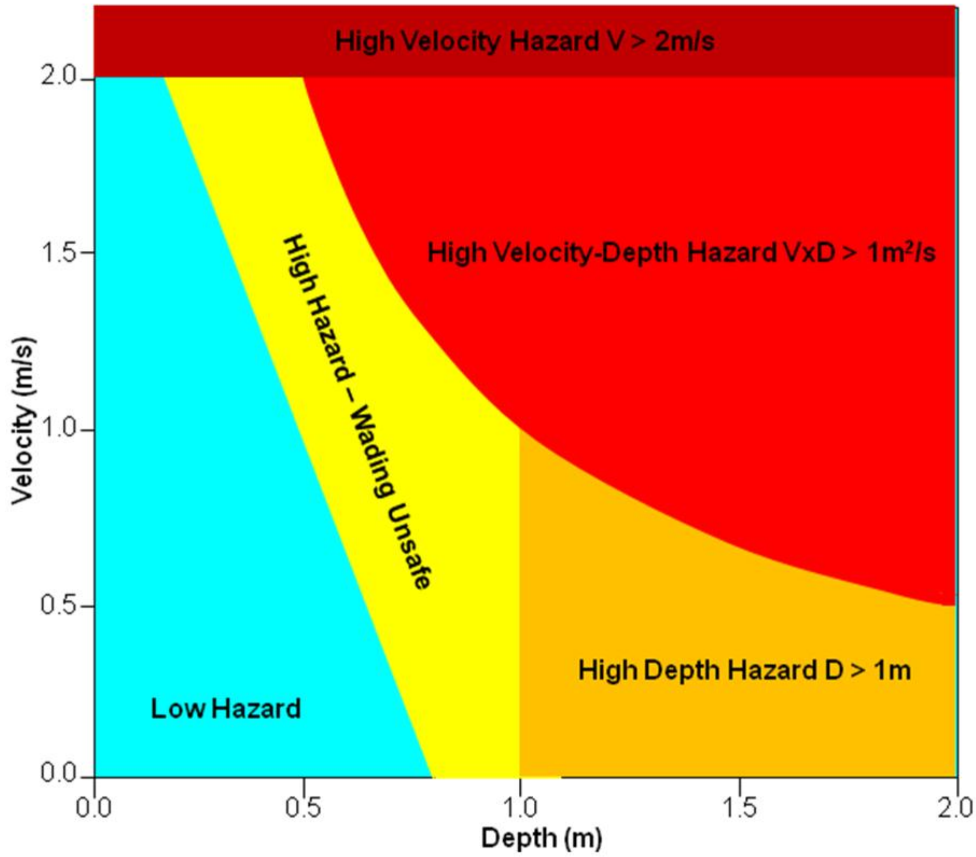


Figure 2-8 Hydraulic Hazard as a function of depth and velocity

2.4.3 Flood Readiness

The term 'flood readiness' encompasses a broad range of factors, including familiarity with flooding in the catchment, awareness of evacuation procedures and preparation for a flood (e.g. development of flood plans). Flood readiness can refer to individuals, organisations, communities and businesses.

The lack of recent major flood events in the Burrill Lake catchment is considered to undermine the flood awareness of the local community. Since a large flood has not occurred for over 20 years, the community has had little opportunity for first-hand experience of major flooding and therefore be aware of the potential flood risk . A flood of 1% AEP magnitude has not been experienced in living memory such that appreciation of the implications of an event of this magnitude is also limited.

General questions on flood awareness were targeted through the community questionnaire issued during the course of the study. A significant proportion of the community were unaware if their property was at risk flooding at all, unaware of any flood warning procedures or available flood information, and generally indicated a low-level of flood preparedness in terms of personal flood emergency response.

The lack of flood awareness for the Burrill Lake community is heightened given that the area is a popular holiday destination with substantial increase in the local population during holiday periods. This transient population raises the level of exposure to potential flood risk, and the level of flood awareness of visitors to the area is likely to be significantly lower than within the resident community.

2.4.4 Rate of Rise

The rate of rise of floodwaters is typically a function of the catchments topographical characteristics such as size, shape and slope, and also influences such as soil types and land use. Flood levels rise faster in steep, constrained areas and slower in broad, flat floodplains. A high rate of rise adds an additional hazard by reducing the amount of time available to prepare and evacuate.

Given the relative steepness of the upper catchment of Burrill Lake, the flood response of the catchment can be relatively fast. Whilst the Lake storage itself provides for some flood attenuation, the progression of the flood to the lower system and subsequent increases in flood water levels can occur over a matter of hours.

Figure 2-9 shows the simulated water level rise for 1% AEP flood event in response to the adopted design rainfall pattern. The critical storm duration resulting in the highest peak flood level conditions was found to be the 18-hour storm event.

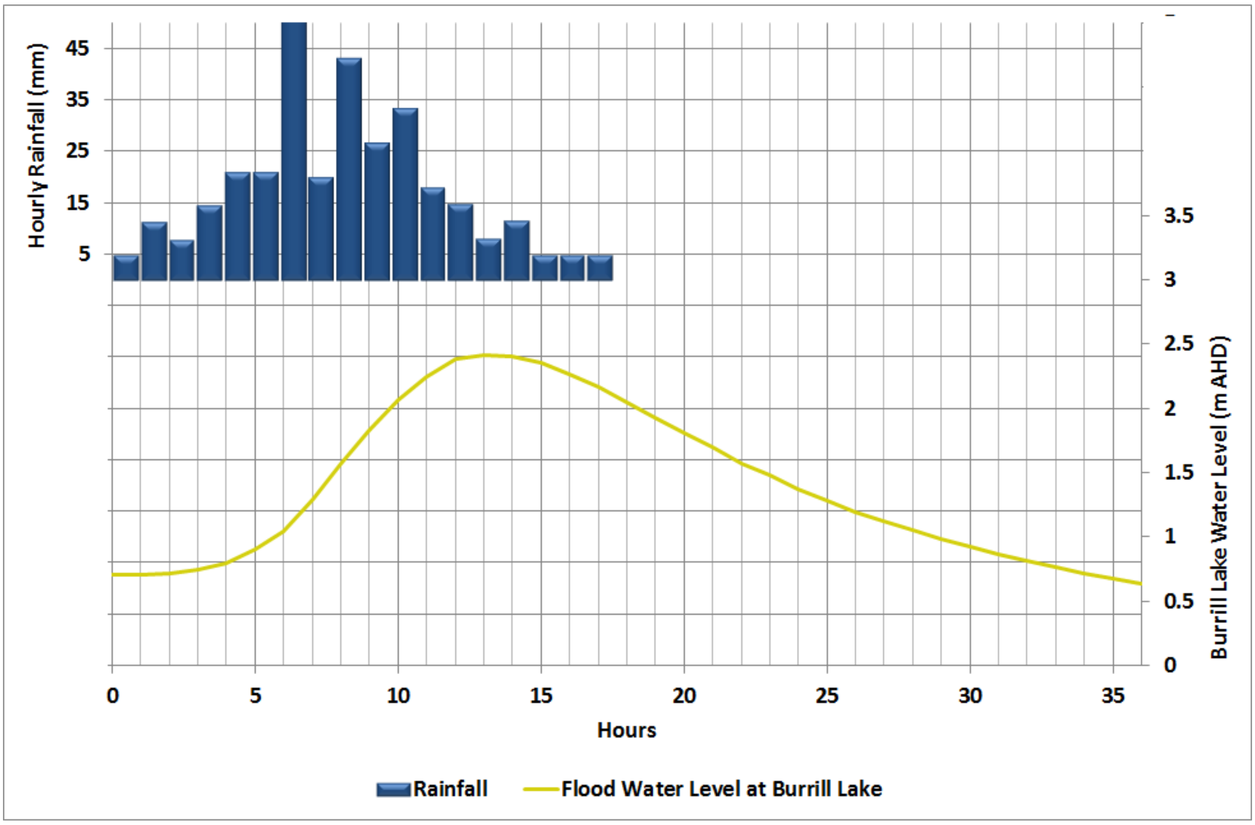


Figure 2-9 Rate of Rise of Floodwater (Design 1% AEP Catchment Flood)

2.4.5 Duration of Flooding

The greater the duration of flood inundation the greater the potential impacts on damages and disruption to the community.

The duration of flooding is largely related to the size and duration of the rainfall event over the catchment. As noted in Section 2.4.4, the critical duration for peak flood levels in the catchment was estimated as the 18-hour storm event. The overall volume of runoff will be more for longer storm durations, and whilst perhaps not providing for highest peak flood level condition, the duration of overbank inundation may be extended. Figure 2-9 showed a typical Lake response for the 18-hour storm event. Inundation to developed areas can begin at levels as low as 1m AHD and the duration of flooding for this event would be expected to be in excess of 12 hours. For lower intensity longer duration events, duration of inundation may exceed a day.

2.4.6 Flood Warning Times

The amount of warning available for an approaching flood can have a significant impact on the risk to life. Less warning time clearly represents a greater risk to the community as there is less opportunity to respond appropriately and implement risk-reduction measures. Minimal warning time also means that emergency services are unlikely to be able to provide any assistance or direction for affected communities.

To assess flood warning opportunity for Burrill Lake, consideration has been given to the levels of warning times as defined in Table 2-5.

Table 2-5 Flood warning time categories

no effective warning	<1 hr	No time for pro-active and systematic organisation of flood mitigation, evacuation, emergency response etc. Individuals would be self-directed in regards to emergency response.
minimal warning	1-6 hrs	Limited assistance and direction likely from emergency services. Measures requiring minimal time for implementation may be appropriate for flood management.
moderate warning	6-12 hrs	Potential assistance and direction from emergency services, depending on time of day. Measures requiring moderate time, or less, for implementation may be appropriate for flood management.
good warning	12+ hrs	Significant assistance and direction from emergency services may be available, including assistance with evacuation. Most measures requiring some form of on-demand implementation would be appropriate for flood management.

Again utilising Figure 2-9 as a typical flood response, the expected peak flood conditions in Burrill Lake may be experience 6-12 hours after the onset of flood producing rainfall. It should be noted however, that for major flood events (e.g. 1% AEP event) inundation to the lowest-lying areas of the floodplain may happen sooner.

2.4.7 Effective Flood Access

Access and evacuation difficulties arise from:

- high depths and velocities of floodwaters over access routes;

- difficulties associated with wading (uneven ground, obstruction such as fences);
- the distance higher, flood free ground;
- the number of people and capacity of evacuation routes;
- the inability to communicate with evacuation and emergency services;
- the availability of suitable equipment (e.g. heavy vehicles, boats);
- a low level of community awareness of evacuation procedures or requirements; and
- a willingness of residents to remain at their property.

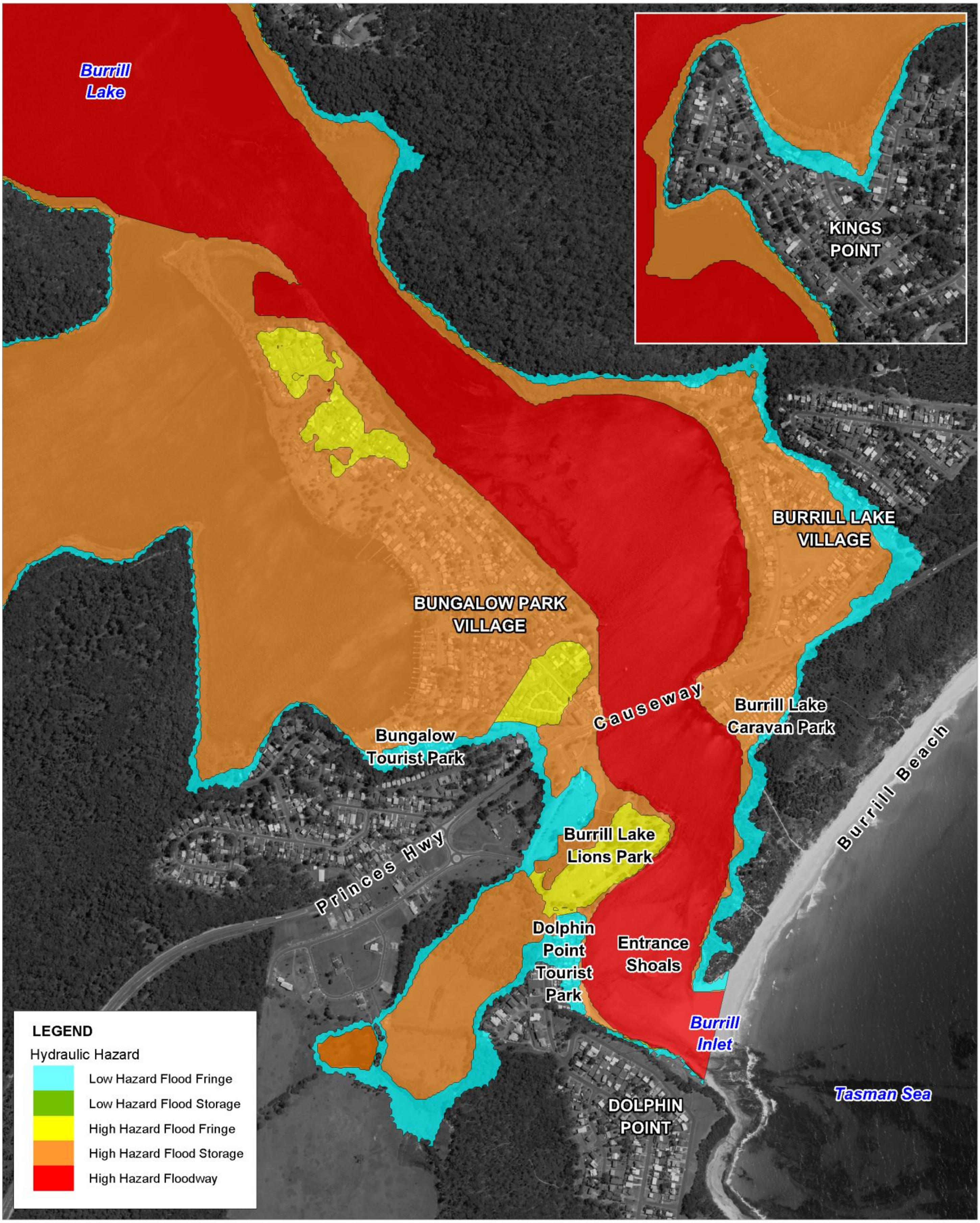
There are significant areas of Bungalow Park and Burrill Lake Village, and a number of tourist parks, that are likely to require evacuation in a major flood event. The Bungalow Park Village is perhaps the major concern in the catchment in regard to evacuation access. The local topography in this locality was shown in Figure 2-2. Parts of Thistleton Drive and Balmoral Road are as low as 1.1m AHD and would be some of the first area of land subject to inundation. At the peak of major flood events inundation of these critical access routes will be in excess of 0.5m and accordingly be impassable for most vehicular and pedestrian traffic.

The Causeway would be overtopped in major events thereby severing access between the north and south areas of Burrill Lake. This may also impede the opportunity for emergency services to access some locations.

2.4.8 Adopted Flood Hazard Categories

The Burrill Lake floodplain has been classified into flood hazard categories as shown in Figure 2-10 with consideration of the above factors.

Large areas of existing development particularly within Bungalow Park and Burrill Lake Village have been classified as high hazard. Most of the area is subject to high hydraulic hazard, i.e. high depths and/or velocity of floodwater. In addition, a number of areas are considered high hazard as a function of the potential difficulties in evacuation.



Title:

Hydraulic Hazard Mapping (1% AEP Flood)
Catchment Flooding Existing Conditions

Figure: 2-10

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_024_120329_Hazard_Map.WOR

3 CLIMATE CHANGE

The general flood behaviour discussed in the previous chapter identifies a significant existing flood risk in Burrill Lake that needs to be managed. This flood risk may be heightened in the future as a result of a changing climate.

The impacts of future climate change are likely to lead to a wide range of environmental responses by coastal lagoon systems such as Burrill Lake, having potential influence on the flood behaviour of the system and implications for medium and long term floodplain management.

The potential for climate change impacts is now a key consideration for floodplain management. Low-lying coastal areas, such as those surrounding Burrill Lake will be at increasingly high risk due to a range of predicted climate change impacts. The NSW Sea Level Rise Policy Statement (2009) advises that mean sea level could potentially rise, up to 0.4m by 2050, and up to 0.9m by 2100, relative to the 1990 levels. These values are used by Council for strategic planning and landuse management purposes.

The NSW Government has also released a guideline for practical consideration of climate change in the floodplain management process that advocates consideration of increased design rainfall intensities of up to 30%.

3.1 Impacts on Flood Behaviour

The potential climate change impacts of rising sea levels and increased rainfall intensity and their impact on design flood conditions are discussed below with reference to the three different flooding mechanisms considered for Burrill Lake

3.1.1 Catchment Flooding

The potential impact of climate change on catchment flooding behaviour affects three key processes:

- Design rainfall intensities;
- Coincident tidal conditions at the ocean boundary; and
- Entrance berm and general shoaling levels.

Current guidelines predict that a likely outcome of future climatic change will be an increase in extreme rainfall intensities. Climate Change in New South Wales (CSIRO, 2004) provides projected increases in annual extreme rainfall intensities for south-east NSW of 7% and 5%, for the years 2030 and 2070 respectively. The summer extreme rainfall intensities are projected to increase by 12% and 10% for the years 2030 and 2070 respectively. These figures are based on a 2.5% AEP 24h duration rainfall event. Based on these guidelines a design rainfall intensity increase of 10% was selected as being appropriate for assessing the potential impact of climate change on design rainfall in the Burrill Lake catchment.

Normal tide levels will increase in line with sea level rise and accordingly the tidal boundaries and initial lake water levels adopted for catchment flooding scenarios are increased by 0.4m and 0.9 respectively for the 2050 and 2100 planning horizons.

There are no government guidelines concerning the impact of future climatic change of entrance berm geometries. A change in entrance berm processes is likely to result from the predicted sea level rise and changes to coastal storm intensity. From this change, a net upward shift in typical berm heights at the entrance may be expected commensurate with sea level rise estimates. Accordingly, a typical shoaled entrance at an approximate level of 1.0m AHD under existing conditions is expected to build to level of 1.4m and 1.9m respectively for the sea level rise scenarios to 2050 and 2100 respectively.

The design 1% AEP flood inundation extent and depth of flooding in Burrill Lake for the year 2100 design condition (i.e. with 0.9m sea level rise) is shown in Figure 3-1. The corresponding inundation pattern under existing conditions was presented in Figure 2-5 which showed extensive inundation. The peak flood levels and depths of inundation are increased significantly under the climate change scenario. A flood event of this magnitude would result in an extensive inundation of existing property, particularly on the Bungalow Park Village peninsula and Burrill Lake Village (north Burrill Lake). Typical flood depths of the order of 1.5m – 2.0m would result in above floor flooding to a significant depth of a large number of properties, and thus result in extensive damage. The depth of flooding also heightens the risk to life and existing constraints on evacuating certain parts of the floodplain such Bungalow Park.

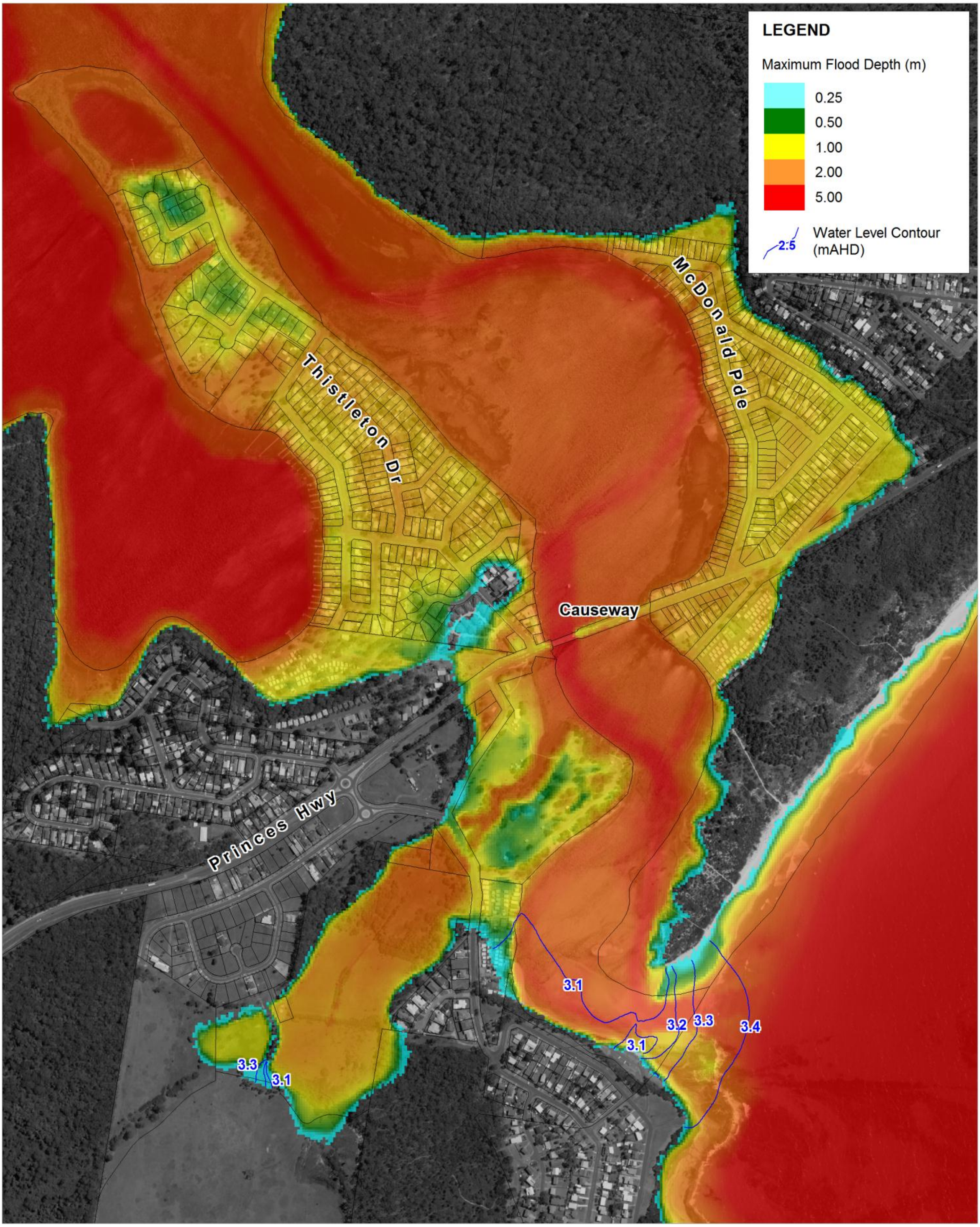
3.1.2 Ocean Flooding

Elevated ocean water levels typically comprise a combination of:

- Barometric pressure set up of the ocean surface due to the low atmospheric pressure of the storm;
- Wind set up due to strong winds during the storm “piling” water upon the coastline;
- Astronomical tide; and
- Wave set up.

Sea level rise will directly increase the design still water levels used which incorporate allowance for tides, meteorological influences and other water level anomalies, but exclude wave setup influences. The impact of climate change on the wave set up component is unknown, and as such an additional increase on adopted values for existing conditions may not be warranted.

As for the catchment flooding scenarios, the sea level rise allowances provide for substantial increases in peak flood conditions. A comparison of peak flood levels under existing conditions and climate change scenarios for both catchment and ocean flooding is shown in Table 3-1 . The levels reference the location of the existing gauge in Burrill Lake (upstream of the Causeway). The direct impact of the sea level rise scenarios on peak flood level conditions is clearly evident. Also to note that the flood risk from either catchment flooding or ocean derived flooding is relatively similar, such that due consideration of both flooding mechanisms is required in assessment appropriate floodplain risk management options.



Title:

Combined Catchment and Ocean Flood (2100 Open)
1% AEP Maximum Flood Depths and Water Levels

Figure: 3-1

Rev: A

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_008_101126 2100 Open 1% Depths.WOR

Table 3-1 Comparison of Peak Flood Conditions with Climate Change Scenarios

Event Conditions	Planning Horizon		
	Existing	2050	2100
5% AEP Catchment Event	2.2	2.5	2.8
5% AEP Ocean Event	1.5	2.0	2.6
1% AEP Catchment Event	2.4	2.7	3.0
1% AEP Ocean Event	1.8	2.4	3.0

3.1.3 Low-level Persistent Flooding

Under potential sea level rise scenarios, the low-level persistent flooding levels now typically encountered during periods of entrance closure would then be experienced on a regular basis as part of the normal tidal cycle whenever the entrance is open. The lowest parts of the existing foreshore environment would be subject to permanent inundation given the expected increase in general lake levels.

For example, applying the 0.4m sea level rise scenario to an existing typical high water level in the Lake of 0.8m AHD, would provide for a regular water level (under tidal conditions) at the existing entrance management trigger level. The 0.9m sea level rise scenario would see permanent inundation of an extensive area of existing development under normal tidal conditions.

As noted above, the entrance berm levels are expected to increase at approximately the same rate as sea levels. Current entrance management policies were largely adopted to protect existing low-lying development from low-level persistent inundation and will eventually become redundant. Current trigger levels will eventually be reached by normal tidal variability. The impact of sea level rise on current entrance management would in fact be seen much sooner, with the effectiveness of artificial breakouts gradually diminishing as high tailwater conditions limit the formation of an effective scour channel.

Changes to rainfall patterns will affect hydrology and water balance in the estuary. If the estuary tends towards closure due to sea level rise, and overall rainfall patterns tend towards drier conditions, albeit with more intense flood producing rainfall bursts, significantly longer periods of closure can be expected, as more frequent rainfall events will be less significant and less capable of filling and overtopping the entrance barrier.

Ground levels in the low-lying parts of Bungalow Park and Burrill Lake are typically around 1.0 to 1.3m AHD. It is expected that under a sea level rise of about 0.4 metres, roads, structures and even ground vegetation would start to become detrimentally impacted by high groundwater levels, while a sea level rise of 0.9 metres would lead to deep inundation within many streets and yards on a frequent basis under both open and closed entrance conditions.

3.2 Issues for Consideration

Potential climate change impacts are expected to increase the severity and frequency of flooding. Whilst these changes are progressive, and may take several years for critical flooding thresholds to be reached, flood planning in Burrill Lake must be sufficiently robust and flexible to accommodate these changes and include a program for adaptation. It must also be recognised that projected sea level rise will not stop at the end of this century.

Given the design life of infrastructure such as residential homes (e.g. 50-100years) it is inevitable that the decisions we make now in regard to occupation of flood prone land have implications for the future. Potential flood impacts may not eventuate until sometime in the future, but still within the design life of the structure, and accordingly need to be managed from present day. Some general considerations that need to be accounted for are:

- What will the landscape we create now through planning and development controls look like in the future?
- What limitations or problems will this create in the way we own, occupy and use public and private spaces?
- How can we allow for changes in development controls which may be revised in the future in line with improved estimation of flooding and climate change impacts?

One of the most significant impacts of sea-level rise will be the regular inundation of low-lying foreshore areas. Normal tide levels in the Lake are expected to increase in line with broader sea-level rise. We face the prospect under current predictions of normal tide levels being around 1m higher than at present towards the end of the century. These future normal tide conditions exceed the current trigger levels for entrance openings to relieve flooding on low-lying property. As such many existing low-lying properties could be inundated on a daily basis.

The rise in normal tidal levels associated with sea-level rise presents a considerable challenge to Council in managing flood prone land both now and in the future. Whilst protecting development is a major priority, other considerations include:

- Making space to retain access to the foreshore amenity.
- Making space for community infrastructure such as amenity blocks, picnic tables, boat ramps etc.
- Making space for ecological communities (upon which water quality and fish populations depend) to migrate.

4 PROPERTY INUNDATION AND FLOOD DAMAGES ASSESSMENT

A flood damage assessment has been undertaken to identify flood affected property, to quantify the extent of damages in economic terms for existing flood conditions and to enable the assessment of the relative merit of potential flood mitigation options by means of benefit-cost analysis.

The general process for undertaking a flood damages assessment incorporates:

- Identifying properties subject to flooding;
- Determining depth of inundation above floor level for a range of design event magnitudes;
- Defining appropriate stage-damage relationships for various property types/uses;
- Estimating potential flood damage for each property; and
- Calculating the total flood damage for a range of design events.

4.1 Property Database

4.1.1 Location

Property locations have been derived from Council's cadastre information and associated detailed aerial photography of the catchment. Linked within a GIS system, this data enables rapid identification and querying of property details.

A property database has been developed detailing individual properties subject to flood inundation, i.e. within the predicted flood envelopes discussed in Section 3.

4.1.2 Ground and Floor Level

A floor level survey of identified property within the Probable Maximum Flood extent was commissioned during the course of the study. The survey provided ground levels at the building, building floor level, geographic co-ordinate and photographic record to identify property type.

4.1.3 Flood Level

The flood modelling results provide a continuous flood profile across the floodplain. Flood levels calculated from the TUFLOW model were queried from TUFLOW's GIS output at each property reference point. The resulting output was used to identify flooding characteristics such as the number and type of properties affected, frequency of inundation and the depth of inundation.

4.2 Property Inundation

A summary of the number of properties potentially affected by flooding for a range of flood magnitudes is shown in Table 4-1. The counts in the table represent numbers of properties with potential for flooding *above floor level* for each flood magnitude. The flood level used to define the over floor flooding represents the maximum peak flood level for each given return period, either from catchment derived or ocean derived flooding.

Table 4-1 Estimated Number of Inundated Properties (Above Floor level)

Design Event	Inundated Properties
10% AEP (1 in 10)	70
5% AEP (1 in 20)	140
2% AEP (1 in 50)	270
1% AEP (1 in 100)	318

The scale of the existing problem in Burrill Lake with respect to potential property inundation is further illustrated in Figure 4-1. The figure shows the number of properties with ground levels and floor levels below certain levels. For example, at a level of 2.5m AHD (approximately at the 1% AEP peak flood level), some 318 properties have lower floor levels and would be subject to above floor flooding. Some additional properties would still be subject to inundation of the grounds with up to 470 properties with general ground levels on the lot below 2.5m AHD.

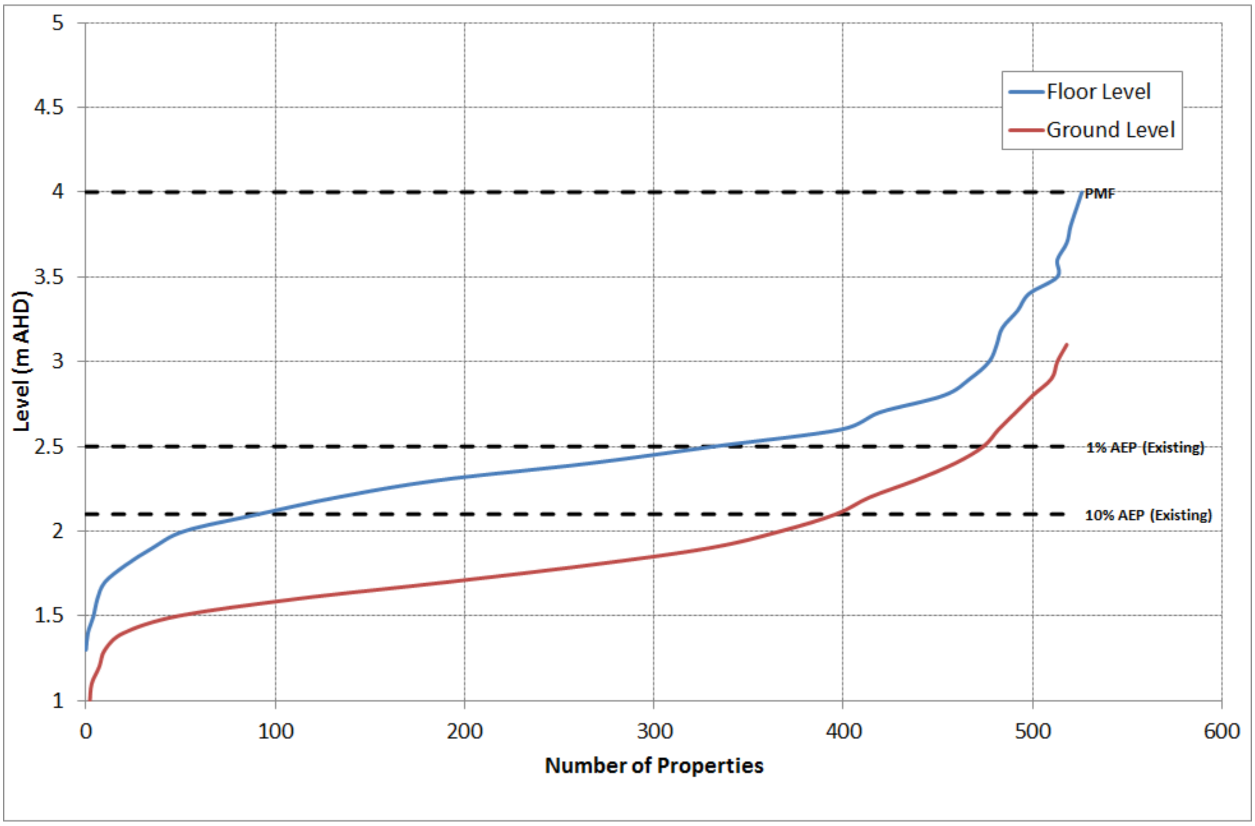
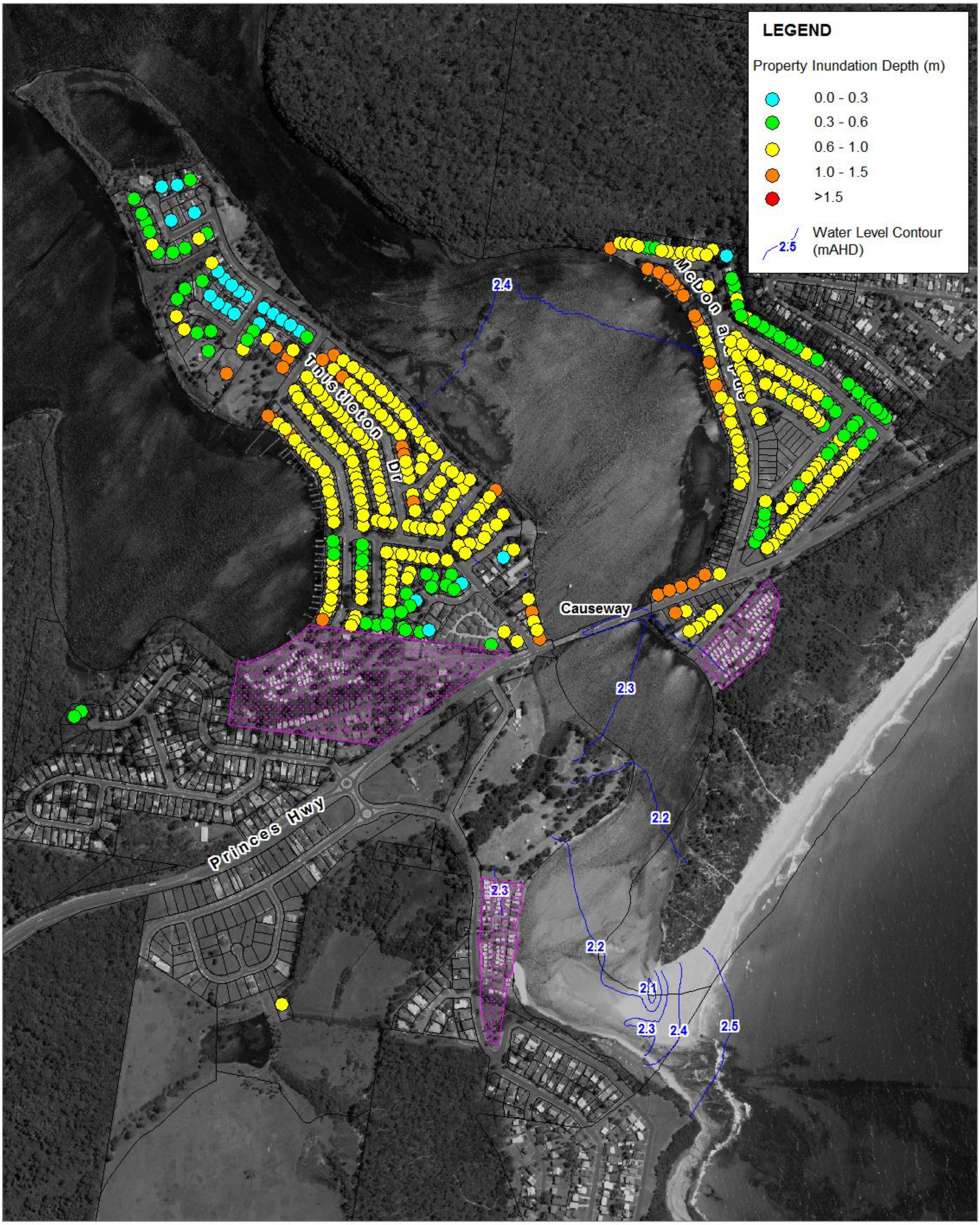


Figure 4-1 Building and Property Inundation at Nominal Water Levels (Existing Conditions)



Title:

Property Inundation
1% AEP Existing Conditions

Figure: **4.2**

Rev: **A**

N

0 200 400m

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_003_101125 EX 1% Depths.WOR

The number of properties affected and the severity of flooding increases considerably under climate change scenarios assessed. Figure 4-3 shows affected property counts with reference various flood level magnitudes for the year 2100 planning horizon. For the 1% AEP flood typical flood inundation depths above floor level are of the order of 1-1.5m. Significantly, up to 100 properties have floor levels below a level of 2.1m AHD, corresponding to the current entrance management trigger level of 1.2m AHD plus 0.9m sea level rise allowance.

