BELLINGEN SHIRE COUNCIL

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LOWER BELLINGER AND KALANG RIVERS FLOODPLAIN RISK MANAGEMENT PLAN

FINAL REPORT

wma water

NOVEMBER 2021

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Project Lower Bellinger and Kalang Rivers Floodplain Risk Management Plan	**Project Number** 111036-13
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ADOPTED TERMINOLOGY

Australian Rainfall and Runoff (ARR, ed Ball et al, 2016) recommends terminology that is not misleading to the public and stakeholders. Therefore the use of terms such as “recurrence interval” and “return period” are no longer recommended as they imply that a given event magnitude is only exceeded at regular intervals such as every 100 years. However, rare events may occur in clusters. For example there are several instances of an event with a 1% chance of occurring within a short period, for example the 1949 and 1950 events at Kempsey. Historically the term Average Recurrence Interval (ARI) has been used.

ARR 2016 recommends the use of Annual Exceedance Probability (AEP). Annual Exceedance Probability (AEP) is the probability of an event being equalled or exceeded within a year. AEP may be expressed as either a percentage (%) or 1 in X. Floodplain management typically uses the percentage form of terminology. Therefore a 1% AEP event or 1 in 100 AEP has a 1% chance of being equalled or exceeded in any year.

ARI and AEP are often mistaken as being interchangeable for events equal to or more frequent than 10% AEP. The table below describes how they are subtly different.

For events more frequent than 50% AEP, expressing frequency in terms of Annual Exceedance Probability is not meaningful and misleading particularly in areas with strong seasonality. Therefore the term Exceedances per Year (EY) is recommended. Statistically a 0.5 EY event is not the same as a 50% AEP event, and likewise an event with a 20% AEP is not the same as a 0.2 EY event. For example an event of 0.5 EY is an event which would, on average, occur every two years. A 2 EY event is equivalent to a design event with a 6 month Average Recurrence Interval where there is no seasonality, or an event that is likely to occur twice in one year.

The Probable Maximum Flood is the largest flood that could possibly occur on a catchment. It is related to the Probable Maximum Precipitation (PMP). The PMP has an approximate probability. Due to the conservativeness applied to other factors influencing flooding a PMP does not translate to a PMF of the same AEP. Therefore an AEP is not assigned to the PMF.

This report has adopted the approach recommended by ARR and uses % AEP for all events rarer than the 50 % AEP. As the intensity frequency duration data used for the study developed a 5 year ARI rainfall, this terminology has been retained for this event only.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	19.5
	0.02	2	50	49.5
	0.01	1	100	99.5
Very Rare	0.005	0.5	200	199.5
	0.002	0.2	500	499.5
	0.001	0.1	1000	999.5
	0.0005	0.05	2000	1999.5
Extreme	0.0002	0.02	5000	4999.5
			↓	
			PMP/ PMP Flood	

FOREWORD

The NSW State Government's Flood Prone Land Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any 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 liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

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

1. Flood Study

- Determine the nature and extent of the flood problem.

2. Floodplain Risk Management

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

3. Floodplain Risk Management Plan

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

4. Implementation of the 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.

The Lower Bellinger and Kalang Rivers Floodplain Risk Management Plan constitutes the third stage of the management process. This study has been prepared by WMAwater for Bellingen Shire Council and provides the basis for the future management of flood prone lands in the Lower Bellinger and Kalang River.

Funding for this study was provided by Bellingen Shire Council and the Department of Planning, Industry and Environment. This document does not necessarily represent the opinions of the NSW Government or the Department of Planning, Industry and Environment.

EXECUTIVE SUMMARY

The recommended Floodplain Risk Management Plan for Lower Bellinger and Kalang Rivers has been prepared in accordance with the NSW Development Manual (Reference 9) and:

- is based on a comprehensive and detailed evaluation of all factors that affect and are affected by the use of flood prone land; and
- provides a long-term plan for the future development of the floodplain.

