BALLINA SHIRE COUNCIL

WARDELL FLOODPLAIN RISK MANAGEMENT PLAN

Issue No. 3
OCTOBER 2009

WorleyParsons
resources & energy

Patterson Britton
& Partners Pty Ltd
consulting engineers

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Document Amendment and Approval Record

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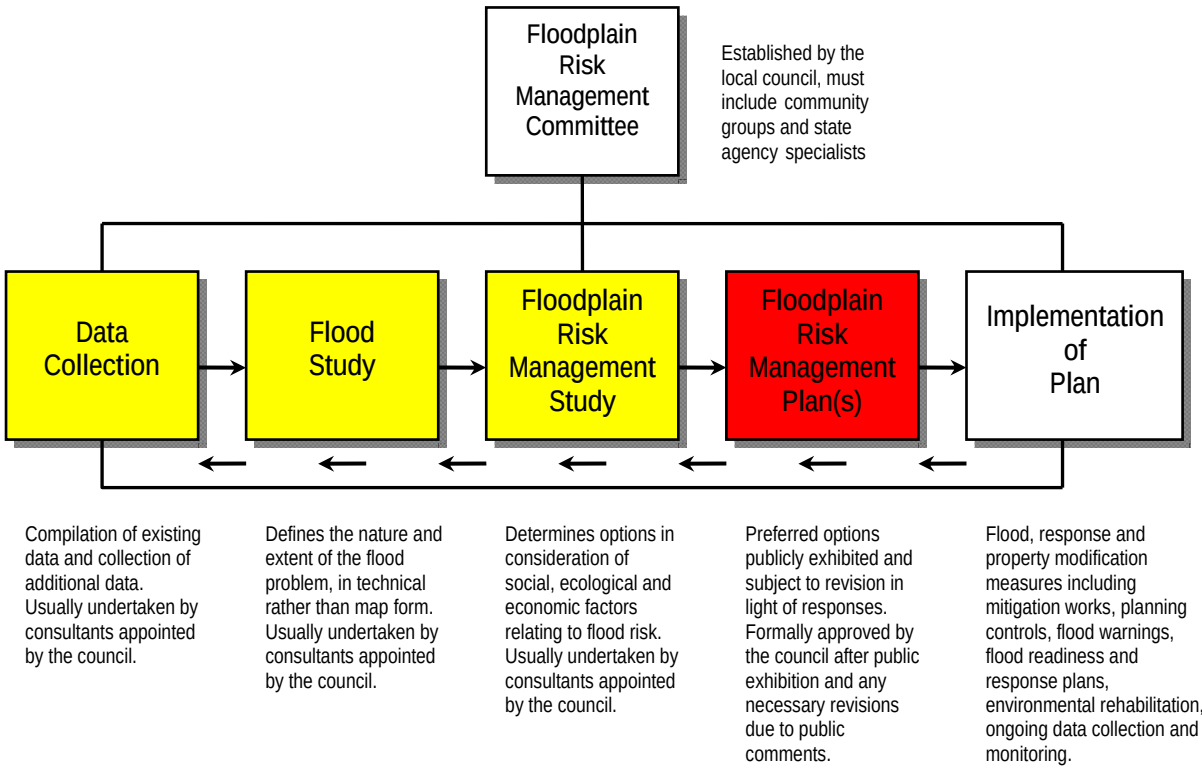
FOREWORD

The State Government's *Flood Prone Land Policy* is directed at 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. The primary objective of the NSW Government's *Flood Prone Land Policy* is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible. Policy and practice are outlined in the NSW Government publication titled, '*Floodplain Development Manual: the management of flood liable land*' (*2005*).

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

A detailed description of the inter-relationship between the six iterative stages of floodplain risk management under the NSW Government's *Flood Prone Land Policy* is shown in the flow chart presented below. This flow chart also shows the link between the various outcomes of the studies involved in the floodplain risk management process and the implementation of measures (*both planning and structural*) to reduce flood damages and other negative impacts.



FLOODPLAIN RISK MANAGEMENT PROCESS

The policy provides for technical and financial support by the Government through the following five sequential stages:

1. Data Collection
   - Involves the compilation of existing flood related data such as rainfall records, recorded flows and peak flood levels that have been recorded for historical floods. It also involves the collection of additional data such as river and floodplain cross-sections or spot elevations that define the floodplain topography, as well as social, economic, ecological, land use and emergency management data.

2. Flood Study
   - Determines the nature and extent of the flood risk, including the specification of peak flood levels and flow velocities for floods of varying severity up to and including the probable maximum flood (*PMF*). It also provides information on the extent of floodwaters and on the distribution of floodwaters across various sections of the floodplain.

3. Floodplain Risk Management Study
   - Identifies and evaluates management options for the floodplain in terms of their capacity to reduce existing and potential future flooding problems.
   - Provides information on flood behaviour and flood hazard, so that community aspirations for future land-use can be assessed.
   - Provides a framework for revisions to planning instruments such as Local Environmental Plans (*LEPs*), so that land-use controls are consistent with flood risk and flood hazard.

4. Floodplain Risk Management Plan
   - Involves the development of a plan of action for reducing existing flood damages, minimising the potential for further problems in the future and providing mechanisms for flood emergency response management.
   - Involves formal adoption by Council of a plan of management for the floodplain.

5. Implementation of the Plan
   - Construction of flood mitigation works to protect existing development;
   - Modification of local environmental plans to ensure that new development is compatible with the flood hazard;
   - Preparation of Development Control Plans for areas of the floodplain where flood compatible development is considered appropriate.

The first, second and third stages of the process were completed in February 2008 with the publication of the *'Wardell & Cabbage Tree Island Floodplain Risk Management Study'* (*refer boxes in flow chart highlighted in yellow*).

Preparation of the *'Wardell Floodplain Risk Management Plan'* and the *'Cabbage Tree Island Floodplain Risk Management Plan'* constitutes the fourth stage of the management process for the floodplain of Richmond River in the vicinity of Wardell and Cabbage Tree Island. They have been prepared for Ballina Shire Council to provide an action plan for the future management of flood liable land that adjoins the Richmond River (*refer to box in flow chart that is highlighted in red*).

1 SETTING

1.1 BACKGROUND

Wardell is located on the banks of the Richmond River about 15 kilometres upstream from the coastal town of Ballina. The Richmond River is a relatively large coastal river that drains a catchment of about 6900 km^2. It rises in the McPherson Ranges near the Queensland-NSW border and discharges to the South Pacific Ocean at Ballina. As shown in **Figure 1**, the lower reaches of the river follow the coastline between Woodburn and Ballina. Wardell is located along this reach of the Richmond River.

As shown in **Figure 1**, Wardell is located on the northern bank of the river north from Bingal Creek. The town has a population of about 500 and includes a mixture of commercial, industrial and residential precincts. Development has occurred along both sides of the river, although the extent of development along the southern bank is more recent and less extensive. The smaller urban area on the south-eastern bank of the Richmond River is known as East Wardell. East Wardell and Wardell are connected by the Pacific Highway bridge crossing of the Richmond River.

The topography of the region is generally flat, with ground levels typically between 2 and 8 metres above sea level. East Wardell is situated on a low lying section of the floodplain which has typical ground elevations of between 2 and 3 metres above mean sea level. Due to their proximity to the river, parts of both Wardell and East Wardell are susceptible to flooding. It is estimated that about 40 dwellings are currently susceptible to inundation in major floods at Wardell and East Wardell.

In recent years, development applications in the locality have been assessed by Ballina Shire Council on an individual basis. However, Council wishes to employ a more strategic approach based on a floodplain management plan for the region. This approach aims to reduce the impact of flooding and flood liability on individual owners and occupiers, and to reduce the potential for private and public losses from flooding. At the same time, it aims to provide consistency in the guidelines for development on floodplain lands.

The existing flood problem at Wardell has been detailed in a number of previous investigations, the most recent of which is the *'Wardell and Cabbage Tree Island Flood Study'* (*Issue No 4*), which was published in 2007. Investigations for this report determined that flooding of the Richmond River can result in damage to both public and private property at Wardell.

