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Woolgoolga Floodplain Risk Management Study and Plan

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Final Report

Coffs Harbour City Council

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Woolgoolga Floodplain Risk Management Study and Plan

Prepared for:	Coffs Harbour City Council
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Synopsis:	**This report documents the Woolgoolga Floodplain Risk Management Study and Plan, which investigates and presents a flood risk management strategy for the catchment. The study identifies the existing flooding characteristics and canvasses various measures to mitigate the effects of flooding. The end product is the Floodplain Management Plan, which describes how flood liable lands within Woolgoolga are to be managed in the future.**	

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Executive Summary

Introduction

Woolgoolga is situated on the north coast of NSW approximately 20km north of the city of Coffs Harbour. The Woolgoolga Lake is fed primarily by Woolgoolga Creek and Poundyard Creek. The township of Woolgoolga is the main community within the catchment, with a population of over 4,000. It is situated to the south of Woolgoolga Lake, straddling both Woolgoolga and Jarrett Creeks. A flood study for Woolgoolga was completed by BMT WBM in 2012.

The primary objective of the flood study was to define the flood behaviour in Woolgoolga through the establishment of appropriate numerical models. The study produced information on flood flows, velocities, levels and extents for a range of flood event magnitudes under existing catchment and floodplain conditions.

The outcomes of the Woolgoolga Flood Study established the basis for subsequent floodplain management activities in Woolgoolga, addressing both local catchment and mainstream Woolgoolga Creek flooding issues. The Floodplain Risk Management Study (FRMS) aims to derive an appropriate mix of management measures and strategies to effectively manage flood risk in accordance with the NSW Government Floodplain Development Manual. The findings of the study will be incorporated in a Plan of recommended works and measures and program for implementation.

The objectives of the Woolgoolga Floodplain Risk Management Study and Plan are to:

- Identify and assess measures for the mitigation of existing flood risk;
- Identify and assess planning and development controls to reduce future flood risks; and
- Present a recommended floodplain management plan that outlines the best possible measures to reduce flood risk in the Woolgoolga locality.

This report documents the Floodplain Risk Management Study and presents a recommended Floodplain Risk Management Plan for Woolgoolga.

The following provides an overview of the key findings and outcomes of the study, incorporating a review of design flood conditions within the catchment, assessment of potential floodplain management measures and a recommended Floodplain Management Plan.

This project has been conducted under the State Assisted Floodplain Management Program and received State financial support.

Flooding Behaviour

Flooding in Woolgoolga is due to both mainstream flooding from Woolgoolga Creek and Jarrett Creek and local catchment runoff from the south. The catchments are relatively steep in nature and the majority of flood waters are contained within the watercourses and adjacent floodplain. However, within Woolgoolga itself there is more extensive inundation of low-lying areas, including developed zones.

During major flood events, when the capacity of Woolgoolga Creek is exceeded, flood flows occur through the Haines Close and Sunset Caravan Park localities. This can present a highly hazardous environment with associated risk to life and property, particularly at the latter location. Elevated water levels in Woolgoolga Creek also generate backwater flooding along the lower reaches of Jarrett Creek and the small watercourse between Wharf Street and Ganderton Street.

There is limited out-of-bank flooding along the Poundyard Creek alignment. However, flooding emanating from Jarrett Creek and smaller local catchments does present an associated flood risk within Woolgoolga, with the flood risk to developed areas primarily affecting these two locations.

Given the size of the Woolgoolga Lake catchment, and relative steepness along the main flow path alignments, the catchment is highly responsive to rainfall such that the critical flood conditions within Woolgoolga relate to high intensity short duration events of the order of 2 to 6 hours.

The Woolgoolga Flood Study (BMT WBM, 2012) defined design flood levels within Woolgoolga for a range of design event magnitudes. The detailed hydraulic model (TUFLOW) was calibrated and verified to June 2011, January 2012 and March 1974 historical event data.

A flood damages databases has been developed to identify potentially flood affected properties and to quantify the extent of damages in economic terms for existing flood conditions. In developing the damages database, a floor level survey of all existing properties identified within the 1% AEP extent was undertaken. Key results from the flood damages database indicate:

- 384 residential homes, 169 caravan park dwellings and 52 commercial buildings would be flooded above floor level in a PMF event;
- 27 residential homes, 37 caravan park dwellings and 4 commercial buildings would be flooded above floor level in a 1% AEP flood;
- The predicted flood damage costs for the 1% AEP flood is in the order of $4M.

Community Consultation

Community consultation was undertaken aimed at informing the community about the development of the Floodplain Risk Management Study and its likely outcome as well as improving the community's awareness and readiness for flooding. The consultation process provided an opportunity to collect information on the community's flood experience, their concern on flooding issues and to collect feedback and ideas on potential floodplain management measures and other related issues. The key elements of the consultation program involved:

- Consultation with the Floodplain Management Committee through meetings and presentations;
- Distribution of questionnaires;
- Public exhibition of the Draft Floodplain Risk Management Study and Plan (dates tbc); and
- Community information sessions (completed shortly after project initiation and during the public exhibition period) to present and discuss the outcomes of the flood study, potential and recommended floodplain risk management options.

The key information provided in the responses to the community questionnaires included:

- Concerns over the Lake entrance management and resultant elevated lake levels;
- Issues relating to the siltation of the lake body and creeks;
- The maintenance of the stormwater drainage network to prevent blockages and improve the functionality during flood events;
- The potential for stormwater drainage improvements to help reduce flood risk within the local catchments; and
- Improved development control to help manage future flood risk.

The outcome of the community information session was that the community was more concerned with prolonged periods of elevated lake levels, such as had occurred earlier in the year, than they were about the risk posed by a major flood event. This was certainly the case for the majority of the attendees, who were residents of the Sunset Caravan Park. Section 7.4 of the report considers these concerns in detail.

Floodplain Management Options Considered

The Woolgoolga Floodplain Risk Management Study considered and assessed a number of floodplain management measures, summarised below.

- *Sunset Caravan Park and Haines Close levee construction* – two levee alignments have been considered for Woolgoolga, one protecting properties in Haines Close, and a second levee around the Sunset Caravan Park. The Haines Close alignment would tie into high ground of the ridge to the north. The Sunset Caravan Park alignment would tie in into the Woolgoolga High School farm lands and higher ground at the end of Newman Street. The levee works have considered providing flood immunity to the 1% AEP flood. Levee construction works have not been recommended in the Plan due to the large capital cost and unlikely acceptance from the community.
- *Bunding along Trafalgar Lane for the purposes of flood detention* – there is an existing wetland situated at the eastern end of Trafalgar Street. It covers an area of around 4ha and has a contributing catchment of some 30ha. The alignment of Trafalgar Street provides an existing bund with a crest elevation of around 5.1m AHD, behind which approximately 18ML of storage volume is available. There is an existing outlet pipe of 750mm diameter that connects the wetland to the stormwater drainage network. By raising the bund to a level of 5.9m AHD, additional upstream flood storage can be provided to achieve a 1% AEP flood immunity. However, due to the relatively low flood damages the works have not been recommended in the Plan.
- *Breakwater to provide permanent open entrance* – the design of training breakwaters needs to take into account the local wave climate and the depth to which the breakwaters have to be extended for the entrance to remain clear of sand. In aligning the breakwaters the natural direction of flows exiting the Lake during flood conditions also needs to be considered in an attempt to reduce significant impacts on the passage of major floods. Dune stabilisation works and beach nourishment may also be required alongside the constructed breakwaters. Regardless of the actual design, any constructed permanent entrance opening would involve a

large scale construction and associated capital cost of works. This results in a low Benefit-Cost Ratio (BCR) and has therefore not been recommended in the Plan.

- *Moore Street drainage diversion* – to the west of the Solitary Islands Way there is a small 12ha catchment that drains behind the properties on Smith Street. Catchment runoff is currently discharged into the stormwater drainage network under the Solitary Islands Way. During major flood events the available drainage capacity is exceeded and flooding occurs along Solitary Islands Way and Turon Parade. The nature of the flooding is not particularly hazardous or damaging, but it is extensive. There is potential to divert the catchment runoff away from its current discharge point and into Woolgoolga Creek. This can be undertaken upstream of Moore Street, where there is currently a culvert draining under the road. Through construction of a drainage channel and/or culverts the catchment can instead be discharged west along the southern side of Moore Street. The scheme has been recommended for consideration in the Plan, should future development make it more economically viable.
- *Trafalgar Street drainage improvement works* – catchment runoff is currently diverted to the trunk drainage alignment along Queen Street. However, when the capacity of the existing drainage on Trafalgar Street and Trafalgar Lane is exceeded, excess runoff flows overland into the topographic depression on Market Street to the north. Flooding here has the potential to flood the commercial properties. There is the potential to augment the existing drainage capacity along Trafalgar Road to divert all of the upstream catchment runoff into the Queen Street stormwater drainage. This can be undertaken through the provision of increased stormwater pipe drainage and/or increasing the capacity of the roadway to convey excess flows. The scheme has been recommended for consideration in the Plan, should scheduled road or drainage works make it more economically viable.
- *Voluntary Purchase Schemes*: are generally applicable only to areas where flood mitigation is impractical and the existing flood risk is unacceptable. No property has been identified as suitable for voluntary purchase within the Woolgoolga catchment and therefore there is no recommendation for such a scheme in the Floodplain Risk Management Plan. However, the current predictions for sea level rise may improve the viability of such a scheme in the future.
- *Voluntary house raising* - raising floor levels where practical to elevate habitable floor levels to required levels above the flood planning level. Not all houses are suitable for raising. Houses of brick construction or slab on ground construction are generally not suitable for house raising due to expense and construction difficulty. Generally this technique is limited to structures constructed on piers. This scheme has been recommended for further investigation within the Plan to identify suitable properties and funding. The current predictions for sea level rise may further improve the viability of such a scheme in the future.
- *Flood Proofing* – Flood proofing is proposed as part of the Plan for those properties that are below the 1% AEP flood level. A detailed list of individual property levels relative to predicted flood levels has been established. For those properties identified within the 1% AEP flood envelope, advice may be provided to individual landowners on available opportunities to reduce on-site flood damages. Temporary flood gates in particular are identified as a feasible option for

mitigating against local catchment flooding of the commercial centre and accordingly recommended in the Plan.

- *Planning and development controls* - Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within Woolgoolga. This will ensure that new development is compatible with the flood risk, and allows for existing problems to be gradually reduced over time through sensible redevelopment. The Plan has recommended the adoption of 1% AEP flood level plus 0.5m freeboard as the flood planning level (maintains the existing design flood standard) and a review of current land-use zoning with respect to Floodway areas.
- *Flood Warning* – Despite the short flood warning time available it is recommended that real time data from the catchment gauges be used to inform a flood warning system, given the potential for high hazard conditions, particularly within Sunset Caravan Park. Although short this warning could save many lives in the event of a major flood.
- *Improved flood evacuation access* – during the recent flood events the SES experienced problems with obtaining safe access to assist in the evacuation of Sunset Caravan Park due to the flooding of Bultitude Street from Jarrett Creek. The establishment of an easement to secure vehicular access is likely to be the most viable option to assist in improving the flood evacuation of Sunset Caravan Park. The Plan recommends investigations should be undertaken to identify the potential for purchasing property to establish a permanent easement connecting Turon Parade or Kim Close through to the Solitary Islands Way.
- *Improved flood awareness* – raising and maintaining flood awareness will provide the community with an appreciation of the flood problem and what can be expected during flood events. An ongoing flood awareness program should be pursued through collaboration of the SES and Council (e.g. FloodSafe program specific for Woolgoolga). The focus of this program should be on Sunset Caravan Park where the greatest risk to life during a major flood exists. It is also recommended that the owners of Sunset Caravan Park be encouraged to develop their own Flood Plan for the site.
- *Strategic planning* – voluntary house raising, house purchase and land swap programs are likely to become increasingly desirable. Investigations should be undertaken into the identification of suitable properties for such schemes, under predicted climate change scenarios for the 2050 and 2100 planning horizons. Funding arrangements for these schemes and potential sites for a land swap program should be considered by Council as a long term on-going management of flood risk. The existing flood risk within the Sunset Caravan Park is high, with many residences situated within land designated high hazard floodway. The long-term continued occupation of the site is not sustainable and future habitation within the high risk areas should be discouraged.
- *Lake amenity* – in the short term, the amenity of the lake foreshore between the Sunset Caravan Park and Jarrett Creek is compromised under elevated lake level conditions that are close to the manual entrance breakout trigger level. The use of the lake foreshore and pedestrian access between Newman Street and Lake Road can be maintained under such conditions through minor landscaping of the foreshore area and raising of the footpath.

The Recommended Floodplain Management Plan and Implementation

A recommended floodplain management plan showing preferred floodplain management measures for Woolgoolga is presented in Section 8 in the main body of the report. The key features of the plan are tabulated below with indicative costs, priorities and responsibilities for implementation.

Option	Estimated Cost	Responsibility	Priority	BCR
Recommended options that modify flood behaviour				
Trafalgar Street drainage improvements to divert more runoff to Queen Street	$150k	Council	Low to medium	0.4*
Drainage diversion of Local catchment flows from Moore Street to Woolgoolga Creek	$260k	Council	Low to medium	0.3*
Continued implementation of current entrance management policy	No additional expense	Council	High	NR
Recommended options that modify property				
Planning and development controls	Staff costs	Council	High	NR
Flood proofing of individual buildings (installation of flood gates at commercial centre)	$5k	Landowner	High	3.7
Investigate voluntary house raising program	$50k	Council / Landowner	Medium	1.0
Recommended options that modify flood response				
Improved flood awareness through issue of flood information, with a particular education focus for Sunset Caravan Park	$2k	Council / SES	High	NR
Update of Local Flood Plans with current design flood information	Staff costs	Council / SES	High	NR
Improve flood evacuation access for Sunset Caravan Park	$100k to $500k	Council / SES	High	NR
Improve flood warning system	$20k	Council / SES	High	NR
Other recommended options				
Long-term strategic planning and climate change adaption	Staff costs	Council	Medium	NR
Improved lake amenity access for periods of elevated lake levels during entrance closure	$40k	Council / Sunset Caravan Park	Medium	NR

Notes: NR – Not a capital cost orientated option, or benefits difficult/impossible to quantify in financial terms.

** BCR estimate will increase if these works are undertaken in conjunction with non-flood related works, e.g. future subdivision development.*

The steps in progressing the floodplain management process from this point forward are as follows:

1. Council allocates priorities to components of the Plan, based on available sources of funding and budgetary constraints;

2. Council negotiates other sources of funding as required such as through OEH and the "Natural Disaster Mitigation Package" (NDMP); and

3. as funds become available, implementation of the Plan proceeds in accordance with established priorities.

The Plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding or changes to the area's planning strategies. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the Plan.

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1 Introduction

The Woolgoolga Flood Study was prepared for Coffs Harbour City Council (Council) by BMT WBM in 2012. The study defined the flood behaviour of the Woolgoolga Creek catchment and other minor watercourses within Woolgoolga. This included the representation of some trunk drainage from the stormwater pipe network.

The primary objective of the flood study was to define the flood behaviour within Woolgoolga through the establishment of appropriate numerical models. The study produced information on flood flows, velocities, levels and extents for a range of flood event magnitudes under existing catchment and floodplain conditions.

The outcomes of the Woolgoolga Flood Study establish the basis for subsequent floodplain management activities in Woolgoolga, addressing both local and mainstream flooding issues. The Floodplain Risk Management Study (FRMS) aims to derive an appropriate mix of management measures and strategies to effectively manage flood risk in accordance with the Floodplain Development Manual. The findings of the study will be incorporated in a Plan of recommended works and measures and program for implementation.

The objectives of the Woolgoolga Floodplain Risk Management Study and Plan are to:

- Identify and assess measures for the mitigation of existing flood risk;
- Identify and assess planning and development controls to reduce future flood risks; and
- Present a recommended floodplain management plan that outlines the best possible measures to reduce flood damages in the Woolgoolga locality.

This report documents the Floodplain Risk Management Study and presents a recommended Floodplain Risk Management Plan for Woolgoolga.

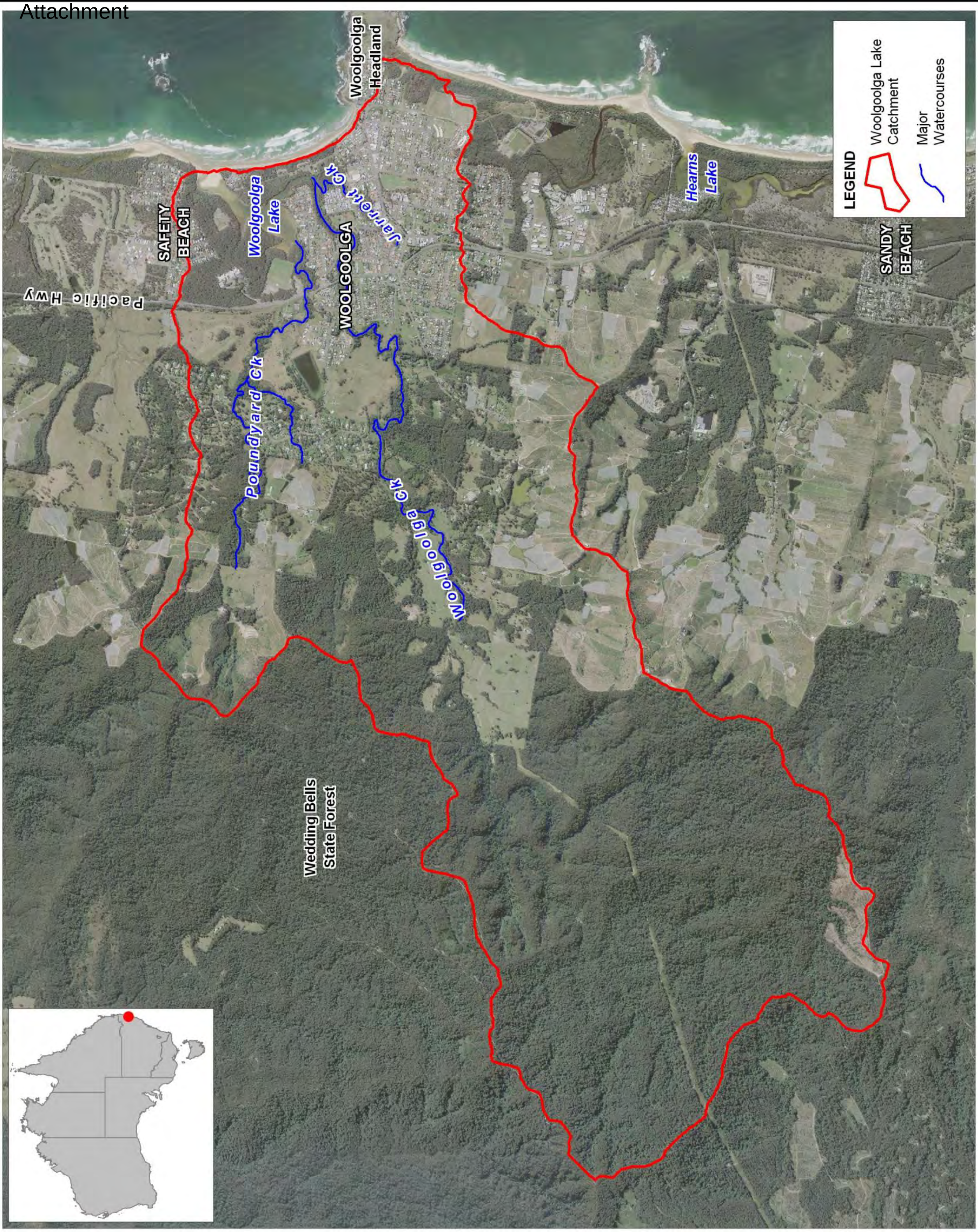
This project has been conducted under the State Assisted Floodplain Management Program and received State financial support.

1.1 Study Location

The Woolgoolga Lake catchment encompasses an area of approximately 22km^2 located on the New South Wales North Coast as shown in Figure 1-1. The lake is located behind the coastal dune system and is connected to the Tasman Sea via an entrance channel.

The township of Woolgoolga is the main community within the catchment. It is situated to the south of Woolgoolga Lake, straddling both Woolgoolga and Jarrett Creeks, towards the creek entrance in the south-east of the catchment. The community of Safety Beach is located at the northern boundary of the Woolgoolga Lake catchment. Apart from these existing development areas, land use in the catchment is predominantly forested or rural pasture.

Attachment



Title:

Study Locality

Figure: **1-1**

Rev: **A**

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

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Approx. Scale

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1.2 The Need for Floodplain Management at Woolgoolga

The historic flooding of Woolgoolga in 1974 and more recently in 2011 and 2012 has highlighted the risk to developed areas situated within the floodplain of Woolgoolga Lake and its contributing creeks. Future sea level rise predictions put further pressure on current and planned development situated within low-lying coastal areas.

Current practice in floodplain management requires consideration of the impact of potential climate change scenarios on design flood conditions. For the Woolgoolga Lake catchment this includes increases in design rainfall intensities and sea level rise scenarios that impact on ocean boundary conditions. These potential changes will translate into increased design flood inundation in the Woolgoolga Lake catchment, and future planning and floodplain management in the catchment will need to take due consideration of this increased flood risk.

Floodplain risk management considers the consequences of flooding on the community and aims to develop appropriate management measures to minimise and mitigate the impact of flooding. It includes considering existing flood risk associated with current development, and future flood risk associated with future development and changes in land use.

Accordingly, it is necessary to undertake local floodplain management in a considered and systematic manner. This study comprises the initial stages of that systematic approach, as outlined in the Floodplain Development Manual (NSW Government, 2005). The approach will enable more informed planning decisions within the floodplain of Woolgoolga Lake and the contributing creeks.

1.3 The Floodplain Management Process

The 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 can provide specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the State Government through the sequential stages outlined in Table 1-1.

The Woolgoolga Flood Study defines the existing flood behaviour and establishes the basis for future floodplain management activities.

The Woolgoolga Floodplain Risk Management Study and Plan (this document) constitutes the fourth and fifth stages of the management process. It has been prepared for Council to provide the basis for future management of flood liable land within the catchment.

Table 1-1 Stages of Floodplain Management

	Stage	Description
1	Formation of a Committee	Established by Council and includes community group representatives and State agency specialists.
2	Data Collection	Past data such as flood levels, rainfall records, land use, soil types etc.
3	Flood Study	Determines the nature and extent of the flood problem.
4	**Floodplain Risk Management Study**	**Evaluates management options for the floodplain in respect of both existing and proposed developments.**
5	**Floodplain Risk Management Plan**	**Involves formal adoption by Council of a plan of management for the floodplain.**
6	Implementation of the Floodplain Risk Management Plan	Construction of flood mitigation works to protect existing development. Use of local environmental plans to ensure new development is compatible with the flood hazard.

1.4 Structure of Report

This report documents the Study's objectives, results and recommendations.

Section 1 introduces the study.

Section 2 provides background information including a catchment description, history of flooding and previous investigations.

Section 3 outlines the community consultation program undertaken.

Section 4 describes the flooding behaviour in the catchment including climate change analysis.

Section 5 provides a summary of the flood damages assessment including identification of property potentially affected by flooding.

Section 6 provides a review of relevant existing planning measures and controls.

Section 7 provides an overview of potential floodplain risk management measures.

Section 8 presents the recommended measures and an implementation plan.

2 Background Information

2.1 Catchment Description

Woolgoolga is situated on the north coast of NSW approximately 20km north of the city of Coffs Harbour. The Woolgoolga Lake catchment occupies a total catchment area of around $22km^2$, extending from the Coast Range in Wedding Bells State Forest, and flowing east to the coast via Woolgoolga and Poundyard Creeks.

The topography of the catchment is shown in Figure 2-1. From a high elevation of around 250m AHD at the top of the catchment, the topography grades steeply from the upper slopes to the floodplain areas of Woolgoolga Creek. Woolgoolga Lake is fed primarily by Woolgoolga Creek and Poundyard Creek. The major tributary of Jarrett Creek merges with Woolgoolga Creek around 400m upstream of the lake. The catchment areas of Woolgoolga Creek, Poundyard Creek and Jarrett Creek are some $16km^2$, $3km^2$ and $2km^2$ respectively.

Woolgoolga Lake is an Intermittently Closed and Open Lake or Lagoon (ICOLL), which are a characteristic feature of the NSW coastline. An ICOLL has an intermittent connection to the ocean, being terminated periodically by an accumulation of marine sediment in the form of an entrance berm. The entrance berm typically undergoes a period of building during heavy seas, in which the berm level is raised, reducing the connectivity between lake and ocean. Catchment runoff following rainfall events is the natural process through which the entrance berm overtops and scours (entrance breakout), increasing connectivity between lake and ocean.

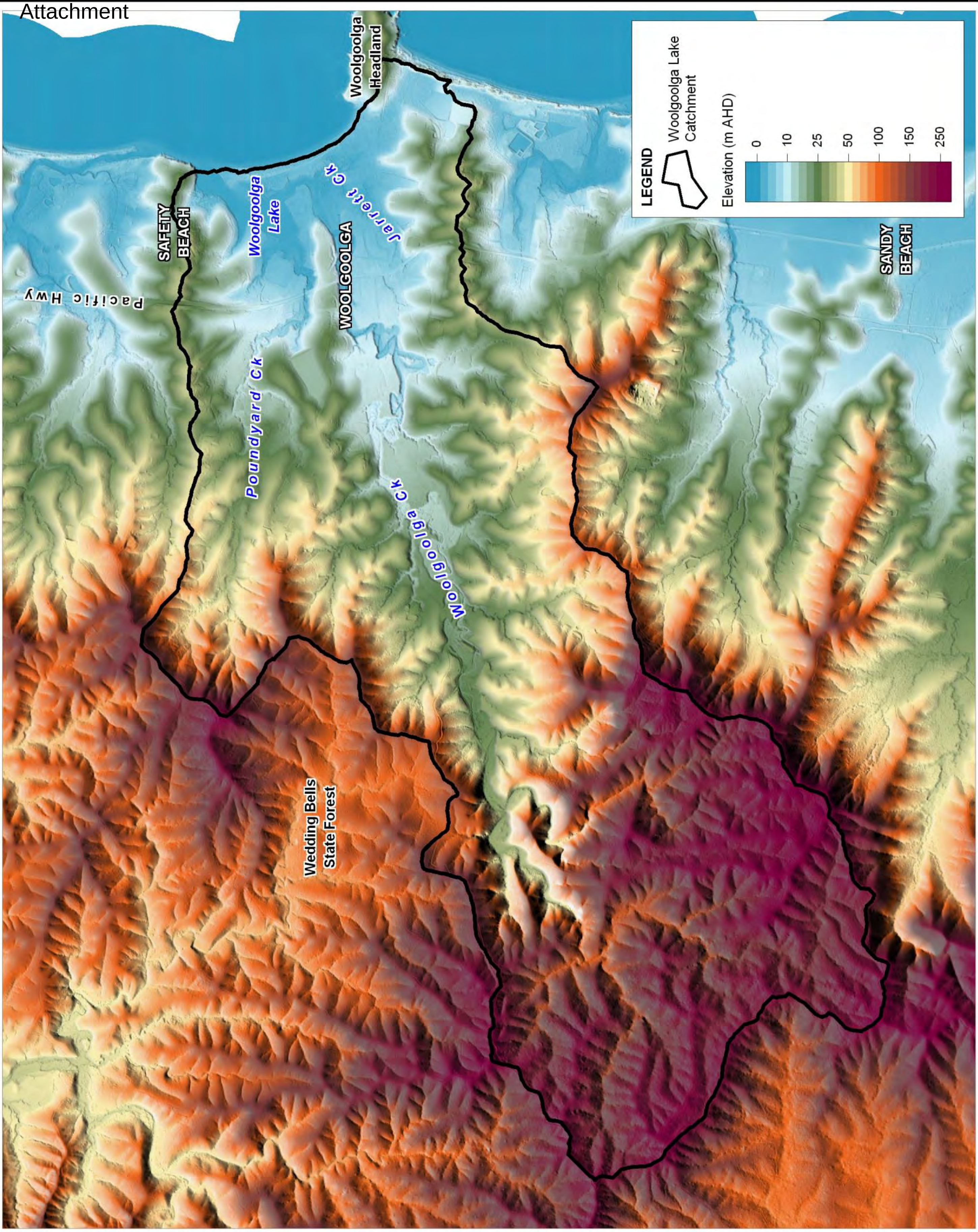
The natural breakout of Woolgoolga Lake typically occurs when water levels in the lake are between 1.2 to 1.8m AHD (GeoLINK, 2011). When the water level in the lake reaches 1.6m AHD and natural breakout does not occur then Council may initiate a mechanical breakout of the lake entrance. This is to prevent flooding of property and other key assets. During the period from July 1982 to April 1988 Council initiated nine mechanical breakouts. However, the frequency of mechanical breakouts has reduced more recently. The last opening initiated by Council was in 2007 (GeoLINK, 2011).