The study area (refer to Figure 1) includes the Lower Bellinger River and Kalang River catchments. The Bellinger and Kalang Rivers are located within Bellingen Shire Council on the Mid North Coast of NSW. The Bellinger and Kalang Rivers join and discharge into the Pacific Ocean near Urunga. The total catchment area of both rivers is 1110 km^2. The catchment area of the Kalang River upstream of its junction with the Bellinger River is approximately 340 km^2.

The Lower Bellinger and Kalang Rivers Floodplain Risk Management Study (Reference 8) undertook a detailed assessment of flood risk in the catchment. The assessment included a description of flood hazard, as well as an estimate of the economic impact of flooding. The study gave a description of the relevant flood policy, as well as a review of the flood planning level and flood planning area.

The Floodplain Risk Management Study (FRMS) also included an investigation of possible options for the management of flood risk in the area. The measures were assessed for their ability to reduce flood risk while also considering their economic, social and environmental impact. A multi-criteria matrix assessment was used to directly compare the options. Of the options identified, 13 were recommended for implementation, with a priority and time frame assigned to each.

1. FINDINGS OF THE FLOODPLAIN RISK MANAGEMENT STUDY

1.1. Background

The study area (refer to Figure 1) includes the lower reaches of the Bellinger River and Kalang River catchments. The Bellinger and Kalang Rivers are located within Bellingen Shire Council. The Bellinger and Kalang Rivers join and discharge into the Pacific Ocean near Urunga. The total catchment area of both rivers is 1110 km^2. The catchment area of the Kalang River upstream of its junction with the Bellinger River is approximately 340 km^2 and therefore contributes about 30% of the total catchment area.

The headwaters of the catchments are located in the Dorrigo Plateau escarpment and are characterised by steep topography. Annual rainfall averages within the catchment are among some of the highest in New South Wales. The steep terrain results in an orographic effect that enhances rainfall.

The lower reaches are characterised by broad floodplains and farmland. Flooding in the lower reaches of the estuary is influenced by elevated ocean levels. Residential development within the catchments generally consists of small settlements. Major centres exist at Bellingen and Urunga. Small settlements include Rayleigh, Newry Island and Repton.

A flood study was undertaken for the Lower Bellinger and Kalang Rivers in 2016 (Reference 5) to define the existing flood behaviour. This study forms the basis and extent for the current floodplain risk management study and plan.

1.2. Description of existing flood behaviour

As part of the floodplain risk management study the existing hydraulic model for the study area was updated to include additional detail within the urban area and use ARR 2019 methodology.

Peak Flood Depth results for the 1% AEP and PMF events are presented in Figure 2 to Figure 7.

1.2.1. Floodplain

Flooding on the Bellinger and Kalang Rivers is generated by long duration storm events. The low lying floodplain downstream of Bellingen is subject to flood depths typically greater than 2 metres, and long inundation times. Once the banks are overtopped on the Bellinger River, velocities in the 1% AEP can exceed 4m/s.

The Kalang River floodplain is narrow compared to the Bellinger floodplain. The floodplain is particularly confined upstream of the Pacific Highway. The floodplain broadens downstream of the Pacific Highway Bridge. High velocity flows particularly in rare events, divert from the main channel around Newry Island, forming a flow path over the island to join back up with the Kalang River upstream of Urunga. Overbank Velocities on the Kalang River are typically less than 2.5 m/s.

1.2.2. **Cemetery Creek, Bellingen**

Cemetery Creek runs through Bellingen. It is characterised by short duration flooding, particularly in the headwaters and in the central parts of Bellingen. It drains to the South East and connects with the Bellinger River. Anecdotally, residents have commented on Cemetery Creek flooding being the major cause of inundation of properties through Bellingen during the 1974 flood, due to elevated river levels.

When it overtops its banks the creek can cause significant inundation of low lying areas to the south of Waterfall Way, particularly between Ford and Prince Streets.

