BMT WBM

Ballina Floodplain Risk Management Plan

Final Report

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NSW GOVERNMENT Environment & Heritage

ballina shire council

Ballina Floodplain Risk Management Plan

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

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Title :	Ballina Floodplain Risk Management Plan
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Synopsis :	The Ballina Floodplain Risk Management Plan is a document to be used by Ballina Shire Council to assist in implementation of the outcomes of the Ballina Floodplain Risk Management Study.

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FOREWORD

Section 733 of the Local Government Act 1993 exempts Local Government from liability with respect to flood liable land on condition that planning instruments and manuals for the management of flood liable land are prepared in accordance with the principles of the relevant government manual. In 2005 the New South Wales (NSW) Department of Infrastructure, Planning and Natural Resources (now the Office of Environment and Heritage) revised their Floodplain Development Manual (DIPNR, 2005), which relates to management of development on flood liable land to assist Local Governments to meet their obligations under the afore mentioned Act.

The manual incorporates the NSW Government's Flood Prone Land Policy, which aims to reduce the impact of flooding on individual owners and occupiers of flood prone property and to reduce private and public losses resulting from floods. The 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.

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

The policy provides for technical and financial support by the State Government through the Floodplain Risk Management Process, which is discussed further in Section 2 of this report.

For Ballina Shire, the first, second and third step in this process (Data Collection, Flood Study and Floodplain Risk Management Study) have been completed. This report forms the fourth step – development of a Floodplain Risk Management Plan. The subsequent (and final) step of the NSW Floodplain Risk Management Process is to implement this plan.

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1 INTRODUCTION

1.1 Study Area

The study area, which is administered by Ballina Shire Council (Council), includes the town of Ballina and surrounding areas. Ballina is a coastal town located at the mouth of the Richmond River in the Northern Rivers Region of New South Wales, approximately 750km north of Sydney and 200km south of Brisbane. The town is the administrative centre for the Ballina Shire (total area 484km^2), which is one of five local government areas within the Richmond River catchment (total area 6,900km^2).

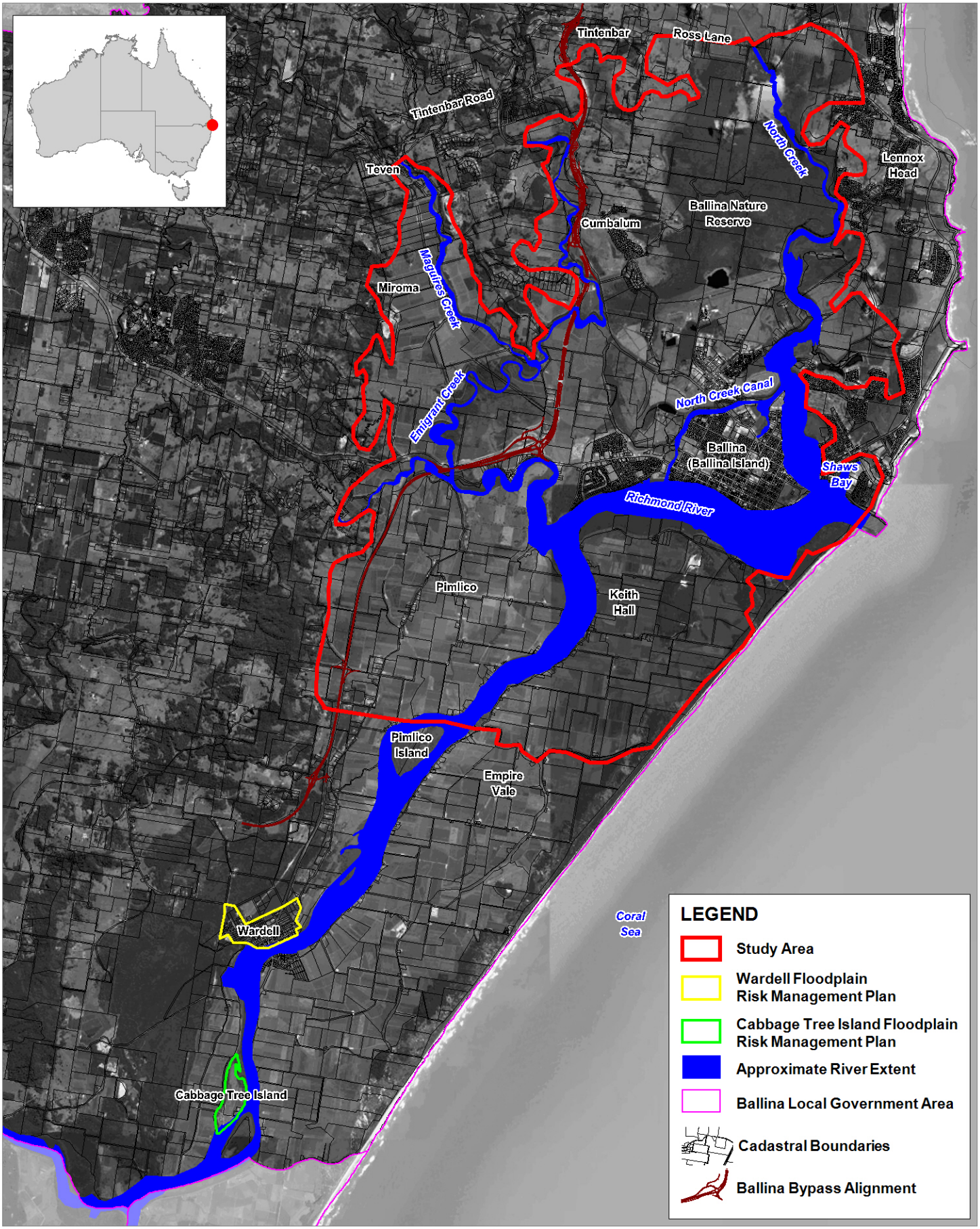
Ballina's population of 17,000 people accounts for 40% of the Ballina Shire's total population of 39,000 people (Council's website). Other population centres within the Shire include the smaller towns of Alstonville (15%), Wollongbar (5%), Wardell (1%), Lennox Head and Skennars Head (20%). The remaining 19% of people are distributed across the rural parts of the Shire. The study area, as defined for the preceding Ballina Floodplain Risk Management Study, is defined by the extent of the Richmond River floodplain from Empire Vale in the south to Ross Lane in the north (see Figure 1-1).The major tributaries of North Creek, Maguires Creek and Emigrant Creek are included in the study area, because flooding across Ballina's urban area is influenced by these creeks as well as the Richmond River itself.

While the study area excludes Wardell and Cabbage Tree Island, the recommended actions from the respective Floodplain Risk Management Plan's for those areas have been included in this Floodplain Risk Management Plan for completeness.

Ballina's town centre is bounded by the Richmond River on its southern end, North Creek on its eastern end and the North Creek Canal joining them along the north-western side. The three watercourses form an island referred to here as Ballina Island. The developed areas surrounding Ballina Island to the east of North Creek, north of the canal and west of the canal are referred to as East Ballina, North Ballina and West Ballina respectively. Ballina Island is adjacent to the Richmond River mouth and is, therefore, also subjected to high ocean tides that propagate up the Richmond River and North Creek.