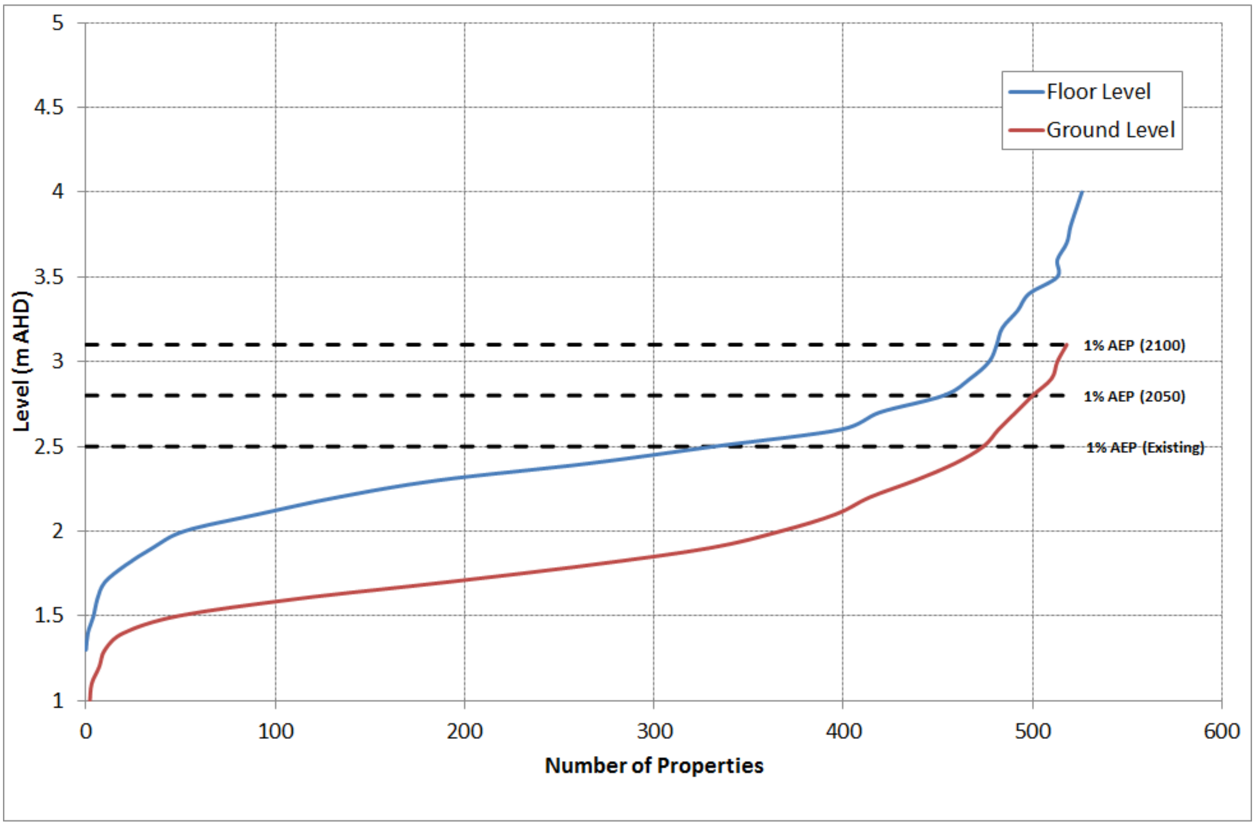


Figure 4-3 Building and Property Inundation at Nominal Water Levels (Future Conditions)

4.3 Flood Damages Assessment

A 'baseline' damages assessment has been completed for the entire floodplain study area. Flood damages have been calculated using the data base of potentially flood affected properties and a number of stage-damage curves derived for different types of property within the catchment. These curves relate the amount of flood damage that would potentially occur at different depths of inundation, for a particular property type.

Different stage-damage curves for direct property damage have been derived for:

- Residential dwellings (categorised into small, typical or raised categories); and
- Commercial premises (categorised into low, medium or high damage categories).

A full description of the flood damages calculation process adopted for the Burrill Lake study is included in Appendix B.

The peak depth of flooding was determined at each property for the range of flood events considered up to the Probable Maximum Flood. The associated flood damage cost to each property was subsequently estimated from the stage-damage relationships. Total damages for each flood event were determined by summing the predicted damages for each individual property.

The Average Annual Damage (AAD) is the average damage in dollars per year that would occur in a designated area from flooding over a very long period of time. In many years there may be no flood damage, in some years there will be minor damage (caused by small, relatively frequent floods) and, in a few years, there will be major flood damage (caused by large, rare flood events). Estimation of the AAD provides a basis for comparing the effectiveness of different floodplain management measures (i.e. the reduction in the AAD).

The results of the flood damages assessment are summarised in Table 4-2.

Table 4-2 Summary of Flood Damages

Flood Event	Flood Damage Estimates (millions of $)		
	Existing Year 2012	+0.4m SLR Year 2050	+0.9m SLR Year 2100
20% AEP (1 in 5)	$2.2	$11.0	$29.4
10% AEP (1 in 10)	$4.4	$16.7	$32.1
5% AEP (1 in 20)	$8.9	$23.8	$35.4
2% AEP (1 in 50)	$17.2	$30.3	$38.3
1% AEP (1 in 100)	$21.3	$32.1	$39.3
0.5% AEP (1 in 200)	$24.9	$34.4	$40.5
PMF	$59.1	$60.7	$64.6
Average Annual Damage	**$1.9**	**$5.6**	**$11.1**

5 CURRENT FLOOD MANAGEMENT

Flooding in Burrill Lake is already managed to some degree through a range of initiatives that have been established and supported by Council and other agencies, including the SES. Current flood management approaches are described in this chapter.

Current flood management approaches have been divided into elements that aim to:

- Reduce specific flood risks (through physical works);
- Improve resilience in living with flood risks; and
- Facilitate emergency management.

5.1 Reducing Flood Risks

No specific structural works have been undertaken in Burrill Lake to reduce/manage the impacts of flooding. The principal management technique utilised to date is the mechanical opening of the entrance to address low-level persistent flooding during periods of entrance closure.

5.1.1 Entrance Management Works

The Burrill Lake Interim Entrance Policy (Peter Spurway and Associates, 2008) was adopted to provide a staged trigger approach for entrance management at Burrill Lake, including monitoring and procedural details, be adopted as an interim measure. The policy provides for artificial breakout of the entrance at defined trigger levels to relieve inundation to low-lying property during periods of entrance closure and subsequent sustained periods of elevated Lake levels.

The conditions of the existing policy are provided below.

The following summarises conditions under which the lake entrance can be breached.
1. Conditions that are <u>essential</u> before mechanical lake opening occurs are:

a) Lake water level at or exceeding **1.20 m AHD** initiates an <u>immediate entrance opening</u> at any time on the first available high tide

OR

b) If the lake reaches and stabilises at a level between **1.10m and 1.20m AHD**, a <u>planned opening</u> shall be made under suitable conditions defined by Point 2 below.

OR

c) If the lake level reaches and stabilises at a level between **1.00 m and 1.10 m AHD** and it is within one month prior to or at the time of the Christmas or Easter holiday periods, a <u>planned opening</u> shall be made under suitable conditions defined by Point 2 below

AND

d) Non-breeding season for threatened shorebirds, or clearance from NPWS has been obtained (see Point 4 below).

2. The following conditions are <u>required for a planned opening</u> to maximise the opportunity for effective entrance scour and flushing. (This may result some delay in an opening to await suitable conditions.)

a) Moderate to heavy rainfall is ongoing or predicted in the catchment
b) Relatively large ocean tidal range (greater than 1.0 m) with opening to coincide with a falling tide
c) Slight ocean swell
a) High Barometric pressure.

3. Council outdoor staff are to be alerted at a lake level of 0.85m AHD that an opening may be imminent, pending further rainfall.

4. A check for the presence and breeding activity of threatened resident or migratory shorebirds (particularly Pied Oystercatcher and Little Tern) must be made with the Parks and Wildlife Group of DECC prior to artificial lake opening. No excavation work across Burrill Beach is to be undertaken without consent from NPWS if birds, nests or fledglings are known to be present. Presence or absence of threatened bird species should be confirmed by NPWS upon request from council. The likely breeding period collectively extends from late August to March in any year.

5. A set of gauge plates over the full lake height range are to be installed at the southern end of the Princes Highway bridge in Apex Park and at the Kendall Crescent boatramp, both sites relating lake level to AHD for consistency. The gauges should be marked with the minimum lake opening levels in accordance with this interim policy.

The Policy was noted as interim with a final entrance management policy to follow from the development of a Floodplain Risk Management Plan for the Burrill Lake. It was recommended the Interim Policy and REF be reviewed in response to the development of the Burrill Lake Floodplain Risk Management Study and Plan.

The current Entrance Management Policy and associated trigger levels for an artificial opening is largely for the protection of low-lying assets subject to inundation from elevated lake levels as a result of entrance closure. In developing the Policy and associated Review of Environmental Factors (Peter Spurway and Associates, 2008), consideration was given to Lake water quality, ecology, tourism, social and community issue. No major drivers for entrance management were identified from the water quality and ecological considerations. However, there is a significant social and community pressure for entrance openings to address the perceived impacts of the changing Lake foreshore environment during periods of closure.

From a floodplain management perspective however, the benefit of entrance management is largely restricted to the low-level persistent flooding regimes.

5.2 Living with Flood Risks

5.2.1 Legal and Planning Controls

The prime responsibility for planning and management of flood prone land in New South Wales rests with local government. Management of existing and future flood risks must be investigated and advanced within a legislative, legal, policy and planning framework.

Land use planning and development controls are a key mechanism by which Council can manage future flood risk by legally controlling and directing future development and redevelopment of private and public lands. Because of the incremental nature of development, the benefits of flood planning controls may not be realised for many years. Local Environment Plans (LEP) and Development

Control Plans (DCP) can be amended at any stage in the future hence the opportunity always remains to improve flood planning controls as our understanding of flood risks become more refined.

One of the future challenges of Council will be managing the potential flood risks associated with climate change and sea level rise. Without intervention, certain localities within the LGA will experience gradual changes in flooding frequency, duration and depth as time passes. The LEP and DCP are potentially key mechanisms by which to pre-emptively adapt to this future.

The principal planning mechanism for managing floodplain within Shoalhaven City Council is provided through:

- Shoalhaven Local Environmental Plan
- Development Control Plan 106 (Amendment No 1)

5.2.2 Draft Shoalhaven Local Environmental Plan 2009

Local Environmental Plans (LEP) are prepared in accordance with Part 3 Division 4 of the *Environmental Planning and Assessment Act 1979*. The intent of the LEP is to define the legal framework for land use and development by 'zoning' all land. The LEP incorporates standard planning provisions, clauses, definitions and zones into the one document. It identifies standard zones and zone objectives and specifies permitted and prohibited uses in zones, and identifies compulsory and optional provisions.

An LEP is essentially a legal document of words and maps which sets out the legal standards or requirements for development to control the use of private and public land. Council is currently in the process of updating the city's Local Environmental Plan in accordance with the NSW Government Standard LEP template, which is intended to provide consistency in planning terminology and structure across the state.

The Minister for Planning, under section 117(2) of the Environmental Planning and Assessment Act 1979 (EP&A Act) issues directions that relevant planning authorities such as local councils must follow when preparing planning proposals for new LEPs. On the 31st January 2007, the Minister released Direction No. 15 – Flood Prone Land to apply when a council prepares a draft LEP that creates, removes or alters a zone or a provision that affects flood prone land.

The Draft Shoalhaven LEP 2009 includes a flood related local provision, requiring Council to consider flooding impacts in land use planning and development approval. This clause (Clause 7.8) as included in the LEP is reproduced below:

7.8 Flood Planning Land [local]

(1) The objectives of this clause are as follows:

(a) to maintain the existing flood regime and flow conveyance capacity,

(b) to enable safe occupation and evacuation of land subject to flooding,

(c) to avoid significant adverse impacts on flood behaviour,

(d) to avoid significant effects on the environment that would cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses,

(e) to limit uses to those compatible with flow conveyance function and flood hazard.

(2) This clause applies to land shown as "flood planning area" on the Shoalhaven Council Local Environmental Plan 2009 Flood Planning Area Map and to land subject to the discharge of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metres freeboard.

(3) Development consent is required for any development on land to which this clause applies.

(4) Development consent must not be granted for development on land to which this clause applies unless the consent authority is satisfied that the development will not:

(a) adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, or

(b) significantly alter flow distributions and velocities to the detriment of other properties or the environment of the floodplain, or

(c) affect the safe occupation or evacuation of the land, or

(d) significantly detrimentally affect the floodplain environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, or

(e) be likely to result in unsustainable social and economic costs to the community as a consequence of flooding, or

(f) if located in a floodway:

(i) be incompatible with the flow conveyance function of the floodway, or

(ii) cause or increase a flood hazard in the floodway.

The current Draft Shoalhaven LEP 2009 Flood Planning Area Map appears to reflect the 1% AEP flood extent for Burrill Lake. The Floodplain Development Manual requires consideration of flood risk up to and including the PMF, and indeed the definition of flood liable land on the Manual includes all land up to and including the PMF. Council's existing DCP 106 amendment 1 provides more detailed controls to support the LEP, with a graded set of controls dependent on the flood classification up to the PMF level also. Accordingly there is some inconsistency in the Flood Planning Area.

Further to the above, the LEP has no explicit definition of flood planning areas with consideration of climate change impacts. DCP 106, particularly in relation to Flood Planning Levels, is specific in incorporation of climate change impacts (0.4m sea level rise allowance to establish 2050 flood planning levels).

The Draft Shoalhaven LEP 2009 identifies a number of broad land use zones including Rural, Residential, Business, Industrial, Special Uses, Recreation, Environment Protection and National Parks/Nature Reserves. There is no specific zoning category related to flooding, however, the flood planning area is defined in the separate overlay as discussed above.

The new LEP template introduces a new suite of pre-defined land use zoning categories, aimed at providing consistency from one LGA to the next. Council will be required to assign land use zonings to all areas within the LGA, including existing and future development areas, based on stated objectives for each zoning and provisions made for each zoning.

Land Use Zoning in the Burrill Lake study area is shown in Figure 5-1. The flood planning area at the 1% AEP flood level + 0.5m is shown for reference. The key land use categories in Burrill Lake are described below.

R2 - Low Density Residential – This zoning represents the majority of existing development within the Burrill Lake floodplain generally comprising standard size house lots.

R3 - Medium Density Residential – comprising two existing developments of higher density residential.

RE1 – Public Recreation – Includes the majority of the foreshore that is under public ownership through Shoalhaven City Council or Crown land.

B2 – Local Centre – Incorporates the existing commercial enterprises at Burrill Lake on the northern side of the causeway.

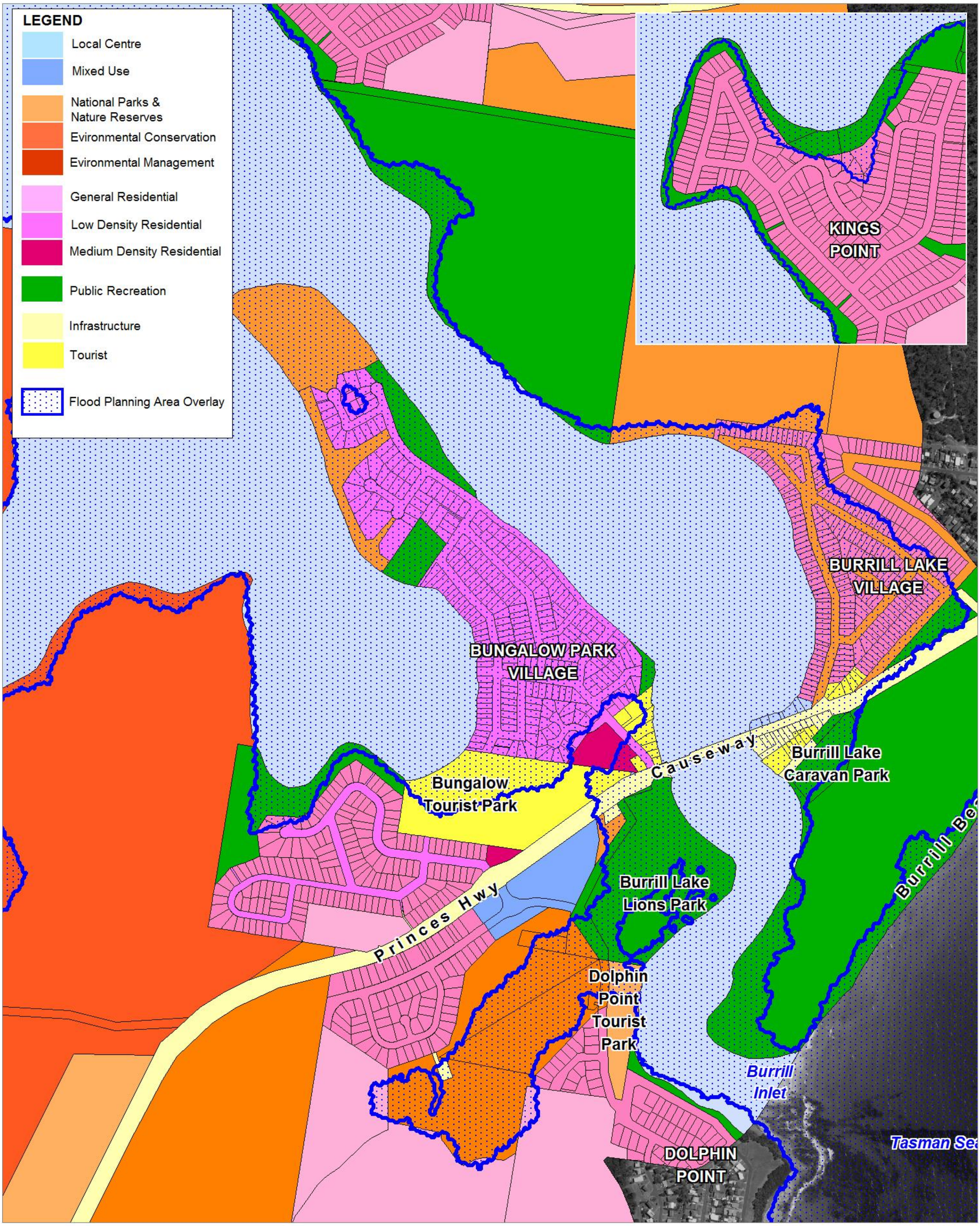
E1 – National Parks and Nature Reserves – Principally includes the Woodburn State Forest areas on the western side of the Burrill Lake water body.*E2 – Environmental Conservation* - This zone is generally intended to protect land that has high conservation value. The main areas in Burrill Lake include the northern parts of the Bungalow Park peninsula and the wetland area adjacent Dolphin Point Road.

E3 – Environmental Management – Land has environmental or scenic values or hazard risk where a limited range of development can be permitted. Limited in Burrill Lake to the area currently occupied by the Dolphin Point Tourist Park.

SP2 – Infrastructure - This zone relates to some infrastructure uses, specifically for Burrill Lake the Princes Highway corridor, sewerage infrastructure such as pump stations.

SP3 – Tourist – Locations where a variety of tourist-oriented land uses are permitted. Largely incorporates the caravan parks and other visitor accommodation.

Current land use zonings within Burrill Lake would limit the amount of future new development within the flood planning area. Nevertheless, appropriate development controls for new development are required with consideration of the flood risk. Existing development is consistent with the land use zonings.



Title:

Land Use Zoning and Flood Planning Area

Figure: 5-1

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_027_120329_Land_Use.WOR

5.2.3 Development Control Plan 106 – Amendment No. 1 (2011)

A Development Control Plan (DCP) is established under the provisions of Part 3 Division 6 of the EP&A Act 1979. A DCP provides more detailed provisions with respect to development in particular areas, and is to be considered by Council in determining development applications.

The Development Control Plan 106 – Floodplain Management provides guidelines to Development Applications for assessment by Council. Development Control Plan 106 amendment 1 specifically addresses floodplain management, and applies to all development on flood prone land. The DCP superseded the previous Council Flood Policy and is to be taken into consideration by Council when exercising its environmental assessment and planning functions in relation to new development within the LGA.

The DCP addresses the new directions in flood risk management that are embodied in the NSW Government's *Flood Prone Land Policy* and which are emphasised in the 2005 edition of the government's *Floodplain Development Manual*.

The general objectives of the DCP in relation to flooding are:

- Reduce risk to life and property resulting from floods;
- Ensure that the impacts of the full range of flood sizes up to and including the PMF are considered when assessing development on flood prone land;
- Ensure that the impacts of climate change are considered when assessing development on flood prone land;
- Ensure the future use of flood prone land does not cause undue distress to individuals nor unduly increases potential flood liability to individuals or the community; and
- Incorporate site specific floodplain management recommendations from local Floodplain Risk Management Plans into Council's overall Planning Framework.

For areas where Council has not adopted a Floodplain Risk Management Plan (as for Burrill Lake prior to completion of the current study), a set of generic development controls apply related to specific land use categories and the appropriate flood risk category defined by hydraulic and hazard criteria. Some of the key development controls are discussed below.

Flood Planning Levels

The Flood Planning Level (FPL) is used to define land subject to flood related development controls and is generally adopted as the minimum level to which floor levels in flood affected areas must be built. The FPL includes a freeboard above the design flood level to account for uncertainties in estimation of the flood level. Council has adopted a graded set of FPLs dependent on type of development and categorisation of the floodplain.

The principal floor level control for residential land uses is the 1% AEP flood level plus 0.5m freeboard.

One of the significant changes in the current DCP is the inclusion of sea level rise allowances in determination of Flood Planning Levels. For most development types, the policy provides for inclusion of 0.4m sea level rise allowance in determining flood planning levels, consistent with the previous NSW Government sea level rise planning benchmark of 0.4m by 2050.

For all new subdivision applications a 0.9m sea level rise allowance is required in setting FPLs consistent with the previous sea level rise planning benchmark of 0.9m by 2100.

The current flood planning levels in Burrill Lake are derived from the Burrill Lake Flood Study (BMT WBM, 2007). Sea level rise allowances were not included in the establishment of design flood conditions in this study. Accordingly, in the interim a nominal 0.4m or 0.9m has been directly applied to the design flood levels in establishing the appropriate flood planning level. With the adoption of the Floodplain Risk Management Study and Plan, this previous method will now be superseded by the more current information that does consider the impacts of sea level rise.

Hydraulic Impact

Development within the floodplain has the potential to impact on existing flood behaviour by restricting or redirecting floodwaters that may cause an increase in flood levels or flow velocities elsewhere. Dependent on the scale of the development, an applicant much demonstrate the impacts of the proposed development on existing flood behaviour through the provision of an appropriate engineers report.

The current DCP has provisions to limit the amount of filling within the floodplain giving consideration to loss of floodplain storage volume and the potential to redirect floodwaters thereby exacerbating flooding to neighbouring property. The current controls on filling would limit the number of existing properties in Burrill Lake that could use local filling to increase flood immunity.

Access

The DCP requires consideration of the availability or provision of reliable emergency access prior to or during 1% AEP flood event. Reliable access is defined as the ability for people to evacuate an area subject to imminent flooding within effective warning time having regard to the depth and velocity of floodwaters, the suitability of the evacuation route, and without the need to travel through high depth and/or velocity floodwaters. Dependent on the nature of the development, consideration is given to required vehicular and/or pedestrian access and access for emergency services.

Flood Evacuation Plan

For developments located in high hazard areas of the floodplain, a flood evacuation plan is required to support development applications. The objective of this provision is to ensure effective evacuation is possible for residents/occupiers under their own accord and that the development would not add significant cost and disruption to the community and to emergency services such as the SES.

Building Structure and Design

A number of provisions relating the building structure and design are incorporated into DCP 106. These principally relate to ensuring structural soundness of buildings to withstand the force of floodwaters (relating to depths, velocities and debris loads) and utilising flood compatible building materials and techniques to minimise flood damage.

5.2.4 Education and Awareness Programs

The Council website is the central information tool to educate the community about floodplain management and emergency response in the Shoalhaven. The site contains basic but practical advice in regards to "what to do in times of flood". The web portal also serves as an avenue for landholders and resident to access details on flood affectation, flood planning controls and completed flood study and management plan documentation (refer to Figure 5-2).

The NSW State Emergency Service (SES) provides general information about emergency management including flood response but they do not provide specific flood emergency information for Burrill Lake.

The responses to the community questionnaire indicated a general low level of awareness of where to find flood related information relevant to Burrill Lake, but also a high interest in accessing and receiving this information.

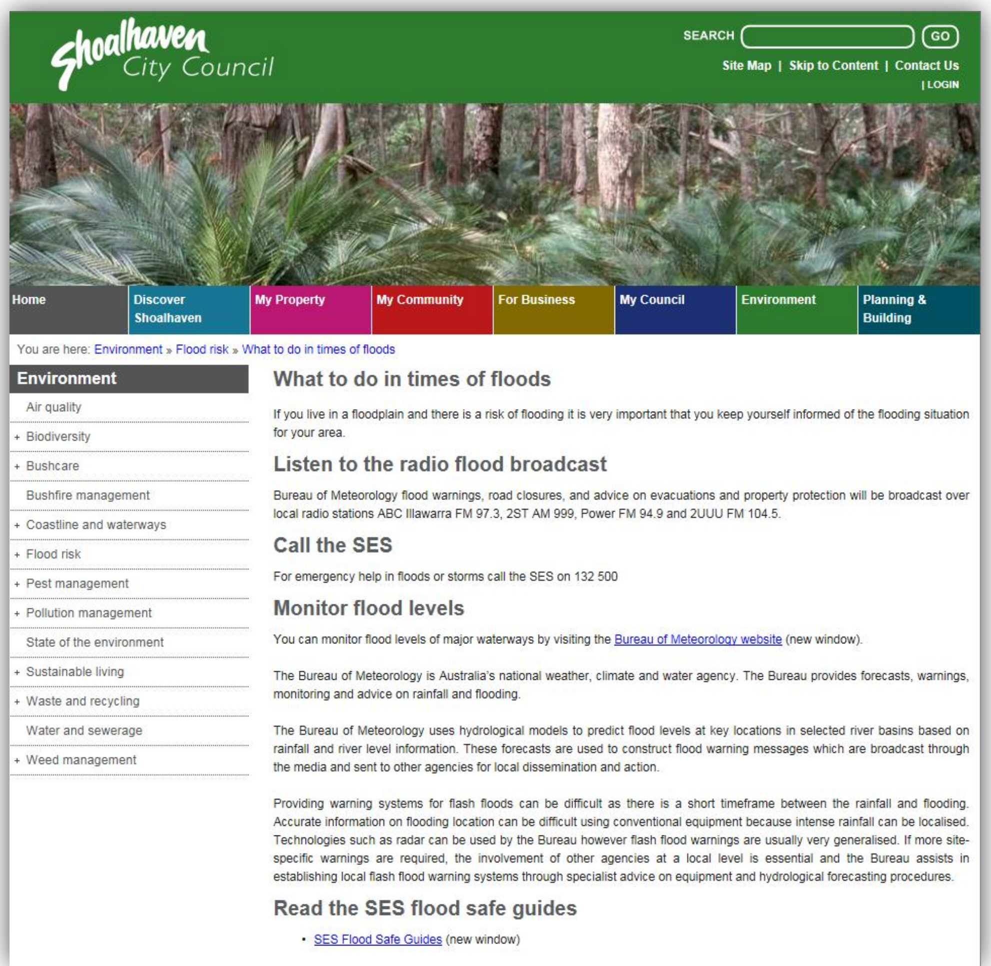


Figure 5-2 Example Flood Information Page (Shoalhaven City Council Website)

5.3 Emergency Management

5.3.1 Shoalhaven City Local Plan

The State Emergency Service (SES) has formal responsibility for emergency management operations in response to flooding. Other organisations normally provide assistance, including the Bureau of Meteorology, council, police, fire brigade, ambulance and community groups. Emergency management operations are usually outlined in a Local Flood Plan.

This plan covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the Shoalhaven City Council area.

Shoalhaven City Council produced an updated local flood plan in February 2004 as a supporting plan to the Shoalhaven DISPLAN (Disaster Plan). The plan is divided into several key sections which serve to outline the preparation measures (Preparedness), the conduct of response operations (Response) and the co-ordination of immediate recovery measures (Recovery) for flooding within the Shoalhaven Council Area.

The SES maintains specific flood intelligence data for Burrill Lake including general flooding behaviour, the number of properties potentially affected by flooding including property floor level details and their location, potential road closure points and relative levels and basic evacuation procedures.

Some 57 dwellings are noted with a floor level below 2m AHD with more than 400 properties with ground levels below 2m AHD. The caravan/tourist parks are also noted as having a high concentration of low-lying dwellings.

The identified access road problem points include:

- Princes Highway (immediately north of the Causeway);
- Balmoral Drive;
- Rackham Crescent;
- McDonald Parade; and
- Commonwealth Avenue.

Evacuation procedures for Burrill Lake are linked to monitoring of water levels at the gauge and general flood warnings issued by the BoM. Specifically, evacuation of residents and caravan parks in the low-lying areas that may be subject to inundation is considered in conjunction with local knowledge of the flood behaviour, if a flood warning is current for the region and floodwaters reach 0.3m above mean sea level and warnings indicate further rises.

Given that no major flooding of Burrill Lake has occurred in recent years, the effectiveness of current flood warning and evacuation procedures has not been tested.

5.3.2 Flood Warnings

The Bureau of Meteorology (BoM) prepares and disseminates flood forecasts and warnings and information to the public in close cooperation with state, territory and local government agencies and other stakeholders. Users of flood warning services include emergency management agencies and members of the public, particularly those in flood-prone areas. More detailed local interpretation of BoM flood warning products and information is provided directly to the public by flood response agencies. BoM warning products include early alerts to the possibility of flooding through a flood watch product, with site-specific forecasts of river height and the expected impact in terms of minor, moderate or major flooding in specific river basins.

Where dedicated flood forecasting systems have not been installed, more generalised products are issued on a regional basis. The free exchange of data in real time among stakeholder agencies and the timely availability of warnings, data reports and flood information to the public are cornerstones of the flood warning service. (Bureau of Meteorology, 2007).

There is no site specific flood warning system for Burrill Lake, however there are a number of general warning services provided by the Bureau including:

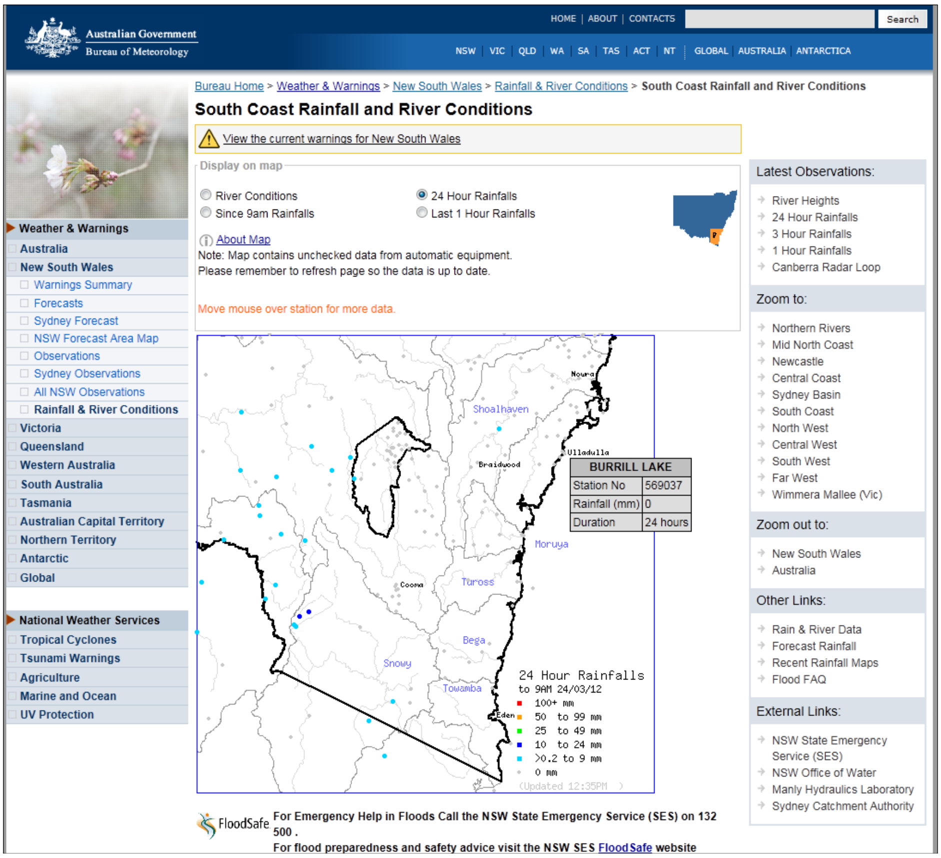
- **Flood Watches –** typically provide 24-48 hour notice. These are issued by the NSW Flood Warning Centre providing initial warnings of potential flooding based upon current catchment conditions and future rainfall predictions.
- **Severe Thunderstorm Warnings –** typically provide 0.5 to 2 hours notice. These short range forecasts are issued by the Bureau's severe weather team and are based upon radar, data from field stations, reports from storm spotters as well as synoptic forecasts.
- **Severe Weather Warnings –** for synoptic scale events that cause a range of hazards, including flooding. Examples of synoptic scale events are the deep low pressure systems off the NSW coast.