Accordingly, it is appropriate, under the NSW Government's *Floodplain Management Program*, to consider options for reducing the flood damages that could be experienced by residents and to reduce the risk for loss of life. The associated assessment has been documented in the *'Wardell and Cabbage Tree Island Floodplain Risk Management Study'* (*Issue No 5, February 2008*).

FIGURE 1

LEGEND

- Catchment Boundary
- Floodplain Area

Source: Richmond Valley Floodplain Management Study (1980)

Scale

500 0 500 1000 1500

Metres

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RICHMOND RIVER CATCHMENT

This Plan documents the preferred floodplain risk management options for Wardell and incorporates them into a program of works that identifies the likely cost of each measure and their projected benefit to the Wardell community.

1.2 FLOOD BEHAVIOUR

1.2.1 Design Flood Levels

Design flood levels have been determined for the Richmond River in the vicinity of Wardell for a range of hypothetical design events (*refer* **Table 1**).

Table 1 PREDICTED PEAK FLOOD LEVELS ALONG RICHMOND RIVER

DESCRIPTION OF LOCATION	SURVEYED CROSS-SECTION (*refer* Figure 2)	PEAK FLOOD LEVEL (*mAHD*)					
		5 Year	10 Year	20 Year	50 Year	100 Year	PMF
Carney Lane	12	1.54	1.89	2.05	2.46	2.84	4.48
Downstream of Wardell Bridge crossing	13	1.55	1.91	2.08	2.51	2.90	4.57
Wardell Bridge crossing	14	1.55	1.92	2.10	2.53	2.92	4.58
Upstream of Wardell Bridge crossing	15	1.58	1.97	2.17	2.62	3.01	4.68
Old Bagotville Road	16	1.60	1.99	2.20	2.65	3.04	4.68
Owens Lane / River Drive	17	1.61	2.01	2.21	2.67	3.06	4.69

Flood extent mapping has also been prepared showing the extent of the land susceptible to inundation during major flooding. The extent of inundation in the 100, 50 and 10 year recurrence events is shown in **Figure 2**.

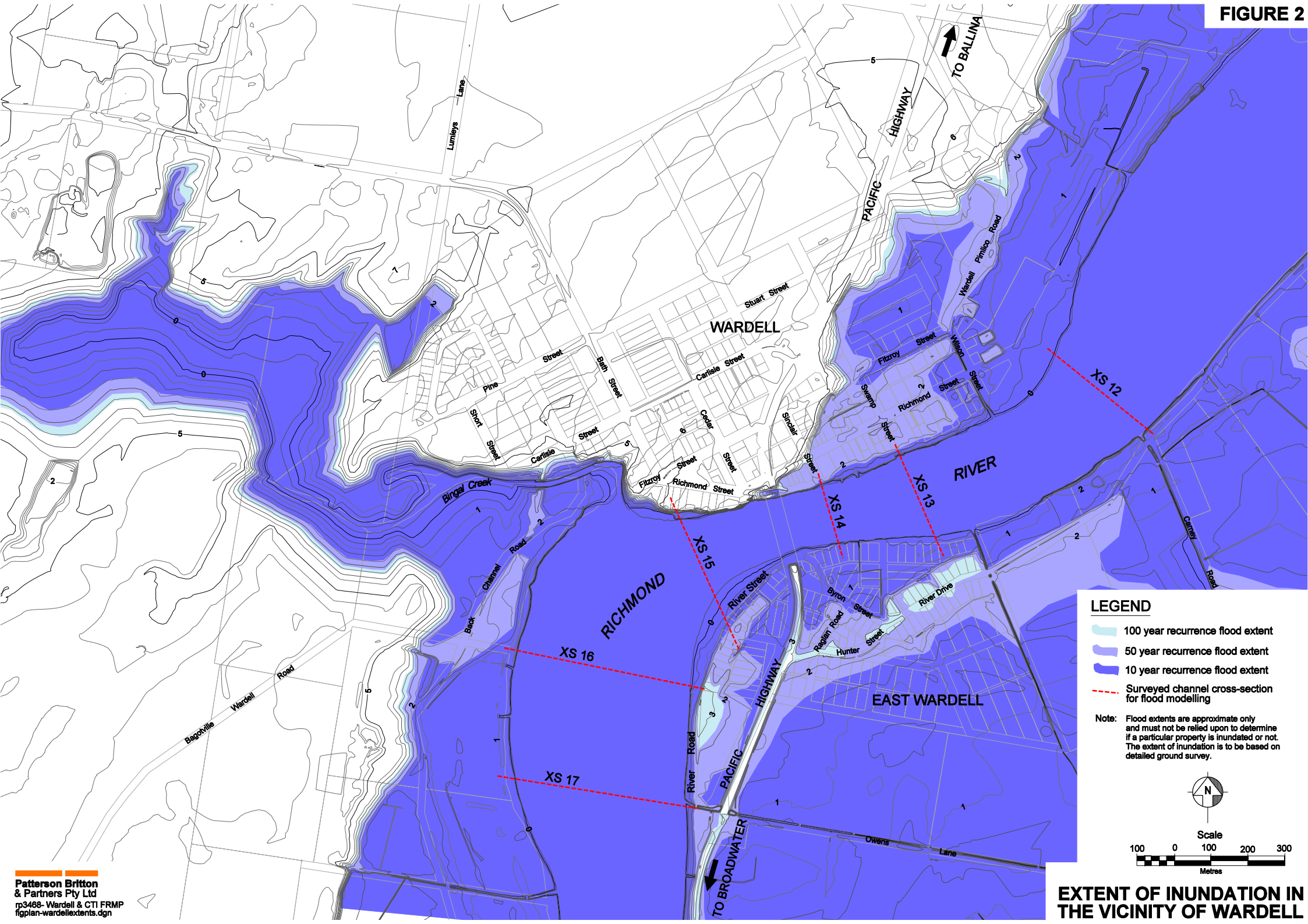
As shown, flooding will lead to inundation of commercial and residential areas of Wardell during the design 100 year recurrence event.

The peak level of the 100 year recurrence flood downstream from the Pacific Highway bridge crossing is predicted to be 2.9 mAHD. As a result, areas of Wardell that are located to the east of the Pacific Highway are expected to be almost completely inundated during the 100 and 50 year recurrence floods.

East Wardell will be completely inundated during the 100 year recurrence flood and a significant portion would be inundated during the 10 year recurrence flood.

An assessment has also been made of floods rarer than the 100 year recurrence event. Peak flood levels have been generated for the Probable Maximum Flood (*PMF*) and are shown in **Table 1**. Flood modelling shows that peak flood levels are predicted to be up to 1.7 metres higher than the peak levels predicted for the 100 year recurrence event.

FIGURE 2



LEGEND

- 100 year recurrence flood extent
- 50 year recurrence flood extent
- 10 year recurrence flood extent
- Surveyed channel cross-section for flood modelling

Note: Flood extents are approximate only and must not be relied upon to determine if a particular property is inundated or not. The extent of inundation is to be based on detailed ground survey.