1.2 Objective

Due to the proximity of Ballina and rural surrounds to various rivers and creeks, the study area is exposed to a risk of flooding (see Section 3). The objective of this document is to facilitate managing this risk, by documenting a Floodplain Risk Management Plan (hereafter referred to as the 'Plan') on behalf of Council, in line with the NSW Floodplain Risk Management Process (see Section 2). This Plan aims to mitigate flood risk in the study area, and is based on the conclusions and recommendations of the preceding Ballina Floodplain Risk Management Study (BFRMS; BMT WBM, 2012).



Title:

Site Location Plan

Figure: 1-1

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2 FLOODPLAIN RISK MANAGEMENT

2.1 The Process

The New South Wales 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 Floodplain Development Manual (DIPNR, 2005).

The policy provides for technical and financial support by the State Government through the following sequential stages, as outlined in Figure 2-1, below:

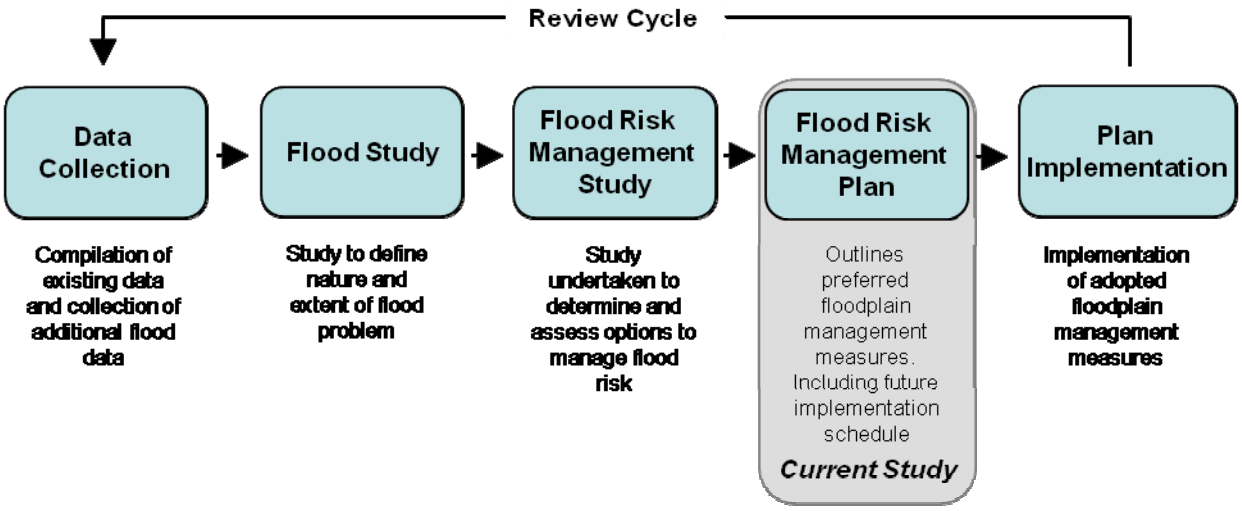


Figure 2-1 Floodplain Risk Management Process

Community consultation occurs throughout the process.

For Ballina Shire, the first and second steps in the process (Data Collection and Flood Study) were completed in 2008 (BMT WBM, 2008). In early 2009, Council engaged BMT WBM to undertake the third and fourth steps of the process (Floodplain Risk Management Study and Floodplain Risk Management Plan). The BFRMS was put on public exhibition in June/July 2012 and finalised thereafter. The Floodplain Risk Management Plan is presented in this report.

More information about the New South Wales floodplain management process can be found in the Floodplain Development Manual (DIPNR, 2005), which can be downloaded here: http://www.environment.nsw.gov.au/floodplains/manual.htm.

2.2 The Plan

This Plan provides practical information in regard to the recommended floodplain management measures such as timing, priority, expense and responsibility, or recommendation for further investigation. For the purposes of this study, flood risk can be broadly categorised as:

Existing Risk, which describes the flood risk in the floodplain as it stands today;

Future Risk, which is associated with future developments and climate change; and

Continuing Risk (sometimes called residual risk), which is the flood risk remaining after all of the floodplain management measures have been implemented (applies to both existing and future situations).

To address these three types of flood risk, the floodplain management plan ensures that:

- The use of flood prone land is planned and managed in a manner compatible with the assessed frequency and severity of flooding;
- Flood prone lands are managed having regard to social, economic and ecological costs and benefits, to individuals as well as the community;
- Floodplain management matters are dealt with having regard to community safety, health and welfare requirements;
- Information on the nature of possible future flooding is available to the public;
- All reasonable measures are taken to alleviate the hazard and damage potential resulting from development on floodplains;
- There is no significant growth in hazard and damage potential resulting from new development on floodplains; and
- Appropriate and effective flood warning systems exist, and emergency services are available for future flooding.

2.3 Responsibilities

The responsibility for flood management in the Ballina area, including land use planning, lies primarily with Ballina Shire Council. The primary responsibilities of Council are:

- Commissioning a Floodplain Risk Management Study and Plan (this study) and implementing the Plan (this document);
- Preparation of a Development Control Plan (DCP) which incorporates the planning provisions recommended in the draft DCP (separate document which has been refined subsequent to the public exhibition in June/July 2012);
- Provide flood related information on planning certificates at time of property sale;
- Design, construct and maintain and construct flood mitigation works;
- Assist the SES to promote flood readiness in the community via flood education; and
- Assist the SES in revision of the Local Flood Plan (LFP).

Council is supported in this role by a number of other agencies.

The **Office of Environment and Heritage** (OEH) co-fund the study (along with Council and Federal Government), subsidise flood mitigation works to alleviate existing problems and provide specialist technical advice as a member of Councils' technical committee.

The **Department of Planning and Infrastructure** (DPI) are also engaged in the floodplain management process through the development of regional strategies and plans under the Environmental Planning and Assessment Act (EP&A Act).

The **Bureau of Meteorology** (BoM) provides specialist advice regarding flood warning and prediction and is responsible for continuing to support the Plan through continued advice in these areas.

The **State Emergency Service** (SES) provides specialist technical advice about emergency planning and development controls throughout the study process. The SES is responsible for implementing emergency planning and response measures recommended in the Plan. Interpret and disseminate BoM's flood warnings (if applicable) to the public. Provide additional flood warnings for areas not serviced by BoM.

The **Department of Community Services** (DoCS) provides assistance to the community during flood events and is responsible for assisting the SES with emergency planning – particularly in relation to the evacuation centres.