Real time water levels (recorded at the gauge upstream of the causeway) and rainfall information (refer to Figure 5-3 for an example) is available from the BoM and Manly Hydraulics Laboratory websites:

Bureau of Meteorology: http://www.bom.gov.au/nsw/flood/southcoast.shtml

Manly Hydraulics Laboratory: http://new.mhl.nsw.gov.au/Site-216435

This data is presently not linked to a specific warning system for Burrill Lake.



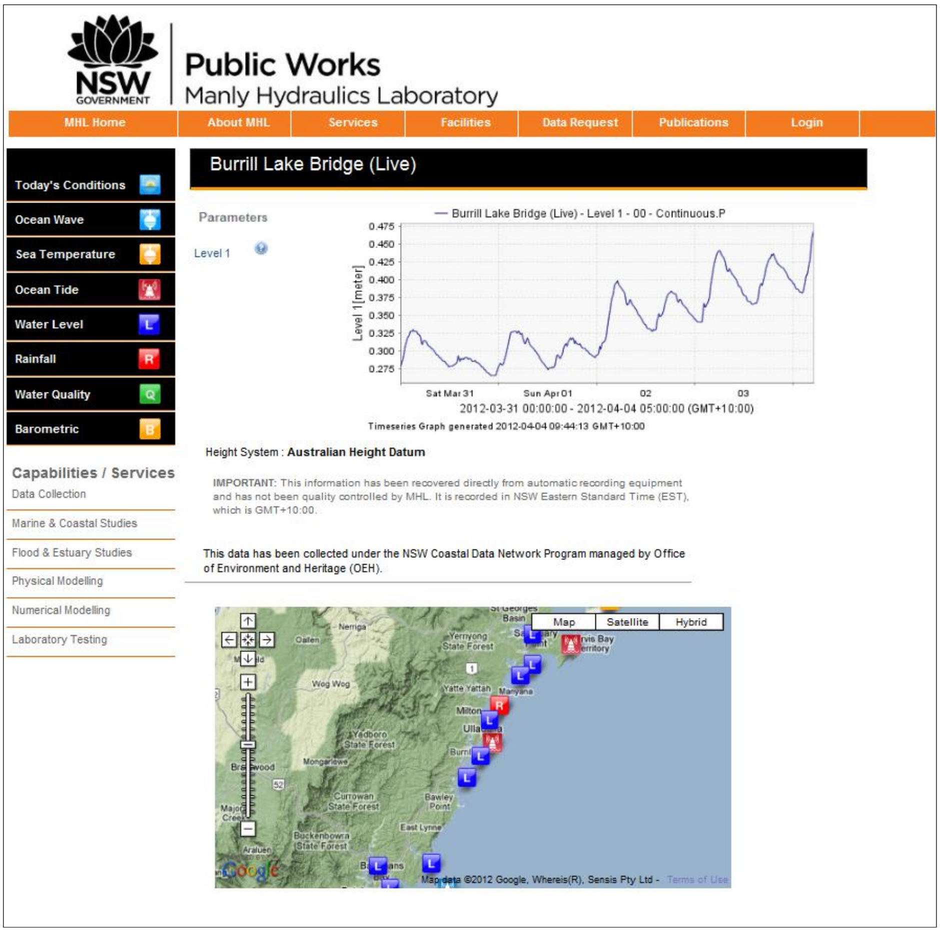


Figure 5-3 Examples of Existing Website Flood Information for Burrill Lake

6 POTENTIAL OPTIONS FOR IMPROVING FLOOD MANAGEMENT

This chapter identifies options for improving flood management within Burrill Lake with respect to existing flood risks, future flood risks, and continuing flood risks. Options considered for improved flood management can be categorised into:

- Flood modification measures;
- Property modification measures; and
- Response modification measures.

As well as describing potential options, the following sections also provide a first pass assessment of options by determining if they would be applicable/suitable to the flooding environments of Burrill Lake. For those options that were considered applicable/suitable, more detailed assessment was undertaken.

6.1 Overview of Potential Options

6.1.1 Flood Modification Measures

These measures are designed to modify or manipulate the behaviour of the flood, either by changing its passage (redirection of flow paths) or its characteristics of flow depth and velocity. Flood modification measures have been identified and considered based on:

- Excluding floodwaters from vulnerable locations (Table 6-1);
- Containing floodwaters to reduce flood peaks downstream (Table 6-2); and
- Enhancing conveyance efficiency or diverting floodwaters (Table 6-3).

Table 6-1 Flood Modification Options to Exclude Floodwaters

Exclusion of floodwaters	Applicable to Burrill?	Comments
Earthen levee (permanent)	✓	Levees are built to exclude areas of foreshore from inundation up to a certain design level. Requires available space, high capital and maintenance costs.
Wall levee (permanent)	✓	Costs potentially prohibitive as the walls would need to be very high to be effective
temporary tilt-up / pop-up levees	✖	Requires ample warning time in order to raise the levee. Usually suitable for small isolated areas only.
sand bags	✖	Requires ample warning time for installation. Is very manual-labour intensive and requires a ready supply of bags and sand. Could possibly be utilised for ocean flooding to protect small areas.
hinged floodgates	✖	Prevents backwater inundation of floodplains, or low-lying areas subject to tidal inundation. Only suitable for low-level frequent flood events.
one-way flow valves	✖	As per hinged floodgates
automated pop-up barriers	✖	The automated mechanism removed the need to physically

		install the barrier, however, it is very costly, and would be suitable for isolated areas only, e.g. individual property.

Table 6-2 Flood Modification Options to Contain Floodwaters

Containment of floodwaters	Applicable to Burrill?	Comments
flood mitigation dam	✖	Large flood mitigation dams within the catchment are not viable on economic, social and environmental grounds.
Large detention / retardation basin	✖	Only suited to controlling flooding in small catchments. There is limited opportunity for building large flood storage basins in the upper catchments.
on site retention/detention	✖	Only suited to controlling flooding in small catchments. The local catchments within existing developed areas of Burrill Lake are insignificant in terms of the overall catchment
increased floodplain storage	✖	Very limited areas of the natural floodplain have been removed in terms of the natural flood storage function

Table 6-3 Flood Modification Options to Enhance Conveyance or Divert Floodwaters

Diversion of floodwaters	Applicable to Burrill?	Comments
Entrance channel dredging	✓	Potential increase in flow conveyance through a general deepening and widening of the channel. Likely to have only a limited impact on ocean flooding controlled by tailwater levels rather than bed levels
Permanent Entrance (e.g. breakwater)	✓	Would relieve issues in regard to low-level flooding from entrance closure. Viability questionable given very high cost in relation to benefits through flood level reduction.
Artificial Entrance Openings	✓	Continuation of existing entrance interventions with appropriate review of trigger levels and opening procedures
Bypass channel	✖	Some suggestions for a second breakout channel to the north. Potential for wide scale damage to existing stabilised dune.
Enlargement of Causeway	✖	Identified in previous studies as having little influence on flood behaviour.
Removal of flow impediments in floodways and across floodplains (including development)	✖	There is little impediment to existing flood flows which are principally confined to the inlet channel. Flows from the southern basin of the Lake pass across existing development in Bungalow Park with little impact on broader flood condition.
Pump out of floodwaters	✓	In combination with a levee or dyke, any floodwaters behind the structure could be pumped out. The size of the pumps would need to be compatible with the expected ingress of floodwaters (pumps in New Orleans were completely overwhelmed by flow rates). Pumps are not fail-safe and may only delay inundation, thereby adding time for appropriate emergency response.

6.1.2 Summary of Potential Property Modification Measures

These measures are designed to reduce the potential risks to life and property by modifying individual properties. Property modification measures have been identified and considered based on whether the measures address existing development or future development, as outlined in Table 6-4 and Table 6-5, respectively.

Table 6-4 Existing Development Property Modification Measures

Existing Development	Applicable to Burrill?	Comments
Voluntary purchase	✓	Target high priority areas only. Can be a very costly option, and will reduce both risks to life and property.
House raising	✓	Applicable to some areas, but may have aesthetic issues. Need to ensure structural stability, and can be used to provide flood free refuge as well as reduce flood damages.
Flood proofing of buildings (walls, floors etc)	✓	Aimed at minimising damages to properties through modifications to buildings.
Raise electrical and fixed assets	✓	As per flood proofing. Aims to minimise damages if property is inundated. The level to which electrics is raised would need to consider the probability of the flood.
Temporarily relocate contents	✓	Raising valuable to as high as possible can be effective at limiting some damage, but dependent on having enough time to perform the relocation process.
Sand bags and drop-in boards	✓	Is manually intensive and requires ample warning time for installation.
Relocate suburb (e.g. Claymore, QLD), esp. in response to potential SLR	✓	Broadscale relocation of dwellings would be subject to having a suitable alternative location. With no such alternative and flood-free locations available, some areas may need to be abandoned if sea levels rise extensively.

Table 6-5 Future Development Property Modification Measures

Future Development	Applicable to Burrill?	Comments
Zonings to restrict development in critical areas	✓	In particular, certain types of development are considered more suited to development within the floodplain, including developments that contain the elderly or infirm, or developments that are critical to the provision of emergency services.
Time-dependent zoning, for SLR for example, property removal on expiry	✓	Would need to consider triggers for response (e.g. sea level rise gets to *x* cm, or inundation frequency exceeds *x* times per year).
Development / building controls requiring flood-smart design and structural integrity	✓	Controls could require other mechanisms for minimising flood-related damages, especially in relation to building materials, electrics etc.
Property fill	✓	Limited amounts of fill could be used to help raise future

		development, providing that the development is not located within floodway or flood storage areas.
Adaptive construction - allow for future modifications	✓	Involves construction that will allow for future changes relatively easily in order to better adapt to changing flood conditions (eg progressive raising in response to SLR).

6.1.3 Summary of Potential Response Modification Measures

These measures are designed to reduce the potential risks to life and property by modifying the overall response of individuals before, during and after a flood event. These are presented in Table 6-6, Table 6-7 and Table 6-8, respectively. It is considered that all response modification measures are equally applicable to all flooding mechanisms.

Table 6-6 Pre-Flood Response Modification Measures

Before a Flood	Applicable to Burrill?	Comments
General education to understand flood risks the community is living with	✓	Key messages regarding what to do and what not to do if caught in a flood
Targeted education (property or neighbourhood specific) to understand specific risks to individuals	✓	Key messages regarding how to manage risks to life and risks to property at an individual property basis, including closest evacuation centres, where roads would likely be flooded, and measures that can be implemented to be better prepared.
Periodic updates given new residents and new data (including new events)	✓	As new residents move into communities and as complacency sets in on longer term residents, education is required on a periodic basis – constant updating and renewal.
Local flood plans and pre-planned evacuation arrangements	✓	Evacuation centres and emergency responses need to be set-up at very short notice, so pre-planning is required. Evacuation centres need to be flood free, and potentially cater for large numbers of affected people.
Disclosing information and sharing knowledge beyond experience (readily available, eg on internet)	✓	Available via S149 certificates, publicly available flood studies and flood plans. Property-scale flood information should be available via the internet.
Raising access roads to facilitate evacuation and extend effective flood warning times	✓	Raising of roads such as Thistleton Drive and Balmoral Road to allow for safe evacuation of residents within this area. At present the road becomes inundated relatively early in a flood.

Table 6-7 During-Flood Response Modification Measures

During a Flood	Applicable to Burrill?	Comments
Improved flood warning system, based on integrated rainfall and river level gauging, and real-time radar	✓	A total flood warning system can buy extra time for appropriate flood response, if the information can get to the community in time. The system needs to be locally specific and not generic. A system is very acceptable to the community, but can lead to a false sense of security.

Automated voice and text messaging for notification of flood warnings	✓	One possible method of disseminating flood warning information. Multiple methods would be required.
Multi-media bulletins for notification of flood warnings	✓	Urgency of disseminating flood warnings is critical to providing the community with as much preparation time as possible. This should extend to all radio and TV channels, not just local ABC.
Social media channels, such as twitter and facebook	✓	Much of the flood information that was distributed and accessed during the 2011 floods across Queensland, NSW, Victoria and WA was via social media (facebook, twitter) and internet sites. Emergency services set up direct feeds to these channels with latest updates and information. Community were able to supplement the information with first hand knowledge (thus making sure the information was as current as possible).
flood markers indicating problem areas	✓	Flood markers indicate flood depths – historical and design possible flood events,

Table 6-8 Post-Flood Response Modification Measures

After a Flood	Applicable to Burrill?	Comments
Inter-agency co-operation and arrangements and recovery plans	✓	Post-flood recovery co-ordination between agencies is required to outline roles and responsibilities, especially as community starts seeking out support and assistance.
Financial assistance	✓	Assistance is provided through various schemes state and federal schemes – subject to conditions
Charity assistance	✓	Assistance provided by charity organisations (food, clothes, shelter, basic needs)

6.2 Options Assessment

Based on the initial coarse assessment there are a number of flood modification, property modification and response modification measures that are further considered for implementation at Burrill Lake. The following sections detail the further assessment of these options.

6.2.1 Flood Modification

Four broad flood modification approaches are detailed:

- Levee protection to existing flood affected development;
- Permanent entrance opening (e.g. breakwater) ;
- Entrance channel dredging; and
- Artificial entrance opening.

6.2.1.1 Levee or Flood Wall

Description

Levees are built to exclude potentially inundated areas of the foreshore from flooding up to a prescribed design event level. Provided the integrity of the levee can be assured, levees are very effective in providing direct protection of property to flood inundation to the levee design height. Structural failure of the levee, or overtopping of the levee from a flood event larger than the design standard, can result in rapid inundation of areas behind the levee. This can in fact provide a greater flood hazard to both people and property.

Different types of levee construction are available, e.g. earthen levee, flood wall arrangement. In terms of their function for floodwater exclusion they perform the same way. However, there is considerable variation in construction costs, land area requirements, visual impact and impact on foreshore access.

Design

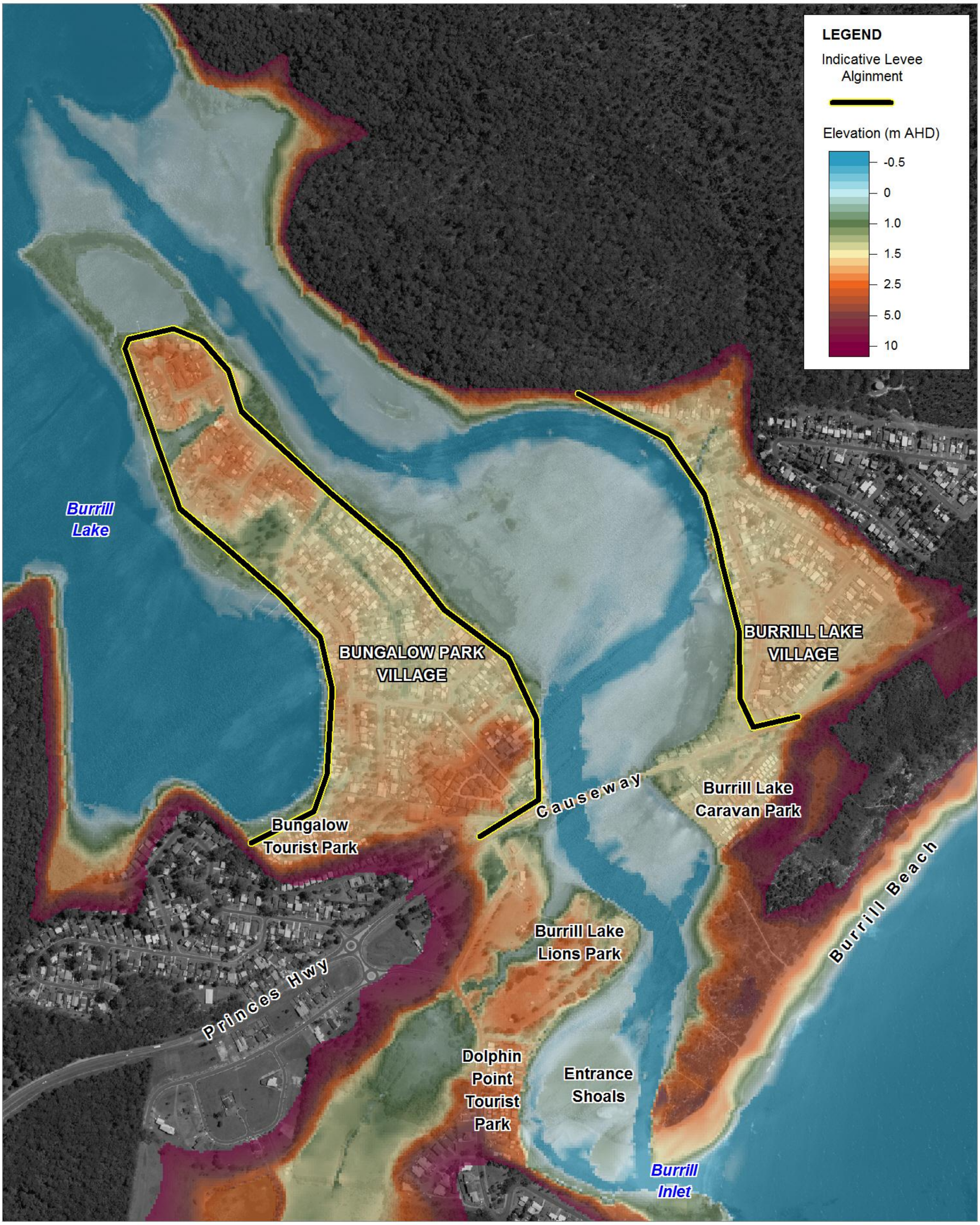
Any levee alignment will be required to tie into existing high ground to ensure no bypass of the levee system by floodwater. Two levee alignments have considered for Burrill Lake, one protecting properties in Bungalow Village on the southern side of the entrance channel, and a second levee protecting property in Burrill Lake Village on the northern side. The indicative levee alignments and protected areas are shown in Figure 6-1.

The number of existing properties within the nominal levee protection zones that have been identified at risk of above floor flooding summarised in Table 6-9.

Table 6-9 Existing Properties at Risk in Levee Protection Zones

Design Event	Bungalow Park	Burrill Lake Village
20% AEP (1 in 5)	14	15
5% AEP (1 in 20)	71	66
1% AEP (1 in 100)	169	131

The planning, design and construction effort and cost involved in implementing a levee protection system is a substantial investment. In order to maximise the benefit of this investment in terms of reducing flood risk, it is assumed a minimum levee design standard would be at the existing 1% AEP flood level plus an appropriate freeboard allowance (say 0.5m). This would require the construction of the levee to a height of around 3m AHD.



Title:

Potential Levee Alignments

Figure: **6-1**

Rev: **A**

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_028_120329_Levee_Alignmnet.WOR

The existing level of the foreshore around the indicative levee alignment is of the order of 1.0 to1.5m AHD. Accordingly, a levee constructed to 3m AHD provides for a marked change to the foreshore landscape. An earthen levee construction typically would have a minimum 1 to 2m top width (greater if vehicular access was required) and sloping side batters (e.g. 1:4 vertical: horizontal). Just the space therefore required to construct an earthen levee represents a substantial footprint and land take area. Given in some places the limited width of public space on the foreshore, current private land would be required to construct the levee. The footprint for a wall type construction would be considerably less, but may still require some private land take.

Local drainage behind levees is an important consideration in the design. Flood gates allow local run-off to be drained from areas behind the levee when water levels in the Lake/channel is low and prevent floodwaters from entering under elevated water level conditions. Pumps may also be used to remove local runoff behind levees when flood gates are closed.

Performance

Assuming the integrity of the levee is sustained, the levee would be effective in eliminating flood damage to protected properties for events up to the nominal design height. Based on the number of properties protected (refer Table 6-9) the reduction in property flood damages afforded by the levee system in summarised in Table 6-10. The damages calculations assume flood protection up the existing 1% AEP + 0.5m level.

Table 6-10 Reduction in Flood Damages for Levee Option

Design Event	Reduction in Damage Cost ($M)
20% AEP (1 in 5)	$1.1
10% AEP (1 in 10)	$2.6
5% AEP (1 in 20)	$6.7
2% AEP (1 in 50)	$14.7
1% AEP (1 in 100)	$18.7

Whilst the levee option is effective for addressing current at risk property, the impacts of potential sea level rise would provide for a diminishing level of protection over time. Considering the 0.4m and 0.9m sea level rise allowances for the years 2050 and 2100 respectively, the frequency of overtopping of the levee (if maintained at original height) would increase.

The existing 1% AEP flood level represents a future 2050 flood condition equivalent to an approximate 2% AEP (1 in 50) flood event. Similarly, the current 1% AEP flood level would be surpassed by an event representing a magnitude of around a 20% AEP (1 in 5) event for projected 2100 conditions. It must also be recognised that sea level rise would continue beyond 2100 providing for further reductions in flood immunity over time.

Levees are not a failsafe management option in terms of eliminating inundation from protected areas, noting potential failure or overtopping by a larger event. The available storage volume in the area protected behind the levee is small relative to the overall flood volumes being conveyed through the Lake system and would be expected to fill quickly once overtopping occurs.

Economic Viability

Levees represent a substantial capital cost. The estimated cost of an earthen levee construction of the Bungalow Park option (approximately 2.7km in length) represents a cost of the order of $4M. The estimated capital cost for the Burrill Lake Village levee option (approximately 0.9km in length) is of the order of $1.5M. A levee system also requires regular inspections for erosion/failure and maintenance for vegetated banks.

Substantial additional capital cost would be added through acquisition of property to construct the levee. There is little buffer between the property boundaries and the foreshore/waterway for many of the Lake front properties. The alignments shown Figure 6-1 are adjacent to some 140 properties. Dependent on the alignment and construction technique, acquisition of part or full property would be required. The cost of acquisition would likely be in excess of the levee construction cost.

With reference to the reductions in flood damages afforded by the levee system (under existing flood conditions), the benefit-cost comparison would indicate some feasibility to the levee construction. With sea-level rise however, there would be a diminishing return as average annual damages increase.

Pros and Cons

A summary of the expected pros and cons relating to the concept proposed is provided as Table 6-11. These issues would need to be investigated to quantify their impact, as part of a detailed design and environmental impact assessment.

Table 6-11 Pros and Cons for Burrill Lake Levee Concept

Pros	Cons
Effective protection to a large number of properties	High Cost
Relatively low maintenance costs	Low to medium benefit cost ratio
	Visually obtrusive
	Impact on public access to foreshore
	Creates problem for local drainage behind levee require pumps/tidal gates
	Can create false sense of security - potential for levee to be overtopped or possible failure

6.2.1.2 Permanent Entrance Opening

Description

The basic objectives of a permanent entrance opening for Burrill Lake in terms of flood management is the elimination of low-level flooding as a result of entrance closure, and the increase in conveyance of catchment floods out through the entrance.

A significant rock shelf exists to the south of the entrance, below Dolphin Point. A gutter through this rock shelf facilitates some tidal exchange (albeit limited), even when a barrier extends all of the way across the entrance. The entrance at Burrill Lake tends towards closure during periods with relatively low rainfall and high wave activity.

The construction of breakwaters is a potential option to achieve a stable entrance.

Design

The entrance is somewhat protected from ocean waves, with Dolphin Point providing some protection from the dominant south to south easterly incoming waves which prevail along the New South Wales coast. Entrance training works would need to guard against the influx of sand from the beach to the north. However, the presence of the rock platform to the south, and the apparent minimal bypassing of sand around Dolphin Point, means that a southern training wall is probably not required.

A preliminary conceptual design has been developed for a breakwater configuration for Burrill Lake as shown in Figure 6-2. The derivation has involved the use of simplified methods (e.g. Escoffier analyses for dredged channel shape, Hudson's equation for stone sizing). The purpose of the concept is to provide an appreciation of the scale and capital cost of works that would be required to achieve a stable entrance.

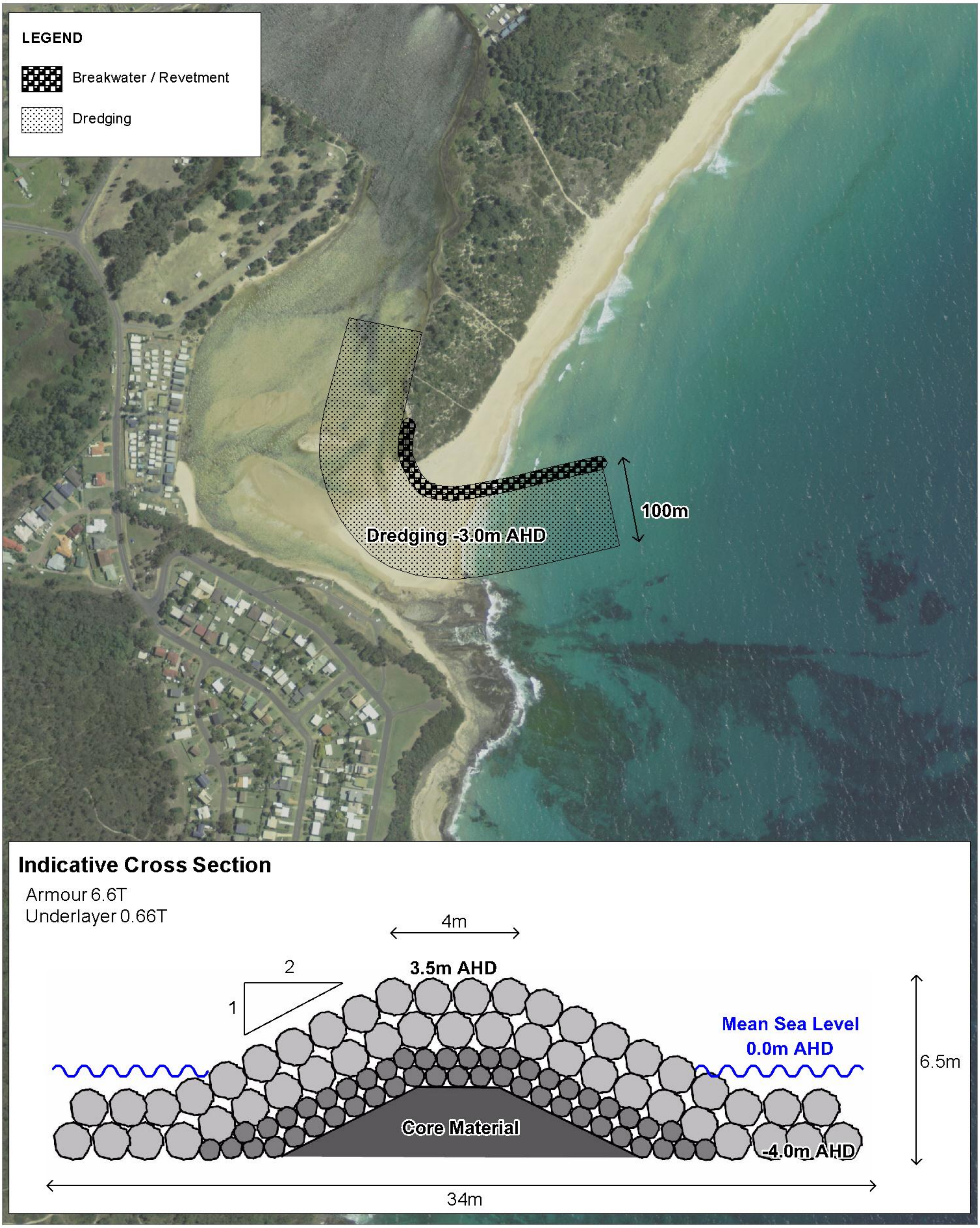
A more detailed assessment could result in refinements that either reduce or increase the scale and costs significantly. For example, rock is likely to be present underneath the area where works are indicated, and this would greatly increase the cost of construction, or may require a revised design. The design life of the structure was considered to extend to 2050, after which the structure may need modification or replacement.

It is estimated that the end of any training breakwaters would need to extend beyond the -3.0 m contour. Accordingly this provides for significant length of breakwater/revetments of around 230m. The scale of this structure is similar to other open coast environments. Figure 6-2 includes an inset photograph of the entrance at Bermagui, being of a similar configuration to the Burrill Lake entrance.

Performance

The perceived flooding benefits of an open entrance are elimination of the low-level persistent flooding occurring as a result of entrance closure and a reduction in catchment flood levels through better flood conveyance through the entrance. Enlarging of the entrance channel however will provide for greater penetration of ocean water into the estuary under normal tides and storm surge (ocean flooding) conditions.

The flood models have been used to assess the potential change in flooding behaviour with the construction of an open entrance. Both catchment flooding and ocean flooding scenarios were simulated. A comparison of the change in peak flood level from a typically shoaled entrance to an open breakwater entrance for both catchment and ocean flooding scenarios is shown in Table 6-12. The levels reference the location of the existing gauge in Burrill Lake (upstream of the Causeway).



Title:

Burrill Lake: Trained Entrance Concept

Figure: 6-2

Rev: A

N

0 125 250m

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_029_120329_Burrill_Breakwater.WOR

Table 6-12 Change in Peak Flood Level (m) with Breakwater Option

Event Conditions	Planning Horizon		
	Existing	2050	2100
5% AEP Catchment Event	-0.16	-0.18	-0.34
5% AEP Ocean Event	-0.5	-0.5	-0.7
1% AEP Catchment Event	-0.15	-0.18	-0.34
1% AEP Ocean Event	-0.5	-0.6	-0.8

The results in Table 6-12 show that only modest reductions in peak catchment flood levels are achieved with a large open entrance. The reductions are relatively small given the presence of other controls within the entrance channel which limit how much flow can be conveyed through the channel. Of particular note is the natural "pinch-point" in the entrance channel opposite the Burrill Lake Lions Park. Accordingly, irrespective of the entrance size, the control of this narrower width section of the inlet channel still has an influence on peak flood levels.

Conversely, for ocean flood conditions, the open entrance provides for larger decreases in peak flood level. These reductions are attributable to the reduction in wave set-up at the entrance. For trained entrances that have a wide and deep entrance channel, wave set-up as a result of waves breaking at the coastline is significantly lower than for small or closed channels. This offsets the increased flow of ocean water into the inlet channel and Lake system through the wider entrance.

Generally a reduction in flood levels is achieved with a large trained entrance. With the catchment flooding condition being the dominant flooding mechanism, the relatively small change in peak flood levels still means that a significant number of existing properties would be subject to inundation. Accordingly, the trained entrance option does not eliminate the flood risk. Flood levels, and hence flood damages, will also continue to increase with sea level as it may eventuate irrespective of the entrance condition.

Economic Viability

The orders of cost for construction of a breakwater of this nature at Burrill Lake are $10M. Given the relatively minor changes in flood levels and hence potential changes in flood damages, the breakwater option is considered economically unviable from a floodplain risk management perspective alone.

Pros and Cons

A summary of the expected pros and cons relating to the breakwater concept proposed is provided as Table 6-13. These issues would need to be investigated to quantify their impact, as part of a detailed design and environmental impact assessment.

Table 6-13 Pros and Cons for Burrill Lake Breakwater Concept

Pros	Cons
Reduction in ongoing entrance management effort and costs	Very Costly;
Enhanced tidal flushing and potential improvements to water quality	Forced alignment may affect the efficiency of extreme floods. Could exacerbate flooding from the most extreme events;
Reduction in nuisance flooding prior to managed opening, during times when the entrance would have otherwise closed	May increase inundation during extreme surge events;
Reductions in peak flood levels, most notably for ocean driven events	Increased tidal transmission may increase nuisance flooding due to normal astronomical (e.g. King) tides;
	Loss of north-south access across the entrance
	Reduced safety for swimming / boating / kayaking
	Will alter tidal characteristics related to wader habitat inside the entrance of the Lake
	Uncertainty regarding the presence, or otherwise of rock at the entrance.
	Entrance still exposed to SE swell. This means that safe navigation would not be certain (a southern training wall would be required to provide more consistent, safe navigation, if this were an objective
	may require construction of an internal wave trap, to minimise exposure of internal shoreline to erosion

6.2.2 Property Modification

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

6.2.2.1 Voluntary House Purchase

The primary objective of voluntary house purchase (VHP) is to reduce risks to personal safety by purchasing houses located in areas subject to excessive hazard. A VHP scheme is generally applicable only to areas where flood mitigation is impractical and the existing flood risk is unacceptable. Such measures can only be undertaken on a voluntary basis with the property owner. Post-purchase the property should be rezoned for flood compatible use.

Properties which may be suitable for VHP have the highest hydraulic hazard in the study area. The following potential criteria were compared for identifying high risk properties. These were based on hydraulic criteria in the 1% AEP event for properties with above floor flooding.

Table 6-14 Assessment of Properties Numbers for VHP

Potential Criteria	No. Of Properties
High hydraulic hazard	32
Floodways (vxd > 0.3m/s)	0

Depth of flooding is the principal characteristic defining the high hazard status for the identified properties, with a depth of flooding in excess of 1m. A VHP scheme based on this criteria for Burrill Lake would be cost-prohibitive. Alternative flood modification options such as house raising would be considered more appropriate.

This option however may be more practical when considering future flooding conditions with sea level rise impacts, with land and buildings affected by normal tidal inundation or frequent flooding. Protection measures for these properties may be expensive to build and maintain (e.g. levees) and have high environmental impacts. In this situation VHP schemes may be more attractive. Property purchases at this stage are not considered necessary, and possibly may not be required for a considerable time in the future. Nevertheless, such schemes should be included in planning for future management of sea level rise impacts in vulnerable areas such as Bungalow Park and Burrill Lake.

6.2.2.2 Voluntary House Raising

Voluntary house raising is aimed at reducing the flood damage to houses by raising the habitable floor level of individual buildings above an acceptable design standard (e.g. 1% AEP Flood Level +0.5m). Voluntary house raising generally only provides a benefit in terms of reduced economic damages but does not eliminate the risk. Larger floods than the design flood (used to establish minimum floor level) will still provide building damages and the option does not address personal safety aspects. These risks are still present as the property and surrounds are subject to inundation and therefore the flood access and emergency response opportunity is still compromised.

House raising does have limited application in that it is not suited to all building types. Typically house raising is suited to most non-brick (e.g. clad, timbered framed houses) single story houses constructed on piers and not for slab on ground construction. An indicative cost to raise a house is of the order of $70,000 which can vary considerably depending on the type and size of the structure. Eligibility criteria for house raising schemes vary around the country but funding is available for house raising in NSW and has been widely applied.

As an alternative to direct house raising, subsidies schemes have also been made available to re-building. For many properties, the opportunity to rebuild may be more attractive than raising the existing dwelling. Fairfield City Council, which arguably operates the largest house raising scheme in the country, has a subsidy scheme for residential property owners with houses with floor levels which are low enough to qualify. They can then choose to invest this subsidy into physically raising the house or into demolishing and rebuilding the house at a higher floor level.

Potential eligible properties for such a scheme in Burrill Lake are identified based on above floor flooding over a range of flood event magnitudes as summarised in Table 6-15. Properties number have been restricted to timber framed houses on piers (not slab on ground) as identified from the property survey.

Table 6-15 Potential Properties for House Raising

Design Event	No of properties
10% AEP (1 in 10)	61
5% AEP (1 in 20)	119
1% AEP (1 in 100)	217

For the purposes of evaluating the economic viability of such a scheme, it was assumed that eligible houses would have their floor levels raised to 0.5m above the 1% AEP flood level and a mean property raising price would be $70,000.