Land use within the catchment primarily consists of forested areas (65%). Other land uses include pastureland and other cultivated areas (20%) and urban development (15%). The lower lying areas around Woolgoolga Lake are largely developed, occupied by Woolgoolga township, whereas the upper catchment principally remains undeveloped and largely occupied by rural farming and state forest.

The township of Woolgoolga is the main community within the catchment, with a population of over 4,000. It is situated to the south of Woolgoolga Lake, straddling both Woolgoolga and Jarrett Creeks, towards the creek entrance in the south-east of the catchment. The community of Safety Beach is located at the northern boundary of the Woolgoolga Lake catchment.

The catchment is traversed by the major transport routes of the Pacific Highway and Solitary Islands Way. There is the potential for sections of the latter to become overtopped by flood waters during large magnitude flood events.

Attachment



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Topography of the Woolgoolga Lake Catchment

Figure: **2-1**

Rev: **A**

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2.2 History of Flooding

Until recently there was little recorded history of flooding in Woolgoolga. The largest historic flood on record is understood to be the March 1974 event, when a peak flood level of 2.1m AHD was reached at the Council depot in Ganderton Street. There were no significant flood events since 1974 until June 2011 when a peak flood level of around 2m AHD occurred in the lake. This event was followed only seven months later by another significant flood event in January 2012, which occurred during the undertaking of the flood study. The January 2012 event was of a similar magnitude to that of June 2011 but there is no record of the peak lake level available. There have been other recorded flood levels of around 1.9m AHD in the lake, but these are typically driven by the lake entrance conditions rather than catchment flood conditions.

There are two water level recording gauge sites located within the study catchment. The first is situated on Woolgoolga Creek some 6km upstream of the ocean. It is elevated at around 17m AHD and has a contributing catchment area of around $11km^2$. It was established by the Water Resources Commission NSW in 1960 and remained operational until 1983. It was then re-established by Manly Hydraulics Laboratory (MHL) in 1990 and is still currently operational.

Table 2-1 shows the ten highest gauge readings at Woolgoolga Creek gauge from the annual maxima series, referenced to gauge datum. It shows that the March 1974 event provided the largest recorded water level on Woolgoolga Creek, followed by the recent events of June 2011 and January 2012. Given the lack of other known historical flood events, it is likely that a gauge reading of over 3m is required before significant flooding problems are encountered in the catchment.

Table 2-1 Woolgoolga Creek Peak Gauge Levels

Year	Gauge Height (m)
1974	4.25
2011	3.83
2012	3.57
1962	3.52
1963	3.27
1991	2.97
2001	2.92
1977	2.77
1964	2.76
2009	2.57

The other location in the study area where water levels are recorded is the MHL operated gauge at Woolgoolga Lake. The gauge is situated just upstream of the downstream limit of Woolgoolga Creek and is representative of the lake levels. The gauging site was established in 2004, but only has a consistent period of record available since 2007.

2.3 Previous Studies

2.3.1 Woolgoolga Flood Study (BMT WBM, 2012)

Council commissioned BMT WBM to define the flood behaviour of the Woolgoolga Creek catchment and other minor watercourses within Woolgoolga and establish the basis for subsequent floodplain management activities. The study encompassed the watercourses of Woolgoolga Creek, Poundyard Creek and Jarrett Creek, as well as some trunk drainage of the stormwater pipe network. The study aimed to produce information on flood behaviour for a wide range of flood events under existing catchment and floodplain conditions.

Woolgoolga Lake is fed primarily by Woolgoolga Creek and Poundyard Creek. The major tributary of Jarrett Creek merges with Woolgoolga Creek around 400m upstream of the lake. The catchment areas of Woolgoolga Creek, Poundyard Creek and Jarrett Creek are some 16km^2, 3km^2 and 2km^2 respectively.

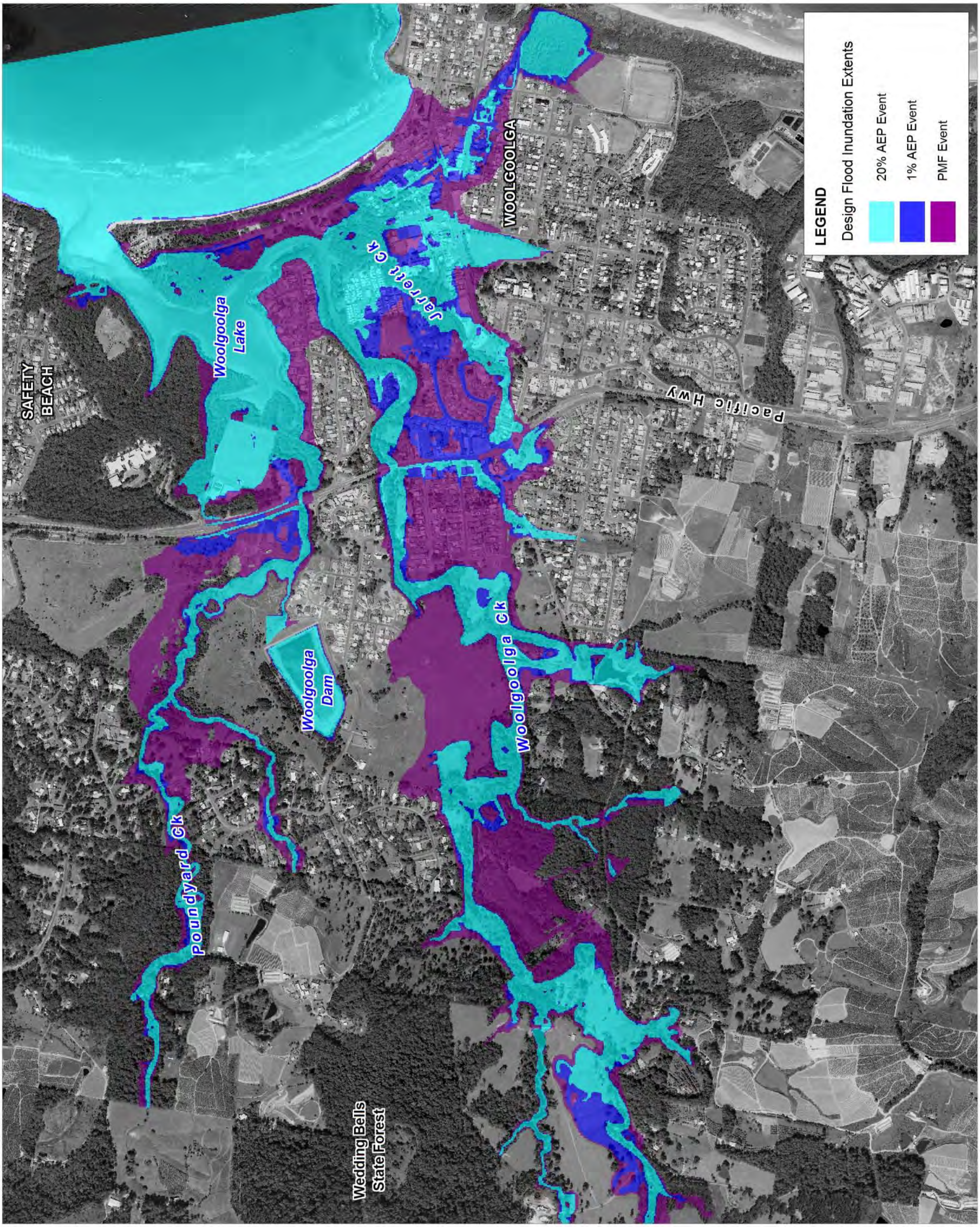
A 2D/1D hydraulic model (TUFLOW) was developed extending from the Woolgoolga Lake entrance at the downstream limit, upstream along the major tributary routes. The model incorporates the whole of Woolgoolga Lake and Woolgoolga Creek to upstream of the stream gauge, some 5.7km in length. Around 3.7km of Poundyard Creek is modelled, as is the full 1.2km length of Jarrett Creek. The area modelled within the 2D domain comprises a total area of some 9km^2 which represents the lower 40% of the entire Woolgoolga Lake catchment. The model was based on a 4m square grid.

Channel topography of the modelled watercourses was incorporated into the 2D model representation, using the available ground survey data. The modelled sections of the stormwater network were incorporated as a 1D model representation, dynamically linked to the 2D domain. Pipe details were obtained from the available survey data. The morphology of the entrance berm breakout was also dynamically modelled using the TUFLOW MORPH module.

The TUFLOW model was calibrated based on the historical data available for the March 1974, June 2011 and January 2012 events.

The TUFLOW model was used to derive a detailed representation of Woolgoolga for the 20%, 5%, 2%, 1% and 0.2% AEP design flood events as well as the probable maximum flood. The 20% AEP, 1% AEP and PMF extents are shown in Figure 2-2.

Attachment



Title:

Design Flood Inundation Extents

Figure: **2-2**

Rev: **A**

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3 Community Consultation

3.1 The Community Consultation Process

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

- Consultation with the Floodplain Management Committee through meetings and presentations;
- Distribution of information brochure and community questionnaire;
- Public exhibition of the Draft Floodplain Risk Management Study and Plan; and
- Community information sessions to present and discuss the potential and recommended floodplain risk management options.

These elements are discussed in detail below.

3.2 The Floodplain Management Committee

The study has been overseen by the CHCC Floodplain Management Committee (Committee). The Committee has assisted and advised Council in the development of the Woolgoolga Floodplain Risk Management Study and Plan.

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

3.3 Community Questionnaires

In May 2014 a community questionnaire was distributed to landowners, residents and businesses located within the study area in which respondents were asked to provide information on previous flood history, and their concerns or issues in regard to ongoing floodplain risk management in the catchment. Council received a total of 71 responses to the community questionnaire. A copy of the community newsletter and questionnaire is provided in Appendix B. The key information provided in the responses includes:

- Concerns over the Lake entrance management and resultant elevated lake levels;
- Issues relating to the siltation of the lake body and creeks;
- The maintenance of the stormwater drainage network to prevent blockages and improve the functionality during flood events;
- The potential for stormwater drainage improvements to help reduce flood risk within the local catchments; and
- Improved development control to help manage future flood risk.

3.4 Public Exhibition

The draft Woolgoolga Floodplain Risk Management Study and Plan was presented and discussed with the Floodplain Management Risk Advisory Committee at its meeting on the 29th April 2015.

In line with a recommendation by the committee, Council approved the draft Woolgoolga Flood Risk Management Study and Plan for public exhibition at its Ordinary Council meeting on 13th August 2015.

The Public Exhibition period ran from 2nd September 2015 to 13th October 2015 and was advertised in the local newspapers and on Council's website. Copies of the plan were available from Council's website, and at the Woolgoolga and Coffs Harbour libraries. A copy was also provided for the Woolgoolga Caravan Park.

Two submissions from the community were received by the close of the public exhibition process. In essence, the key submission views expressed were"

- Of being unsupportive of the building of levees to mitigate flood risk to the residents of Haines Close and the view that people living close to waterways do so in the knowledge that they are at some risk of flooding, but take this risk for the sake of natural beauty; and
- A request for amenity improvements in Trafalgar Lane, including replacement of open roadside drainage with kerb and guttering and underground drainage, installation of street lighting and footpaths, and general concern with regard to narrow laneway width and absence of street parking.

Each of these views is not in discord with the Floodplain Risk Management Plan exhibited, as explained below:

- The levee building option for Haines Close was not recommended in the Floodplain Risk Management Plan as placed on public exhibition. It was however one of several unselected mitigation measures that were investigated and considered as part of the study; and
- The Trafalgar Lane issues are not typically a matter of focus within a Flood Risk Management Plan, as they do not involve mainstream or major drainage flooding risk. Other Council processes are suited to such upgrade requests. Accordingly, a budget project bid for Trafalgar Lane upgrade was submitted for consideration at the next Council budget process.

Consideration of Public Exhibition submissions was undertaken at the Floodplain Management Risk Advisory Committee meeting on 3rd February 2016. The committee recommended to Council that the Woolgoolga Floodplain Risk Management Study and Plan be adopted.

Subsequently Council approved the Woolgoolga Flood Risk Management Study and Plan for adoption at its Ordinary Council meeting on 25th February 2016.

3.5 Community Information Sessions

A Community Information Session was held at the Woolgoolga Community Centre on the evening of Tuesday 3rd June 2014. The purpose of the information session was to present an overview of the findings and outputs of the Woolgoolga Flood Study. The Floodplain Risk Management Process was discussed, as were potential options that might be considered during the course of the Floodplain Risk Management Study. The session provided another opportunity for members of the community to voice their concerns regarding flooding within the catchment, building on feedback and information collected through the community questionnaire in May.

The information session was supported by around 20 community attendees in addition to representatives from Council and BMT WBM. Many of the attendees were residents of the Sunset Caravan Park. The outcome of the community information session was that the community was more concerned with prolonged periods of elevated lake levels, such as had occurred earlier in the year, than they were about the risk posed by a major flood event. This was certainly the case for residents of the Sunset Caravan Park. These issues are considered in more detail within Section 7.4.

Additionally, some attendees appeared to come with the misconception that flooding of the caravan park was solely tied to elevated lake levels. Given this misconception and the tangible risks posed by flooding at all lake levels, including low levels, it is recommended that this aspect be included within future flood awareness programs.

During the Public Exhibition period a further Community Information Session/Meeting was held at the Woolgoolga Village Community Hall on 14th September 2015. The session was advertised in the local newspapers and on Council's website.

Attendance at the community meeting was relatively low with five members of the community attending. At the meeting, a presentation of the Flood Risk Management Plan was provided, including the mitigation options investigated within the study, and the mix of management measures and strategies proposed for managing future flood risk and damage within Woolgoolga.

Community members expressed interest in understanding more about the plan, and engaged with questions and discussion. Key discussion points included, amongst others:

- The option of implementing a permanent entrance opening for the lake; and
- The option of lowering the intervention levels for the lake opening.

During discussions, both of these options were outlined in detail, including limitations of their feasibility and effectiveness, which gave the audience an awareness of many aspects they had not considered. Other discussion topics raised included:

- One attendee wanted the intervention level for the lake to be triggered by a more reliable mechanism, instead of the existing water level recorder. This issue was flagged to Council's Waterway Engineer for further investigation;
- Another member of the public expressed concern that their insurance premiums were exorbitant (>$5k), given that the house floor level was quite high. It was suggested that this issue may be progressed by providing the insurance company with a floor elevation certificate from a registered surveyor; and
- One attendee raised localised nuisance stormwater issues. Although these issues were important, they were not particularly relevant to major flooding. Subsequent discussions centred on the ability for Council's maintenance department to clean out swale drains within mangrove areas around the lake, in consideration of NSW government permit approval constraints.

4 Existing Flood Behaviour

4.1 Flood Behaviour

The Woolgoolga Flood Study (BMT WBM, 2012) defined design flood levels within Woolgoolga for a range of design event magnitudes. The detailed hydraulic model (TUFLOW) was calibrated and verified to June 2011, January 2012 and March 1974 historical event data.

4.1.1 Woolgoolga Lake Catchment Flooding

As previously discussed, the catchment of Woolgoolga Lake encompasses an area of approximately 22km^2. The catchment is drained principally by Woolgoolga Creek and also the smaller (3km^2) Poundyard Creek. Jarrett Creek (2km^2) is a tributary of Woolgoolga Creek and drains the urban area of Woolgoolga. The catchments are relatively steep in nature and the majority of flood waters are contained within the watercourses and confined adjacent floodplain. However, within Woolgoolga itself there is more extensive inundation of low-lying areas.

During major flood events, when the capacity of Woolgoolga Creek is exceeded, flood flows occur through the Haines Close and Sunset Caravan Park localities. This can present a highly hazardous environment with associated risk to life and property, particularly at the latter location. Elevated water levels in Woolgoolga Creek also generate backwater flooding along the lower reaches of Jarrett Creek and the small watercourse between Wharf Street and Ganderton Street.

There is limited out-of-bank flooding along the Poundyard Creek alignment. However, flooding emanating from Jarrett Creek and smaller local catchments does present an associated flood risk within Woolgoolga, with the flood risk to developed areas primarily affecting these two locations.

Given the size of the Woolgoolga Lake catchment, and relative steepness along the main flow path alignments, the catchment is highly responsive to rainfall such that the critical flood conditions within Woolgoolga relate to high intensity short duration events of the order of 2 to 6 hours.

The flood extents for events up to and including the 1% AEP event are broadly similar, albeit with some additional flood flow paths becoming active, particularly in Woolgoolga between the Solitary Islands Way and Jarrett Creek, as seen in Figure 2-2. The inundation extents for the PMF event show a much increased area at risk to flooding, especially in the following locations:

- The area to the west of the Solitary Islands Way including Nash Street, Dalgety Street, Knox Street and Moore Street;
- The area between the Solitary Islands Way and Jarrett Creek including Turon Parade;
- The area between Woolgoolga Creek and Woolgoolga Lake including Melaleuca Avenue, Pandanus Place and Clear Place; and
- The area around the Woolgoolga beachfront including the Woolgoolga Beach Caravan Park.

Peak in channel flood velocities are typically around 1.5m/s to 2.5m/s. Velocities in the floodplain areas are typically less than 0.5m/s.

4.1.2 Ocean Derived Flooding

Flooding occurring due to the backwater influence of elevated ocean water levels affects the low-lying areas around Woolgoolga Lake and Woolgoolga Creek. The limit of ocean derived flooding on Woolgoolga Creek extends some 500m or so beyond the Solitary Islands Way. Peak flood levels resulting from ocean flooding are lower in comparison to peak flood levels from catchment only derived events of equivalent exceedance probability.

4.1.3 Coincident Flooding

Coincident flooding, which considers both catchment and ocean flooding occurring at the same time, was adopted for design purposes as it provides a more conservative approach. The Woolgoolga Flood Study considered a range of design flood scenarios with respect to the following variables:

- Rainfall – different storm durations were modelled to determine the critical duration of flooding for different areas of the catchment;
- Berm Geometry – the entrance was modelled as either closed or open, with initial saddle height set at 1.5m AHD or -0.5m AHD respectively; and
- Ocean Boundary Peak Water Level – a water level time series was adopted for the downstream boundary condition to represent either a regular neap tide (peaks at 0.6m AHD) or a design ocean level that includes the influence wind and wave set up.

An overview of the final model conditions adopted for design events is presented in Table 4-1. For each design event, results from the alternate scenarios were combined to produce the peak flood condition across the catchment.

Table 4-1 Adopted Design Model Scenario for Coincident Flood Events

Design Flood	Rainfall	Berm Geometry	Ocean Boundary Peak Water Level (m AHD)
20% AEP	• 20% AEP 2h duration • 20% AEP 6h duration	Closed (1.5m AHD Berm Saddle)	• 0.6 (Regular Neap Tide) • 1.85 (20% AEP)
5% AEP	• 5% AEP 2h duration • 5% AEP 6h duration	Closed (1.5m AHD Berm Saddle)	• 0.6 (Regular Neap Tide) • 1.85 (20% AEP)
2% AEP	• 5% AEP 2h duration • 5% AEP 6h duration	Closed (1.5m AHD Berm Saddle)	• 0.6 (Regular Neap Tide) • 1.85 (20% AEP)
1% AEP	• 5% AEP 2h duration • 5% AEP 6h duration	Closed (1.5m AHD Berm Saddle)	• 0.6 (Regular Neap Tide) • 2.10 (5% AEP)
0.2% AEP	• 5% AEP 2h duration • 5% AEP 6h duration	Closed (1.5m AHD Berm Saddle)	• 0.6 (Regular Neap Tide) • 2.40 (1% AEP)
PMF	• PMP 1.5h duration • PMP 3h duration	Closed (1.5m AHD Berm Saddle)	• 0.6 (Regular Neap Tide) • 2.70 (0.2% AEP)

The magnitude of flooding experienced during coincident events is typically equal to the equivalent design event derived from catchment flooding only. The exception is the low-lying areas of Woolgoolga Creek and the lower reaches of Jarrett Creek, where flood issues are exacerbated further through elevated ocean water levels. This includes areas of Haines Close, the Sunset Caravan Park and the area around Wharf Street and Ganderton Street.

Simulated peak flood levels for design coincident flood events at selected locations shown in Figure 4-1 are summarised in Figure 4-2. Longitudinal profiles showing predicted flood levels along Woolgoolga Creek are shown in Figure 4-3.

Table 4-2 Modelled Peak Flood Levels (m AHD) for Design Coincident Flood Events

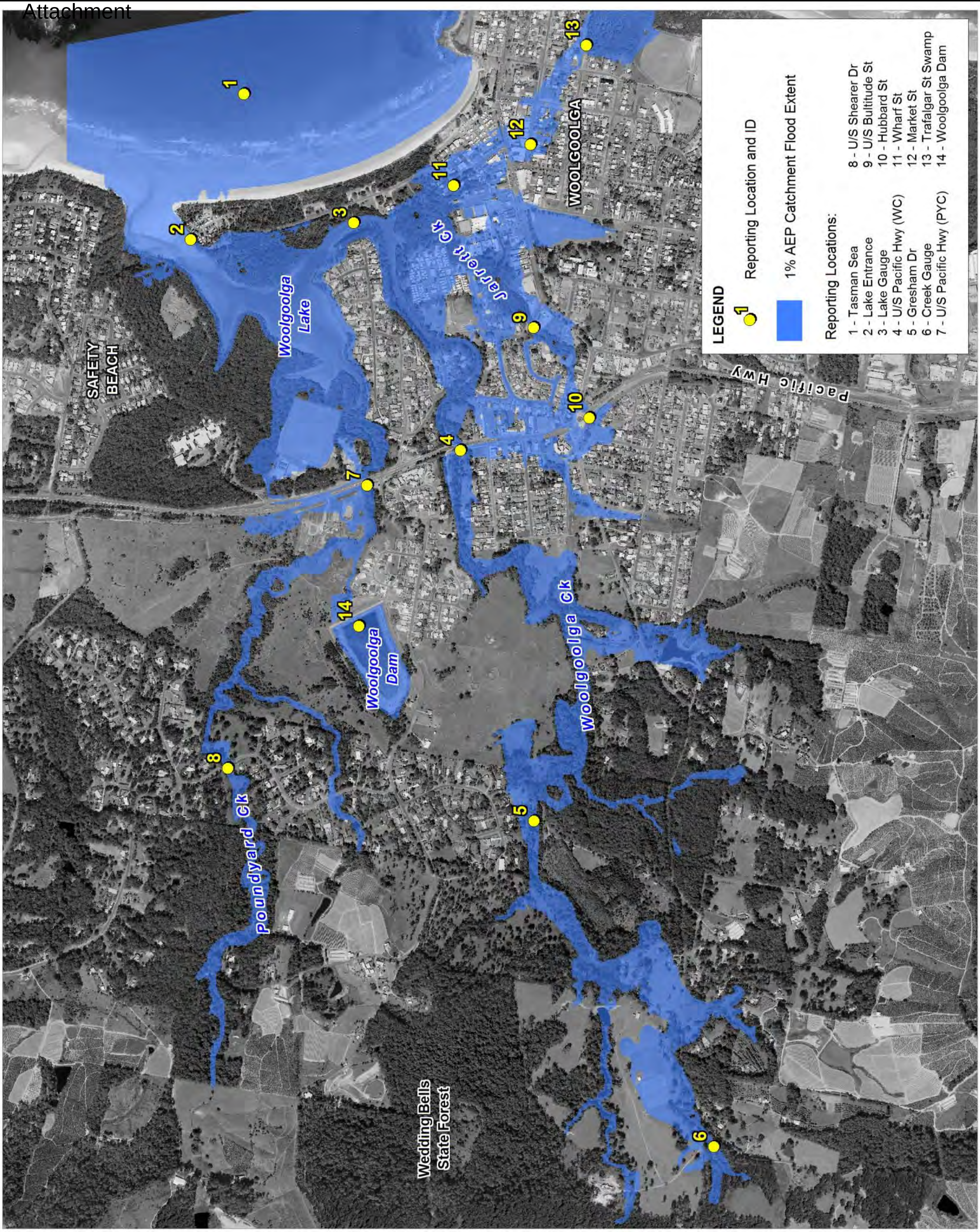
ID	Location	Flood Event Frequency					
		20% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP	PMF
1	Tasman Sea	1.9	1.9	1.9	2.1	2.4	2.7
2	Lake Entrance	2.5	2.6	2.7	2.7	2.9	3.2
3	Lake Gauge	2.6	2.7	2.8	2.9	3.1	4.4
4	U/S Solitary Islands Wy (WC)	3.7	4.2	4.4	4.6	5.0	7.6
5	Gresham Dr	12.3	12.6	12.7	12.8	13.1	14.6
6	Creek Gauge	20.1	20.7	21.0	21.1	21.5	23.3
7	U/S Solitary Islands Wy (PYC)	3.5	3.9	4.1	4.3	4.8	6.7
8	U/S Shearer Dr	17.1	17.7	18.2	18.5	18.8	19.7
9	U/S Bultitude St	3.1	3.2	3.3	3.3	3.4	5.3
10	Hubbard St	6.1	6.3	6.4	6.5	6.7	7.1
11	Wharf St	2.6	2.8	2.9	3.1	3.4	4.9
12	Market St	3.4	3.5	3.5	3.6	3.8	5.0
13	Trafalgar St Wetland	5.2	5.3	5.3	5.3	5.4	5.9
14	Woolgoolga Dam	18.1	18.2	18.3	18.3	18.5	19.0

4.2 Flood Risk Mapping

As part of this study, the existing TUFLOW model developed for the Flood Study was refined to represent changes in the catchment subsequent to completion of the study and to allow for testing of floodplain risk management options. Changes included modification of stormwater drainage representation around Market Street and Trafalgar Street and inclusion of the supermarket development on the corner of Solitary Islands Way and Pullen Street.

Design flood mapping for the 5% AEP, 2% AEP, 1% AEP, 0.2% AEP and PMF events (derived from coincident flood conditions) has been reproduced utilising the updated model and is contained in Appendix A. For each design event, a map of peak flood level and depth, velocity and preliminary hazard is presented covering the modelled area. Additional mapping has been undertaken as part of this floodplain risk management study to include hydraulic categorisation for all design events and to define the true flood hazard distributions.

Attachment



Title:

Water Level Reporting Locations

Figure: **4-1**

Rev: **A**

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

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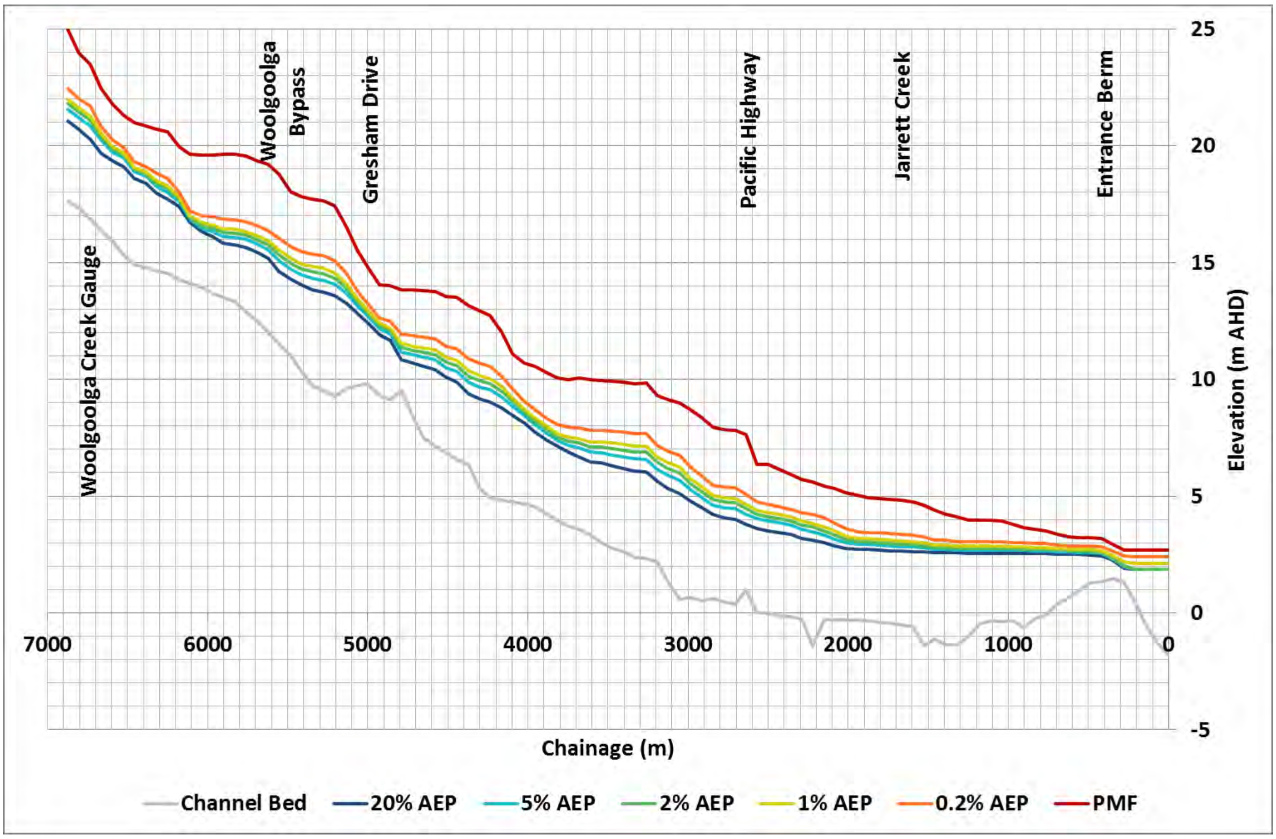


Figure 4-2 Woolgoolga Creek Coincident Event Peak Flood Level Profiles

4.2.1 Hydraulic Categorisation

There are no prescriptive methods for determining what parts of the floodplain constitute floodways, flood storages and flood fringes. Descriptions of these terms within the Floodplain Development Manual (NSW Government, 2005) are essentially qualitative in nature. Of particular difficulty is the fact that a definition of flood behaviour and associated impacts is likely to vary from one floodplain to another depending on the circumstances and nature of flooding within the catchment.