1.2.3. **Central Drainage Line, North Bellingen**

The Central Drainage line describes a small catchment in North Bellingen that captures overland flow paths from Tamarind Drive, Sunset Ridge Drive, Kenny Close and Elliot Close. Floodwaters flow behind properties to the west of Lyon Street towards Wheatley Street and Hammond Street. While there is a 1.2 m diameter pipe under Wheatley Street, it is overtopped in a 1% AEP event to a depth of 0.42 m. Significant ponding occurs on the property behind the pipe.

The most severe flooding in North Bellingen comes from riverine flooding, rather than local catchment flooding, which results in flood depths of up to 2.5 m at properties on Black Street in the 1% AEP event. Depths greater than 2 m occur on properties along Hammond Road and Dowle Street. In the PMF, a flow path develops between the Bellinger River and the Central Drainage Line, isolating properties between Hobson Close and the Bellinger River.

1.2.4. **Urunga Urban Area**

In frequent events flood behaviour in Urunga is largely dominated by overland flow while in larger events the longer duration river dominated events generate higher flood levels, except in areas with steep topography such as Lourdes Avenue, and South Street. Riverine levels can restrict the drainage of overland flow. Flood waters pool behind the North Coast railway embankment to depths of 1.7 m within the reserve. There is one 1.2 m diameter circular culvert under the railway embankment, which struggles to convey water beneath the embankment, particularly with elevated downstream levels. Similar flood behaviour is experienced in the 5%, 1% and 0.2% AEP flood events. In the 1% AEP flood event, flood depths in the order of 1 m occur in Pilot Street and at the intersection of Newry St East and Bonville Street. In the PMF event, as the flood approaches the peak, the railway embankment is overtopped with flood waters flowing in a south westerly direction.

1.3. Flood Hazard

1.3.1. Hazard Classification

Classification of flood hazard in the catchments (Figure 8 to Figure 12) was based on a the *NSW Floodplain Development manual, Managing the floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR, 2016) and Book 6, Chapter 7 of ARR 2016 provide procedures for determining the hazard based on the flood velocity and depth. Under this classification, for a 1% AEP event much of the floodplain between Bellingen and Urunga is considered unsafe for all people and all vehicles with buildings requiring special engineering design and construction. For a 1% AEP event, large areas upstream of the Pacific Highway crossing of the Bellinger River are considered as H6 (unsafe for people and vehicles. All building types considered vulnerable to failure). In a PMF, only small fringe areas of both the Bellinger and Kalang Rivers are not classified as H6.

A detailed description of the flood hazard classification is given in Section 7.2 of the Lower Bellinger Kalang Rivers FRMS.

1.4. Economic Impact of Flooding

The economic impact of flooding in the Lower Bellinger and Kalang Rivers was assessed as part of the FRMS and are summarised in Table 1. Damages were calculated for residential and commercial/industrial properties, based on a floor level survey of properties inundated up to the PMF. The flood damages estimate does not include the cost of restoring or maintaining public services and infrastructure. It should be noted that damages calculations do not take into account flood damages to any basements or cellars. Further details on the approach are provided in Section 8.3 of the FRMS.

Damages calculated for the Lower Bellinger and Kalang Rivers floodplain are provided in Table 1. A total of 293 houses within the floodplain are flooded in a 1% AEP event and approximately 1062 properties are flooded above floor level in the PMF event. A total of 31 properties have been identified in the Lower Bellinger and Kalang Rivers catchment, that are flooded above floor level in events of 20% AEP or more frequent. The assessment estimated the average annual damage to be approximately $1.9 Million for the Lower Bellinger and Kalang Rivers floodplain.

