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# SMITHS LAKE FLOODPLAIN RISK MANAGEMENT STUDY


**Issue 1**

**10th October 2015**

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**SMITHS LAKE FLOODPLAIN RISK MANAGEMENT STUDY**

## Disclaimer



**Project: 301015-02840 - SMITHS LAKE FLOODPLAIN RISK MANAGEMENT STUDY**

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# ACKNOWLEDGEMENTS

The following report was prepared by WorleyParsons Services Pty Ltd on behalf of the Great Lakes Council's Floodplain Risk Management Committee.

The Smiths Lake Floodplain Risk Management Study has been funded jointly by Council and the Office of Environment and Heritage on a 1:2 subsidy basis, under the New South Wales Government's Floodplain Management Program.

It has been prepared by incorporating contributions from individuals from the local community and a range of key stakeholders.  Contributions from members of the Smiths Lake Floodplain Risk Management Committee have been essential to the formation of management strategies that have been considered as part of the Study and are greatly appreciated.

# FOREWORD

The NSW State Government's Flood Prone Land Policy is directed towards providing solutions to existing flooding problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas. Policy and practice are defined in the Government's Floodplain Development Manual (*2005*).

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

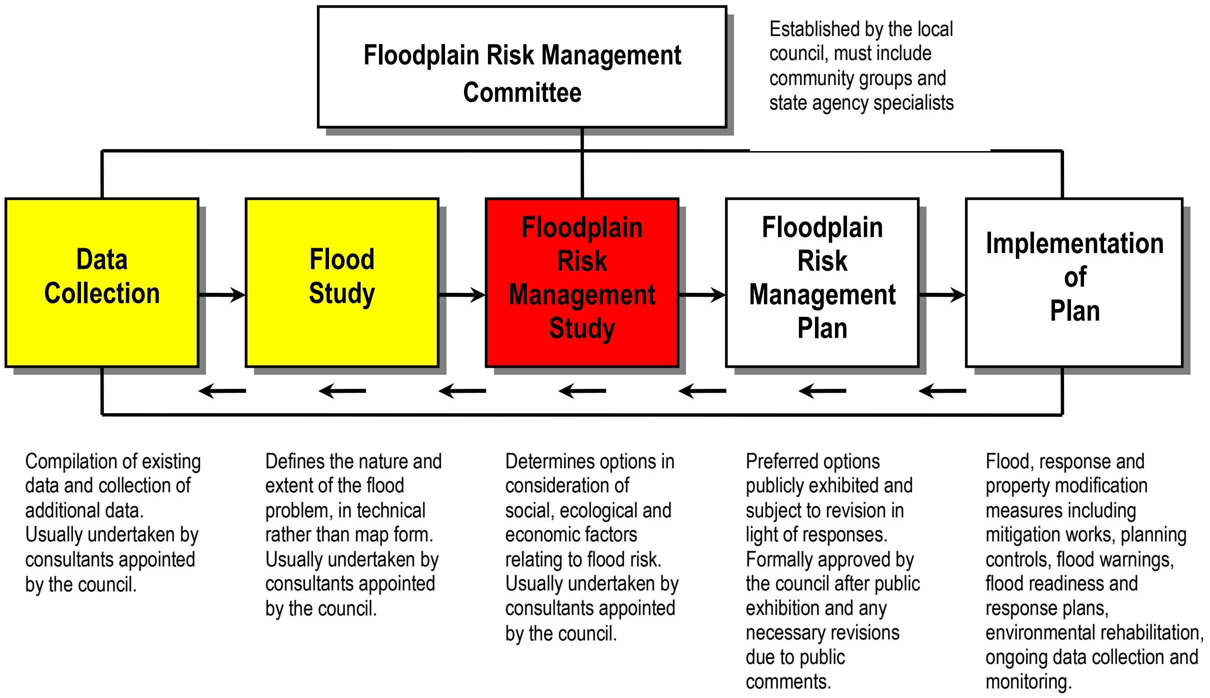
The Policy provides for technical and financial support by the State Government through the following four sequential stages:

## STAGES OF FLOODPLAIN RISK MANAGEMENT

| STAGE | DESCRIPTION |
|---|---|
| **1. Flood Study** | Determines the nature and extent of the flood problem. |
| **2. Floodplain Risk Management Study** | Evaluates management options for the floodplain in respect of both existing and proposed developments. |
| **3. Floodplain Risk Management Plan** | Involves formal adoption by Council of a plan of management for the floodplain. |
| **4. Implementation of Plan** | Results in construction of flood mitigation works to protect existing development and the application of environmental and planning controls to ensure that new development is compatible with the flood hazard. |

A detailed description of the inter-relationship between these stages is provided overleaf. The link between the various outcomes of the studies involved in the floodplain risk management process and the implementation of measures (*both planning and structural*) to reduce flood damages is also shown.

The Flood Study (*September 2008*) prepared by Webb McKeown & Associates represents the first of the four stages. It was prepared to assist the Great Lakes Council and the local community in understanding the extent and characteristics of flooding that could occur. The results from the Flood Study have been used as a base for investigations undertaken to prepare this Floodplain Risk Management Study for the area.




Source: *'Floodplain Development Manual'* (2005)

# GLOSSARY

Source: '*Floodplain Development Manual*' (*2005*).

**annual exceedance probability (AEP)**
The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. E.g., if a peak flood discharge of 500 $m^3/s$ has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m3/s or larger events occurring in any one year (see ARI).

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

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

**average recurrence interval (ARI)**
The long-term average number of years between the occurrence of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.

**caravan and moveable home parks**
Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.

**catchment**
The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.

**consent authority**
The council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the council, however legislation or an EPI may specify a Minister or public authority (other than a council), or the Director General of DIPNR, as having the function to determine an application.

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| **development** | Is defined in Part 4 of the EP&A Act:<br>– infill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development<br>– new development: refers to development of a completely different nature to that associated with the former land use. E.g., the urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.<br>– redevelopment: refers to rebuilding in an area. E.g., as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services. |
| **disaster plan (DISPLAN)** | A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies. |
| **discharge** | The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s). |
| **effective warning time** | The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions. |
| **emergency management** | A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding. |
| **flash flooding** | Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain. |

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| **flood** | Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage (refer Section C6) before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami. |
| **flood awareness** | Awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures. |
| **flood education** | Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness. |
| **flood fringe areas** | The remaining area of flood prone land after floodway and flood storage areas have been defined. |
| **flood liable land** | Is synonymous with flood prone land (ie) land susceptible to flooding by the PMF event. Note that the term flood liable land covers the whole floodplain, not just that part below the FPL (see flood planning area). |
| **flood mitigation standard** | The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding. |
| **floodplain** | Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land. |
| **floodplain risk management options** | The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options. |
| **floodplain risk management plan** | A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives. |

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| **flood plan (local)** | A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the SES. |
| **flood planning area** | The area of land below the FPL and thus subject to flood related development controls. The concept of flood planning area generally supersedes the "flood liable land" concept in the 1986 Manual. |
| **flood planning levels (FPLs)** | Are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "standard flood event" in the 1986 manual. |
| **flood proofing** | A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages. |
| **flood prone land** | Land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land. |
| **flood readiness** | Readiness is an ability to react within the effective warning time. |
| **flood risk** | Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below.<br>– existing flood risk: the risk a community is exposed to as a result of its location on the floodplain.<br>– future flood risk: the risk a community may be exposed to as a result of new development on the floodplain.<br>– continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure. |

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| **flood storage areas** | Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas. |
| **floodway areas** | Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels. |
| **freeboard** | Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. (See Section K5). Freeboard is included in the flood planning level. |
| **habitable room** | in a residential situation: a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom.<br>in an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood. |
| **hazard** | a source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in Appendix L of the Floodplain Development Manual. |
| **hydraulics** | term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity. |
| **hydrograph** | a graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood. |
| **hydrology** | term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods. |
| **local overland flooding** | inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam. |

**local drainage** — smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.

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

**major drainage** — councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purposes of this manual major drainage involves:

- the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or
- water depths generally in excess of 0.3m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or
- major overland flowpaths through developed areas outside of defined drainage reserves; and/or the potential to affect a number of buildings along the major flow path.

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

**merit approach** — the merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains.

The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into council plans, policy, and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local flood risk management policy and EPIs.

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| **minor, moderate and major flooding** | both the SES and the BoM use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:<br>– minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level ridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.<br>– moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.<br>– major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated. |
| **modification measures** | measures that modify either the flood, the property or the response to flooding. Examples are provided in Table 2.1 with further discussion in Appendix J of the Floodplain Development Manual. |
| **peak discharge** | the maximum discharge occurring during a flood event. |
| **probable maximum flood** | the PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snowmelt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event.<br>The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study. |
| **probable maximum precipitation** | the PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation. |
| **probability** | a statistical measure of the expected chance of flooding (see AEP). |

| | |
|---|---|
| **risk** | chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment. |
| **runoff** | the amount of rainfall which actually ends up as streamflow, also known as rainfall excess. |
| **stage** | equivalent to water level (both measured with reference to a specified datum). |
| **stage hydrograph** | a graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum. |
| **survey plan** | a plan prepared by a registered surveyor. |
| **water surface profile** | a graph showing the flood stage at any given location along a watercourse at a particular time. |

# 1. INTRODUCTION

Smiths Lake is located on the Mid North Coast of New South Wales, approximately 25 kilometres south of Forster and 250 kilometres north of Sydney. The lake drains a catchment area of 34 $km^2$ and has a surface area of approximately 12 $km^2$.

The township of Smiths Lake (*population approximately 1,000*) is the closest urban centre to Smiths Lake. The township is situated along the northern banks of the lake. A number of other townships border the lake including Tarbuck Bay and parts of Bungwahl. The "Sandbar" and "Bushland" caravan parks border Symes Bay and the University of NSW operates a research centre south of the lake, near Horse Point. The lake and its surrounds are shown on **Figure 1**.

Smiths Lake is classified as an Intermittently Open and Closed Lake or Lagoon (*ICOLL*). For the majority of time, the Lake entrance is closed to the ocean. Periodically however, the lake entrance is opened mechanically by Council in accordance with specified floodplain management protocols. The current trigger for mechanical opening of the entrance to Smiths Lake is based on a water levels within the lake reaching an elevation of 2.1 mAHD. Records of relief channel openings have been maintained since 1996, with 17 recorded openings between January 1996 and March 2013.

Elevated water levels in Smiths Lake can occur as a function of both catchment rainfall and elevated ocean levels, which can be caused by weather events including "East Coast Lows" and ex-tropical cyclones. It is not unusual for the weather systems which lead to elevated ocean levels to also bring large volumes of rainfall.

Great Lakes Council commissioned the 'Smiths Lake Flood Study' (2008), which was prepared by Webb McKeown & Associates Pty Ltd. This Floodplain Risk Management Study builds upon the findings of the 2008 Flood Study and identifies a number of measures to manage the existing flood risk, and provide appropriate measures for managing the future and continuing flood risk. An important aspect of this is the identification of appropriate plans to respond to the potential impact of climate change. These aspects need to be considered in the context of the *'Floodplain Development Manual'* (2005) and the NSW Government's Flood Prone Land Policy.

The primary objective of the NSW Government's *Flood Prone Land Policy* is to reduce the impact of flooding on individual owners and occupiers of flood prone land, and to reduce private and public losses caused by flooding. In this regard, the Policy recognises:

- that flood prone land is a valuable resource that should not be sterilised by unnecessarily precluding its development; and,
- that if all applications for development on flood prone land are assessed according to rigid and prescriptive criteria, some proposals may be unjustifiably disallowed or restricted, and equally, quite inappropriate proposals could be approved (NSW Government, 2005).

The first stage in this process involved the preparation of the *Smiths Lake Flood Study*. The Flood Study defined the flood behaviour at Smiths Lake. This included information on flood flows, levels and flood extents, for a range of design flood events under existing floodplain and catchment conditions.

FIGURE 1


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Rp2840_00 – Smiths Lake Floodplain Risk Management Study
fg02840_00gr121114-Fig1 [Catchment Area].doc

TOWNSHIPS AND OTHER FEATURES IN THE VICINITY OF THE SMITHS LAKE CATCHMENT

The next stage involves preparation of a Floodplain Risk Management Study. The associated assessment first involves consideration of the flood damages that residents and the broader community may experience as a consequence of the existing flood problem. These damages are a measure of the cost of flooding under existing conditions. The NSW Government's *Floodplain Management Program* is targeted toward determining measures that can be cost effectively implemented to reduce existing flood damages.

Typically, a range of potential flood damage reduction measures (*structural measures*) and potential planning controls (*non-structural measures*) are identified that could reduce the impact of floods. These measures are tested to establish their relative benefit, which is usually assessed in terms of the potential reduction in flood damages, or the potential for additional future development that can occur at no increased risk to the community. The measures are also costed and their respective costs compared to their net benefit, thereby allowing a benefit-cost ratio to be determined for each measure.

Measures with a high benefit-cost ratio are typically recommended for inclusion within a Floodplain Risk Management Plan, which is the fourth phase in the floodplain management process (*refer to flow chart in Foreword*).

Great Lakes Council has also recognised the importance of accounting for the potential flood related climate change impacts in management of the Smiths Lake floodplain. Council has adopted as policy the NSW Government's 2009 Sea Level Rise benchmarks. This study also considers the potential changes to flooding associated with the sea level rise benchmarks that have been adopted by Council. In doing so, the potential impacts on the existing entrance opening policy and infrastructure around the lake have also been assessed.

Therefore, this Floodplain Risk Management Report sets out to:

- Update the flood related investigations, for both present day and year 2060/2100 climate change conditions.
- Define the flood damages for both existing and Year 2060 climate change conditions.
- identify and evaluate management options for the floodplain in terms of their capacity to reduce existing and potential future flooding problems.
- Provide information on flood behaviour and flood hazard, so that community aspirations for future land use can be assessed on a consistent basis.
- Provide a framework for updating Council's flood related policies, so that land use controls are consistent with the flood risk defined by the study.

# 2. THE FLOODING PROBLEM

The contemporary flooding problem (or risk) in Smiths Lake can be broken up into three major components, namely:

- the existing flooding problem;
- the potential future flooding problem; and,
- the residual, or continuing flooding problem.

Measures to address these components are complicated by the social consequences of removing people from flood affected areas and the political and economic attractiveness of the floodplain lands due to their accessibility to existing infrastructure and their lower cost per hectare. Each component of the flooding problem is discussed in the following sections.

## 2.1 EXISTING FLOODING PROBLEM

The existing flooding problem relates to those areas where flood damages are likely to arise as a consequence of flooding. It concerns existing dwellings, commercial premises and tourist facilities that would be inundated during a flood, as well as all associated infrastructure within the floodplain, including roads, railways and utility services. In this context, the existing flooding problem is usually addressed by structural measures which aim to modify flood behaviour and thereby reduce flood damages.

Investigations undertaken as part of the *Smiths Lake Flood Study* involved detailed flood modelling of these processes to define the existing behaviour of flooding and tidal surge in Smiths Lake. The peak design flood levels established in the Flood Study are presented in **Table 1**. In this instance, the modelling undertaken for the Flood Study established that for all events from the 5% AEP up to the 0.2% AEP events, the peak flood level in the lake rises to a uniform level of 2.3 mAHD when analysed for flooding due to catchment rainfall. This is because the outflow capacity of the entrance channel, once formed, significantly exceeds inflows to the lake. For this reason, elevated ocean conditions defined the peak flood level for the 2% and 1% AEP events (*refer* **Table 1**).

**Table 1 ADOPTED DESIGN FLOOD LEVELS FOR SMITHS LAKE**

| Design Event Annual Exceedance Probability | Peak Flood Level (*mechanism*) |
|---|---|
| PMF | 3.5 mAHD (rainfall induced) |
| 1% | 2.6 mAHD (ocean induced) |
| 2% | 2.4 mAHD (ocean induced) |
| 5% | 2.3 mAHD (rainfall induced) |

*Source: Smiths Lake Flood Study* (*Webb McKeown & Associates, 2008*)

The Flood Study established that only one structure is inundated during the 1% AEP event. This is the "Frothy Coffee" café. A total of 7 residential properties are inundated by the PMF flood level of 3.5 mAHD.

There are two camping areas located at the eastern edge of the lake. The topography in the vicinity of the camping grounds is below the level of the 1% AEP event. While permanent structures at both camping grounds remain unaffected during the 1% AEP event, adequate evacuation of temporary infrastructure needs to be considered.

## 2.2 FUTURE FLOODING PROBLEM

The potential *future* flooding problem refers to those areas of the floodplain that are likely to be proposed for future development or to be the subject of rezoning applications.

As land resources for development become increasingly scarce, pressures mount to allow development within floodplain areas where it might otherwise be avoided.

Council has a duty of care to ensure that its current planning instruments recognise the potential flood risk. Council also has a responsibility to ensure that a Floodplain Management Plan is in place and that this Plan, or an associated *Flood Policy*, can be used to support decisions to approve or reject development proposals on flood affected sections of the Local Government Area (*LGA*).

## 2.3 RESIDUAL FLOODING PROBLEM

Unless the Probable Maximum Flood (*PMF*) is adopted as the basis for determining structural and planning measures aimed at reducing flood damages, there will always be a residual or continuing flooding problem.

However, the adoption of the PMF as the 'planning flood' is not realistic or practical because it would sterilise a large area of land, thereby forcing development to areas of higher ground which may not historically be serviced or which could introduce unrealistically high infrastructure costs.

Hence, a lesser flood standard is adopted. As a result, measures that are put in place to control flood damage will ultimately be overwhelmed by a flood that is larger than that adopted as the threshold for the planning control of land use, or as the limiting flood for the design of structural measures. Accordingly, it is incumbent upon Council to consider the implications of floods greater than the adopted planning flood and to work with the State Emergency Service (*SES*) to develop a contingency plan for such events.

# 3. CONSULTATION

Development of the Smiths Lake Floodplain Risk Management Study has involved consultation with the following key stakeholders:

- Great Lakes Council officers – provision of available data and technical information
- The NSW Office of Environment and Heritage (OEH) – provision of available data and technical review.
- Great Lakes Floodplain Management Committee – anecdotal flood information and technical advice provided during Committee meetings
- State Emergency Service (*Hunter Region*) – provision of existing Local Flood Plans for emergency management
- The local community – provision of historic flood information during Flood Study phase of work, in addition to feedback on the proposed management strategies that were obtained during community consultation.
- Advice from local utilities related to infrastructure surrounding the lake, particular Mid-Coast Water.

Great Lakes Council has also employed an integrated floodplain management approach for flood risk management for Smiths Lake. This was guided by a Gateway Determination that was issued by the NSW Department of Planning and Environment on 28 August 2014. Community engagement effort was shared between Council's Design and Investigation Division and its Strategic Planning Division. This approach provided a more effective forum for the public to discuss a wider range of matters covering flood modelling, flood hazard, emergency response and potential strategic planning approaches for managing the flood risk.

The Planning Proposal, Draft Great Lakes Development Control Plan (DCP) Amendments and Draft Smiths Lake Floodplain Risk Management Study, were all placed on public exhibition together in accordance with the Gateway Determination. The public exhibition of these documents occurred between 22nd December 2014 and 30th January 2015, inclusive. During the public exhibition period Council officers organised official notifications in all local newspapers. During this period, public information sessions were held in Stroud, Nabiac, Tea Gardens, Pacific Palms and Forster. Media releases were also issued and a notification was placed in the January 2015 edition of the Council Communicator. The Council Communicator was sent to 18,376 rate payers. An information session was also held at Tea Gardens on Thursday, 15th January 2015.

The hard copy documents were available at all Council District Offices and the Customer Service Centre in Forster during the public exhibition period and all information was available on Council's website. No submissions were received in response to the public exhibition of the Smiths Lake Floodplain Risk Management Study. This is viewed as being due to the general acceptance of the modelling approach and the results contained in the final report. It is also likely to reflect a public realisation that flooding of the lake system is not expected to result in any significant consequences for private residents. Larger landowners and potential developers are already in discussion with Council and are aware of flooding implications for their particular properties. Future developments and release areas can therefore be guided by the management options proposed by the Study.

# 4. EXISTING FLOODPLAIN RISK MANAGEMENT MEASURES

## 4.1 THE ROLE OF PLANNING IN FLOODPLAIN MANAGEMENT

Flooding is a significant naturally occurring hazard to the utilisation of land. Since the early days of European settlement of New South Wales, development has occurred within the floodplain which has not fully appreciated the implications of the nature and extent of the flood hazard. Development of these areas has occurred due to the proximity of transport corridors such as the rivers flowing through the floodplain, the flatness of floodplain lands which rendered them easier to build on, and more recently, the relatively lower cost per hectare.

Future changes to the Smiths Lake community including population increases and new developments may lead to pressure to maximise the utilisation of land in the Smiths Lake catchment area. These pressures include urban expansion within the context of existing land-uses and current zonings, as well as programmed and potential future urban releases.

In this context, appropriate floodplain management needs to recognise the <u>full</u> flood risk. That is, it must relate to the <u>whole of the floodplain</u> and not just to one isolated component of the floodplain defined by a particular flood occurrence, such as the area inundated in the 1% AEP flood.

This, however, does not mean that there should be restrictions on development within the entire floodplain. Instead, there should be a holistic approach to the management of the floodplain commencing from its broadest extent and progressively focusing inwards to more critical aspects of the use of the floodplain, such as development on land frequently affected by floods. This holistic approach may in some cases, reveal the capacity for more intense development for certain types of land-uses, as opposed to the rigid application of a global flood standard.

Generally, the management of a floodplain is approached by the imposition of either structural or non-structural measures. Traditionally, structural measures have played a major role. However, contemporary thinking in floodplain management is more focussed toward the implementation of non-structural measures. Non-structural measures include increased public awareness, property acquisition and the establishment of flood evacuation procedures. More recently, there has been an increased emphasis on developing floodplain management plans that recommend changes to planning controls contained within Council planning instruments such as Local Environmental Plans (*LEPs*) and Development Control Plans (*DCPs*).

## 4.2 EXISTING FLOOD MITIGATION MEASURES

The *Smiths Lake Flood Study* established that flooding presents a low risk to life and property in the vicinity of Smiths Lake. This is a consequence of adoption of appropriate planning controls and also the manner in which the lake entrance opening is managed. Mechanical opening of the Smiths Lake entrance represents the main existing flood mitigation measure which is implemented at Smiths Lake.

The current operating procedure for mechanically opening the entrance at Smiths Lake is described in Appendix B of the '*Smiths Lake Coastal Zone Management Plan*' (*in draft, 2010*). This indicates that entrance opening is to be initiated once the lake level reaches 2.1 mAHD and that the location for the entrance opening is defined by the MGA grid coordinates 0454742 East and 6415678 North.

The entrance is opened mechanically by an excavator digging a channel across the berm which is then scoured and progressively deepened by lake outflows. As shown in the results of flood modelling, levels in the lake typically rise a maximum of 0.2 metres above the trigger level, limiting the inundation on low lying property.

## 4.3 CURRENT PLANNING INSTRUMENTS

The Great Lakes Council's *Flood Management Policy* was adopted in 1985. The Policy is generally consistent with the NSW Government's *Floodplain Development Manual*. The Policy specifies that the 1% AEP flood event is adopted as the design flood for planning and general risk management purposes and that a minimum of 0.5 metres freeboard above the 1% AEP peak flood level should be provided for development.

In addition to the Flood Management Policy, there are a number of reports which address flooding in the Smiths Lake catchment, including:

- *Great Lakes Local Environmental Plan* (*1996*).
- *Draft Great Lakes Local Environmental Plan 2012* (*in draft*).
- *Great Lakes Council Sea Level Rise Policy* (*2011*).

The flood related aspects of these policies are summarised below.