The hydraulic categories as defined in the Floodplain Development Manual are:

- **Floodway** - Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.
- **Flood Storage** - Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated water levels and/or elevated discharges. Flood Storage areas, if completely blocked would cause peak flood levels to increase by 0.1m and/or would cause the peak discharge to increase by more than 10%.
- **Flood Fringe** - Remaining area of flood prone land, after Floodway and Flood Storage areas have been defined. Blockage or filling of this area will not have any significant effect on the flood pattern or flood levels.

A number of approaches were considered when attempting to define flood impact categories across the study catchment. The approach that was adopted derived a preliminary floodway extent from the velocity * depth product (sometimes referred to as unit discharge). The floodway extent was then locally adjusted where appropriate. The peak flood depth was used to define flood storage areas. The adopted hydraulic categorisation is defined in Table 4-3.

Table 4-3 Hydraulic Categories

Floodway	Velocity * Depth > 0.3 at the design event	Areas and flowpaths where a significant proportion of floodwaters are conveyed (including all bank-to-bank creek sections).
Flood Storage	Velocity * Depth < 0.3 and Depth > 0.5 metres at the design event	Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks.
Flood Fringe	Flood extent of the design event	Areas that are low-velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour.

Hydraulic category mapping for the 20% AEP, 5% AEP, 2% AEP, 1% AEP, 0.2% AEP and PMF events is presented in Appendix A.

4.2.2 Flood Hazard

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

4.2.2.1 Size of Flood

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

The design flood extent for a range of flood magnitudes is shown in Figure 2-2.

4.2.2.2 Flood Readiness

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

The recent flood events of June 2011 and January 2012 highlighted the risk of flooding to the community as many current residents would not have experienced the 1974 event and were not aware of the potential flood risk in Woolgoolga. The June 2011 event was around a 5% AEP event in terms of design rainfall intensity. The rainfall during January 2012 event was more intense, with the 3-6hr rainfall burst equivalent to around 1% AEP design rainfall over the upper catchment. Due to the different berm conditions in place during each event, the resulting flood levels through the catchment do not correspond directly to the equivalent design flood event. A largely open entrance berm condition during the January 2012 event resulted in lower flood levels through the catchment compared to June 2011 where a higher entrance berm was present at the onset of the event.

General questions on flood awareness were targeted through the community questionnaire issued during the course of the study. Given two large flood events have occurred in recent years, residents affected by these events, primarily those located in the Sunset Caravan Park, are well aware of the flood risk.

4.2.2.3 Rate of Rise

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

Given the small size and relative steepness of the local catchment, the flood response of the local catchment is rapid.

Figure 4-3 shows the simulated water level rise in Woolgoolga Lake for 1% AEP coincident flood event in response to the adopted design rainfall pattern for the 2 hour storm event. It is evident that the catchment is highly responsive to the design rainfall pattern with the peak flood level within the lower catchment reached in around 2 hours after then onset of the storm. In terms of peak flood level reached at the lake gauge, the 6 hour storm duration is critical. However, less intense rainfall characteristic of the longer design storm results in slightly slower runoff through the catchment, with the peak water level of 2.9m AHD reach around 4 hours after the onset of the storm.

4.2.2.4 Duration of Flooding

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

The duration of flooding is largely related to the size and duration of the rainfall event over the catchment. The critical duration for peak flood levels in the catchment was estimated as the 2 hour and 6 hour design flood events for the upper and lower catchment areas respectively. Given the highly responsive nature of flooding within the catchment the period of inundation is expected to be in the order of a few to several hours.

4.2.2.5 Flood Warning Times

The amount of warning available for an approaching flood can have a significant impact on the risk to life. Less warning time clearly represents a greater risk to the community as there is less opportunity to respond appropriately and implement risk-reduction measures. Minimal warning time also means that emergency services are unlikely to be able to provide any assistance or direction for affected communities. To assess flood warning opportunity for Woolgoolga, consideration has been given to the levels of warning times as defined in Table 4-4.

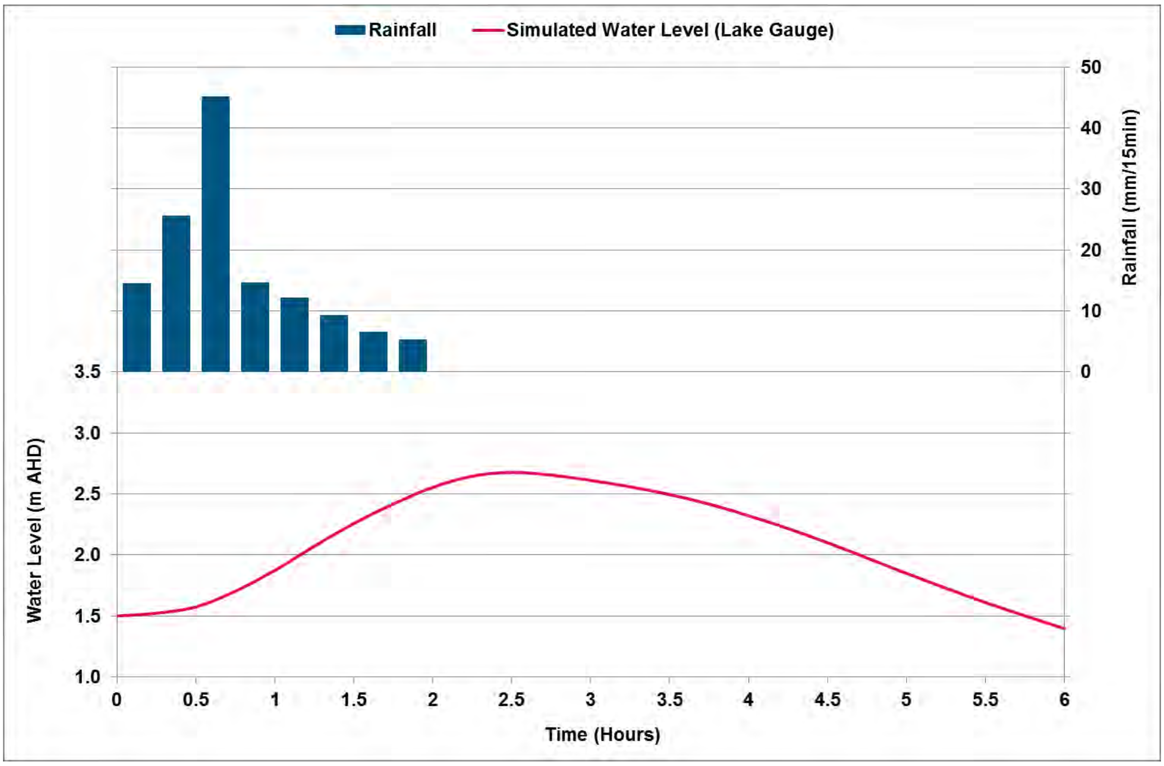


Figure 4-3 Rate of Rise of Floodwater (1% AEP 2 hour Design Event)

Table 4-4 Flood Warning Time Categories

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

As discussed in Section 4.2.2.3, the catchment is highly responsive to the design rainfall pattern with the peak flood level reached in around 2 hours after the onset of flood producing rainfall. The residents of Woolgoolga would therefore have minimal warning time of an approaching flood event.

4.2.2.6 Effective Flood Access

Access and evacuation difficulties arise from:

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

The Sunset Caravan Park is situated on low-lying land between the confluence of Woolgoolga Creek and Jarret Creek and can be subject to high levels of inundation during flood events meaning evacuation will likely be required during a flood event. The only access road to the Caravan Park is via Bultitude Street which becomes inundated by fast moving, deep floodwater at the Jarrett Creek crossing. Given the number of people needing to evacuate the area and the lack of suitable access for SES personnel to provide assistance, the residents of the park are exposed to considerable risk.

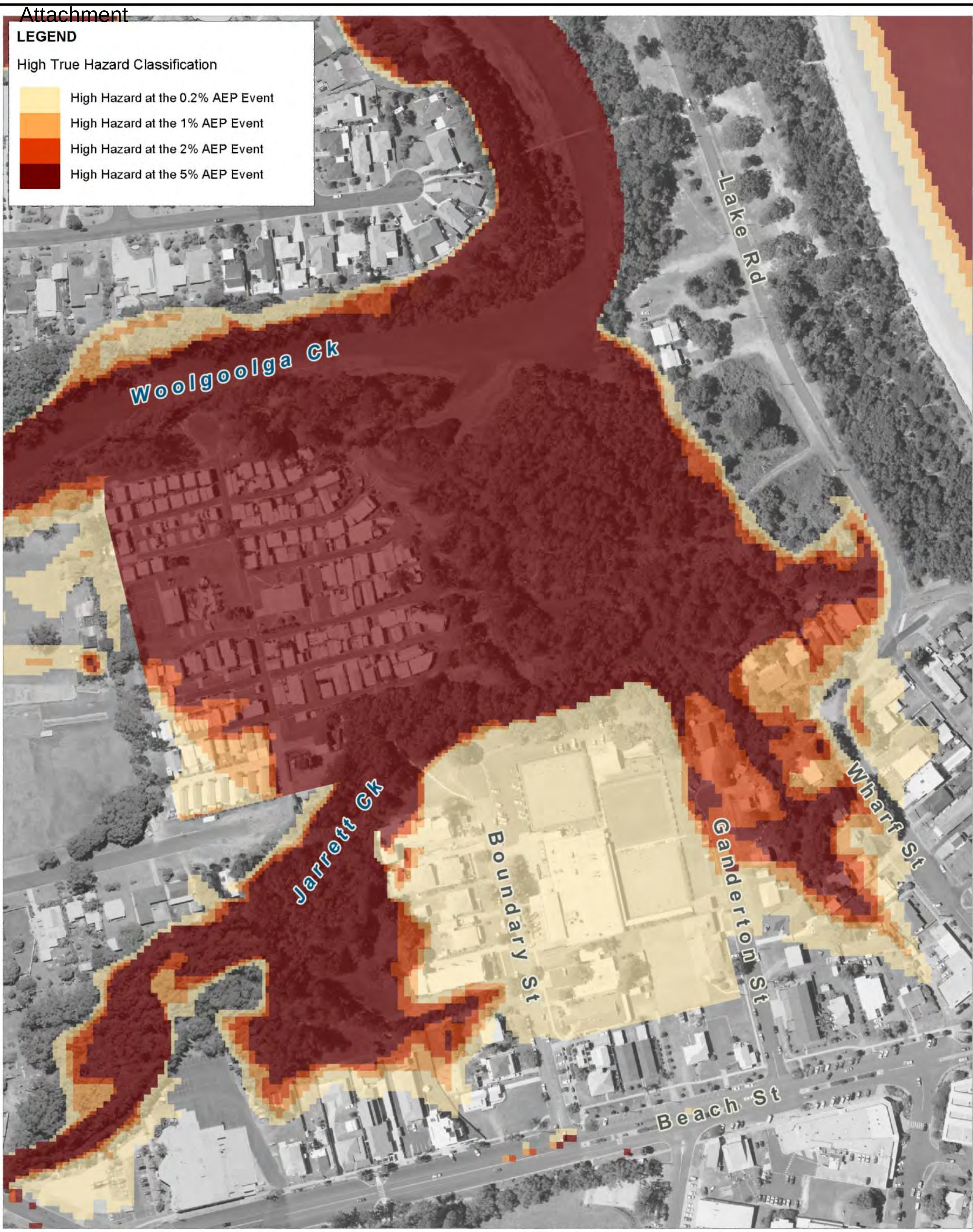
4.2.2.7 True Hazard Categorisation

The true hazard categorisation is typically based on the hydraulic hazard categorisation discussed in Section 4.2.1. However, it also takes into consideration other flood risks, particularly those relating to personal safety and evacuation, as detailed in Section 4.2.2. The main consideration for updating the provisional hazard maps arises from the limited flood warning time available for the residents of Woolgoolga.

Given the potential for rapidly rising floodwaters to isolate areas of Low Hazard within High Hazard areas, the provisional hazard has been modified to reclassify islands of Low Hazard as High Hazard. Developed areas where evacuation would be difficult when access roads are cut-off by High Hazard areas have also been reclassed as High Hazard. This primarily includes properties between Boundary Street and Ganderton Street that do not have direct access to Beach Street. The entire caravan park area has been assigned High Hazard categorisation for all design flood events due to the dwellings being particularly vulnerable to flooding, the absence of a safe evacuation route and the density of residents that may require assistance evacuating. Flooding around the Turon Parade area is of such shallow depth that residents could safely shelter in their homes if necessary during flood events.

True hazard category mapping is included in Appendix A, and is presented for the 20% AEP, 5% AEP, 2% AEP, 1% AEP, 0.2% AEP and PMF events. The extent of land classified as High Hazard at the 5% AEP, 2% AEP, 1% AEP and 0.2% AEP events has been presented in Figure 4-4. This highlights the level of flood risk within the lowest-lying areas, particularly Sunset Caravan Park.

Attachment



Title:

Woolgoolga High True Hazard Classification

Figure: 4-4

Rev: A

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

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Approx. Scale

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Areas that have been classified as high hazard typically experience flood waters that are deep and/or fast flowing, which are unsuitable for both vehicles and wading persons; or are isolated by areas with such conditions. During a flood event of sufficient magnitude light vehicles such as cars would be lifted by the flood waters and transported towards the major flow paths of the creek alignments. Floating debris of this size presents a serious risk to people and potentially building structures within the floodplain.

Similarly, wading through the flood waters would be unsuitable even for able-bodied adults. People exposed to the high hazard flood waters would likely be swept off their feet and placed in extreme danger. This risk to life is a particular focus of floodplain management and requires targeted flood education program to better inform residents exposed to such risks.

4.3 Climate Change

The NSW Government has published guidelines on the practical consideration of climate change (DECCW, 2007). For Woolgoolga a range of design events was defined to model the potential impacts of future climatic change within the study catchment. There are three outcomes of current climate change predictions which may have a significant impact of flood behaviour within Woolgoolga:

- Future sea-level rise;
- Elevated berm heights, themselves a function of sea-level rise;
- Increased extreme rainfall intensities.

These three factors were considered in combination with each other for two future horizons, 2050 and 2100. The outcomes of these climate change considerations will help understand the potential changes in future flood behaviour and how to best plan for future development within the catchment. The design events for which climate change impacts were considered were therefore focussed on the main planning event – 1% AEP event. A range of model conditions for these climate change events were assessed in the Woolgoolga Flood Study (BMT WBM, 2012).

The climate change scenario adopted for design purposes considered all climate change predictions occurring concurrently, and is summarised in Table 4-5. Elevated berm heights and sea level rise had significant impact on flood levels within the lower catchment, whereas increased rainfall intensities impacted on peak flood levels in the upper catchment.

Table 4-5 Adopted Design Model Scenario for Climate Change Scenarios

Design Flood	Rainfall	Berm Geometry	Ocean Boundary Peak Water Level (m AHD)
1% AEP 2050	• 1% AEP 2h duration +10% • 1% AEP 6h duration +10%	Closed (1.9m AHD Berm Saddle)	• 1.00 (Regular Neap Tide +0.4m to 2050) • 2.60 (5% AEP +0.5m to 2050)
1% AEP 2100	• 1% AEP 2h duration +10% • 1% AEP 6h duration +10%	Closed (2.4m AHD Berm Saddle)	• 1.50 (Regular Neap Tide +0.9m to 2100) • 3.30 (5% AEP +1.2m to 2100)

The most significant impact for Woolgoolga Lake will be from the impact of the predicted increase in berm height, which is in line with the 0.4m and 0.9m sea level rise for the 2050 and 2100 planning horizons. Increases in peak flood level of similar magnitude extend into the low-lying floodplain areas including at Bultitude Street and Wharf Street. For areas further upstream, the 10% increase in rainfall intensities gives typical peak flood level increases of between 0.1m to 0.2m.

Flood mapping presenting peak flood depths and water levels for future climate change scenarios has been included in this study. The impacts of sea level rise only have been mapped, specifically to allow for consideration of sea level rise in the future flood planning of Woolgoolga.

5 Flood Damages Assessment

5.1 Types of Flood Damage

The definitions and methodology used in estimating flood damage are summarised in the Floodplain Development Manual. Figure 5-1 summarises the "types" of flood damages as considered in this study. The two main categories are 'tangible' and 'intangible' damages. Tangible flood damages are those that can be more readily evaluated in monetary terms, while intangible damages relate to the social cost of flooding and therefore are much more difficult to quantify.

Tangible flood damages are further divided into direct and indirect damages. Direct flood damages relate to the loss, or loss in value, of an object or a piece of property caused by direct contact with floodwaters. Indirect flood damages relate to loss in production or revenue, loss of wages, additional accommodation and living expenses, and any extra outlays that occur because of the flood.

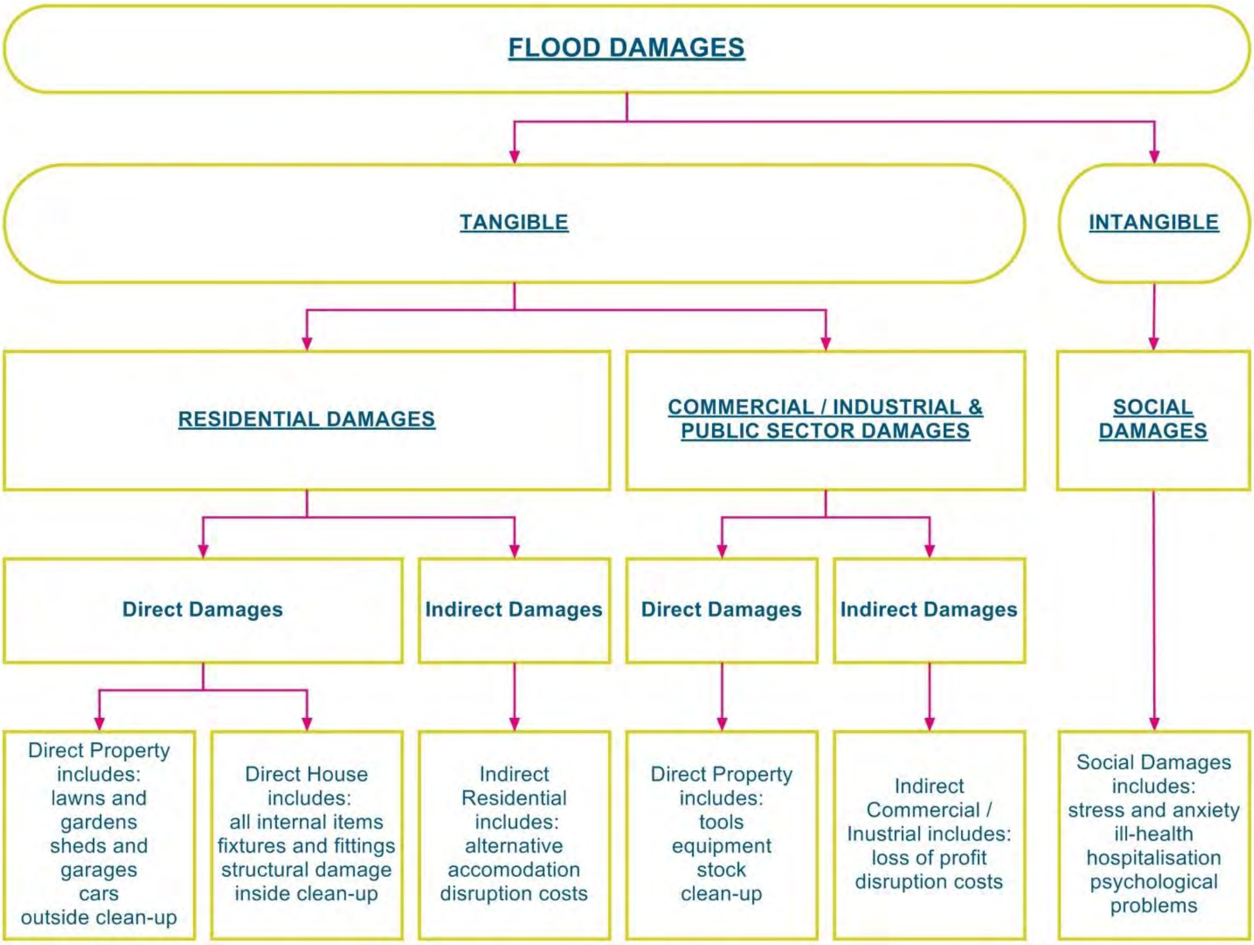

Figure 5-1 Types of Flood Damage

5.2 Basis of Flood Damage Calculations

Flood damages have been calculated using the data base of potentially flood affected properties and a number of stage-damage curves derived for different types of property within the catchment.

These curves relate the amount of flood damage that would potentially occur at different depths of inundation, for a particular property type. Residential damage curves are based on the OEH guideline stage-damage curves for residential property.

The property floor level survey undertaken during this study has been used for the database of flood affected properties. Properties located within the floodplain (but outside of the 1%AEP extent) that did not have floor level survey available were estimated from the LiDAR DEM, assuming a floor level 0.3m above ground.

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

- Residential dwellings (categorised into small, typical or raised categories);
- Caravan Park dwellings (at half the value of the residential dwellings); and
- Commercial premises (categorised into low, medium or high damage categories).

Apart from the direct damages calculated from the derived stage-damage curves for each flood affected property, other forms of flood damage include:

- Indirect residential, commercial and industrial damages, taken as a percentage of the direct damages;
- Infrastructure damage, based on a percentage of the total value of residential and business flood damage; and
- Intangible damages relate to the social impact of flooding and include:
  - inconvenience,
  - isolation,
  - disruption of family and social activities,
  - anxiety, pain and suffering, trauma,
  - physical ill-health, and
  - psychological ill-health.

The damage estimates derived in this study are for the **tangible damages only**. Whilst intangible losses may be significant, these effects have not been quantified due to difficulties in assigning a meaningful dollar value.

5.3 Tangible Flood Damages

5.3.1 Assessment of Direct Damages

The peak depth of flooding was determined at each property for the 20%, 5%, 2%, 1% and 0.2% AEP events and the PMF. The associated direct flood damage cost to each property was subsequently estimated from the stage-damage relationships. For residential properties the flood damage curves include external damages incurred below floor level. For external damages where the flood depth is below 0.3m a nominal $1,000 value has been adopted. Total damages for each flood event were determined by summing the predicted damages for each individual property.

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

5.3.2 Estimation of Indirect Damages

The indirect damages are more difficult to determine and would vary for each flood event, particularly with the duration of the flood inundation. Previous studies detailing flood damages from actual events have found that the indirect damages for residential properties are typically in the order of 20% of the direct damages. The indirect damages associated with commercial properties are typically higher and a value of 40% of the calculated direct damages has been adopted.

5.4 Woolgoolga Flood Damages

A significant challenge in the flood damages assessment for Woolgoolga is the sensitivity of flood levels in the Lake foreshore areas to the coincident entrance berm and sea level conditions during a catchment flood event. The Flood Study established design flood conditions for the purposes of flood planning, following OEH guidelines. Whilst this is appropriate for determining flood planning controls, the adopted conditions are somewhat conservative.

This is evident when considering the more frequent flood events such as the 20% AEP. Under the adopted design conditions, with a closed entrance berm (crest level of 1.5m AHD) and coincident ocean flooding (peak ocean level of 1.85m AHD), this event has a peak flood level of 2.6m AHD at the Lake gauge, which results in significant property inundation. However, flooding of this magnitude does not occur with this frequency. The two recent flood events of June 2011 and January 2012 recorded rainfall in the order of a 5% AEP and 2% AEP magnitude respectively, yet the peak flood levels reached at the Lake gauge were around 2.0m AHD for both. This was due to the more open entrance conditions that were prevalent at the time. Had the events occurred during a period of entrance closure then the flooding would have been much more severe.

The adopted design conditions present perhaps a “worst case” scenario, which is planned for through appropriate development controls. The “best case” scenario would be when a catchment flood occurs during an open entrance condition with typical sea levels – such as was the case in the January 2012 event. If flood records were available for a 10,000 year period then we would expect to have around 100 1% AEP floods, each with a different set of coincident entrance/ocean conditions. The average flood conditions of these 100 floods would be the most suitable to use for the purposes of flood damage assessment. This result would lie somewhere between the “best case” and “worst case” scenarios and would be expected to be “left of centre”.

A range of entrance and sea level conditions were simulated for model sensitivity purposes when establishing the design flood conditions for the Flood Study. One set of conditions was the adoption of a 1m AHD entrance berm and a design still water level in the ocean (around 1.4m AHD). These conditions have been selected as being more appropriate for the purposes of the flood damages assessment. The average Lake level (and most likely, the entrance berm height) is around 0.7m

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AHD and a sea level of 1.4m AHD is perhaps higher than would be typical during a flood. Therefore these conditions still probably represent a slightly conservative case for flood damages assessment. However, they are more appropriate than using the adopted design conditions. The PMF conditions have not been altered.

It should be noted that although the more typical conditions adopted for the flood damages assessment are better suited for estimating average annual damages, a major flood event occurring during a closed entrance condition would be much worse and cause substantial flood damages.

The properties within Woolgoolga that have been identified as having above floor flood inundation are presented in Figure 5-2.

5.4.1 Residential Flood Damages

The assessment of the residential flood damages is presented in Table 5-1. From this data the AAD for residential properties was calculated as being $122,000 in direct damages and $24,000 in indirect damages, giving a total value of $146,000 for all affected residential properties.

Table 5-1 Summary of Residential Flood Damages

Event Magnitude	Lake Gauge Flood Level (m AHD)	Properties Flooded Above Floor (and Ground)	Direct Damages ($)	Indirect Damages ($)	Total Damages ($)
20% AEP	2.10	1 (53)	$101,000	$20,000	$121,000
5% AEP	2.25	5 (77)	$302,000	$60,000	$362,000
2% AEP	2.35	14 (90)	$773,000	$155,000	$928,000
1% AEP	2.45	27 (110)	$1,633,000	$327,000	$1,960,000
0.2% AEP	2.50	38 (141)	$2,615,000	$523,000	$3,138,000
PMF	4.4	384 (415)	$29,089,000	$5,818,000	$34,907,000
AAD for all Floods			**$122,000**	**$24,000**	**$146,000**

5.4.2 Caravan Park Flood Damages

The flood damages associated with the caravan park have used the residential flood damage curves with a factor of 0.5 applied to the damage value. The assessment of the caravan park flood damages is presented in Table 5-2. From this data the AAD for caravan park properties was calculated as being $150,000 in direct damages and $30,000 in indirect damages, giving a total value of $180,000 for all affected caravan park properties.