3 FLOOD RISK IN BALLINA

3.1 Flood Behaviour

As part of the BFRMS, a computer based flood model was used to simulate hypothetical design floods. The design floods were established using standard engineering practice during the Ballina Flood Study Update (BMT WBM, 2008). Design storms for the following likelihood of Annual Recurrence Intervals (ARI) have been assessed: 5, 10, 20, 50, 100 and 500 years and a Probable Maximum Flood (PMF; largest flood that is conceptually possible). Where, for example, the 100 year flood event is a flood that can be expected to be equaled or exceeded every 100 years on average over a long period of time. A 100 year ARI flood has a 1% probability of being exceeded in any year, which leads to a 50% probability of occurring within a 70 year period.

The flood model simulates how the design floods spread through the catchment, thereby facilitating an assessment of flood risk. The model has been used to assess current flood risk. The flood model's predicted 100 year ARI flood extent is illustrated in Figure 3-1.

There are three main sources of flooding in the study area:

1 Richmond River flooding caused by a widespread storm system (with precipitation typically occurring over multiple days) over the broader Richmond River catchment. These floods rise and fall relatively slowly at Ballina, with flood conditions lasting multiple days.

2 Local catchment flooding caused by smaller storm systems in the local creek catchments with intense rainfall bursts typically lasting less than 12 hours. Flood waters rise and fall quickly. This form of flooding presents a high hazard due to short warning times and fast flowing water.

3 Ocean storm surge flooding caused by low pressure systems, strong onshore winds and storm wave conditions, which lead to higher than usual ocean levels. This form of flooding is influenced by tides, and will typically occur in combination with one or two high tides.

Richmond River flooding causes the most widespread flooding through the study area. This form of flooding is also the most dominant in terms of peak water levels through the majority of the study area. Flood water on the Richmond River travels in a north easterly direction towards Ballina, spilling out into the floodplain to the south of Ballina. These floodwaters also affect flooding on the local catchment creeks, especially in their lower reaches. Flood levels in the North Creek valley, to the north of Ballina Island, are dominated by this form of flooding due to the catchment being relatively flat and the long time period over which flooding occurs.

Local catchment flooding dominates flood levels in the Emigrant and Maguires Creek valleys. These valleys spread out and flatten towards their confluences with the Richmond River, where local catchment and Richmond River flooding become equally dominant.

Ocean storm flooding dominates in the lower reach of the Richmond River and North Creek, thus affecting parts of West Ballina, Ballina Island, Shaws Bay, East Ballina and North Ballina. These areas constitute the most concentrated urban development, which highlights the importance of this form of flooding in Ballina.

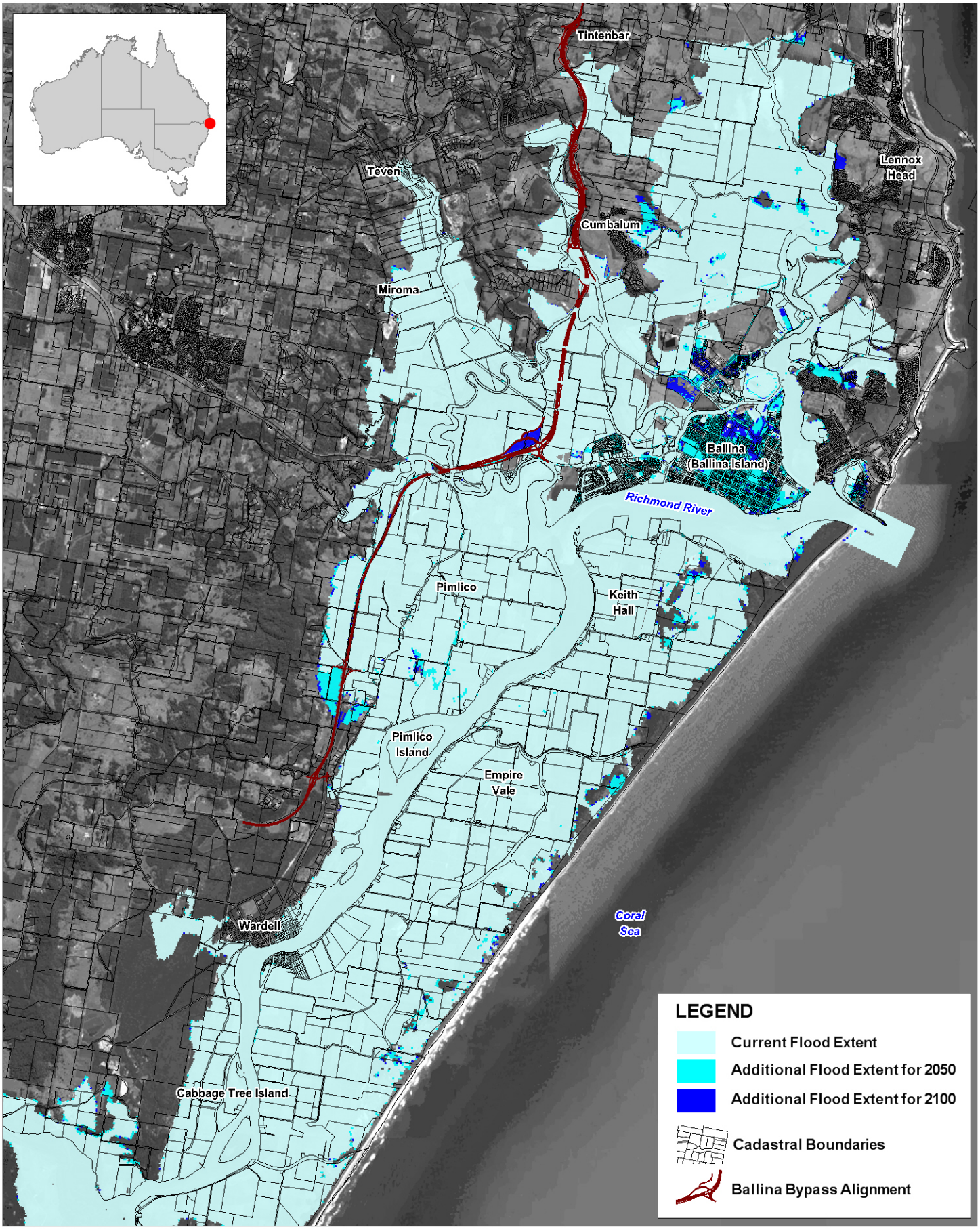
As discussed above, there is an existing flood risk to both rural and urban areas in the study area. This flood risk may be exacerbated by future climate change. Scientists are predicting sea levels to rise, which is a concern for Ballina being sited on relatively low lying land. The NSW Department of Planning released a planning guide on *Adapting to Sea Level Rise* (DoP, 2010). The guide presents two planning horizons:

- An increase above 1990 mean seal levels of 40cm by 2050; and
- An increase above 1990 mean sea levels of 90cm by 2100.

Another consequence of a changing climate is increased rainfall intensity, which may increase the frequency and severity of flooding. In 2007 the NSW Department of Environment, Climate Change and Water[1] (DECCW) published a floodplain risk management guideline titled *Practical Consideration of Climate Change* (DECCW, 2007). Based on this document and through further discussion with the OEH, a 10% increase in rainfall intensity was adopted for both the 2050 and 2100 climate change horizons.