Table 1: Estimated Combined Flood Damages for the Lower Bellinger Kalang Floodplain

Event	Number of Properties Flood Affected	No. of Properties Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
5 Year ARI	121	31	$1,389,400	$11,500
5%	214	62	$3,465,200	$16,200
1%	557	293	$19,327,200	$34,700
0.2%	712	588	$46,140,400	$64,800
PMF	1108	1062	$144,894,100	$130,800
Average Annual Damages (AAD)			$1,827,600	$1,600

2. RECOMMENDED MANAGEMENT MEASURES

The Lower Bellinger and Kalang Rivers FRMS made a full assessment of the existing flood risk in the Lower Bellinger and Kalang Rivers catchment. Based on this assessment, the study investigated a range of management measures for the area, which can be categorised as Response Modification Measures, Property Modification Measures, and Flood Modification Measures, as per the NSW Floodplain Development Manual (Reference 9). Measures were assessed for their efficacy across a range of criteria, which allowed them to be compared against one another and their overall effectiveness ranked. Measures which were shown to cost-effectively improve the management of flood risk in the catchment were selected and form the primary content of this Plan.

The measures have been categorised by their type (Response, Flood or Property) and given a priority ranking. The ranking is based upon a combination of reduction in flood risk, ease of implementation, cost/funding implications and outcomes based on the multi-criteria matrix assessment (refer to Section 10 of the FRMS). More information on each measure is available in the FRMS, including discussion of its implementation and its effect on the existing flood behaviour.

2.1. Timeframe for Implementation

Floodplain management measures recommended in this Plan have been assigned a timeframe for implementation in order to form short, medium and long-term strategies for the area's floodplain management. Use of different timeframes ensures that priority is given to those measures, which can be undertaken in the near future, while also retaining less feasible options for long-term implementation.

Short term measures are those that are able to be implemented in the next 1 – 5 years, medium term refers to 5 - 15 year timeframe. Long term measures are those have greater constraints (usually financial or logistical) and are therefore planned to be implemented in the next 15 – 50 years.

2.1. High Priority Management Measures

2.1.1. Flood Awareness and Preparedness (Option RM2)

The success of any flood warning system and evacuation process is partly dependant on the flood awareness and preparedness of the community at risk.

Residents of the Lower Bellinger and Kalang River Catchments generally have a moderate level of flood awareness, particularly with the flood affectation caused in 2009 and 2013 through the catchment and particularly at Newry Island and Urunga. However, this awareness is usually of the smaller more frequent events in the order of 10% AEP (recent events e.g. 2013) and for events that are larger on the Bellinger River than on the Kalang River. The 2009 event was larger on the Lower Kalang River than on the Bellinger River, catching residents off guard. Different messages will be required for the Urunga (including Newry Island) and Bellingen communities as the nature

flooding and experience of flooding is different in these communities.

As time passes since the last significant flood, the direct experience of the community with historical floods will diminish. It is recommended that a high level of awareness is maintained through implementation of a suitable Flood Awareness Program that would include Floodsafe brochures, additional flood markers, flood history reminders on significant anniversaries of major events, as well as advice provided on the Council's and SES's websites. These need to be updated on a regular basis. It is important that the system be web/GIS based and publicly available. A specific fact sheet should be produced for each catchment relating specifically to the local issues.

The cost of this option is minimal.

2.1.2. **Evacuation Planning (Option RM3)**

It may be necessary for some residents to evacuate their homes in a major flood. This would be undertaken under the direction of the SES who are the lead agency under the Displan. Some residents may choose to leave on their own accord based on flood information from the radio or other warnings, and may be assisted by local residents.

The NSW SES Local Flood Plan was prepared in November 2015 and schedule for review in 2020. This should be updated to include the new overland flow information for Urunga, Bellingen and North Bellingen.

Any major future events within this time should be incorporated into flood intelligence and evacuation planning. Signs advising of the risk of driving through floodwaters should be placed on inundated roads to reduce the number of people driving through floodwaters.

2.1.3. **Maintenance plan for removal of blockage for culverts (Option FM9)**

A hydraulic assessment where all bridges with spans less than 6m and all culverts were blocked by 50% determined that the majority of the study area is insensitive to blockage, however in Urunga, blockage results in an increase of flood levels in the 1% AEP of up to 0.75m. The impacts of blockage are localised to the structures and mostly minimal. However this can be a nuisance, and can be mitigated with a maintenance plan for the regular clearing of blockage from culverts. It is recommended that council develops and implements a culvert maintenance plan with a focus on the urban areas of Urunga and Bellingen.