Attachment

LEGEND

Inundated Buildings

- 20% AEP Catchment Event
- 5% AEP Catchment Event
- 2% AEP Catchment Event
- 1% AEP Catchment Event
- 0.2% AEP Catchment Event
- PMF Event

Title:

Properties Inundated Above Floor Level (Ocean Level of 1.4m AHD and Entrance Berm Crest Level of 1.0m AHD)

Figure: **5-2**

Rev: **A**

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Approx. Scale

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Table 5-2 Summary of Caravan Park Flood Damages

Event Magnitude	Lake Gauge Flood Level (m AHD)	Properties Flooded Above Floor (and Ground)	Direct Damages ($)	Indirect Damages ($)	Total Damages ($)
20% AEP	2.10	4 (52)	$160,000	$32,000	$192,000
5% AEP	2.25	19 (86)	$681,000	$136,000	$817,000
2% AEP	2.35	28 (96)	$1,016,000	$203,000	$1,219,000
1% AEP	2.45	37 (114)	$1,326,000	$265,000	$1,591,000
0.2% AEP	2.50	66 (126)	$2,357,000	$471,000	$2,828,000
PMF	4.4	169 (169)	$8,636,000	$1,727,000	$10,363,000
AAD for all Floods			**$150,000**	**$30,000**	**$180,000**

5.4.3 Commercial Flood Damages

The assessment of the commercial flood damages is presented in Table 5-3. From this data the AAD for commercial properties was calculated as being $12,000 in direct damages and $5,000 in indirect damages, giving a total value of $17,000 for all affected commercial properties.

Table 5-3 Summary of Commercial Flood Damages

Event Magnitude	Lake Gauge Flood Level (m AHD)	Properties Flooded Above Floor	Direct Damages ($)	Indirect Damages ($)	Total Damages ($)
20% AEP	2.10	0	$-	$-	$-
5% AEP	2.25	2	$34,000	$14,000	$48,000
2% AEP	2.35	4	$39,000	$16,000	$55,000
1% AEP	2.45	4	$67,000	$27,000	$94,000
0.2% AEP	2.50	12	$250,000	$100,000	$350,000
PMF	4.4	52	$6,336,000	$2,534,000	$8,870,000
AAD for all Floods			**$12,000**	**$5,000**	**$17,000**

5.4.4 Public Utilities Damages

Public utilities include roads, railways, parklands and underground water, sewerage, power and telephone services and installations. The damages sustained by public utilities comprise the replacement or repair of assets damaged by floodwaters, the cost of clean-up of the installations as well as the collection and disposal of clean-up material from private property.

For the purposes of this study an estimate of the damage cost of $12,000 per hectare has been adopted, based on the findings of previous studies. The flood extents of the 20% AEP event under an open entrance condition have been used to define areas that would experience frequent inundation. The areas used to determine flood damage estimates have therefore been taken as the flooded areas beyond those of that event. The assessment of public utilities damages is presented in Table 5-4. From this data the AAD for public utilities was calculated as being $31,000.

Table 5-4 Summary of Public Utilities Flood Damages

Event Magnitude	Lake Gauge Flood Level (m AHD)	Area of Urban Area Flooded (ha)	Total Damages ($)
20% AEP	2.10	4	$48,000
5% AEP	2.25	11	$132,000
2% AEP	2.35	14	$168,000
1% AEP	2.45	19	$228,000
0.2% AEP	2.50	27	$324,000
PMF	4.4	69	$828,000
AAD for all Floods			**$31,000**

5.4.5 Total Tangible Flood Damages

The total tangible flood damages for residential, caravan park and commercial properties and the damage to public utilities were combined, as presented in Table 5-5. From this data the combined AAD was calculated as being $374,000, comprised as follows:

- $146,000 from residential properties;
- $180,000 from properties within the caravan park;
- $17,000 from commercial properties; and
- $31,000 from public utilities.

Table 5-5 Summary of Total Tangible Flood Damages

Design Event	Residential Flood Damages ($)	Caravan Park Flood Damages ($)	Commercial Flood Damages ($)	Public Utilities Flood Damages ($)	Total Tangible Flood Damages ($)
20% AEP	$121,000	$192,000	$-	$48,000	$361,000
5% AEP	$362,000	$817,000	$48,000	$132,000	$1,359,000
2% AEP	$928,000	$1,219,000	$55,000	$168,000	$2,370,000
1% AEP	$1,960,000	$1,591,000	$94,000	$228,000	$3,873,000
0.2% AEP	$3,138,000	$2,828,000	$350,000	$324,000	$6,640,000
PMF	$34,907,000	$10,363,000	$8,870,000	$828,000	$54,968,000
AAD	**$146,000**	**$180,000**	**$17,000**	**$31,000**	**$374,000**

Note: Encompasses design ocean level of 1.4m AHD and an entrance berm level of 1.0m AHD.

5.4.6 Flood Damage Sensitivity

As discussed, the numbers presented are from a representative set of entrance and ocean conditions, selected to give a reasonable estimation of average annual damages. The actual damages incurred would vary from event to event, particularly in those areas surrounding the Lake foreshore, which are sensitive to the entrance/ocean conditions. The flood damages assessment has also been undertaken under the "best case" (where the catchment flooding occurs in isolation, with an open entrance condition) and "worst case" (where catchment and ocean flooding are coincident, with a closed entrance condition) scenarios, as presented in Table 5-7.

Table 5-6 Flood Damages under a "Best Case" Scenario

Design Event	Residential Flood Damages ($)	Caravan Park Flood Damages ($)	Commercial Flood Damages ($)	Public Utilities Flood Damages ($)	Total Tangible Flood Damages ($)
20% AEP	$101,000	$1,000	$-	$-	$102,000
5% AEP	$180,000	$70,000	$48,000	$84,000	$382,000
2% AEP	$521,000	$325,000	$55,000	$132,000	$1,033,000
1% AEP	$1,039,000	$761,000	$94,000	$192,000	$2,086,000
0.2% AEP	$2,752,000	$1,979,000	$350,000	$300,000	$5,381,000
PMF	$34,907,000	$10,363,000	$8,870,000	$828,000	$54,968,000
AAD	**$108,000**	**$40,000**	**$17,000**	**$14,000**	**$179,000**

Note: Encompasses design ocean level of 0.6m AHD and an entrance berm level of 0m AHD.

Table 5-7 Flood Damages under a "Worst Case" Scenario

Design Event	Residential Flood Damages ($)	Caravan Park Flood Damages ($)	Commercial Flood Damages ($)	Public Utilities Flood Damages ($)	Total Tangible Flood Damages ($)
20% AEP[1]	$664,000	$1,296,000	$-	$108,000	$2,068,000
5% AEP[1]	$1,426,000	$2,023,000	$48,000	$192,000	$3,689,000
2% AEP[1]	$2,070,000	$2,672,000	$55,000	$228,000	$5,025,000
1% AEP[2]	$2,994,000	$3,245,000	$116,000	$288,000	$6,643,000
0.2% AEP[3]	$5,076,000	$4,174,000	$476,000	$396,000	$10,122,000
PMF[4]	$34,907,000	$10,363,000	$8,870,000	$828,000	$54,968,000
AAD	**$406,000**	**$588,000**	**$18,000**	**$52,000**	**$1,064,000**

Notes: 1 – Encompasses design ocean level of 1.85m AHD and an entrance berm level of 1.5m AHD.

2 – Encompasses design ocean level of 2.1m AHD and an entrance berm level of 1.5m AHD.

3 – Encompasses design ocean level of 2.4m AHD and an entrance berm level of 1.5m AHD.

4 – Encompasses design ocean level of 2.7m AHD and an entrance berm level of 1.5m AHD.

The numbers show a significant variation in flood damages depending on the coincident ocean and, more significantly, the entrance berm conditions during catchment flood events. The adopted conditions for the flood damages assessment aim to provide a more reasonable estimate of the typical conditions, but are still perhaps a little conservative. Flood levels under the "worst case" conditions are in the order of 0.5m higher than those of the adopted conditions and may be indicative of future flood damages with projected sea level rise of around a 50 year horizon. As sea levels (and berm heights) gradually rise, so too will the expected annual average damages.

6 Review of Existing Planning Provisions

Land use planning and development controls are key mechanisms by which Council can manage some of the flood related risks within flood-affected areas of Woolgoolga (as well as across the wider Local Government Area (LGA)).

A review of existing planning controls has been undertaken with the objective to:

- review the existing planning and development controls framework relevant to the formulation of planning instruments and the assessment of development applications in the Woolgoolga Creek floodplain, and
- make specific planning recommendations in regards to flood risk management, including an outline of suggested planning controls.

6.1 Local Environment Plan

A Local Environmental Plan (LEP) is prepared in accordance with Part 3 Division 4 of the EP&A Act 1979 and operates as a local planning instrument that establishes the framework for the planning and control of land uses. The LEP defines zones, permissible land uses within those zones, and specific development standards and special considerations with regard to the use or development of land.

The Coffs Harbour Local Environment Plan 2013 (LEP 2013) (Coffs Harbour City Council, 2013) has been prepared in accordance with the NSW State Government's Standard Instrument (Local Environmental Plans) Order 2006, which requires local Councils to implement a Standard Instrument LEP. The State Government has created the Standard Instrument LEP to assist in streamlining the NSW Planning system.

Clause 7.3 of the Coffs Harbour Local Environment Plan 2013 relates to development on flood liable land. The LEP provisions incorporate general considerations in regard to development of flood liable land. These provisions require the approval process to consider the impact of proposed development on local flood behaviour, the impact of flooding on the development and the requirements of adopted Floodplain Management Plans that are applicable. Specifically Clause 7.3 states:

(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; and

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

(2) This clause applies to land at or below the flood planning level.

(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:

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a) is compatible with the flood hazard of the land, and

b) is not likely to 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) is not likely to 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) A word or expression used in this clause has the same meaning as it has in the NSW Government's *Floodplain Development Manual* (ISBN 0 7347 5476 0), published in 2005 by the NSW Government, unless it is otherwise defined in this clause.

(5) In this clause:

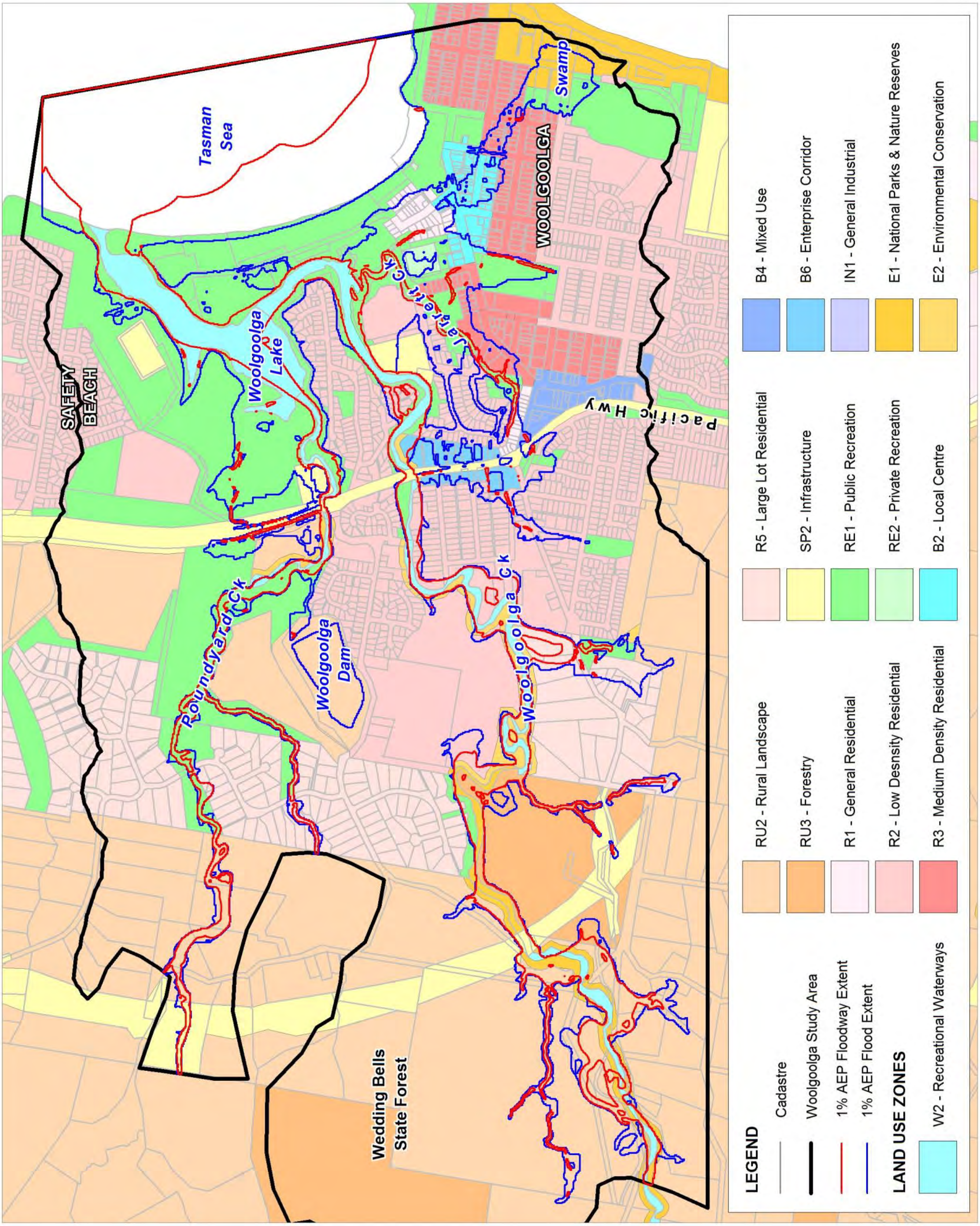
flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metres freeboard.

6.1.1 Land Use

The Coffs Harbour LEP 2013 identifies a number of land use zones including existing and future development areas, based on stated objectives for each zoning and provisions made for each zoning. The land use zones under the Coffs Harbour LEP 2013 are as follows:

- Rural Zones: RU2 Rural Landscape and RU3 Forestry;
- Residential Zones: R1 General Residential, R2 Low Density Residential, R3 Medium Density Residential, R4 High Density Residential and R5 Large Lot Residential;
- Business Zones: B1 Neighbourhood Centre, B2 Local Centre, B3 Commercial Core, B4 Mixed Use, B5 Business Development and B6 Enterprise Corridor;
- Industrial Zones: IN1 General Industrial, IN3 Heavy Industrial and IN4 Working Waterfront;
- Special Purpose Zones: SP1 Special Activities, SP2 Infrastructure and SP3 Tourist;
- Recreation Zones: RE1 Public Recreation and RE2 Private Recreation;
- Environment Protection Zones: E1 National Parks and Nature Reserves and E2 Environmental Conservation;
- Waterway Zones: W1 Natural Waterways, W2 Recreational Waterways and W3 Working Waterways.

Within the Woolgoolga Floodplain Risk Management Study area much of the flood affected land is classified as RE1 (Public Recreation and W2 (Recreational Waterways), as shown in Figure 6-1.



Title:

Woolgoolga Land Use Zones

Figure: **6-1**

Rev: **A**

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These land zones already have significant development restrictions applied to them, they are considered to be compatible with the flood risk.

However, it is evident in Figure 6-1 that significant areas of land zoned as R2 (Low Density Residential), R3 (Medium Density Residential, B2 (Local Centre) and B6 (Enterprise Corridor) lies within the 1% AEP flood extent. In addition, a portion of this land is also classified as a Floodway and typically would not be considered suitable for residential development. Future rezoning of this flood affected land to be more compatible with the flood risk should be considered.

For further information on land use zones refer to the Coffs Harbour LEP 2013.

6.2 Coffs Harbour Floodplain Development and Management Policy

The Coffs Harbour Floodplain Development and Management Policy (POL-07 4) was adopted on the 22nd August 2013. The policy is an interim measure pending incorporation of appropriate controls in Council's LEP and DCP. The Policy is based on previously adopted policy relating to Floodplain Development and guidelines in the Coffs Creek Floodplain Risk Management Study and Plan.

Policy Statement

To provide guidelines for development on flood prone land or potentially flood prone land.

Policy Aims

- To minimise risk, both physical and economic, due to mainstream flooding;
- To minimise the effects of development on flooding in natural watercourses; and
- To give developers clear guidelines for the requirements of particular developments on flood liable land.

The Policy contains 14 clauses relating to development within the floodplain. For development and building approvals for properties that Council considers flood liable the conditions of these clauses must be met. For the purposes of assessment the proposed developments are categorised as follows:

- Category 1 – Building a structure;
- Category 2 – Activity other than a building; and
- Category 3 – Caravan and Mobile Home Parks.

Table 6-1 identifies which of the 14 clauses are relevant to each category of development.

6.2.1 Policy Clauses

1) No development shall be allowed in Floodway areas with the exception of infrastructure or limited recreational / non-urban development (see Coffs Creek Floodplain Risk Management Study or Plan for more details).

2) Development within the 1% AEP (1 in 100 year) flood extents shall not be encouraged.

Table 6-1 Clauses Relevant to Specific Categories of Development

	Category 1 – Building a Structure	Category 2 – Activity other than a Building	Category 3 – Caravan and Mobile Home Parks
Clause No. 1	X	X	X
Clause No. 2	X	X	X
Clause No. 3	X		
Clause No. 4	X	X	X
Clause No. 5	X		X
Clause No. 6	X		X
Clause No. 7	X		X
Clause No. 8	X		X
Clause No. 9	X		
Clause No. 10		X	
Clause No. 11		X	
Clause No. 12	X	X	X
Clause No. 13	X		X
Clause No. 14	X	X	

However, development within this area may be permitted, provided that evidence can be submitted in the form of a flood study by a suitably experienced and qualified Engineer, which will substantiate that the development will not increase upstream or downstream flood levels to the detriment of any other property.

All works required by the flood study to offset the effects of development are to be completed as part of the current development.

In staged developments, all works required by the flood study to offset the effects of development, in a particular stage of the subdivision, are to be completed as part of that particular stage of development.

Permission of affected owners to allowing increased flood levels may be an alternative to flood mitigation works. Written confirmation of the acceptance of all adversely affected owners shall be provided as part of the study.

3) Where the ground level at the building site is below the design flood level the structure below floor level shall be certified by a suitably qualified and experienced engineer as being capable of withstanding the loads and conditions likely to be encountered under design flood conditions.

4) Freeboard requirements for floor levels above design flood level shall be as set out in this clause.

4.1) Where current flood information is available all structures shall be a minimum of 0.5 metres above the design flood.

4.2) Where only outdated flood information is available at the site. Either:

4.2.1) A flood study, in accordance with the latest council and State Government guidelines and policies, shall be undertaken to define the design flood levels for the site.

OR

4.2.2) Where Council is satisfied that the development will not affect flooding on other properties the floor levels of all structures shall be a minimum of 1.0 metres above the design flood.

4.3) Where no flood data is available at the site a flood assessment undertaken by a suitably qualified and experienced engineer shall be submitted prior to further consideration of development approval to assess likely restrictions on development.

4.3.1) Where the flood assessment indicates that the development will not impact on other properties then conditional development consent may be given with minimum floor levels.

4.3.2) Where the flood assessment indicates that the development will impact on other properties or developments, but these impacts can be offset by mitigation works or the owners of the affected properties give written permission to the increased flood levels then conditional development consent may be given requiring a flood study to be undertaken in accordance with Clause 2.

4.3.3) Where the flood assessment indicates that the development will impact on other properties and these impacts cannot be offset by mitigation works and the owners of all the affected properties will not give written permission to the increased flood levels by mitigation works then development consent will be refused.

5) Gully traps on all structures are to be a minimum of 0.3m above the design flood level and at least 0.15m below floor level.

6) Where a development has been protected from the design flood level by a levee bank and water is not able to pond behind a levee, structures on land protected behind the levee shall have a minimum floor level of 0.3 metres above the natural or finished ground level prior to excavation for building construction, at the highest point in the building envelope, whichever is higher.

However, where a suitable design is submitted that can demonstrate that flood waters that overtop the levee can be diverted past a structure then consideration will be given to a reduced floor level. No other property may be adversely affected by this work. A report by a suitably qualified and experienced engineer must be submitted prior to approval being given to a reduced floor level.

7) Where a development involves filling to raise the development above the design flood level, minimum floor levels shall apply to all structures placed within the development where the finished ground level is less than the required freeboard above the design flood level in accordance with Clause 4.

8) In each case where a minimum floor level is required a survey certificate shall be supplied by a registered surveyor. For buildings this shall be supplied prior to proceeding with construction

above floor level. For UMD's and rigid annexes which are being placed in an area identified as flood liable a survey certificate shall be provided within 7 days of set up on the site.

9) Additions to existing buildings are to be dealt with on a flexible "merits" based approach. This involves the following steps:-

a) Council setting a minimum floor level for the addition.

b) Where the applicant wants to vary this to suit the existing floor level then the applicant shall:-

i) Provide a survey certificate of the existing floor level

ii) Provide details of the reasons for the required floor level not being feasible.

c) Where Council determines that the required floor level is not feasible and the above information is submitted the owner may then build at, but not below, the floor level of the existing building.

10) For urban, rural/residential subdivisions, rural subdivisions, and community titles, each lot must have a house site having a minimum area of 400 square metres, with a minimum width of 15 metres, above the design flood level. A contour plan of the site showing surveyed finished ground levels to A.H.D. is to be provided, with limits of flooding shown.

Where enough area is not available without filling, filling may be allowed to create enough area if Clause E2 is also satisfied.

All filling shall be completed as part of the current development.

Access to the house site is to be designed and constructed to Council's Guidelines and be constructed as part of the development and its effects on flood levels considered as part of Clause E2.

11) In commercial and industrial subdivisions, the finished surface of the block shall be above the design flood level. If part of the subdivision is below this level then filling may be placed to satisfy this condition if the placement of this fill also satisfies Clause E2.

All filling shall be completed as part of the current development.

12) Developments involving the use of levees for protection of properties against flooding shall not be permitted unless the following requirements are met:-

a) It complies with Clause 2.

b) It can be shown that it is not feasible to fill to the design flood level.

c) The area behind the levee is free draining. Fill levels within the subdivision shall consider backwater flooding from the drainage outlet.

d) The effects of the Probable Maximum Flood on the development are to be assessed.

e) The top level of the levee is to be a minimum of 1.0 metre above the design flood levels adjacent to the levee.

f) The whole of the levee is to be outside the property boundaries, in a drainage reserve dedicated to Council. Vehicular access to the levee from a public road is to be provided.

13) If council considers it necessary a 'Flood Plan' will be required as part of the development. Flood Plans will generally be required where the site is affected by the 1% flood event and there is a risk to life and property.

14) For major developments and new subdivisions the possible impacts of climate change, including sea level rise and increased rainfall intensities, are to be considered. The assessment is to be undertaken in accordance with the latest Council and State Government Guidelines and Policies.

15) The Coffs Creek Floodplain Risk Management Study and Plan contain more detailed flood planning controls based around the flood risk mapping for Coffs Creek. Development in the Coffs Creek catchment is to comply with the flood planning controls in the study and plan. The principals and controls applied in Coffs Creek may be applied to other urban areas, where appropriate, in the Coffs Harbour local government area.

6.3 Development Control Plan

6.3.1 Coffs Harbour Development Control Plan 2013

A Development Control Plan (DCP) is prepared in accordance with Section 72 of the Environmental Planning and Assessment Act 1979 and Clauses 16 to 25 of Part 3 of the Environmental Planning and Assessment Regulation 2000. A DCP effectively complements an LEP by providing more detailed provisions with respect to development in particular areas, and is to be considered by Council in determining development applications.

The Coffs Harbour Development Control Plan was adopted on the 13th December 2012 and combines into one document various policies and guidelines affecting development proposals within the Coffs Harbour LGA.

6.3.2 Coffs Harbour Development Control Plan 2013 – Component D3 Flooding and Coastal Hazards

The Coffs Harbour Development Control Plan 2013 – Component D3 Flooding and Coastal Hazards is a DCP that relates directly to development within floodplains across the Coffs Harbour LGA.

The Coffs Harbour Development Control Plan 2013 – Component D3 Flooding and Coastal Hazards applies to whole of the LGA and was adopted on the 8th August 2013. The DCP does not contain specific details relating to development controls in relation to flood liable land and instead refers to the Coffs Harbour Floodplain and Development Management Policy.

6.3.3 Coffs Harbour Development Control Plan 2013 – Component E12 West Woolgoolga

The Coffs Harbour Development Control Plan 2013 – Component E12 West Woolgoolga is a DCP relating only to the West Woolgoolga area. The Plan was adopted on the 13th December 2012. The DCP contains no specific information relating to flooding.

6.3.4 Review of DCP

It is understood that Council is currently in the process of reviewing and updating the DCP. The format of the flood liable land related content in the updated DCP will be similar to that within the Coffs Harbour Floodplain Development and Management Policy.

It is expected that the updated DCP will contain more specific requirements related to different development types within the floodplain and once adopted will replace the function of the Coffs Harbour Floodplain Development and Management Policy for guiding the requirements of development within the floodplain.

7 Potential Options for Improving Flood Management

This chapter identifies options for improving flood management within Woolgoolga with respect to existing flood risks, future flood risks, and continuing flood risks. Measures which can be employed to mitigate flooding and reduce flood damages can be separated into three broad categories:

Flood modification measures: modify the flood's physical behaviour (depth, velocity) and includes flood mitigation dams, retarding basins, on-site detention, channel improvements, levees, floodways or catchment treatment.

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

Response modification measures: modify the community's response to flood hazard by informing flood-affected property owners about the nature of flooding so that they can make informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

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

7.1 Overview of Potential Options

7.1.1 Flood Modification Measures

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

- Excluding floodwaters from vulnerable locations (Table 7-1);
- Containing floodwaters to reduce flood peaks downstream (Table 7-2); and
- Enhancing conveyance efficiency or diverting floodwaters (Table 7-3).

7.1.2 Property Modification Measures

These measures are designed to reduce the potential risks to life and property by modifying individual properties. Property modification measures have been identified and considered based on whether the measures address existing development or future development, as outlined in Table 7-4 and Table 7-5, respectively.

Table 7-1 Flood Modification Measures to Exclude Floodwaters

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

Table 7-2 Flood Modification Measures to Contain Floodwaters

Containment of Floodwaters	Applicable to Woolgoolga?	Comments
Flood mitigation dam	✖	Large flood mitigation dams within the catchment are not viable on economic, social and environmental grounds.
Large detention / retardation basin	✓	Suited to controlling flooding in small catchments. There is limited opportunity for building large flood storage basins in the upper catchments.
On-site retention / detention	✓	Suited to controlling flooding in small catchments.
Increased floodplain storage	✖	Very limited areas of the natural floodplain have been removed in terms of the natural flood storage function

Table 7-3 Flood Modification Measures to Enhance Conveyance or Divert Floodwaters

Diversion of Floodwaters	Applicable to Woolgoolga?	Comments
Entrance channel dredging	✓	Potential increase in flow conveyance through a general deepening and widening of the channel. Likely to have only a limited impact on ocean flooding controlled by tailwater levels rather than bed levels
Permanent Entrance (e.g.	✓	Would relieve issues in regard to low-level

Diversion of Floodwaters	Applicable to Woolgoolga?	Comments
breakwater)		flooding from entrance closure. Viability questionable given very high cost in relation to benefits through flood level reduction.
Artificial Entrance Openings	✓	Continuation of existing entrance interventions with appropriate review of trigger levels and opening procedures.
Flow diversion	✓	Channel constructed to divert floodwaters away from impacted locations. Potential use within the smaller local catchments.
Stormwater drainage improvements	✓	Existing stormwater network alignments augmented to provide increased flow capacity or new drainage alignments constructed.
Bypass/Relief culvert	✖	Some suggestions for relief culvert to provide for Lake drainage. Ocean side outlet would be prone to blockage and rendered useless.
Removal of flow impediments in floodways and across floodplains (including development)	✖	There is little impediment to existing flood flows which are principally confined to the watercourses and overland flow paths.
Pump out of floodwaters	✓	In combination with a levee or dyke, any floodwaters behind the structure could be pumped out. The size of the pumps would need to be compatible with the expected ingress of floodwaters (pumps in New Orleans were completely overwhelmed by flow rates). Pumps are not fail-safe and may only delay inundation, thereby adding time for appropriate emergency response.

Table 7-4 Existing Development Property Modification Measures

Existing Development	Applicable to Woolgoolga?	Comments
Voluntary purchase	✓	Target high priority areas only. Can be a very costly option, and will reduce both risks to life and property.
House raising	✓	Applicable to some areas, but may have aesthetic issues. Need to ensure structural stability, and can be used to provide flood free refuge as well as reduce flood damages.
Flood proofing of buildings (walls, floors etc)	✓	Aimed at minimising damages to properties through modifications to buildings.
Raise electrical and fixed assets	✓	As per flood proofing. Aims to minimise damages if property is inundated. The level to which electrics is raised would need to consider the probability of the flood.
Temporarily relocate contents	✓	Raising valuable to as high as possible can be effective at limiting some damage, but dependent on having enough time to perform the relocation process.