N

Scale

100 0 100 200 300

Metres

EXTENT OF INUNDATION IN THE VICINITY OF WARDELL

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figplan-wardellextents.dgn

1.2.2 Flood Hazard

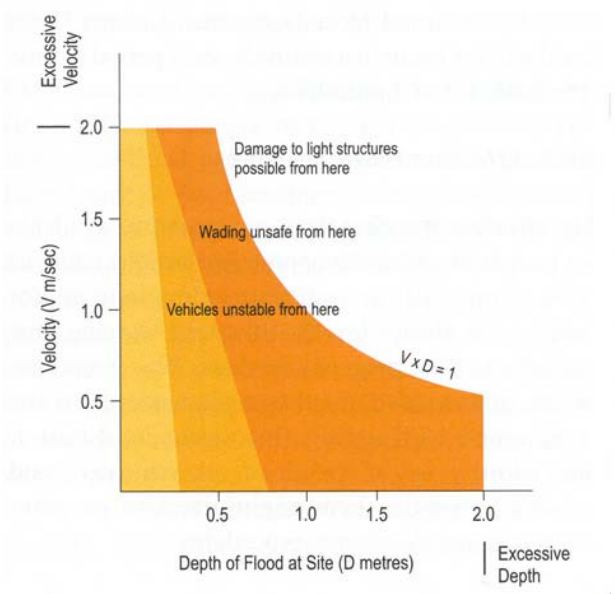
Background

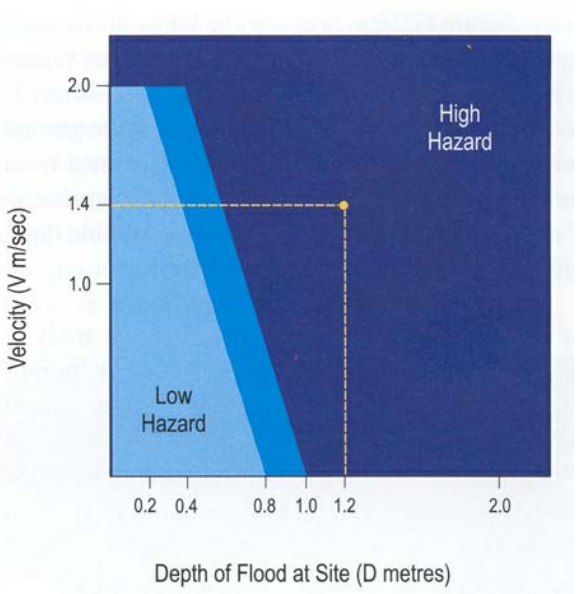
The personal danger and physical property damage caused by a flood varies both in time and place across the floodplain. Accordingly, the variability of flood patterns across the floodplain needs to be understood by flood prone landholders and by floodplain managers.

Representation of the variability of flood hazard across the floodplain provides floodplain managers with a tool to assess the existing flood risk and to determine the suitability of land use and future development. The hazard associated with a flood is represented by the static and dynamic energy of the flow, which is in essence, the depth and velocity of the floodwaters.

Therefore, the flood hazard at a particular location within the floodplain, is a function of the velocity and depth of the floodwaters at that location.

The NSW Government's *'Floodplain Development Manual'* (*2005*), divides hazard associated with flooding into two categories, namely, high and low hazard. An interpretation of the hazard at a particular site can be established from the following graphs, which have been taken directly from the Manual.





The first of these shows approximate relationships between the depth and velocity of floodwaters and the resulting hazard. This relationship has been used to define the provisional low and high hazard categories represented in the second of these plots.

As shown, flood hazard is a measure of the degree of difficulty that pedestrians, cars and other vehicles will have in egressing flooded areas, and the likely damage to property and infrastructure. At low hazard, passenger cars and pedestrians (*adults*) are able to move out of a flooded area. At high hazard, wading becomes unsafe, cars are immobilised and damage to light timber-framed houses would occur.

Therefore, the flood hazard is categorised according to a combination of the flow velocity and the depth of floodwater. The categories are defined by lower and upper bound values for the product of flow velocity and floodwater depth.

Adopted Hazard Categories

A summary of the adopted criteria defining each hazard category is shown in **Table 2**, which have been derived from the relationships contained in the *Manual* (*refer above*).

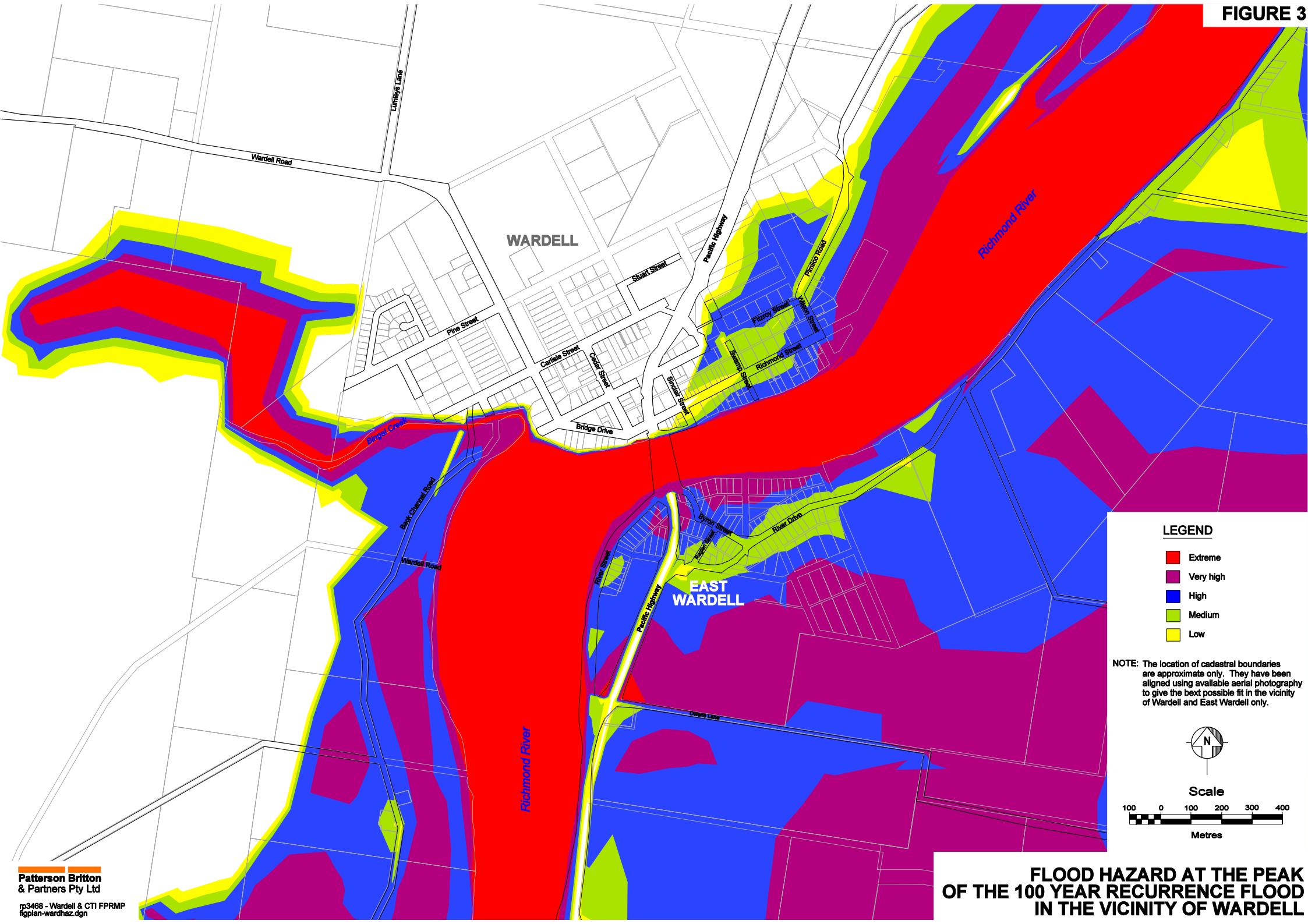
Table 2 CRITERIA FOR HAZARD CATEGORIES

HAZARD CATEGORY	CRITERIA
Low	Depth (d) < 0.4 m & velocity (v) < 0.5 m/s
Medium	exceeding Low criteria, and $d \leq 0.8$ m, $v \leq 2.0$ m/s, and $v \times d \leq 0.5$
High	exceeding Medium criteria, and $d \leq 1.8$ m, $v \leq 3.0$ m/s, and $v \times d \leq 1.5$
Very High	exceeding High criteria, and with $d > 1.8$m, 0.5 m/s < velocity < 4 m/s & $v \times d \leq 2.5$
Extreme	exceeding Very High criteria and $v > 0.5$ m/s

The results from computer modelling undertaken as part of the Flood Study (*2007*) and Floodplain Risk Management Study (*2008*) were used to determine the variation in flood hazard across the floodplain of Richmond River.

Provisional flood hazard mapping for Wardell is presented in **Figure 3** for the 100 year recurrence flood.

FIGURE 3



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FLOOD HAZARD AT THE PEAK OF THE 100 YEAR RECURRENCE FLOOD IN THE VICINITY OF WARDELL

2 EXISTING FLOOD PROBLEM

2.1 GENERAL

The "existing flood problem" relates to those areas of the existing floodplain where damages are likely to arise as a consequence of flooding. It concerns existing dwellings and properties that would be inundated during a flood, as well as all associated infrastructure within the floodplain, including roads and utility services.