It is recommended that a culvert maintenance plan should be developed and implemented as part of council's general operations with a focus on the urban areas of Urunga and Bellingen.

2.1.4. **Raise Frenchmans Creek Low Point (Option PM3 and PM4)**

One of the main ways of improving evacuation is to ensure that there are adequate evacuation routes, and appropriate warning is to be provided as to when routes will become impassable.

Council is currently considering raising a low point in North Bank Road at Frenchmans Creek as part of its regular maintenance program. This section of road is frequently cut in small events, isolating residents with properties along and which access North Bank Road. Two options were modelled in the hydraulic model and are described in Section 10.4.6 of the Study.

Maximum impacts of raising the road by 0.5m in a 5 Year ARI event are 0.001m, while for a raising to the 5y ARI event are 0.077m. No houses are impacted as a result of the proposed work, and impacts are within the acceptable range for agricultural land uses.

While this option is not a complete fix for the flood affectation along North Bank Road, it is the first low point from Bellingen and a first step in improving evacuation access to evacuation centres in North Bellingen and connectivity of the community. The raising of the low points on North Bank Road should be considered as part of future road maintenance or works budgets.

The costs for the works cannot be justified solely on a flood risk management basis, but should be considered as part of future road maintenance or works budgets.

2.1.5. Raise Waterfall Way lower of 5 Year ARI level or 500mm overlay (Option PM5)

Waterfall Way is subject to frequent and significant flooding. Parts of the road are inundated in a 1 Year ARI or 2 Year ARI event. Raising the road to a 1% AEP level would be cost prohibitive and have substantial impacts on flood behaviour. The hydraulic model was modified to raise the road to the lower of the following:

- 500mm above the existing level
- equal to the 5 Year ARI flood level

The maximum flood level increase in a 20% AEP event is 0.072 m and occurs upstream of Short Cut Road. As only riverine flood levels are assessed the maximum reduction in the 20% AEP flood levels is 3.83 m at Sweedmans Lane.

The benefits of this option will be achieved through a broader upgrade over a number of years. The raising of the low points on Waterfall Way should be considered as part of future road maintenance or works budgets and will require consultation with Transport for NSW.

2.1.6. House Raising (Option PM12)

House raising has been widely used throughout NSW to eliminate inundation from habitable floors, and is suitable for most non-brick single storey buildings on piers. It is particularly relevant to those houses situated in low hazard areas on the floodplain. Most houses in the study area which are subject to frequent flooding have been raised in the past.

In a 5 Year ARI event 26 residential properties are flooded above floor level. A total of 48 residential properties are flooded above floor level in a 5% AEP event, and removing properties that are two storeys and those within H5 and H6 hazard categories, an estimated 18 properties

may be eligible for the scheme. The cost of basic house raising is typically in the order of $80-120,000 per house.

It is recommended that Council investigate a house raising program and prioritise houses should Floodplain Management Program Grant Funding become available.

2.2. Medium Priority Management Measures

2.2.1. Flood Warning (Option RM1)

The amount of time for evacuation depends on the available warning time. Providing sufficient warning time has the potential to reduce the social impacts of the flood as well as reducing the strain on emergency services. It can also reduce the damages if the community is given sufficient time to raise goods, move cars, etc.

There are limited rainfall gauges within the catchment. An additional rainfall gauge is recommended at:

- Urunga where the daily gauge under recorded the 2009 event,
- Where the Bellinger, Kalang and Nambucca catchments join to assist in capturing the significant orographic rainfall effects that occur in this catchment.

The estimated cost of an additional gauge is $20,000 plus maintenance costs.

Bellingen Shire Council has installed 4 flood cameras, which monitor flood levels at low level bridges in the Bellinger and Kalang River Catchments. The camera locations are:

- Lavenders Bridge - Bridge Street, Bellingen,
- Lean's Bridge - Darkwood Road, Thora,
- Moodys Bridge - Kalang Road, Kalang and
- Spicketts Bridge - Bowraville Road, Brierfield.