### *Great Lakes Local Environmental Plan* (*in draft, 2012*)

The draft *Local Environment Plan* (*LEP*) includes the following provisions for the regulation of works that are proposed on flood prone land:

*7.4 Flood Planning*

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

*(a) to minimise the flood risk to life and property associated with the use of land,*

*(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,*

*(c) to avoid significant adverse impacts on flood behaviour and the environment.*

*(2) This clause applies to:*

*(a) land that is shown as "Flood planning area" on the Flood Planning Map, and*

*(b) other land at or below the flood planning level not shown as 'flood planning area' on the Flood Planning Map.*

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

*(a) is compatible with the flood hazard of the land; and*

*(b) will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and*

*(c) incorporates appropriate measures to manage risk to life from flood, and*

*(d) will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and*

*(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.*

*(4) Subclause (5) applies to:*

*(a) land shown as "projected 2100 flood planning area" on the Flood Planning Map; and to*

*(b) other land below the projected 2100 flood planning level as a consequence of projected sea level rise not shown as 'flood planning area' on the Flood Planning Map*

*(5) When determining development to which this subclause applies, council must take into consideration any relevant matters outlined in subclause 3(a) – (e), depending on the context of the following:*

*(a) the proximity of the development to the current flood planning area; and*

*(b) the intended design life of the development; and*

*(c) the scale of the development; and*

*(d) the sensitivity of the development in relation to managing the risk to life from any flood; and,*

*(e) the potential to relocate, modify or remove the development.*

*(6) A word or expression used in this clause has the same meaning as it has in the NSW Government's Floodplain Development Manual published in 2005, unless it is otherwise defined in this clause.*

*(7) In this clause:*

***flood planning area** means the land shown as "Flood planning area" on the Flood Planning Map*

***flood planning level** means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metres freeboard.*

***Flood Planning Map** means the Great Lakes Local Environmental Plan 2012 Flood Planning Map.*

***projected sea level rise** means the 2100 sea level rise planning benchmarks as specified in the NSW Government's Sea Level Rise Policy Statement 2009.*

### *Great Lakes Council Sea Level Rise Policy (2011)*

In 2009, the NSW Government set benchmarks for sea level rise based on the upper bound of projections, as identified by CSIRO. The benchmarks are a rise of 0.4 metres by year 2050 and a rise of 0.9 metres by 2100. Council has also adopted a rise of 0.5 metres for year 2060, which represents a linear interpolation between the 2050 and 2100 levels. The significance of 2060 conditions is that it corresponds to a 50 year timeframe, which represents Council's adopted baseline planning timeframe.

## 4.4 LOCAL FLOOD PLAN AND EMERGENCY RESPONSE PROTOCOLS

It is understood there is no DISPLAN in place for Smiths Lake. However, the SES has prepared a DISPLAN for the Great Lakes Council Local Government Area, which provides general guidance regarding evacuation during flood and storm events.

# 5. UPDATED FLOOD MODEL DEVELOPMENT

Both the hydrologic and hydraulic models developed as part of the *Smiths Lake Flood Study* were updated in the course of preparing the Smiths Lake Floodplain Risk Management Study. The following section summarises the process used to update the hydrologic and hydraulic models which were developed to assist in preparing the Floodplain Risk Management Study.

## 5.1 HYDROLOGIC MODEL UPDATE

A hydrologic model of the Smiths Lake catchment was developed to simulate rainfall and runoff processes and produce creek flows (*discharges*) that are required to determine flood levels. Hydrologic modelling undertaken for the *Smiths Lake Flood Study* employed the Watershed Bounded Network Model (*WBNM*) hydrologic modelling software.

In preparing the Floodplain Risk Management Study, the existing hydrologic model was updated to the Runoff Analysis and Flow Training Simulation (XP-*RAFTS*) software package. XP-RAFTS is a deterministic runoff routing model that is recognised in *Australian Rainfall and Runoff – A Guideline to Flood Estimation* (1987), as one of the available tools for use in flood routing within Australian catchments.

While WBNM and XP-RAFTS have similar capabilities, XP-RAFTS was selected since it provides the user a greater level of control over treatment of the entrance break-out. This meant that RAFTS could be employed to inform the cases considered critical for assessment via the hydrodynamic model. The following sections describe the RAFTS model development process.

### 5.1.1 Sub-Catchment Details

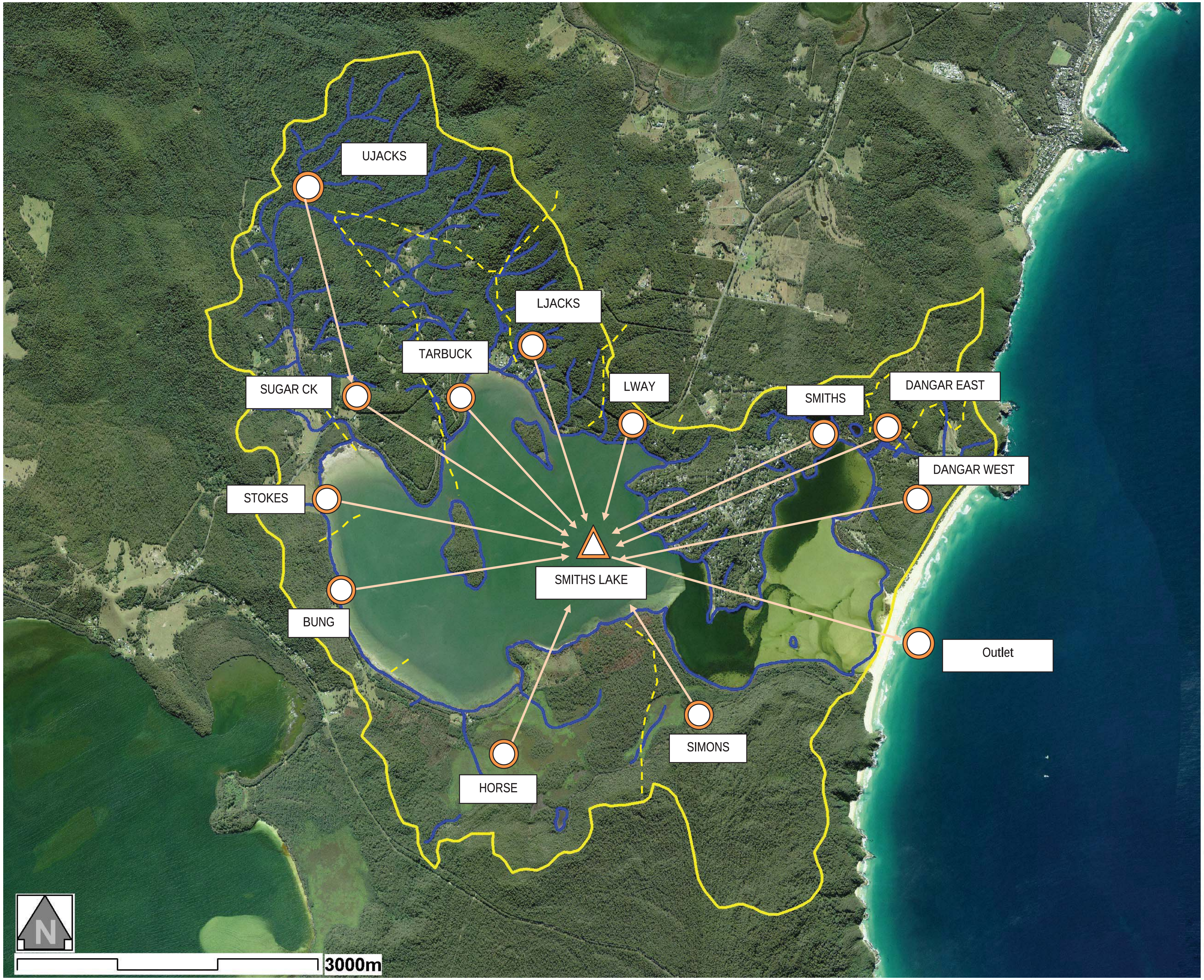
The sub-catchment delineation adopted for the 2008 Flood Study was maintained for the XP-RAFTS model. The Smiths Lake catchment was divided into 12 sub-catchments, including the lake itself. The RAFTS model was developed using the physical characteristics of the catchment including catchment area, slope, percentage impervious area and vegetation cover. The model was used to estimate sub-catchment runoff peaks and to generate discharge hydrographs for tributary inflows to Smiths Lake. These tributary inflows form the upstream boundary conditions for the proposed hydraulic model.

The adopted catchment break-up and model layout is shown in **Figure 2**. The parameters adopted for each of the sub-catchment areas are provided in **Appendix A**.

### 5.1.2 Rainfall Loss Model

In a typical rainfall event, not all of the rainfall that falls onto the catchment is converted to runoff. Depending on the prevailing wetness conditions of the catchment at the commencement of the storm (*i.e., the antecedent wetness conditions*), some of the rainfall may be lost to the groundwater system through infiltration into the soil, or may be intercepted by vegetation and stored. This component of the overall rainfall is considered to be ‘lost’ from the system and does not contribute to the catchment runoff.

FIGURE 2




**LEGEND**

Catchment boundary

Sub-catchment breakup

XP-RAFTS Model node

XP-RAFTS Storage node

XP-RAFTS model link

WorleyParsons
resources & energy

Rp2840_00 – Smiths Lake Floodplain Risk Management Study
fg02840_00gr121210-Fig2 [RAFTS Layout].doc

**SMITHS LAKE CATCHMENT AREA**
**XP-RAFTS HYDROLOGICAL MODELLING LAYOUT**

To account for rainfall losses of this nature, a rainfall loss model can be incorporated within the RAFTS hydrologic model. For this study, the *Initial-Continuing Loss Model* was used to simulate rainfall losses across the catchment.

This model assumes that a specified amount of rainfall (*e.g., 10 mm*) is lost from the system to simulate initial catchment wetting when no runoff is produced, and that further losses occur at a specified rate per hour (*e.g., 1.5 mm/hr*). These further losses are referred to as continuing losses which aim to account for infiltration once the catchment is saturated.

Both the initial and continuing losses are effectively deducted from the total rainfall over the catchment, thereby leaving the remaining rainfall to be distributed through the watershed as runoff.

As no definitive loss rate data is available for the Smiths Lake catchment, the same rainfall loss rates as those adopted for the 2008 Flood Study, namely an initial loss of 0 mm/hour and a continuing loss of 2.5 mm/hour have been maintained for the current model.

### 5.1.3 Hydrologic Model Calibration

Flood routing models such as XP-RAFTS should be calibrated and verified using rainfall and streamflow data from specific historical flood events. Rainfall records from a major storm that caused flooding, are input into the model to reflect the variability of rainfall over the catchment through the course of the storm.

In this instance, the existing WBNM model was used to compare and verify that the XP-RAFTS model was reproducing the characteristics of the storm. Given the system is primarily volume driven, and there is no streamflow data on individual creeks draining to the lake, then this was considered to be adequate.

## 5.2 HYDRAULIC MODEL UPDATE

The *Smiths Lake Flood Study* employed the RUBICON hydrodynamic modelling software to simulate flood behaviour of the lake. In the model, the lake was defined as a series of one dimensional channel cross sections. The model also simulated the breakout of the entrance channel through application of the Ackers-White sediment transport theory.

One of the most important outcomes from the study is the determination of peak flood levels and velocities for a range of design floods. This information can be used to determine the variability in flood hazard across the floodplain and will assist Great Lakes Council in the assessment of development proposals.

As part of the Smiths Lake Floodplain Risk Management Study the existing one-dimensional hydraulic model was updated to a fully two dimensional hydrodynamic model. The MIKE 21 software was selected as the preferred software for developing a two dimensional hydrodynamic model of Smiths Lake. MIKE 21 was developed by the Danish Hydraulic Institute (*DHI*) and is a fully two-dimensional modelling tool used to simulate flows in rivers and floodplains.

The benefits associated with upgrading to a two dimensional model include:

- The ability to better investigate interaction between elevated ocean conditions and filling of the lake. In this regard, filling of the lake via the ocean will be controlled by an entrance channel due to the topography of the berm.
- The potential to reliably investigate alternative entrance opening scenarios including those required for climate change.
- The ability to develop a tool which can be augmented to account for other factors, for example, sediment transport and water quality studies.

The hydraulic computer model was developed to simulate flooding behaviour in Smiths Lake. From the hydraulic model, key characteristics can be extracted such as the peak flood levels, flow velocities, floodwater depth and flood hazard at selected points of interest. The results of the modelling can be used to determine provisional hazard categories across the study area.

The hydraulic model utilised existing bathymetric of Smiths Lake and the terrain surrounding the lake. Inflow to the lake is defined by output hydrographs generated from the XP-RAFTS model and outflow is controlled by the entrance channel characteristics and the adopted ocean boundary characteristics.

The MIKE 21 modelling software includes the 'landslide' feature, which facilitates variation in the model terrain as a function of time. The 'landslide' option is used to simulate the dynamic scouring that occurs from the mechanical opening of the lake entrance to relieve flood water levels.

The hydraulic model has been used to:

- establishing design flood conditions;
- setting flood standards for planning, so that future land-use is managed appropriately; and,
- investigate the potential impacts associated with climate change.

### 5.2.1 Development of the MIKE 21 Hydrodynamic Model

A two-dimensional hydrodynamic model of the lake and entrance berm was developed using the MIKE 21 software. The model terrain was defined from airborne laser scanning (*ALS*) survey terrain data and bathymetric survey of Smiths Lake. The topographic and bathymetric features of Smiths Lake and its immediate surrounds were captured in the model via a rectangular grid network with 10 metre by 10 metre cells. Terrain elevation values are specified for at each corner of each cell within the grid. The selected dimensions of the grid were such that a sufficient level of topographic detail is captured by the mesh without generating an excessive number of cells which would results in resource intensive processing (*and excessive simulation time*).

The MIKE 21 model covers an area of approximately 15 square kilometres. The extent of the rectangular model network was defined approximately by the 6 mAHD contour surrounding the Smiths Lake water body.

At the location of entrance breakout, the model's terrain varies with time, which re-creates the dynamic entrance breakout. This has been represented in the model via the 'landslide' feature. The 'landslide' feature allows the user to specify bathymetry values which vary throughout the simulation period. In simulating the entrance breakout a trigger time is defined after which the bathymetry through the lake entrance channel changes to simulate the opening of the relief channel and subsequent scour that occurs as water is discharged through the channel.

The trigger time for the initial opening of the relief channel is specified in the model run file. Trigger times for each storm type are calculated in an approximate manner by treating lake as a basin with inflows extracted from the XP-RAFTS model. The trigger time represents the amount of time taken for the cumulative volume of inflow to fill the lake to the specified trigger level.

The characteristics of the relief channel change due to scouring of the channel from the discharge of water from Smiths Lake. The time-varying characteristics of the relief channel incorporated into the Mike 21 model are based on the observations of historical channel openings as outlined in the *Smiths Lake Flood Study* by Webb, McKeown & Associates in 2008 and verified through a comparison of the MIKE 21 results with those predicted by the previous RUBICON model. The entrance scour characteristics were also verified via empirical methods involving application of the Ackers-White sediment transport theory.

### 5.2.2 Hydrodynamic Model Boundary Conditions

The inflow hydrographs which defined the MIKE 21 model's upstream boundary were extracted from the XP-RAFTS hydrological model. The volumetric flowrate from each sub-catchment in the Smiths Lake system was extracted from the XP-RAFTS model to define the boundary conditions for the MIKE simulation. The MIKE model contains a total of 11 inflows, corresponding to each sub-catchment which drains directly to the lake (*refer* **Figure 2**). The model also captured rainfall which falls directly on the lake.

The downstream ocean boundary condition was defined with reference to the Department of Environment & Climate Change's (*DECC*) Floodplain Risk Management Guideline titled '*Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments*'. This guideline defines a design 40 hour tidalgraph for the ocean boundary conditions of a normal tidal condition, a 5% AEP and the 1% AEP events. These tidalgraphs account for the effects of elevated ocean water levels, tidal anomalies and wave setup. They provide a conservative approach to simulating the ocean boundary conditions in lieu of a more sophisticated site specific approach.

The peak flood levels within Smiths Lake are dependent on the interaction between the upstream and ocean boundaries especially with regard to the coincidence of peak inflows and maximum tide. For example, maximum flood levels occur for a given rainfall event when the peak high-tide occurs at the same time as flood levels in Smiths Lake due to runoff reach peak levels.

### 5.2.3 Lakebed and Terrain Roughness

It is common engineering practice in numerical modelling for Manning's '*n*' to be used as a measure of energy loss or hydraulic resistance. It is also typically used as a calibration parameter, with adjustments made to Manning's 'n' until simulated and recorded values are sufficiently close.

The MIKE21 model required specification of Manning's roughness parameter for each cell within the model grid. Given the homogenous nature of the sandy terrain at Smiths Lake and surrounds, a universal Manning's 'n' value of 0.033 was adopted.

### 5.2.4 Initial Lake Water Level

Another consideration for the design flood events relates to an appropriate initial water level to assume for the lake. It is evident that the higher the assumed initial water level the higher the ultimate flood level.

In this instance, an initial lake water level of 1.9 mAHD was adopted as an appropriate initial water level in the lake.

### 5.2.5 Model Calibration

In the case of a river floodplain, a hydrodynamic model is calibrated to recorded flood marks, where available. The *Smiths Lake Flood Study* established that the peak flood level is dominated by the rate of entrance scour, with the capacity of the outflow channel significantly exceeding inflows to the lake for events up to and including the 0.2% AEP event.

The characteristics of entrance breakout have been adjusted to provide a good fit between the rate of fall of the lake as recorded historically and that produced by the hydrodynamic model.

# 6. DESIGN FLOOD ESTIMATION

## 6.1 GENERAL

Design floods are hypothetical floods that are commonly used for planning and floodplain risk management investigations. Design floods are based on statistical analysis of rainfall and flood records and are defined by their probability of occurring in a given year. For example, there is a 1% chance of the 1% Annual Exceedance Probability (*AEP*) flood occurring in any given year.

Design floods can also be expressed by their probability of recurrence. For example the 1% AEP flood can also be expressed as the 100 year Average Recurrence Interval flood, which represents the best estimate of a flood that willlikely occur on average, once in every one hundred years.

It should be noted that there is no guarantee that the design 1% AEP flood event will occur just once in a one hundred year period. It may occur more than once, or at no time at all in the one hundred year period. This is because the design floods are based upon a statistical 'average'.

The computer models described in **Sections 5.1** and **5.2** were used to derive design flood estimates for the 5%, 2%, 1% AEP floods as well as the PMF. The models were also used to simulate the flood related impacts of climate change. The procedures employed in deriving these design floods are outlined in the following sections.

## 6.2 HYDROLOGIC MODELLING

### 6.2.1 Design Simulations

The RAFTS hydrologic model described in **Section 5.1** was used to simulate runoff from the catchment for design storm conditions. The design storm conditions were based on rainfall intensities and temporal patterns for the study area, which were derived using standard procedures outlined in *Australian Rainfall and Runoff – A Guide to Flood Estimation* (*1987*) (*ARR 87*). The design storm rainfall data was generated by applying the principles of rainfall intensity estimation described in Chapter 2 of *ARR 87*.

Due to the small catchment area, constant intensity-frequency-duration data was adopted across the Smiths Lake catchment. Design temporal patterns outlined in ARR 87 were also applied. These temporal patterns specify the variation in rainfall intensity over the duration of the design storms.

The critical storm duration corresponds to the duration of the rainfall event which results in the highest peak water surface levels in Smiths Lake (a*ssuming ocean tides do not influence levels in the lake*). The critical storm duration is determined in conjunction with hydraulic modelling and outlined in **Section 6.3.2**.

In this case, Smiths Lake is a storage driven system, which is more sensitive to the volume of inflow rather than the peak rainfall intensity. Therefore, although the catchment area is relatively small, it is likely that a longer duration storm will be more critical to determining peak flood levels in the lake. The storm duration which represents the critical duration will also be a function of the timing of opening, as dictated by the lake level and the influence of a storm tide.

Rainfall intensities for the 20%, 5%, 2% and 1% AEP events were derived using the procedures outlined in AR&R87. These rainfall estimates were routed through the XP-RAFTS model to define inflows to the hydrologic model.

In the case of the Probable Maximum Flood, as outlined in ARR87, it is not possible to derive a 'true' or 'correct' estimate of a very rare flood, such as the PMF. This is because only limited data exists on rare flood events in Australia, and very little of this literature relates to extreme precipitation and flooding in inland catchments. Nevertheless, ARR87 advocates an approach for the estimation of extreme floods whereby the PMF estimate should constitute a limiting value for floods that could *reasonably* expect to occur.

Estimates of the PMF are typically derived from the Probable Maximum Precipitation (*PMP*) with the resultant runoff routed through the catchment over which the rainfall occurs. Standard procedures for deriving the PMP for small catchments are outlined in the Bureau of Meteorology's *'Bulletin 53 - The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method'* (*June, 2003*). This document is applicable to catchments with areas of less than 1000 $km^2$ and storm durations of less than 6 hours.

An assessment was also made of the sensitivity of the catchment to a longer duration Probable Maximum Precipitation event via application of the Generalised South-East Australian Method (*GSAM*). This established that the catchment is not as sensitive to the longer duration storms.

A summary of the PMP calculations for the Smiths Lake catchment using the Generalised Short Duration Method is provided in **Appendix B**.

### 6.2.2 Hydrologic Modelling Results

Design discharge hydrographs determined using the RAFTS hydrologic model were used to define inflows into the MIKE21 hydraulic model.

A summary of the peak discharges for each tributary inflow is provided in **Table 2**. The peak discharges are referenced to the RAFTS sub-catchment which are shown in **Figure 2**.

## 6.3 HYDRODYNAMIC MODELLING

### 6.3.1 Design Simulations

The MIKE 21 hydrodynamic model is used to the define flood characteristics of Smiths Lake, including the interaction between run-off in the lake catchment and elevated ocean conditions. The model was used to simulate each of the design 20%, 5%, 2% and 1% AEP flood events and the probable maximum flood (*PMF*). The design simulations were based on a range of boundary condition data which is described in the following sections.

### Table 2 PEAK DESIGN FLOWS FOR THE SMITHS LAKE CATCHMENT

| RAFTS NODE ID | PEAK DISCHARGE (m³/s) | | | |
|---|---|---|---|---|
| | PMF | 1% AEP | 5% AEP | 20% AEP |
| SIMON | 153.23 | 28.36 | 22.92 | 17.67 |
| HORSE | 194.99 | 35.8 | 28.47 | 22.15 |
| BUNG | 46.38 | 12.42 | 10.53 | 8.42 |
| STOKES | 28.04 | 7.34 | 6.19 | 4.94 |
| SUGARCK | 325.64 | 16.45 | 12.89 | 9.94 |
| LJACKS | 77.43 | 21.17 | 18.24 | 14.76 |
| TARBUCK | 100.12 | 22.63 | 18.71 | 14.53 |
| LWAY | 15.44 | 4.13 | 3.5 | 2.8 |
| SMITHS | 122.49 | 28.84 | 24.02 | 18.98 |
| DANGARWEST | 67.63 | 25.35 | 20.82 | 16.02 |
| DANGAREAST | 54.94 | 22.62 | 18.71 | 14.53 |
| LAKE | 445.5 | 61 | 49.21 | 39.49 |

*NOTE: Peak discharges do not necessarily occur simultaneously*

#### *Catchment Runoff*

Upstream boundary conditions were defined for each design flood based on the inflow hydrographs generated using the RAFTS hydrologic model (*refer* **Section 5.2.2**). For example, the design 1% AEP flood discharge hydrographs for lake inflows were extracted from the RAFTS hydrologic model output and used to define the rate of flow into the area covered by the hydrodynamic model.

However, since the characteristics of flooding in the lake are a function of inflows, ocean levels and the timing of the entrance opening, it has been necessary to test a number of different event durations in order to establish the critical event duration for the lake.