In this context, the "existing flood problem" is usually addressed by structural measures which aim to modify flood behaviour and thereby reduce flood damages.

2.2 FLOOD DAMAGES

Data defining the floor levels of residential dwellings and commercial buildings located within Wardell and East Wardell was provided by Ballina Shire Council. This data was used with peak flood levels generated from flood modelling to determine the depth of flooding in the vicinity of each building. This allowed the depth of 'over floor' flooding to be determined (*if any*). The flood affected dwellings in the vicinity of Wardell are identified in **Figure 4**.

At least three existing dwellings are predicted to be inundated during the 20 year recurrence flood. Most houses at East Wardell will experience some flood affectation during floods rarer than the 10 year recurrence event.

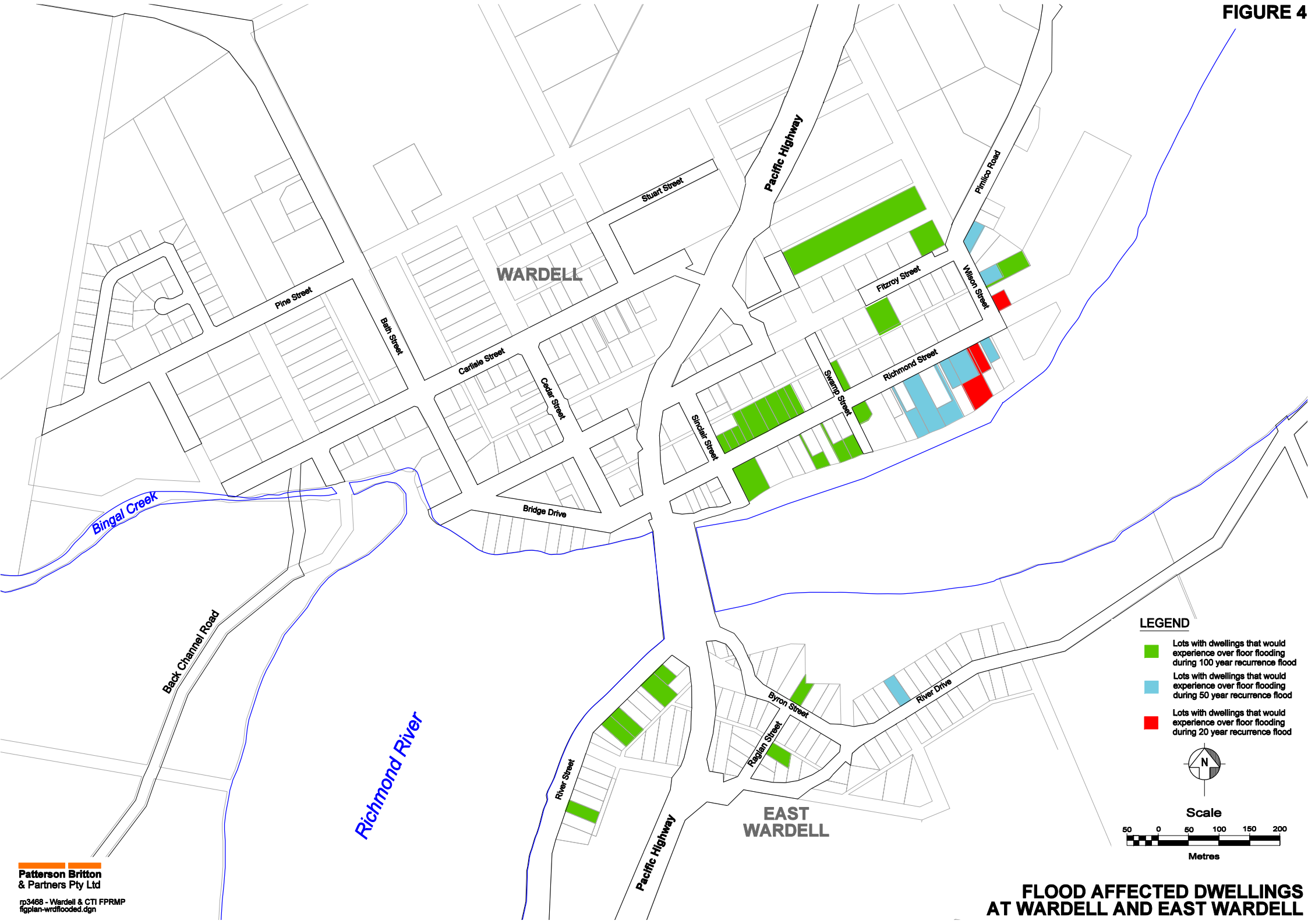
Estimates of the flood damages associated with each of the 100, 50, 20, 10 and 5 year recurrence floods and the Probable Maximum Flood (*PMF*) are listed in **Table 3**. The number of properties predicted to be inundated during each flood are also listed. All damage costs are expressed in 2006 dollars.

Up to 33 residential dwellings and five commercial sites would experience overfloor flooding during the 100 year recurrence event, which would result in a total tangible flood damage bill of over $3,000,000.

The relative cost of the potential flood damages is typically expressed in terms of the Average Annual Damage (*AAD*), which represents the average damage per year that would occur from flooding over a very long period of time. Based on the damages analysis presented in **Table 3**, the Average Annual Damage (*AAD*) for Wardell and East Wardell is estimated to be about $145,000. This estimate of the AAD is based on the total tangible damages only. That is, the calculations do not consider the potential intangible costs that are likely to be experienced, particularly during the larger floods.

For example, in the case of Wardell, if intangible damages corresponding to 50% of the corresponding tangible damages for events rarer than the 50 year recurrence flood, the AAD for Wardell would increase to about $210,000.

FIGURE 4



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figplan-wrdflooded.dgn

FLOOD AFFECTED DWELLINGS AT WARDELL AND EAST WARDELL

Table 3 EXISTING FLOOD DAMAGE COSTS FOR WARDELL

FLOOD EVENT (Average Recurrence Interval)	RESIDENTIAL DAMAGES			INDUSTRIAL / COMMERCIAL DAMAGES		INFRASTRUCTURE DAMAGES	TOTAL DAMAGE COST (2006 $)
	Number of Dwellings Inundated	Number of Dwelling Sites Inundated	Estimated Cost of Damages	Number of Sites Inundated	Estimated Cost of Damages	Estimated Cost of Damages	
5 Year	0	3	$2,030	0	$0	$610	$2,650
10 Year	0	18	$27,130	0	$0	$8,140	$35,500
20 Year	3	33	$254,460	0	$0	$76,340	$331,000
50 Year	12	64	$952,860	1	$7,480	$288,100	$1,248,500
100 Year	33	95	$2,254,590	5	$85,090	$701,900	$3,041,000
Probable Maximum Flood	110	110	$10,202,150	10	$897,730	$3,329,960	$14,430,000

2.3 OPTIONS TO ADDRESS THE EXISTING FLOOD PROBLEM

Three structural floodplain management options have been identified that could potentially reduce flood damages and address the existing flood problem. Refer to the Wardell & Cabbage Tree Island Floodplain Management Study (*2008*) for a complete list of all measures considered.

These options consist of the following two flood damage reduction measures, either as isolated measures and as a combined third option:

- Construction of a levee with a nominal crest elevation of 2.5 mAHD extending along the western river bank at Wardell from Sinclair Street to Wilson Street; and,
- Dredging of the Richmond River channel extending from Little Pimlico Island upstream to Meaneys Lane.

These flood damage reduction measures are shown graphically in **Figure 5**. A description of each structural floodplain management option is presented in **Table 4**.