The system also records relative water level. It is recommended that survey of the gauge zero be undertaken so that this can easily be converted to mAHD. This will provide a valuable source of information in future flood events. It is recommended Council continue to maintain these gauges into the future. Potential sites for additional flood cameras would be Newry Island Bridge and Frenchman's Creek.

2.2.2. Bridge Modification Options (Option PM1 And PM2)

One of the main ways of improving evacuation is to ensure that there are adequate evacuation routes, and appropriate warning is to be provided as to when routes will become impassable.

Lavenders Bridge, which spans the Bellinger River, is understood by the local community to be highly flood prone, and is largely an accepted flood risk, with closures of the bridge due to flooding at least once per year on average (see Section 8.1.1 of the Study). The current deck level is 4.7mAHD. Increasing the deck level would provide less disruption to daily life during events. Daily life would also return to normal more quickly following an event. It would also give the NSW SES more time at the start of an event to get resources in place. Options to raise the bridge level were evaluated as part of the study.

This option has been assessed for two deck levels to understand what benefits can be achieved:

- PM1 - 50% AEP level (approximately 2m higher than the existing deck)
- PM2 - 5 Year ARI level (3.1m higher than the existing deck)

Modelling showed the proposed bridge levels would generate minimal impacts on flood levels. Additionally, if raised to the 5 year ARI level, it would reduce the time the bridge is closed per year on average by 75% from 45.7 hours to 12.5 hours. Using a priority matrix, the larger benefit in the reduction of closure time form the 5y ARI level, places Option PM2 in the high priority measurement section, however it has been grouped with PM1 here for clarity.

Concerns were raised by the community representatives in the Committee with regards to the aesthetic value of the existing bridge. The community value of this highly photographed aspect of Bellingen is acknowledged. All attempts should be made to make use natural materials such as wood or maintain the aesthetic of the existing bridge.

A new bridge would need to be designed to maintain or enhance existing river amenity, including recreational areas on the north and south banks, and access to the river. Additionally, the proposed design of the bridge will need to ensure that any existing traffic congestion is not exacerbated, and this will provide most benefit in the same corridor as the current bridge.

The existing bridge was built in 1993 and may be nearing the end of its design life. A recent survey of the current bridge found it is structurally sound therefore this option should be progressed as an option for when the bridge is no longer sound, should damage occur to the bride during an event or funding becomes available.

Raising Lavenders bridge deck provides a localised reduction in flood levels with minimal impact on surrounding properties. This option has significant intangible benefits including improved flood resilience of the community which cannot be quantified.

2.2.3. **Voluntary Purchase (Option PM7)**

Voluntary purchase (VP) involves the acquisition of flood affected residential properties (particularly those frequently inundated in high hazard areas) and demolition of the residence to remove it from the floodplain.

Three properties in Bellingen and one in North Bellingen should further be considered for voluntary purchase. Further investigation and an assessment of their viability should be undertaken in the short term, and if shown to be viable, implemented over the long term.

2.2.4. **Flood Planning Levels (Option PM8)**

Flood Planning Levels (FPLs) are an important development control in floodplain risk management. Through planning controls Council has requirements for all new development to set finished floor levels above a given flood level. Stipulating FPLs for all new development is one of the most effective measures in reducing flood damages to new properties without preventing development in a flood prone area entirely.

For ease of implementation and consistency, a freeboard of 0.5m is recommended for the study area. It is recommended that Council update its flood planning area and flood planning levels based on the current modelling. Council should consider making the FPL and other flood information and extents available on its website.

2.3. Low Priority Management Measures

2.3.1. Water sensitive urban design (WSUD) policy (Option PM9)

Water Sensitive Urban Design promotes sustainable use of water in an urban environment. Bellingen Shire Council currently has an adopted report on the WSUD guidelines. However this documented is now put of date and no longer aligns with best practice. Council should consider the addition of one to its DCP or an updating of the report.