Prioritising houses flooded at the existing 10% AEP flood level would account for 61 properties at a cost of some $4.4M. Considering the reduction in flood damages, the scheme would have a benefit cost ratio of 3.2 making it economically worthwhile. If the scheme was extended to houses flooded at the 1% AEP flood level, then approximately 217 houses would qualify at a cost of $15.2M with a benefit cost ratio of about 1.3

Notwithstanding, it must be recognised that:

- not all timber framed, clad homes are structurally suitable for raising;
- it changes the appearance of a house;
- may create difficulties in accessing public utility services; and
- those with mobility restrictions may not be able to easily access the house.

The broader impacts of house raising should not be overlooked, as it will potentially change the visual character of a house and possibly the street / suburb.

Such a scheme would only be possible if funding was able to be attracted from State and Federal Government programs. As the majority of houses suitable for house raising are located on the lowest parts of the Burrill Lake floodplain, the long term viability and management of these suburbs should first be addressed given the potential threat associated with future sea level rise. That is, there would be little value in raising these houses if after 40 years or so these locations either become unliveable, are unable to be readily serviced by public utility and infrastructure (e.g. roads, drainage, water supply) for the life of the asset or are subject to broadscale acquisition and redevelopment.

6.2.2.3 Flood Resistance / Flood-proofing

Of particular interest to building owners (and insurers) is making changes to building materials to reduce damages during flood. This would include for example replacing composite timber kitchen cupboards with solid timber cupboard, replacing carpet with floor tiles, replacing plasterboard wall lining with fibrous cement etc. These changes can often be done during building renovations, and at a relatively marginal additional cost.

6.2.2.4 Flood Planning Controls

The existing Development Control Plan 106 provides a suite of planning controls for new development as discussed in Section 5.2.2. Specific elements of this DCP and how it impacts on Burrill Lake are discussed hereunder, with some recommendations for modifications or additional controls.

Flood Planning Levels

Climate change effects are expected to influence flood levels gradually over time. Flood levels based on predicted climate conditions in 2100 will be reached gradually. The application of FPLs expected to be reached at 2100 is considered excessive for development of existing urban areas due to practicalities of raising land and buildings on a property by property basis if and when redevelopment occurs. The application of FPLs based on current climate conditions is also considered inappropriate in light of existing Government Policy, the broadly accepted climate change science and indeed the potential impacts imposed by the sea level threat.

Council's current FPLs for existing developed areas detailed in DCP 106 provides for inclusion of 0.4m sea level rise allowance consistent with the NSW Government sea level rise planning benchmark of 0.4m by 2050. A graded set of FPLs are in place dependent on the nature of the development and the appropriate flood risk classification of the floodplain.

The 100 year flood level (plus freeboard) has been retained as the principal floor level control for residential land uses in the study area. This is an important component of the proposed planning controls. The decision was based on a consideration of:

- the unacceptable increase in flood risks and damages, should a lower level be adopted;
- an unacceptable impost on future development, if a higher level was adopted;
- inconsistencies with recent development approvals if a level different from the 100 year flood was adopted;
- recognition that the community views the residential floor level control as the principal component of the Council floodplain controls, and that changes to this control should not be made unless very strong arguments exist.

Minor development at existing property, e.g. small renovations with limited scale in relation to existing floor space, is encouraged to be constructed at the full 1% AEP flood planning level. However, the current policy provides opportunity for floor levels to be at existing habitable floor levels.

The imposition of elevated floor levels will mostly be realised in Burrill Lake in association with redevelopment of existing property. Redevelopment will be sporadic and be undertaken over many years. It will be some time before the existing flood risk is reduced significantly through redevelopment of property. The magnitude of the existing problem is evident in Table 6-16 showing the distribution of existing floor levels on a suburb by suburb basis. A representative flood planning level taken as the 1% AEP flood level incorporating 0.4m sea level rise and 0.5m freeboard is approximately 3.2m AHD.

Table 6-16 Number of Properties by Locality and Floor Level

Locality	Floor Level Range (m AHD)				
	1.0 – 1.5	1.5 – 2.0	2.0 – 2.5	2..5 – 3.0	3.0 – 3.5
Dolphin Point	0	0	0	0	0
Bungalow Park	1	22	146	99	19
Burrill Lake	1	25	120	34	3
Kings Point	0	0	1*	5	6

* - Kings Point property a two-storey dwelling, lower floor level flagged above, potentially not a habitable floor

As noted previously, most of the existing flood affected property is concentrated within Bungalow Park Village and Burrill Lake Village. The existing property at Dolphin Point is largely located on the higher ground of the headland. This is also largely the case for Kings Point, however, there are a number of lower-lying properties that are susceptible to flooding in major events, with current floor levels below the FPL incorporating the 2050 sea level rise allowances.

With approximately 400 existing properties with floor levels below current FPLs, it unlikely that a significant reduction in flood risk will be achieved through redevelopment within a reasonable timeframe (even say 20 years). Nevertheless, application of floor level controls will provide incremental improvement in the existing situation.

It is recommended Council Policy is updated to reflect the design flood level conditions determined in the current study. Further, the flood risk classification of the Burrill Lake floodplain, as mapped at the 2050 and 2100 planning horizons should be adopted in the Policy.

An “envelope” approach is used to establish FPLs throughout the study area combining the maximum peak flood levels of catchment derived flooding (assuming a closed entrance) and ocean derived flooding (assuming an open entrance).

The initial berm height assumptions have some influence on design flood conditions. The standard design flood conditions adopted for events referenced through the FRMS report have the following berm condition assumptions:

- Existing closed condition: 1.0m AHD;
- 2050 closed condition: 1.5m AHD; and
- 2100 closed condition: 2.0m AHD.

These berm heights are representative of a closed condition to a height reflective of the trigger levels for manual intervention in the current entrance management policy, with allowances for higher berm conditions under sea level rise scenarios.

Whist the Floodplain Risk Management Study recommends the continuation of the current entrance management policy in the interim; it is likely with implementation of other options in the Recommended Plan to transition away from entrance management for flood mitigation purposes. In the very least it would be anticipated that current trigger levels would be gradually raised in order to provide more effective breakouts through this transition period. Accordingly, FPLs defined for future development should include some provision for higher entrance berm conditions.

The dominant flooding mechanism in defining the peak flood levels in the lower estuary changes dependent on the adopted berm conditions. At the 2050 planning horizon, assuming berm levels are lower than approximately 1.8m AHD (below existing trigger levels) the ocean flooding condition with coincident catchment inflow is the dominant mechanism. Accordingly in setting FPLs in the lower estuary, the entrance berm condition needs to be higher than under current entrance management regimes to affect the maximum flood envelope.

In establishing catchment derived flood conditions for determination of FPLs at the 2050 planning horizon, an initial berm height of 2m AHD has been adopted. The typical difference in peak 1% AEP flood levels is 0.2m between a 1.5m AHD and 2.0m AHD initial berm height. Significantly however, the 2.0m AHD berm level condition only provides for flood levels of approximately 0.1m above the corresponding 2050 ocean flooding scenario.

Filling

Local land filling can be an effective means to eliminate or reduce the frequency of flood inundation. Typically the filling would be undertaken to provide an elevated building pad above a nominal flood level (usually the 1% AEP design flood standard). Consideration however needs to be given to the potential impacts of filling within the floodplain, including the loss of flood storage volume and redistribution of flow.

The existing controls on filling in DCP 106 provide restrictions on the amount of fill permissible within the floodplain. Council's stated objective in this regard is "to ensure that filling or excavation in the floodplain does not have a significant impact on flood behaviour, conveyance and storage capacity, as well as surrounding properties or structures and the environment in the specific area where the development is proposed".

Council's existing policy indicates an acceptable scenario as having a fill volume occupying less than 1% of the available 20%, 5% and 1% AEP flood volume, does not exceed a fill depth exceeding 1m above the natural ground level or require more than 250 cubic metres of fill material. Given existing ground levels, and depth of flooding for major design events, the fill requirements would exceed these nominal limits for most properties. The extensive depth of filling required on most properties is illustrated in Table 6-17 providing the number of properties and their respective range of existing ground levels on a suburb by suburb basis. With an indicative FPL of 3.3m AHD, some of the lowest-lying property could require up to 2m of fill depth with the majority of properties requiring in excess of 1m. Even for a minimum lot size of the order of 500m^2, fill volumes in excess of 500m^3 would be required.

Council's existing policy allows for consideration of this scale of filling, subject to preparation of an appropriate consulting engineers report to demonstrate the proposal does not adversely impact on existing flood behaviour.

Table 6-17 Number of Properties by Locality and Indicative Ground Level

Locality	Ground Level Range (m AHD)			
	1.0 – 1.5	1.5 – 2.0	2.0 – 2.5	2.5 – 3.0
Dolphin Point	0	0	0	0
Bungalow Park	22	155	82	18
Burrill Lake	25	150	10	1
Kings Point	0	0	4	6

The cumulative impacts of filling on the conveyance of floodwater is unlikely to be a problem for Burrill Lake in terms of general flood levels attained in the Lake and estuary. This is largely due to the conveyance of floodwaters being already largely restricted by the size of the entrance channel, most notably at the natural restriction adjacent to the Burrill Lake Lions Park where the channel and floodplain is at its narrowest. The proportion of lost storage from the floodplain as a result of filling is also very small in comparison to the overall Lake storage volume.

The local redistribution of floodwaters however is a significant concern. Local filling on a lot basis may result in floodwaters to be redirected and/or concentrated to neighbouring lots. There is also associated problems with local drainage through blocking of drainage paths and potential creation of low points.

Access

Given the low-lying nature of many roads and the expected depth of flooding for major events, it is unlikely that new developments will be able to demonstrate reliable access during a 1% AEP event as required in Council's existing policy. Recommendations for a road raising program within Burrill Lake are discussed further in Section 6.2.3.3, which would be expected to increase the opportunity for effective evacuation via established road connections.

Flood Evacuation Plan

A flood emergency response and evacuation plan should be mandatory for all new development. Such plans would be required to demonstrate understanding of flood warning, emergency response procedures and effective evacuation routes. Given the limited potential to reduce flood inundation through structural works, planning controls and improved emergency management procedures are key to floodplain management in Burrill Lake. Continued occupation of the floodplain will be reliant on such procedures to help reduce flood risks.

6.2.3 Response Modification

Given the extensive area of existing development within flood prone land, it may be necessary to evacuate a large number of residents (from parts of Bungalow Park, Burrill Lake and a number of tourist parks) from their homes in a major flood. The nature of flooding is such that warning times can be short. The amount of time available for evacuation is largely dependent on the available warning time. Adequate warning time can give residents the opportunity to move property above the reach of floodwaters and to evacuate from the area to higher ground.

A lack of warning time means that there is only a limited amount of assistance that can be provided during the event. In reality, most people would be largely self-reliant during a flood. Agencies can, however, help people make more appropriate decisions during these floods through giving as much warning as possible (via an integrated flood warning system), and through flood emergency planning provisions. Education and flood preparedness before the event would also greatly improve the resilience of the community to flooding.

6.2.3.1 Flood Warning System

The flood warning system commences with the issue of Flood Watches and Flood Warnings from the Bureau of Meteorology (BoM) and concludes with the public receiving a detailed message about flood risk and required action.

At present, the only warnings available for Burrill Lake are generic, and automatically generated by the Bureau of Meteorology in response to severe weather warnings. Water levels are monitored at the water level gauge just upstream of the Causeway. Being located right at the downstream end of the system, the use of real-time water level data at the gauge to issue flood warnings provides for little effective warning and response time. Furthermore, the time from the onset of rain to the point at which floodwaters become hazardous can be a matter of hours in some locations, particularly in the more extreme events. This means that any realistic warnings would need to be disseminated to a large number of people very rapidly.

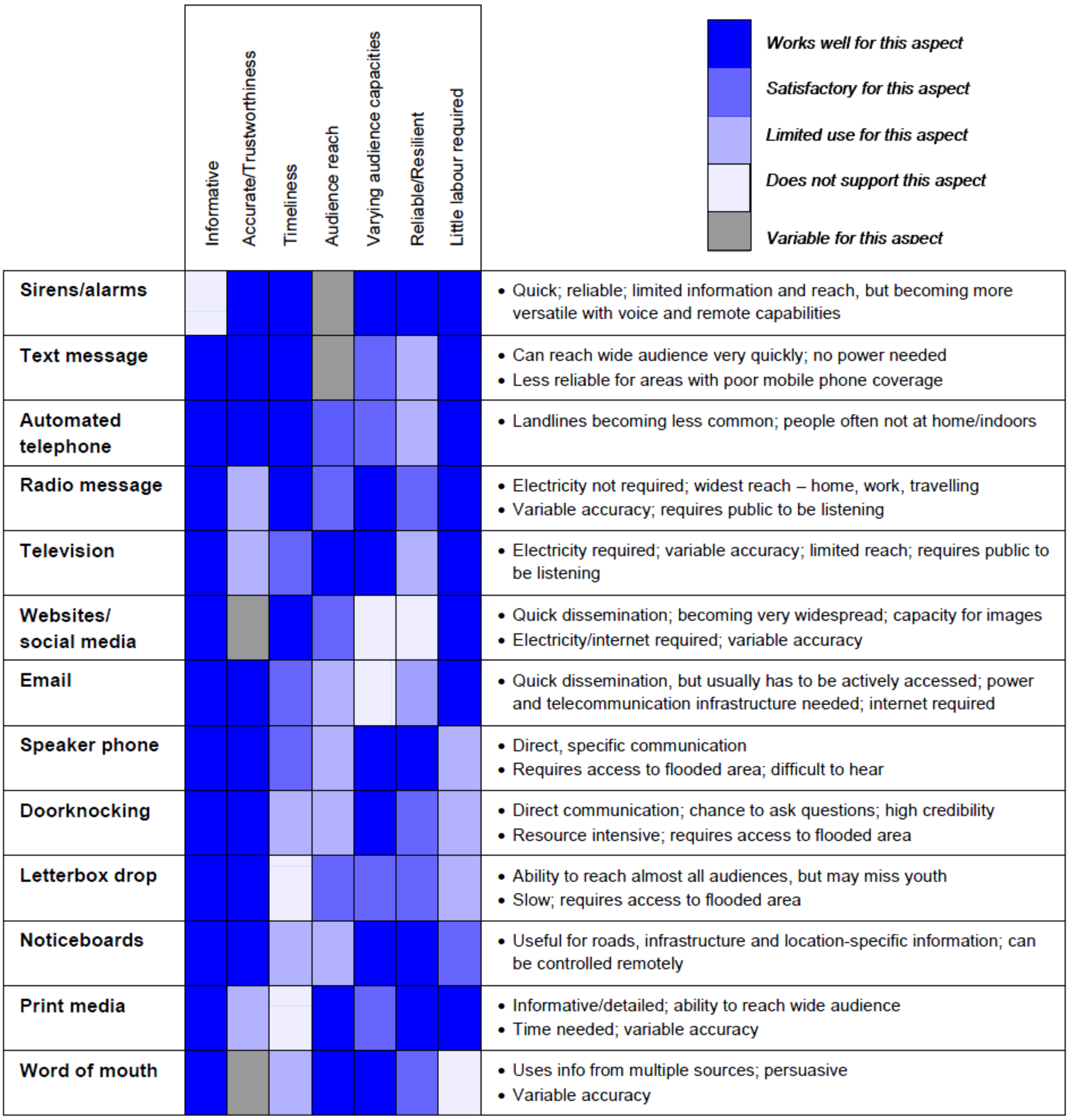
The main improvement that could be made to the existing system is the forecast of levels at Burrill Lake based on combinations of real-time and forecast rainfall. Additional telemetered gauges for Stony Creek, the principal tributary upstream of Burrill Lake, should also be considered in further developing a warning system capability for the catchment.

Method of Flood Warning

Flood warnings to residents can be issued by a variety of measures, from automated messaging to door knocking. A comparison of various warning methods is provided in Figure 6-3.

In recent riverine floods the NSW SES has used the new national telephone warning system Emergency Alert to issue flood warnings and evacuation orders in addition to traditional methods such as media broadcasts, internet postings and door knocking. During floods in NSW, Victoria and Queensland in 2011, social media emerged as a significant flood warning dissemination tool. The use of social media to enhance other warning dissemination channels should be considered further for Burrill Lake.

It is also recommended that the SES review and update their response plans based on the outcomes of this study, e.g. to include risk-based prioritisation of resources and plans to manage the warning process, where there are likely to be insufficient resources to achieve the most efficient rate of evacuation.



Office of the Queensland Chief Scientist, 2011

Figure 6-3 Comparison of Flood Warning Communication Methods

6.2.3.2 Flood Emergency Planning

The Shoalhaven Local Flood Plan (LFP) outlines preparedness and management operations for all flooding events within the Shoalhaven local government area, including Burrill Lake. Information contained in the LFP is largely derived via local knowledge, historical record and completed flood studies.

A range of information and data is incorporated to inform the evacuation planning process, including:

- Demographic data;
- Major evacuation routes;

- Location of evacuation centres;
- Relevant historical flood information;
- Gauge levels associated with road closures (where known);
- Vulnerable centres, such as schools, nursing homes and caravan parks; and
- Descriptions of local flood behaviour (e.g. speed of flood onset between villages, potential sources of flooding, etc).

The SES follows the LFP, using information from Flood Intelligence and BoM's predictions, to respond in actual flood events. Local flood intelligence needs to be updated with the flood level data derived from the current flood study and linked to the property databases established.

Much of the existing property inundation data is limited to property floor levels below 2m AHD which is some level below the estimated 1% AEP flood level. Larger events up to the PMF must also be considered as it is these events where risk to life is exacerbated.

The Local Flood Plan should be updated to provide design flood data for the full range of events considered in the Flood Study and Floodplain Risk management Study (20% AEP up to the PMF). The property inundation database established in the current study will also be provided to the SES to enable an update of then priority property for local flood response.

For rapid onset of flooding in Burrill Lake, it would not be realistic to expect the SES to be able to undertake much in the way of emergency response for several reasons:

- The SES is principally a volunteer organisation and the time required to mobilise personnel could exceed the warning time available;
- A major flood event in Burrill Lake is likely to coincide to major flooding in other catchments within the Shoalhaven Region further stretching already limited emergency response resources;
- Many of the principal roads within the region are cut early in major floods making access difficult for mobilising or responding; and
- There is generally insufficient time to undertake tasks such as sandbagging or evacuation to reduce impacts on property or people.

In some floods for Burrill Lake, the SES's role in flooding may be limited to executing rescues and assisting with recovery after the event.

That is not to say that the flood warning system or the SES Flood Emergency Plan will not in some measure mitigate the impacts of flooding. What it does mean is that they cannot be relied upon alone to provide an appropriate level of protection, particularly the protection of lives. In the rapid onset of a flood, individuals and groups of people must essentially take appropriate actions to protect themselves.

Occupants of premises within the flood prone areas should be encouraged to have private flood emergency response plans which have evacuation as the preferred initial response if that is practical. Should evacuation not be possible before floodwaters cut off evacuation routes then remaining in the building should be the alternative. While the NSW SES does not encourage people to stay inside flooding buildings, it acknowledges that a number of circumstances can prevent evacuation in some situations, and once trapped in a building, it is generally safer to stay inside than to exit into high hazard floodwaters.

The concept of a "Community Flood Emergency Response Plan" should be explored. The Plan would provide information regarding evacuation routes, refuge areas, what to do/not to do during a flood event etc. If such a plan is developed and embraced at a community level, the self-sufficiency in terms of flood response of what is a relatively concentrated community at Burrill Lake would maximise potential for effective emergency response and a non-reliance on formal emergency services. Council and the SES would be expected to have a key role in developing the CFERP for the vulnerable areas of Burrill Lake.

6.2.3.3 Evacuation Access

The availability of appropriate access to or from affected areas during times of flooding is important to ensure:

- people have the chance to evacuate themselves and valuables/belongings before becoming inundated or trapped by raising floodwaters,
- emergency services (SES, ambulance, police, etc.) are not restricted or exposed to unnecessary hazards in carrying out their duties,
- areas are not isolated for extended periods of time, preventing people from going about their normal routines or business or restricting access to essential services.

One of the principal concerns within the study area is low-level of roads within Bungalow Park Village. Many of the roads including Thistleton Drive, Rackham Crescent, Balmoral Road have low points between 1.1 and 1.4m AHD, with event the remainder of roads typically around 1.5 to 1.8m AHD. Accordingly, these roads would be subject to inundation even for relatively small flood events. For major events such as the 1% AEP event, depths of inundation at the peak of the flood are in excess of 1m. For such events, parts of these roads may become impassable well before the flood peak thereby limiting flood access and potentially isolating a significant number of residents.

A recommendation in the Flood Plan will be investigation of local road raising to provide an appropriate flood access route. The Thistleton Drive – Balmoral Road route alignment represents the most effective route for road raising. It is likely to be impractical to raise this route to provide flood free access up to the 1 % AEP considering potential constraints on access to existing properties, local drainage and other buried services. The road should be constructed as high as practical which would need to be determined through a detailed local design assessment. One key design criteria however, will be to provide a constantly upward grading road the northern end of the peninsula through to the intersection of the Princes Highway.

In Burrill Lake Village, Kendall Crescent and MacDonald Parade have low points at the crossing of the local Coopers Creek, with road levels as low as 1m AHD. These low points are right at the limit of the existing development with access to approximately 20 properties affected. Nevertheless, removal of this local low point would improve flood access.

6.2.3.4 Flood Awareness

It is recognised that there are a number of flood-related messages which need to be conveyed to the public as part of a flood awareness program. These messages, along with the type of information which should be used to convey the message is provided in Table 6-18 below.

Table 6-18 Flood Awareness Messages

Message	Information
General flood information	Floods can cause damage to property and endanger human life, different types and sizes of floods
General flood preparedness advice	What to do to prepare for a flood
You live in a flood prone area	Floods can occur in your area (and may have in the past)
Location specific flood information	Type of flooding in the area, Burrill Lake gauge (and relation to floor / ground level), likely speed of onset, historical flood level, residual risk (e.g. behind levees)
Location specific evacuation information	Evacuation routes and centres, where to find evacuation information (radio stations, road closure websites)
Details on flood management schemes / initiatives	What has been completed and planned, how initiatives manage flooding, timeframes for implementation etc

The conveyance of these messages can be through a range of formats; it will be necessary to select the best format for the message and the targeted audience. Possible formats include:

- Informative flyer with utility bill / rates notice (can be general or targeted to flooding in specific areas);
- Briefings at social and civic clubs, e.g. Rotary, Lions;
- Expert panels (flooding, emergency and planning experts);
- Newspaper feature story on general flooding issues or historical (flood commemorations);
- Information booth at community festivals, shows etc;
- Information repository at libraries, Council office etc;
- Newspaper insert (fact-sheet style);
- Flood information website;
- Signposting of evacuation routes;
- Noticeboards in public areas to signpost floodways, structures etc;
- School projects on floods and floodplain management;
- Historical flood markers;
- Flood certificates; and
- Email newsletters.

The community consultation program undertaken in development of the Flood Plan, and previously during the Flood Study, have initiated dialogue with the community in respect to flood risk as an initial step in increasing flood awareness.

Through the questionnaire response provided, the general awareness of potential flood risk in the community was relatively low, particularly in relation to the scale of potential flooding and property inundation. It is imperative that the initial progress made through the development of the Flood Plan is built upon.

An ongoing flood awareness program should be pursued through collaboration of the SES and Council (e.g. FloodSafe program specific for Burrill Lake). The aim of this program would be to:

- Increase community awareness of flood risk;
- Increase community understanding of what to do before / during / after floods; and
- Increase awareness of SES role and other agencies.

Further planned strategies to pursue may include media releases, SES community education training, additional brochures targeting sectors of the community, flood risk workshops with community groups, tourist park owners, and businesses.

6.3 Strategic Planning

The potential for climate change impacts increasing flood risk in the future presents immediate challenges for floodplain management in Burrill Lake. Many of the floodplain management options in addressing flood risk to existing property are dependent on the long-term viability of continued occupation of the floodplain in these areas.

Through ongoing approval of development in flood risk areas identified in Burrill Lake and investment (public and private) in flood protection measures there is the inherent assumption that development in these areas has a viable future.

However, under sea level rise scenarios, the continued habitation and redevelopment of parts of the Burrill Lake floodplain will become increasingly difficult to sustain. With increasing flood risk, the provision and maintenance of services and infrastructure become increasingly expensive or impractical.

Burrill Lake has a significant amount of low-lying development subject to significant existing flood risk as discussed in this report. Various management options have been identified which aim to provide for an acceptable level of flood risk to support existing development. However, the potential for permanent inundation, increased flooding, and foreshore recession as a result of rising Lake levels in response to sea level rise may make some land unsuitable for redevelopment or future development.

The extent of the problem is illustrated in Figure 6-4. At some time in the future with sea level rise, the majority of the existing areas of Bungalow Park Village and Burrill Lake Village will be subject to permanent inundation from normal Lake levels. Even before permanent inundation however, the increased frequency of flooding and high groundwater levels will become an issue. It is expected that under a sea level rise of about 0.4 metres, roads, structures and even ground vegetation would start to become detrimentally impacted by high groundwater levels, while a sea level rise of 0.9 metres would lead to deep inundation within many streets and yards on a frequent basis. Even under existing conditions, low-level persistent flooding presents problems to the community, noting the current entrance management trigger level of between 1.0 and 1.2m AHD.

In the longer term, it is expected that a strategic plan will be required to decide if the low-lying areas affected frequent inundation should be *abandoned* or *adapted*. With some streets currently at a level of about 1m AHD, these areas will become unlivable with a sea level rise of a 0.5 metre or so (i.e. the street level would be the same level as mean Lake level, while groundwater level would likely be at the surface, making the areas permanently wet.

The continued occupation of currently affected land in Burrill Lake would require raising of existing ground level through extensive land filling to combat the risk of rising lake levels and associated inundation and groundwater problems. If adaptation of existing developed areas cannot be achieved in an economically, socially and environmentally acceptable manner, then a planned retreat of current occupied flood prone land may be appropriate land use strategy.

6.3.1 Adapting Existing Areas

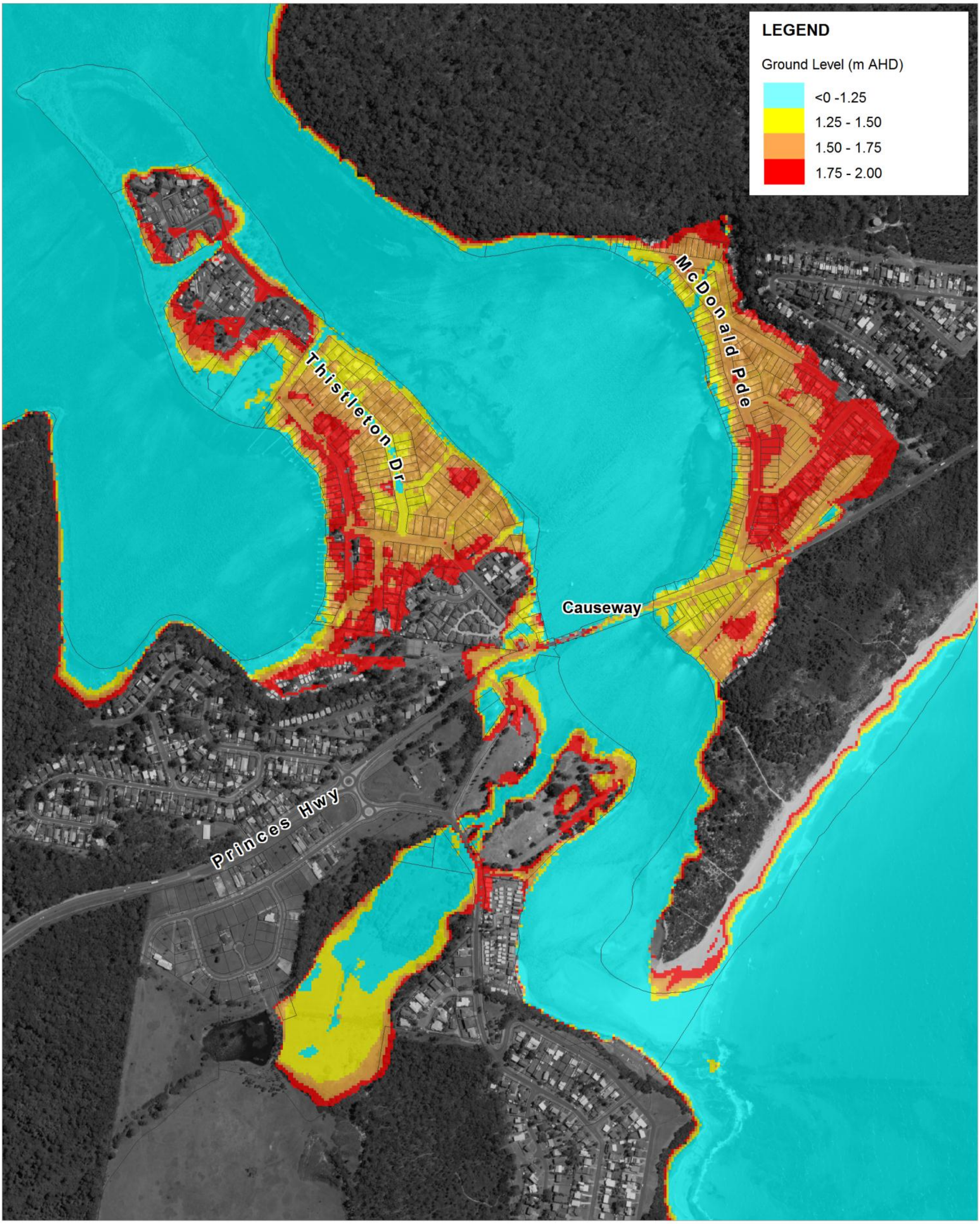
The flood risk management options already discussed such as levee protection, house raising, flood planning levels etc. considered future flooding conditions under sea level rise scenarios. However, previous discussion was not provided on potential impact of permanent inundation. For example, low-lying areas located behind levees will be subject to increased groundwater levels, broadly commensurate with sea level rise. Thus, for areas that are already low lying, the construction of a levee for protection from sea inundation will be futile, as the inundation will literally come up through the ground.

Similarly, whilst house raising options to raise habitable floor levels above a nominal design standard (such as the 1% AEP event) provide for appropriate flood protection to the property in terms of above floor flooding, the issue of frequent inundation at ground level and high groundwater tables isn't addressed. Indeed, the very structural stability of a property is potentially at risk given the impact of high groundwater levels on foundation integrity.

Extensive filling of the floodplain in these low-lying areas would be required to combat the problems associated with rising Lake levels. Filling can only be done when redevelopment takes place. This presents two potential scenarios 1) incremental filling of the floodplain on a property by property basis, and 2) broadscale redevelopment. Some of the issues for consideration with these options are provided below.

Incremental Filling

This response involves a planned incremental filling of private land and roads and redevelopment of property with higher floor levels. Filling can only be done when redevelopment takes place. One of the challenges in the first instance is the setting of appropriate fill levels. Given the uncertainty of sea level predictions and timeframes involved, design flood levels won't remain fixed as in a static climate, but rather progressively increase over time. Accordingly a degree of flexibility may be built in to flood planning levels.



Title:

Progressive Inundation of Burrill Lake with Sea Level Rise (Existing Ground Surface)

Figure: 6-4

Rev: A

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_021_110720_Burrill_Sea_Level_Rise_inundation.WOR

Considering the design life of property, say 50 to 70 years, there is limited opportunity to readily adapt fill levels. Progressive filling of a lot over time is obviously not practical, as such fill levels at redevelopment need to accommodate the future flood planning levels.

Considering the changes to design 1% AEP flood levels at the 2050 and 2100 planning horizons, flood planning levels incorporating 0.5m freeboard may be expected to be of the order of 3.0 – 3.5 m AHD. As noted typical ground levels vary in the affected areas, but are as low as 1m AHD and typically less than 2.0m AHD. Accordingly, raising of lot levels would typically require an extensive volume of fill and at a significant expense to property owners.

Filling of property can be effective in reducing or eliminating flood inundation. The incremental filling of land on a property by property basis however presents complex engineering challenges and practical issues of implementation. Some of these issues are discussed briefly below.

- Loss of foreshore – filling to existing lot boundaries on properties adjacent to the public space foreshore areas of Burrill Lake will ultimately provide for a complete loss of the foreshore environment with sea level rise. Unless public foreshore areas are also raised, rising Lake water levels will eventually reach the boundaries of filled private land providing a hard edge between private property and the Lake waterbody. With private property boundaries right at the water edge, public access to the waterway would be limited as would the opportunity for public foreshore infrastructure such as boat ramps, picnic tables and chairs etc.

- Environmental impacts – the loss of foreshore may have significant environmental impacts. Shallow foreshore areas are important for a range of terrestrial and aquatic flora and fauna and creating a hard edge at the waterway provides no space for ecological communities to migrate in response to rising Lake levels.

- Access to infrastructure and services – land filling options will only work if there is a corresponding adaptation of roads, stormwater drainage, water supply, sewerage, communications and other public and utility infrastructure. The piecemeal approach to land filling via redevelopment of individual properties provides issues with connectivity to these services.

- Boundary continuity – given the depth of fill involved in the land filling options, retaining wall type structures would be required at property boundaries, or sufficiently graded batters to ensure stability. The retaining wall approach would provide a 1.5. -2.0m high walled property boundary providing significant discontinuity to a neighbouring “unfilled” lot. An appropriately graded batter slope would involve a significant loss of developable area on the lot, particularly if employed around all four sides of a typical rectangular lot shape.

- Local drainage – incremental filling will provide for considerable discontinuity in the local land surface which may cause issues for local drainage. Impediment to local overland drainage, creation of sag points and interference to existing subsurface drainage systems are potential impacts.

- Concentration of floodwaters – in times of flood, filled lots would provide for a complete obstruction to flood flows which may result in a redirection and concentration of floodwater on unfilled lots. This impact can considerably increase the flood risk on affected lots through increased velocity of floodwater. In extreme cases, higher velocities may provide for structural damage of properties.

- Overshadowing – the required fill heights and subsequent reconstruction of suitable dwellings is likely to provide significant overshadowing of "unfilled" neighbouring property.
- Visual impact (suburb character) – ultimately when entire areas are redeveloped, the general character of the area may be improved. However the piecemeal approach of incremental redevelopment would have a marked impact on the landscape in the interim period with a random mix of existing and redeveloped property at significantly different levels.

Filling lot by lot is only expected to work if there is a commitment to raise roads and other infrastructure and utilities. The option would come at a significant public and private cost. The staging of the redevelopment presents the most challenges and would require community support.

Broad Scale Redevelopment

Broadscale redevelopment would effectively provide for the same end result as the incremental filling discussed above, but undertaken in a coordinated approach to provide a planned redevelopment in a short time frame.

Boadscale filling would involve (compulsory) acquisition of hundreds of properties, plus finding a suitable source of fill material (volume of fill required would be about 0.5 - 1 million cubic metres). Clearly the costs of this plan would be enormous, but depending on the final developable land options, the plan could still be economically viable (subject to available up front financing).

The biggest challenges with this option are the community acceptance, economic feasibility and political will to implement.

Whilst the challenges of incremental filling would be addressed, the broadscale redevelopment option would still provide for the net loss in foreshore environment and associated environmental impacts.

6.3.2 Planned Retreat

With the prospect of permanent inundation, increased (unmanaged) flooding and foreshore recession with rising Lake level conditions, the continued occupation of flood prone land may be unviable if the costs to adapt these vulnerable areas are too high or if the risks remain acceptable. The planned retreat may be one of the few policy options available to Council to address long term risk within parts of the Burrill Lake community.