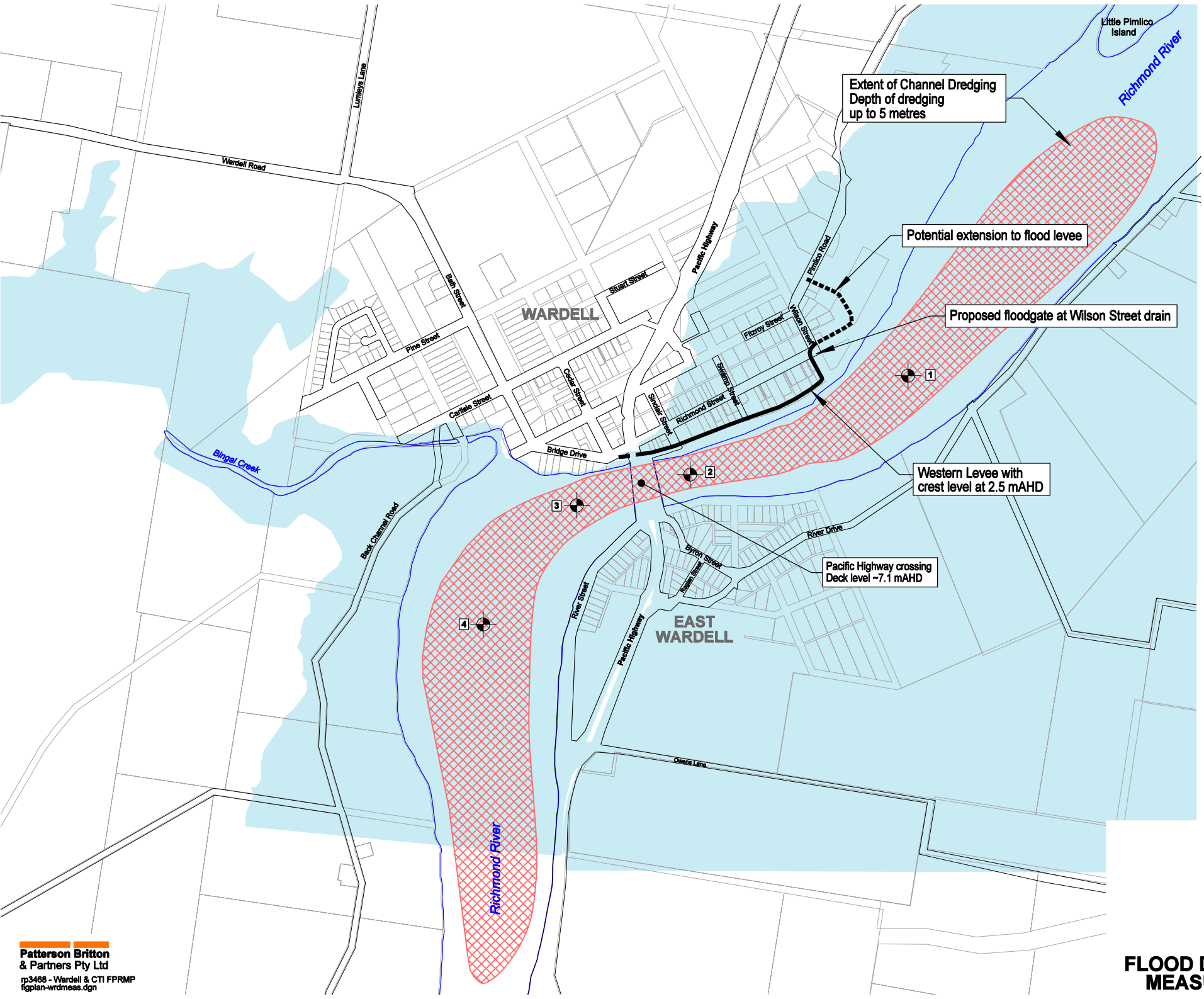
2.4 ASSESSMENT OF STRUCTURAL FLOODPLAIN MANAGEMENT OPTIONS

2.4.1 Hydraulic Assessment

To enable the effectiveness of each flood management option to be evaluated, each option was incorporated into the RMA-2 hydraulic model that was originally developed to define existing flood behaviour as part of the *'Wardell and Cabbage Tree Island Flood Study'* (*2007*). The RMA-2 model was then used to simulate flood behaviour with each of the proposed structural measures in place. The impact of each management measure was then quantified by developing flood level and flow velocity difference mapping for each option.

Difference maps are created by comparing peak flood level and flow velocity estimates at each node in the RMA-2 model from simulations undertaken for both existing and post-development (*i.e., incorporating the proposed management options*) scenarios. This effectively creates a contour map of predicted changes in peak flood levels and flow velocities and allows easy determination of the impact that each proposed management options is likely to have on existing flood behaviour.

FIGURE 5



Location	Peak Flood Level (mAHD)			
	PMF	100yr	50yr	20yr
1	4.50	2.84	2.52	2.10
2	4.55	2.86	2.54	2.12
3	4.66	2.99	2.65	2.21
4	4.68	3.03	2.69	2.25

LEGEND

- Approximate extent and alignment of levee
- Approximate extent of channel dredging
- 2 Reference location for peak flood level table
- Extent of inundation at the peak of the 100 year recurrence flood

N

Scale

100 0 100 200 300 400

Metres

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figplan-wrdmeas.dgn

FLOOD DAMAGE REDUCTION MEASURES FOR WARDELL

Table 4 SUMMARY OF STRUCTURAL FLOODPLAIN MANAGEMENT OPTIONS

OPTION	S1	S2	S3
Description of Measure	Construction of a levee with a nominal crest elevation of 2.5 mAHD extending along the western river bank at Wardell from Sinclair Street to Wilson Street	Dredging of the Richmond River channel extending from Little Pimlico Island upstream to Meaneys Lane	Construction of a levee with a nominal crest elevation of 2.5 mAHD extending along the western river bank at Wardell from Sinclair Street to Wilson Street and dredging of the Richmond River channel extending from Little Pimlico Island upstream to Meaneys Lane
Details	The alignment and extent of the proposed levee is shown in Figure 5. The proposed levee would afford additional protection to those low-lying properties located on the western floodplain of the Richmond River. The proposed levee extends from near the intersection of Richmond Street and Bridge Drive and follows an alignment that is generally parallel to the river. The levee extends around the southern end of Wilson Street and terminates east of the Wilson and Richmond Streets intersection. The crest of the levee is to be constructed at a nominal elevation of 2.5 mAHD. This will afford protection during floods up to and including the 20 year recurrence flood, with provision of a freeboard of between 300 to 400 mm. The proposed levee would need to be elevated up to 1.5 metres above the adjoining floodplain.	The dredging will involve deepening the river channel by up to 5 metres and the removal of about 1.2M m^3 of material from the river bed. The dredging will aim to increase the flow carrying capacity of the Richmond River channel. This will potentially allow a greater proportion of flood flows to be contained to the river channel, thereby, reducing the proportion of flows discharged across the floodplain in the vicinity of Wardell and East Wardell. Hydraulic assessment of the dredging option shows that flood levels upstream from Wardell may be reduced by up to 0.08 metres.	This option is essentially a combination of S1 and S2. Implementation of this option is predicted to result in a decrease in peak 100 year recurrence flood levels of up to 0.07 metres at locations upstream from Wardell. However the reduction in peak level in the vicinity of Wardell is expected to be limited to about 0.02 to 0.05 metres.
Preliminary Cost Estimate	$300,000	$24.4Million	$24.7Million
Reduction in Annual Average Damage	$100	$39,700	$10,900
Benefit-Cost Ratio	< 0.01	0.02	< 0.01
Additional Considerations	Floodwaters may still inundate the township by 'backing up' around the downstream end of the proposed levee. There may be potential to extend the levee further around the downstream sections of Wardell. However, this would require the length of the levee to be extended by around 600 metres and would extend through privately owned property.	The cost of dredging is a prohibitive factor. Dredging of the Richmond River is also likely to have significant environmental implications.	Again, the cost of dredging is a prohibitive factor, in addition to the potential for significant environmental implications.

2.4.2 Benefit - Cost Assessment

A benefit-cost analysis was also undertaken to assess the economic viability of implementing the proposed flood management options. The cost of construction works was estimated and compared with the predicted monetary benefit offered by each option in terms of the potential reduction in flood damages.

Flood damages for floodplain management options were determined according to the process outlined above. Direct and indirect costs have been included in all damage cost estimates (*excluding infrastructure damages which stand alone*). All damage costs are expressed in 2006 dollars.