The key tasks of the policy in the framework of the DCP and proposed developments in urban areas would be to:

- ensure that proposed development does not compromise the existing stormwater capacity and exacerbate localised flooding to downstream properties, including key local roads,
- ensure that proposed development does not cause deterioration of the downstream water quality.

An example of a WSUD policy currently in use in the region is the Coffs Harbour City Council WSUD Guideline, available on their website.

2.3.2. Revise LEPs and DCPs (Option PM10)

The primary objective of the NSW Government's Flood Policy is "to reduce the impact of flooding and flood liability on individual owners and occupiers, and to reduce private and public losses resulting from flooding, utilising ecologically positive methods wherever possible".

Appropriate development controls involve consideration of the social, economic, environmental and risk to life of consequences associated with the occurrence and management of floods. This involves trading off various benefits of reducing the impacts of flooding on development, against the costs of restricting land use in flood prone areas and of implementing appropriate management measures.

The outcomes of the FRMS should feed into an updated DCP in respect to flood related development controls or, alternatively, the existing documents can simply refer to this study and plan. Council has recently updated its LEP to the NSW standard instrument and adopted a revised DCP.

Updated and relevant planning controls are important in flood risk management. Council to consider changes to LEP and DCP including a detailed review of Chapter 8 and 12 to align with appropriate development controls which balance the benefits of development with the impacts of

managing flooded land water sensitive urban design with the Shire.

A review of Council's existing planning policy was undertaken as part of the FRMS, and a number of recommendations for revision made. These are detailed in Section 10.4.3 of the FRMS.

One of the recommendations is that the flood planning area is based on the 1% AEP event plus a 0.5m freeboard. In addition to the 1% plus 0.5m freeboard, all other events and flood characteristics should remain the same.

2.3.3. **Section 10.7 Certificates (Option PM11)**

Section 10.7 Planning Certificates (formerly S149 Planning Certificates) are issued in accordance with the Environmental Planning & Assessment Act 1979. They contain information on how a property may be used and the restrictions on development that apply. A person may request a Section 10.7 Planning Certificate at any time to obtain information about his or her own property, but generally the certificate will be requested when a property is to be redeveloped or sold. When land is bought or sold the Conveyancing Act 1919 requires that a Section 10.7 Planning Certificate be attached to the Contract for Sale.

It is recommended that Bellingen Shire Council provides a notice within relevant rate notices regarding the outcomes of this study, and the ability for property owners to request Section 10.7 certificates should they wish. In the Section 10.7 Planning Certificates, notations regarding flooding should provide information on all mechanisms of flood risk at the site, including riverine, overland flow, or if appropriate, both. Other recommendations include a greater level of detail can be provided via Section 10.7(5) certificates using high-resolution outputs from the study and that the flood information is provided as GIS on Council's website.

2.3.4. **Flood Proofing (Option PM13)**

Flood proofing is a good solution for reducing flood risk to commercial and industrial properties. Flood proofing for residential dwellings is considered less appropriate as there can still be risk to life if people remain in the building; raising floor levels above flood levels is considered to be safer. However, as existing houses cannot be raised, flood proofing is useful for existing properties.

Grant funding is not usually available for flood proofing. This option is generally less expensive than house raising. Although Council cannot be responsible for flood proofing existing properties, they can enforce flood proofing for any new development within flood prone areas through planning controls. Furthermore, Council can, through a flood awareness campaign targeted at both commercial and residential property owners, make available information on flood proofing existing buildings such as temporary flood barriers. It is recommended that Council promote flood proofing for commercial properties in Bellingen and Urunga, and residential properties below the habitable floor level.