Planned retreat policies have been adopted by a number of Council's in addressing coastal recession risk where active erosion is likely to result is loss of developable area directly to the sea. The impacts of progressive sea level rise on permanent inundation and flooding risk are perhaps more subtle with a perception of less dynamic and catastrophic impact.

There are potentially a number of Land Use Transition Strategies to provide for a planned retreat from existing developed areas of Burrill Lake.

- Restrict Further Development – Future development may be actively limited in affected areas through rezoning and development controls. This would assume the progressive abandonment of properties as they become inhabitable in their current form. There are substantial economic costs to individuals associated with diminishing property values and regional costs over time.

- Voluntary purchase – a purchase scheme could be established to provide a funding mechanism for active property purchase. With potentially some 400+ properties involved would come at significant cost for which funding opportunity may be limited. A number of social problems would be encountered with many residents unwilling to sell, inability to find alternate accommodation with similar attributes, diminishing property value over time.

- Compulsory acquisition – as with voluntary purchase, compulsory acquisition would come at a significant social and economic cost, with potentially limited funding opportunities and significant community acceptance challenges.

- Land Swap – a successful land swap strategy was recently implemented in Grantham in the Lockyer Valley following the devastating floods of January 2011 in Queensland. The opportunity to re-locate whole suburbs is dependent on the availability of suitable land. To some degree this is limited in Burrill Lake with limited privately held developable land available. The successful Grantham land swap worked only after tragic first-hand experience of major flooding. Community acceptance for such a scheme in Burrill Lake may be low. Achieving a “like for like” swap is almost impossible.

These measures would see a gradual removal of existing development from the floodplain to remove existing and future flood risks. The interim period would see significant social disruption and would come at a major economic cost.

The planned retreat option is not without limitations in terms of addressing flood risk. The limitations imposed on development and the futility in major investment in flood protection measures provides for an interim period where existing flood risks are not likely to be effectively addressed.

The discussion above only provides a cursory overview of potential land use transition strategies and potential impacts. These are very complex issues with considerable social implications requiring extensive consultation with the community and detailed supporting investigations of social, economic and environmental issues. Depending on the rate at which sea level rise impacts manifest, implementation of adaptation plans may not be necessary for some years. Whilst such a decision does not need to be made immediately, Council should be preparing for such an ultimatum in the near future (within the next 10 years or so, or as the realities of sea level rise start to manifest). Nevertheless, appropriate planning should be commenced immediately to provide sufficient time to develop site specific adaptation plans and develop funding models. Further, Council should be considerate of these long term objectives in setting zonings and building controls for new development proposed in these areas.

7 RECOMMENDED FLOOD MANAGEMENT STRATEGY

7.1 Overview

The primary objective of the Floodplain Risk Management Study is to identify, assess and compare a range of potential risk management options and strategies to address existing and future flood risk in Burrill Lake. The outcomes of the study provide the basis for the Floodplain Risk Management Plan, containing an appropriate mix of management measures and strategies, to help direct and coordinate the responsibilities of Government and the community in undertaking immediate and future flood management works and initiatives.

Fundamental to establishment of the Plan is the understanding of flooding behaviour in the catchment and the potential risks to people and property within flood prone land. Given the extensive area of relatively low-lying land currently developed in Burrill Lake and the nature of flooding in the catchment, **existing flood risk is high** with significant potential for wide-scale property inundation and damages and risks to life.

Existing flood risks generally represents the legacy of past development, wherein roads, services and buildings were sited and constructed within flood liable lands. Management of existing development in Burrill Lake is difficult given the potential frequency of inundation and numbers of properties potentially affected.

Climate change and sea level rise is expected to have a significant impact on flooding within Burrill Lake. The NSW Government's adopted values for future sea level rise have been incorporated into Council's Flood Models. Typical Lake level conditions are expected to increase in line with sea-level rise providing for higher mean water level and higher tide levels. The sea level rise allowances also provide for impact on flooding regimes, both catchment derived and ocean derived flooding, increasing peak flood levels by similar orders of magnitude. Overall the frequency and severity of flooding is expected to increase across the catchment.

Current FPLs for the flood-prone land in Burrill Lake incorporate a sea level rise projection of 0.4 metres. It is considered, however, that if sea level rose by 0.4 metres, parts of these low lying suburbs would actually be uninhabitable, as groundwater would be permanently at surface level, making the areas permanently swampy. Indeed this situation is likely to occur for some properties with a sea level rise of less than 0.4 metres (i.e. within about 40 years based on government sea level rise projections). It is for this reason that this Flood Plan recommends the development of a *Strategic Position* on either abandoning or rescuing these low-lying suburbs within a timeframe of about 50 years.

This is a complex planning issue which goes far beyond floodplain management alone. Whilst permanent inundation and flooding may be the driver, there is far reaching social, economic and environmental implications to consider. For Council, this scenario is not isolated to Burrill Lake, and other existing low-lying communities will be subject to the same considerations. This only enhances the requirement for undertaking appropriate assessments and establishing a strategic position for such development across the LGA.

Given this ultimatum position and the associated timeframe/trigger for impacts, it would seem unreasonable to impose FPLs or embark on extensive flood mitigation works within these suburbs at levels based on a sea level rise that cannot be accommodated. It is recommended that further consideration be given to the longer term management of these low lying areas, including interim measures for development, or indeed moratoriums on development if more radical alternatives are to be pursued in the future.

Ongoing flood risk management at Burrill Lake is a complex issue and require a number of further studies to establish a position for appropriate future land use. Unfortunately in this regard, the recommended floodplain management plan has shortcomings in identifying appropriate measures for managing future risk.

Nevertheless, there is a requirement in the interim period to deal with the existing flood risk and minimise the potential for hurt and damage to existing residents and property.

Assessment of a range of major structural works such as levees and breakwaters have indicated poor economic viability given the considerable capital costs compared to limited value in reduction of potential flood damages. Indeed, the viability of these types of measures is further reduced if future land filling options are pursued.

Accordingly the recommended Flood Plan for Burrill Lake is heavily focused on improvements to flood warning and emergency response. An extensive community awareness program is the centre piece of the Plan, and it is recommended that significant financial investment be made in community education

7.2 Option Assessment

A simple assessment of the relative merit of identified floodplain management actions has been undertaken. The aim of the rapid analysis is to provide a straightforward overview of the various actions applicable at Burrill Lake, presenting quickly and clearly to community the benefits and trade-offs of a particular action, to assist in the prioritising and ordering of works within the immediate, medium and longer terms.

The criteria applied in the assessment are summarised below.

Performance

The performance criterion considers how well the action would actually address the risks it is specifically targeting. The performance criterion also factors whether the action provides a long term solution, or is just a short term fix.

The criterion for Performance is based on a scale from high to low, where high performance represents effectiveness of the action in addressing flood risks, and low performance represents low performance or uncertainty in the outcomes.

Practicality

The practicality criterion considers how easy and practical the action will be to implement. If the action can be considered standard process for Council or other agencies with minimal delays and hurdles, then the practicality would be high. If there are some barriers or delays to the option being implemented, then the practicality would be lower. With reducing practicality, it is expected that the effort (and costs) required to implement the action would increase.

Community Acceptance

The community acceptance criterion aims to reflect the general support for the action by the community as a whole. It is recognised that some actions may have a small section of the community that is most affected (e.g. landholders subject to voluntary purchase or house raising), however, it is the expected opinions of community at large should be captured by this criterion.

Costs / Resource Needs

Floodplain Risk Management actions can be inherently costly, especially when dealing with engineered works or property modifications. Planning controls are the exception to this, although these can still require significant effort from Council and others.

The Costs / Resource Needs criterion represents a rating wherein a High Rating reflects the lowest costs, while a Low Rating reflects the highest costs. This has been adopted for consistency with the other criteria.

These criteria have been built into a simple colour-coded matrix to assess how each measure performs.

Table 7-1 Rapid Analysis (Traffic Light Assessment) Criteria

	Performance	Practicality	Community Acceptability	Costs / Resources
LOW (STOP / reassess)	Action is not particularly effective over the short or longer terms	Acton would be difficult to implement through existing constraints, approvals required etc. Would be very demanding to successfully implement.	Unlikely to be acceptable to the majority of the community and politically unpalatable. Significant championing required by Council and State.	Very Expensive (more than $1,000,000) and/or very high (unmanageable) resource demands on authorities
MEDIUM (SLOW)	Action provides only a short-term fix, or is only partly effective over the long term	Action would have some hurdles for implementation, which may take longer and demand more effort to overcome.	Would be palatable to some, not to others. Community education required	Moderately expensive (e.g. $100,000 - $1,000,000) and/or high resource demands on authorities
HIGH (GO)	Action provides an effective long term solution to the risks identified	Action is straightforward to implement with few barriers or uncertainties.	Is very politically palatable, acceptable to community. Minimal education required	Manageable costs (< $100,000) and manageable resource demands on authorities

A summary of the options assessment is provided in Table 7-2.

Table 7-2 Rapid Assessment of Flood Risk Management Options Considered

Options Considered	Recommended	Performance	Practicality	Community Acceptance	Costs / Resources	Comment
Flood Modification						
• Continue to apply Current Entrance Management Policy	YES	MED	HIGH	MED	HIGH	Provides for effective management of low-level persistent flooding. Limited benefit for major flood mitigation.
• Construction of levee to protect existing property	NO	MED	MED	LOW	LOW	High cost option providing direct benefit in reducing flood inundation. Substantial residual risks. Restricts public foreshore access
• Construction of breakwater for permanent entrance opening	NO	LOW	LOW	HIGH	LOW	Very high cost with limited overall flood reduction benefits. Low economic viability. Community would perceive benefit in permanent lake flushing
• Dredging of entrance channel	NO	MED	LOW	HIGH	LOW	Only a short term benefit due to likely ingress of further sediment. Only small impact in reducing major flooding.
• Raising of Local Roads for Improved Flood Access	YES	HIGH	HIGH	HIGH	MED	Provision of higher standard of flood free access and evacuation routes through road raising. Local drainage and other services may require modification.
Property Modification						
• Revision of FPLs, triggered when climate change impacts start to manifest	YES	MED	MED	MED	HIGH	Current FPL's set at predicted 2050 levels (include 0.4m sea level rise allowance). Suitable as interim measure subject to review.
• Voluntary purchase of existing properties in high hazard areas	NO	HIGH	LOW	LOW	LOW	High cost per property and should be restricted to highest hazard zones. No suitable properties identified.

Options Considered	Recommended	Performance	Practicality	Community Acceptance	Costs / Resources	Comment
• Voluntary house raising	YES	MED	HIGH	MED	MED	Investigate house raising for properties affected by frequent flooding, and pursue if determined to be appropriate. High total cost and funding model needs to be established.
• Flood proofing.	YES	MED	HIGH	HIGH	HIGH	Encourage redevelopment and building renovations with more flood resilient materials and design. Doesn't remove flood risk.
• Land Filling	NO	MED	LOW	LOW	MED	Can raise property above design flood level. Multiple engineering problems and difficulties with uncontrolled incremental filling.
Response Modification						
• Provide improved flood warning for Burrill Lake	YES	HIGH	MED	HIGH	HIGH	Effective flood warning imperative to enable appropriate emergency response. Benefit from new and emerging means of mass communication of flood warnings.
• Provide flood forecasting for Burrill Lake	YES	HIGH	MED	HIGH	MED	Extension of BoM flood warnings to include forecasting of flood levels at Burrill Lake.
• Update and implement SES Flood Emergency Plan	YES	HIGH	HIGH	HIGH	HIGH	Update of Local Flood Plan and procedures with enhanced flood intelligence data derived from the study
• Undertake extensive community education and awareness program	YES	HIGH	HIGH	HIGH	LOW	It is critical that the community knows how to self-respond to an actual flood without assistance from combat agencies such as SES.
Other Management Measures						
• Undertake appropriate technical, social and economic investigations to develop a Strategic Position that will decide	YES	HIGH	MED	HIGH	LOW	Detailed, multi-faceted investigations required to establish long term viability of land subject to future

Options Considered	Recommended	Performance	Practicality	Community Acceptance	Costs / Resources	Comment
between abandoning or rescuing low-lying areas / suburbs in the long-term (within a 50 yr horizon)						permanent inundation. Outcomes have direct impact on direction for floodplain management.
• Investigate alternative building forms	YES	MED	MED	MED	HIGH	Investigate appropriate construction methods/designs suitable for future adaptation to help guide redevelopment
• Undertake review of the provision and maintenance of infrastructure and services	YES	LOW	MED	HIGH	MED	Asset life, access to services and adaptation strategies need to be established for each public infrastructure and utility service.
• Investigate changes to entrance management procedures	YES	MED	HIGH	LOW	HIGH	Review of trigger levels and entrance opening procedures required considering potential sea level rise impacts. Community education necessary.

7.3 Recommended Actions

The following provides a brief overview of those management measures considered to be suitable for implementation to address flooding issues in the main affected areas of Burrill Lake.

7.3.1 Flood Modification Measures

Continued Implementation of Entrance Management Policy

The current policy provides effective management for low-level flooding during periods of entrance closure. Current trigger levels are set to protect some of the lowest property along the foreshore. The relatively low trigger levels do however impact on the effectiveness of the breakout. Breakouts at higher trigger levels will increase the level and scour and may lead to more successful intervention in terms of reducing the opportunity for rapid re-closure of the entrance.

Continued opening at current trigger levels will not be possible with potential sea level rise and will require adaptation of existing infrastructure to accommodate an expected increase in low-level flooding severity and frequency. Ongoing adaptation of existing infrastructure implemented through other measures in the recommended Plan will gradually reduce the requirement of entrance opening for flood management purposes.

In transitioning away from the current entrance management policy of manual breakouts at relatively low trigger levels, future entrance management should consider the maintenance of a “dry notch” to maintain a maximum berm saddle height. The maintenance of a dry notch provides some control on the entrance breakout location and at a level to limit flood risk. This level may reflect the maximum berm height conditions used to establish Flood Planning Levels.

Continued implementation of the existing policy is therefore recommended as an interim measure. As the requirement for the current policy for flood management purposes is negated through implementation of other measures in this Plan, future revisions of the Policy and the Floodplain Risk Management Plan will consider alternatives such as maintenance of a dry notch.

Road Raising to Provide Improved Flood Access

Current road levels in parts of Bungalow Park Village and Burrill Lake Village that are principal evacuation routes are currently some of the first areas to be inundated during flood events. Generally the levels of existing roads are very low such that even in minor flood events access is cut. For major flood events where evacuation of residents is critical, depths of flooding at the peak of the event exceed 1m depth.

Raising key access routes above a nominal design flood standard is flagged as a high priority. Roads to be prioritised include Thistleton Drive, Balmoral Road, Kendall Crescent and MacDonald Parade. The road raising program could be expanded to include all roads in flood affected zones subject to available budgets.

7.3.2 Property Modification Measures

Review of Flood Planning Levels (FPLs)

It is recommended Council Policy is updated to reflect the determination of design flood level conditions determined in the current study as discussed in Section 6.2.2.4. Further, the flood risk classification of the Burrill Lake floodplain, as mapped at the 2050 and 2100 planning horizons should be adopted in the Policy.

Investigation of Voluntary House Raising Program

A voluntary house raising scheme would not commence until it is known whether there will be a funding mechanism available to raise buildings from high hazard areas. Investigations should commence with confirming which properties would be offered voluntary house raising, through more detailed property analysis. Given the high costs associated with house raising, and the limited State Government funding (to date), it is expected that the scheme would take many years or decades to implement fully. Also, being voluntary schemes there is the need for the co-operation of property owners, which may further delay implementation and completion of the schemes.

Encourage redevelopment and renovations with more flood resilient materials and design

In response to the devastating floods in Queensland, NSW, Victoria and WA in early 2011, which affected more than 28,000 properties, the Australian Building Codes are being modified to make greater provision for flood resilience. While the specifics of any changes to the code will likely be directed by the outcomes of the Queensland Floods Commission of Inquiry (and may take several years thereafter to work their way into adopted Building Codes), Council can still encourage landholders who plan to undertake new developments or renovations to existing buildings to use materials that are more compassionate to flooding.

Property owners would be expected to undertake works at their own convenience. A public awareness campaign may help to inform the community of flood proofing measures, and could be supplemented with individual building inspections and property owner interviews. Encouragement to be more flood-resilient can be linked to the recommended Community Education Program.

7.3.3 Response Modification Measures

Improved Flood Warning System

When integrated with community education, the development of a complete Flood Warning System for Burrill Lake forms the cornerstone of this Floodplain Risk Management Plan. With improved warning of an approaching flood, the community will hopefully be able to respond in a more responsible and appropriate manner. Clearly the earlier the warnings are given then the more time communities have to respond.

There are many new and emerging means of mass communication of flood warnings. ‘Emergency Alert’ is a telephone-based warning system developed following the 2009 Victorian bushfires, and is under consideration for use in other emergencies, such as flooding. Although research suggests that Emergency Alert only reaches about 60% of intended recipients, such personalized warnings would hopefully have a much greater and targeted response compared to current generic (and usually conservative) flood broadcasts (especially flash flood broadcasts).

It is expected that mobile phone-based SMS warnings could also be developed for registered message recipients. Recently in Japan, millions of people received SMS tsunami alerts on their mobile phones almost immediately after the formal warning was issued. Social media channels such as facebook and twitter have also been used over the last couple of years to supplement traditional methods of dissemination for flood and other emergency information.

Clearly there is a key role here for the Bureau of Meteorology. This would include integrating with the existing flood detection equipment (rainfall and water level gauges), and providing warnings on the basis of data collected locally (including other regional telemetered gauges, as well as short and long ranging radar – noting that Sydney and Wollongong have now been upgraded to high resolution Doppler radars).

Provide Flood Level Predictions for Burrill Lake

Whilst there is continuous water level gauge at Burrill Lake (just upstream of the causeway), there is currently no flood forecasting for water levels in flood conditions.. This Plan recommends that Bureau of Meteorology extends its flood warning to include forecasting of flood levels at the Burrill Lake gauge. This would provide a local reference for the Burrill community as well as the SES to gauge the imminent flood risk, and respond accordingly.

Update and implement as required the SES Flood Emergency Plan

It is important that the SES Plan incorporates all relevant technical data and specific community vulnerabilities (including addresses of areas at highest risk) that have been determined through the Floodplain Risk Management process. Provision of this data is particularly important with regard to those parts of Burrill Lake that need to evacuate ahead of ocean or catchment flooding cutting off their evacuation routes.

The development of a Community Flood Emergency Response Plan specific for Burrill Lake should be considered.

Undertake community education

Community education is being given the highest priority in this Floodplain Risk Management Plan for several reasons:

- Education is required to build a flood-resilient community who is prepared for flooding and able to respond to and recover from actual flooding. The Burrill Lake community have had limited flood experience across the full range of flood frequencies and flood types but are particularly vulnerable;
- This Plan is underpinned by the concept of shared responsibility where government, business, community groups and individuals all have a role to play in building resilience, preparedness, response and recovery. Community education will be important in helping people understand the risks and how they can be managed and equipping themselves to fulfil their role;
- Without community education, other elements of the plan such as flood warning, evacuation planning, personal response plans, road warning signage, rezoning, development control, voluntary purchase schemes, voluntary house raising schemes, flood refuges and flood proofing would be less effective;

- Because of their dependence on technology and human action, flood warnings and emergency response cannot be considered as failsafe, particularly in the flash flood catchments, so it is critical that the community knows how to self-respond to an actual flood without assistance from combat agencies such as SES or Police.
- It will take time for many elements of the plan to be implemented, particularly those that will gradually remove development from the most hazardous parts of the floodplain. In the interim, community flood response will be the only effective way to manage risks to life and property in these areas;
- Even if all other elements of the plan are fully implemented, there will still be a residual or continuing risk that needs to be managed by appropriate community flood responses; and
- There are few planning or administrative barriers that would delay the development and implementation of a community education plan. Education and flood awareness should be a key role for combat agencies such as the SES. Community-specific education is also required to maximise effectiveness, and as such, Council has a key supporting role to play in assisting SES with the technical elements of flood characteristics of Burrill lake.

7.3.4 Other Management Measures

- Undertake appropriate studies to establish strategic position in regards to land at risk from permanent inundation and identify appropriate land use transition strategies
- Investigate alternative building forms to provide housing stock more adaptable to climate change. Can include a review of the suitability of slab on ground construction in foreshore areas.
- Undertake a detailed review of the provision and maintenance of services and infrastructure with consideration of future climate change scenarios (responsibility of Council, Shoalhaven Water and other services providers) ;
- Investigate changes to current entrance management practices with a view to raising current trigger levels to provide for more effective manual breakouts.

PART B – FLOODPLAIN RISK MANAGEMENT PLAN

8 BURRILL LAKE FLOODPLAIN RISK MANAGEMENT PLAN

8.1 Introduction

The Burrill Lake Floodplain Risk Management Plan (FRM Plan) has been developed to direct and co-ordinate the future management of flood prone lands beside Burrill Lake. The FRM Plan sets out a strategy of actions and initiatives that are to be pursued by agencies and the community in order to adequately address the risks posed by flooding. Development of the FRM Plan has been guided by the NSW Government's Floodplain Development Manual (2005).

The FRM Plan covers the Burrill Lake floodplains incorporating the main urban developments of Dolphin Point, Burrill Lake, Bungalow Park and Kings Point. Emphasis is placed on the flood prone parts of the villages around the Burrill Inlet.

The outcomes of the Study provide the basis for this FRM Plan, containing an appropriate mix of management measures and strategies, to help direct and coordinate the responsibilities of Government and the community in undertaking immediate and future flood management works and initiatives.

Completion of the study and ultimately adoption of the recommended FRM Plan represents a major step in ongoing floodplain risk management in Burrill Lake with a number of positive outcomes including:

- that a number of options have been identified and recommended that would alleviate the impacts of a flood on the community at Burrill Lake;
- once adopted the FRM Plan will open the doors to funding for council and property owners to implement a number of actions such as flood warning, voluntary house raising, etc.;
- the recommended actions will inform council's capital works program;
- the FRM Plan recommends further investigations that will require active community involvement and engagement; and
- there are no recommended actions that will impose any modifications to existing dwellings at risks.

8.2 Recommended Measures

The Floodplain Risk Management Study identified and assessed a range of risk management measures which would help mitigate flooding to reduce existing and future flood damages. Each of the measures was assessed with consideration of:

- Performance in reducing flood risk;
- Impact on flood behaviour;
- Economic costs;
- Environmental issues;

- Community acceptance / social impacts; and
- Legal, funding and land tenure constraints.

With due consideration of these constraints, as well as discussions with the Far South Natural Resource and Floodplain Management Committee and community consultation, suitable risk management measures have been selected and recommended for implementation as part of this plan. A number of the other measures were considered but deemed unsuitable for implementation due to a combination of hydraulic, environmental, economic and social issues. Summary sheets of the key options considered are provided in Appendix D. The recommended measures are summarised below.

8.2.1 Community Education Program

Raising and maintaining flood awareness will provide the community with an appreciation of the flood problem and what can be expected during flood events.

An ongoing flood awareness program should be pursued through collaboration of the SES and Council (e.g. FloodSafe program specific for Burrill Lake). The aim of this program would be to:

- Increase community awareness of flood risk;
- Increase community understanding of what to do before / during / after floods; and
- Increase awareness of SES role and other agencies.

Further planned strategies to pursue may include media releases, SES community education training, additional brochures targeting sectors of the community, flood risk workshops with community groups, tourist park owners, and businesses.

Action: Develop and implement an ongoing flood education and awareness program

8.2.2 Flood Prediction Capability

At present, the only warnings available for Burrill Lake are generic, and automatically generated by the Bureau of Meteorology in response to severe weather warnings. Water levels are monitored at the water level gauge in the entrance channel. Being located towards the downstream end of the system, the use of real-time water level data at the gauge to issue flood warnings provides for little effective warning and response time.

This Plan recommends that Bureau of Meteorology extends its flood warning to include forecasting of flood levels at the Burrill Lake gauge. This would provide a local reference for the Burrill Lake community as well as the SES to gauge the imminent flood risk, and respond accordingly. The main improvement that could be made to the existing system is the forecast of levels at Burrill Lake based on combinations of real-time and forecast rainfall. Additional telemetered gauges for Stony Creek, the principal tributary upstream of Burrill Lake, should also be considered in further developing a warning system capability for the catchment.

Action: Develop flood prediction capability with cooperation of Council, BoM and SES

8.2.3 Improved Flood Warning

An accurate, prompt warning system ensures that residents are given the best opportunity to remove their possessions and themselves from the dangers of floodwaters. The ultimate success of flood warning and emergency planning is closely linked to the effectiveness of issued warnings and the level of flood awareness throughout the community.

Flood warnings to residents can be issued by a variety of measures, from automated messaging to door knocking. The community would benefit from new and emerging means of mass communication of flood warnings and general improvement in access to flood information. The use of social media to enhance other warning dissemination channels should be considered further for Burrill Lake to supplement traditional methods such as media broadcasts, internet postings and door knocking.

Action: Develop and implement methods/systems for improved Flood Warning communication

8.2.4 Update Local Flood Plan

The Shoalhaven Local Flood Plan (LFP) outlines preparedness and management operations for all flooding events within the Shoalhaven local government area, including Burrill Lake. The SES follows the LFP, using information from Flood Intelligence (derived via local knowledge, historical record and completed flood studies) and BoM’s predictions, to respond in actual flood events.

The Local Flood Plan should be updated to provide design flood data for the full range of events considered in the Flood Study and Floodplain Risk Management Study (20% AEP up to the PMF). The property inundation database established in the current study will also be provided to the SES to enable an update of then priority property for local flood response.

The concept of a “Community Flood Emergency Response Plan” should be explored. The Plan would provide information regarding evacuation routes, refuge areas, what to do/not to do during a flood event etc. If such a plan is developed and embraced at a community level, the self-sufficiency in terms of flood response of what is a relatively concentrated community at Burrill Lake would maximise potential for effective emergency response and a non-reliance on formal emergency services. Council and the SES would be expected to have a key role in developing the CFERP for the vulnerable areas of Burrill Lake.

Action: Update Local Flood Plan

8.2.5 Improve Flood Evacuation Access

Investigation of raising of local roads / key access routes is recommended to provide for improved flood access. The availability of appropriate access to or from affected areas during times of flooding is important to ensure:

- people have the chance to evacuate themselves and valuables/belongings before becoming inundated or trapped by rising floodwaters,
- emergency services (SES, ambulance, police, etc.) are not restricted or exposed to unnecessary hazards in carrying out their duties,

- areas are not isolated for extended periods of time, preventing people from going about their normal routines or business or restricting access to essential services.

Action: Investigate local road raising to improve flood access

8.2.6 Continue Implementation of Entrance Management

The current entrance management policy should continue to be implemented in the short term to relieve low-level persistent flooding. Through implementation of other Plan measures such as road and house raising, this type of flood risk will eventually be eliminated from the floodplain at which point on-going entrance management for this purpose will be redundant.

Action: Continue implementation of current Entrance Management Policy

8.2.7 Investigate Voluntary House Raising Program

Investigations should be undertaken to establish if a voluntary house raising program is viable. A voluntary house raising scheme would not commence until it is known whether there will be a funding mechanism available to raise buildings from high hazard areas. Investigations should commence with confirming which properties would be offered voluntary house raising, through more detailed property analysis and consultation with owners.

Action: Undertake further investigations to establish viability of VHR scheme

8.2.8 Development Controls

Continue to apply existing generic controls in Development Control Plan 106 Amendment 1 (which are largely deemed appropriate) and update DCP with following specific controls in the study area:

- No intensification of development - no dual occupancies or sub-divisions to be permitted in high hazard flood zones which would increase potential risk to life and demands on emergency services.

- No filling – a moratorium on filling is proposed until a long term climate change adaptation strategy is established.

- Emergency plans - A flood emergency response and evacuation plan to be mandatory for all new development. Such plans would be required to demonstrate understanding of flood warning, emergency response procedures, effective evacuation routes and post-flood recovery considerations.

- Flood Planning Levels – current FPLs based on design flood levels incorporating 0.4m sea level rise (projected 2050 case) appropriate. Given susceptibility of the study area to increased flood risk associated with potential sea-level rise , and general design life of development (>50years), regular review (say 5-10yrs) of adequacy of FPLs recommended.

Action: Update Development Control Plan 106 Amendment 1

8.2.9 Flood Proofing Existing Property

Undertake program to encourage the retrofit of existing property with appropriate water resistant materials such that flood damage is minimised should the building be inundated. Property owners would be expected to undertake works at their own convenience. A public awareness campaign may help to inform the community of flood proofing measures, and could be supplemented with individual building inspections and property owner interviews. Encouragement to be more flood-resilient can be linked to the recommended Community Education Program.

Action: Provide advice/ information package for property owners on flood proofing

8.2.10 Additional Studies

The following additional studies are recommended as a priority to further develop appropriate long-term floodplain risk management strategies:

- Undertake appropriate studies to establish strategic position in regards to land at risk from permanent inundation and identify appropriate land use transition strategies
- Investigate alternative building forms to provide housing stock more adaptable to climate change. Can include a review of the suitability of slab on ground construction in foreshore areas.
- Undertake a detailed review of the provision and maintenance of services and infrastructure with consideration of future climate change scenarios (responsibility of Council, Shoalhaven Water and other services providers).

Action: Undertake studies and review FRM Plan in light of findings

8.3 Plan Implementation

The recommended measures included in the FRM Plan are summarised in Table 8-1 with details on what action need to be undertaken, responsibilities and a priority schedule.

The next steps in progressing the floodplain risk management process from this point includes:

- Public exhibition of the draft Floodplain Risk Management Study and Plan;
- Review of comments/submissions received and amendments as considered appropriate;
- Adoption by Council following recommendation from the Natural Resource Management Committee;
- Determination of program of works for responsible authorities based on overall priority, available funds and other constraints;
- Implementation of the Plan proceeds as funds become available in line with established priorities.

The recommended FRM Plan contains relatively modest financial implications for Council and other responsible authorities. This is largely as a result of no major capital works in terms of flood modification being recommended.

The timing of the implementation of recommended measures will depend on overall budgetary commitments of Council and the availability of funds from other sources. It is envisaged that the Plan would be implemented progressively over a 2 to 5 year time frame.

There are a variety of sources of potential funding that could be considered to implement the FRM Plan. These include:

i) Council funds;

ii) Section 94 contributions;

iii) State funding for flood risk management measures through the Office of Environment and Heritage;

iv) State Emergency Service, either through volunteered time or funding assistance for emergency management measures;

State funds are available to implement measures that contribute to reducing existing flood problems. Funding assistance is likely to be available on a 2:1 (State:Council) basis. Although much of the FRM Plan may be eligible for Government assistance, funding cannot be guaranteed. Government funds are allocated on an annual basis to competing projects throughout the State. Measures that receive Government funding must be of significant benefit to the community. Funding is usually available for the investigation, design and construction of flood mitigation works included in the FRM Plan.

8.4 Review of Plan

The plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change can include new flood events and experiences, legislative change, alterations in the availability of funding, or changes to local planning strategies.

The completion of the strategic planning study recommended as part of the FRM Plan to investigate the long term occupation of existing developed flood prone land will require an initial review of the adopted Plan. Following this, a thorough review every 5-10 years is recommended to ensure the ongoing relevance of the FRM Plan.

Ongoing monitoring and review of plan progress & success should be undertaken more regularly. In broad terms the review should identify:

- The strategies that have been implemented, a measure of the relative performance of implemented measures, review of the appropriateness of the strategy, and if necessary, required modifications in the FRM Plan to define a more desirable/achievable outcome.

- The strategies that are outstanding, reasons for delay in implementation if relevant, revision of the FRM to reflect alternate timeframe for implementation.

Table 8-1 Recommended Floodplain Risk Management Measures

Summary of Proposed Actions, Works and Initiatives	*Responsibility*	*Cost*	*Priority*
Education Initiatives			
Undertake community education, facilitated through a flood liaison officer	*Council, SES*	*Moderate*	*High*
Flood Prediction & Warning			
Provide water level forecasting for Burrill Lake gauge	*Council, BoM*	*Moderate*	*Medium*
Development of improved Flood Warning System for Burrill Lake (covering Catchment and Ocean Flooding), including effective broadcasting of warnings and relevant information through multimedia and social media channels	*Council, BoM, SES, OEH*	*Moderate*	*High*
Emergency Management			
Update and implement as required the SES Local Flood Plan for Burrill Lake to include catchment and ocean flood risks and issues	*SES*	*Low*	*High*
Investigate a road raising program to provide suitable emergency access routes for low-lying development at Bungalow Park and Burrill Lake Village for small to medium flood events recognising that suitable emergency routes for the highest flood events may not be achievable. Initiate discussion with the Roads and Maritime Service to upgrade the Princes Highway causeway and bridge (+Racecourse Creek near Ulladulla) to a 1% AEP or better service standard so as to facilitate emergency response operations	*Council*	*Moderate*	*High*
Property Works			
Continued implementation of Interim Entrance Management Policy to address low-level flooding issues recognising that mechanical entrance intervention may not be achievable in the long term should sea level rise manifest	*Council*	*Low*	*Medium*
Investigate Voluntary House Raising Program through prioritisation of eligible properties and establishment of funding model	*Council*	*Low*	*Medium*
Encourage redevelopment and renovations with more flood resilient materials and design	*Council*	*Low*	*Low*
Planning Controls			
Existing generic planning controls in DCP 106 Amendment 1(including Flood Planning Levels) have been confirmed appropriate with additional local controls recommended relating to no intensification of development, control on land filling, triggers for FPL review relating to climate change information and entrance management.	*Council*	*Low*	
Other Initiatives			
Undertake appropriate technical, social and economic investigations to establish a Strategic Position in that will decide between abandoning or rescuing low-lying areas/suburbs in the long-term (50-year horizon). Technical investigation to include investigation of alternative building forms review of the provision and maintenance of infrastructure and services, feasibility of a voluntary house purchase scheme.	*Council, SES, OEH, Utilities*	*High*	*High*

9 REFERENCES

Australian Rainfall and Runoff (AR&R) (1987) *A Guide to Flood Estimation*, Institution of Engineers, Australia, Barton, ACT

BMT WBM (2007) *Burrill Lake Flood Study*. Prepared for Shoalhaven City Council. BMT WBM Broadmeadow

DoP (2010). *NSW Coastal Planning Guideline: Adapting to Sea Level Rise*. NSW Department of Planning.

NSW Government (2005), *Floodplain Development Manual: the management of flood liable land.* Prepared by the Department of Infrastructure, Planning and Natural Resources (DIPNR).

NSW Government (2009). *NSW Sea Level Rise Policy Statement*. Prepared by the Department of Environment, Climate Change and Water (DECCW).

NSW Government (2010). *Flood Risk Management Guide: Incorporating sea level rise benchmarks in flood risk assessments*. Prepared by the Department of Environment, Climate Change and Water (DECCW).