The 'average annual damage' (*AAD*) was determined for each scenario by summing the damages corresponding to the different design events, which were factored by their probability of occurrence. The reduction in AAD for each management option relative to the AAD that would be incurred under existing conditions was used to determine the total net present value of the 'benefit' provided by the option, considering a design life of 30 years for each option.

Each floodplain management option has been assessed in terms of the benefit-cost ratio associated with their implementation. The 'cost' is an estimate of the capital required to implement the management option in 2006 dollars.

The estimated benefit-cost ratio for each option is listed in **Table 4**.

2.5 DISCUSSION

The potential structural options are considered to have too low a benefit-cost to support funding. Accordingly, it is recommended that they not be included in a schedule of works as part of this Floodplain Risk Management Plan. In this regard, options for addressing flooding issues in Wardell and East Wardell will rely on planning or non-structural measures that aim to manage the occurrence of flooding, or limit non flood compatible development through building controls.

3 FUTURE FLOOD PROBLEM

3.1 GENERAL

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

Council has a duty of care to ensure that its current planning instruments recognise the flood hazard and that a Floodplain Risk Management Plan is in place and can support decisions to approve or reject development proposals for land within the Richmond River floodplain at Wardell and East Wardell.

3.2 FUTURE DEVELOPMENT

The most significant issue confronting the further development of Wardell and East Wardell relates to the constraints placed on owners of land that is zoned 2(b) – Residential, Village Area, but which requires substantial filling to meet requirements for flood protection.

Following public exhibition of the *'Wardell and Cabbage Tree Island Floodplain Risk Management Study (Feb, 2007)'*, Council amended its flood levels policy, *'Combined Development Control Plan, Chapter 1 - Urban Land, Policy Statement No 11 - Flood Levels (March 2008)'* to incorporate the following clauses related to Wardell Village.

> ***"Wardell Village***
>
> *The Wardell and Cabbage Tree Island Floodplain Risk Management Study (Feb 2007), prepared by Patterson, Britton & Partners Pty Ltd, was adopted by Council with Amendments, in June 2007.*
>
> *The study assessed the requirement for site filling of entire allotments for flood protection purposes within the Residential Village Area of Wardell.*
>
> *The following applies to the Residential Village Area of Wardell:*
>
> - *Minimum habitable floor heights shall be Map 1 heights plus 0.5m AHD.*
> - *Filling of allotments along River Street, upstream of the Pacific Highway Bridge, shall remain as the most appropriate method for achieving protection (due to flood hazard). Minimum fill heights shall be Map 1 heights.*
> - *Where the filling of the allotment does not occur, and the habitable floor is supported on structure, the following shall apply:*
>   - *Certification of flood proofing of the structure including enclosures shall be provided which shall include but not be limited to, structural assessment, electrical safety assessment etc.*

- *Sub-floor areas (areas located beneath the habitable floor level and subject to 1:100 year inundation) may be enclosed up to a maximum area of 50m^2.*
- *Sub-floor enclosures beyond the 50m^2 is not permitted. It is intended that the movement of floodwaters be allowed to pass beneath the building.*
- *Any alterations and additions to existing buildings will be considered on their individual merits. Council may require the adoption of minimum habitable floor heights depending on circumstances and practicability."*

3.3 RECOMMENDATIONS FOR PLANNING CONTROLS AND POLICIES

3.3.1 Building Controls

As specified in Council's flood levels policy (*refer above*), the existing minimum requirement for habitable floor levels is the 100 year recurrence flood level plus a specified freeboard of 500 mm. This requirement should be retained.

There will be proposals for dwellings to be sited on flood prone land and constructed using either pier and beam construction techniques or pole or "stilt" construction. In these circumstances it is recommended that a covenant be placed over individual lots to prevent enclosure of ground level or sub-floor areas beyond an area of 50 m^2, and that the enclosed areas of the building be fully flood proofed (*refer glossary in Appendix A for explanation of flood proofing*). This should apply to both single storey dwellings with a sub-floor area, and two storey dwellings.

The basis for the 50 m^2 area is that it is considered to be an area that is sufficiently small to result in no significant impact on flood behaviour, while at the same time being of a size that would allow ground floor laundry and or garage areas to be constructed.

It is noted that this may present an issue for single storey dwellings of pier and beam construction which have a substantial sub-floor height. Property owners may wish to enclose these sub-floor areas to improve the appearance of their dwelling. It is recommended that this be avoided where possible, but that individual proposals for perimeter enclosure of sub-floor areas be considered on a merits basis with due recognition of the local flood hydraulics at the site for all events up to the 200 year recurrence flood.

In this context, it would be necessary for the property owner to show that measures to enclose the perimeter of the dwelling would not adversely impact on the movement of floodwaters that might otherwise have travelled beneath the building.

3.3.2 Revised Flood Policy

It is also recommended that a revised Flood Policy be developed which incorporates the recommended changes outlined above and which links them to other existing flood related requirements for development. The revised flood policy should also incorporate the following additional requirements:

- Building development proposals on flood prone land for all sites provisionally classified as High to Extreme Hazard by mapping contained in **Figure 3** of this Plan should not be supported.
- Council will only support building developments on flood prone land provided the applicant can demonstrate to Council's satisfaction that the development will not adversely impact on flooding across adjoining properties. The applicant is also required to show that flooding will not adversely impact on the development proposal. Such applications are to be prepared by a suitably qualified civil engineer/surveyor/hydrologist with a demonstrated experience in flood assessment of land development proposals.
- Council should only support residential or commercial building developments in flood prone land where effective warning time and reliable access is available for evacuation. Evacuation should be consistent with flood evacuation strategies detailed in the following section and the SES Local DISPLAN.
- Council will not support new building development on flood prone land where emergency evacuation can only occur through high to extreme hazard areas.
- Developments that can demonstrate effective evacuation through low hazard conditions during the early warning phases of a flood may be supported. Applicants are to provide details of the evacuation route and likely flood conditions encountered during an effective evacuation.

3.3.3 Restrictions to Future Subdivision / Development

Figure 3 shows that a number of areas of foreshore land, particularly downstream from the bridge at East Wardell, would be classified as either high hazard floodway or high hazard flood storage.

Accordingly, it is recommended that development of the River Street frontage downstream from the Pacific Highway Bridge crossing be prohibited along a strip of land extending 50 metres back from the existing southern shoreline of the river. Any development of land south from this exclusion zone would need to be justified on the grounds of the development (*e.g., filling*) not adversely affecting flood behaviour on areas where existing development occurs, as well as provision of evidence to show that flooding would not lead to severe damage of dwellings that may be proposed for construction on the land.

In terms of the land upstream from the bridge, there is merit in considering voluntary house raising of the 5 properties in this area that would experience over floor flooding in the design 100 year recurrence event (*refer* **Figure 4**). The likely cost of these works is estimated to be $70,000 per dwelling.

Notwithstanding, it needs to be recognised that all of these dwellings would not be inundated in a 20 year recurrence flood. It is the Department of Environment & Climate

Changes' experience that funding for voluntary house raising is difficult to obtain unless over floor flooding is predicted in more frequent events than the 20 year recurrence flood.

In this context, although relaxation of the fill requirement has been incorporated into Council's existing Flood Levels Policy, it is likely that filling of currently undeveloped lots along this section of River Street presents as the most appropriate means of meeting the floor level requirements for dwellings.

Figure 3 also shows that there are three properties in Wardell village near the intersection of Richmond and Wilson Streets, that would experience over floor flooding in moderate flood events; i.e., in the order of the 20 year recurrence flood. It would also be appropriate to consider the potential for voluntary house raising of these properties, albeit that the same caveats as outlined above for East Wardell (*viz., difficulty in obtaining funding*) should be recognised.

4 RESIDUAL FLOOD PROBLEM

4.1 WHAT IS THE RESIDUAL FLOOD PROBLEM?

Unless the Probable Maximum Flood (*PMF*) is adopted as the basis for determining structural and planning measures to reduce flood damages, there will always be a residual or continuing flooding problem. That is, there will always be the risk of a flood occurring that is larger than the adopted planning flood (*eg., the 100 year recurrence flood*). Measures put in place to control flood damage will ultimately be overwhelmed by a flood that is larger than that adopted as the threshold for planning controls imposed on land-use, or as the limiting flood for the design of structural flood damage reduction measures.