#### *Ocean Levels*

Peak flood levels in Smiths Lake may be influenced by ocean levels at the time of flooding. Tides and storm surge in the Pacific Ocean can have a significant effect on flooding in the lake if ocean levels are of a level such that:

- The benefits associated with entrance opening are redundant since the ocean level is equal to or exceeds the lake level; or,
- Wave action overtops the beach berm separating Smiths Lake and the ocean resulting in ocean levels directly influencing peak flood levels within Smiths Lake.

In recognition of the need to provide a consistent approach to defining ocean boundary conditions for flood modelling in coastal catchments, the Department of Natural Resources (DNR) developed a guideline document titled *Floodplain Risk Management Guideline No 5 – Ocean Boundary Conditions* (*in draft, November 2004*). Guideline No 5 provides advice on the derivation of appropriate ocean boundary conditions for a variety of ocean entrance types, including ICOLLS such as Smiths Lake. Guideline No. 5 has since been incorporated as part of Department of Environment, Climate Change and Water's Draft Floodplain Risk Management Guide titled '*Incorporating Seal Level Rise Benchmarks in Flood Risk Assessments*' (*2009*) in an essentially unchanged format.

For ICOLLS such as Smiths Lake, Guideline No 5 recommends the adoption of an upper limit 'design envelope'. The upper limit 'design envelope' is developed by using the highest peak flood level generated from flood modelling undertaken assuming:

- the design flood occurs during a normal (*neap*) tidal cycle; and,
- a small design flood (*e.g., the 5 year recurrence flood*) occurs in conjunction with elevated ocean levels.

The guideline defines the 5% AEP peak ocean level to be 2.3 mAHD and the 1 % AEP peak ocean level to be 2.6 mAHD. The influence of elevated ocean tidal conditions was tested for a range of duration storm events.

While it is recognised that the guideline does not specifically recommend testing a 1% AEP run-off event coinciding with a 1% AEP ocean tidalgraph, in this instance, the sensitivity of the lake system has also been tested for this scenario. This is in recognition of the close proximity of the catchment to the ocean and the potential for coincidence of the prevailing weather conditions contributing to rare rainfall and elevated ocean conditions. It is noted the "joint probability" of catchment storm events and elevated ocean conditions is being investigated as part of the Australian Rainfall and Run-off update project.

The elevated ocean conditions adopted for the purpose of analysing its influence on flooding is still subject to the normal diurnal tidal cycle which occurs along the NSW coastline. Therefore, the peak of the elevated ocean condition occurs at the peak of the normal tidal cycle.

In testing the influence of elevated ocean conditions on flooding, it is important to ensure the flood hydrograph coincides with the elevated ocean conditions. For this reason, a range of sequences for the tidal cycle were tested relative to inflows to Smiths Lake to establish the conditions which lead to the maximum levels in the lake.

For example, peak levels within Smiths Lake resulting from the 12 hour storm are estimated to occur approximately 18 hours after the commencement of the storm. Hence, in order to test the sensitivity of the lake to coincident elevated ocean conditions, the tidalgraph is time such that the peak high tide occurs approximately 18 hours after the commencement of the storm.

### *Lake Entrance Opening*

The lake entrance opening process was simulated using MIKE 21 'landslide' feature. The landslide feature allows variation in the lake bathymetry during the hydrodynamic simulation period. Simulations were conducted such that the time-varying bathymetry was initiated at approximately the time when water levels within Smiths Lake reached 2.1 mAHD (*Council's informal trigger level for the entrance opening procedure*). The time at which the trigger level of 2.1 mAHD was reached was calculated for each design rainfall event assuming a closed entrance lake entrance and no interaction between the levels in the lake and the ocean.

A summary of the time at which the opening of the relief channel is triggered is presented in **Table 3**. The time at which the relief channel is triggered is expressed in hours since the commencement of rainfall.

**Table 3 TRIGGER TIME OF THE LAKE ENTRANCE OPENING**

| DESIGN FLOOD EVENT | RAINFALL EVENT DURATION | ENTRANCE TRIGGER TIME[1] |
|---|---|---|
| 1% | 12 hours | 10:30 |
| 1% | 24 hours | 12:00 |
| 1% | 72 hours | 18:00 |

[1] *Hours after the commencement of rainfall in the catchment*

The simulation of the opening of the Smiths Lake relief channel is based upon the detailed observations made by engineers of the mechanical opening which occurred in November 2006. Observations were recorded alongside other historical entrance opening in the *Smiths Lake Flood Study* (WMA, 2008). The mechanics of the entrance opening were adjusted to fit the scale of the bathymetric grid used in the hydraulic model. A summary of the dynamic parameters of the entrance are presented in **Table 4**. The 'Time' column is the number of hours which have elapsed since the water levels within Smiths Lake reach the specified trigger level of 2.1mAHD (*2.6mAHD for the 2050 climate change scenario*).

### Table 4 LAKE ENTRANCE OPENING PARAMETERS

| TIME SINCE TRIGGER[1] | RELIEF CHANNEL DEPTH (*m*) | RELIEF CHANNEL WIDTH (*m*) |
|---|---|---|
| 00:00 | 0.50 | 10 |
| 02:30 | 1.00 | 20 |
| 03:00 | 2.00 | 40 |
| 03:30 | 2.00 | 50 |
| 04:00 | 2.00 | 70 |
| 08:00 | 2.00 | 90 |

[1] *Hours after the initial triggering of the relief channel*

#### *Entrance Channel Open*

Following mechanical opening of the entrance channel at Smiths Lake, the channel remains open for a period of time. The water level recorder at Tarbuck Bay indicates that the channel typically remains open for between one month and two months. However, the record also indicates there is the potential for the channel to remain open for a longer period of time, for example when a wetter period proceeds immediately after the lake has been opened.

There is the potential for elevated ocean conditions to coincide with an open entrance. Depending on the width of the channel, this may present a more adverse scenario for flooding in the lake. For this reason, this scenario has also been investigated as part of the updated flood modelling. It is noted that the flood study previously assumed the lake would fill to a level of 2.6 mAHD.

### 6.3.2 Flood Modelling Results and Discussion

The following outlines the results of flood modelling undertaken as part of the Floodplain Risk Management Study, for present day conditions. A number of different scenarios have been assessed, representing different combinations of rainfall, ocean and entrance conditions.

Due consideration needs to be given to each of these cases to establish the case which is critical to defining the design 1% AEP flood level in the lake and its surrounds.

#### *100 year ARI Peak Flood Levels – Initial Closed Entrance Condition*

Peak flood level estimates were obtained from computer hydrodynamic modelling for each design flood event.

As outlined above, the DNR's Guideline No 5 recommends the adoption of an upper limit 'design envelope'. The design envelope comprises the highest design flood level at any specific location from the results of the following simulations:

- a 20% AEP catchment event occurring concurrently with a 2.6 mAHD ocean level; and,
- a 1% AEP catchment event occurring with ocean entrance conditions defined by a normal "neap" tidal cycle.

In addition, the scenario involving a 1% AEP storm event coinciding with a 1% AEP ocean tidal condition has also been assessed for the reasons summarised in the previous section.

For the "neap tide" condition, the sensitivity of the lake's flood levels to a range of storm durations was tested using the MIKE 21 model. The results of modelling the 12, 24 and 72 hour storm durations are reported in **Table 6**. The XP-RAFTS model was employed to discount the influence of storm events with a shorter duration than 12 hours. The results indicate that the predicted peak flood level in the lake for the 12 and 24 hour events are almost identical, while the flood level is slightly lower for the 72 hour storm. This indicates that for the case involving a neap tidal cycle, between a 12 and 24 hour storm is considered critical for this scenarios. The flood level predicted by the model is consistent with the 2008 Flood Study.

### Table 5 PEAK 100 YEAR ARI DESIGN FLOOD LEVELS – NEAP TIDE

| DESIGN FLOOD EVENT | RAINFALL EVENT DURATION | PEAK FLOOD LEVEL (mAHD) |
|---|---|---|
| **1%** | **12 hours** | **2.33** |
| 1% | 24 hours | 2.32 |
| 1% | 72 hours | 2.25 |

The results of modelling the 1% AEP ocean tidalgraph coinciding with a range of design catchment rainfall events are presented in **Table 6**. It is noted that both the 20% AEP rainfall event and the 1% AEP rainfall event have been modelled. The 1% AEP rainfall event was tested for three different storm durations.

The results presented in **Table 6** indicate that according to a strict interpretation of the Floodplain Risk Management guideline that catchment derived rainfall is more critical to elevated levels in the lake, than the influence of the ocean tidalgraph. The peak flood level in the lake for the 1% AEP 12 hour storm duration event coinciding with a neap tide is 2.33 mAHD, while the 20% AEP combined with the 1% AEP storm duration only generates a flood level in the lake of 2.17 mAHD.

### Table 6 PREDICTED PEAK DESIGN FLOOD LEVELS- 1% AEP OCEAN BOUNDARY

| DESIGN FLOOD EVENT ($m^3/s$) | RAINFALL EVENT DURATION | PEAK FLOOD LEVEL (mAHD) |
|---|---|---|
| 5 years | 12 hours | 2.17 |
| 100 years | 12 hours | 2.33 |
| 100 years | 24 hours | 2.42 |
| 100 years | 72 hours | 2.36 |

The results also indicate that the flood level in the lake is relatively insensitive to the adopted ocean tidal condition. In the case of both the 12 hour duration storm and the 72 hour duration storm, there is no difference in the predicted flood level between the neap tide scenario and the 1% AEP tidal graph scenario.

However, the results also indicate that the peak flood level for the 1% AEP 24 hour duration storm coinciding with a 1% AEP ocean tide generates flood levels in the lake approximately 100 mm above the neap tide scenario.

This analysis also suggests that adopting the 1% AEP flood level as 2.6 mAHD is overly conservative in the case of Smiths Lake and that a slightly lower flood level of 2.42 mAHD is more appropriate. This analysis may also be important when considering planning for future sea level rise scenarios.

### *100 year ARI Peak Flood Levels – Open Entrance*

As outlined in **Section 6.3.1**, another area associated with flooding of the lake which requires examination involves the potential flood characteristics which occur when the entrance remains open and elevated ocean tidalgraph occurs. The potential for filling of the lake will be a function of both the width of the channel and the duration of the elevated tide.

The analysis undertaken for the 1% AEP ocean tidalgraph established that the lake would fill to approximately **2.35 mAHD**. Therefore, this case is less critical than catchment run-off. Significantly, it also suggests there is insufficient capacity in the channel entrance for the lake to fill up to equivalent to the design elevated ocean ocean condition. This was not previously tested as part of the flood study.

### *Adopted Design Flood Levels*

The above assessment has been used to develop a set of revised design flood levels for the Smiths Lake system. This information is important as it provides a benchmark for floodplain management in and around Smiths Lake.

### Table 7 ADOPTED DESIGN FLOOD LEVELS – SMITHS LAKE

| FLOOD EVENT ($m^3/s$) | RAINFALL EVENT DURATION | TIDALGRAPH | PEAK FLOOD LEVEL (mAHD) |
|---|---|---|---|
| 5% AEP | 24 hour | 5% AEP | 2.3 |
| 1% AEP | 24 hour | 1% AEP | 2.42 |
| PMF | 6 hour | 100 year storm surge | 3.58 |

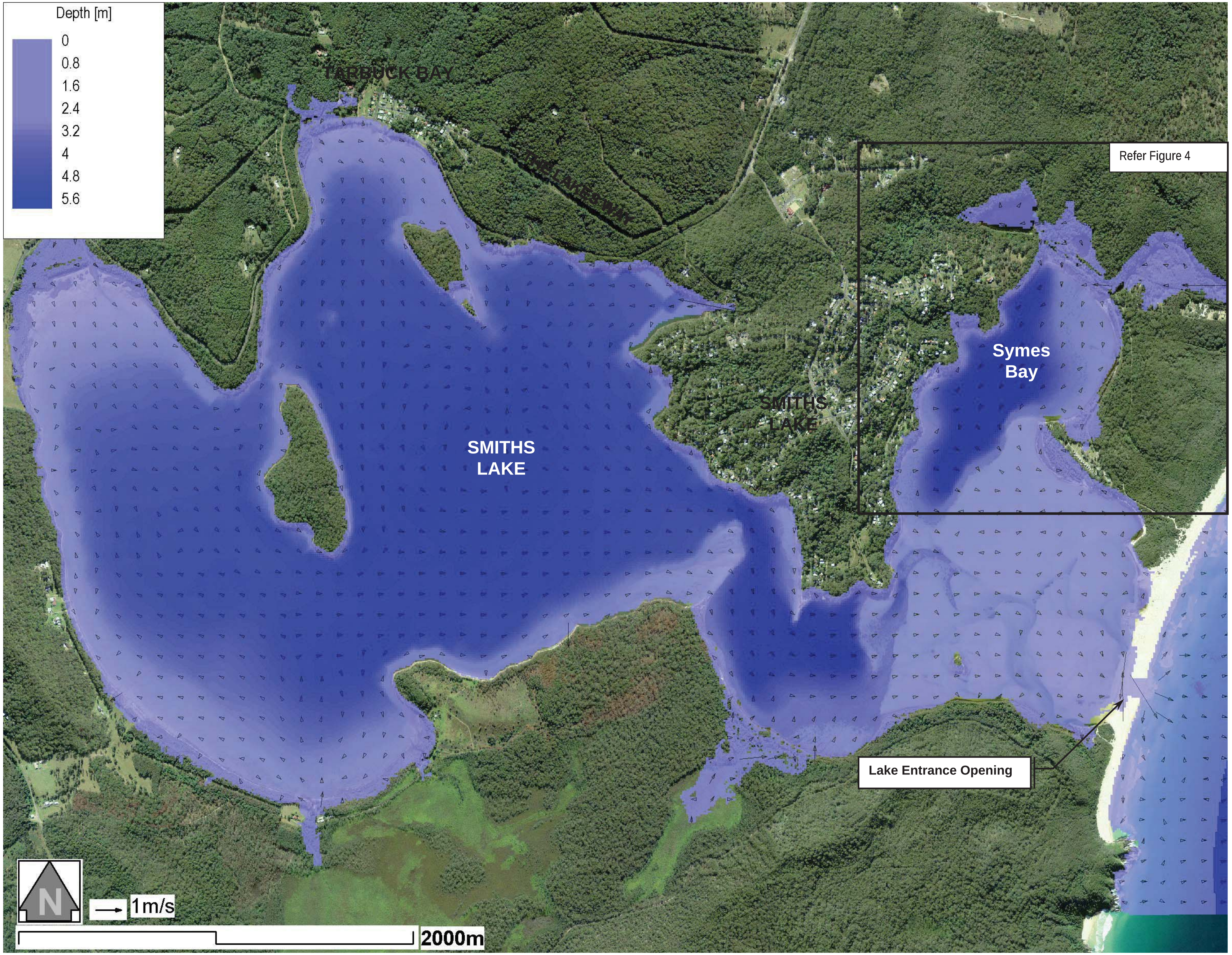
### *Extent of Inundation*

The predicted extent of inundation across Smiths Lake for the 1% AEP design event is presented in **Figure 3** and a close-up of the Symes Bay area, where the majority of floodplain inundation occurs, is shown in **Figure 4**. Areas that would be inundated include areas in the vicinity of the Sandbar and Bushland Caravan Parks, the Sandbar Golf Course and the low lying area near Sugar Creek.

### *Flow Velocities*

Peak floodwater flow velocities for the adopted design 100 year recurrence flood are superimposed as velocity vectors over the floodwater depth plots shown in **Figure 3** and **Figure 4**. These figures indicate that the peak flow velocities are largest within the entrance channel to Smiths Lake. Peak velocity within Smiths Lake is typically about 1.5 m/s. Elevated flow velocities occur in the entrance channel of the lake. Peak flow velocities across much of the lake are typically less than 0.5 m/s.

FIGURE 3

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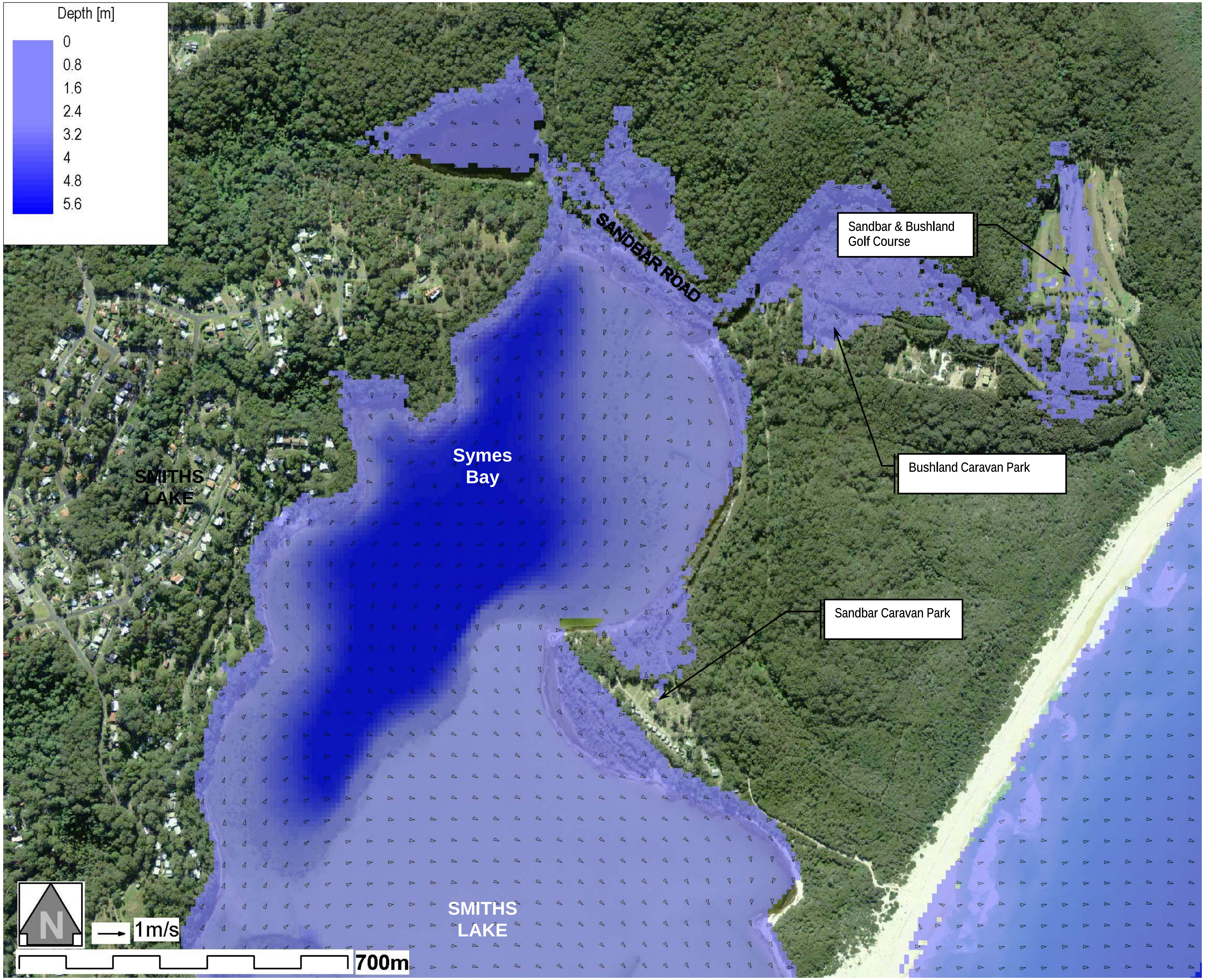
Rp2840_00 – Smiths Lake Floodplain Risk Management Study
fg02840_00gr121211-Fig6.1 [100yr Design Event Inundation].doc

**PEAK FLOODWATER DEPTHS AND VELOCITY VECTORS FOR THE DESIGN 1% AEP FLOOD EVENT AT SMITHS LAKE**

FIGURE 4

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Rp2840_00 – Smiths Lake Floodplain Risk Management Study
fg02840_00gr121211-Fig6.2 [100yr Design Event Inundation Sandbar].doc

**PEAK FLOODWATER DEPTHS AND VELOCITY VECTORS FOR THE DESIGN 1% AEP FLOOD IN THE VICINITY OF SYMES BAY**

# 7. ASSESSMENT OF CLIMATE CHANGE IMPACTS ON FLOODING AND FLOODPLAIN MANAGEMENT

The NSW Government has published a number of documents which provide guidance to account for climate change impacts on flooding. These documents include:

- Department of Environment and Climate Change (*DECC*) Floodplain Risk Management Guideline titled: *'Practical Consideration of Climate Change'* (*2007*).

  This guideline provides an estimate of the range for increases in sea level associated with climate change. It also provides an estimate for the change in "Extreme Rainfall" in different parts of NSW.

- Department of Environment, Climate Change and Water (*DECCW*) Draft Flood Risk Management Guide titled *'Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments'* (*2009*).

  This provides direction concerning the appropriate risk mitigation techniques for flood planning areas, as well as an updated direction for the assessment of ocean boundary conditions for use in flood modelling.

- DECCW Technical Note titled *'Derivation of the NSW Government's Sea Level Risk Planning Benchmarks'* (*2009*).

  This document provides the technical background for the sea level rise projections adopted in the above documents.

These documents do not represent an exhaustive list of the information prepared by the NSW Government. However, they are considered the most pertinent to the scope of this assessment into climate change impacts on flooding.

As addressed in the above documents, there are two main drivers for climate change related flood impacts:

1. Sea Level Rise (SLR) - Assessment of the impacts using the NSW Government's SLR benchmarks of 0.4 m by 2050 and 0.9 m by 2100.
2. Changes to rainfall intensity - Modelling suggests that rainfall intensity on the Mid North Coast may either increase or decrease by up to 10% on present day levels over the next 60 years. There is less certainty of this modelling (*compared to SLR*). Research is currently being carried out to provide greater confidence on the changes to rainfall intensity.

This study examines the flood related impacts of climate change on:

(i) All aspects of flood behaviour including potential future flood planning levels.

(ii) Present development, infrastructure and the environment.

(iii) Proposed flood risk management measures including emergency management, structural measures such levees etc.

The results of the assessment of climate change flood levels will assist Council in the identification of appropriate development controls, which are considered further in **Section 7.1**.

## 7.1 GREAT LAKES COUNCIL ADOPTED SEA LEVEL RISE PLANNING SCENARIO

The NSW Government acknowledged in 2009 that increased sea levels will have a significant effect on coastal communities in the medium to long term. In October 2009 the then NSW Department of Environment, Climate Change and Water (*now department of Environment and Heritage*) released the *NSW Sea Level Rise Policy Statement*. As discussed above, the NSW Government had adopted sea level rise benchmarks to be used for planning purposes relative to 1990 tidal levels. These benchmarks are for a 40 cm rise in ocean levels on the NSW Coast by 2050, and for a 90 cm rise by 2100.

Subsequently in 2012, the NSW Government amended its approach to planning for sea level rise and has elected to allow individual Local Governments to decide on their approach to planning for climate change.

Great Lakes Council has adopted a 50 year planning window to manage the potential impacts associated with climate change. In effect, this means that the 2060 sea level rise scenario represents Great Lakes Council's current benchmark to inform development related planning controls that account for sea level rise. A 2060 sea level rise means adopting a 0.5 metre increase in ocean level above the current threshold. The benchmarks adopted in the hydraulic model are consistent with the Great Lakes Council's Policy *'Impacts of Sea Level Rise on Developments'* (*2011*).

Accordingly, it is appropriate to investigate the flood related impacts of the projected changes in sea level rise and rainfall. The following outlines the results of this assessment.

## 7.2 INVESTIGATION OF CLIMATE CHANGE RELATED IMPACTS ON FLOODING

### 7.2.1 Review of Smiths Lake Entrance Opening

The entrance opening regime of Smiths Lake is a key concern with respect to flooding in and around the lake. Smiths Lake is classifies as an ICOLL. As such, Smiths Lake is blocked from the ocean for long periods by a sand berm which is in the order of 150 metres wide, as defined by the distance above mean sea level. This will vary depending on the prevailing ocean conditions.