These predicted increases in sea levels and rainfall intensity were simulated in the flood model for a 2050 and 2100 horizon. The resulting increase in flood extent for the 100 year ARI flood is shown in Figure 3-1.

[1] *Note that DECCW has now formed part of the Office of Environment and Heritage*



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100 Year ARI Flood Extents

Figure: **3-1**

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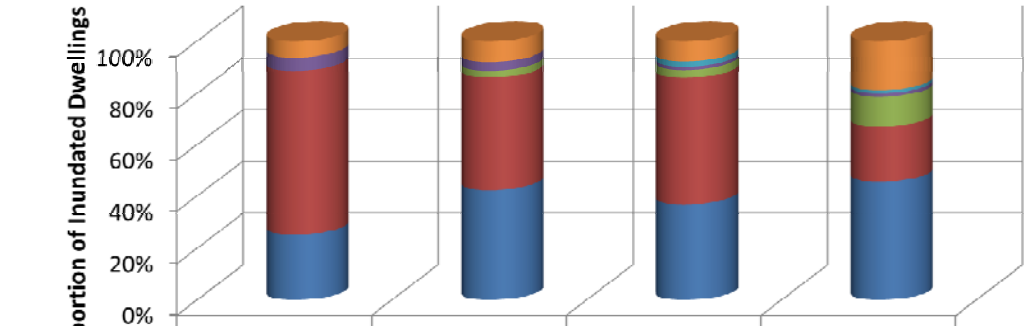
3.2 Consequences of Flooding

The flood risk predicted by the flood model is likely to impact on development, farming activities and the community's livelihood and welfare. Figure 3-2 shows the distribution of inundated dwellings (above flood flooding) within the study area; the following observations are drawn:

- The majority of inundated dwellings during small floods are in West Ballina (64%).
- The majority of inundated dwellings during moderate to large floods are in West Ballina and Ballina Island (86%).
- There is a large increase (385%) in the number of inundated dwellings between a large and extreme flood.
- The majority of inundated dwellings during extreme floods are on Ballina Island (46%).
- There is a notable increase in the number of dwellings in rural areas inundated in an extreme event.



	Small Flood (5 year ARI)	Moderate Flood (20 year ARI)	Large Flood (100 year ARI)	Extreme Flood (500 year ARI)
Rural	11	34	127	1,204
Shaws Bay	0	0	33	77
East Ballina	9	14	20	88
North Ballina	0	11	49	746
West Ballina	113	188	814	1,381
Ballina Island	45	181	603	2,923
Total:	178	428	1646	6419

Number of Inundated Dwellings (Above Floor Flooding)

Figure 3-2 Inundated Dwellings (Current Day Climate)

The number of dwellings inundated during a flood is predicted to increase due to climate change (see Figure 3-3 and climate change discussion in Section 3.1). This figure shows the following:

- The number of dwellings inundated in small, moderate and large floods is predicted to be much higher in future. Thus, climate change may greatly increase flood risk in future.
- A small flood under a 2100 climate horizon inundates 2.5 times more dwellings than a large flood under the current climate. This highlights the increase on flood risk noted in the previous point.

- Under the 2100 climate horizon the number of flooded dwellings for small to large floods is relatively similar.
- The change in the number of dwellings inundated during an extreme flood changes little in future climate horizons.

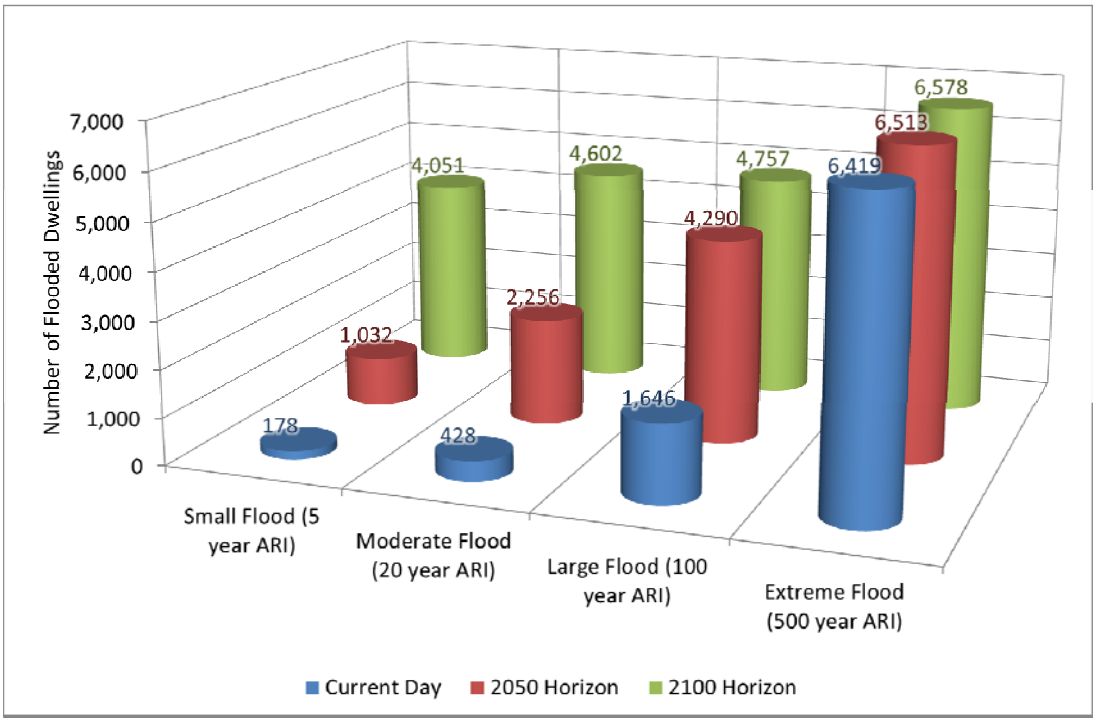


Figure 3-3 Number of Dwellings Inundated in the Study Area

A flood damage assessment was carried out during the BFRMS to establish the tangible socio-economic costs of flooding to society within the study area. The following damages were estimated:

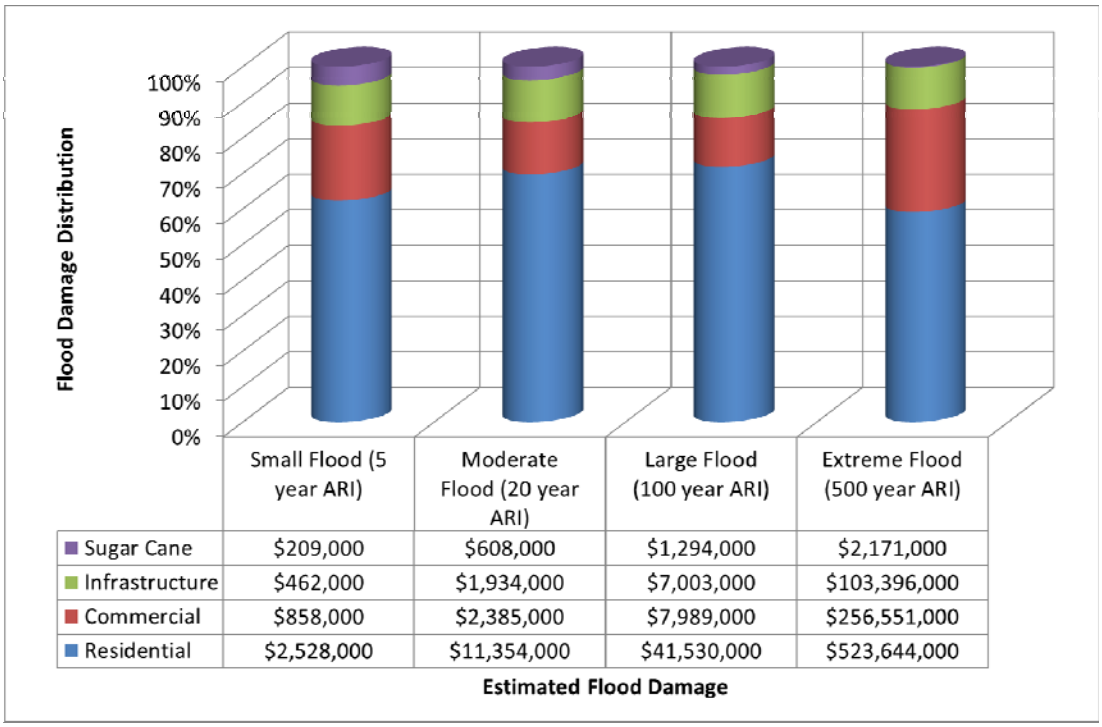
i. Residential damages – includes direct damage to residential property and contents, and indirect damages such as cleanup and alternative accommodation;

ii. Commercial damage – includes direct damage to commercial/industrial property and contents, and indirect damages such as loss of production/revenue and cleanup costs;

iii. Infrastructure damages; and

iv. Sugar cane damages – estimated loss of sugar cane yield due to flooding. Note that only sugar cane damages were assessed as sugar cane was assumed to be the dominant form of crop within the floodplain in the study area.

The estimated current day flood damages are shown in Figure 3-4. The results indicate that residential damages make up the majority of the total damage, and that the loss of sugar cane yield is small compared to residential and commercial damages.



	Small Flood (5 year ARI)	Moderate Flood (20 year ARI)	Large Flood (100 year ARI)	Extreme Flood (500 year ARI)
Sugar Cane	$209,000	$608,000	$1,294,000	$2,171,000
Infrastructure	$462,000	$1,934,000	$7,003,000	$103,396,000
Commercial	$858,000	$2,385,000	$7,989,000	$256,551,000
Residential	$2,528,000	$11,354,000	$41,530,000	$523,644,000

Figure 3-4 Flood Damage (Current Day Climate)

The consequence of the predicted flood risk under a future climate has a marked impact on the damage bill caused by flooding. It is estimated that the current day flood damage bill is $9 million per annum on average (if the long term flood damage is spread evenly year on year). This figure increases to $15 million and $88 million for the 2050 and 2100 climate horizons respectively. The reason for such a large increase is that the relatively frequent smaller floods impose far more damage under a future climate than they do under the current day climate.

Managing this current and future flood risk in Ballina poses a significant challenge to the Council. To this end, the Plan recommends a number of flood mitigation measures in the following section.

4 RECOMMENDED FLOOD MITIGATION MEASURES

Floodplain Risk Management Plans consider three distinct types of management measures: flood modification, response modification and property modification. Selection of an appropriate and effective mixture of management measures ensures that the Plan best addresses the local flood risk and is appropriate for the region and community.

Property modification measures seek to reduce flood risk through careful planning of future developments. Property modification measures can also be applied to existing developments to either reduce the flood risk by raising the house, or by removing the property from the flood prone location altogether. Property modification measures include development controls.

Flood modification measures are designed to modify the behaviour of floodwaters by either reducing flood depths and velocities, or by excluding floodwater from certain areas.

Response modification measures change the way we respond to flood risk, through measures such as evacuation planning and education. In general, response modification measures are the simplest and most cost effective measures to install, alongside planning controls. These measures primarily mitigate the residential flood risk.

The recommended flood mitigation measures that compose this Plan have been listed in Table 4-1.

Table 4-1 Recommended Flood Mitigation Measures

ID	Recommendation and Description	Constraints / Limitations / Challenges	Benefits
Property Modification Measures			
P1	**Update Development Controls** The imposition of development controls can be an effective means of managing flood risks associated with future development (including redevelopment). *Ballina Shire Combined DCP 2006, Policy Statement No. 11 - Flood Levels* was adopted by Council on 26 August 2010. While these controls will manage future flood risk, a more flexible approach to managing future flood risk could be considered. A draft DCP has been developed by Bewsher Consulting in close collaboration with Council's planners during the Ballina Floodplain Risk Management Study. In addition, the draft Wardell and Cabbage Tree Island Floodplain Risk Management Plans provide specific advice as follows: • Council develop policy to limit residential dwellings on Cabbage Tree Island to maintenance or replacement of existing premises. It is recommended that community related buildings be allowed, provided they are constructed with flood compatible materials and meet other general requirements for development on flood prone land (Worley Parsons, 2009b). • Provisions are made in Council's DCP that give suitable consideration to flood risk, flood hazard, flood warning and evacuation for proposed development and the impact on these facets to neighbouring development. More detail is provided in the draft Wardell Floodplain Risk Management Plan (Worley Parsons, 2009a). The intent of the recommendations provided in the Cabbage Tree Island and Wardell Floodplain Risk Management Plans are captured in the draft DCP.	• Complexity in the development controls can lead to misinterpretations and/or impose a burden on developers and planners. • Mitigation is employed over time - does not mitigate the immediate flood problem.	• Flood mitigation can be targeted; i.e. vulnerable development (such as hospitals) placed in lower flood risk areas and tolerant development (such as sports fields) placed in higher flood risk areas. • Flood mitigation is adaptable – controls can be updated as flood intelligence improves. • Mitigates future flood risk by considering potential implications of climate change. • Relatively low cost to implement.
P2	**Develop Agricultural Levee Guidance** Levees are used by farmers in the study area to protect arable land from flooding. Particularly flooding associated with high tides where salt intrusion may degrade the quality of the soil. Currently there are no formal controls on this form of development. In some areas these levees impact on flood levels to neighbouring properties. Thus, it is recommended that some limitations are developed. Such limitations are currently being considered within the Newrybar Swamp Flood and Drainage Assessment (BMT WBM, 2013). This issue is common to the Richmond River County Council (RRCC). Thus, it is recommended that this is done in collaboration with RRCC.	• Removal/lowering of levees may increase flood risk in some areas. • Enforcement of the levee limitations may be difficult.	• Reduction of flood risk in some areas.
P3	**Develop Voluntary House Raising Scheme** House raising typically involves the raising of dwellings to above Council's flood planning level. Houses can be raised vertically on piers; reconstructed at a higher level on fill or piers; or relocated within the property. In the BFRMS 49 properties within the 20 year ARI flood event were selected for consideration in a voluntary house raising scheme. Also, consideration should be given to voluntary house raising for existing dwellings at East Wardell (upstream from the Pacific Highway Bridge) that are expected to experience over floor flooding during the 100 year ARI flood, and existing dwellings at Wardell Village (near the intersection of Richmond and Wilson Streets) that are affected by over floor flooding during the 20 year ARI event It is recommended that a voluntary house raising scheme is investigated. Floor levels should be limited to 3.5m above ground level due to practicality and aesthetic reasons. The onus will be on the owner to engage a contractor and undertake the works. It is recommended that the voluntary house raising grant is capped at $40,000, and increased each year to account for market trends. The grant will be provided following completion of the works and Council inspection.	• The occupation of areas beneath a raised house may offset reduction in damage potential. • People living in raised houses may be less likely to evacuate, increasing the threat to life in the rare event that a flood reaches the floor level; Risk to emergency services if rescue required. • House isolated at times of flood; some intangible costs remain; Risk to emergency services if rescue required due to medical emergency. • Building may prove to be incapable of withstanding force of floodwater and debris loading, resulting in structural collapse. [Note that the Floodplain Development Manual regards VHR as a suitable management measure only for low hazard areas of the floodplain]. • Steps to gain access to the house may not be suitable for older people or those with disabilities. • Aesthetic and town planning constraints may apply: e.g. isolated raising of individual properties in a street may be less desirable than schemes that include a	• Reduced risk to personal safety and intangible costs such as anxiety, stress and post-flood trauma. • Reduced tangible flood damage. • Provision of under-house space for a garage, laundry or storage. • Enhanced resale value of property.