Existing Development	Applicable to Woolgoolga?	Comments
Sand bags and drop-in boards	✓	Is manually intensive and requires ample warning time for installation.
Relocate suburb (e.g. Claymore, QLD), esp. in response to potential SLR	✓	Broad scale relocation of dwellings would be subject to having a suitable alternative location. With no such alternative and flood-free locations available, some areas may need to be abandoned if sea levels rise extensively.

Table 7-5 Future Development Property Modification Measures

Future Development	Applicable to Woolgoolga?	Comments
Zonings to restrict development in critical areas	✓	In particular, certain types of development are considered less suited to development within the floodplain, including developments that contain the elderly or infirm, or developments that are critical to the provision of emergency services.
Time-dependent zoning, for SLR for example, property removal on expiry	✓	Would need to consider triggers for response (e.g. sea level rise gets to x cm, or inundation frequency exceeds x times per year).
Development / building controls requiring flood-smart design and structural integrity	✓	Controls could require other mechanisms for minimising flood-related damages, especially in relation to building materials, electrics etc.
Property fill	✓	Limited amounts of fill could be used to help raise future development, providing that the development is not located within floodway or flood storage areas.
Adaptive construction - allow for future modifications	✓	Involves construction that will allow for future changes relatively easily in order to better adapt to changing flood conditions (eg progressive raising in response to SLR).

7.1.3 Response Modification Measures

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

Table 7-6 Pre-Flood Response Modification Measures

Existing Development	Applicable to Woolgoolga?	Comments
General education to understand flood risks the community is living with	✓	Key messages regarding what to do and what not to do if caught in a flood
Targeted education (property or	✓	Key messages regarding how to manage risks to life and risks to property at an individual property

Existing Development	Applicable to Woolgoolga?	Comments
neighbourhood specific) to understand specific risks to individuals		basis, including closest evacuation centres, where roads would likely be flooded, and measures that can be implemented to be better prepared.
Periodic updates given new residents and new data (including new events)	✓	As new residents move into communities and as complacency sets in on longer term residents, education is required on a periodic basis – constant updating and renewal.
Local flood plans and pre-planned evacuation arrangements	✓	Evacuation centres and emergency responses need to be set-up at very short notice, so pre-planning is required. Evacuation centres need to be flood free, and potentially cater for large numbers of affected people.
Disclosing information and sharing knowledge beyond experience (readily available, eg on internet)	✓	Available via S149 certificates, publicly available flood studies and flood plans. Property-scale flood information should be available via the internet.
Provision of flood free access to assist in the flood emergency response.	✓	Provision of flood free access to the Sunset Caravan Park. Flooding of Bultitude Street can currently make access difficult.

Table 7-7 During-Flood Response Modification Measures

Existing Development	Applicable to Woolgoolga?	Comments
Improved flood warning system, based on integrated rainfall and river level gauging, and real-time radar	✓	A total flood warning system can buy extra time for appropriate flood response, if the information can get to the community in time. The system needs to be locally specific and not generic. A system is very acceptable to the community, but can lead to a false sense of security.
Automated voice and text messaging for notification of flood warnings	✓	One possible method of disseminating flood warning information. Multiple methods would be required.
Multi-media bulletins for notification of flood warnings	✓	Urgency of disseminating flood warnings is critical to providing the community with as much preparation time as possible. This should extend to all radio and TV channels, not just local ABC.
Social media channels, such as twitter and facebook	✓	Much of the flood information that was distributed and accessed during the 2011 floods across Queensland, NSW, Victoria and WA was via social media (facebook, twitter) and internet sites. Emergency services set up direct feeds to these channels with latest updates and information. Community were able to supplement the information with first-hand knowledge (thus making sure the information was as current as possible).
flood markers indicating problem areas	✓	Flood markers indicate flood depths – historical and design possible flood events.

Table 7-8 Post-Flood Response Modification Measures

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

7.2 Options Assessment

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

7.2.1 Flood Modification

Four broad flood modification approaches are detailed:

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

7.2.1.1 Levee or Flood Wall

Description

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

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

Design

Any levee alignment will be required to tie into existing high ground to ensure no bypass of the levee system by floodwater. Two levee alignments have been considered for Woolgoolga, one protecting properties in Haines Close, and a second levee around the Sunset Caravan Park. The Haines Close alignment would tie into high ground of the ridge to the north. The Sunset Caravan

Park alignment would tie in into the Woolgoolga High School farm lands and higher ground at the end of Newman Street. The indicative levee alignments and protected areas are shown in Figure 7-1. A levee to protect low-lying properties on Wharf Street would not be feasible due to the significant catchment draining from the south into Jarrett Creek.

The number of existing properties within the nominal levee protection zones that have been identified at risk of above floor flooding summarised in Table 7-9.

Table 7-9 Existing Properties at Risk in Levee Protection Zones

Design Event	Haines Close	Sunset Caravan Park
20% AEP	0	96
5% AEP	2	119
2% AEP	5	125
1% AEP	11	133
0.2% AEP	12	152

The planning, design and construction effort and cost involved in implementing a levee protection system is a substantial investment. In order to maximise the benefit of this investment in terms of reducing flood risk, it is assumed a minimum levee design standard would be at the existing 1% AEP flood level plus an appropriate freeboard allowance (say 0.5m). This would require the construction of the levees to a height of around 3.5 to 4.5m AHD.

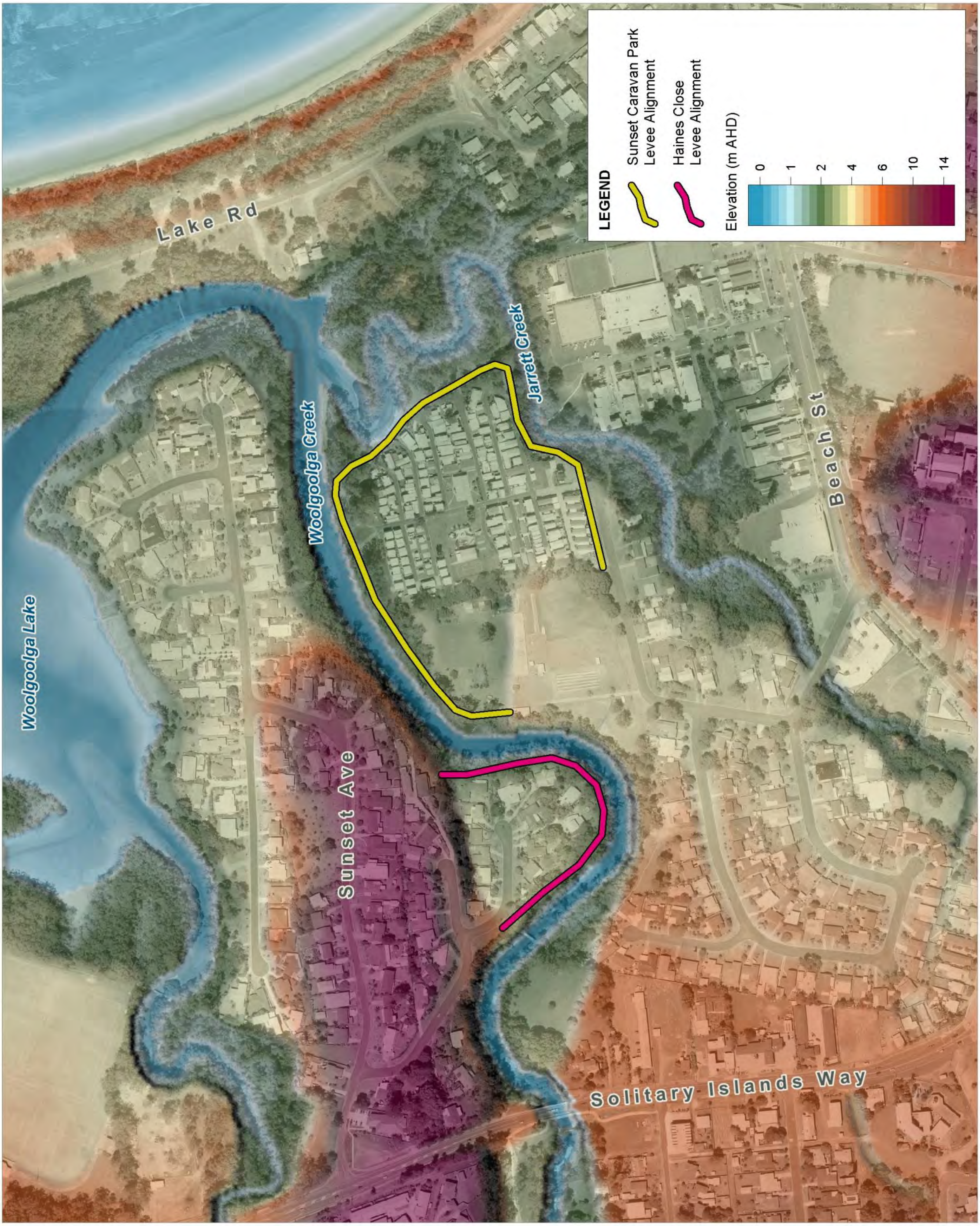
The existing level of the foreshore around the indicative levee alignments is in the order of 1.5 to 2.0m AHD. Accordingly, levees constructed to 3.5 to 4.5mAHD provides for a marked change to the foreshore landscape. An earthen levee construction typically would have a minimum 1 to 2m top width (greater if vehicular access was required) and sloping side batters (e.g. 1:4 vertical: horizontal). Just the space therefore required to construct an earthen levee represents a substantial footprint and land take area. Given in some places the limited width of public space on the foreshore, current private land would be required to construct the levee. The footprint for a wall type construction would be considerably less, but may still require some private land take.

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

Performance

Assuming the integrity of the levees is sustained, the levees would be effective in eliminating flood damage to protected properties for events up to the nominal design height. Based on the number of properties protected (refer Table 7-9) the reduction in property flood damages afforded by the levee system in summarised in Table 7-10. The damages calculations assume flood protection up the existing 1% AEP + 0.5m level.

Attachment



Title:
Potential Levee Alignments

Figure: **7-1**

Rev: **A**

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Table 7-10 Reduction in Flood Damages for Levee Option

Design Event	Haines Close	Sunset Caravan Park
20% AEP	$ -	$160,000
5% AEP	$74,000	$680,000
2% AEP	$269,000	$1,020,000
1% AEP	$662,000	$1,330,000
0.2% AEP	$858,000	$2,360,000
Average Annual Damage	$24,000	$149,000

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

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

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

Economic Viability

Levees represent a substantial capital cost. The estimated cost of an earthen levee construction incorporating both the Haines Close and Sunset Caravan Park alignments (approximately 1.1km in length) represents a cost of the order of $2M. A levee system also requires regular inspections for erosion/failure and maintenance for vegetated banks.

Substantial additional capital cost can also be incurred through acquisition of property to construct the levee. This may be required where there is little buffer between the property boundaries and the foreshore/waterway. Dependent on the alignment and construction technique, acquisition of part or full property would be required. The cost of acquisition could be in excess of the levee construction cost.

With reference to the reductions in flood damages afforded by the levee system (under existing flood conditions), the benefit-cost comparison would indicate some feasibility to the levee construction around Sunset Caravan Park but not for Haines Close. With sea-level rise however, there would be a diminishing return as average annual damages increase.

When assessing the performance of a levee scheme over a standard 50 year life span, the reduction in damages must be reduced to a net present day value. When adopting a discount rate of 7% this gives a benefit-cost ration (BCR) of 1.19, or between 0.78 and 1.86 when adopting a discount rate of 11% or 4% respectively.

Pros and Cons

A summary of the expected pros and cons relating to the concept proposed is provided in Table 7-11. These issues would need to be investigated to quantify their impact, as part of a detailed design and environmental impact assessment.

Table 7-11 Pros and Cons for Woolgoolga Levee Concept

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

7.2.1.2 Flood Detention

Description

Flood detention is the provision of flood storage to detain floodwaters upstream of the flood affected location. This typically involves the creation of a basin to store flood waters, with an outlet control structure to limit the downstream flow rates. The outlet capacity is much smaller than the flood flows generated by the upstream catchment runoff. This builds up the flood level within the basin, using up the available storage capacity. A high level outlet structure is also provided to accommodate floods above and beyond the design capacity of the detention basin.

Detention basins are an effective means of reducing flood risk downstream. However, they inherently increase flood levels upstream of the basin outlet and can therefore potentially impact on properties adjacent to the detention basin.

Design

The provision of flood detention requires the availability of land in which to store flood waters. A suitable location in Woolgoolga has been identified for potential flood detention. This is an existing wetland situated at the eastern end of Trafalgar Street. It covers an area of around 4ha and has a contributing catchment of some 30ha. The alignment of Trafalgar Street provides an existing bund with a crest elevation of around 5.1m AHD, behind which approximately 18ML of storage volume is available. There is an existing outlet pipe of 750mm diameter that connects the wetland to the stormwater drainage network.

By raising the bund above the existing level of 5.1m AHD, additional upstream flood storage can be provided. This has implications for the few properties adjacent to the western side of the wetland. Table 7-12 shows the existing peak flood levels within the wetland for the 2-hour design storm duration (which is the critical flood condition for the downstream properties). The peak flood levels with a bund height detaining all of the storm runoff are also presented. It can be seen that a bund height of the 1% AEP level +0.5m freeboard is around 5.9m AHD. At this level the wetland would detain flows up to and including the 0.2% AEP flood. This would provide for an additional 40ML of flood storage, totalling some 60ML The outlet structure would remain unaltered from the existing configuration.

The increased flood detention storage would provide for a reduction in the frequency and depth of flood inundation for the properties situated between the wetland bund and Carrington Street. An increase in peak flood levels on the few lots to the west of the wetland would be experienced. However, the increased flood levels would not impact above floor flooding as the floor levels are situated above 6m AHD. There may be some increase in flooding to the affected lots but this could be offset through the provision of additional local bunding.

Table 7-12 Peak Flood Levels (m AHD) within the Trafalgar Street Wetland

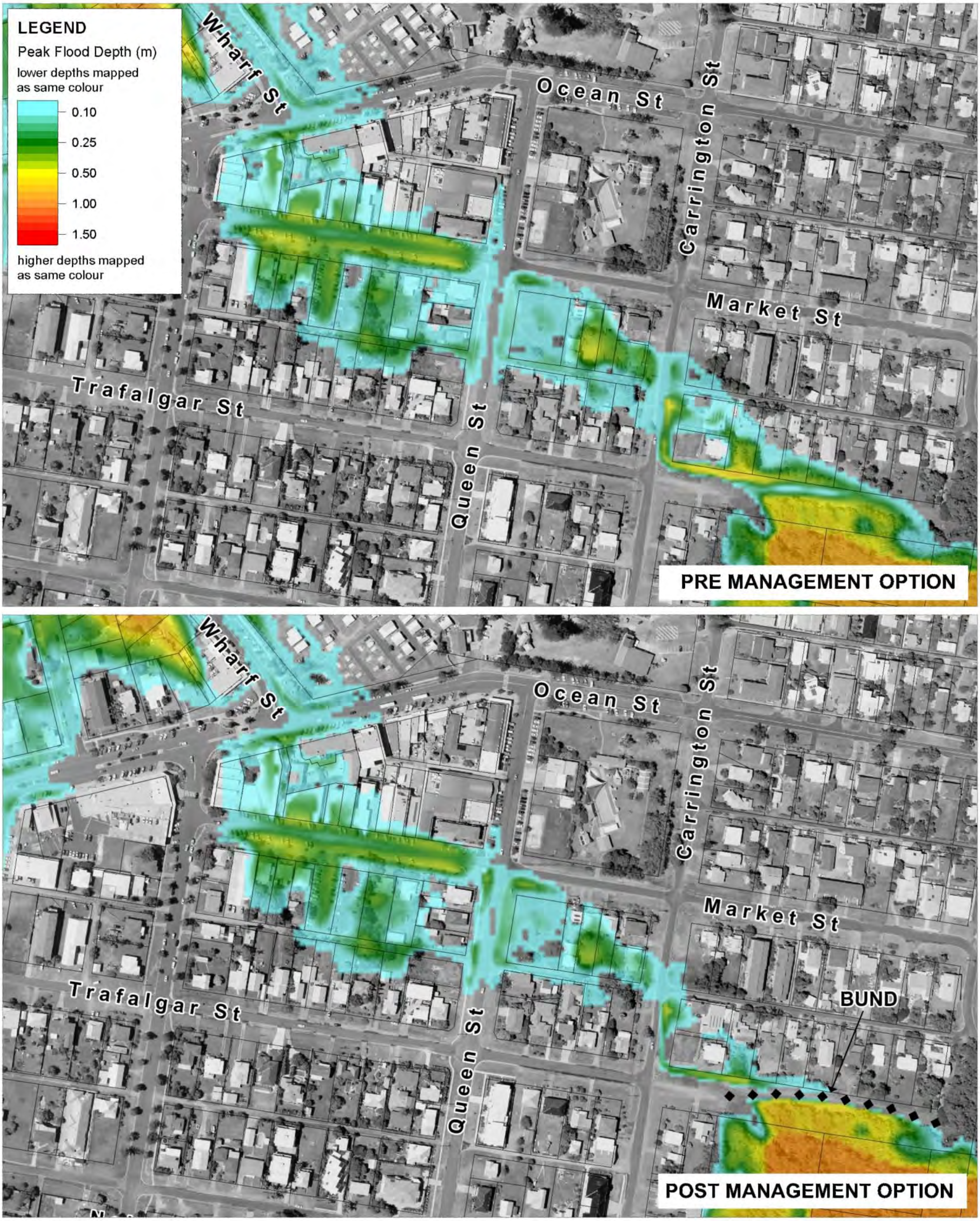
Design Event	Existing	Flood Detention
20% AEP 2-hour	5.11	5.11
5% AEP 2-hour	5.22	5.26
2% AEP 2-hour	5.27	5.36
1% AEP 2-hour	5.31	5.44
0.2% AEP 2-hour	5.39	5.62

Performance

The TUFLOW model was simulated with the increased bund height to determine the reduction in downstream flood conditions. This was found to be in the order of up to 0.3m, as presented in Table 7-13. The actual flood levels vary spatially, but the presented numbers give an indicative representation of the reduction in peak flood levels. Reductions in flood damages are presented in Table 7-14. The change in modelled flood extents and depths for the 1% AEP event is presented in Figure 7-2.

Table 7-13 Peak Flood Levels (m AHD) Downstream of the Trafalgar Street Wetland

Design Event	Existing	Flood Detention
20% AEP 2-hour	4.89	4.89
5% AEP 2-hour	5.07	4.95
2% AEP 2-hour	5.18	4.98
1% AEP 2-hour	5.24	4.99
0.2% AEP 2-hour	5.34	5.05



Title:

Impact of Trafalgar Street Detention on the 1% AEP Flood

Figure: 7-2

Rev: A

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Table 7-14 Reduction in Flood Damages for Trafalgar Street Detention

Design Event	Flood Damage Reduction
20% AEP	$1,000
5% AEP	$4,000
2% AEP	$4,000
1% AEP	$16,000
0.2% AEP	$16,000
Average Annual Damage	$1,000

Economic Viability

The properties situated to the east of Carrington Street are elevated above the design flood levels and so the reduction in flood damages associated with the flood detention are quite modest, as presented in Table 7-14. The cost of raising the bund level is likely to be in the order of $50k to $100k.

When assessing the performance of the scheme over a standard 50 year life span, the reduction in damages must be reduced to a net present day value. When adopting a discount rate of 7% this gives a benefit-cost ration (BCR) of 0.18, or between 0.12 and 0.29 when adopting a discount rate of 11% or 4% respectively.

Pros and Cons

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

Table 7-15 Pros and Cons for Trafalgar Street Detention

Pros	Cons
Relatively low construction and maintenance costs	Low benefit cost ratio
Some level of flood damage reduction	Impact on adjacent properties to the west

7.2.1.3 Permanent Entrance Opening

Description

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

At Woolgoolga Lake, the entrance channel is highly dynamic. The entrance at Woolgoolga Lake tends towards closure during periods with relatively low rainfall, and following relatively larger, longer period waves. The entrance is afforded some protection from ocean waves, being protected to some extent from the dominant south to south easterly incoming waves which prevail along the New South Wales coast.

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

Design

The design of training breakwaters needs to take into account the local wave climate and the depth to which the breakwaters have to be extended for the entrance to remain clear of sand. In aligning the breakwaters the natural direction of flows exiting the Lake during flood conditions also needs to be considered in an attempt to reduce significant impacts on the passage of major floods. Dune stabilisation works and beach nourishment may also be required alongside the constructed breakwaters. Regardless of the actual design, any constructed permanent entrance opening would involve a large scale construction and associated capital cost of works.

Performance

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

The flood models have been used to assess the potential change in flooding behaviour with the construction of an open entrance, as shown in Table 6 12. The adopted design conditions and those adopted for the estimation of flood damages have been considered. The levels reference the location of the existing gauge in Woolgoolga Lake.

It shows that a permanent open entrance would reduce peak flood levels within the Lake by the order of 0.5m to 0.6m, when compared to a closed entrance condition. Peak flood levels under more typical entrance conditions would be reduced by around 0.4m.

Table 7-16 Peak Flood Levels (m AHD) in Woolgoolga Lake

Design Event	Existing "Worst Case"[1]	Open Entrance "Worst Case"[2]	Existing "Best Estimate"[3]	Open Entrance "Best Estimate"[2]
20% AEP[i]	2.55	2.00	2.10	1.70
5% AEP[i]	2.70	2.10	2.25	1.85
2% AEP[i]	2.80	2.15	2.35	1.95
1% AEP[ii]	2.90	2.40	2.45	2.05
0.2% AEP[iii]	3.10	2.70	2.50	2.10

Notes: 1 – Incorporates an entrance berm level of 1.5m AHD.

2 – Incorporates an entrance berm level of 0.0m AHD.

3 – Incorporates an entrance berm level of 1.0m AHD.

i – Incorporates a design ocean level of 1.85m AHD.

ii – Incorporates a design ocean level of 2.1m AHD.

iii – Incorporates a design ocean level of 2.4m AHD.

The reductions in flood levels for the "best estimate" scenario have been used to estimate the likely reduction in flood damages, as presented in When assessing the performance of the scheme over a standard 50 year life span, the reduction in damages must be reduced to a net present day value. When adopting a discount rate of 7% this gives a benefit-cost ration (BCR) of 0.17, or between 0.11 and 0.26 when adopting a discount rate of 11% or 4% respectively.

Table 7-17.

Economic Viability

Breakwaters represent a substantial capital cost, which would most likely be in excess of $10M.

When assessing the performance of the scheme over a standard 50 year life span, the reduction in damages must be reduced to a net present day value. When adopting a discount rate of 7% this gives a benefit-cost ration (BCR) of 0.17, or between 0.11 and 0.26 when adopting a discount rate of 11% or 4% respectively.

Table 7-17 Reduction in Flood Damages for Permanent Entrance Opening

Design Event	Flood Damage Reduction
20% AEP	$44,000
5% AEP	$738,000
2% AEP	$1,288,000
1% AEP	$1,498,000
0.2% AEP	$1,290,000
Average Annual Damage	$122,000

Pros and Cons

A summary of the expected pros and cons relating to the breakwater concept proposed is provided as Table 7-18. These issues would need to be investigated to quantify their impact, as part of a detailed design and environmental impact assessment.

Table 7-18 Pros and Cons for Woolgoolga Lake Breakwater Concept

Pros	Cons
Reduction in ongoing entrance management effort and costs	Very Costly;
Enhanced tidal flushing and potential improvements to water quality	Forced alignment may affect the efficiency of extreme floods. Could exacerbate flooding from the most extreme events;
Reduction in nuisance flooding prior to managed opening, during times when the entrance would have otherwise closed	May increase inundation during extreme surge events;

	Increased tidal transmission may increase nuisance flooding due to normal astronomical (e.g. King) tides; Will alter tidal characteristics related to foreshore habitats inside the entrance of the Lake Uncertainty regarding the presence, or otherwise of rock at the entrance. May require construction of an internal wave trap, to minimise exposure of internal shoreline to erosion. Would reduce typical water levels within the lake and may therefore impact on the recreational use and amenity.

7.2.1.4 Flow Diversion

Description

Flow diversion measures are more readily implemented in small catchments. The design of the diversion measures may include channel works, the construction of bunds or culverts. The function of the works is to divert flood waters around or away from the flood affected location. This may involve the diversion of catchment runoff into a neighbouring catchment.

Constraints on the ability to divert flood waters include the surrounding topography. If the diversion must traverse an area much higher than the water surface then the scale of works required is likely to be cost prohibitive. Consideration also needs to be given to the location receiving the diverted flood waters, as the diversion could potentially increase flooding elsewhere.

Design

There is a location within Woolgoolga with the potential for flood flow diversion. To the west of the Solitary Islands Way there is a small 12ha catchment that drains behind the properties on Smith Street. Catchment runoff is currently discharged into the stormwater drainage network under the Solitary Islands Way. During major flood events the available drainage capacity is exceeded and flooding occurs along Solitary Islands Way and Turon Parade. The nature of the flooding is not particularly hazardous or damaging, but it is extensive.

There is potential to divert the catchment runoff away from its current discharge point and into Woolgoolga Creek. This can be undertaken upstream of Moore Street, where there is currently a culvert draining under the road. Through construction of a drainage channel and/or culverts the catchment can instead be discharged west along the southern side of Moore Street.

The drainage channel construction considered is at an invert level of 6m AHD, which is approximately 2.5m deep, as presented in Figure 7-3. The minimum length of channel required is around 180m and includes the provision of a twin 1200mm RCP culvert under an existing property access. The channel would discharge into the Woolgoolga Creek floodplain and would flow through the properties to the north before reaching Woolgoolga Creek. In order to discharge directly to Woolgoolga Creek an additional 75m channel length would be required. Depending on arrangements with the land owners and the available land area a different channel configuration or more extensive culverted sections may be required.

Performance

The TUFLOW model was simulated with the diversion works incorporated. This was found to eliminate the extensive flooding of properties along Solitary Islands Way and Turon Parade for events up to and including the 1% AEP, as presented in Figure 7-4.

The peak flood conditions in Woolgoolga Creek are not increased due to the difference in the relative timings of the catchment flood response. The local catchment being diverted is much smaller and so the flood is largely discharged to Woolgoolga Creek before the flood wave arrives from the Woolgoolga Creek catchment. The local catchment flows are also small in comparison to those of Woolgoolga Creek.

In the 1% AEP 2-hour event (critical duration for the local catchment) the peak flow from the local catchment diversion is under $5m^3/s$ and occurs around 45 mins after the onset of rainfall. The peak flow in Woolgoolga Creek is around $50m^3/s$ and occurs almost an hour later. The addition of the diverted flows increases the Woolgoolga Creek flood peak by around 2%. The difference between the flood peak timings and magnitudes is greater for the 6-hour duration storm, which is the critical condition for Woolgoolga Creek, reducing peak the peak flow increase in Woolgoolga Creek to less than 1%.

The reduction in flood damages associated with the flow diversion is presented in Table 7-19.

Table 7-19 Reduction in Flood Damages for Moore Street Diversion

Design Event	Flood Damage Reduction
20% AEP	$10,000
5% AEP	$16,000
2% AEP	$18,000
1% AEP	$103,000
0.2% AEP	$262,000
Average Annual Damage	$6,000

Economic Viability

Although the flooding along the Solitary Islands Way and Turon Parade is extensive, the depths are generally shallow and so flood damages are also relatively low.

The cost of constructing the flow diversion would vary depending on and required land acquisition and the length of culverts required. Cost estimates indicate that with only a 10m culvert length the scheme might require in the order of $260k, increasing to around $650k if culverting the 180m length. Extending the diversion works by 75m to Woolgoolga Creek would increase these cost estimates by around 40%. The estimates are for construction only and do not include any land acquisition.

When assessing the performance of the scheme over a standard 50 year life span, the reduction in damages must be reduced to a net present day value. When adopting a discount rate of 7% this gives a benefit-cost ration (BCR) of 0.32 when assuming a cost of $260k, or between 0.21 and 0.50 when adopting a discount rate of 11% or 4% respectively.

It should be noted that costs for this option could be reduced if tied in with future possible residential development (if any) of adjoining land by property owners.

7.2.1.5 Stormwater Drainage Improvements

Description

Stormwater drainage improvements involve increasing the capacity of the stormwater pipe network to convey flood flows, reducing the amount of overland flooding. The most effective way to achieve this is to increase the size and/or number of stormwater pipes along the affected alignments.