As a result of the berm, inflows to the lake collect following entrance closure. Currently the opening of the lake entrance is managed by the Council. The lake entrance is opened by a mechanical digger when water in the lake reaches a level of 2.1 m AHD. It is estimated that the natural entrance opening level is approximately 3.1 m AHD (*Webb, McKeown & Associates Pty. Ltd, 2008*).

The entrance opening level of 2.1 m AHD is a compromise between flood mitigation and entrance scour potential. A higher entrance opening trigger level would result in the scour of a greater sand volume from the lake entrance, and as a result it would take longer for wave and wind action to infill the entrance. However, a higher entrance trigger level also increases the risk that a flood event will elevate lake levels and inundate low lying properties and Council assets.

Conversely, a lower entrance opening trigger level increases the volume available for flood storage prior to the entrance being opened, however the volume of sand scoured from the berm is reduced making it more prone to infilling with sand needing more frequent entrance openings.

However, under the projected climate change scenario, openings are likely to be more frequent if the current trigger level of 2.1 mAHD is maintained. This is because the lake level at the time of closure is a function of the mean sea level. A higher level in the lake at the time of closure will reduce the volume of inflow required and therefore the time required for the lake to be mechanically opened. Therefore, if the current opening level of 2.1 mAHD is maintained, the lake is expected to open more frequently, since the proportion of available storage volume is reduced.

In preparing the Smiths Lake Floodplain Risk Management Study, a review has been undertaken of the proposed trigger level, with reference to climate change impacts. The trigger level is proposed to increase in conjunction with observed changes in sea level. This issue is discussed in greater detail in **Section 11.2.1**.

For the purpose of the climate change related investigations, it is assumed that the trigger level for lake opening will increase in line with the median rise in sea level. For this reason, a trigger level of 2.6 mAHD has been adopted for lake opening for the 2060 sea level rise scenario.

### 7.2.2 Climate Change Related Flood Modelling Results

The existing hydrodynamic model was modified to assess the impacts of climate change. This was undertaken by analysing the scenarios investigated for the existing 100 year ARI flood levels and modifying the upstream and downstream boundary conditions to account for climate change. In this case, the rainfall intensity was increased by 10% to account for the current upper bound estimate of rainfall related climate change, and the downstream boundary condition was increased by 0.5 metres to assess the impact of elevated ocean conditions on flood levels.

However, it is apparent that under the current regime, an increase in the neap tide from 0.55 to 1.05 will not measurably affect flood levels in the lake, since this remains below the control level for the lake. For this reason, the climate change related investigation has focussed on the potential increase in flood levels within the lake for 2060 conditions for the 1% AEP tidalgraph scenario. This involved providing an assessment of the peak flood level in the lake with the 1% AEP tidalgraph adopted as a downstream boundary condition for the 5% AEP run-off event and the 1% AEP run-off event, with run-off updated to account for increases in rainfall intensity.

The 3.1 mAHD level is equivalent to the 0.5 m and SLR benchmark for the peak 1% AEP storm tide level. **Table 8** provides a summary of the peak flood levels at in Smiths Lake for the climate change scenarios included in modelling.

Table 8 PREDICTED FLOOD LEVELS FOR THE CLIMATE CHANGE SCENARIOS

| FLOOD MODELING SCENARIO | PEAK FLOOD LEVEL (*mAHD*) | | |
|---|---|---|---|
| | EXISTING | 2060 SEA LEVEL RISE AND RAINFALL INTENSITY INCREASE SCENARIO | 2090/ 2100 SEA LEVEL RISE AND RAINFALL INTENSITIY INCREASE SCENARIO |
| 1% AEP RAINFALL & 1% AEP TIDE | 2.42 | 2.87 | 3.15 |
| 20% AEP RAINFALL & 1% AEP TIDE | 2.17 | 2.78 | 3.05 |

The results presented in **Table 8** indicate that although there is an increase in the flood level in the lake consistent with the predicted increase in sea level rise, the increase itself is less than the sea level rise. This is consistent with the findings of the revised flood modelling investigations which established that the potential for elevated ocean levels to fill the lake is a function of the entrance dynamics.

The predicted increase in level has been used to inform appropriate flood planning levels for the climate change related scenarios.

## 7.3 CONCLUSIONS AND RECOMMENDATIONS

Since peak flood levels in Smiths Lake may be induced by rainfall, ocean and a combination of the two, the impacts of climate change on each flood mechanism should be considered separately. Given the small size of the Smiths Lake catchment area, increases in design rainfall in the order of 10% are not expected to influence peak flood levels in Smiths Lake by more than 0.05 metres. However, simulated climate change induced sea level rise in the order of 0.5 metres for the 2060 scenario indicate peak flood levels in Smiths Lake could rise by up to 0.32 metres.

Increased peak flood levels in Smiths Lake for design flood events will result in increased annual average damages associated with flooding. Various floodplain management options are presented and evaluated in **Section 11** using estimates of present day damages. Increases in the annual average damages will likely improve the cost-benefit analysis for the options, making each more viable. Climate change adaption strategies are outlined in **Section 11.2.3**, **11.2.4** and **11.2.5**.

Modelling undertaken in this study allow the potential impacts of climate change on design 1% AEP flood levels to be quantified. The methodology that was adopted is considered to be robust and provides a realistic assessment of the predicted impacts for the 2060 climate change scenario.

# 8. HYDRAULIC AND HAZARD CATEGORISATION

## 8.1 INTRODUCTION

The NSW Floodplain Development Manual (*2005*) defines three hydraulic categories of flood prone land: “floodways”, “flood storage” and “flood fringe”. Each of these hydraulic categories are used as a guide to determine the risk on existing development and also the appropriate types of future land development in flood-prone areas.

Floodways are those areas of a floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels and are areas that if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood level. By definition floodways are areas of high flow conveyance and can often be identified by areas of high flow velocity.

The blocking of floodways typically results in significant impacts on flood characteristics such as increases in predicted peak flood level and changes in flow velocities. Therefore, it is important to define floodways in floodplain risk management so that areas where development is undesirable can be identified.

The development of appropriate hydraulic categories for Smiths Lake are discussed following.

## 8.2 ADOPTED METHODOLOGY FOR DETERMINATION OF HYDRAULIC CATEGORIES

The hydraulic categories adopted by the manual are of limited importance for the Smiths Lake catchment. It is unlikely that any development will occur in any areas classified as floodway, since this would require infilling of a section of the lake. Furthermore, it is unlikely that should filling occur to facilitate development in flood storage areas, that there will be any notable impact on flood levels, since the total loss of storage associated with development will be negligible compared with the storage volume of the lake. Notwithstanding, the provisional floodway extent (*to indicate the edge of the floodway*) was determined from the assessment of aerial photography, topographic data and the results of modelling the 1% AEP flood event.

Areas in the Smiths Lake catchment with a peak depth of inundation greater than 0.3 metres were considered “flood storage”/ “floodway” and areas with a peak depth of inundation less than 0.3 metres were considered “flood fringe”. It was decided that a criteria for the classification of hydraulic categories based on peak depth of inundation was more appropriate than, for example, a velocity-depth (*V x D*) approach due to Smith Lake’s status as an Intermittently Closed and Open Lake or Lagoon (ICOLL) in which the Lake serves as a flood storage basin when the entrance is closed.

**Figures 5** presents the provisional hydraulic categorisation for Smiths Lake. A more detailed figure showing the hydraulic categories in the vicinity of the Symes Bay is presented in **Figure 6**.

FIGURE 5


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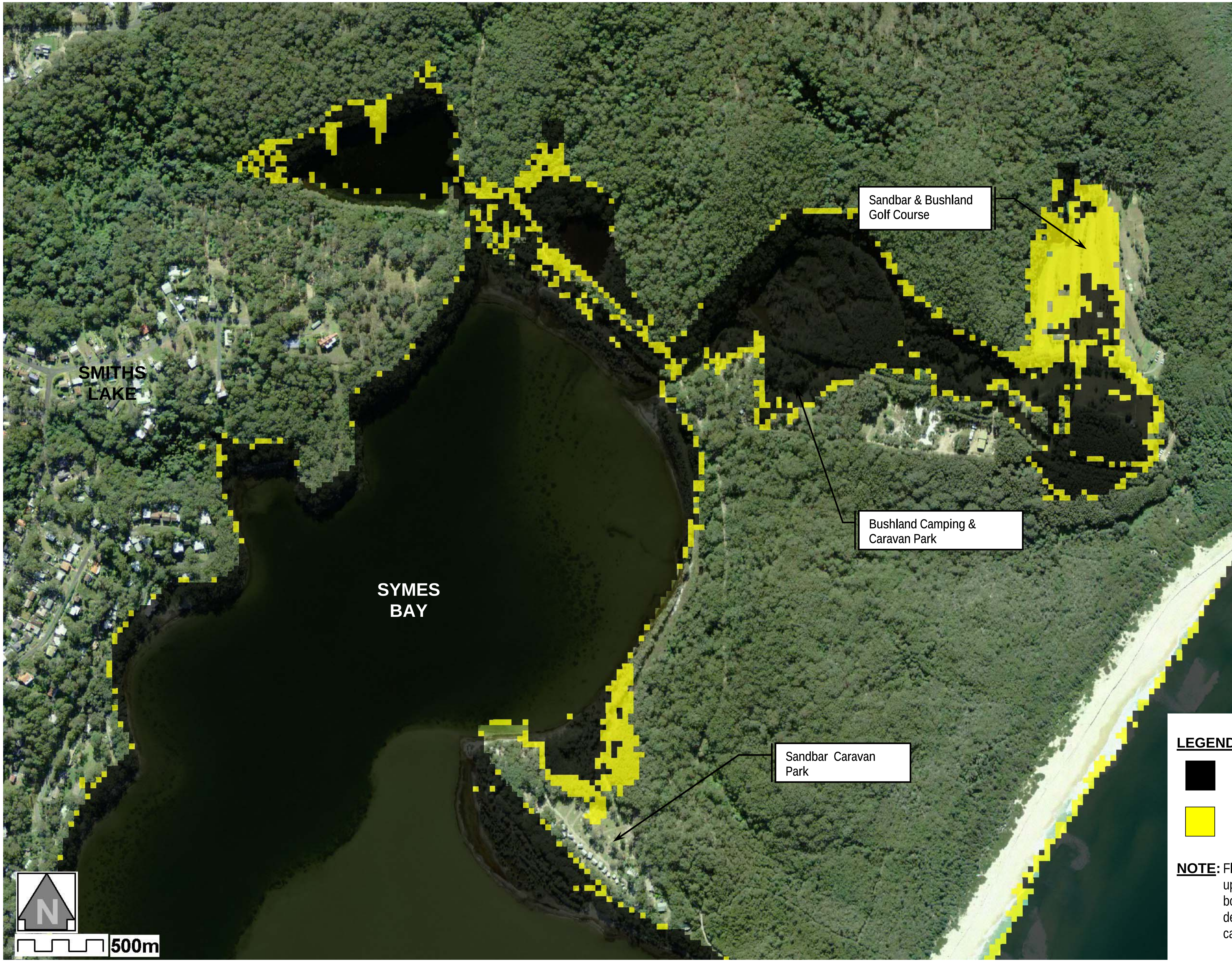
# PROVISIONAL HYDRAULIC CATEGORIES FOR SMITHS LAKE

FIGURE 6




**LEGEND**:

- Floodway/ Flood Storage
- Flood Fringe

**NOTE**: Floodway corridors for tributaries extending upstream from the floodway investigation boundaries are not shown and should be determined as an outcome of independent local catchment investigations.

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Rp2840 – Smiths Lake FPRMS
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**PROVSIONAL HYDRAULIC CATEGORIES IN THE VICINITY OF SYMES BAY**

## 8.3 HAZARD CATEGORISATION

'Hazard categorisation' refers to the assessment of the risk that flooding presents to the population. Two hazard categories are identified in the '*Floodplain Development Manual*' (*2005*), which are referred to as "High" and "Low".

The process of defining flood hazard categories begins by developing the provisional hazard category. The provisional hazard category is based on comparison of the depth and velocity of flooding against a defined hazard category scale (*refer* **Table 9**).

Once complete, the provisional categories are refined through consideration of additional factors which contribute to hazard such as the available flood warning time, the challenges posed by evacuation and the flood awareness of the community. This leads to the development of final hazard categories.

The development of provisional hazard categories and final hazard categories is addressed in the following sections.

### 8.3.1 Provisional Hazard Categorisation Based on Flood Depths and Velocities

Provisional hazard mapping was prepared for the 1% AEP flood event and the PMF flood event. A review of the results of the hazard mapping has identified that hazard categorisation needs to be focussed on the Sandbar and Bushland Holiday Parks and Golf Course and, to a lesser extent, the residents of Dogwood Road in the vicinity of Horse Point.

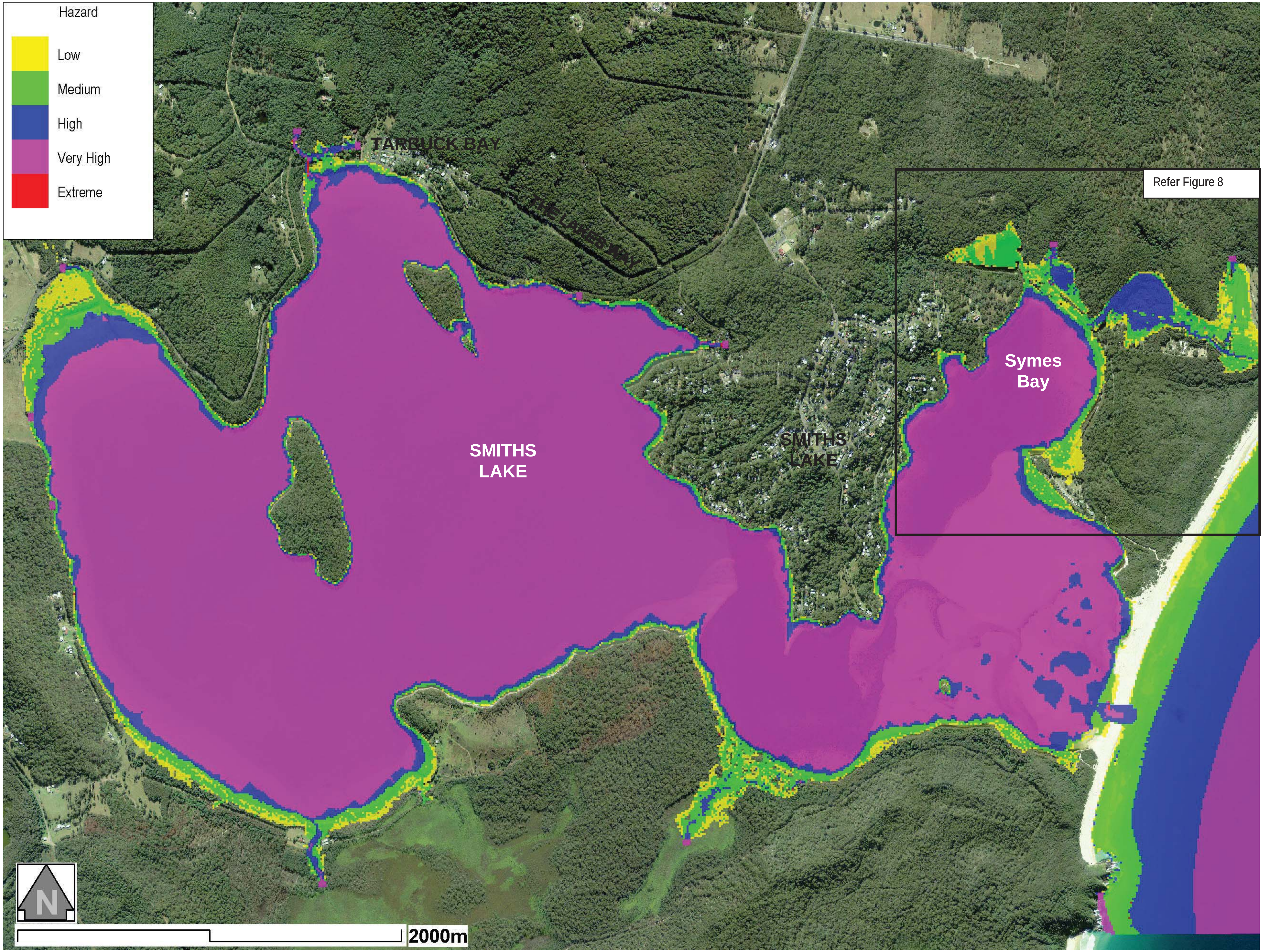
The provisional flood hazard categorisation has been defined in accordance with the depth, velocity and depth/velocity product limits summarised in **Table 9**.

The results of flood modelling indicate that flood hazards in the Smiths Lake township and nearby Tarbuck Bay are relatively minor as most dwellings lie outside of the extent of the probable maximum flood (*PMF*). Furthermore, any properties in the Smiths Lake and Tarbuck Bay townships which experience inundation during the PMF are located sufficiently rising roads access such that evacuation is possible without risk of isolation.

**Figures 7** presents the provisional 1% AEP hazard categories for Smiths Lake. A more detailed figure showing the 1% hazard categories in the vicinity of the Symes Bay is presented in **Figure 8**.

**Figures 9** presents the provisional PMF hazard categories for Smiths Lake. A more detailed figure showing the PMF hazard categories in the vicinity of the Symes Bay is presented in **Figure 10**.

FIGURE 7

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Rp2840 – Smiths Lake FPRMS
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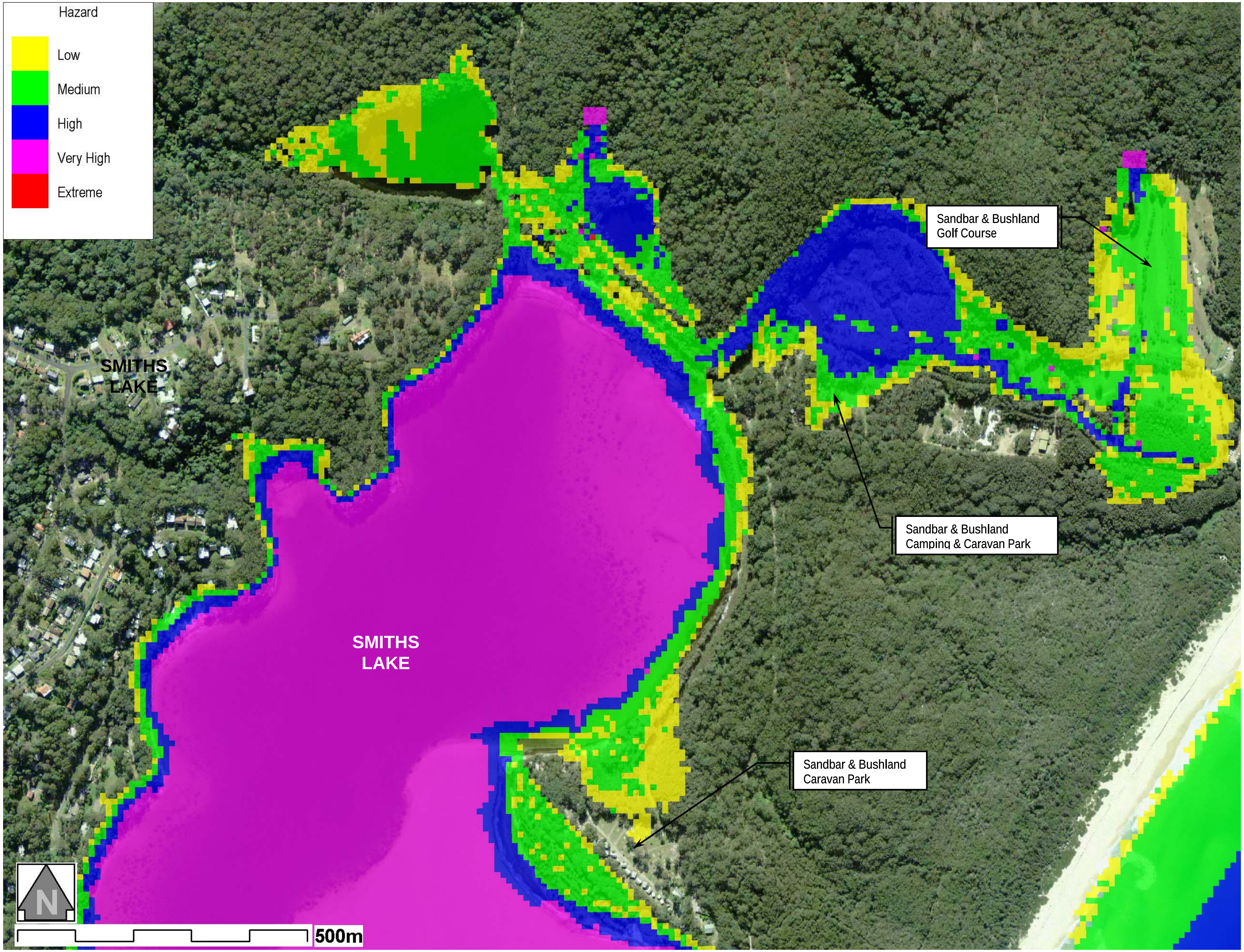
**PROVISIONAL HAZARD MAPPING FOR THE 1% AEP FLOOD EVENT AT SMITHS LAKE**

FIGURE 8

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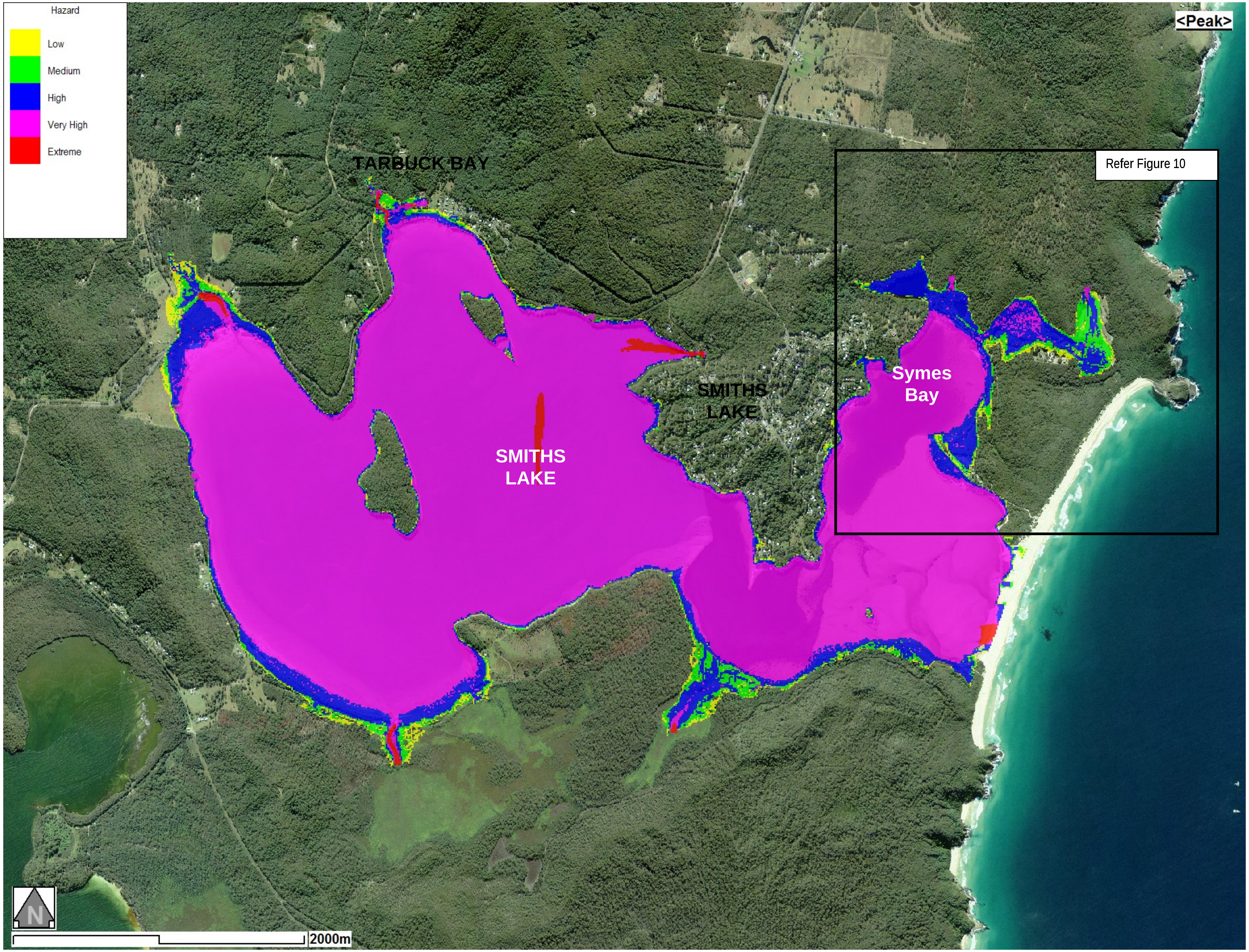
**PROVISIONAL HAZARD MAPPING FOR THE 1% AEP DESIGN EVENT IN THE VICINITY OF SMITHS LAKE**