ID	Recommendation and Description	Constraints / Limitations / Challenges	Benefits
		group of properties in a street. • Raise some houses, such as slab on ground, may be economically unfeasible or impractical. • Voluntary house raising can take a considerable time to implement in full.	
Response Modification Measures			
R1	**Finalise Selection of Evacuation Centres** A key aspect of the evacuation process is to have adequate facilities at the evacuation centres that house the evacuees. At the inception of the BFRMS there was no formal plan on where evacuation centres would be located and what the limitations at those centres may be. The BFRMS identified a number of potential evacuation centres. Council attempted to contact the NSW Department of Community Services (DoCS) to discuss the proposed evacuation centres further, but were unsuccessful in getting a response from DoCS at the time. It is recommended that DoCS are engaged to discuss the feasibility of using the proposed evacuation centres. If inadequacies are identified it may be necessary to seek alternative evacuation centres.	• Evacuation centres need to be located outside the floodplain with good access to the evacuation routes. • There needs to be adequate space and facilities for the evacuees.	• Provides a safe location for the community to shelter during a flood. • Assists the SES with formulating and implementing an evacuation plan. • Reduces the residual flood risk through a more effective response to flooding.
R2	**Update Evacuation Planning** Evacuation planning in the Shire in specific trouble areas like Cabbage Tree Island and Teven Valley have been thought-out and documented in the existing local flood plan. Additional evacuation procedures have been proposed in the draft Cabbage Tree Island and Wardell Floodplain Risk Management Plans (Worley Parsons, 2009a, 2009b). It is recommended that these proposed plans are appended to the Local Flood Plan There is little structure to the evacuation procedure within the BFRMS area. Preliminary evacuation routes and zones have been proposed in the BFRMS. It is recommended that these are included in the Local Flood Plan along with the proposed evacuation centres following completion of recommendation R1. Once the Local Flood Plan has been updated, it is recommended that a street signage strategy is devised and implemented.	• If the evacuation plan is complex or poorly documented it may not be interpreted correctly or may cause confusion. • A rigid procedure may not be flexible enough to cope with unforeseen circumstances.	• Assists the SES with formulating and implementing an evacuation plan. • Expedite evacuation during a flood emergency • Provides material for knowledge sharing within the SES and community. • Reduces the residual flood risk – reduced risk to life and welfare of the community and SES.
R3	**Develop Community Engagement Strategy** The community needs to know how to react when receiving a flood warning or evacuation order. It is recommended that an ongoing flood education programme is implemented, as the community is dynamic and may constantly change. It is recommended that a community engagement strategy is developed. For example: • Lismore City Council runs a successful programme through one of its committees. • Richmond Valley Council is currently developing a flood information website in collaboration with the SES and OEH.	• Disseminating the flood awareness message to a varied and changing audience. • Retaining the awareness during long periods without flooding.	• Reduces the residual flood risk through a more effective response to flooding. • Expedite evacuation during a flood emergency • Reduced risk to life and welfare of the community and SES.
R4	**Extend Gauge Network** Rain and stream gauges provide essential flood intelligence during a flood event. It is recommended that a minimum of three additional rain gauges (Newrybar Swamp, Brooklet and Cumbalum Ridge) and two river gauges (Emigrant Creek and North Creek) are installed. More appropriate locations may be determined during discussions with Council, the SES and OEH.	• Gauges are relatively expensive to install and require ongoing maintenance. • Gauges can be susceptible to vandalism.	• Improved flood intelligence may assist with flood warning, and therefore reduce flood risk to people.