However, this is achieved through significant capital cost. There is also the residual risk associated with stormwater pipe and/or inlet blockages that can reduce the effective capacity of the network during a flood event. Often the stormwater drainage infrastructure is designed to around a 20% AEP capacity, with flows up to the 1% AEP capacity being conveyed within the roadway. However, in locations with poorly aligned roads the provision of higher pipe drainage capacities may be viable.

Design

The location in Woolgoolga in which the improvement of stormwater drainage alignments is potentially viable is within the 9ha catchment draining to Market Street. Catchment runoff is currently intercepted by stormwater drainage along Trafalgar Street and Trafalgar Lane and diverted to the trunk drainage alignment along Queen Street. However, when the capacity of the existing drainage on Trafalgar Street and Trafalgar Lane is exceeded, excess runoff flows overland into the topographic depression on Market Street to the north. Flooding here has the potential to flood the commercial properties.

There is the potential to augment the existing drainage capacity along Trafalgar Road to divert all of the upstream catchment runoff into the Queen Street stormwater drainage. This can be undertaken through the provision of increased stormwater pipe drainage and/or increasing the capacity of the roadway to convey excess flows.

The option considered in the modelling has been the construction of a bund to retain excess runoff in the roadway. This involves a 250m length of bund constructed in the road reserve of Trafalgar Street and Queen Street. The bund would need to be 0.3m high, or around 0.1m above the crest of the road. However, the design is complicated by the need to raise the level of the Market Street and Queen Street intersection, in order to retain water within the Queen Street alignment and prevent spilling into Market Street.

Attachment

Title:
Moore Street Drainage Diversion Concept

Figure: 7-3

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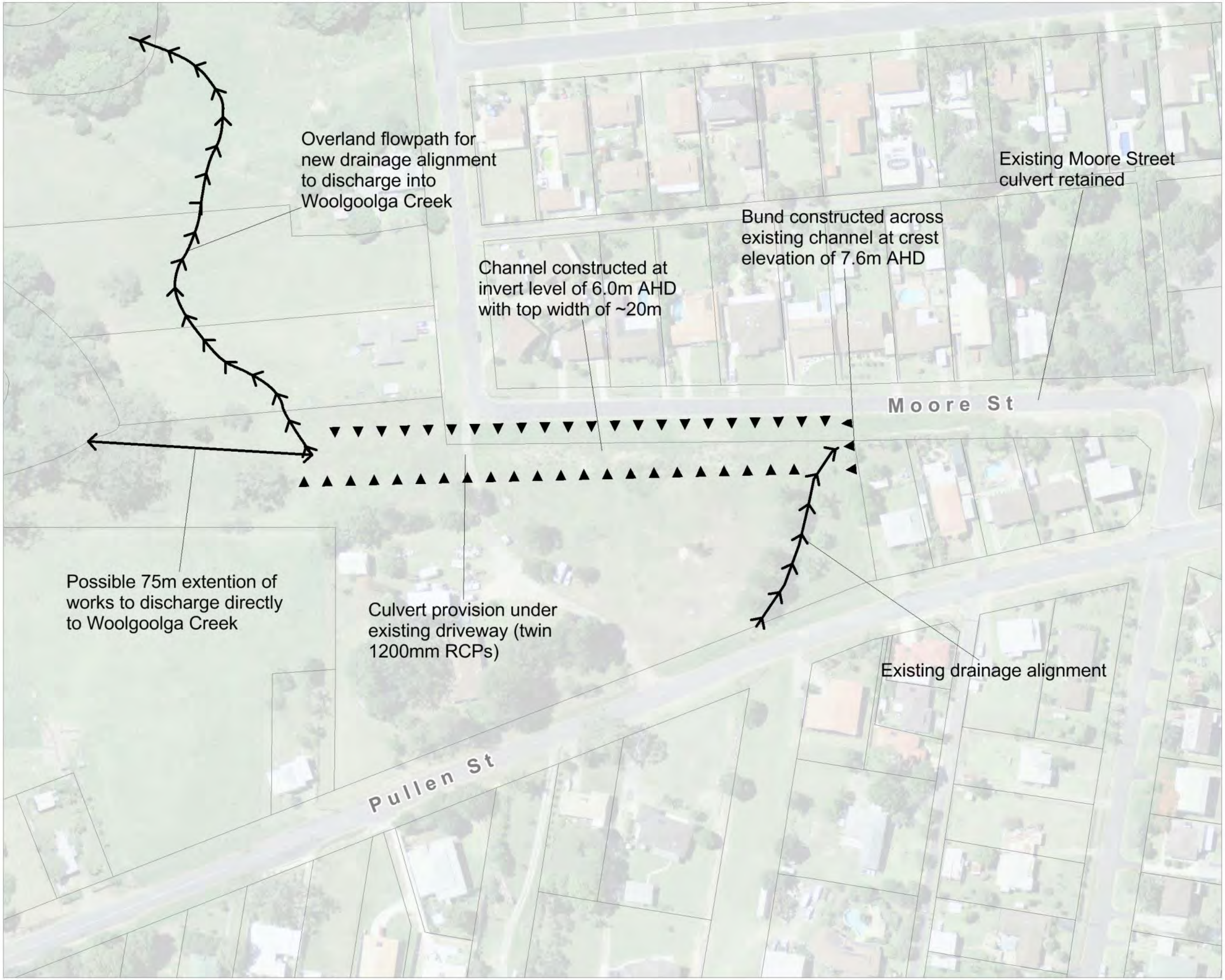

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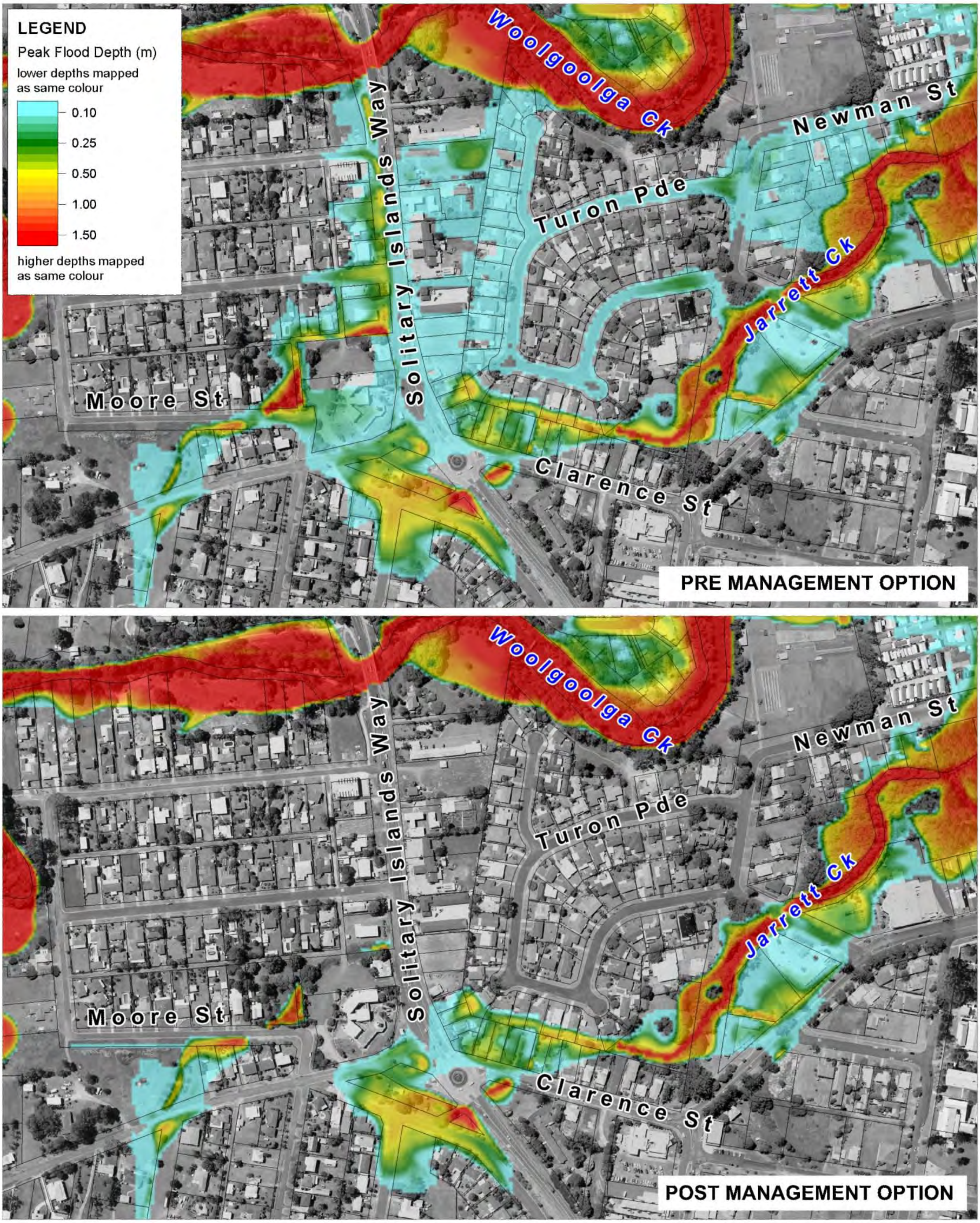

Title:

Impact of Moore Street Drainage Diversion on the 1% AEP Flood

Figure: 7-4

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Performance

The TUFLOW model was simulated to include the bund and associated catchment runoff diversion. The results show that the retention of catchment runoff upstream of Trafalgar Street within the Queen Street drainage alignment provides for some reduction of flood levels within Market Street, as presented Figure 7-5. However, the flooding problem is not eliminated as catchment runoff downstream of Trafalgar Street still exceeds the available drainage capacity along Trafalgar Lane.

The economic benefits of such a scheme are limited due to the relatively low level of existing flood damages. The reduction in flood damages achieved through the works is presented in Table 7-20.

Economic Viability

The cost of constructing the bund, including driveway improvements is estimated to cost around $150k. However, local road raising works at the Market Street and Queen Street intersection would cost a similar amount, bring the total cost to around $300k.

When assessing the performance of the scheme over a standard 50 year life span, the reduction in damages must be reduced to a net present day value. When adopting a discount rate of 7% this gives a benefit-cost ration (BCR) of 0.41, or between 0.27 and 0.64 when adopting a discount rate of 11% or 4% respectively.

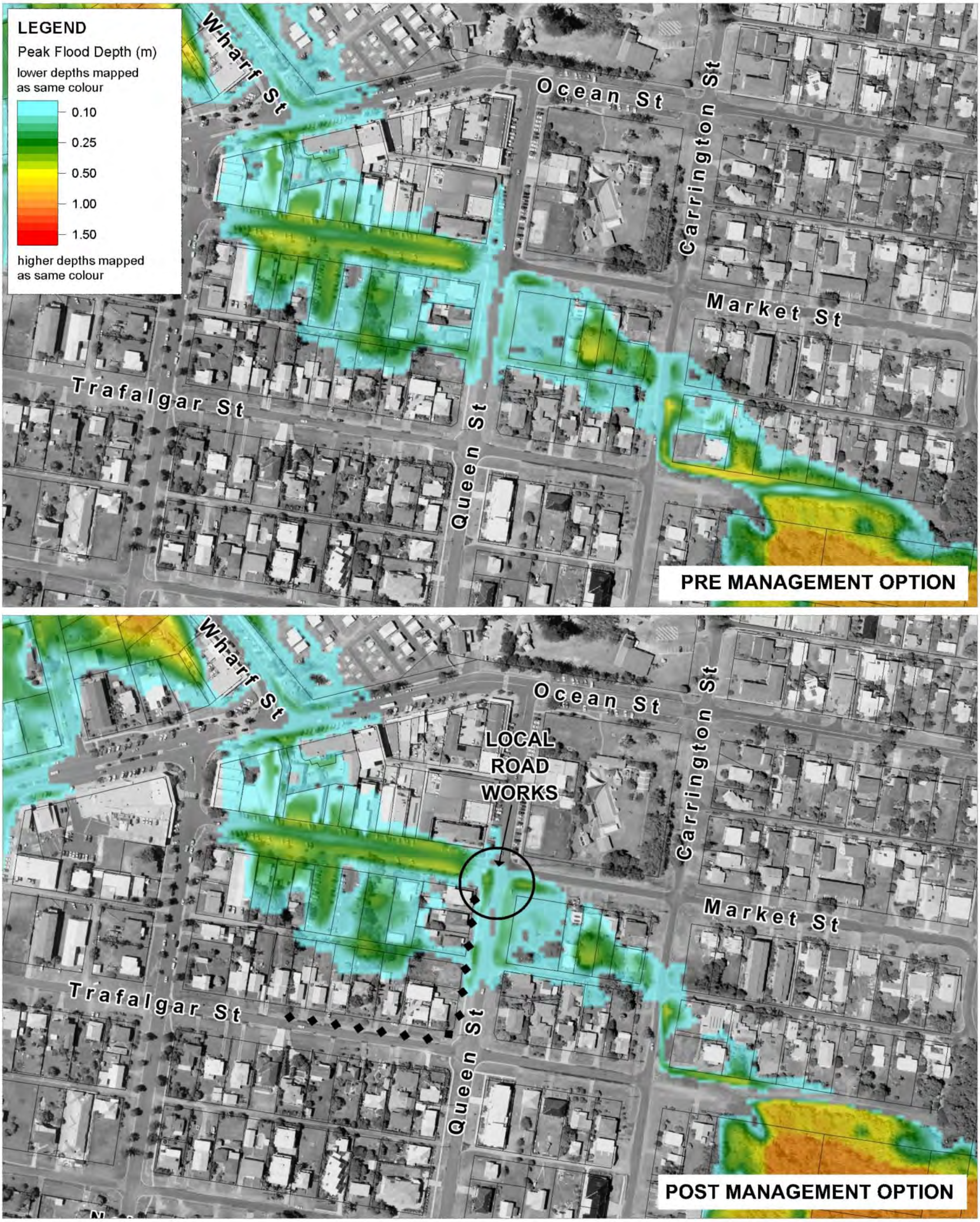
Similar or better results can be achieved through the provision of substantial drainage pipes and inlets along Trafalgar Lane that convey the majority of upstream catchment runoff into the Queen Street alignment. However, this would constitute around a 150m length of pipe upgrade and could cost significantly more than the Trafalgar Street option.

Table 7-20 Reduction in Flood Damages for Trafalgar Street Drainage Improvement

Design Event	Flood Damage Reduction
20% AEP	$1,000
5% AEP	$63,000
2% AEP	$49,000
1% AEP	$46,000
0.2% AEP	$288,000
Average Annual Damage	$9,000

The economic justification for a stormwater drainage improvement scheme to reduce flooding in Market Street is marginal. However, the modelling tests have shown that there is sufficient capacity within the Queen Street trunk drainage. It may therefore be worthwhile considering providing additional drainage capacity along Trafalgar Street and Trafalgar Lane as part of any other scheduled works, such as the provision of kerb and gutter along Trafalgar Street.

Attachment



Title:

Impact of Trafalgar Street Drainage Improvement on the 1% AEP Flood

Figure: 7-5

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It is understood that a strategic plan for Woolgoolga Town Centre is currently being developed. If any physical works are recommended to be undertaken as part of this plan then this may provide an opportunity to provide some additional benefit to the flooding conditions on Market Street. This potential should be discussed as and when it arises, but in principal even minor increases to property entrance levels and minor reductions in the levels of access routes between properties on the northern side of Market Street will assist in reducing the current level of flood damages.

7.2.2 Property Modification

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

7.2.2.1 Voluntary House Purchase

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

Residential properties (excluding those situated within the caravan parks) which may be suitable for VHP have the highest hydraulic hazard in the study area. The following potential criteria (see Table 7-21) were compared for identifying high risk properties. These were based on hydraulic criteria in the 1% AEP event for properties with above floor flooding.

Table 7-21 Assessment of Property Numbers for VHP

Potential Criteria	Number of Properties
High hydraulic hazard	7
Floodways (VxD > 0.3)	0

Depth of flooding is the principal characteristic defining the high hazard status for the identified properties, with a depth of flooding in excess of 1m. For non-brick buildings alternative flood modification options such as house raising would be considered more appropriate and generally suitable for the type of construction.

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

7.2.2.2 Voluntary House Raising

Voluntary house raising is aimed at reducing the flood damage to houses by raising the habitable floor level of individual buildings above an acceptable design standard (e.g. 1% AEP Flood Level

+0.5m). Voluntary house raising generally only provides a benefit in terms of reduced economic damages but does not eliminate the risk. Larger floods than the design flood (used to establish minimum floor level) will still provide building damages and the option does not address personal safety aspects. These risks are still present as the property and surrounds are subject to inundation and therefore the flood access and emergency response opportunity is still compromised.

House raising does have limited application in that it is not suited to all building types. Typically house raising is suited to most non-brick (e.g. clad, timbered framed houses) single story houses constructed on piers and not for slab on ground construction. An indicative cost to raise a house is of the order of $75,000 which can vary considerably depending on the type and size of the structure. Eligibility criteria for house raising schemes vary around the country, but funding is available for house raising in NSW and has been widely applied.

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

Potential eligible properties for such a scheme in Woolgoolga are identified based on above floor flooding over a range of flood event magnitudes as summarised in Table 7-22. Property numbers have been restricted to timber framed houses on piers (not slab on ground constructions), as identified from the property survey data. The numbers do not include dwellings situated within the Caravan Parks.

Table 7-22 Assessment of Property Numbers for House Raising

Design Event	Number of Properties
20% AEP	0 (0 to 5)
5% AEP	1 (0 to 6)
2% AEP	5 (2 to 9)
1% AEP	7 (2 to 11)

Note – the numbers in parentheses indicate the range between the "best case" and "worst case" scenarios, compared to the "best estimate"

For the purposes of evaluating the economic viability of such a scheme, it was assumed that eligible houses would have their floor levels raised to 0.5m above the 1% AEP flood level and a mean property raising price would be $50,000.

Raising houses flooded at the existing 1% AEP flood level would account for seven properties at a cost of some $350k. The reduction in average annual flood damages is in the order of some $24,500.

When assessing the performance of the scheme over a standard 50 year life span, the reduction in damages must be reduced to a net present day value. When adopting a discount rate of 7% this gives a benefit-cost ration (BCR) of 0.97, or between 0.63 and 1.50 when adopting a discount rate of 11% or 4% respectively.

Notwithstanding, it must be recognised that:

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

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

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

OEH provides financial assistance for land owners willing to participate in a voluntary house raising scheme. This is provided at an estimated cost of $50,000 per property, with the state government providing a 2:1 funding ratio. This is usually reliant on a feasibility study following the FRMS&P to determine the technical feasibility of and assist with the prioritising of house raising. Individual Councils may typically raise one to two houses per year.

7.2.2.3 Flood Resistance / Flood-proofing

Flood proofing refers to the design and construction of buildings with appropriate materials (i.e. material able to withstand inundation, debris and buoyancy forces) so that damage to both the building and its contents is minimised should the building be inundated during a flood. Flood proofing can be undertaken for new buildings or be retrofitted to existing buildings; however flood proofing is generally more effectively achieved during construction with appropriate selection of materials and design. Generally these works would be undertaken on a property by property basis at no cost to Council.

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

Council’s Development Control Plan already includes requirements for the use of flood compatible building components for new development in the floodplain. However, there are a number of non-structural options that can be retrofit to existing property to help reduce flood damage including changes to joinery and fittings, floor coverings and electrical services.

The commercial centre along Market Street would be an ideal location for the flood-proofing of properties. There are a number of available flood barrier technologies including permanent fixtures such as automatic 'flip up' flood barriers as shown in Figure 7-6; or temporary fixtures that can be installed in less than 5 minutes in the event of a flood such as the Floodgate technology shown in Figure 7-7.

Whilst flood proofing may limit the damage to the building and its contents, the occupant (particularly in the case of commercial property) may still suffer from the social and economic disruption of flooding such as the closure of businesses and lack of access during and after flood events. Flood barriers are easy to install at a relatively low cost and would be a recommended measure for properties that experience above floor flooding.

The installation of such measures may cost in the order of $5,000 per property. It is difficult to compare directly with the major capital works, but for comparative purposes, if applied to the three properties flooded at the 1% AEP event then over a 50 year period when adopting a discount rate of 7% this gives a benefit-cost ration (BCR) of 3.68, or between 2.41 and 5.73 when adopting a discount rate of 11% or 4% respectively.

7.2.2.4 Planning and Development Controls

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within the study area. Such mechanisms will influence future development (and redevelopment) and therefore the benefits will accrue gradually over time. Without comprehensive floodplain planning, existing problems may be exacerbated and opportunities to reduce flood risks may be lost.

As discussed in Section 6, Council currently has a number of land use planning and development controls in place to manage flood-affected areas within the Coffs Harbour LGA.

Flood Planning Levels (FPLs) are used for planning purposes, and directly determine the extent of the Flood Planning Area (FPA), which is the area of land subject to flood-related development controls. The FPL is the level below which a Council places restrictions on development due to the hazard of flooding. Traditional floodplain planning has relied almost entirely on the definition of a singular FPL, which has usually been based on the 100 year ARI flood level for the purposes of applying floor level controls.

Adoption of a single FPL can provide for:

- unnecessary restriction of some land uses from occurring below the FPL, while allowing other inappropriate land uses to occur immediately above the FPL; and lack of recognition of the significant flood hazard that may exist above the FPL (and as a result, there are very few measures in place to manage the consequences of flooding above the FPL).

Figure 7-6 Permanent Automatic 'Flip up' Flood Barrier (source: http://www.spec-net.com.au/press/0212/flo_150212.htm)

Figure 7-7 Temporary Floodgate Flood Barrier (source: http://www.hydroresponse.com/floodgate.htm)

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

The recommended flood planning area (i.e. area under the recommended FPLs) is presented in Figure 7-8 and should be adopted within Council's Policy. The flood planning areas for the 2050 and 2100 flood planning horizons should also be considered for adoption.

Under the standard LEP template developed by the State Government there are restrictions on using flood events other than the 100 year event. There are also restrictions on the application of Climate Change (sea level rise) in planning considerations.

It is recommended that detailed assessment of possible alternatives to Council controls be considered in the future within the bounds of State legislation.

It is recommended that detailed assessment of possible alternatives to Councils flood policy be made prior to update of the DCP to facilitate appropriate flood mitigation controls.

7.2.3 Response Modification

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

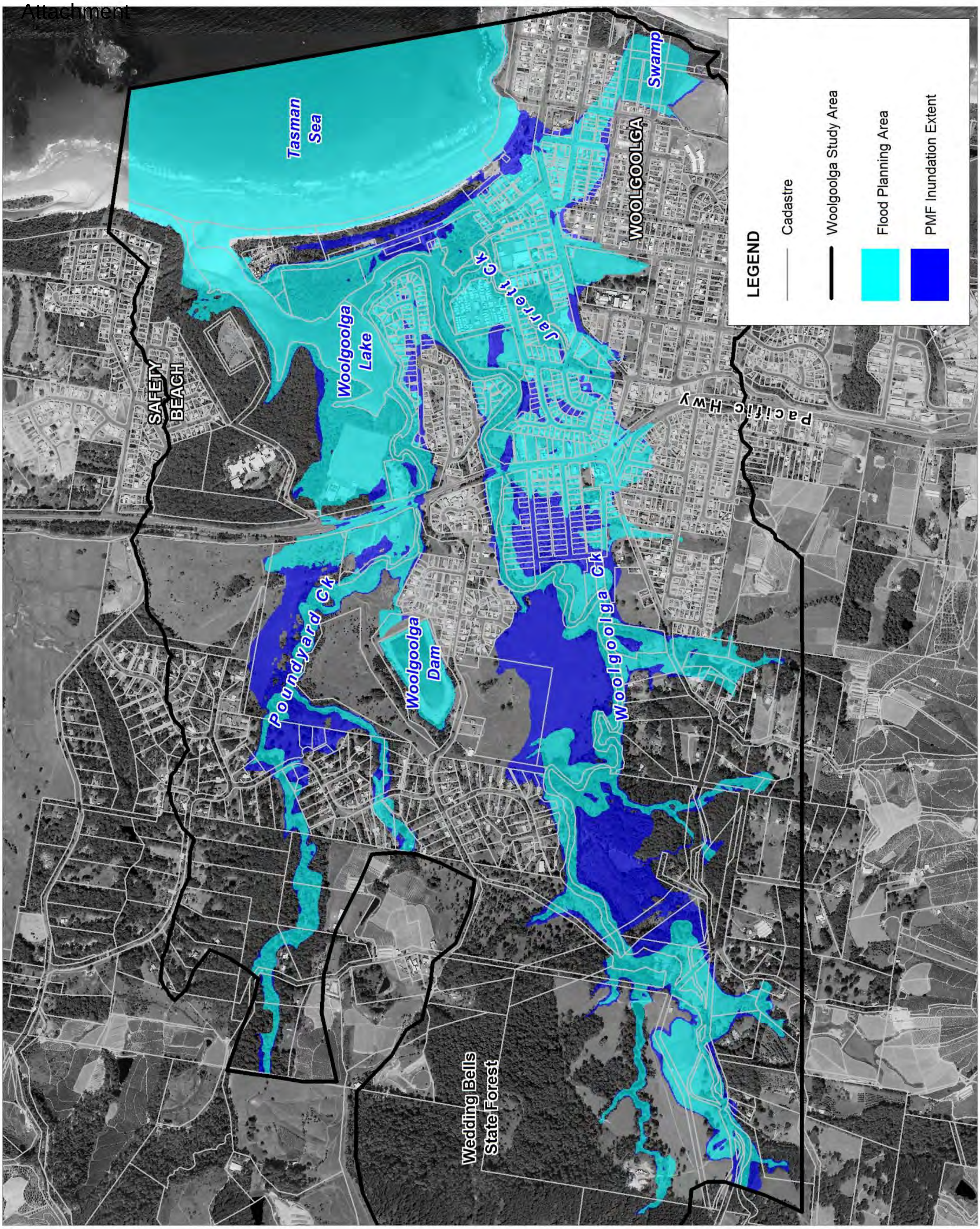
A lack of warning time means that there is only a limited amount of assistance that can be provided during the event. In reality, most people would be largely self-reliant during a flood. Agencies can, however, help people make more appropriate decisions during these floods through giving as much warning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

7.2.3.1 Flood Warning System

The flood warning system commences with the issue of Flood Watches and Flood Warnings from the Bureau of Meteorology (BoM) and concludes with the public receiving a detailed message about flood risk and required action. The location for which flood warning is most critical is the Sunset Caravan Park, due to the potentially hazardous nature of flooding.

At present, the only warnings available for Woolgoolga are generic, and automatically generated by the Bureau of Meteorology in response to severe weather warnings. Water levels are monitored at the water level gauges located at Woolgoolga Lake (1km upstream of the ocean) and Woolgoolga Creek (6km upstream of the ocean). With Woolgoolga Lake having a relatively small catchment,

Attachment



Title:

Woolgoolga Flood Planning Area
Based on the 1% AEP Event + 0.5m Freeboard

Figure: **7-8**

Rev: **A**

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

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Approx. Scale

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Filepath : K:\N20192_Woolgoolga_FRMS\MapInfo\Workspaces\DRG_00X_150414_Flood_Planning_Area.WOR the use of real-time water level data at the gauges to issue flood warnings provides for little effective warning and response time. Furthermore, the time from the onset of rain to the point at which floodwaters become hazardous can be a matter of hours in some locations, particularly in the more extreme events. This means that any realistic warnings would need to be disseminated to a large number of people very rapidly.

Analysis of the design flood results shows that the maximum warning time that could be expected to be achieved is around one hour – between a rainfall or water level gauge trigger and the onset of inundation within the Sunset Caravan Park. It is likely that by that stage the access to the caravan park via Bultitude Street may already be flooded.

A further complication to any flood warning for Woolgoolga is the influence of coincident entrance berm and tide/surge conditions during a catchment flood event. With a high entrance berm and/or coincident elevated sea levels, flooding of Sunset Caravan Park can occur in events as frequent as the 20% AEP. However, with an open entrance and more typical sea level conditions, flooding may not occur until around the 5% AEP.

A conservative flood warning will result in many “false alarms”, which in turn can encourage residents to become dismissive of flood warnings. Alternatively, a less conservative flood warning system could ignore a rainfall event that results in flooding, if the coincident entrance/ocean conditions are significant.