FIGURE 9

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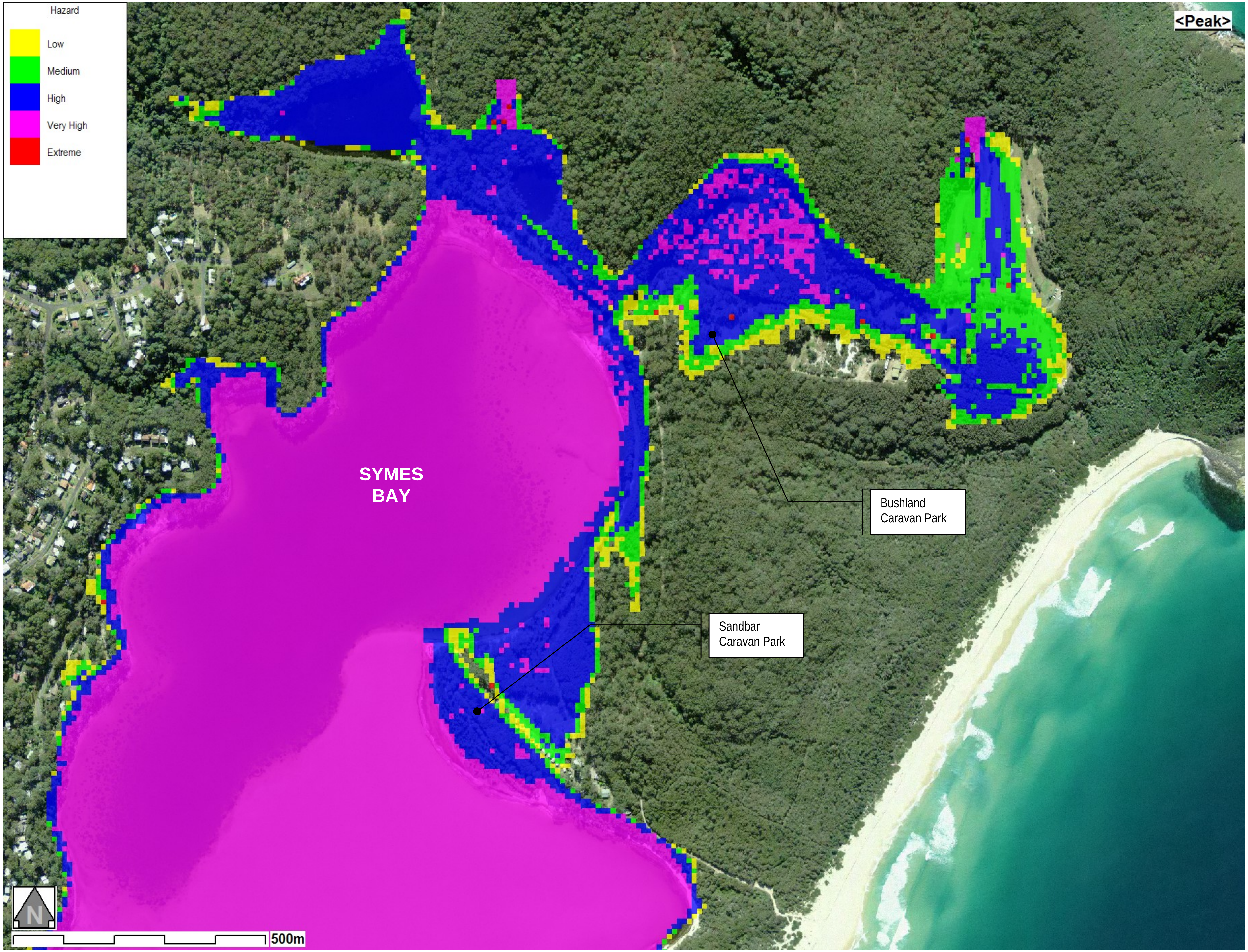
**PROVISIONAL HAZARD MAPPING FOR THE PROBABLE MAXIMUM FLOOD EVENT AT SMITHS LAKE**

FIGURE 10

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**PROVISIONAL HAZARD MAPPING FOR THE PROBABLE MAXIMUM FLOOD EVENT IN THE VICINITY OF SYMES BAY**

### Table 9 ADOPTED PROVISIONAL HAZARD CRITERIA

| HAZARD CATEGORY | CRITERIA | PRACTICAL APPLICATION |
|---|---|---|
| **Low** | Depth (*d*) < 0.4 m & velocity (*v*) < 0.5 m/s | Suitable for cars |
| **Medium** | exceeding Low criteria, and $d \leq 0.8$ m, $v \leq 2.0$ m/s, and $v \times d \leq 0.5$ | Suitable for heavy vehicles and wading by able bodied adults |
| **High** | exceeding Medium criteria, and $d \leq 1.8$ m, $v \leq 2.0$ m/s, and $v \times d \leq 1.5$ | Suitable for light construction, timber frame, brick veneer etc |
| **Very High** | exceeding High criteria, and 0.5 m/s < velocity < 4 m/s & $v \times d \leq 2.5$ | Suitable for heavy construction, steel frame, concrete etc |
| **Extreme** | exceeding Very High criteria and $v > 0.5$ m/s | Unsuitable for development – indicates significant conveyance of flow or floodway |

### 8.3.2 Additional Hazard Factors

#### *Evacuation Problems*

A number of communities have been identified as being vulnerable in the event that an evacuation due to flooding is ordered. These communities are: residents and visitors to the Sandbar and Bushland Holiday Park and Golf Course; and, residents of Dogwood Road near Horse Point. The primary concern is the potential for key access routes to become inundated such that communities are isolated from vehicular evacuation and that temporary infrastructure such as caravans are damaged by flooding.

The issue of flood emergency response protocols is addressed in greater detail in **Section 11.2.7**. However, the following is noted in regard to evacuation:

- Resident of Dogwood Road are likely to experience inundation of access routes during minor flood events and when levels in Smiths Lake are high;
- The Sandbar and Bushland community could be isolated from vehicular evacuation approximately 2 hours and 30 minutes after the commencement of rainfall during the 100 year ARI and PMF events;

- During the peak holiday season, large numbers of people may require evacuation from the holiday park. It is estimated that the combined maximum capacity of the two Sandbar and Bushland sites is approximately 800 (*between 200 caravan and camping berths*).
- There is the potential for increased hazard to result in the scenario where the entrance fails to openly mechanically during a large storm event. This is considered further in **Section 11.2.2**.

Notwithstanding, the relatively small number of people and the available evacuation areas which remain free from flooding during the PMF indicate that the hazard posed by flooding to inhabitants of the floodplain is consistent with the provisional hazard categories shown in **Figures 7** to **10**.

# 9. FLOOD DAMAGE ASSESSMENT

## 9.1 WHAT ARE FLOOD DAMAGES?

Flood damages are adverse impacts that private and public property owners experience as a consequence of flooding. They can be both tangible and intangible and are usually measured in terms of a dollar cost.

Tangible damages include direct damages such as the damage to property as a consequence of inundation (*e.g., the cost of replacing carpets and removing mud from houses in the aftermath of a flood*). Tangible damages can also be indirect damages such as the cost to the community of individuals being unable to get to work because they are isolated due to flooding. These costs can usually be measured and data has been gathered over many years to provide a reliable indication of the likely damage costs that can be incurred by residential, commercial and industrial property owners.

It is more difficult to quantify intangible damages. Intangible damages include less ‘concrete’ impacts such as the trauma felt by individuals as a result of a major flood and the associated health related impacts. Only limited data is available, but it has been stated that intangible damages could be as much or more than the tangible damage cost.

As part of a Floodplain Risk Management Study, it is necessary to determine the total damages that could be incurred as a consequence of flooding. If the total damage cost is significant, it can be argued that works or planning measures to reduce the cost can be justified. The justification process involves determining an estimate of the flood damage that could be expected to occur over the design life of the works (*say 30 years*). This damage cost is then compared to the damage cost if no works were undertaken. The difference defines the reduction in flood damage cost, or the net benefit. The net benefit of the works is compared against the cost of the works, thereby generating a benefit-cost ratio for the works.

If the benefit-cost ratio is sufficiently high (*i.e., ideally greater than 1*), it is likely that the works will attract State Government funding and could proceed.

### 9.1.1 Flood Damage Categories

Flood damage costs for Smiths Lake were determined based on consideration of the different types of land use within each village. The predominant land uses are:

- residential
- commercial; and,
- infrastructure.

Residential and commercial flood damages include damage to structures (*e.g., buildings, houses, factories, offices*) and damage to the items within those structures. They also include damages to outdoor facilities and associated infrastructure, and to the land on which the structures are sited.

Damage to infrastructure as a result of flooding includes losses associated with damage caused by inundation of roads, water supply and sewerage services, and damage to utilities such as electricity, gas and telecommunications systems.

**Figure 11** shows the infrastructure at Smiths Lake that is located below RL 10 mAHD. It is noted that this does not necessarily represent the infrastructure considered to be “at risk” of flooding. This represents the infrastructure surveyed as part of the Floodplain Risk Management Study

Residential and commercial damages can be separated into direct and indirect damages. Direct damages are the result of the physical contact of floodwaters with the structure and may include the costs associated with repair, replacement or the loss in value of inundated items. Indirect damages represent all other costs not associated with physical damage to property and typically include the loss of income incurred by residents affected by flooding, as well as flood recovery items such as clean-up costs.

The approach developed to calculate flood damages for Smiths Lake is based upon the development of a representative damage curve for a typical house in the Smiths Lake region. A damage curve is a numerical relationship that correlates the depth of flooding to the cost of damages that would result from that flooding. The cost of the damages associated with the flooding increases as the depth of flooding increases.

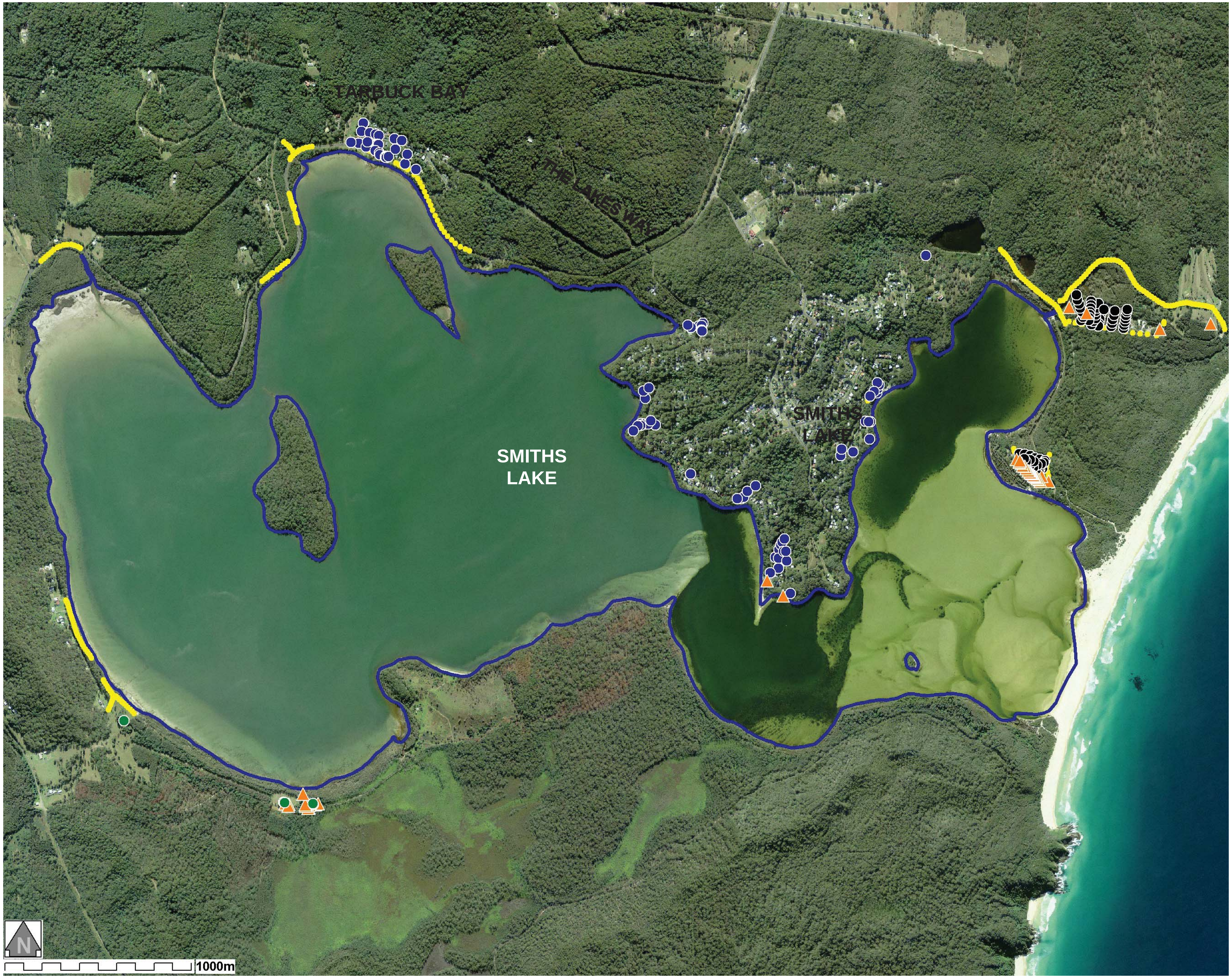
The approach employed applies procedures outlined in the DECC Floodplain Risk Management Guideline titled, *‘Residential Flood Damages’* (*2007*). It involves the application of the damage curves documented in the literature with flood data documented in the *Smiths Lake Flood Study* (*2008*), which has been reviewed and updated as part of this current study.

As outlined in the Guideline, the data available on flood damages only applies to residential properties. Therefore, an estimate of the direct damages associated with the inundation of commercial premises (*such as at Sandbar & Bushland Holiday Park*) was based on recorded damage costs for similar premises reported in the literature. This literature includes a range of previous floodplain management studies and recorded data presented in intergovernmental reports. DECCW has advised that this approach is suitable, provided that the damage curve data is updated to reflect current day Average Weekly Earnings (*AWE*) and GST (*if applicable*).

It was not possible to calculate indirect damages for each individual lot or property. Therefore, the indirect damage costs were assumed to be 5% of the direct damage costs incurred by residential properties.

This is in keeping with procedures adopted in other studies such as the *‘Camden Haven Floodplain Management Study’ (2001)*, and is considered a reasonable approximation based on the relatively short duration of flooding at Smiths Lake.

Indirect damages for commercial and industrial premises were assumed to be 50% of the corresponding direct damages. The higher proportion was assumed to account for the greater impact of indirect influences such as the slowdown that a business could experience due to employees being unable to get to work due to inundation of roads.




LEGEND

Residential & commercial properties below 10mAHD

Manhole covers below 10mAHD

Camping sites below 10mAHD

Septic tanks below 10mAHD

Roads below 10mAHD

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# LOCATION OF PROPERTIES AND INFRASTRUCTURE BELOW 10 mAHD AT SMITHS LAKE

Infrastructure damage costs resulting from flooding were determined using a combination of existing survey data plus an additional contingency factor. Public infrastructure considered in the damages assessment included:

- roads,
- manholes,
- sewerage pump stations; and,
- septic tanks.

In order to account for other forms of infrastructure that might incur damage in the event of flooding (such as electricity, gas and private infrastructure), a contingency of 5% of the total direct and indirect residential (*including dwellings and property damages*) and commercial costs was included in the total infrastructure costs. This is in keeping with damages analyses undertaken for other areas of NSW.

### 9.1.2 Stage – Damage Relationships

Stage-damage curves reflect the potential direct flood damage as a function of the depth of over floor flooding of a building, or the extent of inundation of the land on which the building is sited.

DECC's guideline *'Residential Flood Damages'* (*2007*) outlines the method for determining stage-damage curves for residential dwellings. This procedure is recommended as the basis for derivation of average annual damages and net present values of damages to enable the comparison of floodplain management options.

Standard stage-damage curves have also been developed from records of damages gathered from interviews with residents and landowners in flood affected communities. For example, Smith et al (*1979*) determined stage-damage relationships for different land use types based on data gathered during and following the Lismore floods in 1974.

Accordingly, stage-damage curves were developed for residential properties and commercial/industrial sites based on consideration of the available stage-damage relationships in the literature. Stage-damage curves for infrastructure were developed in a similar manner with damage values altered to account for the reparation or replacement costs of the infrastructure. The adopted stage-damage curves are included within **Appendix C**.

### 9.1.3 Average Annual Damage

The relative cost of the potential flood damages is typically expressed in terms of the Average Annual Damage (AAD). The AAD is the average damage per year that would occur from flooding over a very long period of time.

In understanding this concept, there may be periods where no floods occur or the floods that do occur are too small to cause significant damage. On the other hand, some floods will be large enough to cause extensive damage.

The average annual damage is equivalent to the total damage caused by all floods over a long period of time divided by the number of years in that period (*DECC, 2007*). It provides a measure for comparing the economic benefits of potential flood damage reduction options.

## 9.2 FLOOD DAMAGES ANALYSIS FOR SMITHS LAKE

### 9.2.1 Estimation of Floor Level and Property Data

In order to calculate the potential flood damages, it is necessary to have data that defines the floor levels of structures and infrastructure that could potentially be flooded and details of the type of structure; e.g., residential dwelling or commercial premises. This data can be used with peak flood levels generated from modelling completed for the *'Smiths Lake Flood Study' (September 2008)* to determine the depth of "over floor" flooding for each residential and commercial property.

Damage costs can then be assigned to individual buildings according to the depth of inundation and the associated "damage" as reflected in stage-damage curves that have been developed from data gathered following major floods.

Data defining the minimum elevation levels of residential and commercial buildings, roadways and manholes within the Smiths Lake locality was provided by Council. Data defining the minimum elevation levels of sewerage pump stations and septic tanks was provided by MidCoast Water. This data was used with peak flood levels generated from modelling completed for the *'Smiths Lake Flood Study'* (*2008*), to determine the depth of flooding in the vicinity of each structure. This allowed the depth of '<u>over floor</u>' flooding to be determined (*if any*).

Damage costs were assigned to individual structures according to the depth of inundation and the associated 'damage' as reflected in the applicable stage-damage curve. The elevation of the land on which potentially flood affected buildings are sited was also extracted from available detailed survey data. This allowed an estimate of the costs associated with damage to the land around the dwellings.

### 9.2.2 Predicted Flood Damages

Estimates of the tangible flood damages associated with each of the 5%, 2% and 1% AEP flood events and the adopted extreme flood are outlined in **Table 10**.

The results indicate that the total direct and indirect damage is estimated to be **$84,563** for the design 1% AEP flood event. This damage cost does not account for intangible damages, which have the potential to be as much as the direct and indirect cost. The results of the analysis indicate that the <u>Average Annual Damage</u> for Smiths Lake, incorporating all events up to the extreme flood, is estimated to be $14,045.

The potential impacts of climate change on flooding in Smiths Lake are also considered. **Table 11** presents the estimated flood damages associated with each flood event in 2060, taking into account expected changes in ocean levels. The estimated total direct and indirect damages in 2060 may increase to **$266,472** for the design 1% AEP flood event. This results in an increased in the Average Annual Damage for Smiths Lake to $61,732.

A break-up of the estimated damages for different areas of the floodplain is represented below in **Figure 9.1**, which shows the location proportional distribution of the total damages for all events up to and including the Extreme Flood.

As shown in **Table 10** and **Table 11**, the damages associated with the Extreme Flood are significant. As a result, the Extreme Flood damages can 'skew' the interpretation of damages that might be applied to different areas of the floodplain. This can result in the identification of flood damage reduction options for areas that only experience major damage in very severe floods. These options are likely to have a very low benefit-cost and may be difficult to justify.

**Table 10 DIRECT AND INDIRECT FLOOD DAMAGES (PRESENT DAY)**

| FLOOD EVENT | RESIDENTIAL | | COMM & INDUST | | INFRASTRUCTURE | TOTAL |
|---|---|---|---|---|---|---|
| | Number | Cost | Number | Cost | | |
| 5% AEP | 0 | 0 | 30 | 12,789 | 8,858 | 21,647 |
| 2% AEP | 0 | 0 | 37 | 32,718 | 16,056 | 48,774 |
| **1% AEP** | **0** | **0** | **44** | **55,989** | **28,574** | **84,563** |
| Extreme Flood | 1 | 74,944 | 82 | 539,205 | 139,214 | 757,110 |

**Table 11 DIRECT AND INDIRECT FLOOD DAMAGES (2060)**

| FLOOD EVENT | RESIDENTIAL | | COMM & INDUST | | INFRASTRUCTURE | TOTAL |
|---|---|---|---|---|---|---|
| | Number | Cost | Number | Cost | | |
| 20 Year ARI Flood | 0 | 0 | 48 | 76,146 | 38,093 | 114,239 |
| 50 Year ARI Flood | 0 | 0 | 50 | 89,042 | 47,051 | 136,093 |
| **100 Year ARI Flood** | **1** | **60,947** | **57** | **142,070** | **63,455** | **266,472** |
| Extreme Flood | 15 | 988,323 | 93 | 1,126,220 | 250,063 | 2,364,605 |

Hence, a proportional distribution of the flood damages for all events up to and including the 1% AEP event has been considered and is presented in **Figure 9.2** (*i.e., excluding the Extreme Flood*).