ID	Recommendation and Description	Constraints / Limitations / Challenges	Benefits
R5	**Develop Flood Intelligence Cards** The use of reliable flood intelligence to base decisions upon can improve the human response to a flood emergency. The quicker the potential implications of a flood can be understood, the more time is available to act on the appropriate response. One method used by the SES for managing flood intelligence is the use of flood intelligence cards. It is recommended that SES flood intelligence cards are developed for each of the gauges surrounding the catchment (including gauges proposed under measure R4). Whereby, the implications on flooding in Ballina for prescribed gauge recordings are defined. It is recommended that this measure is supported by additional flood modelling covering a wider range of potential flooding scenarios.	• Rainfall patterns and tidal conditions causing a flood may differ from what has been pre-assessed during establishment of the flood intelligence cards.	• Flood intelligence cards may expedite evacuation decisions and therefore reduce flood risk to people.
R6	**Assess Alternative Evacuation Order Methods** The traditional method used by the SES for issuing evacuation orders is door knocking. Significant time-savings could be made by opting for a fast dissemination method such as broadcast radio and television, mass telephone dialling, SMS or sirens warning. Increasing use of social media by society may also provide an opportunity for enhancing flood warning and dissemination of evacuation orders. Use of a website such as 'Twitter' may provide a fast means of sharing flood information between emergency services and the public. It is understood that the SES has already begun looking at alternative dissemination methods. It is recommended that several dissemination methods are used simultaneously to improve the time of response.	• If a purpose built website is used for dissemination of flood information, the website should be designed such that it is capable of handling high web traffic during a flood event. • Utilising high-tech methods may not ensure that all people are warned, especially considering the high proportion of elderly people in Ballina. • Improved evacuation capability may be limited by the road capacity; a very short warning time can lead to traffic congestion.	• Expedite evacuation during a flood emergency. • Reduced risk to life and welfare of the community and SES.
R7	**Investigate Flood Warning and Prediction System Options** It is recommended that Council investigates the potential for installing a dedicated flood warning system. The flood warning system would automatically monitor gauge recordings in the catchment, and disseminate warnings through email/SMS to prescribed personnel when specific triggers are reached Such a system already exists in the Shire in the Teven Valley. Since the Richmond River catchment is presided over by a number of local councils, and a flood could affect several of these council areas, it is recommended that such a system would be set up at a catchment scale. The BoM provide a national flood forecasting service. They use rainfall-runoff models to forecast flood flows, and in some instances they also use pre-existing flood model results to assist with predicting flood levels. The BoM currently provides flood forecasting to major towns along the Richmond River up to the downstream end of Woodburn. However, they don't currently have a formal flood forecasting system that covers Ballina Shire. For the Ballina area, the BoM has a weather system model that they use to issue a flood watch. Gauges in the Richmond River catchment are then monitored by the SES, who has ultimate responsibility for deciding whether to evacuate. It is recommended that the BoM are engaged to extend their flood forecasting to Ballina. It is recommended that the feasibility of developing flood predictive tools is investigated in more detail. Consideration should be given to doing this at a catchment scale, encompassing other local councils in the Richmond River catchment.	• Improved evacuation capability may be limited by the road capacity; a very short warning time can lead to traffic congestion. • Some areas are susceptible to flash flooding, which occurs rapidly and is difficult to predict with adequate lead time. • Cross collaboration across Councils may present some administrative and funding challenges. • Flood predictions may be overestimated at times, causing the community to become complacent in regards to responding to the predictions. • Cross collaboration across Councils may present some administrative and funding challenges.	• Improved warning methods would expedite the dissemination of a flood warning, thus expediting the response and reduce risk to people's lives and welfare. • Reduced demand on SES resources. • Flood prediction would lead to earlier warning, thus expediting the response to a flood and reducing risk to people.
R8	**Raise Low Points on Evacuation Routes** Various evacuation routes have been identified in the study area in the BFRMS. An assessment of the closure of these routes was undertaken. It was found that the route closure can be delayed through raising the low points along some routes. It is recommended that the potential to delay evacuation route closure by raising low points on Moon Street, Kerr Street and River Drive (see Figures D-1 and D-6 in Appendix D in the BFRMS) is investigated further. In addition, consideration should be given to raising sections of Tamarind Drive and River Street.	• The BFRMS assessment was undertaken using a Digital Elevation Model, which has some innate inaccuracy in ground levels. Therefore, the levels of the low points should be surveyed to confirm their existence and nature. • Road raising may adversely impact the flood behaviour. Therefore, the potential flood impacts should be considered.	• Increase the time available for evacuation, thus reducing the risk to life and welfare of the community and SES.

ID	Recommendation and Description	Constraints / Limitations / Challenges	Benefits
Flood Modification Measures			
F1	**Implement Gallans Road Cycleway Floodway** Lying to the south of the Cumbalum Ridge between the Emigrant Creek and North Creek floodplains is the Gallans Road Cycleway. The cycleway has been constructed on an embankment containing water and sewer rising mains which service Ballina Heights. Minimal cross drainage infrastructure has been provided to allow flow between Emigrant Creek and North Creek. The proposed flood modification measure involves removal of the southern 100m of the embankment and incorporates clearing of drains and Roberts Creek. A cost-benefit analysis undertaken in the BFRMS indicated that the scheme has a cost-benefit ratio of 2.8 (or 5.6 when accounting for intangible damages). It is recommended that a preliminary design, which includes a more detailed feasibility assessment and environmental impact assessment, is undertaken.	• High initial cost outlay – estimated $400k. • Small increase in flood levels in the North Creek valley – impacts on a few properties. • Requires diversion of water mains housed in the embankment. • Only provides a small reduction in flood levels along Emigrant Creek Valley; no notable improvement to risk to people lives / welfare.	• Reduces damage caused by flooding – estimated flood damage saving of $1.1million (net present value) over the next 50 years. • Potential to improve environmental values of watercourses through Ballina Nature reserve.
F2	**Consider Removal or Lowering of Deadmans Creek Road** Deadmans Creek Road, which services development on the Cumbalum Ridge, is located along an embankment across the Emigrant Creek floodplain in Cumbalum. This embankment acts like a weir, raising upstream flood levels. A new road providing a similar service is proposed approximately 1km north of Deadmans Creek Road. Therefore, there may be an opportunity to remove or lower Deadmans Creek Road.	• Before implementation it will need to be demonstrated that the new road provides an improved service in terms of flood immunity and as a flood evacuation route. • This measure will increase the route length for local residents travelling to Ballina.	• Reduced flood levels upstream of Deadmans Creek Road in the Emigrant Creek valley; by as much as 20mm to 30mm for moderate size flood events (20 year ARI).
F3	**Implement Cabbage Tree Island Low Level Deflector Levee** *(from Cabbage Tree Island Floodplain Risk Management Plan - Worley Parsons, 2009a)* Construction of a low level deflector levee with a nominal crest elevation of 2.6 mAHD (10 year ARI flood level plus a freeboard of 300mm) extending around the southern end of Cabbage Tree Island. The levee would be elevated up to 2 metres above the island. It would 'deflect' flood flows around the southern end of Cabbage Tree Island and prevent floodwaters from discharging in a northerly direction across the habited areas during floods up to and including the 10 year ARI flood. The levee would also serve to slow the progression of floodwaters during larger floods. Flood modelling for the levee has shown that the 100 year ARI flood level would be decreased by 100mm at the island and flow velocities are expected to decrease by up to 0.4 m/s behind the levee.	• Floodwaters continue to inundate the island by 'backing up' around the downstream end of the proposed deflector levee. • Will require ongoing maintenance. • For large floods there may be considerable erosive forces acting on the levee. Thus, erosion protection on the levee may be a design challenge.	• Reduces flood hazard on the island; i.e. through reduced flow velocities.
	Implement Structural Measures Assessed Separately From BFRMS:	• Apportionment of responsibility and cost for implementation is complicated, particularly when many stakeholders are concerned.	• Reduce existing flood levels / mitigate impacts on flooding caused by proposed development.
F4	West Ballina Flood Relief		
F5	Waste Transfer Floodway		
F6	Development specific flood mitigation measures		
F7	Recommendations from the Newrybar Swamp Flood and Drainage Assessment		

5 IMPLEMENTATION PLAN

The creation of a Floodplain Risk Management Plan is not the end point of this study: rather, the Plan acts as a dynamic resource which will be utilised by Council to guide future floodplain management in the Ballina Shire.