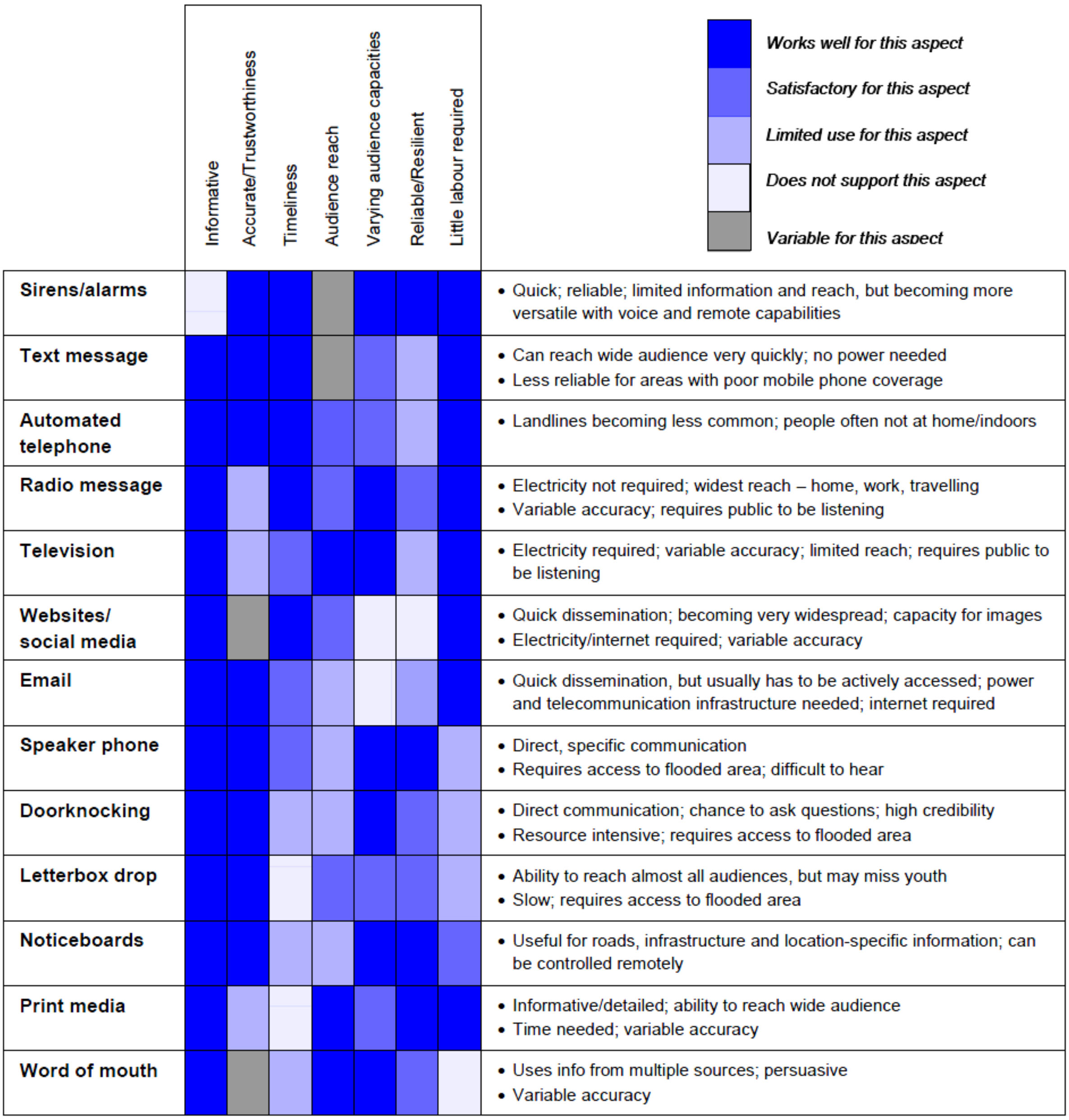
Despite the short flood warning time available it is recommended that real time data from the catchment gauges be used to inform a flood warning system, given the potential for high hazard conditions, particularly within Sunset Caravan Park. It is understood that a telemetered rainfall gauge has recently been installed at Woolgoolga Dam. Data from this gauge is automatically sent to the SES when triggered by a predetermined rainfall intensity. Currently the trigger is set at 60mm within a three hour period. It is recommended that these triggers be set at 45mm within a one hour period or 60mm within a two hour period. These thresholds are similar to the 50% AEP design rainfall curves, so would be expected to be exceeded on average every two years.

The Woolgoolga Creek water level gauge is also telemetered and for around $20,000 could also be incorporated into a flood warning system for Woolgoolga. A trigger level at a gauge height of 1.5m is also similar to a 50% AEP condition and might be expected to be exceeded on average every two years. Combined with the rainfall triggers from the Woolgoolga Dam gauge it is likely that a flood warning could be issued in Woolgoolga on average every one to two years. The issuing of a flood warning under this system would not always result in flooding, but inundation of low-lying areas would likely occur if coincident with elevated entrance berm and/or sea level conditions. Such a system should provide a warning time of around one hour before inundation of Sunset Caravan Park begins. Although short this warning could save many lives in the event of a major flood.

Given the sensitivity of upstream flood levels to the entrance berm conditions a further improvement of any implemented flood warning system may warrant investigation. This may include reference to the lake gauge height and/or installation of a remote camera on the beach to confirm the entrance conditions during the triggering of a flood warning from intense rainfall and/or catchment runoff.

Method of Flood Warning

Flood warnings to residents can be issued by a variety of measures, from automated messaging to door knocking. A comparison of various warning methods is provided in Figure 7-9.In recent riverine floods the NSW SES has used the new national telephone warning system Emergency Alert to issue flood warnings and evacuation orders in addition to traditional methods such as



Office of the Queensland Chief Scientist, 2011

Figure 7-9 Comparison of Flood Warning Communication Methods

media broadcasts, internet postings and door knocking. During floods in NSW, Victoria and Queensland in 2011, social media emerged as a significant flood warning dissemination tool. The use of social media to enhance other warning dissemination channels should be considered further for Woolgoolga.

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

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

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

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

- The SES is principally a volunteer organisation and the time required to mobilise personnel could exceed the warning time available;
- A major flood event in Woolgoolga is likely to coincide to major flooding in other catchments within the Coffs Harbour Region further stretching already limited emergency response resources;

There is generally insufficient time to undertake tasks such as sandbagging or evacuation to reduce impacts on property or people.In some floods for Woolgoolga, the SES's role in flooding may be limited to executing rescues and assisting with recovery after the event.

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

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

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

7.2.3.2 Evacuation Access

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

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

One of the principal concerns within the study area is the low level of the Sunset Caravan Park and the hazardous flood conditions that would eventuate in a major flood event. With the high flood risk and short flood warning time it is essential that the SES can access the site to assist with evacuation. However, there are concerns about the access as Bultitude Street becomes flooded even in a 20% AEP event, preventing easy access to Turon Parade and Newman Street. This would typically occur prior to the flooding from Woolgoolga Creek, given the small catchment size of Jarrett Creek.

Potential options for maintaining flood free access include:

- The purchase of property situated between Turon Parade/Kim Close and the Solitary Islands Way in order to create an easement for vehicular access;
- Road raising works along Bultitude Street; and
- Construction of a footbridge to maintain pedestrian access to Sunset Caravan Park.

All of these options would have significant costs associated with them. The most expensive is likely to be the road raising works and these may also have upstream flood impacts associated with them. Of the two less expensive options a vehicular access easement would be preferable to securing pedestrian access only.

In order to secure a permanent easement linking Turon Parade or Kim Close to the Solitary Islands Way it may be necessary to purchase two properties backing onto each other to provide the necessary linkage. However, there are a number of options that can reduce the financial cost of establishing a dedicated easement, including:

- Reaching an agreement with one of the commercial properties on the Solitary Islands Way to use existing open space as an easement; and
- Purchasing a property on Turon Parade or Kim Close and formalising an easement within the lot before re-developing the site and selling to reduce the net cost of the acquisition.

Ultimately there are a number of potential mechanisms for securing a dedicated easement for flood emergency response. These should be further investigated to establish a preferred route forward.

7.2.3.3 Classification of Communities

The SES classifies communities according to the impact that flooding has on them. The primary purpose for doing this is to assist SES in the planning and implementation of response strategies. Flood impacts relate to where the normal functioning of services is altered due to a flood, either directly or indirectly, and relates specifically to the operational issues of evacuation, resupply and rescue.

Flood Islands

Flood Islands are inhabited areas of high ground within a floodplain which are linked to the flood free valley sides by only one access / egress route. If the road is cut by floodwaters, the community becomes an island, and access to the area may only be gained by boat or aircraft. Flood islands are classified according to what can happen after the evacuation route is cut as and are typically separated into:

- High Flood Islands;
- Low Flood Islands

A *High Flood Island* include sufficient land located at a level higher than the limit of flooding (i.e., above the PMF) to provide refuge to occupants. During flood events properties may be inundated and the community isolated, however, as there is an opportunity for occupants to retreat to high ground, the direct risk to life is limited. If it will not be possible to provide adequate support during the period of isolation, evacuation will have to take place before isolation occurs.

The highest point of a *Low Flood Island* is lower than the limit of flooding (i.e., below the PMF) or does not provide sufficient land above the limit of flooding to provide refuge to the occupants of the area. During flood events properties may be inundated and the community isolated. If floodwater continues to rise after it is isolated, the island will eventually be completely covered. People left stranded on the island may drown.

Trapped Perimeter Areas

Trapped Perimeter Areas are inhabited areas located at the fringe of the floodplain where the only practical road or overland access is through flood prone land and unavailable during a flood event. The ability to retreat to higher ground does not exist due to topography or impassable structures. Trapped perimeter areas are classified according to what can happen after the evacuation route is cut as follows.

High Trapped Perimeter Areas include sufficient land located at a level higher than the limit of flooding (i.e., above the PMF) to provide refuge to occupants. During flood events properties may be inundated and the community isolated, however, as there is an opportunity for occupants to retreat to high ground, the direct risk to life is limited. If it will not be possible to provide adequate support during the period of isolation, evacuation will have to take place before isolation occurs.

Low Trapped Perimeter Areas is lower than the limit of flooding (i.e., below the PMF) or does not provide sufficient land above the limit of flooding to provide refuge to the occupants people of the area. During a flood event the area is isolated by floodwater and property may be inundated. If floodwater continues to rise after it is isolated, the area will eventually be completely covered. People trapped in the area may drown.

Areas Able to be Evacuated

These are inhabited areas on flood prone fringe areas that are able to be evacuated. However, their categorisation depends upon the type of evacuation access available, as follows.

Areas with Overland Escape Route are those areas where access roads to flood free land cross lower lying flood prone land. Evacuation can take place by road only until access roads are closed by floodwater. Escape from rising floodwater is possible but by walking overland to higher ground. Anyone not able to walk out must be reached by using boats and aircraft. If people cannot get out before inundation, rescue will most likely be from rooftops.

Areas with Rising Road Access are those areas where access roads rising steadily uphill and away from the rising floodwaters. The community cannot be completely isolated before inundation reaches its maximum extent, even in the PMF. Evacuation can take place by vehicle or on foot along the road as floodwater advances. People should not be trapped unless they delay their evacuation from their homes. For example people living in two storey homes may initially decide to stay but reconsider after water surrounds them.

These communities contain low-lying areas from which people will be progressively evacuated to higher ground as the level of inundation increases. This inundation could be caused either by direct flooding from the river system or by localised flooding from creeks.

Indirectly Affected Areas

These are areas which are outside the limit of flooding and therefore will not be inundated nor will they lose road access. However, they may be indirectly affected as a result of flood damaged infrastructure or due to the loss of transport links, electricity supply, water supply, sewage or telecommunications services and they may therefore require resupply or in the worst case, evacuation.

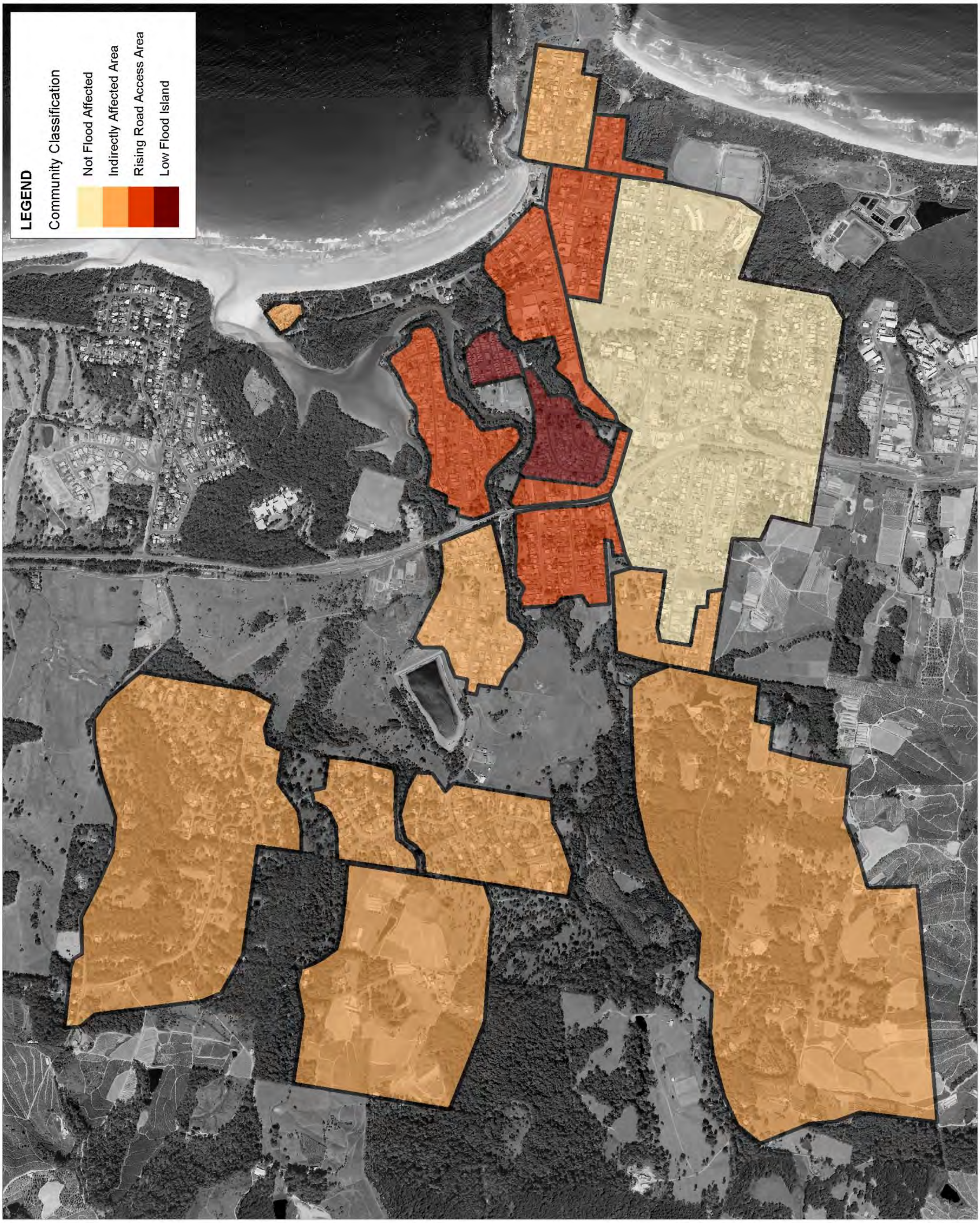
Overland Refuge Areas

These are areas that other areas of the floodplain may be evacuated to, at least temporarily, but which are isolated from the edge of the floodplain by floodwaters and are therefore effectively flood islands or trapped perimeter areas. They should be categorised accordingly and these categories used to determine their vulnerability.

Note that Flood Management Communities identified as Overland Refuge Areas on Low Flood Island have been classified according to the SES Flow Chart for Flood Emergency Response Classification. These are areas where vehicular evacuation routes are inundated before residential areas of the Community.

Classification of Communities for Woolgoolga

A classification of communities has been undertaken for Woolgoolga and is presented in Figure 7-10.



Title:

Flood Emergency Response Planning
Classification of Communities

Figure: 7-10

Rev: A

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7.2.3.4 Flood Awareness

It is recognised that there are a number of flood-related messages which need to be conveyed to the public as part of a flood awareness program. These messages, along with the type of information which should be used to convey the message is provided in Table 7-23 below.

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

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

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

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

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

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

Table 7-23 Flood Awareness Messages

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

The focus of this program should be on Sunset Caravan Park where the greatest risk to life during a major flood exists. It is also recommended that the owners of Sunset Caravan Park be encouraged to develop their own Flood Plan for the site.

7.3 Strategic Planning

This section deals with long-term planning considerations for Woolgoolga, but would also be applicable to other low-lying coastal locations throughout the LGA, which may be better addressed through a holistic climate change adaptation study. The issues discussed below are not recommendations for immediate adoption. They are more so issues that warrant strategic consideration, so that potential future floodplain management options are not unnecessarily compromised within the short to medium term planning horizons.

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

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

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

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

Figure 7-11 shows the Woolgoolga Lake foreshore with mapped inundation at key threshold elevations.

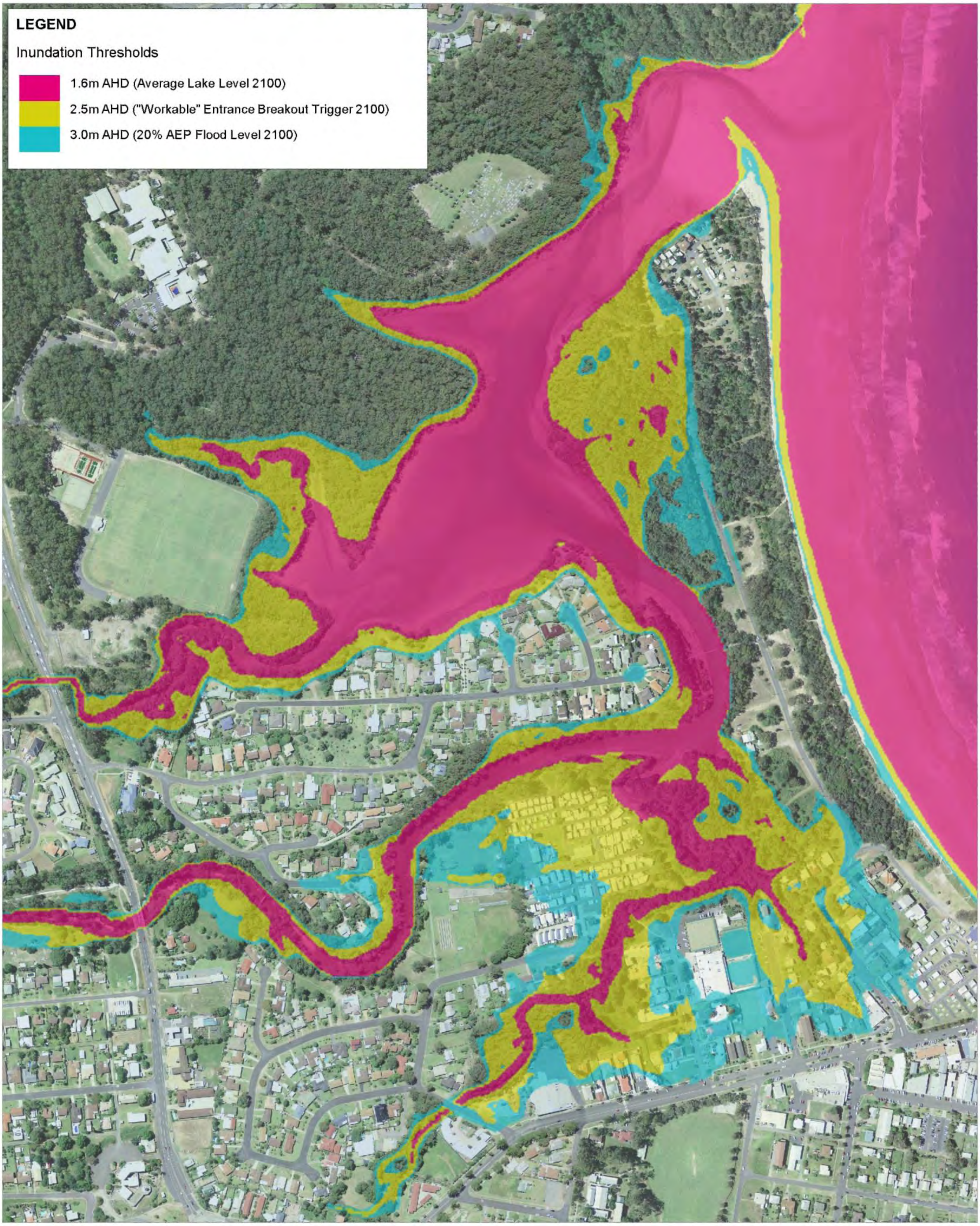
Current sea level rise predictions consider increases of up to 0.9m by the end of the century. This would result in an average lake level of around 1.6m AHD. The entrance breakout trigger level would rise to 2.5m AHD, if maintaining a consistent frequency of opening. Land situated below 3.0m AHD would be expected to flood in the order of every five years.

The average lake level in 2100 would largely be confined within the existing lake extents, although inundation of parts of the recreational foreshore would occur adjacent to the Sunset Caravan Park. However, a significant extent of Lake foreshore would experience frequent inundation during high tides and entrance closure. This includes a large area of Sunset Caravan Park and low-lying areas along Boundary Street, Ganderton Street and particularly Wharf Street. Minor flood events in the order of a 20% AEP would see more extensive inundation to these areas spreading south to Beach Street and also affecting Haines Close and Lake Road.In the longer term, it is expected that a strategic plan will be required to decide if the low-lying areas affected by frequent inundation should be abandoned or adapted. The continued occupation of currently affected land in Woolgoolga would require raising of existing ground level through extensive land filling to combat the risk of rising lake levels and associated inundation and groundwater problems. If adaptation of existing developed areas cannot be achieved in an economically, socially and environmentally acceptable manner, then a planned retreat of current occupied flood prone land may be an appropriate land use strategy.

7.3.1 Adapting Existing Areas

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

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



Title:

Progressive Inundation of Woolgoolga with Sea Level Rise

Figure: **7-11**

Rev: **A**

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

Incremental Filling

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

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

Considering the changes to design 1% AEP flood levels at the 2050 and 2100 planning horizons, flood planning levels incorporating 0.5m freeboard may be expected to be of the order of 4.0 – 4.5 m AHD. As noted typical ground levels vary in the affected areas, but are as low as 2m AHD and typically less than 3m AHD. Accordingly, raising of lot levels would typically require an extensive volume of fill and a significant expense to property owners.

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

- Loss of foreshore – filling to existing lot boundaries on properties adjacent to the public space foreshore areas of Woolgoolga Lake will ultimately provide for a complete loss of the foreshore environment with sea level rise. Unless public foreshore areas are also raised, rising Lake water levels will eventually reach the boundaries of filled private land providing a hard edge between private property and the Lake waterbody. With private property boundaries right at the water edge, public access to the waterway would be limited as would the opportunity for public foreshore infrastructure such as boat ramps, picnic tables and chairs etc.
- Environmental impacts – the loss of foreshore may have significant environmental impacts. Shallow foreshore areas are important for a range of terrestrial and aquatic flora and fauna and creating a hard edge at the waterway provides no space for ecological communities to migrate in response to rising Lake levels.
- Access to infrastructure and services – land filling options will only work if there is a corresponding adaptation of roads, stormwater drainage, water supply, sewerage, communications and other public and utility infrastructure. The piecemeal approach to land filling via redevelopment of individual properties provides issues with connectivity to these services.

- Boundary continuity – given the depth of fill involved in the land filling options, retaining wall type structures would be required at property boundaries, or sufficiently graded batters to ensure stability. The retaining wall approach would provide a 1.5. - 2.0m high walled property boundary providing significant discontinuity to a neighbouring “unfilled” lot. An appropriately graded batter slope would involve a significant loss of developable area on the lot, particularly if employed around all four sides of a typical rectangular lot shape.
- Local drainage – incremental filling will provide for considerable discontinuity in the local land surface which may cause issues for local drainage. Impediment to local overland drainage, creation of sag points and interference to existing subsurface drainage systems are potential impacts.
- Concentration of floodwaters – in times of flood, filled lots would provide for a complete obstruction to flood flows which may result in a redirection and concentration of floodwater on unfilled lots. This impact can considerably increase the flood risk on affected lots through increased velocity of floodwater. In extreme cases, higher velocities may provide for structural damage of properties.
- Overshadowing – the required fill heights and subsequent reconstruction of suitable dwellings is likely to provide significant overshadowing of “unfilled” neighbouring property.
- Visual impact (suburb character) – ultimately when entire areas are redeveloped, the general character of the area may be improved. However the piecemeal approach of incremental redevelopment would have a marked impact on the landscape in the interim period with a random mix of existing and redeveloped property at significantly different levels.

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

Broad Scale Redevelopment

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

Broad scale filling would involve (compulsory) acquisition of properties, plus finding a suitable source of fill material. The costs of this plan would be significant, but depending on the final developable land options, the plan could still be economically viable (subject to available up front financing).

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

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

7.3.2 Planned Retreat

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

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

There are potentially a number of Land Use Transition Strategies to provide for a planned retreat from some of the particularly vulnerable and high flood risk liable developed areas of Woolgoolga.

Each Land use Transition Strategy has its various challenges and levels of effectiveness. A key aspect is determining an option that balances the need to minimise personal dangers and financial costs to residents while still supporting a reasonable degree of acceptance from the community.

Should planned retreat policies be considered by Council in the future, then the following options are available for consideration:

- Restrict Further Development – Future development may be actively limited in affected areas through rezoning and development controls. This would assume the progressive abandonment of properties as they become inhabitable in their current form. There are substantial economic costs to individuals associated with diminishing property values and regional costs over time.
- Voluntary purchase – a purchase scheme could be established to provide a funding mechanism for active property purchase. This would come at significant cost for which funding opportunity may be limited. A number of social problems would be encountered with many residents unwilling to sell, inability to find alternate accommodation with similar attributes, diminishing property value over time.
- Compulsory acquisition – as for the voluntary purchase, compulsory acquisition would come at a significant social and economic cost, with potentially limited funding opportunities and significant community acceptance challenges.
- Land Swap – a successful land swap strategy was recently implemented in Grantham in the Lockyer Valley following the devastating floods of January 2011 in Queensland. The opportunity to re-locate whole suburbs is dependent on the availability of suitable land. To some degree this is limited in Woolgoolga with limited privately held developable land available. The successful Grantham land swap worked only after tragic first-hand experience of major flooding. Community acceptance for such a scheme in Woolgoolga may be low. Achieving a “like for like” swap is almost impossible.

Future Land Swap – although there is currently little need for a land swap strategy or land available to implement it, the potential for such an option could increase if future sea level rise predictions eventuate. Council may potentially investigate possible development of the Woolgoolga Dam footprint. This could be considered as an opportunity to set aside part of the developable land for a future land swap strategy.

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

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

The discussion above only provides a cursory overview of potential land use transition strategies and potential impacts. These are very complex issues with considerable social implications requiring extensive consultation with the community and detailed supporting investigations of social, economic and environmental issues. Depending on the rate at which sea level rise impacts manifest, implementation of adaptation plans may not be necessary for some years. Nevertheless, appropriate planning should be commenced within a reasonable time period to provide sufficient time to develop site specific adaptation plans and develop funding models. Further, Council should be considerate of these long term objectives in setting zonings and building controls for new development proposed in these areas.

If planned retreat policies are to be considered by Council in the future, some parts of this report may assist in providing a starting point for initial discussion, dialog and investigation. These sections may include:

- Section 4.2.2.7 and Figure 4-4 (particularly with reference to High True Hazard Classifications within 1% AEP event);
- Section 5.4 and Figure 5-2 (particularly with reference to building floor levels falling within the 1% AEP event);
- Section 6.1.1 and Figure 6-1 (particularly with reference to land use zones within the 1% AEP event);
- Section 7.2.3.3, including figure 7-10;
- Figure A-12 (particularly with reference to high flood hazard categorisation);
- Figure A-26 (particularly with reference to floodway hydraulic categorisation);
- Figure A-34 (particularly with reference to high true hazard categorisation);

7.4 Lake Amenity

The majority of concerns expressed by the community through both the questionnaire and the information session did not relate to major flood events from catchment runoff but to elevated lake levels during periods of lake entrance closure. This is particularly relevant to the residents of Sunset Caravan Park, where some land is situated below the manual entrance breakout trigger level of 1.6m AHD.

During early 2014 the lake entrance was closed for an extended period of time, during which the water level in the lake was held at almost 1.6m AHD for a period of several weeks. This impacted directly on the lake amenity of the Sunset Caravan Park lake foreshore and a footpath which serves as a link between Newman Street and access to the beach via Lake Road.

The lake level of around 1.6m AHD inundated the grassed recreational area (of some 0.1ha) situated between Sunset Caravan Park and Jarrett Creek, where a number of picnic tables are located. Although the footbridge over Jarrett Creek was clear of the water, around a 30m length of the footpath beyond was flooded. This presents a potential risk to residents attempting to utilise these amenities, which was further compromised through a possible leaking of sewage into the water during the 2014 event.