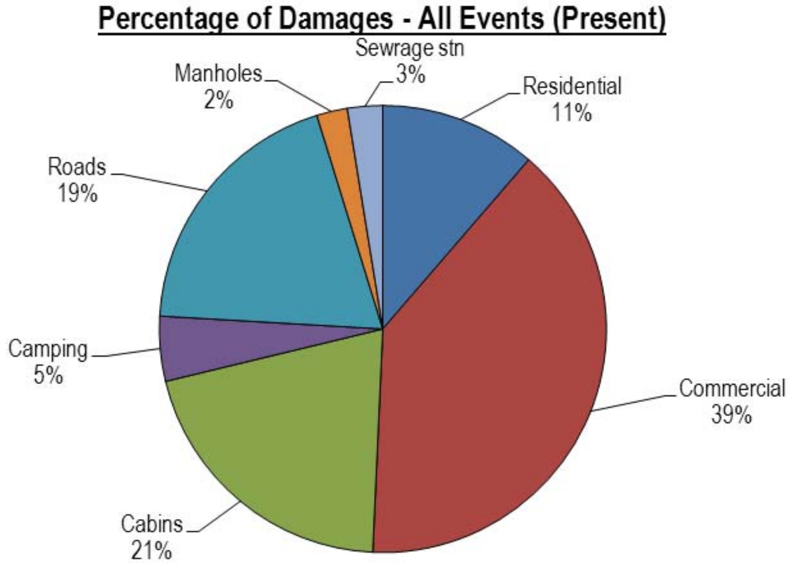



**Figure 12 DISTRIBUTION OF DAMAGES FOR ALL DESIGN FLOOD EVENTS**

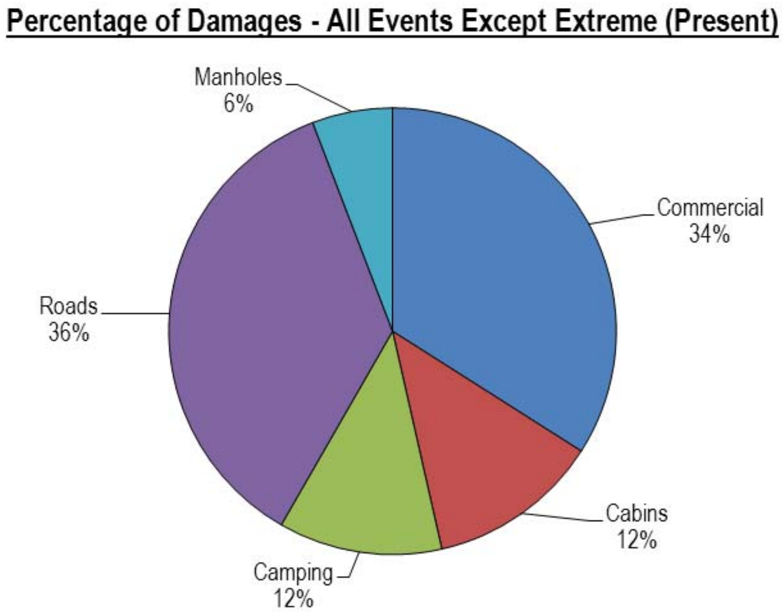



**Figure 13 DISTRIBUTION OF DAMAGES FOR ALL EVENTS UP TO AND INCLUDING THE 1% AEP FLOOD EVENT**

The comparison of damages shown in **Figures 9.1** and **9.2** indicates that residential areas would not experience such significant damage in all floods up to and including the 100 year recurrence flood, but would contribute a significant proportion of the total damages bill if all floods up to and including the Extreme Flood are considered. That is, residential dwellings would experience substantial damage in events rarer than the 1% AEP flood event.

These figures also show that the areas that experience the greatest flood damage are typically:

- Commercial;
- Roads; and,
- Sandbar & Bushland Holiday Park cabins and camping sites.

Accordingly, it is appropriate through the Floodplain Risk Management Study process, to investigate flood damage reduction options targeted toward reducing flood damages in these areas.

## 9.3 INTANGIBLE FLOOD DAMAGES

Intangible flood damages are those that are unable to be quantified in monetary terms. These damages are related to the physical and mental health of individuals, environmental concerns, the ability to undertake necessary evacuation measures and disruption to essential community services and operations.

Notwithstanding, emotional stress and mental illness can stem from a number of experiences associated with damage to family homes and businesses. These include:

- destruction of memorabilia (*i.e., family photos*);
- death of pets;
- financing the replacement of damaged property;
- living in temporary accommodation;
- children attending a different school;
- loss of business income and potential clients;
- loss of wages; and,
- anxiety experienced by young children.

This type of intangible damage to the well-being of residents could be significant in the event of a major flood. Accordingly, it is possible that the intangible damage cost could be close to the total tangible damage cost.

# 10. FLOODPLAIN MANAGEMENT OPTIONS

Information presented in the *Smiths Lake Flood Study* (*2008*) and the damages analysis outlined in **Section 8**, indicates that there is relatively minimal damage due to flooding in Smiths Lake. In particular, the results indicate that there are no residential properties inundated due to flooding in all events except the PMF.

However, the results of modelling undertaken for the project indicate that there are a number of properties potentially at risk from flooding. This includes the Frothy Coffee Boatshed and certain facilities owned and managed by the University of New South Wales' School of Zoology near Horse Point. However, the extent of existing flood affected infrastructure at Smiths Lake is relatively minor.

Although the flood affected infrastructure under existing conditions is considered to be relatively minor, there are a range of related issues which must also be addressed. These include the continuing flood risk to users of the "Bushland" and "Sandbar" Caravan Parks.

Separately, the predicted impact on flooding associated with climate change has the potential to affect flood planning at Smiths Lake. Although the results of the modelling indicates that climate change is unlikely to affect any dwellings, it will be necessary to review the proposed entrance opening regime in conjunction with the projected increase in sea level rise. Climate Change is also predicted to impact infrastructure including roads, bridges and elements of the waste water treatment system.

Additionally, an important outcome of the study is to set the flood planning level for the lake, both for present day conditions and for the adopted 2060 climate change scenario. This will guide decision making regarding appropriate future development at the lake.

A list of options was developed in consultation with representatives from Council, OEH and the Great Lakes Floodplain Risk Management Committee. The measures were devised with a view to reducing the existing flood damages that could be incurred by the community and with a view to providing a mechanism for ensuring that the risk faced by future development was minimised.

The potential floodplain management options assessed comprise a combination of 'flood damage reduction options' (*structural measures*) and 'planning options' (*non-structural measures*). The flood management options that were adopted for investigation are listed below in **Table 12**. Each of these options was investigated to assess their respective advantages and disadvantages considering issues associated with flood hydraulics, environmental constraints and economics.

The options identified in **Table 12** were considered to be suitable and to have the potential to provide additional flood protection.

## Table 12 CONSIDERED FLOOD DAMAGE REDUCTION OPTIONS

| OPTION | DESCRIPTION OF WORKS / ACTIONS ASSOCIATED WITH OPTION |
|---|---|
| **Option 1** | Review current entrance opening protocols for Smiths Lake in the context of climate change related impacts on lake filling cycles. Identify contingency measures which plan for climate change while mitigating the effect of flooding at the lake. |
| **Option 2** | Assess the risk and develop contingency protocols in the event that the adopted entrance opening protocol fails during a major storm event. |
| **Option 3** | Determine and develop potential climate change adaptation strategies for flood risk management planning for the built and natural environment. This includes the following:<br>• Option 3A: Voluntary House Raising.<br>• Option 3B: Levee Upgrade Alignment.<br>• Option 3C: Road Raising Program |
| **Option 4** | Determine the Flood Planning Level for various land use in the context of the potential variables (i.e. entrance opening conditions/ climate change) identified above. |
| **Option 5** | Review future land use planning in the context of existing design flood levels, together with potential changes associated with modified entrance opening protocols and climate change |
| **Option 6** | Review existing planning controls related to the management of flood prone land |
| **Option 7** | Review emergency response protocols with a particular focus on any “at-risk” communities located within flood prone land, or which may become isolated during major flooding. |

# 11. FLOODPLAIN MANAGEMENT OPTIONS ASSESSMENT

## 11.1 OPTIONS FOR INVESTIGATION

One of the major objectives of the Smiths Lake Floodplain Risk Management Study is to identify and assess opportunities for reducing the impact of floods on flood affected communities located around the perimeter of Smiths Lake.

The damage assessment documented in **Section 9** established that the single occurrence of the design present day 1% AEP flood event would lead to damages amounting to **$84,560**. This damage cost does not account for intangibles, which have the potential to be as much again. Commercial properties such as the Sandbar & Bushland Holiday Parks and Golf Course would incur the greatest proportion of this damage cost.

The results of the analysis also indicate that the present Average Annual Damage (AAD) for all events up to and including the extreme flood is in the order of **$14,000**. That is, funds in the order of $14,000 would need to be put aside each year on average, in order to cover the damage bills that could be incurred as a consequence of flooding.

The relatively small cost of the 1% AEP flood event and the predicted AAD indicate that compared to a number of other coastal communities, flooding does not pose a significant risk, when considering the overall cost. Notwithstanding, appropriate management of the floodplain is required to ensure this continues into the future. It is also important to ensure those areas of the floodplain currently at risk during flooding are managed appropriately.

The following chapter details the investigation of each of the structural flood damage reduction option that were considered, including the benefits and dis-benefits arising from their installation and the cost to implement. This has been undertaken for the purpose of identifying those structural options that provide the greatest cost-benefit to communities located in the vicinity of Smiths Lake.

## 11.2 INVESTIGATION OF OPTIONS

### 11.2.1 Option 1: Investigation of Entrance Berm Breakout Options for 2060 Conditions

As discussed in **Section 7**, peak flood levels for the 2060 climate change scenario are expected to increase to approximately 2.9 mAHD. It is noted that the peak 1% AEP flood level in the lake is predicted to increase by approximately 0.4 metres in response to a combination of sea level rise and increased rainfall intensity during major storm events.

The current entrance opening trigger level was adopted following extensive consultation between Council, the community and other interest groups. It is beyond the scope of the current investigation to consider the potential ecological impacts of sea level rise on Smiths Lake. However, it is considered appropriate to identify a number of measures to account for the flood related impacts of climate change.

Climate change has the potential to affect a number of flood related aspects of Smiths Lake. These include an increase in the elevation of the entrance berm due to changes in coastal processes associated with sea level rise and increases in evapotranspiration as a consequence of higher average temperatures. Although there is also projected to be an overall decrease in average annual rainfall, the intensity of individual storm events is predicted to increase.

By themselves, the rainfall and evapotranspiration related factors can be expected to lead to lower than average lake levels compared to present day, with levels rising more rapidly during major storm events. However, these factors are considered to be off-set by changes in average sea level.

As discussed, the upper level prediction for 2060 sea level rise conditions is 0.5 metres, which is equivalent to a maximum neap tide level of around 1.1 mAHD. The effects of this are discussed in the following section.

### *Predicted Increase in Lake Entrance Opening Frequency*

A tide gauge operated by the Manly Hydraulics Laboratory records water levels in Smiths lake at Tarbuck Bay. Records are available from 1995 to present. The record at the Tarbuck Bay water level recorder indicates the lake closes to the ocean at around 0.6 mAHD. Although this will vary as a function of the ocean and climate conditions which prevail following entrance opening, this is considered to be a reasonable representation.

Currently, for the lake level to rise from 0.6 mAHD at closure to the trigger level of 2.1 mAHD, a total net volume of approximately 15,200 ML is required to discharge to the lake. In reality, the required volume of runoff will be greater as a consequence of losses due to evaporation.

The water level record at Tarbuck Bay indicates that the lake was opened 17 times in the period between June 1995 and March 2013. This equates to an opening frequency of once every 17 months. The actual frequency is a function of the prevailing climate. For example, during 2011, which was characterised by wetter than average conditions, the lake was opened twice. Conversely, there have been several dry periods where close to 2 years has occurred between openings.

However, it is expected that with sea level rise, the level in the lake will typically be higher at the time of closure in comparison to existing conditions. This is because this level is largely dependent upon the tidal climate. In the absence of more detailed information regarding the effects of climate change, it can be assumed that the level in the lake at the time of closure will typically remain consistent with the neap tide level.

Therefore, under the 2060 scenario and assuming the upper level of projection for sea level rise occurs, the level in the lake at the time of closure will be approximately 1.1 mAHD.

This feature of climate change means that the total volume available to capture run-off to the lake is reduced. In this instance, the volume required to fill the lake, commencing from closure at 1.1 mAHD, would reduce from around 15,200 ML to 9,500 ML.

As sea level rises, it is reasonable to expect that the level in the lake at the time of closure will decrease. This will also decrease the volume which is necessary to fill the lake to the existing trigger level of 2.1 mAHD. **Table 13** provides a summary of the volume of run-off which is required to reach the existing entrance opening trigger level and an assessment of the reduction in time between openings.

**Table 13 PREDICTED AVERAGE INTERVAL BETWEEN ENTRANCE OPENING FOR PROJECTED SEA LEVEL RISE SCENARIOS**

| YEAR | Neap Tide Level (m AHD) | AVAILABLE STORAGE VOLUME TO 2.1 mAHD (ML) | Approximate average Duration Between Required Openings |
|---|---|---|---|
| Present day | 0.6 | 15,240 | 17 months |
| 2020 | 0.7 | 14,260 | 16 months |
| 2030 | 0.8 | 13,280 | 15 months |
| 2040 | 0.9 | 12,290 | 14 months |
| 2050 | 1.0 | 11,290 | 13 months |
| 2060 | 1.1 | 10,300 | 11.5 months |

As **Table 13** indicates, there will be a gradual increase in the frequency of entrance opening as a result of sea level rise. Although the increase will be gradual, it will be necessary to adapt to the change in conditions. To compensate, it is recommended that the trigger level of the lake be increased incrementally as a function of the average increase in sea level.

Although the current entrance opening regime could be maintained, this will lead to increased costs. Currently the entrance opens more frequently than would occur without mechanical intervention. Therefore, it is considered appropriate to target an opening frequency under climate change conditions which mirrors the average existing frequency.

It is recognised that increasing the trigger level in the lake has the potential to influence flood related characteristics. The changes in the flood regime associated with a modified trigger level have been considered in **Section 7**.

In addition, a range of measures which are targeted towards mitigating the impact of climate change on infrastructure around the lake are outlined in **Sections 11.2.3**, **11.2.4** and **11.2.5**.

### 11.2.2 Option 2: Emergency Protocols In the Event of Mechanical Opening Failure

The current adopted water level trigger for entrance opening is at an elevation of 2.1 mAHD. In practice, the lake may be opened any time the water level rises above 1.9 mAHD, subject to forecast rainfall and the availability of an experienced operator and Council staff.

In general, there is adequate warning time to mobilise an excavator and formalise a 'pilot' channel through the entrance berm. However, there are a number of different scenarios whereby the current protocol to open the entrance to the lake may fail. These include the following:

(i) Instances where the excavator malfunctions

(ii) Instances when an operator is unavailable

For this reason, modelling was undertaken to establish the likely level that would be reached in the lake in the event that the entrance wasn't opened. This has been prepared assuming that no entrance channel is formed and the lake fills in response to the rainfall event. It is also assumed that the initial water level in the lake is at 1.9 mAHD.

A summary of the peak water level which would occur in the lake is provided in **Table 14**. This information will be considered further as part of the identification of appropriate development controls.

**Table 14 PEAK LAKE FLOOD LEVEL – ENTRANCE OPENING FAILURE**

| FLOOD EVENT | RAINFALL EVENT DURATION | PEAK FLOOD LEVEL (mAHD) |
|---|---|---|
| 20% AEP | 72 hour | 2.43 |
| 5% AEP | 72 hour | 2.6 |
| 1% AEP | 72 hour | 2.8 |
| PMF | 6 hour | 4.2[1] |

1. It is noted that entrance breakout from the lake will have developed and it is unlikely that the level would eventuate. Nonetheless, this level provides a representation.

### 11.2.3 Option 3A: Climate Change Related Measure - Voluntary house raising

#### *Description of Option*

House raising is a process whereby an existing structure is separated from its foundation and elevated by hydraulic jacks to a desired height (typically around 3 metres). A new foundation is then constructed beneath the raised structure. The cost of raising a structure depends on several factors, such as the size of the building, construction material and the type of foundation. For example, the cost of raising a single storey, non-brick house on a pier foundation to a height of roughly 3 metres is typically in the order of $40,000 to $50,000. This cost would increase for a large brick house with concrete foundations.

House raising is an option offered to residents on a voluntary basis. Council subsidies are offered to residents based on the severity of the risk of flooding for each property. Even if this option is not pursued by a particular resident, the ongoing offer of a subsidy by Council may influence the future saleability of the property, as prospective purchasers consider potential flood risk.

Current estimates of flood damages in Smiths Lake are not significant enough to justify investigation of voluntary house raising as a flood risk management option. However, with the expected increases in flood levels over the next 50 years due to climate change and the resulting predicted rise in sea levels, voluntary house raising will become a more viable long-term management option. Hence, it has been included in this investigation.

The current model indicates that for the estimated 0.5 metre rise in flood levels over the next 50 years, there will be four structures at risk of flooding in the design 2060 1% AEP flood event. One structure at risk is a residential home and the remaining three are commercial properties. These four structures are identified as potential candidates for voluntary house raising as they are most likely to incur damage during flood events. A description of the structures is povided in **Table 15**.

**Table 15 Buildings Investigated for Voluntary House Raising**

| DESCRIPTION | LEVEL (*m AHD*) | USAGE | FOUNDATION | ESTIMATED COST OF RAISING |
|---|---|---|---|---|
| **Residential Property** | 3.017 | Residential | Concrete slab | **$60,000** |
| **UNSW Zoology Room** | 2.961 | Commercial | Pier | **$50,000** |
| **Frothy Coffee** | 2.224 | Commercial | Pier | **$40,000** |
| **Golf Shed** | 2.956 | Commercial | Concrete slab | **$40,000** |

### *Benefit Cost Assessment*

The estimated cost of raising each building is based on approximate quotes obtained from several contractors in NSW for a range of structures, as well as other flood risk management reports which investigate house raising options. From **Table 15**, the total cost of raising all four structures is approximately **$190,000**.

The financial benefit of raising all four structures is the estimated reduction in damage incurred during each flood event for the individual properties according to the relevant damage curve. This benefit is deducted from the existing flood damages to obtain new AAD values for both the present day and 2060. The net annual benefit of implementing the house raising option is equal to the value of the reduction in AAD.

If house raising was implemented on all four structures such that flood risk to each structure was mitigated for all flood events, the present day AAD would decrease from $14,000 to $9,000. This yields an approximate annual benefit of **$5,000**. For the predicted flood level increase in 2060 due to climate change, house raising would decrease the estimated 2060 AAD from $62,000 to $36,000 resulting in an annual benefit of **$26,000**.

The net benefit in AAD reductions resulting from house raising are interpolated linearly for intermittent years between the present day and the 2060 value. Assuming an interest rate of 7% and an ensuing working life of 50 years for each building, the net present value of the benefits is approximately $145,800. The resulting cost-benefit ratio is **0.77**. Hence the present value of the costs of implanting house raising exceed the expected benefits.

The scope of this investigation into voluntary house raising has been the four properties considered at most risk from flood damages. A total of fifteen residential and fifteen commercial properties are identified as being at risk from the estimated 2060 PMF event. Given that when only the most suitable candidates are considered house raising is a negative net present value option, expanding the scope of the investigation to include the remaining at-risk properties is expected to be a less economically viable option.

### 11.2.4 Option 3B: Climate Change Related Measure - Construction of Two Levees to Protect Two Sandbar holiday Park Sites

#### *Description of Option*

The Sandbar & Bushland Holiday Parks and Golf Course maintains two holiday park sites and one golf course located on the eastern side of Smiths Lake. The Sandbar Holiday Park site is located north of the entrance channel on the banks of Smiths Lake and contains berths for caravans and approximately 16 permanent cabins. Bushland Holiday Park is located approximately 1 km to the north-east, along Bushland Creek and comprises camping grounds and caravan berths (*refer* **Figure 14**).

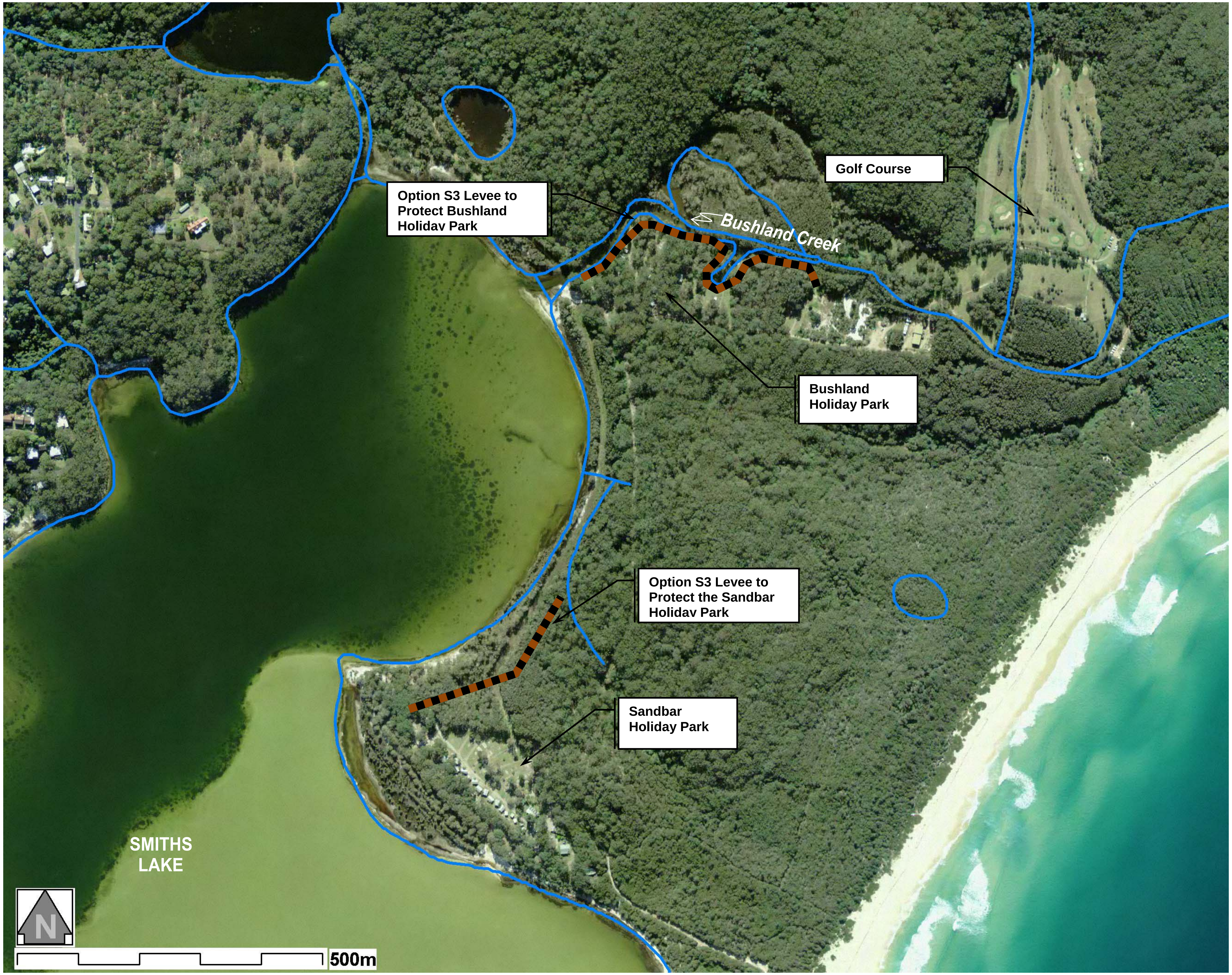
In order to protect both sites from flooding, two levees could be constructed. The alignment of the proposed levees is shown in **Figure 14**. The proposed levees would serve to prevent inundation from the lake.

The proposed levee at the southern site has a length of 315 metres and the proposed levee at the northern site has a length of 430 metres. The levees would need to be constructed to a minimum crest elevation of 3.4 m AHD, which would protect against the design 2060 1% AEP flood event (*with an allowance of 0.5 m freeboard*). The proposed levees would protect <u>all</u> berths within each holiday park site.

#### *Benefit Cost Assessment*

The proposed levees are expected to protect both sites in all flood events up to and including the 2060 1% AEP flood event. There is not expected to be any notable flood impacts, provided drainage from Bushland Creek is adequately maintained.

The estimated cost of the southern levee is estimated to be **$225,000** and the estimated cost of the northern levee is **$340,000**.

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# ALIGNMENT OF THE PROPOSED LEVEES FOR FLOODPLAIN MANAGEMENT OPTION S3B

The levees will protect all infrastructure contained within the holiday park sites from flood damage. Construction of the levees is not expected to significantly affect peak flood levels. Nor is there any neighbouring infrastructure that might be affected by any changes in peak flood levels in the vicinity of the levees.

Construction of the levees is estimated to result in reduced damages in the amount of **$3,882** in the present AAD and of **$11,565** in the 2060 AAD. These values are linearly interpolated over the intermittent 50 year period to calculate a present value of benefits of $43,800.