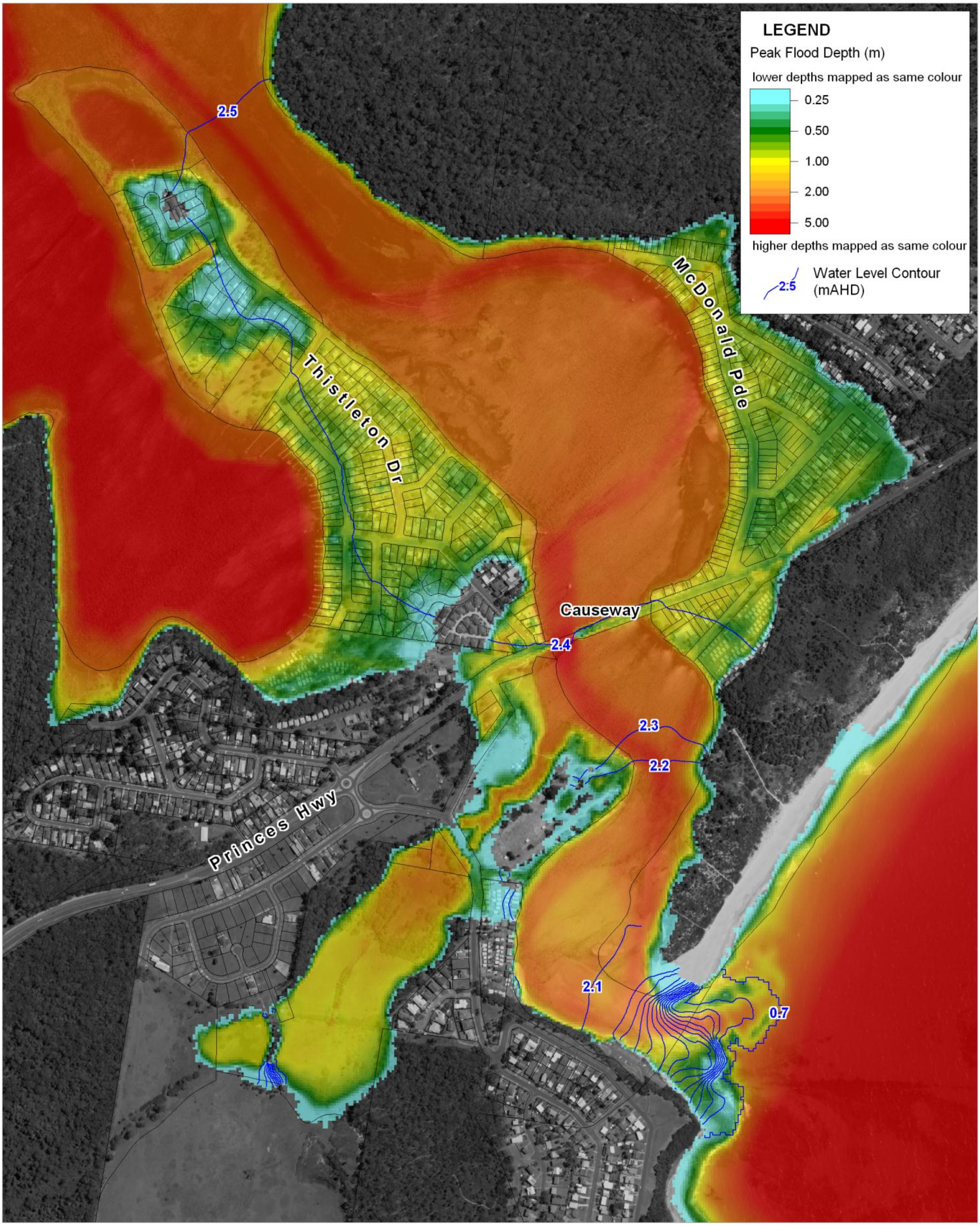
NSW Government (2010) *Coastal Risk Management Guide: Incorporating sea level rise benchmarks in coastal risk assessments.* Prepared by the Department of Environment, Climate Change and Water (DECCW).

Office of the Queensland Chief Scientist (2011), *Understanding Floods: Questions and Answers,* Queensland Government.

Peter Spurway and Associates (2008). *Burrill Lake Interim Entrance Management Policy.* Prepared for Shoalhaven City Council.

Peter Spurway and Associates (2008). *Review of Environmental Factors Artificial Opening of Burrill Lake Entrance.* Prepared for Shoalhaven City Council.

APPENDIX A: DESIGN FLOOD RISK MAPPING



Title:

Existing Catchment Flood (Closed Entrance Condition) 1% AEP Maximum Flood Depths and Water Levels

Figure: **A-1**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

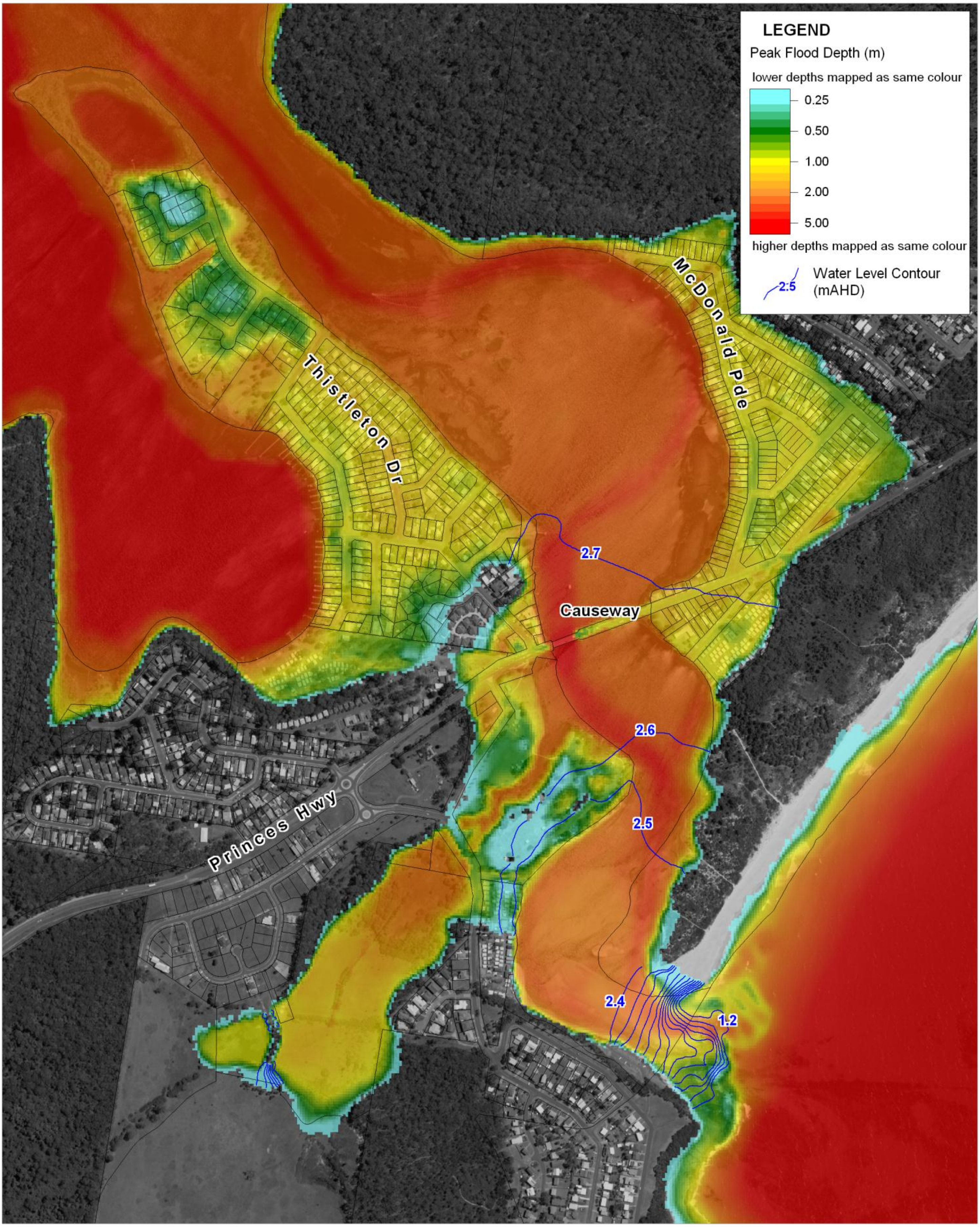
0 200 400m

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_003_101125 EX 1% Depths.WOR



Title:

2050 Catchment Flood (Closed Entrance Condition) 1% AEP Maximum Flood Depths and Water Levels

Figure: A-2

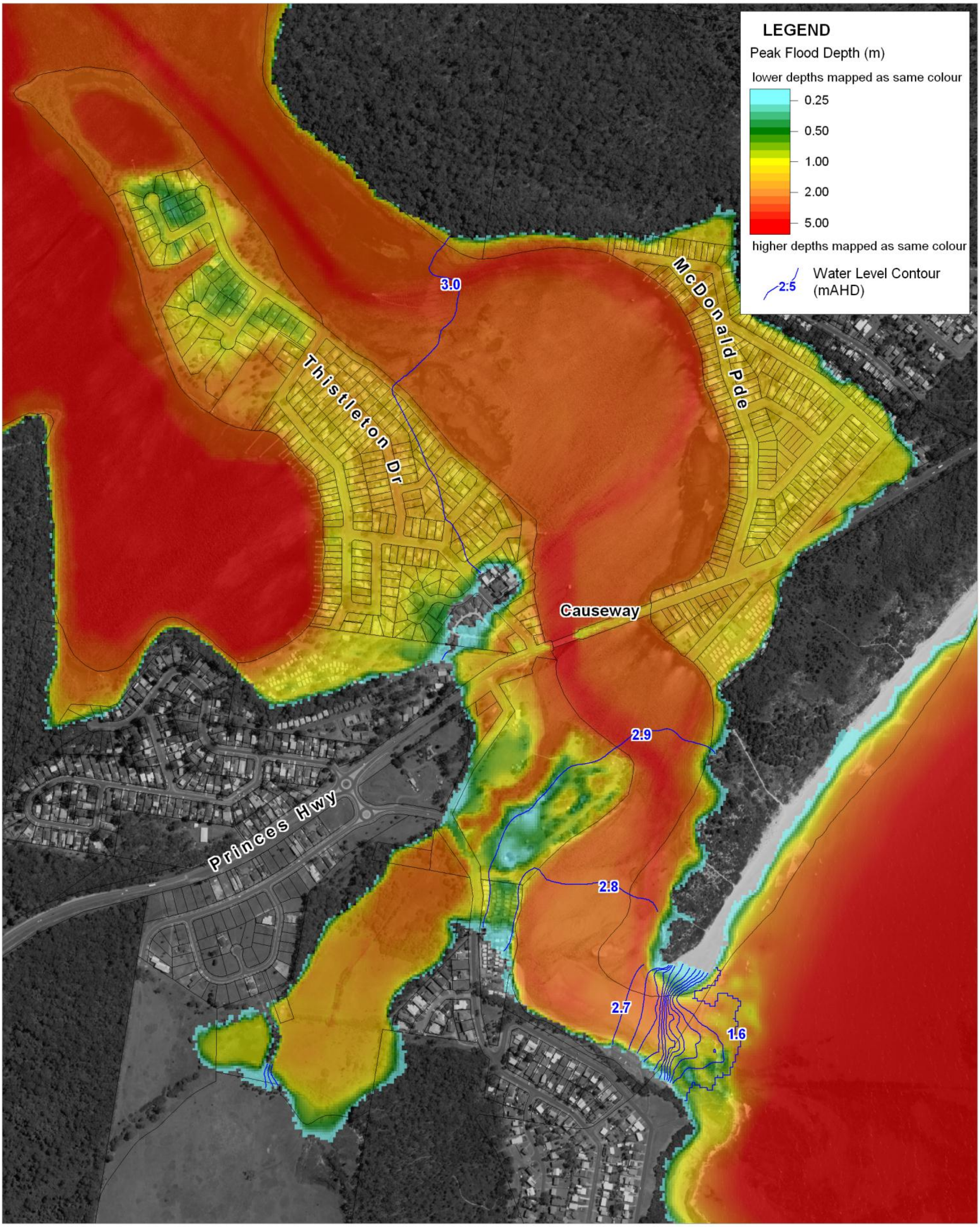
Rev: A

N

0 200 400m
Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_004_101126 2050 1% Depths.WOR



Title:

2100 Catchment Flood (Closed Entrance Condition)
1% AEP Maximum Flood Depths and Water Levels

Figure: **A-3**

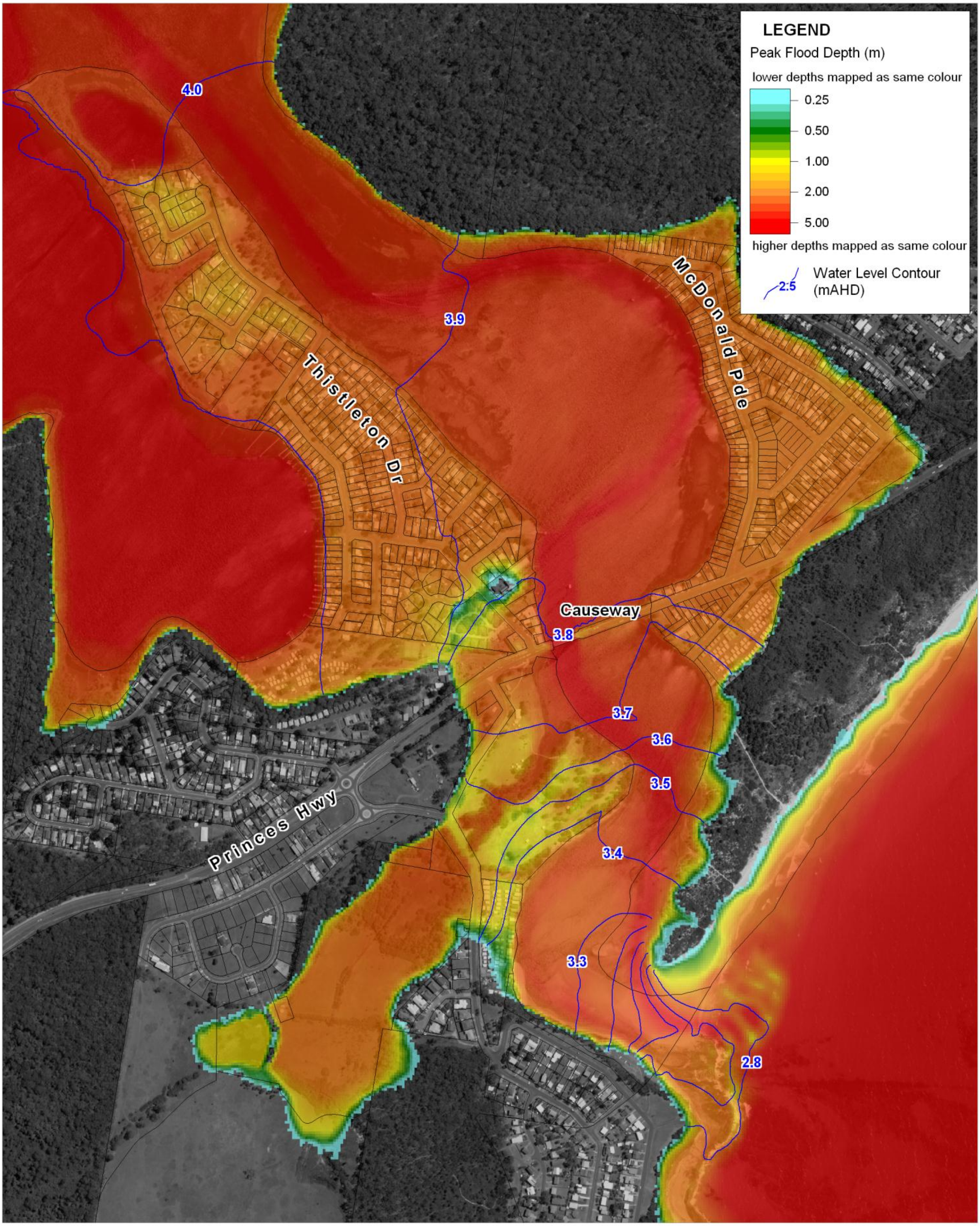
Rev: **A**

N

0 200 400m
Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_005_101126 2100 1% Depths.WOR



Title:

Catchment Flood (Closed Entrance Condition)
PMF Maximum Flood Depths and Water Levels

Figure: **A-4**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 200 400m

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N1777_Burrill_Lake_FRMS\MI\Worskpaces\DRG_009_101126 EX PMF Depths.WOR

APPENDIX B: COMMUNITY CONSULTATION DETAILS

B.1.1 Public Exhibition Submissions

The Draft Burrill Lake Floodplain Risk Management Study and Plan was placed on public exhibition for a 4-week period to 12 September 2012. Landowners, residents and businesses were invited to participate in the study by providing comment on the Draft report. As part of the public exhibition of the Draft, a Public Workshop was held on Wednesday 22 August 2012, at Burrill Lake Community Hall (refer to Section B.1.2 for further detail on the workshop).

Following the close of public exhibition, one (1) submission was received from the community. A copy of the submission is attached for reference (names and addresses of respondents have been withheld). A summary of the key issues arising from the submission is summarised in Table B.1.

Table B.1 Summary of Issues from Public Submission

Topic	Issues summarised
Community Awareness and Flood Response	• **Support for community awareness initiatives –** general support for community education initiatives to build flood resilient community • **Recognition of requirement for community to be partly responsible for flood response –** there is a potential for building and training a volunteer network within the community The study acknowledges the potential for limited external support in the case of a flood event and therefore has placed emphasis on the community awareness program. A Community Emergency Response Plan based on local inputs has been recommended. It is anticipated that some level of responsibility in such a Plan would be devolved to local community representatives. Council and the SES will have the prime responsibilities (working in collaboration) to develop flood resilience within the community through various education and awareness activities. Community support for such measures is welcomed and indeed necessary to maximise benefits in reducing flood risks.
Development Controls / Land Use Planning	• **Issues with rising Flood Planning Levels and Height Restrictions** – with higher FPLs and existing height restriction policies, potential developments are being "squeezed". Council is aware of this issue and policies will continue to evolve. Planning staff will need to consider development cases on their merits. • **Study canvasses a moratorium on development** – although not included in recommendations, a move to such a blanket approach would be opposed due to unfair restrictions for existing landowners. The Floodplain Risk Management Plan recommends further detailed investigations in relation to strategic planning for Burrill Lake and longer-term land use strategies. These are very complex issues with considerable social implications requiring extensive consultation with the community and detailed supporting investigations of social, economic and environmental issues. Accordingly, no such recommendation for a moratorium on development is included in the current Plan. • **No Fill Policy** – this approach is opposed given potential restrictions imposed on existing landowners. Alternative to limit fill similar to existing policies i.e. up to 1m of fill height? Existing Council Policy on fill limitations are targeted towards minimising the impact of

	filling on existing flood behaviour. The “no fill policy” was recommended to avoid the legacy of incremental filling of the floodplain should a planned retreat option eventually be realised for Burrill Lake. Such a strategic land-use adaptation policy requires significant further investigation. Nevertheless, the control on filling as an interim measure was recommended so as not provide additional constraints on future land use. Further consideration of acceptable filling on flood fringe land may be considered. • **Restricting development and forcing abandonment over time** – this approach is considered unfair and prejudicial to existing landholders without effective compensation. Discussion of potential purchase schemes refers to “residential” property only. The study has flagged the potential of a planned retreat model for Burrill Lake should permanent inundation and flooding risks not be able to be effectively managed in the future. This problem is not unique to Burrill Lake and indeed there are a number of similar low-lying coastal communities within the Shoalhaven. Again, the investigation of such options requires a detailed assessment process and community consultation. It was not the intention to restrict possible future land purchase to residential property only. The reference to residential property has been modified in the documentation to reflect all current tenure. • **No intensification of development** – objection to this approach where flood classifications are provisional and not in high inundation category, and for tourist type development where evacuation can be coordinated. The key to this development control is to ensure that future development does not increase the risk to property and people. As redevelopment takes place, it is imperative that the overall flood risk in Burrill Lake is reduced, particularly considering the potential for increasing severity of flooding under climate change scenarios. In considering future development applications, including intensification of existing development, Council should consider the overall risk of the development including proposals to mitigate flood risk. Examples of this may be through site specific emergency flood plans (as required in development applications on flood prone land), improvements to existing evacuation routes and flood warning implementation. Each development application should be considered on its merits.
Levee Option	• **Levee option opposed** – opposed on the basis that some properties are excluded for the protection zone and may have flooding exacerbated by levee construction. The levee option has not been recommended in the Plan. Should the option be considered further sometime in the future, detailed investigations would be required to fully establish all impacts (negative and positive) on neighbouring development

Submission on Draft Burrill Lake Floodplain Risk Management Study

Submission- Draft Burrill Lake Floodplain Study 3 September 2012

We commend approaches to proactively involve the community in flood manangement awareness and response . This needs leadership and responsibilty from one key driver – and not the usual crossed wires and duck shoving multi authority approach. There is latent potential for building and training a volunteer network of “wardens”. Involvement may be a requisite for managers of high population commercial sites . The keys are provision of training, co ordination, and a strong early warning information system.

As a commercial operator struggling to keep up with compliance requirements for our planned re development of tourist accommodation on a site zoned tourist, we make these observations on the issues raised in the Report and recommendations, so far as commercial develpoment is concerned.

1) Recommendations on FPL such as in 7.3.2 seem unlikely to worsen our current position – where our approved habitable floor level on redevelopment has gone from 3.08m AHD, to 3.5mAHD- effectively requiring on our site an elevation of 1.8m floor over natural land.Our architect plans had included provision for 1.3m fill, but 1.8m is impractical. In complying with this , we are trying to redesign to elevate “ground” floor over parking / storage space. In doing so, we are caught in the squeeze between suggested height limits, and the ever rising floor. If we are now limited to one habitable floor for a new development, it will destroy project viability. We rely upon the absence of a DCP for tourist zone, so as to permit judgement on what is acceptable- ie, subject to an acceptable design, the height implications may be exceeded- as this has been previously explained to us by Council planning staff. We request that this approach continue for our site, and that Council give realistic sympathetic consideration to height restrictions where negotiations have been pre existing, for effected sites.It would be unnecessarily unfair to retrospectively remove the flexibility of planning for Tourist zone, for continuing projects such as ours.

2) Page 83 canvasses a moratorium on development on effected sites. Although this is not reflected in recommendations, we would strongly object to such a blanket approach, especially for sites such as ours with a history of a redevelopment proposal consistent with Councils own zoning requirements. Simply put, such an approach could bankrupt projects, especially for sites such as ours where we believe the real risk to life in flood is minimal (motel stayers could be packed and gone well before life threatening flood heights, with an effective early warning community based warden suystem).

3) Page 96 talks of a “no fill” policy – again such a simplistic bureaucratically attractive solution can inflict unnecessary loss on commercial operators such as us. Sure limit future fill, but give some reasonable

hurdles – for example in our case where the understorey would be storage/ parking – non habitable- why not continue to allow say up to 1M fill as outlined on page 68 ??

4) Page 80 talks of restricting further development , forcing abandonment over time. That is unfair and prejudicial to long term holders such as ourselves, without some effective compensation. The options table at page 85 talks of selective offers to purchase existing effected “residential” property. We strongly suggest the word “residential “ should be removed. Based on your own prioritisation of risk , our site could be a better purchase

priority – with over 50 possible occupants in peak holiday time – in 10 family motel units plus a 2 level 3 bedroom plus rumpus house. Additionally, our site may be important for a new parallel bridge – so why limit applicability of purchse application?

5) We would object to application of levee construction as outlined in Fig 6 and page 59- because the levee design excludes us , and its construction could raise our flooding , in a major event. Any policy to construct levees must be accompanied by offers to purchase properties negatively effected by the levee.

6)Page 96 recommends no intensification of development, no dual occupancies or subdivisions in high hazard flood zones. We would object to such a blanket approach to commercial sites such as ours- where our flood classification is provisional , much of our site is not in the high inundation category in models, and where departure of motel occupants can easily be achieved with timely notice.We are vastly different from the resident who would be reluctant to leave his home- our occupants are short term holidayers, who would be keen and able to go on short notice- and we are very close to the highway(which the Report suggest be raised anyway).

Again , we suggest some sensible flexibility, with clearly set out hurdles , rather than a blanket ban on development or subdivision- especially for a tourist zoning. Subdivision is an important feature of our plan. Why not permit it where there is no intensification of maximum occupancy? To do otherwise simply prejudicially destroys continuing projects like ours,for no real gain.

Thank you for this opportunity to make a submission on something which is of major concern for our site. With a house in Mollymook and this commercial motel and redevelopment plan, I have been a continuous ratepayer in this region for nearly 40 years.

I urge you to reconsider some of the Reports recommendations for those few existing commercial sites effected, so as to minimise unnecessary pain and loss to owners.

3 September 2012

B.1.2 Public Exhibition Workshop

As a part of this community consultation process, a Public Workshop was held Wednesday 22 August 2012, at Burrill Lake Community Hall. The objectives of the workshop were to:

- Present the key findings of the Floodplain Risk Management Study and proposed Plan (exhibition document); and
- Provide a forum for the local community to discuss the proposed floodplain management options.

A total number of 24 people attended the workshop comprising:

- 14 residents;
- 4 Shoalhaven City Council Flood Management Officers;
- 2 Shoalhaven City Council other staff;
- 1 Office of Environment and Heritage representative;
- 1 Consultant

The workshop opened with a presentation by consultant BMT WBM focusing on the key elements of the recommended Floodplain Risk Management Plan as documented in Section 8. The workshop was then opened for general discussion and questions from the community. Provided hereunder is a brief summary of the key issues raised.

Issue/Query: Summary in document doesn't include evacuation routes

***Response:**. Detailed evacuation route planning to be undertaken and confirmed by the SES. Detailed information for residents to be made available through community education initiatives.*

Issue/Query: The NSW Roads and Maritime Services investigation of Princes Highway bridge/causeway upgrades not part of this Plan.

***Response:** The Plan provides recommendation to upgrade the bridge/causeway to provide flood immunity and has liaison with RMS has taken place in this regard. RMS is aware of Plan recommendations. Details of additional modelling investigations undertaken by RMS not part of the Plan documentation.*

Issue/Query: There are height restrictions on waterfront properties – how will this policy affect options such as house raising?

Response: Council is aware of this issue and Council's land use planning and development control policies will continue to evolve to address these issues.

Issue/Query: There could be signs showing historical/predicted flood levels for community education purposes.

Response: *These have been used in others areas with various success. Whilst a good public education mechanism on the potential flood risk, there is some sensitivity amongst the community with perceptions of degreasing property value. The use of flood level signage will be considered further as part of the ongoing community awareness and will likely require additional consultation.*

Issue/Query: The Lake water quality is in issue and silt and pollutant traps in developed areas could be used.

Response: *Whilst excessive siltation can exacerbate flooding in some situations, these issues are not really considered in the floodplain risk management due to minimal influence on overall Lake flood behaviour. These estuary health issues will be ongoing considerations and can be pursued through the Estuary Management Plan. .*

Issue/Query: The link to the electronic exhibition documents has not been working.

Response: *This problem appears to be isolated to iPhone users.*

Website Details: http://gis.wbmpl.com.au/BurrillLake/

Shoalhaven City Council

BURRILL LAKE
Floodplain Risk Management Study

About the Study

Shoalhaven City Council is carrying out a floodplain risk management study to manage flood risks in the Burrill Lake catchment. This includes the main urban areas in the catchment: Dolphin Point, Burrill Lake Village, Bungalow Park and Kings Point. This study follows from the recently completed Burrill Lake Flood Study in 2007 and is being prepared to meet the objectives of the NSW State Government's Flood Policy.

View Electronic copy of the Burrill Lake Catchment Flood Study Report

Download pdf copy of the Burrill Lake Catchment Flood Study Report

Burrill Lake

Latest News

- Live water level and rainfall information can now be accessed - follow the links under the "Water Level and Rainfall" page
- Community Information Session to be held at Ulladulla Civic Centre on Tuesday 19th October, please feel free to drop-in anytime between 3:30pm - 6:30pm.

Shoalhaven City Council

BURRILL LAKE
Floodplain Risk Management Study

About the Study | Who's Responsible | Potential Flood Risk | Climate Change | Entrance Management | Flood Management Options | Community Input | Water Level and Rainfall | Important Terms | Contact

Contact

The Far South Natural Resources and Floodplain Management Committee is also looking at filling vacant community representatives positions in the committee. If you are interested to be part of the committee please contact council on *4429 3392* and request an information package.

Want more information?

For more information about the Burrill Lake Floodplain Risk Management Study & Plan, please contact:

Shoalhaven City Council Ms Isabelle Ghetti Natural Resources and Floodplain Manager Ph 4429 3300	BMT WBM (Consultant) Mr Darren Lyons Project Manager Ph 4940 8882

Website: http://gis.wbmpl.com.au/BurrillLake/

View Electronic copy of the Burrill Lake Catchment Flood Study Report

Download pdf copy of the Burrill Lake Catchment Flood Study Report

Burrill Lake

Round 1 Information Brochure

Entrance channel following June 2007 opening

The Far South Natural Resources and Floodplain Management Committee is also looking at filling vacant community representatives positions in the committee. If you are interested to be part of the committee please contact council on 4429 3392 and request an information package.

Want more information?

For more information about the Burrill Lake Floodplain Risk Management Study & Plan, please contact:

Shoalhaven City Council
Ms Isabelle Ghetti
Natural Resources and Floodplain Manager
Ph 4429 3300

BMT WBM (Consultant)
Mr Darren Lyons
Project Manager
Ph 4940 8882

Website: *http://gis.wbmpl.com.au/BurrillLake/*

Important Terms

Catchment flooding: is the inundation of land due to significant rainfall in the catchment. The runoff generated from the catchment flows into Burrill Lake from local streams.

Ocean flooding: is the inundation of land by sea water and results from one or a combination of storm surge, wave set-up and tidal conditions.

Low-level persistent flooding: is the inundation of land due to elevated lake levels in periods of entrance closure, with lake water level fluctuations due to local catchment rainfall and lake evaporation.

ICOLLs: Intermittently Closed and Open Lakes and Lagoons (such as Burrill Lake) are separated from the ocean by a sand beach barrier or berm. This entrance barrier forms and breaks down depending on the movement and redistribution of sand and sediments by waves, tides, flood flows and winds. ICOLLs open and close to the ocean naturally in a constant but irregular cycle.

Natural breakout: Following heavy rainfall, water levels in the ICOLL rise and may eventually spill over the entrance sand berm and with sufficient force can scour an entrance channel through the beach and reopen the ICOLL to the ocean.

Artificial opening: Artificial breaching of the entrance barrier is undertaken to 'drain' the ICOLL to the ocean and lower water levels to relieve flooding of foreshore development and infrastructure or avoid the likely threat of flooding which would occur before the ICOLL entrance opens naturally.

Artificial channel opening May 2010

Existing property on Burrill Lake foreshore

Shoalhaven City Council BMT WBM

BURRILL LAKE

Floodplain Risk Management Study

Community Newsletter October 2010

Shoalhaven City Council BMT WBM

What is the study about?

Shoalhaven City Council is carrying out a floodplain risk management study to manage flood risks in the Burrill Lake catchment. This includes the main urban areas in the catchment: Dolphin Point, Burrill Lake Village, Bungalow Park and Kings Point. This study follows from the recently completed Burrill Lake Flood Study in 2007 and is being prepared to meet the objectives of the NSW State Government's Flood Policy.

Who is responsible?

Shoalhaven City Council will administer the project with input from the Far South Natural Resources and Floodplain Management Committee. The Committee has a broad representation including Councillors, Council Staff, State Government Department representatives and community members. BMT WBM, an independent company specialising in flooding and floodplain risk management, will undertake the study.

Potential Flood Risks

Flooding in Burrill Lake comes from three general sources: significant catchment rainfall, oceanic inundation (tide and storm surge) and low-level, persistent flooding from backed up lake water when the lake entrance is closed.

Burrill Lake flooding June 1991

The Burrill Lake Flood Study, investigated flooding in the catchment to identify the critical or worst case flood conditions for a range of flood events for both catchment and ocean derived flooding. For different locations within the catchment, and for different size flooding events, the dominant flooding mechanism can vary, being either catchment rainfall or ocean flooding.

The condition of the entrance has a significant influence on flood behaviour in Burrill Lake. For catchment flooding, an effective open entrance provides for lower flood levels in comparison to a shoaled or closed entrance. However, generally for ocean derived flooding, an open entrance condition will provide worst case conditions, through greater penetration of ocean water into the estuary under storm surge (ocean flooding) conditions.

As part of the current study, we are investigating a range of entrance conditions, both open and in various states of closure to assess the impact on flooding (under current conditions and future conditions considering potential sea level rise). Accordingly there will be some quantification of potential changes in flood conditions for various entrance states for both catchment and ocean flooding. From the floodplain risk management perspective, we need to look at a range of events from frequent low level persistent flooding to extreme events with significant inundation and high flood risk exposure of property and people.

Climate Change

The primary impacts of climate change in coastal areas are likely to result from sea level rise, which, coupled with storms, may lead to increased coastal erosion, tidal inundation and flooding.

The NSW Government recently adopted sea level rise planning benchmarks to ensure consistent consideration of sea level rise in coastal areas of NSW. These planning benchmarks are an increase above 1990 mean sea levels of 40cm by 2050 and 90cm by 2100.

For Burrill Lake, rising sea level is expected to increase the frequency, severity and duration of flooding. This is particularly the case when the entrance is open, with potentially more ocean water flowing through the entrance and into the main body of the Lake.

Projected sea level rise will also result in higher sand levels at the entrance when it is closed. This means that lake levels will need to be even higher in the future in order to initiate effective break-out channels.

During the course of the study, the changes to flood inundation patterns under climate change scenarios will be identified to determine the increased flood risk.

Entrance Management

The management of the entrance is a complex issue, with a variety of inter-related dependencies on the condition and operation of the entrance (e.g. catchment and ocean flooding, normal tidal exchange, water quality, recreation) sometimes with conflicting objectives. In developing the Floodplain Risk Management Plan for Burrill Lake, due consideration therefore needs to be given to balancing ecological, economic and social impacts of entrance management options.

Some of the entrance management options include:

- Artificial opening maintaining current management levels
- Artificial opening with new or progressively changing trigger levels
- Permanently open entrance
- Do-nothing

Each of these entrance management options, and other potential options identified by the community, will be assessed. It is also important to acknowledge that entrance management options are not the only options available to manage the flood risks. Other options will also be assessed.

Developing Management Options

The study will consider the consequences of flooding on the community and aims to develop appropriate floodplain management measures to reduce the damages caused by floods. This is achieved through identification of flood risks (outcomes of the flood modelling) and evaluation of a range options.
Some of the types of options to be considered include:

- Entrance management options
- Planning and development controls
- Raising/flood proofing individual properties
- Flood warning
- Improving evacuation and emergency response
- Developing community awareness and flood preparedness

This list is by no means exhaustive – ***we need your input*** and want to hear your ideas and opinions to make sure all options are considered.
The recommendations of the Study will include the best possible, most equitable, and locally supported measures to reduce flood problems.
Recommendations will be brought together in the Burrill Lake Floodplain Risk Management Plan, which will guide Council in managing the floodplain.

Community input

Community involvement in the development of appropriate floodplain management options is essential to improve the decision making process, to identify local concerns and values, and to inform the community about possible options and their potential consequences. The success of the Burrill Lake Floodplain Risk Management Plan hinges on the community's input and acceptance of the proposals.