3. FLOODPLAIN RISK MANAGEMENT PLAN

Option ID	Option Description	Impacts	Costs	Responsibility	Overall Rank	Reference
RM03	Evacuation Planning	Reduces Risk to residents and emergency workers	Minimal	Council, SES	1	2.1.2
RM02	Flood Emergency Response	Reduces Risk to residents and emergency workers	Minimal	Council, SES	2	2.1.1
PM12	House Raising	Eliminates inundation to the height of the flood and consequently reduces flood damages	$60,000 per house	Council, Residents	3	2.1.6
FM09	Maintenance Plan for clearing blockage on culverts	Not significant for the range of AEPs considered in this study, however likely to have a larger impact in smaller events. Impacts up to 0.75m in Urunga CBD.	Minimal	Council	3	2.1.3
PM02	Raise Lavenders Bridge to 5y ARI	Provides flood free access for longer periods during flood events	High	Council	5	2.2.2
PM03	Raise North Bank Road at Frenchmans Creek by 0.5m	reduced inundation of North Bank Road	Council Cost	Council	5	2.1.4
PM04	Raise North Bank Road at Frenchmans Creek to 5y ARI	Provides flood free access up to and including the 5 year ARI flood event.	Council Cost	Council	5	2.1.4
PM05	Raise Waterfall Way	Provides flood free access up to and including the 5 year ARI flood event.	RMS Cost	Council, Transport For NSW	5	2.1.5
PM01	Raise Lavenders Bridge to 50% AEP	Provides flood free access for longer periods during flood events	High	Council	9	2.2.2
PM07	Voluntary Purchase	Reduces risk to residents and emergency workers		Council	9	2.2.3
PM08	Flood Planning Levels	Ensures new development does not incur flood damages	Minimal	Council	11	2.2.4
RM01	Bellingen Shire Flood Warning System Review	Improves evacuations and increases preparedness	$20,000 per gauge	Council, BoM, SES	11	2.2.1
PM09	Water Sensitive Urban Design Policy	Ensures new development does not adversely impact runoff	Minimal	Council	13	2.3.1
PM10	Revise LEP and DCPs	Ensures development is compatible with flood risk and an effective measuring in reducing flood damages	Minimal	Council	14	2.3.2
PM11	Provision of flood information to residents via Section 10.7 Planning Certificates	Raise awareness of flooding to those properties within the FPA	Minimal	Council	14	2.3.3
PM06	Land Use Zoning	No changes to current land use zoning.	Minimal	Council	16	NA
PM13	Flood Proofing	Will reduce flood damages	Owner cost	Council, Residents	17	2.3.4

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- Council's Coast and Estuary Committee
- Residents of Bellingen Shire

5. REFERENCES

1. Pilgrim DH (Editor in Chief)
Australian Rainfall and Runoff – A Guide to Flood Estimation
Institution of Engineers, Australia, 1987.

2. WBM BMT
Tuflow User Manual – GIS Based 2D/1D Hydrodynamic Modelling
2010

3. DeGroot and Benson Pty Ltd
South Arm Road Flood Study (Final)
June 2000

4. WMAwater
Hydraulic Modelling Report - Bellinger and Kalang Rivers
2012

5. WMAwater
Lower Bellinger and Kalang River Flood Study
2016

6. AUSTROADS
Guide to Road Design
2015

7. De Groot and Benson
Central Urunga Flood Study
2009

8. WMAwater
Lower Bellinger and Kalang River Floodplain Risk Management Study
2020

9. NSW State Government
NSW Floodplain Development Manual
April 2005

Figures

Appendix A

APPENDIX A. GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	The Council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill development:** refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.

	redevelopment: refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.
disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).
flood mitigation standard	

	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammetic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the Aflood liable land@ concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPL=s are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the Astandard flood event@ in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood

	storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves: • the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or • water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These

conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or

- major overland flow paths through developed areas outside of defined drainage reserves; and/or
- the potential to affect a number of buildings along the major flow path.

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

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

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

minor, moderate and major flooding — Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:

minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.

moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.

major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

modification measures — Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.

peak discharge — The maximum discharge occurring during a flood event.

Probable Maximum Flood (PMF) — The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.

Probable Maximum Precipitation (PMP) — The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of

	the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
probability	A statistical measure of the expected chance of flooding (see AEP).
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to Awater level@. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.