Hence, it is incumbent upon Council to consider the implications of floods greater than the adopted planning flood and to work with the State Emergency Services (*SES*) to develop a contingency plan for such events. This approach ensures that the residual flood problem is addressed and measures are implemented to ensure the safety of residents and visitors of Wardell and East Wardell.

4.2 EXISTING PROTOCOLS FOR EMERGENCY RESPONSE

Due to its location on the floodplain, it is considered that the greatest risk to life as a result of the residual flood hazard will occur at East Wardell. Residents of Wardell will be able to leave their dwellings or businesses once floodwaters exceed the top of bank level and "walk out of the floodplain" to higher ground.

According to the *Ballina Local Flood Plan (2000),* a sub-plan of the Ballina Local Disaster Plan (*DISPLAN*), it is understood that provisions for evacuation of East Wardell are based on door knocking by SES personnel. Residents are to evacuate by means of private vehicle to Ballina. The potential evacuation route is shown in **Figure 6**.

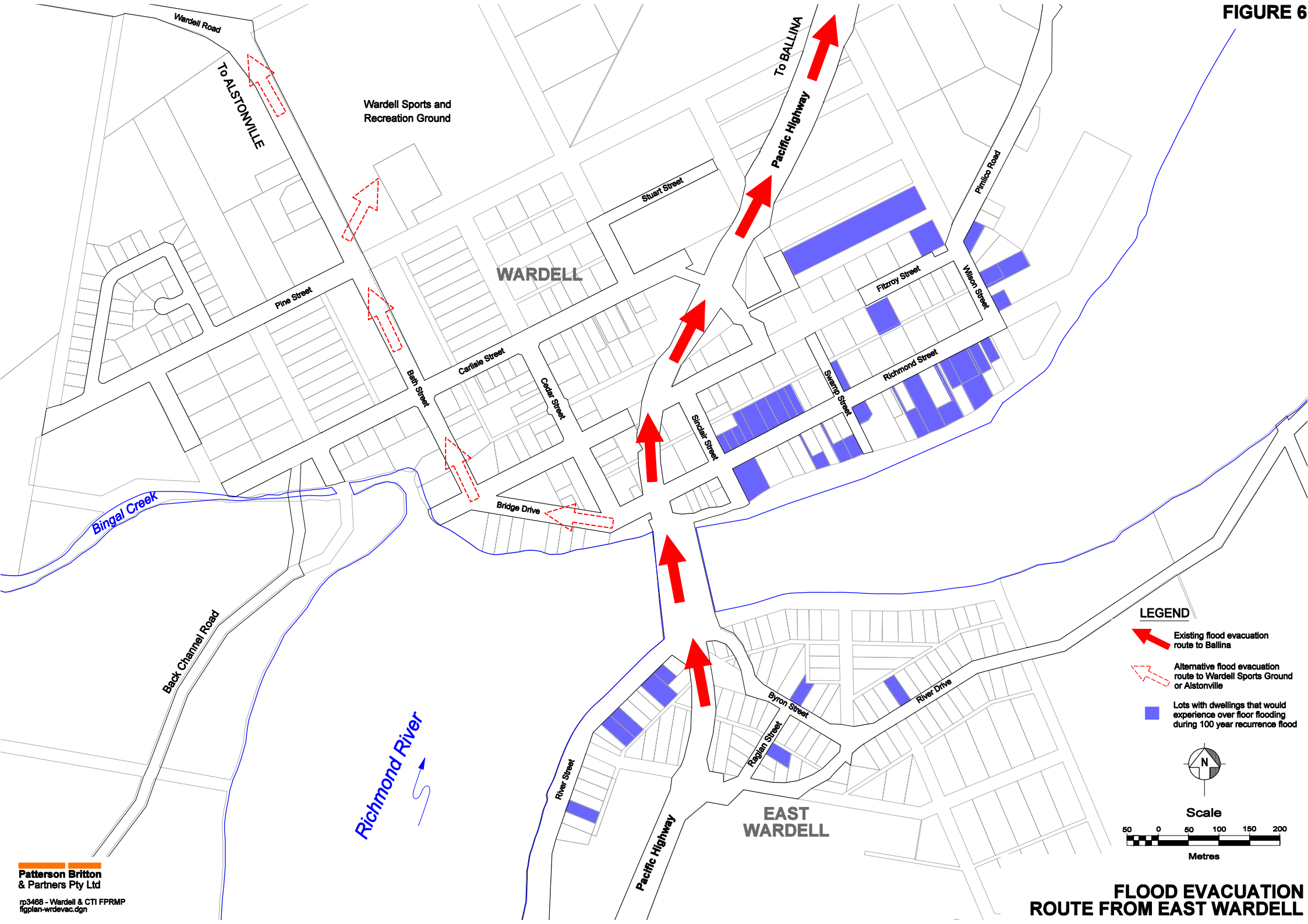
There is currently no information that indicates the time from when floodwaters reach a particular level upstream (*say at Coraki or Broadwater*) to when flooding will occur at Wardell. This will be dependent on the rate of rise of floodwaters, which may vary from flood to flood.

4.3 RECOMMENDED FLOOD EMERGENCY RESPONSE MEASURES

In a major Richmond River flood, Ballina would also be significantly affected by flooding. This may place a strain on evacuation centres and emergency services operating in the Ballina area. It may also mean that parts of the highway between Wardell and Ballina are either cut or choked with traffic.

The number of residents at East Wardell and Wardell that would be affected during a flood is small. Therefore, it may be more appropriate for residents to be evacuated to the Wardell Sports and Recreation Ground which is on relatively high ground (*refer* **Figure 6**). This would ensure

FIGURE 6



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FLOOD EVACUATION ROUTE FROM EAST WARDELL

residents are closer to their homes and would be well positioned to take part in recovery operations at their homes in the aftermath of the flood.

Alternatively, residents could be evacuated to the entertainment centre at Alstonville via Wardell Road (*refer* **Figure 6**). This would avoid any additional risk associated with travel along potentially flooded roads between Wardell and Ballina, and would reduce the burden on emergency services activities in and around Ballina.

In this context, it is recommended that the Ballina Local DISPLAN be modified to incorporate the following alternative options for flood evacuation from Wardell (*refer* **Figure 6**):

- Relocation of flood affected residents at Wardell and East Wardell to the Wardell Sports and Recreation Ground for temporary refuge during relatively short episodes of flooding; or,
- Relocation of flood affected residents to the entertainment centre at Alstonville if the duration of flooding is expected to be more than one or two days.

Based on an assessment of historical and design flood hydrographs for the Richmond River, it has been determined that a flood warning system for Wardell and East Wardell should be based on real-time gauge levels recorded upstream at Coraki and, to a lesser extent, at Woodburn.

Once flood levels reach the 10 year recurrence level at Coraki, there will be at least 10 hours warning time before 10 year recurrence flood levels are experienced at Wardell (*even if the event goes on to be something rarer, such as of the order of a 100 year recurrence flood*). Coraki has been adopted as the reference point for flood warning times due to there being more reliable data available from the Coraki stream gauge record. In addition, the Coraki gauge is far enough upstream to provide sufficient warning time for evacuation to be implemented at Wardell.

The modelled hydrographs for the Woodburn gauge indicate that the flood warning time relative to Woodburn would be about 1 hour, which would be insufficient to allow evacuation to be implemented. Furthermore, flood warnings are not typically issued by the Bureau of Meteorology relative to gauges that are tidally affected like the Woodburn gauge.

Notwithstanding, real-time monitoring of flood levels at Woodburn can be undertaken to verify the gauged levels at Coraki.

Accordingly, it is recommended that the DISPLAN be modified to incorporate the dissemination of flood warnings to residents at Wardell and East Wardell based on levels recorded at Coraki (*and Woodburn*). It is envisaged that warnings could be broadcasted by the media to assist in reducing the burden of SES in relation to door knocking and ensuring all residents are evacuated.