There are a number of ways you can be involved in the study:

- A community information session will be held at Ulladulla Civic Centre on ***Tuesday 19th October from 3:30pm – 6:30pm.*** Please come along to hear about the existing and future flood risk posed to the community, and to give your ideas and concerns in regard to ongoing management of flooding in Burrill Lake.
- Further community sessions are planned at a later stage following assessment of available floodplain management options and to collect people's ideas and opinions before coming up with the recommended plan.
- A website has been established to keep the community informed on the study progress. The website has further information on flooding in Burrill Lake and will be updated throughout the study as new information becomes available. Community members will also be able to post their views and comments on the website so they can be considered during the course of the study.

Round 2 Information Brochure

Burrill Lake Floodplain Risk Management Study

Community Newsletter August 2011

An Update on the Study

Shoalhaven City Council is carrying out a floodplain risk management study to manage flood risks in the Burrill Lake catchment. This includes the main urban areas in the catchment: Dolphin Point, Burrill Lake Village, Bungalow Park and Kings Point. A community workshop was held in October 2010 to outline the study objectives and to get your ideas and concerns in regard to ongoing management of flooding in Burrill Lake. Following this workshop, further detailed analysis and mapping of flood behaviour, land use and infrastructure has been undertaken to establish current and future flood risks as the basis of what needs to be managed.

A second community workshop is now planned to discuss in further detail what are the priorities of the community and what management options are available. This newsletter is accompanied by a questionnaire to help identify the broader views of the community on what is most important and highly valued and accordingly should be incorporated into the floodplain management plan. The newsletter is intended to provide some further background information which may be considered when deciding on the most appropriate measures to manage existing and future flood risk.

Existing Flood Risk

Flooding in Burrill Lake comes from three general sources: significant catchment rainfall, oceanic inundation (tide and storm surge) and low-level, persistent flooding from backed up lake water when the lake entrance is closed.

As part of the study, a survey of property floor levels was undertaken recently in order to identify "at-risk" property. Shown over the page is the **1 in 100-year** (see note below) flood extent under existing conditions and the number of properties with floor levels below this flood level. Some 400 properties in the study area have been identified with floor levels below the 1 in 100-year flood level, for many this equates to a flood depth over one metre inside the house for this event.

The condition of the entrance, being open, closed or heavily shoaled, has an influence on flood behaviour. However, flooding can come from both directions, either from the lakeside which would be worse if the entrance is closed, or from the ocean side which would be worse if the entrance is opened, in fact the extreme ocean and catchment flooding conditions provide for similar peak water levels, such that a similar peak flood risk is posed irrespective of the entrance condition. Entrance management is often seen as a key option to reduce flooding potential. This certainly is this case for low-level persistent flooding when the entrance is closed, but is less effective for major flood events.

What is a 1 in 100-year flood? - A '100 year flood' means that in any one year there is a '1 in 100' or 1% chance that a flood of this size or larger will happen. Over many centuries, a '100 year flood' will happen on average once every 100 years. For instance, if you leave in the area for 50 years you will have more than a 1 in 3 chance of experiencing such an event at least once. Typically flood levels for this event are used to define minimum floor levels for residential property.

Shoalhaven City Council BMT WBM

Existing 1 in 100-year flood extent in Burrill Lake showing extensive potential property inundation

The Changing Environment

Coastal lake and estuary systems such as Burrill Lake are particularly vulnerable to potential climate change impacts such as sea-level rise, increased storminess and higher rainfall intensities, leading to increased coastal erosion, tidal inundation and flooding.

As identified above, there is already a large number of properties at flood risk in Burrill Lake under existing conditions. However, both the severity and frequency of flood inundation is expected to increase.

One of the most significant impacts of sea-level rise will be the regular inundation of low-lying foreshore areas. Normal tide levels in the Lake are expected to increase in line with broader sea-level rise. We face the prospect under current predictions of normal tide levels being around 1m higher than at present towards the end of the century. These future normal tide conditions exceed the current trigger levels for entrance openings to relieve flooding on low-lying property. As such many existing low-lying properties could be inundated on a daily basis.

The rise in normal tidal levels associated with sea-level rise presents a considerable challenge to Council in managing flood prone land both now and in the future. Whilst protecting development is a major priority, other considerations include:

- Making space to retain access to the foreshore amenity
- Making space for community infrastructure such as amenity blocks, picnic tables, boat ramps etc.
- Making space for ecological communities (upon which water quality and fish populations depend) to migrate

Regular foreshore flooding expected to become more prevalent with sea-level rise

Managing Both Existing and Future Flood Risk

The scale of the existing flood risk at Burrill Lake is significant considering the number of existing properties occupying flood-prone land. The floodplain management plan accordingly must incorporate appropriate measures to address the existing flood risk through measures such as modifications to individual properties to minimise flood damage, improved flood warning, evacuation procedures and community preparedness and ensuring evacuation routes are available.

Potential climate change impacts are expected to increase the severity and frequency of flooding. Whilst these changes are progressive, and may take several years for critical flooding thresholds to be reached, flood planning in Burrill Lake must be sufficiently robust and flexible to accommodate these changes and include a program for adaptation. It must also be recognised that projected sea level rise will not stop at the end of this century.

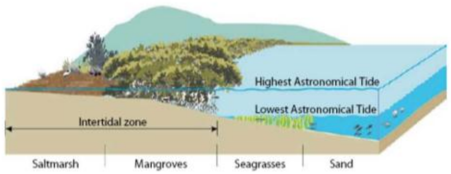
Given the design life of infrastructure such as residential homes (e.g. 50-100years) it is inevitable that the decisions we make now in regard to occupation of flood prone land have implications for the future. Potential flood impacts may not eventuate until some time in the future, but still within the design life of the structure, and accordingly need to be managed from present day. Some general considerations that need to be accounted for are:

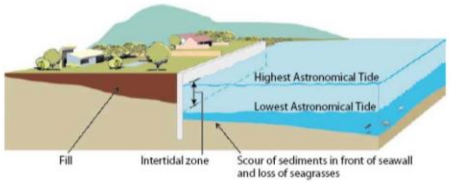
• What will the landscape we create now through planning and development controls look like in the future?

•What limitations or problems will this create in the way we own, occupy and use public and private spaces?

• How can we allow for changes in development controls which may be revised in the future in line with improved estimation of flooding and climate change impacts?

An example of the complexity of managing existing and future flood risks can be illustrated considering the option to fill existing low-lying land and construction of a seawall to provide for future flood level protection. Whilst achieving the desired flood protection, as tidal levels rise the natural foreshore will make way for a vertical seawall dropping directly into the Lake with loss of ecological communities. Public access to the foreshore may also be compromised as private land extends to the waterfront.





Diagrams from *Environmentally Friendly Seawalls* (DECCW, 2007)

Examples of a natural foreshore and sea-wall protected foreshore area

Management Options and Community Assets

The assessment of floodplain management options considers not only the impact on flood behaviour but also the social, economic, ecological and cultural costs and benefits of options. The floodplain management plan requires to be much more comprehensive than protecting residential property alone. Below is a list of community assets that are all affected by flooding, and are integral components of land use planning and development in the catchment. When considering what floodplain management options you believe are required for Burrill Lake, consider the impacts on all types of infrastructure and assets outlined below.

Parks, Beaches and open space	***Transport Infrastructure***
Beaches	Major (arterial) roads, bridges
Parks, Public open space / reserves	Local Roads, (including car parks)
Private recreational land (e.g. Sporting grounds, bowls clubs, tennis courts)	Public jetties, wharves, boat ramps
Wetlands / Forests / Other Habitats (including estuary entrances)	***Water and sewage infrastructure***
Coastal Dune Systems	Stormwater drainage network, outlets
Community Infrastructure	Sewage reticulation scheme, sewage pumping stations
Caravan Parks	Water supply networks
Heritage / Historic Sites and Significant Aboriginal Sites	***Residential Development***
Cycleway / Shared Pathway	Existing Residences
Community halls, other public buildings	Vacant Land (Future Development)
Amenities blocks, sheds, etc (Council facilities / assets)	***Institutional Infrastructure***
Commercial and Industrial Development	Schools, child care facilities
Tourism	Aged care facilities

Questionnaire

Attached to this newsletter is a questionnaire with a range of questions aimed at identifying what the community regards as important in developing the floodplain management plan. It is not intended as an all-encompassing questionnaire looking at every possible management option or issue within the study area, rather a tool to help identify and prioritise the broader community values and concerns. Space is provided for you to include other potential options or other issues of concern you feel are important.

Please take some time to consider the questions and provide answers. The responses received will be discussed at the next community workshop and provide a basis for discussion of what the community would like to see in the floodplain risk management plan.

Community Workshop

A second community workshop will be held **Wednesday 9th November** from 4pm to 6pm at Ulladulla Civic Centre-Seniors Hall. Please come along to hear about the existing and future flood risk posed to the community, and to give your ideas and concerns in regard to ongoing management of flooding in Burrill Lake.

For further information regarding the workshop or study please contact:

Shoalhaven City Council
Ms Isabelle Ghetti
Natural Resources and Floodplain Manager
Ph: 4429 3300

BMT WBM (Consultant)
Mr Darren Lyons
Project Manager
Ph: 4940 8882

Website: http://gis.wbmpl.com.au/BurrillLake/

Community Questionnaire

Burrill Lake Floodplain Risk Management Study and Plan Community Questionnaire August 2011

Managing Existing and Future Flood Risk

Under the NSW State Government's Flood Policy, Shoalhaven City Council (Council) is responsible for local planning, development controls and land management within the flood prone land of Burrill Lake. The Flood Policy states that Councils need to prepare a Floodplain Management Study and Plan to outline how they plan to manage flood prone land now and in the future.

Do you generally agree that decisions made today to mitigate the existing flood risks should not make future flood risk worse?

☐ Yes ☐ No

Do you generally agree that decisions made today to mitigate the existing flood risks should not prevent the implementation of "tomorrow" options to mitigate future flood risks?

☐ Yes ☐ No

Do you agree that flood levels may increase over time as a result of climate changes such as sea-level rise and changes to rainfall?

☐ Yes ☐ No

Do you agree that the frequency of flooding may increase over time as a result of climate changes such as sea-level rise and changes to rainfall?

☐ Yes ☐ No

Do you agree that people may not be able to live where you live today due to increased flood risk in the future?

☐ Yes ☐ No

Land Use Planning

Would you generally agree with the concept of occupying the land for as long as possible until such time that it becomes unviable (i.e. land regularly affected by tidal inundation or by regular flooding)?

☐ Yes ☐ No

Would you generally agree with the concept of relocating if the whole parcel of land is regularly affected by tidal inundation or regular flooding?

☐ Yes ☐ No

Would you generally agree with the concept of when redevelopment occurs on flood liable waterfront land, the new development should be located as far away as possible from the waterway?

☐ Yes ☐ No

Burrill Lake Floodplain Risk Management Study and Plan Community Questionnaire August 2011

Flood Planning Levels

How often do you think it would be acceptable to have your property flooded in this way - garden/shed/garage flooded but no flooding inside the house.

- a few times a year
- once a year
- every few years
- a few years in my lifetime
- once in my lifetime
- 1 in 100 chance of occurring in my lifetime
- never

How often do you think it would be acceptable to have your house flooded in this way - water inside house just above floor level.

- every few years
- a few years in my lifetime
- once in my lifetime
- 50/50 chance of occurring in my lifetime
- 1 in 6 chance of occurring in my lifetime
- 1 in 100 chance of occurring in my lifetime
- never

How often do you think it would be acceptable to have your house flooded in this way - 2m of water above floor level in main living area of home.

- every few years
- a few years in my lifetime
- once in my lifetime
- 50/50 chance of occurring in my lifetime
- 1 in 6 chance of occurring in my lifetime
- 1 in 100 chance of occurring in my lifetime
- never

Burrill Lake Floodplain Risk Management Study and Plan
Community Questionnaire August 2011

Flood Warning and Preparedness

Do you know if your property is at risk of flooding?

☐ Yes ☐ No ☐ Unsure

Do you think that your property may be flooded in the future or if already flood affected, be more regularly and/or severely flooded in the future?

☐ Yes ☐ No ☐ Unsure

Are you aware of any flood warning procedures or information available for Burrill Lake ?

☐ Yes ☐ No

In the event of a flood, how would you expect to receive flood warnings and any advice regarding evacuation or protecting your property?

☐ Radio broadcast ☐ Television broadcast ☐ Internet ☐ Friends/neighbours

☐ Door knock from SES or other emergency service ☐ Phone call/text message from SES

How much warning time do think is necessary for you to prepare for an imminent flood?

☐ Less than 1 hour ☐ 1 – 2 hours ☐ 2 – 4 hours ☐ more than 4 hours

What notifications do you consider Council should give about the potential flood risk of individual properties?

☐ Advise every resident and property owner on a regular basis of the known potential flood risk

☐ Advise only those who enquire to Council about the known potential flood risk

☐ Advise prospective purchasers of property of the known potential flood risk

Environmental Considerations

Do you agree that future planning and floodplain management options should consider environmental factors?

☐ Yes ☐ No

Do you think it is important to protect/conserve ecological communities and habitat? (e.g. seagrass which fish and water quality depend upon)

☐ Yes ☐ No

Should protection of the vulnerable ecological communities which give the lake its natural character be an important factor when considering further new developments?

☐ Yes ☐ No

Burrill Lake Floodplain Risk Management Study and Plan
Community Questionnaire August 2011

Protecting Existing Property

Do you think any of these options should be considered for existing properties affected by flooding? (please tick more than one box if appropriate)

☐ Use property as is until abandoning when tidal inundation and flooding problems are unbearable

☐ Relocate property if suitable alternative location is available

☐ Council / State Govt purchase up-front properties at highest risk

☐ Protect property by flood levee or sea-wall

☐ Raise individual property through land filling and redevelopment

☐ Broad scale redevelopment of existing township

☐ Other (please specify)

....

....

....

Protecting Future Property

What level of control do you consider Council should place on new development to minimise flood-related risks? (please tick more than one box if appropriate)

☐ Stop all new development on land with any potential for flooding

☐ Stop all new development only in the most dangerous areas of the floodplain

☐ Place restrictions on development such as minimum floor levels and/or the use of flood compatible building materials

☐ Advise people of flood risks, and allow individuals to choose how they would reduce flood damage

☐ There should be no control on development in flood-affected areas

☐ Other (please specify)

....

....

....

Burrill Lake Floodplain Risk Management Study and Plan
Community Questionnaire August 2011

The Foreshore Environment

The foreshore environment is a valued community asset. Some methods of managing flood impacts may affect foreshore areas.

Is maintaining future public access to the foreshore important to you?

☐ Yes ☐ No

Do you consider community infrastructure such as amenity blocks, boat ramps, picnic tables, barbecue facilities etc. an essential part of the foreshore area?

☐ Yes ☐ No

Would you prefer to see a foreshore made of grass and trees or made of vertical sea walls?

☐ Natural foreshore ☐ Seawalls

Would you be happy to see some areas filled by up to 2 metres in order to prevent flooding?

☐ Yes ☐ No

Which of these do you consider as the more important issue for Burrill Lake?

☐ Tidal flushing of the estuary ☐ Flood protection for people and property

Would you generally support a permanent training wall at the lake entrance (with its possible impacts such as effect on north-south beach access/increased flood levels upstream due to storm surges)?

☐ Yes ☐ No

Would you generally support a permanent dredging operation at the lake entrance (with its associated impacts such as noise/lost amenity due to large sand stockpiling/exclusion of public access to lease areas)?

☐ Yes ☐ No

Contact Details

Name:..

Address:..

Phone or email:...

Which of the following best describes your age?

☐ <18 ☐ 18 – 34 ☐ 35 – 49 ☐ 50 – 64 ☐ >65

Are you happy for us to contact you to discuss your questionnaire responses if required?

☐ Yes ☐ No

Please return questionnaire by **31st August** in the **reply paid envelope** to:

BMT WBM

PO Box 266

Broadmeadow NSW 2292

THANK YOU FOR YOUR ASSISTANCE IN COMPLETING THE SURVEY. PLEASE PROVIDE ANY ADDITIONAL INFORMATION YOU FEEL IS RELEVANT TO THE STUDY ON THE SPACE PROVIDED OVER PAGE

Burrill Lake Floodplain Risk Management Study and Plan
Community Questionnaire August 2011

PLEASE USE THE SPACE BELOW TO PROVIDE ANY FURTHER COMMENTS. THIS MAY INCLUDE IDEAS FOR OTHER FLOODPLAIN MANAGEMENT OPTIONS, YOUR PRIORITIES AS TO WHAT THE STUDY NEEDS TO ADDRESS OR EXISTING VALUES OF THE COMMUNITY AND AREA THAT ARE IMPORTANT TO PRESERVE OR ENHANCE.

....

Newspaper Advertisement for Workshops

Burrill Lake Floodplain Risk Management Study

Council is seeking the community's input in the development of a Floodplain Risk Management Study and Plan for Burrill Lake.

The study is being conducted on behalf of Shoalhaven City Council by a team of consultants specialising in floodplain management. The study will look at various options to reduce the risks and damage caused by flooding in Burrill Lake. The study's recommendation will be brought together in the Burrill Lake Floodplain Risk Management Plan, which will guide Council in managing the flood prone land now and into the future.

Landowners, residents and businesses are invited to participate in the study by expressing their views and providing comment on flooding issues throughout the course study. A public information session will be held on 11th October 2010 1:30pm – 4:30pm at Council's Ulladulla Office.

For more information on the Burrill Lake Floodplain Risk Management Study please contact Ms Isabelle Ghetti at Council on 4429 3300, or Mr Darren Lyons at BMT WBM (Consultant) on 4940 8882.

Community Workshop Schedule

Table B.1 Community Workshops

Date	Workshop Type	Location	Time
19 October 2010	Information	Ulladulla Civic Centre	1:30 -4:30pm
9th November 2011	Options Workshop	Ulladulla Civic Centre	4-6pm

APPENDIX C: FLOOD DAMAGES CALCULATION

A flood damages assessment has been undertaken to identify and, where possible, estimate the cost of damages associated with the risks of flooding. The main objective of the flood damages assessment is to establish the 'baseline' economic costs of flooding (i.e. based on current conditions) which can then be used to help quantify the benefits of potential mitigation measures.

It is important to note that the assessment of flood damages is never referred to as the *calculation* of flood damages, but rather the *estimation* of flood damages. The distinction is important. Estimating flood damages is not an exact science as methodologies and data used in the valuation process vary. Certain assumptions within the process can have a noticeable impact on damage estimations. The methodology and associated assumptions are outlined within the following sections and in further detail in Appendix B.

Types of Flood Damages

Flood damages can be classified as tangible or intangible, depending on whether costs can be assigned monetary values. **Intangible damages** arise from adverse social and environmental effects caused by flooding, including factors such as loss of life and limb, stress and anxiety. **Tangible damages** are monetary losses directly attributable to flooding. The flood damages assessment estimates tangible damages to provide information on the economic impact of flooding and potential management measures. Intangible impacts by their nature cannot generally be quantified in the flood damages assessment; however they are considered throughout the study, alongside the economic impacts, in terms of identifying key risks and weighing up the costs and benefits of various management options.

Tangible damages comprise both direct and indirect flood damages. **Direct damages** result from the actions of floodwaters, inundation and flow, on property and structures. **Indirect damages** arise from the disruptions to physical and economic activities caused by flooding. Examples include losses due to the disruption of business, expenses of alternative accommodation, disruption of public services, emergency relief aid and clean-up costs.

Direct damages are typically estimated separately for urban, rural and infrastructure damages. **Rural damages** have not been estimated or included in the damage totals here, as the scope of this study does not include assessing measures for mitigating rural losses. The assessment therefore is focussed on quantifying estimates of **urban damages** together with preliminary estimates of **infrastructure damages**. Urban damages are typically further separated into damage to residential and commercial / industrial properties, and internal, external and structural components.

Figure C-1 depicts the different classifications of flood damages.

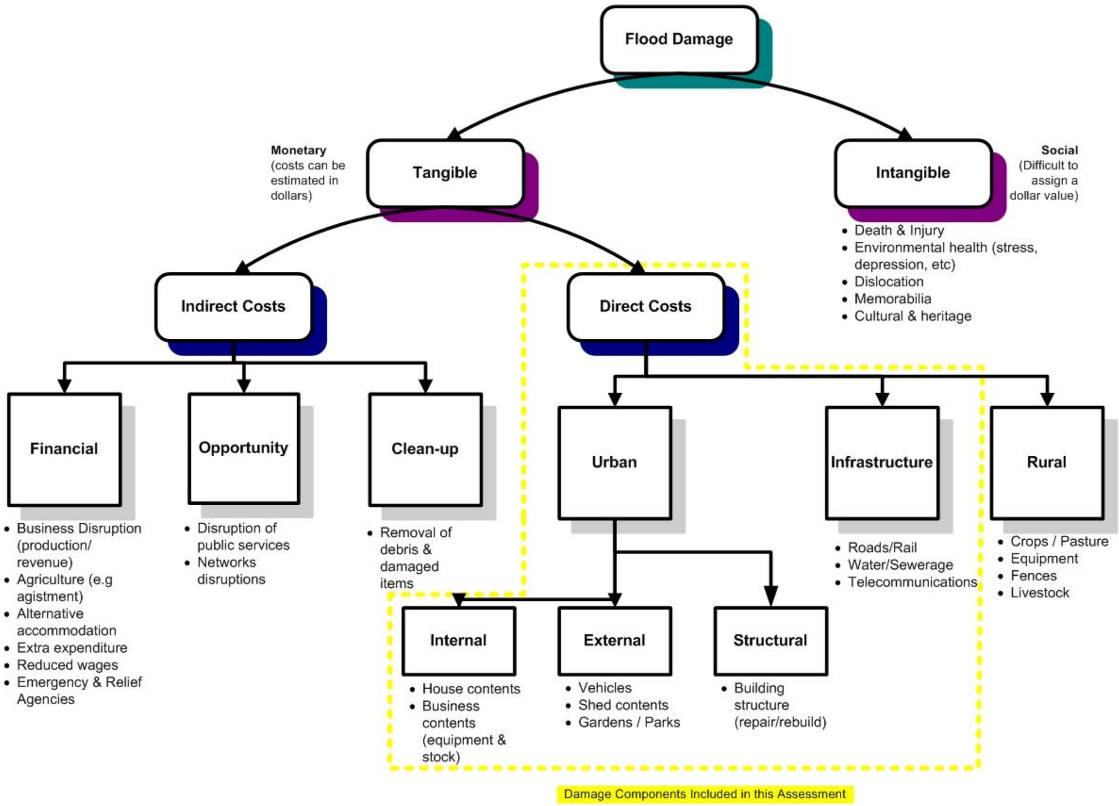


Figure C-1 Types of Flood Damages

Methodology

There are a range of industry-standard approaches for estimating the cost of the different types of flood damages described previously. **Stage-damage curves** are typically used to estimate internal damage sustained based on the depth of flooding through the property. These curves are estimated relationships between damage and depth generally derived from loss adjustor surveys which vary for different types of property and contents. An example of a stage-damage curve and how it is used in the estimation of damages is shown in Figure C-2. External, structural, infrastructure and indirect damages are generally estimated using other approaches.

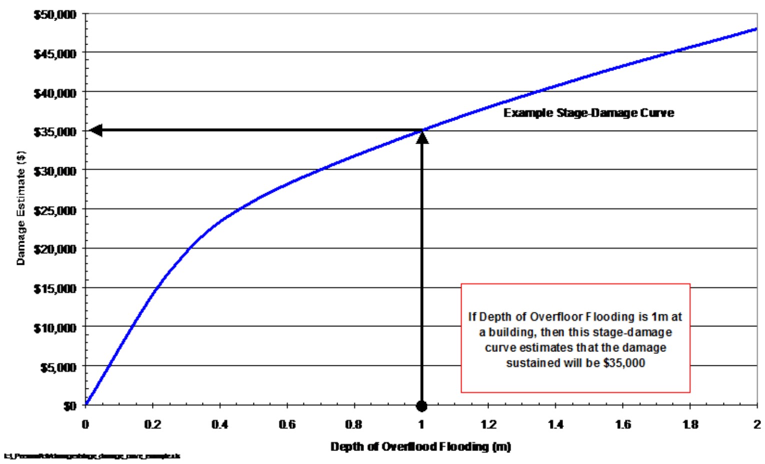


Figure C-2 Example of Stage-Damage Curve

The following is an overview of the methodology adopted for the flood damages assessments.

- **Residential damages** are based on *Floodplain Risk Management Guideline: Residential Flood Damages* (DECC, 2007). This utilises stage-damage curves for three typical dwelling types; low set, high set and double storey. The curves include external and indirect damages. It does not however include multi-unit dwellings or vehicles. Units have been directly multiplied by number of units per storey. Vehicles have been excluded as they are often moved to higher ground, and also to ensure vehicle damage does not drive justification for mitigation works.
- **Commercial damages** are based on *Guidance on the Assessment of Tangible Flood Damages* (NRM, 2002). This utilises a set of stage-damage curves for different types of businesses based on size and contents value. For simplicity, commercial and industrial properties and damages are referred to in this study as *commercial*, but in all cases refer to both. Indirect damage to commercial property can be substantial due to loss of production / revenue etc, for which the guidance suggests an estimate of 55% of direct damages. External damage has been excluded with the majority of damage typically expected to be allowed for when assigning appropriate contents value.
- **Structural damage** to buildings was assumed for properties where the velocity-depth product exceeded 1 m^2/s, the depth above floor exceeded 2 metres, or the velocity exceeded 2 m/s. A nominal value of $20,000 per property has been assigned.
- **Infrastructure damages** are difficult to quantify without an extensive valuation and assessment of each of the individual infrastructure at risk. Instead, infrastructure damages have been approximated as 15% of direct urban damages.

Table C-1 Summary of Flood Damages Assessment Approach

TANGIBLE	DIRECT ►	Urban►	Internal►	Commercial►	NRM Stage-Damage Curves
				Residential►	DECC Stage-Damage Curves
			External►	Commercial►	Not explicitly included
				Residential►	DECC Stage-Damage Curves
			Structural►	$20,000 per property based on high depth / velocity criteria	
		Infrastructure►	15% of direct urban damages (DECC)		
		Rural ►	Not included in this assessment		
	INDIRECT►	Commercial►	55% of Direct Damages (NRM)		
		Residential►	DECC Stage-Damage Curves		

Data

The assessment of flood damages required the following data:

- **Flood data** was obtained from the flood model for a range of event magnitudes from the 5 year ARI to the PMF. This included estimates of peak flood levels at each property to inform estimates of internal damages, as well as peak depth, velocity and depth-velocity product (required to estimate structural damages).

- **Property data** from the property survey including location, floor level and other building information (e.g. type, size etc) was used to select appropriate stage-damage curves and above-floor depths for estimation of internal damages.
- **Ground level data** was derived from the DEM developed for the Flood Study Update and used to estimate external inundation and damages.

Outputs

Using the above data and methodology, flood damages were estimated for a range of event magnitudes.

These range of event estimates were then used to calculate the **Average Annual Damage**, or **AAD**, which represents the estimated economic cost of flooding on average each year. AAD takes into account both the likelihood and consequence of flooding, from events such as a 5 year ARI that may cause millions of dollars damage, to extremely rare and unlikely events where damage may be in the billions of dollars.

AAD is calculated by combining estimated damages for each magnitude event with probability, and represents the area under the curve, as per the example shown in Figure C-3. The reduction in damages in individual events (and thus AAD) due to a particular mitigation option then represents the tangible, economic benefit of that option. This benefit can then be used to inform a cost-benefit assessment for the option.

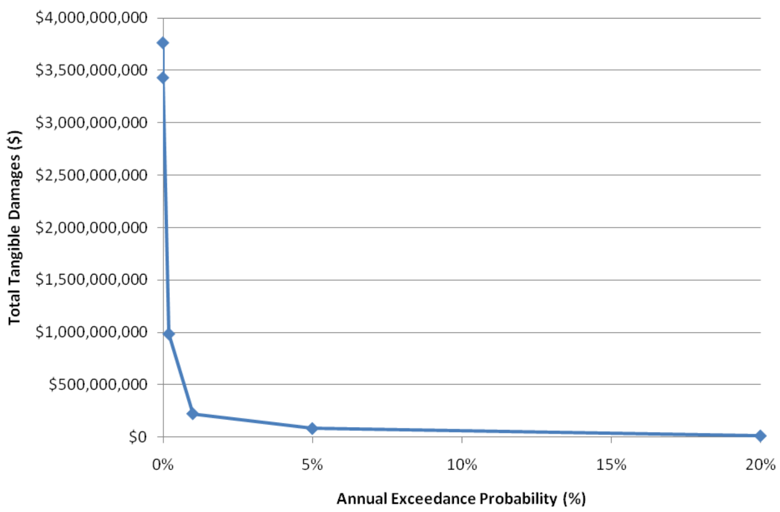


Figure C-3 Average Annual Damage Curve

Cost Benefit Assessment

The flood damages assessment and AAD described above provides an estimate of the current financial cost of flooding in the study area. This can be used in a cost benefit assessment to determine the relative merits of different options identified to reduce flood damage, and inform selection and prioritisation of preferred measures.

The general procedure for undertaking a cost benefit assessment is as follows:

- **Estimate average annual benefit** associated with the measure, based on the reduction in annual average damages from a flood damages assessment;
- **Estimate total benefit** by multiplying by the present worth factor (see below);
- **Estimate total cost** of the measure; and
- **Calculate monetary benefit-cost ratio** (BCR) as a factor of the total benefit to total cost:

The **present worth factor** is a standard economic approach to quantify future benefits in today's dollars. The adopted present worth factor is 13.8 over a 50 year period (i.e. the annual average benefit is converted to total benefit by multiplying by 13.8).

Monetary BCRs are used to evaluate the economic potential for the measure to be undertaken. A BCR greater than 1 indicates that the monetary benefits outweigh the costs, while a ratio less than 1 indicates that the costs outweigh the benefits. It is important to reiterate however that economics and financial viability is only one criteria for consideration in respect to the value of a measure. As mentioned previously, other issues such as social and psychological impacts, although difficult to quantify, must be taken into account in the complete assessment.

APPENDIX D: OPTIONS ASSESSMENT SUMMARY SHEETS

Entrance Management Policy Continue to apply Current Interim Entrance Management Policy Review of policy should sea level rise impact manifest	**Recommended**

Description of the Option

The current interim entrance management policy provides for artificial breakout of the entrance in the short term at defined trigger levels to relieve inundation to low-lying property during periods of entrance closure and subsequent sustained periods of Lake levels elevated above normal tidal range. The artificial opening is achieved through excavation of a channel through the shoaled entrance, reinstating the connectivity between the Lake and the ocean and allowing the Lake system to drain.

Performance	Medium

The current interim policy provides for management of low-level flooding during periods of entrance closure. Current trigger levels are set to protect some of the lowest property from inundation, including public foreshore areas, private property and some local roads. The relatively low trigger levels do however impact on the effectiveness of the breakout. Breakouts at higher trigger levels will increase the level and scour and may lead to more successful intervention in terms of reducing the opportunity for rapid re-closure of the entrance.

Whilst effective for low-level flooding, the opening of the entrance does not substantially reduce peak flood levels for the major catchment flood events. Major catchment flood events tend to scour the entrance naturally, such that the initial berm condition only has a minor impact on peak flood levels attained. For ocean derived flooding, an open entrance condition provides for a greater flow into the estuary, potentially exacerbating peak flooding. Accordingly, the option has a limited benefit considering the full range of potential flood events.

With potential sea level rise, normal tide levels in the Lake will approach and eventually exceed the current trigger levels. Whilst long term continuation of an artificial entrance opening policy is not recommended in this FRM Plan, future openings would need to be at significantly higher trigger levels to be effective. Low-lying land currently impacted by flooding during Lake closure periods will be subject to regular (or permanent) tidal inundation. Accordingly, adaptation of existing property to accommodate sea level rise is required. Appropriate adaptation of property would negate the requirement for ongoing entrance management to alleviate low-level flooding.

Periods of closure are a natural function of an ICOLL system. The long-term impact on the natural eco-system of artificial openings, at lower levels and higher frequencies than natural breakouts, is unknown. The Review of Environmental Factors (REF) prepared in association with the Entrance Management Policy noted continued implementation of the Policy would represent a significant change from the natural hydrological cycle and likely to have significant environmental impact.

Practicality	High

Artificial opening is undertaken as a direct response to entrance closure and provides immediate relief of low-level inundation from elevated Lake levels. The established policy, including monitoring and opening procedures, has been implemented on a number of occasions.

Continued application of the current entrance management policy is only recommended as an interim measure in the FRM Plan. Entrance management provides little benefit in reducing the impact of major flood events, and accordingly, other measures are required to provide for a gradual reduction in the overall flood risk to existing property over time. Implementation of these measures is expected to negate the need for ongoing entrance management in the long term, however, the benefits may only accrue incrementally over time, for instance as redevelopment takes place. Until these benefits are realised, ongoing implementation of the entrance management policy is recommended to address low-level persistent flooding of existing low-lying development.

Continued opening at current trigger levels will not be possible with potential sea level rise and will require adaptation of existing infrastructure to accommodate an expected increase in low-level flooding severity and frequency.

Community Acceptance (based on previous consultation)	Medium

Generally the opening of the entrance is viewed in the community as an effective option to relieve low-level persistent flooding. There is some conjecture regarding the process of opening (e.g. location, timing), in terms of the effectiveness of previous openings, however there is general support for ongoing entrance management.

Some parts of the community do not support the ongoing management of the entrance, with concerns on the intervention in the natural system processes and potential environmental impacts. The Entrance Management Policy REF does not support on-going intervention due to potential environmental impacts.

Cost /resources	High

On an individual opening basis, the cost of intervention is relatively minor with no major issues in availability and mobilisation of resources. This is one of a number of ICOLL systems managed by Council, such that available funding for this type of entrance management needs to be distributed across the systems.

Artificial openings are undertaken on an as-needs basis in response to entrance closure which is a highly variable and unpredictable natural process governed by climatic conditions. Accordingly, the numbers of openings potentially required over say a 5 to 10 year period is difficult to estimate.

Flood Protection Levee Construction of levees to protect existing property from inundation	**Not Recommended**

Description of the Option

Levees are built to exclude potentially inundated areas of the foreshore from flooding up to a prescribed design event level. Different types of levee construction are available, e.g. earthen levee, flood wall arrangement. In terms of their function for floodwater exclusion they perform the same way. However, there is considerable variation in construction costs, land area requirements, visual impact and impact on foreshore access.

Performance — Medium

Provided the integrity of the levee can be assured, levees are very effective in providing direct protection of property to flood inundation to the levee design height. Structural failure of the levee, or overtopping of the levee from a flood event larger than the design standard, can result in rapid inundation of areas behind the levee. This can in fact provide a greater flood hazard to both people and property.

The impacts of potential sea level rise would provide for a diminishing level of protection over time. Future levee raising would be required to maintain the appropriate flood protection standard.

Practicality — Medium

Any levee alignment will be required to tie into existing high ground to ensure no bypass of the levee system by floodwater. Suitable alignments have been identified to provide protection for a majority of existing flood affected properties.

The planning, design and construction effort and cost involved in implementing a levee protection system is a substantial investment. In order to maximise the benefit of this investment in terms of reducing flood risk, it is assumed a minimum levee design standard would be at the existing 1% AEP flood level plus an appropriate freeboard allowance (say 0.5m). This would require the construction of the levee to a height of around 3m AHD or higher.