An improvement of these amenities to maintain dry access during periods of elevated lake levels could be undertaken and would involve the raising of the Jarrett Creek foreshore to a level of 1.8m AHD (0.2m above the trigger level) and also the raising of the footpath to a continuous elevation of 1.8m AHD. Drainage from Sunset Caravan Park would need to be maintained through the provision of pipes, to enable runoff from the site to drain through to Jarrett Creek.

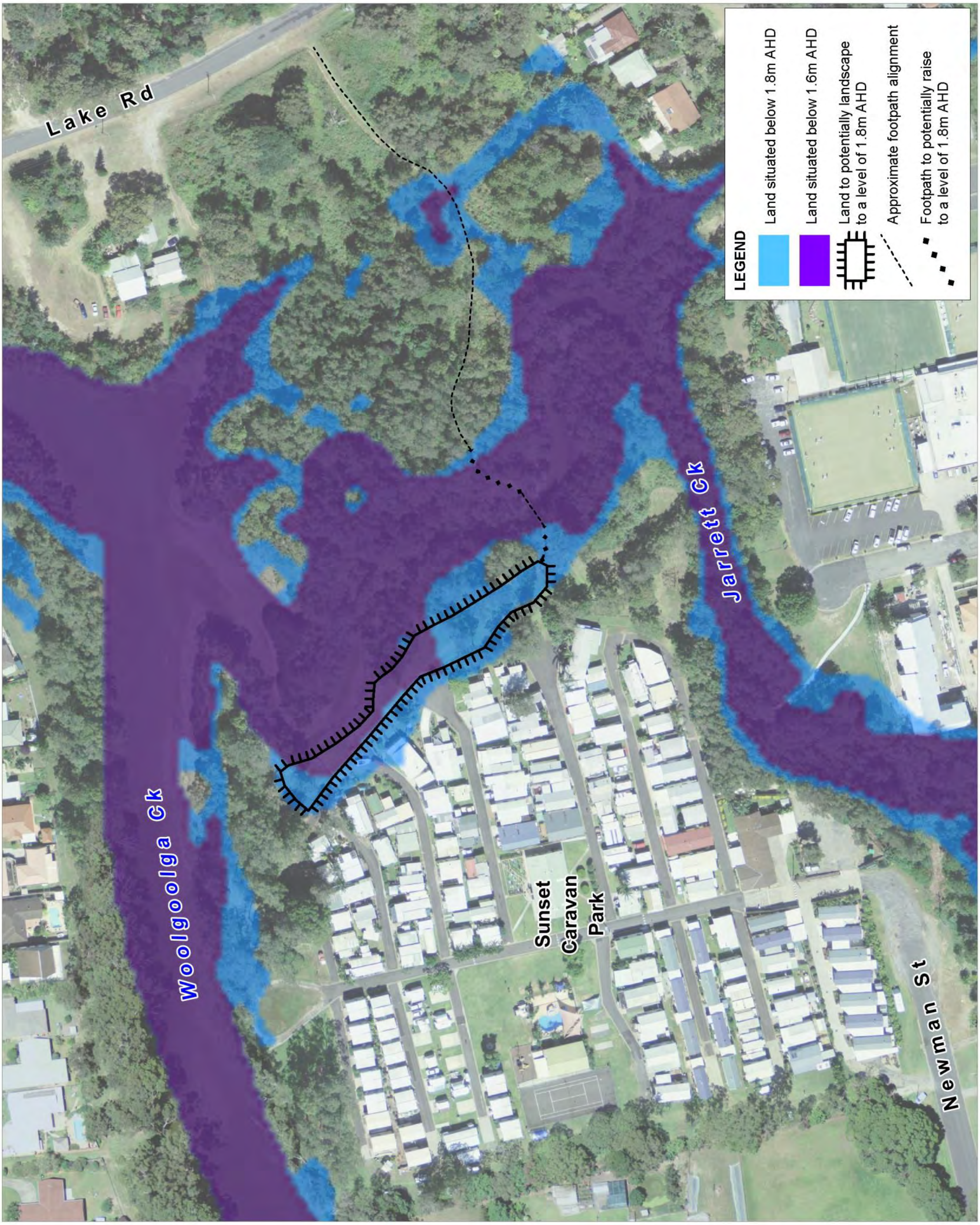
The low-lying areas around Sunset Caravan Park affected by elevated lake levels are identified in Figure 7-12, together with an indicative layout of potential works to reduce these impacts.

Another issue that was raised through the community consultation process that relates to the amenity of Woolgoolga Lake was the apparent siltation of the Lake and the possible need for dredging. The impact of siltation within the Lake was tested to determine potential impacts on flooding, but was found to be relatively insignificant. It is the elevation of the entrance berm crest that is the critical topographical influence on flooding. Periodic flooding of Woolgoolga Creek through natural processes will provide clearance of siltation within the Lake. The high velocities associated with major flood events will bring settled sediments into suspension and transport them out to sea.

The relatively flood free period between 1974 and 2011 is likely to have seen an associated build-up of siltation within the Lake. Lowering the trigger level for manual entrance breakout also serves to increase siltation as a higher water level within the Lake at the onset of entrance breakout will generate higher velocities and greater removal of sediments. A progressive lowering of the trigger level will inherently increase siltation within the broader lake body. Excess siltation can be removed through dredging, but this is an expensive undertaking usually reserved for waterways with a large volume of recreational boating.

7.5 Lake Entrance Management

As discussed previously, the flooding conditions within the lower reaches of Woolgoolga Creek are highly sensitive to the condition of the lake entrance during the flood event. The recent catchment flood events of June 2011 and January 2012 were comparable to around a 5% AEP and 2% AEP design rainfall condition. During both events the entrance was in lightly shoaled condition, estimated from the recorded lake levels as being around 0.6m AHD and 0.4m AHD for June 2011 and January 2012 respectively. Had the entrance been closed during these events then the flooding could have been much worse, particularly in Sunset Caravan Park.



Title:

Impact of Elevated Lake Levels on the Lake Amenity

Figure: **7-12**

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Lowering the level of the manual entrance breakout trigger level from the current 1.6m AHD would help to reduce the maximum elevation that the entrance berm crest is able to reach. This would also see a reduction in the level of flood damages upstream at the locations of Sunset Caravan Park, Wharf Street and Haines Close.

The Woolgoolga Lake Estuary Coastal Zone Management Plan (GeoLINK, 2013) summarises the typical lake levels experienced through analysis of the recorded lake water level data. The lake entrance was found to be open for around 66% of the time, when lake levels are typically in the order of 0.6m AHD. Shoaled or closed entrance conditions see the recorded lake levels rise in response to the rising berm height. For 90% of the time the lake level can be as high as 1.1m AHD. For the remaining 10% of the time the lake level (and likely the entrance berm) exceeds 1.1m AHD, with the highest recorded lake level in the analysed period being around 1.6m AHD, which is similar to the manual entrance breakout trigger level.

This information was used to establish a relationship between the various entrance berm elevations and the proportion of time over which they occur, as presented in Figure 7-13. Model sensitivity testing for the Woolgoolga Flood Study had tested the impact of the entrance berm height on the resultant flood conditions for an open entrance, a berm elevation of 1m AHD and a berm elevation of 1.5m AHD. The results of these model simulations were used to derive estimates of Average Annual Damages (AADs), using the method described in Section 5.

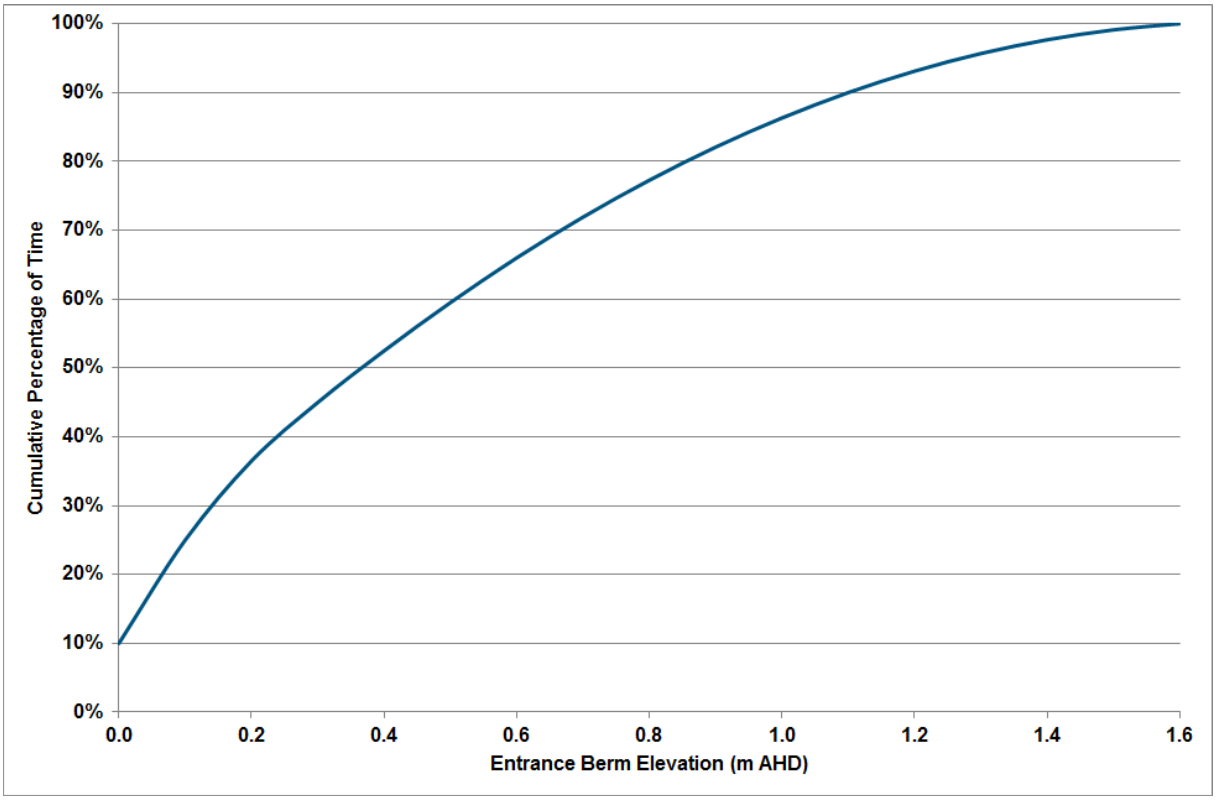

Figure 7-13 Summary of Entrance Berm Conditions over Time

A relationship was established from the results of the flood damages sustained under each of the modelled entrance conditions to derive a relationship between the range of typical entrance berm heights and the expected flood damages. Combining this relationship with that presented in Figure

7-13 enables a weighted AAD estimate to be derived for the range of expected berm heights, i.e. 66% of the time a flood will coincide with an entrance berm of around 0.6m AHD or lower and for 90% of the time a flood will coincide with an entrance berm of around 1.1m AHD or lower, etc.

An indicative impact of lowering the manual entrance breakout trigger level was then able to be established by reducing the maximum berm height from 1.6m AHD in the weighted AAD calculations. The results of this are presented in in Figure 7-14. This analysis considered catchment flood events with no coincident ocean flooding and only for the locations where the flood damages are impacted by entrance berm conditions, i.e. Sunset Caravan Park, Wharf Street and Haines Close. The indicative AADs estimated from this analysis of entrance management are summarised in Table 7-24.

The current recommendation from OEH is to maintain manual entrance breakout levels as close to natural levels as possible, except in extraordinary circumstances. This is because there are a number of problems which can be caused by trigger levels which are too low, including:

- Impacts on the health of the estuarine environment;
- Increased sedimentation within the estuary due to reduced scour potential of the breakouts; and
- Increased costs with having to initiate manual breakouts more frequently.

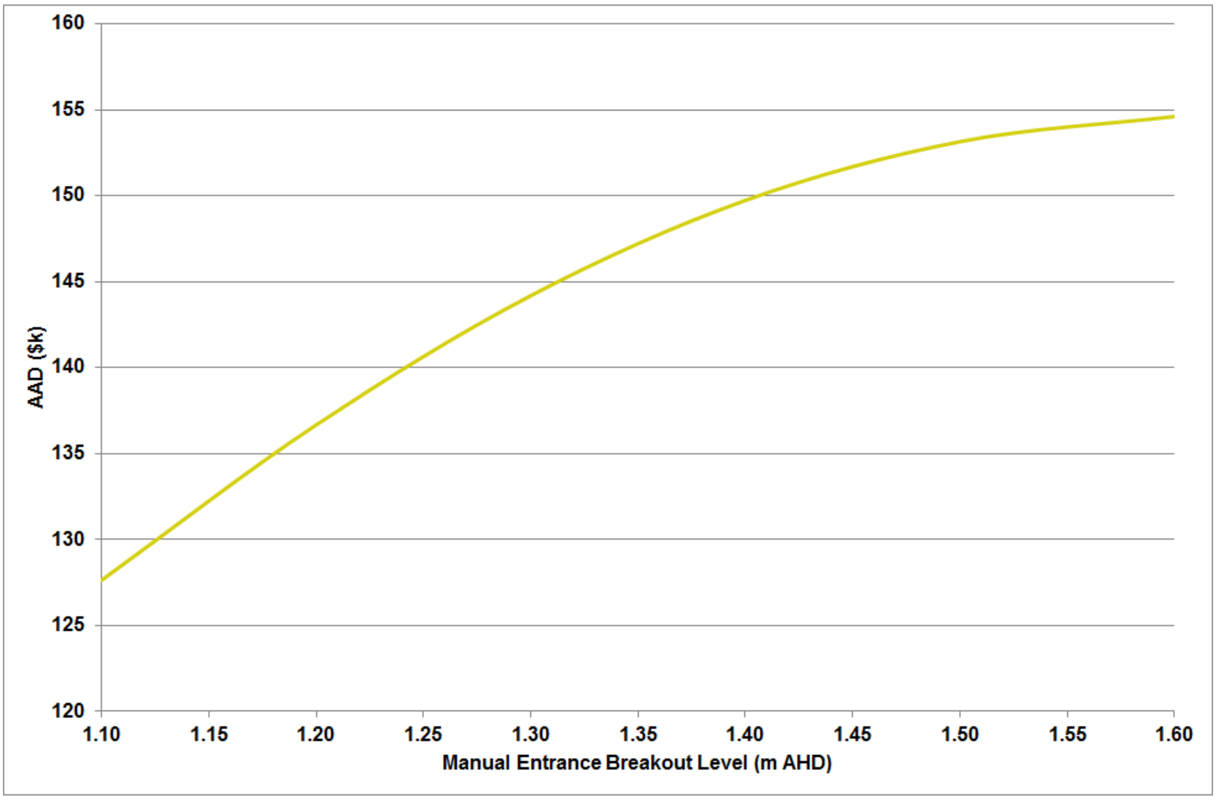

Figure 7-14 Relationship between Manual Entrance Breakout Level and AAD

The current trigger level for manual entrance breakout is 1.6m AHD, which is similar to the range of natural entrance breakouts. Due to the minimal impact on property and infrastructure at a flood level of 1.6m AHD, the detrimental effects of lowering the entrance breakout level and the relatively minimal reduction in AADs, it is recommended to retain the current trigger level of 1.6m AHD.

Table 7-24 Impact of Manual Entrance Breakout Trigger Level on Expected AADs

Trigger Level (m AHD)	Estimate of AAD ($)	Reduction in AAD ($)
1.6	$155,000	$-
1.5	$153,000	$2,000
1.4	$150,000	$5,000
1.3	$144,000	$11,000
1.2	$137,000	$18,000
1.1	$128,000	$27,000

Should the current estimates of future sea level rise eventuate then the level of the entrance berm crest and lake water level would also increase at a similar rate. This will place increasing pressures on the lake entrance management, as manual breakout will be required more frequently. The cost of flood damages would also be expected to increase, placing further strain on the conflicts between the requirement to raise the trigger level for environmental drivers and lower the trigger level for socio-economic drivers. It is recommended that the entrance management policy be reviewed periodically in response to changes in sea levels.

7.6 Options Summary

The flood damages assessment predicted that AAD costs totalling $374,000 could be caused by future flooding within the Woolgoolga floodplain. It should be noted that these costs are derived from predicted future flooding events taken over a long period of time.

Various options for mitigating flooding costs were reviewed in this section of the report. Reference can be made for full details of each option.

The more viable capital cost options are listed in Table 7-25. These options are not listed in the sequence as presented within Section 7.2, but are somewhat ordered after cursory consideration of option affordability and complexity.

Table 7-25 Summary of Capital Cost Options

Rank	Option	Cost Estimate	BCR
1	Flood proofing of commercial properties	$5k per property	3.68
2	Voluntary house raising	$50k per property	0.97
3	Trafalgar Street drainage improvements	$300k	0.41
4	Moore Street drainage diversion	$260k	0.32
5	Trafalgar Lane bund for flood detention	$75k	0.18
6	Flood levee for Sunset Caravan Park and Haines Close	$2M	1.19
7	Permanent entrance opening	$10M	0.17
8	Land swap program	$100k per property	
9	Voluntary house purchase	$300k per property	

8 Draft Woolgoolga Floodplain Risk Management Plan

8.1 Introduction

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

The FRM Plan covers the township of Woolgoolga and considers both local catchment flooding as well as flooding emanating from Woolgoolga Creek and its major tributaries.

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

The floodplain management measures and strategies that are recommended for inclusion in the FRM Plan are summarised below.

8.1.1 Flood Modification Measures

8.1.1.1 Trafalgar Street Drainage Improvements

The proposed drainage improvement works involve the augmentation of the existing drainage capacity along Trafalgar Road to divert upstream catchment runoff into the Queen Street stormwater drainage. This can be undertaken through the provision of increased stormwater pipe drainage and/or increasing the capacity of the roadway to convey excess flows.

The option considered in the modelling has been the construction of a bund to retain excess runoff in the roadway. This involves a 250m length of bund constructed in the road reserve of Trafalgar Street and Queen Street. The bund would need to be 0.3m high, or around 0.1m above the crest of the road. However, the design is complicated by the need to raise the level of the Market Street and Queen Street intersection, in order to retain water within the Queen Street alignment and prevent spilling into Market Street. The estimated cost for the Trafalgar Street drainage diversion is around $150k, with an additional $150k to raise the Market Street and Queen Street intersection.

The scheme is not that economically viable, given the relatively low AADs of the affected properties along Market Street. However, Trafalgar Street is yet to be upgraded to kerb and gutter and so the provision of additional capacity to direct flows to Queen Street may warrant consideration as an addition to the required drainage works. It should be noted that the implementation of individual flood proofing of properties on Market Street would reduce the potential benefits of these drainage improvements.

Estimated Cost **- $150K** Responsibility **– Council** Priority – **Low to Medium**

8.1.1.2 Moore Street Drainage Diversion

There is potential to divert local catchment runoff away from its current discharge point under Moore Street and into Woolgoolga Creek. This can be undertaken upstream of Moore Street, where there is currently a culvert draining under the road. Through construction of a drainage channel and/or culverts the catchment can instead be discharged west along the southern side of Moore Street in an effort to reduce flooding downstream.

The drainage channel construction considered is at an invert level of 6m AHD, which is approximately 2.5m deep. The minimum length of channel required is around 180m and includes the provision of a twin 1200mm RCP culvert under an existing property access. The channel would discharge into the Woolgoolga Creek floodplain and would flow through the properties to the north before reaching Woolgoolga Creek.

The scheme is not that economically viable, given the relatively low AADs of the affected properties. However, it would remove a reasonably extensive area of shallow flood inundation. Should future development of properties along Moore Street occur then it may present an opportunity to reduce the cost of the required works and hence increase the economic viability of the scheme.

Estimated Cost **- $260K** Responsibility **– Council** Priority – **Low to Medium**

8.1.1.3 Continue Implementation of Entrance Management

The current entrance management policy should continue to be implemented in the short to medium term to relieve low-level persistent flooding. Dependent of future sea level rise outcomes the current manual entrance breakout trigger level of 1.6m AHD may require review. As sea levels and thus the entrance berm elevation rises so the continued implementation of the existing entrance management plan will become less sustainable, as more frequent manual intervention will be required.

Estimated Cost **– no additional** Responsibility **– Council** Priority – **High**

8.1.2 Property Modification Measures

8.1.2.1 Planning and Development Controls

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within Woolgoolga. This will ensure that new development is compatible with the flood risk, and allows for existing problems to be gradually reduced over time through sensible redevelopment.

The following planning measures are recommended:

- Adoption of 1% AEP flood level plus 0.5m freeboard as the flood planning level (maintains the existing design flood standard); and
- Review of current land-use zoning with respect to Floodway areas.

Estimated Cost **– staff costs** Responsibility **– Council** Priority – **High**

8.1.2.2 Flood Proofing

Flood proofing refers to the design and construction of buildings with appropriate materials (i.e. material able to withstand inundation, debris and buoyancy forces) so that damage to both the building and its contents is minimised should the building be inundated during a flood. Flood proofing can be undertaken for new buildings or be retrofitted to existing buildings. Generally these works would be undertaken on a property by property basis at no cost to Council.

Council's Development Control Plan already includes requirements for the use of flood compatible building components for new development in the floodplain. However, there are a number of non-structural options that can be retrofit to existing property to help reduce flood damage including changes to joinery and fittings, floor coverings and electrical services.

Flood barriers are a form of flood proofing that is easy to install at a relatively low cost. Flood barriers can be permanent fixtures or temporary installations and effectively block floodwaters from entering through doorways assuming the rest of the building is constructed from flood compatible materials). Flood barriers are recommended in particular for existing buildings that have or may experience above floor flooding such as the affected properties on Market Street.

Estimated Cost **- $5,000** Responsibility **– Landowner** Priority – **Medium**

8.1.2.3 Investigate Voluntary House Raising Program

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

Estimated Cost **– $50,000** Responsibility **– Council and Landowner** Priority – **Medium**

8.1.3 Response Modification Measures

8.1.3.1 Emergency Response

Information from the current floodplain management study (FRMS) and flood damages database will provide valuable data to enable specific Woolgoolga catchment detail to be incorporated into the Woolgoolga Local Flood Plan (LFP). The information provided by the FRMS will enable flood mapping to be updated and aid the SES in prioritising the areas in Woolgoolga with the highest flood risk.

The flood mapping and property database including property locations, floor levels will be provided to the SES for incorporation into existing systems and emergency management procedures.

Estimated Cost **– staff costs** Responsibility **– Council/SES** Priority – **High**

8.1.3.2 Improve Flood Evacuation Access

During the recent flood events the SES experienced problems with obtaining safe access to assist in the evacuation of Sunset Caravan Park due to the flooding of Bultitude Street from Jarrett Creek.

The establishment of an easement to secure vehicular access is likely to be the most viable option to assist in improving the flood evacuation of Sunset Caravan Park. Investigations should be undertaken to identify the potential for purchasing property to establish a permanent easement connecting Turon Parade or Kim Close through to the Solitary Islands Way.

Estimated Cost **– $500k** Responsibility **– Council/SES** Priority – **High**

8.1.3.3 Improved Flood Warning

Despite the short flood warning time available it is recommended that real time data from the catchment gauges be used to inform a flood warning system, given the potential for high hazard conditions, particularly within Sunset Caravan Park.

It is recommended that the telemetered rainfall gauge at Woolgoolga Dam be used to set flood warning triggers at 45mm of rain within a one hour period or 60mm within a two hour period. These thresholds are similar to the 50% AEP design rainfall curves, so would be expected to be exceeded on average every two years.

The Woolgoolga Creek water level gauge is also telemetered and for around $20,000 could also be incorporated into a flood warning system for Woolgoolga. A trigger level at a gauge height of 1.5m is also similar to a 50% AEP condition and might be expected to be exceeded on average every two years. Combined with the rainfall triggers from the Woolgoolga Dam gauge it is likely that a flood warning could be issued in Woolgoolga on average every one to two years.

The issuing of a flood warning under this system would not always result in flooding, but inundation of low-lying areas would likely occur if coincident with elevated entrance berm and/or sea level conditions. Such a system should provide a warning time of around one hour before inundation of Sunset Caravan Park begins. Although short this warning could save many lives in the event of a major flood.

Estimated Cost **– $20k** Responsibility **– Council/SES** Priority – **High**

8.1.3.4 Community Education

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

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

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

The focus of this program should be on Sunset Caravan Park where the greatest risk to life during a major flood exists. It is also recommended that the owners of Sunset Caravan Park be encouraged to develop their own Flood Plan for the site.

Estimated Cost **– staff costs** Responsibility **– Council/SES** Priority – **High**

8.1.4 Strategic Planning

Outside of the Sunset Caravan Park the existing flood risk and potential flood damages are relatively low, making many flood risk management schemes generally unattractive. However, into the medium to long term future planning horizons, should predicted sea level rise eventuate, the economic viability of some schemes will increase.

Voluntary house raising, house purchase and land swap programs are likely to become increasingly desirable. Investigations should be undertaken into the identification of suitable properties for such schemes, under predicted climate change scenarios for the 2050 and 2100 planning horizons. Funding arrangements for these schemes and potential sites for a land swap program should be considered by Council as a long term on-going management of flood risk.

The existing flood risk within the Sunset Caravan Park is high, with many residences situated within land designated high hazard floodway. The long-term continued occupation of the site is not sustainable and future habitation within the high risk areas should be discouraged.

Estimated Cost **– staff costs** Responsibility **– Council** Priority – **Medium**

8.1.5 Lake Amenity

In the short term, the amenity of the lake foreshore between the Sunset Caravan Park and Jarrett Creek is compromised under elevated lake level conditions that are close to the manual entrance breakout trigger level. The use of the lake foreshore and pedestrian access between Newman Street and Lake Road can be maintained under such conditions through minor landscaping of the foreshore area and raising of the footpath.

Estimated Cost **– $40k** Responsibility **– Council/Caravan Park** Priority – **Medium**

8.1.6 Lake Entrance Management

In the short term there is no justification for changing the manual entrance opening trigger level from its current 1.6m AHD. Raising the trigger level would have consequences for low-lying properties and infrastructure. Lowering the trigger level is less sustainable, both from an environmental and economic perspective and gives no significant reductions in flood risk or flood damages. However, it is recommended that the entrance management policy be reviewed periodically in response to predicted future sea level rise.

Estimated Cost **– no change** Responsibility **– Council** Priority – **Low**

8.2 Plan Summary

The recommendations of the Woolgoolga Floodplain Risk Management Plan (as detailed in Section 8.1) have been summarised within Table 8-1. A brief description of each option, together with the estimated cost, responsible body and priority for implementation are presented.

Table 8-1 Summary of Plan Recommendations

Option	Estimated Cost	Responsibility	Priority	BCR
Recommended options that modify flood behaviour				
Trafalgar Street drainage improvements to divert more runoff to Queen Street	$150k	Council	Low to medium	0.4*
Drainage diversion of Local catchment flows from Moore Street to Woolgoolga Creek	$260k	Council	Low to medium	0.3*
Continued implementation of current entrance management policy	No additional expense	Council	High	NR
Recommended options that modify property				
Planning and development controls	Staff costs	Council	High	NR
Flood proofing of individual buildings (installation of flood gates at commercial centre)	$5k	Landowner	High	3.7
Investigate voluntary house raising program	$50k	Council / Landowner	Medium	1.0
Recommended options that modify flood response				
Improved flood awareness through issue of flood information, with a particular education focus for Sunset Caravan Park	$2k	Council / SES	High	NR
Update of Local Flood Plans with current design flood information	Staff costs	Council / SES	High	NR
Improve flood evacuation access for Sunset Caravan Park	$100k to $500k	Council / SES	High	NR
Improve flood warning system	$20k	Council / SES	High	NR
Other recommended options				
Long-term strategic planning and climate change adaption	Staff costs	Council	Medium	NR
Improved lake amenity access for periods of elevated lake levels during entrance closure	$40k	Council / Sunset Caravan Park	Medium	NR

Notes: NR – Not a capital cost orientated option, or benefits difficult/impossible to quantify in financial terms.

** BCR estimate will increase if these works are undertaken in conjunction with non-flood related works, e.g. future subdivision development.*

8.3 Funding and Implementation

The timing of the implementation of recommended measures will depend on the available resources, overall budgetary commitments of Council and the availability of funds and support from other sources. It is envisaged that the FRM Plan would be implemented progressively as funding becomes available.

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

(1) Council funds;

(2) Section 94 contributions;

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

(4) State Emergency Service, either through volunteered time or funding assistance for emergency management measures.

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

8.4 Plan Review

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

A thorough review every 5 years is warranted to ensure the ongoing relevance of the FRM Plan.