However, given the total cost of levee construction is estimated to be $565,000, the costs of levee construction significantly outweighs the benefits. The cost-benefit ratio is calculated as **0.14**. This suggests there is limited economic support for construction of a levee.

### 11.2.5 Option 3C: Climate Change Related Measure - Road Raising

#### *Description of Option*

Road raising involves removing existing roadways which are at-risk of flood damage, raising the embankment and re-surfacing the roadway. The process of raising the surface profile of roadways requires removal of the existing roadway surface, construction of an embankment to elevate the road and subsequent re-profiling of the crest of the embankment.

Road embankment raising has been investigated as an option for delivering protection in the present day design 5% AEP flood event and the 2060 design 5% AEP flood event. Four sections of roadway within the Smiths Lake district were identified as being at-risk from flooding in events of this magnitude. The alignment of these roadways is shown in **Figure 15**.

The peak level for the present day design 5% AEP flood event is 2.3 mAHD. The total length of road that would need to be raised to prevent inundation is approximately 1.3 kilometres. The estimated 2060 design flood level is 2.8 mAHD and the total length of road that would need to be raised to prevent inundation is 3 kilometres. Road raising will also assist with providing adequate evacuation from isolated communities.

The cost of construction of each roadway is:

- Design present day 5% AEP flood event: **$1,129,500**
- Design 2060 5% AEP flood event: **$2,900,500**

#### *Benefit Cost Assessment*

The scope of roadworks required to protect existing roadways from the two flood events is considerable. The process requires the excavation, transportation and deposition of large volumes of fill material as well as the relaying of a significant area of basecourse and the repaving of the bitumen surface.


**LEGEND**

Section of roadway identified for raising in Option S3

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# SECTIONS OF ROADWAY IDENTIFIED FOR RAISING IN FLOODPLAIN MANAGEMENT OPTION S3C

Analysis of the benefits of implementing the road raising option shows that the costs of construction significantly outweigh the estimated benefits. The benefits were calculated as the reduction in AAD which occurred under present day design flood levels and design 2060 flood levels. The values were interpolated for a 50 year working life for the proposed roadways.

The present value of the benefits of constructing the 2.3mAHD roadway embankment is **$77,341**. The present value of the benefits of constructing the 2.8 mAHD roadway embankment is **$207,321**. For both cases, the benefit-cost ratio is **0.07**. Hence, in isolation, any proposal to raise the road embankment is not considered to be justifiable from an economic perspective.

A large proportion of the costs of the road raising option are accounted for through re-surfacing of the road (*approximately 60% of the total cost of road surface raising*). As part of Council's ongoing management of local roadways, sections of road at risk of flooding may require resurfacing due to ordinary use. Hence, Council might consider implementing roadway raising as part of its ongoing road maintenance program or as opportunity arises. The additional cost of embankment construction would represent a smaller investment but would yield the same result in terms of potential flood damage reduction. If the total cost of roadway raising is taken as the cost of embankment construction only (*approximately 40% of total costs*) the benefit-cost ratio increases to **0.18**.

### 11.2.6 Option 4: Adopt Flood Planning Levels

One of the key aspects of the NSW Government's Flood Liable Land Policy is the definition of appropriate Flood Planning Levels. Flood Planning Levels have been developed with an aim to reduce the likelihood that dwellings are inundated by flooding and to reduce the likelihood of people being exposed to dangerous flood situations.

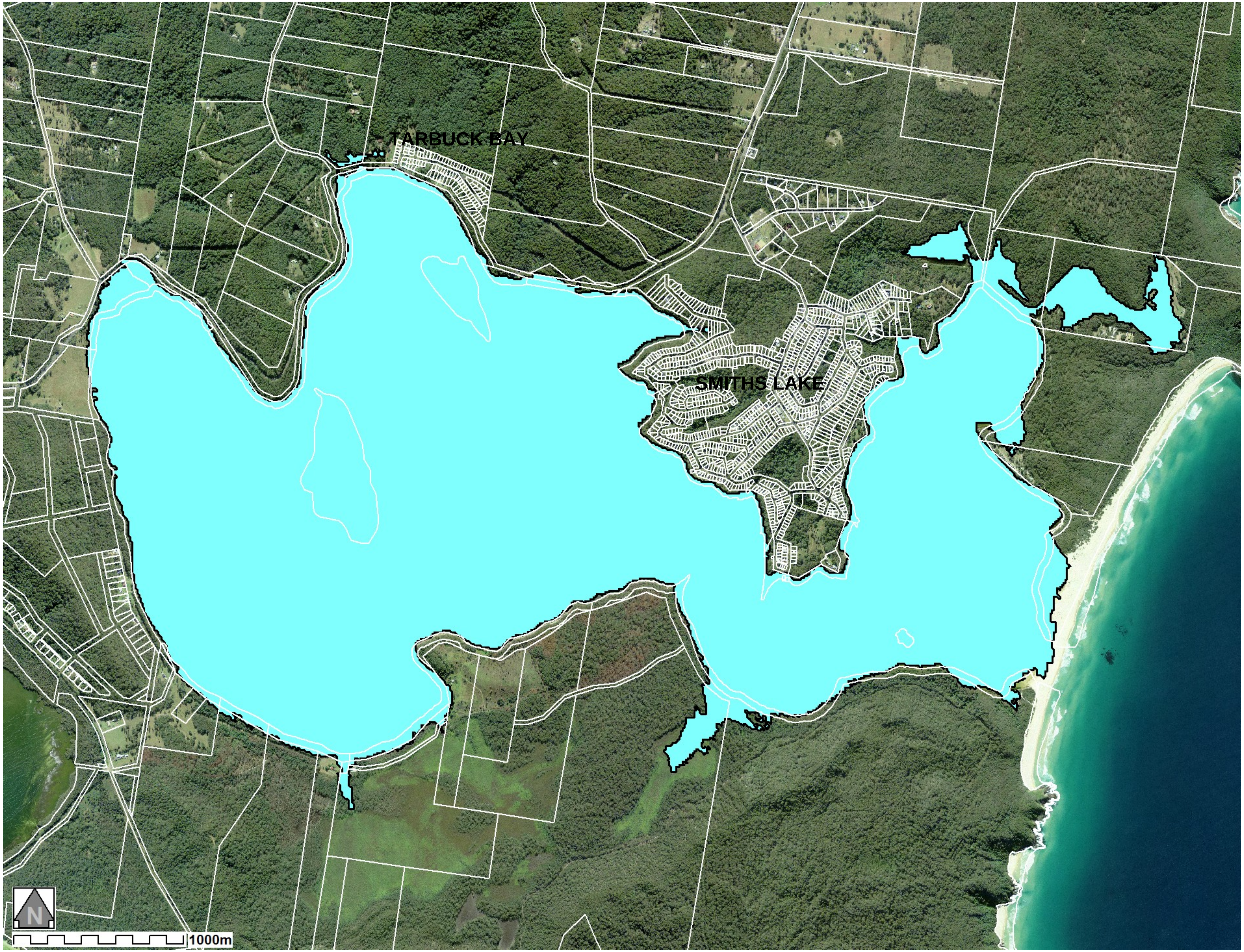
A number of different Flood Planning Levels (FPL) may be defined for different land uses. The FPL is defined by an ARI flood event combined with a freeboard considered appropriate for the land use in question. The purpose of a specified freeboard is to account for the risk associated with various uncertainties in the predicted flood level. These risks may include the variation between flood modelling results and actual flood events, the effect of localised factors on flood levels and potential wave action. In some instances, a zero freeboard may be adopted.

#### *Residential Flood Planning Levels*

The default design flood event for defining the Residential Flood Planning Level as defined by the Floodplain Development Manual (2005) is the 1% AEP event. The most commonly adopted freeboard is 500 millimetres. However, there is scope to modify the freeboard should the prevailing flood conditions suggest this freeboard to be not appropriate.

An overview of the Flood Planning Area (FPA) corresponding to the standard Flood Planning Level for the Smiths Lake Floodplain Risk Management Study area is provided in **Figure 16**.

FIGURE 16

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Rp2840 – Smiths Lake FPRMS
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**SMITHS LAKE**
**FLOOD PLANNING AREA MAP**
**FOR 1% AEP FLOOD WITH 0.5 m FREEBOARD**

A range of scenarios were assessed to define the 1% AEP flood level for Smiths Lake for present day conditions, including consideration of closed and open entrance scenarios and elevated ocean tidal graphs (*refer* **Section 6.3.2**). A 1% AEP flood level for present day conditions of 2.42 mAHD was selected. Allowing for a freeboard of 0.5 metres, a standard residential flood planning level of 2.92 mAHD is recommended for adoption.

A review of various factors that affect the appropriate freeboard was also undertaken. This included consideration of the potential risk to life, flood behaviour, and social, economic and environmental issues. In particular, consideration was given to the potential for the lake to rise in the event that mechanical opening of the entrance was not able to be undertaken during a 1%AEP event.

The results presented in **Table 14** indicate that without opening, levels in the lake would rise to 2.8 mAHD. Therefore, a freeboard of 500 mm incorporates adequate provision for contingency against a failure in mechanical opening during the 1% AEP event. Hence, a freeboad of 500 mm is considered appropriate in the derivation of an FPL for Smiths Lake.

The hazard posed by flooding to residents, as documented elsewhere in this report, has also been considered. Particular attention was given to hydraulic and hazard categorisation. Notably, the hazard throughout most of the floodplain during the 1% AEP event is predominantly Low (refer **Section 8.3**). This suggests that hazard associated with flooding is not significant enough to warrant any increase in the standard freeboard.

Mapping for the 2060 Residential Flood Planning Level has also been prepared based on the results of modelling documented in **Section 7**. The FPA map for the 2060 conditions is presented in **Figure 17**.

A comparison between the extent of the two Flood Planning Area maps is shown in **Figure 18**.

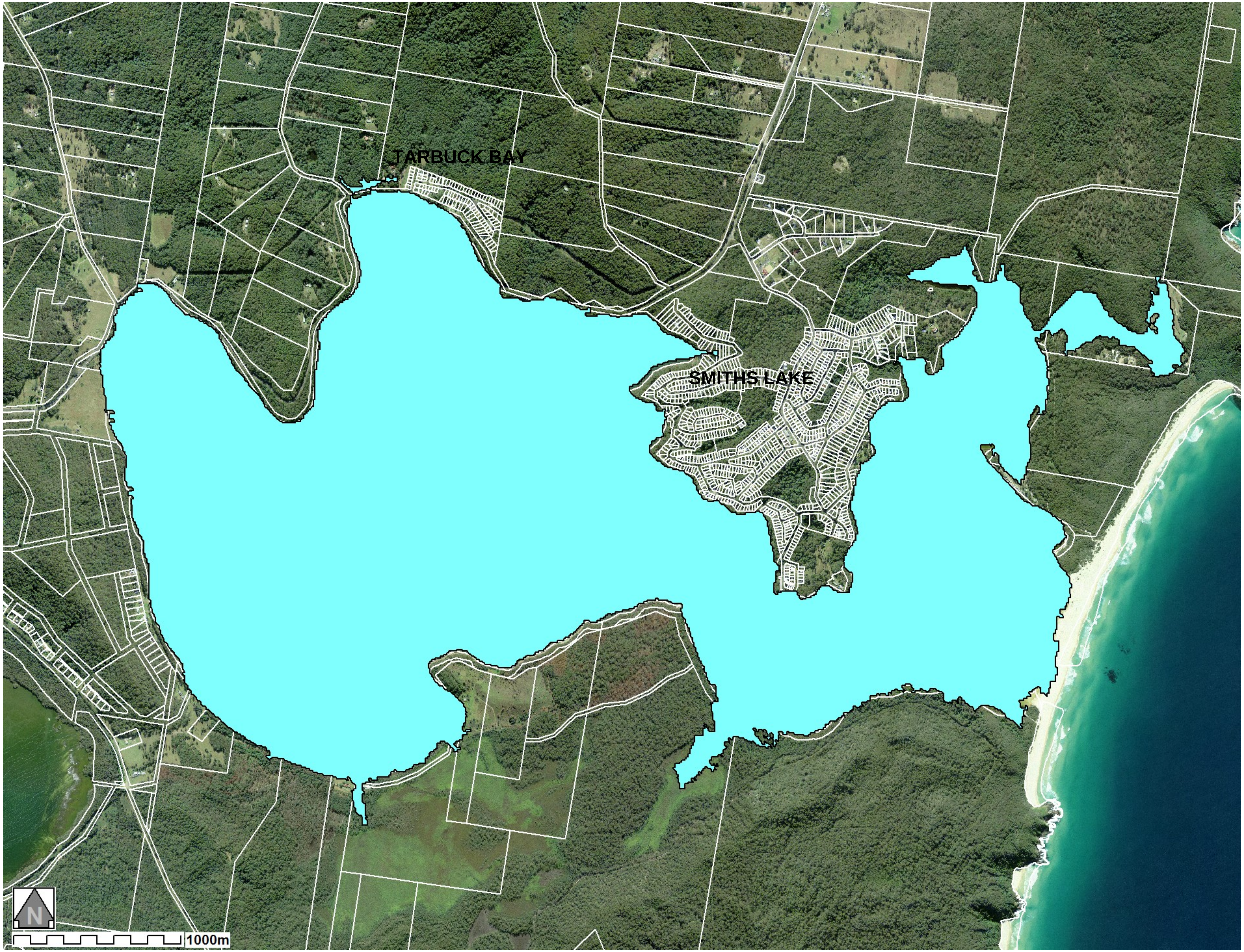
**Figure 18** illustrates that there is almost no difference in the extent of land affected by the Flood Planning Area map for the existing and 2060 flood planning levels, even though an increase in flood level of approximately 0.4 metres is predicted. Similarly, this is the case for the FPA corresponding to the Year 2100 conditions.

### *Identification of Other Alternative Flood Planning Levels*

A number of alternative FPL's may also apply to particular land uses. The alternative FPL's are summarised in **Table 16**.

The FPL's documented in **Table 16** have been developed based on experience with floodplain management at other locations, together with consideration of the particular characteristics of flooding at Smiths Lake.

FIGURE 17

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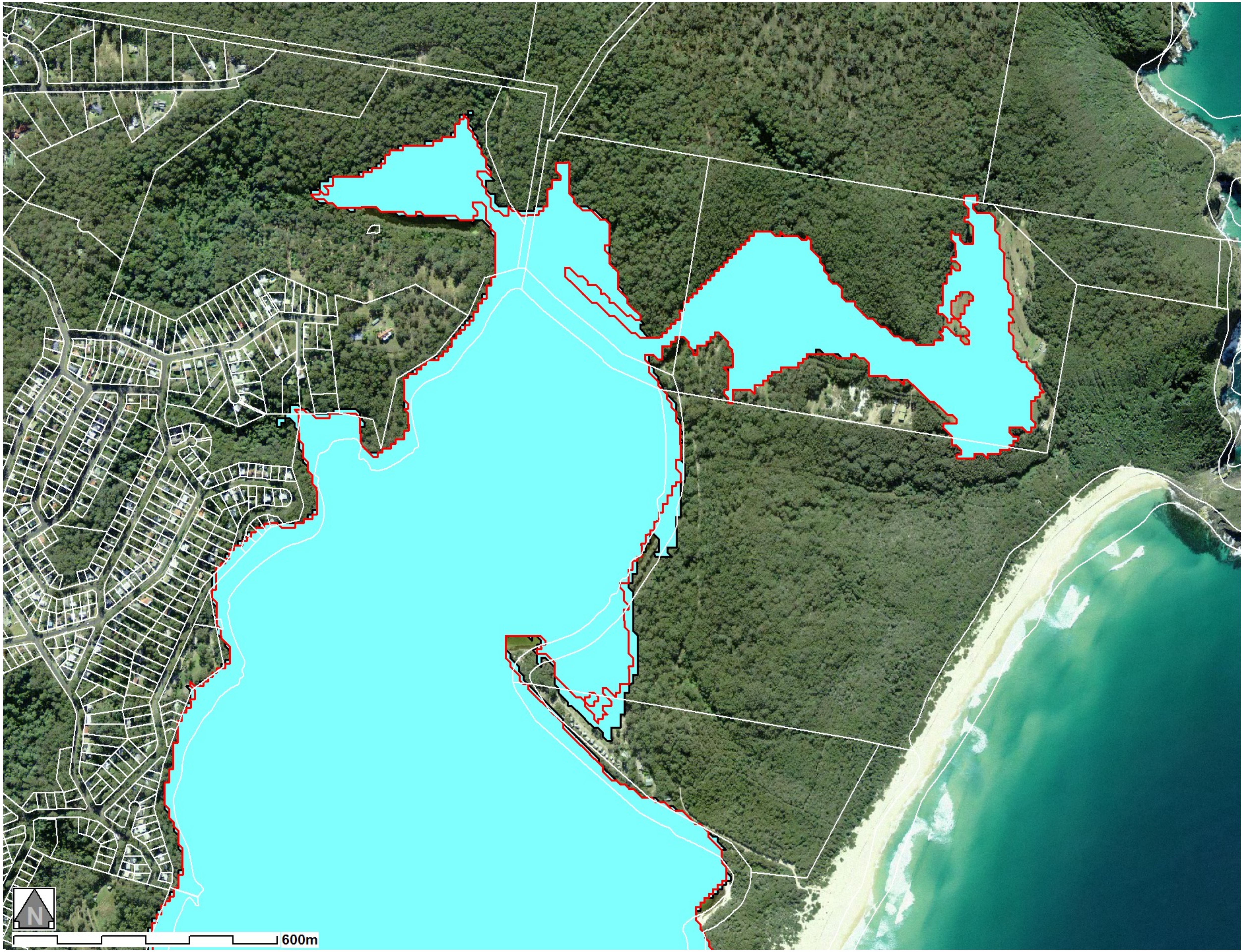
fg2840_00gr121206-Fig11.2 [Option S3 Road Raising].doc

**SMITHS LAKE**
**FLOOD PLANNING AREA MAP – YEAR 2060**
**FOR 1% AEP FLOOD WITH 0.5 m FREEBOARD**




Note
The present day Flood Planning Area is shown as the solid red line. The 2060 Flood planning area is the extent of the light blue surface shown on the figure.

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fg2840_00gr121206-Fig11.2 [Option S3 Road Raising].doc

**COMPARISON BETWEEN 1% AEP FLOOD PLANNING MAP BETWEEN "PRESENT DAY" AND YEAR 2060 CLIMATE CHANGE SCENARIO**

## Table 16 SUMMARY OF FLOOD PLANNING LEVELS

| LAND USE | ARI FLOOD EVENT TO DEFINE LEVEL | ADOPTED FREEBOARD | COMMENTS |
|---|---|---|---|
| Residential / rural residential / rural | 100 year | 500 mm | Applies to standard residential development and residential sub-division |
| Commercial | 100 year | 75% of floor area – 0 mm<br>25% floor area – 500 mm | Consideration may be given to floor level below 100 year ARI flood level in certain circumstances |
| Critical Utilities | PMF | As required | Preference to locate critical utilities outside extent of Flood Prone Land |
| Garages & storage sheds | 20 year flood level | 0 mm | Non- habitable rooms |

The following is noted in regard to the FPL's:

- Provision is made for commercial and industrial land uses to have a proportion of their floor space below the standard Flood Planning Level.

  *This will assist with the development of an appropriate shop frontage. However, in order to provide adequate storage space to protect goods during a flood, it will be necessary for the remaining proportion of the floor space to be elevated to the Standard Flood Planning Level. At Smiths Lake, there are likely to be very limited instances where this issue arises, however it has been included as a recommendation to cover its eventuation.*

  *Consideration may be given to a lower floor level being used in certain circumstances, provided the proponent can demonstrate the need for the proposal and that adequate provision is made to manage flood impacts, including potential flood damages.*

- Where possible, critical utilities and infrastructure should be located outside the extent of Flood Prone Land; that is, above the level of the Probable Maximum Flood (PMF). However, it is recognised that some utilities will inevitably be required within the boundary of Flood Prone Land. Where this is the case, the utility should be sited at an elevation above the predicted peak level of the PMF.

- The floor level of garages, storage sheds and other non-habitable rooms may be sited at the 20 year ARI flood level.

  *This provision is made since these areas are not expected to afford refuge to persons during rare flood events. This recognises the economic burden associated with protecting infrastructure against flooding and has been developed so as not to not increase this burden unnecessarily.*

### 11.2.7 Option 5: Review Future Land Use Planning

Great Lakes Council is currently in the process of updating its existing Local Environmental Plan. A Local Environmental Plan (LEP) is defined as:

> "*a legal document that sets the direction for future growth and conservation in the Local Government Area (LGA) by providing controls and guidelines for development. It determines what can be built, where it can be built and in some cases it set out additional controls and requirements for certain developments*"[1].

That is, the LEP outlines the development which is or is not permitted by the current zoning.

The updated Local Environmental Plan has been publicly exhibited and is currently being finalised by Council. As part of the LEP update, existing land use zonings have been changed to the standard planning instrument. The proposed zonings in the vicinity of Smiths Lake are presented in Land Zoning Map "*Sheet LZN_012A*" of the draft Great Lakes Local Environmental Plan 2012. A copy of the zoning map has been extracted from the LEP and included for reference in **Appendix D**.

A review of the draft Land Zoning Map in the vicinity of Smiths Lake indicates that there is limited opportunity for future development around the lake, given the existing zoning and land use development. In terms of land which falls within the extent of the existing flood planning area, the land is zoned either:

- RU2 – Rural Landscape (*between Bushland Caravan Park and Smiths Lake, including Bushland Caravan park, in the vicinity of Tarbuck Bay and Bungwahl*)
- RU5 – Village (*Tarbuck Bay and Smiths Lake*)
- E1 – National Parks & Nature Reserve (*most of the southern edge of the lake*)
- E2 – Environmental Conservation (*lot between Bushland and Sandbar Caravan Park*)
- E3 – Environmental management (*rural residential properties around Bungwahl, Sandbar Caravan Park*)

It is unlikely that additional development or modified land use will be permitted at any areas with a proposed zoning of E1 or E2.

However, Great Lakes Council Local Environmental Plan Fact Sheet No. 12 indicates that a limited range of development may be permitted within Environmental Management Zone E3. A complete list of activities which are permitted with consent is provided in the draft Great Lakes LEP (2012).

[1] Sourced from Great Lakes Council's website http://www.greatlakes.nsw.gov.au/Development/Controls/Draft_LEP_2012


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**EXTENT OF AREA ZONED "RU2" OR E3 IN GREAT LAKES DRAFT LEP 2012 THAT COINCIDES WITH FLOOD PLANNING AREA**

There are a number of allotments currently zoned RU2, including areas zoned 1(c) '*Future Urban Investigation*' by the 1996 LEP. The findings of the Floodplain Management Study show that at least some of these lands are classified as "flood prone land" and therefore any proposal to rezone these would need to address the flood related development controls identified by Council.

**Figure 19** identifies the allotments that are zoned either RU2 or E3, where a variety of development may be undertaken. Planning controls are nominated for these areas below. It is understood that a rezoning application would be required where residential sub-division was proposed at these allotments.

In addition, there are properties that are zoned RU5. Standard planning controls would apply to these properties.

### 11.2.8 Option 6: Proposed Flood Related Development Controls

The draft 2012 LEP provides an overall direction regarding permissible development on flood prone land. Clause 7.4 of the draft LEP has been included for reference at **Section 4.3**.

A development control plan is typically prepared to assist in providing practical guidelines for the application of the directions provided by an LEP. Great Lakes Council has prepared a draft Development Control Plan (DCP) for the Great Lakes Council Local Government Area (*LGA*). Although the DCP provides direction regarding flood related development controls for select locations (*for example, Failford*), it does not include a set of general flood clauses. It is understood from consultation with Council that it is planning to prepare an LGA wide Flood Policy.