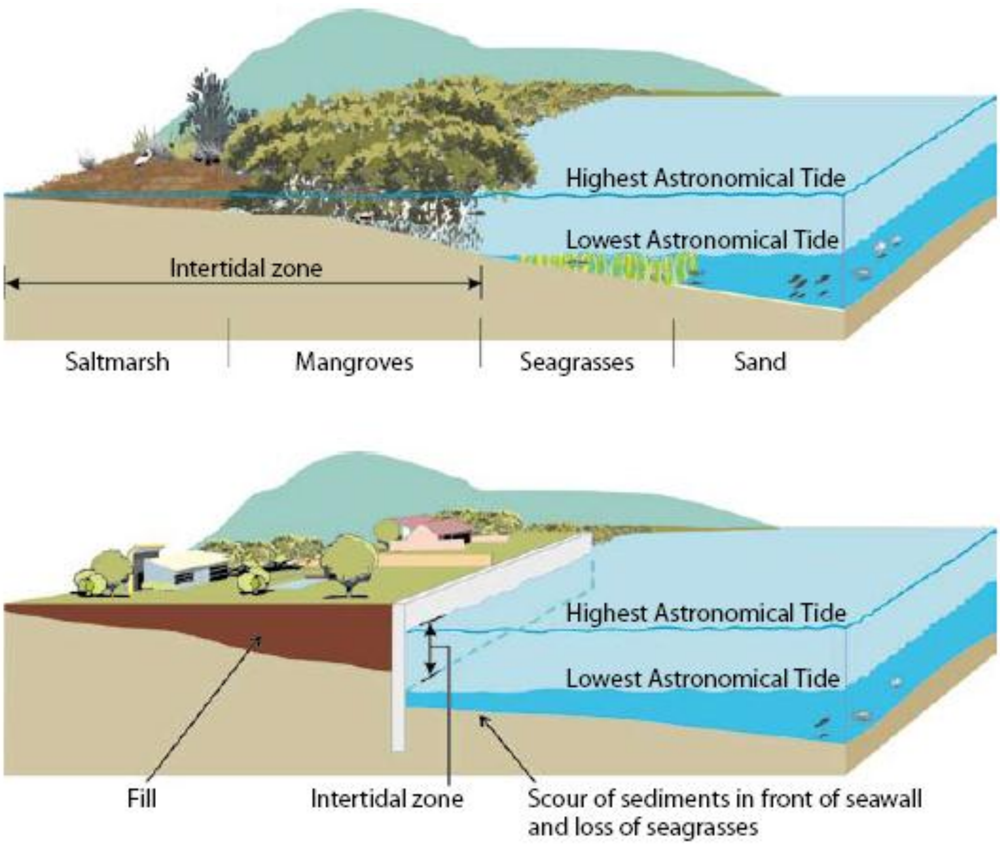
Construction of such a levee would see a marked change in the foreshore landscape. The levee would provide for a major visual impact and access to the foreshore would be affected. Drainage behind the levee would be impacted on, requiring pump systems or other alternatives for managing local runoff.

Community Acceptance (based on previous consultation) — Low

Whilst acknowledging the potential for effective protection from flood inundation, the associated impact of loss of foreshore access and visual impact provides for little community support for this option. The foreshore access, amenity and natural environment values are held high in the general community's regard and would not wished to be compromised.

Cost /resources	Low

Levees represent a substantial capital cost and on-going maintenance cost requirements. With reference to the reductions in flood damages afforded by the levee system (under existing flood conditions), the benefit-cost comparison would indicate some feasibility to the levee construction. With sea-level rise however, there would be a diminishing return as average annual damages increase.



Example change from natural foreshore to levee/flood wall protected foreshore
(Diagrams from *Environmentally Friendly Seawalls* (DECCW, 2007))

Breakwater Construction of breakwater to provide a permanent entrance opening	**Not Recommended**

Description of the Option

The construction of breakwaters is a potential option to achieve a stable and permanently open entrance. The objective of a permanent entrance opening in terms of flood management is the elimination of low-level flooding as a result of entrance closure, and the increase in conveyance of catchment floods out through the entrance.

To maintain a stable opening and prevent sand being washed back into the entrance, the breakwaters need to extend typically beyond the surf zone into relatively deep water. Accordingly, most breakwaters are structures of significant size, providing for a wide and relatively deep entrance channel.

Performance	Low

A stable, permanently open entrance eliminates the low-level persistent flooding associated with periods of entrance closure. In the event of future sea level rise, however, low level flooding would still occur with the open entrance under normal tide levels in the Lake. For example, for a mean Lake level of 0.4m AHD under existing conditions, a 0.9m sea level rise would increase the mean Lake level to 1.3m AHD – a level which at presents results in inundation of low-lying property.

The breakwater option does provide for an increase in the flow capacity through the entrance, with some reduction in peak flood levels. These reductions in flood levels will reduce the frequency and severity of catchment flood events, however, significant inundation will still occur for major events affecting a large number of existing properties.

The community will also still be susceptible to ocean flooding with the open entrance. The impacts of potential sea level rise would provide for a diminishing level of protection over time. Normal tide levels will increase with sea level rise such that low-lying lands will eventually be subject to regular tidal inundation. A breakwater entrance opening will provide for a greater tidal exchange thereby expecting also to increase normal high tide conditions.

Overall, some benefit in terms of reduced peak flood levels may be achieved through construction of breakwaters for particular events. However, the susceptibility to major flood inundation remains. There are additional impacts beyond flooding considerations which are discussed below.

Practicality	Low

Construction of breakwaters is a major engineering project and would provide for a substantial disruption to the community during the construction phase including:

- Restricted access to the beach/entrance and foreshore area;
- Heavy machinery on local access roads; and

- Noise and visual impact during construction.

More significant however, are the permanent changes to the existing environment of the lake and entrance channel. The existing function of the entrance and recreational amenity is likely to be changed significantly, including:

- Loss of north-south access across the Lake at the entrance. The permanent channel will be sufficiently deep and fast-flowing to limit access, even at low-tide condition;
- Reduced safety for swimming. The deeper, faster-flowing channel will provide for more hazardous conditions for swimming in the entrance channel;
- Changed landscape and visual impact. The move from a natural landscape to a large engineered structure markedly changes the visual amenity.
- Loss of entrance shoals which currently provide extensive wader habitat; and
- No longer a natural functioning ICOLL with potential environmental and ecological impacts. A large permanent entrance opening will increase the tidal exchange with impacts on normal water levels and water quality.

Community Acceptance (based on previous consultation)	High

A proportion of the community see a permanently open entrance as the best option to reduce potential flooding by preventing heavy shoaling at the entrance and subsequent closures which result in flooding to low-lying parts of the foreshore. Much of the perceived benefit is in improved tidal flushing and water quality, and not necessarily related to floodplain risk management. Parts of the community have concerns on the previous management of the entrance, including ineffectiveness of previous artificial openings, and perceive the breakwater to be a permanent solution.

Cost /resources	Low

The capital cost breakwater construction is of the order of tens of millions of dollars. Given the somewhat limited reduction in flood levels and subsequent potential flood damages to existing property, the option is not economically viable from the floodplain risk management perspective alone.

Example of breakwaters at Bermagui showing general scale of works

Dredging Channel widening/deepening to improve flow conveyance	**Not Recommended**

Description of the Option

Dredging would be undertaken to provide an increase in the width and depth of the main entrance channel in order to increase the tidal flows, with an objective of maintaining a more open entrance, and to provide additional capacity to convey floodwater through the channel.

The dredged channel would be expected to be of the order of 40-50m wide with a typical depth of around 2m. The volume of sand required to be removed would be dependent on the condition of the entrance shoals.

Performance	Medium

Dredging provides for an increase in the flow capacity through the entrance, with some reduction in peak flood levels. These reductions in flood levels will reduce the frequency and severity of catchment flood events, however, significant inundation will still occur for major events affecting a large number of existing properties. The reductions in flood levels across the full range of flood events are relatively modest and accordingly dredging would not provide for a significant level of protection to existing property.

A dredged channel will provide for a greater exchange of water between the ocean and the Lake. For ocean flooding conditions, this can exacerbate flooding through a greater penetration of the storm surge into the estuary.

Overall, some benefit in terms of reduced peak flood levels may be achieved through dredging of the entrance channel. However, the susceptibility to major flood inundation remains. There are additional impacts beyond flooding considerations which may provide benefits to the community including increased tidal flushing and improved navigation.

Practicality	Medium

Dredging operations are routinely undertaken on a number of estuary systems along the NSW coast for navigational purposes and management of low-level flooding. . Appropriate environmental impact assessments are required and approvals in place prior to operations.

There would be some disruption to community during the dredging operation including:

- Restricted access to some foreshore area (area needed for dewatering and sand stockpiling);
- Heavy machinery on local access roads for sand removal;
- Restrictions on navigation with dredger in operation; and
- Noise and visual impact during dredging.

In terms of environmental impacts, dredging can have major impacts on sea grass and benthic communities (small organisms that live on the bed of the channel). The EIS process would identify impacts and establish controls or restrictions on dredging in certain areas.

Community Acceptance (based on previous consultation)	High

Community support for a dredging program is mostly related to the perceived benefits in increased tidal flushing and improved navigation. These two issues are foremost concerns for many of the residents and dredging is seen as a direct method for achieving both.

Cost /resources	Low

An Environmental Impact Study would be required initially to determine environmental feasibility of dredging, following which approvals would need to be obtained from relevant Government authorities. The cost of dredging works depends on the volume of material to be removed but would be expected to be of the order of $0.5 - $1.0M to achieve a significant increase in the channel conveyance. As noted, this provides for limited flood damages reduction. Smaller scale dredging could be undertaken to increase tidal exchange and navigation, however cannot be recommended as part of a floodplain risk management program given the limited benefit in this regard.

Ongoing maintenance dredging would be required. The frequency of maintenance dredging is difficult to estimate and is dependent on the influx of sand through the entrance, itself dependent on the unpredictable nature of ocean storm conditions.

Raising of Local Roads Investigate raising of local roads for improved flood access	**Recommended**

Description of the Option

A number of the local roads which are important for flood evacuation and access are currently at a relatively low level with respect to flood levels. These roads would be subject to significant inundation in flood events, thereby limiting flood access. Given the depth of flooding that may occur within the road network, even for relatively minor flood events, the opportunity to evacuate property may be lost well before the peak of the flood arrives, potentially isolating residents.

It is recommended that a targeted road raising program of key access roads be investigated.

Performance	High

The availability of appropriate access to or from affected areas during times of flooding is important to ensure:

- people have the chance to evacuate themselves and valuables/belongings before becoming inundated or trapped by rising floodwaters,
- emergency services (SES, ambulance, police, etc.) are not restricted or exposed to unnecessary hazards in carrying out their duties,
- areas are not isolated for extended periods of time, preventing people from going about their normal routines or business or restricting access to essential services.

Raising of key access routes would have direct benefit in improving flood access, and coupled with other emergency response measures would provide greater opportunity to minimise flood risk to existing property.

Evacuations by boat in some areas have been raised previously within the community as an alternative. Whilst possible as a last resort, it is not the preferred evacuation method given the additional risk imposed on rescuers in navigating in floodwaters and reliance on the availability of suitable vessels given the expected high velocity flow conditions.

Practicality	High

There are no major constraints to undertaking the initial investigations; however, there are some practical considerations in the implementation of a road raising program which would need to be addressed.

It is likely to be impractical to raise roads to provide flood free access up to the 1 % AEP considering potential constraints on access to existing properties, local drainage and other buried services. The road should be constructed as high as practical which would need to be determined through a detailed local design assessment. The residual risk associated with lower road levels in combination with other adopted measures (e.g. flood warning, community awareness) will need to be considered. Increases in flood conditions associated with sea level rise would also gradually reduce the flood immunity of the road over time.

Community Acceptance (based on previous consultation)	High

Improvement of flood access through local road raising is expected to have general community support. Individual landholders may be impacted upon through the construction process.

Cost /resources	Medium

The initial cost of investigation is relatively minor, though would need coordination with a number of service providers. The planning, design and capital costs associated with the program would be dependent of the scale of works, including the requirement to relocate or modify existing services such as drainage, water supply, sewer etc..

Flood Planning Controls Incorporated in Development Control Plan 106 Amendment 1	**Recommended**

Description of the Option

The existing Development Control Plan 106 Amendment 1 provides a suite of planning controls for new development on flood prone land. DCP 106 includes a schedule of generic controls which apply to flood prone land where a Floodplain Risk Management Plan has not been adopted.

In addition to the existing generic controls (which are largely deemed appropriate) the following specific controls in the study area are recommended to be included in DCP 106 upon adoption of the Floodplain Risk Management Plan:

- No intensification of development - no dual occupancies or sub-divisions to be permitted in high hazard flood zones which would increase potential risk to life and demands on emergency services.
- No filling – a moratorium on filling is proposed until a long term climate change adaptation strategy is established and practical guidelines established for incremental filling if pursued. (refer to filling option summary sheet for further detail)
- Emergency plans - A flood emergency response and evacuation plan to be mandatory for all new development. Such plans would be required to demonstrate understanding of flood warning, emergency response procedures, effective evacuation routes and post-flood recovery considerations.
- Climate change review – current FPLs based on design flood levels incorporating 0.4m sea level rise – projected 2050 case. Given susceptibility of the study area to increased flood risk associated with potential sea-level rise, and general design life of development (>50years), regular review (say 5-10yrs) of adequacy of FPLs recommended.

Performance	Medium

Implementation of the development controls recommended will provide for future development more compatible with the flooding environment. The controls will prevent existing flood risk and demand on emergency services being exacerbated through inappropriate development of the identified flood prone lands.

Because of the incremental nature of development, the benefits of flood planning controls may not be realised for many years. Given the number of existing properties identified at risk of flooding, there is not expected to be any significant reduction in existing flood risk in the short-medium term (5 – 20yrs) achieved through controls on redevelopment.

Practicality	High

Land use planning and development controls are a key mechanism by which Council can manage future flood risk by legally controlling and directing future development and redevelopment of private and public lands.

One of the future challenges of Council will be managing the potential flood risks associated with climate change and sea level rise. Without intervention, certain localities within the LGA will experience gradual changes in flooding frequency, duration and depth as time passes. The DCP in association with broader land-use zoning are key mechanisms by which to pre-emptively adapt to this future.

Development Control Plans (DCP) can be amended at any stage in the future hence the opportunity always remains to improve flood planning controls as understanding of flood risks become more refined.

Community Acceptance (based on previous consultation)	Medium

The community acknowledge the importance of flood planning controls to restrict inappropriate development in flood prone areas. The controls don't impose any modifications to existing dwellings at risks. However, implementation of the controls through redevelopment will see a gradual change in the building landscape.

Cost /resources	High

There are minimal cost implications representing Council staff costs to modify and maintain the appropriate flood planning policy and control documents which would be covered under normal operating budgets. Implementation of the policies would be achieved through the normal development assessment and approval functions within Council.

Voluntary House Raising Raising of floor levels of individual properties - further investigation of scheme viability	**Recommended**

Description of the Option

Voluntary house raising is aimed at reducing the flood damage to houses by raising the habitable floor level of individual buildings above an acceptable design standard (e.g. 1% AEP Flood Level +0.5m).

House raising does have limited application in that it is not suited to all building types. Typically house raising is suited to most non-brick (e.g. clad, timbered framed houses) single story houses constructed on piers and not for slab on ground construction. An indicative cost to raise a house is of the order of $70,000 which can vary considerably depending on the type and size of the structure. Eligibility criteria for house raising schemes vary around the country but funding can be available for house raising in NSW and has been widely applied.

As an alternative to direct house raising, subsidies schemes have also been made available to re-building. For many properties, the opportunity to rebuild may be more attractive than raising the existing dwelling. Residential property owners with houses with floor levels which are low enough to qualify may choose to invest this subsidy into physically raising the house or into demolishing and rebuilding the house at a higher floor level.

Performance	Medium

Voluntary house raising provides a direct benefit in terms of reduced economic damages. Given the number of existing at-risk property, if an extensive house raising program was established, a significant reduction in flood damages may be realised.

House raising does not eliminate the risk. Larger floods than the design flood (used to establish minimum floor level) will still provide building damages and the option does not address personal safety aspects. These risks are still present as the property and surrounds are subject to inundation and therefore the flood access and emergency response opportunity is still compromised. To be effective, house raising would need to be undertaken in concert with a road raising program to address the potential problems of raised property becoming isolated by floodwaters.

Practicality	High

The viability of such a scheme is dependent on establishing a suitable funding model and the uptake of the scheme given that it is on a voluntary basis. Further investigation is recommended to establish the level of community support and therefore uptake potential, to assess the merit of including a Voluntary House Raising scheme in the Floodplain Risk Management Plan.

As the majority of houses suitable for house raising are located on the lowest parts of the floodplain, the long term viability and management of these areas should first be addressed given the potential threat associated with future sea level rise. That is, there would be little value in raising these houses if after 40 years or so these locations either become unliveable, are unable to be readily serviced by public utility and infrastructure (e.g. roads, drainage, water supply) for the life of the asset or are subject to broadscale acquisition and redevelopment.

In considering a house raising of individual property, it must also be recognised that:

- not all timber framed, clad homes are structurally suitable for raising;
- it changes the appearance of a house;
- may create difficulties in accessing public utility services; and
- those with mobility restrictions may not be able to easily access the house.

The broader impacts of house raising should not be overlooked, as it will potentially change the visual character of a house and possibly the street / suburb.

Community Acceptance (based on previous consultation)	Medium

Direct consultation with landholders with potential for house raising must be undertaken initially to establish the level of support, with explanation of:

- conditions of the subsidy offer (to be determined)
- susceptibility of the house to flooding;
- anticipated benefits of raising the floor level of the house
- funding arrangements.

Cost /resources	Medium

As noted, the scheme can only be implemented if a suitable funding model/program is established. The overall cost will be dependent on the uptake, with potential for several millions of dollars.

Improved Flood Warning Provide improved flood forecasting and warning system/procedures	**Recommended**

Description of the Option

At present, the only warnings available are generic, and automatically generated by the Bureau of Meteorology in response to severe weather warnings. Water levels in the entrance channel are monitored at the water level gauge. Being located right at the downstream end of the system, the use of real-time water level data at the gauge to issue flood warnings provides for little effective warning and response time. Furthermore, the time from the onset of rain to the point at which floodwaters become hazardous can be a matter of hours in some locations, particularly in the more extreme events. This means that any realistic warnings would need to be disseminated to a large number of people very rapidly.

The main improvement that could be made to the existing system is the forecast of levels based on combinations of real-time and forecast rainfall. Additional telemetered gauges for the upstream area should also be considered in further developing a warning system capability for the catchment.

Performance	High

A lack of warning time means that there is only a limited amount of assistance that can be provided during the event. In reality, most people would be largely self-reliant during a flood. Agencies can, however, help people make more appropriate decisions during these floods through giving as much warning as possible (via an integrated flood warning system), and through flood emergency planning provisions.

The nature of flooding is such that warning times are can be short. The amount of time available for evacuation is largely dependent on the available warning time. Adequate warning time can give residents the opportunity to move property above the reach of floodwaters and to evacuate from the area to higher ground. The effectiveness of a flood warning scheme depends on both the actual warning time provided before the onset of flooding and the flood awareness/readiness of the community in responding to a warning.

Practicality	Medium

The prime responsibility for flood warning rests with the Bureau of Meteorology. At a local level, the SES is responsible for dissemination of warnings and implementation of emergency response procedures. An improved flood warning scheme would need to be consistent and integrated with the existing formal responsibilities and systems of the Bureau of Meteorology.

Options for flood warning enhancement will need to consider appropriate gauge/reporting locations, integration into existing flood warning systems, installation and operating costs, ownership, management and maintenance responsibilities, and opportunities for funding of a proposed system.

Community Acceptance (based on previous consultation)	High

There is general widespread support for this option.

Cost /resources	High

Improving the flood warning system is relatively inexpensive and is likely to have a high benefit/cost ratio. Improvements in the system will require considerable cooperation between Council, BoM and the SES to develop and implement an appropriate system, consistent with the existing functions and responsibilities of each agency.

Update Flood Emergency Plan

Update and implement the SES local Flood Emergency Plan

Recommended

Description of the Option

The Shoalhaven Local Flood Plan (LFP) outlines preparedness and management operations for all flooding events within the Shoalhaven local government area. Information contained in the LFP is largely derived via local knowledge, historical record and completed flood studies. The SES follows the LFP, using information from Flood Intelligence and BoM's predictions, to respond in actual flood events.

It is important that the SES Plan incorporates all relevant technical data and specific community vulnerabilities (including addresses of areas at highest risk) that have been determined through the Floodplain Risk Management process. Provision of this data is particularly important with regard to those areas that need to evacuate ahead of ocean or catchment flooding cutting off their evacuation routes.

The concept of a "Community Flood Emergency Response Plan" should be explored. The Plan would provide information regarding evacuation routes, refuge areas, what to do/not to do during a flood event etc. If such a plan is developed and embraced at a community level, the self-sufficiency in terms of flood response of what is a relatively concentrated community would maximise potential for effective emergency response and a non-reliance on formal emergency services.

Performance — High

A range of information and data is incorporated to inform the evacuation planning process, including:

- Demographic data;
- Major evacuation routes;
- Location of evacuation centres;
- Relevant historical flood information;
- Gauge levels associated with road closures (where known);
- Vulnerable centres, such as schools, nursing homes and caravan parks; and
- Descriptions of local flood behaviour (e.g. speed of flood onset between villages, potential sources of flooding, etc).

Local flood intelligence needs to be updated with the flood level data derived from the current flood study and linked to the property databases established. An extensive amount of flood data has been generated through the flood study and floodplain risk management study which is readily available to be incorporated into the existing Plan.

Practicality	High

For rapid onset of flooding it would not be realistic to expect the SES to be able to undertake much in the way of emergency response for several reasons:

- The SES is principally a volunteer organisation and the time required to mobilise personnel could exceed the warning time available;
- A major flood event is likely to coincide to major flooding in other catchments within the Shoalhaven Region further stretching already limited emergency response resources;
- Many of the principal roads within the region are cut early in major floods making access difficult for mobilising or responding; and
- There is generally insufficient time to undertake tasks such as sandbagging or evacuation to reduce impacts on property or people.

In some floods the SES's role may be limited to executing rescues and assisting with recovery after the event.

Community Acceptance (based on previous consultation)	High

There is general widespread support for this option.

Cost /resources	High

Update of the Local Flood Plan will require some inputs from both Council and the SES, however, the nominal staff costs are expected to be covered under normal operating budgets and responsibilities of each agency.

Community Awareness Program Undertake extensive community education and awareness program	**Recommended**

Description of the Option

An ongoing flood awareness program should be pursued through collaboration of the SES and Council (e.g. specific FloodSafe program). The aim of this program would be to:

- Increase community awareness of flood risk;
- Increase community understanding of what to do before / during / after floods; and
- Increase awareness of SES role and other agencies.

Further planned strategies to pursue may include media releases, SES community education training, additional brochures targeting sectors of the community, flood risk workshops with community groups, tourist park owners, and businesses.

Performance	High

The proposed Community Education Program aims to help people make the right decisions when faced with flooding. The Program will provide people with a greater understanding of local flooding conditions, including flooding that has not been experienced to date. The Program also aims to arm the community with knowledge about what to do during a flood event, and more importantly, what not to do in a flood. Community education is being given the highest priority in this Floodplain Risk Management Plan for several reasons:

- Education is required to build a flood-resilient community who is prepared for flooding and able to respond to and recover from actual. The community have had limited flood experience across the full range of flood frequencies and flood types but are particularly vulnerable;
- Community education will be important in helping people understand the risks and how they can be managed and equipping themselves to fulfil their role;
- Without community education, other elements of the plan such as flood warning, evacuation planning, personal response plans and flood proofing would be less effective;
- Because of their dependence on technology and human action, flood warnings and emergency response cannot be considered as failsafe, particularly in the flash flood catchments, so it is critical that the community knows how to self-respond to an actual flood without assistance from combat agencies such as SES or Police.
- It will take time for many elements of the plan to be implemented, particularly those that will gradually remove development from the most hazardous parts of the floodplain. In the interim,

community flood response will be the only effective way to manage risks to life and property in these areas;

- Even if all other elements of the plan are fully implemented, there will still be a residual or continuing risk that needs to be managed by appropriate community flood responses.

Practicality	High

The community consultation program undertaken in development of the Flood Plan, and previously during the Flood Study, have initiated dialogue with the community in respect to flood risk as an initial step in increasing flood awareness. Through the questionnaire response provided, the general awareness of potential flood risk in the community was relatively low, particularly in relation to the scale of potential flooding and property inundation. It is imperative that the initial progress made through the development of the Flood Plan is built upon.

A Community Awareness program will need to be ongoing such that flood information relayed to the community is kept up to date, maintaining flood awareness during periods of no flooding, and to ensure new members of the community have access to appropriate flood information.

Community Acceptance (based on previous consultation)	High

The community has generally voiced an interest in understanding more about flooding including how they may be affected, where to find flooding information, what flood warnings are available and through what means they are available.

Cost /resources	Medium

Council and the SES will have the prime responsibility for undertaking the community awareness and education program. A range of initiatives are available e.g. printed brochures, community displays, workshops, school programs, websites and social media. The ongoing measures to be implemented will require coordination between agencies and ongoing refinement and assessment of the effectiveness of each element.

Additional Investigations Undertake a range of additional technical, social and economic studies	**Recommended**

Description of the Option

The following additional studies have been identified to be undertaken as a priority to further inform ongoing Floodplain Risk Management:

- Undertake appropriate studies to establish strategic position in regards to land at risk from permanent inundation and identify appropriate land use transition strategies.
- Investigate alternative building forms to provide housing stock more adaptable to climate change. Can include a review of the suitability of slab on ground construction in foreshore areas.
- Undertake a detailed review of the provision and maintenance of services and infrastructure with consideration of future climate change scenarios (responsibility of Council, Shoalhaven Water and other services providers).
- Investigate changes to current entrance management practices (recommended to continue as an interim measure in the short-term), including raising current trigger levels, to provide for more effective manual breakouts.
- Discuss Princes Highway upgrade, to 1%AEP standard or higher to promote serviceability during floods, with RMS

Performance	High

The potential for climate change impacts increasing flood risk in the future presents immediate challenges for floodplain management. Many of the floodplain management options in addressing flood risk to existing property are dependent on the long-term viability of continued occupation of the floodplain in these areas. Through ongoing approval of development in flood risk and investment (public and private) in flood protection measures there is the inherent assumption that development in these areas has a viable future.

However, under sea level rise scenarios, the continued habitation and redevelopment of parts of the floodplain will become increasingly difficult to sustain. With increasing flood risk, the provision and maintenance of services and infrastructure become increasingly expensive or impractical.

The continued occupation of currently affected flood prone land would require raising of existing ground level through extensive land filling to combat the risk of rising lake levels and associated inundation and groundwater problems. If adaptation of existing developed areas cannot be achieved in an economically, socially and environmentally acceptable manner, then a planned retreat of current occupied flood prone land may be appropriate land use strategy.

The range of additional investigations recommended are essential to establish a long-term strategy for continued occupation of the floodplain which directly impacts on floodplain risk management in the short, medium and long-term.

Practicality	High

These are very complex issues with considerable social implications requiring extensive consultation with the community a detailed supporting investigations of social, economic and environmental issues. Depending on the rate at which sea level rise impacts manifest, implementation of adaptation plans may not be necessary for some years. Whilst such a decision does not need to be made immediately, Council should be preparing for such an ultimatum in the near future (within the next 10 years or so, or as the realities of sea level rise start to manifest). Nevertheless, appropriate planning should be commenced immediately to provide sufficient time to develop site specific adaptation plans and develop funding models. Further, Council should be considerate of these long term objectives in setting zonings and building controls for new development proposed in these areas.

This is a complex planning issue which goes far beyond floodplain management alone. Whilst permanent inundation and flooding may be the driver, there is far reaching social, economic and environmental implications to consider. For Council, this scenario is not isolated to the study area, and other existing low-lying communities will be subject to the same considerations. This only enhances the requirement for undertaking appropriate assessments and establishing a strategic position for such development across the LGA.

Community Acceptance (based on previous consultation)	High

A significant component of the additional investigations will involve extensive community consultation. Accordingly, the community's expectations and views will play a major role in long term land use strategies.

Cost /resources	Low

The additional investigations are detailed multi-faceted studies requiring input from a range of Council departments, State and Federal Government Departments and Agencies, utility service provides, local industry and commerce and the broader community. . Despite potential costs and timeframes involved in completing the assessments, they are considered essential for appropriate ongoing floodplain risk management.

Flood Proofing Building renovations with use of more flood resilient materials	**Recommended**

Description of the Option

Flood proofing refers to the design and construction of buildings with appropriate water resistant materials such that flood damage is minimised should the building be inundated. Flood proofing is more effectively achieved during construction with appropriate selection of materials and design. Development Control Plan 106 already includes requirements for flood proofing of buildings for new development. However, there are a number of non-structural options that can be retrofit to existing property to help reduce flood damage including changes to joinery and fittings, floor coverings and electrical services.

Performance — Medium

The extent of damage, cost of repairs, inconvenience and cleaning required following a flood event will depend on many factors including depth and velocity of water, period of inundation, amount of debris and silt in floodwater, and type of materials and construction. If floodwaters cannot be excluded from a property through other measures, flood proofing may provide a direct benefit in terms of reduced economic damages and social disruption.

Practicality — High

Homeowners of flood prone property are potentially vulnerable to major losses in the absence of comprehensive domestic flood insurance. These losses may be reduced through suitable material selection. It is likely however that retrofitting existing property would only come after a flood event rather than an initial outlay as a pre-emptive measure. Nevertheless, future flood damages can be reduced.

Community Acceptance (based on previous consultation) — High

Property owners would be expected to undertake works at their own convenience. A public awareness campaign may help to inform the community of flood proofing measures, and could be supplemented with individual building inspections and property owner interviews. Encouragement to be more flood-resilient can be linked to the recommended Community Education Program.

Cost /resources — High

Costs are borne by individual landholders with works on a voluntary basis.

Land Filling Local filling of lots for redevelopment at higher elevation	**Not Recommended**

Description of the Option

Local land filling can be an effective means to eliminate or reduce the frequency of flood inundation. Typically the filling would be undertaken to provide an elevated building pad above a nominal flood level (usually the 1% AEP design flood standard).

Existing development occupies the majority of land that would benefit from filling, accordingly, filling would only take place in conjunction with redevelopment. . Given existing ground levels, and depth of flooding for major design events, some of the lowest-lying property could require up to 2m of fill depth with the majority of properties requiring in excess of 1m.

Performance	Medium

With redevelopment over time, much of the existing flood risk can be removed with houses rebuilt at higher levels. Given the incremental nature of redevelopment, this benefit would accrue relatively slowly and would not address the flood risk effectively in the short to medium term.

Filling of floodplain areas can affect the overall flood storage volume available and can impede flow paths. The proportion of lost storage from the floodplain for identified fill areas is relatively small in comparison to the overall Lake storage volume, and also the conveyance of floodwaters is already largely restricted by the size of the entrance channel. Accordingly, the cumulative impacts of filling on general flood levels attained in the Lake and estuary is not significant.

Practicality	Low

The incremental filling of land on a property by property basis however presents complex engineering challenges and practical issues of implementation:

- Access to infrastructure and services – land filling options will only work if there is a corresponding adaptation of roads, stormwater drainage, water supply, sewerage, communications and other public and utility infrastructure. The piecemeal approach to land filling via redevelopment of individual properties provides issues with connectivity to these services.

- Local drainage – incremental filling will provide for considerable discontinuity in the local land surface which may cause issues for local drainage. Impediment to local overland drainage, creation of sag points and interference to existing subsurface drainage systems are potential impacts.

- Concentration of floodwaters – in times of flood, filled lots would provide for a complete obstruction to flood flows which may result in a redirection and concentration of floodwater on unfilled lots. This impact can considerably increase the flood risk on affected lots through increased velocity of floodwater. In extreme cases, higher velocities may provide for structural damage of properties.

- Overshadowing – the required fill heights and subsequent reconstruction of suitable dwellings is likely to provide significant overshadowing of "unfilled" neighbouring property.
- Visual impact (suburb character) – ultimately when entire areas are redeveloped, the general character of the area may be improved. However the piecemeal approach of incremental redevelopment would have a marked impact on the landscape in the interim period with a random mix of existing and redeveloped property at significantly different levels
- Loss of foreshore – filling to existing lot boundaries on properties adjacent to the public space foreshore areas of the Lake will ultimately provide for a complete loss of the foreshore environment with sea level rise. With private property boundaries right at the water edge, public access to the waterway would be limited as would the opportunity for public foreshore infrastructure such as boat ramps, picnic tables and chairs etc.
- Environmental impacts – the loss of foreshore may have significant environmental impacts. Shallow foreshore areas are important for a range of terrestrial and aquatic flora and fauna and creating a hard edge at the waterway provides no space for ecological communities to migrate in response to rising Lake levels.

Community Acceptance (based on previous consultation)	Low

Property owners would be expected to undertake works at their own cost at time of redevelopment. . A public awareness campaign may help to inform the community of flood proofing measures, and could be supplemented with individual building inspections and property owner interviews. Encouragement to be more flood-resilient can be linked to the recommended Community Education Program. The staging of the redevelopment presents the most challenges and would require community support.

Cost /resources	Medium

Costs are borne by individual landholders with works on a voluntary basis. Filling lot by lot is only expected to work if there is a commitment to raise roads and other infrastructure and utilities, which would. come at a significant public and private cost.

BMT WBM Brisbane	**Level 8, 200 Creek Street Brisbane 4000** **PO Box 203 Spring Hill QLD 4004** **Tel +61 7 3831 6744 Fax +61 7 3832 3627** **Email bmtwbm@bmtwbm.com.au** **Web www.bmtwbm.com.au**
BMT WBM Denver	**8200 S. Akron Street, Unit 120** **Centennial Dever Colorado 80112 USA** **Tel +1 303 792 9814 Fax +1 303 792 9742** **Email denver@bmtwbm.com** **Web www.bmtwbm.com.au**
BMT WBM Mackay	**Suite 1, 138 Wood Street Mackay 4740** **PO Box 4447 Mackay QLD 4740** **Tel +61 7 4953 5144 Fax +61 7 4953 5132** **Email mackay@bmtwbm.com.au** **Web www.bmtwbm.com.au**
BMT WBM Melbourne	**Level 5, 99 King Street Melbourne 3000** **PO Box 604 Collins Street West VIC 8007** **Tel +61 3 8620 6100 Fax +61 3 8620 6105** **Email melbourne@bmtwbm.com.au** **Web www.bmtwbm.com.au**
BMT WBM Newcastle	**126 Belford Street Broadmeadow 2292** **PO Box 266 Broadmeadow NSW 2292** **Tel +61 2 4940 8882 Fax +61 2 4940 8887** **Email newcastle@bmtwbm.com.au** **Web www.bmtwbm.com.au**
BMT WBM Perth	**Suite 3, 1161 Hay Street West Perth 6005** **Tel +61 8 9328 2029 Fax +61 8 9484 7588** **Email perth@bmtwbm.com.au** **Web www.bmtwbm.com.au**
BMT WBM Sydney	**Level 1, 256-258 Norton Street Leichhardt 2040** **PO Box 194 Leichhardt NSW 2040** **Tel +61 2 9713 4836 Fax +61 2 9713 4890** **Email sydney@bmtwbm.com.au** **Web www.bmtwbm.com.au**
BMT WBM Vancouver	**401 611 Alexander Street Vancouver** **British Columbia V6A 1E1 Canada** **Tel +1 604 683 5777 Fax +1 604 608 3232** **Email vancouver@bmtwbm.com** **Web www.bmtwbm.com.au**