5 FLOODPLAIN RISK MANAGEMENT PLAN

5.1 IMPLEMENTATION OF THE PLAN

The following floodplain management strategies are recommended for implementation under this Floodplain Risk Management Plan. Further details of the actions associated with each strategy are provided in **Table 5**, overleaf.

(1) Further revision of Policy Statement No.11 (*Flood Levels*) within Council's Combined Development Control Plan Chapter 1 – *Urban Land* to incorporate additional requirements for Wardell Village and general flood-related requirements for development across the Ballina Shire LGA, as described in Section 3.3.2 above.

(2) State Emergency Services to update the Ballina Local Flood Plan 2000 to incorporate flood warning protocols for Wardell and alternative options for flood evacuation and refuge.

(3) Consider 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 recurrence flood, and for existing dwellings at Wardell Village (*near the intersection of Richmond and Wilson Streets*) that are affected by over floor flooding during the 20 year recurrence event.

5.2 ESTIMATED COST OF STRATEGIES

The cost of implementation of each of the above strategies has been estimated and included in **Table 5** (*refer overleaf*).

The total cost of the proposed strategies is determined to be approximately **$570,000** (*exclusive of GST*). However, a majority of this cost is associated with voluntary house raising for properties in East Wardell, for which obtaining funding may prove difficult.

TABLE 5 WARDELL FLOODPLAIN RISK MANAGEMENT PLAN - IMPLEMENTATION SCHEDULE

ITEM	RECOMMENDED STRATEGY	ACTIONS	ESTIMATED COST	SUGGESTED RESPONSIBILITY	PROJECTED DATE FOR COMMENCEMENT
1	Further revision of Policy Statement No.11 (Flood Levels) within Council's Combined Development Control Plan Chapter 1 – Urban Land to incorporate additional requirements for Wardell Village and general flood-related requirements for development across the Ballina Shire LGA.	1. Rename Policy Statement No.11 to 'Flood Policy'. 2. Incorporate additional clauses into Section 4.4 of the Policy for Wardell Village to include the requirements outlined in Section 3.3.2 of this Plan 3. Incorporate additional clause into Section 4.4 for Wardell Village that specifies that development is prohibted within 50 metres of the shoreline at East Wardell, downstream from the Pacific Highway Bridge. For development immediately south of this zone, it needs to be shown that substantial flood damages will be avoided and the impact on flooding will be minimal.	$5,000	Ballina Shire Council	2010 (in progress)
2	Update the Ballina Local Flood Plan 2000 to incorporate flood warning protocols for Wardell and alternative options for flood evacuation and refuge.	1. Consult with Local and Regional SES officers to modify the Local Flood Plan. 2. Update the Flood Plan to incorporate the dissemination of flood warnings to residents at Wardell and East Wardell based on flood levels recorded at Coraki (and Woodburn). Monitoring of flood levels at Coraki will provide approximately 10 hours warning time. 3. Warnings should be broadcasted by the local media to assist in reducing the burden of SES in relation to door knocking and ensuring all residents are evacuated. 4. Update the Flood Plan to incorporate the relocation of flood affected residents at Wardell and East Wardell to the Wardell Sports and Recreation Ground for temporary refuge during relatively short episodes of flooding. 5. Update the Flood Plan to incorporate the relocation of flood affected residents to the entertainment centre at Alstonville if the duration of flooding is expected to be more than one or two days.	$5,000	SES / Ballina Shire Council	2010
3	Consider 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 recurrence 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 yea recurrence event.	1. Consult with property owners to determine support for house raising proposal. 2. Consult with DECCW regarding the likelihood of gaining funding for works. 3. Undertake a detailed assessment of the costs, benefits and flood impacts associated with the proposed house raising works. 4. Seek funding for works. 5. Subject to funding approval and technical assessment, undertake voluntary house raising.	$560,000	Ballina Shire Council / DECCW	2010

* Construction cost estimates are based on WorleyParsons' experience and judgement as a firm of practising professional engineers familiar with the construction industry.
Construction cost estimates can NOT be guaranteed as we have no control over Contractor's prices, market forces and competitive bids from tenderers.
Construction cost estimates may exclude items which should be considered in a cost plan. Examples of such items are design fees, project management fees, authority approval fees, contractors risk and project contingencies (*e.g. to account for construction and site conditions, weather conditions, ground conditions and unknown services*).
Construction cost estimates by WorleyParsons are not to be relied upon. If a reliable cost estimate is required, then an appropriately qualified Quantity Surveyor should be engaged.

6 REFERENCES

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(9) Department of Environment and Climate Change (*May, 2007*), *'Floodplain Risk Management Guideline – Residential Flood Damages'*.

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(12) Smith DI, Den Exter P, Dowling MA, Jellife PA, Munro RG & Martin WC (*1979*), *'Flood Damage in the Richmond River Valley, New South Wales – An assessment of tangible and intangible damages'*; Report prepared for the Richmond River Inter-departmental Committee Flood Mitigation Investigation; ISBN 0 86740 312 8.

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APPENDIX A
GLOSSARY OF TECHNICAL TERMS

GLOSSARY OF TECHNICAL TERMS

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 a one-in-twenty chance*) of a peak flood discharge of 500 m^3/s or larger occurring in any one year (*see average recurrence interval*).
Australia Height Datum (AHD)	A common national surface level datum corresponding approximately to mean sea level.
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. The ARI is another way of expressing the likelihood of occurrence of a flood event.
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.
design flood	A hypothetical flood representing a specific likelihood of occurrence (*for example the 100 year ARI or 1% annual exceedance probability flood*). The design flood may comprise two or more single source dominated floods.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (*EP&A Act*). infill development: refers to 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: may involve 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.

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*).
effective warning time	The time available after receiving advice of an impending flood and before 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.
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 6 hours of the causative rainfall.
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 water course, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood behaviour	The pattern/characteristics/nature of a flood. The flood behaviour is often presented in terms of the peak average velocity of floodwaters and the peak water level at a particular location.
flood awareness	An appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood frequency analysis	A statistical analysis of historical flood records to determine estimates of the magnitude of floods of a selected probability of exceedance (*as adapted from Institution of Engineers' publication titled, Australian Rainfall & Runoff* (*1998*))
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood hazard	See hazard
flood level	The height or elevation of flood waters relative to a datum (*typically the Australian Height Datum*). Also referred to as "stage".
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.
flood planning levels (FPLs)	The combinations of flood levels and freeboards selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans. The use of FPL's supersedes the "standard flood event" referred to in the 1986 edition of the *'Floodplain Development Manual'*.

flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures to reduce or eliminate flood damages.
floodplain management	The coordinated management of the risks associated with human activities that occur on the floodplain.
flood prone land	Land susceptible to flooding by the probable maximum flood (PMF) event. Flood prone land is synonymous with flood liable land.
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 can be divided into three types, existing, future and continuing risk. 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 storages 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 areas often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
freeboard	A factor of safety typically used in relation to the setting of floor levels and levee crest levels etc. It is usually expressed as the difference in height between the adopted flood planning level and the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related such as levee and embankment settlement, and other effects such as “greenhouse” and climate change. Freeboard is included in the flood

	planning level.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this study 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 *Floodplain Development Manual* (*2005*).
historical flood	A flood which has actually occurred.
hydraulics	The 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	The 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.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
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.
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.
peak discharge	The maximum discharge occurring during a flood event.
probable maximum flood (PMF)	The largest flood that could conceivably occur at a particular location,

	usually estimated from the probable maximum precipitation. 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 the PMF event should be addressed in a floodplain risk management study.
probable maximum precipitation (PMP)	The greatest depth of precipitation for a given duration that is 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 the estimation of the probable maximum flood.
probability	A statistical measure of the expected chance of flooding (*see annual exceedance probability*).
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this flood study (*and the subsequent floodplain risk management study*) it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to "water level". Both 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.
velocity	The speed or rate of motion (*distance per unit of time*) in a specific direction at which the flood waters are moving. Typically, modelled flood velocities in a river or creek are quoted as the depth and width averaged velocity, i.e., the average velocity across the whole river or creek section (*adapted from Chambers English Dictionary 1988*).