It is recommended that the following items, specific to Smiths Lake, should be considered for inclusion in the Flood Policy/ Development Control Plan. It is envisaged that the DCP/Policy could be incorporated into Council's existing draft development control plan. The DCP should incorporate the following requirements:

- Mechanical opening of the entrance channel to Smiths Lake is triggered by a lake water level of 2.1 mAHD. It is recommended that Council formalise the entrance opening policy as part of the flood policy that it is planning to develop. In addition to flood relief issues, the entrance opening policy should also address entrance opening procedures relating to sea level rise (*SLR*) and water quality.

- Building development proposals on flood prone land for all sites provisionally classified as High Hazard/Floodway by the Manual 2005 or the relevant Floodplain Risk Management Plan should not be supported.

- Council will only support building developments on flood prone land provided the applicant can demonstrate to Council's satisfaction that the development will not adversely impact on flooding across adjoining properties. The applicant is also required to show that flooding will not adversely impact on the development proposal. Such applications are to be prepared by a suitably qualified civil engineer/surveyor/hydrologist with demonstrated experience in flood assessment for land development proposals.

- The finished floor levels of habitable rooms shall be at least equal to the Flood Planning Level (*FPL*), which is to be defined as 500 mm above the 1% AEP flood level, as determined by investigations completed for the *'Smiths Lake Flood Study'* (*2008*).

- Other development shall comply with the Flood Planning Levels nominated in **Table 16**.

- Renovations including re-cladding or re-roofing and floor extensions greater than 60 m$^2$ in flood prone sites are classified in accordance with the 2005 Manual as "major additions". Council will support applications provided the applicant can demonstrate to Council's satisfaction that flood proofing measures have been considered in accordance with guidelines presented in Appendix J of the 2005 Manual. Such applications are to be prepared by a suitably qualified civil engineer with demonstrated experience in floodplain management.

- Council will not support habitable floor extensions greater than 20 m$^2$ where the dwelling is located in a high hazard area.

- Council should only support residential or commercial or tourist building developments in flood prone land where effective warning time and reliable access is available for evacuation.

- Council will not support new building development on flood prone land where emergency evacuation can only occur through high hazard floodway or high hazard flood storage areas.

- Developments that can demonstrate effective evacuation through low hazard conditions during the early warning phases of a flood may be supported. Applicants are to provide details of the evacuation route and likely flood conditions encountered during an effective evacuation.

This would serve to complement the information presented in Council's existing draft 2012 LEP and draft DCP.

### 11.2.9 Option 7: Emergency Response Management Review

Current emergency protocols for emergency response and management within the Great Lakes Council Local Government Area (*LGA*) are detailed in the *Great Lakes Local Disaster Plan (DISPLAN)*. The DISPLAN identifies the individuals and organisations with the authority to issue an order to evacuation of the Great Lakes Local Government Area. The DISPLAN also describes the means in which an evacuation order is communicated to residents and the responsibilities of the Combat Agency in managing a withdrawal.

The DISPLAN does not provide any specific information pertaining to Smiths Lake. As outlined in **Section 8.3.2**, flooding does not pose a risk to a significant number of inhabitants of the floodplain. Furthermore, there is ready access to areas that remain flood free during the Probable Maximum Flood, although it is noted that people evacuating the Bushland and Sandbar Caravan Parks have the potential to become isolated.

Smiths Lake has no flood warning system in place. Flood warning systems assist authorities and residents in understanding the immediate flood risks and, if required, in coordinating a timely evacuation of at-risk areas. However, given the relatively small size of the Smiths Lake catchment and the rate of rise of Smiths Lake during major flood events (*up to 320mm per hour during the PMF*), it is expected that the additional warning time gained from a flood warning system would be insufficient to justify the cost of implementing the system.

As discussed in **Section 8.3.2**, the Sandbar and Bushland Holiday Park and Golf Course community have been identified as being vulnerable to isolation during major flood events due to the inundation of access roadways prior to floodwaters reaching the respective communities. While the issue of isolation is serious from an evacuation and supply perspective, risks to human life during flooding are minimal due to the abundant high ground that adjoins both communities. This high ground effectively prevents the community becoming a "flood island".

The stage hydrograph for the 1% AEP flood event indicates that the key access route to the Sandbar and Bushland community (*Sandbar Road*) is inundated at its lowest point approximately 2 hours and 30 minutes after the commencement of rainfall in the catchment. The section of roadway that lies below the peak level of the 1% AEP flood is relatively short, being only about 240 metres in length.

Evacuation access routes could be improved structurally by constructing new roadway embankments over low-lying and vulnerable sections of roadway. The estimated cost of raising the vulnerable section of Sandbar Road to a minimum level above the PMF (*i.e., to a minimum surface elevation of 3.5 mAHD*) is approximately **$781,000** (*estimated from 'Rawlinson's Australian construction Handbook'*).

However, it is difficult to justify this cost, especially given the low risk posed by flooding to inhabitants of the Bushland and Sandbar Caravan Parks. Notwithstanding, there may be opportunity to incrementally increase the embankment height in the future as part of Council's road maintenance capital works program.

# 12. CONCLUSIONS

## 12.1 RECOMMENDED INCLUSIONS FOR THE FLOODPLAIN MANAGEMENT PLAN

The recommendations, which will form the basis for the Smiths Lake Floodplain Risk Management Plan are summarised in the following. The recommendations have been developed from the structural and planning options assessment conducted as part of this study. The prefix “PL” has been used signify a planning recommendation, while “ST” has been used to signify a structural recommendation.

In this regard, an analysis of the flood characteristics of Smiths Lake has established that the risk posed by flooding remains relatively minor.

### 12.1.1 Floodplain Structural Options

The following structural recommendations have been identified as an outcome of this report. Reference is made to **Section 11** of the Study for a comprehensive description of the options investigated.

**ST1.** The road upgrades outlined in **Sections 11.2.5** and **11.2.9** should be undertaken to improve flood evacuation and increase evacuation times. However, these upgrades should be prioritised based on opportunities that may arise as a function of Council’s road infrastructure upgrade capital works program.

**ST2.** Options to optimise the cost of the levee arrangements considered in **Section 11.2.4**, particularly in the context of observed future flood related climate change impacts.

**ST3.** A program should be developed to raise properties identified in **Section 11.2.3**, as funding allows.

The plan will recognise that further investigation, consultation and design is required before any of the above options would be constructed.

### 12.1.2 Floodplain Planning Recommendations

The following planning recommendations have been identified as an outcome of this report. Reference is made to **Sections 8** to **11** of the Study for a comprehensive description of the planning options investigated.

**PL1.** The relevant clauses in Council’s LEP should be updated to reflect the latest standard clauses for flood prone land, which has been agreed to by the relevant stage government agencies (*if not already*).

**PL2.** That Council proceed with the incorporation of flood related planning controls for Smiths Lake, in the context of the proposed LGA wide Flood Policy.

**PL3.** The entrance opening protocols currently in place for Smiths Lake should be formalised and included in the flood policy, or an equivalent appropriate document.

**PL4.** A set of Flood Planning Levels should be adopted, both for present day conditions and for the year 2060 climate change scenario projections.

**PL5.** Hydraulic categorisation mapping prepared as part of the study should be included in the proposed flood policy/ development control plan.

**PL6.** Existing Section 149 certification for flood prone properties in the study area be reviewed. Where necessary, Section 149 certificates be updated and re-issued to contain up-to date flood data and information.

# 13. REFERENCES


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# Appendix A – ADOPTED RAFTS HYDROLOGIC MODEL PARAMETERS

TABLE A1: ADOPTED SUB-CATCHMENT PARAMETERS FOR RAFTS HYDROLOGIC MODEL OF THE SMITHS LAKE CATCHMENT

| RAFTS MODEL SUB-CATCHMENT | RAFTS MODEL NODE AT DOWNSTREAM END OF SUB-CATCHMENT | AREA (Ha) | SLOPE (%) | % IMPERVIOUS (%) | PERVIOUS 'n' | INITIAL RAINFALL LOSS (mm) | CONTINUING RAINFALL LOSS (mm/hr) | DOWNSTREAM LAG TIME *(mins)* |
|---|---|---|---|---|---|---|---|---|
| DANGAR POINT | DANGAR | 251.7 | 9.2 | 0 | 0.080 | 0 | 2.5 | 0 |
| SMITHS LAKE (VILLAGE) | SMITHS | 248.0 | 6.2 | 0 | 0.045 | 0 | 2.5 | 0 |
| THE LAKES WAY | LWAY | 29.3 | 18.8 | 0 | 0.080 | 0 | 2.5 | 0 |
| TARBUCK CREEK | TARBUCK | 204.0 | 11.7 | 0 | 0.080 | 0 | 2.5 | 2 |
| LOWER JACKS CREEK | LJACKS | 140.6 | 16.0 | 0 | 0.025 | 0 | 2.5 | 25 |
| UPPER JACKS CREEK | UJACKS | 299.7 | 1.0 | 0 | 0.080 | 0 | 2.5 | 0 |
| WAMWARRA CREEK | WAMW | 240.2 | 7.2 | 0 | 0.080 | 0 | 2.5 | 0 |
| SUGAR CREEK | SUGARCK | 299.7 | 1.0 | 0 | 0.080 | 0 | 2.5 | 0 |
| STOKES HILL | STOKES | 54.7 | 12.8 | 3 | 0.080 | 0 | 2.5 | 0 |
| BUNGWAHL | BUNG | 88.7 | 28.4 | 0 | 0.080 | 0 | 2.5 | 0 |
| HORSE POINT | HORSE | 402.1 | 7.6 | 0 | 0.080 | 0 | 2.5 | 0 |
| SIMONS POINT | SIMONS | 315.9 | 7.1 | 0 | 0.080 | 0 | 2.5 | 13 |
| SMITHS LAKE (WATERBODY) | LAKE | 1000.7 | 0.0 | 100 | 0.030 | 0 | 2.5 | 0 |

***NB.*** *Refer to* ***Figure 2*** *for location of RAFTS model nodes and sub-catchments*

# Appendix B – GENERALISED SHORT DURATION METHOD PROBABLE MAXIMUM PRECIPITATION CALCULATIONS

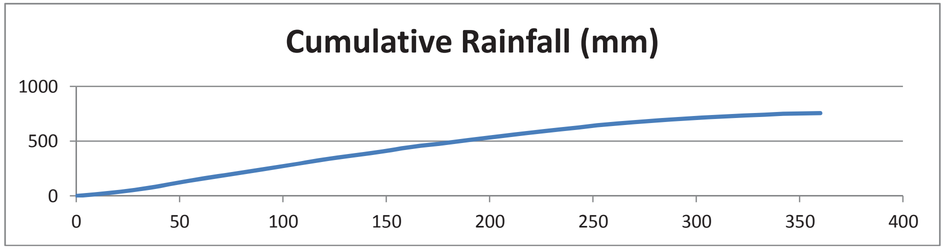
**301015-02840**
**Smiths Lake FPRMS**
**Probable Maximum Precipitation - Generalised Short-Duration Method**

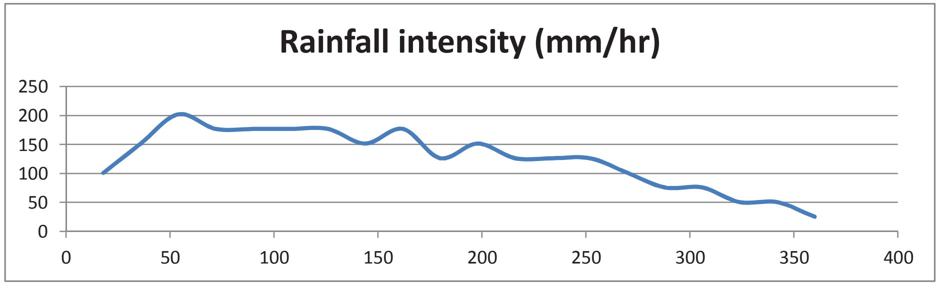
Calculations according to BOM's 'The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method'
Available at: http://www.bom.gov.au/water/designRainfalls/pmp/document/GSDM.pdf

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % of time | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 |
| % of PMP | 0 | 4 | 10 | 18 | 25 | 32 | 39 | 46 | 52 | 59 | 64 | 70 | 75 | 80 | 85 | 89 | 92 | 95 | 97 | 99 | 100 |
| **Time (min)** | **0** | **18** | **36** | **54** | **72** | **90** | **108** | **126** | **144** | **162** | **180** | **198** | **216** | **234** | **252** | **270** | **288** | **306** | **324** | **342** | **360** |
| Interval time (min) | | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| Cumulative Rainfall (mm) | 0 | 30 | 76 | 136 | 189 | 242 | 295 | 348 | 394 | 447 | 485 | 530 | 568 | 606 | 644 | 674 | 697 | 720 | 735 | 750 | 758 |
| Rainfall intensity (mm/hr) | | 101 | 152 | 202 | 177 | 177 | 177 | 177 | 152 | 177 | 126 | 152 | 126 | 126 | 126 | 101 | 76 | 76 | 50 | 50 | 25 |
| **Rainfall during Interval (mm/interval)** | **0** | **30** | **45** | **61** | **53** | **53** | **53** | **53** | **45** | **53** | **38** | **45** | **38** | **38** | **38** | **30** | **23** | **23** | **15** | **15** | **8** |

| | | |
|---|---|---|
| **Catchment size** | **34.00** | km2 |
| **4.1 Duration limit** | **6** | hrs |
| **4.2 Terrain Category** | | |
| **Percentage rough** | **100%** | |
| **Percentage smooth** | **0%** | |
| **4.3 Adjustment for catchment elevation** | **1** | |
| **4.4 Adjustment for moisture** | **0.75** | |
| **4.5 PMP Estimate** | | |
| **Rainfall depth (rough)** | **1010** | mm |
| **Rainfall depth (smooth)** | **0** | |
| **PMP** | **757.5** | **mm** |

Note: 100yr6hr rainfall = mm



# Appendix C – STAGE DAMAGE CURVES

## Appendix C - Floodplain Specific Damage Curves for Individual Residences

**Steps in Curve** 0.1 m

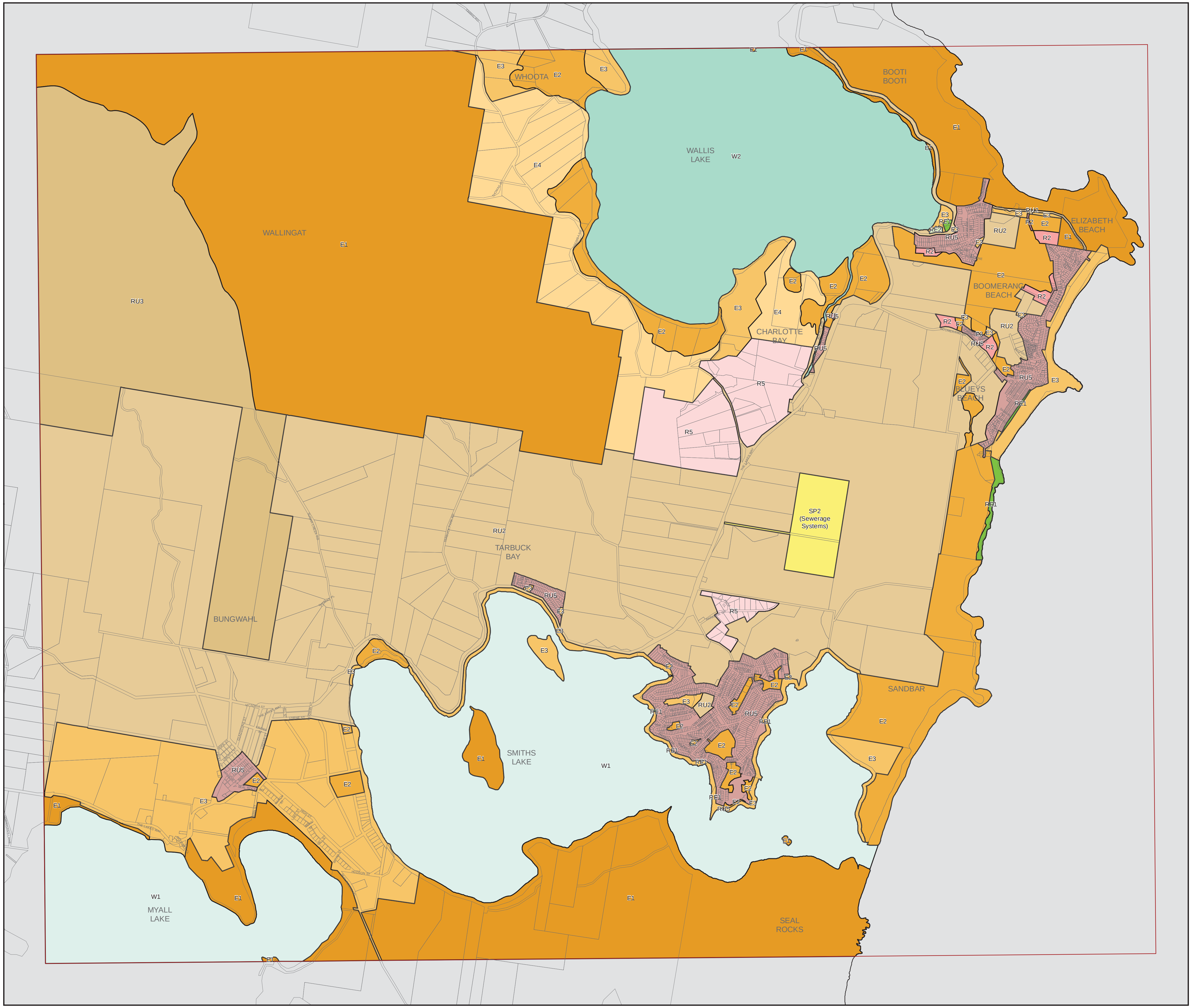
| | Residential | Commercial | Public Facilities | Cabin | Camping/Caravan | Manholes | Sewerage | Roads |
|---|---|---|---|---|---|---|---|---|
| **Type** | **R** | **C** | **P** | **CZ** | **T** | **M** | **S** | **B** |
| **AFD from Modelling** | **Damage** | **Damage** | **Damage** | **Damage** | **Damage** | **Damage** | **Damage** | **Damages** |
| 0 | $32,208 | $0 | $0 | $5,000 | $113 | $257 | $6,750 | $233 |
| 0.1 | $63,337 | $6,443 | $0 | $7,200 | $118 | $287 | $7,544 | $268 |
| 0.2 | $66,368 | $12,886 | $0 | $8,047 | $123 | $318 | $8,338 | $302 |
| 0.3 | $69,398 | $19,329 | $0 | $8,894 | $128 | $348 | $9,132 | $336 |
| 0.4 | $72,429 | $24,483 | $0 | $9,741 | $133 | $378 | $9,926 | $371 |
| 0.5 | $75,460 | $29,637 | $0 | $10,588 | $136 | $408 | $10,721 | $405 |
| 0.6 | $78,490 | $34,791 | $0 | $11,435 | $143 | $438 | $11,515 | $439 |
| 0.7 | $81,521 | $41,663 | $0 | $12,282 | $148 | $469 | $12,309 | $473 |
| 0.8 | $84,552 | $45,960 | $0 | $13,129 | $153 | $499 | $13,103 | $508 |
| 0.9 | $87,582 | $47,677 | $0 | $13,976 | $158 | $529 | $13,897 | $542 |
| 1 | $96,053 | $52,831 | $0 | $14,824 | $310 | $559 | $14,691 | $576 |
| 1.1 | $99,356 | $56,053 | $0 | $15,671 | $326 | $590 | $15,485 | $611 |
| 1.2 | $102,658 | $59,274 | $0 | $16,518 | $342 | $620 | $16,279 | $645 |
| 1.3 | $105,961 | $63,913 | $0 | $17,365 | $358 | $650 | $17,074 | $679 |
| 1.4 | $109,264 | $65,459 | $0 | $18,212 | $374 | $680 | $17,868 | $714 |
| 1.5 | $112,566 | $67,006 | $0 | $19,059 | $390 | $711 | $18,662 | $748 |
| 1.6 | $115,869 | $68,552 | $0 | $19,906 | $406 | $741 | $19,456 | $782 |
| 1.7 | $119,172 | $70,098 | $0 | $20,753 | $423 | $771 | $20,250 | $816 |
| 1.8 | $122,474 | $71,644 | $0 | $21,600 | $439 | $801 | $21,044 | $851 |
| 1.9 | $125,777 | $73,190 | $0 | $22,447 | $455 | $832 | $21,838 | $885 |
| 2 | $129,080 | $74,737 | $0 | $23,294 | $471 | $862 | $22,632 | $919 |
| 2.1 | $129,934 | $74,737 | $0 | $24,141 | $487 | $892 | $23,426 | $954 |
| 2.2 | $130,789 | $74,737 | $0 | $24,988 | $503 | $922 | $24,221 | $988 |
| 2.3 | $131,643 | $74,737 | $0 | $25,835 | $519 | $953 | $25,015 | $1,022 |
| 2.4 | $132,498 | $74,737 | $0 | $26,682 | $535 | $983 | $25,809 | $1,057 |
| 2.5 | $133,352 | $74,737 | $0 | $27,529 | $551 | $1,013 | $26,603 | $1,091 |
| 2.6 | $134,207 | $74,737 | $0 | $28,376 | $567 | $1,043 | $27,397 | $1,125 |
| 2.7 | $135,062 | $74,737 | $0 | $29,224 | $584 | $1,074 | $28,191 | $1,160 |
| 2.8 | $135,916 | $74,737 | $0 | $30,071 | $600 | $1,104 | $28,985 | $1,194 |
| 2.9 | $136,771 | $74,737 | $0 | $30,918 | $616 | $1,134 | $29,779 | $1,228 |
| 3 | $137,625 | $74,737 | $0 | $31,765 | $632 | $1,164 | $30,574 | $1,262 |
| 3.1 | $141,445 | $74,737 | $0 | $32,612 | $637 | $1,194 | $31,368 | $1,297 |
| 3.2 | $146,886 | $74,737 | $0 | $33,459 | $642 | $1,225 | $32,162 | $1,331 |
| 3.3 | $152,326 | $74,737 | $0 | $34,306 | $647 | $1,255 | $32,956 | $1,365 |
| 9.9 | $154,717 | $74,737 | $0 | $36,000 | $647 | $1,285 | $33,750 | $1,400 |

# Appendix D – GREAT LAKES COUNCIL DRAFT 2012 LEP ZONING MAP FOR SMITHS LAKE

# Great Lakes Local Environmental Plan 2012

Great Lakes COUNCIL

## Land Zoning Map - Sheet LZN_012A

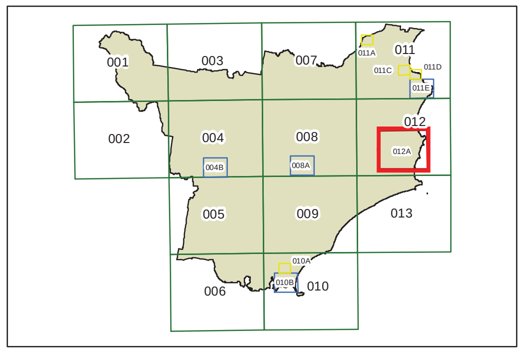



### Zone

- B1 Neighbourhood Centre
- B2 Local Centre
- B4 Mixed Use
- B5 Business Development
- E1 National Parks and Nature Reserves
- E2 Environmental Conservation
- E3 Environmental Management
- E4 Environmental Living
- IN1 General Industrial
- IN2 Light Industrial
- IN4 Working Waterfront
- R2 Low Density Residential
- R3 Medium Density Residential
- R4 High Density Residential
- R5 Large Lot Residential
- RE1 Public Recreation
- RE2 Private Recreation
- RU2 Rural Landscape
- RU3 Forestry
- RU5 Village
- SP2 Infrastructure
- SP3 Tourist
- W1 Natural Waterways
- W2 Recreational Waterways

### Cadastre

Cadastre 12/04/2010 © Land and Property Information (LPI)




N

0 400 800 1,200 1,600 Metres

Scale:1:40,000 @ A3

Projection: GDA 1994
MGA Zone 56

Map identification number:
3400_COM_LZN_012A_040_20120305