Council will have to make decisions about how to coordinate and prioritise the various recommendations. These decisions will be influenced by factors such as:

- When the measure can be implemented;
- What resources are required to implement the measure;
- What constraints may need to be addressed prior to implementing the measure (or may prevent implementing the measure);
- How to address the identified constraints; and
- How effective the measures are likely to be.

In general, measures which are readily implemented for a low cost should be prioritised, however the committee must also consider the measures which are likely to improve personal safety for the greatest number of residents.

An implementation plan has been developed, summarising the required actions, responsibilities, estimated costs and priorities for each of the recommended measures. This plan is provided in Table 5-1.

Table 5-1 Implementation Plan

ID	Required Actions	Estimated Cost	Responsibility
Property Modification Measures			
P1	Adopt new Development Control Plan (DCP). Ongoing reviews of the DCP may be required to keep the controls up to date, particularly as climate change predictions change.	Low	Council
P2	Develop formal document providing guidance on appropriate limits for levees used to protect arable land in the lower Richmond River catchment - engage with Richmond River County Council (RRCC).	Low	Council / OEH / RRCC
P3	Investigate feasibility of raising the properties identified in the Ballina Floodplain Risk Management Study and draft Wardell Floodplain Risk Management Plan for consideration in a voluntary house raising scheme, i.e. how many are slab on ground and would therefore be cost prohibitive to raise. Consult with property owners to determine support for house raising proposal. Following the above two tasks, develop a list of properties to be included in the scheme and consult with OEH regarding the likelihood of gaining funding for works. Subject to funding approval, undertake voluntary house raising.	Low $40k per house $560,000 in total for Wardell	Council / OEH / Property Owners
Response Modification Measures			
R1	Engage DoCS to appraise the proposed evacuation centres and compose a list of adopted evacuation centres. Document the list of selected evacuation centres and capacities in the Local Flood Plan.	Low	DoCS/Council / SES / DoCS
R2	Develop revised Local Flood Plan taking into account the following: • Evacuation procedures proposed in the draft Cabbage Tree Island and Wardell Floodplain Risk Management Plans (Worley Parsons 2009a and 2009b). • Evacuation routes and zones presented in the BFRMS. • Evacuation centres adopted through measure 'R1'. • Prioritising of flood warning to parts of Zone A which have the furthest to travel (see Figure D-10 in Appendix D of the BFRMS). Note that this recommendation would become redundant should road raising in Zone A, discussed in item 'R9', be undertaken. Develop and implement street signage strategy	Low	SES / Council
R3	Develop community engagement strategy to improve community awareness and preparedness.	$10k Ongoing	SES/Council

	Implement community engagement strategy.		
R4	Identify locations for additional gauges in the catchment. Install additional gauges in the catchment.	Low $150k	SES/Council
R5	Undertake further modelling to facilitate flood intelligence card development. Prepare flood intelligence cards .	$20k $20k	Council / SES
R6	Investigate and implement alternatives to door knocking for disseminating evacuation orders.	Low	SES
R7	Undertake feasibility study on potential flood warning and prediction systems. Engage BoM to discuss the possibility of extending their flood forecasting down to Ballina. Implement flood warning and/or predictive tool strategy.	$20k Unknown	Council / SES/BoM
R8	Investigate the potential to improve evacuation route capacity through raising low points on Moon Street, Kerr Street and River Drive (see Figures D-1 and D-6 in Appendix D in the BFRMS). Also consider other routes, such as sections of Tamarind Drive and River Street.	Depends on scope	Council
Flood Modification Measures			
F1	Undertake a preliminary design and detailed feasibility of the Gallans Road Cycleway floodway. Consider potential environmental impacts in the feasibility assessment. Undertake detailed design and seek funding for the works. Subject to funding approval, community support and environmental assessment, construct proposed floodway.	$400,000	Council
F2	Undertake detailed feasibility of lowering or removal of Deadmans Creek Road, including investigation on social impacts and impacts on flood evacuation. If deemed feasible, undertake design and seek funding for the works. Subject to funding approval, community support and environmental assessment, undertake the works.	$500,000	Council
F3	Consult with property owners and the Jali Aboriginal community to gauge support for construction of the proposed low level levee on Cabbage Tree Island. Undertake a detailed assessment of the costs, impact on flooding and potential environmental impacts associated with construction of the proposed levee. Also consider feasibility of the levee in terms of structural resilience to high flows. Prepare detail design drawings and seek funding for the works. Subject to funding approval, community support and	$500,000	Council

	environmental assessment, construct the deflector levee.		
F4	Design and construct West Ballina flood relief culverts		Council / Developers
F5	Design and construct waste transfer floodway.		Council
F6	Design and construct development specific flood mitigation measures.		Council / Developers
F7	Implement recommendations from the Newrybar Swamp Flood and Drainage Assessment (ref: R.B17689.001.00.docx).		Council / RRCC
General Flood Risk Management			
G1	Maintain Flood Model.		Council
G2	Review Floodplain Risk Management Plan.		Council / OEH

Table 5-2 Prioritisation Schedule

ID	Measure	Precursor	2014	2015	2016	2017	2018	2019
P1	Update Development Controls							
P2	Develop Agricultural Levee Guidance							
P3	Develop Voluntary House Raising Scheme							
R1	Finalise Selection of Evacuation Centres							
R2	Update Evacuation Planning	R1						
R3	Develop Community Engagement Plan	R2; P1						
R4	Extent Gauge Network							
R5	Develop Flood Intelligence Cards	R4						
R6	Assess Alternative Flood Warning Methods							
R7	Investigate Flood Warning and Prediction System Options	R4						
R8	Raise Low Points on Evacuation Routes							
F1	Implement Gallans Road Cycleway Floodway							
F2	Consider Removal or Lowering of Deadmans Creek Road							
F3	Implement Cabbage Tree Island Low Level Levee							
F4	West Ballina Flood Relief		*Triggered by development*					
F5	Waste Transfer Floodway		*Triggered by development*					
F6	Development specific flood mitigation measures		*Triggered by development*					
F7	Recommendations from the Newrybar Swamp Flood and Drainage Assessment							
G1	Maintain Flood Model							
G2	Review Floodplain Risk Management Plan							

Approximate year/s for measure implementation

Ongoing revisions may need to be incorporated

6 MONITORING AND REVIEW

One of the major tasks in implementing the Plan is monitoring and review. The Plan is not considered to be a static, unchangeable document, but should be reviewed and updated over time. Some of the events that might prompt review of the Plan are:

- When a significant flood occurs in Ballina Shire which will provide new data on flood behaviour;
- When significant impediments to planned measures are identified;
- When a major milestone is reached or a new study / investigation is completed;
- When relevant legislation changes (such as regional planning); and
- When new issues are identified which were not considered or known at the time the FRMS was undertaken.

A thorough review of the Plan should be undertaken every 5 years, irrespective of whether other, smaller reviews have been completed in the interim. This major review should consider all the issues which were addressed in the original Plan and identify any emergent issues.

7 REFERENCES

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